ADULT STRIPED BASS

TAGGING PROGRAM

SPRING 1984

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The 1984 Striped Bass Tagging Program compared Scottish seining and trawling as sampling methods to collect, tag, and release striped bass (*Morone saxatilis*) as part of future adult stock assessment programs for the Hudson River estuary. Data was also obtained and analyzed from other studies which utilized gill nets and trammel nets to sample striped bass. A summary of statistics pertinent to the evaluation and design of an adult striped bass tagging program for the Hudson River estuary is presented in the following 13 tables. These data were condensed from detailed analyses and discussion in the report. Topics considered, and the appropriate tabular summaries were:

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TABLE 1-1. HANDLING MORTALITY PRESENTED BY RIVER REGION FOR TRAWL AND SCOTTISH SEINE CAPTURED STRIPED BASS FROM THE HUDSON RIVER, SPRING 1984.

RIVER REGION (river miles)	PERCENTAGE STRIPED BASS DEAD		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
Tappan Zee (24-33)	6 (54)[a]	16 (25)	10 (375)
Croton-Haverstraw (34-38)	4 (23)	0 (4)	12 (296)
Indian Point (39-46)	0 (4)	NS[b]	NS
West Point (47-55)	49 (37)	NS	NS
Cornwall (56-61)	17 (456)	40 (87)	33 (84)
Poughkeepsie (62-76)	0 (0)	NS	NS
All regions	17 (574)	33 (116)	14 (755)

[a] Number of striped bass captured in parentheses (does not include fish released without being measured).

[b] No samples taken.

TABLE 1-2. STRIPED BASS HANDLING MORTALITY IN RELATION TO BOTTOM WATER TEMPERATURE FOR TRAWL AND SCOTTISH SEINE SAMPLES FROM THE HUDSON RIVER, SPRING 1984.

	PERCENTAGE STRIPED BASS DEAD		
		SCOTTISH SEINE	
BOTTOM WATER TEMPERATURE (°C)	TRAWL	1 COIL SETS	2 COIL SETS
8-14	10 (377)[a]	5 (41)	10 (694)
15-16	66 (197)	50 (75)	30 (61)

[a] Number of striped bass captured in parentheses.

TABLE 1-3. STRIPED BASS HANDLING MORTALITY IN RELATION TO WATER TEMPERATURE AND SET TIME FOR GILL NET SAMPLES FROM THE KOUCHIBOUGUAC AND ST. JOHN RIVERS, CANADA, 1974-1984.

	PERCENTAGE STRIPED BASS DEAD	
SET TIME (HRS)	0-14°C	15-18°C
1-2	0 (8)[a]	29 (12)
3-4	8 (40)	37 (35)
5-6	12 (75)	50 (8)
7-8	3 (29)	80 (10)
>8	18 (186)	96 (28)

[a] Number of striped bass captured in parentheses.

TABLE 1-4. SHORT-TERM (24 HOUR) MORTALITY IN RELATION TO GEAR TYPE AND HOLDING WATER TEMPERATURE FOR STRIPED BASS CAPTURED IN THE HUDSON RIVER, SPRING 1984.

HOLDING WATER TEMPERATURE (°C)	PERCENTAGE STRIPED BASS DEAD		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
8-14	30 (72)[a]	30 (16)	30 (126)
14.5-16.5	80 (12)	90 (20)	(0)

[a] Number of striped bass held for 24 hours in parentheses.

TABLE 1-5. SHORT-TERM (24 HOUR) MORTALITY IN RELATION TO TAG TYPE AND HOLDING WATER TEMPERATURE FOR STRIPED BASS CAPTURED IN THE HUDSON RIVER, SPRING 1984.

	PERCENTAGE STRIPED BASS DEAD			
HOLDING WATER TEMPERATURE (°C)	FLOY INTERNAL ANCHOR TAG	FLOY FD-68B TAG	DOUBLE TAG[a]	CONTROL[b]
8-14	38 (50)[c]	27 (49)	25 (50)	34 (50)
14.5-16.5	67 (12)	61 (12)	83 (12)	83 (12)

[a] Double tagged fish received both Floy Internal Anchor Tag and Floy FD-68B tag.

[b] Control fish received no tags.

[c] Number of striped bass held for 24 hours in parentheses.

TABLE 1-6. STRIPED BASS CATCH PER DEPLOYMENT (ALL SIZE CLASSES COMBINED) FOR TRAWL AND SCOTTISH SEINE GEARS IN THE HUDSON RIVER, SPRING 1984.

RIVER REGION (river miles)	MEAN STRIPED BASS CATCH PER DEPLOYMENT		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
Tappan Zee (24-33)	1.6 (20)[a]	8.3 (3)[b]	20.8 (18)
Croton-Haverstraw (34-38)	2.2 (9)	1.3 (3)	6.9 (43)
Indian Point (39-46)	0.3 (8)	NS[c]	NS
West Point (47-55)	1.2 (18)	NS	NS
Cornwall (56-61)	3.4 (102)	1.9 (47)	3.4 (25)
Poughkeepsie (62-76)	0.0 (2)	NS	NS
All Regions	2.6 (159)	2.2 (53)	8.8 (86)

(a) Number of 10 minute tows completed without sampling problems in parentheses (Use Code = 1).

(b) Number of Scottish Seine sets completed without sampling problems in parentheses (Use Code = 1).

(c) No samples taken.

TABLE 1-7. CATCH OF TAGGABLE SIZE STRIPED BASS (>300 MM TOTAL LENGTH) PER SUCCESSFUL GEAR DEPLOYMENT IN THE HUDSON RIVER, SPRING 1984.

RIVER REGION (river miles)	CATCH OF TAGGABLE SIZE STRIPED BASS PER DEPLOYMENT		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
Tappan Zee (24-33)	1.4 (29)[a]	5.7 (3)	11.0 (18)
Croton-Haverstraw (34-38)	1.4 (13)	0.7 (3)	6.0 (43)
Indian Point (39-46)	0.1 (11)	NS[b]	NS
West Point (47-55)	1.8 (21)	NS	NS
Cornwall (56-61)	3.1 (126)	1.4 (47)	1.6 (25)
Poughkeepsie (62-76)	0 (2)	NS	NS
All Regions	2.4 (200)	1.6 (53)	5.8 (86)

[a] Number of deployments without sampling problems (Use Code =1) in parentheses. For trawl samples, includes all Use Code 1 tows between 5 and 20 minutes in duration.

[b] No samples taken.

TABLE 1-8. NUMBER OF STRIPED BASS CAPTURED BY WEEK AND RIVER REGION FOR TRAWL AND SCOTTISH SEINE GEARS IN THE HUDSON RIVER, SPRING 1984.

	TAPPAN-ZEE			CROTON-HAVERSTRAW			INDIAN POINT			WEST POINT			CORNWALL			POUGHKEEPSIE		
WEEK	T[a]	SS1[b]	SS2[c]	T	SS1	SS2	T	SS1	SS2	T	SS1	SS2	T	SS1	SS2	T	SS1	SS2
4/12-15	41		249															
4/16-22	3		6	13	2	69												
4/23-29	9	19	105	7		68							73	16				
4/30-5/6	[d]			0	0	146							130	0	3			
5/7-13			11		2	3							73	0	11			
5/14-20	1	6	4	3		4	4						4					
5/21-27						6				8			86	42				
5/28-6/3										1			82	27	25			
6/4-9										28			8	2	45	0		
All Weeks	54	25	375	23	4	296	4			37			456	87	84			

(a) Trawl.

(b) Scottish Seine 1 Coil Sets.

(c) Scottish Seine 2 Coil Sets.

(d) Empty cells indicate no samples taken.

TABLE 1-9. AVERAGE NUMBER OF GEAR DEPLOYMENTS PER DAY FOR TRAWL AND SCOTTISH SEINE GEARS DURING THE 1984 ADULT STRIPED BASS PROGRAM.

RIVER REGION (River Miles)	AVERAGE NUMBER OF DEPLOYMENTS PER DAY								
	TRAWL			SCOTTISH SEINE					
				1 COIL SETS			2 COIL SETS		
	USE CODE[a]			USE CODE			USE CODE		
	1	2	5	1	2	5	1	2	5
Tappan Zee (24-33)	4.1	0.0	0.1	2.0	0.0	1.0	2.3	0.8	0.5
Croton-Haverstraw (34-38)	3.3	0.0	0.8	4.0	0.0	0.0	4.2	0.2	0.6
Indian Point (39-46)	4.4	0.0	0.4		NS[b]			NS	
West Point (47-55)	2.3	0.0	0.0		NS			NS	
Cornwall (56-61)	7.2	0.6	0.6	5.7	0.8	0.8	5.5	0.8	2.5
Poughkeepsie (62-76)	4.0	0.0	0.0		NS			NS	
All Regions	4.9	0.3	0.4	5.2	0.7	0.8	3.8	0.5	1.0

[a]Use Code 1 = Valid sample, no sampling problems, all data were available for calculations including catch per unit effort. Use Code 1 samples were used in all data analyses.
2 = Sample completed but sampling problems were encountered. Fish captured were marked and released if in good condition, but catch per unit effort was not calculated from this data.
5 = Void sample, usually resulting from hang down or damage to equipment. No fish were caught.

[b]NS = No samples taken.

TABLE 1-10. DEPLOYMENT SUCCESS (PERCENTAGE OF VOID SAMPLES) FOR TRAWL AND SCOTTISH SEINE GEARS IN HUDSON RIVER REGIONS, SPRING 1984.

RIVER REGION (river miles)	PERCENTAGE VOID SAMPLES		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
Tappan Zee (24-33)	3 (30)[a]	25 (4)	17 (29)
Croton Haverstraw (34-38)	19 (16)	0 (3)	12 (51)
Indian Point (39-46)	8 (12)	NS[b]	NS
West Point (47-55)	0 (21)	NS	NS
Cornwall (56-61)	7 (148)	11 (61)	33 (42)
Poughkeepsie (62-76)	0 (2)	NS	NS
All Regions	7 (229)	12 (68)	20 (122)

[a] Number of samples in parentheses.

[b] No samples taken.

TABLE 1-11. COSTS PER STRIPED BASS CAUGHT IN THE HUDSON RIVER, SPRING 1984.

RIVER REGION (river miles)	COST PER FISH CAPTURED IN DOLLARS [a]			
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS	TRAMMEL NET
Tappan Zee (24-33)	128 (54)[b]	100 (25)	53 (375)	NS
Croton-Haverstraw (34-38)	171 (23)	469 (4)	87 (296)	NS
Indian Point (39-46)	616 (4)	NS[c]	NS	NS
West Point (47-55)	240 (37)	NS	NS	34 (176)[d]
Cornwall (56-61)	38 (456)	237 (87)	156 (84)	NS
Poughkeepsie (62-76)	(0)	NS	NS	NS
All Regions	70 (574)	216 (116)	78 (755)	34 (176)

[a] Costs include labor, boat rental, nets, and fuel in 1984 dollars.
[b] Number of fish captured in parentheses.
[c] No samples taken.
[d] EA Engineering Science and Technology, Inc. 1984, estimate.

TABLE 1-12. ESTIMATED COST PER STRIPED BASS CAPTURED FROM 1981 LMS GILL NET SETS.[a]

1981 DATES	RIVER MILES FISHED	DAILY COST[b]	DAYS FISHED	NUMBER OF STRIPED BASS CAPTURED	COST PER STRIPED BASS[c]
April 7-10	30-34	$589	7	278	$ 15
April 13-17	39-43	589	6	28	126
April 21-24	34-38	589	8	75	63

[a] LMS (Lawler Matusky and Skelly, Engineers) data from personal communication from D. Dunning (New York Power Authority) to M. Mattson (Normandeau Associates, Inc.).

[b] Costs include labor, boat rental, nets, and fuel in 1984 dollars.

[c] This analysis assumes:

- Catch totals listed in LMS 1981 data reflect all fish captured, not adjusted for handling mortality.
- Labor costs for tending gill nets are the same as trammel net labor costs (Table 1-11).
- Nets were tended at 12 hour intervals with each crew working 8 hours each interval.
- Each 12 hour interval represents a day's fishing effort.

TABLE 1-13. COSTS PER STRIPED BASS TAGGED AND RELEASED ALIVE FROM TRAWLS, SCOTTISH SEINE SETS, AND GILL NETS IN THE HUDSON RIVER.

RIVER REGION (river miles)	COST PER FISH TAGGED AND RELEASED ALIVE IN DOLLARS			
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS	GILL AND TRAMMEL NET
Tappan Zee (24-33)	181 (38)[a]		192 (13)	143 (140)
Croton-Haverstraw (34-38)	246 (16)	938 (2)	165 (155)	42 (296)[d]
Indian Point (39-46)	NT[b]	NS[c]	NS	
West Point (47-55)	466 (19)	NS	NS	
Cornwall (56-61)	64 (271)	516 (40)	320 (41)	43 (158)[e]
Poughkeepsie (62-76)	NT	NS	NS	
All Regions	116 (344)	455 (55)	175 (336)	

(a) Number of fish tagged and released alive in parentheses.

(b) No fish tagged and released alive.

(c) No samples taken.

(d) LMS (Lawler, Matusky and Skelly, Engineers) 1981 gill net data from personal communication from D. Dunning (New York Power Authority) to M. Mattson (Normandeau Associates, Inc.).

(e) EA Engineering, Science and Technology, Inc. 1984 trammel net data from hatchery broodstock collections; alive fish were not tagged but considered comparable to tagged fish from other gear.

2.0 INTRODUCTION

This report presents the findings of the 1984 Adult Striped Bass Program which was designed to 1) compare fly dragging (Scottish seining) with otter trawling of a high-rise net as methods of collecting striped bass for a tag-return survey and 2) to double tag and release striped bass which were $\geq$ 300 mm total length (TL) and in good condition. A tag-return survey requires a sampling gear that can collect fish in good condition to maximize survival after tagging. During the 1980 stock assessment study, mortality was greater than 50% by the week of April 14 in gill nets, and the week of April 28 in trawls (Battelle, 1983). Therefore, it became necessary to evaluate a different means of capture for tagging experiments that might have a lower mortality rate. Scottish seining was selected for evaluation because of the possibilities of large catches with relatively low handling mortality (Crowley, 1982).

The goals of this program can be summarized as:

I. To evaluate the feasibility of Scottish seining in comparison with otter trawling as a method of collecting striped bass in the Hudson River for tagging. This included an analysis of:

1. striped bass handling mortality as a function of water temperature and gear type,

2. effects of gear type, fishing effort, and location of sampling on catch, and

3. cost of the field program by gear, including the unit cost per taggable fish.

II. To evaluate 24 hour tagging mortality and tag retention.

III. To evaluate the use of hydroacoustic gear to locate striped bass as a method of increasing striped bass catch.

Handling mortality, as a function of water temperature, was compared between Scottish seining and trawling to determine which gear captured the greatest proportion of fish in good, taggable condition. Gill net data from previous Hudson River striped bass tagging studies (Lawler, Matusky and Skelly Engineers, LMS, 1981) and data from Hogans *et al.* (1984) were used to evaluate effects of water temperature and set time on handling mortality of striped bass in gill nets. In addition, catch per unit effort as a function of river region, and catch characteristics were compared between the Scottish seine and otter trawl to determine geographic variations in catch, and gear selectivity. Since cost can be an important factor in determining the suitability of a sampling gear, costs per taggable fish were compared between Scottish seining, and otter trawling, to determine the most economical means of sampling. Costs per taggable fish for gill net, and trammel net gears were estimated using data from other studies.

An ideal fish tag should have the following characteristics (Everhart *et al.*, 1975):

- Remain unaltered during the life time of the fish.
- Have no effect on fish behavior or make the fish more available to predators.
- Not tangle with weeds or nets.
- Be inexpensive and easily obtained.
- Fit any size fish with little alteration.
- Be easy to apply without anesthetic and with little or no stress to the fish.
- Permit enough variation to at least separate groups.
- Create no health hazard.
- Cause no harm to fish as food or to aesthetics.
- Be easy to detect in the field by untrained individuals.
- Cause no confusion in reporting.
- Remain unaffected by preservation.

This program compared the short-term (24 hr) tagging mortality, and tag retention rates between a Floy internal anchor tag inserted between the vent and anal fin, and a FD-68B (Dennison-type) anchor tag inserted with a tagging gun below the origin of the second dorsal fin. All striped bass ≥300 mm TL captured during this sampling program were double tagged with the Floy internal anchor tag and FD-68B Dennison-type anchor tag. Short-term (24 hour) tag retention and the effects of sampling gear, tag type, and holding water temperature on 24 hour survival were evaluated.

Hydroacoustic techniques were used in this sampling program as a means to locate striped bass for capture. The efficacy of hydroacoustic gear to locate striped bass and increase catch was also evaluated.

3.0 METHODS

3.1 FIELD PROCEDURES

3.1.1 Field Sampling

This section summarizes the field procedures used in the 1984 Adult Striped Bass Tagging Program. A complete description of the field procedures appears in the Quality Assurance Manual (NAI, 1984). Trawl and Scottish seine samples of striped bass were collected approximately 4 days per week, each week from 9 April to 7 June 1984 between Piermont Pier at River Kilometer 40 (RK 40) and Newburgh (RK 98)in shoal (≤6 m depth) and channel (>6 m depth) areas thought to contain an abundance of striped bass based on netting and hydroacoustic data (Figure 3-1).

Trawl samples were collected from the R/V *Fritcher* (Appendix A) equipped with a high-rise trawl (Table 3-1). Scottish seine samples were collected from the F/V *Kit Kat* (Appendix B) equipped with a Jackson 280 modified box trawl (Table 3-2). A Kosalt 360 Plaice net (Table 3-3) was used as an alternate gear to continue fishing on days when the Jackson box trawl was badly damaged.

Trawl samples were collected primarily during the month of May (Table 3-4). Most tows were made during daylight hours (Table 3-5) while towing against the river current at a relative speed of 1.0 to 1.5 $m \bullet sec^{-1}$ for 10 minutes along the river bottom. After 4 June, both day and night tows were made (Table 3-5). Tow duration, distance, speed, and tow line scope were empirically determined and recorded on field data sheets. Speed was measured by engine RPM and by a calibrated electronic flowmeter deployed beside the boat near the water surface.

Previous information (Battelle, 1983) suggested high striped bass handling mortality could occur at water temperatures greater than 18°C (65°F). The following criteria were used after each trawl sample to determine striped bass handling mortality and to modify trawl deployment to minimize mortality:

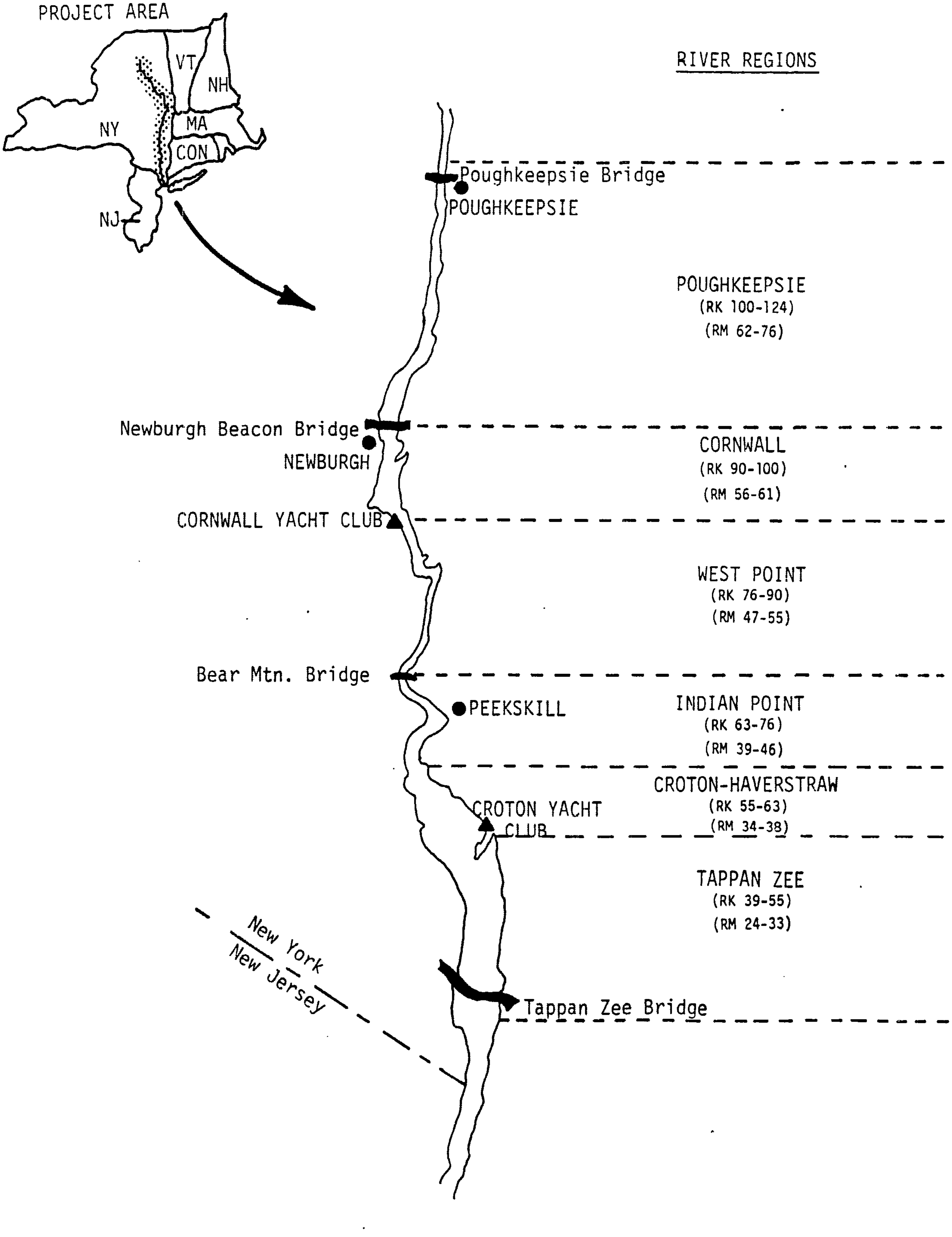

Figure 3-1. Adult striped bass sampling regions, Hudson River, spring, 1984.

TABLE 3-1. SPECIFICATIONS OF THE STRIPED BASS HIGH-RISE TRAWL

Head rope length	6.7 m
Foot rope length (Sweep)	12.2 m
Legs (between doors and net)	18.3 m
Approximate vertical lift	4.9 m
Doors (steel V-doors)	1.0 m
Mesh - body of net	13 cm (stretch) mesh polypropylene; 3 mm diameter twine
- cod end	7.5 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	15 and 10 cm large cookie disks with 5 cm cookie disks as spacers

TABLE 3-2. SPECIFICATIONS OF THE SCOTTISH SEINE

Jackson 280, modified box trawl design

Head rope length	30.5 m
Foot rope length	36.5 m
Mesh - wings	15.9 cm (stretch) mesh polypropylene; 1.6 mm diameter twine
- body of net	15.9 cm (stretch) mesh polypropylene at mouth of net, tapering to 10.2 cm (stretch) mesh polypropylene at the cod end; 1.6 mm diameter twine
- cod end	7.5 cm (stretch) mesh knotless, polypropylene; 1.6 mm diameter twine
Coils (towing warps)	219 m each of lead core rope. 14 total coils available for each leg; rope is 7.5 cm in circumference with a breaking strength of 6,350 kg.

TABLE 3-3. SPECIFICATIONS OF THE KOSALT PLAICE NET

Kosalt 360, modified box trawl design

Head rope length	36.5 m
Foot rope length	48.8 m
Mesh - wings	11.4 cm (stretch) mesh polypropylene; 1.6 mm diameter twine
- body of net	10.2 cm (stretch) mesh polypropylene from mouth to cod end. 1.6 mm diameter twine
- cod end	7.5 cm (stretch) mesh knotless polypropylene; 1.6 mm diameter twine
Coils (towing warps)	219 m each of lead core rope. 14 total coils available for each leg; rope is 7.5 cm in circumference with a breaking strength of 6,350 kg.

TABLE 3-4. SPATIAL DISTRIBUTION OF SUCCESSFUL[(a)] TRAWL AND SEINE SAMPLES IN THE HUDSON RIVER, SPRING 1984.

REGION	RIVER KILOMETERS	(MILES)	TRAWL	NUMBER OF SAMPLES SCOTTISH SEINE ONE COIL SETS	TWO COIL SETS
Tappan Zee	39-55	24-33	29	3	18
Croton-Haverstraw	55-63	34-38	13	3	43
Indian Point	63-76	39-46	11	0	0
West Point	76-90	47-55	21	0	0
Cornwall	90-100	56-61	124	47	25
Poughkeepsie	100-124	62-76	2	0	0
Total	39-124	24-76	200	53	86

(a) Appendix C tabulates success status of trawl and seine samples.

TABLE 3-5. TEMPORAL DISTRIBUTION OF SUCCESSFUL[(a)] TRAWL AND SEINE SAMPLES IN THE HUDSON RIVER, SPRING 1984.

MONTH	NUMBER OF TRAWL SAMPLES		NUMBER OF SEINE SAMPLES ONE COIL SETS		TWO COIL SETS	
	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
April	41	0	5	0	26	0
May	116	0	39	0	40	0
June	24	19	5	4	15	5
	181	19	49	4	81	5
Total	200		53		86	

(a) Appendix C tabulates success status of sampling efforts.

- The percent of striped bass in each sample which are dead or mortally wounded was determined (number dead ÷ total catch x 100).

- If two consecutive 10 minute trawl tows had striped bass mortality >30%, trawl duration was reduced by 50% to 5 minutes.

- If two consecutive 5 minute trawl tows had striped bass mortality >30%, trawl duration was reduced by 50% to 2.5 minutes.

- If two consecutive 2.5 minute trawl tows have striped bass mortality >30%, trawl sampling ceased.

- Trawl sampling ceased if water temperatures exceeded 18°C (65°F).

Scottish seine samples were collected primarily during the daylight hours in the month of May and consisted of one or two-coil sets (Table 3-4; Table 3-5). All seine sets were made in water deeper than 3.0 m and the seine was fished either against or with river currents. For a set against the river current, one warp was set parallel to river currents in a downstream direction, the seine deployed across current, followed by the remaining warp in an upstream fashion (Figure 3-2). Both towing warps were attached to the winch and the haul was completed by retrieving the net against the current direction while the boat remained stationary or moved slowly upstream. For seine sets in the same direction as the river current, the leading warp was set upstream, and the seine deployed across current. The remaining warp was set downstream and the haul was completed towing downstream with the boat remaining stationary or moving slowly downstream.

The following criteria were used after each Scottish seine sample to determine striped bass handling mortality and to modify seine deployment to minimize mortality:

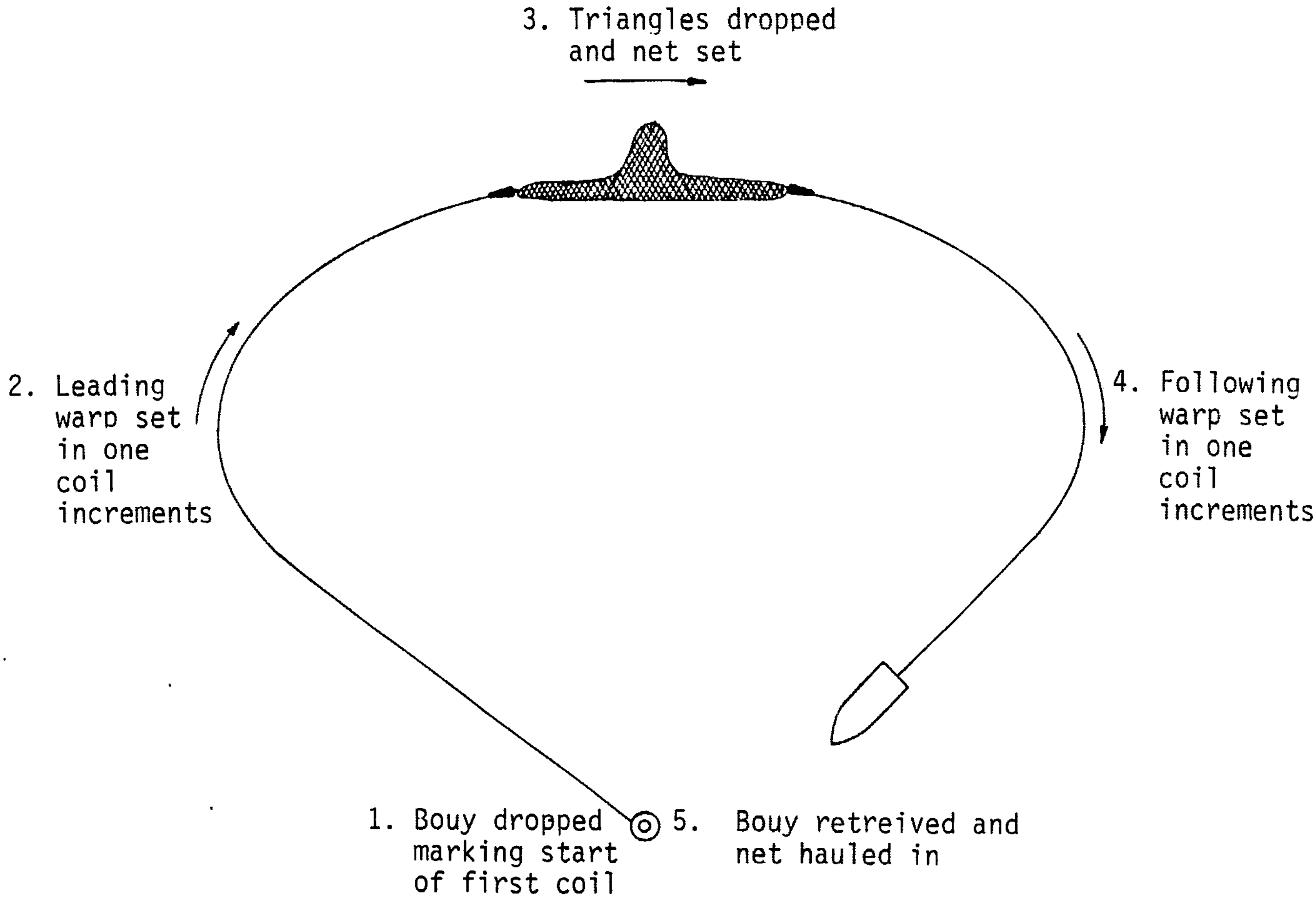

Figure 3-2. Scottish seining operations.

- The percent of striped bass in each sample which were dead or mortally wounded was determined (number dead ÷ total catch x 100).
- If two consecutive Scottish seine sets had striped bass mortality >30%, the number of coils in the set was reduced by 50%.
- If two consecutive Scottish seine sets had striped bass mortality >30%, the number of coils in the set was reduced a second time.
- If two consecutive sets of the doubly reduced Scottish seine samples had striped bass mortality >30%, Scottish seine sampling ceased.
- Scottish seine sampling ceased when water temperatures exceeded 18°C (65°F).

Striped bass captured by Scottish seine and trawl gears received identical handling designed to provide lightly stressed healthy fish for tagging in accordance with procedures approved by the New York State Department of Environmental Conservation (Brandt, pers. comm. 1984). Captured fish were held in the water in the bunt, cod-end, or in a tank on board filled with fresh river water. Fish were removed from the water using a dip net or brail, and all surfaces that contacted live fish were wet. Striped bass were not handled by eye sockets, gill arches, isthmus, or opercular flaps, and struggling fish were quieted by covering the head and eyes with a wet cloth.

All striped bass were measured for total length (TL) and examined for tags and tag wounds. If tags or tag wounds were observed, the location of recapture, type of tag(s), tag number, condition of the fish, and location of the tag wound were recorded. All striped bass greater than 300 mm TL and in good condition were double tagged with a Floy internal anchor tag, and a Floy FD-68B anchor tag (Dennison-type) and released, except for fish that were used in the short-term survival and tag retention study (Figure 3-3). "Good condition" was defined as:

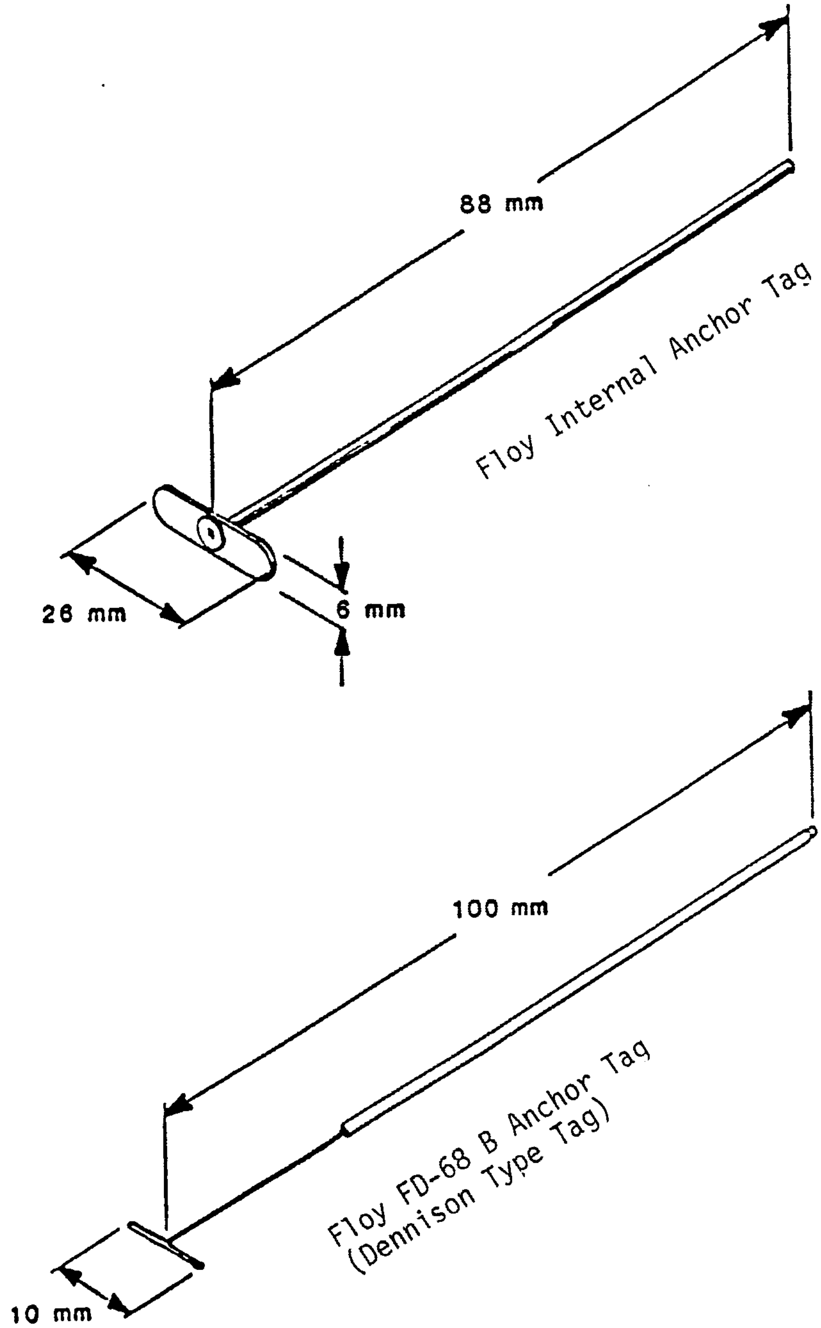

Figure 3-3. Description of tags used on striped bass for the 1984 Hudson River Survey. Both tags were labeled with either a $10, $5-1000, or $10-1000 reward, and the following return address:

HRF

Box 1731

Grand Central Station

NY, NY 10163

1. Lack of bleeding from gills or body wounds.
2. No significant loss of scales.
3. Good swimming ability.
4. No loss of equilibrium.

Floy FD-68B anchor tags were inserted at a 90° angle with a Dennison tagging gun into the left side of the fish 3 scale rows below the origin of the second dorsal fin. This procedure was the same as that used in previous striped bass tagging procedures (TI, 1981). Floy internal anchor tags were inserted by removing a scale midway between the vent and the posterior tip of the pelvic fins, and slightly to one side of the ventral mid-line. A horizontal incision about 5 mm long was made with a hooking motion of a scalpel with a curved blade. The incision was made just through the peritoneum but not deep enough to damage intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with Woundex (a merbromine based topical antiseptic). Fish were released at least 400 m from active fishing gear, but within 1.5 km of capture location. Scales were taken from each tagged fish, but were not read as part of this study.

3.1.2 Tagging Mortality and Tag Retention

Each week up to a maximum of 100 striped bass greater than 300 mm TL were held in floating holding cages (1.0 m x 1.0 m x 2.0 m with 6 mm knotless nylon mesh) at ambient temperature in Hudson River water to determine short-term (24 hour) survival and tag retention. The Croton Yacht Club served as a site for the holding facility during downriver fishing (below RK 61), and the Cornwall Yacht Club was the holding facility site for upriver fishing efforts (Figure 3-1). Striped bass were transported to the appropriate holding facility within 15 to 45 minutes of capture (15 minutes for Cornwall and 45 minutes for Croton) in a 5.5 m Monark boat equipped with a 90-hp outboard and holding tanks. Water in each holding tank was treated with Shieldex (a biologically inactive polymer) to minimize physiological stress from loss of slime coat. Fish from each gear were systematically allocated to an experimental tag group or a control group so that for each group of four fish arriving at the holding facility, one fish was tagged with a Floy internal anchor tag, one fish was tagged with a FD-68B Dennison-type anchor tag, one control fish was double tagged with Floy internal anchor and FD-68B Dennison-type anchor tags, and one control fish was not tagged. At the end of the holding period, all fish that were in good condition were double-tagged as described above. All double tagged fish in good condition were released into the Hudson River at least 400 m away from active fishing gear. Tags on fish that died during the holding period were destroyed by cutting the tags in half, and fish were examined to determine if the tag wound may have contributed to mortality.

3.1.3 Hydroacoustic Techniques

A Ranger 420 chart recorder (Apelco Marine Electronics Co. of Manchester, New Hampshire) was the primary device used to examine the relationship between hydroacoustic records of fish and catch of striped bass in Scottish seine or trawl samples. The trawl sampling vessel (R/V *Fritcher*) made a hydroacoustic strip chart recording of the area swept by the trawl simultaneous to trawling. The transport boat (5.5 m Monark) made a strip chart hydroacoustic record in the confines of selected Scottish seine sets while the set was made. Field notes were also taken onboard the F/V *Kit Kat* to evaluate the effectiveness of an EPSCO model CVS-886 chromoscope in locating schools of striped bass. Hydroacoustics were also used on the transport boat to scout selected areas for striped bass abundance before sampling. Sample number, date, and location were recorded on the chart strip to allow later comparison with the actual catch. Hydroacoustic records were assigned a relative echo scale (range: 1-5) based on a visual comparison between records.

This scale was compared with the actual catch to determine any relationship between catch and hydroacoustic record.

3.1.4 Water Quality Sampling

Immediately after each otter trawl and before each Scottish seine sample, direction of tow, location and duration of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 57 dissolved oxygen meter and YSI model 33 salinity-conductivity-temperature meter were used to take surface (1 meter) and bottom measurements of water temperature, conductivity and dissolved oxygen.

3.2 ANALYTICAL METHODS

3.2.1 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass captured at a given temperature in a "successful" trawl or seine sample by the following formula:

$$\text{Propd} = \frac{D_t}{T_t} \qquad \text{Formula 1}$$

where, Propd = the proportion of dead striped bass,

D_t = the number of dead striped bass captured at temperature t, and

T_t = total number of striped bass captured at temperature t.

A trawl or seine sample was considered "successful" if a valid sampling effort was completed, all data were obtained, and no sampling problems were encountered (Appendix C). Regressions of propd or arcsin ($\sin^{-1}$)

propd on surface water temperature or bottom water temperature, were calculated to quantify the relationship between water temperature and handling mortality. The arcsin propd (angular) transformation was used to normalize the proportion of dead fish in a sample (Sokal and Rohlf, 1981).

All regressions were calculated using the PROC GLM procedure of the Statistical Analysis System (SAS, 1982). Models used were:

$$\text{Propd or } \sin^{-1} \text{ Propd} = \beta_1 \text{TempS}_1 + b \qquad \text{Formula 2}$$

$$\text{Propd or } \sin^{-1} \text{ Propd} = \beta_2 \text{TempB}_2 + b \qquad \text{Formula 3}$$

where, TempS_1 = surface water temperature (°C),

TempB_2 = bottom water temperature (°C),

β_1 = regression coefficient for TempS_1,

β_2 = regression coefficient for TempB_2, and

b = intercept.

3.2.2 Variations in Catch by Fishing Effort

The relationship between fishing effort and trawl catch was evaluated by comparing adjusted catch per ten minute tow for successful samples (Appendix C) between tow durations (T) of 5 (n=4), 10 (n=177), 15 (n=12), and 20 (n=7) minutes. Adjusted catch per ten minute tow (c/f) was calculated as:

$$\frac{\Sigma C_T}{\Sigma E_T} \times 10 \qquad \text{Formula 4}$$

where, ΣC_T = total number of fish captured during tow duration T,

ΣE_T = the sum of all fishing effort in minutes during tow duration T, and

T = 5, 10, 15 or 20 minutes.

The relationship between fishing effort and Scottish seine catch was evaluated by comparing adjusted catch per one-coil set between fishing efforts of one and two-coil sets. Adjusted catch per one-coil set (c/f) was calculated as:

$$\frac{\Sigma C_S}{\Sigma E_S} \qquad \text{Formula 5}$$

where, ΣC_S = total number of fish captured during fishing effort S,

ΣE_S = the sum of all coils set during fishing effort S, and

S = 1 or 2 coil sets.

One extremely large Scottish seine catch of striped bass, estimated at over 600 fish (30 April 1984, RK 56) was excluded from analysis because fish were released without an exact count to minimize mortality.

3.2.3 Variations in Catch by River Region

Variations in trawl catch per unit effort by river region were determined by calculating mean striped bass catch per 10 minute tow for each river region. Mean catch per 10 minute tow was calculated as:

$$\bar{X}_{TR} = \sum_{i=1}^{n} \frac{C_i}{E_i} \div n_R \times 10 \qquad \text{Formula 6}$$

where, $\bar{X}_{TR}$ = the mean trawl catch per 10 minute tow duration in river region R,

C_i = the number of fish captured in trawl i,

E_i = the tow duration of trawl i, and

n_R = the number of tows in river region R.

Variations in mean Scottish seine catch per unit effort were evaluated in a similar method as the trawl catch. Mean catch per one coil set was calculated as:

$$\bar{X}_{SR} = \sum_{i=1}^{n} \frac{C_i}{E_i} / n_R \qquad \text{Formula 7}$$

where, $\bar{X}_{SR}$ = the mean Scottish seine catch per 1 coil set in river region R,

C_i = the number of fish captured in Scottish seine set i,

E_i = the number of coils used in Scottish seine set i, and

n_R = the number of Scottish seine sets in river region R.

3.2.4 Variations in Length Frequency of the Catch by Method of Capture

Variations between gear types in the length frequency distributions of all fish captured during the sampling program were determined through chi-square (χ^2) analysis. The chi-square statistic was calculated from standardized length frequency distributions (Snedecor and Cochran 1967) using the following formula:

$$\chi^2 = \sum_{i=1}^{n} \frac{(T_x - S_x)^2}{S_{x^2}} \qquad \text{Formula 8}$$

where, T_x = the number of trawl-captured fish in length class x of the standardized distribution, and

S_x = the number of seine-captured (one-coil or two-coil sets) fish in length class x of the standardized distribution.

Length frequency distributions were standardized for comparison by the following formula:

$$T_x = \frac{t_x}{\sum_{i=1}^{n} t_x} \times 100 \quad \text{and} \quad S_x = \frac{s_x}{\sum_{i=1}^{n} s_x} \times 100 \qquad \text{Formula 9}$$

where, t_x and s_x are the actual number of trawl or seine captured fish observed in length class x.

3.2.5 Costs per Taggable Fish by Gear

Estimates of cost per taggable fish were made including salary, boat rental, gear, nets, and fuel for Scottish seine and trawl gear for the entire sampling period, and for each river region.

Trammel nets, as part of another study by EA Environmental Science and Technology, Inc. (EA), were fished from 24 May to 6 June in the vicinity of the seining and trawling operations of this study (RK 88). Estimates of cost per taggable fish were made for the trammel nets using the data of EA (pers. comm., 1984) and compared with cost estimates for the Scottish seine and trawl gears fished in the same river region.

Gill nets were fished from 7 April to 24 April 1981 between RK 48 and RK 54 (LMS 1981). Data from LMS (1981) were used to estimate cost per taggable fish captured in gill nets.

3.2.6 Tagging Survival

The effects of tag type, method of capture, and holding water temperature on short-term (24 hour) survival of striped bass were analyzed using a mixed model multiple analysis of variance using the PROC GLM procedure of SAS. The model used was:

$$\% \text{ survival} = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_2 X_3 + \text{error}$$

where, X_1 = water temperature,
X_2 = tag type,
X_3 = gear type,
β_o = intercept
β_1 = regression coefficient for temperature,
β_2 = regression coefficient for tag type,
β_3 = regression coefficient for gear type,
β_4 = regression coefficient for interaction between tag and gear type, and
error = variation not explained by the model.

4.0 RESULTS AND DISCUSSION

4.1 HANDLING MORTALITY

Handling mortality, expressed as the proportion of dead fish captured by the sampling gear at a temperature (1°C increments), increased with increasing temperature for both Scottish seine and trawl gears (Tables 4-1 and 4-2). Handling mortality was greatest at 15°C for the trawl (47%) and two-coil Scottish seine sets (33%), and greatest at 16°C for one-coil Scottish seine sets (39%). However, regressions of proportion of dead fish against surface or bottom water temperatures were not significant ($p>0.05$) with low correlation coefficient values (Appendix D). An arcsin transformation (Sokal and Rohlf, 1981) of the proportion dead fish did not improve model fit. The poor fits of these data to linear regression models were primarily due to "rare events" when few fish were captured in a temperature class. However, when temperature classes containing less than 1% of the total catch were excluded from the analysis, regressions were significant ($p<0.05$) for the proportion of dead fish regressed against either bottom water temperatures for two-coil Scottish seine sets or surface water temperature for the trawl (Appendix D).

Scottish seine one-coil sets had the greatest handling mortality among all temperatures (Tables 4-1 and 4-2), however, the one-coil sets collected few fish and the majority of the captures were at relatively high water temperature (15-16°C) where handling mortality was highest for all gears. Handling mortality was slightly higher for the trawl compared to Scottish seine two-coil sets primarily due to high mortality in the trawl at temperatures greater than 15°C. Scottish seine two-coil sets might be expected to have high handling mortality due to relatively long haulback phase which could last up to one-half hour, but instead had the lowest overall handling mortality.

TABLE 4-1. HANDLING MORTALITY (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE) IN RELATION TO SURFACE WATER TEMPERATURE.

SURFACE WATER TEMPERATURE (°C)	STRIPED BASS HANDLING MORTALITY AS PERCENT DEAD		
	TRAWL	SCOTTISH SEINE ONE COIL	SCOTTISH SEINE TWO COIL
8	8 (40)[a]	NS[b]	11 (265)
9	4 (97)	19 (21)	13 (213)
10	11 (9)	0 (4)	17 (23)
11	15 (79)	NS	0 (3)
12	0 (25)	0 (0)	21 (43)
13	5 (59)	0 (2)	0 (0)
14	16 (55)	NS	25 (28)
15	47 (60)	0 (5)	33 (39)
16	36 (89)	39 (28)	14 (7)
17	0 (3)	NS	0 (0)
18	0 (1)	NS	NS
All Temperatures	18 (517)	25 (60)	15 (621)

(a) Number of striped bass captured in 1°C temperature increments in parentheses.

(b) No samples taken at that 1°C water temperature increment.

TABLE 4-2. HANDLING MORTALITY (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE) IN RELATION TO BOTTOM WATER TEMPERATURE.

BOTTOM WATER TEMPERATURE (°C)	STRIPED BASS HANDLING MORTALITY AS PERCENT DEAD		
	TRAWL	SCOTTISH SEINE	
		ONE COIL	TWO COIL
7	NS[a]	NS	0 (5)
8	6 (62)[b]	0 (2)	12 (275)
9	5 (93)	21 (19)	13 (192)
10	0 (1)	0 (4)	17 (23)
11	13 (90)	NS	0 (3)
12	0 (19)	0 (0)	21 (43)
13	11 (94)	0 (2)	0 (3)
14	21 (28)	0 (1)	27 (26)
15	51 (102)	15 (20)	33 (40)
16	0 (7)	67 (12)	20 (5)
All temperatures	18 (486)	25 (60)	15 (615)

[a] No samples taken at that 1°C water temperature increment.

[b] Number of striped bass captured in 1°C temperature increments in parentheses.

4.2 CATCH CHARACTERISTICS

4.2.1 Variations in Catch by Fishing Effort

Catch per unit effort for trawl gear (striped bass per ten minute tow) decreased with tow duration. Adjusted catch per ten minute tow was greatest at 5 minutes duration (3.5) and lowest at 20 minutes duration (0.4; Table 4-3). However these extremes represent 4 and 7 tows respectively and may be strongly influenced by a few exceptionally large or small catches. The majority of tows (177) were of ten minutes duration and catch per unit effort was an intermediate 2.9 striped bass per ten minute tow.

Catch per unit effort for Scottish seine gear (striped bass per one-coil set) increased from 2.2 for one-coil sets to 4.4 for two-coil sets (Table 4-3). This two-fold increase in catch per unit effort was less than the estimated increase in sample unit size of 3.4 times for smooth bottom sets (Table 4-4), which suggested that catch was less than proportional to area fished.

4.2.2 Variations in Catch by River Region

Mean trawl catch of striped bass per ten minute tow (C/f) varied greatly by river region, and was greatest, 3.7, in the Cornwall region (RK 90-100; Table 4-5; Appendix E). C/f was almost identical in the Tappan Zee (RK 39-55) Croton-Haverstraw (RK 55-63) and West Point (RK 76-90) regions and ranged from 1.5 to 1.8. The Indian Point region (RK 63-76) had a low C/f of 0.4 and no striped bass were captured in the Poughkeepsie region (RK 100-124) in two tows.

Mean Scottish seine catch per sample for both one-coil and two-coil sets were highest in the Tappan Zee region and reduced in the Croton-Haverstraw and Cornwall regions (Table 4-5). Catches were extremely variable in the Tappan Zee region for two-coil sets due to a

TABLE 4-3. CATCH PER UNIT EFFORT STATISTICS FOR TRAWL AND SCOTTISH SEINE GEAR.

TRAWL

TOW DURATION (minutes)	NUMBER OF SAMPLES(a)	CATCH/EFFORT (striped bass/10 minute tow)
5	4	3.5
10	177	2.9
15	12	2.6
20	7	0.4

SCOTTISH SEINE

COILS	NUMBER OF SAMPLES(a)	CATCH/EFFORT (striped bass/1 coil set)
1	53	2.2
2	86	4.4

(a) Number of successful samples completed without sampling problems.

TABLE 4-4. APPROXIMATE SAMPLE UNIT SIZE FOR SCOTTISH SEINE AND TRAWL SAMPLES.

GEAR	APPROXIMATE SAMPLE UNIT
Scottish Seine [a]	
one-coil set	17,000 m^2
two-coil set	58,000 m^2
Trawl (10 min) [b]	18,000 m^2

[a] Estimate derived for sets on smooth bottom from set dimensions provided by the captain of the F/V *Kit Kat* and from Crowley (1982).

[b] Estimate derived from Wilcox Marine, Inc. Pers. Comm. for estimated distance between trawl doors of 34 m x 1.0 $m \cdot sec^{-1}$ x 0.9 (filtration efficiency) x 10 minutes x 60 seconds • min^{-1} $\approx$ 18,000 m^2.

TABLE 4-5. MEAN CATCH OF STRIPED BASS BY TRAWL AND SCOTTISH SEINE GEARS IN THE HUDSON RIVER, SPRING 1984.

REGION (River Kilometers)	GEAR	NUMBER OF SAMPLES	MEAN CATCH OF STRIPED BASS PER SAMPLE	STANDARD ERROR OF THE MEAN
Tappan Zee	T[a]	29	1.8[d]	0.54
(39-55)	SS1[b]	3	12.5	6.50
	SS2[c]	18	20.8	9.52
Croton-Haverstraw	T	13	1.7	0.44
(55-63)	SS1	3	1.3	0.67
	SS2	43	6.8	1.82
Indian Point	T	11	0.4	0.24
(63-76)	SS1	0		
	SS2	0		
West Point	T	21	1.5	0.51
(76-90)	SS1	0		
	SS2	0		
Cornwall	T	124	3.7	0.56
(90-100)	SS1	47	1.8	0.39
	SS2	25	3.2	0.84
Poughkeepsie	T	2	0.0	0.00
(100-124)	SS1	0		
	SS2	0		
All regions	T	200	2.8	0.37
	SS1	53	2.2	0.48
	SS2	86	8.7	2.28

(a) Successful trawl tows.

(b) Successful Scottish seine one coil sets.

(c) Successful Scottish seine two coil sets.

(d) Trawl catch is standardized to ten minute tows.

few exceptionally large catches. The largest catch in the entire program (estimated >600 striped bass) was made in the Tappan Zee region on 30 April by a two-coil Scottish seine set, but was not included in this analysis because fish were released to the river and not counted to minimize handling mortality.

4.2.3 Variations in Length Frequency of the Catch by Method of Capture

Two-coil Scottish seine sets captured striped bass of a greater mean length than the trawl or one-coil Scottish seine sets in the Cornwall and Croton-Haverstraw regions, and of approximately the same length in the Tappan Zee region (Table 4-6; Appendix F). Length-frequency distributions were significantly different between the trawl, one-coil Scottish seines, and two-coil Scottish seine sets (Table 4-7). In the combined Tappan Zee, Croton-Haverstraw regions, the trawl captured proportionately more striped bass from 301 to 400 mm while two-coil Scottish seine sets had more fish in the tails of the distribution (251-300 mm; >450 mm). Not enough fish were captured in one-coil Scottish seine sets in the Tappan Zee, Croton-Haverstraw regions to allow meaningful comparisons. In the Cornwall region, the two-coil Scottish seine sets caught proportionately more fish greater than 401 mm than the trawl, while the trawl had signficiantly greater representation from 251 to 400 mm. Similarly one-coil Scottish seine sets had significantly more fish at lengths greater than 450 mm while the trawl caught more bass in the 301 to 350 mm size range. A comparison of one versus two-coil Scottish seine sets showed the two-coil sets caught more striped bass between 401 and 500 mm while one-coil sets had more fish between 251 and 350 mm. To summarize, the Scottish seine appears to collect significantly more striped bass greater than 400 mm

TABLE 4-6. SUMMARY STATISTICS FOR STRIPED BASS LENGTH-FREQUENCY DISTRIBUTIONS BY METHOD OF CAPTURE AND REGION OF THE HUDSON RIVER, SPRING 1984.

REGION (River Kilometers)	GEAR	NUMBER OF STRIPED BASS	MEAN LENGTH (mm TL)	STANDARD ERROR OF THE MEAN
Tappan Zee (39-55)	T[a]	54	351	11.6
	SS1[b]	25	346	31.2
	SS2[c]	375	341	5.3
Croton-Haverstraw (55-63)	T	23	370	20.3
	SS1	4	370	74.0
	SS2	296	444	7.2
Indian Point (63-76)	T	4	258	20.6
	SS1	NS[d]		
	SS2	NS		
West Point (76-90)	T	37	503	14.6
	SS1	NS		
	SS2	NS		
Cornwall (90-100)	T	456	377	3.7
	SS1	87	418	12.3
	SS2	84	469	10.9
Poughkeepsie (100-124)	T	0		
	SS1	NS		
	SS2	NS		
All regions	T	574	382	3.63
	SS1	116	400	11.77
	SS2	755	396	4.53

[a] Trawl.

[b] Scottish seine one-coil sets.

[c] Scottish seine two-coil sets.

[d] No samples taken.

TABLE 4-7. CHI-SQUARE COMPARISONS OF STRIPED BASS LENGTH-FREQUENCY DISTRIBUTIONS FOR TRAWL, ONE-COIL SCOTTISH SEINE, AND TWO-COIL SCOTTISH SEINE SAMPLES.

REGION (River Kilometers)	GEARS COMPARED	PROB $>\chi^2$ (a)	LENGTH CLASSES WITH SIGNIFICANT DIFFERENCES
Tappan Zee and Croton-Haverstraw (39-63)	T, SS2	<0.01	251-400
			>450
Cornwall (90-100)	SS1[b], SS2[c]	<0.01	251-350
			401-450
	T[d], SS2	<0.01	>251
	T, SS1	<0.01	301-350
			>450

[a] Probabilities <0.05 were considered significant.

[b] One-coil Scottish seine sets.

[c] Two-coil Scottish seine sets.

[d] Trawl.

than the trawl, while the trawl selects far more striped bass between 251 and 400 mm. The above analysis assumes that two different populations of striped bass are present in the Tappan Zee, Croton-Haverstraw regions, and the Cornwall region which prevents pooling of the length-frequency distributions.

4.2.4 Recapture of Tagged Fish

Striped bass tagged during this study were not recaptured by the trawl or Scottish seine. Two striped bass tagged by State University of New York personnel were recaptured and released by Scottish seine gear. On 14 April 1984, a 333 mm TL striped bass (tag number 63991) was captured and released at RK 35 near the east bank of the river. On 17 April 1984, a 462 mm TL striped bass (tag number 63281) was captured and released at RK 56 near the east bank.

4.3 COSTS PER FISH TAGGED AND RELEASED ALIVE

Costs per fish tagged and released alive, were $455 per fish for one-coil Scottish seine sets, $175 per fish for two-coil Scottish seine sets, and $116 per fish for trawl gear (Table 4-8). These costs included labor, boat rental, fuel, and nets. Even though more fish were tagged and released by the Scottish seine gear, the high cost of boat rental, greater fuel consumption, and necessity for a large crew to handle occasional large catches, increased cost per fish.

The largest Scottish seine catches were made in the Tappan Zee, Croton-Haverstraw regions. Striped bass apparently congregate in the Haverstraw Bay region early in their migration before dispersing further upstream (TI, 1981). Costs per fish for these areas $143 per fish (n=140) for two-coil Scottish seine sets, $192 (n=13) for the one-coil Scottish seine sets, and $181 per fish (n=38) for the trawl.

TABLE 4-8. COST PER FISH TAGGED AND RELEASED ALIVE FOR TRAWL, SCOTTISH SEINE ONE-COIL SETS, SCOTTISH SEINE TWO-COIL SETS, GILL AND TRAMMEL NETS IN THE HUDSON RIVER.

	COST IN DOLLARS PER FISH TAGGED AND RELEASED ALIVE			
RIVER REGION (River Kilometers)	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS	GILL AND TRAMMEL NETS
Tappan Zee (39-55)	181 (38)	192 (13)	143 (140)	
Croton-Haverstraw (55-63)	246 (16)	938 (2)	165 (155)	47 (266)[c]
Indian Point (63-76)	NT[a]	NS[b]	NS	
West Point (76-90)	466 (19)	NS	NS	
Cornwall (90-100)	64 (271)	516 (40)	320 (41)	43 (158)[d]
Poughkeepsie (100-124)	NT	NS	NS	
All regions	116 (344)	455 (55)	175 (336)	

[a] No fish tagged and released alive.

[b] No sample.

[c] LMS (Lawler, Matusky and Skelly, Engineers) 1981 gill net data from personal communication from D. Dunning (New York Power Authority) to M. Mattson (Normandeau Assoc. Inc.). This analysis assumed all fish captured were taggable, and a 10% handling and ragging mortality rate (EA 1984).

[d] EA Engineering Science and Technology, Inc. 1984. Trammel net data from personal communication to D.J. Dunning, New York Power Authority. This analysis assumed 10% handling and tagging mortality rate (EA 1984).

Trammel net collections of striped bass were made from 24 May to 6 June in the Cornwall region at RK 90 (EA, pers. comm., 1984). Trawl and Scottish seine operations as part of this study were conducted in the same area at approximately the same time. Costs per fish for this period and area were $43 per fish (n=158) for the trammel net, $64 per fish (n=271) for the trawl, $516 per fish (n=40) for the one-coil Scottish seine sets, and $320 per fish (n-41) for the two-coil sets. Trammel net cost estimates assume that 90% of the fish caught were taggable, greater than 300 mm TL, in good condition, and survived the tagging operation. If less than 90% of the striped bass were taggable, costs would be higher.

The high cost per fish captured by the Scottish seine was primarily the result of the river bottom topography in the Cornwall region. The Scottish seine was most efficient when it could be set over a wide area to maximize the area swept. Long narrow areas of river bottom suitable for sampling in the West Point and Cornwall Regions did not allow the seine to be deployed efficiently compared to the trawl or trammel net.

Cost estimates per taggable fish were made from April 1981 gill net catch data from the Hudson River (LMS, 1981). These data were collected between RK 48 and RK 54 from 7 April to 10 April 1981. Cost per taggable fish was $47 per fish (n=266), similar to trammel net cost estimates. However, cost estimates should only be directly compared between gears that were fished in the same area and time, to ensure that the same fish population was exposed to capture. It is probable that striped bass population levels were different 1981 and 1984, which would limit the effectiveness of direct comparisons of cost per taggable fish between years.

4.4 TAGGING SURVIVAL AND TAG RETENTION

Short-term survival of striped bass held for 24 hours after tagging at ambient river temperatures did not appear to differ between tag type or method of capture, but was strongly related to holding water temperature (Appendix G). Short term tag mortality was equal (30%) for all methods of capture at water temperatures less than 14°C (Table 4-9). At water temperatures greater than 14°C, tag mortality was similar between striped bass captured by the trawl (80%) and one-coil Scottish seine sets (90%). No striped bass captured in two-coil Scottish seine sets were held at water temperatures greater than 14°C. Due to the relatively small sample sizes, and apparent similarity in mortality rates, data from one and two-coil Scottish seine sets were pooled. There were no apparent differences in 24 hour survival between untagged (control), Dennison tagged, anchor tagged, and double tagged (Dennison plus anchor tags) striped bass ($Pr>F = 0.48$; Appendix H). Method of capture, trawl or Scottish seine, also did not greatly affect survival ($Pr>F = 0.24$; Appendix H). Holding water temperature was the most important factor in determining survival of striped bass ($Pr>F<0.0001$). Holding water temperature was negatively correlated with striped bass survival (Figure 4-1).

Capture and subsequent handling may have been more stressful to the fish than being held in a net cage. Therefore the stress resulting from capture may have resulted in latent mortality that was influenced by holding water temperature. It appears that this potential latent stress was expressed at higher holding water temperatures perhaps by increasing striped bass metabolic demands during recovery from capture and handling.

Tag retention was 100%, and no lost tags of either type were observed in the 247 striped bass held in the 24 hour experiments.

TABLE 4-9. SHORT-TERM (24 HOUR) MORTALITY IN RELATION TO GEAR TYPE AND HOLDING WATER TEMPERATURE FOR STRIPED BASS CAPTURED IN THE HUDSON RIVER, SPRING 1984.

HOLDING WATER TEMPERATURE (°C)	PERCENTAGE STRIPED BASS DEAD		
	TRAWL	SCOTTISH SEINE 1 COIL SETS	SCOTTISH SEINE 2 COIL SETS
8-14	30 (72)[(a)]	30 (16)	30 (126)
14.5-16.5	80 (12)	90 (20)	(0)

[(a)] Number of striped bass held for 24 hours.

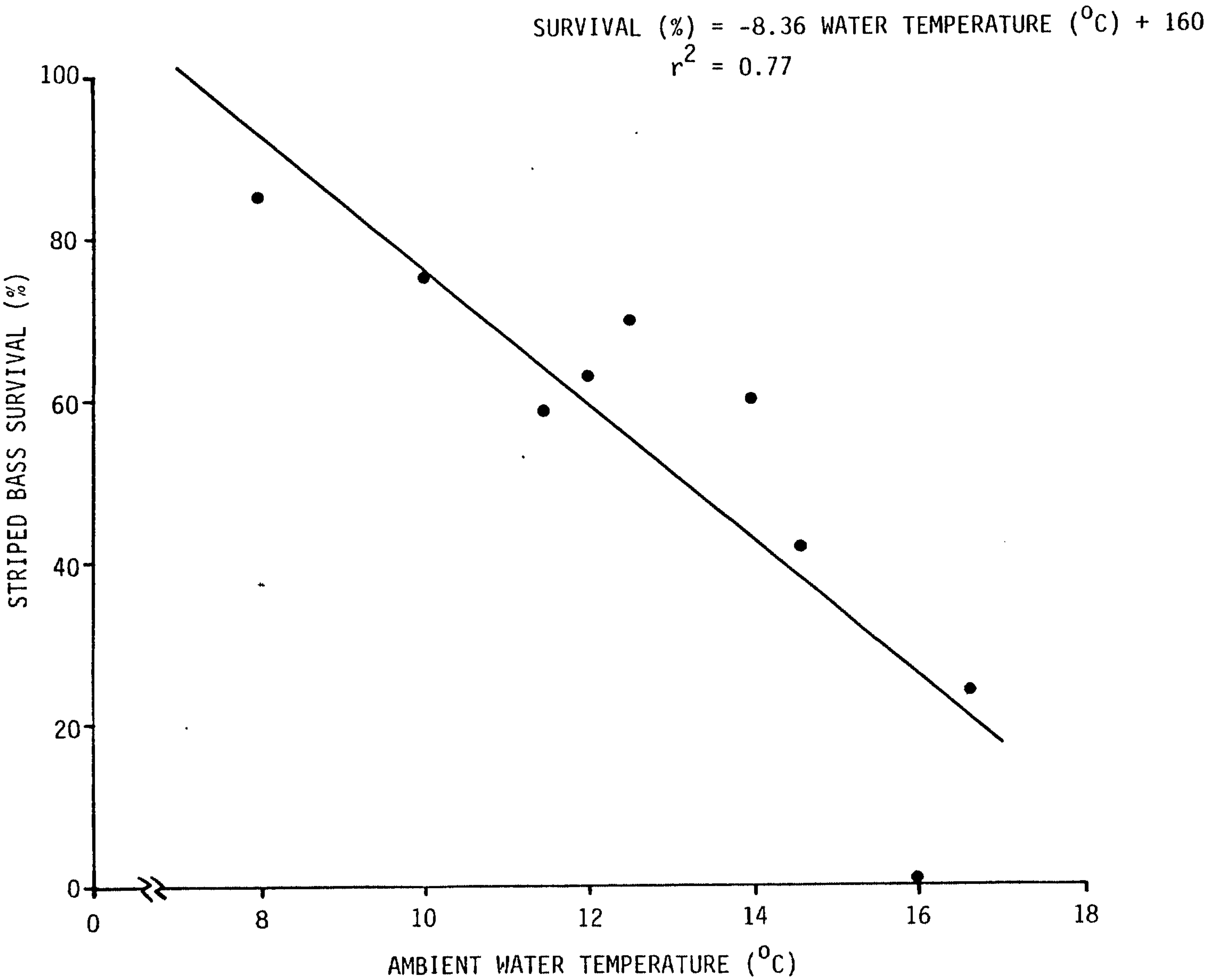

Figure 4-1. Relationship between ambient water temperature and survival of tagged striped bass (pooled across gear types, and tag types) held in the Hudson River, spring, 1984.

4.5 HYDROACOUSTIC SURVEY

The hydroacoustic techniques used in this project were generally not useful for locating striped bass and improving catch efficiency. Although the hydroacoustic equipment used in this study had the highest commercially available combination of resolution (200 kHz) and scanning path (25° beam angle) designed to locate fish, in many cases few to no bass were captured when hydroacoustic signals were intense (Figure 4-2; Appendix I) and striped bass were often captured when hydroacoustic records were light (Figure 4-3; Appendix I) or intermediate (Figure 4-4; Appendix I).

The lack of correlation between Ranger 420 hydroacoustic records and captured striped bass could be due to 1) avoidance of sampling gear, 2) narrow hydroacoustic scanning path due to shallow depths, or 3) the inability to distinguish striped bass from other fishes on the hydroacoustic record.

If the sampling gear is avoided, fish that appear as echoes on the hydroacoustic record may not be sampled by the gear. In the relatively shallow water sampled during this study (most samples were in water between 3 m and 10 m deep), fish may have detected vibrations of the boat, moved out of the tow path and escaped the net. For trawling, a wire angle and scope was used which caused the gear to fish behind the boat approximately 2-3 times the depth of the water. At a towing speed of 1 $m \cdot sec^{-1}$, fish in 3 m of water would have approximately 6-9 seconds to escape before they encountered the doors of the trawl; in 10 meters of water, fish would have approximately 20-30 seconds to escape. For the Scottish seine, the disturbance caused by first passing over an area with hydroacoustic gear at least once with the Monark scout boat and once with the F/V *Kit Kat* may have displaced fish from the area where the gear was finally set and retrieved.

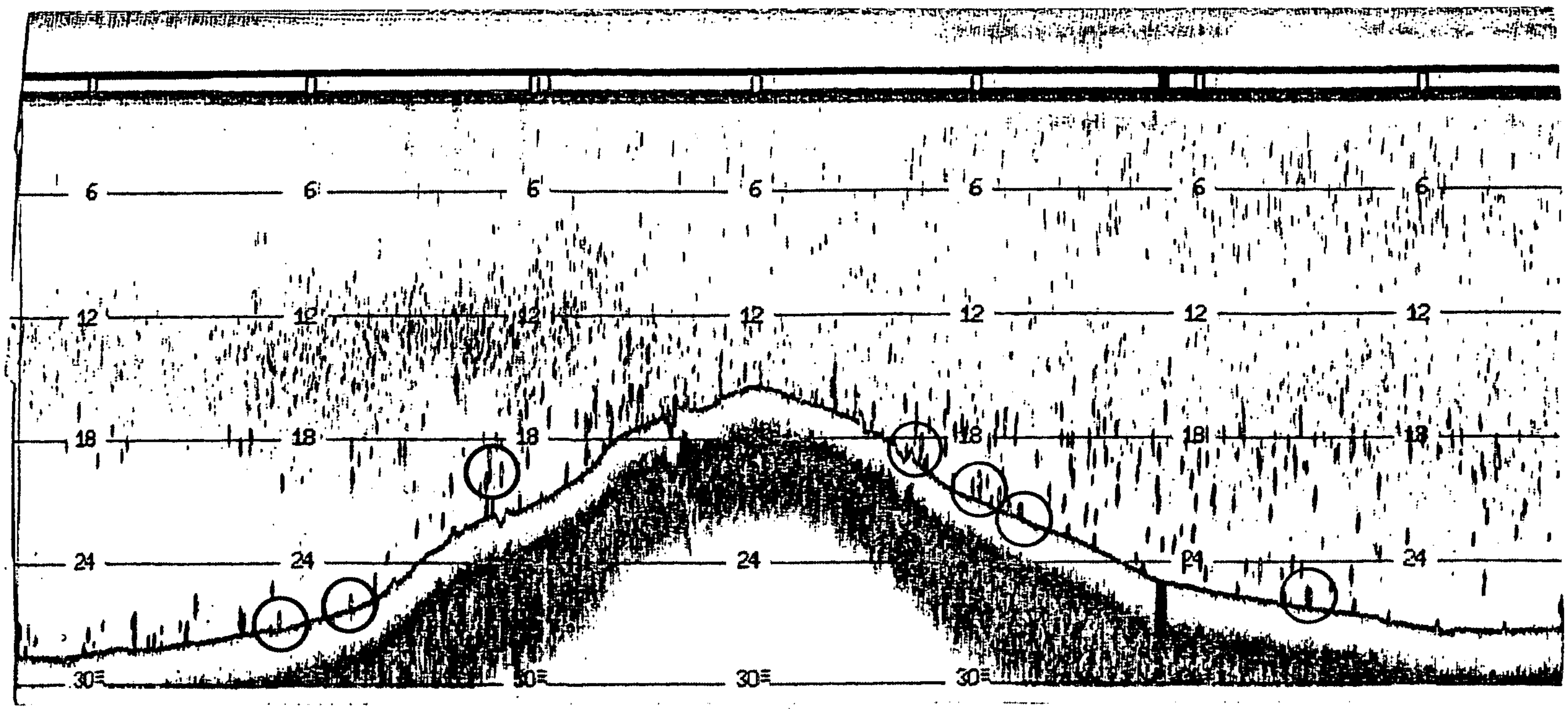

Figure 4-2. Hydroacoastic record, for a trawl sample, river kilometer 47, from the Hudson River, spring 1984, showing many strong echoes. Actual catch was 2 adult striped bass. Circles indicate possible striped bass. Relative echo scale = 5. Note: Depth below the river surface in feet is printed in six-foot increments on the record.

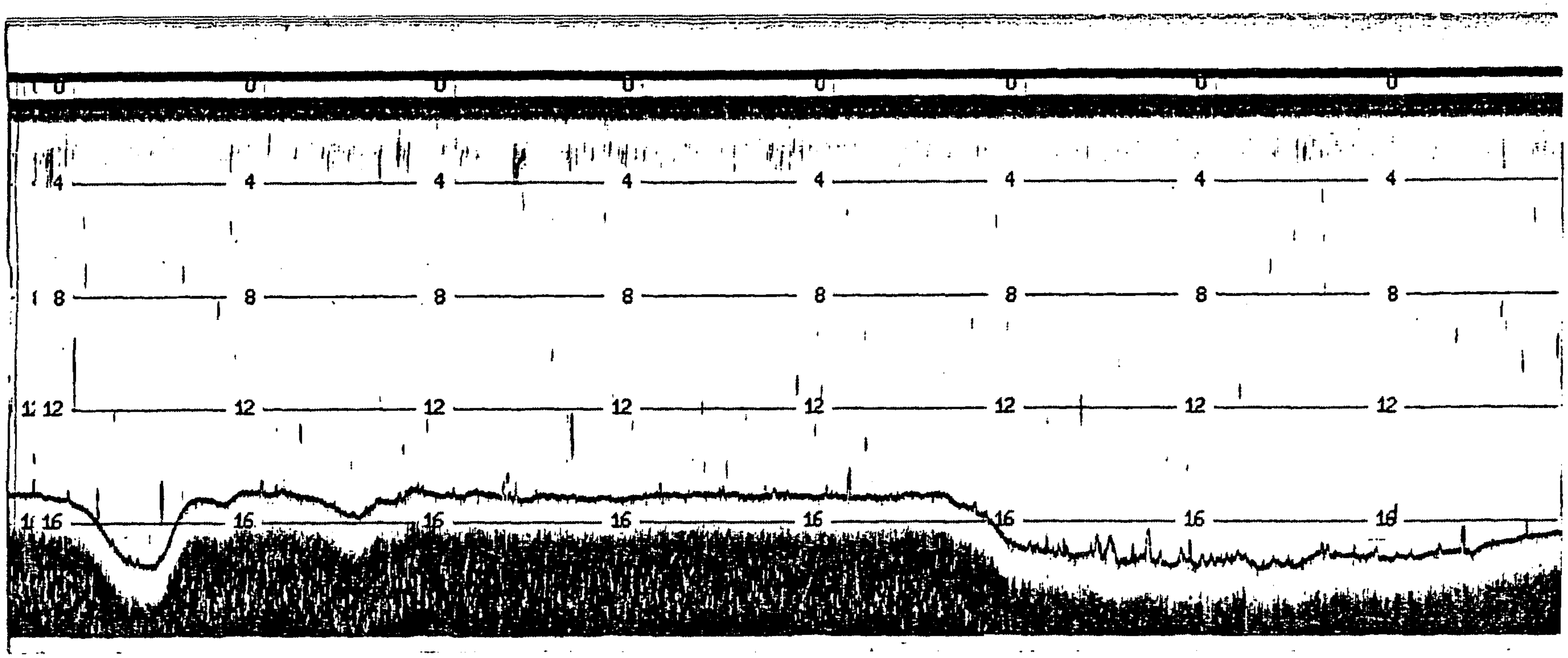

Figure 4-3. Hydroacoastic record, for a trawl sample, river kilometer 48, from the Hudson River, spring 1984, showing few echoes. Actual catch was 8 adult striped bass. Relative echo scale = 1. Note: Depth below the river surface in feet is printed in four-foot increments on the record.

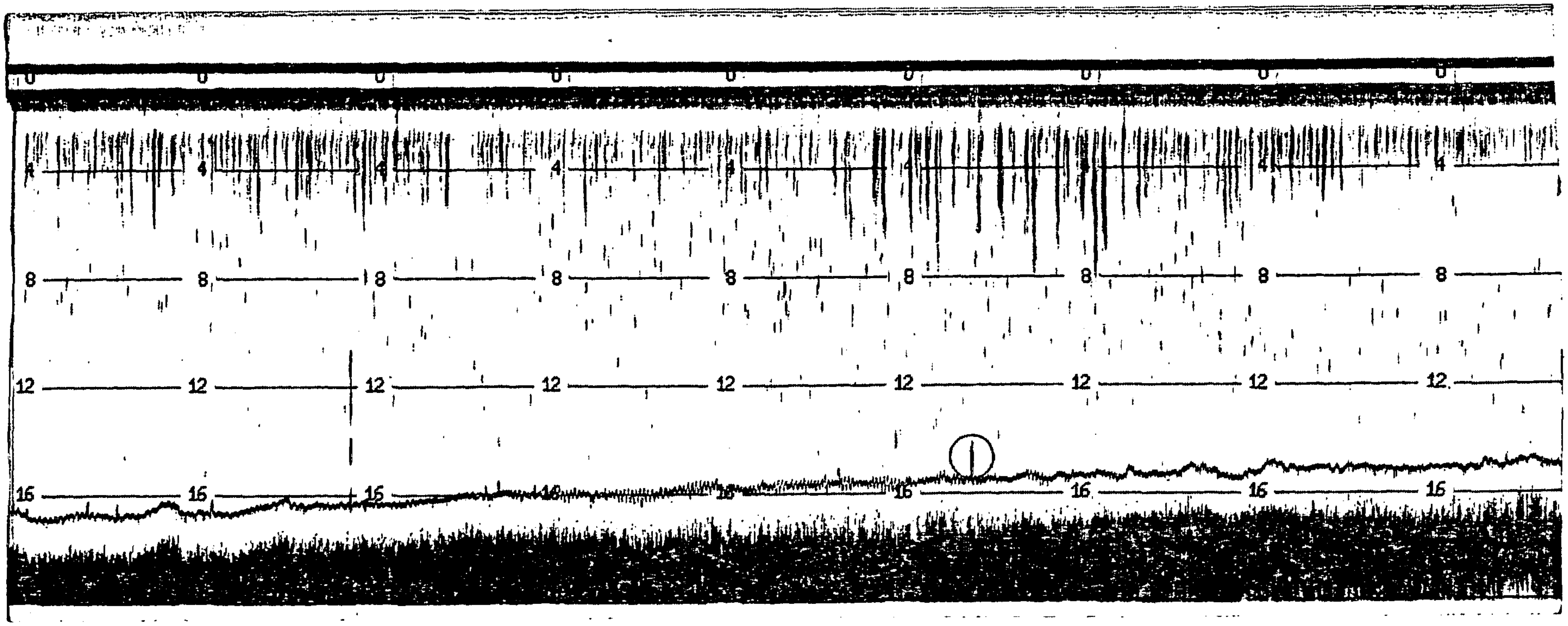

Figure 4-4. Hydroacoustic record, for a trawl sample, river kilometer 48 from the Hudson River, spring 1984, showing intermediate strength echoes. Actual catch was 7 striped bass. Circle indicates possible striped bass. Relative echo scale = 3. Note: Depth below the river surface in feet is printed in four-foot increments on the record.

Shallow depths may also have limited the effectiveness of sonar by restricting the area "scanned" by the sonar beam to a small amount of the area fished by each sample. In shallow water, the path scanned by the Ranger 420 sonar beam was considerably less than the width between the doors of the trawl (approximately 34 m, Table 4-4) or area swept by the Scottish seine (Table 4-4). For example, the 25° beam angle of the Ranger 420 would scan a path approximately 2.8 m wide at 3 m of depth, 5.6 m wide at 6 m of depth and 9.4 m wide at 10 m of depth. Since the sonar actually viewed only a small percentage of the area fished for each sample, the hydroacoustic record may not adequately predict the catch of striped bass. Commercial hydroacoustic gear is also manufactured which scans a 60° angle, however this gear is only available with a 50 kHz transducer which has limited resolution and is used primarily for navigation.

If striped bass cannot be distinguished from other fishes on the hydroacoustic record, it will be impossible to quantify the number of striped bass available for capture. Echoes apparently resulting from striped bass were identified as relatively large, hollow, oval markings, generally found near the river bottom (Figure 4-2). These echoes were easily confused with echoes apparently resulting from large carp and sturgeon. Similarly, it was difficult to distinguish between hydroacoustic echoes apparently resulting from large shad or other schools of clupeids and small striped bass.

Observations by field crews of the Epsco Chromoscope on the F/V *Kit Kat* during Scottish seine sets suggested that the chromoscope provided better resolution of the density and composition of fish schools than the Ranger 420, however we did not observe a correlation between concentrations of fish on the chromoscope and large catches by the seine. Striped bass were identified on the chromoscope by field crews as relatively large, inverted "V" shaped marking with white lines for the legs of the "V" and orange or red trim near the point of the "V". Sturgeon were distinguished from bass as white, "cotton puff" shapes. Both bass and sturgeon were observed in the bottom third of the water column. Schools of clupeids were identified as large "cotton puffs" in mid-water or near the surface with red or orange centers, while white perch schools appeared in the bottom third of the water column as large white "puffs" with yellow or orange boarders. Field notes indicated the two largest catches by the seine, 143 fish in 5 m of water at river kilometer 40 on 15 April 1984 and more than 600 fish in 4 m of water at river kilometer 56 on 30 April 1984 were not even anticipated by watching the chromoscope screen during the set and haulback phases of the sample. Shallow depth and the observation that most chromoscope readings were from the perimeter of each Scottish seine set suggest the chromoscope may have observed fish escaping from the set instead of the catch.

Sources of error in hydroacoustic sensing include attitude and location of the fish in relation to the hydroacoustic beam (O'Bryan, 1982). A large fish on the edge of the beam will return an echo of similar strength to one resulting from a small fish in the center of the beam. Similarly, if the fishes attitude is not horizontal, the returning echo will be weaker than an echo from a horizontal fish. Problems in hydroacoustic sensing may be partially resolved with more sophisticated gear, but the inability to distinguish among species will continue to be the principal factor limiting the use of hydroacoustic gear in complex fish communities such as those found in the Hudson River. The best use of commercially available hydroacoustics in the Hudson River may be to locate general areas of abundant fish and to select the most likely fishing sites from several widely separated areas.

5.0 GENERAL DISCUSSION

The results of this study indicate that the Scottish seine two-coil sets were most effective in the Tappan Zee, Croton-Haverstraw regions. The largest catches of any gear (>100 striped bass per set) were made by the Scottish seine two-coil sets in late April in these regions. Although the Scottish seine appeared to be less size selective, the cost per taggable fish was greater than the trawl.

The high-rise trawl was most effective in the Cornwall region. The relatively narrow reaches of the river available in this region for fishing restricted the potential area swept by the Scottish seine. In addition, numerous bottom obstructions made this area unsuitable for Scottish seining. The trawl, equipped with roller gear, was able to move over obstructions without "hanging down".

There were no statistically significant differences between striped bass caught by the Scottish seine and trawl in 24 hour tagging mortality studies. Handling mortality was highest for one-coil (Scottish seine sets (25%), however, most one-coil sets were made late in the sampling program at high water temperatures when handling mortality was high for all methods of capture. Handling mortality was similar for the trawl (18%) and two-coil Scottish seine sets (15%). The potential for extremely large Scottish seine catches necessitates special preparations to keep handling mortality within the limits set in this study. These preparations would include extra holding facilities and tagging crews. However, if the mortality occurs as the seine is being retrieved to the sampling vessel, extra facilities will be superfluous and handling mortality may be high. Further study on the effects of total catch on handling mortality is needed to determine if extremely large catches are desirable in a tagging study.

Hogans *et al.* (1984) found mortality of striped bass in gill nets from the Saint John, and Kouchibouguac Rivers, New Brunswick, Canada, primarily related to water temperature and set time. Set time is the time between setting and retrieving the gill net. They observed that at temperatures between 1 and 5.9°C there was no striped bass mortality at set times less than 12 hours. At 6 to 11.9°C, mortality greater than 40% occurred at set times greater than 8 hours. Mortality exceeded 40% at 12 to 17.9°C when set times were greater than 4 hours, and mortality was greater than 50% when water temperatures exceeded 18°C at all set times.

These data suggest that gill nets can be an effective gear for collecting striped bass for tagging at water temperatures up to 18°C if the gill nets are tended every 4 hours or less. Water temperatures of 18°C were never reached in the 1984 tagging program indicating gill nets as a sampling gear would only be slightly limited by temperature. Trammel nets, which fish in a manner similar to gill nets but are less size selective, may have a lower gear-related mortality rate (Nielsen and Johnson, 1983).

It appears that in terms of handling mortality, catch per unit effort and cost per fish, Scottish seine two-coil sets were most efficient in the Tappan Zee, Croton-Haverstraw regions, while the trawl was most efficient in the Cornwall region.

6.0 SUMMARY

The primary objectives of the 1984 Adult Striped Bass Program were to compare Scottish seining and otter trawling as methods of collecting striped bass (*Morone saxatilis*) for tagging and to double tag striped bass which were $\geq$ 300 mm total length and in good condition. Scottish seining is a fishing method where the warps and net are set around the area to be sampled and the warps are retrieved onto the fishing vessel, herding the fish into the net. Otter trawling is a more traditional means of fishing where the net is towed through the water. Subobjectives of this program included analyses of handling mortality as a function of water temperature and gear type, and effects of gear type, fishing effort and location of sampling on catch. Costs of the field program (unit cost per taggable fish) were estimated directly for the Scottish seine, and otter trawl. Costs for gill nets and trammel nets were obtained using data from other studies. Short-term (24 hour) tag retention and tagging mortality rates were estimated. Finally, the use of hydroacoustic gear as a method of locating striped bass and improving catch efficiency was also evaluated.

Striped bass handling mortality, expressed as the proportion of dead fish captured by the sampling gear at a given temperature (1°C increments) increased with increasing temperature (range: 8-16°C) for both the Scottish seine and the otter trawl. However, regression of proportion of dead fish on water temperature were generally not significant, even when temperatures where few fish were captured were deleted. The Scottish seine captured striped bass of a greater mean length than the trawl when both gears were fished in the same river region. Chi-square analysis also revealed significant differences in striped bass length frequency distributions between the Scottish seine and trawl. The Scottish seine generally captured more striped bass >400 mm TL compared with the trawl.

Costs per fish tagged and released alive over the entire program were $455 per fish for the Scottish seine one-coil sets, $175 per fish for Scottish seine two-coil sets, and $116 per fish for the trawl. Costs in the Tappan-Zee, Croton-Haverstraw regions (River Kilometer, RK 39-63), where Scottish seine catch per unit effort was greatest and the gear fished most effectively, were $143 per fish for the Scottish seine two-coil sets, and $181 per fish for the trawl. Costs in the Cornwall region (RK 90-100) where trawl catches were greatest and trawling was most effective, were $64 per fish for the trawl, and $516 per fish for the Scottish seine one-coil sets, and $320 per fish for Scottish seine two-coil sets. Estimated costs for trammel net gear fished in the Cornwall region, simultaneous to the seining and trawling operations of this study, were $43 per fish. Estimated costs for gill nets fished between RK 48 and RK 54 in 1981 were $47 per fish.

Survival of striped bass held for 24 hours after tagging, as analyzed by analysis of variance, did not appear to differ between tag type, or method of capture, but was strongly negatively correlated with holding water temperature (range: 8-17°C). The two tags used in this study were a Floy internal anchor tag inserted through a 5 mm incision between the vent and anal fins, and a Floy FD-68B Dennison-type anchor tag inserted with a tagging gun below the origin of the second dorsal fin. There was no tag loss and no apparent differences in 24 hour survival between untagged (control), Dennison-tagged, anchor-tagged, and double-tagged (Dennison plus anchor tags) striped bass. Method of capture, trawl or Scottish seine, did not affect survival. Holding water temperature was the most significant factor related to survival of striped bass.

Trawl catch per unit effort (striped bass per ten minute tow) was highest (3.5) at five minutes tow duration, and lowest (0.4) at twenty minutes tow duration. The majority of tows (177) were of ten minutes duration and catch per unit effort was 2.9 striped bass per ten minute tow. Scottish seine catch per unit effort (striped bass per one-coil set) was 2.2 for one-coil sets, and 4.4 for two-coil sets. Mean trawl catch of striped bass was greatest (3.7 fish per 10 minute tow) in the Cornwall region (RK 90-100). Mean Scottish seine two-coil and one-coil catch was greatest in the Tappan Zee region (RK 39-55) (20.8 fish per two-coil set; 12.5 fish per one-coil set).

The hydroacoustic techniques used in this project generally were not useful for locating striped bass and apparently did not increase striped bass catch. The lack of correlation between hydroacoustic records and striped bass catch could be due to 1) avoidance of sampling gear, and 2) shallow sampling depth and narrow path scanned by the hydroacoustic beam, 3) the inability to distinguish striped bass from other fishes on the hydroacoustic record.

Scottish seine catches were highest during late April in the Tappan Zee, Croton-Haverstraw regions, where the seine effectively fished in the shallow waters of these regions over the relatively smooth hard bottom. Trawl catches were highest in the Cornwall region, where the trawl effectively fished the long, narrow, rough bottom. Passive fishing gears such as trammel or gill nets are less expensive methods for collecting striped bass than Scottish seining or trawling and can be used in areas unsuitable for active fishing methods. These passive gears may be size-selective, but size selectivity may be either an advantage or disadvantage depending on the objectives of the program.

7.0 LITERATURE CITED

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APPENDICES

APPENDIX A. SPECIFICATIONS OF THE R/V *Fritcher*

Built at Baldwinsville Boat Yard, 1977
Moored at Viking Boat Yard, Verplanck, New York
Owned by NAI, Bedford, NH

Dimensions:	Hull material	- steel
	LOA	- 9.7 m
	Weight	- 7.7 metric tons
	Beam	- 3.4 m
	Draft	- 1.2 m
	Fuel tanks	- 378 liter
	Propeller	- 53 cm diameter
	Pitch	- 50 cm pitch
Power:	Engine	- GM 453 Diesel, 100 hp
	Gear Box	- Borg/Warner
	Winch	- Hancock 46 cm double drum hydraulic winch with horizontal capstan
Cooling:	Closed cycle, 76 liter capacity, keel cooled	
Rigging:	Mast	- 4.7 m
	Booms	- 3.1 m
	A Frame	- each leg 3.8 m, positioned 1.6 m from the stern
LORAN:	Northstar 7000	
Hydroacoustics:	Apelco Ranger 420	
	Pulse Width	- 0.5 msec (200 kHz)
	Transducer Beam Angle	- 25°

APPENDIX B. SPECIFICATIONS OF THE R/V *Kit Kat*

Built at Commercial Marine Enterprise, So. Portland, Me.
Moored at Haverstraw Marina, Haverstraw, New York
Owned by Mr. James Homstead, Portland, Maine

Dimensions:	Hull material	-	fiberglass
	LOA	-	17 m
	Weight	-	65.9 metric tons
	Beam	-	5 m
	Draft	-	2.5 m
	Fuel tanks	-	4 - 9085 liter cap.
	Propeller	-	4 blade, 120 cm diameter 110 cm pitch
Power:	Engine	-	NTA 855 Cummins
	Gear Box	-	Twin disc 514 MG 1:5:1
	Winch	-	Lossie Seine winch
Rigging:	Stern crane with power block		
LORAN:	Northstar 600, Epsco 2-track plotter and C-plot		
Hydroacoustics:	Epsco chromoscope fish finder CVS-886 with a Simrad Skipper 607 chart recorder		

APPENDIX C. STATUS OF SAMPLES COLLECTED DURING 1984 ADULT STRIPED BASS TAGGING PROGRAM IN THE HUDSON RIVER, SPRING 1984.

	USE CODE = 1 (SUCCESSFUL)[a]			USE CODE = 2 (SAMPLING PROBLEMS)[a]			USE CODE = 5 (VOID)[a]		
		SCOTTISH SEINE			SCOTTISH SEINE			SCOTTISH SEINE	
	TRAWL	ONE COIL SETS	TWO COIL SETS	TRAWL	ONE COIL SETS	TWO COIL SETS	TRAWL	ONE COIL SETS	TWO COIL SETS
Tappan Zee	29	3	18	0	0	6	1	1	4
Croton-Haverstraw	13	3	43	0	0	2	3	0	6
Indian Point	11	NS[b]		0	NS		1	NS	
West Point	21	NS		0	NS		0	NS	
Cornwall	126	47	25	11	7	4	11	7	13
Poughkeepsie	2	NS		0	NS		2	NS	
TOTALS									

[a] Use Codes 1 = Valid sample, no sampling problems, all data obtained.
Use Code 1 samples were used in all data analyses.
2 = Sample completed but sampling problems encountered.
Fish captured were marked and released if in good condition.
5 = Void sample. Usually resulting from hang down or damage to equipment.

[b] NS = not sampled.

APPENDIX D. REGRESSION STATISTICS FOR REGRESSIONS OF PROPORTION OF DEAD FISH ON SURFACE AND BOTTOM WATER TEMPERATURES FOR HIGH RISE TRAWL AND SCOTTISH SEINE GEARS.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	Pr>F[a]	r^2	COMMENTS
Scottish Seine 1 Coil Sets				
Propd[b]	Temp S[c]	0.62	0.09	NS[d]
$\sin^{-1}$ Propd	Temp S	0.78	0.03	NS
Propd	Temp B[e]	0.24	0.26	NS
$\sin^{-1}$ Propd	Temp B	0.28	0.23	NS
Selected Data[f]				
Propd	Temp S	0.62	0.09	NS
$\sin^{-1}$ Propd	Temp S	0.78	0.03	NS
Propd	Temp B	0.25	0.26	NS
$\sin^{-1}$ Propd	Temp B	0.28	0.23	NS
Scottish Seine 2 Coil Sets				
Propd	Temp S	0.19	0.27	NS
$\sin^{-1}$ Propd	Temp S	0.32	0.16	NS
Propd	Temp B	0.08	0.33	NS
$\sin^{-1}$ Propd	Temp B	0.17	0.22	NS
Selected Data[g]				
Propd	Temp S	0.15	0.37	NS
$\sin^{-1}$ Propd	Temp S	0.14	0.38	NS
Propd	Temp B	<0.01	0.98	Significant
$\sin^{-1}$ Propd	Temp B	<0.01	0.98	Significant

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	Pr>F[(a)]	r^2	COMMENTS
Trawl				
Propd	Temp S	0.56	0.04	NS
$\sin^{-1}$ Propd	Temp S	0.95	<0.01	NS
Propd	Temp B	0.25	0.19	NS
$\sin^{-1}$ Propd	Temp B	0.46	0.08	NS
Selected Data[(h)]				
Propd	Temp S	0.03	0.50	Significant
$\sin^{-1}$ Propd	Temp S	0.08	0.38	NS
Propd	Temp S	0.35	0.19	NS
$\sin^{-1}$ Propd	Temp B	0.64	0.04	NS

(a) If Pr>F is less than 0.05, model is considered significant.

(b) Propd = Proportion of dead fish.

(c) Temp S = Surface water temperature (°C).

(d) NS = Not signficiant at α=0.05.

(e) Temp B = Bottom water temperature (°C).

(f) Surface and bottom water temperatures of 12°C deleted.

(g) Surface water temperatures of 11, 13, and 17°C deleted.
Bottom water temperatures of 7, 11, 13, and 16°C deleted.

(h) Surface water temperatures of 17 and 18°C deleted.
Bottom water temperatures of 10°C deleted.

APPENDIX E. STRIPED BASS CATCH FREQUENCIES FOR TRAWL AND SCOTTISH SEINE GEARS IN HUDSON RIVER REGIONS, SPRING 1984.

NUMBER OF STRIPED BASS	METHOD OF CAPTURE	NUMBER OF SAMPLES BY REGION				
		TAPPAN ZEE	CROTON-HAVERSTRAW	INDIAN POINT	WEST POINT	CORNWALL
0-10	T[a]	15	13	11	21	115
	SS1[b]	2	3	NS[d]	NS	41
	SS2[c]	13	34	NS	NS	29
11-20	T	14	0	0	0	8
	SS1	1	0	NS	NS	1
	SS2	2	6	NS	NS	2
21-30	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	0	1	NS	NS	0
31-40	T	0	0	0	0	3
	SS1	0	0	NS	NS	0
	SS2	0	1	NS	NS	0
41-50	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	0	1	NS	NS	0
51-60	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	0	1	NS	NS	0
61-70	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	0	0	NS	NS	0
71-80	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	1	0	NS	NS	0
81-90	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	0	0	NS	NS	0
91-100	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	1	0	NS	NS	0
>100	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	1	0	NS	NS	0

(a) Trawl

(b) Scottish seine one-coil sets

(c) Scottish seine two-coil sets

(d) Not sampled

APPENDIX F. STRIPED BASS LENGTH CLASS FREQUENCIES FOR TRAWL AND SCOTTISH SEINE GEARS IN HUDSON RIVER REGIONS, SPRING 1984.

LENGTH CLASS (mm TL)	METHOD OF CAPTURE	NUMBER OF STRIPED BASS CAUGHT IN REGION				
		TAPPAN ZEE	CROTON-HAVERSTRAW	INDIAN POINT	WEST POINT	CORNWALL
0-100	T[a]	0	0	0	0	0
	SS1[b]	3	0	NS[d]	NS	0
	SS2[c]	0	0	NS	NS	0
101-200	T	1	0	0	0	0
	SS1	3	0	NS	NS	0
	SS2	9	5	NS	NS	0
201-300	T	11	5	3	0	70
	SS1	2	2	NS	NS	16
	SS2	168	33	NS	NS	3
301-400	T	30	11	1	4	237
	SS1	5	0	NS	NS	24
	SS2	87	73	NS	NS	16
401-500	T	8	5	0	14	109
	SS1	9	1	NS	NS	26
	SS2	77	85	NS	NS	37
501-600	T	4	3	0	15	36
	SS1	2	1	NS	NS	16
	SS2	29	70	NS	NS	16
601-700	T	0	0	0	3	4
	SS1	1	0	NW	NS	5
	SS2	5	21	NS	NS	10
701-800	T	0	0	0	1	0
	SS1	0	0	NS	NS	0
	SS2	0	8	NS	NS	2
801-900	T	0	0	0	0	0
	SS1	0	0	NS	NS	0
	SS2	1	0	NS	NS	0

(a) Trawl.

(b) Scottish seine one-coil sets.

(c) Scottish seine two-coil sets.

(d) Not sampled.

APPENDIX G. PERCENT SURVIVAL AT TEMPERATURE FOR CONTROL, DENNISON, ANCHOR, AND DOUBLE TAGGED STRIPED BASS CAPTURED BY SCOTTISH SEINING AND TRAWLING IN THE HUDSON RIVER, SPRING 1984.

TAG TYPE	CONTROL				DENNISON				ANCHOR				DENNISON AND ANCHOR			
GEAR	SCOTTISH SEINE		TRAWL		SCOTTISH SEINE		TRAWL		SCOTTISH SEINE		TRAWL		SCOTTISH SEINE		TRAWL	
MAXIMUM TEMPERATURE	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL	n	% SURVIVAL
8.0	2	100	3	33	2	100	3	100	2	100	3	66	2	100	3	100
8.5																
9.0																
9.5																
10.0	18	78			18	67			17	76			18	78		
10.5																
11.0																
11.5			3	66			3	33			3	33			3	100
12.0	10	80	3	66	10	40	3	33	10	70	3	66	10	60	3	100
12.5			7	43			7	71			7	86			7	75
13.0																
13.5																
14.0	2	0	2	50	2	50	2	100	2	50	2	100	2	0	2	100
14.5	4	25			4	50			4	75			4	25		
15.0																
15.5																
16.0	2	0	1	0	2	0	1	0	2	0	1	0	2	0	1	0
16.5	3	33	2	0	3	0	2	100	3	0	2	50	3	33	2	0

APPENDIX H. ANALYSIS OF VARIANCE FOR THE EFFECTS OF TAG TYPE, GEAR, AND HOLDING WATER TEMPERATURE ON STRIPED BASS FROM THE HUDSON RIVER, SPRING 1984. RESPONSE VARIABLE = PERCENT SURVIVAL OF STRIPED BASS.

SOURCE	df	SS	MS	F	pr>F
Model	8	40055.99	5007.00	6.55	0.0001
Water temperature	1	34319.44		44.86	0.0001
Tag type	3	1936.20		0.84	0.48
Gear	1	1076.16		1.41	0.24
Tag x Gear	3	2390.34		1.04	0.38
Error	47	35954.56	764.99		
Total	55	76010.55			

r^2 = 0.53
df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F ratio
pr>F = probability of obtaining a larger F-ratio

APPENDIX TABLE I. INTERPRETATION OF HYDROACOUSTIC RECORDS FROM ADULT STRIPED BASS TAGGING PROGRAM ON THE HUDSON RIVER, SPRING 1984. R/V FRITCHER CONDUCTED TRAWLING. F/V KIT KAT CONDUCTED SCOTTISH SEINING.

STRIP	SAMPLE	VESSEL	DATE	RIVER MILE	SITE	RELATIVE ECHO SCALE (1=light 5=heavy)	COMMENTS	ACTUAL NUMBER CAPTURED
1	530003	Fritcher	4/13/84	26	4	3		0
1	530004	Fritcher	4/13/84	31	5	4		0
1	530005	Fritcher	4/14/84	30	4	2		3
1	530006	Fritcher	4/14/84	30	4	3		7
1	530007	Fritcher	4/14/84	30	4	1		8
1	530008	Fritcher	4/14/84	29	4	3		1
1	530009	Fritcher	4/14/84	29	4	3		0
1	530010	Fritcher	4/15/84	21	5	3	large echoes	7
1	530030	Fritcher	4/15/84	26	4	3-4	more echoes at start of tow, many on bottom	3
1	530031	Fritcher	4/15/84	28	6	3		7
1	530032	Fritcher	4/15/84	29	5	5	river bottom rises in middle, large echoes	2
1	530033	Fritcher	4/15/84	30	6	4	distributed throughout water column	1
1	530034	Fritcher	4/15/84	31	4	3		14
1	530035	Fritcher	4/17/84	38	6	3	concentrated at bottom	4
1	530036	Fritcher	4/17/84	38	6	2		4
1	530037	Fritcher	4/17/84	37	6	2		3
1	530038	Fritcher	4/17/84	37		2	heavy backscatter	2
1	530040	Fritcher	4/18/84	31	4	2		0
1	530041	Fritcher	4/18/84	31	4	3		1
2	530042	Fritcher	4/18/84	31	5	3-4	more echoes at start	2
2	530043	Fritcher	4/18/84	31	4	3		0
2	530044	Fritcher	4/18/84	37	4	2		0
3	530045	Fritcher	4/24/84	37	5	3	concentrated at bottom, small echoes	1
3	530046	Fritcher	4/24/84	37	5	3	concentrated at bottom	0
3	530047	Fritcher	4/24/84	36	5	1		0
3	530048	Fritcher	4/24/84	37	6	1		3
3	530049	Fritcher	4/24/84	37	6	1	heavy backscatter	3
3	530050	Fritcher	4/25/84	26	5	4	concentrated at bottom	3
3	530076	Fritcher	4/25/84	26	4	3	heavy backscatter	3
3	530077	Fritcher	4/25/84	26	5	3		0
3	530078	Fritcher	4/25/84	26	4	3		2
3	530080	Fritcher	4/25/84	30	4	1		0
3	530079	Fritcher	4/25/84	31	4	1	heavy backscatter	1
3	530097	Fritcher	4/25/84	59	6	4		8
3	530098	Fritcher	4/26/84	59	5	3		27
3	530099	Fritcher	4/26/84	59	5	4	large echoes near bottom, bass?	31
3	530100	Fritcher	4/26/84	59	5	3	large echoes near bottom	8
3	530101	Fritcher	4/26/84	59	5	1		6
3	530102	Fritcher	4/26/84	59	5	4		44
4	530152	Fritcher	4/30/84	59	5	2		0
4	530153	Fritcher	4/30/84	59	6	4		5
4	530155	Fritcher	4/30/84	59	6	2		6
4	530156	Fritcher	4/30/84	59	5	5		10

continued

APPENDIX TABLE I. (Continued)

STRIP	SAMPLE	VESSEL	DATE	RIVER MILE	SITE	RELATIVE ECHO SCALE (1=light 5=heavy)	COMMENTS	ACTUAL NUMBER CAPTURED
5	530067	Kit-Kat	5/1/84	36	6	3		3
5	530105	Kit-Kat	5/2/84	60	5	2		3
5	530106	Kit-Kat	5/2/84	60	5	3		0
5	530107	Kit-Kat	5/2/84	60	5	3		0
5	530109	Kit-Kat	5/2/84	60	5	2		1
5	530111	Kit-Kat	5/3/84	35	6	3		7
5	530113	Kit-Kat	5/3/84	35	6	2		9
5	530114	Kit-Kat	5/3/84	35	6	1		10
8	530173	Fritcher	5/7/84	59	6	4		0
8	530175	Fritcher	5/7/84	59	5	5		0
8	530176	Fritcher	5/7/84	59	6	4		1
8	530132	Fritcher	5/8/84	59	6	5		4
8	530133	Fritcher	5/8/84	59	6	4		0
8	530134	Fritcher	5/8/84	59	6	3		5
8	530135	Fritcher	5/8/84	59	6	4		0
8	530136	Fritcher	5/9/84	56	4	4		0
8	530138	Fritcher	5/9/84	59	6	3-5	many echoes at end of trawl	2
8	530139	Fritcher	5/9/84	59	6	3		0
8	530141	Fritcher	5/9/84	59	6	5	very many echoes	0
8	530142	Fritcher	5/9/84	56	5	3	many echoes near surface	2
8	530143	Fritcher	5/9/84	56	6	5	heavy backscatter	8
8	530144	Fritcher	5/9/84	56	6	4	heavy backscatter	5
8	530145	Fritcher	5/9/84	56	6	4		9
8	530146	Fritcher	5/10/84	56	6	2	backscatter	6
8	530147	Fritcher	5/10/84	56	6	3	backscatter	1
9	530157	Fritcher	5/1/84	59	6	4		9
9	530158	Fritcher	5/1/84	59	5	4		9
9	530159	Fritcher	5/1/84	56	5	2		0
9	530160	Fritcher	5/1/84	58	5	3	many small echoes near bottom	0
9	530161	Fritcher	5/1/84	59	6	3	very heavy backscatter	40
9	530162	Fritcher	5/2/84	59	6	4		1
9	530163	Fritcher	5/2/84	59	6	4		2
9	530164	Fritcher	5/2/84	59	6	4		16
9	530166	Fritcher	5/2/84	59	6	4-5		8
9	530167	Fritcher	5/3/84	59	5	3		1
9	530168	Fritcher	5/3/84	59	5	3		12
9	530170	Fritcher	5/3/84	59	6	5		9
9	530172	Fritcher	5/3/84	59	6	4		5
10	530148	Fritcher	5/10/84	56	5	2		3
10	530149	Fritcher	5/10/84	56	5	2		2
10	530150	Fritcher	5/10/84	56	5	2		4
10	530103	Fritcher	5/14/84	56	5	3		0
10	530104	Fritcher	5/14/84	56	5	3		2
10	530200	Fritcher	5/14/84	56	6	3		2

continued

APPENDIX TABLE I. (Continued)

STRIP	SAMPLE	VESSEL	DATE	RIVER MILE	SITE	RELATIVE ECHO SCALE (1=light 5=heavy)	COMMENTS	ACTUAL NUMBER CAPTURED
10	530201	Fritcher	5/14/84	56	5	4		0
10	530202	Fritcher	5/14/84	56	6	5		0
10	530203	Fritcher	5/15/84	40	5	2	small echoes	0
10	530204	Fritcher	5/15/84	39	6	1	heavy backscatter	0
10	530205	Fritcher	5/15/84	39	6	3		0
10	530208	Fritcher	5/15/84	33	6	2	many echoes near surface	0
10	530209	Fritcher	5/15/84	31	4	2	many echoes near surface	0
10	530215	Fritcher	5/16/84	39	6	1-2	backscatter	0
10	530223	Fritcher	5/16/84	39	6	2		0
10	530224	Fritcher	5/16/84	39	6	2-3	more echoes at end	0
10	530225	Fritcher	5/16/84	42	5	2		2
10	530226	Fritcher	5/16/84	42	4	2		2
10	530227	Fritcher	5/16/84	44	5	2		1
11	530228	Fritcher	5/16/84	43	5	1	heavy backscatter	0
11	530229	Fritcher	5/17/84	33	6	1		0
11	530230	Fritcher	5/17/84	37	6	1		0
11	530231	Fritcher	5/17/84	37	6	2		3
11	530233	Fritcher	5/17/84	39	6	2	confused tracings	1
11	530241	Fritcher	5/17/84	38	6	3		2
11	530242	Fritcher	5/21/84	55	6	3		3
11	530243	Fritcher	5/21/84	55	6	2		1
11	530244	Fritcher	5/21/84	56	6	3	short tracing	0
11	530246	Fritcher	5/21/84	56	6	3-2	more echoes at beginning	0
11	530247	Fritcher	5/21/84	56	6	2		0
11	530234	Fritcher	5/22/84	59	6	5	backscatter	1
11	530235	Fritcher	5/22/84	59	5	4		1
11	530236	Fritcher	5/22/84	59	6	5		1
11	530237	Fritcher	5/22/84	59	6	4		0
11	530238	Fritcher	5/22/84	59	6	4-5		0
11	530248	Fritcher	5/22/84	58	5	2	most echoes near bottom	5
12	530249	Fritcher	5/22/84	56	5	3		2
12	530250	Fritcher	5/22/84	56	5	3		1
12	530251	Fritcher	5/22/84	57	5	3		8
12	530252	Fritcher	5/22/84	57	5	2	small echoes at beginning	6
12	530283	Fritcher	5/23/84	55	6	3	incomplete tracing	0
12	530284	Fritcher	5/23/84	55	6	2		3
12	530285	Fritcher	5/23/84	56	6	2		1
12	530286	Fritcher	5/23/84	56	5	2	most echoes near bottom	4
12	530287	Fritcher	5/23/84	56	5	2	most echoes near bottom	14
12	530288	Fritcher	5/23/84	56	5	2		5
12	530289	Fritcher	5/23/84	56	5	2	most echoes near bottom	11
12	530290	Fritcher	5/23/84	57	5	2	most echoes near bottom	7
12	530291	Fritcher	5/23/84	56	6	3	confused tracings	0
14	530292		5/23/84	56	6	3	variable bottom	1

continued

APPENDIX TABLE I. (Continued)

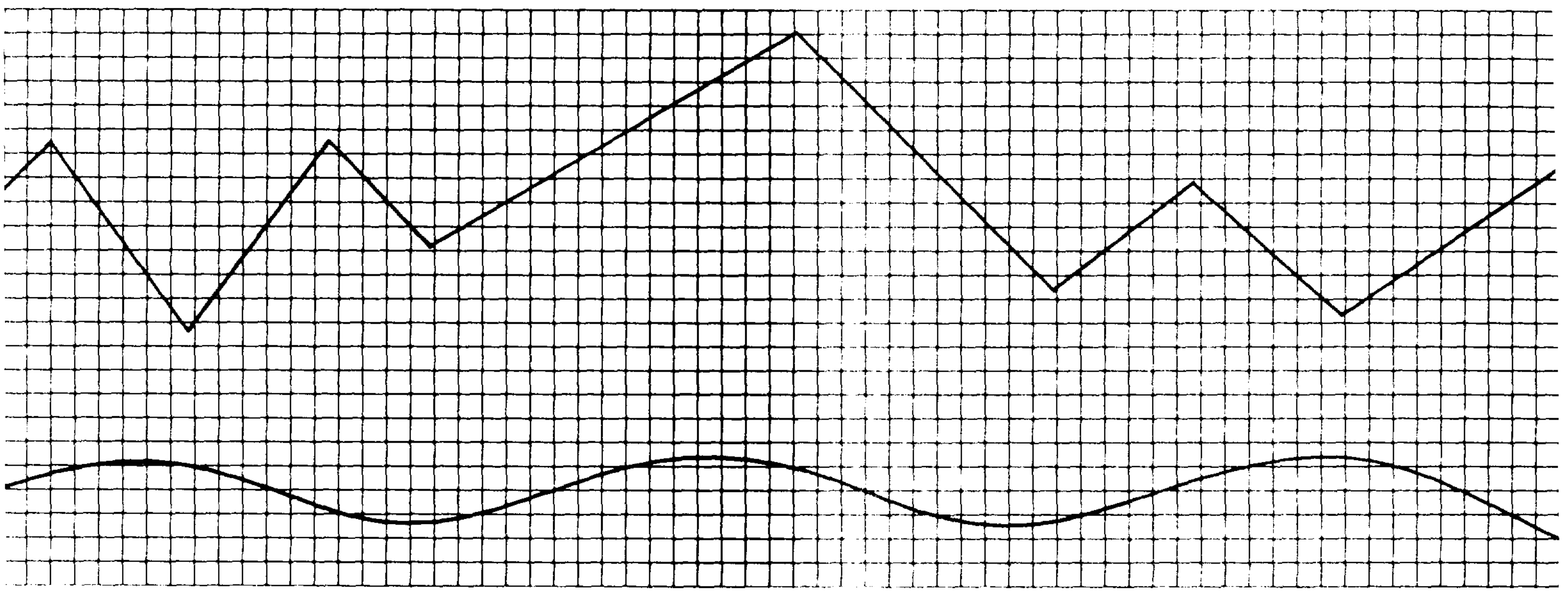
STRIP	SAMPLE	VESSEL	DATE	RIVER MILE	SITE	RELATIVE ECHO SCALE (1=light 5=heavy)	COMMENTS	ACTUAL NUMBER CAPTURED
15	530294	Fritcher	5/24/84	56	6	2	backscatter	0
15	530295	Fritcher	5/24/84	56	5	3		2
15	530296	Fritcher	5/24/84	56	5	2		1
15	530297	Fritcher	5/24/84	57	5	3		4
15	530298	Fritcher	5/24/84	57	5	2		3
15	530300	Fritcher	5/24/84	56	5	2		4
15	530376	Fritcher	5/24/84	56	5	3		3
15	530317	Fritcher	5/24/84	56	5	2		1
15	530318	Fritcher	5/24/84	54	5	3	confused tracings	0
15	530319	Fritcher	5/29/84	55	5	3		1
15	530320	Fritcher	5/29/84	55	5	3	most echoes on bottom	0
15	530321	Fritcher	5/29/84	50	6	2		0
15	530322	Fritcher	5/29/84	56	5	2		1
15	530323	Fritcher	5/29/84	55	5	2		0
15	530324	Fritcher	5/29/84	55	5	2		0
15	530325	Fritcher	5/29/84	56	5	2		0
16	530329	Fritcher	5/30/84	56	5	3-2	more echoes at beginning	9
16	530330	Fritcher	5/30/84	56	5	3	confused tracings	1
16	530307	Fritcher	5/30/84	56	5	2-5	more echoes at end	6
16	530308	Fritcher	5/30/84	56	5	4		2
16	530309	Fritcher	5/30/84	56	5	4		4
16	530310	Fritcher	5/30/84			4		3
16	530353	Fritcher	5/31/84	56	5	3		4
16	530354	Fritcher	5/31/84	56	5	2		2
16	530355	Fritcher	5/31/84	56	5	4		4
16	530356	Fritcher	5/31/84	56,57	6	2		0
16	530357	Fritcher	5/31/84	56	5	2		1
17	530359	Fritcher		60	5	3		0
17	530360	Fritcher	5/31/84	56	5	2		0
17	530361	Fritcher	5/31/84	56	5	3	echoes concentrated on bottom	0
17	530362	Fritcher	5/31/84	56	5	2	echoes concentrated on bottom	1
17	530363	Fritcher	5/31/84	56	5	3		0
17	530364	Fritcher	5/31/84	56	5	2	echoes concentrated on bottom	0
17	530366	Fritcher	5/31/84	57	5	2		11
18	530393	Fritcher	6/4/84	56	5	2		1
18	530394	Fritcher	6/4/84	57	5	2		0
18	530396	Fritcher	6/4/84	56	6	4		1
18	530398	Fritcher	6/4/84	55	5	2		1
18	530399	Fritcher	6/4/84	55	6	4		0
18	530400	Fritcher	6/4/84	55	5	2		1
18	530401	Fritcher	6/4/84			2		0
18	530402	Fritcher	6/5/84	62	5	3		0
18	530403	Fritcher	6/5/84	62	5	2		0
18	530404	Fritcher	6/5/84	61	5	3	small echoes near surface, large echoes at bottom	3

continued

APPENDIX TABLE I. (Continued)

STRIP	SAMPLE	VESSEL	DATE	RIVER MILE	SITE	RELATIVE ECHO SCALE (1=light 5=heavy)	COMMENTS	ACTUAL NUMBER CAPTURED
18	530405	Fritcher	6/5/84	60	5	3	small echoes near surface, large echoes at bottom	0
18	530406	Fritcher	6/5/84	59	5	2	small echoes near surface	0
18	530409	Fritcher	6/5/84	56	5	2		0
18	530410	Fritcher	6/5/84	56	5	2		0
18	530411	Fritcher	6/6/84	57	5	2		0
18	530412	Fritcher	6/6/84	57	5	2		0
18	530413	Fritcher	6/6/84	56	5	2		0
18	530414	Fritcher	6/6/84	56	5	3		0
18	530415	Fritcher	6/6/84	56	5	3		0
18	530416	Fritcher	6/6/84	56	5	2		1
18	530417	Fritcher	6/6/84	57	5	2		0
18	530418	Fritcher	6/7/84	56	5	2		0
18	530419	Fritcher	6/7/84	55	5	2		14
18	530420	Fritcher	6/7/84	55	5	3		4
18	530421	Fritcher	6/7/84	54	5	2		0
18	530422	Fritcher	6/7/84	55	5	3		0
18	530423	Fritcher	6/7/84	54	5	3		4
18	530424	Fritcher	6/7/84	55	5	4		4
18	530425	Fritcher	6/7/84	56	5	2		0
18	530426	Fritcher	6/7/84	56	6	3		0
18	530376	Fritcher	6/7/84	55	6	3		0
18	530377	Fritcher	6/7/84	56	6	3		0

HUDSON RIVER
FOUNDATION



1984
Hudson River Striped Bass Tagging Program

HRF Report #1985-1

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1984 HUDSON RIVER STRIPED BASS

TAGGING PROGRAM

Final Report

Prepared under contract with

NEW YORK POWER AUTHORITY
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1.0 EXECUTIVE SUMMARY

Preparatory to an adult Hudson River striped bass stock assessment program, a gear and tag evaluation study was conducted from April through June 1984, with tags returned through February 1985. The findings of this study, by objective, are:

Objective I. - Determine the loss rate for Dennison style and internal anchor tags on striped bass released into the Hudson River.

Internal anchor tag loss (2%) was significantly lower ($P<0.001$) than Dennison-style tag loss (58%) based on the capture of 50 double-tagged striped bass over a one year period. This difference in loss rates indicates that selection of tag style is of critical importance in tagging studies and that the current preference for the Dennison-style tag may be due to its ease of placement rather than its holding ability.

Objective II. - Calculate the recapture rates of striped bass released from a Scottish seine and a trawl.

The recapture rate for striped bass released from the Scottish seine at river temperatures between 6-13.9°C increased significantly ($P<0.05$) with length from 3.9% for 300-399 mm fish to 18.5% for ≥500 mm fish. There was no significant difference ($P>0.05$) or increase in the recapture rate by length for striped bass released from the trawl at river temperatures between 6-13.9°C. Recapture rates in the trawl ranged from 1.6% for 300-399 mm striped bass to 6.3% for 400-499 mm fish.

The higher recapture rates for larger striped bass initially captured in the seine are probably due to a combination of differential migration by size and differences in fishing pressure between recapture regions. The absence of increasing recapture rates with increasing length for striped bass released from the trawl appears to be attributable to a relatively low recapture rate in the ≥500 mm length category.

Objective III. - Determine the relative effect of reward value on tag return rates.

Return rates from tags with rewards of $10-1000 were not significantly higher than return rates from tags bearing $5-1000 or $10, possibly because of the incentive of entry into a drawing for larger rewards.

Objective IV. - Provide information on the migration of Hudson River striped bass.

The movements of the Hudson River stock in 1984 did not appear to differ from those during 1972-1979. There appears to be a dispersal of striped bass out of the Hudson River in the spring into a region extending from Sandy Hook, New Jersey to both shores of Long Island and the Connecticut shoreline. A smaller portion of Hudson River striped bass travel further, to Rhode Island, Massachusetts and central New Jersey. The proportion of recoveries from outside the Hudson River within 50 km of the river mouth was 56%.

Objective V. - Provide information on the striped bass fishery.

About 92% of the fishermen caught their tagged striped bass with hook and line, the remainder were caught in net gear or by unknown means. Of the 52 striped bass recaptured, 58% were reported to be released unharmed.

2.0 INTRODUCTION

The Hudson River Cooling Tower Settlement Agreement was a voluntary agreement among utilities[a], government agencies[b], and environmental protection groups[c] with respect to the utilities' responsibility to protect and enhance Hudson River fish populations. The Settlement Agreement stipulates that the utilities will conduct a biological monitoring program annually from 1981 through 1990, which meets the approval of the New York State Department of Environmental Conservation (NYSDEC), and that a major component of the biological monitoring program will be an adult stock assessment. The utilities and the NYSDEC agree that a striped bass (Morone saxatilis) tagging program will constitute a portion of that program.

Objectives of the 1984 Adult Striped Bass Program were:

Objective I. - Determine the loss rate for Dennison style and internal anchor tags on striped bass released into the Hudson River.

Objective II. - Calculate the recapture rates of striped bass released from a Scottish seine and a trawl.

Objective III. - Determine the relative effect of reward value on tag return rates.

Objective IV. - Provide information on the migration of Hudson River striped bass.

Objective V. - Provide information on the striped bass fishery.

Objective VI. - Evaluate 24 hour tagging mortality and tag loss.

To accomplish objectives I-V, the Hudson River Foundation for Science and Environmental Research, Inc. ("HRF") processed striped bass tag returns, conducted a publicity effort to increase awareness of the striped bass tagging program in the fishing community, surveyed previous striped bass tagging studies for information on tag retention and return rates, and analyzed the tag return data from the 1984 Adult Striped Bass Program.

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a. Central Hudson Gas & Electric; Consolidated Edison; New York Power Authority; Niagara Mohawk Power Corporation; Orange and Rockland Utilities.

b. US Environmental Protection Agency; NY State Department of Environmental Conservation; New York Attorney General.

c. Hudson River Fishermen's Association; Natural Resources Defense Council; Scenic Hudson, Inc.

Normandeau Associates, Inc. (NAI 1985) provided information on objective II by examining the efficiency of Scottish seining versus trawling in selected regions of the Hudson River and on objective VI by examining 24 hour tagging mortality and tag loss. Dunning and Ross (1985) provided additional data on objective VI in a study of Dennison style and internal anchor tag loss in striped bass held in pools.

3.0 MATERIALS AND METHODS

3.1 Tagging

Seven hundred thirty-six striped bass were tagged and released in the Hudson River between April 12 and June 7, 1984. All fish were $\geq$ 300 mm in total length, the largest measuring 1064 mm. Tagging was performed between river miles 26 and 61, corresponding approximately to the town of Piermont and the city of Newburgh (Figure 1).

Two vessels were employed. The 32 foot R/V FRITCHER was outfitted with a high-rise otter trawl specifically designed to catch striped bass. The trawl had an approximate vertical lift of 16 ft., with a head rope length of 22 ft. and a footrope measuring 40 ft. The 56 foot F/V KIT-KAT was employed to evaluate Scottish seining as a technique for capturing striped bass in the Hudson River. The KIT-KAT was equipped with 720 ft. of lead-core rope for seine warps, and four Scottish seines ranging in spread from 100 to 243 ft.

Striped bass were double-tagged with a Floy FD68-B anchor (Dennison-type) tag and a Floy FTF-69 internal anchor tag (Figure 2) in order to compare tag loss rates. Dennison-type tags were inserted in the left side of the fish three scale rows below the origin of the second dorsal fin. Internal anchor tags were inserted midway between the vent and the posterior tip of the pelvic fins along the ventral midline.

All tags displayed the message, "RTN to HRF Box 1731 GRAND CENTRAL STN, NY 10163", on one side, and a tag number and reward value on the other side. To provide a test of various reward levels, each tag bore amounts of either $10, $10-1000, or $5-1000.

In order to estimate short-term survival and tag retention, 149 of the 736 striped bass tagged were held caged for 24 hours in the Hudson River, prior to their release (NAI 1985). A detailed description of the gear and procedures used in tagging are available in NAI (1984a).

3.2 <u>Tag Return Processing</u>

Upon receipt of a tag, the HRF issued a check for the minimum reward value displayed on the tag. The reward check and a questionnaire (Appendix IIIA) were then mailed to the respondent along with a stamped envelope addressed to the HRF post office box.

The information from each return was entered on a tag return form (Appendix IIIB) which summarized all of the release and recapture information for that fish. Although some information was occasionally provided by the initial contact from the respondent, completion of the tag return form was invariably dependent on receipt of the questionnaire. The dates of mailings and responses were recorded so that if a response did not occur within about six weeks, a second mailing was made. Follow-up mailings were also made if critical information was missing. If this did not elicit a response, telephone contact was attempted.

Following receipt of a satisfactorily completed questionnaire, an information form was sent to the respondent indicating when and where their fish was tagged (Appendix IIIC) and that the respondent was entered in a drawing for prizes ranging from $100-$1000. If the questionnaire was received before February 27, 1985, the respondent was entered in the 1st yearly drawing held on February 28, 1985. All returns were eligible for the drawing regardless of whether the tag stated "REWARD $5-1000", "REWARD $10-1000", or simply "REWARD $10".

In accordance with the drawing rules, nine tags were randomly selected. The first five fishermen whose numbers were drawn received $100 per tag, the next two received $500 per tag, and the final two received $1000 per tag.

An extensive publicity campaign was undertaken to encourage fishermen to check striped bass for tags and to return those tags. A two-color poster and a flier (Appendix IV) describing the program were developed. The poster was hand-delivered to over 85 fishing tackle shops and boat liveries, and posted at approximately 50 boat launch and fishing sites from the mid-Hudson Valley through New York City and the Hudson River shore of New Jersey, eastward to Westport, Connecticut, and to both forks of Long Island. The flier was mailed to over 100 fishing-oriented facilities which were not visited.

The poster was also displayed as an advertisement in the <u>Fisherman</u> publication series once per month from July through November 1984. This publication reached at least 60,000 fishermen weekly from Maine to southern New Jersey. In an attempt to focus on the Hudson Valley, the same advertisement was also displayed in the July <u>Pennysaver</u> for the central Hudson River Valley region.

Several press releases were developed and were either printed in various newsletters and newspapers, or were instrumental in generating newspaper articles.

Near the end of 1984, a computer program was developed to facilitate tag processing and to provide an SAS tape of tag return information.

3.3 Data Analysis

Fishermen who caught tagged striped bass provided a variety of responses to the HRF. Therefore, the term "return" is used to indicate a tag actually received by HRF, whereas "recapture" is defined as the return of information on a tagged fish, regardless of whether the tag was actually sent to the HRF.

All analyses were conducted using striped bass lengths at release because many fishermen reported either broad length ranges for a single fish, or lengths that were shorter, and in some instances substantially shorter than the known length at release. Recapture rates were computed from striped bass directly released from their capture gear, i.e. they did not include fish released from the holding facility which was used to determine 24 hour survival.

In this report spring is the period of March 21 - June 20; summer = June 21 - Sept. 20; autumn = Sept. 21 - Dec. 20; and winter = Dec. 21 - March 20.

Data on releases are from NAI (1984b), and on water temperature at release from NAI (1984c). Statistical significance was determined with a Chi-square utilizing the formulas and Chi-square tables of Sokal and Rohlf (1969). Significance was determined at the $P < 0.05$ level.

The recapture data were partitioned by release temperature (6-13.9°C and ≥14°C) and total striped bass length (300-399 mm, 400-499 mm and ≥500 mm). The 14°C division was selected because NAI (1985) reported significantly higher initial sampling mortality above this temperature than below it. Inasmuch as future striped bass programs are likely to be conducted at river temperatures below 14°C, it was prudent to look at these recapture data separately from the recapture of striped bass released at ≥14°C.

McLaren et al. (1981) reported higher recapture rates for Hudson River striped bass ≥500 mm. Therefore, striped bass ≥500 mm were examined separately from those <500 mm. Since the legal size for striped bass in the Hudson River fishery is 457 mm and 3 year old striped bass can grow 50 mm in one year (TI 1981), fish 400-499 mm were examined separately from those 300-399 mm.

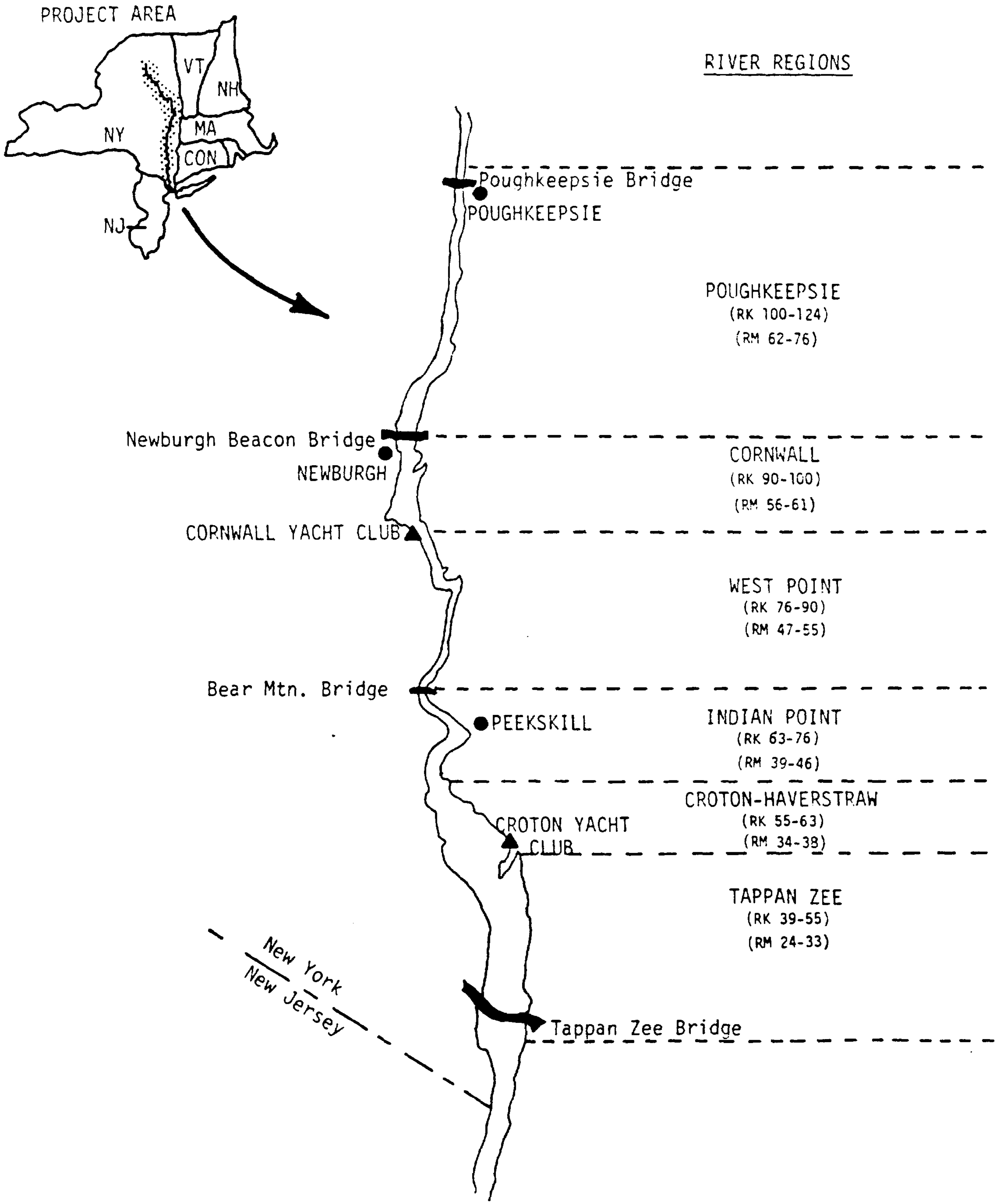


Figure 1. Adult striped bass sampling regions, Hudson River, spring, 1984.

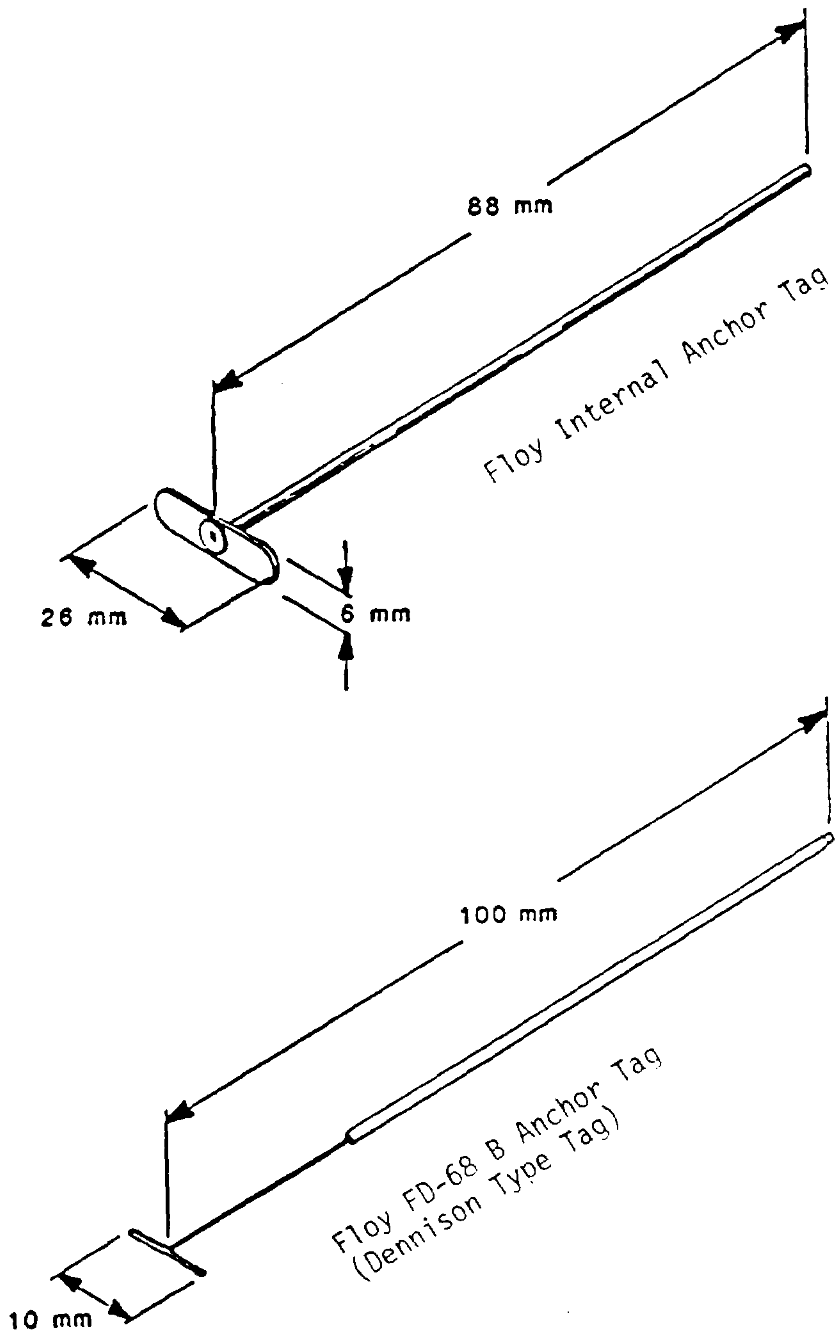


Figure 2. Description of tags used on striped bass for the 1984 Hudson River Survey. Both tags were labeled with either a $10, $5-1000, or $10-1000 reward.

4.0 RESULTS

By February 28, 1985, the HRF had received tags or recapture information from 53 of the 736 striped bass tagged and released in 1984. One Dennison tag was found on a Connecticut beach. Therefore the total number of recaptures was 52. In two instances, returns were made from fish initially released with only one tag. Twice, anglers captured double-tagged striped bass but subsequently lost one of the tags. Another fisherman caught a fish bearing two tags but retained only the more easily removed Dennison tag. One angler provided detailed information on a recapture including the tag number, but failed to remove the single tag before releasing the fish.

4.1 Tag Retention

Internal anchor tag loss (2%) was significantly lower (X^2=26.1, P < 0.001) than Dennison style tag loss (58%) based on the capture of 50 double tagged striped bass (Table 1).

Most respondents reported no abrasion at the tag insertion sites (Table 2). Differences between the conditions reported for both types of tags were not significant.

4.2 Recapture Rate

The recapture rate for striped bass released from the seine at river temperatures between 6-13.9°C increased significantly (P<0.05) with length (Table 3) from 3.9% for 300-399 mm fish to 18.5% for ≥500 mm fish. There was no significant difference (P>0.05) or increase in the recapture rate by length for striped bass released from the trawl at river temperatures between 6-13.9°C. Recapture rates in the trawl ranged from 1.6% for 300-399 mm fish to 6.3% for 400-499 mm fish.

The number of recaptures for striped bass released at river temperatures between 14-17.9°C were too small to analyze by gear and length (Table 3), i.e. the expected values in the X^2 analysis were less than 5 (Sokal and Rohlf 1969).

4.3 Tag Rewards

Return rates from tags with rewards of $10, $10-1000 and $5-1000 were not significantly different (Table 4).

4.4 Striped Bass Movement

Striped bass were recaptured from as far north in the Hudson River drainage as Cohoes, New York in the Mohawk River, as far south as Asbury Park, New Jersey, and as far east as Somerset, Massachusetts (Figure 3). The number of recaptures increased from the spring through the fall and declined sharply in the winter (Figures 4-7).

The mean distance between release and recapture sites for tagged striped bass was very similar during the spring, summer and fall. Time between tagging and recapture ranged from 0 to 250 days. An analysis of recapture by 20 day intervals following release showed no clear trend, with a low of zero recaptures for the period of 40 - 59 days after release, and a peak of 10 recaptures during the 140 - 159 day interval. The mean number of days-at-large was 133 days.

4.5 The Striped Bass Fishery

A single fisherman returned HRF tags from five striped bass. However, the great majority of respondents contributed individual returns, with two fishermen each returning tags from two fish.

Of the 53 returns and recaptures, at least 48 originated through the use of hook and line, while two were reported caught with net gear, both by the same respondent. It is not known what percentage of the angling returns were the result of commercial hook and line efforts.

Respondents were asked if their recaptured striped bass were released unharmed. It was not possible to determine if fish reported as not released unharmed were released in a stressed condition or actually harvested. Of the recaptures for which answers were received, 58% of the recaptured striped bass were released unharmed.

Fishermen were also surveyed as to how many days per year they fish for striped bass and for all species. Not all responses were quantifiable, but the 34 that were averaged 65.6 days of effort per year towards striped bass, and 91.7 days per year for all species including striped bass. The greatest effort reported was by a fisherman who stated that he fishes for striped bass an average of 250 days per year.

Table 1. -- Recaptures and tag loss rates by tag type.

	Both tags	Dennison tag	Internal anchor tag
Number recaptured	20	1	29
Loss rate	---	29/50 = 58%	1/50 = 2%

There was a highly significant difference ($P<0.001$) in loss rates between the two tag types.

Table 2. -- Condition of tag insertion sites on striped bass as reported by respondents.

Conditions	Dennison tag	Internal Anchor tag
No abrasion	15	28
Some abrasion	4	11
Substantial abrasion	0	3
Don't know	1	2
No response	2	6

Chi^2 independent variable test indicated no statistical significance at $P>0.05$ between condition of tag insertion sites reported for both tag types.

Table 3. -- Percent of striped bass recaptured by gear, length and temperature.

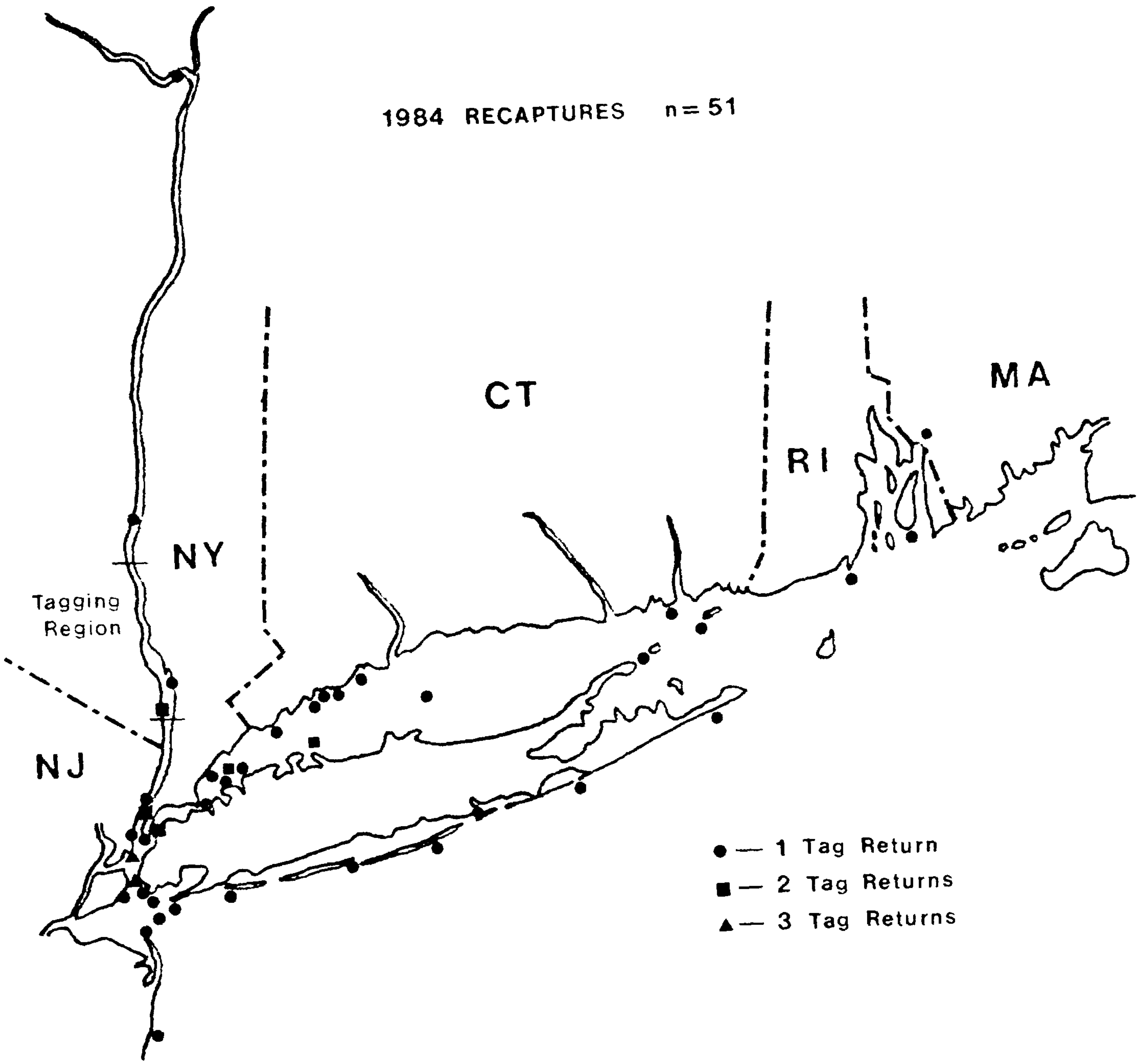
Temperature °C	Percent Recaptures: Trawl 300-399 mm	Trawl 400-499 mm	Trawl ≥500 mm	Seine 300-399 mm	Seine 400-499 mm	Seine ≥500 mm
6-13.9b	1.6 (128)[a]	6.3 (48)	5.0 (20)	3.9 (77)	10.7 (75)	18.5 (92)
14-17.9	0.0 (26)	9.5 (42)	3.6 (28)	0.0 (14)	14.3 (21)	6.6 (15)

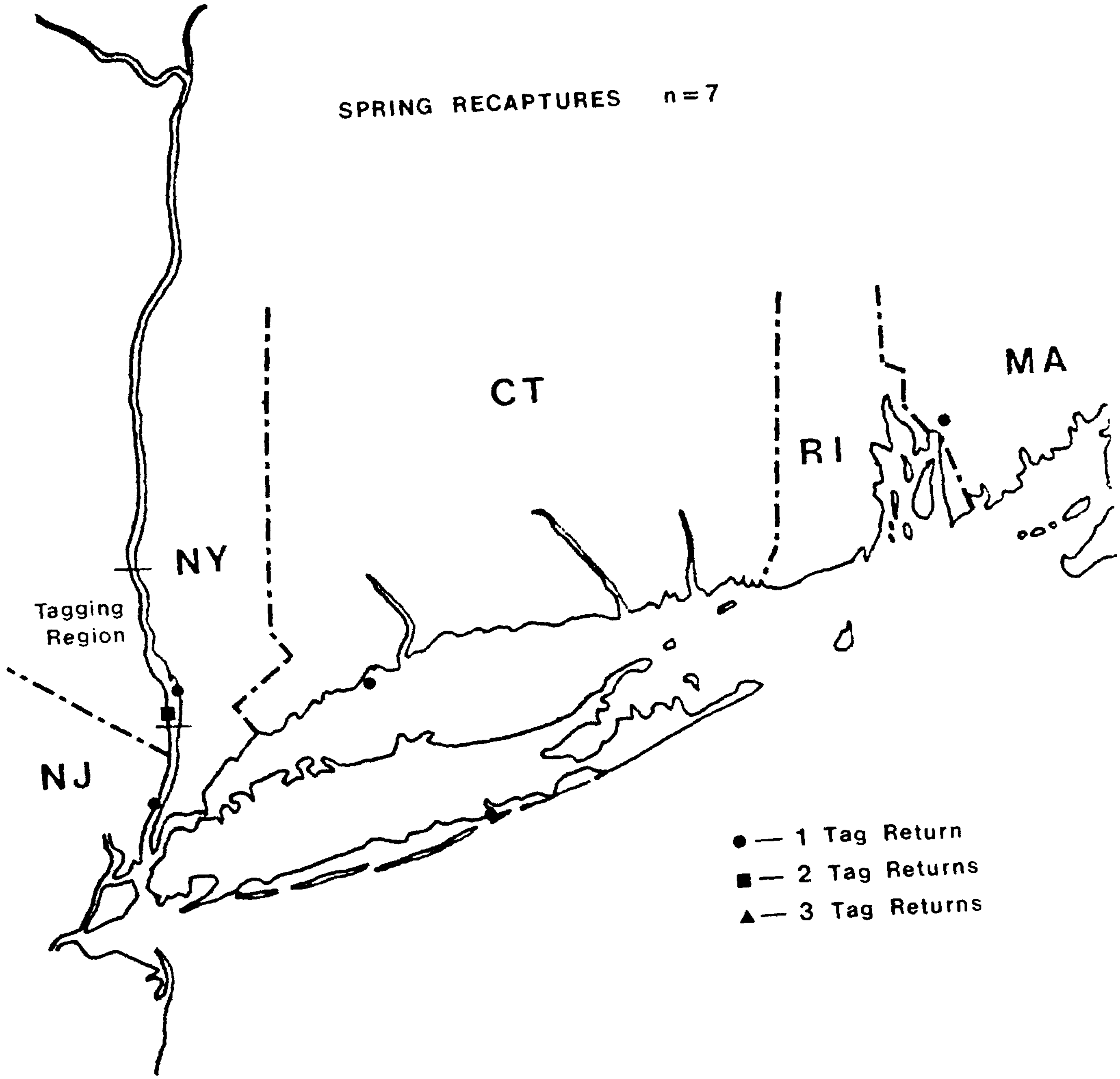
(a) Sample size

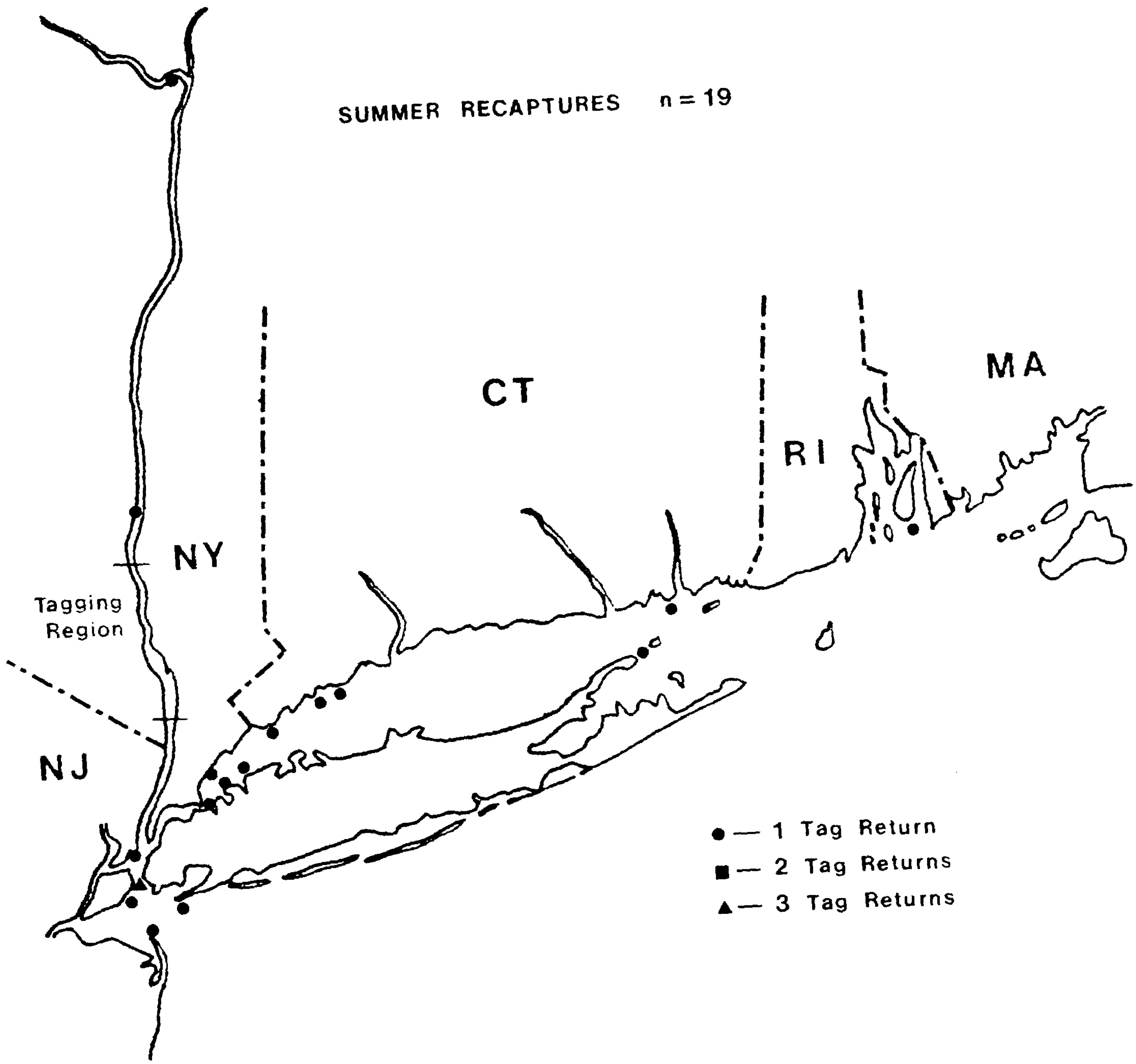
(b) Trawl recaptures by length were not significantly different $P>0.05$ ($X^2=2.66$, 2df).
Seine recaptures by length were significantly different $P<0.05$ ($X^2=8.81$, 2df).

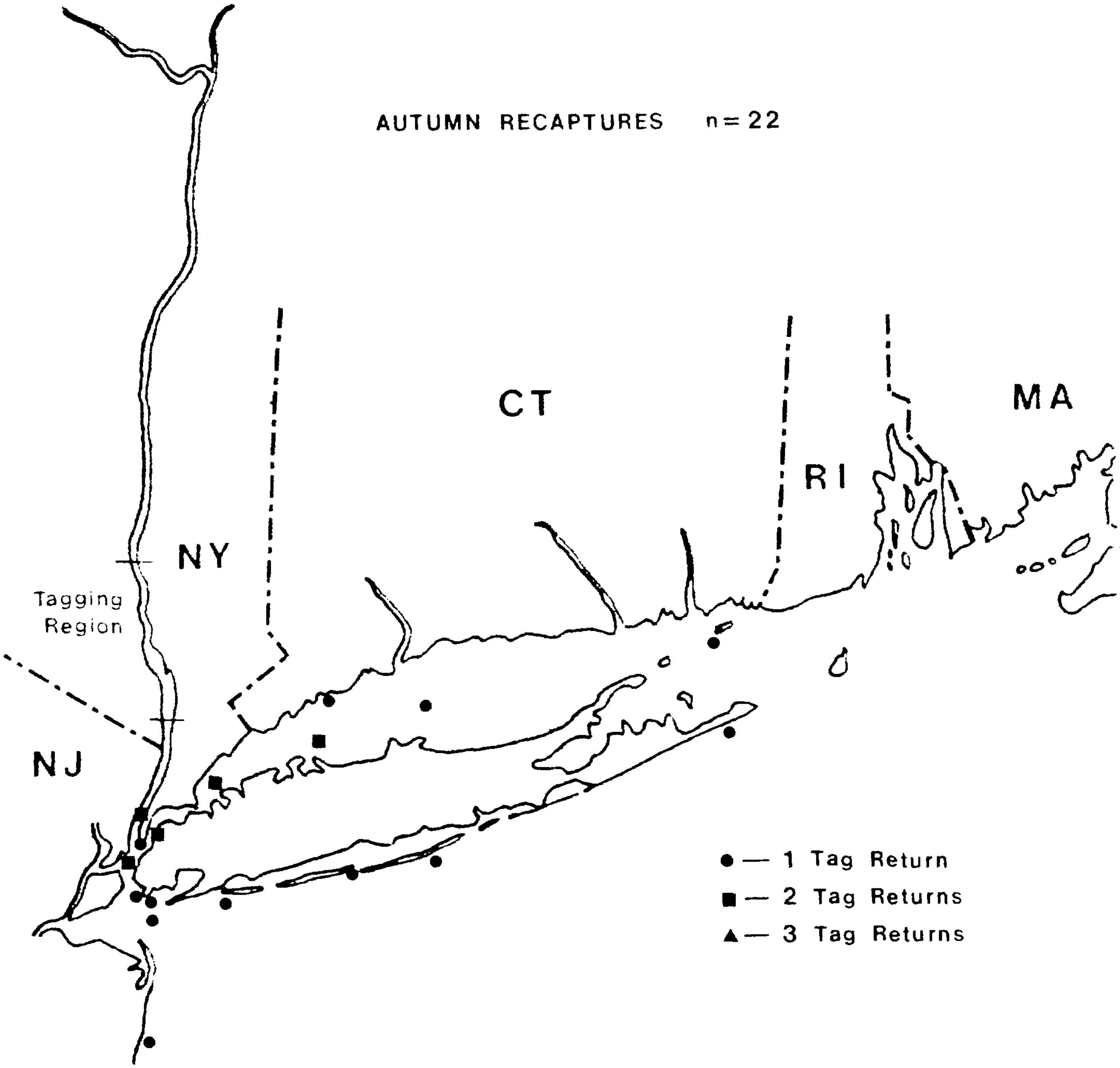
Table 4. -- Number of releases and number and percent returns by tag type and dollar value printed on tag. RC = Number of releases, RL = Number of returns.

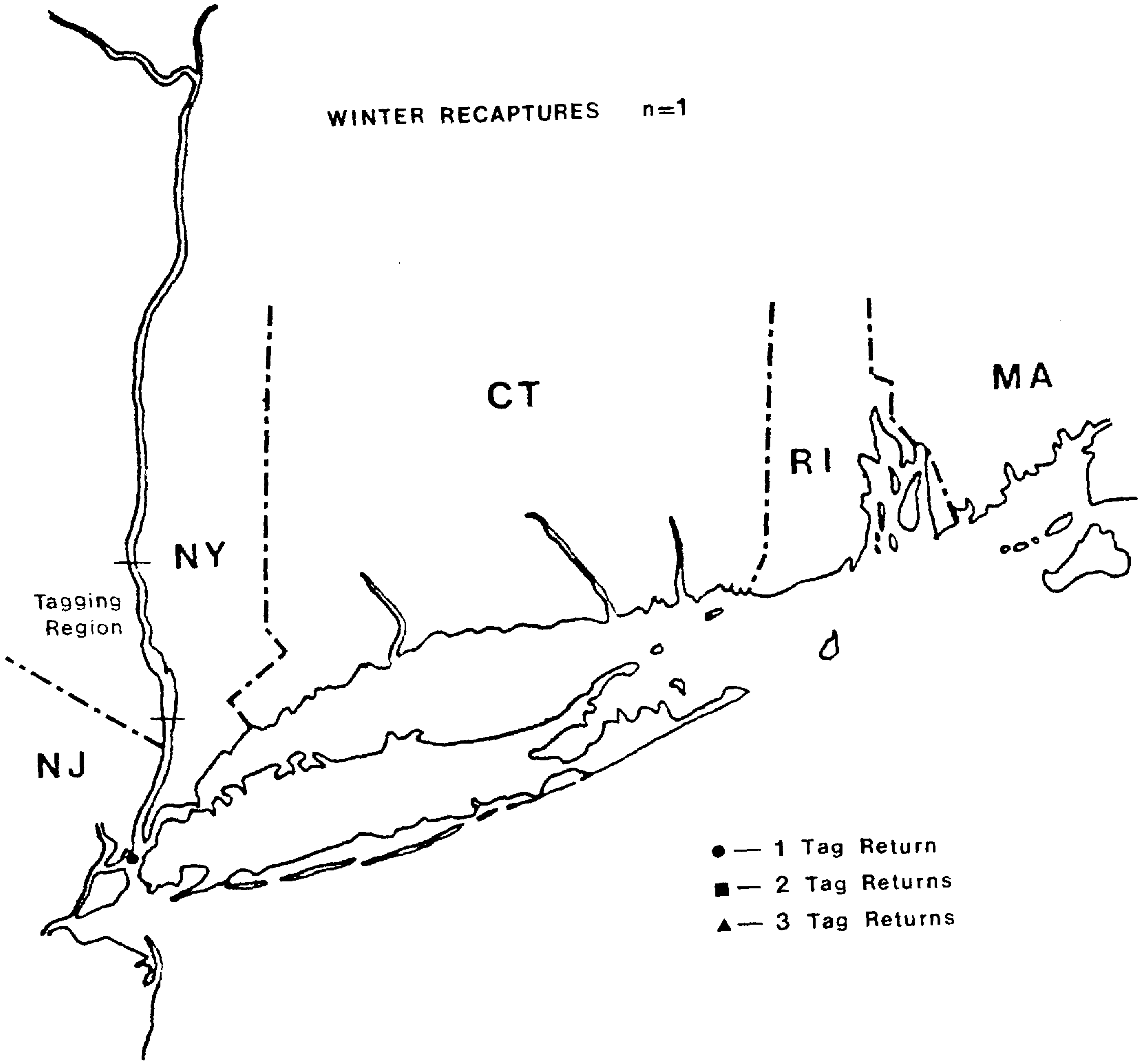
Tag value	Dennison tag RC/RL	%	Internal anchor tag RC/RL	%
$10	15/452	3.3	34/444	7.7
$10-1000	5/118	4.2	6/145	4.1
$ 5-1000	3/165	1.8	5/146	3.4


1984 RECAPTURES n = 51
CT
MA
RI
NY
Tagging
Region
NJ
● — 1 Tag Return
■ — 2 Tag Returns
▲ — 3 Tag Returns


SPRING RECAPTURES n = 7
CT
RI
MA
NY
Tagging Region
NJ
● — 1 Tag Return
■ — 2 Tag Returns
▲ — 3 Tag Returns


SUMMER RECAPTURES n = 19
CT
RI
MA
NY
Tagging
Region
NJ
● — 1 Tag Return
■ — 2 Tag Returns
▲ — 3 Tag Returns


AUTUMN RECAPTURES n=22
CT
MA
RI
NY
Tagging Region
NJ
● — 1 Tag Return
■ — 2 Tag Returns
▲ — 3 Tag Returns



WINTER RECAPTURES n=1
CT
RI
MA
NY
Tagging Region
NJ
● — 1 Tag Return
■ — 2 Tag Returns
▲— 3 Tag Returns

5.0 DISCUSSION

5.1 Tag Retention

Double-tagging studies provide the only direct means of estimating tag loss in the natural environment. Despite this, double-tagging of striped bass in previous studies has rarely been performed (Appendix V). The single-year recapture rate of striped bass in the present study was 7.1%. Had the HRF study employed Dennison tags alone, the single-year recapture rate would be estimated at 2.9%.

The higher retention of the internal anchor tag is most probably due to the design of its anchor, as the external vinyl tube portions of both tags are very similar. Unlike the Dennison-style tag with its narrow monofilament and 10 mm long T-bar, the internal anchor tag has a 6 x 26 mm oblong disc (Figure 2). An apparent disadvantage of the internal anchor tag is that it is supported only by soft tissue, whereas the Dennison tag when inserted properly, is retained by the bony, fin-supporting pterygiophores of the dorsal spines or rays. However, this is not as significant a difference as it seems because the pterygiophores of a living fish are flexible, particularly the large medial blades which comprise the bulk of the target area for a Dennison tag. Furthermore, vertical placement of the T-bar may result in minimal contact with the pterygiophores, thereby leaving it exposed to little but muscle tissue. It is also possible that the monofilament of the Dennison-style tag, which is much more flexible at the insertion point than the vinyl tube of the internal anchor tag, wobbles more as the fish swims, thereby causing more tissue erosion.

Another possible explanation for differences in retention between these two tag types is an effect related to differences in their external positions on the fish. The Dennison tag is perpendicular to the side-to-side swimming motion of the fish whereas the internal anchor tag is parallel to it.

An examination of 62 striped bass tagging study reports (Appendix V) found only four that included double-tagging. Two of these involved Dennison-style tags (White 1972, Dunning and Ross 1985) and only one involved internal anchor tags (Dunning and Ross 1985). The latter reported a loss rate for internal anchor tags (2.3%) which was similar to that in the present study (2.0%), but a much lower loss rate for Dennison tags (4.3% versus 58%) in a 180-day study using freshwater and marine holding pools. Based on preliminary data from the present study, they suggested two explanations for the difference in Dennison tag loss rates: 1) the environment in the Hudson River and surrounding waters was more rigorous than in the holding pools; and 2) in their study the Dennison tags were placed further posteriorly, where pterygiophores were more closely spaced than for the holding pool fish. White (1972) reported a six-month loss rate for Dennison tags, anchored by the spinous dorsal fin pterygiophores, of 7.1%. This loss rate is about six times lower than that for the present study but similar to the rate reported by Dunning and Ross (1985). White (1972) conducted his study in two South Carolina reservoirs. If the environment of the reservoir was less rigorous than that experienced by Hudson River striped bass, which migrate between the Hudson River estuary and the Atantic Ocean, it could explain part of the recapture rate difference between the present study and that of White (1972).

There are two additional factors which could have contributed to this difference but cannot be evaluated based on the available information: fish length and tag location. White (1972) did not report on either of these variables. Insufficient data were available from the present study to evaluate the effect of length on retention, although Dunning and Ross (1985) reported no difference in tag loss by length. However, the present study did indicate a difference in return rates by length. The combined results of the present study and those of Dunning and Ross (1985) indicate that tag location chosen by White (1972) could have contributed to the difference in the loss rate between his study and the present one.

5.2 Recapture Rate

The increase in recapture rate with increasing length observed in the fly seine data for striped bass released at water temperatures between 6-13.9°C is consistent with the observations of McLaren et al. (1981). When they compared the return rates for tagged striped bass <500 mm and $\geq$500 mm, they found a significantly higher return rate ($P<0.05$) for striped bass over 500 mm. The higher recapture rate for larger striped bass is probably attributable to a combination of differential migration by size, and differences in fishing pressure between recapture regions. If a higher proportion of larger striped bass than smaller ones migrated out of the Hudson River and greater numbers of striped bass were captured outside of the Hudson River than within it, then the recapture rate should have been higher for larger fish.

Although differential movement by size in this study was difficult to demonstrate due to the small number of recaptures from the Hudson River, there is good circumstantial evidence for this phenomenon. Alperin (1966), Westin and Rogers (1978), and Kohlenstein (1981) noted a general tendency for subadult striped bass to migrate out of their natal river to a lesser degree than adult fish. Alperin (1966) cited a Hudson river tagging study which supported this concept (Neville 1940), in which no recaptures were made outside the Hudson River from 200 tagged striped bass, few of which were greater than 400mm.

Lower fishing pressure for striped bass within the Hudson River than outside of it was likely because of a ban on commercial fishing for the species in the river and a New York State health advisory that striped bass from the Hudson River recreational fishery not be eaten. Having exited the Hudson, however, striped bass became available to an intensive coastal sport fishery, in addition to active commercial fishing efforts based primarily in New York Harbor and Long Island's southeast fork. The fact that in the HRF Study only 10 of 51 recaptures with locality data originated from the Hudson River itself supports the observation that fishing pressure on the Hudson River striped bass stock is much greater in coastal waters.

Differential fishing pressure on size classes within and outside the Hudson River can also be attributed to recent changes in the minimum length regulations. In November, 1983, the minimum length limit for striped bass caught north of the George Washington Bridge was raised from 16" FL to 18" TL, while in the Marine District of New York which includes the Hudson River south of the George Washington Bridge and both shores of Long Island, the minimum length was raised from 16" FL to 24" TL.

Increasing recapture rate with increasing length for striped bass released between 6-13.9°C was not observed in the trawl as it was in the fly seine. This difference appears to be attributable to a relatively lower recapture rate in the $\geq$500 mm length category from the trawl as compared with the seine. This may reflect a gear difference or it may be due to the small number of $\geq$500 mm fish released from the trawl (20).

5.3 Tag Rewards

The absence of a significant difference between the return rate of tags with reward values of $5-1000 and $10-1000 is consistent with previous studies which observed no difference in the return rate between tags with reward values of $5 and $10 (TI 1981). The absence of a significant difference between the return rate of tags with a reward value of $10 versus $10-1000 could be due to a small sample size, or to $1000 not being a greater incentive than $10. However, it is more likely that respondents were aware that tags with reward values of $10 would be treated the same as those with $10-1000. These results, coupled with the fact that the annual tag drawing provides good publicity, suggest that a $5-1000 reward value be used in future studies.

The lower return rates reported in this study (Table 4) in comparison with those reported in TI (1981: Table III-6) is probably attributable to a combination of new health advisories concerning consumption of striped bass, the relative newness of the tag return program, and the smaller number of fish tagged.

5.4 Striped Bass Movement

The movements of the Hudson River adult stock in 1984 did not appear to differ from those during 1972-1979 (TI 1979, 1981 and McLaren et al. 1981). Both the HRF and the TI studies indicate that there is a general dispersal of striped bass out of the Hudson River in spring into a region extending from Sandy Hook, New Jersey to both shores of Long Island and the Connecticut shoreline. A smaller portion of Hudson River striped bass travel further, to Rhode Island, Massachusetts and central New Jersey. In autumn and early winter, there is a return migration towards the river. Some portion of the Hudson stock remains in the river throughout the summer. This pattern describes the movement of striped bass 300-800 mm (i.e. ages II-VIII), because comparatively few fish over 800 mm were tagged in these studies. Large striped bass do not necessarily spawn every year (Lewis 1962), nor do they always winter in estuaries (Clark 1968), and may therefore exhibit a different yearly movement pattern.

Of the recaptures, two were made north of the tagging region, three within it, and the remainder to the south or out of the river. No recaptures were made by the tagging teams of striped bass tagged earlier in this study. The recapture of a tagged striped bass above the Troy Dam provides evidence that migratory fish may travel beyond the dam by passing through its navigational lock.

The most distant return from the striped bass released in 1984 was from southwestern Massachusetts. TI recovered several tags from the north coast of Cape Cod and beyond, but these returns originated from a much larger tagging effort. Unlike the Rhode Island fishery, recaptures of Hudson River striped bass from Massachusetts tend to originate relatively early in the year. All six of those reported in McLaren et al. (1981) were made in June or July. The single recapture from Massachusetts in this study came in May. Recaptures from Rhode Island occurred as late as November in the 1976 and 1977 tagging reported by McLaren et al. (1981) and late October in the present study.

Relatively few Hudson River striped bass travel south, with most New Jersey returns originating from the northern portion of the state. TI received only two returns from south of New Jersey, and it is possible that they were from more southerly stocks. Both Raney (1954) and Clark (1968) reported occasional penetration of the Hudson River by Chesapeake stock.

McLaren et al. (1981) examined the proportion of striped bass recaptured outside the river that were made within 50km (31 miles) of the river mouth. Of the striped bass released in 1976 and 1977, 70% and 56% respectively of the recaptures made outside the river were from that zone. The proportion of recoveries from outside the Hudson within 50 km of the river mouth in this study was comparable at 56%.

Raney et al. (1954) analyzed returns from an angler-based volunteer tagging program that took place from 1948 to 1952. From the substantial number of recaptures of fish originally tagged in the Hudson, the authors suggested that the Hudson River striped bass population rarely strays beyond a line between Fairfield, CT and Northport, NY in Long Island Sound, nor beyond Jones Beach on Long Island's south shore. This range seems to have been significantly exceeded since at least the mid-1970's. Explanations for this difference include but are not limited to factors involving relative changes in the size of the Hudson population compared to the size of the Chesapeake stock with which it mingles in the New York area.

Commercial net gear returns were low, representing less than 4% of all recaptures in the 1984 HRF study. The two returns of this type were made within the tagging area by a shad fisherman. The Hudson River striped bass fishery has been closed since 1976, but this stock was fished commercially outside the river in 1984 mainly by hook and line fishermen in the New York Harbor region and by haul seine and trap-net fishermen on Long Island's east end. The absence of returns from the net fishery directed at striped bass could have resulted from few recaptures, or underreporting by these fishermen. Young (1983) noted a decrease in cooperation by east end commercial fishermen with the NYSDEC striped bass research program over a proposed increase in minimum length regulations, which subsequently passed and may have led to underreporting.

5.5 The Striped Bass Fishery

Responses to the questions on the time spent per year fishing for striped bass and other species indicated that the majority of these fishermen fish frequently, averaging over 90 days per year, and that almost three-fourths of this effort is directed towards striped bass. Several of the respondents who recaptured tagged fish through angling stated that they are commercial hook and line fishermen.

6.0 CONCLUSIONS

6.1 Retention

The significantly higher loss rate of Dennison tags (58%) versus internal anchor tags (2%) in the present study indicates that selection of tag style is of critical importance in tagging studies and that the current favor enjoyed by the Dennison tags may be due to its ease of placement rather than its holding ability.

Because the Dennison tag loss rate reported by White (1972) was approximately six times lower than that from the present study, additional studies are necessary to determine whether this difference is due to fish length, environmental rigor or tag location.

6.2 Recapture Rate

The increasing recapture rate with increasing length for striped bass released from the seine between 6-13.9°C in this study is consistent with the results of McClaren et al. (1981). From this, and the fact that all recaptures from the present study were made by fishermen, it is evident that recapture rates reported by fishermen are biased towards larger fish. Therefore, an alternative to fishermen recaptures may be desirable if tagging is being conducted to estimate population size.

The significant difference in the recapture rate by length for striped bass released between 6-13.9°C from the seine, unlike that for the trawl results, suggests that the two gear may have a different effect on striped bass survival and therefore, catchability. As a result, it is not appropriate to compare the recapture rates for the trawl and the seine based upon striped bass of all lengths combined, comparisons should be based on recapture rates as a function of length. Additional studies are planned to examine the recapture rate for striped bass released from trawls.

6.3 Tag Rewards

The absence of a significant difference between the return rates of tags with reward values of $10, $5-1000 and $10-1000, and the positive publicity provided by the annual tag drawing, suggests that a $5-1000 reward value be used in future studies.

6.4 Striped Bass Movement

The movements of Hudson River adult striped bass in 1984 did not differ significantly from those during 1972-1979.

6.5 The Striped Bass Fishery

The great majority of Hudson River striped bass recaptured were caught by either recreational or commercial anglers. Fishermen reported releasing unharmed more than 50% of the tagged striped bass recaptured.

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APPENDICES

APPENDIX I.

Table I-1. -- Releases and recaptures for length and temperature intervals of striped bass tagged and released directly from the otter trawl. Values = recaptures/releases.

Length interval	Temperature interval (°C) 6.0-7.9	8.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9[a]	16.0-17.9
300-399	0/0	1/68	1/28	0/32	0/22	0/4
400-499	0/0	2/33	1/7	0/8	4/38	0/4
500-599	0/0	1/15	0/2	0/1	1/22	0/2
600-699	0/0	0/1	0/1	0/0	0/3	0/0
>700mm	0/0	0/0	0/0	0/0	0/1	0/0

(a) Does not include one fish tagged and released but not measured.

Table I-2. -- Releases and recaptures for length and temperature intervals of striped bass tagged and released directly from the fly seines. Values = recaptures/releases.

Length interval	Temperature interval (°C) 6.0-7.9	8.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-17.9
300-399	2/20	1/42	0/10	0/5	0/11	0/3
400-499	3/7	5/49	0/12	0/7	3/21	0/0
500-599	0/0	8/37	2/17	0/3	0/9	0/0
600-699	0/0	1/11	4/15	0/2	1/3	0/1
>700mm	0/0	1/2	1/5	0/0	0/2	0/0

APPENDIX II.

LIST OF INDIVIDUAL RETURNS AND RECAPTURES

(Sorted by river mile at release)

Variable Definitions

River Mile	=	river mile at release site
City	=	nearest city to recapture site
Distance (Miles)	=	minimum distance from release to recapture
99 or 9999	=	information not available

Gear Codes (at release):

52	=	otter trawl
72	=	Kosalt Plaice net (fly seine)
73	=	Scottish seine

SUMMARY REPORT

REPORT SORTED BY RIVER MILE

RELEASE DATE	TAGNO1	TAGNO2	LENGTH (MM) RELEASE	LENGTH (MM) RECAPTURE	RIVER MILE	RECAPTURE CITY	RECAPTURE STATE	DISTANCE (MILES)	RECAPTURE DATE	DAYS-AT-LARGE	GEAR CODE
04/14/84	A0000027	B0000027	383	457	26	BRIDGEPORT	CT	80	06/20/84	67	73
04/14/84	A0000028	B0000028	391	381	26	SOMERSET	MA	201	05/18/84	34	73
04/14/84	A0000020	B0000020	474	457	26	COHOES	NY	131	07/14/84	90	73
04/14/84	A0000014	B0000014	410	445	26	OSSINING	NY	7	05/02/84	18	73
04/14/84		B0000006	424	508	26	NORTHPORT	NY	66	11/18/84	218	73
05/08/84		B0000628	432	508	28	NYC	NY	30	12/02/84	208	73
04/14/84	A0000031	B0000031	590	584	29	STAMFORD	CT	63	06/25/84	72	73
04/15/84		B0000185	545	559	30	SANDS POINT	NY	51	07/08/84	84	73
04/15/84		B0000163	558	533	30	KINGS POINT	NY	46	07/21/84	97	73
04/15/84		B0000043	517	635	30	NORWALK	CT	72	07/19/84	95	73
04/15/84		B0000190	523	584	30	ORIENT POINT	NY	131	08/28/84	135	73
04/15/84	A0000171		415	406	30	MASTIC BEACH	NY	104	05/99/84	9999	73
04/14/84		B0000064	408	457	30	NYC	NY	31	11/01/84	201	52

RELEASE DATE	TAGN01 TAGN02	LENGTH (MM) RELEASE	LENGTH (MM) RECAPTURE	RIVER MILE	RECAPTURE CITY	RECAPTURE STATE	DISTANCE (MILES)	RECAPTURE DATE	DAYS-AT-LARGE	GEAR CODE
04/15/84	B0000200	401	483	30	BROOKLYN	NY	45	11/25/84	224	73
04/15/84	A0000043	517	0	30	9999999		9999	99/99/99	9999	73
04/15/84	A0000160	524	610	30	PATCHOGUE	NY	101	11/99/84	9999	73
04/23/84	A0000302 B0000226	516	516	31	NYACK	NY	4	04/23/84	0	73
04/30/84	A0000653 B0000371	696	610	35	DARIEN	CT	74	08/17/84	109	73
04/30/84	A0000491	609	610	35	SANDY HOOK	NJ	51	07/02/84	63	73
04/30/84	A0000470	618	660	35	NORTHPORT	NY	75	09/29/84	152	73
04/30/84	B0000143	546	9999	35	POINT JUDITH	RI	176	10/20/84	173	73
04/30/84	B0000140	584	711	35	MONTAUK	NY	149	11/06/84	190	73
04/17/84	B0000224	410	559	35	STONY BROOK	NY	91	11/24/84	221	73
04/30/84	B0000374	866	965	35	BROOKLYN	NY	45	11/24/84	208	73
04/30/84	B0000362	684	9999	35	SHINNECOCK	NY	9999	93/99/99	9999	73
05/04/84	A0000610 B0004085	498	508	36	QUEENS	NY	50	08/04/84	94	73

RELEASE DATE	TAGN01 TAGN02	LENGTH (MM) RELEASE	RECAPTURE	RIVER MILE	RECAPTURE CITY	STATE	DISTANCE (MILES)	RECAPTURE DATE	DAYS-AT-LARGE	GEAR CODE
04/15/84	A0000032	388	483	36	WATERFORD	CT	143	08/27/84	134	73
04/24/84	B0000240	482	533	36	NEWPORT	RI	192	09/10/84	141	73
05/04/84	B0004057	390	457	36	QUEENS	NY	84	09/26/84	147	52
04/18/84	B0000284	465	432	36	STATEN ISLAND	NY	44	09/20/84	157	73
05/04/84	A0003092 B0004042	413	457	36	NYC	NY	42	09/16/84	137	73
04/24/84	B0000239	525	559	36	ASBURY PARK	NJ	70	11/06/84	196	73
04/24/84	B0000237	412	406	36	NYC	NY	37	12/30/84	250	73
05/04/84	A0002507	370	483	36	NYC	NY	39	11/15/84	195	73
04/23/84	B0000278	370	330	37	GLEN COVE	NY	62	09/05/84	135	72
04/17/84	A0000125 B0000099	537	584	37	OAK BEACH	NY	85	09/21/84	157	52
05/23/84	B0000642	481	432	55	NYC	NY	62	09/16/84	116	52
05/30/84	A0000790 B0002225	525	559	56	SANDS POINT	NY	77	10/09/84	132	52
05/23/84	B0000147	403	432	56	MANHATTAN	NY	47	10/11/84	141	52

RELEASE DATE	TAGN01 TAGN02	LENGTH (MM) RELEASE	RECAPTURE	RIVER MILE	RECAPTURE CITY	STATE	DISTANCE (MILES)	RECAPTURE DATE	DAYS-AT-LARGE	GEAR CODE
05/30/84	B0002227	462	483	56	MANHATTAN	NY	56	10/03/84	126	52
05/22/84	A0000720 B0000631	406	356	56	MANHATTAN	NY	47	10/18/84	149	52
05/23/84	B0002198	468	483	56	BROOKLYN	NY	59	12/13/84	203	73
06/01/84	B0002157	659	660	57	GREENPORT	NY	167	10/21/84	142	72
06/01/84	B0002185	467	508	57	DARIEN	CT	95	12/06/84	188	72
04/26/84	B0000442	372	635	59	BRONX	NY	78	07/15/84	80	52
05/01/84	A0003011 B0004063	475	508	59	HOBOKEN	NJ	60	06/99/84	9999	52
05/02/84	A0003083 B0004090	337	381	59	ROSETON	NY	6	08/99/84	9999	52
04/26/84	B0000454	485	660	59	99999		9999	09/16/84	143	52
04/26/84	A0000473 B0000343	706	706	60	NYACK	NY	33	05/15/84	19	73
04/26/84	B0000372	505	711	60	FORT LEE	NJ	49	05/12/84	16	73
04/26/84	A0000452 B0000358	483	483	60	NYC	NY	67	07/07/84	72	73
04/26/84	B0000350	475	406	60	BROOKLYN	NY	70	09/23/84	150	73

RELEASE DATE	TAGNØ1 TAGNØ2	LENGTH (MM) RELEASE	LENGTH (MM) RECAPTURE	RIVER MILE	RECAPTURE CITY	STATE	DISTANCE (MILES)	RECAPTURE DATE	DAYS-AT-LARGE	GEAR CODE
Ø4/26/84	BØØØØ344	656	686	6Ø	SANDS POINT	NY	81	1Ø/15/84	172	73

APPENDIX III.

HRF TAG RETURN PROGRAM STANDARD FORMS

A. Striped Bass Tag Return Questionnaire

B. Tag Return Form

C. Release Information Form

Appendix IIIA.

HUDSON RIVER FOUNDATION

Striped Bass Tag Return Questionnaire

Your cooperation is appreciated. This data forms the basis for our research.

Tag Numbers ____________________ Your name: ________________________

____________________ Your address: ____________________

____

Date of Capture: ______________

Length in Inches: ______________ (Circle one) Length: a) measured
b) estimated

Location of Catch (be as specific as possible): ___________________________

____

Circle one answer for each of the following questions:

Method of Capture: a) rod and reel; b) net; c) other (specify) __________

Were both tags present? a) Yes b) No

What was the condition of the fish at the tag insertion site for each tag?	Dennison Tag (in fish's back)	Internal Anchor Tag (in belly area)
	a) No abrasion	a) No abrasion
	b) Some abrasion	b) Some abrasion
	c) Substantial abrasion	c) Substantial abrasion
	d) Don't know	d) Don't know

Was the fish released in good condition? a) Yes b) No

Additional comments: ____

____

Optional: On average, how many days per year do you fish? _________________
How many of these days are spent fishing for striped bass? ______

Please return to:

Hudson River Foundation
P.O. Box 1731
Grand Central Station
New York, NY 10163

Reminder: Completion and return of this questionnaire is necessary for entry into the HRF Tag Return Drawing, to be held in February, 1985 for nine rewards of $100-1,000.

Appendix IIIB.

HUDSON RIVER FOUNDATION - STRIPED BASS TAG RETURN PROJECT

TAG RETURN FORM

Name: ____________________________ Date Received: ________________________

Address: ____________________________ Tel. No. (if given): ________________

____________________________ Recapture: rod and reel/net

Tag(s) returned: ____________________ If one tag returned, was there another tag present at initial release? yes/no. If yes, #____________

TAG INFORMATION	RELEASE	RECAPTURE
Date & Time Captured		
Location		
Length		meas./est.
Weight (if given)		
Gear		

Days at large: ______________________ Minimum distance travelled: __________

Condition tag insertion sites:
Dennison tag - a) no abrasion; b) some abrasion; c) substantial abrasion; d) don't know
Anchor tag - a) no abrasion; b) some abrasion; c) substantial abrasion; d) don't know

Other comments: ____

____

Reward info: Amount $__________ Check No. __________ Date _____________

Action: Check mailed______; Quest. mailed_____; Quest. received______; Release info. mailed______; Followup mailed______; Tel. contact______, ______; Info. complete______; Eligible for drawing? _____Yes _____No

Fish released in good condition? _____Yes _____No

Optional info: Days fished/year_____; days fished for striped bass/year_____

Comments by tag return processor: ____

____

HUDSON RIVER FOUNDATION
FOR SCIENCE AND ENVIRONMENTAL RESEARCH

HRF

Striped Bass Tag Return Project 212 949-0028

(Appendix IIIC.)

Thank you for returning tag numbers ________ and ________.
The information you have provided will be a valuable part of a multi-year study of Hudson River striped bass population biology.

Your striped bass was originally caught and tagged
at ____,
on ____.

Hudson River Foundation
Box 1731
Grand Central Station
New York, NY 10163

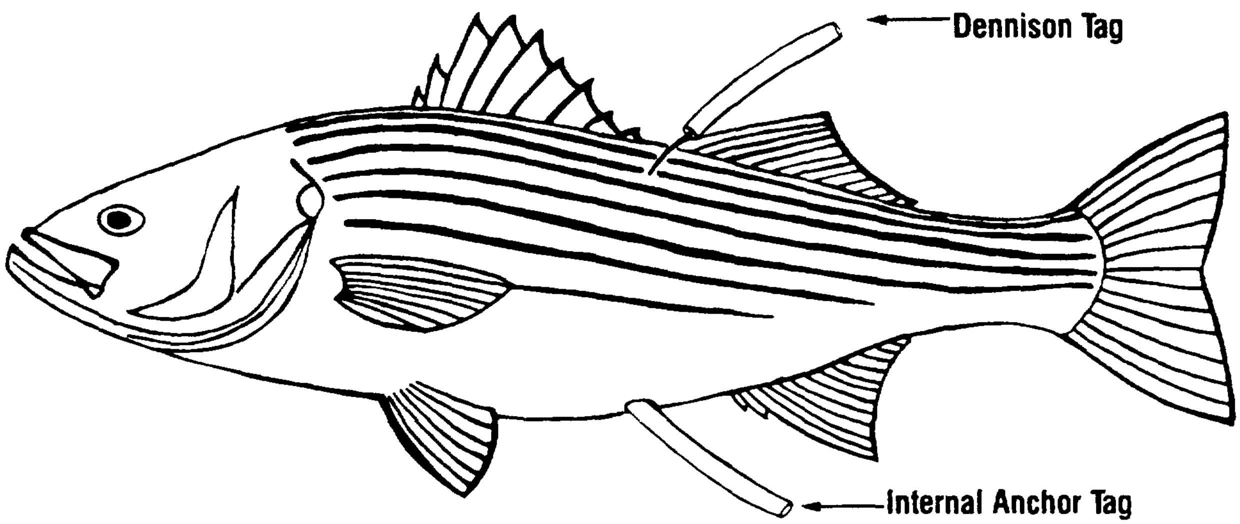
You have been entered on the eligibility list for the tag reward drawing for 9 rewards of $100-1,000, to be held in February, 1985. You will be notified immediately if you win.

APPENDIX IV.

TAG RETURN POSTER

$5 TO $1000 REWARD $10 TC $1000

FOR STRIPED BASS TAGS



PURPOSE The Hudson Foundation (HRF*) is coordinating a multi-year study of Hudson River striped bass population biology. You can participate in this study by returning tags from striped bass which you catch, and the HRF will pay for your assistance. The HRF will gladly accept any non-HRF tags without return addresses, however, no reward will be offered.

TAGS: During the spring, striped bass greater than 11.8 inches (30 cm) in total length will be doubled tagged as illustrated above. The tags are made of yellow vinyl tubing. The striped bass which you catch may only have one tag, due to the loss of the other. Both tags bear a letter and a five digit number (for example A00000 or B 00000), a reward value and the mailing address of the HRF (listed below). Most tags will read "REWARD $5-$1000" or "REWARD $10-$1000." Some tags will read "REWARD $10" but will be treated as if they read "REWARD $10-$1000." If you catch a tagged striped bass, whether you intend to keep it or release it, carefully cut off the tag where it passes through the fish's skin. When you return a tag, the HRF will send you the minimum reward printed on the tag ($5 or $10) and a questionnaire asking for the date on which you captured the fish bearing the tag submitted, the fish's length, the location and method of capture and the condition of the tag insertion site. Upon completion and return of the questionnaire, your tag number will be added to the eligibility list for a drawing to be held in February. Nine tag numbers will be randomly selected from all of those returned. The HRF will award $100 per tag to the first five fishermen whose numbers are drawn, $500 per tag to the next two fishermen whose numbers are drawn and $1000 per tag to the last two fishermen whose numbers are drawn.

*The HRF is a not for profit organization which sponsors scientific, economic and public policy research on matters of environmental, ecological and public health concern to the Hudson River and its tributaries.

HUDSON RIVER FOUNDATION
P.O. BOX 1731 GRAND CENTRAL STATION, NEW YORK, N.Y. 10163

APPENDIX V.

TABULAR SUMMARY OF PREVIOUS STRIPED BASS TAGGING STUDIES

In some instances return rates were not provided in the studies cited, but were calculated by HRF if the data presented allowed. All return rates were for more than a single year unless otherwise noted. Tag shedding rates when available, were footnoted (footnotes appear on page V-5). Asterisks denote studies that included double-tagging.

Variable Definitions

F	=	fisherman (recreational and commercial)
R	=	researchers
F & R	=	primarily fishermen
R & F	=	primarily researchers
H	=	hatchery stocked
S	=	single year return rate
N	=	no information

TAGGING STUDIES IN THE NATURAL ENVIRONMENT

REFERENCE	TAG TYPE	RETURN RATE %	TAGGED BY	RECAP-TURED BY
ALPERIN 1966	PETERSEN DISC, PLASTIC DANGLER, SPLIT RING JAW W/ PLASTIC DANGLER	14.7	R	F
AUSTIN & CUSTER 1977 [1]	SPAGHETTI	N	F	F
BEAULIEU 1962	FLAT RING, SPLIT RING W/ PLASTIC PLATE	9.9	R	F
CALHOUN 1952	PETERSEN DISC	10	R	F
CHADWICK 1963	DART	9.0	R	F
	DISC DANGLER	26		
	HYDROSTATIC	29		
	SPAGHETTI	54.8		
	STREAMER	20.4		
CHADWICK 1967	SAME AS CHADWICK (1963) BUT MAINLY DISC DANGLER	N	R	F
CHAPOTON & SYKES 1961 [2]	JAW RING, NYLON STREAMER, PETERSEN DISC, SPAGHETTI	18.1	R	F
CLARK, G. 1934	PETERSEN DISC	6S	R&F	F
CLARK, G. 1936	PETERSEN DISC	9.8	R&F	F
CLARK, J. 1968	PETERSEN DISC	7.5	F	F
CLARK, J., & SMITH 1969	PETERSEN DISC	N	F	F
CLARK, J., WESTERFIELD, & AUSTIN 1964	PETERSEN DISC	N	F	F
DAVIS 1959	PETERSEN DISC	63.1	R	F
	SPAGHETTI (HARD)	28.0		
	SPAGHETTI (SOFT)	33.3		
	STREAMER	38.4		
DUDLEY, MULLIS, & TERRELL 1977	DART	1.6	R	F
FREEMAN 1977 [3]	SPAGHETTI	N	F	F
GRANT et al. 1969	DART	7.2 [4]	R	F
	DENNISON	16.7 [5]		
	STREAMER DISC	15.8 [6]		
HAMER 1971	PETERSEN DISC	28.5	R	F
HASSLER 1984	N	15.9	R	F
HASSLER, HILL, & BROWN 1981	DENNISON	25.1	R	F
HASSLER & TAYLOR 1984	N	10.4	R	F
HAWKINS 1980	DENNISON	15.8	R	F
HOLLAND & YELVERTON 1973	DART	11.2	R	F
HOLLIS & DAVIS 1955	PETERSEN DISC	17.1	R	F
JOHNSON, HOLLAND, & KEEFE 1977	DENNISON	20.0	R	F
KRIETE, MERRINER, & AUSTIN 1978	DENNISON, PETERSEN DISC	15.3	R	F

LEWIS 1961 [7]	PETERSEN DISC	50.7	R	R&F
	JAW RING W/PETERSEN DISC	19.9		
	NYLON STREAMER W/PETERSEN DISC	15.9		
MANSUETI 1961 [8]	PETERSEN DISC, JAW RING W/ PETERSEN DISC, NYLON STREAMER W/PETERSEN DISC	37.9	R	R&F
MARSHALL 1976	DENNISON	9.4	R	F
MASSMANN & PACHECO 1961	NYLON STREAMER, PETERSEN DISC	27.8	R	R&F
McLAREN et al. 1981	DENNISON	6.5S[9]	R	F&R
MERRIMAN 1941	INTERNAL BELLY, PETERSEN DISC	21.1	R	F
MERRINER & HOAGMAN 1974	DENNISON	15.9	R	F
MILLER 1974	DISC DANGLER	28.4	R	F
MOORE & BURTON 1975	PETERSEN DISC	41.0	R	F
MORGAN & GERLACH 1950	PETERSEN DISC	13.1S	R	F
MOSS 1985	DENNISON	6.2	R	R
NICHOLS & MILLER 1967	STREAMER	37.3	R	F
ORSI 1971	DISC DANGLER	10	R	F
PEARSON 1938	PETERSEN DISC	29.1	R	F
PLANT 1969	DISC DANGLER	31.4	R	F
RANEY, WOOLCOTT, & MEHRING 1954	PETERSEN DISC	8.5	F	F
RITCHIE & KOO 1973	CARLIN	14.2	R	F&R
SCHAEFER 1968	JAW RING W/PLASTIC DANGLER, PETERSEN DISC	13.8	R	F
SMITH, G. 1978 [10*]	DISC DANGLER	27.8	R	F&R
SMITH, L. 1973	ATKINS STREAMER	21.3	R	F&R
STOLTE 1973	JAW RING	14.3	F	F
STREET et al. 1975	DART	31.6S	R	F
	DENNISON	15.0S		
TEXAS INSTRUMENTS 1979	DENNISON	2.9 [11]	R	F&R
TEXAS INSTRUMENTS 1981	DENNISON	13.2 [12]	R	F&R
VLADYKOV 1957	METAL RING	7.6	R	F
	SPLIT RING W/PLATE	9.4		
VLADYKOV & WALLACE 1952	PETERSEN DISC	31.9	R	F
WHITE 1972 [13*]	DENNISON	4.6	R	F
WHITNEY 1961	JAW, NYLON STREAMER, PETERSEN DISC	3.3	R	F
WINSLOW & JOHNSON 1984	CARLIN	9.2	H	F
WINSLOW et al. 1983	DART, DENNISON	15.6 [14]	R	F
WOOLEY & CRATEAU 1983 [15*]	SPAGHETTI	20.6	R	F&R
YOUNG 1976	CARLIN	2.1	R	F
	DENNISON	10.6		
YOUNG 1980	CARLIN	2.5	R	F
	DENNISON	4.1		
YOUNG 1982	DENNISON	11.6	R	F

TAG RETENTION STUDIES IN AQUARIA OR HOLDING POOLS

REFERENCE	TAG TYPES	COMMENTS
BONNER 1965	ATKINS STREAMER	Some information on short term shedding.
CALHOUN 1953	ATKINS, PETERSEN DISC, STAPLE, STRAP	Information on tag placement, materials, some on shedding.
DUNNING & ROSS 1985*	DART	44.3% shed over 180 days.
	DENNISON	4.3% shed over 180 days.
	INTERNAL ANCHOR	1.9% shed over 180 days.

FOOTNOTES

(1) Based on same tagging program as Freeman (1977).

(2) Analysed returns from large fish only (>6 lbs.).

(3) Based on same tagging program as Austin & Custer (1977).

(4) Winter 1968 tagging only.

(5) Summer-fall 1968 tagging only.

(6) Winter 1968 tagging only.

(7) Based on same tagging program as Mansueti (1961).

(8) Based on same tagging program as Lewis (1961).

(9) Return rate is for 1967 tagging only.

(10) 50% double-tagged with same tag type. Annual shedding rate from placement under posterior dorsal fin (8.4%) was higher than from under anterior dorsal fin (4.9%).

(11) 1973 tagging only.

(12) 1976-1979 tagging only.

(13) Some double-tagging with same tag type indicated six month loss rates for Dennison tags anchored internally (7.1%) were lower than when anchored externally (28.6%).

(14) Adult return rate only, results from tagged hatchery produced juveniles reported in Winslow & Johnson (1984).

(15) Double-tagging indicated a 17.7% yearly shedding rate.

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APPENDIX VI.

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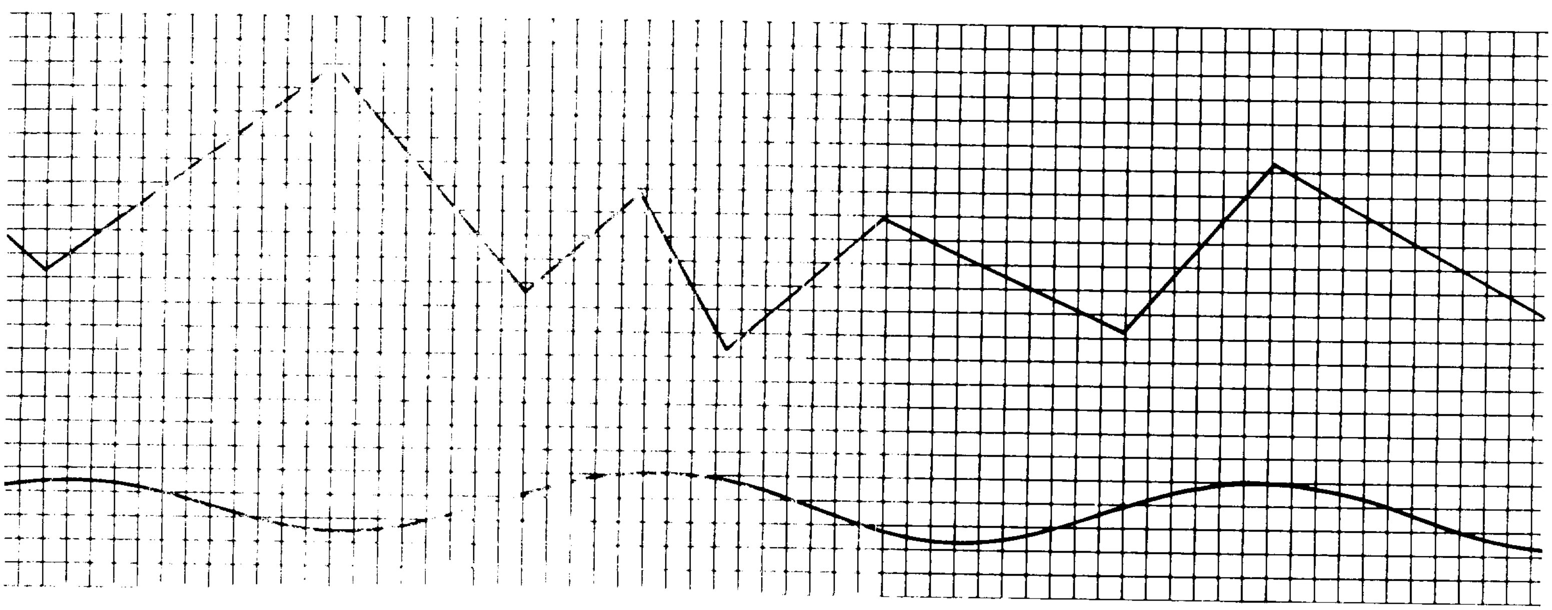
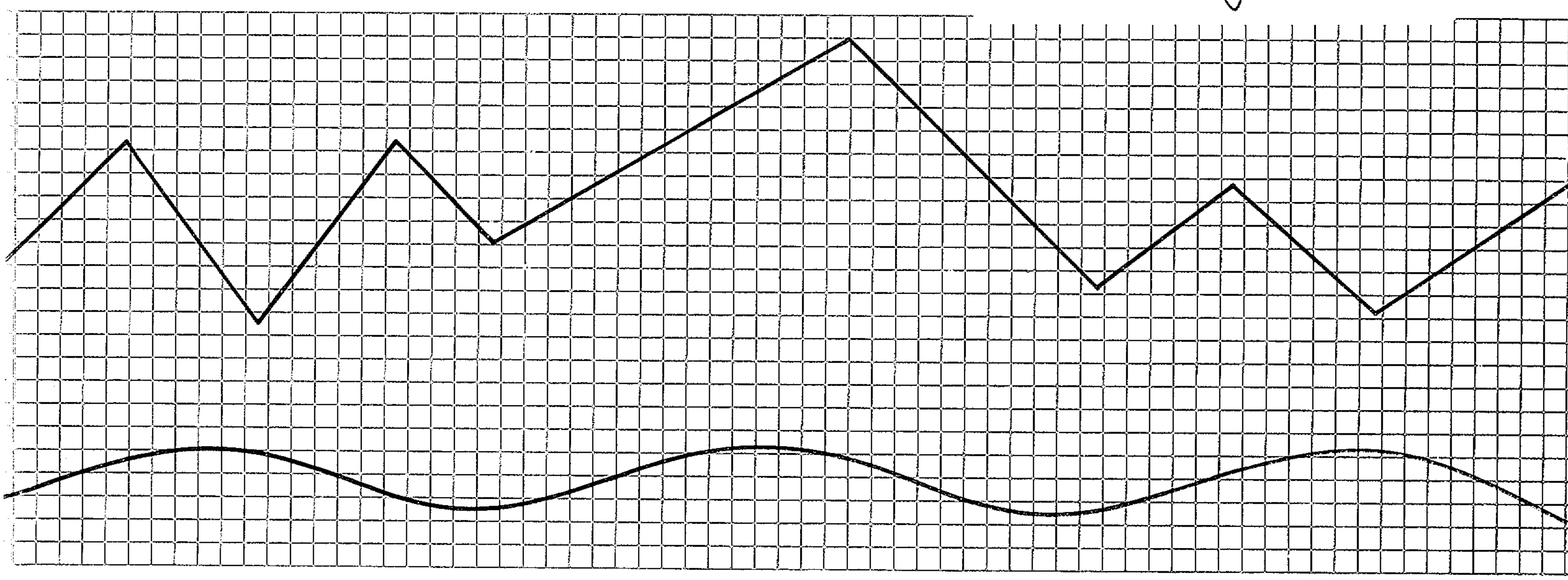


HUDSON RIVER FOUNDATION



1985 Hudson River Striped Bass Tagging Program

HRF Report #1986-1

1985 HUDSON RIVER STRIPED BASS TAG RETURN PROGRAM

Final Report

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Jointly Financed by

Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
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INTRODUCTION

As part of the Hudson River Cooling Tower Settlement Agreement among utilities, government agencies, and environmental protection groups, the utilities agreed to conduct biological monitoring of Hudson River fish stocks, including striped bass (Morone saxatilis). Hudson River striped bass were tagged and released during April-June 1984 and November 1985-May 1986. Recaptures through the first year tag reward drawing (Feb. 1985) were reported by the Hudson River Foundation (HRF) (1985). The current report provides information on tag recaptures received between the first and second year (Feb. 1986) tag reward drawings.

MATERIALS AND METHODS

A detailed description of the materials and methods used in tagging, administration, and analytical processing is provided in HRF (1985). Further information on sampling and tagging procedures appear in Normandeau (1984 and 1985b). Striped bass ≥300 mm TL were double-tagged with Floy FD68-B internal anchor (Dennison-style) and Floy FTF-69 internal anchor-external streamer tags and released during 1984. Striped bass ≥200 mm were internal anchor-tagged in 1985 and 1986. The original number of striped bass tagged in 1984 was 736: 293 and 294 directly from otter trawls and fly seines, respectively; with the remainder released after being held in live cages for 24 hours following capture by the same gear types. Approximately 9000 striped bass were tagged between November 1985 and the second annual tag reward drawing held in late February 1986.

? No report of fish tagged in 1985/1986

SYNOPSIS OF 1984 RECAPTURES

Single or double tags were received from 52 striped bass within the first year following the start of tagging. Fifty recaptures were from originally double-tagged fish. Of these, 20 still possessed two tags, one retained only the Dennison-style tag, and 29 retained the internal anchor-external streamer tag alone, resulting in relative loss rates of 58% and 2%, respectively, for the two tag types.

1985 RESULTS

Tag Retention and Recapture Rate

Thirteen recaptures with analyzable information were reported in 1985 of striped bass tagged in spring 1984. Twelve were of internal anchor-external streamer tags only, and one was of an anchor tag alone. Seven respondents reported no abrasion on the fish from the internal anchor-external streamer tags, two reported some abrasion, and three did not know if abrasion had occurred. Ten of the 13 second year recaptures were originally

DISCUSSION

Relative retention of up to one year of internal anchor-external streamer tags was significantly greater than for internal anchor tags (HRF 1985). Long-term retention (>1 year) of internal anchor-external streamer tags was also shown to be superior to that for internal anchor tags, by the return in 1985 of 12 of the former and only one of the latter tag types from originally double-tagged fish. The longest retention of an internal anchor tag in this study was 590 days. However, the second longest retention of an internal anchor tag was 195 days, a period exceeded by 21 internal anchor-external streamer returns that ranged to 571 days.

The absence of returns of tags marked with $5-1000 or $10-1000 reward values, together comprising approximately 40% of the internal anchor-external streamer tags employed, can probably be explained by water temperature regulated sampling mortality. Tags that stated "REWARD $10" were used primarily in the beginning of the tagging period, a time of lower water temperatures. All of the 1985 recaptures were tagged in April 1984, despite April-tagged fish constituting only 60% of the striped bass released. Normandeau (1985) found a strong correlation between greater handling and 24 hour holding mortalities and higher water temperatures. If a similar relationship existed for water temperature and >24 hour tagging induced mortality, then proportionally fewer recaptures of fish tagged later in the season would occur. Over two years, striped bass tagged in April made up over 77% of all recaptures.

Returns in 1985 were concentrated in two areas - five were made in western Long Island Sound, a region of high recreational fishing effort, and three came from Long Island's south fork, two of which were commercial returns. The scarcity of returns from the harbor region is at least partly due to the closure of the commercial hook and line fishery for striped bass in 1985 because of PCB contamination.

A pattern similar to 1984 of relatively few recaptures from within the Hudson River was observed during the second year. This supports the hypothesis presented in HRF (1985) that fishing pressure on striped bass outside the Hudson River is considerably higher than within it.

The second year results also support an observation made from the first year results - that most Hudson River striped bass are caught by fishermen who devote considerable effort to striped bass fishing, on average over 70 days per year if these data are accurate.

Table 2.--RECAPTURE METHOD AND COMMERCIAL OR NON-COMMERCIAL STATUS.

TAG NO.	RECAPTURE METHOD	COMMERCIAL	APPARENTLY NON-COMMERCIAL
B00325	ANGLING		X
B00316	ANGLING		X
B00338	ANGLING		X
B00156	ANGLING		X
B00361	ANGLING		X
B00375	HAUL SEINE	X	
B00132	ANGLING		X
B00364	ANGLING	X	
B00355	ANGLING		X
B00211	FLOATING FISH TRAP	X	
B00084	ANGLING		X
B00473	ANGLING		X
B00113	ANGLING		X
A00422	GILL NET	X	
A00146 B00437	ANGLING		X

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STRIPED BASS TAG LOSS AND MORTALITY IN HOLDING POOLS

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Abstract

A total of 401 striped bass, 10 to 22 inches in total length, were retained for up to 180 days in order determine tag loss and mortality for internal anchor, Dennison and dart tags. Among tagged and control striped bass there was no significant difference ($P>0.05$) in mortality at 18 days or 180 days after tagging. Almost all tag loss occurred by 18 days after tagging. The loss rates 18 days after tagging for Dennison tags (3.8 percent) and internal anchor tags (2.3 percent) were not significantly different ($P>0.05$). There was a significnt difference ($P<0.005$) between the loss rates for dart tags (50.0 percent) and Dennison and internal anchor tags.

Striped Bass Tag Loss
and Mortality in Holding Pools

Introduction

The Hudson River Settlement Agreement (Sandler and Schoenhard 1981) suggests that an adult fish stock assessment program be considered as a major component of the utilities' biological monitoring. The utilities and the New York State Department of Environmental Conservation (NYSDEC) agree that part of this program should consist of tagging and recapturing striped bass. Recaptures of tagged striped bass can provide information to be used in estimating age specific annual total mortality and fishing exploitation rates.

Based on mark and recapture studies, Floy anchor (FD-68-B) tag loss from Hudson River striped bass was assumed to be negligible by McFadden et al. (1978), 10 percent by Texas Instruments Incorporated (1981) and 82 percent by Ricker (1979). Although quantitative estimates of mortality associated with tagging are not available, the range of suspected mortality values may be equally as large as the tag loss estimates. As a result, annual mortality and exploitation rates based on these estimates vary accordingly.

The NYSDEC and the Emergency Striped Bass Study Planning and Coordinating Committee have recommended a Floy FTF-69 internal anchor-external streamer tag as an alternative to the FD-68-B anchor (Dennison type) tag because it seems to be easier to attach, should result in less erosion and corrosion, and should last more years than the tag currently used on striped bass. However, estimates of FTF-69 internal anchor tag retention in striped bass are not available.

Dadswell (personal communication 1984) suggested from his experience that Floy FT-1 dart tags might also be a good alternative to the Dennison tag.

In order to help select a type of tag or tags for future striped bass stock assessments, 401 striped bass 10 to 22 inches in total length were retained for up to 180 days at Multi Aquaculture Systems, Inc. (MAS), Amagansett, New York, in order to determine internal anchor tag, Dennison tag and dart tag loss and mortality of tagged fish.

Methods and Materials

Study Design

Beginning on April 24, 1984, striped bass were purchased from seven pound net fishermen who had gear set in Napeague Bay between Amagansett and Montauk, New York. Each of the seven fishermen tended two to five nets daily, weather permitting. Striped bass, in quantities of 20 or fewer, were transported directly from the traps to MAS's facility by the fishermen in 30 gallon transport containers. Larger numbers of fish were transported by MAS personel using a 90 gallon box supplied with oxygen. At MAS, striped bass were were placed into saltwater tanks. Loss of scales and abrasions from the pound nets resulted in bacterial infections and death in substantial numbers of fish. As a result, fish were initially treated with 1 ppm copper sulphate solution. This treatment was not effective and was replaced with a 3 ppm solution of potassium permanganate which relieved the bacterial infection but clogged the gill filaments of treated fish. Starting on May 27, 1984 all newly arrived striped bass were dipped in a 1:2000 copper sulphate solution for one minute before being placed into the saltwater pools. This treatment did lower the incidence of bacterial infections without causing mortality.

Striped bass were randomly assigned to one of four treatment groups or a control group. A total of 82 fish were tagged with an internal anchor tag, 81 fish were administered a Dennison type tag, 80 fish were administered both an internal anchor and a Dennison type tag, 79 fish were administered a dart tag and 79 fish were held without being tagged. Approximately 20 fish from each of the four treatment groups and from the control group were assigned to one of four, 14,000 gallon, 26 foot diameter pools. Freshwater was circulated through two of the four pools while sea water was circulated through the other two pools in order to examine the effect of salinity on tag loss and mortality.

Tagging and Handling

The dimensions of the three tag types used in this study are presented in Figure 1.

Dennison tags were placed in the left side of the fish 3 scale rows below the fourth ray of the second dorsal fin using a tagging gun. The tag gun needle was inserted through the dorsal rays toward the anterior of the fin and the tag inserted. The needle was then removed with a slight twist of the tag gun.

Internal anchor tags were inserted midway between the vent and the posterior tip of the pelvic fins along the ventral mid line. A horizontal incision about 5 mm long was made just through the peritonium but not deep enough to damage intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the vinyl tube streamer.

Dart tags were placed in the left side of the fish 3 scale rows below the fourth ray of the second dorsal fin. Tags were placed in the pointed end of a canula, dart showing. The canula was inserted through the dorsal rays toward the anterior of the fin and removed with a slight twist, leaving the dart tag in the fish.

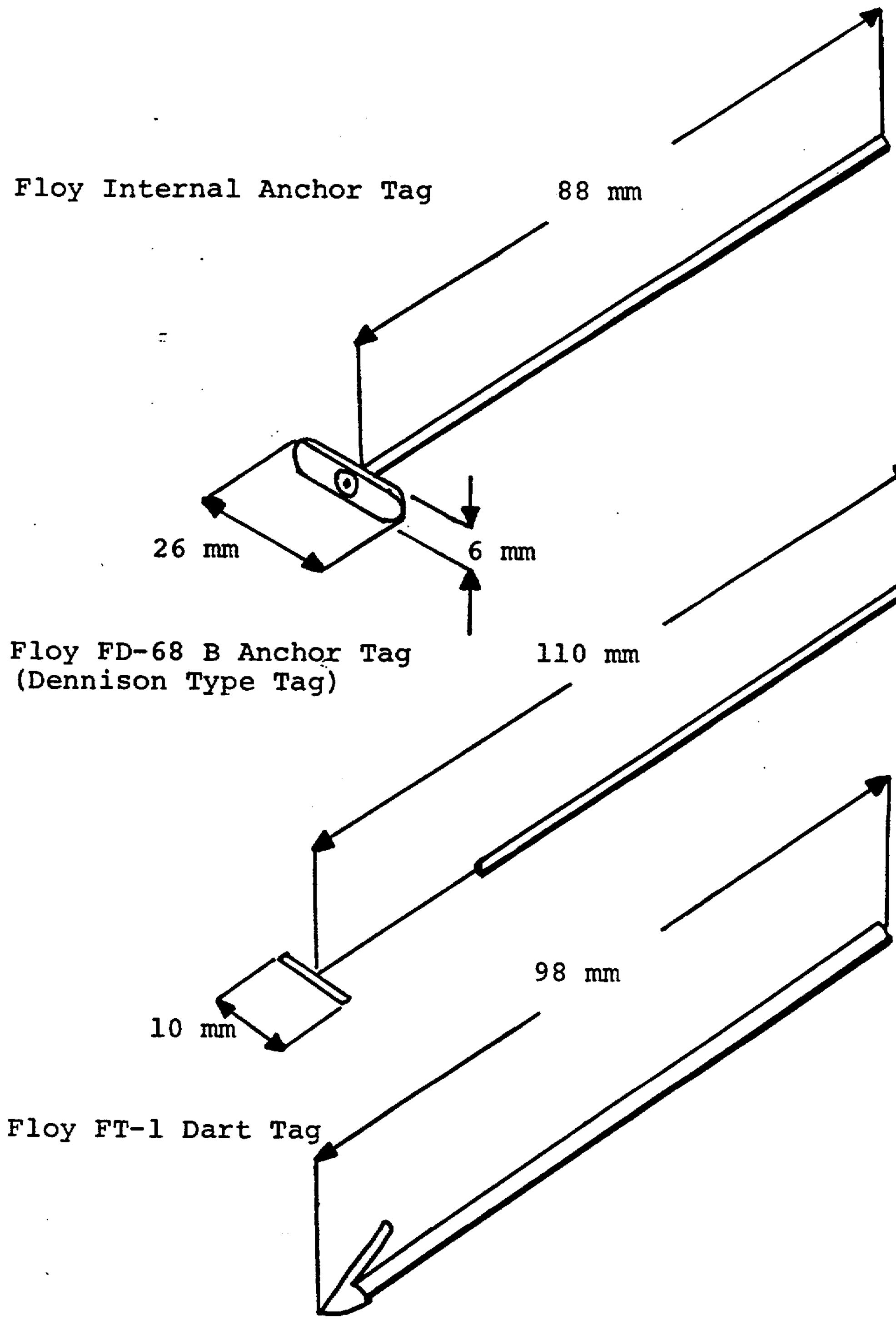

Figure 1. Dimensions of the Floy internal anchor, Dennison type and dart tags.

Fish tagging was conducted on June 4, 11 and 13, 1984. Fish were seined into a small quadrant of a 26 foot diameter holding pool and individually captured using a hand net. Only those fish without abrasions or wounds were kept for the study. Each fish was lifted from the net using the aid of a wet cloth, placed on a measuring board to obtain its total length, and tagged if it was assigned to a treatment group. After tagging or measuring, fish were placed into a concentrated copper sulfate solution (1:2000) for approximately 1 minute as a preventative measure against infection and then released into one of the four experimental 26' diameter pools. No additional prophylaxis was used during the experiment.

The two freshwater pools were maintained with 18°C wellwater. The two saltwater tanks were maintained with 9-25°C and 28-30‰ saltwater from Napeaque Bay (Appendix Table 1). Owing to the large static capacity of the pools and low stocking densities (14,000 gallons to maintain approximately 200 pounds of fish) a single pass (once-through) system was used which provided a maximum of five complete turnovers per pool per day.

All fish were fed twice per day ad libitum, approximately 3 percent of bodyweight daily. A diet of frozen, defrosted, sand lance (Ammodytes americanus) was used exclusively.

Each of the four holding pools was brushed weekly to remove algal material and fecal matter which had not been removed via a central, screened, three-inch standpipe.

Pools were checked daily to retrieve lost tags which either floated to the surface or fell to the pool bottom. Salinity and temperature were recorded daily at 1400 hours in each pool.

Analytical Procedures

Mortality rates were calculated by dividing the number of striped bass which died by the number of striped bass in each experimental group.

Tag loss rates were calculated by dividing the number of tags lost through a specified date by the number of striped bass which survived through that date.

Tests for goodness of fit were computed in accordance with Sokal and Rohlf (1969) and Snedecor and Cochran (1967).

Results

Mortality

Striped bass mortality 18 days after tagging was 16.5 percent in the freshwater pools (Table 1). All of the 200 striped bass held in freshwater died within 28 days after tagging. The significant die off from 19 through 28 days after tagging was attributable to a protozoan infection of the gills (Trichodina).

Striped bass mortality 18 days after tagging was 16.4 percent in the saltwater pools (Table 2). After 28 days, only 21.9 percent of the 201 striped bass held in saltwater died. Between 31-90 days after tagging, mortality increased to 23.9 percent (Table 3). As a result of a dinoflagellate infection of the gills (Oodinium), mortality further increased to 49.3 percent between 91-120 days after tagging. No mortality occurred during the last 60 day period that the fish were held.

Among the treatment and control groups there was no significant difference ($P>0.05$, $X^2=3.03$, 4 df) in mortality at 18 days after tagging (Table 4) or 180 days after tagging ($P>0.05$, $X^2=8.62$, 4 df) (Table 3).

Striped bass tagging mortality over 180 days in the saltwater pools (Table 5) was not a function of total length (in one inch increments) of the fish ($X^2=5.47$, 12 df). No obvious difference in tagging mortality by length was observed for striped bass over 18 days in the freshwater pools (Appendix Table 4).

Tag Loss

A total of 7 out of 161 Dennison tags (4.3 percent), 3 out of 162 internal anchor tags (1.9 percent), and 35 out of 79 dart tags (44.3 percent) were lost over the 180 days during which the striped bass were held. No internal anchor tags and only 2 Dennison tags and 3 dart tags were lost between 19 and 180 days after tagging (Table 6). The following analysis only examines tag loss after 18 days because most of the tag loss occurred during this period and the mortality rates for freshwater and saltwater pools was relatively low and virtually identical through this period.

The loss rates 18 days after tagging for Dennison tags (3.8 percent) and internal anchor tags (2.3 percent) were not significantly different ($P>0.05$, $G=0.534$, 2 df). There was a significant difference ($P<0.005$, $G=83.6$, 2 df) between the loss rates for the dart tags (50.0 percent) and Dennison and internal anchor tags (Table 7).

Table 1. Striped bass mortality 28 days after tagging in freshwater pools by tag type.

Days after Tagging	Number Dead				
	Dennison (N=41)[a]	Internal Anchor (N=41)	Dennison & Internal Anchor (N=40)	Dart (N=39)	Control (N=39)
1	-[b]	-	1	-	-
2	-	1	3	1	-
3	-	-	1	-	-
4	1	-	1	-	-
5	3	-	1	2	-
6	2	1	1	1	-
7	-	1	-	-	1
8	1	-	1	-	1
9	-	1	-	1	-
10	-	-	-	-	-
11	1	-	-	-	1
12	1	1	1	1	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	4	4	9	7	5
20	3	7	6	5	7
21	4	3	-	1	2
22	5	4	4	8	4
23	1	-	-	-	2
24	5	8	2	1	4
25	5	4	3	1	10
26	2	3	3	1	1
27	2	3	3	9	1
28	1	-	-	-	-
Total	41	41	40	39	39

a. Sample size.

b. No fish died.

Table 2. Striped bass mortality 28 days after tagging in saltwater pools by tag type.

Days after Tagging	Number Dead				
	Dennison (N=40)[a]	Internal Anchor (N=41)	Dennison & Internal Anchor (N=40)	Dart (N-40)	Control (N=40)
1	-[b]	1	-	1	-
2	-	2	1	-	-
3	1	2	-	3	-
4	-	1	-	1	2
5	-	-	2	1	-
6	1	-	-	1	-
7	1	-	1	-	-
8	-	1	-	-	-
9	-	1	-	-	-
10	-	1	-	-	1
11	-	-	-	1	-
12	1	-	-	-	-
13	1	-	-	-	-
14	-	-	-	-	1
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	1	-	1
18	-	-	-	1	-
19	-	1	-	-	-
20	-	-	1	-	-
21	-	-	1	1	-
22	-	-	-	-	1
23	-	-	-	1	-
24	-	-	-	-	-
25	1	-	2	-	-
26	-	-	-	-	-
27	-	1	-	-	-
28	-	-	-	-	1
Total	6	11	9	11	7

a. Sample size.

b. No fish died.

Table 3. Striped bass mortality 180 days after tagging in freshwater and saltwater pools by tag type.

Days after Tagging	Number Dead				
	Dennison (N=81)[a]	Internal Anchor (N=82)	Dennison & Internal Anchor (N=80)	Dart (N=79)	Control (N=79)
1-30	47	52	49	50	46
31-60	0	1	2	0	1
61-90	0	0	0	0	0
91-120	12	13	13	3	10
121-150	0	0	0	0	0
151-180	0	0	0	0	0
Total	59	66	64	53	57

a. Sample size.

Table 4. Striped bass mortality 28 days after tagging in freshwater and saltwater pools by tag type.

Days after Tagging	Number Dead				
	Dennison (N=81)[a]	Internal Anchor (N=82)	Dennison & Internal Anchor (N=80)	Dart (N=79)	Control (N=79)
1	-[b]	1	1	1	-
2	-	3	4	1	-
3	1	2	1	3	-
4	1	1	1	1	2
5	3	-	3	3	-
6	3	1	1	2	-
7	1	1	1	-	1
8	1	1	1	-	1
9	-	2	-	1	-
10	-	1	-	-	1
11	1	-	-	1	1
12	2	1	1	1	-
13	1	-	-	-	-
14	-	-	-	-	1
15	-	-	-	-	-
16	-	-	-	-	-
17	-	-	1	-	1
18	-	-	-	1	-
19	4	5	9	7	5
20	3	7	7	5	7
21	4	3	1	2	2
22	5	4	4	8	5
23	1	-	-	1	2
24	5	8	2	1	4
25	6	4	5	1	10
26	2	3	3	1	1
27	2	4	3	9	1
28	1	-	-	-	1
Total	47	52	49	50	46

a. Sample size

b. No fish died.

Table 5. Number and percent of striped bass which were tagged and which died in the saltwater pools by one inch increments of total length.

Length (inches)	Tagged		Died	
	Number	Percent of total	Number	Percent of total
10	4	2.0	1	2.0
11	11	5.5	1	2.0
12	33	16.4	9	17.6
13	35	17.4	12	23.5
14	21	10.4	7	13.7
15	32	15.9	10	19.6
16	25	12.4	4	7.8
17	15	7.5	4	7.8
18	12	6.0	1	2.0
19	10	5.0	2	4.0
20	1	0.5	0	0
21	1	0.5	0	0
22	1	0.5	0	0
Total	201	100	51	100

Table 6. Tag loss after 180 days for striped bass held in freshwater and saltwater pools combined.

Days after Tagging	Tags Lost		
	Dennison (N=161)[a]	Internal Anchor (N=162)	Dart (N=79)
1-18	5	3	32
19-30	1	0	3
31-60	1	0	0
61-180	0	0	0
Total	7	3	35

a. Sample size.

Table 7. Tag loss after 18 days for striped bass held in freshwater and saltwater pools combined.

Days after Tagging	Tags Lost		
	Dennison (N=132)[a]	Internal Anchor (N=133)	Dart (N=64)
1	-[b]	-	-
2	-	-	-
3	-	-	-
4	1	1	2
5	1	-	5
6	-	1	6
7	1	-	3
8	-	-	3
9	-	-	5
10	1	-	1
11	-	-	-
12	-	-	4
13	-	-	-
14	1	1	3
15	-	-	-
16	-	-	-
17	-	-	-
18	-	-	-
Total	5	3	32

a. N = The number of striped bass which were still alive after 18 days.

b. No tags lost.

Discussion

Two characteristics of a good tag are that it should have high retention and cause little mortality. The results of this study suggest that both Dennison tags and internal anchor tags have equally high retention and result in equally low fish mortality. However, preliminary data from fish which were double tagged during the 1984 Hudson River adult striped bass program (Hudson River Foundation, personal communication) indicate that Dennison tag loss from the 1984 Spring through February 1985 was substantially higher (58.0 percent, N=50) than that in the holding pools (4.3 percent).

There are two possible explanations for the difference in Dennison tag loss rates between striped bass in the holding pools and the Hudson River: 1) environmental rigor or 2) skeletal structure at the tag insertion site. It may be that the natural environment is more rigorous and subjects tags to more stress than that experienced in the holding pools. However, this explanation is not supported by the internal anchor tag loss data. The internal anchor tag loss rate for fish tagged in the 1984 adult striped bass program (2.0 percent) and for fish tagged in the holding pools (1.9 percent) were virtually identical.

During the 1984 adult striped bass program Dennison tags were inserted on the left side of the fish 3 scale rows below the origin of the second dorsal fin as was done in previous adult striped bass programs. For holding pool striped bass, Dennison type tags were inserted on the left side of the fish 3 scale rows below the fourth ray of the second dorsal fin. The fact that the pterygiophores in the latter location are closer together in comparison with the former may result in better anchoring of the tags and the lower tag loss observed in the holding pool study. Double tagging of Hudson River striped bass with internal anchor tags and Dennison tags, placed 3 scale rows below the fourth ray of the second dorsal fin, would enable one of the two explanations (skeletal structure or environmental rigor) to be rejected and the other to be identified as the cause of the observed tag loss differences.

The results of this study, which indicate that there was not a significant difference in mortality between tagged striped bass and control fish, are consistent with those reported by NAI (1985), which showed no difference in the mortality among tagged and control striped bass held in the Hudson River for 24 hours. Both the present study and that reported by NAI (1985) indicated that the handling of striped bass, exclusive of actual tagging, is sufficient to result in mortality. In the present study control fish experienced a 10.1 percent mortality rate. NAI (1985) reported a control mortality rate of 57.4 percent, but this included the effect of fish capture. The effects of fish capture were eliminated the present study because fish were not tagged until after the initial capture mortality had occurred.

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Appendix Table 1. June 1984 daily temperature and salinity by holding pool.

June	Temperature and Salinity			
	Pools 13 & 14		Pools 14 & 15	
	°C	‰	°C	‰
4[a]	-[b]	-	24	30
5	-	-	25	28
6	-	-	22	28
7	-	-	24	29
8	-	-	22	30
9	-	-	22	26
10	-	-	24	30
11	-	-	21	30
12[c]	24	30	22	28
13	24	30	22	28
14	22	15	24	28
15	20	5	25	28
16	20	5	23	28
17	18	0	23	28
18	18	0	24	30
19	18	0	24	29
20	18	0	24	29
21	18	0	25	29
22	18	0	25	30
23	18	0	22	30
24	18	0	23	28
25	18	0	24	28
26	18	0	24	28
27	18	0	24	28
28	18	0	24	28
29	18	0	24	28
30	18	0	24	28

a. First day of tagging for saltwater pools.

b. No data collected.

c. First day fish were placed in pools 13 and 14.

Appendix Table 2. July 1984 daily temperature and salinity by holding pool.

July	Pool 13 °C	Pool 13 ‰	Pool 14 °C	Pool 14 ‰	Pool 15 °C	Pool 15 ‰	Pool 16 °C	Pool 16 ‰
	Temperature and Salinity							
1	18	0	18	0	24	28	24	28
2	18	0	18	0	22	28	22	28
3	18	0	18	0	23	28	23	28
4	18	0	18	0	22	29	22	29
5	18	0	18	0	21	29	21	29
6	18	0	--	--[a]	20	29	20	29
7	18	0	--	--	20	29	20	29
8	18	0	--	--	19	28	19	28
9	18	0	--	--	22	30	22	30
10	18	0	--	--	22	30	22	30
11	--	--[a]	--	--	22	29	22	29
12	--	--	--	--	19	29	19	29
13	--	--	--	--	22	28	22	28
14	--	--	--	--	22	28	22	28
15	--	--	--	--	23	28	23	28
16	--	--	--	--	22	28	22	28
17	--	--	--	--	21	28	21	28
18	--	--	--	--	21	30	21	30
19	--	--	--	--	21	30	21	30
20	--	--	--	--	22	30	22	30
21	--	--	--	--	22	28	22	28
22	--	--	--	--	22	28	22	28
23	--	--	--	--	22	28	22	28
24	--	--	--	--	22	28	22	28
25	--	--	--	--	22	28	22	28
26	--	--	--	--	21	28	21	28
27	--	--	--	--	21	28	21	28
28	--	--	--	--	21	28	21	28
29	--	--	--	--	20	29	20	29
30	--	--	--	--	20	28	20	28
31	--	--	--	--	20	28	20	28

a. No data were taken because all fish in pools 13 and 14 had died by this date.

Appendix Table 3 August through December daily temperature and salinity by holding pool.

Date	Aug. Pools 15 & 16 °C	Aug. ‰	Sept. Pools 15 & 16 °C	Sept. ‰	Oct. Pools 15 & 16 °C	Oct. ‰	Nov. Pools 15 & 16 °C	Nov. ‰	Dec. Pools 15 & 16 °C	Dec. ‰
1	20	30	21	28	16	28	14	28	11	29
2	22	28	20	29	16	29	13	29	11	30
3	22	28	21	29	15	29	12	29	11	30
4	22	28	21	29	15	29	12	29	10	29
5	23	29	21	29	15	29	12	29	11	29
6	23	29	20	30	15	30	10	29	8	30
7	24	30	20	30	14	30	10	20	9	30
8	24	30	19	29	14	30	10	29	9	30
9	22	28	20	32	14	30	10	28	10	29
10	23	28	20	32	14	29	9	30	--	--
11	24	29	20	30	12	29	9	30	--	--
12	24	29	20	30	12	29	10	30	--	--
13	24	29	18	29	12	29	10	30	--	--
14	22	29	18	30	12	29	10	30	--	--
15	24	29	17	30	12	29	9	29	--	--
16	21	30	17	29	15	29	9	29	--	--
17	20	30	16	28	15	30	10	30	--	--
18	21	30	17	28	15	30	11	30	--	--
19	22	30	18	28	15	30	12	28	--	--
20	24	30	18	28	15	29	12	28	--	--
21	23	30	18	28	15	29	10	29	--	--
22	23	29	17	30	14	28	11	29	--	--
23	23	29	16	30	12	29	10	29	--	--
24	23	29	16	29	10	29	10	30	--	--
25	24	29	16	29	12	29	9	29	--	--
26	23	28	17	29	12	29	9	29	--	--
27	23	28	17	29	11	29	10	29	--	--
28	23	28	17	29	11	30	9	29	--	--
29	22	29	16	28	10	30	9	30	--	--
30	22	29	17	28	12	29	10	30	--	--
31	22	29			14	29				

NORMANDEAU ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS,
ENGINEERS & PLANNERS

1985-86 HUDSON RIVER

STRIPED BASS PROGRAM

1554

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Jointly Financed by
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Submitted by

NORMANDEAU ASSOCIATES, INC.
25 Nashua Road
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1554

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EXECUTIVE SUMMARY

- Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced the highest catch of striped bass per tow.

- When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit effort for the striped bass trawl was greater than for the tomcod trawl, but mean catch per day was almost identical for the two trawls because more tows could be taken by the tomcod trawl in a day.

- The striped bass trawl captured a significantly lower than expected number of striped bass $\leq$ 250 mm TL and a significantly greater than expected number of striped bass between 251 and 450 mm TL compared to the tomcod trawl.

- The striped bass trawl was more efficient for capturing striped bass of Age 1+ through Age 3+, while the tomcod trawl was more efficient for capturing striped bass of Age 0+ and 1+. over lap at Age 1+ (?)

- Scottish seine catch per unit effort was greater in 1986 than 1984 because most of the fishing effort in 1986 occurred in the weeks and regions of greatest striped bass abundance, based on results from the 1984 program.

- The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May, was efficient for capturing striped bass older than Age 3+.

- Handling mortality was approximately ten to fourteen times lower in 1985-86 compared to 1984, due primarily to use of a holding facility for striped bass that was secured in the water alongside the tagging boat and secondarily to increased speed of tagging.

- The 18,487 fish tagged and released in this study represent the largest one-year striped bass tagging program on the east coast to date.

- Trawl and seine efforts recaptured 250 striped bass released in this program and two fish from the 1984 program.

- No striped bass containing hatchery-administered, magnetic wire tags were detected although all fish were checked for these tags.

- The striped bass population in Upper New York Harbor and the Battery region appeared relatively closed to emigration and immigration during late-December 1985 through February 1986.

- Significant upriver movement was observed in April as some immature striped bass from the winter population in the Battery migrated with the spawning stock through the Tappan Zee and Croton-Haverstraw regions.

- The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery region was 540,000 fish.

1.0 INTRODUCTION

The 1980 Hudson River Cooling Tower Settlement Agreement stipulates that 600,000 striped bass fingerlings should be stocked annually from 1983 through 1990 and that this stocking should be evaluated. To accomplish this, the Hudson River Utilities have operated a striped bass hatchery at Verplanck, New York since 1983. Each striped bass released from the hatchery is tagged with an internal, coded, magnetic, wire tag. These tags can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally spawned striped bass. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desireable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered tags. If these striped bass are tagged with external tags before release, then recapture may provide valuable information for a stock assessment program.

The 1984 adult striped bass program (NAI 1985) demonstrated it was feasible to use a striped bass trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. It was also demonstrated in 1984 that striped bass could be externally tagged and released without significantly increasing the 24-hour mortality. Finally, the 1984 program suggested those river regions in the lower Hudson River estuary that could be most efficiently fished for striped bass with each gear.

The 1985-86 Hudson River Striped Bass Program was conducted in the lower Hudson, Harlem, and East Rivers during the winter and spring of 1985-86. Areas of Raritan Bay, Rockaway Inlet, Upper and Lower New York Harbor were also sampled. The goals of the 1985-86 program were to: 1) determine the best locations, times and fishing gear to capture striped bass for a mark-recapture program, 2) evaluate the catch characteristics and handling mortality of two high-rise otter trawls designed to capture striped bass (striped bass trawl) and Atlantic tomcod (tomcod trawl) and two seines used in Scottish seining (a Jackson 280 seine and a Kosalt plaice net), 3) determine the winter and spring movements of striped bass, 4) determine the feasibility of a downriver marking effort and an upriver recapture effort for estimating population size of Hudson River striped bass, and 5) estimate the striped bass population size in the lower Hudson River through a mark-recapture program.

Data collected in this program were used to determine: 1) the length, weight, sex, and sexual condition of striped bass, 2) differences in size (age) selectivity among gear, 3) the overall handling mortality and feasibility of reducing striped bass handling mortality through the use of a holding facility submerged in the water alongside the tagging boat, 4) differences in space and time in catch per unit effort among fishing gear and techniques, 5) the movements of tagged striped bass in the Hudson River estuary during the winter and spring, and 6) the estimated size of the winter and spring striped bass population in the lower Hudson River. In addition, incidental data collected in the program were also used to determine the predominance of Atlantic tomcod as food item in the stomachs of striped bass during the winter, (per request from New York Department of Environmental Conservation, letter from Horn to Dunning dated 7 November 1985).

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1985-86 Striped Bass Gear Evaluation/Atlantic Tomcod Program Standard Operating Procedures (NAI 1986a). The 1985-86 Striped Bass Gear Evaluation consisted of two phases: winter and spring (Figure 2-1). The winter phase consisted of sampling in the lower Hudson River with a high-rise striped bass trawl and a high-rise Atlantic tomcod trawl (Appendix Table A). The spring phase consisted of trawling with the striped bass trawl in the lower Hudson River and Scottish seining (Appendix Table A) upriver in the Tappan Zee and Croton-Haverstraw regions (Figures 2-1, 2-2). The striped bass trawl and the Atlantic tomcod trawl are high-rise nets of basically the same design. The striped bass trawl, which was fished exclusively to catch striped bass, has a foot rope length of 12.2 m with a 7.5 cm (stretch) mesh cod end. The striped bass trawl is 35% larger than the tomcod trawl, which has a foot rope 9.0 m long and a cod end with 3.8 cm (stretch) mesh. The bycatch of Atlantic tomcod in the striped bass trawl was enumerated, finclipped, and released as part of a concurrent Atlantic tomcod mark-recapture program (NAI 1986b). The tomcod trawl was used to sample Atlantic tomcod in a mark-recapture program for that species (NAI 1986b). Striped bass caught in the tomcod trawl were enumerated, tagged with internal anchor tags, and released. During the spring phase of the program, the tomcod trawl was not deployed and only the striped bass catch was processed in the striped bass trawl.

Two Scottish seines were used to catch striped bass in the spring phase of sampling: a Jackson 280 seine and a Kosalt plaice seine. The Jackson 280 seine was used as the primary seine while the Kosalt plaice seine was the back-up gear if the Jackson 280 seine was

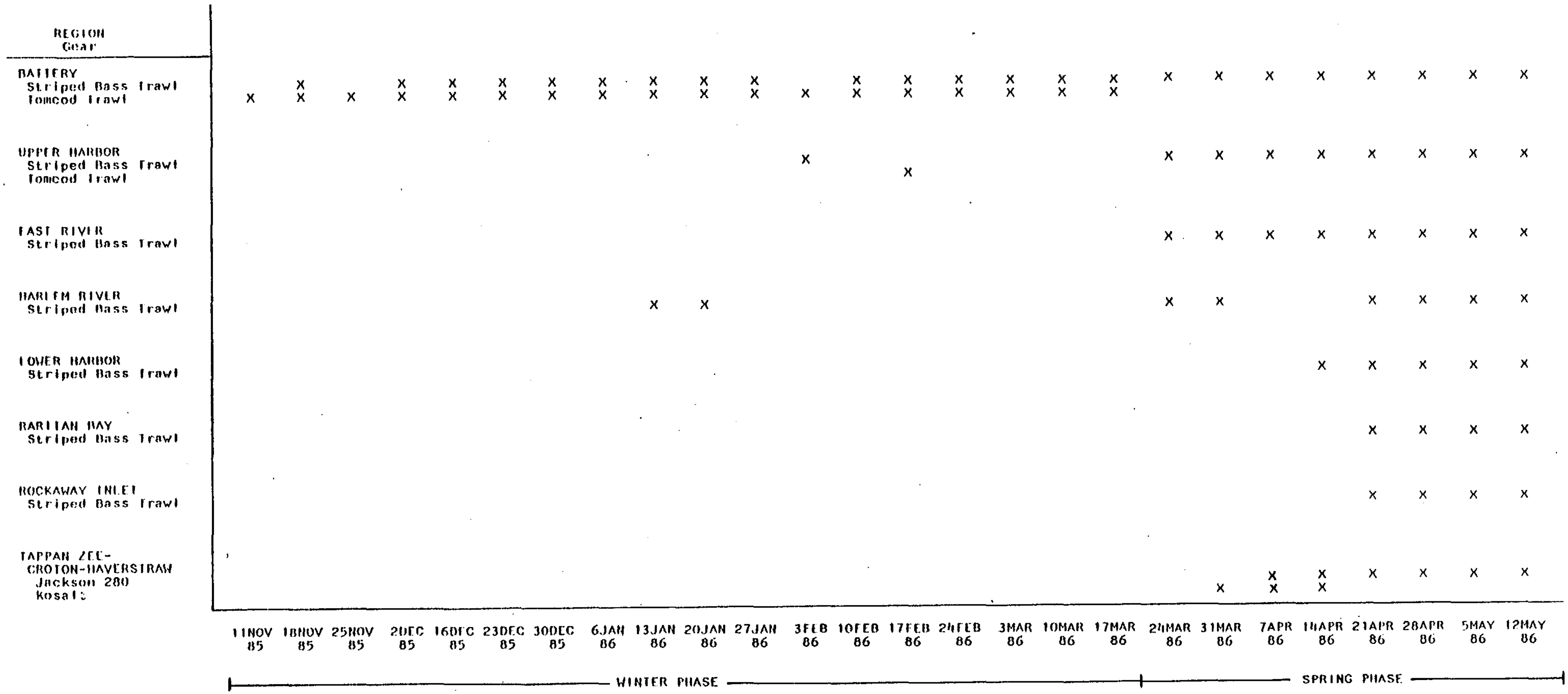

Figure 2-1. Weekly sampling schedule for the winter and spring phases of the 1985-86 Hudson River Striped Bass Program.

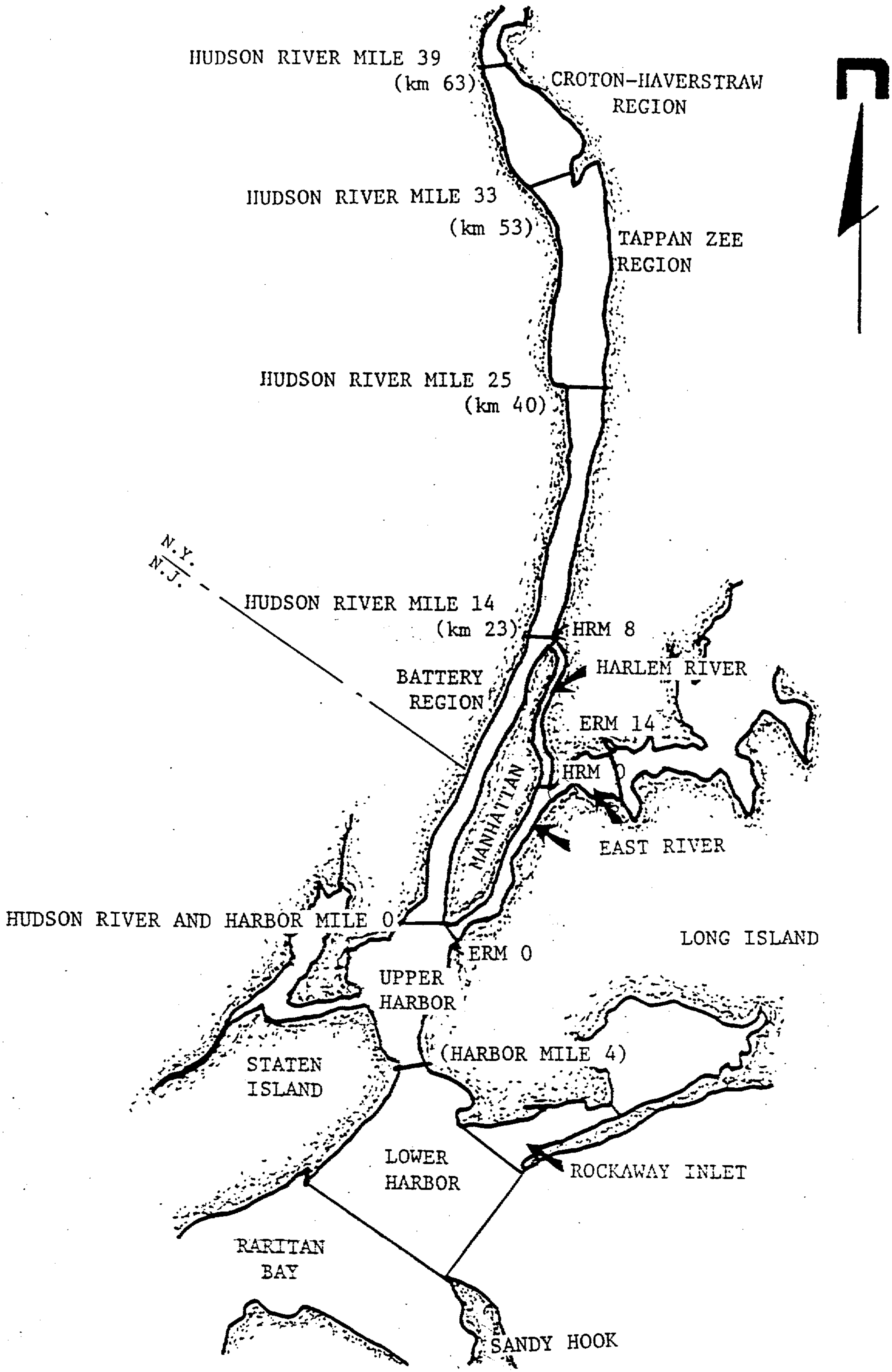

Figure 2-2. Areas sampled during the 1985-86 striped bass gear evaluation program.

damaged and being repaired. The Kosalt plaice seine was approximately 33% larger in head rope and foot rope dimensions than the Jackson 280 seine (Appendix Table A), and had approximately 33% smaller mesh in the wings and body that the Jackson 280 seine. Both Scottish seines and the striped bass trawl had the same cod ends (7.5 cm stretch mesh).

Sampling with the striped bass trawl during the winter phase occurred two days per week from the week of 11 November 1985 through the week of 17 March 1986. On one day per week during this period, the striped bass trawl was fished in the Hudson River in the Battery between river miles 1 and 14 (km 2 and 23), hereafter referred to as river miles. Three days per week during the same time period, the tomcod trawl was deployed in the Battery region to permit comparison of the catch characteristics with the concurrent striped bass trawl sampling. The striped bass trawl was also fished on one day per week during the winter phase in an exploratory effort to identify stations in regions adjacent to the Battery that may have a high abundance of striped bass. Exploratory sampling was conducted in the East River between East River miles 2 and 14 (km 3 and 23) proceeding east from the Battery, and the Harlem River at Harlem River miles 1 and 5 (km 2 and 8) proceeding north from the junction of the Harlem and East Rivers (Figure 2-2). Exploratory sampling with the striped bass trawl also occurred in the upper New York Harbor area near Governors Island between Harbor miles 0 and 4 (km 0 and 6; Appendix Figure A).

The spring phase consisted of fishing with the Scottish seines and the striped bass trawl between the weeks of 31 March 1986 and 12 May 1986. Scottish seining took place in the Tappan Zee and Croton-Haverstraw regions of the Hudson River between river miles 25 and 39 (km 40 and 63). Trawling with the striped bass trawl took place in the Hudson River between river miles 1 and 14 (km 2 and 23); in the East River at river miles 2, 3, and 11 through 14 (km 3, 5, and 18 through 23); and in the Harlem River at river mile 1 (km 2; Figure 2-2). Upper New York

Harbor between the Battery and the Verrazano-Narrows Bridge was sampled with the striped bass trawl as well as the Lower Harbor from the Verrazano-Narrows Bridge to Sandy Hook, New Jersey. Finally, the striped bass trawl was used to sample parts of Raritan Bay (near Sandy Hook) and Rockaway Inlet. The Scottish seining effort was terminated when bottom water temperature in the Croton-Haverstraw area of the Hudson River reached 14.5°C (13 May 1986) in accordance with directions provided by the New York State Department of Environmental Conservation (NYSDEC). Striped bass trawling ended on 16 May 1986 in accordance with the scope of work, at bottom water temperatures less than 14.5°C.

Striped bass captured by the striped bass trawl, the Atlantic tomcod trawl, and the Scottish seine received identical handling to minimize fish stress before tagging. In general, each sampling effort required two boats. One boat conducted the actual sampling (capture boat) while the second boat (tagging boat) tended the capture boat with a holding facility for striped bass that was secured in the water alongside the tagging boat (Figure 2-3). The cod end of the net was transferred through the water from the capture boat to the holding facility alongside the tagging boat. Striped bass were then transferred from the live car to the tagging boat one at a time using the following procedures:

1) fish were removed from the live car using a dip net,

2) all surfaces that came in contact with the live fish were wet,

3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and

4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

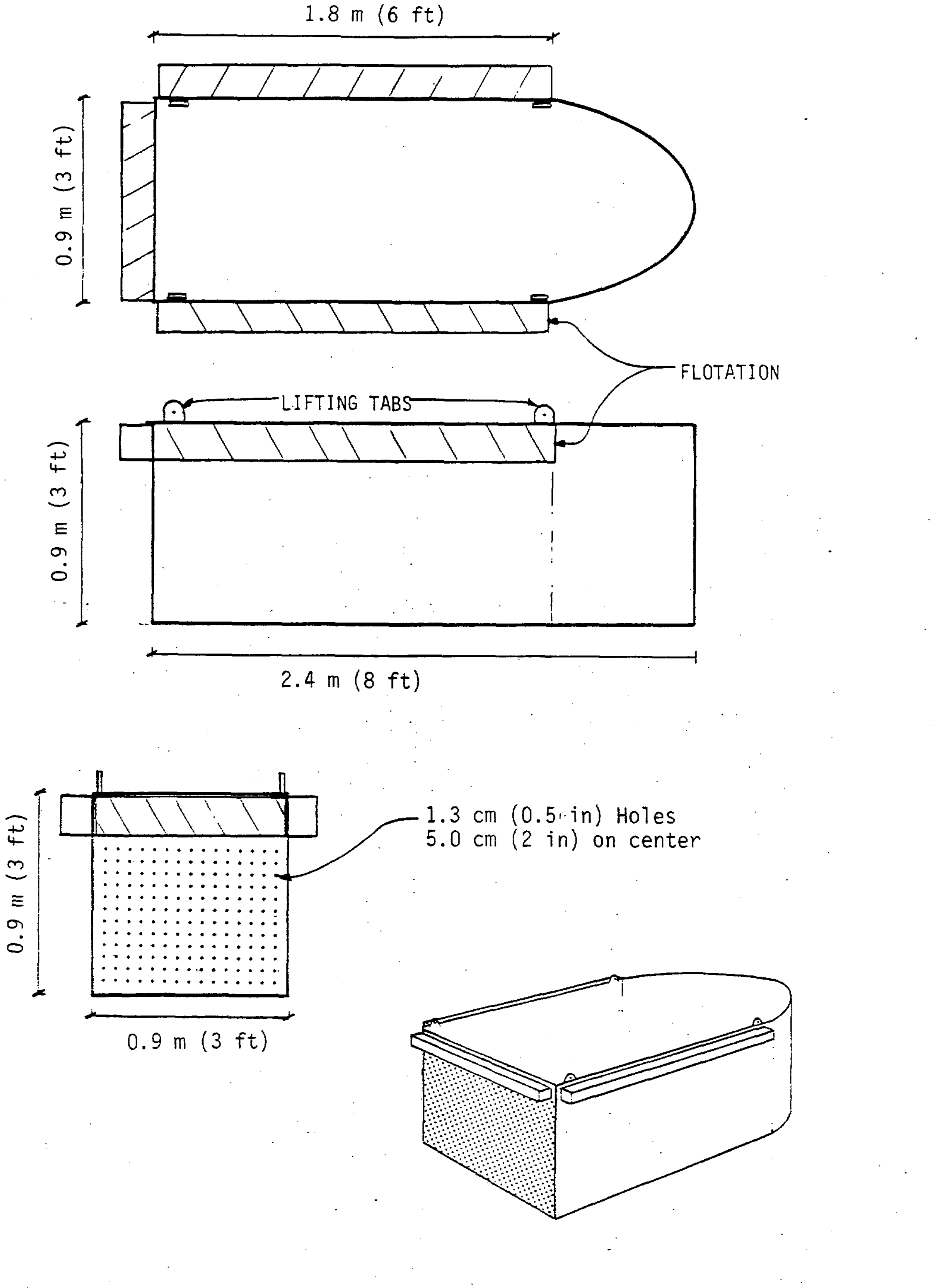

Figure 2-3. Aluminum holding facility for striped bass used in the lower Hudson River during the 1985-86 striped bass gear evaluation program.

All striped bass were measured for total length (mm TL) and examined for external tags, tag wounds, and internal magnetic tags using a magnetic tag detector. All striped bass greater than, or equal to, 200 mm TL, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

1) no bleeding from gills or body wounds,
2) no significant loss of scales, and
3) strong opercular movement.

The internal anchor tags were inserted by removing a scale midway between the vent and posterior tip of the pelvic fins, and slightly to one side of the ventral mid-line. A horizontal incision about 5 mm long was made with a hooking movement of a curved blade scalpel. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromine-based topical anti-septic. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location. Scale samples were taken from the left side of each tagged striped bass midway between the lateral line and the notch between the spinous and soft dorsal fins. Tag numbers of all recaptured striped bass were recorded, and a scale sample was taken from the right side of the fish to avoid regenerated scales. Condition of the tag insertion site of recaptured striped bass was also evaluated.

2.1.2 Water Quality Sampling

During each otter trawl and Scottish seine sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow

Springs Instruments (YSI) model 57 dissolved oxygen meter and YSI model 33 salinity-conductivity-temperature meter were used to take surface (0.3 m), mid-depth, and bottom measurements of water temperature, conductivity, and dissolved oxygen. All conductivity measurements were adjusted to 25°C. Water quality data is summarized by region and week in Appendix Table B.

2.2 LABORATORY METHODS

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics. This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, fish and Atlantic tomcod as requested by the NYSDEC (letter from Horn to Dunning dated 7 November 1986).

2.2.1 Length, Weight, Sex, and Sexual Condition of Striped Bass

Length, weight, sex, and sexual condition were determined for up to 10 striped bass per sampling day. Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table 2-1.

TABLE 2-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS.*

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, less firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and stringlike, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading or into spawning season. Testes considerably larger, white, firm in texture, but milt not running.

*From Con Edison Data Dictionary

2.2.2 Striped Bass Stomach Contents Analysis

The same striped bass that were processed as described above in Section 2.2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks. Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which taggable striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 2 samples were used for mark-recapture analysis and length-frequency analysis, but not for computation of catch per unit effort. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses.

2.3.1 Analysis of Catch Characteristics

2.3.1.1 Catch Per Unit Effort

Characteristics of the catch were compared between gear types, location, and sampling week by analysis of the catch per unit effort (CPUE) and length-frequency. CPUE for the striped bass and Atlantic tomcod trawls was defined as catch per ten-minute tow (Use Code 1) and was calculated as:

$$\bar{X} = \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \times 10 \right] /n \qquad \text{Formula 1}$$

where, $\bar{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,

E_i = the tow duration of trawl i in minutes, and

n = the number of trawls.

Catch per unit effort for the Scottish seines was defined as catch per one coil set (Use Code 1) and was calculated as:

$$\bar{X} = \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \right] /n \qquad \text{Formula 2}$$

where, $\bar{X}$ = the mean Scottish seine catch per one coil set,

C_i = total number of fish captured in set i,

E_i = the number of coils used in set i, and

n = the number of sets.

2.3.1.2 Length-Frequency

Length-frequency histograms, with number of fish on the ordinate and total length on the abscissa were constructed to compare the catch characteristics of the different gear types. Length-frequency distributions were statistically compared between trawls using a chi-square (χ^2) technique for two-sample frequency distributions which was available in the Statistical Analysis System software package (SAS PROC FREQ;SAS 1982).

Chi-square comparisons between the striped bass trawl and the tomcod trawl were calculated for striped bass caught in all non-void samples (Use Code = 1 and 2) from the Battery region (river miles 0-14; km 0-23) between 11 November 1985 and 21 March 1986. Chi-square comparisons between 1984 and 1985-86 Scottish seine data were calculated for striped bass caught in all non-void samples (Use Code = 1 and 2) from the Tappan Zee and Croton-Haverstraw and regions (river miles 25-39; km 40-63) between 1 April and 15 May.

2.3.1.3 Age Determination

Ages of striped bass were estimated through length-frequency analysis. Striped bass age was estimated by comparing actual lengths to length-at-age data for Hudson River striped bass (TI 1979, 1981; McLaren *et al*. 1981). The hatching date of striped bass was assumed to be 15 May. Therefore a yearling fish captured in April would be 23 months old and designed "Age 1+". Similarly, a young-of-the-year striped bass approaching its birth date would be 11 months old and designated "Age 0+".

2.3.2 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl or seine sample (Use Code = 1) by the following formula:

$$PropD_x = D_x/T_x \qquad \text{Formula 3}$$

where, $PropD_x$ = the proportion of dead striped bass in sample x,

D_x = the number of dead striped bass in sample x, and

T_x = total number of striped bass captured in sample x.

Regressions of PropD on water temperature were calculated to evaluate the relationship between water temperature or air temperature and handling mortality. All regressions were calculated using the SAS PROC GLM procedure (SAS 1982). Models used were:

$$PropD_x = \beta_1 \; TempS_x + b$$
$$PropD_x = \beta_2 \; TempB_x + b$$
$$PropD_x = \beta_3 \; TempB_x + b$$

where, TempS = surface water temperature (°C) at sample X

TempB = bottom water temperature (°C) at sample X

TempA = air temperature (°C) at sample X

β_1 = regression coefficient for $TempS_x$
β_2 = regression coefficient for $TempB_x$
β_3 = regression coefficient for $TempA_x$, and
b = intercept.

PropD was transformed by an arcsine transformation which is appropriate for proportions (Sokal and Rohlf 1981). The arcsine transformation served to improve model fit as indicated by increased F-statistics and r^2 values.

2.3.3 Population Movement

Distance, days at large, and minimum rate of travel were calculated for all recaptured striped bass and used to directly evaluate movement of fish within the study area. Each region of the study area (Figure 2-2) was considered as a potential release and/or recapture zone. Movement among regions was determined directly by examining the exchange of fish between regions, by plotting, and regression (PROC GLM) of recapture rates and recapture proportions by week within each region:

Recapture rate = R_{ij}/M_{ij} where Formula 4

R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

M_{ij} = number of tagged striped bass released during time (week) period i in region j.

Recapture Proportion R_{ij}/C_{ij} where Formula 5

R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period i (week) in region j.

2.3.4 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size. This estimator is a weighted linear regression of R_i/C_i as a function of M_i with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the values of R_i/C_i are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$N = \Sigma\ (C_i M_i^2)/\Sigma(R_i M_i)$$ Formula 6

where

N = estimated population size,
C_i = total catch during time interval i,
M_i = Total number of marked fish available for recapture at midpoint of time interval i, and
R_i = number of recaptured fish in C_i.

A 95% confidence interval (CI) for N is determined from:

$$CI = \Sigma(C_iM_i^2)/\left[\Sigma(R_iM_i) \pm t_{k-2\ (0.05)} \left(S^2\Sigma(C_iM_i^2)\right)\right]^{1/2} \quad \text{Formula 7}$$

where

$t_{k-2}(0.05)$ = t value for k sampling intervals (at $\alpha = 0.05$)

$$S^2 = \left[\Sigma\ (R_i^2/C_i) - (\Sigma\ R_iM_i)^2/\Sigma\ (C_iM_i^2)\right]/(k - 2) \quad \text{Formula 8}$$

3.0 RESULTS AND DISCUSSION

3.1 STRIPED BASS FOOD HABITS

Food habits from a subsample of 252 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and tomcod are present in the lower Hudson River during the winter, and as a result, tomcod may be an important winter food item in the diet of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and incidentally noted to be clupeids by laboratory personnel. Invertebrate remains were found in most stomachs of smaller striped bass, and decreased in importance in the larger length groups (Table 3-1). The percentage of striped bass with invertebrate remains decreased as the size of striped bass increased, while the percentage of striped bass with fish remains generally increased with increasing striped bass length. This pattern was most evident for striped bass length groups between 201 and 500 mm TL, where the largest number of fish were observed. The decreasing importance of invertebrates as a food item and increasing importance of fish as striped bass length increased has been reported by other authors (Westin and Rogers 1978). Incidental observations by lab personnel indicated that the predominant invertebrate found in striped bass stomachs were *Crangon* sp. shrimp.

3.2 STRIPED BASS SEXUAL CONDITION

Sexual condition (Table 2-1) was determined for the same striped bass that died and were examined for stomach contents (Section 3.1). Immature fish predominated throughout the sampling period and resting fish did not appear in abundance until May (Table 3-2). No

TABLE 3-1. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS				
LENGTH GROUP (mm TL)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	EMPTY	TOTAL
< 200	66.7 (6)	22.2 (2)	0.0 (0)	11.1 (1)	100.0 (9)
201-300	66.4 (91)	5.8 (8)	0.0 (0)	27.8 (38)	100.0 (137)
301-400	37.0 (27)	16.4 (12)	0.0 (0)	46.6 (34)	100.0 (73)
401-500	20.0 (4)	25.0 (5)	0.0 (0)	55.0 (11)	100.0 (20)
501-600	9.1 (1)	0.0 (0)	0.0 (0)	90.1 (10)	100.0 (11)
601-700	0.0 (0)	50.0 (1)	0.0 (0)	50.0 (1)	100.0 (2)
TOTAL	51.2 (129)	11.1 (28)	0.0 (0)	37.7 (95)	100.0 (252)

TABLE 3-2. SEXUAL CONDITION OF STRIPED BASS CAPTURED DURING THE 1985-86 STRIPED BASS GEAR EVALUATION PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS							
	FEMALES				MALES			
MONTH	IMMATURE	RESTING	DEVELOPING	TOTAL	IMMATURE	RESTING	DEVELOPING	TOTAL
NOV[1]	100 (1)	0 (0)	0 (0)	100 (1)	0 (0)	50 (1)	50 (1)	100 (2)
DEC[1]	100 (28)	0 (0)	0 (0)	100 (28)	59 (16)	0 (0)	41 (11)	100 (27)
JAN[1]	100 (17)	0 (0)	0 (0)	100 (17)	59 (13)	0 (0)	41 (9)	100 (22)
FEB[1]	100 (9)	0 (0)	0 (0)	100 (9)	44 (8)	0 (0)	56 (10)	100 (18)
MAR[1]	100 (16)	0 (0)	0 (0)	100 (16)	61 (11)	0 (0)	39 (7)	100 (18)
APR[2]	100 (24)	0 (0)	0 (0)	100 (24)	19 (12)	0 (0)	81 (50)	100 (62)
MAY[3]	50 (1)	50 (1)	0 (0)	100 (2)	0 (0)	100 (5)	0 (0)	100 (5)
TOTAL	99 (96)	1 (1)	0 (0)	100 (97)	39 (60)	4 (6)	57 (88)	100 (154)

[1]All fish were obtained from trawl samples in the Upper Harbor and Battery regions.
[2]80 fish were obtained from Scottish seine samples in the Tappan Zee and Croton-Haverstraw regions and 6 fish were obtained from April trawl samples in the Upper Harbor and Battery regions. Three of the striped bass from trawl samples were immature females, one fish was an immature male, and the remaining two fish were developing males.
[3]All fish were obtained from Scottish seine samples in the Tappan Zee and Croton-Haverstraw regions.

ripe, or ripe and running fish were captured, although the percentage of developing fish generally increased from December 1985 through April 1986.

The lack of ripe, or ripe and running striped bass in the 1985-86 program is not surprising because the majority of the fish captured were pre-spawning size (<400 mm TL; Section 3-3), and the program terminated before the onset of peak spawning (TI 1981). The results demonstrate a general increase in percentage of developing males with time, as the spawning season approached. However, it appears that both the winter and spring phases of the study sampled predominantely immature fish.

3.3 LENGTH-FREQUENCY DISTRIBUTIONS

Length-frequency distributions for striped bass caught by the striped bass trawl, tomcod trawl, Jackson 280 seine and Kosalt plaice seine were characterized using moment statistics and statistically compared using chi-square analysis. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions. The chi-square technique pools data from the two gear being compared to calculate the hypothetical expected number of fish in each length group, and then statistically tests to determine if the observed number of fish in each length group for each gear is significantly different from the expected. In pooling data, it was assumed that distinct subpopulations of striped bass did not exist within the river region and time period over which pooling occurred, or if subpopulations existed, they were not sampled differently by the two gear being compared.

3.3.1 Tomcod Trawl and Striped Bass Trawl

The mean size of striped bass caught by tomcod trawl was significantly smaller ($p<0.05$) than the mean size of striped bass caught by the striped bass trawl (Table 3-3) when both trawls were fished in the same region (Battery) and time period (11 November 1985 through 21 March 1986). Both frequency distributions were significantly skewed to the right and leptokurtotic indicating more fish were slightly larger than the mean length than would be expected if the length-frequency distributions were bell-shaped (Table 3-3; Figure 3-1). When the tomcod trawl and striped bass trawl length-frequency distributions were compared to each other rather than to a normal distribution, significant differences were observed between the two gear ($\chi^2 = 191.8$, $p<0.0001$; Table 3-4). The striped bass trawl caught a significantly lower than expected number of striped bass in the < 150, 151-199 and 200-250 mm TL length groups and a significantly higher than expected number of striped bass in the 251-300, 301-350, 351-400 and 401-450 mm TL length groups. The Atlantic tomcod trawl caught a significantly higher than expected number of striped bass in the less than 150 and 151-199 mm TL length groups. A significantly lower than expected number of striped bass were caught by the Atlantic tomcod trawl in the 251-300 and 301-350 and 351-400 mm TL length groups. No significant differences between trawls were observed among striped bass length groups greater than 450 mm TL.

A similar chi-square analysis was completed for taggable-sized striped bass in the trawls ($\geq$ 200 mm TL; Table 3-5), and results were comparable to the aforementioned analysis of all length groups. The striped bass trawl caught a significantly lower than expected number of striped bass in the 200-250 mm TL length group and a significantly higher than expected number of striped bass in the 301-350, 351-400 and 401-450 mm TL length groups. The Atlantic tomcod trawl caught a significantly higher than expected number of striped bass in the 200-250 mm TL length group. Similar results for the comparison of all striped bass caught and taggable-sized striped bass were not surprising since more than 92% of the fish were $\geq$200 mm TL.

TABLE 3-3. DESCRIPTIVE STATISTICS FOR STRIPED BASS LENGTH-FREQUENCY DISTRIBUTIONS OBTAINED FROM THE TOMCOD TRAWL, STRIPED BASS TRAWL, JACKSON 280 SEINE AND KOSALT PLAICE SEINE DEPLOYED IN THE LOWER HUDSON RIVER.

GEAR	RIVER MILES (KM)	DATE	N	MEAN (mm TL)	S.D.	SKEWNESS (±95% C.I.)	KURTOSIS (±95% C.I.)	MAXI-MUM	MINI-MUM	DESCRIPTION
Tomcod Trawl	0-14 (0-23)	11 Nov 85- 21 Mar 86	7541	264.7	59.8	1.06 ± 0.06	3.99 ± 0.11	730	64	Leptokurtotic, skewed right
Striped Bass Trawl	0-14 (0-23)	11 Nov 85- 21 Mar 86	3616	278.9	56.5	1.32 ± 0.08	3.74 ± 0.16	731	100	Leptokurtotic, skewed right
Tomcod Trawl (≥200 mm TL)	0-14 (0-23)	11 Nov 85- 21 Mar 86	6825	274.4	53.7	1.76 ± 0.06	5.86 ± 0.12	730	200	Leptokurtotic, skewed right
Striped Bass Trawl (≥200 mm TL)	0-14 (0-23)	11 Nov 85- 21 Mar 86	3495	282.2	54.5	1.55 ± 0.08	4.27 ± 0.16	731	200	Leptokurtotic, skewed right
Kosalt Plaice Seine	25-39 (40-63)	7 Apr 86- 13 Apr 86	1524	514.1	78.5	0.13 ± 0.12	1.38 ± 0.25	891	222	Leptokurtotic, skewed right
Jackson 280 Seine	25-39 (40-63)	7 Apr 86- 13 Apr 86	221	505.4	87.3	-0.60 ± 0.32	0.97 ± 0.65	742	230	Leptokurtotic, skewed left
Jackson 280 Seine	25-39 (40-63)	1 Apr 86- 15 May 86	3525	420.4	101.2	0.19 ± 0.08	-0.31 ± 0.16	900	162	Platykurtotic, skewed right
Jackson 280 Seine	25-39 (40-63)	1 Apr 84- 15 May 84	724	383.4	121.9	0.60 ± 0.18	0.04 ± 0.36	866	103	Leptokurtotic, skewed right

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Normal skewness = Skewness not significantly different from 0, which is the value obtained from a normal distribution.
Normal kurtosis = Kurtosis not significantly different from 0, which is the value obtained from a normal distribution.
Right skewness = Significant positive skewness indicating more striped bass were larger than the mean length than would be expected from a normal distribution.
Left skewness = Significant negative skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.
Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.
Platykurtosis = Significant negative kurtosis indicating more striped bass were both higher and lower than the mean length than would be expected from a normal distribution.

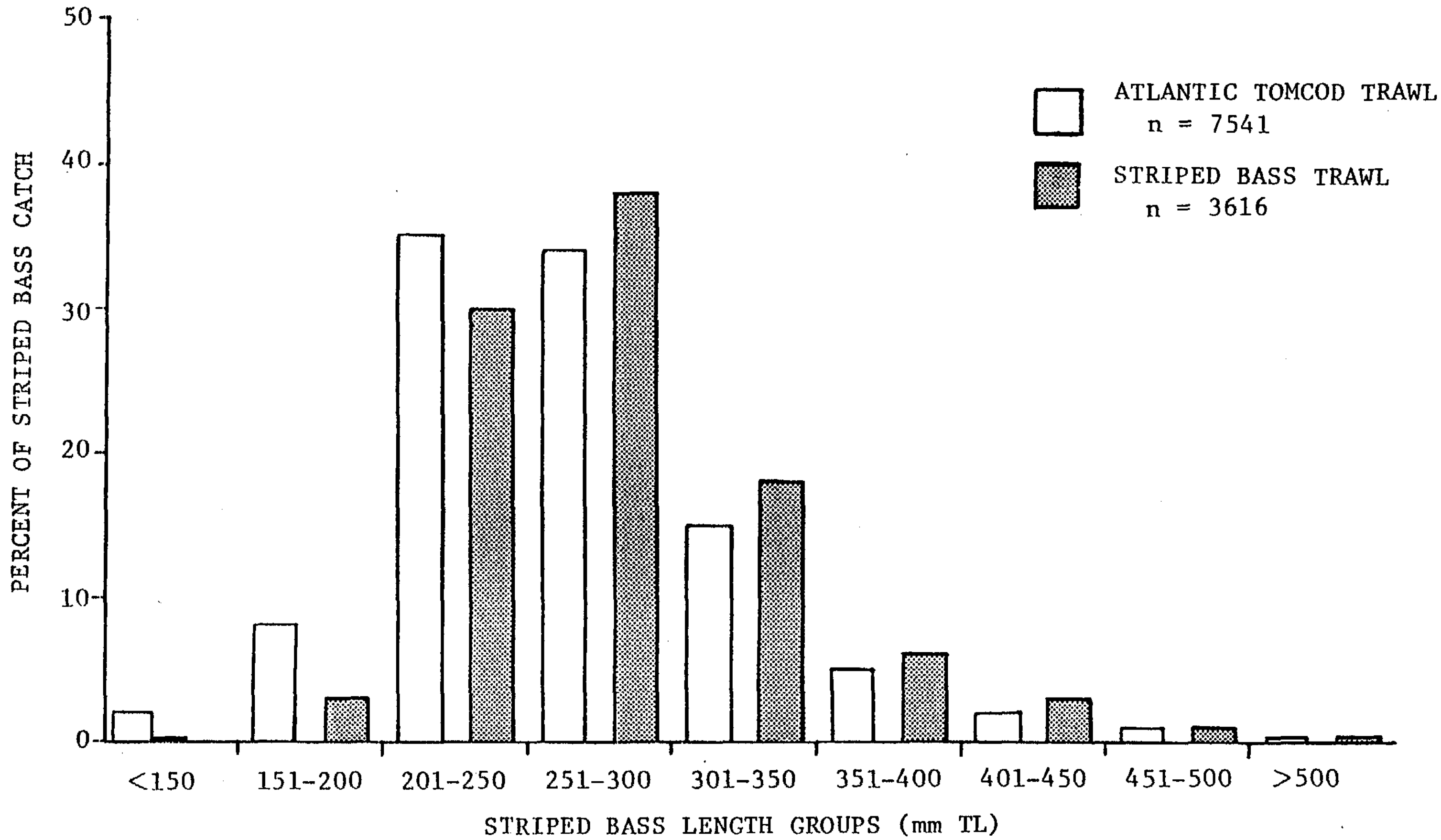

Figure 3-1. Length-frequency distribution for striped bass collected by the striped bass trawl and Atlantic tomcod trawl in the Battery region of the Hudson River, 11 November 1985 through 21 March 1986.

TABLE 3-4. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS FOR STRIPED BASS OBTAINED FROM THE ATLANTIC TOMCOD TRAWL OR STRIPED BASS TRAWL IN THE BATTERY REGION FROM 11 NOVEMBER 1985 THROUGH 21 MARCH 1986.

		LENGTH GROUPS (mm TL)											
GEAR	STATISTIC	<150	151-199	200-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	>600	TOTAL
Atlantic tomcod trawl	Observed	116	600	2614	2547	1116	345	121	54	11	9	8	7541
	Expected	85	484	2529	2665	1201	384	144	56	14	8	7	
	Cell χ^2	11.7	28.1	2.9	5.2	6.0	3.9	3.7	0.1	0.7	0.1	0.1	
Striped bass trawl	Observed	9	112	1110	1377	652	220	91	29	10	3	3	3616
	Expected	41	229	1195	1269	567	181	68	27	7	4	4	
	Cell χ^2	24.5	59.4	6.1	11.0	12.6	8.2	7.8	0.2	1.6	0.3	0.1	
	d.f.=10		χ^2=191.8			Prop>χ^2=0.0001							

LEGEND: observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length group based on the hypothesis that no difference exists between length frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
p>χ^2 = probability of obtaining the overall χ^2 by chance. A p>χ^2 of less than 0.05 was considered significant.

TABLE 3-5. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS FOR TAGGABLE-SIZED STRIPED BASS (≥200 mm TL) OBTAINED FROM THE ATLANTIC TOMCOD TRAWL OR STRIPED BASS TRAWL IN THE BATTERY REGION FROM 11 NOVEMBER 1985 THROUGH 21 MARCH 1986.

		LENGTH GROUPS (mm TL)									
GEAR	STATISTIC	200-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	>600	TOTAL
Atlantic tomcod trawl	Observed	2614	2547	1116	345	121	54	11	9	8	6825
	Expected	2463	2595	1169	374	140	55	14	8	7	
	Cell χ^2	9.3	0.9	2.4	2.2	2.6	<0.1	0.6	0.1	0.1	
Striped bass trawl	Observed	1110	1377	652	220	91	29	10	3	3	3495
	Expected	1261	1329	599	191	72	28	7	4	4	
	Cell χ^2	18.1	1.7	4.7	4.3	5.1	<0.1	1.2	0.3	0.1	
	d.f.=8	χ^2=53.9			Prob>χ^2=0.0001						

LEGEND: observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length group based on the hypothesis that no difference exists between length frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
$p>\chi^2$ = probability of obtaining the overall χ^2 by chance. A $p>\chi^2$ of less than 0.05 was considered significant.

3.3.2 Jackson 280 Seine and Kosalt Plaice Seine

Within the present program, the Jackson 280 seine was considered the primary Scottish seine and the Kosalt plaice seine was the back-up Scottish seine that was used to permit fishing to continue whenever the Jackson 280 seine was damaged and being repaired. Therefore, both gear were not intentionally fished in a manner permitting comparison of the length-frequency distributions of the striped bass catch. The Kosalt plaice seine was fished primarily from 31 March through 9 April 1986, while the Jackson 280 seine was used primarily from 10 April through 13 May 1986. However, sufficient effort was expended by both seines and sufficient numbers of fish were caught during the week of 7 April 1986 to compare length-frequency distribution. The Kosalt plaice seine was fished on 7, 8, and 9 April while the Jackson 280 seine was fished on 10 and 11 April 1986. The mean size of striped bass caught by the Jackson 280 seine was not significantly different from the Kosalt plaice seine during the week of 7 April 1986 (Table 3-3), however, the shape of the frequency distributions differed when compared to a normal distribution. Both frequency distributions had more fish close to the mean length than would be expected from a normal distribution, however the Kosalt plaice seine caught more fish slightly larger than the mean length while the Jackson 280 seine caught more fish smaller than the mean length than would be expected from a normal distribution. The differences in moment statistics describing the shape of the two frequency distributions relative to a normal distribution were confirmed by chi-square analysis (Table 3-6). Significant differences between the length-frequency distributions of the two seines were observed for the week of 7 April (chi-square=20.1; p=0.03; Table 3-6). The Jackson 280 seine captured a greater than expected number of striped bass in the ≤ 300 and 301-350 mm TL length groups and a fewer than expected number of striped bass in the 401-450 mm TL length groups compared to the Kosalt plaice seine.

TABLE 3-6. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS FOR STRIPED BASS OBTAINED FROM THE JACKSON 280 SEINE AND KOSALT PLAICE SEINE IN THE TAPPAN ZEE AND CROTON-HAVERSTRAW REGIONS (COMBINED) DURING THE WEEK OF 7 APRIL 1986.

GEAR	STATISTIC	LENGTH GROUPS (mm TL)											
		≤ 300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	>750	TOTAL
Jackson 280 Seine	Observed	6	9	10	16	49	67	42	15	4	3	0	221
	Expected	2	4	9	27	49	66	39	15.3	6.1	2	1	
	Cell χ^2	6.1	5.1	0.1	4.1	<0.1	<0.1	0.3	<0.1	0.7	0.1	1.0	
Kosalt Plaice Seine	Observed	12	25	62	193	340	454	264	106	44	16	8	1524
	Expected	16	30	63	183	340	455	267	106	42	17	7	
	Cell χ^2	0.9	0.7	0.1	0.6	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	

d.f.=10 χ^2=20.1 Prob> χ^2=0.03

LEGEND: observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length group based on the hypothesis that no difference exists between length frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
$p>\chi^2$ = probability of obtaining the overall χ^2 by chance. A $p>\chi^2$ of less than 0.05 was considered significant.

The mean size of striped bass caught by the Jackson 280 seine in 1986 was significantly larger than in 1984 (Table 3-3; Figure 3-2) for data that were subset to be comparable in space (river miles 25-39; km 40-63) and time (1 April - 15 May) and gear. Striped bass frequency distributions for 1984 and 1986 had more fish larger than the mean size than would be expected from a normal distribution, however 1986 had more fish both larger and smaller than the mean length while in 1984 more fish were close to the mean length than would be expected from a normal distribution. The 1984 sampling effort with the Jackson 280 seine captured a significantly greater than expected number of striped bass in the <150, 201-250, 251-300, and ≥700 mm TL length groups (Table 3-7), and a significantly lower than expected number of striped bass in the 401-450, 451-500, 500-551, 551-600 mm TL length groups. The 1986 sampling effort with the Jackson 280 seine captured a significantly lower than expected number of fish in the <150, 201-250, and 251-300 mm TL length groups.

3.3.3 Weekly Changes in Mean Length and Length-Frequency

Weekly changes in mean length of striped bass caught by the tomcod trawl or the striped bass trawl (Table 3-8) did not exhibit distinct seasonal patterns. The mean length of striped bass caught by the tomcod trawl in the Battery ranged from 232.1 mm TL during the week of 27 January 1986 to 344.8 mm TL during the week of 11 November 1985. The mean length of striped bass caught by the striped bass trawl in the Battery ranged from 248.3 mm TL during the week of 7 April 1986 to 354.0 mm TL during the week of 25 November 1985. Weekly changes in mean length of striped bass caught by the striped bass trawl in the Upper Harbor were similar to the Battery region and ranged between 291.6 mm TL during the week of 21 April 1986 to 383.8 mm TL during the week of 10 February 1986 (Table 3-9).

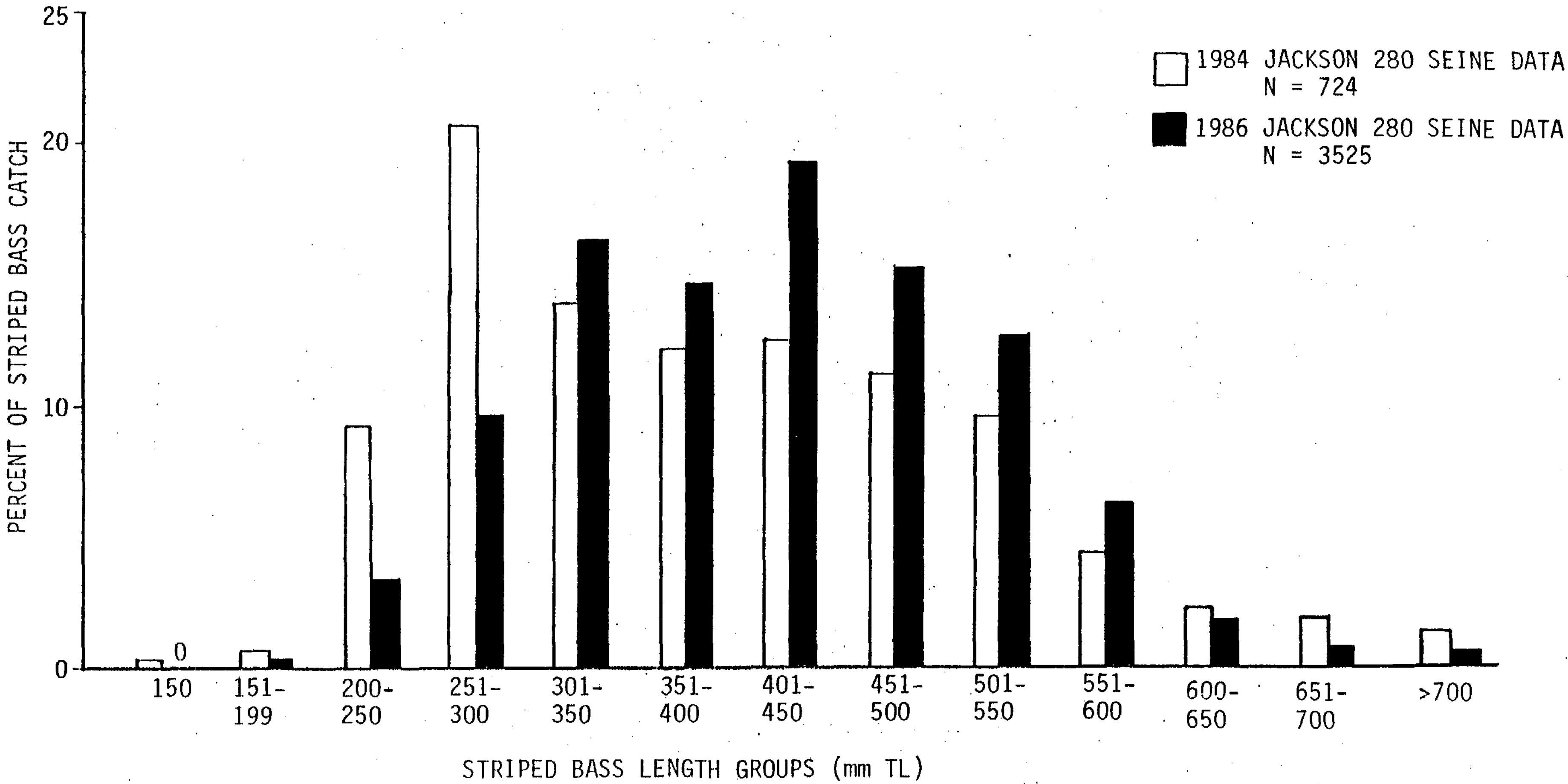

Figure 3-2. Length-frequency distributions for striped bass collected by the Jackson 280 seine in the Tappan Zee and Croton-Haverstraw regions of the Hudson River, 1 April through 15 May 1984 and 1986.

TABLE 3-7. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS OBTAINED FROM THE JACKSON 280 SEINE IN 1984 AND 1986 IN THE TAPPAN ZEE AND CROTON-HAVERSTRAW REGIONS (COMBINED) OF THE HUDSON RIVER, 1 APRIL THROUGH 15 MAY.

		LENGTH GROUPS (mm TL)													
GEAR	STATISTIC	<150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	>700	TOTAL
1984 Jackson 280 Seine	Observed	6	7	68	154	99	86	89	83	67	30	16	10	9	724
	Expected	1.0	3.7	28.1	84.5	111.1	98.3	127.1	107.7	91.7	44.3	16.2	5.8	4.4	
	Cell χ^2	24.2	2.8	56.6	57.1	1.3	1.5	11.4	5.7	6.6	4.6	>0.1	3.1	4.7	
1986 Jackson 280 Seine	Observed	0	15	97	342	553	491	657	549	471	230	79	24	17	3525
	Expected	5.0	18.3	136.9	411.5	540.9	478.7	618.9	524.3	446.3	215.7	78.8	28.2	21.6	
	Cell χ^2	5.0	0.6	11.6	11.7	0.3	0.3	2.3	1.2	1.4	0.9	<0.1	0.6	1.0	

d.f. = 12 χ^2 = 216.7 Prob >χ^2 = 0.0001

LEGEND:
observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length group based on the hypothesis that no difference exists between length frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
$p>\chi^2$ = probability of obtaining the overall χ^2 by chance. A $p>\chi^2$ of less than 0.05 was considered significant.

TABLE 3-8. WEEKLY MEAN LENGTH (mm TL) OF STRIPED BASS CAUGHT BY THE TOMCOD TRAWL AND THE STRIPED BASS TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER BETWEEN 11 NOVEMBER 1985 AND 21 MARCH 1986.

SAMPLING WEEK	TOMCOD TRAWL					STRIPED BASS TRAWL				
	NUMBER OF TOWS	NUMBER OF FISH	MEAN LENGTH (mm TL)	S.D.	S.E.	NUMBER OF TOWS	NUMBER OF FISH	MEAN LENGTH (mm TL)	S.D.	S.E.
11 NOV 85	8	12	344.8	66.6	19.2	NS				
18 NOV 85	68	374	287.6	60.8	3.1	2	13	278.7	38.5	10.7
25 NOV 85	29	94	308.7	81.2	8.4	1	4	354.0	130.5	65.3
02 DEC 85	49	515	267.6	59.8	2.6	6	13	286.9	85.4	23.7
09 DEC 85	46	260	277.2	63.2	3.9	14	99	304.7	75.2	7.6
16 DEC 85	76	1103	252.3	49.8	1.5	8	257	269.2	36.5	2.3
23 DEC 85	21	474	245.9	49.1	2.3	3	373	268.3	37.5	1.9
30 DEC 85	34	718	253.0	41.8	1.6	6	364	258.3	46.2	2.4
06 JAN 86	50	677	250.4	61.2	2.4	2	84	251.8	41.5	4.5
13 JAN 86	56	589	259.8	56.9	2.3	7	278	277.3	56.7	3.4
20 JAN 86	50	449	275.9	56.4	2.7	12	350	277.1	47.6	2.5
27 JAN 86	52	215	232.1	66.3	4.5	6	299	285.1	55.1	3.2
03 FEB 86	53	277	288.0	59.5	3.6	NS				
10 FEB 86	52	322	258.7	62.4	3.5	11	227	294.2	73.4	4.9
17 FEB 86	39	122	319.0	64.6	5.8	6	446	307.2	58.6	2.8
24 FEB 86	61	128	268.1	54.2	4.8	7	224	270.8	59.3	4.0
03 MAR 86	70	159	286.4	57.3	4.5	5	15	262.6	50.4	13.0
10 MAR 86	58	110	271.7	59.9	5.7	17	223	298.8	58.8	3.9
17 MAR 86	68	943	276.6	65.0	2.1	13	347	261.8	57.3	3.1
24 MAR 86	NS					13	170	267.4	61.4	4.7
31 MAR 86	NS					20	241	258.5	62.9	4.1
07 APR 86	NS					18	293	248.3	67.5	3.9
14 APR 86	NS					14	264	261.2	37.4	2.3
21 APR 86	NS					NS				
28 APR 86	NS					8	15	321.3	119.8	30.9
05 MAY 86	NS					10	21	347.2	106.1	23.1
12 MAY 86	NS					9	19	302.0	69.1	15.9
ALL WEEKS	940	7541	264.7	59.8	0.7	218	4499	275.2	57.8	0.9

NS = Not Sampled
S.D. = Standard deviation
S.E. = Standard error

TABLE 3-9. WEEKLY MEAN LENGTH (mm TL) OF STRIPED BASS CAUGHT BY THE STRIPED BASS TRAWL IN THE UPPER HARBOR REGION OF THE HUDSON RIVER BETWEEN 3 FEBRUARY 1986 AND 16 MAY 1986.

	STRIPED BASS TRAWL				
SAMPLING WEEK	NUMBER OF TOWS	NUMBER OF FISH	MEAN LENGTH (mm TL)	S.D.	S.E.
03 FEB 86	7	74	296.9	56.1	6.5
10 FEB 86	2	8	383.8	126.6	44.8
17 FEB 86	NS				
24 FEB 86	NS				
03 MAR 86	NS				
10 MAR 86	1	0	.	.	.
17 MAR 86	1	32	319.9	28.0	5.0
24 MAR 86	9	324	331.0	61.7	3.4
31 MAR 86	11	559	317.0	53.1	2.2
07 APR 86	19	1239	313.8	58.3	1.7
14 APR 86	11	455	299.8	53.3	2.5
21 APR 86	11	89	291.6	45.3	4.8
28 APR 86	8	11	374.6	132.7	40.0
05 MAY 86	3	0			
12 MAY 86	3	0			
ALL WEEKS	86	2791	313.5	57.9	1.1

NS = Not Sampled
S.D. = Standard deviation
S.E. = Standard error

In contrast to the tomcod trawl and striped bass trawl, more large striped bass were caught by the Jackson 280 seine and Kosalt plaice seine during the first two weeks of April 1986 than at any later time (Table 3-10). The mean length of striped bass caught was greater than 500 mm TL during the weeks of 31 March and 7 April 1986. In the remaining weeks of the program, mean length of striped bass caught by the Jackson 280 seine ranged between 474.9 mm TL during the week of 12 May 1986 to 379.6 mm TL during the week of 5 May 1986. The Kosalt plaice seine was only fished for one set after the first two weeks of the program; the mean size of the 7 fish caught in that set during the week of 14 April 1986 was 339.0 mm TL.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50 mm TL length groups, exhibited no distinct seasonal pattern for the tomcod trawl (Table 3-11) or the striped bass trawl (Table 3-12). The highest weekly catch per tomcod trawl tow was 10.2 striped bass for the 201-250 mm TL length group during the week of 23 December 1985. The highest weekly catch per striped bass trawl tow was 60.7 striped bass for the 251-300 mm TL length group during the week of 23 December 1985. The highest overall catch per tow for the tomcod trawl was 2.7 striped bass for both the 201-250 mm TL and 250-300 mm TL length groups. The highest overall catch per tow for the striped bass trawl was 8.9 striped bass for the 251-300 mm TL group.

Unlike the trawls, weekly changes in length-frequency of striped bass caught in the Scottish seines (Jackson 280 and Kosalt plaice seines combined) exhibited a general pattern of decreasing catch per tow for length groups greater than 500 mm TL after 7 April 1986 (Table 3-13). The highest weekly catch per set for the Scottish seine was 10.9 striped bass for the 501-550 mm TL length group during the week of 7 April 1986. The highest overall catch per set for the Scottish seine was 3.5 striped bass for the 501-550 mm TL length group.

TABLE 3-10. WEEKLY MEAN LENGTH (mm TL) OF STRIPED BASS CAUGHT BY THE JACKSON 280 SEINE AND KOSALT PLAICE SEINE IN THE TAPPAN ZEE AND CROTON-HAVERSTRAW REGIONS (COMBINED) OF THE HUDSON RIVER BETWEEN 31 MARCH AND 13 MAY 1986.

	JACKSON 280 SEINE					KOSALT PLAICE SEINE				
SAMPLING WEEK	NUMBER OF TOWS	NUMBER OF FISH	MEAN LENGTH (mm TL)	S.D.	S.E.	NUMBER OF TOWS	NUMBER OF FISH	MEAN LENGTH (mm TL)	S.D.	S.E.
31 MAR 86	NS					15	157	559.1	70.9	5.7
07 APR 86	12	221	505.4	87.3	5.9	36	1524	514.1	78.5	2.0
14 APR 86	60	699	394.1	102.1	3.9	1	7	339.0	57.3	21.7
21 APR 86	59	2022	419.4	97.4	2.2	NS				
28 APR 86	47	406	440.4	92.1	4.6	NS				
05 MAY 86	37	170	379.6	101.6	7.8	NS				
12 MAY 86	9	7	474.9	205.0	77.5	NS				
ALL WEEKS	224	3525	420.4	101.2	1.7	52	1688	517.5	79.7	1.9

NS = Not Sampled
S.D. = Standard deviation
S.E. = Standard error

TABLE 3-11. WEEKLY CATCH OF STRIPED BASS PER TOW IN THE TOMCOD TRAWL FOR 50 mm TL LENGTH GROUPS FROM 11 NOVEMBER 1985 THROUGH 21 MARCH 1986 IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	<151 mm	151-200 mm	201-250 mm	251-300 mm	301-350 mm	351-400 mm	401-450 mm	451-500 mm	501-550 mm	551-600 mm	601-650 mm	651-700 mm	701-750 mm
11 NOV 85	8	0.0	0.0	0.1	0.3	0.5	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0
18 NOV 85	68	<0.1	0.2	1.3	2.2	1.2	0.3	0.2	0.1	<0.1	<0.1	0.0	0.0	0.0
25 NOV 85	29	0.0	0.0	0.7	1.3	0.7	0.1	0.2	0.2	0.0	0.0	0.0	0.0	<0.1
02 DEC 85	49	<0.1	0.6	4.1	3.4	1.8	0.3	0.1	<0.1	<0.1	0.0	<0.1	0.0	<0.1
09 DEC 85	46	<0.1	0.3	1.7	2.2	0.9	0.3	0.1	0.1	0.0	0.0	<0.1	<0.1	0.0
16 DEC 85	76	0.1	1.5	6.2	4.6	1.6	0.3	0.1	0.1	<0.1	0.0	0.0	0.0	0.0
23 DEC 85	21	0.4	2.7	10.2	7.2	1.6	0.5	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
30 DEC 85	34	0.1	1.4	9.1	8.4	1.8	0.3	0.1	<0.1	0.0	0.0	0.0	0.0	0.0
06 JAN 86	50	0.7	1.8	4.7	4.0	1.5	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0
13 JAN 86	56	0.1	1.1	4.2	3.2	1.3	0.5	0.2	0.1	<0.1	<0.1	0.0	0.0	0.0
20 JAN 86	50	0.1	0.5	2.4	3.5	1.6	0.6	0.2	0.1	<0.1	0.0	0.0	0.0	0.0
27 JAN 86	52	0.5	0.7	1.3	1.1	0.3	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
03 FEB 86	53	<0.1	0.2	1.3	1.8	1.3	0.5	0.1	0.1	0.0	<0.1	0.0	0.0	0.0
10 FEB 86	52	0.1	0.5	2.4	2.0	0.7	0.2	0.1	0.1	<0.1	<0.1	0.0	0.0	0.0
17 FEB 86	53	<0.1	<0.1	0.2	0.7	0.8	0.5	0.1	0.1	<0.1	0.0	0.0	0.0	0.0
24 FEB 86	61	<0.1	0.1	0.6	0.8	0.4	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0
03 MAR 86	70	<0.1	<0.1	0.6	0.8	0.6	0.2	<0.1	0.0	0.0	0.0	<0.1	0.0	0.0
10 MAR 86	58	0.0	0.1	0.6	0.7	0.3	0.1	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
17 MAR 86	68	0.3	0.9	3.7	4.5	2.8	1.1	0.4	0.1	0.0	<0.1	<0.1	0.0	0.0
TOTAL TOWS	954													
STRIPED BASS PER TOW		0.1	0.6	2.7	2.7	1.2	0.4	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1

TABLE 3-12. WEEKLY CATCH OF STRIPED BASS PER TOW IN THE STRIPED BASS TRAWL FOR 50 mm TL LENGTH GROUPS FROM 11 NOVEMBER 1985 THROUGH 16 MAY 1986 IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	<151 mm	151-200 mm	201-250 mm	251-300 mm	301-350 mm	351-400 mm	401-450 mm	451-500 mm	501-550 mm	551-600 mm	601-650 mm	651-700 mm	701-750 mm
18 NOV 85	2	0.0	0.0	1.5	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 NOV 85	1	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
02 DEC 85	6	0.0	0.0	0.8	0.8	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
09 DEC 85	14	0.1	0.2	1.4	2.5	1.5	0.8	0.3	0.1	0.2	0.1	0.0	0.0	0.0
16 DEC 85	8	0.0	0.5	9.5	16.9	4.6	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0
23 DEC 85	3	0.7	0.0	45.3	60.7	13.3	4.0	0.7	0.0	0.3	0.0	0.0	0.0	0.0
30 DEC 85	6	0.2	0.4	28.8	19.2	7.2	2.3	0.2	0.0	0.2	0.0	0.0	0.0	0.0
06 JAN 86	2	0.0	3.0	19.0	16.0	3.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
13 JAN 86	7	0.0	1.6	14.0	13.7	6.6	1.6	2.1	0.1	0.0	0.0	0.0	0.0	0.0
20 JAN 86	12	0.2	0.5	9.2	10.8	6.3	2.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
27 JAN 86	6	0.2	1.0	13.0	18.8	11.2	3.3	1.8	0.5	0.0	0.0	0.0	0.0	0.0
03 FEB 86	7	0.0	0.3	2.1	3.7	2.4	1.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0
10 FEB 86	13	0.2	0.4	4.7	6.5	3.2	1.6	0.9	0.3	0.2	0.2	0.0	0.0	0.1
17 FEB 86	6	0.0	0.7	9.8	28.0	22.8	8.0	3.0	1.5	0.2	0.0	0.3	0.0	0.0
24 FEB 86	7	0.3	1.6	11.4	10.3	5.0	2.3	0.7	0.4	0.0	0.0	0.0	0.0	0.0
03 MAR 86	5	0.0	0.2	1.2	1.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 MAR 86	18	0.0	0.2	2.1	5.2	2.8	1.4	0.4	0.2	0.1	0.0	0.0	0.0	0.0
17 MAR 86	14	0.2	2.5	9.4	8.1	4.6	1.3	0.7	0.1	0.1	0.0	0.0	0.0	0.0
24 MAR 86	22	<0.1	0.4	4.0	7.0	5.6	3.4	1.2	0.6	0.2	<0.1	<0.1	0.0	0.0
31 MAR 86	31	0.1	0.9	4.3	8.2	7.9	3.0	0.9	0.3	0.1	<0.1	0.1	0.0	0.0
07 APR 86	37	0.1	1.2	6.9	14.5	10.8	4.7	1.9	0.9	0.2	0.1	<0.1	<0.1	0.0
14 APR 86	25	<0.1	0.2	7.1	12.2	5.8	2.6	0.8	<0.1	<0.1	0.0	<0.1	0.0	0.0
21 APR 86	11	0.0	0.1	1.3	3.5	2.7	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0
28 APR 86	16	0.1	0.0	0.3	0.6	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0
05 MAY 86	13	0.0	0.0	0.2	0.5	0.2	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0
12 MAY 86	12	0.0	0.0	0.6	0.3	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL TOWS	304													
STRIPED BASS PER TOW		0.1	0.7	6.0	8.9	5.4	2.1	0.8	0.3	0.1	<0.1	<0.1	<0.1	<0.1

TABLE 3-13. WEEKLY CATCH OF STRIPED BASS PER SET IN THE SCOTTISH SEINE (JACKSON 280 AND KOSALT PLAICE SEINES COMBINED) FOR 50 mm TL LENGTH GROUPS FROM 31 MARCH THROUGH 13 MAY 1986 IN THE COMBINED TAPPAN ZEE AND CROTON-HAVERSTRAW REGIONS OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF SETS	<151 mm	151-200 mm	201-250 mm	251-300 mm	301-350 mm	351-400 mm	401-450 mm	451-500 mm	501-550 mm	551-600 mm	601-650 mm	651-700 mm	701-750 mm	751-800 mm	>800 mm
31 MAR 86	15	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.6	3.3	2.7	1.7	0.5	0.3	0.1	0.1
07 APR 86	48	0.0	0.0	0.1	0.3	0.7	1.5	4.4	8.1	10.9	6.4	2.5	1.0	0.4	0.1	<0.1
14 APR 86	61	0.0	0.1	0.6	1.6	2.0	1.9	1.9	1.4	1.2	0.4	0.2	0.1	<0.1	<0.1	0.0
21 APR 86	59	0.0	0.1	0.7	3.3	5.6	4.7	7.1	5.5	3.9	2.1	0.7	0.2	0.1	<0.1	<0.1
28 APR 86	47	0.0	<0.1	0.1	0.6	0.9	1.1	1.8	1.6	1.7	0.6	0.2	<0.1	<0.1	0.0	0.0
05 MAY 86	37	0.0	0.1	0.2	0.6	1.3	0.9	0.5	0.4	0.5	0.2	0.1	<0.1	<0.1	0.0	0.0
12 MAY 86	9	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
TOTAL SETS	276															
STRIPED BASS PER SET		0.0	0.1	0.4	1.3	2.1	2.0	3.1	3.3	3.5	1.9	0.8	0.3	0.1	<0.1	<0.1

3.3.4 Length-Frequency Discussion

The Atlantic tomcod trawl selected for more small striped bass (<250 mm TL) compared to the striped bass trawl when both trawls were fished during the same weeks in the Battery. Small striped bass were probably extruded through the relatively coarse mesh (13 cm stretch mesh) in the body of the striped bass trawl or through the cod-end (7.5 cm stretch mesh), compared to the Atlantic tomcod trawl (7.6 cm stretch mesh in the body, 3.8 cm stretch mesh in the cod end; Appendix Table A). The significantly higher than expected number of intermediate-sized striped bass captured by the striped bass trawl compared to the tomcod trawl may be due to the larger area swept by the striped bass trawl, preventing escapement of relatively large fish.

The Jackson 280 seine captured more striped bass than expected in the ≥300 and 301-350 mm TL length groups and fewer than expected numbers of striped bass in the 401-450 mm TL group than the Kosalt plaice seine when the two seines were fished in the same region and week. However, during the week of 7 April 1986, Kosalt plaice seine was deployed on 7, 8 and 9 April while the Jackson 280 seine was fished on 10 and 11 April. It is possible that the two seines were exposed to different groups of striped bass within the week. The possibility of differential exposure to migrating groups of striped bass is suggested by the recapture in the Kosalt plaice seine on 11 April of the first striped bass that had been tagged and released from trawls in the Battery region. Tagged striped bass from the 1985-86 program were not recaptured by the seine effort prior to 11 April 1986 (Section 3.6; Appendix Table G). The appearance in the seine catch of fish tagged in the Battery towards the end of the week of 7 April may indicate that these fish had begun moving upriver and into the Tappan Zee and Croton-Haverstraw regions at that time. The Kosalt plaice seine may have been exposed to smaller fish from the Battery region which had moved into the Tappan Zee and Croton-Haverstraw regions (combined) and mixed with larger fish comprising the spawning stock which were caught earlier in the week of 7 April in the Jackson 280 seine. Additional support for the hypothesis that smaller fish migrated into upriver regions and mixed with larger fish during the week of 7 April is provided by the observed decrease in weekly mean size of the catch before and after the week of 7 April while significant differences did not exist between the mean size of fish caught by the two seines during that week, (Table 3-10), and by left skewness of the frequency distribution for the Jackson 280 seine while the Kosalt plaice seine distribution was skewed right.

The predominance of the smaller length classes (151-300 mm TL) in the striped bass and tomcod trawls and the predominance of larger length classes (301-550 mm TL) in the Jackson 280 seine and Kosalt plaice seine indicates that the trawls and the Scottish seines were exposed to two different groups of striped bass or that the larger striped bass captured by the seines were able to avoid the trawls. Avoidance was probably not important, since in 1984, when the striped bass trawl was fished in the Tappan Zee and Croton-Haverstraw regions at the same time as the Jackson 280 seine and Kosalt plaice seine, no significant difference in mean striped bass length was observed between the two gear (NAI 1985). In 1985-86, large striped bass may have passed through the Battery and Upper Harbor in the upper water column or through areas not fished by the trawls as they migrated upriver into the Tappan Zee and Croton-Haverstraw regions, and were therefore not exposed to capture by the trawls. Large fish may also have overwintered in the Tappan Zee and Croton-Haverstraw regions and were not exposed to the trawl effort.

The age of striped bass most efficiently captured by each gear can be estimated using previously collected age and size data for Hudson River striped bass (McLaren *et al*. 1981; TI 1981; Table 3-14). The tomcod trawl caught a greater than expected number of striped bass less than 250 mm TL, and probably more efficiently captures Age 0+ and Age 1+ striped bass compared to the striped bass trawl. Consequently, the tomcod trawl might be a more efficient gear for capturing young-of-the-

TABLE 3-14. RANGE OF MEAN TOTAL LENGTH FOR FEMALE AND MALE STRIPED BASS COLLECTED IN GILL NETS SET IN THE HUDSON RIVER DURING MARCH THROUGH JUNE 1976-1979.

	FEMALE (mm TL)			MALE (mm TL)		
AGE	1976[a]	1977[a]	1976-1979[b]	1976[a]	1977[a]	1976-1979[b]
1+	271	230		311	239	
2+	389	377	397-434	385	369	377-416
3+	456	469	448-481	439	453	428-460
4+	524	516	512-559	521	484	479-531
5+	577	618	594-642	565	563	568-586
6+	690	669	654-710	640	606	598-662
7+	737	728	723-762	741	647	683-740
8+	906	844	764-874	781	826	718-824
9+	937	924	784-941	867	764	790-872

[a]From McLaren *et al.* 1981

[b]From TI 1981, maximum and minimum values for the four years.

year and yearling striped bass. The striped bass trawl caught a greater than expected number of striped bass 251-450 mm TL, and probably more efficiently captures striped bass of Ages 1+ through 3+ compared to the tomcod trawl. It is more difficult to compare the age-efficiency of the Jackson 280 seine and Kosalt plaice seine to the striped bass and tomcod trawls since the seines fished in an area and time not fished by the trawls. However, based on the 1984 and 1986 length-class frequencies (Table 3-7), the Jackson 280 seine probably is an efficient gear for capturing striped bass older than Age 3+. Alternatively, the Jackson 280 seine may have been exposed for a longer period of time to these older fish because it was fishing in an area where older migrating striped bass are known to congregate (TI 1979).

3.4 HANDLING MORTALITY

Handling mortality statistics provide a basis for comparing fishing gear and methods of capture and for selecting techniques which minimize mortality due to the capture and tagging of striped bass. Differences in striped bass handling mortality by gear (striped bass trawl, tomcod trawl, and Scottish seines), and between programs (1984, 1985-86) were assessed by comparing the percentage of dead fish in the catch in one degree temperature increments and in comparable temperature ranges. Since the 1984 striped bass program was conducted in the spring while the 1985-86 program was conducted in the winter and spring seasons, the only bottom water temperature range common among gear and both programs was 8-14°C. The surface water temperature range common among gear and between the 1984 and 1985-86 programs was 8-13°C.

Striped bass handling mortality in the striped bass trawl at bottom water temperatures of 8-14°C was approximately ten times lower in 1985-86 (<1.0%) than in 1984 (9.6%; Table 3-15). Handling mortality was 2.0% in 1985-86 at bottom water temperatures colder than those experienced in 1984 (1-7°C), and was not significantly different from the

TABLE 3-15. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN A STRIPED BASS TRAWL AND A TOMCOD TRAWL IN RELATION TO BOTTOM WATER TEMPERATURE.

	1984 STRIPED BASS TRAWL HANDLING MORTALITY		1985-86 STRIPED BASS TRAWL HANDLING MORTALITY		1985-86 TOMCOD TRAWL HANLDING MORTALITY	
	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n
Bottom Water Temperature (°C)						
1			0	166	0	45
2			1	548	<1	856
3			1	477	1	1489
4			1	819	1	1521
5			3	573	2	720
6			4	691	1	882
7			2	147	2	403
8	6	62	0	675	1	423
9	5	93	3	65	3	521
10	0	1	0	4	15	13
11	13	90	0	8	0	2
12	0	19	0	20	3	130
13	11	94	0	18	2	309
14	21	28	0	19		
15	51	102				
16	0	7				
All Temperatures	18	496	1.7	4230	1.3	7314

n = number of fish in the catch

handling mortality observed between 8-14°C. The relationship between striped bass handling mortality and surface water temperature was similar for the striped bass trawl as was observed for bottom water temperature (Tables 3-16). Handling mortality in the 8-13°C surface water temperature range was < 1% for the striped bass trawl in 1985-86, and 7.4% for the striped bass trawl in 1984. Handling mortality in the 8-16°C surface water temperature range was 18% for the striped bass trawl in 1984 and < 1% for the striped bass trawl in 1985-86.

Striped bass handling mortality in the tomcod trawl during 1985-86 was similar to the striped bass trawl in the same program, and was approximately ten times less than that observed for the striped bass trawl in 1984. Handling mortality in the 8-13°C bottom water temperature range common to both trawls was 2.4% for the tomcod trawl in 1985-86, compared to < 1% for the striped bass trawl in 1985-86 and 8.6% for the striped bass trawl in 1984. The only temperature increment where handling mortality in the tomcod trawl approached 1984 levels was at 10°C (Table 3-15). However, 13 fish were captured at that temperature and only 2 fish died, relatively small numbers for accurately determining a proportion (percentage) from a binomial distribution. Handling mortality was 1.1% in the 0-7°C bottom water temperature range for the tomcod trawl in 1985-86, and 1.3% over all bottom water temperatures. Striped bass handling mortality in relationship to surface water temperature for the tomcod trawl was 2.4% in the 8-13°C temperature range (Table 3-16) and exhibited the same low mortality compared to the 1984 striped bass trawl as was observed for bottom water temperature (Table 3-15).

Striped bass handling mortality for the Scottish seine (Jackson 280 and Kosalt plaice seines combined) was approximately 14 times lower in 1986 (1.1%) compared to 1984 (15%) for the 7-15°C bottom water temperature range common to both programs (Table 3-17). Similarly, the Scottish seine exhibited dramatic reductions in handling mortality at surface water temperatures comparable with the 1984 program (Table 3-18).

TABLE 3-16. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN A STRIPED BASS TRAWL AND A TOMCOD TRAWL IN RELATION TO SURFACE WATER TEMPERATURE.

	1984 STRIPED BASS TRAWL HANDLING MORTALITY		1985-86 STRIPED BASS TRAWL HANDLING MORTALITY		1985-86 TOMCOD TRAWL HANLDING MORTALITY	
	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n
Surface Water Temperature (°C) 0			6	34	1	126
1			1	624	<1	768
2			1	320	1	822
3			3	1308	1	2305
4			2	741	1	1481
5			2	341	1	225
6			0	59	3	198
7			0	16	2	458
8	8	40	1	255	3	493
9	4	97	<1	427	0	11
10	11	9	0	103	5	59
11	15	79	0	71	6	33
12	0	25	0	6	1	234
13	5	59	0	40	1	115
14	16	55				
15	47	60	0	12		
16	36	89	0	7		
17	0	3				
18	0	1				
All Temperatures	18	517	1.6	4364	1.3	7328

n = number of fish in the catch

TABLE 3-17. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN THE SCOTTISH SEINE IN 1984 AND 1986 IN RELATION TO BOTTOM WATER TEMPERATURE.

		1984 SCOTTISH SEINE HANDLING MORTALITY		1986 SCOTTISH SEINE HANDLING MORTALITY	
		% OF CATCH DEAD	n	% OF CATCH DEAD	n
Bottom Water Temperature (°C)	7	0	5	0	35
	8	12	277	<1	766
	9	14	211	1	1641
	10	15	27	1	2103
	11	0	3	2	1599
	12	21	43	3	215
	13	0	5	1	357
	14	26	27	2	237
	15	27	60	0	3
	16	53	17		
All Temperatures		16	675	1.1	6956

n = number of fish in the catch

TABLE 3-18. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN THE SCOTTISH SEINE IN 1984 AND 1986 IN RELATION TO SURFACE WATER TEMPERATURE.

		1984 SCOTTISH SEINE HANDLING MORTALITY		1986 SCOTTISH SEINE HANDLING MORTALITY	
		% OF CATCH DEAD	n	% OF CATCH DEAD	n
Surface Water Temperature (°C)	7			0	46
	8	11	265	<1	985
	9	14	234	1	1714
	10	15	27	1	2187
	11	0	3	2	1761
	12	21	43	2	473
	13	0	2	1	351
	14	25	28	1	335
	15	30	44	0	19
	16	34	35		
All Temperatures		15.6	681	1	7871

n = number of fish in the catch

3.4.1 Handling Mortality Discussion

3.4.1.1 Improved Handling Mortality Due To Use Of A Holding Facility

Striped bass handling mortality in the 1985-86 program was uniformly low among the gear used and was substantially lower than the 1984 program. The major reason for the ten-fold improvement in overall handling mortality for the trawls and a fourteen-fold improvement in handling mortality for the Scottish seine was reduced stress due to transfer of the cod end into a holding facility that was submerged and secured along side the tagging vessel. The holding facility permitted transfer of each catch from the cod end into the holding tank while the fish remained in the water until they were individually removed and tagged. In contrast, during the 1984 program, the cod end of the net was lifted out of the water and fish were compressed by their weight in air as they were transferred to the on-deck holding tanks.

Higher salinity may also have contributed to the ten-fold improvement in handling mortality for the striped bass trawl in 1985-86 compared to 1984, since trawling during 1985-86 occurred in the lower Hudson River in generally higher salinity waters than experienced during 1984. River salinities in the Battery and Upper Harbor regions (below river mile 14; km 22) ranged between 19 and 26 ppt during the 1985-86 trawl program, while in 1984, salinities ranged from 0-14 ppt in the trawl sampling region between river miles 24 and 100 (km 38-160). Furthermore, most trawl sampling in 1984 occurred in waters with salinity less than 5 ppt. However, a similar order of magnitude improvement in handling mortality was observed for the Scottish seine in 1985-86 compared to 1984, and salinity ranges in both years' seine programs were the same. Therefore, the substantial improvement in striped bass handling mortality in the trawls during 1985-86 does not appear to be due to salinity differences between the 1984 and 1985-86 programs.

3.4.1.2 Improved Handling Mortality Due To Tagging Efficiency

Increased speed of tagging also contributed to the improvement in handling mortality in 1985-96 compared to 1984, but to a lesser extent than the holding facility. With increased tagging speed, striped bass were exposed to air and handled for a relatively brief period of time, thus reducing stress by returning tagged fish to the water quickly. Increased tagging speed was facilitated by fabrication of on-deck tagging tables which helped organize the tagging and data recording, and by availability of the trawling crew to assist the tagging crew in handling large catches. Crew experience probably also improved throughout the program due to the relatively large number of fish handled in 1985-86 compared to 1984.

The contribution of increased tagging speed to improved striped bass handling mortality in 1985-86 can be inferred by identifying the apparent reasons for the observed slight decrease in handling mortality at higher water temperatures for the striped bass trawl while handling mortality increased slightly in the tomcod trawl at higher water temperatures (Tables 3-15 and 3-16). Since most of the striped bass trawl sampling at warmer water temperatures occurred later in the program (April and May 1986; Section 3.5; Appendix Table B), the observed decrease in handling mortality for the striped bass trawl may have been due to increased tagging speed by the field crew. Similarly, the slight increase in handling mortality at higher temperatures in the tomcod trawl may have been due to improvements in handling technique as the program progressed. Warmer water temperatures in the tomcod trawling effort occurred in November 1985 at the start of the sampling season (Section 3-5; Appendix Table B), when tagging speed was probably slower than later in the program. Therefore, the observed small decreases in handling mortality for the tomcod trawl at lower water temperatures may have been due to faster tagging rates at the end of the program. Consistent, low handling mortality for the 1986 Scottish seine effort at comparable warm spring temperatures also supports the hypothesis that the combination of an in-water holding facility and increased tagging speed resulted in substantially lower handling mortality than was observed in 1984.

Striped bass handling mortality at low water temperatures (0-7°C) was generally similar to handling mortality observed at warmer water temperatures (8-14.5°C) and should not present a constraint to tagging operations. Striped bass handling mortality at high temperatures (8-14.5°C) was significantly lower than that observed in 1984, which suggests that with the improved in-water holding facilities and handling techniques developed in the 1985-86 program, tagging could have been conducted at bottom water temperatures greater than 14.5°C with handling mortality less than in 1984.

3.4.1.3 Regression Relationships Between Handling Mortality and Water Temperature

In 1984, regressions of striped bass handling mortality against water temperature were significant with positive slopes for selected (temperature increments with small numbers of fish excluded) data from the Scottish seine (two-coil sets, bottom water temperature) and from the striped bass trawl (surface water temperature), indicating mortality increased at higher water temperatures. The regression approach was also applied to the 1985-86 data to determine if similar positive relationships existed between water or air temperature and handling mortality for the trawls and seines. Regressions of water temperature or air temperature against handling mortality were significant with negative slopes for the striped bass trawl in 1985-86, indicating decreased mortality at warmer water temperatures (subset c, Table 3-19). However, the small magnitude of the regression slopes indicated that a very large change in temperature was needed to observe a measurable change in handling mortality. Although the regressions were

TABLE 3-19. REGRESSION STATISTICS FOR REGRESSION OF HANDLING MORTALITY (PropD) ON ENVIRONMENTAL VARIABLES FOR STRIPED BASS CAPTURED IN AN ATLANTIC TOMCOD TRAWL AND STRIPED BASS TRAWL NOVEMBER 1985 THROUGH MAY 1986.

GEAR	DEPENDENT VARIABLE	F	pr>F	r^2	ARCSINE INTERCEPT (STANDARD ERROR)	ARCSINE SLOPE (STANDARD ERROR)	PREDICTED PropD 0°C	PREDICTED PropD 10°C	ΔPropD[a]
Atlantic tomcod trawl	Surface Water Temperature	13.97	0.0002	0.018	0.521 (0.308)	0.227 (0.061)	<0.0001	0.0024	0.0024
	Bottom Water Temperature	19.59	0.0001	0.024	0.152 (0.346)	0.266 (0.060)	<0.0001	0.0024	0.0024
	Air Temperature	2.31	0.1287	0.004	---	---	Not Significant		
Striped bass trawl[b] (subset)	Surface Water Temperature	2.19	0.1424	0.022	---	---	Not Significant		
	Bottom Water Temperature	0.24	0.625	0.002	---	---	Not Significant		
	Air Temperature	2.12	0.1499	0.028	---	---	Not Significant		
Striped bass trawl[c] (all data)	Surface Water Temperature	26.36	0.0001	0.086	4.194 (0.574)	-0.360 (0.070)	0.0053	0.0001	0.0052
	Bottom Water Temperature	18.18	0.0001	0.06	4.122 (0.663)	-0.359 (0.084)	0.0051	<0.0001	0.0051
	Air Temperature	13.11	0.0004	0.049	2.559 (0.453)	-0.120 (0.033)	0.002	0.0006	0.0014
Scottish seine (all data)	Surface Water Temperature	0.05	0.8230	<0.001	---	---	Not Significant		
	Bottom Water Temperature	0.02	0.8936	<0.001	---	---	Not Significant		
	Air Temperature	0.68	0.4088	<0.002	---	---	Not Significant		

[a] ΔPropD = the change in predicted PropD between 0 and 10°C.

[b] Striped bass trawl data subset for the Battery Region prior to 21 March 1986, to match Atlantic tomcod trawl data set.

[c] Striped bass trawl data including all regions, all dates.

statistically significant, finding a negative relation between water temperature and handling mortality was inconsistent with the common literature on fish physiology (Fry 1967; Prosser 1973). The most meaningful biological interpretation of the slight negative relationship between water or air temperature and handling mortality for the striped bass trawl, was that sampling at warm temperatures with this trawl was primarily late in the program (April and May 1986) when tagging speed had increased to its greatest efficiency. Therefore, crew experience and not increased water temperature was probably the causal factor producing the statistically significant negative regression equations.

Regressions of handling mortality against water temperature were significant with a positive slope for the tomcod trawl, indicating handling mortality increased at warmer water temperatures (Table 3-19). However, the magnitude of the increase was extremely small. A 10°C increase in water temperature from 0 to 10°C resulted in an increase in the percentage of dead striped bass of only 0.24% in the tomcod trawl. As with the striped bass trawl, the regression equations for the tomcod trawl were statistically significant, but r^2 values and slopes were extremely small and probably not biologically meaningful. The most meaningful biological interpretation of the positive relationship found between water temperature and handling mortality for the tomcod trawl, was the aforementioned increase in tagging speed by field crews which occurred later in the tomcod trawling program at colder water temperatures. Since tomcod trawling ended 21 March 1986, warm water temperatures were experienced earlier in the program (November 1985), and the slightly higher handling mortality at warm temperatures was due to slower tagging rates which increased later in the program at colder water temperatures.

3.5 CATCH PER UNIT EFFORT

Mean striped bass catch per unit effort (CPUE) is summarized in this section by gear, region, week, and river mile (km). Mean CPUE was calculated for the striped bass trawl, tomcod trawl, Kosalt plaice seine, and Jackson 280 seine for successful (Use Code = 1) samples to determine the best sampling method, location, and time to capture and tag striped bass in a mark-recapture program. The tomcod trawl was deployed 5 days per week for the period 11 November 1985 through 21 March 1986 in the Battery region as part of an Atlantic tomcod stock assessment program. The striped bass trawl was deployed one day per week during this period in the Battery region to compare CPUE between the two trawls. The striped bass trawl was also deployed one day per week in an exploratory effort to identify sampling regions with high striped bass CPUE outside of the Battery. For the period 22 March through 16 May 1986, the striped bass trawl was deployed 5 days per week in the Battery and adjacent regions to capture, tag, and release striped bass during the spring, upriver spawning migration.

Scottish seining was conducted in the Tappan Zee and Croton-Haverstraw regions from 31 March 1986 through 13 May 1986 between river miles 25 (km 40) and 39 (km 63) in an attempt to recapture striped bass tagged by the striped bass and tomcod trawls as they migrated upriver to spawn. Two seines were used, a Jackson 280 seine, and a Kosalt plaice seine. The Jackson 280 seine was considered the primary Scottish seine and the Kosalt plaice seine was the back-up Scottish seine that was used to permit fishing to continue whenever the Jackson 280 seine was damaged and being repaired. The Kosalt plaice seine was deployed during the weeks of 31 March and 7 April 1986 and once during the week of 14 April 1986. The Jackson 280 seine was deployed from 7 April through 13 May, 1986.

3.5.1 Striped Bass Trawl CPUE

Overall mean CPUE for the striped bass trawl for all regions and weeks combined was 20.74 striped bass per ten minute tow (Table 3-20). Greatest mean CPUE for the striped bass trawl was in the Upper Harbor region (35.90). In decreasing order, mean CPUE was next highest in the Battery region (23.12), Harlem River (10.88), and East River (3.22). The Lower Harbor, Rockaway Inlet, and Raritan Bay had the lowest mean CPUE, and the least amount of sampling effort.

Within the Upper Harbor region, mean CPUE for the striped bass trawl peaked during the weeks of 31 March and 7 April 1986, and was greatest from the weeks of 24 March through 14 April 1986 (Table 3-21). After the week of 14 April, mean CPUE in the Upper Harbor decreased in successive weeks to zero for the last two weeks of the program. Upper Harbor mile 2 (km 3) had the greatest mean CPUE (42.94; Table 3-22).

The Battery region received the greatest amount of sampling effort by the striped bass trawl (56%), and mean CPUE exhibited a distinct peak in the week of 23 December 1985 and a secondary peak in the week of 17 February 1986 (Table 3-23). A period of relatively high mean CPUE was observed from the week of 16 December 1985 through the week of 24 February 1986 (Table 3-23). In the Battery, mean CPUE was greatest between river miles 8 (km 13) through 10 (km 16) and ranged from 27.50 to 54.36 (Table 3-24). River mile 5 (km 8) received the greatest amount of sampling effort (27%) and had a mean CPUE of 18.85.

Coincident with the beginning of the observed period of relatively high CPUE for the striped bass trawl in the Battery was replacement of 3-foot (1.0 meter), steel, V-doors with 4-foot (1.3 meter) doors during the week of 16 December 1985. Although the larger doors may have contributed to the increased striped bass trawl CPUE, a concurrent increase in CPUE in the tomcod trawl was observed (see

TABLE 3-20. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL IN THE LOWER HUDSON RIVER AND ADJACENT REGIONS BETWEEN 11 NOVEMBER 1985 AND 16 MAY 1986.

REGION	MEAN CATCH PER TEN MINUTE TOW	NUMBER OF TOWS	STANDARD ERROR
Upper Harbor	35.90	63	5.61
Battery	23.12	194	2.57
Harlem River	10.88	29	2.16
East River	3.22	35	0.70
Lower Harbor	0.19	16	0.19
Rockaway Inlet	0.00	4	0.00
Raritan Bay	0.00	5	0.00
TOTAL	20.74	346	1.86

TABLE 3-21. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL AND TOMCOD TRAWL IN THE UPPER NEW YORK HARBOR BY WEEK FROM 3 FEBRUARY THROUGH 16 MAY 1986.

UPPER HARBOR						
	TOMCOD TRAWL			STRIPED BASS TRAWL		
		CPUE			CPUE	
	TOWS	MEAN	S.E.	TOWS	MEAN	S.E.
WEEK						
03FEB86	0			5	14.20	4.31
17FEB86	11	0.73	0.30	0		
24MAR86	0			6	30.00	9.06
31MAR86	0			8	65.25	9.28
07APR86	0			15	67.53	17.16
14APR86	0			9	44.11	9.98
21APR86	0			8	8.50	3.01
28APR86	0			8	1.37	0.46
05MAY86	0			1	0.00	
12MAY86	0			3	0.00	0.00
TOTAL MEAN	11	0.73	0.30	63	35.90	5.61

TABLE 3-22. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL AND TOMCOD TRAWL IN UPPER NEW YORK HARBOR AT HARBOR MILES 1 THROUGH 3, 3 FEBRUARY THROUGH 16 MAY 1986.

UPPER HARBOR						
	TOMCOD TRAWL			STRIPED BASS TRAWL		
		CPUE			CPUE	
	TOWS	MEAN	S.E.	TOWS	MEAN	S.E.
HARBOR MILE						
1	2	1.50	1.50	2	24.50	1.50
2	0			47	42.94	7.04
3	9	0.56	0.24	14	13.93	5.93
TOTAL CPUE	11	0.73	0.30	63	35.90	5.61

TABLE 3-23. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL AND TOMCOD TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER BELOW RIVER MILE 14, 11 NOVEMBER THROUGH 16 MAY 1986.

	THE BATTERY					
	TOMCOD TRAWL			STRIPED BASS TRAWL		
		CPUE			CPUE	
	TOWS	MEAN	S.E.	TOWS	MEAN	S.E.
WEEK						
11NOV85	7	1.71	0.94	0		
18NOV85	60	6.00	1.00	2	6.50	0.50
25NOV85	24	3.37	1.49	0		
02DEC85	46	10.93	1.67	6	2.17	0.98
09DEC85	46	5.65	1.03	12	6.42	1.83
16DEC85	68	14.50	2.20	8	32.12	21.98
23DEC85	19	24.95	7.76	3	124.3	52.87
30DEC85	33	21.73	3.30	6	60.67	18.88
06JAN86	49	13.82	2.69	2	42.00	21.00
13JAN86	54	11.57	2.21	7	39.71	4.25
20JAN86	49	9.16	0.87	10	34.30	17.19
27JAN86	51	4.22	0.39	6	49.83	21.89
03FEB86	51	5.24	0.84	0		
10FEB86	48	6.25	0.58	8	21.62	7.46
17FEB86	38	3.18	0.50	5	88.00	26.85
24FEB86	60	2.13	0.33	5	42.80	17.63
03MAR86	67	2.30	0.27	3	4.67	1.86
10MAR86	55	2.00	0.35	12	17.25	4.32

(CONTINUED)

TABLE 3-23. (continued)

THE BATTERY

	TOMCOD TRAWL			STRIPED BASS TRAWL		
		CPUE			CPUE	
	TOWS	MEAN	S.E.	TOWS	MEAN	S.E.
WEEK						
17MAR86	64	14.22	1.15	13	26.69	8.76
24MAR86	0			10	15.30	5.05
31MAR86	0			18	12.57	2.40
07APR86	0			18	16.28	4.60
14APR86	0			14	18.86	6.01
28APR86	0			7	1.71	0.75
05MAY86	0			10	2.10	0.67
12MAY86	0			9	2.11	1.24
TOTAL MEAN	889	8.27	0.42	194	23.12	2.57

TABLE 3-24. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL AND TOMCOD TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER BETWEEN RIVER MILES 1 THROUGH 14, 11 NOVEMBER 1985 THROUGH 16 MAY 1986.

THE BATTERY

	TOMCOD TRAWL			STRIPED BASS TRAWL		
		CPUE			CPUE	
	TOWS	MEAN	S.E.	TOWS	MEAN	S.E.
RIVER MILE						
1	79	9.68	1.00	42	10.21	2.67
2	1	0.00		0		
3	5	2.40	1.25	0		
4	3	1.67	1.20	0		
5	732	7.58	0.44	52	18.85	3.27
6	17	9.76	1.65	1	7.00	
7	2	13.00	1.00	15	15.80	4.83
8	3	27.00	21.00	11	54.36	15.55
9	9	44.56	10.71	43	42.95	8.50
10	11	8.45	4.76	4	27.50	5.56
11	23	9.61	1.19	12	11.67	4.28
12	2	8.50	2.50	0		
13	2	6.00	2.00	0		
14	0			14	9.71	2.67
TOTAL CPUE	889	8.27	0.42	194	23.12	2.57

Section 3.5.2) and that trawl did not undergo any gear modification. Therefore, the increase in CPUE observed in the striped bass trawl from the week of 16 December to the week of 23 December 1985 probably reflects a true increase in abundance of striped bass at that time, not a change in trawl door size.

Lower mean CPUE in the Harlem River, East River, Lower Harbor, Rockaway Inlet, and eastern Raritan Bay than in the Battery and Upper Harbor regions was partially due to the exploratory nature of trawling in those regions. Relatively few tows were taken in this exploratory effort (26%) because most of the time was spent finding sampling stations in these regions with unobstructed bottom conditions. In the Harlem River, mean CPUE was greatest during the weeks of 21 April through 5 May 1986 at Harlem River mile 1, the only site sampled in the Harlem River (Table 3-25). East River mean CPUE was greatest in the week of 7 April 1986 (Table 3-25) at East River miles 13 and 14 (km 21-22). Highest mean CPUE in the East River among all sampling weeks was at East River mile 12 (km 19). One striped bass was captured during the week of 21 April 1986 in the Lower Harbor region and no striped bass were captured in Rockaway Inlet and eastern Raritan Bay.

The mean number of striped bass that can be caught in, and tagged and released from the striped bass trawl in one day, based on the 1985-86 program, is calculable from the mean catch per tow and number of tows per day, or from the maximum daily catch. The striped bass trawl had a mean catch of 23.1 striped bass per tow and a mean of 5.1 tows per sampling day in the Battery region; an estimated mean of approximately 118 striped bass could be enumerated, tagged and released daily. The maximum number of striped bass handled in one day in the Battery region by the striped bass trawl was 373 in 3 tows on 28 December 1985. In the Upper Harbor, the striped bass trawl had a mean catch of 35.9 striped bass per tow and a mean of 4.5 tows per sampling day; an estimated mean of approximately 162 striped bass could be enumerated, tagged and

TABLE 3-25. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE STRIPED BASS TRAWL IN THE EAST RIVER, HARLEM RIVER, AND LOWER NEW YORK HARBOR BETWEEN 13 JANUARY AND 16 MAY 1986.

	EAST RIVER			HARLEM RIVER			LOWER HARBOR		
WEEK	TOWS	CPUE MEAN	S.E.	TOWS	CPUE MEAN	S.E.	TOWS	CPUE MEAN	S.E.
13 Jan 86	0			1	1.00		0		
20 Jan 86	0			2	0.50	0.50	0		
24 Mar 86	3	3.27	2.67	1	2.00		0		
31 Mar 86	4	3.00	2.12	1	2.00		0		
7 Apr 86	4	7.26	4.12	0			0		
14 Apr 86	6	3.17	1.94	0			1	0.00	
21 Apr 86	9	3.11	0.89	9	16.39	4.84	3	1.00	1.00
28 Apr 86	3	2.33	1.86	2	13.50	7.50	5	0.00	
5 May 86	3	0.33	0.33	9	14.11	3.37	4	0.00	
12 May 86	3	2.22	0.62	4	2.00	1.00	3	0.00	
Total	35	3.22	0.70	29	10.88	2.16	16	0.19	0.19

released daily. The maximum number of striped bass handled in one day in the Upper Harbor by the striped bass trawl was 666 in 12 tows on 7 April 1986.

3.5.2 Tomcod Trawl CPUE

The tomcod trawl was primarily deployed in the Battery region for an Atlantic tomcod stock assessment program. Striped bass were enumerated as the bycatch in the Atlantic tomcod trawl to provide additional tagged fish and for comparison of the fishing characteristics of the two trawls. Overall mean CPUE for the tomcod trawl was 8.17 striped bass per ten minute tow (S.E.=0.42). Mean CPUE was greatest in the Battery region (8.27 striped bass per ten minute tow) where the majority (99%) of the tomcod trawl samples were taken. In the Upper Harbor region, where the tomcod trawl was fished only one day in the week of 17 February 1986, mean CPUE was 0.73 based on 11 tows.

Mean CPUE of striped bass in the tomcod trawl peaked during the weeks of 16 through 23 December 1985 and was generally greatest from the week of 16 December 1985 through the week of 20 January 1986 (Table 3-23). Mean CPUE generally decreased after the week of 23 December 1985 until the last week of tomcod trawl sampling (week of 17 March 1986) when mean CPUE increased to 14.22. Mean CPUE in the tomcod trawl was greatest at river mile 9 (km 14), however the majority of tows (82.3%) were taken at river mile 5 (km 8) where the most consistent catches (lowest coefficient of variation; standard error/meanX100 = 5.8%) were observed (Table 3-24).

The mean number of striped bass that can be caught in, and tagged and released from the tomcod trawl in one day, based on the 1985-86 program, is calculable from the mean catch per tow and number of tows per day, or from the maximum daily catch. The tomcod trawl had a mean catch of 8.3 striped bass per tow and a mean of 14.5 tows per sampling day in the Battery region; an estimated mean of approximately 120 striped bass could be enumerated, tagged, and released daily. The maximum number of striped bass handled in one day in the Battery region by the tomcod trawl was 424 in 23 tows on 18 March 1986.

3.5.3 Jackson 280 Seine and Kosalt Plaice Seine CPUE

Mean CPUE for the Jackson 280 seine and the Kosalt plaice seine combined across all weeks in the Tappan Zee and Croton-Haverstraw regions was 19.35 striped bass per one coil set, and was greatest during the weeks of 7 April and 21 April 1986 (Table 3-26). During the week of 7 April, 67% of the seine effort was at river mile 30 (km 49), while in the week of 21 April, 90% of the seine effort was at river mile 36 (km 60). Combined mean CPUE for the seines generally decreased each week after the week of 21 April until the program ended on 13 May 1986. Mean CPUE for the Jackson 280 seine was 15.63, and was greatest during the week of 21 April 1986 (35.40; Table 3-26). Mean CPUE for the Kosalt plaice seine was 36.67, and was greatest during the week of 7 April 1986 (54.56).

The mean number of striped bass that can be caught in, and tagged and released from the Scottish seine (Jackson 280 seine and Kosalt plaice seine combined) in one day, based on the 1985-86 program, is calculable from the mean catch per one coil set and the number of sets per day, or from the maximum daily catch. The Scottish seine had a combined mean daily catch per one coil set of 19.4 and a mean of 7.7 sets per day; an estimated mean of approximately 149 striped bass could be processed daily. The maximum number of striped bass handled in one day was 425 on both 13 and 26 April 1986 from 5 and 8 one coil sets respectively.

TABLE 3-26. MEAN CATCH OF STRIPED BASS PER ONE COIL SET FOR THE JACKSON 280 SEINE AND KOSALT PLAICE SEINE IN THE HUDSON RIVER BETWEEN RIVER MILES 25 AND 39 (km 40-63) FROM 31 MARCH THROUGH 13 MAY 1986.

	JACKSON 280 SEINE			KOSALT PLAICE SEINE			COMBINED		
WEEK	TOWS	CPUE MEAN	S.E.	TOWS	CPUE MEAN	S.E.	TOWS	CPUE MEAN	S.E.
31 MAR 86	0			14	6.86	4.60	14	6.86	4.60
7 APR 86	8	18.31	3.92	25	54.56	8.92	33	47.77	7.32
14 APR 86	53	10.94	1.76	1	7.00		54	10.87	1.73
21 APR 86	47	35.40	6.33	9			47	35.40	6.33
28 APR 86	36	9.64	3.24	0			36	9.64	3.24
5 MAY 86	34	4.79	0.78	0			34	4.79	0.78
12 MAY 86	8	0.75	0.25	0			8	0.75	0.25
TOTAL	186	15.63	1.99	40	36.67	6.84	226	19.35	2.10

3.5.4 Catch per Unit Effort Discussion

3.5.4.1 Exploratory Sampling

Based on exploratory sampling with the striped bass trawl during the 1985-86 program, it appears most efficient to expend sampling effort in the Battery and Upper Harbor regions, because overall mean CPUE of striped bass was greatest in these regions. Mean catches outside of these regions were relatively low and do not appear to justify sampling in a program with the goal of maximizing striped bass catch. The limited number of exploratory tows outside the Battery and Upper Harbor may not have adequately described striped bass densities in the East River, Harlem River, and Lower Harbor regions. However, exploratory sampling was used to select the Upper Harbor (the region of greatest overall CPUE) for weekly sampling and to identify a station in the Harlem River with CPUE greater than in adjacent regions including the Battery and Upper Harbor during the weeks of 21 April through 5 May 1986. Therefore, although relatively labor intensive, the exploratory effort was valuable in this program and should be considered as part of future programs with the goal of maximizing CPUE.

3.5.4.2 Comparison of Trawls in the Battery

Deployment of the striped bass trawl on one day per week in the Battery region permitted comparison of the fishing characteristics of that gear with those of the tomcod trawl between 11 November 1985 and 21 March 1986. The striped bass trawl had a greater mean CPUE (32.4) than the tomcod trawl (8.3) when the two trawls were deployed in the Battery region at the same time. The greater mean CPUE of the striped bass trawl was primarily due to the relatively large mouth opening and spread between the doors compared to the tomcod trawl. This large mouth opening and spread allowed the striped bass trawl to sweep a greater bottom area and to filter more water than the tomcod trawl for every minute of fishing effort.

Both the striped bass trawl and the tomcod trawl are high-rise trawls scaled to the appropriate size based on foot rope dimensions. The striped bass trawl (12.2 m foot rope) is approximately one-third larger than the tomcod trawl (9.0 m foot rope) and has body and cod end mesh that are double the dimensions of the tomcod trawl (Appendix Table A). The striped bass trawl legs (18.3 m of wire rope connecting the head and foot ropes with the doors) are approximately three times longer than the legs of the tomcod trawl (6.0 m). To compare area fished by the two trawls, approximate spread between the doors was estimated as 70% of the linear distance between the doors along the legs and foot rope (personal communication from Mr. Peter Wilcox, net manufacturer, Wilcox Marine, Inc., 1984). Approximate spread between the striped bass trawl doors was 34 meters and was 2.3 times greater than the Atlantic tomcod trawl spread between the doors of approximately 15 meters. Therefore, each unit of effort (tow) by the striped bass trawl represented approximately twice the area fished by a unit of effort for the tomcod trawl. Since doubling the effective fishing area has been observed to more than double the catch (2-3 times; Kuipers 1975), the four-fold increase in CPUE for the striped bass trawl compared to the tomcod trawl was primarily due to the larger area fished.

Extrusion of small striped bass (less than 200 mm TL) through the larger cod end mesh of the striped bass trawl may have reduced the observed difference in CPUE between the trawls (Section 3.3). However, small striped bass were less than 10% of the catch for both the tomcod trawl and the striped bass trawl. This small number of fish would contribute only minimally to the observed difference in CPUE between the trawls compared to the aforementioned differences in area fished. Factors affecting gear avoidance such as detection and towing speed were minimized in this study by Standardized Operating Procedures (NAI 1986a) which required ten-minute tows into river currents at approximately the same towing speed for both trawls, and probably did not contribute substantially to the observed difference in CPUE.

In the Battery region between 11 November 1985 and 21 March 1986, the mean number of striped bass that were handled per day was 155 for the striped bass trawl compared to 120 for the tomcod trawl. However, more tows were made per day by the tomcod trawl (mean = 14.5 tows per day) compared to the striped bass trawl (mean = 5.1 tows per day). The tomcod trawl was deployed more frequently for two reasons: 1) less time was required to handle striped bass catches from the tomcod trawl due to the lower CPUE of striped bass, and 2) the tomcod trawl was easier to deploy, so field crews could set and retrieve the trawl faster than the larger striped bass trawl.

The two most important factors determining the number of striped bass caught, enumerated, tagged and released in one day were: 1) the distribution and density of striped bass within the study area and 2) the size and uniformity of the catch in individual tows. Since one of the objectives of the program was to maximize the number of striped bass caught, tagged and released, little time would be expended traveling among sampling stations if high or uniform densities were encountered. Field crews generally expended the greatest effort during a non-exploratory sampling day fishing at the stations nearest to the location where the sampling vessels were docked (river mile 5; km 8) which produced the largest catches. When catches were low, more time was expended traveling in search of stations with relatively high striped bass densities.

The optimal number of striped bass caught to achieve maximum survival and numbers handled was between 20 and 60 per tow. If catches larger than this were landed, crews on both the trawling boat and tagging boat were needed to process the catch quickly and minimize handling mortality. If catches were between 20 and 60 striped bass per tow, the tagging boat alone could process all fish by the time the trawling boat had completed the next tow. In this manner, the trawling boat sampled continuously and processing of the catch did not limit the number of tows in a day. For example, the tomcod trawl had a greater maximum daily catch of striped bass in the Battery region (424) than the striped bass trawl (373) because the mean catch on that day per tomcod trawl tow was only 18 fish compared to a mean catch per tow of 124 fish in the striped bass trawl. More tomcod trawl tows were taken on that day (23 tows) resulting in a greater maximum catch compared with the striped bass trawl (3 tows). In the Upper Harbor region, the maximum daily catch of striped bass by the striped bass trawl (666) was greater than in the Battery (373) because the mean CPUE for that day was 56 striped bass per tow and more tows could be taken (12 tows) because the trawling crew was not needed to assist the tagging crew.

3.5.4.3 Comparison of Seines

Greater mean catch per unit effort for the Kosalt plaice seine compared to the Jackson 280 seine may be due to 1) different fishing characteristics or 2) exposure to different groups of migrating striped bass. Sampling effort for the two seines was segregated in time, therefore, direct comparisons of CPUE between the two seines was not appropriate. During the one week of apparent overlap in sampling effort by the two seines (7 April 1986), 25 sets were made with the Kosalt plaice seine from 7 April through 9 April 1986, while 8 sets were made with the Jackson 280 seine on 10 April and 11 April 1986. Thus, sampling did not occur on the same days in the week. The upriver movement of tagged striped bass (first recapture by the seines of a fish tagged in the Battery was on 11 April; see Section 3.6) and changes in size distribution of the catch before and after the week of 7 April 1986 (Section 3.3) suggest that the first appearance of relatively small striped bass from the Battery occurred after 9 April 1986. Therefore, the reason for differences in CPUE between the two seines could not be explained in the 1985-86 program.

The mean catch of striped bass per one coil set during the 1984 Scottish seine program was 11.36 (Table 3-27), based upon data which were subset to be comparable with the gear (Jackson 280 and Kosalt plaice seines combined), weeks (1 April-12 May), and Hudson River regions (Tappan Zee and Croton-Haverstraw, river miles 25-39; km 40-63) that were sampled by the Scottish seine in 1986 (Table 3-26). A mid-April peak in mean catch per one coil set was observed in 1984 which corresponded with a similar peak in mean CPUE in 1986. Therefore, the early to mid-April period was the best time to fish the Scottish seine in the Tappan Zee and Croton-Haverstraw regions to maximize CPUE. After mid-April, striped bass apparently move upriver into the West Point and Cornwall regions (river miles 47-61; km 75-98) which cannot be as effectively fished with the Scottish seine due to rocky substrate (NAI 1985). Therefore these regions were not sampled in 1986.

3.6 MOVEMENT OF STRIPED BASS

Striped bass movements within the study area and study period were characterized by examining the recapture patterns of striped bass cross-classified by release and recapture areas and time periods.

3.6.1 Trawl Sampling

The combined Battery and Upper Harbor regions contributed more than 96% of the taggable-size ($\geq$ 200 mm TL) striped bass caught by trawls (14,484 fish) and 98% of the fish recaptured by trawls (174 fish) in this study (Table 3-28, Appendix Table D). Trawling in the Harlem River provided two recaptured fish; one was released in the Harlem River

TABLE 3-27. MEAN CATCH OF STRIPED BASS FOR THE SCOTTISH SEINE (JACKSON 280 AND KOSALT PLAICE SEINES COMBINED) IN THE HUDSON RIVER BETWEEN RIVER MILES 25 AND 39 (KM 40-63) FROM 1 APRIL THROUGH 12 MAY 1984.

DATE (1984)	NUMBER OF SETS	MEAN CATCH PER ONE COIL SET[1]	STANDARD ERROR OF MEAN
1 Apr-07 Apr	0		
8 Apr-14 Apr	5	1.10	0.68
15 Apr-21 Apr	3	39.67	20.54
22 Apr-28 Apr	5	14.90	6.48
29 Apr-05 May	0		
6 May-12 May	5	1.10	0.75
Total	18	11.36	4.75

[1]Catch per two coil set was divided by 2.00 to estimate catch per one coil set for all sets in 1984 except 1 one coil set from the week of 22 April 1984.

TABLE 3-28. RECAPTURE OF STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE LOWER HUDSON RIVER ESTUARY, NEW YORK HARBOR, EAST RIVER AND HARLEM RIVER FROM 11 NOVEMBER 1985 THROUGH 16 MAY 1986.[1]

RELEASE REGION (gear)	NUMBER MARKED (M)	STATISTIC	NUMBER OF RECAPTURES IN REGION (gear): TAPPAN ZEE-CROTON (SCOTTISH SEINE) C = 5198	BATTERY (TRAWLS) C = 11249	UPPER HARBOR (TRAWLS) C = 2794	HARLEM RIVER (TRAWLS) C = 316	EAST RIVER (TRAWLS) C = 121	LOWER HARBOR (TRAWLS) C = 4	TOTAL C = 19682
TAPPAN ZEE-CROTON (SCOTTISH SEINE, RM 25-39; KM 40-63)	4856	R	19	0	1	0	1	0	21
		R/M	0.00391		0.00021		0.00021		0.00432
		R/C	0.00366		0.00036		0.00826		0.00107
BATTERY (TRAWLS RM 0-14; KM 0-23)	10569	R	30	110	38	0	0	0	178
		R/M	0.00284	0.01041	0.00360				0.01684
		R/C	0.00577	0.00978	0.01360				0.00904
UPPER NEW YORK HARBOR (TRAWLS)	2631	R	25	2	19	1	0	0	47
		R/M	0.00950	0.00076	0.00722	0.00038			0.01786
		R/C	0.00481	0.00018	0.00680	0.00316			0.00239
HARLEM RIVER (TRAWLS)	308	R	2	0	0	1	0	0	3
		R/M	0.00649			0.00325			0.00974
		R/C	0.00038			0.00316			0.00015
EAST RIVER (TRAWLS)	119	R	0	0	0	0	0	0	0
		R/M							
		R/C							
LOWER NEW YORK HARBOR (TRAWLS)	4	R	0	0	0	0	0	0	0
		R/M							
		R/C							
Total	18487	R	76	112	58	2	1	0	249
		R/M	0.00411	0.00606	0.00314	0.00011	0.00005		0.01347
		R/C	0.01462	0.00996	0.02076	0.00633	0.00826		0.01265

[1] Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured
M = number of striped bass ≥200 mm TL marked and released
C = number of striped bass ≥200 mm TL caught and examined for tags
R/M = recapture rate
R/C = recapture proportion

and recaptured the same day (5 May 1986) and the second fish was released in the Upper Harbor (1 April 1986) and recaptured 22 days later. Trawling in the East River provided one recaptured bass on 30 April 1986 which was released from the Scottish seine on 11 April 1986, while trawling in the Upper Harbor recaptured one fish on 9 April 1986 which was released from the seine effort in the Tappan Zee and Croton-Haverstraw regions on 11 April 1986 (Table 3-28, Appendix Table E).

The Upper Harbor and Battery regions had the highest overall recapture rates (R/M) and recapture proportions (R/C) for striped bass among the regions sampled with trawls (Table 3-28). Relatively high recapture rates and recapture proportions in the Battery and Upper Harbor are probably a direct result of high catch per unit effort (Section 3.5) and a general lack of movement by striped bass out of these regions. Considerably less trawling effort was expended in the Harlem River (29 tows), East River (35 tows) and Lower New York Harbor (16 tows), than in the Upper Harbor (74 tows) and Battery (1,083 tows) regions, making the recapture rates observed in these regions less reliable. Proportionally more fish were recaptured (R/C) in the Battery and Upper Harbor than in other trawl regions, indicating striped bass tagged and released in the Battery and Upper Harbor were more likely to be recaptured there due to a lack of movement by striped bass into or out of those regions.

Recapture rates and recapture proportions can be used to examine the recapture of fish among different space (and/or time) frames. Recapture rates from the row totals compare the number of fish recaptured throughout the program (recaptured any time after the release date) to the number of fish released in a particular region. Recapture rates from the column totals compare the number of fish recaptured in a region to the number marked throughout the program. For example, in Table 3-28, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 110/10569 or 0.01041, while the recapture rate for fish tagged and released in the Battery and recaptured in all regions (row total) was 178/10569 or 0.01684. The recapture rate for striped bass tagged and released throughout the study area and recaptured in the Battery (column total) was 112/18487 or 0.00606.

In contrast, recapture proportions from row totals compare the number of fish recaptured in a particular region to the number examined for tags throughout the program, while recapture proportions from the column totals compare the number of fish recaptured in a particular region (regardless of origin) to the number of fish caught and examined for tags in that region. For example, in Table 3-28, the recapture proportion for striped bass tagged, released and recaptured in the Battery among fish examined for tags in the Battery (cell total) was 110/11249 or 0.00978, while the recapture proportion for fish recaptured in the Battery compared to all fish examined for tags throughout the program (row total) was 178/19682 or 0.00904. The recapture proportion for striped bass from the entire study area that were recaptured in the Battery (column total) was 112/11249 or 0.00996. It is generally most informative to examine recapture rates from the row totals and recapture proportions from the column totals since these statistics best describe specific movement among regions (or time periods).

Striped bass tagged, and released from trawls, and subsequently recaptured in trawls had the lowest average net rate of movement of any recaptured fish (Table 3-29). Recaptured fish were at large an average of 36 days and moved an average net distance of only 3.3 miles (5.3 km) at a net rate of only 0.1 miles per day (0.1 km per day) before recapture. The low rate of movement in the striped bass population suggests little emigration occurred immediately after fish were caught and tagged during trawl sampling. A lack of immediate emigration by the striped bass population in the contiguous Upper Harbor-Battery region is also suggested by a relatively high frequency of fish which were recaptured on the same day they were released (31/169 or 18%) and a relatively high frequency of fish recaptured in the first ten days after

TABLE 3-29. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE LOWER HUDSON RIVER ESTUARY FROM 11 NOVEMBER 1985 THROUGH 16 MAY 1986.

STATISTIC		RELEASE-RECAPTURE GEAR: TRAWL-TRAWL[1]	SEINE-SEINE[2]	TRAWL-SEINE[2]	TRAWL-SEINE[3]	SEINE-TRAWL[4]
NUMBER TAGGED	(M)	13,631	4,856	3,002	4,856	13,631
NUMBER EXAMINED FOR TAGS	(C)	14,484	5,198	5,198	5,198	14,484
NUMBER RECAPTURED	(R)	171	19	28	57	2
SIZE RANGE OF RECAPTURED FISH (mm TL)	MIN	208	303	215	215	320
	MAX	437	597	383	440	359
	MEAN	277	464	306	307	339
	S.D.	43	89	35	40	28
DAYS AT LARGE	MIN	0	0	7	7	2
	MAX	142	19	36	146	19
	MEAN	36.2	10.7	18.9	45.5	10.5
	S.D.	38.0	7.1	7.1	37.6	12.0
LINEAR DISTANCE TRAVELED IN MILES (km)	MIN	0 (0)	0 (0)	22 (35)	21 (34)	32 (52)
	MAX	13 (21)	6 (10)	45 (72)	45 (72)	43 (69)
	MEAN	3.3 (5.3)	3.6 (5.8)	36.2 (58.2)	32.5 (52.3)	37.5 (60.3)
	S.D	3.6 (5.8)	2.9 (4.7)	5.3 (8.5)	7.1 (11.4)	7.8 (12.6)
AVERAGE MOVEMENT RATE IN MILES PER DAY (km PER DAY)		0.1 (0.1)	0.3 (0.5)	1.9 (3.1)	0.7 (1.1)	3.6 (5.7)

[1] 11 November 1985 through 16 May 1986

[2] 31 March through 13 May 1986

[3] 11 November 1985 through 13 May 1986

[4] 31 March through 16 May 1986

release (63/169 or 37%; Figure 3-3). Nearly 60% (99/169) of the fish recaptured in the Upper Harbor and Battery regions were recaptured within 30 days of release, suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. A relatively constant number of between six and ten striped bass were recaptured in each ten-day interval between 31 and 120 days at large (Figure 3-3).

Striped bass monthly recapture rates (R/M row totals) were relatively constant between December and March suggesting marked fish had randomly mixed with the winter population in upper New York harbor and the Battery (Table 3-30). Furthermore, monthly recapture proportions (R/C column totals) increased from November 1985 through May 1986 indicating an accumulation of marked fish in the population. This pattern of relatively constant recapture rates and increasing recapture proportions suggests that the striped bass population in the Upper Harbor and Battery is relatively closed to immigration and emigration during most of the study period (Ricker 1975). While more variable than monthly statistics, the weekly recapture rate (R/M row totals) remained relatively constant while the weekly recapture proportion (R/C column totals) generally increased (Figure 3-4). These data support the hypothesis that immigration or emigration did not occur throughout most of the mid-winter study period. However, weekly variability in recapture proportions was relatively high after the week of 14 April 1986 (Figure 3-4) due in part to low numbers of fish and perhaps because some fish had emigrated at that time. The 8 week period between 30 December 1985 and 21 February 1986 appears to have been relatively closed with respect to population movement in the Battery and Upper Harbor, since weekly recapture rates were not significantly different during that period and recapture proportions increased during this period (Figure 3-4). This pattern was also supported by monthly recapture rates and recapture proportions for January and February 1986 (Table 3-30).

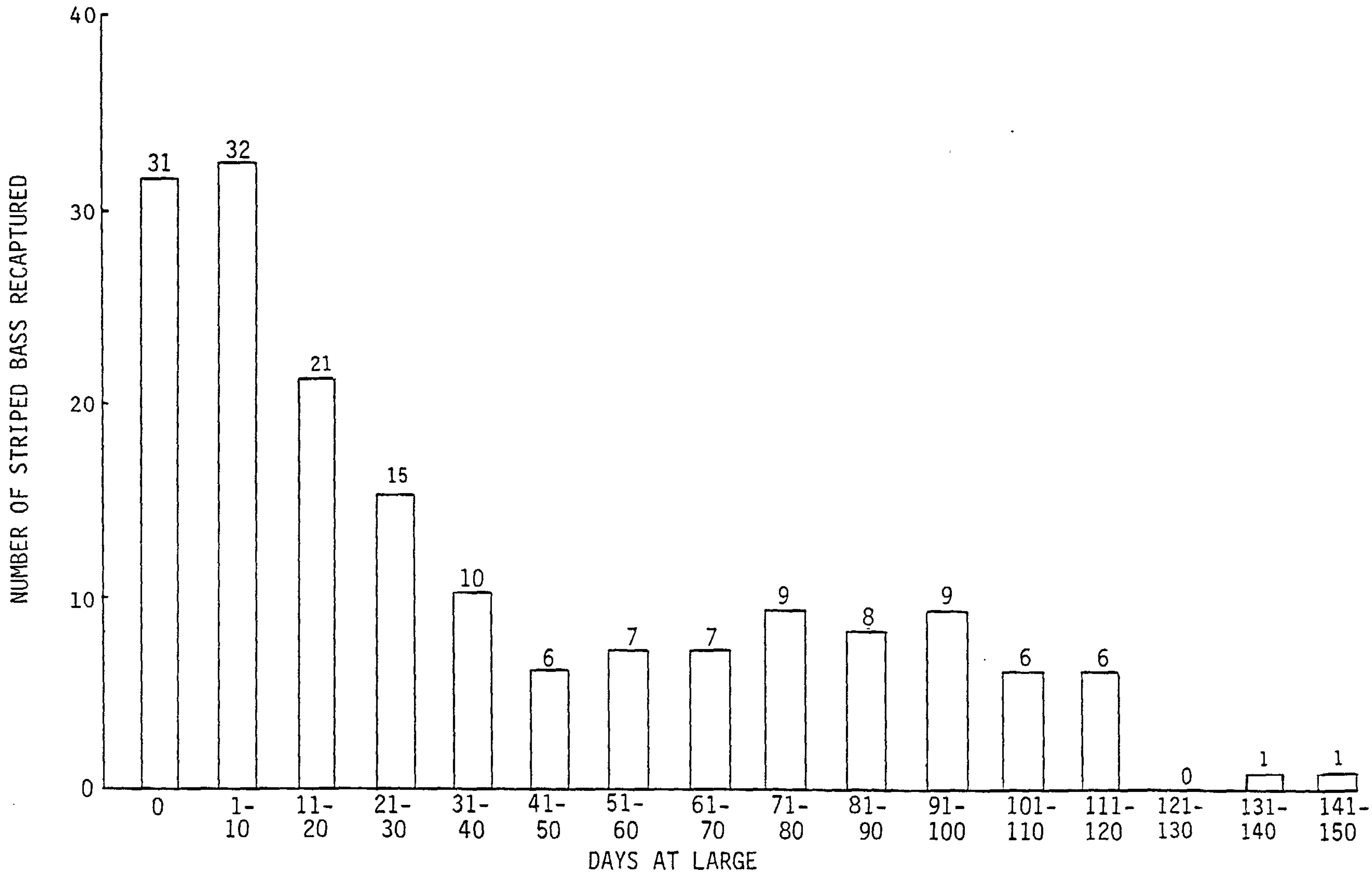

Figure 3-3. Frequency of days at large for 169 striped bass tagged and recaptured by trawls in the Upper Harbor and Battery regions of the Hudson River, 11 November 1985 through 16 May 1986.

TABLE 3-30. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN UPPER NEW YORK HARBOR AND THE BATTERY REGION OF THE HUDSON RIVER FROM 11 NOVEMBER 1985 THROUGH 16 MAY 1986.[1]

			NUMBER OF RECAPTURES IN MONTH							
RELEASE MONTH	NUMBER MARKED (M)	STATISTIC	NOVEMBER C = 485	DECEMBER C = 2855	JANUARY C = 3646	FEBRUARY C = 1758	MARCH C = 2181	APRIL C = 3053	MAY C = 65	TOTAL C = 14043
NOVEMBER	480	R	2	2	2	2	1	1	0	10
		R/M	0.00417	0.00417	0.00417	0.00417	0.00208	0.00208		0.02083
		R/C	0.00412	0.00070	0.00055	0.00114	0.00046	0.00033		0.00071
DECEMBER	2610	R		5	10	6	8	8	1	38
		R/M		0.00192	0.00383	0.00230	0.00307	0.00307	0.00038	0.01456
		R/C		0.00175	0.00274	0.00341	0.00367	0.00262	0.01538	0.00271
JANUARY	3476	R			25	6	6	17	0	54
		R/M			0.00719	0.00173	0.00173	0.00489		0.01554
		R/C			0.00686	0.00341	0.00275	0.00557		0.00385
FEBRUARY	1600	R				7	9	6	0	22
		R/M				0.00438	0.00563	0.00375		0.01375
		R/C				0.00398	0.00413	0.00197		0.00157
MARCH	2032	R					12	17	0	29
		R/M					0.00591	0.00837		0.01427
		R/C					0.00550	0.00557		0.00207
APRIL	2942	R						15	1	16
		R/M						0.00510	0.00034	0.00544
		R/C						0.00491	0.01538	0.00114
MAY	60	R							0	0
		R/M								
		R/C								
TOTAL	13200	R	2	7	37	21	36	64	2	169
		R/M	0.00015	0.00053	0.00280	0.00159	0.00273	0.00485	0.00015	0.01280
		R/C	0.00412	0.00245	0.01015	0.01195	0.01651	0.02096	0.03077	0.01203

[1] Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured
M = number of striped bass ≥200 mm TL marked and relased
C = number of striped bass ≥200 mm TL caught and examined for tags
R/M = recapture rate
R/C = recapture proportion

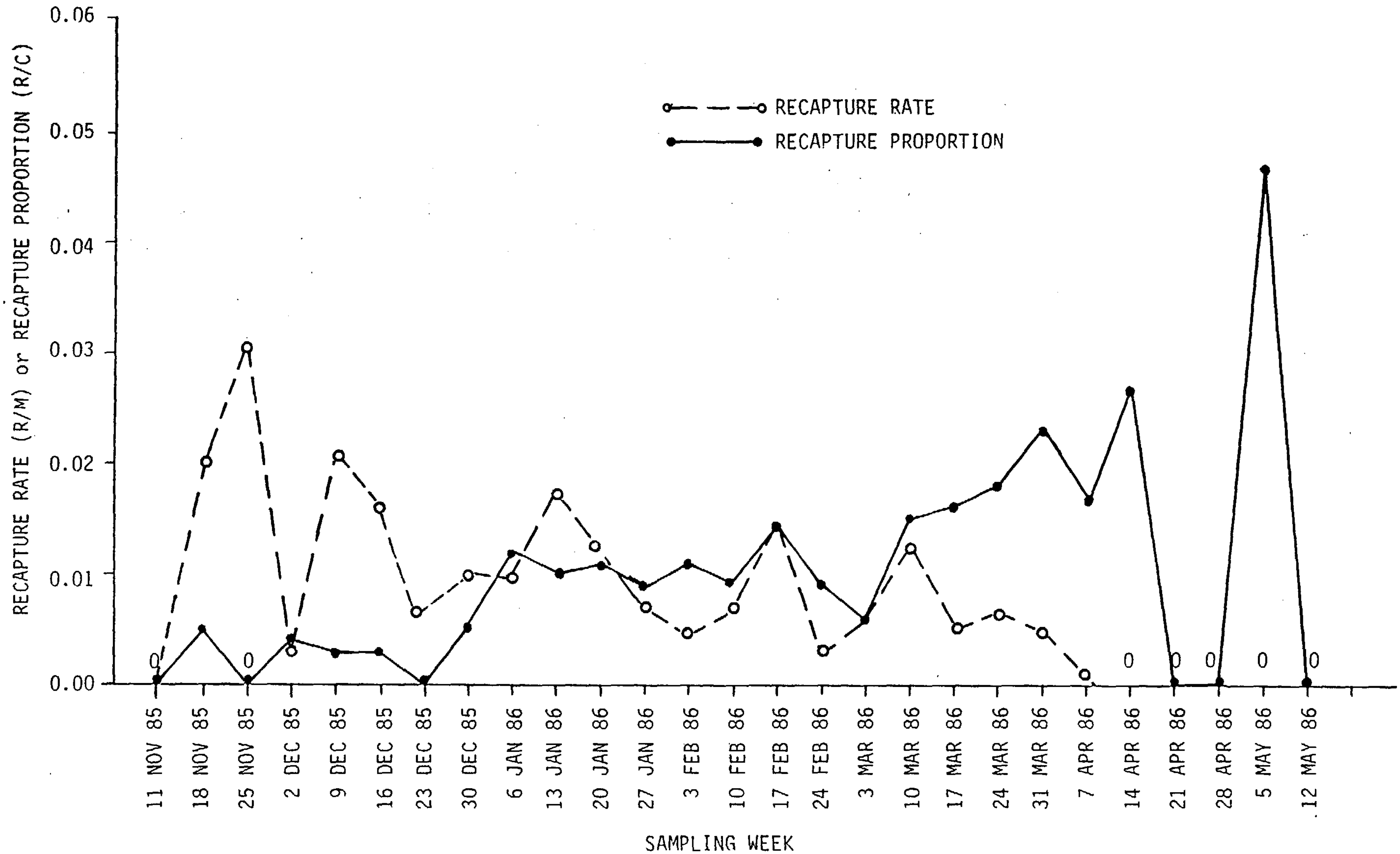

Figure 3-4. Weekly recapture rates (R/M) and recapture proportions (R/C) for striped bass released from trawls in the Battery region and recaptured in the Battery region of the Hudson River, 11 November 1985 through 16 May 1986.

3.6.2 Scottish Seine Sampling

The Scottish seine effort in the Tappan Zee and Croton-Haverstraw regions of the Hudson River between river miles 25-39 (km 40-63) recaptured 19 striped bass that were marked and released from the seines in those regions (Table 3-28, Appendix Table F). The seines also recaptured 57 bass marked and released from trawls in the lower Hudson River (below river mile 14; km 23) and in adjacent regions (Table 3-28, Appendix Table G). All but two of the trawl-released fish that were recaptured by seines were released in the Upper Harbor and Battery region.

Striped bass tagged and released from seines, and recaptured by the seines in the Tappan Zee and Croton-Haverstraw regions were at large an average of approximately 11 days between release and recapture (Table 3-29). Net movement during this period averaged only 3.6 miles (5.8 km) for a net rate of 0.3 miles per day (0.5 km per day) before recapture. In contrast, bass released from the trawls and recaptured by the seine were at large an average of approximately 46 days before recapture, and moved an average net distance of 32.5 miles (52.3 km) at a net rate of 0.7 miles per day (1.1 km per day) before recapture (Table 3-29). The greater distance moved by fish released in the trawl is not surprising since the trawl region is at least 10 river miles below the Tappan Zee Bridge. Striped bass released from the trawl in every sampling month except May were present in the upriver seine catch (Appendix Table G), indicating that a portion of the downriver population migrated upriver in the spring. The Scottish seine recaptured bass released from the Battery and Upper Harbor in the following months: 2 from November 1985, 3 from December 1985, 6 from January 1986, 6 from February 1986, 12 from March 1986, and 26 from April 1986. The high number of fish released by trawls in April and recaptured by the seine in the same month indicates the trawl was tagging fish as they moved from the Battery to upriver regions during the spawning migration.

Striped bass tagged and released from trawls in the Battery and Upper Harbor and recaptured upriver by the Scottish seine (Figure 3-5) generally were at large more days before recapture than fish released and recaptured by trawls (Figure 3-3). No fish tagged and released from trawls were recaptured by seines in the same day indicating it takes more than one day to migrate upriver from below river mile 14 (km 23) to the Tappan Zee and Croton-Haverstraw regions above river mile 25 (km 40). Less than 10% of the fish tagged and released from the trawls and recaptured by the seines were at large less than 10 days. In contrast, 18% of the fish tagged, released and recaptured by the trawls were recaptured in the same day and 37% of these fish were recaptured within 10 days of their release (Figure 3-3).

Striped bass released from trawls and recaptured by the seine exhibited variable recapture rates (R/M row totals) through time, although these rates generally increased from 9 December 1985 until the week of 31 March 1986 (Figure 3-6). After 31 March 1986, recapture rates declined precipitously to zero indicating striped bass were emigrating from the study area. If immigration was occurring instead of emigration, recapture rates would decline to a low plateau but not to zero (Ricker 1975; Cormack 1968). Recapture proportions (R/C column totals) for trawl-released fish also demonstrated the effects of emigration from the Battery and Upper Harbor by generally increasing throughout the seine recapture effort, particularly after 28 April 1986. Striped bass were probably migrating from the trawl zone in the lower Hudson River through the Tappan Zee and Croton-Haverstraw regions enroute to upriver spawning grounds at and above West Point (above river mile 47, km 75; TI 1981).

3.6.3 Discussion of Striped Bass Movements

The 18,487 fish tagged and released in the present study represent the largest one-year striped bass tagging program conducted on

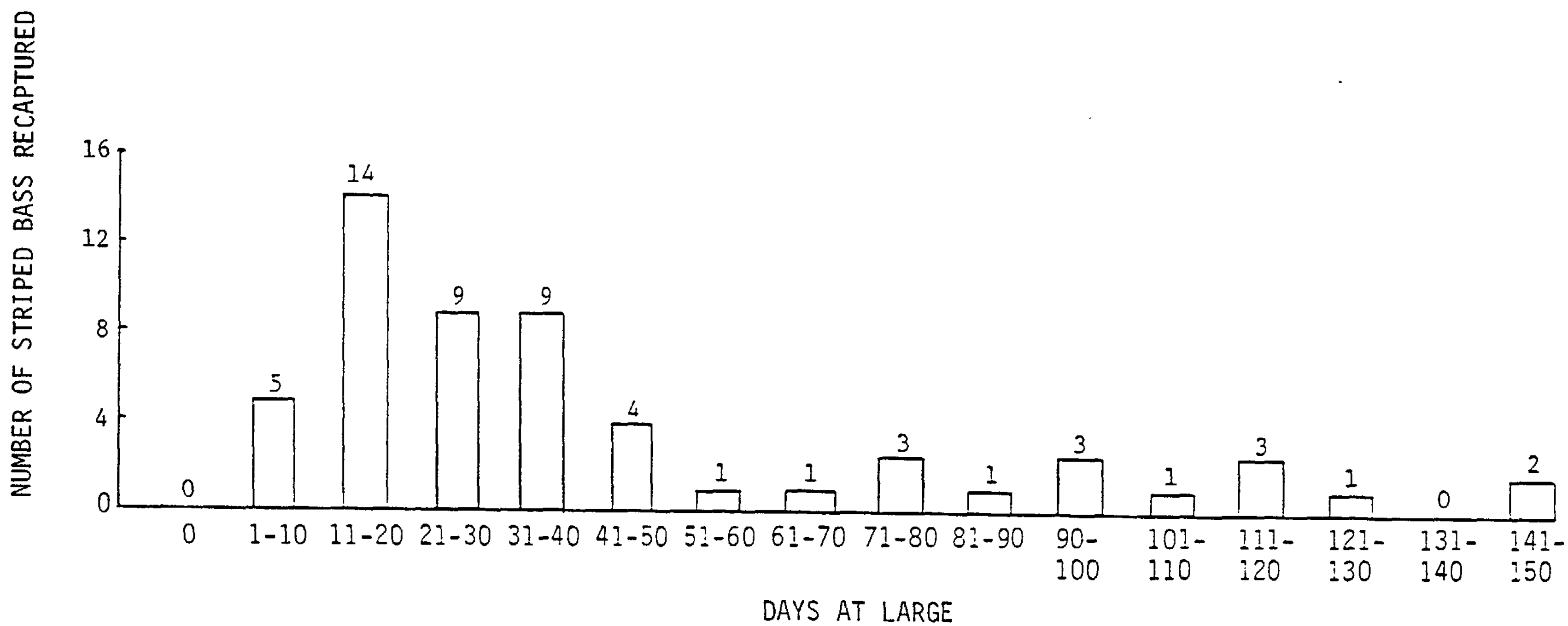

Figure 3-5. Frequency of days at large for 57 striped bass tagged from trawls in the Upper Harbor and Battery regions and recaptured by the Scottish seine in the Tappan Zee and Croton-Haverstraw regions of the Hudson River, 11 November 1985 through 16 May 1986.

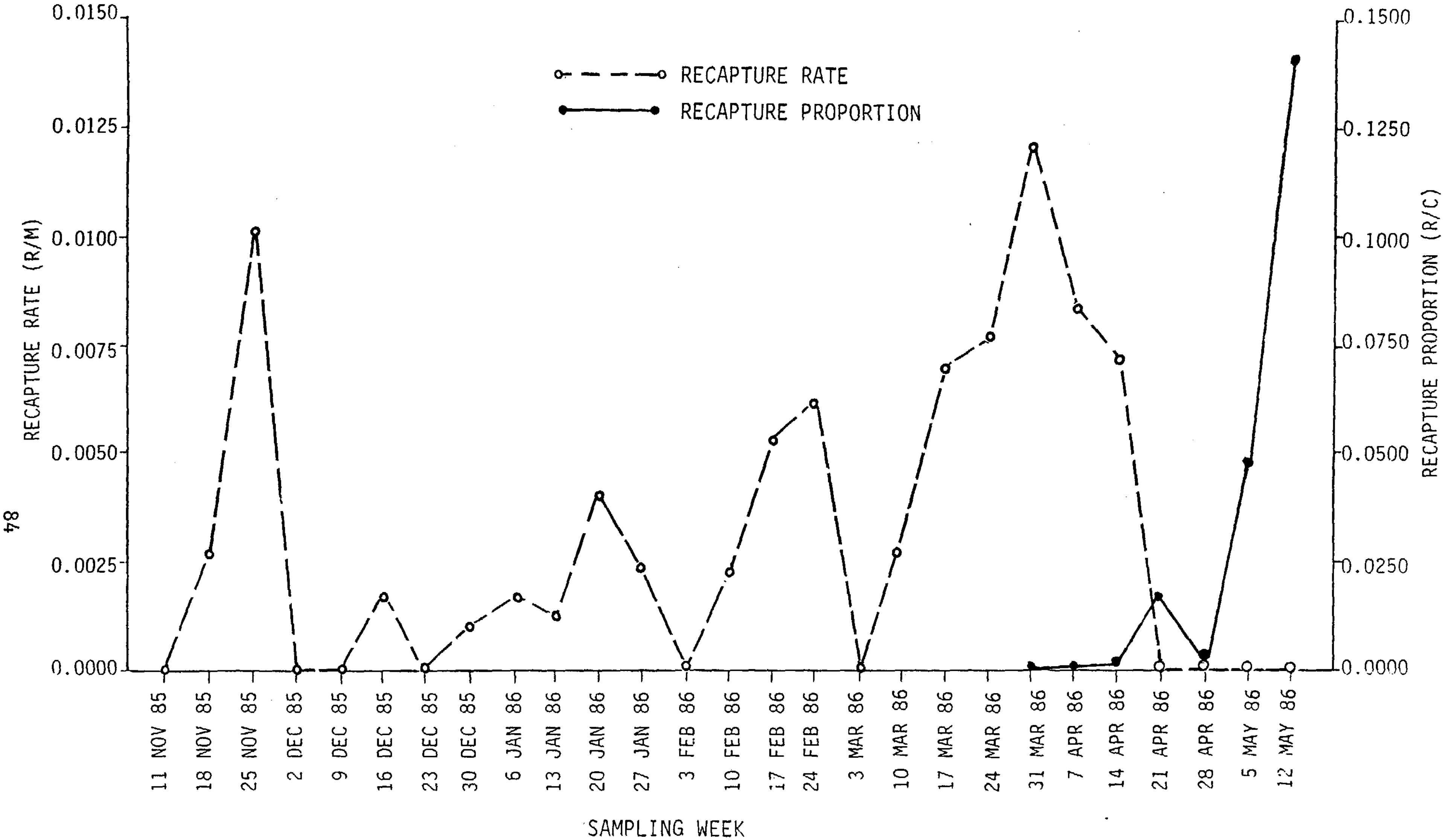

Figure 3-6. Weekly recapture rates (R/M) and recapture proportions (R/C) for striped bass released from trawls in the Battery and Upper Harbor regions (combined) and recaptured by the Scottish seine in the Tappan Zee and Croton-Haverstraw regions of the Hudson River, 11 November 1985 through 16 May 1986.

the east coast to date. Movement of tagged striped bass within the 1985-86 program has important implications for the design of mark-recapture programs with the objective of estimating population size. Almost any mark-recapture estimator requires either a closed population (no immigration or emigration) or an estimate of immigration and emigration (MMES 1986). The winter population of striped bass in the lower Hudson River appears to be relatively closed during the 30 December 1985 through 21 February 1986 period (Table 3-30; Figure 3-4) for three reasons: 1) no fish tagged and released in the Upper Harbor and Battery regions during the eight week period were recaptured outside that contiguous region (Appendix Table D), although the sampling effort was low (Table 3-20), 2) recapture rates were relatively constant and recapture proportions generally increased during the period (Table 3-30; Figure 3-4), and 3) other tagging studies on Hudson River and east coast stocks (Merriman 1941; Berggren and Lieberman 1978; Kohlenstein 1981) suggest that the Hudson River stock of Age 1+ and younger fish resides in the Lower Hudson River and New York Harbor area during the winter months. Age 1+ fish historically have averaged approximately 241 mm TL (calculated from McLaren 1981), which is within the confidence limits about the mean size of fish tagged and released by the striped bass trawl (mean = 279 mm TL; S.D. = 57), the tomcod trawl (mean = 265 mm TL; S.D. = 60); and recaptured by trawls (mean = 277 mm TL; S.D. = 43). Therefore, it appears that the contiguous Upper Harbor and Battery regions can be treated as closed with respect to movement of the winter (30 December 1985 through 21 February 1986) striped bass population.

Before mid-December, immature striped bass (<Age 4+) probably move into New York Harbor and the Battery from coastal areas and from upriver regions of the Hudson River, because recapture rates and recapture proportions were variable early in the program (Figure 3-4) suggesting immigration was occurring. In the late spring (mid-April through mid-May), a portion of the winter striped bass population apparently migrated upriver at least as far as the Tappan Zee and Croton-Haverstraw regions where it was exposed to recapture by the

Scottish seines (Figure 3-6; Appendix Table G). Another part of the winter striped bass population apparently lingered in the Upper Harbor Battery regions and was recaptured by the trawls (Figure 3-4; Appendix Table D). Yet another portion of the winter striped bass population apparently migrates out of the lower Harbor in the spring into adjacent regions, as indicated by Hudson River Foundation (HRF) tag return data from the 1984 program (HRF 1985).

There are three hypotheses for explaining why large, sexually mature striped bass that were captured by the seines in the Tappan Zee and Croton-Haverstraw regions were not caught in the Lower Hudson River by the trawls. They are: 1) that large fish were immigrating upriver from November through May in a stratum of the river not sampled by trawls in the Battery and upper New York harbor, 2) large fish were exposed to the trawling effort in the Battery and Upper Harbor but not caught due to gear avoidance, and 3) large fish migrated upriver before trawl sampling began in mid-November. Since approximately 11% of the striped bass caught by the striped bass trawl in 1984 were larger than 500 mm TL (NAI 1985), while less than 1% of the fish caught by that gear in 1985-86 were larger than 500 mm TL, avoidance of the trawl was probably not as significant as temporal or spatial segregation of the spawning fish from the trawling effort. These large, sexually mature fish may have migrated into the Hudson River from coastal waters during the spring, and remained in the upper water column or moved through the Upper Harbor and Battery regions at times not sampled by the trawls. These striped bass probably first encountered the Scottish seine effort because it fished most of the water column in the shoal areas of the Tappan Zee and Croton-Haverstraw regions. Alternatively, large, sexually mature fish migrated into the Tappan Zee and Croton-Haverstraw regions before the trawling program began in mid-November, and these fish overwintered upriver and were not exposed to trawls. Support for this alternate hypothesis is suggested by the observation that the largest mean size of striped bass from both the tomcod trawl and striped bass trawl was from the first week of sampling in November (Section 3.3). Additionally, limited gill net sampling by the NYSDEC during February 1984, February 1985, and November 1985 in the Croton-Haverstraw region revealed catches of striped bass > 500 mm TL (personal communication from Mr. Robert Mitchell, NYSDEC Region 3, 2 December 1986).

3.7 TAG RETURNS FROM THE HATCHERY AND THE 1984 STRIPED BASS TAGGING STUDY

During the 1985-86 program, no striped bass containing hatchery-administered, coded, magnetic, wire tags were detected although all fish were checked for magnetic tags (NAI 1986a). This could be due to the fact that 1) no hatchery were present among the 14,484 striped bass checked from the trawls and 5,198 fish checked from the Scottish seines, 2) the magnetic tags had demagnetized and were not detected, or 3) the tags were shed before tagged, hatchery-released striped bass were captured in this study.

During the 1985-86 program, only two striped bass were recaptured that were released during the 1984 program, and both fish were recaptured by the Scottish seine. One fish, Tag No. B00324, was caught on 12 April 1986, at river mile 30 (km 48), and was 487 mm TL at the time of recapture. The internal anchor tag, but not the anchor (Dennison) tag placed in this fish during 1984 was present at the time of recapture. This fish had grown 143 mm since its release from the Scottish seine on 25 April 1984 at river mile 26 (km 42). The second fish, Tag No. B04051, was 454 mm TL when it was recaptured at river mile 36 (km 58) on 19 April 1986. This bass had grown 39 mm TL since it was caught in the striped bass trawl, held *in situ* for 24 hours to determine tag retention/survival, and released from the holding facility on 2 May 1984 at river mile 36 (km 58). The internal anchor tag but not the anchor tag was present. Healed, anchor tag wounds were present on both fish indicating that the anchor tags were not lost recently. The internal anchor tag insertion site on both fish was well healed. Recapture of these two striped bass in the Scottish seine was not surprising since the Scottish seine more effectively captured fish larger than 450 mm TL compared to the trawls (Section 3.3.4).

Only two striped bass were recaptured from the 1984 program, however, few fish were tagged in 1984 (736 fish; NAI 1985) compared to the 1985-86 program. Tables provided by MMES were used to estimate the number of fish from the 1984 program that were expected to be recaptured during the 1985-86 program (1986 Appendix E; data table for 8000 harvestable adult fish was used, and the expected number was divided by 10). If the yearly survival rate was assumed to be 40% and approximately 800 striped bass were released in the spring of 1984, then approximately 6 fish from the 1984 season were expected to be recaptured in 1986.

3.8 STRIPED BASS POPULATION SIZE

3.8.1 Winter Population

One objective of the 1985-86 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. Section 3.6 indicated that the striped bass population in the Upper Harbor and Battery regions of the Hudson River was apparently closed to major immigration and emigration during at least the 8 week period from 30 December 1985 through 21 February 1986. Therefore, closed population mark-recapture estimators were examined to estimate the size of the striped bass population. The estimators examined were: Petersen, Bailey's single catch, least squares, inverse sampling technique with and without replacement, Schnabel, Schumacher-Eschmeyer, inverse Schnabel, sequential Schnabel and Overton (Ricker 1975; Seber 1982; MMES 1986). The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently and can be used for migratory populations.

Eight assumptions must be satisfied to estimate the winter striped bass population size in the Lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) tagged bass suffer the same mortality as untagged bass,

2) tagging does not affect bass catchability,

3) tagged bass do not lose their marks,

4) all tags are recognized and reported,

5) natural marking does not occur or is recognizable,

6) immigration and/or emigration is negligible in the study area i.e., the population is closed, and

7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions.

8) marked fish have the same probability of being caught.

With regard to assumption 1, Dunning *et al.* (1986) observed no difference in mortality between tagged and untagged striped bass retained 1) in the Hudson River for 24 hours and 2) in holding pools for up to 180 days. For the purposes of obtaining a mark-recapture population estimate, mortality due to tagging was assumed to be zero.

Differential vulnerability of tagged and untagged striped bass during the winter (assumption 2) was probably not significant. With respect to trawling and Scottish seining as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is generally applied to gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1986a) which would provide evidence of tag loss. QA/QC procedures (NAI 1986a) and audits provide documentation that miss-identification or non-reporting of tags by field crews did not occur. Dunning *et al.* (1986) found 97.7% retention of internal anchor tags up to 180 days in holding pools. Based on a 2.3% loss rate (Dunning *et al.* 1986) and a recapture rate of 250 fish out of 18,487 tagged fish, approximately 6 fish would be expected to have lost tags in the 1985-86 program. Throughout the program, 19,852 striped bass were examined for tags and tag wounds, and no tag loss was observed. Therefore, loss of internal anchor tags was considered zero for this program.

Assumption 4, the recognition and reporting of tags, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1986a). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g. New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration (assumption 6) was apparently negligible during the mid-winter period (30 December 1985 through 21 February 1986) as indicated by recapture rates, recapture proportions, and the movement of striped bass in the lower Hudson River (Section 3.6). Relatively constant weekly recapture rates (row totals) and increasing recapture proportions (column totals) during the 30 December through 21 February mid-winter period in upper New York harbor and the Battery (Table 3-30) support the assumption of random mixing of tagged and untagged striped bass (assumption 7). If tagged fish were not randomly mixed, recapture rates and proportions would either exhibit high variability or a decreasing linear trend (Ricker 1975). Linear (decreasing) trends in a short-term study (within one season) would indicate migration or tag loss, while long-term decreasing trends would indicate mortality (TI 1981; Ricker 1975; Seber 1982).

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2) of similar size (age) composition (Section 3.3) which probably are equally exposed to the trawl recapture effort.

Inasmuch as the assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied in this study, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1985-86 was 540,000 fish with upper and lower 95% confidence limits (based on the t-distribution) ranging from 535,000 to 545,000 fish. If Age 0+ striped bass are assumed to be less than 200 mm TL, Age 1+ fish are between 201 and 350 mm TL, Age 2+ fish are between 351 and 450 mm TL, and Age 3+ fish are between 451 and 500 mm TL (TI 1981; MMES 1986; McLaren *et al*. 1981), then the age composition of the winter population can be approximated using the data from Section 3.3. The following numbers of striped bass were estimated to be present in the winter population in the lower Hudson River:

Age 0+	24,000 fish,
Age 1+	464,000 fish,
Age 2+	46,000 fish,
Age 3+	4,000 fish, and
>Age 3+	2,000 fish.

3.8.2 Spring Population

Too few of the striped bass (3 fish) tagged and released from the seines were recaptured by the trawls to obtain a statistically reliable estimate of population size during the spring. Striped bass tagged in the seines were apparently still migrating upriver when the program ended in May 1986. Although sufficient numbers of fish were released from the trawls and recaptured by the Scottish seine (57 fish), a population estimate was not calculated because the movement of striped bass during the spring was not uniform for all fish tagged and released from the trawls (Section 3.6). Calculating population size based only on the portion of Battery and Upper Harbor population that migrated upriver during the spring would result in an overestimate of abundance, since the number of marked fish (M) must represent the subpopulation that was available for recapture (assumption 7). Similarly, the number of fish examined for tags (C) in the seine catch must represent the subpopulation that was marked (assumption 7). However, the striped bass population in the Tappan Zee and Croton-Haverstraw regions during the spring was composed of both fish from the winter population and fish that recently emigrated or may not have been exposed to the downriver tagging effort. These statements would apply equally to both open and closed population estimators (MMES 1986; Seber 1982).

The best estimate of the portion of the winter striped bass population which migrated upriver during the spring requires the following data:

1) an estimate of the winter striped bass population which remained in the Battery and Upper Harbor during the spring period,

2) an estimate of the proportion of winter fish leaving the Battery and Upper Harbor area and not migrating upriver during the spring period,

3) an estimate of the proportion of fish caught by the seine which had not been exposed to the trawl tagging effort in the lower river, and

4) the number of fish tagged during the winter and recaptured in the spring.

Item 1 and Item 4 are addressed in the present study. Sport and commercial fishermen tag return information can be used to estimate the proportion and number of winter fish which leave the system rather than remain in the lower river or migrate upriver (Item 2). If these data become available, a ratio can be developed from the number of fish caught outside the system and the number recaptured in the lower river to apportion the population into emigrating and resident components. Recapture rates and proportions for the resident population can then be developed to evaluate assumptions of the estimator.

Weekly length-frequency analysis can be used to separate the Scottish seine catch into migratory and resident components (Item 3), under the assumption that large fish either overwintered in the Tappan Zee and Croton-Haverstraw regions or migrated into the estuary and were not exposed or efficiently caught by the downriver trawl effort. A visual comparison of the size-frequency distributions between the trawl and seine catch during 1986 (Section 3.3), and during the 1984 program (NAI 1985) suggests that when both trawl and seine efforts are conducted in the same regions and time periods, comparable size frequencies of the catch are observed. Available HRF data on the movement of striped bass will complement the relatively short-term movement data from the present study to provide a more complete picture of the movements of possible striped bass population components.

4.0 CONCLUSIONS

The goals of the 1985-86 program were to: 1) determine the best locations, times and fishing gear to capture striped bass for a mark-recapture program, 2) evaluate the catch characteristics and handling mortality of two high-rise otter trawls designed to capture striped bass (striped bass trawl) and Atlantic tomcod (tomcod trawl) and two seines used in Scottish seining (a Jackson 280 seine and a Kosalt plaice seine), 3) determine the winter and spring movements of striped bass in the lower Hudson River, 4) determine the feasibility of a downriver marking effort and an upriver recapture effort for estimating population size of Hudson River striped bass, and 5) estimate the striped bass population size in the lower Hudson River through a mark-recapture program.

Mean striped bass catch per ten minute tow over all sampling weeks was highest for the striped bass trawl in the Upper Harbor (CPUE=43) and Battery regions (CPUE=23), and was much lower in the East River (CPUE=3), Harlem River (CPUE=11), Lower Harbor (CPUE=1), Raritan Bay (CPUE=0) and Rockaway Inlet (CPUE=0). Within the Upper Harbor, highest CPUE for the striped bass trawl was 68 striped bass during the week of 7 April 1986. Within the Battery, highest CPUE for the striped bass trawl was 124 striped bass during the week of 23 December 1985 and 88 fish during the week of 17 February 1986. The tomcod trawl, fished primarily in the Battery region, had the highest CPUE during the weeks of 23 December (CPUE=25) and 30 December (CPUE=22) 1985.

When both the tomcod trawl and striped bass trawl were fished in the Battery during the same weeks, the striped bass trawl had the greatest catch per unit effort. The greater mouth opening and spread of the striped bass trawl allowed it to sweep a greater bottom area and filter a greater amount of water than the tomcod trawl for every minute of fishing effort. Weekly changes in catch per unit effort of striped bass ($\geq$ 200 mm TL) caught by the striped bass and tomcod trawls indicated that the Upper Harbor and the Battery can be considered one contiguous region.

Although the tomcod trawl had a smaller catch per unit effort, it was deployed more often per day than the striped bass trawl because 1) the gear was smaller and easier to handle by the crew and 2) the smaller mean catch per tomcod trawl tow could be enumerated, tagged and released faster than the mean catch of the striped bass trawl. Therefore, mean catch of striped bass per day for the tomcod trawl (120) was almost identical to the striped bass trawl (118), suggesting either trawl could be effectively used to capture striped bass for a mark-recapture program. However, differences in length-frequency distributions of the catch for the tomcod trawl and striped bass trawl suggest each gear may be appropriate for capturing different size (age) groups of striped bass. The striped bass trawl caught a significantly lower proportion of small striped bass (<250 mm TL) and a significantly greater proportion of intermediate sized striped bass (251-450 mm TL). The tomcod trawl showed almost opposite results. Therefore, the striped bass trawl is the more efficient gear for a program with the goal of maximizing catch of striped bass greater than 200 mm TL (Age 1+ and older). The tomcod trawl, is a more efficient gear for a program with the goal of maximizing the catch of Age 0+ and Age 1+ striped bass.

Catch per one coil set was greater for the Kosalt plaice seine compared to the Jackson 280 seine. However, since the Kosalt plaice seine was generally used prior to the week of 7 April 1986 and the Jackson 280 seine was used afterwards, it cannot be determined if the increased catch per unit effort for the Kosalt plaice seine was due to differences between the gear or changes in striped bass abundance. The mean catch of 19 bass per one coil set for both seines combined was much greater in 1986 than that observed in 1984 (3 bass per one coil set), indicating information gained during the 1984 Scottish seine program was effectively used to select sampling areas and times that provided a higher mean catch per one coil set in 1986. The Scottish seine was an effective gear when fished in the Tappan Zee and Croton-Haverstraw regions during the spawning migration (April and May).

Striped bass tagged and released from the trawls and subsequently recaptured by the trawls had the lowest average rate of movement of any recaptured fish. The 8 week period from the week of 30 December 1985 through the week of 17 February 1986 was relatively closed with respect to population movement in the Battery and Upper Harbor regions since recapture rates remained relatively constant and recapture proportions appeared to increase during this period. Data from the 1985-86 program suggest that relatively little immigration and emigration of striped bass occurs in the contiguous Upper Harbor and Battery region during January and February. No tagged striped bass released in the Upper Harbor, Battery region during the 8 week period from 30 December 1985 through the week of 17 February 1986 were recaptured outside that contiguous region, although relatively little sampling was conducted outside this region.

During the 1985-86 program, no striped bass containing hatchery-administered, magnetic, wire tags were detected although all fish were checked for tags. Only two striped bass from the 1984 program were recaptured during the 1985-86 program. These fish, recaptured in the Scottish seine, had intact internal anchor tags and no anchor (Dennison) tags. The Scottish seine recaptured 19 striped bass marked and released in 1986 from the Scottish seine in the Tappan Zee and Croton-Haverstraw regions of the Hudson River. The Scottish seine also recaptured 57 striped bass marked and released from trawls in the lower Hudson River and adjacent areas. Striped bass released from the trawl in every sampling month except May were present in the upriver seine catch indicating a portion of the downriver, winter population migrated upriver in the spring.

In the fall, striped bass probably move into New York Harbor and the Battery from coastal areas and from upriver regions of the Hudson River. A portion of the striped bass population may also overwinter in the Tappan Zee and Croton-Haverstraw regions. In the spring, a portion of the winter striped bass population migrated upriver at least as far as the Tappan Zee and Croton-Haverstraw regions. Another part of the winter population lingered in the Upper Harbor and Battery regions and was recaptured by the trawl program. Yet another portion of the winter population apparently migrates out of the lower Harbor in the spring into adjacent regions.

A population estimate of approximately one-half million striped bass was estimated for contiguous Upper Harbor and Battery regions during mid-winter (30 December 1985-21 February 1986) using the Schumacher-Eschmeyer method. An estimate was not made of the number of fish in the spring population upriver in the Tappan Zee and Croton-Haverstraw regions because it appeared that this population may be comprised of 1) fish that had either migrated through the Battery and Upper Harbor without being exposed to the trawl tagging program or 2) fish that had overwintered in the Tappan Zee and Croton-Haverstraw regions and were not tagged, and 3) fish that were tagged during the winter trawl program in the Battery and Upper Harbor regions. The methods of this study did not permit identifying each of the aforementioned population components, which was necessary to obtain a population estimate. However, a procedure was described which would permit an estimate of the portion of the winter population which migrated upriver in the spring once a more complete picture of long term movements of Hudson River striped bass becomes available from tag return data.

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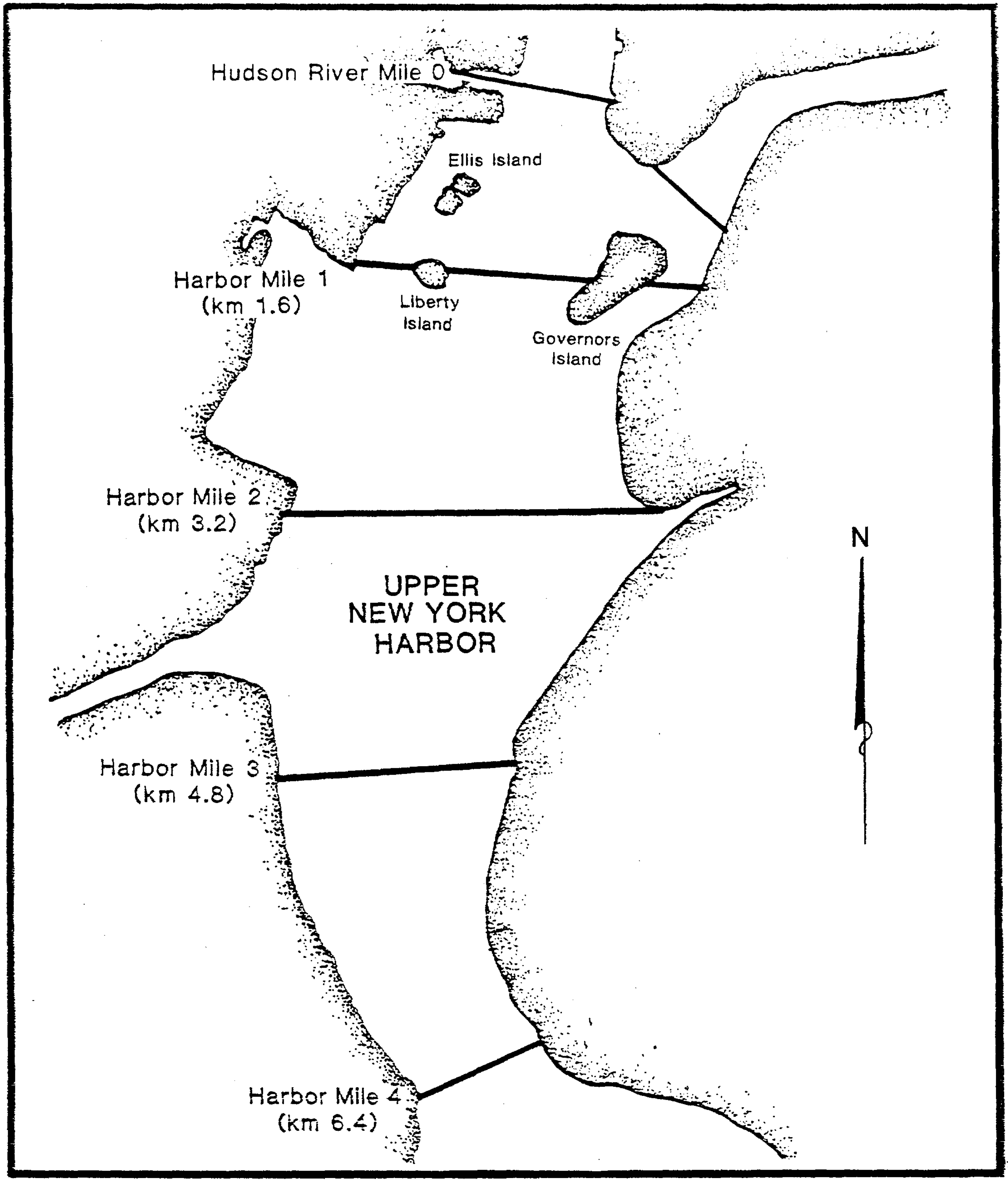
APPENDIX



Appendix Figure A. Harbor mile designations for trawl sampling in The Upper New York Harbor Region of the Hudson River during Winter-Spring 1985-1986.

APPENDIX TABLE A. SPECIFICATIONS OF THE STRIPED BASS HIGH-RISE TRAWL, ATLANTIC TOMCOD HIGH-RISE TRAWL, JACKSON 280 SEINE, AND KOSALT PLAICE SEINE.

STRIPED BASS HIGH-RISE TRAWL (STRIPED BASS TRAWL)	
Head rope length	6.7 m
Foot rope length (Sweep)	12.2 m
Legs (between doors and net)	18.3 m
Approximate vertical lift	4.9 m
Net Body Length	12.5 m
Cod End Length	4.0 m
Doors (steel V-doors)	1.3 m (1.0 m before 16 December 1985)
Mesh - body of net	11.4 cm (stretch) mesh polypropylene; 3 mm diameter twine
- cod end	7.5 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	15 and 10 cm large cookie disks with 5 cm cookie disks

APPENDIX TABLE A. (Continued)

ATLANTIC TOMCOD HIGH-RISE TRAWL (TOMCOD TRAWL)

Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body	7.6 cm (stretch) mesh polypropylene; 3 mm diameter twine
- cod end	3.8 cm (stretch) mesh, knotless 3 mm diameter twine
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

APPENDIX TABLE A. (continued)

JACKSON 280 SEINE	
Jackson 280, modified box trawl design	
Head rope length	30.5 m
Foot rope length	36.5 m
Mesh - wings	15.9 cm (stretch) mesh polypropylene; 1.6 mm diameter twine
- body of net	15.9 cm (stretch) mesh polypropylene at mouth of net, tapering to 10.2 cm (stretch) mesh polypropylene at the cod end; 1.6 mm diameter twine
- cod end	7.5 cm (stretch) mesh knotless, polypropylene; 1.6 mm diameter twine
Coils (towing warps)	219 m each of lead core rope. 14 total coils available for each leg; rope is 7.5 cm in circumference with a breaking strength of 6,350 kg.

KOSALT PLAICE SEINE	
Kosalt 360, modified box trawl design	
Head rope length	36.5 m
Foot rope length	48.8 m
Mesh - wings	11.4 cm (stretch) mesh polypropylene; 1.6 mm diameter twine
- body of net	10.2 cm (stretch) mesh polypropylene from mouth to cod end. 1.6 mm diameter twine
- cod end	7.5 cm (stretch) mesh knotless polypropylene; 1.6 mm diameter twine
Coils (towing warps)	219 m each of lead core rope. 14 total coils available for each leg; rope is 7.5 cm in circumference with a breaking strength of 6,350 kg.

APPENDIX TABLE B. REGIONAL AND WEEKLY AVERAGE WATER QUALITY AND AIR TEMPERATURE DURING THE 1985-86 STRIPED BASS PROGRAM IN THE HUDSON RIVER ESTUARY.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	MID DEPTH WATER TEMPERATURE	MID DEPTH WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY	AIR TEMPERATURE
THE BATTERY	12NOV85	12.9	25941.1	13.1	32699.4	13.2	35456.6	9.9
	18NOV85	12.1	15668.7	12.2	23934.0	12.5	30340.0	16.2
	25NOV85	10.6	19248.0	11.6	30745.6	11.9	32452.9	4.2
	02DEC85	7.3	12392.1	8.1	20141.7	8.8	25930.1	4.0
	09DEC85	8.0	24795.9	8.0	28915.3	8.2	30238.0	7.3
	16DEC85	4.5	13580.5	5.8	25266.2	6.7	30988.2	-1.3
	23DEC85	4.1	25565.5	5.0	31982.7	5.4	33359.6	1.4
	30DEC85	3.8	24436.1	4.8	33580.5	5.2	37000.2	2.3
	06JAN86	3.1	26282.5	3.4	30296.6	3.5	30454.4	-1.6
	13JAN86	1.7	25746.1	2.4	32950.5	2.7	35791.0	-7.8
	20JAN86	2.5	17620.4	3.0	34296.4	3.3	37737.4	7.0
	27JAN86	1.4	17418.0	1.9	25113.3	2.5	30871.3	-1.7
	03FEB86	1.7	19492.0	2.4	30546.1	2.6	32385.5	6.3
	10FEB86	1.3	22598.5	1.9	32504.3	2.3	36813.9	-2.9
	17FEB86	1.1	11227.7	1.8	34395.4	2.1	38551.9	3.0
	24FEB86	2.0	24151.0	2.0	30572.4	2.1	33973.3	1.2
	03MAR86	2.3	19712.5	2.2	31708.0	2.2	34509.1	5.3
	10MAR86	3.1	24230.1	2.9	30550.7	2.9	33023.8	5.1
	17MAR86	3.5	2526.3	3.5	11171.6	3.8	31534.4	6.6
	24MAR86	5.5	16912.1	5.1	22174.2	5.4	25578.1	16.2
	31MAR86	8.4	4560.4	7.7	13322.3	7.3	21626.1	15.8
	07APR86	8.7	12828.0	8.3	18487.0	8.3	21891.0	12.5
	14APR86	9.6	9295.7	8.7	24222.8	8.0	34898.1	11.1
	28APR86	12.4	16692.1	11.5	23281.4	11.3	26693.9	18.0
	05MAY86	13.3	23717.8	12.7	27868.8	12.2	31890.9	18.1
	12MAY86	15.4	17335.3	14.4	24735.3	14.0	27873.0	21.3
EAST RIVER	13JAN86	.	.	.	.	.	.	-8.0
	24MAR86	5.4	30530.3	4.8	32930.0	4.5	34606.0	12.7
	31MAR86	7.6	33406.0	6.5	35672.8	6.2	36582.0	17.9
	07APR86	8.3	31623.8	8.1	32452.7	8.5	32766.7	14.5
	14APR86	8.7	34701.0	8.6	35041.9	8.5	35367.0	7.6
	21APR86	10.1	32569.1	9.7	33549.8	9.6	34041.9	15.7
	28APR86	11.6	34003.3	11.2	35046.3	11.1	35544.0	20.1
	05MAY86	12.2	35347.0	11.8	35916.0	11.6	36360.0	19.0
	12MAY86	14.0	36251.3	13.4	36724.7	13.7	36744.4	17.3
HARLEM RIVER	06JAN86	3.5	35106.0	3.7	35061.0	3.7	35225.0	.
	13JAN86	2.8	36199.0	2.8	37546.0	3.0	38152.0	-5.0
	20JAN86	3.4	37057.0	3.6	37057.5	3.7	37028.0	-1.0
	27JAN86	2.0	28833.0	2.3	29928.0	2.7	32765.0	-6.0
	24MAR86	5.8	29317.0	5.5	30806.0	4.9	31645.0	15.5
	31MAR86	8.7	26879.0	8.4	27228.0	8.3	27442.0	20.5
	14APR86	.	.	.	.	.	.	7.0
	21APR86	9.7	32064.3	9.6	32525.7	9.6	33235.6	13.0
	28APR86	12.0	31338.0	11.4	32393.5	11.3	32676.0	21.3
	05MAY86	12.5	32789.7	12.2	33653.4	12.1	34032.4	18.3

APPENDIX TABLE B. REGIONAL AND WEEKLY AVERAGE WATER QUALITY AND AIR TEMPERATURE DURING THE 1985-86 STRIPED BASS PROGRAM IN THE HUDSON RIVER ESTUARY.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	MID DEPTH WATER TEMPERATURE	MID DEPTH WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY	AIR TEMPERATURE
HARLEM RIVER	12MAY86	13.9	34131.8	13.6	34977.3	13.5	35217.3	17.5
UPPER HARBOR	03FEB86	1.7	23052.0	2.3	31635.6	2.8	37018.6	0.0
	10FEB86	0.2	27479.0	.	.	.	.	-7.3
	17FEB86	1.0	16245.1	2.2	40365.6	2.5	40366.6	3.9
	10MAR86	3.9	34365.5	3.0	38822.0	2.8	39566.0	14.8
	17MAR86	3.7	7373.0	4.0	19812.0	4.0	23547.0	-5.0
	24MAR86	5.8	23211.0	5.5	29732.1	5.5	32700.8	11.8
	31MAR86	7.5	12460.1	7.1	22732.0	6.8	26769.2	18.1
	07APR86	8.5	19996.1	8.2	26873.7	8.1	30206.3	11.8
	14APR86	9.6	16299.1	8.7	26222.0	8.3	31657.1	16.4
	21APR86	10.2	20494.6	9.9	27433.2	9.5	30318.2	12.9
	28APR86	12.3	21947.3	11.8	27741.3	11.4	30514.8	18.1
	05MAY86	13.5	28677.0	12.8	33934.0	12.2	35462.0	20.0
	12MAY86	14.8	26074.7	14.3	31104.3	13.8	34760.0	18.3
LOWER HARBOR	14APR86	8.9	29729.0	8.5	31944.5	8.2	38178.0	14.3
	21APR86	9.2	34859.0	8.7	36671.3	8.6	38816.3	15.5
	28APR86	11.1	35378.2	10.7	37899.2	10.3	39512.3	19.0
	05MAY86	11.7	37991.5	11.5	39203.5	11.0	41942.5	17.7
	12MAY86	13.7	37983.3	13.3	39187.7	13.2	40294.0	20.8
RARITAN BAY	21APR86	10.0	30455.0	9.5	30832.0	9.0	31218.0	21.0
	28APR86	12.9	31401.0	11.0	36483.0	10.2	37195.0	20.0
	05MAY86	13.3	36763.5	12.7	37656.0	12.4	37953.5	24.5
	12MAY86	14.8	38116.0	13.9	38141.0	13.3	39563.0	19.5
ROCKAWAY INLET	21APR86	9.2	40240.0	9.0	40867.0	9.0	41151.0	17.0
	28APR86	10.2	46011.0	10.0	46236.0	9.8	46742.0	15.5
	05MAY86	11.7	43589.0	11.7	43589.0	11.6	45091.0	19.9
	12MAY86	13.4	44071.0	13.0	44479.0	13.0	44479.0	15.5
CROTON-HAVERSTRAW	31MAR86	7.2	186.0	7.1	216.8	7.2	196.5	14.8
	07APR86	8.5	360.2	8.2	372.0	8.4	436.7	11.1
	14APR86	10.5	1926.8	10.4	3621.1	10.3	1947.7	12.7
	21APR86	10.6	7926.2	10.3	8315.6	10.5	8185.0	12.3
	28APR86	12.8	5428.2	12.7	6034.2	12.7	5366.8	18.7
	05MAY86	13.5	4079.8	13.4	5028.5	13.2	4493.9	21.7
	12MAY86	14.4	5612.0	14.4	7681.4	14.0	6616.2	15.4

APPENDIX TABLE C. REGIONAL AND WEEKLY MEAN CATCH PER UNIT EFFORT OF STRIPED BASS CAPTURED IN STRIPED BASS AND TOMCOD TRAWLS DURING THE 1985-86 STRIPED BASS GEAR EVALUATION PROGRAM.

THE BATTERY

		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
RIVER MILE	WEEK	TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
1	18NOV85	1	8.00		0		
	25NOV85	1	0.00		0		
	03FEB86	31	7.35	1.18	0		
	10FEB86	21	6.00	0.83	6	20.50	10.03
	17FEB86	6	5.83	1.17	0		
	10MAR86	0			1	9.00	
	17MAR86	19	19.37	2.45	9	9.22	1.86
	24MAR86	0			2	6.00	1.00
	31MAR86	0			7	3.43	0.57
	07APR86	0			3	3.33	0.67
	14APR86	0			6	27.67	13.21
	28APR86	0			3	0.33	0.33
	05MAY86	0			3	0.33	0.33
	12MAY86	0			2	0.00	0.00
	RM CPUE	79	9.68	1.00	42	10.21	2.67
2	WEEK						
	18NOV85	1	0.00		0		
	RM CPUE	1	0.00		0		

(CONTINUED)

APPENDIX TABLE C. (continued)

THE BATTERY

		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
		TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
RIVER MILE	WEEK						
3	18NOV85	1	1.00		0		
	25NOV85	3	1.33	0.88	0		
	02DEC85	1	7.00		0		
	RM CPUE	5	2.40	1.25	0		
4	WEEK						
	18NOV85	2	0.50	0.50	0		
	25NOV85	1	4.00		0		
	RM CPUE	3	1.67	1.20	0		
5	WEEK						
	12NOV85	7	1.71	0.94	0		
	18NOV85	51	6.53	1.13	2	6.50	0.50
	25NOV85	18	4.06	1.96	0		
	02DEC85	26	8.73	1.44	4	1.75	0.85
	09DEC85	45	5.64	1.05	6	6.17	0.95
	16DEC85	46	13.00	2.19	4	9.25	2.39
	23DEC85	8	28.37	15.64	1	85.00	
	30DEC85	33	21.73	3.30	0		
	06JAN86	38	15.45	3.41	2	42.00	21.00

(CONTINUED)

APPENDIX TABLE C. (continued)

		THE BATTERY					
		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
		TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
RIVER MILE	WEEK						
5	13JAN86	54	11.57	2.21	7	39.71	4.25
	20JAN86	49	9.16	0.87	5	8.80	0.58
	27JAN86	51	4.22	0.39	1	14.00	
	03FEB86	20	1.95	0.63	0		
	10FEB86	27	6.44	0.81	2	25.00	6.00
	17FEB86	32	2.69	0.51	0		
	24FEB86	60	2.13	0.33	1	2.00	
	03MAR86	67	2.30	0.27	0		
	10MAR86	55	2.00	0.35	1	1.00	
	17MAR86	45	12.04	1.14	3	78.33	12.78
	24MAR86	0			3	3.67	0.67
	31MAR86	0			2	10.67	4.67
	07APR86	0			1	14.00	
	14APR86	0			4	11.25	4.96
	28APR86	0			1	0.00	
	05MAY86	0			1	2.00	
	12MAY86	0			1	0.00	
	RM CPUE	732	7.58	0.44	52	18.85	3.27

(CONTINUED)

APPENDIX TABLE C. (continued)

THE BATTERY

RIVER MILE	WEEK	TOMCOD TRAWL TOWS	TOMCOD TRAWL MEAN CPUE	TOMCOD TRAWL S.E.	STRIPED BASS TRAWL TOWS	STRIPED BASS TRAWL MEAN CPUE	STRIPED BASS TRAWL S.E.
6	18NOV85	3	1.67	0.88	0		
	25NOV85	1	0.00		0		
	02DEC85	6	16.00	2.05	0		
	09DEC85	1	6.00		0		
	16DEC85	6	9.83	1.54	1	7.00	
	RM CPUE	17	9.76	1.65	1	7.00	
7	WEEK						
	02DEC85	2	13.00	1.00	1	6.00	
	09DEC85	0			6	6.67	3.72
	16DEC85	0			1	25.00	
	03MAR86	0			1	6.00	
	31MAR86	0			1	25.00	
	07APR86	0			3	41.67	15.17
	28APR86	0			1	5.00	
	05MAY86	0			1	5.00	
	RM CPUE	2	13.00	1.00	15	15.80	4.83
8	WEEK						
	02DEC85	3	27.00	21.00	1	0.00	

(CONTINUED)

APPENDIX TABLE C. (continued)

		THE BATTERY					
		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
		TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
RIVER MILE	WEEK						
8	20JAN86	0			1	18.00	
	27JAN86	0			2	29.00	22.00
	17FEB86	0			4	109.5	20.75
	03MAR86	0			1	7.00	
	24MAR86	0			2	38.50	0.50
	RM CPUE	3	27.00	21.00	11	54.36	15.55
9	WEEK						
	02DEC85	2	21.50	4.50	0		
	16DEC85	6	45.00	13.25	2	94.00	91.00
	23DEC85	1	88.00		2	144	85.00
	30DEC85	0			2	120	5.00
	20JAN86	0			3	89.67	47.24
	27JAN86	0			3	75.67	39.28
	17FEB86	0			1	2.00	
	24FEB86	0			4	53.00	18.57
	03MAR86	0			1	1.00	
	10MAR86	0			8	22.37	5.49
	17MAR86	0			1	29.00	

(CONTINUED)

APPENDIX TABLE C. (continued)

THE BATTERY

		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
		TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
RIVER MILE	WEEK						
9	24MAR86	0			3	17.67	10.17
	31MAR86	0			2	21.00	11.00
	07APR86	0			2	25.50	2.50
	14APR86	0			2	19.50	5.50
	28APR86	0			1	3.00	
	05MAY86	0			2	3.00	2.00
	12MAY86	0			4	4.50	2.40
	RM CPUE	9	44.56	10.71	43	42.95	8.50
10	WEEK						
	02DEC85	4	4.25	0.63	0		
	16DEC85	6	3.33	0.21	0		
	23DEC85	1	56.00		0		
	30DEC85	0			3	32.67	2.91
	20JAN86	0			1	12.00	
	RM CPUE	11	8.45	4.76	4	27.50	5.56
11	WEEK						
	18NOV85	1	12.00		0		
	02DEC85	2	3.00	1.00	0		

(CONTINUED)

APPENDIX TABLE C. (continued)

		THE BATTERY					
		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
		TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
RIVER MILE	WEEK						
11	16DEC85	4	9.75	3.92	0		
	23DEC85	9	11.44	1.88	0		
	30DEC85	0			1	26.00	
	06JAN86	7	8.71	1.86	0		
	10MAR86	0			2	9.00	7.00
	31MAR86	0			2	17.00	0.00
	07APR86	0			4	13.50	12.17
	14APR86	0			1	5.00	
	05MAY86	0			1	2.00	
	12MAY86	0			1	1.00	
	RM CPUE	23	9.61	1.19	12	11.67	4.28
12	WEEK						
	06JAN86	2	8.50	2.50	0		
	RM CPUE	2	8.50	2.50	0		
13	WEEK						
	06JAN86	2	6.00	2.00	0		
	RM CPUE	2	6.00	2.00	0		

(CONTINUED)

APPENDIX TABLE C. (continued)

THE BATTERY

		TOMCOD TRAWL			STRIPED BASS TRAWL		
			MEAN			MEAN	
RIVER MILE	WEEK	TOWS	CPUE	S.E.	TOWS	CPUE	S.E.
14	31MAR86	0			4	20.00	5.08
	07APR86	0			5	7.80	3.79
	14APR86	0			1	9.00	
	28APR86	0			1	3.00	
	05MAY86	0			2	2.50	2.50
	12MAY86	0			1	0.00	
	RM CPUE				14	9.71	2.67
TOTAL CPUE		889	8.27	0.42	194	23.12	2.57

(CONTINUED)

APPENDIX TABLE C. (continued)

UPPER HARBOR

		TOMCOD TRAWL			STRIPED BASS TRAWL		
		TOWS	MEAN CPUE	S.E.	TOWS	MEAN CPUE	S.E.
RIVER MILE	WEEK						
1	03FEB86	0			2	24.50	1.50
	17FEB86	2	1.50	1.50	0		
	RM CPUE	2	1.50	1.50	2	24.50	1.50
2	WEEK						
	03FEB86	0			3	7.33	1.45
	24MAR86	0			6	30.00	9.06
	31MAR86	0			8	65.25	9.28
	07APR86	0			15	67.53	17.16
	14APR86	0			4	51.75	20.11
	21APR86	0			8	8.50	3.01
	28APR86	0			2	3.00	1.00
	12MAY86	0			1		
	RM CPUE	0			47	42.94	7.04
3	WEEK						
	17FEB86	9	0.56	0.24	0		
	14APR86	0			5	38.00	9.74
	28APR86	0			6	0.83	0.31
	05MAY86	0			1	0.00	
	12MAY86	0			2	0.00	0.00
	RM CPUE	9	0.56	0.24	14	13.93	5.93
TOTAL CPUE		11	0.73	0.30	63	35.90	5.61

(CONTINUED)

APPENDIX TABLE C. (continued)

EAST RIVER

STRIPED BASS
TRAWL

RIVER MILE	WEEK	TOWS	MEAN CPUE	S.E.
2	28APR86	1	0.00	
	RM CPUE	1	0.00	
11	WEEK			
	24MAR86	2	4.91	3.66
	31MAR86	3	4.00	2.65
	28APR86	1	6.00	
	05MAY86	2	0.50	0.50
	12MAY86	2	2.00	1.00
	RM CPUE	10	3.28	1.08
12	WEEK			
	14APR86	4	4.75	2.63
	21APR86	7	3.71	1.04
	RM CPUE	11	4.09	1.09
13	WEEK			
	24MAR86	1	0.00	
	31MAR86	1	0.00	
	07APR86	2	1.53	0.47
	14APR86	2	0.00	0.00

(CONTINUED)

APPENDIX TABLE C. (continued)

		EAST RIVER STRIPED BASS TRAWL		
		TOWS	MEAN CPUE	S.E.
RIVER MILE	WEEK			
13	21APR86	2	1.00	0.00
	28APR86	1	1.00	
	05MAY86	1	0.00	
	RM CPUE	10	0.61	0.22
14	WEEK			
	07APR86	2	13.00	6.00
	12MAY86	1	2.67	
	RM CPUE	3	9.56	4.89
TOTAL CPUE		35	3.22	0.70

(CONTINUED)

APPENDIX TABLE C. (continued)

HARLEM RIVER

		STRIPED BASS TRAWL		
			MEAN	
		TOWS	CPUE	S.E.
RIVER MILE	WEEK			
1	13JAN86	1	1.00	
	20JAN86	2	0.50	0.50
	24MAR86	1	2.00	
	31MAR86	1	2.00	
	21APR86	9	16.39	4.84
	28APR86	2	13.50	7.50
	05MAY86	9	14.11	3.37
	12MAY86	4	2.00	1.00
	RM CPUE	29	10.88	2.16
TOTAL CPUE		29	10.88	2.16

(CONTINUED)

APPENDIX TABLE C. (continued)

		LOWER HARBOR		
		STRIPED BASS TRAWL		
			MEAN	
		TOWS	CPUE	S.E.
RIVER MILE	WEEK			
.	14APR86	1	0.00	
	21APR86	3	1.00	1.00
	28APR86	5	0.00	0.00
	05MAY86	4	0.00	0.00
	12MAY86	3	0.00	0.00
	RM CPUE	16	0.19	0.19
TOTAL CPUE		16	0.19	0.19

(CONTINUED)

APPENDIX TABLE C. (continued)

		RARITAN BAY STRIPED BASS TRAWL		
			MEAN	
		TOWS	CPUE	S.E.
RIVER MILE	WEEK			
.	21APR86	1	0.00	
	28APR86	1	0.00	
	05MAY86	2	0.00	0.00
	12MAY86	1	0.00	
	RM CPUE	5	0.00	0.00
TOTAL CPUE		5	0.00	0.00

(CONTINUED)

APPENDIX TABLE C. (continued)

ROCKAWAY INLET

STRIPED BASS
TRAWL

RIVER MILE	WEEK	TOWS	MEAN CPUE	S.E.
.	21APR86	1	0.00	
	28APR86	1	0.00	
	05MAY86	1	0.00	
	12MAY86	1	0.00	
	RM CPUE	4	0.00	0.00
TOTAL CPUE		4	0.00	0.00

EXPLANATION OF VARIABLES USED IN APPENDIX TABLES D, E, F AND G.

RIVER REGION

BT	=	The Battery, Hudson River miles 0-14 (km 0-23).
CH	=	Tappan Zee and Croton-Haverstraw, Hudson River miles 25-39 (km 40-63).
ER	=	The East River.
UH	=	Upper Harbor, between Hudson River mile 0, and the Verrazano-Narrows Bridge.
HR	=	The Harlem River

DISTANCE TRAVELLED

= The minimum distance between release and recapture points.

TAG COND

1	=	Tag present, wound healed.
2	=	Tag present, wound poorly healed, evidence of infection or swelling.

APPENDIX TABLE D. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED AND RECAPTURED IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER SOUTH OF RIVER MILE 14 (km 23), AND IN UPPER NEW YORK HARBOR AND THE HARLEM RIVER DURING WINTER-SPRING 1985-86.

RECAPTURE					RELEASE										
DATE	GEAR	REGION	RIVER MILE	KM	DATE	GEAR	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	TAG COND	TAG NUMBER
20NOV85	TOMCOD TRAWL	BT	5	8	20NOV85	TOMCOD TRAWL	BT	5	8	0	0	0	237	1	4301
21NOV85	STRIPED BASS TRAWL	BT	5	8	21NOV85	TOMCOD TRAWL	BT	5	8	0	0	0	266	.	3978
04DEC85	TOMCOD TRAWL	BT	9	14	19NOV85	TOMCOD TRAWL	BT	5	8	15	4	6	225	1	4638
05DEC85	TOMCOD TRAWL	BT	8	13	20NOV85	TOMCOD TRAWL	BT	5	8	15	3	5	247	1	4673
11DEC85	TOMCOD TRAWL	BT	5	8	11DEC85	TOMCOD TRAWL	BT	5	8	0	0	0	222	.	2829
20DEC85	TOMCOD TRAWL	BT	5	8	20DEC85	TOMCOD TRAWL	BT	5	8	0	0	0	265	.	8552
20DEC85	TOMCOD TRAWL	BT	5	8	20DEC85	TOMCOD TRAWL	BT	5	8	0	0	0	248	.	8578
20DEC85	STRIPED BASS TRAWL	BT	9	14	09DEC85	TOMCOD TRAWL	BT	5	8	11	4	6	271	.	2571
21DEC85	TOMCOD TRAWL	BT	9	14	09DEC85	TOMCOD TRAWL	BT	5	8	12	4	6	232	.	2556
30DEC85	TOMCOD TRAWL	BT	5	8	30DEC85	TOMCOD TRAWL	BT	5	8	0	0	0	222	.	6263
02JAN86	STRIPED BASS TRAWL	BT	9	14	20DEC85	STRIPED BASS TRAWL	BT	9	14	13	0	0	245	1	8983
02JAN86	STRIPED BASS TRAWL	BT	9	14	30DEC85	TOMCOD TRAWL	BT	5	8	3	4	6	257	.	6160
02JAN86	STRIPED BASS TRAWL	BT	10	16	30DEC85	TOMCOD TRAWL	BT	5	8	3	5	8	239	1	6197
02JAN86	STRIPED BASS TRAWL	BT	10	16	02JAN86	STRIPED BASS TRAWL	BT	9	14	0	1	2	245	.	6400
03JAN86	TOMCOD TRAWL	BT	5	8	22DEC85	TOMCOD TRAWL	BT	11	18	12	6	10	227	.	7216
07JAN86	STRIPED BASS TRAWL	BT	5	8	25NOV85	TOMCOD TRAWL	BT	3	5	43	2	3	212	1	4919
08JAN86	TOMCOD TRAWL	BT	5	8	17DEC85	TOMCOD TRAWL	BT	5	8	22	0	0	437	.	3864
08JAN86	TOMCOD TRAWL	BT	5	8	08JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	301	.	9018
10JAN86	TOMCOD TRAWL	BT	5	8	21DEC85	TOMCOD TRAWL	BT	5	8	20	0	0	306	.	1570
10JAN86	TOMCOD TRAWL	BT	5	8	28DEC85	STRIPED BASS TRAWL	BT	9	14	13	4	6	268	1	7332
10JAN86	TOMCOD TRAWL	BT	5	8	03JAN86	TOMCOD TRAWL	BT	5	8	7	0	0	272	.	8344
10JAN86	TOMCOD TRAWL	BT	5	8	08JAN86	TOMCOD TRAWL	BT	5	8	2	0	0	232	.	5072
10JAN86	TOMCOD TRAWL	BT	5	8	10JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	306	.	9159
13JAN86	TOMCOD TRAWL	BT	5	8	19DEC85	TOMCOD TRAWL	BT	5	8	25	0	0	371	.	4499
16JAN86	STRIPED BASS TRAWL	BT	5	8	10JAN86	TOMCOD TRAWL	BT	5	8	6	0	0	309	.	9115
16JAN86	STRIPED BASS TRAWL	BT	5	8	16JAN86	STRIPED BASS TRAWL	BT	5	8	0	0	0	223	1	5614
16JAN86	STRIPED BASS TRAWL	BT	5	8	16JAN86	STRIPED BASS TRAWL	BT	5	8	0	0	0	241	1	5755
16JAN86	STRIPED BASS TRAWL	BT	5	8	16JAN86	STRIPED BASS TRAWL	BT	5	8	0	0	0	235	1	5768
17JAN86	TOMCOD TRAWL	BT	5	8	17JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	316	.	4151
17JAN86	TOMCOD TRAWL	BT	5	8	17JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	258	1	5820
17JAN86	TOMCOD TRAWL	BT	5	8	17JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	375	.	9322
21JAN86	TOMCOD TRAWL	BT	5	8	05DEC85	TOMCOD TRAWL	BT	8	13	47	3	5	217	1	3941
21JAN86	TOMCOD TRAWL	BT	5	8	28DEC85	STRIPED BASS TRAWL	BT	9	14	24	4	6	248	1	8687
21JAN86	TOMCOD TRAWL	BT	5	8	21JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	235	1	5956
22JAN86	TOMCOD TRAWL	BT	5	8	17JAN86	TOMCOD TRAWL	BT	5	8	5	0	0	232	1	5838
22JAN86	TOMCOD TRAWL	BT	5	8	22JAN86	TOMCOD TRAWL	BT	5	8	0	0	0	208	1	5949
23JAN86	STRIPED BASS TRAWL	BT	9	14	20NOV85	TOMCOD TRAWL	BT	5	8	64	4	6	313	2	4344
23JAN86	STRIPED BASS TRAWL	BT	9	14	16DEC85	TOMCOD TRAWL	BT	5	8	38	4	6	256	1	2911
23JAN86	STRIPED BASS TRAWL	BT	9	14	20DEC85	STRIPED BASS TRAWL	BT	9	14	34	0	0	261	.	2732
23JAN86	STRIPED BASS TRAWL	BT	9	14	03JAN86	TOMCOD TRAWL	BT	5	8	20	4	6	250	1	6590
23JAN86	STRIPED BASS TRAWL	BT	9	14	13JAN86	TOMCOD TRAWL	BT	5	8	10	4	6	230	.	6434
23JAN86	STRIPED BASS TRAWL	BT	9	14	22JAN86	TOMCOD TRAWL	BT	5	8	1	4	6	251	.	7575
27JAN86	STRIPED BASS TRAWL	BT	9	14	03JAN86	TOMCOD TRAWL	BT	5	8	24	4	6	252	.	6786
27JAN86	STRIPED BASS TRAWL	BT	9	14	16JAN86	STRIPED BASS TRAWL	BT	5	8	11	4	6	242	.	5791
27JAN86	STRIPED BASS TRAWL	BT	9	14	21JAN86	TOMCOD TRAWL	BT	5	8	6	4	6	240	.	5775

APPENDIX TABLE D. (continued)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE KM	RELEASE DATE	RELEASE GEAR	RELEASE REGION	RELEASE RIVER MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	COND	TAG NUMBER
27JAN86	STRIPED BASS TRAWL	BT	9	14	21JAN86	TOMCOD TRAWL	BT	5	8	6	4	6	260	.	8846
03FEB86	TOMCOD TRAWL	BT	1	2	20JAN86	TOMCOD TRAWL	BT	5	8	14	4	6	275	1	7709
03FEB86	TOMCOD TRAWL	BT	1	2	03FEB86	TOMCOD TRAWL	BT	1	2	0	0	0	245	.	9364
04FEB86	STRIPED BASS TRAWL	UH	1	2	29DEC85	TOMCOD TRAWL	BT	10	16	37	11	18	256	1	8162
04FEB86	STRIPED BASS TRAWL	UH	2	3	20JAN86	TOMCOD TRAWL	BT	5	8	15	7	11	297	.	7739
05FEB86	TOMCOD TRAWL	BT	1	2	31JAN86	TOMCOD TRAWL	BT	5	8	5	4	6	262	1	7776
11FEB86	TOMCOD TRAWL	BT	5	8	11FEB86	TOMCOD TRAWL	BT	5	8	0	0	0	286	1	3263
12FEB86	TOMCOD TRAWL	BT	5	8	02JAN86	STRIPED BASS TRAWL	BT	10	16	41	5	8	250	.	8336
13FEB86	TOMCOD TRAWL	BT	1	2	20DEC85	TOMCOD TRAWL	BT	5	8	55	4	6	226	1	8582
13FEB86	TOMCOD TRAWL	BT	1	2	28DEC85	STRIPED BASS TRAWL	BT	9	14	47	8	13	255	1	7468
14FEB86	TOMCOD TRAWL	BT	1	2	31JAN86	TOMCOD TRAWL	BT	5	8	14	4	6	232	1	7693
20FEB86	STRIPED BASS TRAWL	BT	8	13	09DEC85	TOMCOD TRAWL	BT	5	8	73	3	5	234	1	2550
20FEB86	STRIPED BASS TRAWL	BT	8	13	19DEC85	TOMCOD TRAWL	BT	5	8	63	3	5	290	1	2960
20FEB86	STRIPED BASS TRAWL	BT	8	13	14JAN86	STRIPED BASS TRAWL	BT	5	8	37	3	5	283	1	5453
20FEB86	STRIPED BASS TRAWL	BT	8	13	20FEB86	STRIPED BASS TRAWL	BT	8	13	0	0	0	307	1	10131
21FEB86	STRIPED BASS TRAWL	BT	8	13	18FEB86	TOMCOD TRAWL	BT	5	8	3	3	5	396	1	10111
21FEB86	STRIPED BASS TRAWL	BT	8	13	20FEB86	STRIPED BASS TRAWL	BT	8	13	1	0	0	381	1	10139
21FEB86	STRIPED BASS TRAWL	BT	8	13	20FEB86	TOMCOD TRAWL	BT	5	8	1	3	5	315	.	10696
21FEB86	STRIPED BASS TRAWL	BT	8	13	21FEB86	STRIPED BASS TRAWL	BT	8	13	0	0	0	339	1	3349
24FEB86	TOMCOD TRAWL	BT	5	8	25NOV85	TOMCOD TRAWL	BT	5	8	91	0	0	303	1	3874
27FEB86	TOMCOD TRAWL	BT	5	8	21NOV85	TOMCOD TRAWL	BT	5	8	98	0	0	291	1	4232
28FEB86	STRIPED BASS TRAWL	BT	9	14	19DEC85	TOMCOD TRAWL	BT	5	8	71	4	6	212	2	3120
04MAR86	STRIPED BASS TRAWL	BT	8	13	13FEB86	STRIPED BASS TRAWL	BT	1	2	19	7	11	335	.	10808
11MAR86	STRIPED BASS TRAWL	BT	11	18	16DEC85	TOMCOD TRAWL	BT	6	10	85	5	8	254	1	3094
12MAR86	TOMCOD TRAWL	BT	5	8	22DEC85	TOMCOD TRAWL	BT	11	18	80	6	10	257	1	7012
13MAR86	STRIPED BASS TRAWL	BT	9	14	15JAN86	TOMCOD TRAWL	BT	5	8	57	4	6	329	1	9069
13MAR86	STRIPED BASS TRAWL	BT	9	14	20JAN86	TOMCOD TRAWL	BT	5	8	52	4	6	255	1	7723
13MAR86	STRIPED BASS TRAWL	BT	9	14	24FEB86	TOMCOD TRAWL	BT	5	8	17	4	6	265	1	11873
17MAR86	STRIPED BASS TRAWL	BT	5	8	20DEC85	TOMCOD TRAWL	BT	5	8	87	0	0	300	1	1583
17MAR86	STRIPED BASS TRAWL	BT	5	8	30DEC85	TOMCOD TRAWL	BT	5	8	77	0	0	269	1	6855
17MAR86	STRIPED BASS TRAWL	BT	5	8	21JAN86	TOMCOD TRAWL	BT	5	8	55	0	0	253	1	5803
17MAR86	STRIPED BASS TRAWL	BT	5	8	20FEB86	STRIPED BASS TRAWL	BT	8	13	25	3	5	302	1	3316
17MAR86	STRIPED BASS TRAWL	BT	5	8	13MAR86	STRIPED BASS TRAWL	BT	9	14	4	4	6	275	1	11908
18MAR86	TOMCOD TRAWL	BT	1	2	28DEC85	STRIPED BASS TRAWL	BT	9	14	80	8	13	261	1	7416
18MAR86	TOMCOD TRAWL	BT	1	2	18MAR86	TOMCOD TRAWL	BT	1	2	0	0	0	225	.	12684
19MAR86	TOMCOD TRAWL	BT	5	8	11DEC85	TOMCOD TRAWL	BT	5	8	98	0	0	240	1	2604
19MAR86	TOMCOD TRAWL	BT	5	8	12DEC85	STRIPED BASS TRAWL	BT	7	11	97	2	3	312	1	1674
19MAR86	TOMCOD TRAWL	BT	5	8	10MAR86	TOMCOD TRAWL	BT	5	8	9	0	0	212	1	12423
20MAR86	TOMCOD TRAWL	BT	5	8	25NOV85	TOMCOD TRAWL	BT	5	8	115	0	0	285	1	4826
20MAR86	TOMCOD TRAWL	BT	5	8	08JAN86	TOMCOD TRAWL	BT	5	8	71	0	0	314	1	9272
20MAR86	TOMCOD TRAWL	BT	5	8	12FEB86	TOMCOD TRAWL	BT	5	8	36	0	0	218	1	11642
20MAR86	TOMCOD TRAWL	BT	5	8	20FEB86	TOMCOD TRAWL	BT	5	8	28	0	0	314	1	10694
20MAR86	TOMCOD TRAWL	BT	5	8	20FEB86	STRIPED BASS TRAWL	BT	8	13	28	3	5	282	.	11080
20MAR86	TOMCOD TRAWL	BT	5	8	20MAR86	TOMCOD TRAWL	BT	5	8	0	0	0	283	.	12993
20MAR86	TOMCOD TRAWL	BT	5	8	20MAR86	TOMCOD TRAWL	BT	5	8	0	0	0	346	.	21477

APPENDIX TABLE D. (continued)

RECAPTURE					RELEASE										
DATE	GEAR	REGION	RIVER MILE	KM	DATE	GEAR	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TOTAL LENGTH IN MM	COND	TAG NUMBER
21MAR86	STRIPED BASS TRAWL	BT	1	2	10JAN86	TOMCOD TRAWL	BT	5	8	70	4	6	283	1	5349
21MAR86	STRIPED BASS TRAWL	BT	1	2	12MAR86	TOMCOD TRAWL	BT	5	8	9	4	6	238	1	12167
25MAR86	STRIPED BASS TRAWL	BT	1	2	07MAR86	TOMCOD TRAWL	BT	5	8	18	4	6	277	1	12201
26MAR86	STRIPED BASS TRAWL	BT	5	8	11DEC85	TOMCOD TRAWL	BT	5	8	105	0	0	276	1	2804
26MAR86	STRIPED BASS TRAWL	BT	8	13	26MAR86	STRIPED BASS TRAWL	BT	9	14	0	1	2	288	.	17255
27MAR86	STRIPED BASS TRAWL	UH	2	3	04DEC85	TOMCOD TRAWL	BT	6	10	113	8	13	304	.	4579
27MAR86	STRIPED BASS TRAWL	UH	2	3	13FEB86	TOMCOD TRAWL	BT	1	2	42	3	5	335	1	9503
27MAR86	STRIPED BASS TRAWL	UH	2	3	13FEB86	STRIPED BASS TRAWL	BT	5	8	42	7	11	244	.	11410
27MAR86	STRIPED BASS TRAWL	UH	2	3	24FEB86	TOMCOD TRAWL	BT	5	8	31	7	11	264	1	11030
27MAR86	STRIPED BASS TRAWL	UH	2	3	20MAR86	TOMCOD TRAWL	BT	5	8	7	7	11	209	.	12880
27MAR86	STRIPED BASS TRAWL	UH	2	3	21MAR86	STRIPED BASS TRAWL	UH	2	3	6	0	0	331	1	21048
27MAR86	STRIPED BASS TRAWL	UH	2	3	21MAR86	STRIPED BASS TRAWL	UH	2	3	6	0	0	367	.	21404
27MAR86	STRIPED BASS TRAWL	UH	2	3	27MAR86	STRIPED BASS TRAWL	UH	2	3	0	0	0	262	.	17869
31MAR86	STRIPED BASS TRAWL	UH	2	3	04DEC85	TOMCOD TRAWL	BT	3	5	117	5	8	290	1	4877
01APR86	STRIPED BASS TRAWL	UH	2	3	30DEC85	TOMCOD TRAWL	BT	5	8	92	7	11	250	1	8752
01APR86	STRIPED BASS TRAWL	UH	2	3	08JAN86	TOMCOD TRAWL	BT	5	8	83	7	11	265	.	5050
01APR86	STRIPED BASS TRAWL	UH	2	3	08JAN86	TOMCOD TRAWL	BT	5	8	83	7	11	240	1	6098
01APR86	STRIPED BASS TRAWL	UH	2	3	10JAN86	TOMCOD TRAWL	BT	5	8	81	7	11	297	1	9371
01APR86	STRIPED BASS TRAWL	UH	2	3	20FEB86	TOMCOD TRAWL	BT	5	8	40	7	11	356	1	10731
01APR86	STRIPED BASS TRAWL	UH	2	3	13MAR86	STRIPED BASS TRAWL	BT	9	14	19	11	18	278	1	12417
01APR86	STRIPED BASS TRAWL	UH	2	3	27MAR86	STRIPED BASS TRAWL	UH	2	3	5	0	0	281	1	17840
01APR86	STRIPED BASS TRAWL	UH	2	3	27MAR86	STRIPED BASS TRAWL	UH	2	3	5	0	0	326	1	21725
02APR86	STRIPED BASS TRAWL	BT	14	23	20DEC85	STRIPED BASS TRAWL	BT	7	11	103	7	11	258	1	8654
02APR86	STRIPED BASS TRAWL	BT	9	14	13JAN86	TOMCOD TRAWL	BT	5	8	79	4	6	261	1	6516
02APR86	STRIPED BASS TRAWL	BT	14	23	24JAN86	STRIPED BASS TRAWL	BT	10	16	68	4	6	240	1	7922
04APR86	STRIPED BASS TRAWL	BT	14	23	17DEC85	TOMCOD TRAWL	BT	5	8	108	9	14	264	1	3147
04APR86	STRIPED BASS TRAWL	BT	14	23	04APR86	STRIPED BASS TRAWL	BT	14	23	0	0	0	263	.	13372
07APR86	STRIPED BASS TRAWL	UH	2	3	30DEC85	TOMCOD TRAWL	BT	5	8	98	7	11	255	1	8600
07APR86	STRIPED BASS TRAWL	UH	2	3	27JAN86	STRIPED BASS TRAWL	BT	8	13	70	10	16	328	1	6311
07APR86	STRIPED BASS TRAWL	UH	2	3	04FEB86	STRIPED BASS TRAWL	UH	1	2	62	1	2	270	1	10759
07APR86	STRIPED BASS TRAWL	UH	2	3	13FEB86	STRIPED BASS TRAWL	BT	1	2	53	3	5	267	1	11432
07APR86	STRIPED BASS TRAWL	UH	2	3	13MAR86	STRIPED BASS TRAWL	BT	9	14	25	11	18	297	.	12045
07APR86	STRIPED BASS TRAWL	UH	2	3	18MAR86	TOMCOD TRAWL	BT	1	2	20	3	5	287	1	3325
07APR86	STRIPED BASS TRAWL	UH	2	3	18MAR86	TOMCOD TRAWL	BT	1	2	20	3	5	242	.	12681
07APR86	STRIPED BASS TRAWL	UH	2	3	20MAR86	TOMCOD TRAWL	BT	5	8	18	7	11	281	.	13070
07APR86	STRIPED BASS TRAWL	UH	2	3	24MAR86	STRIPED BASS TRAWL	BT	8	13	14	10	16	247	1	17319
07APR86	STRIPED BASS TRAWL	UH	2	3	01APR86	STRIPED BASS TRAWL	UH	2	3	6	0	0	336	1	9809
07APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	0	0	0	411	.	21285
07APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	0	0	0	346	1	21290
08APR86	STRIPED BASS TRAWL	BT	1	2	19NOV85	TOMCOD TRAWL	BT	5	8	140	4	6	267	.	4613
08APR86	STRIPED BASS TRAWL	BT	7	11	27DEC85	TOMCOD TRAWL	BT	5	8	102	2	3	226	.	7048
08APR86	STRIPED BASS TRAWL	BT	9	14	28DEC85	STRIPED BASS TRAWL	BT	9	14	101	0	0	302	.	10574
08APR86	STRIPED BASS TRAWL	BT	11	18	11MAR86	STRIPED BASS TRAWL	BT	9	14	28	2	3	245	.	11769
11APR86	STRIPED BASS TRAWL	UH	2	3	19DEC85	TOMCOD TRAWL	BT	5	8	113	7	11	286	.	2979
11APR86	STRIPED BASS TRAWL	UH	2	3	02JAN86	STRIPED BASS TRAWL	BT	10	16	99	12	19	276	.	6767

APPENDIX TABLE D. (continued)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE KM	RELEASE DATE	RELEASE GEAR	RELEASE REGION	RELEASE RIVER MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	TAG COND	TAG NUMBER
11APR86	STRIPED BASS TRAWL	UH	2	3	27JAN86	STRIPED BASS TRAWL	BT	9	14	74	11	18	308	.	9277
11APR86	STRIPED BASS TRAWL	UH	2	3	13FEB86	STRIPED BASS TRAWL	BT	1	2	57	3	5	311	1	10834
11APR86	STRIPED BASS TRAWL	UH	2	3	05MAR86	TOMCOD TRAWL	BT	5	8	37	7	11	363	1	21984
11APR86	STRIPED BASS TRAWL	UH	2	3	18MAR86	TOMCOD TRAWL	BT	1	2	24	3	5	296	.	6864
11APR86	STRIPED BASS TRAWL	UH	2	3	21MAR86	STRIPED BASS TRAWL	UH	2	3	21	0	0	353	.	21427
11APR86	STRIPED BASS TRAWL	UH	2	3	01APR86	STRIPED BASS TRAWL	UH	2	3	10	0	0	340	.	9851
11APR86	STRIPED BASS TRAWL	UH	2	3	01APR86	STRIPED BASS TRAWL	UH	2	3	10	0	0	298	.	9888
11APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	4	0	0	249	.	13489
11APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	4	0	0	257	.	13495
11APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	4	0	0	284	.	13521
11APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	4	0	0	243	1	13545
11APR86	STRIPED BASS TRAWL	UH	2	3	11APR86	STRIPED BASS TRAWL	UH	2	3	0	0	0	344	.	14225
14APR86	STRIPED BASS TRAWL	UH	3	5	10JAN86	TOMCOD TRAWL	BT	5	8	94	8	13	300	1	1398
14APR86	STRIPED BASS TRAWL	UH	3	5	10JAN86	TOMCOD TRAWL	BT	5	8	94	8	13	288	1	5173
14APR86	STRIPED BASS TRAWL	UH	3	5	21JAN86	TOMCOD TRAWL	BT	5	8	83	8	13	255	1	5720
14APR86	STRIPED BASS TRAWL	UH	2	3	23JAN86	STRIPED BASS TRAWL	BT	9	14	81	11	18	280	1	7533
14APR86	STRIPED BASS TRAWL	UH	2	3	03FEB86	TOMCOD TRAWL	BT	1	2	70	3	5	305	1	3286
14APR86	STRIPED BASS TRAWL	UH	2	3	18MAR86	TOMCOD TRAWL	BT	1	2	27	3	5	328	1	21846
14APR86	STRIPED BASS TRAWL	UH	2	3	07APR86	STRIPED BASS TRAWL	UH	2	3	7	0	0	310	1	21129
14APR86	STRIPED BASS TRAWL	UH	2	3	14APR86	STRIPED BASS TRAWL	UH	2	3	0	0	0	363	1	14602
15APR86	STRIPED BASS TRAWL	BT	1	2	02JAN86	STRIPED BASS TRAWL	BT	9	14	103	8	13	239	1	6136
15APR86	STRIPED BASS TRAWL	BT	5	8	15JAN86	TOMCOD TRAWL	BT	5	8	90	0	0	248	1	6837
15APR86	STRIPED BASS TRAWL	BT	1	2	18MAR86	TOMCOD TRAWL	BT	1	2	28	0	0	231	1	12659
15APR86	STRIPED BASS TRAWL	BT	1	2	18MAR86	TOMCOD TRAWL	BT	1	2	28	0	0	256	1	12664
15APR86	STRIPED BASS TRAWL	BT	1	2	14APR86	STRIPED BASS TRAWL	UH	2	3	1	3	5	266	1	14764
17APR86	STRIPED BASS TRAWL	BT	9	14	19DEC85	TOMCOD TRAWL	BT	5	8	119	4	6	217	1	2980
17APR86	STRIPED BASS TRAWL	BT	9	14	27JAN86	STRIPED BASS TRAWL	BT	9	14	80	0	0	315	1	10890
17APR86	STRIPED BASS TRAWL	BT	9	14	17MAR86	STRIPED BASS TRAWL	BT	5	8	31	4	6	234	1	12563
17APR86	STRIPED BASS TRAWL	BT	11	18	14APR86	STRIPED BASS TRAWL	UH	2	3	3	13	21	240	1	14685
18APR86	STRIPED BASS TRAWL	UH	3	5	21DEC85	TOMCOD TRAWL	BT	9	14	118	12	19	329	1	1573
18APR86	STRIPED BASS TRAWL	UH	3	5	18MAR86	TOMCOD TRAWL	BT	1	2	31	4	6	282	1	12479
21APR86	STRIPED BASS TRAWL	UH	2	3	21FEB86	STRIPED BASS TRAWL	BT	8	13	59	10	16	332	1	10299
23APR86	STRIPED BASS TRAWL	HR	1	2	01APR86	STRIPED BASS TRAWL	UH	2	3	22	11	18	288	1	13089
01MAY86	STRIPED BASS TRAWL	UH	2	3	08APR86	STRIPED BASS TRAWL	BT	14	23	23	16	26	269	.	13774
05MAY86	STRIPED BASS TRAWL	HR	1	2	05MAY86	STRIPED BASS TRAWL	HR	1	2	0	0	0	258	.	16326
07MAY86	STRIPED BASS TRAWL	BT	14	23	16DEC85	TOMCOD TRAWL	BT	5	8	142	9	14	263	1	2820

APPENDIX TABLE E. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED IN THE SCOTTISH SEINE BETWEEN RIVER MILES 25 (km 40) AND 39 (km 63) DURING WINTER-SPRING 1985-86.

RECAPTURE					RELEASE										
DATE	GEAR	REGION	RIVER MILE	KM	DATE	GEAR	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	TAG COND	TAG NUMBER
11APR86	STRIPED BASS TRAWL	UH	2	3	09APR86	SCOTTISH SEINE	CH	30	48	2	32	52	359	1	880
30APR86	STRIPED BASS TRAWL	ER	13	21	11APR86	SCOTTISH SEINE	CH	30	48	19	43	69	320	1	2314

APPENDIX TABLE F. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED AND RECAPTURED IN THE SCOTTISH SEINE BETWEEN RIVER MILE 25 (km 40) AND RIVER MILE 39 (km 63) OF THE HUDSON RIVER DURING SPRING 1986.

RECAPTURE					RELEASE										
DATE	GEAR	REGION	RIVER MILE	KM	DATE	GEAR	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	TAG COND	TAG NUMBER
11APR86	SCOTTISH SEINE	CH	30	48	11APR86	SCOTTISH SEINE	CH	30	48	0	0	0	569	1	2362
13APR86	SCOTTISH SEINE	CH	36	58	13APR86	SCOTTISH SEINE	CH	36	58	0	0	0	341	1	1193
22APR86	SCOTTISH SEINE	CH	38	61	21APR86	SCOTTISH SEINE	CH	36	58	1	2	3	398	.	15874
23APR86	SCOTTISH SEINE	CH	36	58	09APR86	SCOTTISH SEINE	CH	30	48	14	6	10	546	1	781
24APR86	SCOTTISH SEINE	CH	36	58	07APR86	SCOTTISH SEINE	CH	30	48	17	6	10	541	1	9672
25APR86	SCOTTISH SEINE	CH	36	58	09APR86	SCOTTISH SEINE	CH	30	48	16	6	10	503	1	12561
26APR86	SCOTTISH SEINE	CH	36	58	09APR86	SCOTTISH SEINE	CH	30	48	17	6	10	597	.	1953
26APR86	SCOTTISH SEINE	CH	36	58	12APR86	SCOTTISH SEINE	CH	36	58	14	0	0	537	.	2442
26APR86	SCOTTISH SEINE	CH	36	58	16APR86	SCOTTISH SEINE	CH	36	58	10	0	0	347	1	15958
26APR86	SCOTTISH SEINE	CH	36	58	17APR86	SCOTTISH SEINE	CH	37	60	9	1	2	303	1	15948
27APR86	SCOTTISH SEINE	CH	36	58	08APR86	SCOTTISH SEINE	CH	30	48	19	6	10	463	1	10348
27APR86	SCOTTISH SEINE	CH	36	58	12APR86	SCOTTISH SEINE	CH	36	58	15	0	0	524	1	2473
28APR86	SCOTTISH SEINE	CH	36	58	09APR86	SCOTTISH SEINE	CH	30	48	19	6	10	500	1	1981
28APR86	SCOTTISH SEINE	CH	30	48	24APR86	SCOTTISH SEINE	CH	36	58	4	6	10	478	.	20035
29APR86	SCOTTISH SEINE	CH	30	48	13APR86	SCOTTISH SEINE	CH	36	58	16	6	10	394	1	11590
29APR86	SCOTTISH SEINE	CH	30	48	24APR86	SCOTTISH SEINE	CH	36	58	5	6	10	363	1	20032
02MAY86	SCOTTISH SEINE	CH	30	48	13APR86	SCOTTISH SEINE	CH	36	58	19	6	10	498	1	17692
02MAY86	SCOTTISH SEINE	CH	30	48	24APR86	SCOTTISH SEINE	CH	36	58	8	6	10	541	1	19916
09MAY86	SCOTTISH SEINE	CH	36	58	09MAY86	SCOTTISH SEINE	CH	36	58	0	0	0	377	1	29455

APPENDIX TABLE G. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED BY TRAWLS SOUTH OF RIVER MILE 14 (km 23) AND RECAPTURED BY SCOTTISH SEINE BETWEEN RIVER MILES 25 (km 40) AND 39 (km 63) OF THE HUDSON RIVER DURING WINTER-SPRING 1985-86.

RECAPTURE					RELEASE										
DATE	GEAR	REGION	RIVER MILE	KM	DATE	GEAR	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	COND	TAG NUMBER
11APR86	SCOTTISH SEINE	CH	30	48	28FEB86	STRIPED BASS TRAWL	BT	9	14	42	21	34	254	1	12069
14APR86	SCOTTISH SEINE	CH	36	58	19NOV85	TOMCOD TRAWL	BT	5	8	146	31	50	307	1	4710
14APR86	SCOTTISH SEINE	CH	36	58	20FEB86	STRIPED BASS TRAWL	BT	8	13	53	28	45	305	1	10163
16APR86	SCOTTISH SEINE	CH	36	58	20DEC85	TOMCOD TRAWL	BT	9	14	117	27	43	287	1	8773
17APR86	SCOTTISH SEINE	CH	36	58	25NOV85	TOMCOD TRAWL	BT	5	8	143	31	50	364	1	3807
21APR86	SCOTTISH SEINE	CH	36	58	23JAN86	STRIPED BASS TRAWL	BT	9	14	88	27	43	245	1	7555
21APR86	SCOTTISH SEINE	CH	36	58	27MAR86	STRIPED BASS TRAWL	UH	2	3	25	38	61	331	1	21550
21APR86	SCOTTISH SEINE	CH	35	56	01APR86	STRIPED BASS TRAWL	UH	2	3	20	37	60	331	1	9982
21APR86	SCOTTISH SEINE	CH	36	58	14APR86	STRIPED BASS TRAWL	UH	2	3	7	38	61	354	1	14673
21APR86	SCOTTISH SEINE	CH	36	58	14APR86	STRIPED BASS TRAWL	UH	2	3	7	38	61	254	1	15051
22APR86	SCOTTISH SEINE	CH	36	58	17MAR86	STRIPED BASS TRAWL	BT	9	14	36	27	43	372	1	10335
22APR86	SCOTTISH SEINE	CH	36	58	20MAR86	TOMCOD TRAWL	BT	5	8	33	31	50	331	1	21496
22APR86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	15	38	61	275	1	13531
23APR86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	22	38	61	360	1	21631
24APR86	SCOTTISH SEINE	CH	36	58	17MAR86	STRIPED BASS TRAWL	BT	5	8	38	31	50	316	2	9566
24APR86	SCOTTISH SEINE	CH	35	56	19MAR86	TOMCOD TRAWL	BT	5	8	36	30	48	294	1	17922
24APR86	SCOTTISH SEINE	CH	36	58	04APR86	STRIPED BASS TRAWL	BT	14	23	20	22	35	308	1	21328
24APR86	SCOTTISH SEINE	CH	36	58	11APR86	STRIPED BASS TRAWL	UH	2	3	13	38	61	272	1	14109
24APR86	SCOTTISH SEINE	CH	36	58	11APR86	STRIPED BASS TRAWL	UH	2	3	13	38	61	327	1	14213
25APR86	SCOTTISH SEINE	CH	36	58	04APR86	STRIPED BASS TRAWL	BT	11	18	21	25	40	331	1	21332
26APR86	SCOTTISH SEINE	CH	36	58	20DEC85	TOMCOD TRAWL	BT	9	14	127	27	43	237	1	8906
26APR86	SCOTTISH SEINE	CH	36	58	16JAN86	STRIPED BASS TRAWL	BT	5	8	100	31	50	331	1	1435
26APR86	SCOTTISH SEINE	CH	36	58	23JAN86	STRIPED BASS TRAWL	BT	9	14	93	27	43	323	1	9410
26APR86	SCOTTISH SEINE	CH	36	58	24FEB86	TOMCOD TRAWL	BT	5	8	61	31	50	250	1	11375
26APR86	SCOTTISH SEINE	CH	36	58	13MAR86	STRIPED BASS TRAWL	BT	9	14	44	27	43	440	1	21841
26APR86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	25	38	61	302	1	9836
26APR86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	19	38	61	331	1	21025
26APR86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	19	38	61	312	1	21306
26APR86	SCOTTISH SEINE	CH	36	58	08APR86	STRIPED BASS TRAWL	BT	5	8	18	31	50	304	1	1729
26APR86	SCOTTISH SEINE	CH	36	58	11APR86	STRIPED BASS TRAWL	UH	2	3	15	38	61	272	1	14221
26APR86	SCOTTISH SEINE	CH	36	58	14APR86	STRIPED BASS TRAWL	UH	2	3	12	38	61	321	1	14763
26APR86	SCOTTISH SEINE	CH	36	58	17APR86	STRIPED BASS TRAWL	BT	9	14	9	27	43	215	1	15259
27APR86	SCOTTISH SEINE	CH	36	58	02JAN86	STRIPED BASS TRAWL	BT	9	14	115	27	43	272	1	6301
27APR86	SCOTTISH SEINE	CH	36	58	23JAN86	STRIPED BASS TRAWL	BT	9	14	94	27	43	249	1	7508
27APR86	SCOTTISH SEINE	CH	36	58	13FEB86	STRIPED BASS TRAWL	BT	5	8	73	31	50	302	1	11409
27APR86	SCOTTISH SEINE	CH	36	58	19MAR86	TOMCOD TRAWL	BT	5	8	39	31	50	279	1	17895
27APR86	SCOTTISH SEINE	CH	36	58	21MAR86	STRIPED BASS TRAWL	UH	2	3	37	38	61	325	1	21050
27APR86	SCOTTISH SEINE	CH	36	58	27MAR86	STRIPED BASS TRAWL	UH	2	3	31	38	61	344	1	21708
27APR86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	26	38	61	298	.	9828
27APR86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	26	38	61	383	1	9877
27APR86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	26	38	61	287	1	13254
27APR86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	20	38	61	318	1	21132
27APR86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	20	38	61	322	1	21261
27APR86	SCOTTISH SEINE	CH	36	58	17APR86	STRIPED BASS TRAWL	BT	9	14	10	27	43	277	1	15262
28APR86	SCOTTISH SEINE	CH	36	58	20MAR86	TOMCOD TRAWL	BT	5	8	39	31	50	257	1	12888

APPENDIX TABLE G. (continued)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE GEAR	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TOTAL LENGTH IN MM	TAG COND	TAG NUMBER
28APR86	SCOTTISH SEINE	CH	36	58	11APR86	STRIPED BASS TRAWL	UH	2	3	17	38	61	280	1	14042
05MAY86	SCOTTISH SEINE	CH	36	58	10JAN86	TOMCOD TRAWL	BT	5	8	115	31	50	335	1	9129
05MAY86	SCOTTISH SEINE	CH	36	58	20FEB86	TOMCOD TRAWL	BT	5	8	74	31	50	355	1	10731
06MAY86	SCOTTISH SEINE	CH	30	48	21FEB86	STRIPED BASS TRAWL	BT	8	13	74	22	35	351	1	10220
06MAY86	SCOTTISH SEINE	CH	30	48	07APR86	STRIPED BASS TRAWL	UH	2	3	29	32	52	315	1	21131
07MAY86	SCOTTISH SEINE	CH	36	58	18MAR86	TOMCOD TRAWL	BT	1	2	50	35	56	311	1	10238
07MAY86	SCOTTISH SEINE	CH	36	58	01APR86	STRIPED BASS TRAWL	UH	2	3	36	38	61	323	.	9445
07MAY86	SCOTTISH SEINE	CH	36	58	07APR86	STRIPED BASS TRAWL	UH	2	3	30	38	61	270	1	13484
07MAY86	SCOTTISH SEINE	CH	36	58	22APR86	STRIPED BASS TRAWL	HR	1	2	15	45	72	295	1	20453
09MAY86	SCOTTISH SEINE	CH	36	58	27JAN86	STRIPED BASS TRAWL	BT	9	14	102	27	43	284	2	7679
09MAY86	SCOTTISH SEINE	CH	36	58	30APR86	STRIPED BASS TRAWL	HR	1	2	9	45	72	340	1	19547
12MAY86	SCOTTISH SEINE	CH	36	58	26MAR86	STRIPED BASS TRAWL	UH	2	3	47	38	61	281	.	17322

NORMANDEAU ASSOCIATES INC.

a unit of TE Thermo Water Management Inc.

1986-1987 HUDSON RIVER

STRIPED BASS HATCHERY EVALUATION

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Jointly financed by
Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

Submitted by

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R-0012

September 1987

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1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. To address this requirement, the Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York. Fingerling striped bass produced at the hatchery have been released since 1983. The total number of hatchery striped bass that has been stocked into the Hudson River is:

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program be conducted through 1990 that includes an evaluation of mitigation measures. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery have been tagged prior to release. Each striped bass released from the hatchery is tagged with an internal, coded, magnetic, wire tag (magnetic tag). These magnetic tags can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally spawned striped bass. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered

tags. If these striped bass are tagged with external tags before release, then recapture may provide valuable information for a stock assessment program.

The 1984 Adult Striped Bass Program (NAI 1985) demonstrated it was feasible to use a striped bass trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. It was also demonstrated in 1984 that striped bass could be externally tagged and released without significantly increasing the 24-hour mortality (Dunning *et al.* 1987 in press). Finally, the 1984 program suggested those river sections in the lower Hudson River estuary that could be most efficiently fished for striped bass with each gear.

The 1985-86 Hudson River Striped Bass Program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers during the winter and spring of 1985-86. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced the highest catch of striped bass per tow. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit effort for the 12 m striped bass trawl was greater than for the 9 m tomcod trawl, but mean catch per day was almost identical for the two trawls because more tows could be taken by the 9 m tomcod trawl in a day. The 12 m striped bass trawl was more efficient for capturing striped bass in a size range which includes Age 1+ through Age 3+, while the 9 m tomcod trawl was more efficient for capturing striped bass in the Age 0+ and 1+ size range. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May, was efficient for capturing striped bass of sizes that would be older than Age 3+. Trawl and seine efforts tagged and released 18,487 striped bass ≥200 mm total length (TL) and recaptured 250 striped bass released during 1985-86. Two tagged fish from the 1984 program were also recaptured. However, no striped bass of any age containing magnetic tags were detected although all fish were checked for these tags. Based on the recapture of tagged fish released during late December 1985 through February 1986, the estimated size of the mid-winter striped bass population in upper New York Harbor and the Battery-region was approximately 540,000 fish.

Data from the 1984 and 1985-86 field studies (NAI 1985, 1986) were also evaluated in a report which provides recommendations for conducting studies for evaluating the proportion of hatchery-reared striped bass in the population of Hudson River striped bass (MMES 1986). Of the seven sampling options reviewed for the hatchery evaluation, three were felt to deserve further consideration. These options were retained because they satisfied underlying statistical assumptions and the required sampling effort for their implementation was feasible. They include:

1) sampling yearling striped bass in the mouth of the river in winter,

2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and

3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring.

A review of alternate estimators suggested that the mark-recapture methodologies could be used to estimate annual survival rate of the adult stock. However, sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high. Consequently, the recommended program focuses on estimating annual survival rate from Age 1+ to Age 2+.

The 1986-1987 Hudson River Striped Bass Hatchery Evaluation was conducted to address the following objectives:

1) determine if hatchery striped bass, stocked during any year between 1983 and 1985, have contributed to the Hudson River population,

2) estimate the proportion of the 1984 year class of Hudson River striped bass composed of hatchery fish at Age 2+, if hatchery fish are detected,

3) estimate the proportion of the 1985 year class of Hudson River striped bass composed of hatchery fish at Age 1+, if hatchery fish are detected,

4) tag all striped bass greater than or equal to 200 mmTL in total length, that are in good condition, with internal anchor tags, and

5) determine catch rate and survival of striped bass handled during 1986-1987.

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1986-87 Hudson River Striped Bass Hatchery Evaluation Standard Operating Procedures (NAI 1987). The 1986-87 Hudson River Striped Bass Hatchery Evaluation Program consisted of sampling in the lower Hudson River (Figure 2-1) with 9 m and 12 m high rise trawls, and with 9 m and 12 m high rise trawls equipped with 2.5 cm (stretch) mesh cod end liners (Appendix Tables A-1 and A-2). The 9 m and 12 m trawls are high-rise nets of basically the same construction. The 12 m trawl has a foot rope length of 12.2 m with a 7.5 cm (stretch) mesh cod end, or a 2.5 cm (stretch) mesh cod end liner. The 12 m trawl has a foot rope that is 35% larger than the 9 m trawl which has a 9.0 m foot rope and a cod end equipped with a 3.0 cm (stretch) mesh cod end, or a 2.5 cm (stretch) mesh cod end liner. Striped bass captured in each trawl were enumerated, tagged with internal anchor tags if judged in good condition, and released.

Sampling with the 12 m trawl occurred at least two days per week for the period beginning the week of 21 December 1986 through the week of 4 January 1987 (Figure 2-2). The 9 m trawl was deployed three days per week for the same period. Beginning the week of 11 January 1987, the 9 m trawl was deployed on Monday of each sampling week. Each of the four gear (9 m trawl, 9 m trawl with a cod end liner, 12 m trawl, and 12 m trawl with a cod end liner) were then deployed on a randomly assigned day among the remaining four days of the sampling week. However, damage and loss of trawls, and stormy weather did not always permit this design to be repeated in each week (Figure 2-2).

Striped bass captured by the trawls received identical handling to minimize fish stress before tagging. In general, each

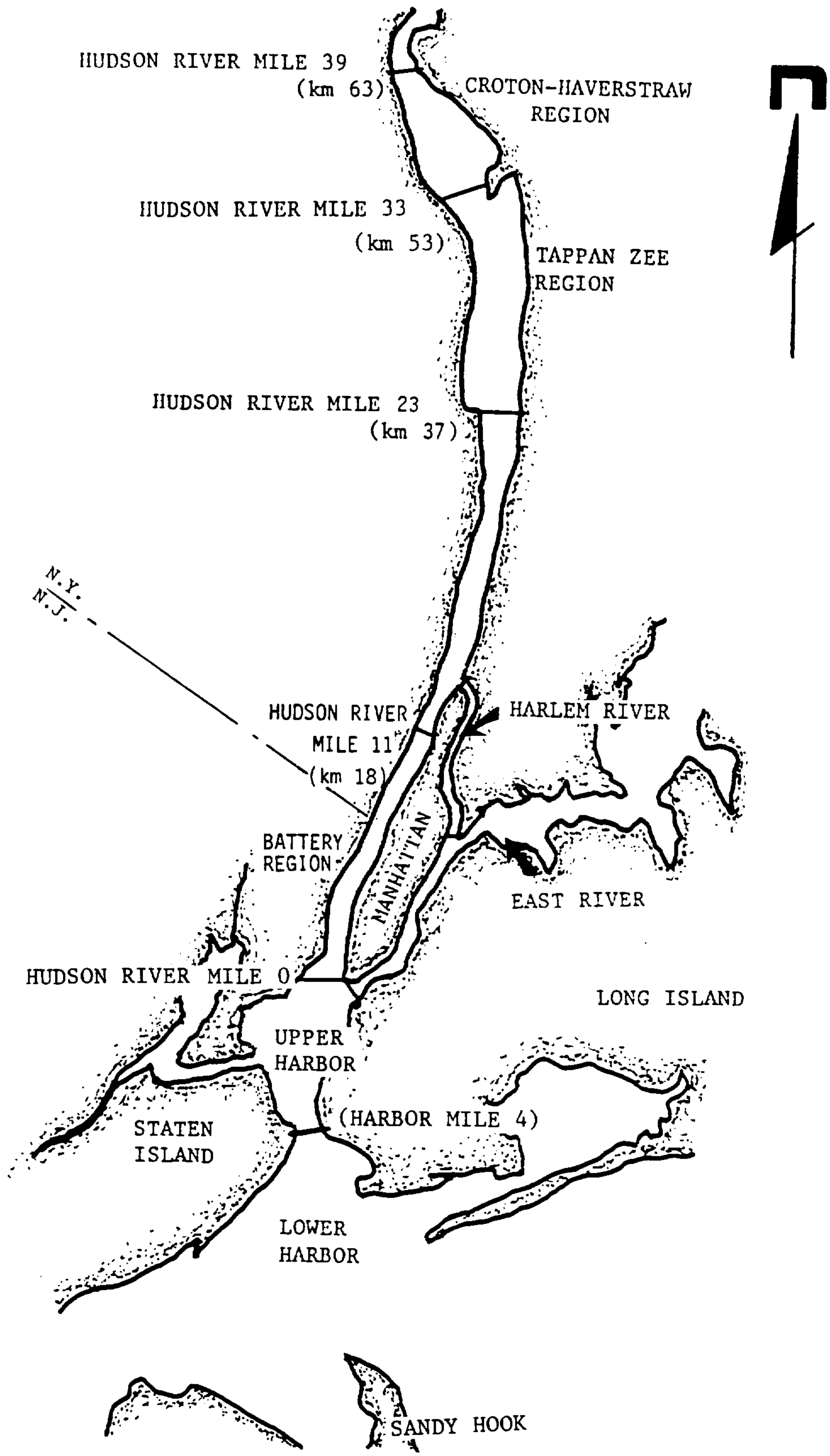

Figure 2-1. Areas sampled during the 1986-1987 Hudson River Striped Bass Hatchery Evaluation.

REGION AND GEAR	21 DEC	28 DEC	4 JAN	11 JAN	18 JAN	25 JAN	1 FEB	8 FEB	15 FEB	22 FEB	1 MAR	8 MAR	15 MAR	22 MAR	29 MAR	5 APR	12 APR	19 APR	26 APR	3 MAY
BATTERY																				
9 m trawl	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9 m trawl w/liner				X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
12 m trawl		X	X		X	X	X	X	X	X		X	X	X		X	X	X	X	
12 m trawl w/liner			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
UPPER HARBOR																				
9 m trawl			X														X			
9 m trawl w/liner															X	X	X			
12 m trawl			X	X							X							X		
12 m trawl w/liner				X							X									
TAPPAN ZEE																				
9 m trawl																				X
9 m trawl w/liner																				X
12 m trawl												X								
12 m trawl w/liner																				X
CROTON-HAVERSTRAW																				
9 m trawl																				X
9 m trawl w/liner																				X
12 m trawl																				X
12 m trawl w/liner																				
		1986									1987									

Figure 2-2. Weekly sampling schedule for the 1986-87 Hudson River Striped Bass Hatchery Evaluation.

sampling effort required two boats. One boat conducted the actual sampling (capture boat) while the second boat (tagging boat) tended the capture boat with a holding facility for striped bass that was secured in the water alongside the tagging boat (Figure 2-3). The cod end of the net was transferred through the water from the capture boat to the holding facility alongside the tagging boat. Striped bass were then transferred from the live car to the tagging boat one at a time using the following procedures:

1) fish were removed from the live car using a dip net,
2) all surfaces that came in contact with the live fish were wet,
3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and
4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

All striped bass were measured for total length (mmTL) and examined for external tags, tag wounds, and hatchery administered internal, magnetic, wire tags (magnetic tags) using a magnetic tag detector. A V-shaped field detector was used throughout the study period to examine fish for magnetic tags. Additionally, a more sensitive "tube-shaped" detector was used in tandem with the field detector between 30 January and 18 February 1987 to evaluate the effectiveness of the field detector.

All striped bass greater than, or equal to, 200 mmTL, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

1) no bleeding from gills or body wounds,
2) no significant loss of scales, and
3) strong opercular movement.

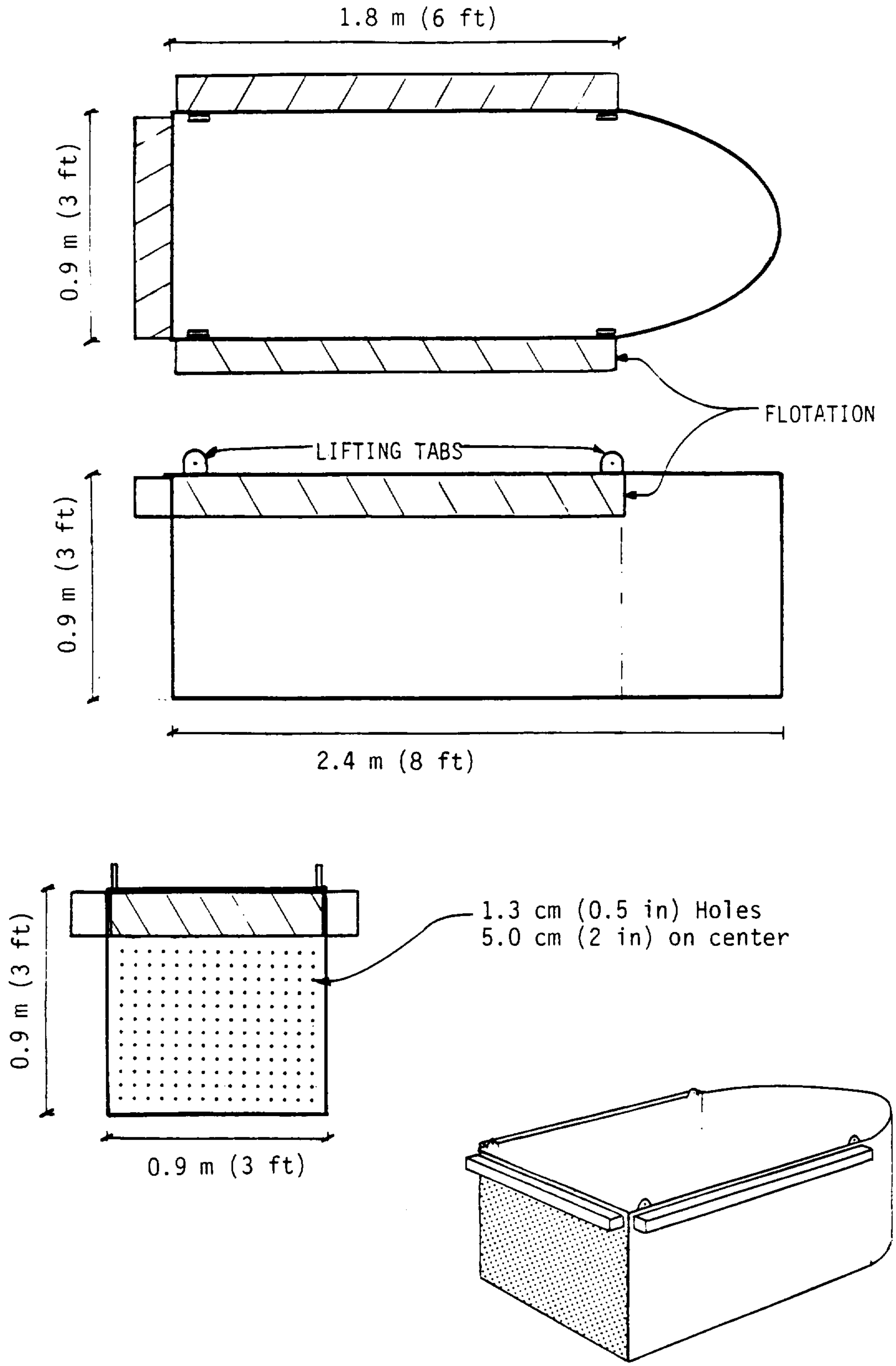

Figure 2-3. Aluminum holding facility for striped bass used in the lower Hudson River during the 1986-1987 Hudson River Striped Bass Hatchery Evaluation.

The internal anchor tags were inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. A horizontal incision about 5 mm long was made with a hooking movement of a curved blade scalpel. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromine-based topical antiseptic. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location. Scale samples were taken from the left side of all striped bass caught from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins, except for recaptured, tagged fish from which a scale sample was taken on the right side of the fish to avoid regenerated scales. Condition of the tag and tag insertion site of recaptured striped bass was also evaluated.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter were used to take surface (0.3 m), and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C. Water quality data is summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, fish and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random subsample of striped bass using scales collected from the fish in the field. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mmTL length group in which an Age 1+ fish was expected to occur. Expected numbers of Age 1+ striped bass in each 10 mmTL length group were calculated from age at length data (McLaren *et al.* 1981, TI 1979) and further refined by intermediate results from age determinations of random selected scale samples during the first two months of field sampling.

The hatching date of striped bass was assumed to be 15 May. Therefore, a yearling fish captured in April would be 23 months old and designated "Age 1+". Similarly, a young-of-the-year striped bass approaching its birth date would be 11 months old and designated "Age 0+".

Striped bass scales were pressed on 0.050 in thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined through a scale projector at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were 1) changes in the relative spacing of circuli in the anterior field of the scale, 2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and 3) variations in the thickness, and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was also measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks. Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which taggable striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 2 samples were used for mark-recapture analysis only. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses.

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among trawls, locations, and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Effort

Catch Per Unit Effort (CPUE) for the trawls was defined as catch per ten-minute tow (Use Code = 1) and was calculated as:

$$\bar{X} = \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \times 10 \right] / n \qquad \text{Equation 1}$$

where, $\bar{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,

E_i = the tow duration of trawl i in minutes, and

n = the number of trawls.

Analysis of Variance (ANOVA) was used to compare CPUE among the trawls and sampling weeks. The ANOVA model used was:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \text{error} \qquad \text{Equation 2}$$

where: β_0 = regression coefficient for the intercept,

β_1 and β_2 = regression coefficients for main effects gear (X_1) and week (X_2),

β_3 = regression coefficient for the interaction between gear and week,

error = amount of variation not explained by the model, and

the dependent variable Y = density.

Only sampling weeks in the Battery region in which all trawl/cod end combinations were deployed were used as blocking factors in this comparison. The statistical analysis system software package (SAS PROC GLM: SAS 1985) was used to evaluate the ANOVA model; a logarithmic transformation (log to the base ten) was used to normalize the dependent variable (Y).

2.3.1.2 Length-Frequency

Length-frequency histograms, with number of fish on the ordinate and total length on the abscissa were constructed to compare the catch characteristics of the different gear types. Length-frequency distributions were statistically compared between sampling gear using a chi-square (χ^2) technique for frequency distributions (SAS PROC FREQ: SAS 1985). Chi-square comparisons were calculated for striped bass caught in (Use Code = 1) samples from the Battery region (river miles 0-11; km 0-18) between 11 January and 25 April 1987.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula:

$$PropD_x = D_x/T_x \qquad \text{Equation 4}$$

where, $PropD_x$ = the proportion of dead striped bass at water temperature x,

D_x = the number of dead striped bass at water temperature x, and

T_x = total number of striped bass captured at water temperature x.

PropD was calculated by sampling gear for samples collected in the Battery at both surface and bottom water temperatures, and for two time (temperature) periods to assess the affect of gear and descending or ascending water temperatures on handling mortality. A 4.9°C decrease in weekly mean bottom water temperature in the nine week period between 21 December 1986 and 21 February 1987 defined the period of descending water temperatures (Appendix Table B-1). The period of ascending water temperatures was defined as the eleven week period between 22 February and 8 May 1987 when weekly mean bottom water temperature increased by 8.5°C. Comparisons of handling mortality between the 1985-86 and 1986-87 programs were also made, using data subset by gear within the Battery region in both programs.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 Estimated Number of Striped Bass in Each Age Category

A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1986-87 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mmTL length increment and the variance of the proportion of Age 1+ fish in each 10 mmTL length group. This Neyman allocation scheme is considered optimum with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish, and is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n(N_h\sqrt{p_h q_h}/\Sigma N_h\sqrt{p_h q_h}) \qquad \text{Equation 5}$$

where

n_h = number of scale samples selected for age determination from length group h,

n = number of scale samples to be selected from the total of N fish caught,

N_h = total number of fish caught in length group h,

p_h = proportion of Age 1+ fish in length group h from the laboratory sample, and

$q_h = 1 - p_h$.

The stratified sampling plan was implemented in successive stages intended to obtain the most precise estimate of the number of Age 1+ striped bass caught during the 1986-87 program for the number of scale samples examined (Figure 2-4). First, the actual age of fish in each 10 mmTL length group was determined from a random sample of 300 fish (Box 1, Figure 2-4), and the proportion of Age 1+ fish in each length group was calculated (Box 2, Figure 2-4). Length group proportions of Age 1+ fish were used in Equation 5 to randomly select 700 unique scale samples for age determination according to the Neyman allocation scheme (Box 3, Figure 2-4). The age and proportion of Age 1+ fish in each length group from the sample of 700 fish (Box 4, Figure 2-4) was used to evaluate the relationship between the number of scales analyzed and precision of the estimated proportion of Age 1+ fish among the total fish caught during the 1986-87 program (Box 5, Figure 2-4). If the precision of the calculated proportion and number of Age 1+ fish in the entire 1986-87 data set was acceptable, (Box 6, Figure 2-4), then the "true" proportion and number of each Age fish in the sample was calculated (Box 8, Figure 2-4). Otherwise, a revised Neyman allocation (Box 7, Figure 2-4) was used to randomly select an additional 700 unique scale samples for age determination and Boxes 3, 4, 5 and 6 were repeated. Estimates of the proportion of Age 1+ fish in each length group for the revised Neyman allocation were then combined, and 1,400 fish were used to evaluate the relationship between sample size (n) and precision of the estimated proportion of Age 1+ fish in the total catch. The procedure described in Boxes 3-6 was repeated until the acceptable level of precision was obtained. In this study, a total of three iterations (approximately 2100 scale samples) was determined to be acceptable. This iterative procedure was noted by Cochran (1977) to produce estimates of the "true" proportion with slightly higher variance and a slight bias compared to that expected from a theoretically optimum allocation consisting of only one sample. No method is known for calculating the exact effect of iteratively approximating the true Neyman allocation, and this bias is considered negligible for this study. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived

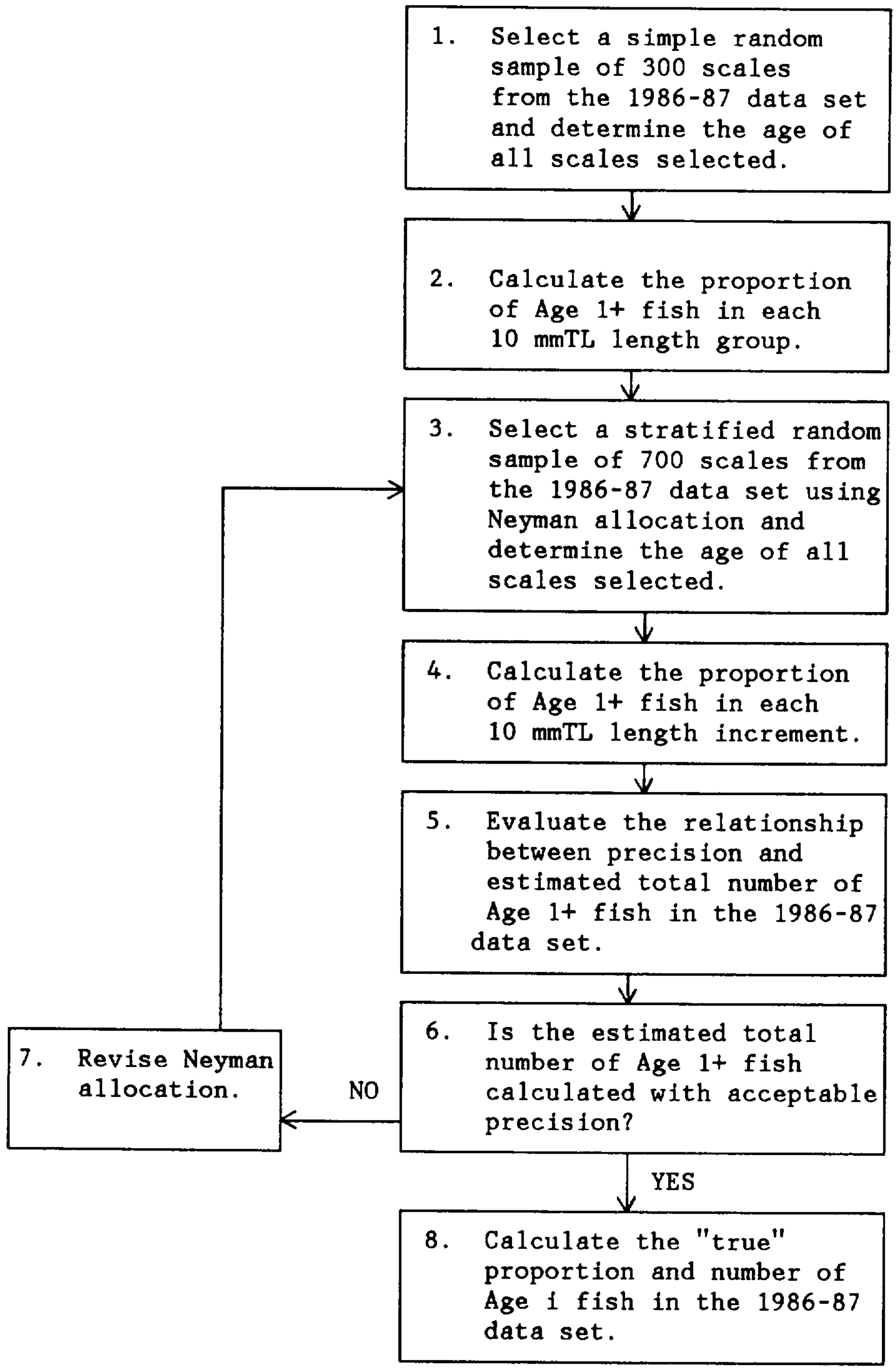

Figure 2-4. Flowchart of iterative procedure used to estimate the proportion and number of Hudson River striped bass in age cohorts using stratified random sampling and Neyman allocation to select scales for analysis from 10 mmTL length groups, winter 1986-87.

from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1986-87 program was estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \Sigma(N_h p_{hi}/N) \qquad \text{Equation 6}$$

where

p_{sti} = the stratified mean proportion of Age i fish,
p_{hi} = the proportion of Age i fish in length group h, and
N_h and N are as defined in Equation 5.

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N(p_{sti}) \qquad \text{Equation 7}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2_{p_{sti}}$) is (Cochran 1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h^2(N_h - n_h)/(N_h - 1)][(p_{hi}q_{hi})/(n_h - 1)]\right] \qquad \text{Equation 8}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 5 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish are calculated based on Cochran (1977) Equations 5.14 and 5.15 are:

$$95\% \text{ CI for } p_{sti} = p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 9}$$

$$95\% \text{ CI for } A_i = N\left(p_{sti} \pm t\, s_{p_{sti}}\right) \qquad \text{Equation 10}$$

where

$$s_{p_{sti}} = \sqrt{s^2_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 5-8.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1986-87 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 5.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} N_{hi}\, \bar{y}_{hi}\right] / N_i \qquad \text{Equation 11}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

N_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least 2 Age i fish were measured.

The variance of the stratified mean length of striped bass of a given age was estimated using the following formula (Cochran 1977, Equation 5.12):

$$S^2_{\bar{y}_{sti}} = 1/N_i^2 \left[\Sigma\, N_{hi}(N_{hi}-n_{hi})\, S^2_{hi}/n_{hi}\right] \qquad \text{Equation 12}$$

where

$S^2_{\bar{y}_{sti}}$ = variance of the stratified mean length of striped bass of Age i,

n_{hi} = number of Age i fish measured for length in length group h of the laboratory sample,

S^2_{hi} = variance of the mean length of Age i fish measured for length in length group h of the laboratory sample, and

N_i, N_{hi} are as defined in Equation 11.

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ \text{CI for } \bar{y}_{sti} = \bar{y}_{sti} + t\, S_{\bar{y}_{sti}} \qquad \text{Equation 13}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = student's t statistic as defined in Equation 10, and

$\bar{y}_{sti}$ is as defined in Equation 11.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1986-87 sampling program were examined for hatchery-administered, magnetic, coded wire tags (magnetic tags) and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following formula (MMES 1986):

$$P_i = H_i \ / \ (H_i + W_i) \qquad \text{Equation 14}$$

where

P_i = the proportion of Age i hatchery striped bass in the population,

H_i = the number of Age i verified hatchery recaptures caught, and

W_i = the number of Age i wild striped bass caught.

By substituting the upper or lower 95% CI values from Equation 10 for the number of Age i striped bass (W_i) in Equation 14, the exact binomial variance of P_i can be calculated and confidence limits are determined for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (EAI 1985, 1986, 1987) and non-detection of tags on an age-specific basis (Table 2-1) as follows:

$$H_{ai} = H_i(1 + TAG_i + NDET_i) \qquad \text{Equation 15}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

TAG_i = weighted, decimal percent magnetic tag loss for Age i hatchery striped bass, and

$NDET_i$ = decimal percent non-detection rate for magnetic tags.

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then substituted for H_i in Equation 14. The total number of hatchery striped bass that were stocked in each year was also adjusted to reflect the loss of fish due to tagging and handling mortality (EAI 1985, 1986, 1987) as follows:

$$N_{ai} = N_i(1 - MORT_i) \qquad \text{Equation 16}$$

where

N_{ai} = total number of hatchery striped bass of age cohort i adjusted for 72-hour tagging and handling mortality,

N_i = the total number of hatchery striped bass of age cohort i stocked (see Section 1.0, page 1), and

$MORT_i$ = weighted, 72-hour stocking mortality for Age i hatchery striped bass release with magnetic tags (Table 2-1).

TABLE 2-1. FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOSS (TAG), NON-DETECTION OF TAGS ($NDET_i$), AND 72-HOUR STOCKING MORTALITY ($MORT_i$).

COHORT	AGE	TAG_i	$NDET_i$	$MORT_i$
1986	0+	0.071	0.00094	0.008
1985	1+	0.063	0.00094	0.0025
1984	2+	0.276	0.00094	0.136

2.3.4 Population Movement

Distance between tagging and recovery locations, days at large, and minimum rate of travel were calculated for all recaptured striped bass and used to directly evaluate movement of fish within the study area. Each region of the study area (Figure 2-1) was considered as a potential release and/or recapture zone. Movement among regions was determined directly by examining the exchange of fish between regions, by plotting, and comparison of recapture rates and recapture proportions by week within each region:

$$\text{Recapture rate} = R_{ij}/M_{ij} \qquad \text{Equation 17}$$

where R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

M_{ij} = number of tagged striped bass released during time (week) period i in region j.

$$\text{Recapture Proportion } R_{ij}/C_{ij} \qquad \text{Equation 18}$$

where R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period i (week) in region j.

2.3.5 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently and can be used for migratory populations (Ricker 1975).

This estimator is a weighted linear regression of R_i/C_i as a function of M_i with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the values of R_i/C_i are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$1/N = \Sigma(R_i M_i)/\Sigma(C_i M_i^2) \qquad \text{Equation 19}$$

where

N = estimated population size,
C_i = total catch during time interval i,
M_i = total number of marked fish available for recapture at the midpoint of time interval i, and
R_i = number of recaptured fish in C_i.

The variance of the recriprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\Sigma(R_i^2/C_i) - (\Sigma R_i M_i)^2/\Sigma(C_i M_i^2)}{m-1} \qquad \text{Equation 20}$$

where

S^2 = mean of squared deviations from the regression model described above,
m = the number of data points in the regression, and
C_i, M_i and R_i are as defined above in Equation 19.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_i M_i^2 \times t_{m-1} \qquad \text{Equation 21}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and $\alpha=0.05$.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE TRAWLS

3.1.1 Catch Per Unit Effort

Mean striped bass catch per ten minute tow (CPUE) is compared in this section among the four trawl/cod end liner combinations that were fished in the lower Hudson River between 21 December 1986 and 8 May 1987. Mean CPUE was calculated for the 9 m trawl, the 9 m trawl with a cod end liner (9 m trawl w/liner), the 12 m trawl, and the 12 m trawl with a cod end liner (12 m trawl w/liner) for successful (Use Code = 1) samples to compare differences in catch rates among gear. The 9 m trawl was deployed on Monday of each week. Each of the four gear were then deployed on a randomly assigned day from Tuesday through Friday of each week. Damage and loss of trawls, and stormy weather conditions did not always permit this design to be repeated in each week.

Most of the trawling effort (92%) was expended in the Battery region which exhibited statistically indistinguishable striped bass mean CPUE when compared with the Upper Harbor over all sampling weeks combined (Table 3-1). CPUE was significantly lower in the Tappan Zee and Croton-Haverstraw Regions, which were sampled only briefly during the weeks of 8 March and 3 May 1987 (Appendix Tables C-1 and C-2). Because of the relatively high and consistent trawling effort expended by all four trawls in the Battery region throughout this program (Figure 2-2), subsequent comparisons of CPUE among gear and weeks are made within this region only.

In the Battery region, striped bass weekly mean CPUE was generally highest for the 12 m trawl and the 12 m trawl w/liner (Figure 3-1; Appendix Tables C-1 and C-2). Mean CPUE for the 12 m trawl w/liner reached a peak of 82.67 striped bass per ten minute tow during the week

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL, 12 m TRAWL WITH A COD END LINER, AND ALL FOUR TRAWLS COMBINED IN THE LOWER HUDSON RIVER BETWEEN 21 DECEMBER 1986 AND 8 MAY 1987.

REGION	TRAWL	NUMBER OF TOWS	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Upper Harbor	9 m	14	135	9.64	1.69
	9 m w/liner	16	140	8.75	2.86
	12 m	14	319	22.79	6.12
	12 m w/liner	3	47	15.67	5.78
	Combined	47	641	13.64	2.29
Battery	9 m	612	5,617	9.18	0.46
	9 m w/liner	203	2,424	11.94	1.01
	12 m	94	1,988	21.15	2.61
	12 m w/liner	108	2,926	27.09	2.54
	Combined	1,017	12,955	12.74	0.53
Tappan Zee	9 m	3	2	0.67	0.33
	9 m w/liner	5	3	0.60	0.40
	12 m	2	0	0.00	0.00
	12 m w/liner	6	3	0.50	0.22
	Combined	16	8	0.50	0.16
Croton-Haverstraw	9 m	12	19	1.58	0.53
	9 m w/liner	10	4	0.40	0.22
	12 m	5	1	0.20	0.20
	12 m w/liner	0			
	Combined	27	24	0.89	0.27

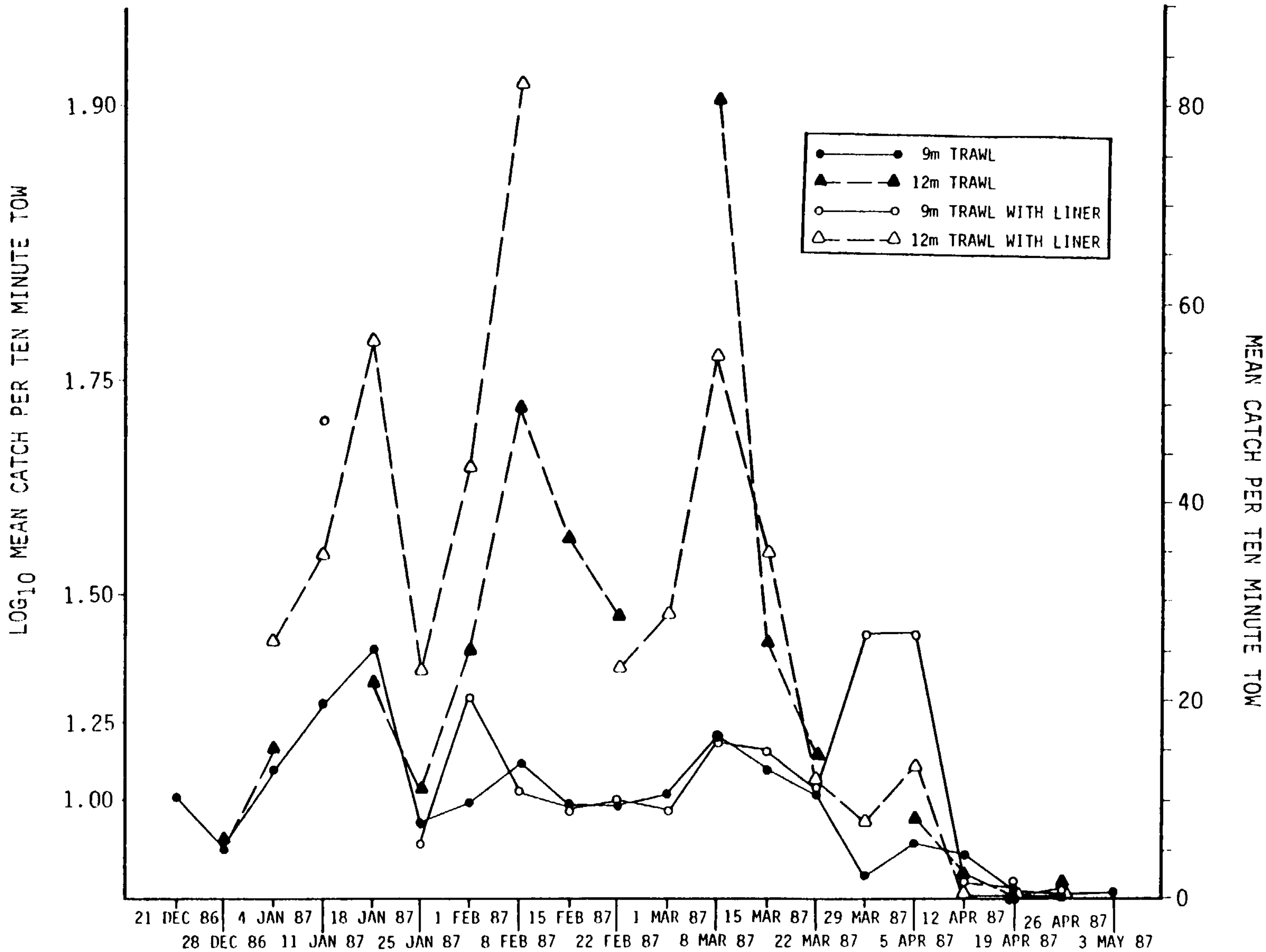

Figure 3-1. Log_{10} mean catch per ten minute tow and mean catch per ten minute tow for the 9m and 12m trawls, with and without cod end liners, deployed in the Battery Region (RM 0-11; KM 0-18) of the Hudson River between the weeks of 21 December 1986 and 3 May 1987.

of 8 February 1987. Mean CPUE for the 12 m trawl reached a peak of 80.60 striped bass per ten minute tow one month later during the week of 8 March 1987. The highest CPUE for the 9 m trawl was 25.54 striped bass per ten minute tow during the week of 18 January 1987. For the 9 m trawl w/liner, the two weeks with highest mean striped bass CPUE were 27.00 and 27.17 during the weeks of 5 April and 12 April 1987, respectively.

The 9 m trawl was deployed in the Battery on Monday and again on a randomly assigned day from Tuesday through Friday of each sampling week to assess the effects of within-week variability on the comparison of CPUE among the four trawl/cod end combinations. In general, the pattern of weekly mean striped bass CPUE appeared to vary randomly between Monday and the randomly picked day (Figure 3-2; Appendix Tables C-3 and C-4). One noteworthy exception was observed during the week of 11 January 1987, when mean CPUE for the 9 m trawl on Monday (CPUE = 8.40) was more than four times lower than on the randomly picked day (CPUE = 36.43).

Analysis of variance (ANOVA) was used to compare within-week variability in striped bass CPUE of the 9 m trawl. The ANOVA model was highly significant ($p<0.0001$; Table 3-2). No significant differences among days within a week were observed ($p<0.2522$), however, significant differences were seen among weeks ($p<0.0001$) and in the interaction between sampling day and week ($p<0.0001$). The significant sampling day x week interaction is consistent with the observed pattern of random variation in which CPUE of the 9 m trawl was higher on Monday of some weeks than on other sampling days (Figure 3-2). No period of two or more weeks existed in which CPUE on Monday was significantly higher than the other randomly picked sampling day in each week (Table 3-3). Therefore, variation in CPUE was considered random within each weekly time block and the procedure of allocating sampling effort for the four trawl/cod end combinations among days in each week was valid.

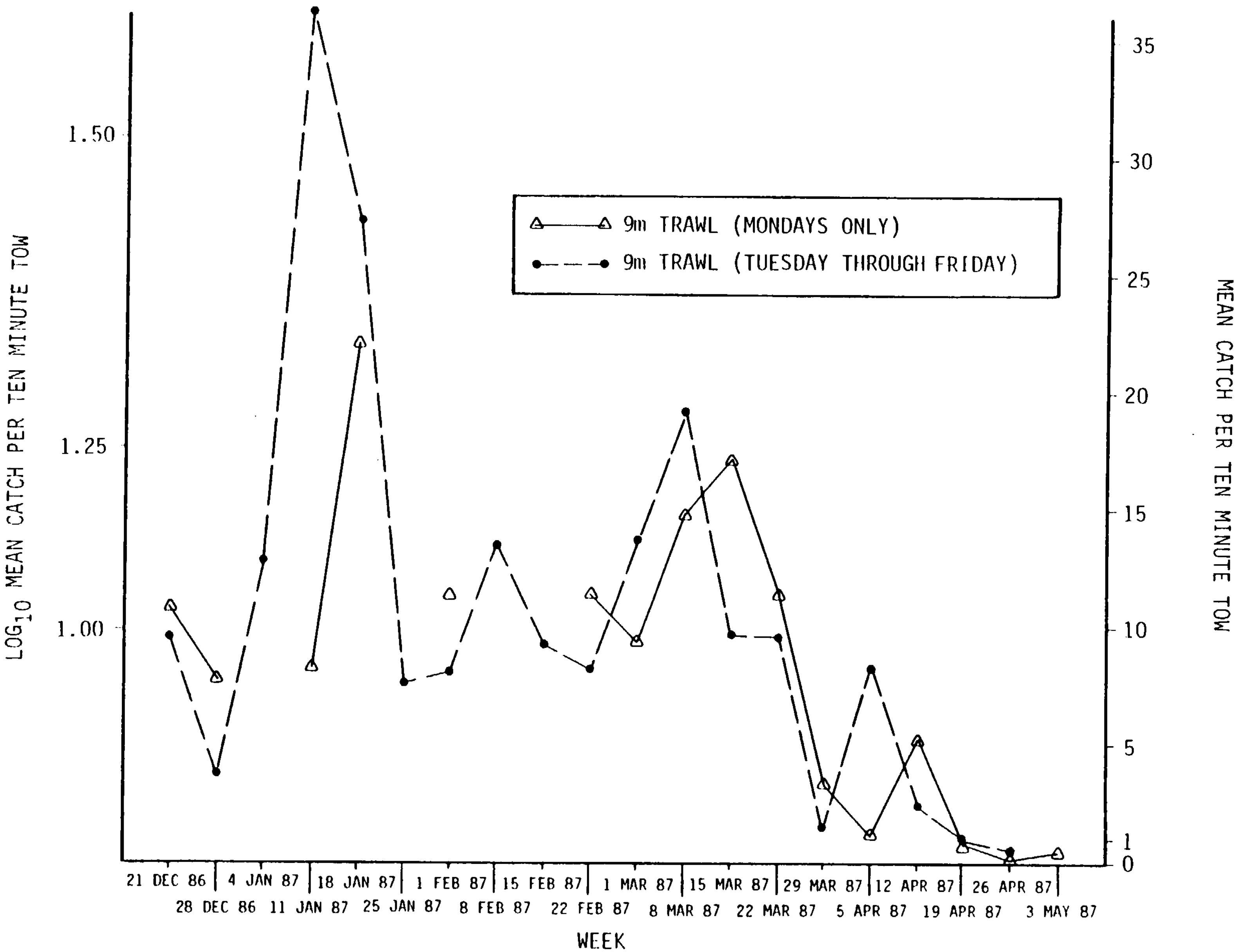

Figure 3-2. Log_{10} mean catch per ten minute tow and mean catch per ten minute tow for the 9m trawl deployed on Monday or Tuesday through Friday between the weeks of 21 December 1986 and 3 May 1987 in the Battery Region (RM 0-11; KM 0-18) of the Hudson River.

TABLE 3-2. TWO-WAY ANALYSIS OF VARIANCE EXAMINING THE RELATIONSHIP BETWEEN CATCH PER TEN MINUTE TOW OF STRIPED BASS IN THE 9 m TRAWL ON MONDAY OR ANOTHER RANDOMLY SELECTED DAY IN EACH SAMPLING WEEK BETWEEN 21 DECEMBER 1986 AND 2 MAY 1987 IN THE BATTERY REGION OF THE LOWER HUDSON RIVER.

SOURCE	df	SS	MS	F	p>F
MODEL	29	58.64	2.02	22.01	0.0001
SAMPLING DAY	1	0.12		1.31	0.2522
WEEK	14	53.19		41.36	0.0001
DAY X WEEK	14	5.5		4.28	0.0001
ERROR	475	43.63	0.09		
TOTAL	504	102.27			

Response variable = Log_{10} CPUE

R^2 = coefficient of determination = 0.57

df = degrees of freedom

SS = sum of squares

MS = mean square

F = calculated F-ratio

p>F = probability of obtaining a larger F-ratio

TABLE 3-3. SELECTED LEAST SQUARE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE 9 m TRAWL COMPARING THE INTERACTION BETWEEN SAMPLING DAY (MONDAY OR ONE DAY RANDOMLY PICKED TUESDAY - FRIDAY) AND SAMPLING WEEK IN THE BATTERY REGION OF THE LOWER HUDSON RIVER, 21 DECEMBER 1986 THROUGH 2 MAY 1987.

LOG_{10} LEAST SQUARE MEAN CPUE					
	MONDAY		RANDOM DAY TUESDAY - FRIDAY		
WEEK	MEAN	S.E.	MEAN	S.E.	SIGNIFICANT DIFFERENCE
21 Dec 86	0.96	0.08	0.96	0.06	
28 Dec 86	0.69	0.08	0.61	0.06	
11 Jan 87	0.88	0.10	1.37	0.11	**
18 Jan 87	1.31	0.10	1.36	0.08	
1 Feb 87	1.03	0.08	0.94	0.08	
22 Feb 87	1.02	0.08	0.89	0.06	
1 Mar 87	0.90	0.07	1.13	0.08	*
8 Mar 87	1.13	0.07	1.08	0.07	
15 Mar 87	1.17	0.08	0.95	0.07	*
22 Mar 87	0.98	0.07	0.94	0.06	
29 Mar 87	0.60	0.07	0.35	0.06	**
5 Apr 87	0.32	0.09	0.91	0.06	***
12 Apr 87	0.49	0.07	0.42	0.11	
19 Apr 87	0.22	0.07	0.24	0.08	
26 Apr 87	0.09	0.08	0.16	0.08	

* significant difference at $p<0.05$
** significant difference at $p<0.01$
*** significant difference at $p<0.001$

ANOVA was also used to compare striped bass CPUE among the 9 m trawl, 9 m trawl w/liner, 12 m trawl, and 12 m trawl w/liner across sampling weeks in the 1986-87 program. The ANOVA model for this comparison was also highly significant ($p<0.0001$), as were the main factors gear and week, and the interaction between gear and week (Table 3-4). CPUE for the 9 m trawl was significantly lower than for the other trawl/cod end combinations, and CPUE for the 9 m trawl w/liner was significantly lower than for both 12 m trawls (Table 3-5). No significant difference was observed in the striped bass CPUE for the 12 m trawl with or without a cod end liner. The significant interaction between gear and week indicates that the pattern of significant differences in CPUE among the four trawl/cod end combinations was not consistent across all weeks.

CPUE for the 9 m trawl in the Battery was similar when the entire 1986-87 data set was compared to the 9 m trawl during 1985-86 (Table 3-6). The 12 m trawl exhibited similar CPUE when fished in the Battery during 1985-86 and 1986-87. However, when the 1986-87 data was subset for a comparable time period to the 1985-86 data set, significant differences appeared and 1985-86 exhibited higher CPUE than 1986-87 for the 9 m trawl.

3.1.2 Length-Frequency Distributions

Length-frequency distributions for striped bass caught by the 9 m trawl, 9 m trawl with cod end liner, 12 m trawl and 12 m trawl with liner were characterized using moment statistics and statistically compared using chi-square analysis. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions. A chi-square technique was used to compare the effect of adding a cod end liner to the 9 m trawl and the 12 m trawl. The chi-square technique pools data from the two trawls being

TABLE 3-4. TWO-WAY ANALYSIS OF VARIANCE EXAMINING THE RELATIONSHIP BETWEEN CATCH OF STRIPED BASS PER TEN MINUTE TOW OF STRIPED BASS IN THE 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL AND 12 m TRAWL WITH A COD END LINER DURING COMPARABLE SAMPLING WEEKS BETWEEN 21 DECEMBER 1986 AND 8 MAY 1987 IN THE BATTERY REGION OF THE LOWER HUDSON RIVER.

SOURCE	df	SS	MS	F	p>F
MODEL	43	103.18	2.40	27.57	0.0001
GEAR	3	10.20		39.06	0.0001
WEEK	10	61.22		70.33	0.0001
GEAR X WEEK	30	7.95		3.04	0.0001
ERROR	619	53.88	0.09		
TOTAL	662	157.06			

Response variable = Log_{10} CPUE

R^2 = coefficient of determination = 0.66

df = degrees of freedom

SS = sum of squares

MS = mean square

F = calculated F-ratio

p>F = probability of obtaining a larger F-ratio

TABLE 3-5. COMPARISON OF LEAST SQUARE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL AND 12 m TRAWL WITH A COD END LINER FISHED IN COMPARABLE WEEKS IN THE BATTERY REGION OF THE LOWER HUDSON RIVER, 21 DECEMBER 1986 THROUGH 8 MAY 1987.

GEAR	LOG_{10} LEAST SQUARE MEAN CPUE	S.E.	SIGNIFICANT DIFFERENCE ($p<0.05$)
9 m TRAWL	0.76	0.02	<9 m trawl w/liner <12 m trawl <12 m trawl w/liner
9 m TRAWL W/LINER	0.87	0.03	>9 m trawl <12 m trawl <12 m trawl w/liner
12 m TRAWL	1.05	0.04	>9 m trawl >9 m trawl w/liner
12 m TRAWL W/LINER	1.13	0.04	>9 m trawl >9 m trawl w/liner

TABLE 3-6. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW FOR THE 9 m TRAWL AND THE 12 m TRAWL FISHED IN THE BATTERY REGION OF THE LOWER HUDSON RIVER DURING WINTER 1985-86 AND WINTER 1986-87.

GEAR	YEAR	TOWS	MEAN CPUE	95% CI
9 m trawl	1985-86[a]	889	8.3	±0.8
	1986-87[b]	612	9.2	±0.9
	1985-86[c]	638	8.1	±1.0
	1986-87[c]	385	12.2	±1.2
12 m trawl	1985-86[a]	194	23.1	±5.0
	1986-87[b]	94	21.1	±5.1

[a] 9 m trawl 11 November 1985-21 March 1986
12 m trawl 18 November 1985-16 May 1986

[b] 9 m trawl 21 December 1986-8 May 1987
12 m trawl 28 December 1986-8 May 1987

[c] 9 m trawl 23 December 1985-21 March 1986
9 m trawl 21 December 1986-21 March 1987

compared to calculate the hypothetical expected number of fish in each length group, and then statistically tests to determine if the observed number of fish in each length group for each gear is significantly different from the expected. In pooling data, it was assumed that distinct subpopulations of striped bass did not exist within the river region and time period over which pooling occurred, or if subpopulations existed, they were not sampled differently by the two trawls being compared.

The mean size of striped bass caught by the 9 m trawl with a cod end liner was significantly ($p<0.05$) smaller than the mean size of striped bass caught by the 9 m trawl (Table 3-7). The mean size of striped bass caught by both 9 m trawls was significantly smaller than the mean size of striped bass caught by the 12 m trawl with or without a cod end liner. The 12 m trawl caught striped bass with the largest mean size. Length-frequency distributions for all trawl/cod end combinations except the 12 m trawl with a cod end liner were skewed right, indicating more fish were larger than the mean length than would be expected if the length-frequency distributions were bell shaped (Table 3-7; Figure 3-3). Length-frequency distributions for both the 9 m trawl and 12 m trawl were leptokurtotic, indicating more fish were found in length groups close to the mean length than would be expected if the length-frequency distributions were bell-shaped. Length-frequency distributions for the 9 m trawl with a cod end liner and the 12 m trawl with a cod end liner were platykurtotic, indicating the use of the cod end liner spread the catch of striped bass among more length groups above and below the mean length than would be expected if the length-frequency distributions were bell-shaped. This difference was due primarily to an increased catch of fish <150 mmTL (Figure 3-3).

Since Age 1+ (yearling) and Age 2+ striped bass were recommended as target age groups for a winter hatchery evaluation program (MMES 1986), chi-square analysis was conducted to compare the

TABLE 3-7. DESCRIPTIVE STATISTICS FOR STRIPED BASS LENGTH-FREQUENCY DISTRIBUTIONS OBTAINED FROM THE 9m AND 12 m TRAWLS (WITH AND WITHOUT LINERS) DEPLOYED IN THE BATTERY REGION OF THE HUDSON RIVER, 21 DECEMBER 1986 THROUGH 8 MAY 1987.

GEAR	N	MEAN (mmTL)	S.D.	SKEWNESS (±95% C.I.)	KURTOSIS (±95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
9 m TRAWL	5616	237.6	90.3	0.42±0.06	0.15±0.13	57	708	Right skewness Leptokurtotic
9 m TRAWL WITH LINER	2423	233.2	91.1	0.34±0.10	-0.51±0.20	67	563	Right skewness Platykurtotic
12 m TRAWL	1987	293.1	82.1	0.36±0.11	1.15±0.22	68	680	Right skewness Leptokurtotic
12 m TRAWL WITH LINER	2926	258.9	94.7	0.05±0.09	-0.51±0.18	60	597	Normal skewness Platykurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Normal skewness = Skewness not significantly different from 0, which is the value obtained from a normal distribution.
Normal kurtosis = Kurtosis not significantly different from 0, which is the value obtained from a normal distribution.
Right skewness = Significant positive skewness indicating more striped bass were larger than the mean length than would be expected from a normal distribution.
Left skewness = Significant negative skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.
Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.
Platykurtosis = Significant negative kurtosis indicating more striped bass were both higher and lower than the mean length than would be expected from a normal distribuiton.

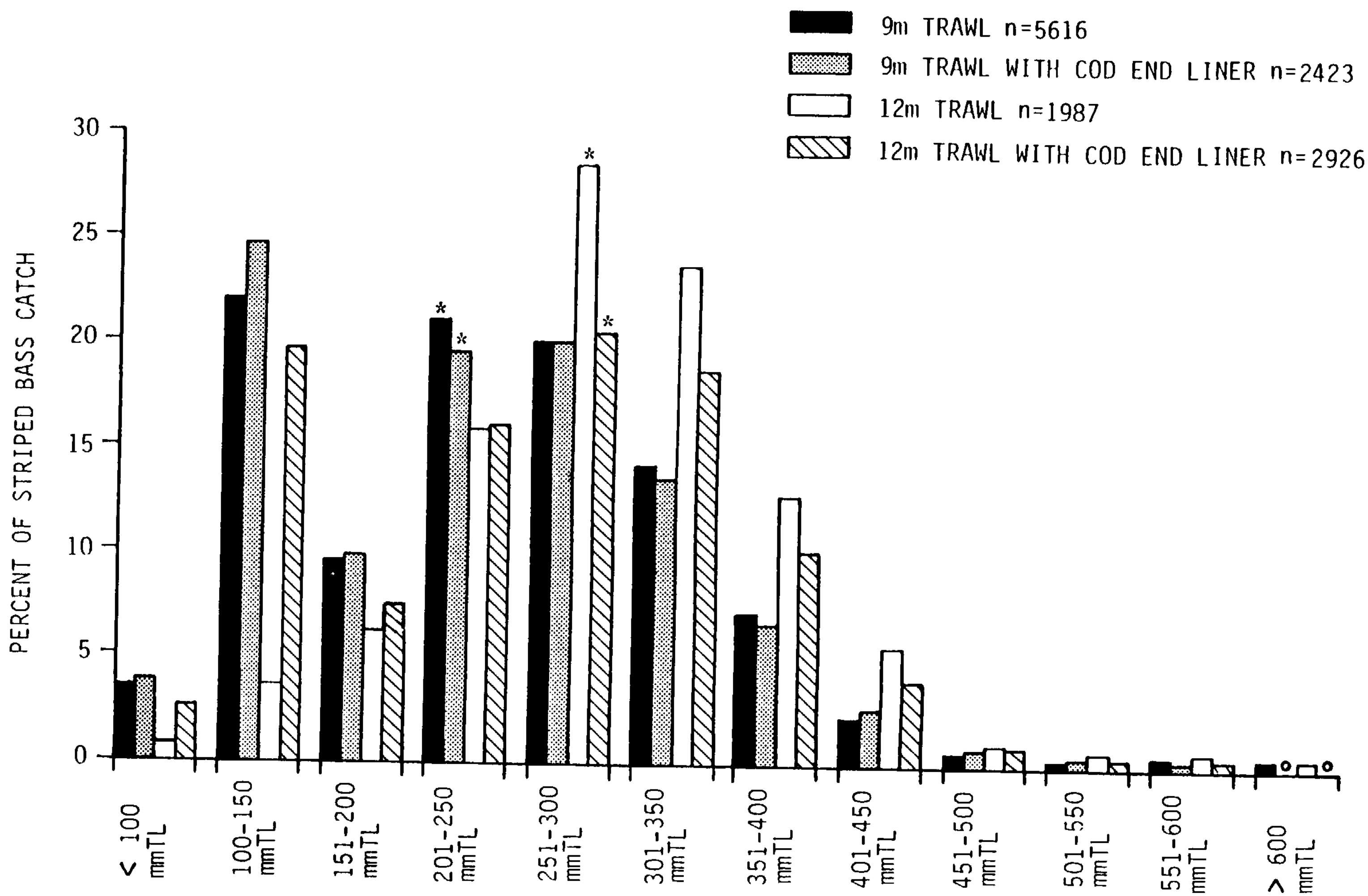

Figure 3-3. Length-frequency distribution for striped bass collected by the 9m trawl, 9m trawl with cod end liner, 12m trawl, and 12m trawl with cod end liner in the Battery region of the Hudson River, 21 December 1986 through 8 May 1987. (Note: * indicates the length group containing the mean length.)

length-frequency distributions of striped bass estimated to be at least Age 1+ (>150 mmTL, Section 3.2). The length-frequency distributions for striped bass caught by the 9 m trawl were not affected by the use of a cod end liner (Table 3-8), while significant differences were observed when a cod end liner was used in the 12 m trawl (Table 3-9). The 12 m trawl with a cod end liner caught significantly more striped bass in the 151-199 mmTL group as might be expected since the 12 m trawl has a 7.5 cm (stretch) mesh cod end while the cod end liner has a 2.5 cm (stretch) mesh (Appendix Table A-1). The 9 m trawl has a 3.8 cm (stretch) mesh cod end and would not be expected to demonstrate a marked improvement when compared with the catch from the 9 m trawl with a 2.5 cm (stretch) mesh cod end liner (Appendix Table A-2). If the 12 m trawl is used for future hatchery evaluation studies, the cod end should be changed to match the 9 m trawl or a cod end liner should be used to ensure Age 1+ and older striped bass are efficiently caught.

Weekly changes in mean length of striped bass caught by the 9 m trawl, 9 m trawl with a cod end liner, 12 m trawl and 12 m trawl with a cod end liner (Table 3-10) did not generally exhibit distinct seasonal patterns. The mean length of striped bass caught by the 9 m trawl in the Battery ranged from 182 mmTL during the week of 3 May 1987 to 303 mmTL during the week of 25 April 1987. The mean length of striped bass caught by the 9 m trawl with a cod end liner in the Battery ranged from 129 mmTL during the week of 26 April 1987 to 292 mmTL during the week of 8 February 1987. Weekly changes in mean length of striped bass caught by the 12 m trawl in the Battery ranged between 234 mmTL during the week of 1 February 1987 to 418 mmTL during the week of 26 April 1987. Similarly, weekly mean length of striped bass caught by the 12 m trawl with a cod end liner ranged between 197 mmTL during the weeks of 18 January and 1 February 1987 and 318 mmTL during the week of 4 January 1987 (Table 3-10).

TABLE 3-8. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS FOR STRIPED BASS AGE 1+ AND OLDER OBTAINED FROM THE 9m TRAWL WITH OR WITHOUT A COD END LINER IN THE BATTERY REGION OF THE HUDSON RIVER FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.

		LENGTH GROUPS (mmTL)								
GEAR	STATISTIC	151-199	200-250	251-300	301-350	351-400	401-450	451-500	>500	TOTAL
9m trawl	Observed	443	987	934	667	333	99	23	26	3512
	Expected	455	957	946	663	330	108	29	23	
	Cell χ^2	0.3	0.9	0.2	0.02	0.02	0.7	1.4	0.5	
9m trawl w/liner	Observed	238	445	481	325	161	62	21	8	1741
	Expected	226	475	469	329	164	53	15	11	
	Cell χ^2	0.7	1.8	0.3	0.04	0.05	1.4	2.8	0.9	
	d.f. = 7			χ^2 = 12.093		Prob > χ^2 = 0.0980 not significant				

LEGEND: observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length groups based on the hypothesis that no difference exists between length-frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
p> χ^2 = probability of obtaining the overall χ^2 by chance. A p> χ^2 of less than 0.05 was considered significant.

TABLE 3-9. CHI-SQUARE CONTINGENCY ANALYSIS COMPARING LENGTH-FREQUENCY DISTRIBUTIONS FOR STRIPED BASS AGE 1+ AND OLDER OBTAINED FROM THE 12m TRAWL WITH OR WITHOUT A COD END LINER IN THE BATTERY REGION OF THE HUDSON RIVER FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.

		LENGTH GROUPS (mmTL)								
GEAR	STATISTIC	151-199	200-250	251-300	301-350	351-400	401-450	451-500	>500	TOTAL
12m trawl	Observed	114	295	533	445	238	105	37	23	1790
	Expected	140	334	502	436	235	97	29	17	
	Cell χ^2	4.9	4.6	1.9	0.2	0.03	0.7	2.4	2.2	
12m trawl w/liner	Observed	193	437	566	510	277	107	26	14	2130
	Expected	167	398	597	519	280	115	34	20	
	Cell χ^2	4.1	3.9	1.6	0.2	0.03	0.6	2.0	1.9	
	d.f. = 7			χ^2 = 31.117		Prob > χ^2 = 0.0001 significant				

LEGEND: observed = number of striped bass collected in the length group.
expected = calculated number of striped bass in the length groups based on the hypothesis that no difference exists between length-frequency distributions for each gear.
cell χ^2 = χ^2 value comparing the significance of differences between observed and expected values for each gear in each length group. A cell χ^2 of 3.84 or larger was significant at $p<0.05$.
df = degrees of freedom for the overall χ^2.
p> χ^2 = probability of obtaining the overall χ^2 by chance. A p> χ^2 of less than 0.05 was considered significant.

TABLE 3-10. WEEKLY MEAN LENGTH (mmTL) OF STRIPED BASS CAUGHT BY THE 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL AND 12 m TRAWL WITH A COD END LINER IN THE BATTERY REGION OF THE HUDSON RIVER BETWEEN 21 DECEMBER 1986 AND 8 MAY 1987.

WEEK	9 M TRAWL					9 M TRAWL WITH LINER					12 M TRAWL					12 M TRAWL WITH LINER				
	N TOWS	N FISH	LENGTH			N TOWS	N FISH	LENGTH			N TOWS	N FISH	LENGTH			N TOWS	N FISH	LENGTH		
			MEAN	S.D.	S.E.			MEAN	S.D.	S.E.			MEAN	S.D.	S.E.			MEAN	S.D.	S.E.
21DEC86	42	425	252	96.17	4.66	0					0					0				
28DEC86	39	211	243	79.44	5.47	0					2	10	265	52.47	16.59	0				
04JAN87	22	284	216	99.25	5.89	0					7	105	240	96.16	9.38	7	184	318	70.78	5.22
11JAN87	17	339	241	85.48	4.64	6	277	275	91.28	5.48	0					8	279	231	85.07	5.09
18JAN87	24	613	228	97.50	3.94	0					5	111	261	73.97	7.02	5	283	197	94.62	5.62
25JAN87	18	138	240	85.78	7.30	9	50	213	79.90	11.30	7	80	310	89.31	9.98	6	138	274	87.44	7.44
01FEB87	28	272	232	81.08	4.92	14	289	276	69.44	4.08	12	304	234	74.11	4.25	10	435	197	89.62	4.30
08FEB87	25	341	233	86.83	4.70	8	89	292	77.99	8.27	5	248	314	69.82	4.43	3	248	291	84.44	5.36
15FEB87	27	253	248	90.61	5.70	15	137	232	93.30	7.97	5	183	310	65.39	4.83	0				
22FEB87	43	410	238	91.18	4.50	23	227	244	81.56	5.41	2	56	301	67.75	9.05	11	257	304	86.31	5.38
01MAR87	31	349	211	80.98	4.33	15	131	257	85.37	7.46	0					3	86	287	70.61	7.61
08MAR87	37	635	263	89.86	3.57	17	275	252	104.7	6.31	5	403	338	74.91	3.73	7	387	284	88.04	4.48
15MAR87	32	425	246	82.96	4.02	20	300	193	77.12	4.45	10	259	280	63.80	3.96	9	314	263	80.18	4.52
22MAR87	42	442	228	82.08	3.90	18	204	203	79.14	5.54	9	132	283	44.88	3.91	12	149	305	64.22	5.26
29MAR87	46	113	188	90.13	8.48	8	216	156	69.08	4.70	0					5	38	230	90.96	14.76
05APR87	34	200	260	75.09	5.31	6	163	240	65.29	5.11	8	66	298	75.72	9.32	8	105	263	80.43	7.85
12APR87	25	111	239	101.3	9.61	13	30	144	65.64	11.98	9	23	406	113.3	23.63	5	11	217	146.3	44.10
19APR87	34	31	186	116.3	20.89	16	23	180	69.82	14.56	3	1	303	.	.	4	5	305	108.2	48.39
26APR87	31	15	303	125.5	32.39	15	12	129	30.22	8.72	5	6	418	155.2	63.35	5	7	292	166.2	62.80
03MAY87	15	9	182	63.72	21.24	0					0					0				
ALL WEEKS	612	5616	238	90.35	1.21	203	2423	233	91.12	1.85	94	1987	293	82.08	1.84	108	2926	259	94.74	1.75

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50 mmTL length groups, exhibited no distinct seasonal pattern for the 9 m trawl (Table 3-11), 9 m trawl with a cod end liner (Table 3-12), the 12 m trawl (Table 3-13) or the 12 m trawl with a cod end liner (Table 3-14). The highest weekly catch per 9 m trawl tow was 4.6 striped bass for the 251-300 mmTL length group during the week of 11 January 1987. The highest weekly catch per tow for the 9 m trawl with liner was 8.8 striped bass for the 201-250 mmTL length group during the week of 5 April 1987. The highest overall catch per tow for the 9 m trawl was 2.0 striped bass for the 101-150 mmTL and 1.8 striped bass for the 201-250 and 251-300 mmTL length groups. The highest overall catch per tow for the 9 m trawl with liner was 3.0 striped bass for the 101-150 mmTL group. The highest weekly catch per 12 m trawl tow was 24.4 striped bass for the 301-350 mmTL length group during the week of 8 March 1987. The highest weekly catch per tow for the 12 m trawl with a cod end liner was 24.4 striped bass for the 101-151 mmTL length group during the week of 18 January 1987. The highest overall catch per tow for the 12 m trawl was 5.9 striped bass for the 251-200 mmTL length group. The highest overall catch per tow for the 12 m trawl with liner was 5.7 striped bass for the 251-300 mmTL group.

3.1.3 Handling Mortality

Handling mortality statistics provide a basis for comparing methods of capture and for selecting techniques which minimize mortality due to the capture and tagging of striped bass. Handling mortality statistics can also provide a basis for comparing the effects of releasing tagged striped bass during different water temperature periods. A water temperature period is defined as an interval of time with a common trend in water temperature. The nine week period from the week of 21 December 1986 through the week of 21 February 1987 was a

TABLE 3-11. WEEKLY CATCH OF STRIPED BASS PER TEN MINUTE TOW IN THE 9 m TRAWL FOR 50 mmTL LENGTH GROUPS FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mmTL LENGTH GROUPS													
		<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750
21 DEC 86	42	0.5	1.9	1.0	1.5	2.0	1.8	1.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0
28 DEC 86	39	0.2	0.8	0.5	1.4	1.3	0.8	0.4	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0
04 JAN 87	22	0.8	4.3	1.4	1.7	2.1	1.3	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0
11 JAN 87	17	0.5	3.8	1.5	4.5	4.6	2.8	1.7	0.5	0.0	0.0	0.1	0.0	0.0	0.0
18 JAN 87	24	1.6	7.3	1.7	3.9	4.3	3.8	2.0	0.9	0.1	0.0	0.0	0.0	0.0	0.0
25 JAN 87	18	0.2	1.3	0.9	2.2	1.3	1.2	0.4	0.2	0.1	0.0	0.0	0.1	0.0	0.0
01 FEB 87	28	0.4	1.6	1.1	2.8	2.2	0.6	0.8	0.1	0.0	0.0	0.0	<0.1	0.0	0.0
08 FEB 87	25	0.4	3.0	1.6	3.1	2.3	1.8	1.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0
15 FEB 87	27	0.1	1.7	1.0	2.0	2.4	1.1	0.8	0.1	<0.1	0.1	<0.1	0.0	<0.1	0.0
22 FEB 87	43	0.3	2.0	1.1	2.0	1.4	1.7	0.8	0.2	0.1	0.0	0.0	0.0	<0.1	0.0
01 MAR 87	31	0.3	3.5	1.8	2.3	1.6	1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
08 MAR 87	37	0.1	2.9	1.2	2.8	4.3	3.5	1.6	0.4	0.2	0.1	0.1	<0.1	0.0	0.0
15 MAR 87	32	0.2	2.3	1.3	2.9	3.2	1.8	0.9	0.3	0.1	0.0	<0.1	0.0	0.0	0.0
22 MAR 87	42	0.2	2.5	1.0	2.8	2.3	1.3	0.3	0.1	<0.1	<0.1	0.0	<0.1	<0.1	0.0
29 MAR 87	46	0.1	1.3	0.3	0.2	0.2	0.2	<0.1	0.1	0.0	0.0	<0.1	0.0	0.0	0.0
05 APR 87	34	0.1	0.8	0.4	1.1	1.6	1.4	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
12 APR 87	25	<0.1	0.9	0.7	1.3	0.7	0.4	0.2	0.1	<0.1	<0.1	0.0	<0.1	0.0	<0.1
19 APR 87	34	0.1	0.4	0.1	0.1	0.1	<0.1	0.1	<0.1	0.0	<0.1	0.0	0.0	0.0	0.0
26 APR 87	31	0.0	0.1	0.0	<0.1	0.1	0.1	0.1	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0
03 MAY 87	15	0.0	0.3	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL TOWS	612														
STRIPED BASS PER TOW		0.3	2.0	0.9	1.8	1.8	1.3	0.7	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1

TABLE 3-12. WEEKLY CATCH OF STRIPED BASS PER TEN MINUTE TOW IN THE 9 m TRAWL WITH A COD END LINER FOR 50 mmTL LENGTH GROUPS FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mmTL LENGTH GROUPS													
		<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750
21 DEC 86	0														
28 DEC 86	0														
04 JAN 87	0														
11 JAN 87	6	1.2	6.3	3.0	4.5	11.8	9.0	7.3	2.2	0.8	0.0	0.0	0.0	0.0	0.0
18 JAN 87	0														
25 JAN 87	9	0.0	1.8	1.0	1.1	0.7	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
01 FEB 87	14	0.0	0.8	1.3	5.8	5.5	4.4	1.9	0.8	0.2	0.0	0.0	0.0	0.0	0.0
08 FEB 87	8	0.0	0.2	1.2	2.2	2.0	2.6	2.0	0.5	0.1	0.1	0.0	0.0	0.0	0.0
15 FEB 87	15	0.1	2.6	0.7	1.9	1.7	1.1	0.5	0.4	0.0	0.1	0.0	0.0	0.0	0.0
22 FEB 87	23	<0.1	2.0	1.1	2.3	1.8	1.6	0.8	0.3	<0.1	0.0	0.0	0.0	0.0	0.0
01 MAR 87	15	0.1	0.9	1.5	1.9	1.5	1.6	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0
08 MAR 87	17	0.6	3.2	1.9	1.8	3.7	2.3	1.2	0.7	0.5	0.2	0.1	0.0	0.0	0.0
15 MAR 87	20	1.0	5.6	2.2	2.4	2.4	1.1	0.2	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0
22 MAR 87	18	0.6	3.9	1.2	1.9	2.4	0.9	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
29 MAR 87	8	2.5	17.2	0.9	2.8	2.0	1.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
05 APR 87	6	0.0	3.5	2.8	8.8	8.0	2.8	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0
12 APR 87	13	0.5	1.4	0.2	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19 APR 87	16	0.1	0.5	0.4	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 APR 87	15	0.1	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03 MAY 87	0														
TOTAL TOWS	203														
STRIPED BASS PER TOW		0.4	3.0	1.2	2.2	2.4	1.6	0.8	0.3	0.1	<0.1	<0.1	0.0	0.0	0.0

TABLE 3-13. WEEKLY CATCH OF STRIPED BASS PER TEN MINUTE TOW IN THE 12 m TRAWL FOR 50 mmTL LENGTH GROUPS FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mmTL LENGTH GROUPS													
		<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750
21 DEC 86	0														
28 DEC 86	2	0.0	0.0	0.5	2.0	1.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04 JAN 87	7	0.4	3.4	1.1	3.3	2.7	2.3	0.9	0.7	0.0	0.0	0.1	0.0	0.0	0.0
11 JAN 87	0														
18 JAN 87	5	0.6	1.8	1.8	4.0	7.6	4.8	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
25 JAN 87	7	0.1	0.1	0.9	2.1	1.6	2.1	2.3	2.0	0.0	0.0	0.1	0.0	0.0	0.0
01 FEB 87	12	0.2	3.5	5.2	6.6	4.8	3.2	1.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0
08 FEB 87	5	0.2	0.2	2.6	5.4	13.8	13.2	9.2	3.2	1.4	0.4	0.0	0.0	0.0	0.0
15 FEB 87	5	0.0	0.0	0.6	6.2	10.4	9.6	6.6	2.2	1.0	0.0	0.0	0.0	0.0	0.0
22 FEB 87	2	0.0	0.0	1.5	5.0	9.0	7.0	2.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0
01 MAR 87	0														
08 MAR 87	5	0.0	0.0	1.2	5.2	20.4	24.4	15.0	8.2	3.6	1.2	1.0	0.4	0.0	0.0
15 MAR 87	10	0.1	0.9	0.8	5.3	10.3	6.3	1.5	0.3	0.2	0.1	0.0	0.1	0.0	0.0
22 MAR 87	9	0.0	0.0	0.4	2.8	6.7	3.7	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
29 MAR 87	0														
05 APR 87	8	0.0	0.5	0.4	0.8	2.8	1.9	1.6	0.1	0.1	0.1	0.0	0.0	0.0	0.0
12 APR 87	9	0.0	0.1	0.0	0.0	0.1	0.6	0.6	0.6	0.2	0.1	0.2	0.1	0.0	0.0
19 APR 87	3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26 APR 87	5	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.0	0.0	0.2	0.0	0.0	0.2	0.0
03 MAY 87	0														
TOTAL TOWS	94														
STRIPED BASS PER TOW		0.1	1.0	1.3	3.4	5.9	4.9	2.6	1.2	0.4	0.1	0.1	<0.1	<0.1	0.0

TABLE 3-14. WEEKLY CATCH OF STRIPED BASS PER TEN MINUTE TOW IN THE 12 m TRAWL WITH A COD END LINER FOR 50 mmTL LENGTH GROUPS FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mmTL LENGTH GROUPS													
		<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750
21 DEC 86	0														
28 DEC 86	0														
04 JAN 87	7	0.0	0.3	0.9	3.3	6.4	7.4	5.1	1.9	0.7	0.3	0.0	0.0	0.0	0.0
11 JAN 87	8	1.4	8.0	2.0	9.2	7.4	3.5	2.8	0.2	0.4	0.0	0.0	0.0	0.0	0.0
18 JAN 87	5	4.0	24.4	6.2	6.0	4.8	6.4	3.6	1.0	0.2	0.0	0.0	0.0	0.0	0.0
25 JAN 87	6	0.0	2.5	1.8	4.2	5.7	4.8	2.2	1.2	0.5	0.0	0.2	0.0	0.0	0.0
01 FEB 87	10	2.9	16.9	5.4	7.1	4.6	3.2	2.5	0.6	0.2	0.0	0.1	0.0	0.0	0.0
08 FEB 87	3	1.3	7.0	3.0	11.3	18.7	21.3	13.0	6.0	0.7	0.3	0.0	0.0	0.0	0.0
15 FEB 87	0														
22 FEB 87	11	0.0	1.5	1.7	2.7	4.2	6.0	4.1	2.5	0.4	0.2	0.0	0.0	0.0	0.0
01 MAR 87	3	0.3	1.7	0.7	4.7	9.3	7.0	3.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0
08 MAR 87	7	0.6	6.9	2.1	6.1	12.9	16.0	6.9	2.7	0.6	0.4	0.1	0.0	0.0	0.0
15 MAR 87	9	0.1	4.2	2.1	8.9	9.7	5.7	2.9	0.7	0.3	0.1	0.2	0.0	0.0	0.0
22 MAR 87	12	0.0	0.1	0.7	1.0	4.3	3.9	1.4	0.7	0.2	0.1	0.0	0.0	0.0	0.0
29 MAR 87	5	0.0	2.8	0.4	0.6	2.2	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05 APR 87	8	0.2	1.6	0.9	2.1	4.0	2.9	1.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
12 APR 87	5	0.2	1.0	0.2	0.2	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0
19 APR 87	4	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
26 APR 87	5	0.2	0.2	0.0	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
03 MAY 87	0														
TOTAL TOWS	108														
STRIPED BASS PER TOW		0.7	5.0	1.9	4.2	5.7	5.2	2.9	1.1	0.3	0.1	0.1	0.0	0.0	0.0

period of descending water temperatures, where the mean weekly bottom water temperature fell 4.9°C (Appendix Table B-1). Water temperature began to rise in the week of 22 February 1987, and during this period of ascending water temperature, a total increase of 8.5°C occurred before the end of the program on 8 May 1987. Handling mortality during these two water temperature periods were investigated to determine if the trend in water temperature to which a striped bass has been exposed will affect its probability of surviving handling and tagging. It is possible that ascending water temperatures during the last eleven weeks of the program, in conjunction with potential gametogenesis as the spawning period approaches, increases handling mortality. If no differences in handling mortality are found between water temperature periods, than data can be pooled across time within a program, and comparisons can be made between gear, and the 1985-1986 and 1986-1987 programs. Differences in striped bass handling mortality by gear (9 m trawl, 9 m trawl with a cod end liner, 12 m trawl, and 12 m trawl with a cod end liner) and differences between programs (1985-1986, 1986-1987) were therefore assessed by comparing the percentage of dead fish in the catch in one degree temperature increments within decreasing or increasing water temperature periods.

Striped bass handling mortality in the 9 m trawl was 1% for both the descending and ascending water temperature periods for both surface and bottom water temperatures (Tables 3-15, 3-16). The highest handling mortality in the 9 m trawl occurred during the period of ascending water temperature at a bottom water temperature of 10°C (11% mortality, Table 3-15) and at a surface water temperature of 12°C (6% mortality, Table 3-16). In both of these observations, few fish were caught and the mortality calculation was influenced by the death of relatively few fish. The relatively consistent, low handling mortality observed over the range of water temperature experienced in this study indicates that no differences in handling mortality in the 9 m trawl can be attributed to changing water temperature.

TABLE 3-15. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN A 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL, AND 12 m TRAWL WITH A COD END LINER, IN RELATION TO BOTTOM WATER TEMPERATURE IN THE PERIODS OF DESCENDING AND ASCENDING WATER TEMPERATURES.

DESCENDING WATER TEMPERATURES (21 DECEMBER 1986 - 21 FEBRUARY 1987)

Bottom Water Temperature (°C)	9 m TRAWL % OF CATCH DEAD	9 m TRAWL n	9 m TRAWL W/LINER % OF CATCH DEAD	9 m TRAWL W/LINER n	12 m TRAWL % OF CATCH DEAD	12 m TRAWL n	12 m TRAWL W/LINER % OF CATCH DEAD	12 m TRAWL W/LINER n
0			0	6				
1	5	65	0	18	0	79	<1	343
2	1	425	1	156	<1	421	1	147
3	1	536	1	305	<1	344	1	83
4	<1	471	<1	354	0	150	<1	520
5	1	686	0	3	0	30	2	435
6	1	287			0	18	0	39
7	1	347						
8	0	62						
All Temperatures	1	2879	1	842	<1	1042	1	1567

ASCENDING WATER TEMPERATURES (22 FEBRUARY THROUGH 8 MAY 1987)

Bottom Water Temperature (°C)	9 m TRAWL % OF CATCH DEAD	9 m TRAWL n	9 m TRAWL W/LINER % OF CATCH DEAD	9 m TRAWL W/LINER n	12 m TRAWL % OF CATCH DEAD	12 m TRAWL n	12 m TRAWL W/LINER % OF CATCH DEAD	12 m TRAWL W/LINER n
1			0	7				
2	1	348	3	203	0	56	1	178
3	<1	761	2	423	0	339	0	554
4	<1	531	0	188	<1	323	2	242
5	1	287	0	112	2	132	1	234
6	0	8	1	166				
7	1	255	0	40			0	23
8	<1	311	6	346	7	30	1	90
9	0	79	0	61	2	60	5	19
10	11	28	20	20	0	1	0	7
11	0	66	13	32	0	6	0	13
12	0	5			0	2		
All Temperatures	1	2679	3	1598	1	949	1	1360

TABLE 3-16. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN A 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL, AND 12 m TRAWL WITH A COD END LINER IN RELATION TO SURFACE WATER TEMPERATURE IN THE PERIODS OF DESCENDING AND ASCENDING WATER TEMPERATURES.

DESCENDING WATER TEMPERATURES (21 DECEMBER 1986 - 21 FEBRUARY 1987)

Surface Water Temperature (°C)	9 m TRAWL % OF CATCH DEAD	n	9 m TRAWL W/LINER % OF CATCH DEAD	n	12 m TRAWL % OF CATCH DEAD	n	12 m TRAWL W/LINER % OF CATCH DEAD	n
0	0	9	0	24			0	37
1	1	250	0	65	0	151	<1	398
2	1	538	1	168	<1	711	1	638
3	1	840	1	172	0	162	3	215
4	1	393	1	413	0	7	1	92
5	<1	572					0	187
6	2	156			0	1		
7	2	126			0	10		
All Temperatures	1	2884	1	842	<1	1042	1	1567

ASCENDING WATER TEMPERATURES (22 FEBRUARY THROUGH 8 MAY 1987)

Surface Water Temperature (°C)	9 m TRAWL % OF CATCH DEAD	n	9 m TRAWL W/LINER % OF CATCH DEAD	n	12 m TRAWL % OF CATCH DEAD	n	12 m TRAWL W/LINER % OF CATCH DEAD	n
1			4	27				
2	1	649	3	245	0	395	<1	266
3	<1	351	2	345	0	64	0	268
4	0	500	0	125	<1	259	1	365
5	0	371	0	149			0	87
6	1	166	0	52	7	30	1	164
7	3	35	1	101	0	102	0	63
8	1	339	0	109			0	18
9	0	266	5	340	0	39	2	116
10	0	27	2	56	6	50	0	2
11	0	37	5	20	0	8	0	9
12	6	49	15	20	0	2	0	2
13	0	11	44	9				
All Temperatures	1	2801	3	1598	1	949	1	1360

Striped bass handling mortality in the 9 m trawl with a cod end liner was 1% for the descending and 3% for the ascending water temperature periods for both bottom and surface water temperatures (Tables 3-15 and 3-16). Handling mortality was highest at water temperatures greater than 9°C during the ascending water temperature period for both bottom and surface water temperatures. However, bottom and surface water temperatures greater than 9°C contributed only 3% and 7%, respectively, of the total number of striped bass caught by the 9 m trawl with a cod end liner. Additional sampling effort is needed at ascending water temperatures greater than 9°C to determine if a positive relationship exists between mortality in the 9 m trawl with a cod end liner and water temperature.

The 12 m trawl showed relatively consistent, low handling mortality of <1% mortality at descending, and 1% mortality during periods of ascending water temperature for both bottom and surface water temperatures (Tables 3-15, 3-16). There appears to be no relationship between handling mortality and water temperature in the 12 m trawl over the range of temperature experienced in this study. Similarly, the 12 m trawl with a cod end liner exhibited low handling mortality (1%) for the descending and ascending water temperature periods for both bottom and surface water temperatures (Tables 3-15 and 3-16). There appears to be no difference in handling mortality in the 12 m trawl with a cod end liner between water temperature periods, and no positive relationship between handling mortality and water temperature.

With the possible exception of the 9 m trawl with a cod end liner, there is no apparent difference in handling mortality among descending and ascending water temperature periods for the four trawls used in the 1986-1987 Hudson River Striped Bass Hatchery Evaluation. Therefore, handling mortality data were pooled within gear across ascending and descending water temperature periods to compare handling mortality among gear.

Total handling mortality in the 9 m trawl was 1% for both bottom and surface water temperature (Table 3-17). As noted previously, relatively high handling mortality was observed at water temperatures greater than 9°C for the 9 m trawl with a cod end liner, but the total number of fish captured at these temperatures represents a small percentage of the total catch. Total handling mortality in the 9 m trawl with a cod end liner was 2% for both bottom and surface water temperatures (Table 3-17). An increase in handling mortality with water temperature is apparent for the 9 m trawl with a cod end liner, particularly at surface water temperatures of 12 and 13°C. However, the number of fish captured at these temperatures represents only 1% of the total number of striped bass captured by this gear, and is easily influenced by the death of a few fish. The 12 m trawl with a cod end liner had a handling mortality of 1% (Table 3-17). Within the temperature range observed, no trends in handling mortality were apparent.

Handling mortality in the 1986-1987 program was equal to or slightly lower than that observed in the 1985-1986 program (Table 3-17). Total handling mortality in the 9 m trawl during the 1985-1986 program was equal to that observed in the 9 m trawl in the 1986-1987 program (1%). Handling mortality observed in the 12 m trawl in the 1986-1987 program (2%) decreased in the 1986-1987 program (<1%).

3.1.3.1 Handling Mortality Discussion

No significant differences in handling mortality were observed between periods of descending and ascending water temperature for any trawl used in the 1986-1987 program, with the possible exception of the 9 m trawl with a cod end liner. Handling mortality during the period of ascending water temperature was low for all gear, indicating that the approach of the spawning season, coupled with handling stress,

TABLE 3-17. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED IN A 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL, 12 m TRAWL WITH A COD END LINER, DURING THE 1986-1987 STRIPED BASS HATCHERY EVALUATION PROGRAM, AND THE 9 m TRAWL AND 12 m TRAWL DURING THE 1985-86 HUDSON RIVER STRIPED BASS PROGRAM.

	1986-1987 9 m TRAWL		1985-1986 9 m TRAWL		1986-1987 12 m TRAWL		1985-1986 12 m TRAWL		1986-1987 9 m TRAWL W/LINER		1986-1987 12 m TRAWL W/LINER	
	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n
BOTTOM WATER TEMPERATURE (°C)												
0									0	6		
1	5	65	0	45	0	79	0	166	0	25	<1	343
2	1	773	<1	856	<1	477	1	548	2	359	1	325
3	1	1297	1	1489	<1	683	1	477	2	728	<1	637
4	<1	1002	1	1521	<1	473	1	819	<1	542	1	762
5	1	973	2	720	1	162	3	573	0	115	1	669
6	1	295	1	882	0	18	4	691	1	166	0	39
7	1	602	2	403			2	147	0	40	0	23
8	<1	373	1	423	7	30	0	675	6	346	1	90
9	0	79	3	521	2	60	3	65	0	61	5	19
10	11	28	15	13	0	1	0	4	20	20	0	7
11	0	66	0	2	0	6	0	8	13	32	0	13
12	0	5	3	130	0	2	0	20				
13			2	309			0	18				
14							0	19				
ALL TEMPERATURES	1	5558	1	7314	<1	1991	2	4230	2	2440	1	2927

TABLE 3-17. (Cont)

	1986-1987 9 m TRAWL		1985-1986 9 m TRAWL		1986-1987 12 m TRAWL		1985-1986 12 m TRAWL		1986-1987 9 m TRAWL W/LINER		1986-1987 12 m TRAWL W/LINER	
	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n	% OF CATCH DEAD	n
SURFACE WATER TEMPERATURE (°C)												
0	0	9	1	126			6	34	0	24	0	37
1	1	250	<1	768	0	151	1	624	1	92	<1	398
2	1	1187	1	822	<1	1106	1	320	2	413	<1	904
3	1	1191	1	2305	0	226	3	1308	2	517	1	483
4	<1	893	1	1481	<1	266	2	741	1	538	1	457
5	<1	943	1	225			2	341	0	149	0	274
6	1	322	3	198	7	31	0	59	0	52	1	164
7	2	161	2	458	0	112	0	16	1	101	0	63
8	1	339	3	493			1	255	0	109	0	18
9	0	266	0	11	0	39	<1	427	5	340	2	116
10	0	27	5	59	6	50	0	103	2	56	0	2
11	0	37	6	33	0	8	0	71	5	20	0	9
12	6	49	1	234	0	2	0	6	15	20	0	2
13	0	11	1	115			0	40	44	9		
14												
15							0	12				
16							0	7				
ALL TEMPERATURES	1	5685	1	7328	<1	1991	2	4364	2	2440	1	2927

contributed little more mortality than would be expected from handling stress alone. However, few striped bass exhibited gametogenesis (Appendix E), so the affect of the approaching spawning season on striped bass handling mortality is probably not fully described by this program.

Striped bass handling mortality in the 1986-1987 program was uniformly low among gear used, similar to that observed in the 1985-1986 program, and approximately ten times less than that observed in the 1984 program. The findings of the 1986-1987 program support those of the 1985-1986 program; that the primary reasons for the decrease in handling mortality observed after 1984 are the use of the submerged holding facility and the increased tagging efficiency of field crews (NAI 1986). The holding facility used in the 1985-1986 and 1986-1987 programs permitted transfer of each catch from the cod end into the holding tank without having to lift both the net and fish out of the water, i.e., the fish remained in the water until they were individually removed and tagged. In contrast, during the 1984 program, the cod end of the net was lifted out of the water and fish were compressed by their weight in the air as they were transferred to the on-deck holding tanks. The increased tagging efficiency observed in the 1985-1986 and 1986-1987 programs contributed to decreased handling mortality by lessening exposure of striped bass to the air, thus reducing stress by returning tagged fish to the water quickly.

The small decrease in handling mortality observed between the 1985-1986 and 1986-1987 programs may indicate that the improvements to handling mortality brought about by crew experience may be maximized. Despite an additional year of experience in handling and tagging striped bass, little improvement in the already low handling mortality was observed. Alternatively, little decrease in handling mortality may be possible, since mortality in the 1986-1987 program was generally less than 2%. A large decrease in handling mortality similar to that observed between the 1984 and later programs will probably be the result of a significant innovation in either gear deployment or striped bass handling procedures.

No large increases in handling mortality with temperature occurred in the 1986-1987 program. This supports the findings of the 1985-1986 program, that use of the in-water holding facility and increased crew experience are probably the largest factors in determining handling mortality (NAI 1986). The results from both the 1985-1986 and 1986-1987 program indicate that experienced crews using proper handling and tagging techniques probably can tag striped bass with low handling mortality at temperatures greater than those observed in this program.

3.2 STRIPED BASS AGE AND LENGTH DISTRIBUTION

3.2.1 Evaluation of Laboratory Sample Selection by the Stratified Sampling Plan.

Stratified random sampling was extremely efficient (precise) for estimating the proportion and number of Age 1+ striped bass in this study. By determining the age from scale samples from as few as 250 fish, the total number of Age 1+ striped bass out of the 14,136 fish caught could be estimated with 95% confidence limits of ± 385 fish (C.V. = 10.4%, Table 3-18). For the allocation of 2,173 scale samples actually selected, the C.V. based on 95% confidence limits was 3.4% (±125 fish). Little gain in precision would be realized relative to the cost for determining the age of more than 2,000 scale samples.

Stratified sampling for age determination was based on variance estimates derived from the proportion of Age 1+ striped bass in each 10 mmTL length increment, because it was expected *a priori* that a

TABLE 3-18. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAUGHT IN THE LOWER HUDSON RIVER, WINTER 1986-87.

		NUMBER OF AGE 1+ FISH CAUGHT			
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL	LOWER 95%CI	UPPER 95%CI	C.V.(%)[a]
250	0.262	3,703	3,318	4,089	10.4
500	0.262	3,703	3,441	3,965	7.1
1,000	0.262	3,703	3,526	3,881	4.8
1,500	0.262	3,703	3,564	3,843	3.8
2,000	0.262	3,703	3,587	3,820	3.1
2,173[b]	0.262	3,703	3,578	3,828	3.4
2,500	0.262	3,703	3,603	3,804	2.7
3,000	0.262	3,703	3,616	3,791	2.4
3,500	0.262	3,703	3,626	3,781	2.1

[a] C.V. = coefficient of variation = 95% confidence interval (CI) half width/stratified total x 100.

[b] Results for sample size = 2,173 are based on actual allocations which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain the best (most precise and accurate) estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 3+ striped bass (Table 3-19), which collectively comprised 97.5% of the fish caught in this program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The number of Age 3+ striped bass was estimated with lower precision than the number of Age 1+ fish because Age 3+ fish occur over a wide range of sizes, particularly in the larger length increments which had few Age 1+ fish and were not sampled intensively. The number of Age 2+ fish was estimated with approximately the same precision as Age 1+ fish because these two cohorts overlapped extensively in size.

3.2.2 Length Distribution and Associated Statistics for Each Age Cohort

Striped bass were randomly selected by the stratified random sampling plan to maximize the precision of the estimated proportion and number of Age 1+ striped bass caught (Section 3.2.1). This stratified design was also relatively precise in estimating the mean length at age for Age 0+ through Age 3+ striped bass. Mean length averaged approximately 10 mmTL lower for Age 0+ and Age 1+ striped bass caught by the 12 m trawl with a cod end liner compared with Age 0+ fish caught by the other trawls (Table 3-20). The 12 m trawl with a cod end liner also caught Age 3+ striped bass that were smaller than Age 3+ fish caught by the other trawls. Age 1+ striped bass caught by the 12 m trawl averaged 10 mmTL larger than Age 1+ fish caught by the other trawls. These inconsistent differences in age-specific mean length between the catch of the 9 m and 12 m trawl with and without cod end liners suggest that day to day variation in the size of striped bass exposed to each trawl may contribute to the observed size differences. Other factors

TABLE 3-19. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAUGHT IN THE LOWER HUDSON RIVER, WINTER 1986-87.

AGE	PROPORTION	NUMBER OF FISH CAUGHT			
		STRATIFIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	C.V.(%)
0+	0.219	3,093	3,057	3,130	1.2
1+	0.262	3,703	3,578	3,828	3.4
2+	0.402	5,685	5,503	5,866	3.2
3+	0.092	1,304	1,149	1,460	11.9

[a]based on a laboratory sample of scales from 2,173 fish

TABLE 3-20. MEAN LENGTH AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAUGHT BY A 9 m TRAWL, 9 m TRAWL WITH A COD END LINER, 12 m TRAWL, AND 12 m TRAWL WITH A COD END LINER IN THE LOWER HUDSON RIVER, 21 DECEMBER 1986 THROUGH 8 MAY 1987.

AGE	TRAWL	N	STRATIFIED MEAN LENGTH (mmTL)	LOWER 95% CI	UPPER 95% CI
0+	9 m	84	128.3	125.3	131.3
	9 m w/liner	53	128.3	124.6	132.1
	12 m	6	131.5	125.7	137.3
	12 m w/liner	43	118.7	114.8	122.6
	combined	186	126.1	124.1	128.1
1+	9 m	288	220.1	219.6	220.7
	9 m w/liner	170	221.5	221.0	222.0
	12 m	132	234.8	234.2	235.5
	12 m w/liner	145	222.9	222.4	223.4
	combined	735	224.2	224.0	224.4
2+	9 m	361	308.0	307.1	308.9
	9 m w/liner	165	297.7	297.1	298.3
	12 m	263	308.2	307.8	308.6
	12 m w/liner	244	306.9	306.2	307.6
	combined	1033	303.2	302.9	303.5
3+	9 m	56	359.1	349.8	368.4
	9 m w/liner	20	386.0	378.8	393.2
	12 m	47	370.7	359.8	381.6
	12 m w/liner	54	363.9	361.8	366.0
	combined	177	369.6	366.1	373.1

associated with size selectivity such as mesh size differences and net mouth dimensions may also exist but may be confounded by day to day variation in the length (age) composition of the catch. As an example of day to day variation in length composition, the highest weekly mean CPUE for 101-150 mmTL striped bass caught by the 9 m trawl with a cod end liner was 17.2 fish per tow on one randomly selected day (3 April 1987) during the week of 29 March 1987 (Table 3-12); on another randomly selected day during the same week (31 March 1987), the striped bass trawl with a cod end liner caught and average of only 2.8 fish per 10 minute tow (Table 3-14). Similarly, during the week of 1 February 1987, the 12 m trawl with a cod end liner had an average CPUE of 16.9 striped bass in the 101-150 mmTL length group on 5 February 1987 (Table 3-14), while on the next day (6 February 1987) the 9 m trawl with a cod end liner exhibited an average CPUE of only 0.8 striped bass (Table 3-12). Since the 9 m trawl used a cod end liner of exactly the same mesh size as the 12 m trawl with a cod end liner, both trawls should retain the same size fish. However, Age 0+ striped bass caught by the 9 m trawl with a cod end liner averaged 10 mmTL larger than Age 0+ fish caught by the 12 m trawl with a cod end liner. If gear avoidance was the overriding factor, the 12 m trawl with a cod end liner should catch Age 0+ fish of a larger average size than the 9 m trawl because of the larger mouth dimensions. In contrast to observed size differences for Age 0+ fish, both the 9 m and 12 m trawls with cod end liners caught Age 1+ striped bass that were approximately the same average length, while the 9 m trawl with a cod end liner caught Age 2+ striped bass that were smaller than the 12 m trawl with a cod end liner and Age 3+ fish that were larger (Table 3-20).

McLaren *et al.* (1981) observed Hudson River striped bass caught in gill nets and haul seines during March through June of 1976 and 1977 to range in mean length from 230 mmTL (females, 1977) to 311 mmTL (males, 1976) for Age 1+ fish, 369 mmTL (males, 1977) to 389 mmTL (females, 1976) for Age 2+ fish, and 439 mmTL (males, 1976) to 469 mmTL (females, 1977) for Age 3+ fish. While sex-specific mean length at age was not calculated in the present study, striped bass mean length was substantially lower for each age cohort during 1986-87 (Table 3-20) than for the mean length by sex and age cohorts reported by McLaren *et al.* (1981). It is possible that fish caught in McLaren *et al.* (1981) had exhibited growth in the May - June period which was not sampled during 1986-87 and, therefore, were larger than fish from the present study. However, most of the fish in the McLaren *et al.* (1981) study were caught prior to the second week in May of each year (85% in 1976 and 89% in 1977), and therefore were caught within the sampling period of the 1986-87 program. It is more likely that the relatively large mesh of the gill nets (10.2 - 17.8 cm stretch mesh) used in the McLaren *et al.* (1981) study selected for larger striped bass of a given age than were caught by trawls during the present program.

Standardized age frequency by length histograms, presented by 10 mmTL length groups (all four trawls combined) for Age 0+ through Age 3+ striped bass (Figure 3-4) demonstrate minimal overlap between size of Age 0+ and Age 1+ striped bass caught during the 1986-1987 program. Most of the Age 0+ fish are ≤160 mmTL, while most of the Age 1+ fish were between 161 and 260 mmTL. Age 1+ and Age 2+ striped bass overlap in size primarily between 221 and 290 mmTL, Age 3+ striped bass overlap with Age 2+ fish primarily between 300 and 400 mmTL.

3.3 STRIPED BASS HATCHERY PROPORTION

Striped bass stocked in the Hudson River from the Verplanck Hatchery comprised 1.3% of the Age 0+ cohort, 1.5% of the Age 1+ cohort, 0.1% of the Age 2+ cohort, and 0.0% of the Age 3+ cohort of fish caught during the winter 1986-87 (Table 3-21). Comparing 95% confidence limits about the hatchery proportion of striped bass among cohorts indicated the Age 0+ and Age 1+ proportions were similar and significantly larger than the Age 2+ hatchery proportions. However, Age 0+ hatchery fish may

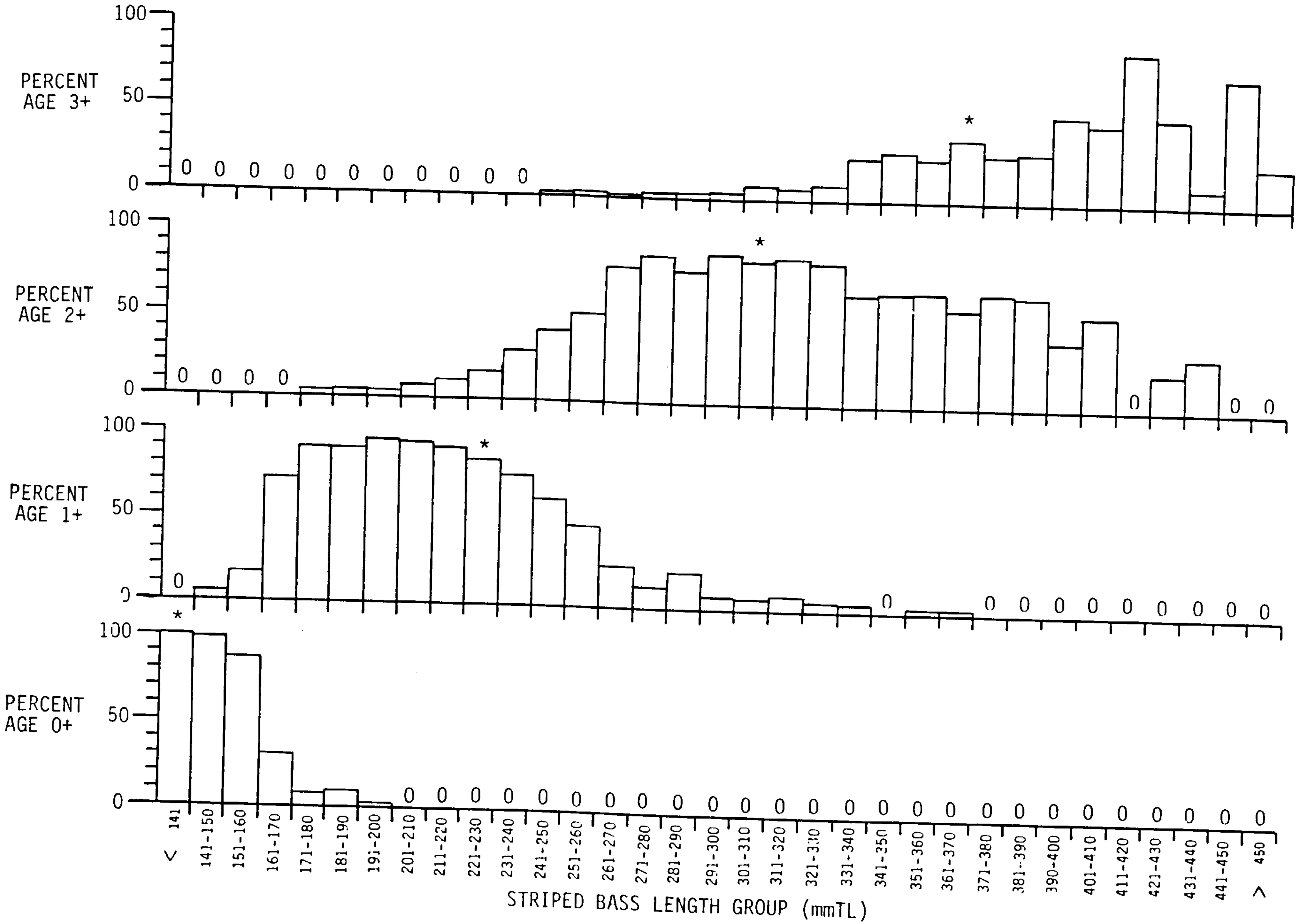

Figure 3-4. Standardized age frequency by length distribution for Age 0+, 1+, 2+, and 3+ striped bass caught by trawls in the lower Hudson River estuary, 21 December 1986 through 8 May 1987.
(Note: Length group which contains the statified mean length at age is marked with an *.)

TABLE 3-21. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAUGHT BY TRAWLS IN THE LOWER HUDSON RIVER, WINTER 1986-87.

STATISTIC	COHORT			
	1986	1985	1984	1983
Age	0+	1+	2+	3+
Total Hatchery Stocking (N_i)	529,563	284,578	147,153	61,357
Adjusted Hatchery Stocking (N_{ai})	525,326	283,867	127,140	61,357*
Hatchery Recaptures (H_i)	38	51	5	0
Adjusted Hatchery Recaptures (H_{ai})	41	54	6	0
Wild Fish Examined (W_i)	3,052	3,649	5,679	1,304
Release Proportion (H_{ai}/N_{ai})	0.00008	0.00019	0.00005	0.00000
Estimated Hatchery Proportion ($H_{ai}/(H_{ai}+W_i)$)	0.0133	0.0146	0.0011	0.0000
Lower 95% C.I.	0.0094	0.0106	0.0003	0.0000
Upper 95% C.I.	0.0182	0.0197	0.0024	0.0000

*Not adjusted

not have been at large for enough time to randomly mix with the wild population (MMES 1986; TI 1977), and 23% of the Age 2+ hatchery fish had magnetic tags placed horizontally (EA 1985) and may have been difficult to detect in the field because of problems with magnetic tag orientation. Thus, the proportion of Age 0+ may be biased but the direction of the bias is not known, and the estimated proportion of Age 2+ hatchery fish is likely to be biased low. Therefore, the hatchery contribution to the 1985 cohort of Age 1+ striped bass is probably the most accurate estimate. Until this study is repeated for several years, we will not know if the proportion of hatchery fish among the Age 1+ fish caught remains similar from year to year.

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

In this section, the size range, distribution and recapture patterns of striped bass are described. During the 1986-87 program recaptures were made of: 1) hatchery striped bass which were tagged with a magnetic, coded, wire tag (magnetic tag) and 2) wild striped bass that were individually tagged with an internal anchor-external streamer tag (internal anchor tag) inserted into the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were sacrificed and taken to the striped bass hatchery at Verplanck, New York to verify the presence of a magnetic tag and to determine the hatchery cohort (stocking year). All striped bass were also examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1986-1987 winter sampling program, 38 Age 0+, 51 Age 1+ and 5 Age 2+ verified hatchery striped bass were caught. Mean length of Age 0+ and Age 1+ hatchery striped bass was significantly smaller than for wild fish of the same age (Table 3-22). Age 0+ hatchery recaptures averaged 18 mm smaller than Age 0+ wild fish, and this size difference persisted between the mean size of Age 1+ hatchery and wild striped bass (19 mm). A similar difference (23 mm) was also observed between the mean length of Age 2+ hatchery and wild striped bass, but was not statistically significant due to the small sample of Age 2+ hatchery fish.

The significantly smaller size of hatchery striped bass compared with wild fish of the same age captured during this program has not been previously observed in the Hudson River. The significant size differences were observed in both Age 0+ and Age 1+ cohorts. The observed differences could be due to 1) size selective mortality, 2) stunting of hatchery fish after stocking, or 3) different distribution of hatchery and wild fish. Since vulnerability to predators generally declines with increasing size, and hatchery fish were longer than wild fish at a given age, size selective mortality is probably not the causal mechanism for the observed size differences. Hatchery fish, which remain in the wild for several months, may exhibit growth rates lower than for wild fish which require several months to be manifested as size differences. However, not enough data are presently available to distinguish between stunting and differential distribution as the causal mechanism for the observed size differences between hatchery and wild striped bass.

Among the 14,136 striped bass examined by the field magnetic tag detector in the program, 98 fish were considered to be hatchery striped bass and 94 of these suspected hatchery recaptures were verified by the Verplanck Hatchery as having magnetic tags present (Appendix Table D-1). To evaluate the effectiveness of the magnetic tag detectors used in the field, an extremely sensitive "tube-shaped" detector was

TABLE 3-22. COMPARISON OF MEAN LENGTH AT AGE BETWEEN AGE 0+, 1+ AND 2+ WILD AND HATCHERY STRIPED BASS CAUGHT IN THE LOWER HUDSON RIVER, 21 DECEMBER 1986 THROUGH 8 MAY 1987.

	WILD				HATCHERY			
AGE	N	STRATIFIED MEAN (mmTL)	LOWER 95% CI	UPPER 95% CI	N	MEAN (mmTL)	LOWER 95% CI	UPPER 95% CI
0+	186	126.1	124.1	128.1	38	108.0	103.0	113.0
1+	735	224.2	224.0	224.4	51	205.5	199.5	211.5
2+	1033	303.2	302.9	303.5	5	280.0	222.1	337.9

also used in tandem with the standard "V-shaped" field detector. Only two fish (0.094%) escaped detection with the standard detector when 2,138 striped bass caught between 30 January and 18 February 1987 were first checked with the "V-shaped detector and then passed through the "tube" detector.

Logistics involved with the use of the "tube" detector limit its application in the field. It is relatively large and heavy, occupying as much deck space as a desk, yet it is apparently not durable enough for constant field use in this program. The reason it was not used in the field beyond 18 February 1987 was that it sustained damage and was returned to the manufacturer for repair. The "tube" detector also required running water to minimize chaffing of fish as they are passed through the tube, and running water can be hazardous in the freezing conditions routinely experienced during the winter in the lower Hudson River. Finally, only fish below approximately 400 mmTL could be passed through the "tube" detector because of the tube diameter (100 mm), making this devise effective for detecting magnetic tags only in striped bass younger than Age 2+. Therefore, we recommend that the "tube" detector be used only as a quality control check on randomly selected days to evaluate the effectiveness of the standard field magnetic tag detector.

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1986-87 winter sampling program, 151 striped bass were recaptured out of 9,388 fish that were caught, tagged with internal anchor tags, and released. An additional 110 striped bass were recaptured with internal anchor tags and verified as originating from previous programs. These two groups of wild striped bass are described below in separate sections.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1986-87 Winter Program

The combined Battery and Upper Harbor regions contributed nearly all (99.4%) of the taggable-size (≥200 mmTL) striped bass caught (10,069) and all of the fish recaptured in this study (Table 3-23, Appendix Table D-2). This is not surprising since most (96%) of the trawl sampling effort was allocated to these regions during 1986-87 as a result of the 1985-86 study (NAI 1986).

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space (and/or time) frames. Recapture rates from the row totals compare the number of fish recaptured throughout the program (recaptured any time after the release date) to the number of fish released in a particular region. Recapture rates from the column totals compare the number of fish recaptured in a region to the number marked throughout the program. For example, in Table 3-23, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 126/8779 or 0.01435, while the recapture rate for fish tagged and released in the Battery and recaptured in all regions (row total) was 136/8779 or 0.01549. The recapture rate for striped bass tagged and released throughout the study area and recaptured in the Battery (column total) was 138/9387 or 0.01470.

In contrast, recapture proportions from row totals compare the number of fish recaptured in a particular region to the number examined for tags throughout the program, while recapture proportions from the column totals compare the number of fish recaptured in a particular region (regardless of origin) to the number of fish caught and examined for tags in that region. For example, in Table 3-23, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among fish examined for tags in the Battery (cell total) was 126/9387 or 0.01342, while the recapture proportion for fish recaptured in the Battery compared to all fish examined for tags throughout the

TABLE 3-23. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE LOWER HUDSON RIVER ESTUARY, FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.[a]

RELEASE REGION	NUMBER MARKED (M)	STATISTIC	NUMBER OF RECAPTURES IN REGION				
			UPPER HARBOR C=622	BATTERY C=9387	TAPPAN ZEE C=36	CROTON-HAVERSTRAW C=24	TOTAL C=10069
UPPER HARBOR	556	R	3	12	0	0	15
		R/M	0.00540	0.02158			0.01786
		R/C	0.00482	0.00128			0.00239
BATTERY	8,779	R	10	126	0	0	136
		R/M	0.00114	0.01435			0.01549
		R/C	0.01608	0.01342			0.01351
TAPPAN ZEE	34	R	0	0	0	0	0
		R/M					
		R/C					
CROTON-HAVERSTRAW	19	R	0	0	0	0	0
		R/M					
		R/C					
TOTAL	9388	R	13	138	0	0	151
		R/M	0.00138	0.01470			0.01609
		R/C	0.02090	0.01470			0.01500

[a] Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured
M = number of striped bass ≥200 mm TL marked and released
C = number of striped bass ≥200 mm TL caught and examined for tags
R/M = recapture rate
R/C = recapture proportion

program (row total) was 136/10069 or 0.01351. The recapture proportion for striped bass from the entire study area that were recaptured in the Battery (column total) was 138/9387 or 0.01470. It is generally most informative to examine recapture rates from the row totals and recapture proportions from the column totals since these statistics best describe specific movement among regions (or time period).

Striped bass monthly recapture rates (R/M row totals) were relatively constant from January through March 1987 suggesting marked fish had randomly mixed with the winter population in upper New York harbor and the Battery (Table 3-24). Furthermore, monthly recapture proportions (R/C column totals) increased from December 1986 through April 1987 indicating an accumulation of marked fish in the population. This pattern of relatively constant recapture rates and increasing recapture proportions suggests that the striped bass population in the Upper Harbor and Battery is relatively closed to immigration and emigration during most of the study period (Ricker 1975). Similar results were seen in the 1985-86 study (Figure 3-4 in NAI 1986).

Striped bass tagged, and released in the Battery and Upper Harbor regions, and subsequently recaptured there exhibited a low average net rate of movement (Table 3-25). Recaptured fish were at large an average of 24 days and moved an average minimum net distance of only 3.5 miles (5.6 km) at a minimum net rate of only 0.15 miles per day (0.24 km per day) before recapture. A nearly identical rate of 0.1 miles per day movement was observed in these regions during the 1985-86 study (NAI 1985-86). The low rate of movement in the striped bass population suggests little emigration occurred immediately after fish were caught and tagged during trawl sampling. A lack of immediate emigration by the striped bass population in the contiguous Upper Harbor-Battery region is also suggested by a relatively high frequency of fish which were recaptured on the same day they were released (35/151 or 23%) and a relatively high frequency of fish recaptured in the first ten days after release (55/151 or 36%; Figure 3-5). Approximately 68% (103/151) of the fish recaptured in the Upper Harbor and Battery regions

TABLE 3-24. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.

RELEASE MONTH	NUMBER MARKED (M)	STATISTIC	NUMBER OF RECAPTURES IN MONTH						
			DECEMBER C = 478	JANUARY C = 2222	FEBRUARY C = 2819	MARCH C = 3573	APRIL C = 913	MAY C = 4	TOTAL C = 10009
DECEMBER	457	R	2	2	1	2	0	0	7
		R/M	0.00438	0.00438	0.00219	0.00438			0.01532
		R/C	0.00418	0.00090	0.00035	0.00056			0.00070
JANUARY	2087	R		8	13	22	4	0	47
		R/M		0.00383	0.00623	0.01054	0.00192		0.02252
		R/C		0.00360	0.00416	0.00616	0.00438		0.00470
FEBRUARY	2671	R			22	23	7	0	52
		R/M			0.00824	0.00861	0.00262		0.01947
		R/C			0.00780	0.00644	0.00767		0.00520
MARCH	3314	R				25	16	0	41
		R/M				0.00754	0.00483		0.01237
		R/C				0.00700	0.01752		0.00410
APRIL	802	R					4	0	4
		R/M					0.00499		0.00499
		R/C					0.00438		0.00040
MAY	4	R						0	0
		R/M							
		R/C							
TOTAL	9335	R	2	10	36	72	31	0	151
		R/M	0.00021	0.00107	0.00386	0.00771	0.00332		0.01618
		R/C	0.00418	0.00450	0.01277	0.02015	0.03395		0.01509

[a] Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured
M = number of striped bass ≥200 mm TL marked and released
C = number of striped bass ≥200 mm TL caught and examined for tags
R/M = recapture rate
R/C = Recapture proportion

TABLE 3-25. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE LOWER HUDSON RIVER ESTUARY FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.

STATISTIC		RELEASED WITHIN THE 1986-87 STRIPED BASS PROGRAM
NUMBER TAGGED (≥200 mmTL)	(M)	9,388
NUMBER EXAMINED FOR TAGS (≥200 mmTL)	(C)	10,069
NUMBER RECAPTURED	(R)	151
SIZE RANGE OF RECAPTURED FISH (mmTL)	Min	200
	Max	464
	Mean	279
	S.D.	50
DAYS AT LARGE	Min	0
	Max	95
	Mean	23.8
	S.D.	24.4
LINEAR DISTANCE [a] TRAVELED IN MILES (km)	Min	0(0)
	Max	12(19)
	Mean	3.5(5.6)
	S.D.	4.0(6.4)

[a] release location - recapture location

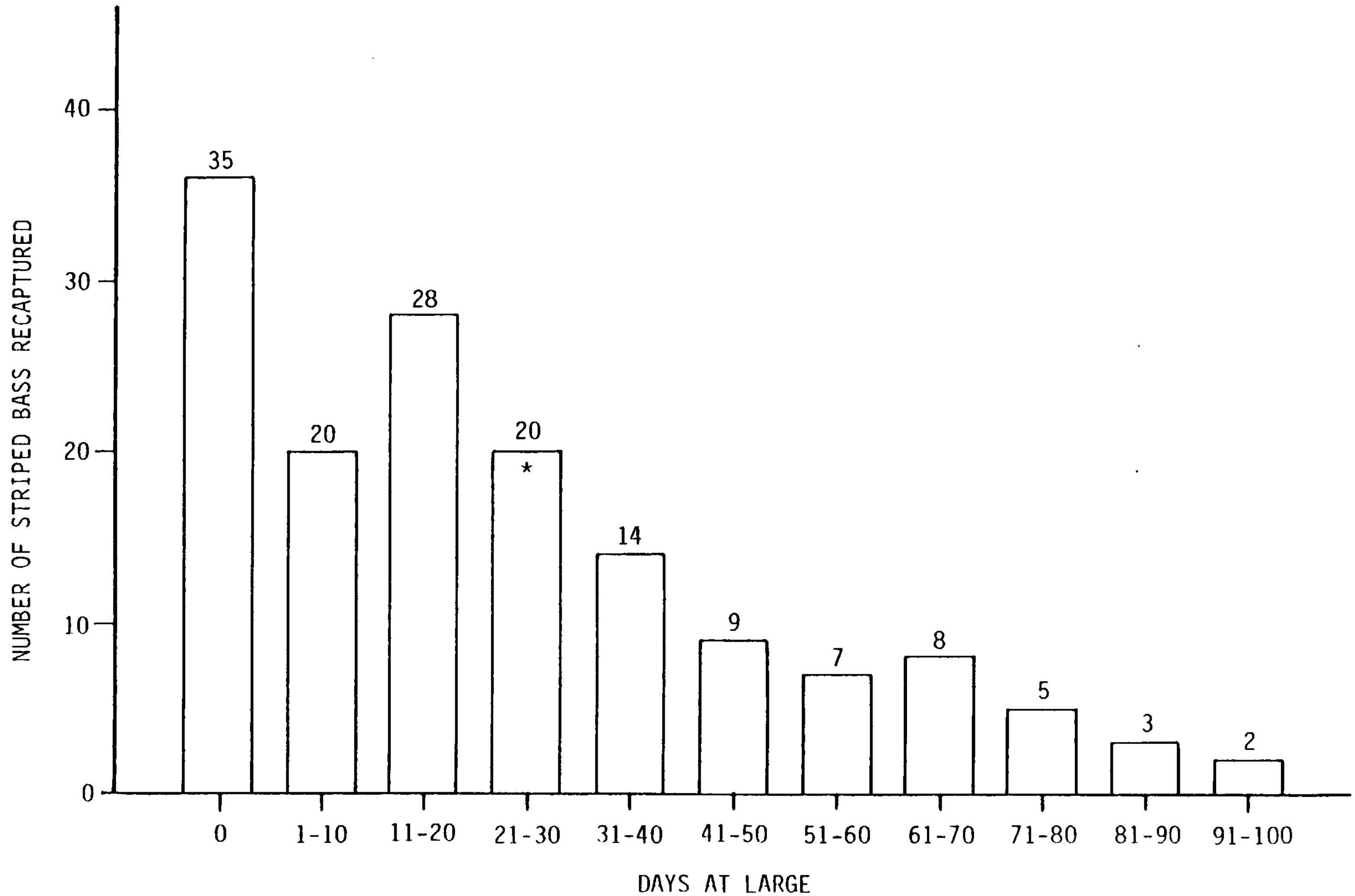

Figure 3-5. Frequency of days at large for 151 striped bass tagged and recaptured by trawls in the Upper Harbor and Battery regions of the Hudson River, 21 December 1986 through 8 May 1987.
(Note: * indicates the group containing the mean days at large.)

were recaptured within 30 days of release, suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. A decreasing number from 14 to 2 striped bass were recaptured in each ten-day interval between 31 and 100 days at large (Figure 3-5).

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1986-87 Winter Program

All of the striped bass recaptured with internal anchor tags from previous programs were caught in the Battery and Upper Harbor regions (Appendix Table D-3). Among the 113 striped bass recaptured from previous programs, three fish were recaptured two times during 1986-87; therefore 110 fish were uniquely captured from previous programs. Among these 113 recaptured striped bass were 17 fish which had tag numbers abraded but the numbers could be read (Table 3-26, Appendix Table D-4). An additional 10 fish were recaptured with partly or totally illegible tag numbers, and 4 fish were observed with tag wounds but no tag present (Table 3-26). Tag numbers were defined as completely illegible if one or more of the 5-digit tag number could not be read in the field. Since tag abrasion was not observed for fish tagged, released and recaptured within the 1985-86 (NAI 1986) or 1986-87 winter programs, it can be assumed that tag abrasion is time dependent and manifested after fish have been at large at least six months. Unfortunately, without the complete tag number, it is impossible to determine in which of the previous two programs (1984 or 1985-86) the fish was released. Fortunately, only 10/123 or 8.1% of the recaptured, tagged fish that were released prior to the winter 1986-87 program had illegible tag numbers, although 27/123 or 22.0% of these fish exhibited some degree of tag abrasion.

TABLE 3-26. INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO, AND RECAPTURED DURING THE WINTER 1986-87 HUDSON RIVER STRIPED BASS PROGRAM.

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH[a]	PERCENT
Tag number completely legible	Healed	83	65.4
	Infected	2	1.6
	Anchor Protruding	11	8.7
		96	75.7
Tag number abraded but legible	Healed	13	10.2
	Infected	2	1.6
	Anchor Protruding	2	1.6
		17	13.4
Tag number partly missing and not legible	Healed	5	3.9
	Infected	1	0.8
	Anchor Protruding	0	0.0
		6	4.7
Tag number missing	Healed	2	1.6
	Infected	1	0.8
	Anchor Protruding	1	0.8
		4	3.2
Tag wound only, tag missing	Healed	3	2.4
	Infected	1	0.8
		4	3.2
	Healed	106	83.5
	Infected	7	5.5
	Anchor Protruding	14	11.0
	TOTAL	127	100.0

[a] striped bass which could be cross-classified by degree of tag number abrasion and condition of the tag insertion site.

The four striped bass observed with tag wounds (Table 3-26) may have originated in two ways. First, the tag could have been removed by a fisherman and mailed to the Hudson River Foundation (HRF) address on the tag legend. This may be the most common method of tag loss since more than 700 tags are mailed to the HRF annually (HRF 1985). In the 1986-87 program, one of the four fish with tag wounds was observed to have what appeared to be the severed stub of a streamer protruding from the tag wound, cut off evenly with the body surface. Second, the tag may have been shed. An indication that tag shedding can occur is seen in the incidence of fish caught with some degree of anchor protrusion. Eleven percent of the 123 striped bass recaptured with tags from previous programs exhibited some degree of anchor protrusion (Table 3-26). Typically only the anterior edge of the internal anchor was exposed, but for two fish the entire anchor was protruding through the body wall at a point anterior to the insertion site. With the entire anchor protruding, the tag was attached to the fish by a thin loop of abdominal musculature in the body wall and could easily be caught on weeds or other material and dislodged.

The anterior edge of the external streamer (i.e., the portion of the tubing on the external streamer facing the anterior end of the fish at the time of recapture) was most often observed to be abraded, and the portion of the legend that was facing anterior was generally partially or totally missing (Appendix Table D-4). Loss of flexibility of the external streamer due to cold water temperatures or exposure to salt water would cause the streamer to protrude almost perpendicular to the mid-ventral axis of striped bass. With the streamer protruding in this manner, it is likely that abrasion occurs as tagged fish swim forward in close proximity (the length of the streamer) to the river bottom or other structures. The same process that causes streamer abrasion is also likely to cause anchor protrusion, since the abrasion force would put leverage on the anterior edge of the anchor as the fish swims forward.

Changing the tag insertion site would not be an appropriate remedy for streamer abrasion or anchor protrusion, since the present insertion site was selected based on internal anatomy of the body cavity to minimize the possibility of damage to internal organs during anchor insertion. Changing the tag insertion site may therefore increase handling mortality. Placing a clear, vinyl sleeve over the external streamer would protect the legend from abrasion but may not prevent anchor protrusion. Tags with protective sleeves were used in the 1986-87 program after 9 March 1987 to mitigate tag abrasion, but this is considered an interim measure. The recommended solution to the tag abrasion problem is to redesign the tag so that the external streamer remains flexible and is therefore not subjected to abrasion.

All of the 113 striped bass recaptured during the 1986-87 program were tagged and released during 1985-86 (Table 3-27). However, with the apparent time dependence of tag abrasion, it is possible that fish from the 1984 program were recaptured with illegible tag numbers and could not be identified. Among the 113 fish recaptured, 32 had been released from the 9 m trawl, 73 from the 12 m trawl, and 8 from the Scottish seine efforts during 1985-86. The average size of these striped bass was 327 mmTL for fish released from the 9 m trawl, 347 mmTL for fish released from the 12 m trawl, and 376 mmTL for fish released from the Scottish seine during 1985-86. These fish were at large between 228 and 495 days.

Recapture rates and recapture proportions for striped bass tagged and released from the 12 m trawl during 1985-86 and recaptured during 1986-87 were nearly an order of magnitude higher than for fish released from the Scottish seine, and were approximately double the recapture rates and recapture proportions for fish released from the 9 m trawl (Table 3-27). Lower recapture rates and recapture proportions for the Scottish seine compared to the trawls are not surprising since it is possible that the seine tagged and released fish that are generally not exposed to the winter trawling effort (NAI 1986). Striped bass tagged and released from the seine in the spring were generally

TABLE 3-27. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED DURING THE 1985-86 WINTER PROGRAM AND RECAPTURED IN THE LOWER HUDSON RIVER ESTUARY FROM 21 DECEMBER 1986 THROUGH 8 MAY 1987.

STATISTIC		RELEASED DURING THE 1985-86 STRIPED BASS PROGRAM[a]		
		9 m TRAWL	12 m TRAWL	SCOTTISH SEINE
NUMBER TAGGED (≥200 mmTL)	(M)	6,366	7,265	4,856
NUMBER EXAMINED FOR TAGS (≥200 mmTL)	(C)	7,314[b]	7,314[b]	7,314[b]
NUMBER RECAPTURED	(R)	32	73	8
SIZE RANGE OF RECAPTURED FISH (mmTL)	Min	243	252	237
	Max	422	473	523
	Mean	327	347	376
	S.D.	44	50	90
DAYS AT LARGE	Min	279	249	228
	Max	495	483	371
	Mean	408.2	342.6	301.8
	S.D.	53.6	44.3	48.8
RECAPTURE RATE	R/M	0.00503	0.01005	0.00165
RECAPTURE PROPORTION	R/C	0.00438	0.00998	0.00109

[a] 11 November 1985 - 16 May 1986

[b] obtained by subtracting the estimated number of Age 0+ (0) and Age 1+ (2,755) fish ≥ 200 mmTL from the total number of fish ≥200 mmTL caught during 1986-87 (10,069).

larger fish which may have either overwintered in Haverstraw Bay (river miles 24-38, km 38-61) or migrated into the estuary in the upper water column and were not exposed to trawl sampling in the Battery and Upper Harbor regions. However, different recapture rates and recapture proportions for fish released from the two trawls cannot be explained based on temporal and spatial segregation of the release and recapture efforts since both trawls generally fished in the same regions at the same times in both 1985-86 and 1986-87.

3.5 STRIPED BASS POPULATION SIZE

One objective of the 1986-87 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. Section 3.4 indicated that the striped bass population in the Upper Harbor and Battery regions of the Hudson River was apparently closed to major immigration and emigration during at least the 21 December 1986 through April 1987 period. Therefore, closed population mark-recapture estimators were examined to estimate the size of the striped bass population. The estimators examined were: Petersen, Bailey's single catch, least squares, inverse sampling technique with and without replacement, Schnabel, Schumacher-Eschmeyer, inverse Schnabel, sequential Schnabel and Overton (Ricker 1985; Seber 1982; MMES 1986). The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently and can be used for migratory populations. This estimator was effectively used during 1985-86 to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the Lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) tagged bass suffer the same mortality as untagged bass,

2) tagging does not affect bass catchability,

3) tagged bass do not lose their marks,

4) all tags are recognized and reported,

5) natural marking does not occur or is recognizable,

6) immigration and/or emigration is negligible in the study area i.e., the population is closed,

7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions, and

8) marked fish have the same probability of being caught.

With regard to assumption 1, Dunning *et al.* (1987 in press) observed no difference in mortality between tagged and untagged striped bass retained 1) in the Hudson River for 24 hours and 2) in holding pools for up to 180 days. For the purposes of obtaining a mark-recapture population estimate, mortality due to tagging was assumed to be zero.

Differential vulnerability of tagged and untagged striped bass during the winter (assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is generally applied to gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1987) which would provide evidence of tag loss. QA/QC procedures (NAI 1987) and audits provide documentation that miss-identification or non-reporting of tags by field crews did not occur. Dunning *et al.* (1987 in press) found 97.7% retention of internal anchor tags of to 180 days in holding pools. Based on a 2.3% loss rate (Dunning *et al.* 1987 in press) and a recapture rate of 151 fish out of 9,388 tagged fish, approximately 4 fish would be expected to have lost tags in the 1986-87 program. Throughout the program, 10,069 striped bass were examined for tags and tag wounds, and only 4 fish were observed with missing tags. However, these fish were likely to have originated from the 1985-86 program since the tag wounds were all well healed. Therefore, loss of internal anchor tags for fish tagged and released during 1986-87 was considered zero this program.

Assumption 4, the recognition and reporting of tags, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1986). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration (Assumption 6) was apparently negligible during the mid-winter period (21 December 1986 through April 1987) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (NAI 1986). Closer examination of weekly recapture proportions plotted against the cumulative number of marked fish (Figure 3-6) reveals a strong, increasing linear trend between the week of 21 December 1986 and the week of 8 March 1987. This is a similar period of stability in the winter striped bass population that was observed during 1985-86 (30 December 1985 through 21 February 1986, NAI 1986). A significant linear regression was observed (Appendix Tables D-5 and D-6) which forms the basis for the Schumacher-Eschmeyer closed population estimator for striped bass in upper New York harbor and the Battery and supports the assumption of random mixing of tagged and untagged striped bass (Assumption 7). The population may not be closed after 8 March 1987, because studies conducted during 1985-86 indicated tagged striped bass began moving from the Battery and Upper Harbor upriver into the Tappan

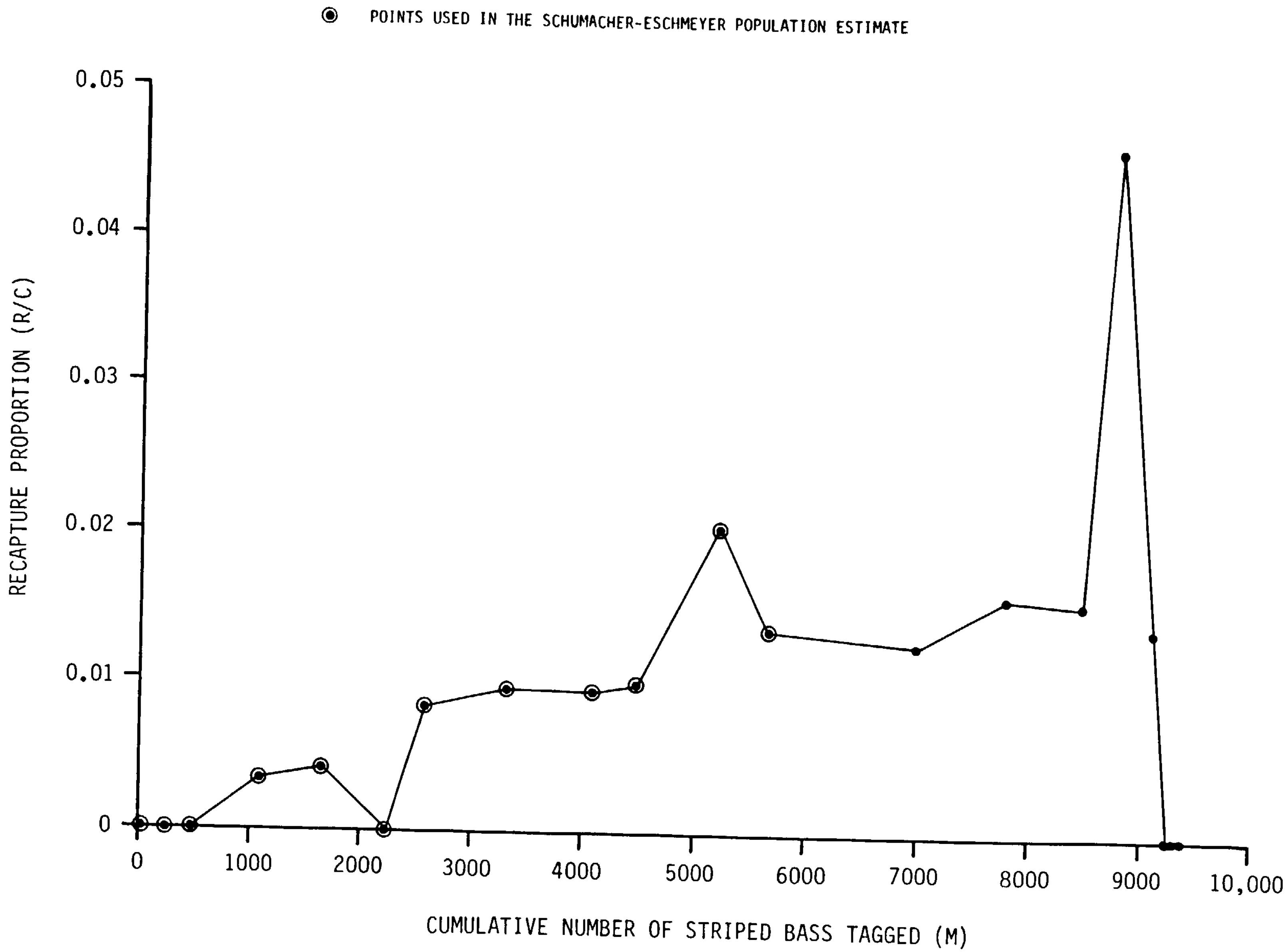

Figure 3-6. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged (M) in the combined Upper Harbor and Battery regions of the Lower Hudson River during winter 1986-1987.

Zee and Croton-Haverstraw regions in late-March and April (NAI 1986). If tagged fish were not randomly mixed, recapture rates and proportions would either exhibit high variability or a decreasing linear trend (Ricker 1975). Linear (decreasing) trends in a short-term (within one season) would indicate migration or tag loss, while long-term decreasing trends would indicate mortality (TI 1981; Ricker 1975; Seber 1982).

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

Inasmuch as the assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied in this study, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1986-87 was 394,000 fish $\geq$ 200 mmTL, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 336,000 to 474,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-28). Based on the estimated hatchery contribution of 1.5% (Section 3.3), approximately 2,000 Age 1+ hatchery fish were present among the striped bass overwintering in the Battery and Upper Harbor regions during winter 1986-87.

An attempt was not made to provide a second estimate of the size of the 1985-86 winter population based on fish recaptured during 1986-87, because of the uncertainty associated with assigning a release year to the fish recaptured with illegible tag numbers (Section 3.4.2.2).

TABLE 3-28. ESTIMATED POPULATION OF STRIPED BASS ≥200 mmTL BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1986-87.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥200mmTL	PROPORTION ≥200mmTL	ESTIMATED POPULATION[a]
1+	3,703	2,755	0.2736	108,000
2+	5,685	5,659	0.5620	221,000
3+	1,304	1,304	0.1295	51,000
>3+	351	351	0.0349	14,000
TOTAL	11,043	10,069	1.0000	394,000

[a]Estimated population based on a Schumacher-Eschmeyer estimate of the number of striped bass marked, released and recaptured in the Upper Harbor and Battery regions of the Lower Hudson River from the week of 21 December 1986 through the week of 8 March 1987.

4.0 SUMMARY

The 1986-1987 Hudson River Striped Bass Hatchery Evaluation was conducted to address the following objectives:

1) determine if hatchery striped bass, stocked during any year between 1983 and 1985, have contributed to the Hudson River population,

2) estimate the proportion of the 1984 year class of Hudson River striped bass composed of hatchery fish at Age 2+, if hatchery fish are detected,

3) estimate the proportion of the 1985 year class of Hudson River striped bass composed of hatchery fish at Age 1+, if hatchery fish are detected,

4) tag all striped bass greater than or equal to 200 mmTL in total length, that are in good condition, with internal anchor tags, and

5) determine catch rate and survival of striped bass handled during 1986-1987.

Mean striped bass catch per ten minute tow over all sampling weeks and gear was highest in the Upper Harbor and Battery regions, and was significantly lower in the Tappan Zee and Croton-Haverstraw regions. Within the Battery, highest CPUE was generally observed for the 12 m trawl and 12 m trawl with liner compared to the 9 m trawl and 9 m trawl with liner. Within the Battery, highest mean CPUE for the 12 m trawl with cod end liner was 83 striped bass per ten minute tow during the week of 8 February 1987 and was 81 fish per ten minute tow during the week of 8 March 1987. The 9 m trawl in the Battery region had the highest CPUE of 26 during the week of 18 January 1987 and the 9 m trawl with cod end liner had the highest CPUE during the weeks of 5 April (CPUE = 27) and 12 April 1987 (CPUE = 27.2).

Use of the cod end liner in the 9 m trawl did not affect the length-frequency distribution of Age 1+ and older striped bass caught in the trawl because of the similarity in mesh sizes. However, use of the liner in the cod end of the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Therefore, it is recommended that a program designed to capture Age 1+ and older striped bass using the 12 m trawl should either change the present cod end to conform to the mesh specifications of the 9 m trawl (3.8 cm stretch mesh) or use a cod end liner similar to the one evaluated in this study (2.5 cm stretch mesh).

Handling mortality was extremely low (<1%) in the 1986-87 program, and was comparable to 1985-86. No relationship was found between gear and handling mortality and ascending or descending water temperature intervals.

Stratified random sampling was extremely precise for estimating the proportion and number of Age 1+ striped bass caught in this study. By determining the age of as few as 1,000 striped bass, reasonably precise 95% confidence limits (± 177 fish) for the estimated number of Age 1+ fish can be calculated. The design based on Age 1+ fish is at least equally as precise for estimating the number of Age 0+ and Age 2+ fish. Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin recaptured during 1986-87, the estimated hatchery proportion was 1.5%.

During the 1986-87 program, the striped bass population in the Battery and Upper Harbor regions remained relatively closed to immigration and emigration from the week of 21 December 1986 through the week of 8 March 1987, permitting a Schumacher-Eschmeyer population estimate to be calculated. The estimated overwintering population in the Battery and Upper Harbor was 394,000 fish. A second estimate of the size of the 1985-86 population using fish tagged and released during 1985-86 and recaptured during 1986-87 was not attempted because of problems associated with assigning a release year to some fish recaptured with missing tag numbers due to tag abrasion.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 12 m TRAWL.

	12 m TRAWL
Head rope length	6.7 m
Foot rope length (Sweep)	12.2 m
Legs (between doors and net)	18.3 m
Approximate vertical lift	4.9 m
Net body length	12.5 m
Cod end length	4.0 m
Doors (steel V-doors)	1.3 m
Mesh - body of net	11.4 cm (stretch) mesh polypropylene; polypropylene; 3 mm diameter twine
- cod end	7.5 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
- cod end liner	2.5 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	15 and 10 cm large cookie disks with 5 cm cookie disks

APPENDIX TABLE A-2. SPECIFICATIONS OF THE 9 m TRAWL.

9 m TRAWL	
Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6 cm (stretch) mesh polypropylene; polypropylene; 3 mm diameter twine
- cod end	3.8 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
- cod end liner	2.5 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. REGIONAL AND WEEKLY AVERAGE WATER QUALITY AND AIR TEMPERATURE DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY	AIR TEMPERATURE
UPPER HARBOR	04JAN87	3.8	18076.0	4.8	24997.6	3.8
	11JAN87	5.2	32867.7	5.2	37527.3	8.7
	01MAR87	2.7	21859.3	2.9	30626.8	4.9
	29MAR87	8.1	5700.6	8.0	17086.1	11.4
	05APR87	9.0	6286.1	7.8	32357.9	13.9
	12APR87	9.0	17282.1	8.8	29899.3	10.4
	19APR87	11.0	17903.5	10.7	32367.0	10.3
THE BATTERY	21DEC86	5.0	10442.0	6.6	28342.6	.
	28DEC86	6.1	23525.6	6.3	30274.1	.
	04JAN87	3.1	12778.8	4.4	22261.8	.
	11JAN87	4.0	22365.2	4.7	31742.6	5.5
	18JAN87	2.7	18243.3	4.2	33348.1	1.3
	25JAN87	2.3	30704.9	2.7	35834.9	1.0
	01FEB87	2.5	22003.5	2.4	30256.2	5.8
	08FEB87	2.1	21317.5	2.8	31899.5	2.6
	15FEB87	1.3	25637.2	1.7	33391.0	-2.9
	22FEB87	2.4	25092.6	2.2	30496.0	2.8
	01MAR87	3.3	21484.1	3.0	28476.9	5.3
	08MAR87	3.0	9964.3	3.3	25806.5	6.6
	15MAR87	4.3	20974.8	3.9	28333.6	8.4
	22MAR87	6.7	16337.8	5.7	29101.5	14.4
	29MAR87	8.0	7417.2	7.4	23181.6	12.1
	05APR87	9.1	2325.4	8.2	26783.9	11.4
	12APR87	8.8	10760.7	8.6	25496.8	10.3
	19APR87	11.6	9442.6	10.3	27451.3	16.9
	26APR87	11.4	17845.1	11.0	26645.3	12.8
	03MAY87	11.0	10804.7	10.7	27151.5	9.7
TAPPAN ZEE	08MAR87	1.8	4386.0	2.7	22570.0	2.7
	03MAY87	12.3	3124.5	12.2	5398.4	10.9
CROTON-HAVERSTRAW	03MAY87	13.1	3789.0	12.8	4393.0	16.5

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH PER UNIT EFFORT OF STRIPED BASS CAPTURED IN THE 9 m AND 12 m TRAWLS, WITH AND WITHOUT COD END LINERS DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

THE BATTERY REGION

	9 M TRAWL				9 M TRAWL W/L [1]				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
		CPUE				CPUE				CPUE				CPUE				CPUE		
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
21DEC	42	425	10.1	1.1	0				0				0				42	425	10.1	1.1
28DEC	39	211	5.4	1.1	0				2	10	5.0	5.0	0				41	221	5.4	1.0
04JAN	22	285	13.0	2.0					7	105	15.0	3.3	7	184	26.3	5.3	36	574	15.9	1.9
11JAN	17	339	19.9	7.3	6	277	46.2	20.3	0				8	279	34.9	5.4	31	895	28.9	5.9
18JAN	24	613	25.5	2.6	0				5	111	22.2	3.7	5	283	56.6	10.9	34	1007	29.6	3.1
25JAN	18	138	7.7	1.4	9	50	5.6	0.9	7	80	11.4	1.8	6	138	23.0	2.9	40	406	10.2	1.2
01FEB	28	272	9.7	1.0	14	289	20.6	2.1	12	304	25.3	2.3	10	435	43.5	7.6	64	1300	20.3	2.0
08FEB	25	341	13.6	3.0	8	89	11.1	3.1	5	248	49.6	25.1	3	248	82.7	36.8	41	926	22.6	5.2
15FEB	27	253	9.4	1.3	15	137	9.1	1.4	5	183	36.6	16.1	0				47	573	12.2	2.2
22FEB	43	410	9.5	1.0	23	228	9.9	1.3	2	57	28.5	14.5	11	257	23.4	6.8	79	952	12.1	1.3
01MAR	31	349	11.3	1.3	15	131	8.7	1.3	0				3	86	28.7	16.5	49	566	11.6	1.4
08MAR	37	635	17.2	3.2	17	275	16.2	3.3	5	403	80.6	16.3	7	387	55.3	11.2	66	1700	25.8	3.5
15MAR	32	425	13.3	1.9	20	300	15.0	1.8	10	259	25.9	3.1	9	314	34.9	7.8	71	1298	18.3	1.7
22MAR	42	442	10.5	1.2	18	204	11.3	2.9	9	132	14.7	2.7	12	149	12.4	1.3	81	927	11.4	1.0
29MAR	46	113	2.5	0.3	8	216	27.0	3.7	0				5	38	7.6	2.0	59	367	6.2	1.2
05APR	34	200	5.9	0.9	6	163	27.2	6.3	8	66	8.2	1.4	8	105	13.1	3.1	56	534	9.5	1.3
12APR	25	111	4.4	2.0	13	30	2.3	0.7	9	23	2.6	0.7	5	11	2.2	0.7	52	175	3.4	1.0
19APR	34	31	0.9	0.2	16	23	1.4	0.3	3	1	0.3	0.3	4	5	1.3	0.3	57	60	1.1	0.1
26APR	31	15	0.5	0.1	15	12	0.8	0.3	5	6	1.2	0.2	5	7	1.4	0.5	56	40	0.7	0.1
03MAY	15	9	0.6	0.2	0				0				0				15	9	0.6	0.2
TOTAL	612	5617	9.2	0.5	203	2424	11.9	1.0	94	1988	21.1	2.6	108	2926	27.1	2.5	1017	1E+4	12.7	0.5

1. W/L = with cod end liner

APPENDIX TABLE C-1. (CONTINUED)

UPPER HARBOR REGION

	9 M TRAWL				9 M TRAWL W/L				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
		CPUE				CPUE				CPUE				CPUE				CPUE		
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
04JAN	2	19	9.5	4.5	0				6	237	39.5	9.5	0				8	256	32.0	8.5
11JAN	0				0				2	4	2.0	1.0	1	8	8.0		3	12	4.0	2.1
01MAR	0				0				4	77	19.2	6.7	2	39	19.5	7.5	6	116	19.3	4.6
29MAR	0				6	111	18.5	5.7	0				0				6	111	18.5	5.7
05APR	0				5	25	5.0	1.6	0				0				5	25	5.0	1.6
12APR	12	116	9.7	1.9	5	4	0.8	0.4	0				0				17	120	7.1	1.7
19APR	0				0				2	1	0.5	0.5	0				2	1	0.5	0.5
TOTAL	14	135	9.6	1.7	16	140	8.8	2.9	14	319	22.8	6.1	3	47	15.7	5.8	47	641	13.6	2.3

APPENDIX TABLE C-1. (CONTINUED)

TAPPAN ZEE REGION

	9 M TRAWL				9 M TRAWL W/L				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
		CPUE				CPUE				CPUE				CPUE				CPUE		
	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
WEEK																				
08MAR	0				0				2	0	0.0	0.0	0				2	0	0.0	0.0
03MAY	3	2	0.7	0.3	5	3	0.6	0.4	0				6	3	0.5	0.2	14	8	0.6	0.2
TOTAL	3	2	0.7	0.3	5	3	0.6	0.4	2	0	0.0	0.0	6	3	0.5	0.2	16	8	0.5	0.2

APPENDIX TABLE C-1. (CONTINUED)

CROTON-HAVERSTRAW REGION

	9 M TRAWL				9 M TRAWL W/L				12 M TRAWL				ALL TRAWLS			
			CPUE				CPUE				CPUE				CPUE	
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
03MAY	12	19	1.6	0.5	10	4	0.4	0.2	5	1	0.2	0.2	27	24	0.9	0.3
TOTAL	12	19	1.6	0.5	10	4	0.4	0.2	5	1	0.2	0.2	27	24	0.9	0.3

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH PER UNIT EFFORT OF STRIPED BASS CAPTURED IN THE 9 m AND 12 m TRAWLS, WITH AND WITHOUT COD END LINERS, DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

THE BATTERY REGION

	9 M TRAWL				9 M TRAWL W/L[1]				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
			CPUE				CPUE				CPUE				CPUE				CPUE	
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
1	123	991	8.1	0.8	53	666	12.6	1.6	29	388	13.4	3.5	48	866	18.0	2.3	253	2911	11.5	0.8
2	1	6	6.0		0				0				0				1	6	6.0	
5	118	570	4.8	0.5	34	327	9.6	1.7	15	94	6.3	1.3	15	101	6.7	1.5	182	1092	6.0	0.5
8	155	1348	8.7	0.9	44	588	13.4	1.4	21	781	37.2	6.9	17	681	40.1	6.0	237	3398	14.3	1.2
9	213	2687	12.6	1.0	71	830	11.7	2.3	28	723	25.8	4.9	27	1239	45.9	6.4	339	5479	16.2	1.1
11	2	15	7.5	1.5	1	13	13.0		1	2	2.0		1	39	39.0		5	69	13.8	6.6
TOTAL	612	5617	9.2	0.5	203	2424	11.9	1.0	94	1988	21.1	2.6	108	2926	27.1	2.5	1017	1E+4	12.7	0.5

1. W/L = with cod end liner

APPENDIX TABLE C-2. (CONTINUED)

UPPER HARBOR REGION

	9 M TRAWL				9 M TRAWL W/L				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
			CPUE				CPUE				CPUE				CPUE				CPUE	
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
2	12	116	9.7	1.9	16	140	8.8	2.9	9	85	9.4	4.1	3	47	15.7	5.8	40	388	9.7	1.6
3	2	19	9.5	4.5	0				5	234	46.8	7.4	0				7	253	36.1	8.6
TOTAL	14	135	9.6	1.7	16	140	8.8	2.9	14	319	22.8	6.1	3	47	15.7	5.8	47	641	13.6	2.3

APPENDIX TABLE C-2. (CONTINUED)

TAPPAN ZEE REGION

	9 M TRAWL				9 M TRAWL W/L				12 M TRAWL				12 M TRAWL W/L				ALL TRAWLS			
		CPUE				CPUE				CPUE				CPUE				CPUE		
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
28	0				0				1	0	0.0		0				1	0	0.0	
29	0				1	1	1.0		0				1	1	1.0		2	2	1.0	0.0
30	1	0	0.0		2	2	1.0	1.0	0				4	1	0.3	0.3	7	3	0.4	0.3
31	1	1	1.0		1	0	0.0		1	0	0.0		1	1	1.0		4	2	0.5	0.3
33	1	1	1.0		1	0	0.0		0				0				2	1	0.5	0.5
TOTAL	3	2	0.7	0.3	5	3	0.6	0.4	2	0	0.0	0.0	6	3	0.5	0.2	16	8	0.5	0.2

APPENDIX TABLE C-2. (CONTINUED)

CROTON-HAVERSTRAW REGION

	9 M TRAWL CPUE				9 M TRAWL W/L CPUE				12 M TRAWL CPUE				ALL TRAWLS CPUE			
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
34	2	0	0.0	0.0	2	1	0.5	0.5	1	0	0.0		5	1	0.2	0.2
35	7	17	2.4	0.7	2	2	1.0	1.0	3	0	0.0	0.0	12	19	1.6	0.5
36	2	2	1.0	1.0	3	0	0.0	0.0	1	1	1.0		6	3	0.5	0.3
37	1	0	0.0		3	1	0.3	0.3	0				4	1	0.3	0.3
TOTAL	12	19	1.6	0.5	10	4	0.4	0.2	5	1	0.2	0.2	27	24	0.9	0.3

APPENDIX TABLE C-3. REGIONAL AND WEEKLY MEAN CATCH PER UNIT EFFORT OF STRIPED BASS CAPTURED IN THE 9 m TRAWL ON MONDAY, TUESDAY THROUGH FRIDAY AND ALL DAYS COMBINED DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

THE BATTERY REGION

	9 M TRAWL (MON)				9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE				CPUE	
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
21DEC	13	142	10.9	2.0	29	283	9.8	1.3	42	425	10.1	1.1
28DEC	15	118	7.9	2.4	24	93	3.9	0.6	39	211	5.4	1.1
04JAN	0				22	285	13.0	2.0	22	285	13.0	2.0
11JAN	10	84	8.4	1.5	7	255	36.4	16.3	17	339	19.9	7.3
18JAN	9	199	22.1	3.9	15	414	27.6	3.5	24	613	25.5	2.6
25JAN	0				18	138	7.7	1.4	18	138	7.7	1.4
01FEB	13	149	11.5	1.8	15	123	8.2	0.8	28	272	9.7	1.0
08FEB	0				25	341	13.6	3.0	25	341	13.6	3.0
15FEB	0				27	253	9.4	1.3	27	253	9.4	1.3
22FEB	16	186	11.6	1.8	27	224	8.3	1.1	43	410	9.5	1.0
01MAR	18	170	9.4	1.6	13	179	13.8	1.8	31	349	11.3	1.3
08MAR	18	267	14.8	2.1	19	368	19.4	5.8	37	635	17.2	3.2
15MAR	15	259	17.3	3.2	17	166	9.8	1.7	32	425	13.3	1.9
22MAR	20	228	11.4	2.0	22	214	9.7	1.5	42	442	10.5	1.2
29MAR	21	72	3.4	0.4	25	41	1.6	0.3	46	113	2.5	0.3
05APR	12	16	1.3	0.3	22	184	8.4	1.1	34	200	5.9	0.9
12APR	17	91	5.4	2.9	8	20	2.5	0.9	25	111	4.4	2.0
19APR	18	15	0.8	0.2	16	16	1.0	0.3	34	31	0.9	0.2
26APR	16	5	0.3	0.1	15	10	0.7	0.3	31	15	0.5	0.1
03MAY	15	9	0.6	0.2	0				15	9	0.6	0.2
TOTAL	246	2010	8.2	0.6	366	3607	9.9	0.7	612	5617	9.2	0.5

APPENDIX TABLE C-3. (CONTINUED)

UPPER HARBOR REGION

	9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE	
	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
WEEK								
04JAN	2	19	9.5	4.5	2	19	9.5	4.5
12APR	12	116	9.7	1.9	12	116	9.7	1.9
TOTAL	14	135	9.6	1.7	14	135	9.6	1.7

APPENDIX TABLE C-3. (CONTINUED)

TAPPAN ZEE REGION

	9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE	
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
03MAY	3	2	0.7	0.3	3	2	0.7	0.3
TOTAL	3	2	0.7	0.3	3	2	0.7	0.3

APPENDIX TABLE C-3. (CONTINUED)

CROTON-HAVERSTRAW REGION

	9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE	
WEEK	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
03MAY	12	19	1.6	0.5	12	19	1.6	0.5
TOTAL	12	19	1.6	0.5	12	19	1.6	0.5

APPENDIX TABLE C-4. REGIONAL AND RIVER MILE MEAN CATCH PER UNIT EFFORT OF STRIPED BASS CAPTURED IN THE 9 m TRAWL ON MONDAY, TUESDAY THROUGH FRIDAY AND ALL DAYS COMBINED DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

THE BATTERY REGION

	9 M TRAWL (MON)				9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE				CPUE	
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
1	37	285	7.7	1.7	86	706	8.2	0.8	123	991	8.1	0.8
2	0				1	6	6.0		1	6	6.0	
5	42	185	4.4	0.8	76	385	5.1	0.6	118	570	4.8	0.5
8	89	719	8.1	1.0	66	629	9.5	1.5	155	1348	8.7	0.9
9	78	821	10.5	1.1	135	1866	13.8	1.4	213	2687	12.6	1.0
11	0				2	15	7.5	1.5	2	15	7.5	1.5
TOTAL	246	2010	8.2	0.6	366	3607	9.9	0.7	612	5617	9.2	0.5

APPENDIX TABLE C-4. (CONTINUED)

UPPER HARBOR REGION

	9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE	
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
2	12	116	9.7	1.9	12	116	9.7	1.9
3	2	19	9.5	4.5	2	19	9.5	4.5
TOTAL	14	135	9.6	1.7	14	135	9.6	1.7

APPENDIX TABLE C-4. (CONTINUED)

TAPPAN ZEE REGION

RIVER MILE	9 M TRAWL (TUES-FRI) TOWS	N	CPUE MEAN	S.E.	9 M TRAWL (ALL DAYS) TOWS	N	CPUE MEAN	S.E.
30	1	0	0.0		1	0	0.0	
31	1	1	1.0		1	1	1.0	
33	1	1	1.0		1	1	1.0	
TOTAL	3	2	0.7	0.3	3	2	0.7	0.3

APPENDIX TABLE C-4. (CONTINUED)

CROTON-HAVERSTRAW REGION

	9 M TRAWL (TUES-FRI)				9 M TRAWL (ALL DAYS)			
			CPUE				CPUE	
RIVER MILE	TOWS	N	MEAN	S.E.	TOWS	N	MEAN	S.E.
34	2	0	0.0	0.0	2	0	0.0	0.0
35	7	17	2.4	0.7	7	17	2.4	0.7
36	2	2	1.0	1.0	2	2	1.0	1.0
37	1	0	0.0		1	0	0.0	
TOTAL	12	19	1.6	0.5	12	19	1.6	0.5

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. RECAPTURE DATA FOR VERIFIED HATCHERY STRIPED BASS RECAPTURED DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	21DEC86	BT	9	108	86
0	9 M TRAWL	22DEC86	BT	9	98	86
0	9 M TRAWL	22DEC86	BT	9	97	86
0	9 M TRAWL	29DEC86	BT	5	95	86
0	9 M TRAWL	02JAN87	BT	9	165	86
0	9 M TRAWL	07JAN87	BT	9	88	86
0	9 M TRAWL	07JAN87	BT	9	85	86
0	9 M TRAWL	07JAN87	BT	9	111	86
0	9 M TRAWL	16JAN87	BT	9	105	86
0	9 M TRAWL	19JAN87	BT	9	102	86
0	9 M TRAWL	19JAN87	BT	9	124	86
0	9 M TRAWL	03FEB87	BT	8	91	86
0	9 M TRAWL	10FEB87	BT	9	85	86
0	9 M TRAWL	10FEB87	BT	9	111	86
0	9 M TRAWL	23FEB87	BT	8	122	86
0	9 M TRAWL	12MAR87	BT	8	104	86
0	9 M TRAWL	12MAR87	BT	8	117	86
0	9 M TRAWL	12MAR87	BT	9	115	86
0	9 M TRAWL	23MAR87	BT	8	119	86
0	9 M TRAWL	23MAR87	BT	9	126	86
0	9 M TRAWL	27MAR87	BT	8	98	86
0	9 M TRAWL	09APR87	BT	1	98	86
0	12 M TRAWL	04FEB87	BT	8	117	86
0	12 M TRAWL WITH LINER	20JAN87	BT	9	97	86
0	12 M TRAWL WITH LINER	20JAN87	BT	9	105	86
0	12 M TRAWL WITH LINER	20JAN87	BT	9	115	86
0	12 M TRAWL WITH LINER	20JAN87	BT	9	120	86
0	12 M TRAWL WITH LINER	05FEB87	BT	9	115	86
0	9 M TRAWL WITH LINER	13JAN87	BT	11	111	86
0	9 M TRAWL WITH LINER	04MAR87	BT	1	119	86
0	9 M TRAWL WITH LINER	13MAR87	BT	8	116	86
0	9 M TRAWL WITH LINER	19MAR87	BT	9	97	86
0	9 M TRAWL WITH LINER	19MAR87	BT	8	112	86
0	9 M TRAWL WITH LINER	19MAR87	BT	8	111	86
0	9 M TRAWL WITH LINER	26MAR87	BT	8	82	86
0	9 M TRAWL WITH LINER	03APR87	BT	8	95	86
0	9 M TRAWL WITH LINER	03APR87	UH	2	118	86
0	9 M TRAWL WITH LINER	03APR87	BT	8	111	86
1	9 M TRAWL	21DEC86	BT	9	175	85
1	9 M TRAWL	29DEC86	BT	1	186	85
1	9 M TRAWL	29DEC86	BT	5	219	85

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL	12JAN87	BT	9	202	85
1	9 M TRAWL	19JAN87	BT	9	178	85
1	9 M TRAWL	29JAN87	BT	1	220	85
1	9 M TRAWL	02FEB87	BT	1	194	85
1	9 M TRAWL	10FEB87	BT	9	191	85
1	9 M TRAWL	10FEB87	BT	9	197	85
1	9 M TRAWL	11FEB87	BT	8	191	85
1	9 M TRAWL	13FEB87	BT	9	215	85
1	9 M TRAWL	19FEB87	BT	5	202	85
1	9 M TRAWL	19FEB87	BT	5	227	85
1	9 M TRAWL	20FEB87	BT	1	261	85
1	9 M TRAWL	23FEB87	BT	9	227	85
1	9 M TRAWL	26FEB87	BT	9	202	85
1	9 M TRAWL	27FEB87	BT	9	197	85
1	9 M TRAWL	03MAR87	BT	8	192	85
1	9 M TRAWL	03MAR87	BT	8	200	85
1	9 M TRAWL	03MAR87	BT	9	214	85
1	9 M TRAWL	04MAR87	BT	9	196	85
1	9 M TRAWL	17MAR87	BT	1	192	85
1	9 M TRAWL	17MAR87	BT	1	209	85
1	9 M TRAWL	23MAR87	BT	9	212	85
1	9 M TRAWL	27MAR87	BT	8	189	85
1	9 M TRAWL	27MAR87	BT	8	239	85
1	9 M TRAWL	01APR87	BT	1	197	85
1	12 M TRAWL	09JAN87	UH	3	206	85
1	12 M TRAWL	22JAN87	BT	9	210	85
1	12 M TRAWL	04FEB87	BT	8	200	85
1	12 M TRAWL	11MAR87	BT	8	167	85
1	12 M TRAWL	20MAR87	BT	8	245	85
1	12 M TRAWL	20MAR87	BT	9	259	85
1	12 M TRAWL WITH LINER	14JAN87	BT	9	234	85
1	12 M TRAWL WITH LINER	20JAN87	BT	9	233	85
1	12 M TRAWL WITH LINER	05FEB87	BT	8	184	85
1	12 M TRAWL WITH LINER	05FEB87	BT	8	189	85
1	12 M TRAWL WITH LINER	05FEB87	BT	9	217	85
1	12 M TRAWL WITH LINER	14MAR87	BT	8	192	85
1	12 M TRAWL WITH LINER	18MAR87	BT	8	206	85
1	9 M TRAWL WITH LINER	28JAN87	BT	9	169	85
1	9 M TRAWL WITH LINER	06FEB87	BT	1	183	85
1	9 M TRAWL WITH LINER	06FEB87	BT	1	214	85
1	9 M TRAWL WITH LINER	25FEB87	BT	9	205	85
1	9 M TRAWL WITH LINER	25FEB87	BT	9	210	85
1	9 M TRAWL WITH LINER	25FEB87	BT	5	228	85

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL WITH LINER	19MAR87	BT	9	180	85
1	9 M TRAWL WITH LINER	19MAR87	BT	9	203	85
1	9 M TRAWL WITH LINER	19MAR87	BT	8	208	85
1	9 M TRAWL WITH LINER	03APR87	BT	5	233	85
1	9 M TRAWL WITH LINER	10APR87	BT	1	180	85
2	9 M TRAWL	23FEB87	BT	9	237	84
2	9 M TRAWL	02MAR87	BT	9	350	84
2	9 M TRAWL	23MAR87	BT	9	238	84
2	12 M TRAWL WITH LINER	06MAR87	BT	1	281	84
2	9 M TRAWL WITH LINER	04MAR87	BT	1	924	84

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED AND RECAPTURED DURING THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE						RELEASE										
DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
21DEC86	9 M	225	BT	9	14	21DEC86	9 M	215	BT	9	14	0	0	0	1	18629
31DEC86	9 M	233	BT	5	8	31DEC86	9 M	230	BT	5	8	0	0	0	1	18489
16JAN87	9 M	273	BT	9	14	23DEC86	9 M	277	BT	5	8	24	4	6	1	18728
16JAN87	9 M	302	BT	9	14	14JAN87	12 M W/L	305	BT	9	14	2	0	0	1	25650
21JAN87	9 M	276	BT	9	14	09JAN87	12 M	277	UH	3	5	12	12	19	1	16164
31JAN87	9 M	238	BT	1	2	28JAN87	9 M W/L	236	BT	9	14	3	8	13	1	17578
02FEB87	9 M	204	BT	1	2	21JAN87	9 M	204	BT	9	14	12	8	13	1	16760
02FEB87	9 M	223	BT	1	2	02FEB87	9 M	229	BT	1	2	0	0	0	1	18821
03FEB87	9 M	229	BT	9	14	02FEB87	9 M	231	BT	1	2	1	8	13	1	18753
11FEB87	9 M	271	BT	9	14	13JAN87	9 M W/L	273	BT	9	14	29	0	0	1	16214
11FEB87	9 M	221	BT	8	13	22JAN87	12 M	224	BT	9	14	20	1	2	1	16918
20FEB87	9 M	204	BT	1	2	12FEB87	9 M W/L	202	BT	1	2	8	0	0	1	22403
20FEB87	9 M	224	BT	1	2	20FEB87	9 M	224	BT	1	2	0	0	0	1	22806
20FEB87	9 M	328	BT	1	2	12FEB87	9 M W/L	326	BT	1	2	8	0	0	1	26436
23FEB87	9 M	238	BT	9	14	09JAN87	12 M	237	UH	3	5	45	12	19	1	16184
26FEB87	9 M	297	BT	9	14	13FEB87	9 M	298	BT	9	14	13	0	0	1	22435
26FEB87	9 M	212	BT	9	14	19FEB87	9 M	212	BT	5	8	7	4	6	1	22803
26FEB87	9 M	257	BT	9	14	26FEB87	12 M	257	BT	9	14	0	0	0	1	23201
03MAR87	9 M	213	BT	9	14	18FEB87	12 M	210	BT	1	2	13	8	13	1	22687
03MAR87	9 M	235	BT	8	13	03MAR87	9 M	234	BT	9	14	0	1	2	1	23440
09MAR87	9 M	229	BT	8	13	04FEB87	12 M	228	BT	8	13	33	0	0	1	18873
09MAR87	9 M	212	BT	5	8	04FEB87	12 M	211	BT	8	13	33	3	5	1	18894
09MAR87	9 M	215	BT	9	14	05FEB87	12 M W/L	215	BT	8	13	32	1	2	1	18961
09MAR87	9 M	266	BT	8	13	09MAR87	9 M	266	BT	8	13	0	0	0	1	22920
09MAR87	9 M	257	BT	9	14	23FEB87	9 M	256	BT	9	14	14	0	0	1	23034
09MAR87	9 M	239	BT	9	14	26FEB87	9 M	242	BT	9	14	11	0	0	1	23329
09MAR87	9 M	320	BT	9	14	16JAN87	9 M	323	BT	9	14	52	0	0	1	25741
09MAR87	9 M	350	BT	5	8	04MAR87	9 M W/L	348	BT	1	2	5	4	6	1	27503
12MAR87	9 M	231	BT	9	14	16JAN87	9 M	230	BT	9	14	55	0	0	1	15285
12MAR87	9 M	287	BT	8	13	09JAN87	12 M	299	UH	3	5	62	11	18	1	16195
12MAR87	9 M	294	BT	9	14	22JAN87	12 M	293	BT	9	14	49	0	0	1	16928
12MAR87	9 M	251	BT	8	13	12MAR87	9 M	252	BT	8	13	0	0	0	1	23987
16MAR87	9 M	268	BT	8	13	09JAN87	12 M	268	UH	3	5	66	11	18	1	16134
16MAR87	9 M	200	BT	8	13	22DEC86	9 M	200	BT	8	13	84	0	0	1	18650
17MAR87	9 M	210	BT	1	2	17MAR87	9 M	210	BT	1	2	0	0	0	1	23870
17MAR87	9 M	296	BT	1	2	12FEB87	9 M W/L	303	BT	1	2	33	0	0	1	26563
23MAR87	9 M	219	BT	8	13	31JAN87	9 M	216	BT	1	2	51	7	11	1	17644
27MAR87	9 M	241	BT	8	13	02MAR87	9 M	239	BT	8	13	25	0	0	1	23404
09APR87	9 M	252	BT	1	2	13JAN87	9 M W/L	251	BT	9	14	86	8	13	1	16255
09APR87	9 M	230	BT	1	2	26FEB87	12 M	228	BT	9	14	42	8	13	1	23187
09APR87	9 M	220	BT	1	2	18MAR87	12 M W/L	220	BT	8	13	22	7	11	1	24442
09APR87	9 M	286	BT	1	2	20MAR87	12 M	284	BT	8	13	20	7	11	1	24469
09APR87	9 M	262	BT	1	2	20MAR87	12 M	262	BT	8	13	20	7	11	1	24645
09APR87	9 M	354	BT	1	2	24FEB87	12 M W/L	354	BT	1	2	44	0	0	1	27204
09APR87	9 M	304	BT	1	2	17MAR87	9 M	309	BT	1	2	23	0	0	1	28496
09APR87	9 M	276	BT	1	2	09APR87	9 M	277	BT	1	2	0	0	0	1	28951
09APR87	9 M	324	BT	1	2	24MAR87	12 M W/L	324	BT	1	2	16	0	0	1	29574

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE GEAR	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
13APR87	9 M	270	BT	1	2	08JAN87	12 M W/L	271	BT	1	2	95	0	0	1	16416
13APR87	9 M	203	BT	1	2	27MAR87	9 M	203	BT	9	14	17	8	13	1	29040
15APR87	9 M	285	UH	2	3	18MAR87	12 M W/L	289	BT	8	13	28	10	16	1	24386
15APR87	9 M	351	UH	2	3	15APR87	9 M	350	UH	2	3	0	0	0	1	30219
06FEB87	9 M W/L	231	BT	1	2	21JAN87	9 M	230	BT	9	14	16	8	13	1	16778
06FEB87	9 M W/L	297	BT	1	2	27JAN87	12 M	294	BT	9	14	10	8	13	1	16916
06FEB87	9 M W/L	286	BT	1	2	30DEC86	12 M	285	BT	5	8	38	4	6	1	18502
06FEB87	9 M W/L	425	BT	1	2	16JAN87	9 M	422	BT	9	14	21	8	13	1	25764
06FEB87	9 M W/L	306	BT	1	2	06FEB87	9 M W/L	307	BT	1	2	0	0	0	1	26327
06FEB87	9 M W/L	351	BT	1	2	06FEB87	9 M W/L	349	BT	1	2	0	0	0	1	26438
12FEB87	9 M W/L	275	BT	1	2	31JAN87	9 M	277	BT	1	2	12	0	0	1	17682
12FEB87	9 M W/L	279	BT	1	2	05FEB87	12 M W/L	281	BT	8	13	7	7	11	1	18948
12FEB87	9 M W/L	215	BT	1	2	05FEB87	12 M W/L	217	BT	8	13	7	7	11	1	22023
12FEB87	9 M W/L	319	BT	1	2	10FEB87	9 M	321	BT	9	14	2	8	13	1	26476
17FEB87	9 M W/L	254	BT	9	14	13JAN87	9 M W/L	253	BT	9	14	35	0	0	1	16282
17FEB87	9 M W/L	225	BT	8	13	06FEB87	9 M W/L	225	BT	1	2	11	7	11	1	22198
25FEB87	9 M W/L	255	BT	5	8	16JAN87	9 M	254	BT	9	14	40	4	6	1	16605
25FEB87	9 M W/L	334	BT	8	13	25FEB87	9 M W/L	334	BT	9	14	0	1	2	1	27196
04MAR87	9 M W/L	280	BT	1	2	06FEB87	9 M W/L	283	BT	1	2	26	0	0	1	22227
04MAR87	9 M W/L	362	BT	1	2	04MAR87	9 M W/L	364	BT	1	2	0	0	0	1	27429
13MAR87	9 M W/L	219	BT	8	13	13MAR87	9 M W/L	221	BT	9	14	0	1	2	1	24234
13MAR87	9 M W/L	329	BT	9	14	09JAN87	12 M	330	UH	3	5	63	12	19	1	25391
13MAR87	9 M W/L	464	BT	8	13	13MAR87	9 M W/L	465	BT	8	13	0	0	0	1	27756
19MAR87	9 M W/L	270	BT	8	13	19MAR87	9 M W/L	272	BT	8	13	0	0	0	1	24553
19MAR87	9 M W/L	311	BT	9	14	21JAN87	9 M	312	BT	5	8	57	4	6	1	25820
26MAR87	9 M W/L	285	BT	9	14	09JAN87	12 M	288	UH	3	5	76	12	19	1	16108
26MAR87	9 M W/L	213	BT	9	14	02MAR87	9 M	211	BT	9	14	24	0	0	1	23348
03APR87	9 M W/L	220	BT	5	8	19MAR87	9 M W/L	221	BT	8	13	15	3	5	1	24549
10APR87	9 M W/L	272	BT	1	2	20FEB87	9 M	272	BT	1	2	49	0	0	1	22802
10APR87	9 M W/L	268	BT	1	2	09MAR87	9 M	267	BT	8	13	32	7	11	1	22958
10APR87	9 M W/L	265	BT	1	2	23FEB87	9 M	265	BT	8	13	46	7	11	1	23041
10APR87	9 M W/L	255	BT	1	2	20MAR87	12 M	256	BT	9	14	21	8	13	1	24624
10APR87	9 M W/L	253	BT	1	2	24MAR87	12 M W/L	254	BT	1	2	17	0	0	1	24868
10APR87	9 M W/L	299	BT	1	2	26FEB87	9 M	300	BT	9	14	43	8	13	1	27379
03APR87	9 M W/L	290	UH	2	3	11FEB87	9 M	288	BT	9	14	51	11	18	1	22333
03APR87	9 M W/L	359	UH	2	3	02FEB87	9 M	357	BT	1	2	60	3	5	1	26187
10APR87	9 M W/L	230	UH	2	3	29JAN87	9 M	229	BT	1	2	71	3	5	1	16990
05JAN87	12 M	416	BT	9	14	05JAN87	12 M	417	BT	9	14	0	0	0	1	25495
04FEB87	12 M	273	BT	9	14	04FEB87	12 M	274	BT	8	13	0	1	2	1	18828
12FEB87	12 M	257	BT	9	14	06FEB87	9 M W/L	255	BT	1	2	6	8	13	1	22165
12FEB87	12 M	337	BT	9	14	22JAN87	12 M	338	BT	9	14	21	0	0	1	25950
18FEB87	12 M	227	BT	1	2	18FEB87	12 M	225	BT	1	2	0	0	0	1	22495
18FEB87	12 M	295	BT	1	2	18FEB87	12 M	295	BT	1	2	0	0	0	1	22662
11MAR87	12 M	279	BT	8	13	12FEB87	12 M	283	BT	9	14	27	1	2	1	22644
11MAR87	12 M	245	BT	8	13	23FEB87	9 M	246	BT	8	13	16	0	0	1	23011
11MAR87	12 M	242	BT	8	13	24FEB87	12 M W/L	239	BT	1	2	15	7	11	1	23081
11MAR87	12 M	402	BT	8	13	30JAN87	12 M W/L	406	BT	1	2	40	7	11	1	26038

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE GEAR	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
11MAR87	12 M	372	BT	8	13	18FEB87	12 M	369	BT	1	2	21	7	11	1	26624
11MAR87	12 M	328	BT	8	13	13FEB87	12 M W/L	331	BT	9	14	26	1	2	1	26842
20MAR87	12 M	281	BT	8	13	09JAN87	12 M	281	UH	3	5	70	11	18	1	16228
20MAR87	12 M	206	BT	8	13	14JAN87	12 M W/L	206	BT	9	14	65	1	2	1	16520
20MAR87	12 M	274	BT	8	13	13JAN87	9 M W/L	272	BT	9	14	66	1	2	1	16527
20MAR87	12 M	258	BT	9	14	12FEB87	12 M	259	BT	9	14	36	0	0	1	22596
25MAR87	12 M	277	BT	1	2	09JAN87	12 M	276	UH	3	5	75	4	6	1	16104
25MAR87	12 M	215	BT	1	2	23MAR87	9 M	215	BT	9	14	2	8	13	1	24687
25MAR87	12 M	279	BT	1	2	24MAR87	12 M W/L	279	BT	1	2	1	0	0	1	24824
25MAR87	12 M	311	BT	1	2	06FEB87	9 M W/L	312	BT	1	2	47	0	0	1	26478
25MAR87	12 M	326	BT	1	2	11MAR87	12 M	326	BT	8	13	14	7	11	1	28106
07APR87	12 M	201	BT	1	2	27MAR87	9 M	200	BT	8	13	11	7	11	1	29001
07APR87	12 M	298	BT	1	2	07APR87	12 M	298	BT	1	2	0	0	0	1	29151
07APR87	12 M	317	BT	1	2	07APR87	12 M	318	BT	1	2	0	0	0	1	30032
09JAN87	12 M	305	UH	3	5	09JAN87	12 M	306	UH	3	5	0	0	0	1	25317
05MAR87	12 M	240	UH	2	3	30JAN87	12 M W/L	233	BT	1	2	34	3	5	1	16998
05MAR87	12 M	297	UH	2	3	20FEB87	9 M	297	BT	1	2	13	3	5	1	22811
05MAR87	12 M	335	UH	2	3	25FEB87	9 M W/L	337	BT	8	13	8	10	16	1	27197
05MAR87	12 M	335	UH	2	3	26FEB87	12 M	337	BT	9	14	7	11	18	1	27245
14JAN87	12 M W/L	291	BT	9	14	29DEC86	9 M	289	BT	1	2	16	8	13	1	15009
14JAN87	12 M W/L	225	BT	9	14	12JAN87	9 M	223	BT	5	8	2	4	6	1	16265
20JAN87	12 M W/L	311	BT	9	14	09JAN87	12 M	311	UH	3	5	11	12	19	1	25536
20JAN87	12 M W/L	304	BT	9	14	20JAN87	12 M W/L	305	BT	9	14	0	0	0	1	25786
05FEB87	12 M W/L	278	BT	8	13	12JAN87	9 M	277	BT	9	14	24	1	2	1	16276
05FEB87	12 M W/L	297	BT	9	14	09JAN87	12 M	296	UH	3	5	27	12	19	1	16292
24FEB87	12 M W/L	287	BT	1	2	17FEB87	9 M W/L	287	BT	8	13	7	7	11	1	22503
24FEB87	12 M W/L	243	BT	1	2	17FEB87	9 M W/L	243	BT	9	14	7	8	13	1	22514
24FEB87	12 M W/L	315	BT	5	8	18FEB87	12 M	317	BT	1	2	6	4	6	1	26671
06MAR87	12 M W/L	299	BT	1	2	20FEB87	9 M	298	BT	1	2	14	0	0	1	22787
06MAR87	12 M W/L	298	BT	1	2	06MAR87	12 M W/L	299	BT	1	2	0	0	0	1	23478
06MAR87	12 M W/L	290	BT	1	2	06MAR87	12 M W/L	290	BT	1	2	0	0	0	1	23526
14MAR87	12 M W/L	227	BT	8	13	14MAR87	12 M W/L	227	BT	9	14	0	1	2	1	23578
14MAR87	12 M W/L	276	BT	8	13	14MAR87	12 M W/L	276	BT	9	14	0	1	2	1	23658
14MAR87	12 M W/L	245	BT	8	13	14MAR87	12 M W/L	245	BT	9	14	0	1	2	1	24119
14MAR87	12 M W/L	322	BT	9	14	08JAN87	12 M W/L	323	BT	1	2	65	8	13	1	25210
14MAR87	12 M W/L	308	BT	9	14	12FEB87	12 M	311	BT	9	14	30	0	0	1	26773
14MAR87	12 M W/L	328	BT	9	14	14MAR87	12 M W/L	330	BT	9	14	0	0	0	1	27627
14MAR87	12 M W/L	332	BT	8	13	14MAR87	12 M W/L	331	BT	9	14	0	1	2	1	27631
14MAR87	12 M W/L	302	BT	9	14	14MAR87	12 M W/L	303	BT	9	14	0	0	0	1	27648
14MAR87	12 M W/L	303	BT	9	14	14MAR87	12 M W/L	303	BT	9	14	0	0	0	1	27651
18MAR87	12 M W/L	210	BT	9	14	16JAN87	9 M	210	BT	9	14	61	0	0	1	15307
18MAR87	12 M W/L	265	BT	8	13	12FEB87	12 M	272	BT	9	14	34	1	2	1	22579
18MAR87	12 M W/L	277	BT	8	13	05MAR87	12 M	274	UH	2	3	13	10	16	1	23634
18MAR87	12 M W/L	323	BT	8	13	12FEB87	12 M	324	BT	9	14	34	1	2	1	26885
18MAR87	12 M W/L	331	BT	8	13	05MAR87	12 M	329	UH	2	3	13	10	16	1	27435
24MAR87	12 M W/L	278	BT	1	2	08JAN87	12 M W/L	278	BT	1	2	75	0	0	1	15476

APPENDIX TABLE D-2. (Continued)

RECAPTURE						RELEASE										
		TOTAL LENGTH	RIVER					TOTAL LENGTH	RIVER			DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	GEAR	IN MM	REGION	MILE	KM	DATE	GEAR	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
24MAR87	12 M W/L	293	BT	1	2	09JAN87	12 M	292	UH	3	5	74	4	6	1	16137
24MAR87	12 M W/L	306	BT	1	2	22DEC86	9 M	304	BT	8	13	92	7	11	1	25072
24MAR87	12 M W/L	328	BT	1	2	27FEB87	9 M	327	BT	9	14	25	8	13	1	27342
08APR87	12 M W/L	228	BT	8	13	16JAN87	9 M	230	BT	9	14	82	1	2	1	15285
08APR87	12 M W/L	244	BT	1	2	12MAR87	9 M	244	BT	9	14	27	8	13	1	24023
08APR87	12 M W/L	297	BT	1	2	25MAR87	12 M	298	BT	1	2	14	0	0	1	24818
08APR87	12 M W/L	320	BT	1	2	09MAR87	9 M	326	BT	5	8	30	4	6	1	27518
08APR87	12 M W/L	417	BT	1	2	24MAR87	12 M W/L	414	BT	1	2	15	0	0	1	29761
06MAR87	12 M W/L	264	UH	2	3	09JAN87	12 M	262	UH	3	5	56	1	2	1	15504
06MAR87	12 M W/L	267	UH	2	3	21JAN87	9 M	266	BT	9	14	44	11	18	1	16903
06MAR87	12 M W/L	385	UH	2	3	30JAN87	12 M W/L	395	BT	1	2	35	3	5	1	26064

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1986-1987 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE							RELEASE										
DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
21DEC86	9 M	.	368	BT	9	14	28DEC85	12 M	.	269	BT	9	14	358	99	2	8421
21DEC86	9 M	3	302	BT	9	14	07MAY86	J.SEINE	2	319	CH	35	56	228	.	2	29410
22DEC86	9 M	3	429	BT	8	13	21FEB86	12 M	2	325	BT	8	13	304	104	1	10239
22DEC86	9 M	2	304	BT	8	13	18MAR86	9 M	1	243	BT	1	2	279	61	2	11206
22DEC86	9 M	2	318	BT	8	13	17APR86	12 M	1	250	BT	9	14	249	68	1	15255
22DEC86	9 M	5	453	BT	9	14	20APR86	J.SEINE	4	417	CH	30	48	246	36	1	15668
06JAN87	9 M	2	360	BT	1	2	16DEC85	9 M	1	261	BT	5	8	386	99	1	2818
06JAN87	9 M	2	296	BT	1	2	17MAR86	12 M	1	215	BT	5	8	295	81	1	12396
07JAN87	9 M	4	408	BT	9	14	21FEB86	12 M	3	357	BT	8	13	320	51	1	10260
16JAN87	9 M	3	302	BT	9	14	27JAN86	12 M	2	229	BT	8	13	354	73	1	7514
16JAN87	9 M	3	365	BT	9	14	20FEB86	12 M	2	310	BT	8	13	330	55	2	10027
16JAN87	9 M	2	363	BT	9	14	11MAR86	12 M	1	273	BT	9	14	311	90	1	11806
16JAN87	9 M	2	366	BT	9	14	17APR86	12 M	1	258	BT	1	2	274	108	1	20296
21JAN87	9 M	.	336	BT	9	14	20DEC85	9 M	.	230	BT	5	8	397	106	1	8565
21JAN87	9 M	2	326	BT	9	14	13FEB86	12 M	1	202	BT	5	8	342	124	1	11433
21JAN87	9 M	2	278	BT	9	14	18MAR86	9 M	1	239	BT	1	2	309	39	2	12752
21JAN87	9 M	3	350	BT	9	14	11APR86	12 M	2	296	UH	2	3	285	54	1	14156
03FEB87	9 M	.	366	BT	9	14	20MAR86	9 M	.	245	BT	5	8	320	121	1	12923
11FEB87	9 M	2	350	BT	9	14	16DEC85	9 M	1	208	BT	6	10	422	142	1	2792
11FEB87	9 M	2	339	BT	9	14	11APR86	12 M	1	258	UH	2	3	306	81	1	14124
13FEB87	9 M	.	404	BT	9	14	03JAN86	9 M	.	295	BT	5	8	406	109	1	8400
20FEB87	9 M	3	332	BT	1	2	20FEB86	12 M	2	275	BT	8	13	365	57	2	11130
23FEB87	9 M	2	303	BT	8	13	28DEC85	12 M	1	250	BT	9	14	422	53	2	7477
26FEB87	9 M	2	252	BT	9	14	18APR86	12 M	1	217	UH	3	5	314	35	2	20390
03MAR87	9 M	.	243	BT	8	13	03JAN86	9 M	.	218	BT	5	8	424	25	2	6581
09MAR87	9 M	2	271	BT	8	13	13MAR86	12 M	1	205	BT	9	14	361	66	1	12190
09MAR87	9 M	3	389	BT	8	13	13MAR86	12 M	2	280	BT	9	14	361	109	1	12502
09MAR87	9 M	2	267	BT	9	14	20MAR86	9 M	1	215	BT	5	8	354	52	2	12980
09MAR87	9 M	3	363	BT	9	14	21APR86	12 M	2	297	UH	2	3	322	66	1	20410
12MAR87	9 M	2	408	BT	8	13	12FEB86	9 M	1	283	BT	5	8	393	125	1	11644
12MAR87	9 M	3	336	BT	9	14	21MAR86	12 M	2	285	BT	1	2	356	51	1	17380
12MAR87	9 M	3	315	BT	9	14	27MAR86	12 M	2	296	UH	2	3	350	19	1	17863

APPENDIX TABLE D-3. (Continued)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
17MAR87	9 M	2	335	BT	1	2	16APR86	J.SEINE	2	346	CH	36	58	335	.	1	12851
09APR87	9 M	3	337	BT	1	2	07APR86	12 M	2	265	UH	2	3	367	72	1	13731
15APR87	9 M	.	293	UH	2	3	27DEC85	9 M	.	241	BT	5	8	474	52	1	8057
13JAN87	9 M W/L	3	285	BT	9	14	02JAN86	12 M	2	247	BT	11	18	376	38	2	8169
13JAN87	9 M W/L	2	275	BT	9	14	20FEB86	12 M	1	251	BT	8	13	327	24	2	11208
13JAN87	9 M W/L	3	367	BT	9	14	13FEB86	9 M	2	275	BT	1	2	334	92	1	11710
13JAN87	9 M W/L	3	352	BT	9	14	19MAR86	9 M	2	275	BT	5	8	300	77	2	12881
28JAN87	9 M W/L	3	320	BT	5	8	05DEC85	9 M	2	275	BT	8	13	419	45	1	3905
06FEB87	9 M W/L	2	298	BT	1	2	16JAN86	12 M	1	220	BT	5	8	386	78	1	5692
06FEB87	9 M W/L	4	446	BT	1	2	21FEB86	12 M	3	396	BT	8	13	350	50	1	10270
06FEB87	9 M W/L	3	365	BT	1	2	17APR86	J.SEINE	2	286	CH	35	56	295	79	1	14803
06FEB87	9 M W/L	3	412	BT	1	2	21MAR86	12 M	2	297	BT	1	2	322	115	1	17360
12FEB87	9 M W/L	3	355	BT	1	2	30DEC85	9 M	2	297	BT	5	8	409	58	1	6942
12FEB87	9 M W/L	3	326	BT	1	2	17MAR86	12 M	2	258	BT	5	8	332	68	1	12059
25FEB87	9 M W/L	2	367	BT	9	14	28DEC85	12 M	1	235	BT	5	8	424	132	2	8503
13MAR87	9 M W/L	2	340	BT	8	13	13JAN86	9 M	1	220	BT	5	8	424	120	1	5167
13MAR87	9 M W/L	3	429	BT	9	14	27APR86	J.SEINE	2	349	CH	36	58	320	80	1	19469
10APR87	9 M W/L	2	297	BT	1	2	30DEC85	9 M	1	230	BT	5	8	466	67	2	6207
10APR87	9 M W/L	2	287	BT	1	2	23APR86	12 M	1	243	HR	1	2	352	44	1	20501
03APR87	9 M W/L	2	279	UH	2	3	22APR86	12 M	1	235	HR	1	2	346	44	2	20452
05JAN87	12 M	2	306	BT	9	14	02JAN86	12 M	1	259	BT	9	14	368	47	1	6306
05JAN87	12 M	3	355	BT	9	14	01APR86	12 M	2	286	UH	2	3	279	69	1	13090
27JAN87	12 M	2	300	BT	5	8	19DEC85	9 M	1	210	BT	5	8	404	90	1	2965
27JAN87	12 M	3	371	BT	5	8	21FEB86	12 M	2	334	BT	8	13	340	37	1	9339
04FEB87	12 M	3	352	BT	8	13	11APR86	12 M	2	288	UH	2	3	299	64	1	14140
12FEB87	12 M	2	367	BT	9	14	20DEC85	12 M	1	257	BT	9	14	419	110	1	8973
12FEB87	12 M	3	321	BT	9	14	11APR86	12 M	2	280	UH	2	3	307	41	1	14042
12FEB87	12 M	2	361	BT	9	14	15APR86	12 M	1	236	BT	1	2	303	125	1	15196
12FEB87	12 M	2	419	BT	9	14	27MAR86	12 M	1	275	UH	2	3	322	144	1	17821
18FEB87	12 M	4	473	BT	1	2	28FEB86	12 M	3	440	BT	9	14	355	33	1	9542
18FEB87	12 M	3	393	BT	1	2	27JAN86	12 M	2	305	BT	9	14	387	88	1	10571
18FEB87	12 M	2	314	BT	1	2	08APR86	12 M	1	265	BT	7	11	316	49	2	13913
26FEB87	12 M	3	440	BT	9	14	27MAR86	12 M	2	351	UH	2	3	336	89	1	21798

APPENDIX TABLE D-3. (Continued)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
11MAR87	12 M	2	325	BT	8	13	03DEC85	9 M	1	243	BT	6	10	463	82	2	4989
11MAR87	12 M	3	298	BT	8	13	22JAN86	9 M	2	248	BT	5	8	413	50	1	5746
11MAR87	12 M	2	363	BT	8	13	28FEB86	12 M	1	260	BT	9	14	376	103	2	12112
20MAR87	12 M	.	302	BT	8	13	25NOV85	9 M	.	285	BT	3	5	480	17	1	4921
20MAR87	12 M	2	273	BT	8	13	08JAN86	9 M	1	232	BT	5	8	436	41	2	6013
20MAR87	12 M	3	355	BT	8	13	27DEC85	9 M	2	267	BT	5	8	448	88	1	8045
20MAR87	12 M	2	266	BT	9	14	29DEC85	9 M	1	224	BT	11	18	446	42	2	8245
20MAR87	12 M	2	294	BT	8	13	17APR86	12 M	1	248	BT	1	2	337	46	1	20301
25MAR87	12 M	3	387	BT	1	2	11MAR86	12 M	2	306	BT	9	14	379	81	1	10662
14APR87	12 M	2	362	BT	1	2	05DEC85	9 M	1	230	BT	8	13	495	132	1	3928
30APR87	12 M	3	523	BT	11	18	24APR86	J.SEINE	2	447	CH	36	58	371	76	1	19832
09JAN87	12 M	3	353	UH	3	5	23JAN86	12 M	2	283	BT	9	14	351	70	2	7537
09JAN87	12 M	2	358	UH	3	5	11APR86	12 M	1	275	UH	2	3	273	83	1	14187
09JAN87	12 M	2	341	UH	3	5	18APR86	12 M	1	269	UH	3	5	266	72	1	20311
08JAN87	12 M W/L	3	411	BT	1	2	01APR86	12 M	2	398	UH	2	3	282	13	1	9860
14JAN87	12 M W/L	3	362	BT	9	14	21DEC85	9 M	2	331	BT	9	14	389	31	1	1604
14JAN87	12 M W/L	2	255	BT	9	14	17MAR86	12 M	1	244	BT	5	8	303	11	1	11859
20JAN87	12 M W/L	3	376	BT	9	14	07APR86	12 M	2	294	UH	2	3	288	82	2	13703
30JAN87	12 M W/L	3	351	BT	1	2	10APR86	12 M	2	308	BT	11	18	295	43	1	1763
30JAN87	12 M W/L	3	368	BT	1	2	28FEB86	12 M	2	294	BT	9	14	336	74	1	11070
05FEB87	12 M W/L	.	337	BT	8	13	27JAN86	12 M	.	281	BT	9	14	374	56	1	7820
13FEB87	12 M W/L	3	422	BT	9	14	10JAN86	9 M	2	357	BT	5	8	399	65	1	9112
13FEB87	12 M W/L	3	390	BT	9	14	23JAN86	12 M	2	309	BT	9	14	386	81	1	10941
13FEB87	12 M W/L	2	287	BT	9	14	20FEB86	12 M	1	252	BT	8	13	358	35	2	11122
13FEB87	12 M W/L	3	458	BT	9	14	11APR86	12 M	2	393	UH	2	3	308	65	1	14052
13FEB87	12 M W/L	2	237	BT	9	14	09MAY86	J.SEINE	1	219	CH	36	58	280	18	1	18555
13FEB87	12 M W/L	2	320	BT	9	14	17APR86	12 M	1	223	BT	5	8	302	97	1	20279
13FEB87	12 M W/L	3	359	BT	9	14	01APR86	12 M	2	307	UH	2	3	318	52	1	21658
24FEB87	12 M W/L	2	387	BT	1	2	02JAN86	12 M	1	249	BT	9	14	418	138	1	6354
24FEB87	12 M W/L	3	309	BT	1	2	20DEC85	9 M	2	281	BT	9	14	431	28	1	8757
24FEB87	12 M W/L	3	352	BT	5	8	23JAN86	12 M	2	304	BT	9	14	397	48	1	10983
24FEB87	12 M W/L	2	253	BT	1	2	21FEB86	12 M	1	217	BT	8	13	368	36	1	11853
24FEB87	12 M W/L	3	341	BT	1	2	07APR86	12 M	2	265	UH	2	3	323	76	1	13731
24FEB87	12 M W/L	3	362	BT	1	2	14APR86	12 M	2	302	UH	3	5	316	60	1	14544

APPENDIX TABLE D-3. (Continued)

RECAPTURE							RELEASE										
				RIVER							RIVER					TAG	
DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	GROWTH IN MM	COND	NUMBER
06MAR87	12 M W/L	3	443	BT	1	2	27MAR86	12 M	2	351	UH	2	3	344	92	1	21798
14MAR87	12 M W/L	2	282	BT	9	14	03FEB86	9 M	1	244	BT	1	2	404	38	1	6017
14MAR87	12 M W/L	3	393	BT	9	14	13FEB86	12 M	2	322	BT	1	2	394	71	1	9333
14MAR87	12 M W/L	.	275	BT	9	14	20FEB86	12 M	.	309	BT	8	13	387	.	1	10163
14MAR87	12 M W/L	2	283	BT	9	14	20FEB86	12 M	1	252	BT	8	13	387	31	2	11122
14MAR87	12 M W/L	3	320	BT	9	14	23APR86	12 M	2	270	HR	1	2	325	50	1	20486
18MAR87	12 M W/L	3	292	BT	9	14	14APR86	12 M	2	241	UH	3	5	338	51	1	14549
24MAR87	12 M W/L	3	363	BT	1	2	19APR86	J.SEINE	2	286	CH	36	58	339	77	1	17002
24MAR87	12 M W/L	3	325	BT	1	2	27MAR86	12 M	2	280	UH	2	3	362	45	2	17862
31MAR87	12 M W/L	3	314	BT	5	8	30DEC85	9 M	2	268	BT	5	8	456	46	2	6903
08APR87	12 M W/L	3	343	BT	8	13	06FEB86	9 M	2	271	BT	5	8	426	72	1	3431
08APR87	12 M W/L	2	334	BT	1	2	16JAN86	12 M	1	225	BT	5	8	447	109	1	5437
08APR87	12 M W/L	2	295	BT	1	2	08JAN86	9 M	1	230	BT	5	8	455	65	2	6042
17APR87	12 M W/L	.	370	BT	1	2	20DEC85	12 M	.	278	BT	9	14	483	92	1	1514

APPENDIX TABLE D-4. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR STRIPED BASS CAPTURED WITH ABRADED TAGS DURING THE 1986-1987 STRIPED BASS PROGRAM.

RECAPTURE INFORMATION							RELEASE INFORMATION							TAG NO.		TAG CONDITION[a]		
TASK CD	SAMPLE NO.	DATE	GEAR	STATION	RIVER MILE	LENGTH	TASK CD	SAMPLE NO.	DATE	GEAR	STATION	RIVER MILE	LENGTH	RELEASE TAG NO.	NEW TAG NO.	TAG NO.	ADDRESS	REWARD INFO.
53	2207	04-14-87	12 m	BT	1	362	43	138	12-05-85	TC	BT	8	230	1928	30212	3	4	3
53	2157	03-20-87	12 m	BT	8	302	43	86	11-25-85	TC	BT	3	285	4921	29409	3	4	3
53	225	02-06-87	9 m w/l	BT	1	298	53	104	01-16-86	SB	BT	5	220	5692	22071	3	3	1
53	2123	03-11-87	12 m	BT	8	298	43	494	01-22-86	TC	BT	5	248	5746	23664	3	4	1
53	2150	03-20-87	12 m	BT	8	355	43	288	12-27-85	TC	BT	5	267	8045	29729	3	2	3
53	738	04-15-87	9 m	UH	2	293	43	288	12-27-85	TC	BT	5	241	8057	11257	3	2	2
53	267	02-13-87	9 m	BT	9	404	43	337	01-03-86	TC	BT	5	295	8400	26535	3	1	4
53	158	01-21-87	9 m	BT	9	336	43	255	12-20-85	TC	BT	5	230	8565	25977	3	4	1
53	2105	02-24-87	12 m w/l	BT	1	309	43	252	12-20-85	TC	BT	9	281	8757	27121	4	2	4
53	2091	02-18-87	12 m	BT	1	393	53	123	01-27-86	SB	BT	9	305	10571	26635	3	2	1
53	2175	03-25-87	12 m	BT	1	387	53	173	03-11-86	SB	BT	9	306	10662	29825	3	4	1
53	2097	02-24-87	12 m w/l	BT	5	352	53	108	01-23-86	SB	BT	9	304	10983	27066	4	2	4
53	453	03-12-87	9 m	BT	8	408	43	631	02-12-86	TC	BT	5	283	11644	28064	3	4	3
53	2102	02-24-87	12 m w/l	BT	1	253	53	155	02-21-86	SB	BT	8	217	11853	23142	3	4	2
53	435	03-09-87	9 m	BT	8	389	53	186	03-13-86	SB	BT	9	280	12502	27584	3	4	1
53	454	03-12-87	9 m	BT	9	315	53	224	03-27-86	SB	UH	2	296	17863	28150	4	4	4
53	2199	04-18-87	12 m w/l	BT	1	295	43	356	01-08-86	TC	BT	5	230	6042	-	3	4	2
53	712	04-10-87	9 m w/l	BT	1	297	43	312	12-30-85	TC	BT	5	230	6207	-	3	4	3
53	410	03-03-87	9 m	BT	8	243	43	325	01-03-86	TC	BT	5	218	6581	-	3	4	1
53	2028	01-14-87	12 m w/l	BT	9	255	53	191	03-17-86	SB	BT	5	244	11859	-	-	-	-
53	2122	03-11-87	12 m	BT	8	363	53	159	02-28-86	SB	BT	9	260	12112	-	3	1	3
53	133	01-16-87	9 m	BT	9	398								-	25769	-	-	-
53	222	02-06-87	9 m w/l	BT	1	404								-	26369	2	3	1
53	2090	02-18-87	12 m	BT	1	372								-	26647	2	3	2
53	2088	02-13-87	12 m w/l	BT	9	455								-	26987	2	4	3
53	2131	03-14-87	12 m w/l	BT	9	349								-	28283	1	4	2
53	2136	03-14-87	12 m w/l	BT	8	329								-	28344	2	2	3
53	2140	03-18-87	12 m w/l	BT	9	339								-	28420	2	2	3
53	2151	03-20-87	12 m	BT	8	321								-	29488	1	4	1
53	44	12-29-86	9 m	BT	5	392								-	-	-	-	-
53	110	01-07-87	9 m	BT	9	362								-	-	-	-	-
53	124	01-13-87	9 m w/l	BT	9	351								-	-	-	-	-
53	133	01-16-87	9 m	BT	9	403								-	-	-	-	-
53	456	03-12-87	9 m	BT	8	302								-	-	2	4	2
53	516	03-17-87	9 m	BT	1	300								-	-	1	4	1
53	557	03-23-87	9 m	BT	9	333								-	-	1	1	1
53	2011	01-08-87	12 m w/l	BT	1	370								-	-	-	-	-
53	2012	01-08-87	12 m w/l	BT	1	307								-	-	-	-	-

a
1 = completely missing
2 = abraded and partly missing
3 = abraded but completely legible
4 = completely legible

APPENDIX TABLE D-5. INTERMEDIATE COMPUTATIONAL DATA IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE LOWER HUDSON RIVER DURING WINTER 1986-87.

SAMPLING WEEK	(≥200 mm) C TOTAL	(≥200 mm) M TOTAL	CUM M TOTAL	R TOTAL	R/C
21 DEC 86	291	281	0	0	0.00000
28 DEC 86	187	176	281	0	0.00000
04 JAN 87	665	602	457	0	0.00000
11 JAN 87	671	638	1,059	2	0.00298
18 JAN 87	560	539	1,697	2	0.00357
25 JAN 87	326	308	2,236	0	0.00000
01 FEB 87	869	822	2,544	7	0.00806
08 FEB 87	778	736	3,366	7	0.00900
15 FEB 87	470	447	4,102	4	0.00851
22 FEB 87	702	666	4,549	7	0.00997
01 MAR 87	498	468	5,215	10	0.02008
08 MAR 87	1,422	1,321	5,683	19	0.01336
15 MAR 87	957	877	7,004	12	0.01254
22 MAR 87	696	648	7,881	11	0.01580
29 MAR 87	197	170	8,529	3	0.01523
05 APR 87	451	395	8,699	21	0.04656
12 APR 87	219	201	9,094	3	0.01370
19 APR 87	22	14	9,295	0	0.00000
26 APR 87	24	22	9,309	0	0.00000
03 MAY 87	4	4	9,331	0	0.00000

APPENDIX TABLE D-6. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 21 DECEMBER 1986 THROUGH THE WEEK OF 8 MARCH 1987.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00083	0.00083	100.03	0.0001
Error	11	0.00009	0.00001		
Total	12	0.00092			

Regression Equation: R/C = (Cumulative M) X + error,

where,

X = 0.0000026 and

Standard Error of X = 0.00000026

R^2 = coefficient of determination = 0.90

df = degrees of freedom

SS = sum of squares

MS = mean square

F = calculated F-ratio

p>F = probability of obtaining a larger F-ratio

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

APPENDIX E. STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 11 December 1986 and 8 May 1987 were taken to the Verplanck, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. The intention of this laboratory program was to gather incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1984 and 1985-86 programs (NAI 1985, 1986). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mmTL tomcod).

E.2.0 LABORATORY METHODS

E.2.1 <u>LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS</u>

Length, weight, sex, and sexual condition were determined for up to 10 striped bass per sampling day. Total length was measured to the nearest mm. total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E2-1.

E.2.2 STRIPED BASS STOMACH CONTENTS ANALYSIS

The same striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass predominated throughout the 1986-87 Striped Bass Program (Table E3-1). Only one female striped bass was captured in the resting stage and male striped bass apparently started to enter the resting and developing stages in numbers after March. No striped bass in the ripe, or ripe and running stages were collected.

The lack of ripe, or ripe and running striped bass in the 1986-87 program agrees with the findings of the 1985-86 program. This is not surprising because the majority of the fish captured in both programs were of pre-spawning size (< 400 mmTL) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the resting and developing stages with time during both the 1985-86 and 1986-87 programs may indicate the approach of the spawning season, and that male striped bass undergo a longer period of gonadal development prior to spawning than females. However, due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 127 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. 11 vertebrate remains were identifiable as fish, and the majority of those were clupeids as incidentally noted by laboratory personnel.

Percentage of striped bass with invertebrate remains in their stomachs was lowest in the ≤ 200 mm length group and increased to a maximum of 59.5% in the 301-400 mmTL length group (Table E3-2). This contrasts with findings from the 1985-86 Hudson River Striped Bass Program where invertebrate remains were most common in striped bass ≤ 300 mm (NAI 1986). The percentage of striped bass with vertebrate remains in their stomachs increased with length in the 1986-87 program in a manner similar to that observed in the 1985-86 program (NAI 1986). As in the 1985-86 program, this trend was most evident for striped bass between 201 and 500 mmTL where the largest number of fish were observed. This trend of increasing importance of vertebrates as a food item as length increases probably represents a switch in striped bass food habits to piscivory in older fish and has been observed elsewhere

(Westin and Rogers 1978). Percent of striped bass with empty stomachs decreased with length in the 1986-87 program as opposed to 1985-86 when the percentage of striped bass with empty stomachs generally increased with length.

TABLE E2-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS.[a]

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, les firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, concoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and stringlike, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in texture, but milt not running.

[a]From Con Edison Data Dictionary

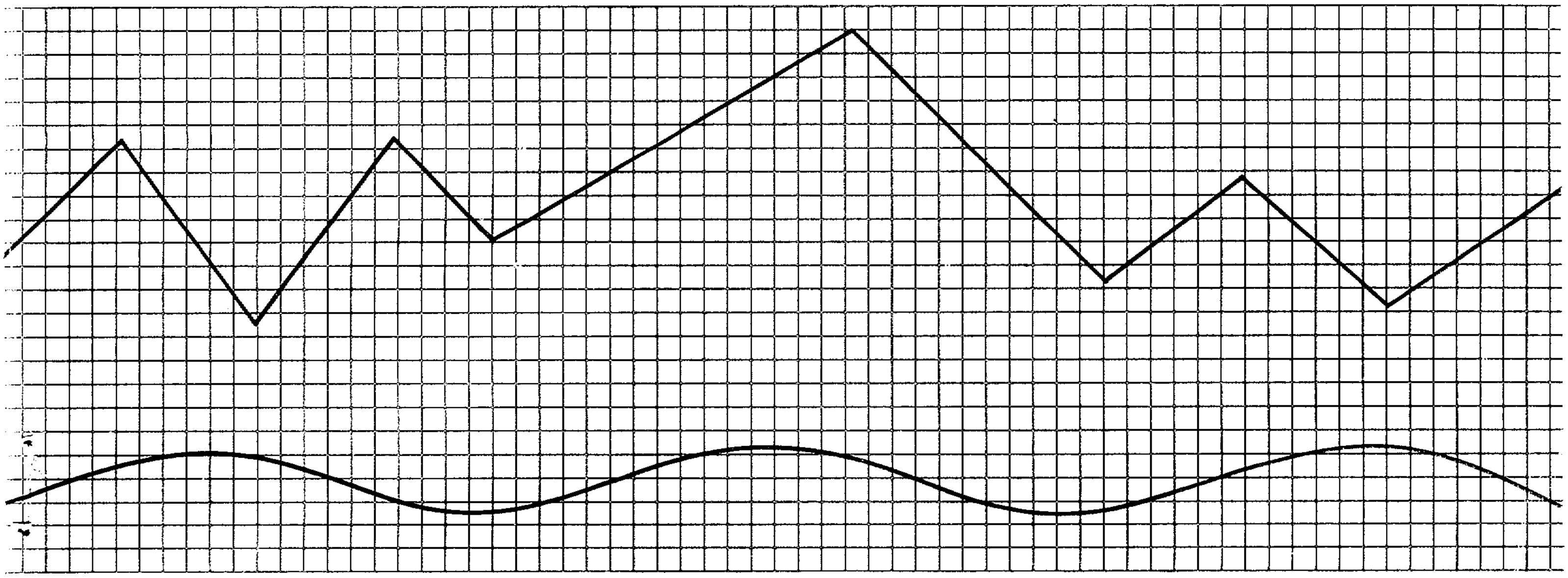
APPENDIX TABLE E3-1. SEXUAL CONDITION OF STRIPED BASS CAPTURED IN THE BATTERY REGION DURING THE 1986-87 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS														
	FEMALES					MALES					UNDETERMINED				
MONTH	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL
DEC	100 (1)	0 (0)	0 (0)	0 (0)	100 (1)	67 (2)	0 (0)	33 (1)	0 (0)	100 (3)	100 (1)	0 (0)	0 (0)	0 (0	100 (1)
JAN	75 (3)	25 (1)	0 (0)	0 (0)	100 (4)	50 (7)	7 (1)	43 (6)	0 (0)	100 (14)	100 (4)	0 (0)	0 (0)	0 (0)	100 (4)
FEB	100 (10)	0 (0)	0 (0)	0 (0)	100 (10)	82 (9)	9 (1)	9 (1)	0 (0)	100 (11)	100 (3)	0 (0)	0 (0)	0 (0)	100 (3)
MAR	100 (16)	0 (0)	0 (0)	0 (0)	100 (16)	33 (10)	27 (8)	40 (12)	0 (0)	100 (30)	100 (4)	0 (0)	0 (0)	0 (0)	100 (4)
APR	100 (9)	0 (0)	0 (0)	0 (0)	100 (9)	88 (14)	0 (0)	12 (2)	0 (0)	100 (16)	100 (5)	0 (0)	0 (0)	0 (0)	100 (5)
TOTAL	97 (39)	3 (1)	0 (0)	0 (0)	100 (40)	57 (42)	13 (10)	30 (22)	0 (0)	100 (74)	94 (16)	0 (0)	0 (0)	6 (1)	100 (17)

APPENDIX TABLE E3-2. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1986-87 HUDSON RIVER STRIPED BASS PROGRAM.

LENGTH GROUP (mm TL)	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS				
	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	EMPTY	TOTAL
≤200	28.6 (8)	0.0 (0)	0.0 (0)	71.4 (20)	100.0 (28)
201-300	57.1 (28)	6.1 (3)	0.0 (0)	36.7 (18)	100.0 (49)
301-400	59.5 (22)	18.9 (7)	0.0 (0)	21.6 (8)	100.0 (37)
401-500	45.4 (5)	27.3 (3)	0.0 (0)	27.3 (3)	100.0 (11)
501-600	50.0 (1)	50.0 (1)	0.0 (0)	0.0 (0)	100.0 (2)
TOTAL	50.4 (64)	11.0 (14)	0.0 (0)	38.6 (49)	100.0 (127)

HUDSON RIVER FOUNDATION



1986 Hudson River Striped Bass Tag Recovery Program

John R. Waldman

New York Power Authority

May 24, 1988

To: Distribution

Enclosed is a copy of the report entitled "1986 Hudson River Striped Bass Tag Recovery Program". The study, which the report addresses, was conducted in accordance with the terms of the Hudson River Cooling Tower Settlement Agreement.

Please call me at 914 681-6401 if you have any questions.

Dennis J. Dunning, Ph.D.
Manager
Hudson River Biological Studies

enclosure

cc: J. Kelly w/enc.
Records Station "

4-5

1986 HUDSON RIVER STRIPED BASS

TAG RECOVERY PROGRAM

Final Report

Prepared under contract with

New York Power Authority
123 Main Street
White Plains, New York 10601

Jointly Financed by

Central Hudson Gas and Electric Corporation
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Orange and Rockland Utilities, Inc.
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New York Power Authority

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1.0 EXECUTIVE SUMMARY

* Overall recapture rates of striped bass tagged and released from trawls and seines were identical (4.9%). There were no significant differences ($P>0.05$) between the two gear types for individual size classes. There was a significant difference among recapture rates across temperatures (7-14°C) for the seines, but not across temperatures (1-14°C) for the trawls.

* Relative retention of internal anchor tags vs. Dennison style tags remained high through the fourth recapture year of 741 striped bass double-tagged with these tag types in 1984. Ten more internal anchor tags alone and paired internal anchor and Dennison tags from two fish were recovered during the program year, raising the total number of individual internal anchor tags returned from the 1984 tagging to 73, and of Dennison tags to 24. The overall recapture rate of 1984 releases is now 10.5%.

* The percentage of striped bass released in good condition vs. not released or released in poor condition by fishermen was significantly lower for fish $\geq$600 mm (68.4%) compared with those <600 mm (92.8%). This may reflect the minimum length regulation of 24 inches (610 mm) total length for keeping striped bass that was in effect for much of the northeast coast in 1986. Angling recapture rates were also significantly higher for larger length classes, ranging from 2.8% for the 200-299 mm length class to 8.2% for the $\geq$700 mm length class.

* Cumulative abrasion of the internal anchor tag from bottom contact resulted in an increasing loss of information on the tag legend with time.

* The 717 tag returns to the Hudson River Foundation from the 18,512 releases during winter 1985-1986 came from seven states and one Canadian Province. The largest number of recaptures was made in May 1986 (116) and the fewest during January - February 1987 (4).

* New northern and southern distance from the Hudson River records were established with recaptures from the Bear River, Nova Scotia and Virginia Beach, Virginia, respectively. The general movement pattern for striped bass that left the river was north and east; relatively few were recaptured south of Sandy Hook, New Jersey. Within the river, recaptures were made progressively north in April and were numerous during May and June at the limit of tidewater - the Federal Dam at Troy.

* In contrast to an earlier study by Texas Instruments, Inc., there were highly significant correlations ($P<0.0001$) between fish length and distance traveled.

* Comparison to historical information indicates that Hudson River striped bass migrate coastally much farther than they did in the 1940's and 1950's, and somewhat farther than in the 1970's.

2.0 INTRODUCTION

The Hudson River Cooling Tower Settlement Agreement (Sandler and Schoenbrod 1981) among electric utilities, government agencies, and environmental protection groups stipulated that the utilities conduct biological monitoring studies of certain Hudson River fish stocks, including striped bass (*Morone saxatilis*). It also stipulated that the utilities evaluate the contribution of stocked striped bass to the Hudson River population. As a result, striped bass have been captured, examined for hatchery marks, and externally tagged and released since 1984. During 1984, a study was conducted to compare three tag styles (Dunning et al., 1987) and to test fishing gear (NAI 1985). During the field portion of that study (April-June 1984), 736 Hudson River striped bass ≥300 mm total length (TL) were tagged and released. From November 1985-May 1986 and from December 1986-May 1987, 18,512 and 9,335 striped bass ≥200 mm TL, respectively, were tagged and released in the Hudson estuary and adjoining waters.

A major objective of these efforts was to develop field procedures for minimizing handling mortality and to determine if striped bass ≥200 mm could efficiently be captured, tagged and released in the lower Hudson River during the winter. Although returns from striped bass marked in 1987 are not analyzed in this report, the 1987 tagging program did provide a number of returns from the 1985-1986 tagging effort, which are included.

The Hudson River Foundation (HRF) was contracted to process tag returns, publicize the program, and analyze the tag return data. Normandeau Associates, Inc. (NAI) performed the tagging, recaptured some fish, evaluated the contribution of stocked fish, and evaluated the efficiency of capture gear and handling techniques. This report analyzes information from tags received during March 1986-February 1987 which were released through May 1986 from the first two tagging programs. Information on tag returns from March 1984-February 1985, and March 1985-February 1986 were reported in HRF (1985) and (1986), respectively.

Objectives of the HRF's component of the 1985-1986 Adult Striped Bass Program were to:

I. Describe the movements of tagged Hudson River striped bass.

II. Examine the effect of fishing gear and water temperature on recapture rates.

III. Test the use of a smaller version of the internal anchor tag on a shorter length class of striped bass.

3.0 MATERIALS AND METHODS

3.1 Tagging

A detailed description of the materials and methods used in tagging, administration, and analysis for the 1984 program is provided in HRF (1985). Further information on sampling and tagging procedures appeared in NAI (1985). In the 1984 study, striped bass ≥300mm TL were double-tagged with Floy FD68-B anchor tags and Floy FT-69 internal anchor tags. Based on the results of the 1984 study and a holding pool study which demonstrated superior retention of the internal anchor tag in striped bass (Dunning et al., 1987), all fish marked in the 1985-1986 studies were single-tagged with internal anchor tags (Figures 1 and 2). Striped bass 200-299mm TL were tagged with a smaller internal anchor tag than fish ≥300 mm during the latter two studies. All tags bore the message "RTN to HRF Box 1731 GCS, NY 10163" on one side, and a tag number and reward value on the other. Reward values for the 1985-1986 program were either $5-1000 or $10-1000.

The 1985-86 sampling effort was divided into two phases (NAI 1986). A winter phase, conducted from the week of 11 November 1985 through the week of 17 March 1986 was performed in the lower Hudson River region with a high-rise striped bass trawl and a high-rise Atlantic tomcod trawl. The spring phase ran between the weeks of 31 March and 12 May 1986 and consisted of continued downriver trawling, and sampling in the Tappan Zee and Croton-Haverstraw regions with two seines: a Jackson 280 seine and a Kosalt plaice seine. Winter trawl sampling took place mainly in the Battery region, defined as the lower Hudson between river miles 1 and 14 (Figure 3). Limited trawling in the East River between East River miles 1 and 5, in the Harlem River at Harlem River miles 1 and 5 and 11 through 14, in the Upper New York Harbor between Harbor miles 0 and 4, and in the Lower Harbor from the Verrazano-Narrows Bridge to Sandy Hook, New Jersey (Figure 3) resulted in low striped bass catches. Limited trawling in Raritan Bay and Rockaway Inlet failed to capture striped bass. All seining occurred in the Hudson River between river miles 25 and 39. Additionally, 25 primarily larger striped bass were captured near Newburgh, NY in gill-nets and tagged by EA Engineering, Science & Technology, Inc. in the course of collecting broodstock for the Hudson River striped bass hatchery.

The NAI tagging effort involved paired vessels, one boat to conduct the actual sampling (capture boat) and a second boat (tagging boat) to process the catch. Fish were transferred directly from the cod end of the net to a floating holding facility secured to the tagging boat. The holding facility was designed to minimize stress on the fish prior to tagging. All striped bass were measured (TL) and examined for external tags, tag wounds, and internal magnetic tags using a Northwest Marine Technology, Inc. field sampling detector.

Striped bass ≥200 mm that were in good condition and not already tagged, were tagged with an internal anchor tag. When NAI recaptured tagged fish the tag was inspected for wear. If

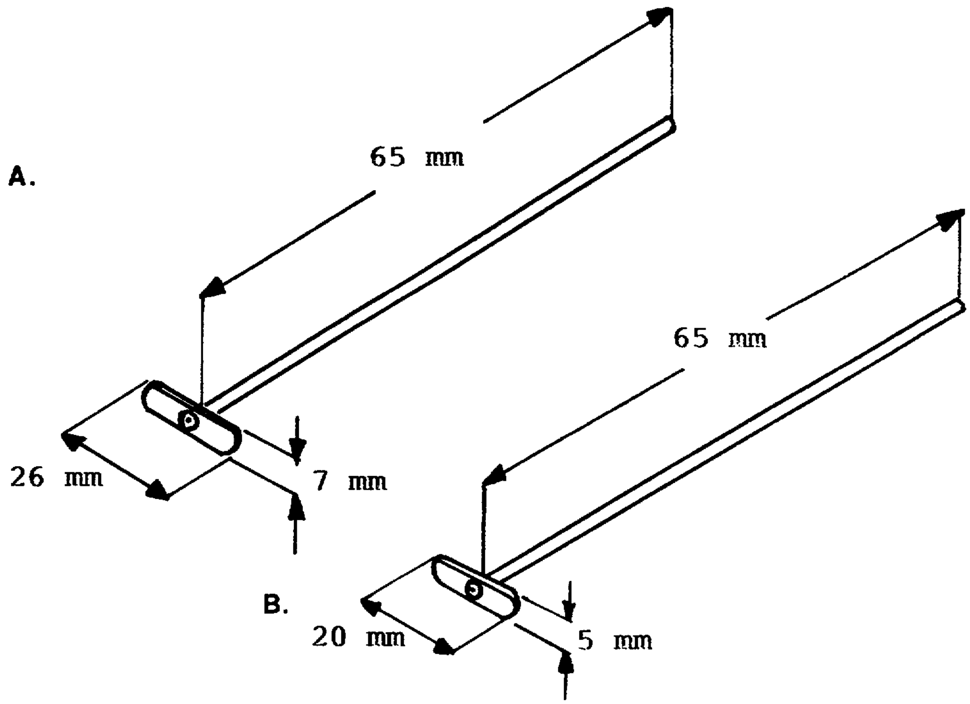

Figure 1. Internal anchor tags used in striped bass: A. $\geq$300 mm TL, and B. 200-299 mm TL.

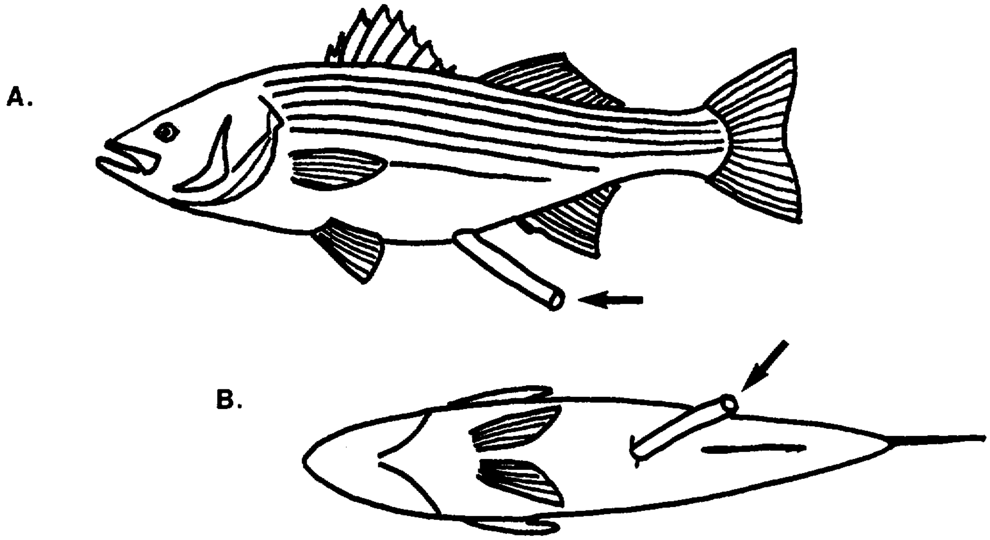

Figure 2. Tagging location used on striped bass: A. lateral view, and B. ventral view.

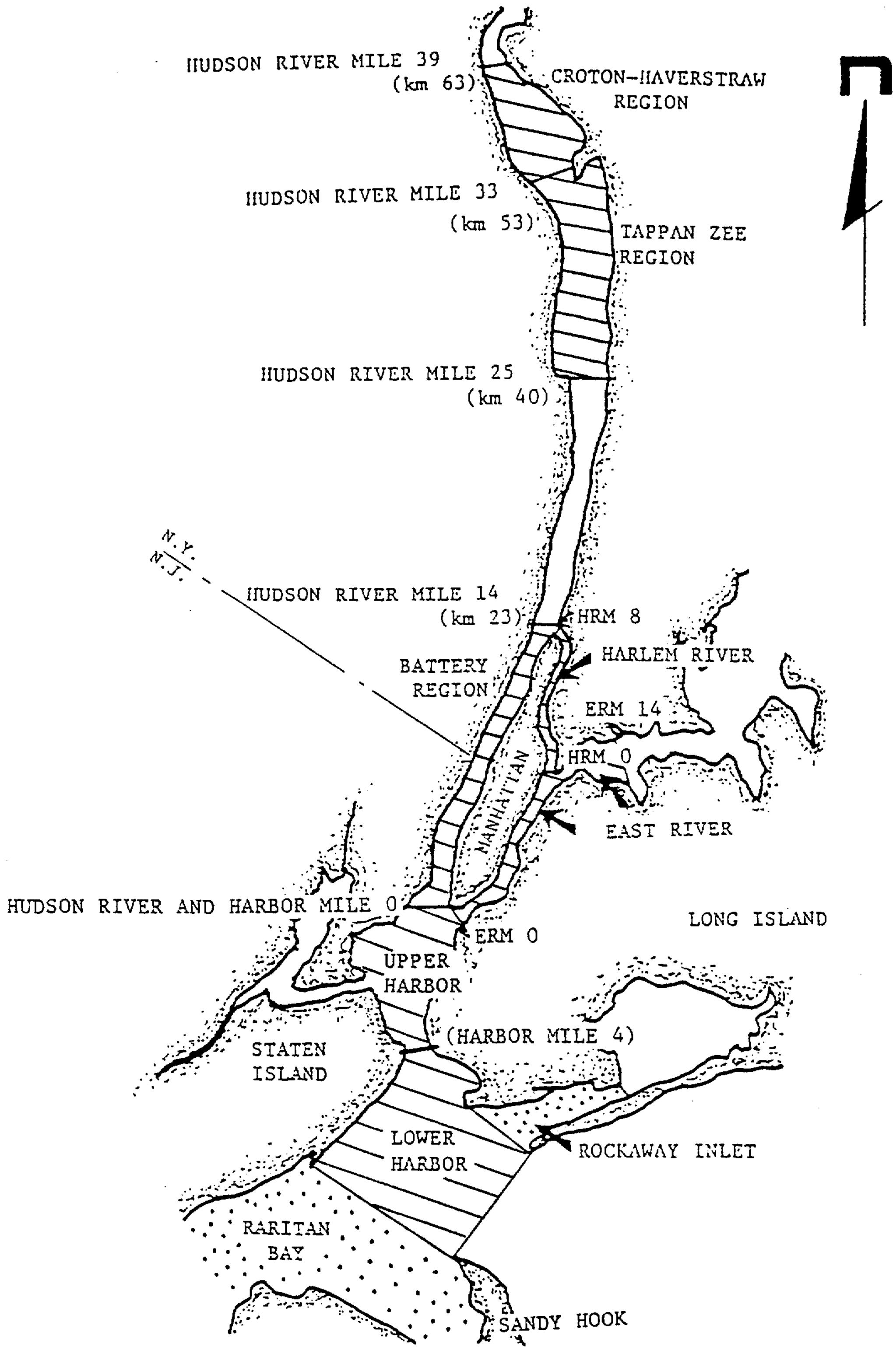

Figure 3. Areas sampled by Normandeau Associates, Inc. during the 1985-1986 program. Lined areas represent regions where striped bass were tagged and released. Stippled areas are those regions sampled, but where no striped bass were collected.

printing on the tag was still clearly legible the fish was re-released with the tag in place; however, if information on the tag was lost or muted through abrasion, the tag was replaced. The tagging site, midway between the vent and the posterior tip of the pelvic fins (Figure 2), was prepared by removing a scale and then making a 5 mm long horizontal incision with a scalpel through the abdominal wall. The anchor of the tag was inserted through the incision and the wound was treated with a merbromine-based topical antiseptic. Fish were released at least 400 m from active fishing gear but within one mile of the capture location.

3.2 Tag Return Processing

When a tag was received, the HRF issued a check for the minimum reward value displayed on the tag, either $5 or $10. The reward check and a questionnaire were then mailed to the respondent along with a stamped return envelope and a flier describing the program. If a response was not received within about six weeks, a second questionnaire was sent. All questionnaires indicated that completion and return of the questionnaire was necessary for inclusion in a reward drawing.

Following receipt of a completed questionnaire, an information form was mailed to the respondent indicating when and where their fish was tagged, and that they were entered in a drawing for prizes ranging from $100-$1000. All those who fulfilled these requirements by late February 1987 were entered in the drawing held on 27 February 1987, once for each tag returned. In accordance with the rules of the drawing, nine tag numbers were randomly selected. The first five fishermen whose numbers were drawn received $100 per tag, the next two received $500 per tag, and the final two received $1000 per tag.

The HRF continued its publicity campaign to create angler awareness of the program. In 1984, a poster and flier describing the program were developed. The poster was hand-delivered to over 85 fishing tackle shops and boat liveries, and posted at approximately 50 boat launch and fishing sites from the mid-Hudson Valley through New York City and the Hudson shore of New Jersey, eastward to Westport, Connecticut, and on Long Island. The flier was mailed to over 100 other fishing oriented facilities not visited, as far as Albany, New York and Massachusetts. The poster was also displayed as an advertisement in the _Fisherman_ publication series (New England Fisherman, Long Island Fisherman, and New Jersey Fisherman) once per month from July through November 1984. This series reaches at least 60,000 recreational fishermen weekly from Maine to southern New Jersey. To increase publicity in the Hudson Valley, the same advertisement was run in the July _Pennysaver_ for the central Hudson Valley region. The HRF also periodically issued press releases describing the purpose, extent, and mechanics of the program which were run in the _Fisherman_ series, and occasionally elsewhere.

Although no new tagging occurred over the winter of 1984-85, the publicity effort continued in order to encourage second year returns from the 1984 study. An article summarizing the first year's results was published in the Fisherman series (Waldman and Dunning 1986), as were press releases. Monthly (May-November) advertisements were again run in the three weekly Fisherman regionals.

The decision to mark striped bass with internal anchor tags alone in the 1985-1986 study required revision in 1986 to the poster and flier (Figure 4). The new poster was hand-delivered to tackle shops in parts of New York City, and along the shore of Long Island Sound from western Connecticut to Watch Hill, Rhode Island. Monthly advertisements from April through November were again displayed in the Fisherman series. The advertisement was also run in a May issue of the Pennysaver in the central Hudson region and in the August and October issues of the New York Sportsman. Press releases were issued that were picked up by the Fisherman publications, Long Island Outdoors, and occasionally by various newspapers. Additionally, the Northeast edition of Field and Stream (November 1986) ran a description of the program.

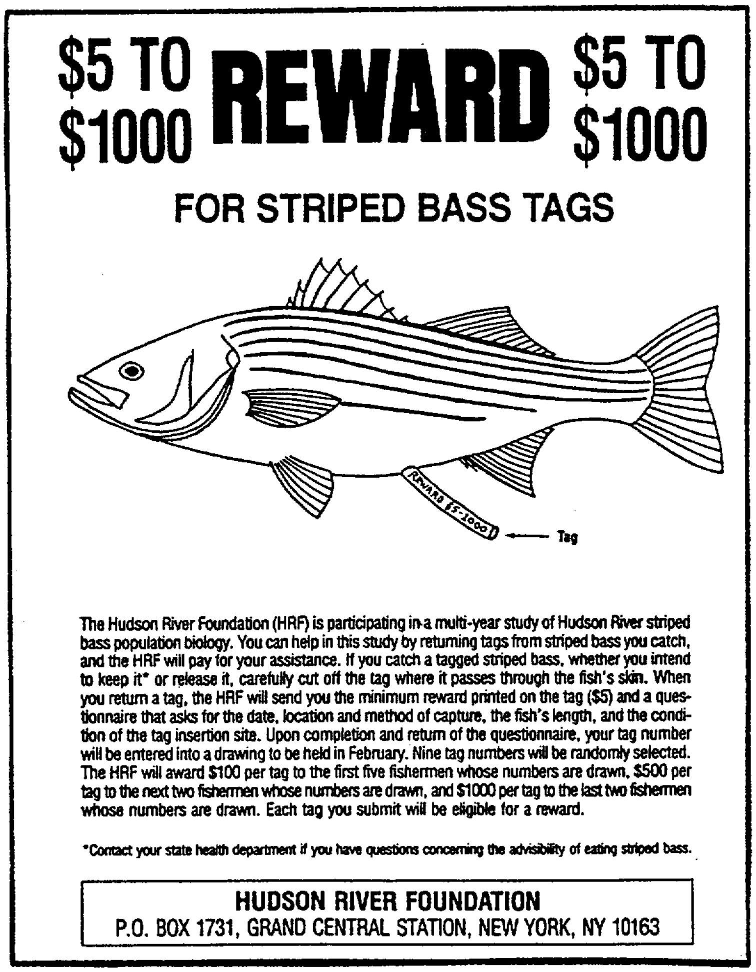

Figure 4. Revised poster and flier used in 1986 program.

3.3 Data Analysis

All analyses were conducted using striped bass lengths at release because of the standardization of the measuring procedure. Much of the length data reported by fishermen were estimates. For the purposes of this report, spring is defined as March-May, summer as June-August, autumn as September-November, and winter as December-February. Data on releases and water quality parameters were obtained directly from NAI.

For the purposes of this report, the term recaptures refers to recaptures of tagged fish for which the HRF was actually notified through return of the tag to HRF, or other form of communication such as a letter from the New York State Department of Environmental Conservation (NYSDEC) or other agency verifying recapture of a tagged fish. Tag retention refers to the continuing attachment of the tag to the fish.

Most statistical analyses were performed using the Statistical Analysis System (SAS 1986) with a microSAS package on an IBM AT system. Statistical significance was sometimes determined utilizing the formulas and Chi-square tables of Sokal and Rohlf (1969).

The relationship between length and distance traveled was assessed for various size classes for coastal striped bass recaptures. For this analysis, distances were calculated from the Battery to eliminate the effect of within-river differences in tagging locations.

Two assumptions were made in calculating minimum distance traveled (statute miles) for recaptures. The first of these involves movement through the Harlem River in New York City. It is clear from tag returns from this program that striped bass utilize this tidal strait between the Hudson and Harlem rivers to some degree. However, the extent of this usage remains unknown. Given that the majority of fish were originally tagged off lower Manhattan south of the confluence of the Hudson and Harlem rivers, it was assumed when calculating distances traveled that all fish tagged in the Hudson River and recaptured outside of the Hudson traveled by way of the Battery. The maximum increase in distance traveled that could result from this treatment if a striped bass actually passed through the Harlem River is about 12 miles.

The second assumption bears on a much smaller percentage of tags, those recaptured from Cape Cod Bay and farther north. Unlike for the Harlem River, significant passage of striped bass through the Cape Cod Canal has been reported (Merriman 1941; Raney 1952). Therefore, it was assumed that striped bass found north of or inside Cape Cod Bay passed through the Canal, and that fish recaptured east of the Elizabeth Islands and on the ocean side of Cape Cod had not utilized the Canal. Treatment of this kind for striped bass recaptured north of Cape Cod, that in actuality migrated around Cape Cod, would underestimate their distance traveled from the Battery by about 65 miles.

4.0 RESULTS

4.1 Recapture Rates

Between the weeks of 11 November 1985 and 12 May 1986, 18,512 striped bass were tagged with HRF tags. Of these, 18,487 were tagged by Normandeau Associates, Inc.: 13,620 from otter trawls (Table 1) and 4,855 from Scottish seines (Table 2). Twenty-five fish were tagged by EA Science and Technology, Inc., from gill nets.

Between 1 March 1986 and 28 February 1987, 727 tags were returned to HRF. Of these, 717 were from the 1985-1986 tagging and 10 were from the 741 fish tagged and released in 1984. NAI recaptures from the 1985-1986 tagging totaled 249; 182 of these occurred in the program year beginning 1 March 1986. NAI also recovered two tags from the 1984 releases.

Table 1.-Numbers released and recaptured and percent recaptured, by size class, of striped bass released from trawls during 1985-1986.

Length class (mm)	Released	Recaptured	Percent recaptured
200-299	9214	424	4.6
300-399	3786	205	5.4
400-499	539	33	6.1
≥500	81	5	6.2
TOTAL	13620	667	4.9

Table 2.-Numbers released and recaptured and percent recaptured, by size class, of striped bass released from seines during 1985-1986.

Length class (mm)	Released	Recaptured	Percent recaptured
200-299	389	13	3.3
300-399	994	42	4.2
400-499	1693	77	4.5
500-599	1448	84	5.8
600-699	283	17	6.0
≥700	48	5	10.4
TOTAL	4855	238	4.9

4.11 Gear and Temperature Effects

Overall recapture rates of striped bass released from the trawls (4.9%) and seines (4.9%) were identical. There was no significant difference ($P>0.05$) in recapture rate for any individual size class between the two gear types. The recapture rates of striped bass released from the seines ranged from 4.0% at 10°C to 7.3% at 7-8°C and averaged 4.9% (Table 3). There was a significant difference in recapture rates ($P<0.04$) across temperatures from 7°C to 14°C due primarily to a higher than expected recapture rate at 7-8°C. The recapture rate for fish released from the trawls at temperatures from 1-14°C ranged between 3.6% at 9°C to 7.3% at 13-14°C and averaged 5.0% (Table 3). There was no significant difference in average return rate ($P>0.05$) across this temperature range.

Table 3.-Recapture rates of Hudson River striped bass released from trawls and seines at various temperatures during 1985-1986.

	Recapture rate (%)			
Temperature (°C)	Trawls		Seines	
1	4.9%	(204)[a]	--	--
2	5.5	(1280)	--	--
3	4.6	(1781)	--	--
4	5.2	(2061)	--	--
5	5.0	(1230)	--	--
6	4.6	(1798)	--	--
7	3.9	(796)	--	--
7-8	--	--	7.3	(827)
8	5.8	(2512)	--	--
9	3.6	(745)	4.5	(1042)
10	4.1	(193)	4.0	(1339)
11	5.8	(87)	4.3	(988)
12	4.5	(220)	4.4	(249)
13	--	--	6.2	(257)
14	--	--	5.3	(153)
13-14	7.3	(372)	--	--
TOTAL	5.0	(13279)	4.9	(4855)

a. Number of fish released in parentheses. Temperature data were not available for all releases. Recapture rates were calculated across a 2°C range in two instances because of small sample sizes.

4.12 Angling Recaptures

Angling recapture rates were generally higher for larger length classes and ranged from 2.8% for fish 200-299 mm long to 8.2% for fish ≥700 mm long (Table 4). The among length class variation was highly significant ($P<0.005$, $X^2 = 25.5$, 2df).

Table 4.-Numbers and percent of angling recaptures by length class.

Length class (mm)	Number released	Number recaptured	Percent recaptured
200-299	9603	269	2.8%
300-399	4780	156	3.3
400-499	2232	96	4.3
500-599	1516	72	4.7
600-699	306	9	2.9
≥700	61	5	8.2
TOTAL	18498	607	3.3

4.13 Tag Retention

Eight more internal anchor tags alone from individual fish, and paired Dennison and internal anchor tags from two fish were received by HRF from the 741 striped bass double-tagged and released in the 1984 tagging (Table 5). NAI recaptured two fish tagged in 1984, both bearing only the internal anchor tag. These third-year returns raised the overall recapture rate from the 1984 study to 10.5%. Fifty-three striped bass were recaptured within the first year following tagging in the pilot study, and 13 were recaptured in the second year.

Table 5.-Number of Dennison and internal anchor tags returned per year from 741 striped bass double-tagged in 1984.

	Number returned		
Recapture Year	Dennison	Internal anchor	Either or both
<2/28/85	21	49	53
3/1/85 - 2/28/86	1	12	13
3/1/86 - 2/28/87	2	12	12
TOTAL	24	73	78

4.14 Condition and Disposition of Recaptures

Respondents were asked whether the tagged striped bass they caught were released in good condition (Table 6). Whereas the answer yes was unambiguous, the answer no could mean either that the fish was kept or that it was released in poor condition. However, the negative response does provide an estimate of fishing-induced mortality if it is assumed that fish released in poor condition later died. The percent released in good condition was significantly lower for striped bass ≥600 mm (68.4%) compared with those <600 mm (92.8%).

Table 6.-Numbers and percent of striped bass released in good condition following recapture, by size class.

Length class (mm)	Total number of responses	Number released in good condition	Percent released in good condition
200-299	203	187	92.1%
300-399	128	121	94.5
400-499	82	76	92.7
500-599	56	51	91.1
≥600	19	13	68.4
TOTAL	488	448	91.8

4.2 Physical Tagging Effects

4.21 Abrasion of Information from Tags

Returns accumulated during the 1985-1986 tagging program indicated that some information printed on the internal anchor tags was being lost due to abrasion. It was possible to indirectly estimate the rate of information loss from tag abrasion based on recaptured fish. To calculate the abrasion rate directly, it would be necessary to know when a fish was tagged. However, if a tag number was not legible, there was no way to determine when the tag was applied. Therefore, differences in tagging dates were ignored. The incidence of illegible tag recoveries from bottom abrasion rose substantially by month from the conclusion of the tagging period (Table 7). The percentage of tags showing any illegible digits or letters, in groups of 100 by order of return to HRF (Table 8) also indicated substantial cumulative abrasion. The percentage of tags with illegible digits or letters in Table 8 is higher than the percentage of tags with illegible serial numbers in Table 7 because the former represents only a small part of the information displayed on the tag, whereas the latter considers information loss from any portion of the legend.

Table 7.-Number and percent of tags with illegible serial numbers from 1985-1986 releases, by recapture month.

Month	No. Illegible/Total	Percent	Cumulative percent
March 1986	0/ 5	0.0%	0.0%
April	0/ 78	0.0	0.0
May	0/121	0.0	0.0
June	0/ 83	0.0	0.0
July	1/ 40	2.5	0.3
August	1/ 48	2.1	0.5
September	1/ 52	1.9	0.7
October	7/ 82	8.5	2.0
November	12/ 83	14.5	3.7
December	1/ 43	2.3	3.6
Jan.-Feb. 1987	0/ 4	0.0	3.6
TOTAL	23/639	3.6	--

Table 8.-Number and percent of tags with illegible digits or letters from 1985-1986 tagging, by order of return, in century groupings.

Tag grouping	No. tags with illegible digits-letters/tags examined	Percent	Cumulative percent
1-99	0/ 99	0.0%	0.0%
100-199	0/ 97	0.0	0.0
200-299	1/ 97	1.0	0.3
300-399	16/ 98	16.3	4.3
400-499	38/100	38.0	11.2
500-599	50/ 99	50.5	17.8
600-699	61/ 90	67.8	24.4
700-717	13/ 17	76.5	25.7
TOTAL	179/697	25.7	--

4.22 Fish Condition at Tag Sites

Based on 489 fishermen who noted the condition of the tag insertion site (Table 9), 73.6% indicated there was no dermal abrasion, 20.7% said there was some abrasion, and 5.7% reported substantial abrasion. There was no significant difference ($P>0.05$) in condition of the insertion sites for striped bass 200-299 mm long, which were tagged with a smaller anchor tag, than for striped bass ≥300 mm.

Table 9.-Condition of tag insertion sites for small and large internal anchor tags (used in 200-299 mm and ≥300 mm length classes, respectively) as reported by fishermen.

	Condition of tag insertion site		
Length class	No abrasion	Some abrasion	Substantial abrasion
200-299 mm	140 (70.4%)	47 (23.6%)	12 (6.0%)
≥300 mm	220 (75.9%)	54 (18.6%)	16 (5.5%)
TOTAL	360 (73.6%)	101 (20.7%)	28 (5.7%)

4.3 Striped Bass Movements

4.31 Distribution of Recoveries

Tags returned to HRF from the 1985-1986 tagging were recovered from seven states and one Canadian Province (Table 10). Excluding NAI recaptures, which were recaptured in a limited geographic area, the largest number of tags were returned in May 1986 (116) and the smallest number during January and February 1987 (4) (Table 11).

A map of the primary recapture area (Figure 5) and summary of monthly tag recovery distributions from March 1986 through February 1987 (Figures 6-16), from the 1985-1986 tagging (excluding NAI recaptures) follows:

March: Angler returns were few. Four of the five recaptures were from New York City waters, the fifth was from Croton, NY.

April: Tags were returned from as far north as Catskill, NY in the Hudson River. The majority of these were recaptured between Cold Spring, NY and the Battery at the mouth of the river. Eight of these were from the Croton River or its mouth. Six were recovered by sportfishermen at the Caven Point Pier in Jersey City, NJ. Of 12 fish recaptured in trawls at Pier 79 in the Hudson River off Manhattan by an environmental consulting firm between late March and late May, seven were taken in April. There was one return from the south shore of Long Island, at Atlantic Beach.

May: Tagged fish were recaptured by anglers and commercial shad netters over the length of the tidal Hudson River, including six at its northern end, the Federal Dam at Troy, NY. The heaviest concentration of returns was from between Croton and Brooklyn, NY in Upper New York Harbor. Returns were also derived from the distal reaches of the Hudson Estuary including Newark Bay, Jamaica Bay, and the mouth of the Raritan River. There was only one recapture along the Long Island's south shore, but many in Long Island Sound. Long Island Sound tag recovery sites included Little Neck Bay and Hempstead Harbor, the Greenwich, CT region and the Housatonic and Connecticut rivers. Eight tagged striped bass, all <400 mm were taken in pound nets at Orient Point, NY. Pound nets also contributed 15 recoveries in spring at Point Judith, RI that did not appear on the maps because of uncertainty as to the month of capture. Single recoveries were made from near Nauset Beach, Cape Cod, MA and from the Mousam River, Maine.

June: There were two recaptures from slightly south of Sandy Hook, the first recaptures in this program from New Jersey's ocean coast. Although seven returns originated from the dam at Troy, the number of Hudson River recaptures declined from May. A substantial number of recoveries came from around New York City and from Long Island Sound. Three returns came from Long Island's south shore bays. Seven tagged fish were captured again between the area of Point Judith, RI and Monomoy Island, Cape Cod, MA. The only two recaptures from north of Cape Cod both came from the mouth of the Merrimack River at Newburyport, MA.

July: The pattern in July was similar to June's, with few recaptures in the Hudson River. The majority of returns originated from New York City and Long Island Sound. Returns from the Federal Dam at Troy declined to one. No returns were made south of Sandy Hook. Two more recoveries were made at Newburyport, MA and two occurred in Maine, near Wiscasset and in the Penobscot River.

August: The summer pattern seen in June and July continued in August. No recaptures were made from the dam at Troy. NYSDEC sampling contributed a number of returns from Little Neck Bay in western Long Island Sound. One recapture was made in the surf on Long Island's south fork, and four were made in south shore bays and inlets. One recovery came from inland New Jersey in the South River at Old Bridge and another came from south of Sandy Hook at Elberon, NJ. Although no returns were made between Cape Cod and Maine, a tagged fish was recaptured from the Bear River, Nova Scotia on the southeast coast of the Bay of Fundy.

September: The tag recovery distribution in September resembled that of June through August, but with a slight increase in concentration in the New York Harbor region. No fish were recaptured south of Sandy Hook. All returns from Long Island Sound came from its western half. Two recaptures occurred in Rhode Island and five in Massachusetts, including two each from Cuttyhunk Island and the Merrimack River. A single recapture was made in Maine in the Kennebec River.

October: Hudson River recaptures remained few. Many more recoveries originated from the ocean coast: one each from Plum Island and Scituate, MA, four from Cape Cod, one from Cuttyhunk, MA, several from Rhode Island pound nets, six from between Montauk and Atlantic Beach on Long Island, and three from northern New Jersey. Long Island Sound recoveries were again concentrated in the western sector. Numerous recaptures were made in the New York Harbor region, including the East River, the Arthur Kill, and Jamaica Bay.

November: The majority of recaptures came from the New York City region. The 69th Street Pier area in Brooklyn alone contributed 15 returns. Other Upper New York Harbor sites that provided numerous recoveries were Robbin's Reef, Liberty and Governor's islands, and the shores adjacent to the lower East River bridges. Returns were made from Staten Island, Sandy Hook Point, and the Tin Can Grounds at the entrance to Lower New York Harbor. No recaptures occurred north of Cape Cod. Seven tags were recovered from pound nets set near Newport, RI. Nine more fish were recaptured in the ocean off Long Island's south shore, but none from its bays. Three tagged striped bass were caught south of Sandy Hook.

Figure 5. Map of primary recapture area for striped bass tagged during winter 1985-1986.

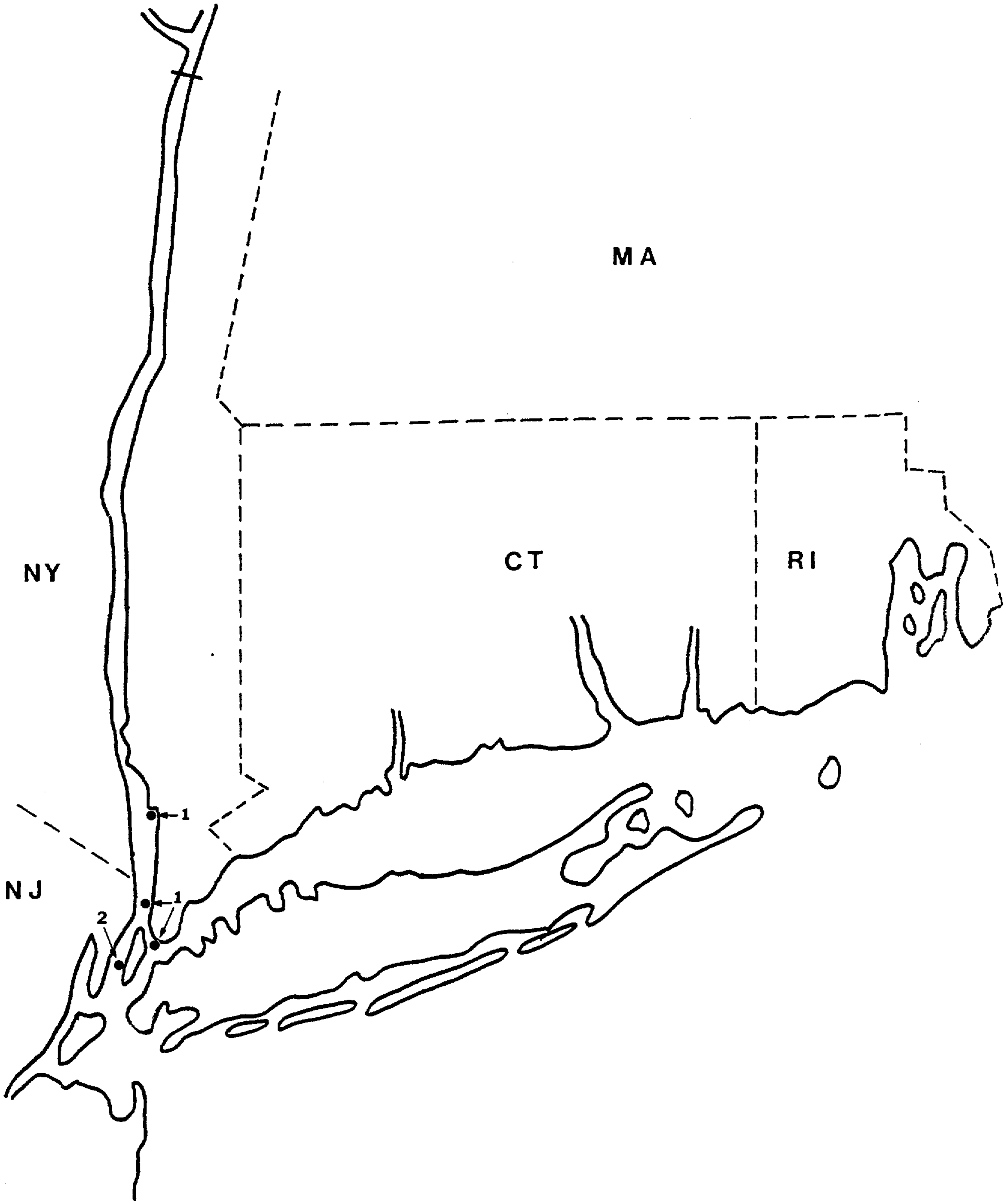

Figure 6. Locations of March 1986 recaptures from releases in winter 1985-1986.

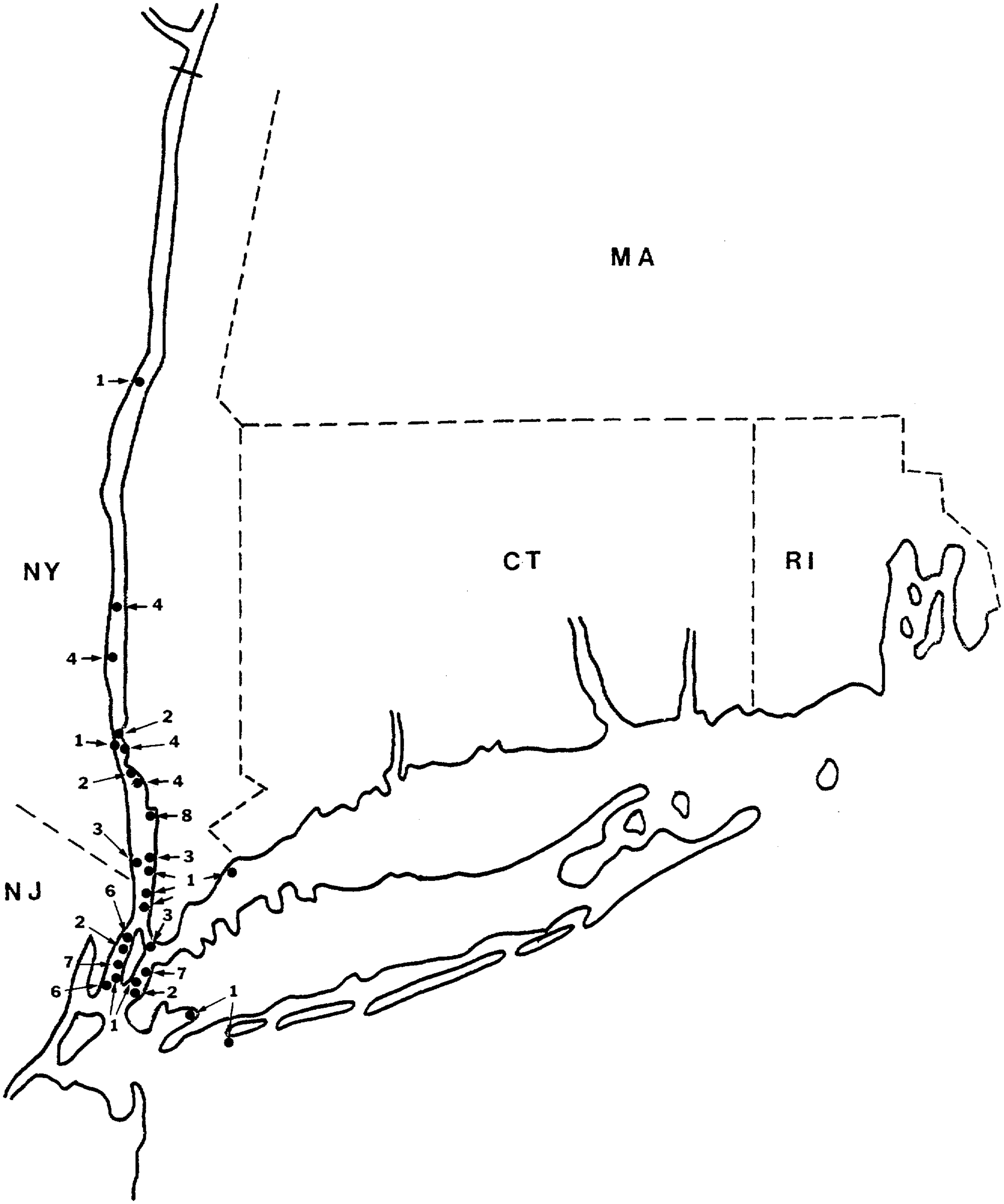

Figure 7. Locations of April 1986 recaptures from releases in winter 1985-1986.

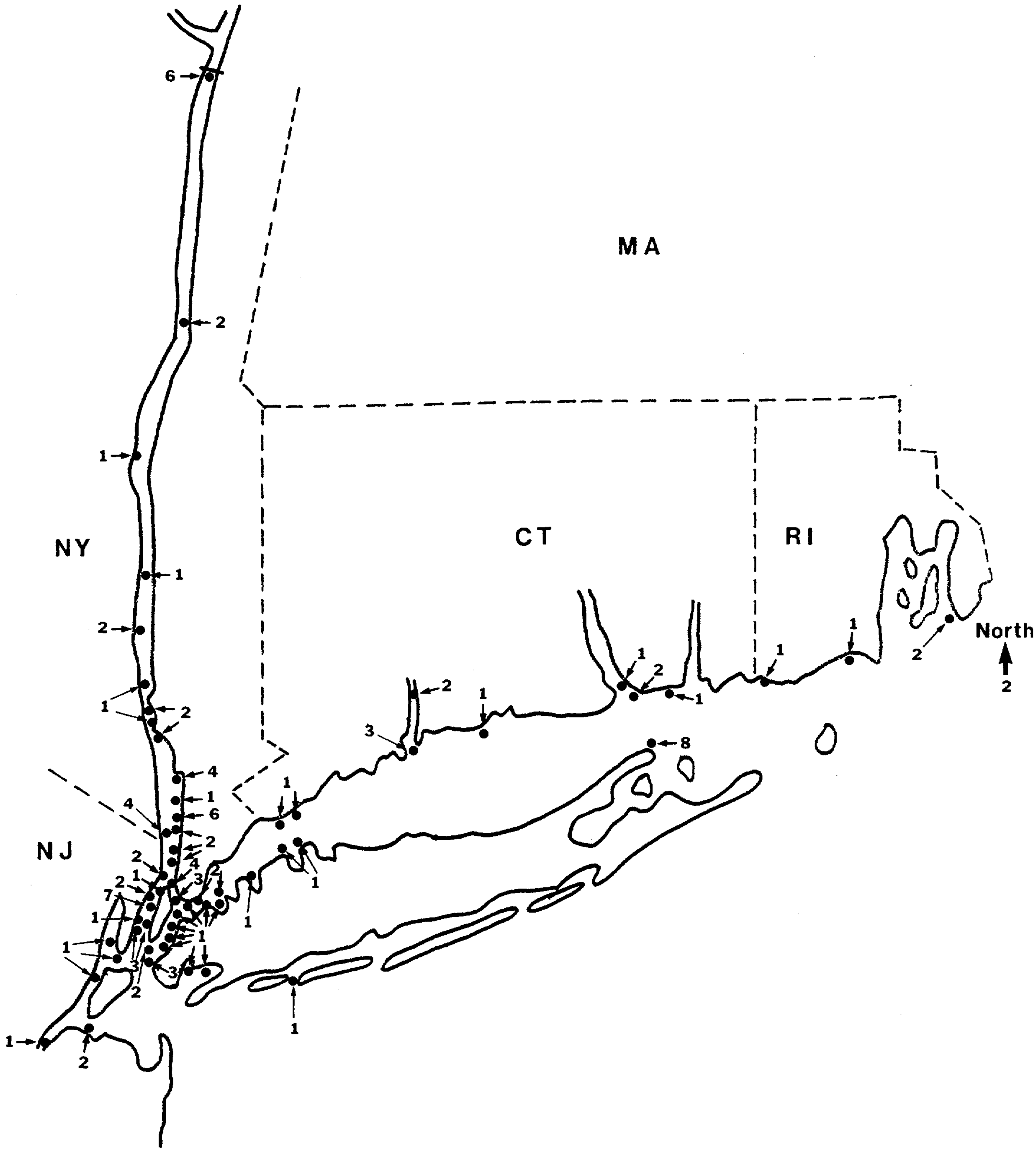

Figure 8. Locations of May 1986 recaptures from releases in winter 1985-1986.

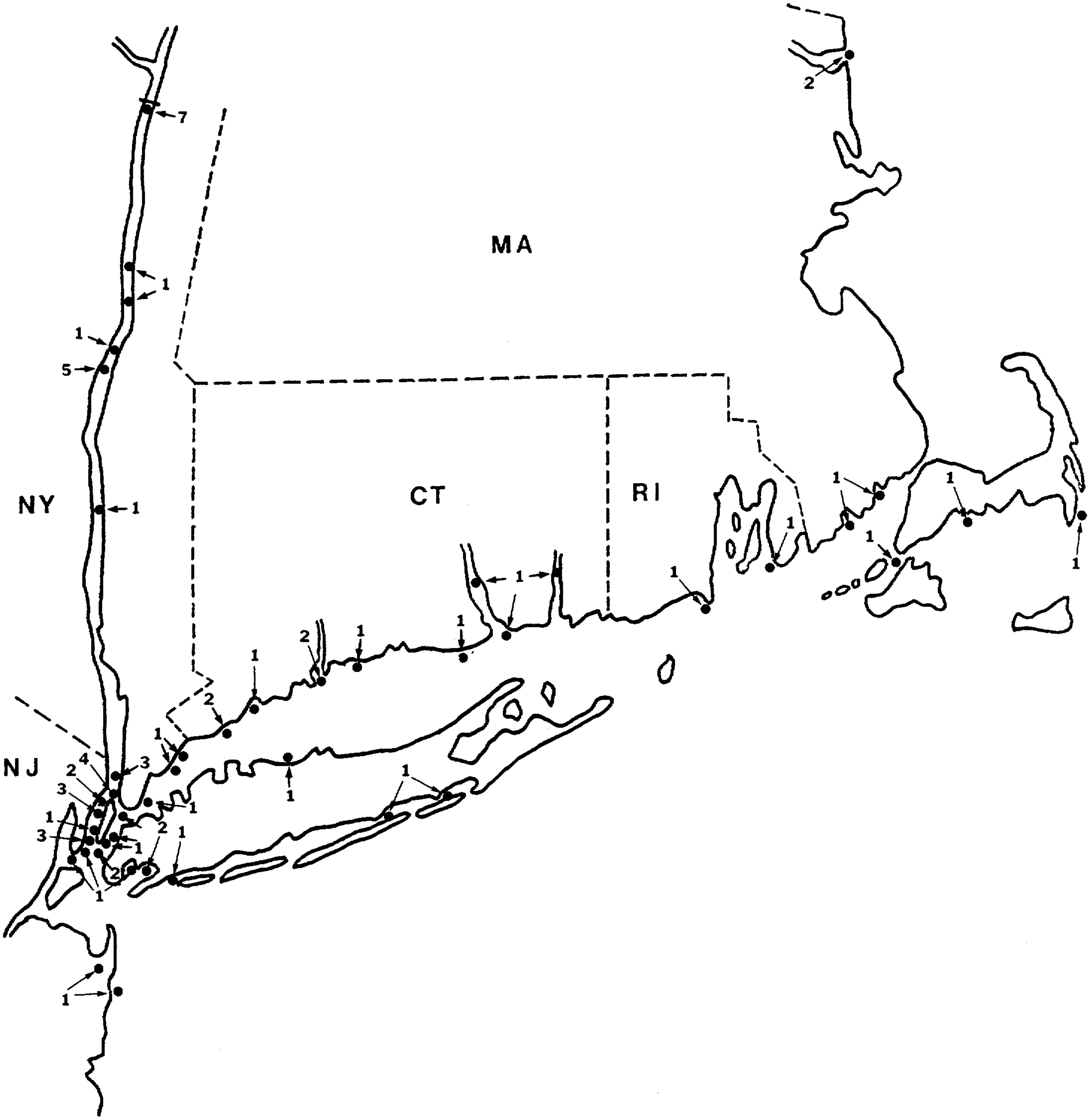

Figure 9. Locations of June 1986 recaptures from releases in winter 1985-1986.

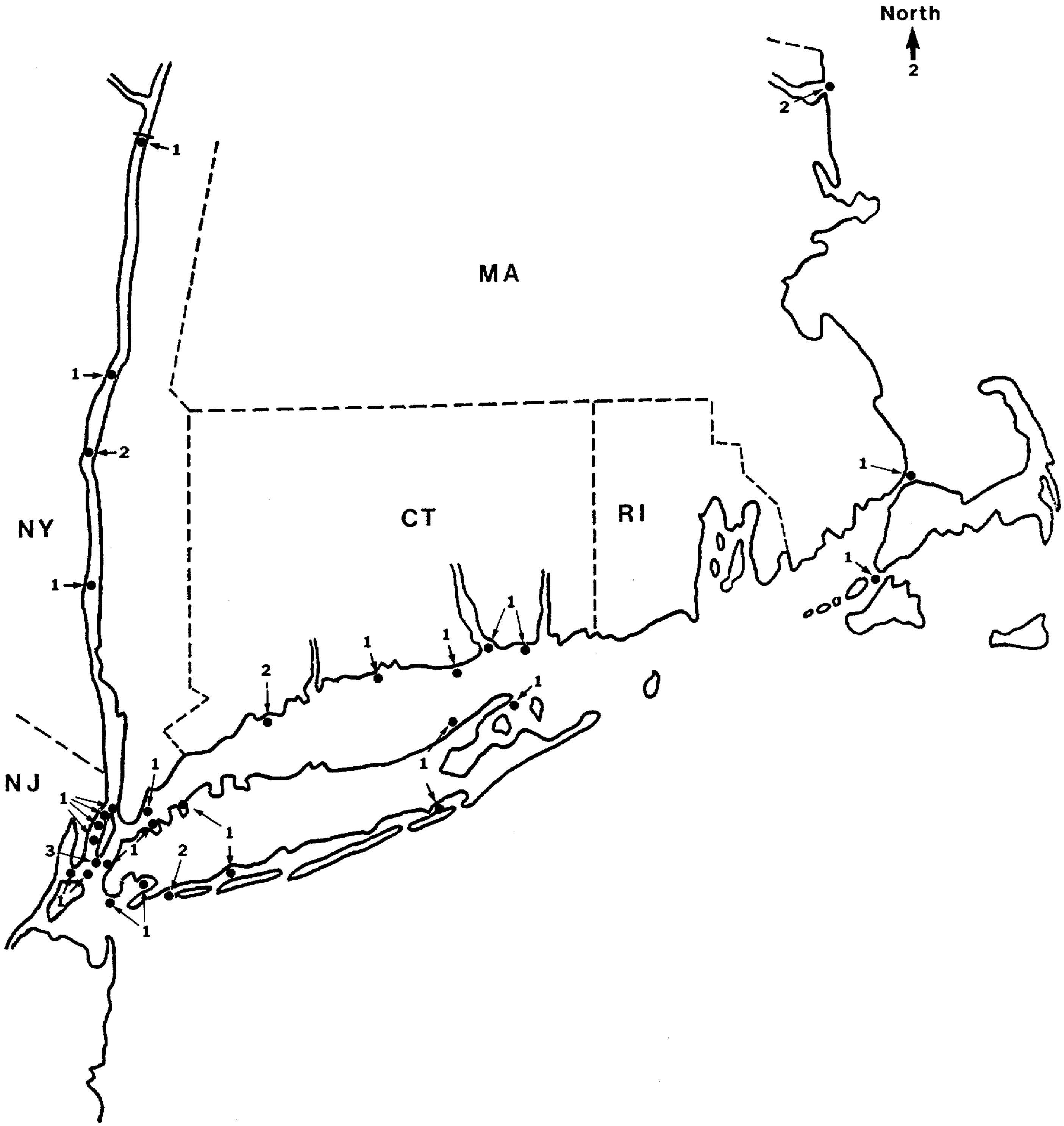

Figure 10. Locations of July 1986 recaptures from releases in winter 1985-1986.

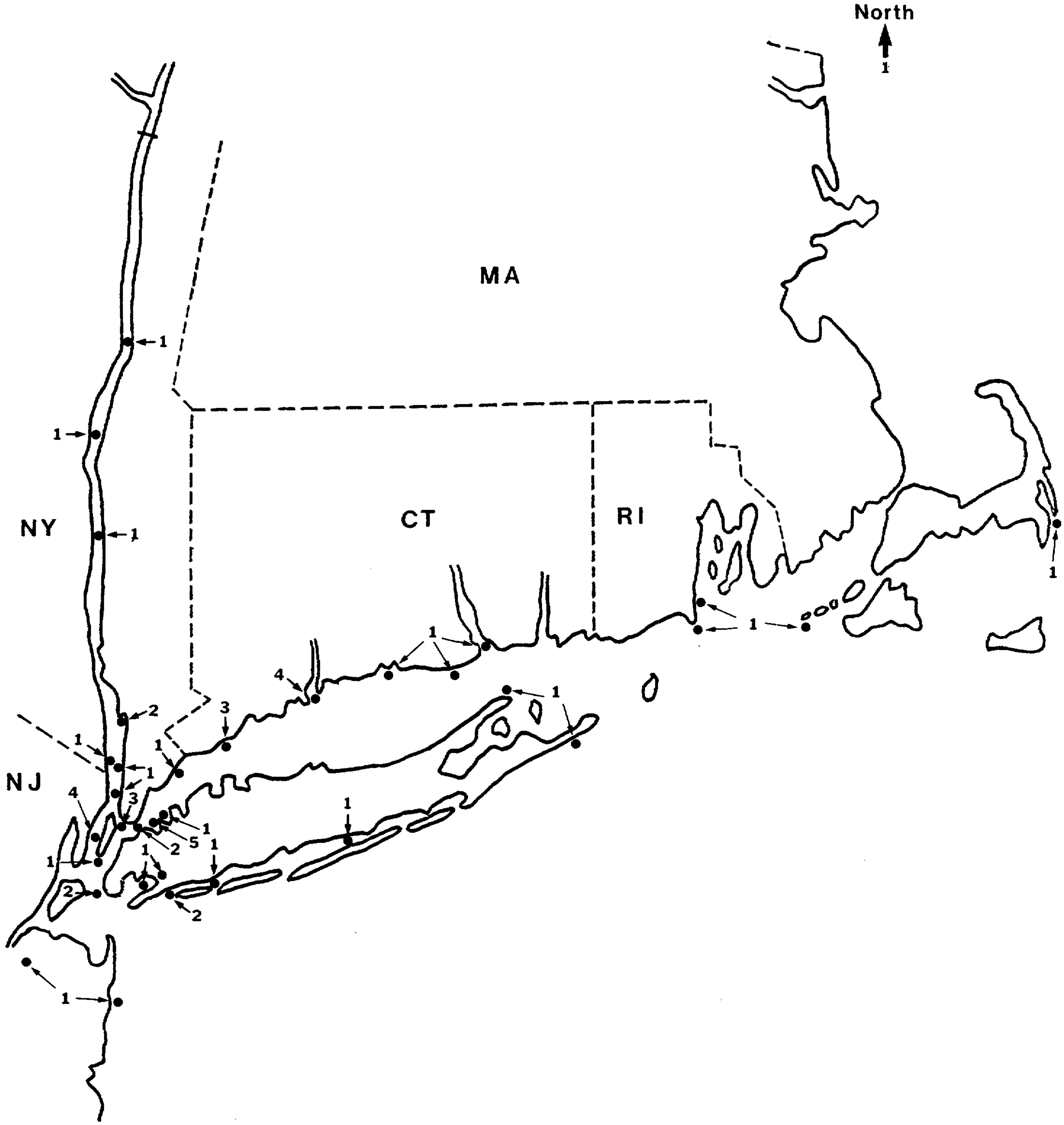

Figure 11. Locations of August 1986 recaptures from releases in winter 1985-1986.

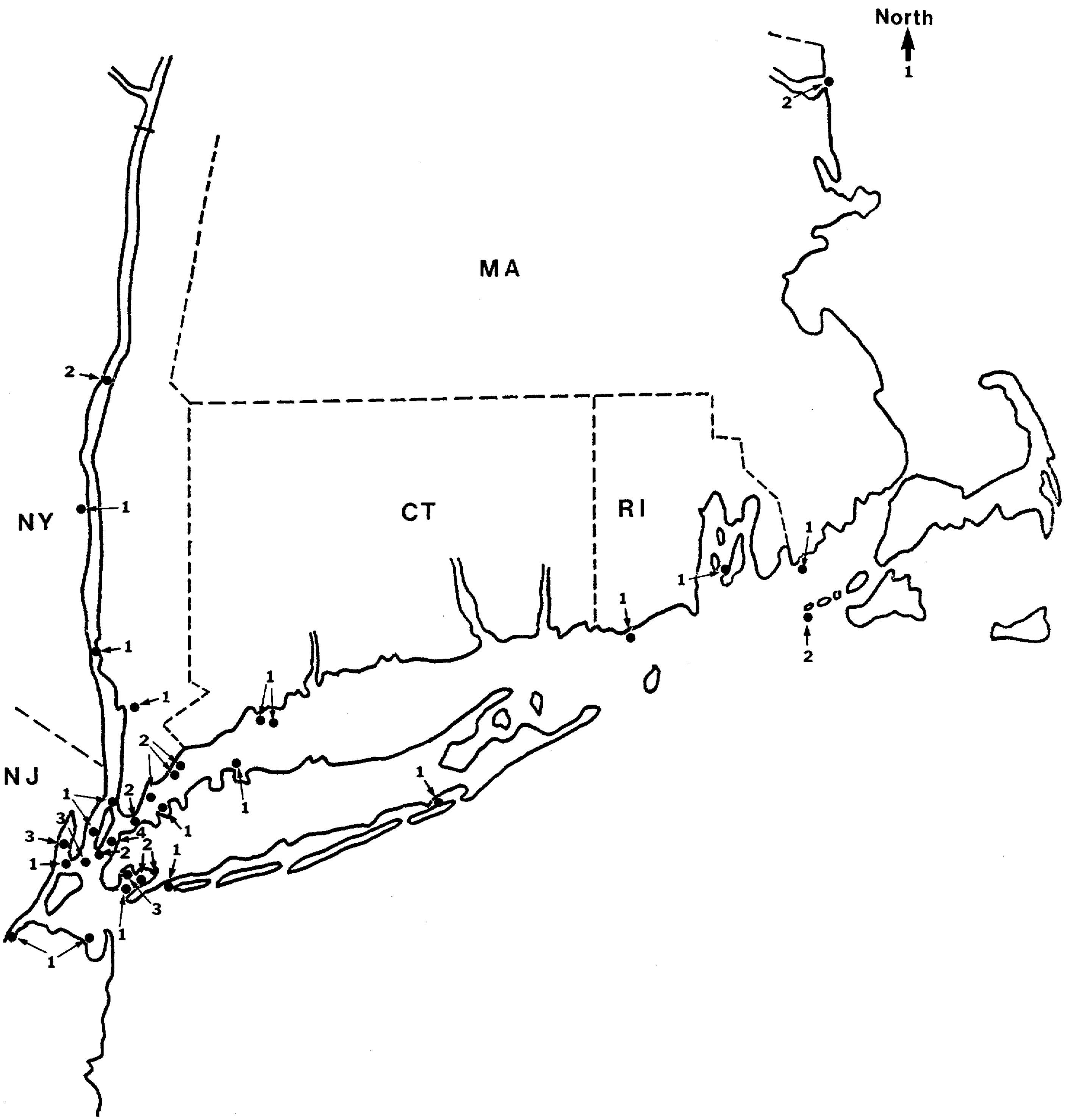

Figure 12. Locations of September 1986 recaptures from releases in winter 1985-1986.

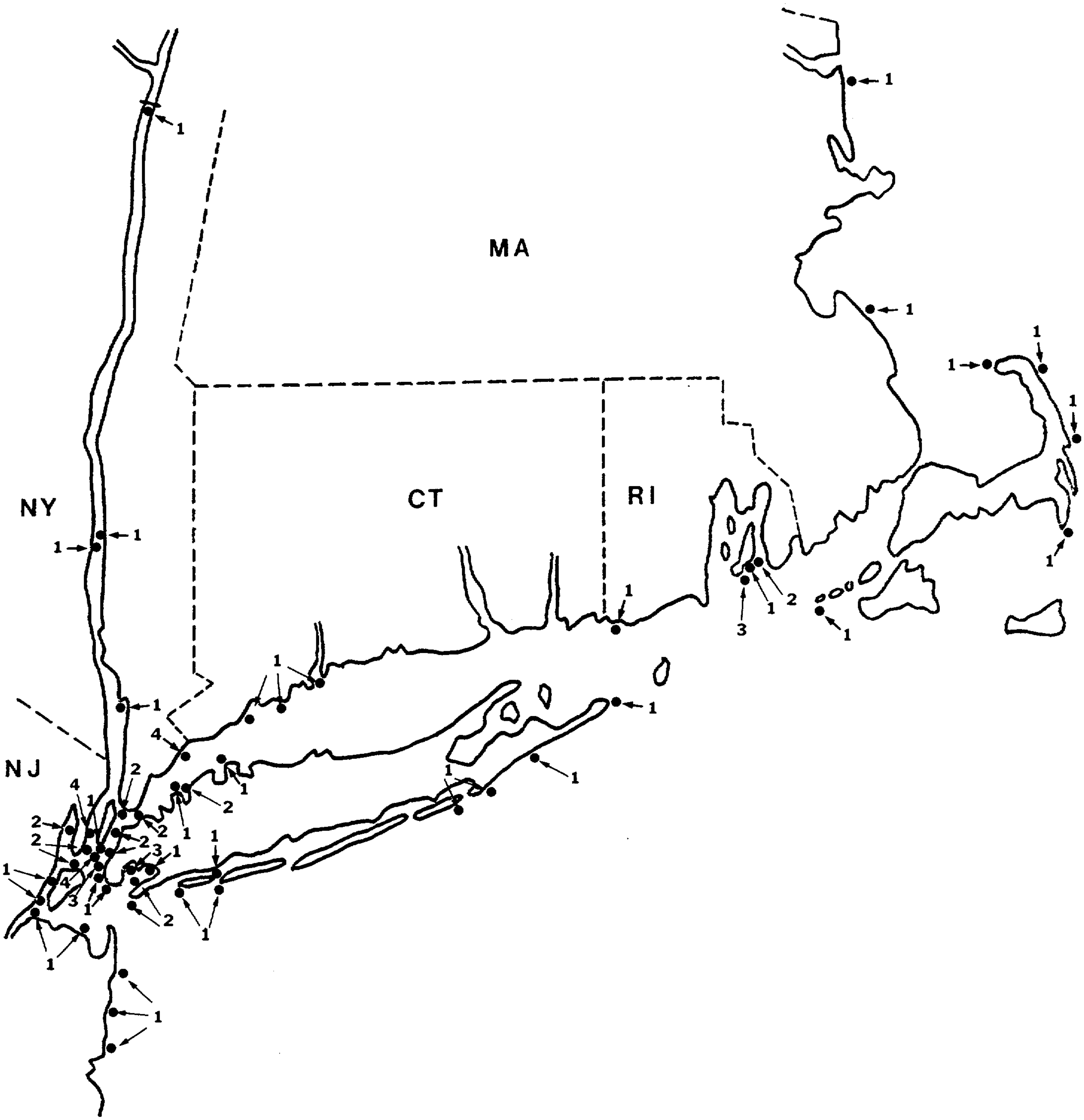

Figure 13. Locations of October 1986 recaptures from releases in winter 1985-1986.

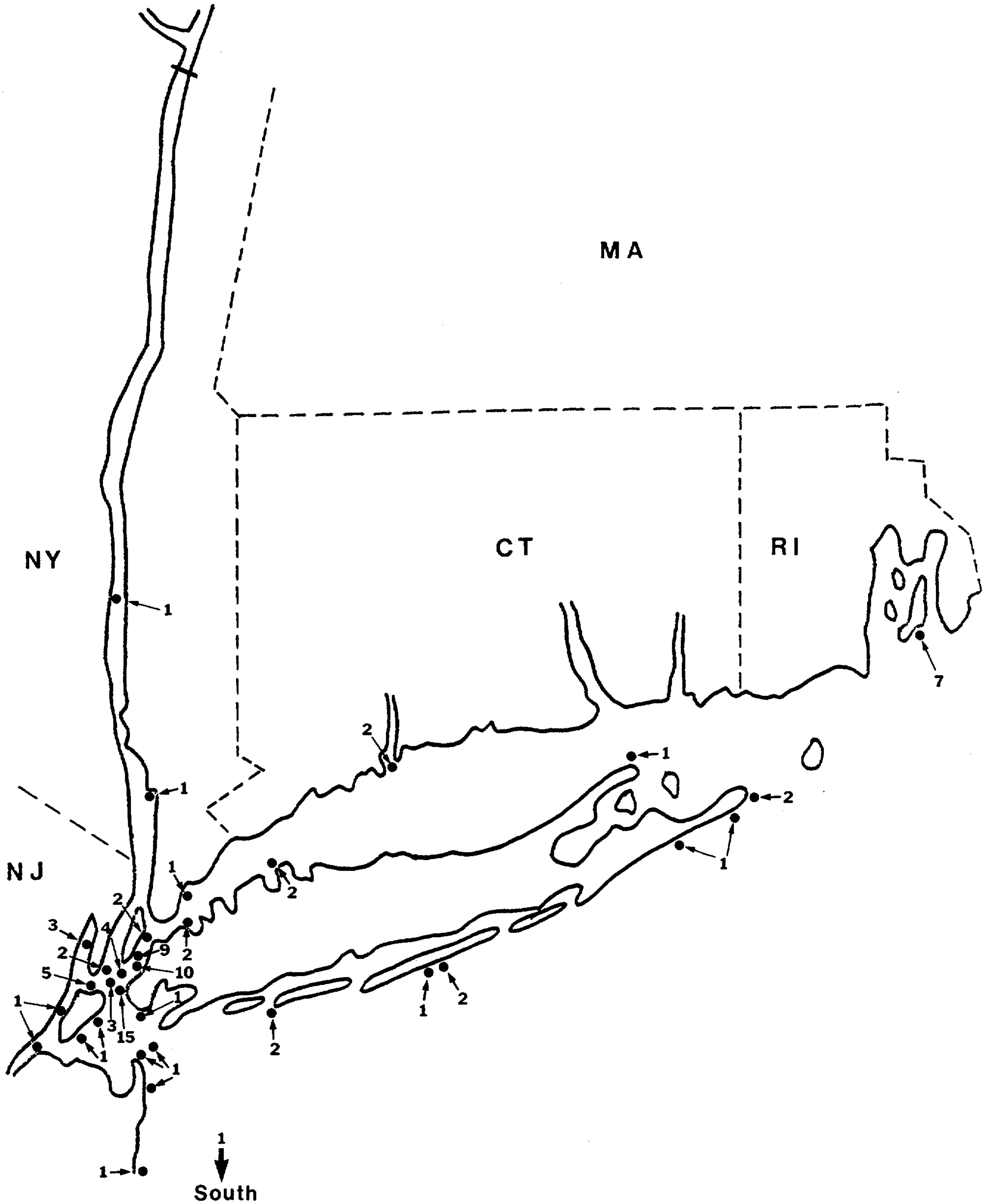

Figure 14. Locations of November 1986 recaptures from releases in winter 1985-1986.

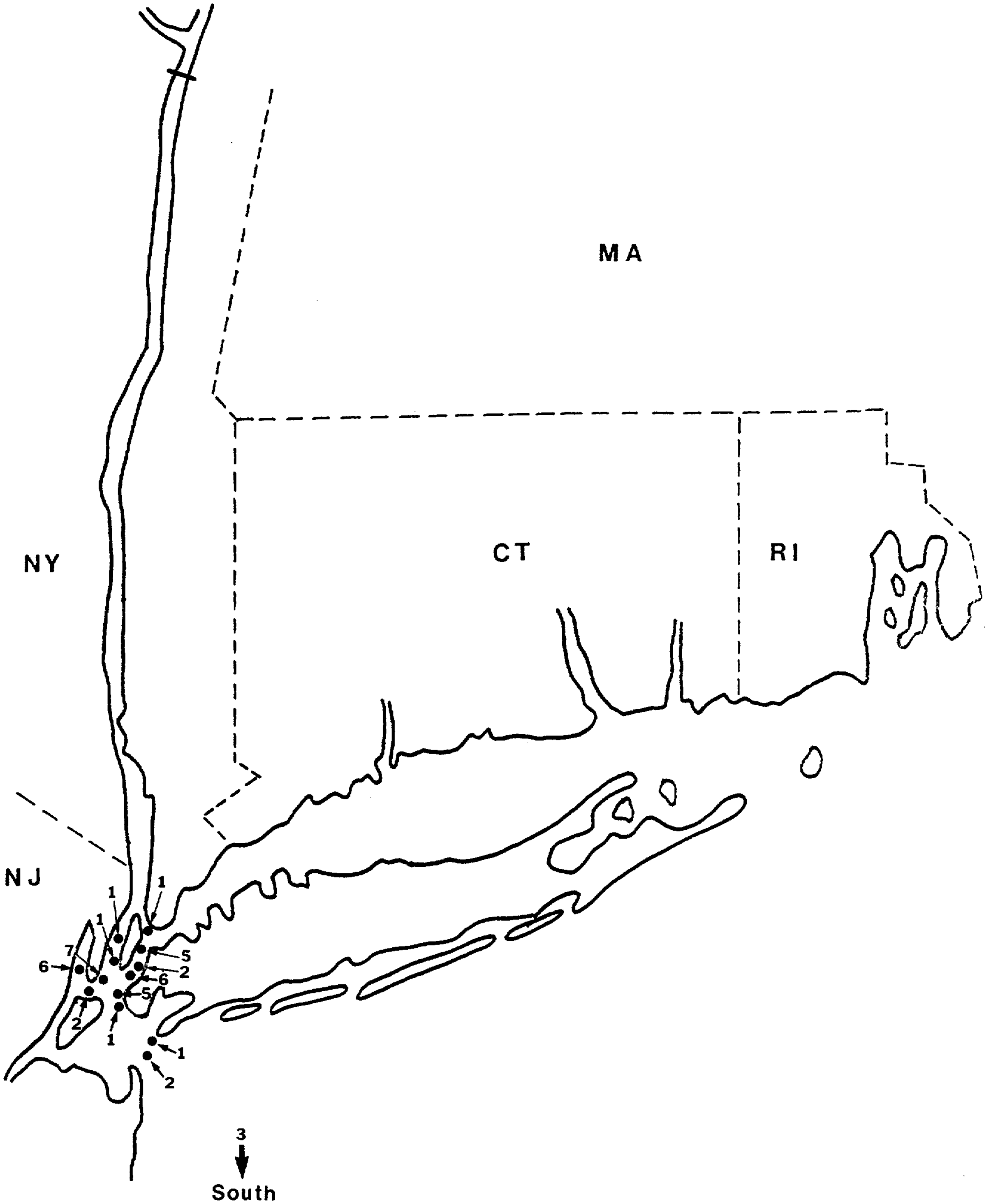

Figure 15. Locations of December 1986 recaptures from releases in winter 1985-1986.

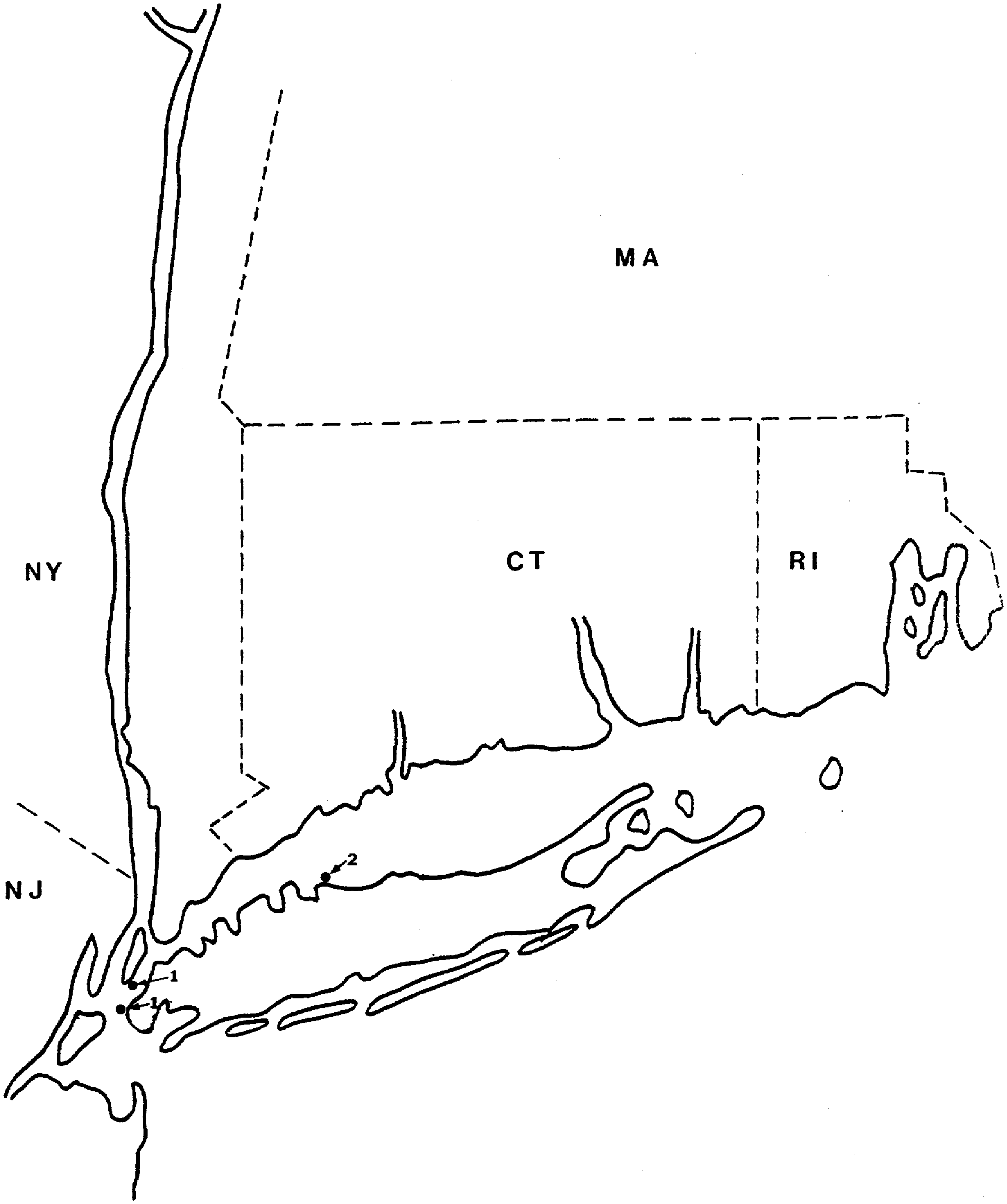

Figure 16. Locations of January - February 1987 recaptures from releases in winter 1985-1986.

December: Virtually all recoveries were from the New York City region, especially the East River and the Upper Harbor. Sites included Brooklyn's 69th Street Pier, East 79th Street in Manhattan, Liberty Island, Newark Bay, and the Tin Can Grounds. The three recaptures not made in this area came from well south of Sandy Hook, one from Beach Haven, NJ and two from Virginia Beach, VA.

January-February: Only four non-NAI recoveries were made during these two months: two in the Upper Bay and two at Northport in the cooling water outflow of the Long Island Lighting Company (LILCO) generating station.

Table 10.-Number and percent of tags returned with locality data by state or Canadian Province, from 1985-1986 tagging.

Location	No. tags returned from	Percent
New York	446	67.9%
New Jersey	97	14.8
Connecticut	44	6.7
Rhode Island	37	5.6
Massachusetts	26	4.0
Maine	4	0.6
Virginia	2	0.3
Nova Scotia	1	0.2

The proportion of tags returned from within the Hudson River in comparison to outside of it, excluding the NAI recoveries, was 31.2%. The rate of recapture from the Hudson River ranged from 80% in March 1986 to 0% in January and February 1987 and generally decreased steadily by month (Table 11). Total monthly recaptures peaked in May with 116, declined to 38 in July, and then rose to an autumn maximum of 87 in November.

Table 11.-Numbers and percent recaptures by month within the Hudson River (north of Battery) of total recaptures with locality data.

Month	Total recaptured	No. recaptured in Hudson River	Percent recaptured in Hudson River
March 1986	5	4	80.0%
April	77	55	71.4
May	116	62	53.4
June	73	32	43.8
July	38	9	23.7
August	49	12	24.5
September	51	7	13.7
October	78	8	10.3
November	87	2	2.3
December	40	2	5.0
Jan.-Feb. 1987	4	0	0.0
TOTAL	618	193	31.2

4.31.1 Multiple and Multi-year Recaptures

There were seven multiple recaptures of fish during the 1985-1986 program. Each of them were at large at least one day following release before being recaptured twice during the program year (Table 12). In every instance, the first recapture was made in the Hudson River or New York Harbor, by NAI, within 40 days after initial release. All but one first recapture was made within 10 miles of the release point; the farthest was 22 miles. Second recaptures ranged from May - December 1986 and from Beach Haven, NJ to Newburgh, NY.

Table 12.-Listing of multiple recaptures. RM = river mile.

Release			First Recapture		Second Recapture	
RM	Date	Length	Date	RM/locat.	Date	Location
1	2/13/86	320 mm	3/4/86	8	11/2/86	East R., NYC, NY
5	2/18/86	397	2/21/86	8	11/18/86	Bayonne, NJ
5	2/20/86	360	4/1/86	NY Harb.	5/5/86	Croton, NY
5	2/24/86	265	3/13/86	9	8/7/86	Highlands, NJ
14	4/4/86	311	4/24/86	36	7/29/86	Newburgh, NY
30	4/8/86	475	4/27/86	36	10/10/86	Leonardo, NJ
30	4/9/86	502	4/25/86	36	12/17/86	Beach Haven, NJ

Tags from ten striped bass of the 741 released in 1984 were returned to HRF. Recapture locations ranged from Point Pleasant, NJ to Catskill, NY, and included Long Beach Island, NJ, Atlantic Beach, NY, and Upper New York Harbor. Two recaptures by NAI of fish tagged in 1984 were made in April 1986 from river miles 26 and 30 in the Hudson River.

4.32 Relationship of Fish Size to Movement

Based on angling recaptures, the mean monthly distances traveled of the 200-299 mm and the 300-399 mm classes did not vary significantly from each other and were combined in Table 13. The 200-399 mm class did show a highly significant difference in distance traveled from the larger length groups. The 400-499 mm and ≥500 mm classes also displayed movements that were significantly different from each other. Recapture locations by length class for June through October - the period of maximum mean monthly distances traveled from the Battery, are shown in Figure 17.

Table 13.-Mean distance in miles between Battery and recapture locations by size class and month for angling recaptures outside of the Hudson River.

Month	Length class 200-399 mm		400-499 mm		≥500 mm	
March 1986	9.0	(1)[a]	--	--	--	--
April	6.9	(12)	11.3	(3)	--	--
May	24.4	(28)	75.4	(11)	69.2	(4)
June	42.2	(15)	98.8	(11)	102.1	(11)
July	41.1	(8)	82.4	(7)	144.9	(10)
Aug.	32.4	(13)	69.7	(7)	128.7	(9)
Sept.	30.2	(18)	60.8	(7)	141.7	(10)
Oct.	17.8	(27)	89.8	(12)	101.3	(15)
Nov.	11.3	(50)	37.3	(7)	57.5	(8)
Dec.	5.8	(21)	7.6	(5)	87.0	(1)
Jan./Feb. 1987	30.7	(3)	--	--	--	--
UNWEIGHTED MEAN	22.9	(196)	59.2	(70)	104.1	(68)

a. Number of fish appears in parentheses.

Larger length classes traveled farther than smaller ones in almost every month. All three size classes showed increasing values through spring and reached maximum mean distances from the Battery during the early summer through early autumn period, followed by a general decline in distances late in the year. Maximum monthly distance from the Battery for the 200-399 mm and 400-499 mm length classes were 42.2 miles and 98.8 miles, respectively, both occurring in June. The ≥500 mm size class had a maximum average distance traveled of 144.9 miles in July, slightly more than its September value of 141.7 miles. The unweighted mean distances traveled were higher for the two larger length classes than were the monthly maxima for the next smallest length class.

In order to facilitate comparison to earlier studies, correlation analyses were performed of fish length with distance traveled from point of release to point of recapture, for those fish at large two or more days and recaptured by any means. The correlations were highly significant for all recaptures ($r = 0.477$, $P < 0.0001$) and for those fish recaptured outside the Hudson River only ($r = 0.536$, $P < 0.0001$).

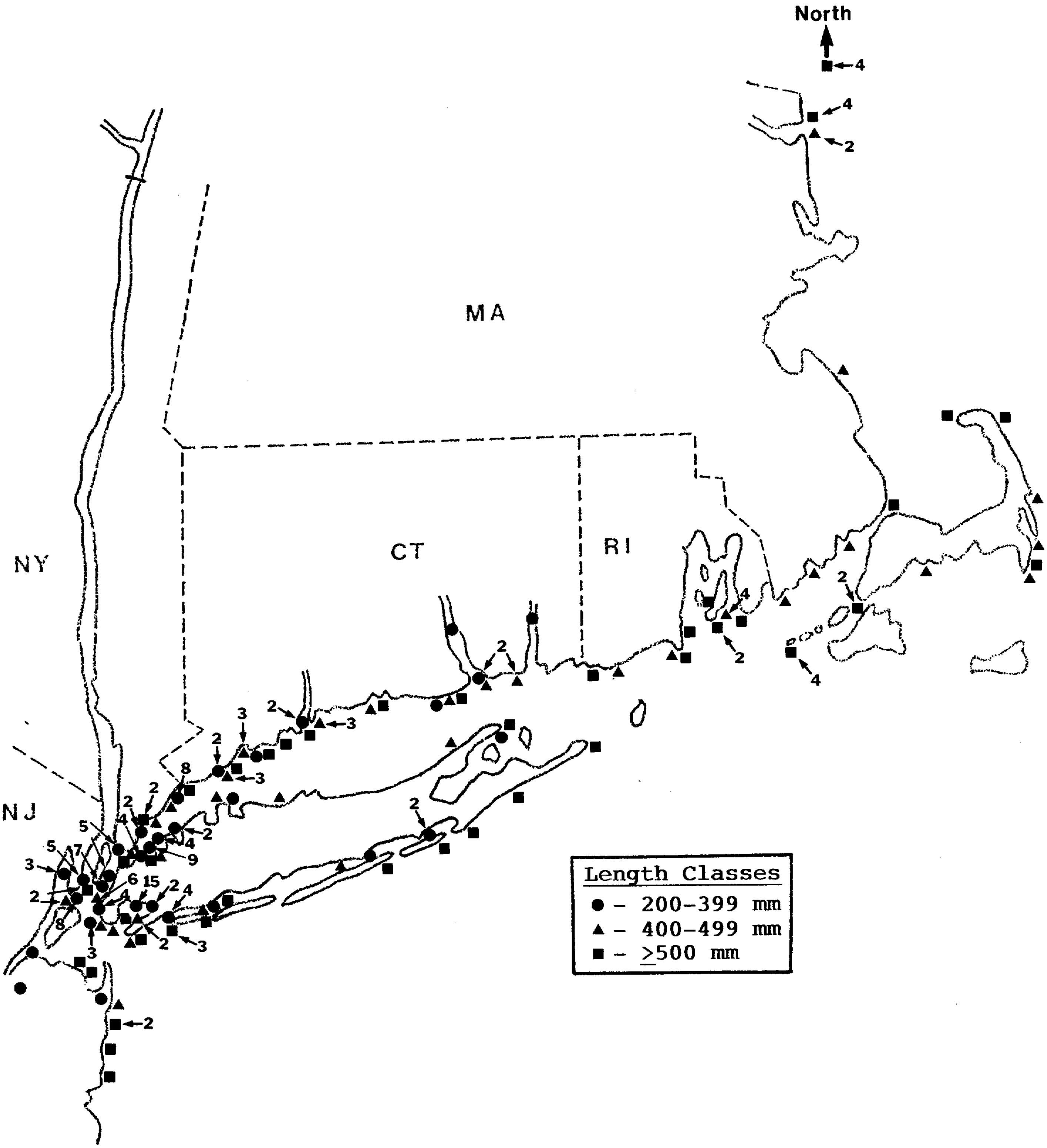

Figure 17. Distribution of coastal recaptures by length class, June through October 1986, from releases in winter 1985-1986.

5.0 DISCUSSION

5.1 Recapture Rates

5.11 Condition and Disposition of Recaptures

The percentage of fish released by anglers in good condition, by size class appeared to reflect the minimum size limits for striped bass fishing in 1986 (see Appendix I). The rate of releases in good condition for the smaller size classes was over 90%. However, for striped bass $\geq$600 mm, the percentage fell to 68.4%. A 600 mm striped bass measures 23.4 inches, which approximates the 24 inch minimum legal length for keeping striped bass that was in effect in 1986 in New Jersey and Connecticut, and the marine waters of New York prior to the moratorium on striped bass possession adopted on 8 May 1986. This region contributed the majority of tag returns. Larger minimum lengths were in effect in Rhode Island and Massachusetts and these limits may have contributed to the pattern observed.

5.2 Physical Tagging Effects

5.21 Abrasion of Information from Tags

A hypothesis is proposed to explain the pattern of significant abrasion of information from internal anchor tags seen in this study. The internal anchor tag that was used is composed of two pieces. The externally-worn vinyl tube of the tag is inserted through a perpendicularly mounted plastic tab that is retained internally in the fish. However, the vinyl tube is free to rotate in the plastic anchor. Although the tags are relatively soft and supple after manufacture, they tend to stiffen under prolonged immersion, and to develop a set curvature. This is significant because the development of a set means that within a short time after implantation, one side of the length of the tag becomes committed to a forward-facing position.

Inspection of well-abraded tags under a dissecting microscope showed a regular pattern of wear. Proceeding down the vinyl tube from the anchor along the forward face, there typically was a short region of no abrasion, followed by a region of deep scarring in a v-shaped pattern. About midway down the tube the abrasion lessened and graded instead into a finely sanded vinyl surface. Striped bass are known to occur over a variety of substrates including rock, gravel, and sand. The abrasion of the vinyl tube is consistent with a pattern of occasional contact with these bottom types, including the barnacles that occur on hard substrates. Differences in the abrasion pattern seen along the length of the tag is consistent with a decline in resistance to horizontal pressure from the proximal to the distal end of the vinyl tube. Firm resistance closer to the anchor would allow the deep scarring repeatedly seen in these tags. Lessened resistance and a more horizontal position as the tag dangles would cause finer abrasion. The tag numbers, located near the distal end of the tag, would be lost in those instances when the tag's set happened to display them in a forward position.

5.22 Fish Condition at Tag Sites

Internal anchor tags of the types used in this study produce irritation to the area of the fish's abdomen around the tagging site in approximately 25% of the fish tagged, based on fishermen's responses. About 20% of those fishermen who observed irritation characterized it as substantial. Several of these said the irritation was extreme, showing infection, sores and bleeding along with some anchor protrusion. It is possible that this reaction is largely responsible for what tag loss occurs. Use of a smaller anchor in the shortest length class, 200-299 mm did not affect the proportion of fish showing irritation around the tag insertion site, however, it is possible that the larger anchor of the tag used in fish ≥300 mm would have produced a higher incidence of irritation if it had been used in the 200-299 mm grouping.

5.3 Striped Bass Movements

5.31 Distribution of Recoveries

Based on recaptures of HRF-tagged fish, the majority of striped bass that moved out of the river traveled to the region extending from Sandy Hook, NJ to both shores of Long Island and the Connecticut and Rhode Island coastlines. A smaller but still substantial number of fish migrated farther, to the mainland and Cape Cod waters of Massachusetts and on north, or to south of Sandy Hook, NJ. Only a minor number of recoveries originated from north of Massachusetts or south of central New Jersey. There was much greater movement out of the river to regions to the north and east in comparison to the south based on the proportion of recaptures from these areas. Although most striped bass that exited the Hudson River were caught in coastal locations, many entered tributaries throughout this range and occasionally ascended them for considerable distances. Tributaries utilized included, for example, small creeks leading to Jamaica Bay, NY, the Housatonic and Connecticut rivers in Connecticut, the Pawcatuck River in Rhode Island, and the Merrimack River in Massachusetts. None of these are known to support breeding populations of striped bass, but this study demonstrates that they serve as habitat for striped bass that emigrate from other systems.

Recapture of an HRF-tagged striped bass from the Bear River, a tributary to the Bay of Fundy, Nova Scotia and one return from Maine have exceeded the documented range of northerly movement for striped bass tagged in the Hudson River. The previous record was from the Kennebec River, ME (TI 1981), although three striped bass tagged in the Bay of Fundy have been recaptured in the Hudson River (Boreman 1985). A new maximum distance traveled was also recorded for southerly movement of Hudson River striped bass with the recapture of two fish near Virginia Beach, VA at the mouth of the Chesapeake Bay. Earlier studies had provided returns from Hudson River-tagged fish from as far as Cape Charles, VA (TI 1981). The movements of the Hudson striped bass stock based on these tag recoveries resembled, with some differences, that seen during 1971-1979 and reported in McFadden (1977), TI (1980b) and McLaren et al. (1981).

Recaptures from Maine and Nova Scotia were notable in that they documented contribution by the Hudson River striped bass population to the migration to these waters of mid-Atlantic stocks that occurs in some years. Merriman (1941) and Bigelow and Schroeder (1953) noted a correlation between the presence of large numbers of striped bass in this region and high recruitment in the Chesapeake Bay, indicating that striped bass fisheries in Maine and Nova Scotia were not soley dependent on local populations.

The recapture during winter of two fish in Chesapeake Bay raises the question of their natality. Several studies have stated that striped bass from Chesapeake Bay may winter in the Hudson (Raney 1952; Vladykov and Wallace 1952; Raney et al. 1954). Little evidence has emerged to support this view beyond that from the morphological stock discrimination study by Berggren and Liebermann (1978). They concluded that there may be a small non-Hudson River stock component of striped bass that winter in the Hudson. The small size at tagging of the two Chesapeake returns (243 and 315 mm) argues against them being Chesapeake-spawned fish in that they would have left the Chesapeake at an even smaller size sometime prior to winter 1985-1986 when they were tagged. Based on growth information from Mansueti (1961) on Chesapeake Bay striped bass, they would most likely have been age-1+ when they migrated north. This is generally considered to be a premigratory age for the Chesapeake stock (Kohlenstein 1981).

February recaptures from the heated water discharge of the LILCO power plant on Long Island Sound in Northport, NY were part of an aggregation of striped bass that has wintered there annually since at least winter 1975-1976 (Young 1980). Young found that the low number of returns from limited tagging there did not provide evidence as to the stock origin of these fish, however, this study demonstrates that at least a portion of them are composed of striped bass from the Hudson River.

A segment of the striped bass population that winters in the region where tagging was performed, between river miles 0 - 36 moves upriver in springtime. Many of these travel beyond the primary spawning grounds located above the Hudson Highlands, to as far as the limit of tidewater at the Federal Dam in Troy, NY at river mile 154. The size of many of the fish that traveled north suggests they were not yet mature. Movement north was gradual, the first recaptures from north of the tagging locations beginning in early April, with many catches made in well known sportfishing locations, such as the mouth of the Croton River. Recaptures from farther north became prevalent in late April with numerous catches occurring in May and June but not afterwards at the Federal Dam. The sharp decrease in summer recaptures from the northern reaches of the tidal Hudson may reflect movement downriver or diminished fishing pressure.

5.31.1 Multiple and Multi-year Recaptures

Of the seven multiple recaptures, six were first recaptured in the Hudson River north of their initial release points. No pattern of movement emerged from the distribution of second recaptures for these fish. The distribution of the 12 third-year recaptures from the 1984 tagging was not substantially different from that seen in the two previous years, nor from the pattern of first-year recaptures in the 1985-1986 study.

5.4 Relationship of Fish Size to Movement

5.41 Fish Size vs. Distance Traveled

This study demonstrated a clear relationship between fish length and distance traveled for striped bass tagged in the Hudson River that were recaptured outside of the Hudson River. Longer length classes were found to travel significantly farther than shorter length classes. Calculation of distances traveled for individual fish from the Battery instead of from the locations where they were tagged would actually have minimized this relationship given that NAI (1986) tagged primarily smaller fish (<300 mm) in the Battery region at the mouth of the River and larger fish (>300 mm) in the Tappan Zee region upriver.

The only prior tagging study to address the relationship between fish size and movement in Hudson River striped bass was the Texas Instruments, Inc. program that marked fish from 1972 through 1979. Results from this program, though reported yearly, were summarized in four segments. Recaptures of striped bass tagged during 1972-1975 were reported by McFadden (1977), during 1976 and 1977 by McLaren et al. (1981), in 1978 in TI (1980b), and in 1979 in TI (1981). McFadden (1977) concluded that "Larger fish recaptured outside the Hudson River had a tendency to move greater distances." Analyses of recaptures from fish tagged in subsequent years provided the opposite conclusion, however. McLaren (1981) found no significant relationship between distance moved and length, or distance moved and age and sex. TI (1979) also found no correlation between length and distance traveled, and noted that McFadden's (1977) finding that there was a relationship may have been due to the relatively large numbers of very small and very large fish tagged during that part of the program and the relative paucity of intermediate sized fish. There were in fact, differences in the proportions of size classes tagged, unlike during 1976-1978 when all were >200 mm, during 1972-1975 over 60% were <200 mm. The difference between the proportions of larger size classes was mimimal though, during 1972-1975, 5.6% were >800 mm, whereas 3.2% were that large during 1976-1978. Although there clearly was a higher percentage of intermediate-sized fish tagged in the later period, that in itself does not necessarily make it a preferred data base from which to draw conclusions. Indeed, if there was a general correlation between size and distance traveled, it should have been more apparent from the greater range of size classes.

There are two hypotheses beyond changes in the proportions of the size classes sampled that might explain the differing conclusions reached regarding the relationship between size and distance traveled within different time spans of the TI tagging program. One is that the fish actually behaved differently between consecutive time periods. The other is that differences in analytical treatment were responsible for the contrasting conclusions. No evidence was found to support the former hypothesis. The general spatial pattern of tag recoveries was similar between periods. However, there were differences in analytical treatment. McFadden (1977) based his conclusion on only those recoveries made from outside the Hudson River. He found that 10 fish >800 mm averaged 343 km traveled but that 15 fish <800 mm averaged only 119 km.

McLaren et al. (1981) used another approach whereby all fish at large at least two days after release were included in a correlation analysis of fish length and distance traveled. They found no relationship between fish length and distance traveled for either of the two years included in their analysis (1976: $r = 0.13$, $P > 0.05$; 1977: $r = 0.003$, $P > 0.05$). It was not clear from the methods described in McLaren et al. (1981) whether they performed the analysis using all recaptures or only those recaptures from outside the Hudson River. Therefore, in order to make a comparison between the TI and HRF studies, correlation analyses were performed both ways on the HRF data. The two approaches each yielded a highly significant correlation ($P < 0.0001$).

The absence of a relationship between size and distance traveled in the study of McLaren et al. (1981) may have been due wholly or in part to differential retention of Dennison tags by size. Inspection of the regression of length vs. distance traveled for recoveries made in 1976 in McLaren et al. (1981) revealed that large fish, particularly those ≥800 mm were recaptured relatively close to their release points. Review of the primary data for both 1976 (in TI 1979) and 1977 (in TI 1980a) indicated low mean days at large for fish ≥800 mm; 21 and 35 days respectively. In 1976, the maximum number of days at large for this length class was 46 days; and in 1977, 90 days. These values contrast with those for the shorter length classes. For example, in 1976, 75% of the 200-399 mm fish were recaptured 50 or more days following tagging. About 63.5% of the 400-599 mm fish and 56.5% of the 600-799 mm fish were recaptured more than 49 days at large. Recovery rates vs. time for the combined 1976 and 1977 TI data sets were tested for statistical significance using the Chi^2 test. It was found that at the division between 2-49 and ≥50 days, there was no significant difference between the 200-399 mm vs. 400-599 mm size classes ($X^2 = 0.06$, $P>0.05$), but that there were significant differences between the 200-599 mm vs. 600-799 mm ($X^2 = 6.41$, $P<0.05$) and 600-799 mm vs. ≥800 mm ($X^2 = 3.94$, $P<0.05$) size classes. Identical length class comparisons did not show statistical significance at the division between 2-99 and ≥100 days, but there was a significant relationship between the 200-599 vs. ≥600 mm size classes. These comparisons are only meaningful as an indicator of relative tag retention by size if it is assumed that there is no seasonally size-selective fishing pressure in which larger striped bass are not fished for beyond mid-summer. In fact, whereas the HRF data showed a secondary peak of overall recoveries in autumn, the TI data showed statistically significant differences from the HRF recovery distribution in time with a steady dwindling of recoveries through late summer and autumn for all size classes in the TI study. This may have been due to the generally poor retention of the Dennison tags used by TI.

The lower Dennison tag retention for larger size classes may be a function of its anchor shape and insertion site. The anchor of the Dennison tag is designed to lodge behind serial osteological elements, usually the pterygiophores or the neural spines. However, it may not be advisable to employ an anchor with a finite width (in this instance, 5 mm wide) in a location on a fish that shows continuous variation with fish length. If a Dennison tag is placed between and perpendicular to the closely-spaced pterygiophores or neural spines of a small fish, it would require rotation of almost 90° before it would no longer be held by the bony elements. But in a large fish with widely-spaced elements, only a slight rotation of the anchor would leave it fastened by muscle tissue alone, a much softer medium of support.

If this hypothesis is correct, then differential tag retention by size inversely countered the tendency for larger fish to migrate farther. Recapture at distant points would have been selected against in larger fish due to greater immediate tag shedding and somewhat higher long-term shedding. Higher tag retention in smaller fish would have permitted tag recoveries from greater distances because they were retained longer. A related phenomenon was seen in the Chesapeake by Mansueti (1961). He found that striped bass tagged with Petersen discs displayed a higher tag shedding rate than those tagged with nylon streamer tags, and that this led to a higher average distance traveled for nylon streamer-tagged fish. The internal anchor tag used in the current study would not have been sensitive to fish size and, therefore, should have produced better representation of fish movements over the range of length classes tagged.

5.5 Historical Changes in Movement Patterns

5.51 Limits of Movement Suggested by Previous Hudson River Striped Bass Tagging Studies

The range of movement of the Hudson River subadult and adult stock continued to greatly surpass that reported from tagging studies conducted in the 1940's and 1950's and to a lesser extent results from the 1970's. First to suggest a boundary was Raney et al. (1954), who analyzed returns from a program conducted between 1948 and 1952 with volunteer anglers tagging striped bass over a region that included the Hudson River. Based on recaptures of striped bass originally tagged in the Hudson River, the authors suggested that the Hudson River stock limited its seasonal movements outside the river to within the region west of Fairfield, CT and Northport, NY in Long Island Sound, and to no farther east than Jones Beach on the south shore of Long Island.

Alperin (1966a) tagged striped bass in Great South Bay, somewhat east of Jones Beach, from 1956 to 1961. He estimated that only 2.4% of the age-2 through age-4 striped bass populating Great South Bay were of Hudson River origin, but noted that the percentage of Hudson River fish was markedly higher in years when migrants from southern striped bass populations were not abundant. Alperin cited the statement in Raney et al. (1954) that the Hudson River stock did "not often go further east along the south shore of Long Island than Jones Beach", and pointed out that this might have underestimated their eastern range inasmuch as tag returns from Great South Bay were unlikely given the negligible amount of fishing for striped bass there. Alperin (1966a) provided an update on the results of an earlier Hudson River tagging study by Neville (1940) in which no recaptures of striped bass were made outside the Hudson River of approximately 200 tagged fish, the great majority of which were ≤400 mm. Alperin (1966a) also reported the results of continued sporadic tagging of mainly subadult striped bass in the Hudson River beyond 1940, to 1956. The 268 fish, tagged over a broad reach of the Hudson River from Coxsackie to Piermont, provided returns from outside the river only as far east as Jamaica Bay in western Long Island.

Although not exclusively a Hudson River tagging study, the large number of fish both tagged and recaptured in the lower Hudson River and surrounding waters during 1959-1963 permitted Clark (1968) to postulate the existence of substocks of Hudson River striped bass which he referred to as contingents, that showed discrete movement patterns. Clark (1968) believed there was a Hudson Estuary contingent that wintered and spawned in the Hudson and then moved downriver to the bays to feed in summer, migrating upriver in autumn. A similar pattern of movement was described for a Hudson - West Sound contingent, which was thought instead to summer in western Long Island Sound. A third contingent of primarily larger fish, the Hudson - Atlantic contingent was believed to move into the river in spring to spawn, and then to spend the rest of the year along the Atlantic coast. Since Clark's (1968) study, no evidence has emerged to strongly support his conclusions. McFadden (1977) suggested that Clark's contingents were instead different age classes from one genetic group displaying different behavior. The greater tendency of larger striped bass to be caught outside of the Hudson River observed in this study and HRF (1985), and the size vs. distance traveled relationship seen in this study favor McFadden's (1977) conclusion.

Based on the same study as Clark (1968), Clark and Smith (1969:Figure 1) provided a map of locations of striped bass tagged outside the Hudson River that were later recaptured in River. The distribution coincided to a high degree with the limits of movement outside the river proposed by Raney et al. (1954). A tagging effort which indicated some minor movement of Hudson River fish to New England was the study by Stolte (1973). Small numbers of fish tagged off New Hampshire in 1966 produced four recoveries in the lower Hudson and New York Harbor.

5.52 Range Expansion

Comparisons between pre-1970 and post-1970 striped bass tagging studies suggest an expansion of range for the Hudson River population. The establishment of new distance traveled maxima by striped bass tagged in the Hudson River since 1984 also suggests an enlargement of range since the Texas Instruments, Inc. studies of the 1970's. It is possible, however, that the apparent changes are artifacts of changes in fishing pressure or study design.

There are two ways to evaluate changes in the range of the Hudson River striped bass stock: 1) absolute change as reflected by the extremes of movement for a given period, and 2) relative, or effective change - the proportion of the stock that travels to a given zone. The first is sensitive to the number of fish marked and not to population size. For example, if Y individuals of the population are marked and X% of the population migrates into a distant zone, then the number of marked individuals in that zone is X% of Y and is a function of the number of fish marked. Therefore, the chances of obtaining recaptures at the periphery of the population's range is dependent on the size of the tagging study, i.e., large studies are more likely to yield new records for distance traveled. Real change in range dynamics is better measured by examining the relative change within the overall range, that is, the proportion of recoveries that occur within the outer limits of that range. Use of an index of this type is probably more representative of general movements than would be the very extremes of movement recorded.

It can be seen from Appendix I that distant recaptures were virtually absent before the 1970's. The Texas Instruments, Inc. annual tagging effort during 1972-1978, which marked striped bass measuring less than 200 mm to over 1000 mm, yielded recaptures over a range that greatly exceeded that seen in earlier Hudson River tagging studies. The northern- and southern-extreme returns of the TI studies were only slightly less than those recorded in the HRF program. In order to evaluate quantitatively the apparent tendency for a portion of the Hudson stock to travel farther, a calculation based on a subjective criterion was made. It was simply, the proportion of total recaptures originating from Rhode Island waters and north and east (Appendix I). The maximum yearly proportion of recaptures from Rhode Island and north and east prior to the 1970's was 1.2% by Clark (1968), and was 0.0% for two earlier studies. In the TI studies, the recapture proportion ranged between 1.7% for 1979 and 12.3% for 1972-1975, but was no higher than 4.8% after 1975. The proportion originating from Rhode Island and north and east in the present study was 69/717 (9.6%).

Proportional analysis indicates an effective range expansion between the pre-1970 and post-1970 periods and possible expansion between the 1970's and 1980's, however, there are complicating factors that suggest alternative explanations. 1) It is possible that fishing pressure has grown substantially in recent years from Rhode Island on north, thereby resulting in a higher proportion of recaptures of Hudson River tagged striped bass in distant locations. However, while it is true that New York imposed a total moratorium for most of 1986, Rhode Island and Massachusetts, the two states that contributed the majority of distant recaptures also maintained highly restrictive regulations (Appendix II). Historically, both Rhode Island and Massachusetts have supported major striped bass fisheries, with data available as far as back as the late 1800's (Koo 1970). Given this high level of effort, it is likely that some Hudson River recoveries would have been made before the 1970's if the Hudson population in the size classes tagged utilized those waters. 2) The reduced level of Dennison tag retention in larger fish in the TI studies, discussed in section 5.41, may have caused an underestimate in the proportion of fish recaptured in the distant zone. This is because larger fish, which are more likely to travel farther, appeared to shed their tags earlier on average and hence, may not have been identifiable as marked fish when they reached distant waters. Therefore, it is possible that there is less difference than appears in the effective range between the HRF and TI studies. 3) Differences in the proportions of length classes tagged among the various Hudson River tagging studies could have influenced the results they obtained. Indeed, the pre-1970's studies tagged primarily small striped bass and these fish, with few exceptions provided returns from waters adjacent to the Hudson River. It is conceivable that at least a portion of the historical differences seen in the movements of the Hudson River striped bass population is due to the tagging of larger fish in the TI and HRF studies.

Given that differences in tag styles and in the sizes of the fish tagged may have influenced the distribution of recaptures of Hudson River striped bass over time, it is difficult to state with certainty that an effective range expansion occurred. Comparison between the smaller size classes tagged is more easily accomplished inasmuch as 1) size biases are removed, and 2) differences in tag retention between the TI and HRF studies are minimized.

5.53 Movements of Smallest Size Classes

Results from this study and complementary evidence indicate that striped bass 200-400 mm, thought through the 1950's and 1960's not to leave the Hudson River, now do so in substantial numbers. Once worthy of a note, was the occurrence in 1964 of yearling fish in the bays of Long Island's south shore (Alperin 1966b). Recently, however, Young (1982) found yearlings in increasing numbers during 1979-1981 in eastern Long Island, as far as Montauk Harbor. Matthiessen (1986) provided anecdotal accounts of numerous small striped bass in pound net catches from the same region in the early 1980's. Regular migration of primarily age-2 striped bass into the Massachusetts waters of the Connecticut River has been observed by Kynard and Warner (1987) from 1979 to the present. This river does not support a spawning population of striped bass and it is likely given the predominantly small size of these fish that they are largely or totally of Hudson River origin, an opinion supported by mitochondrial DNA analysis of Connecticut River specimens (Wirgin 1987). The recapture near Orient, NY of five fish measuring 253-290 mm at tagging in the current study, and many fish <400 mm as far as Rhode Island lend support to the concept that a substantial portion of the Hudson River population of 200-400 mm striped bass, though not as migratory as larger size classes now appears to undertake significant seasonal migrations.

The historical differences seen in the movement patterns for Hudson River striped bass stem from two sources. One, is that it was not always recognized that there are behavioral differences among age and size classes of striped bass and that to ascribe a certain behavior to the entire stock based on study of a relatively small portion of the age spectrum was unjustified. The second is that there has been demonstrable variation in the range dynamics of the Hudson River striped bass population through time. Although extrapolation of the results of the early studies to larger size classes was not warranted, their findings can be justifiably compared for the same size classes now being studied. It is clear from this comparison that the presence on the coast of small striped bass of Hudson River origin, once considered noteworthy, may now be commonplace.

5.54 Evidence for an Influence of Stock Size on Range Dynamics

The increase in range of the <400 mm size class and possibly larger size classes of the Hudson striped bass stock is most probably related to fluctuations in its population size and the population size of the seasonally sympatric Chesapeake striped bass stock. Young (1980) noted a relationship between the presence of age-1+ and -2+ striped bass in western Long Island Sound and larger juvenile indices for those year classes. There is an absence of information for year class success in the Hudson prior to the initiation of an annual juvenile sampling regimen began in 1969, however, the presence of dominant year classes in the Chesapeake Bay have been noted for decades. Merriman (1941) observed an expansion of summer range of these dominant year classes. Whereas average recruitment resulted in migration about as far as southern Massachusetts, in 1937 when the highly dominant 1934 year class reached three years old, striped bass appeared in great numbers north of Cape Cod. More recently, Kriete et al. (1978) found that during years of average abundance only an insignificant portion of age-2 striped bass leave Chesapeake Bay, but that in years of exceptional abundance a greater percentage of age-2 fish joined the offshore migration. It is likely that generally high annual recruitment, the sharply lessened exploitation as the result of restrictive regulations, and a still unknown contribution from hatchery fish have led to an increase in the size of the Hudson River striped bass stock, reflected in its range dynamics.

Beyond any tendency towards range expansion that may occur as a function of increased population size, movements of Hudson fish may be influenced by the currently minimal size of the Chesapeake stock. Predomination by Chesapeake striped bass in the surf zone of southeastern Long Island was noted by Schaefer (1968) through tagging studies during 1961-1963 following the production of the dominant 1958 year class. Only one of 67 tag recoveries was made from the Hudson estuary from this tagging period. In contrast, 14 of 50 returns came from Hudson River or New York Harbor waters from tagging conducted from 1954-1956, indicating a stronger Hudson River component is possible (although also subject to its own year class variation) in coastal waters during those periods of lessened Chesapeake production. There has not been a dominant year class produced in the Chesapeake system since 1970 (Boreman and Austin 1985).

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Appendix 1.

Previous Hudson River or Hudson Estuary Striped Bass Tagging Studies

Study	Years Tagged	Number Tagged in Hudson	Percent Recov'd	Sizes Tagged	Tags Used	Proportion Recov'd east & north of Rhode Island
Alperin (1966a) (contination from study first reported by Neville 1940)	1940-1956	504	16.2	150-940mm	P,J	0.0
Raney et al. (1954)	1948-1952	N	N	150-610mm FL[1]	P	0.0
Clark (1968)	1959-1963	1697[2]	4.8	125-710mm	P	1.2
McFadden (1977)	1972-1975	1793	3.6	<200->1000mm TL	D	12.3
McLaren et al. (1981)	1976	2406	6.4[3]	>200->800mm TL	D	3.2[3]
	1977	2813	11.8[4]	>200->800mm TL	D	3.9[4]
TI (1980b)	1978	3566	15.8[5]	≥300->800mm TL	D	4.8[5]
TI (1981)	1979	2463	11.8[6]	>200->800mm TL	D	1.7[6]
Young (1980)	1973-1978	7536	2.5	80-245mm FL	D,C	0.5
HRF (1985, 1986)	1984	736	9.0	300-1064mm TL	I,D	6.1
Present study	1985-1986	18510	3.9	200->800mm TL	I	9.6

Tag legend: P-Petersen Disc, J-Jaw Ring, D-Dennison, C-Carlin, I-Internal Anchor

Footnotes:

1 Size range for all Hudson River and non-Hudson River tagged fish.

2 Includes Upper and Lower NY harbors and Jamaica Bay, few tagged north of Battery.

3,5,6 First year recoveries only.

4 First year recoveries only; calculated from TI (1980a).

Appendix II.

Striped Bass Fishing Regulations

Tag return rates are directly related to fishing pressure. Fishing pressure is to some degree dependent on the regulations that limit a fishery. Because regulations governing striped bass fishing in the Northeast have been so dynamic in the mid-1980's due to attempts to preserve the Chesapeake stock and to limit consumption of PCB contaminated Hudson River striped bass, a brief summary from Speir (1986) is provided of the regulations in effect in 1986 in those states where the great majority of tag returns originated: New York, New Jersey, Connecticut, Rhode Island, and Massachusetts.

New York*

A. Tidal Hudson River from Troy Dam to George Washington Bridge

minimum size limit	- 18" TL
creel limit	- none
seasons	- closed 1 December - 15 March
methods	- capture of striped bass with seines, hoop nets, fykes or trawls prohibited. Gill nets with mesh sizes >3.5" and <5" cannot be used 15 March - 15 June. Only drift nets can be used in spawning area 15 March - 15 June.
disposition of catch	- may not be sold
commercial fishing license	- $100 resident, $200 non-resident

B. Marine Waters

minimum size limit	- 24" TL
creel limit	- two fish daily
seasons	- closed season 1 December - 7 May
methods	- usual fishing methods
disposition of catch	- May be sold if licensed. May not be sold in New York from 1 January - 7 May.
commercial fishing license	- $100 resident, $200 non-resident

*Emergency regulations, adopted on 8 May 1986, placed a moratorium on the possession of striped bass in New York State due to PCB contamination. Prior to these changes, on 6 November 1983 the minimum size limit for striped bass increased from 16" FL for all New York waters to 18" TL for the Hudson River and 24" TL for the Marine District.

New Jersey

minimum size limit	- 24" TL
creel limit	- 5 per day
seasons	- open season 1 March - 31 December
methods	- hook and line, and underwater spearfishing. Netting is illegal.
disposition of catch	- no sale of fish less than 24" TL regardless of state of origin
commercial fishing license	- not required to sell fish. Commercial gears are licensed.

Connecticut

minimum size limit	- 24" FL
creel limit	- none
seasons	- closed season 15 December - 15 April
methods	- angling only, have gamefish status
disposition of catch	- may not be sold if caught in State waters. Out of state striped bass must be 33" FL to be sold in Connecticut.
commercial fishing license	- not applicable

Rhode Island

minimum size limit	- 33" TL
creel limit	- One per day for sport fishermen.
seasons	- Floating fish traps prohibited between 1 October - 31 October and 31 December - 1 March; gill nets prohibited 1 October - 31 October.
methods	- generally all methods.
disposition of catch	- may not be sold due to PCB contamination
commercial fishing license	- required to operate floating fish traps, gill nets, and trawls. Special $25 license for hook and line fishermen allows sale of catch.

Massachusetts

minimum size limit	- 30" TL effective 1 June 1986
creel limit	- for sport fishermen, one per day, possession limit of one.
season	- commercial season open 1 June - 30 September
methods	- hook and line only
disposition of catch	- May be sold with $10 fishery permit.
commercial fishing license	- license required to sell catches exceeding 100 lbs. plus 1 fish daily; fee - $25 for rod and reel only. Sale of any amount of striped bass requires additional $10 fishery permit.

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Comments by Aug 12.

Use of the Optical Pattern Recognition System in the 1986-87 Hudson River Striped Bass Hatchery Evaluation Study

Draft Report
June 29, 1987

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Table of Contents

1.0 Introduction

This draft report describes the methods and results obtained by using the BioSonics Optical Pattern Recognition System to analyze and classify striped bass scales as per the objectives of the 1986-87 Hudson River Striped Bass Hatchery Evaluation.

1.1 Study Objectives and Experimental Design

There were three basic objectives for this study: aging, hatchery contribution, and stock identification. The objectives were to be accomplished by analyzing quantitative data collected from striped bass scales with BioSonics' Optical Pattern Recognition System (OPRS). Normandeau Associates, Inc. (Normandeau) provided these scales and selected the experimental design. Each objective has unique elements and is discussed separately in the following sections. The experimental designs are discussed as they relate to the sampling theory and statistical inference capabilities of sorting processes.

1.1.1 Objective I - aging

Aging is not a simple process. Experienced age readers use a variety of complex criteria to assign an age to an individual striped bass. The procedure is subjective and easy to criticize because the procedure is rarely repeatable when applied to a representative sample from the population. Thus, it would appear reasonable to initiate a study to determine whether an entirely objective procedure is sufficiently accurate to complement or replace the subjective method. The primary goal would be to effectively eliminate the variability within and among age readers. The stated objective was to:

Parameterize the optical pattern recognition system (OPRS) for age determination using scale samples from age 0+, 1+, 2+ and 3+ striped bass caught in the Hudson River.

Task five also imposed an implicit objective that required the procedure to be efficient as well as effective:

> *If it is determined by NAI that the OPRS is more reliable and cost effective compared to conventional aging techniques for age determination of age 0+, 1+, 2+ and 3+ striped bass caught in the Hudson River, BioSonics, Inc. will be required to determine the age of up to 5,000 uncleaned scale samples (acetate impressions) obtained by NAI during the 1986-87 Hudson River Striped Bass Hatchery Evaluation Program.*

Thus, BioSonics would have to use highly efficient data acquisition procedures to collect quantitative data for the purposes of aging. Any procedure that would result in less throughput than is currently realized by the traditional subjective process was not considered.

These objectives were not entirely consistent with the state-of-the-art for aging striped bass. The traditional aging process for striped bass apparently suffers from many of same weaknesses that are prevalent throughout the fisheries profession. A thorough discussion of these weaknesses is given by Beamish and McFarlane (1983) and a recap is not appropriate; however, certain violated assumptions make it difficult to integrate an objective or indirect aging procedure into the aging process. These weaknesses need elucidation.

Beamish and McFarlane (1983) standardize some important terminology: "*Validation* means proving a technique is *accurate*. *Accuracy* can be proven or estimated; estimates of accuracy are less valuable, but in some cases only an estimate is possible. *Precision* relates to reproducibility and is not a measure of accuracy. The degree of agreement among readers is a measure of the precision of the determinations and not the accuracy of the technique." This has some important implications for the aging of striped bass in general and the objectives of this study in particular.

To properly parameterize the OPRS it is necessary to have a set of standards. Ideally, the standards should be a *representative subsample* from the population at large for which the ages have been *validated*. That is, the ages should be known absolutely. The standards provided for this study could be aged subjectively with a high level of *precision*; however, the standards were not a *representative sample*. It was clear from the aging workshop that there was considerable disagreement on the ages of individual striped bass from the older age classes (2+ and 3+). Thus the *precision* reflected by the standards was contrived for these groups and has not been measured: only individual striped bass scales for which there was agreement were used to comprise the standards. Moreover, it is clear that an estimate of *accuracy* is unavailable for the subjective aging process. It is assumed that the traditional process is sufficiently accurate to provide for management decision making. This is probably true for age 0+ and 1+ striped bass, but is highly unlikely for age 2+ and age 3+ fish. While we are not aware of the specific management decisions being made, it can be argued that there are severe problems for the older age groups that must not be ignored. It would be appropriate to have an estimate of the accuracy of the traditional aging process as a starting point for evaluating alternative procedures such as those investigated here, or to group the older age classes so that the requirement of precision and accuracy for the standards are met.

Since the standards used to parameterize have not been assessed for either accuracy *or* precision, the estimated elements of the classification array obtained by parameterizing the OPRS are biased. Because the standards were selected to reflect an artificially high level of precision the classification array would most likely *overestimate* the accuracy of the OPRS for age 2+ and 3+ fish *relative to the population at large.* It is likely that precision is very high (close to 100%) for the OPRS, and results from the analysis of duplicated samples should verify this. It is not possible to compare the traditional and automated aging techniques for the older age groups without measures of precision and accuracy for the traditional techniques.

1.1.2 Objective II - Hatchery-Wild Discrimination.

The standards provided to parameterize the OPRS for discrimination of wild from hatchery fish were taken from several areas and time periods within the Hudson River. There were no problems with either accuracy or precision in establishing the standards; however, representative sampling may not have been accomplished because the sample coverage was extended to obtain individuals for the test sample. This means that the standards were not representative of the population, and that the test samples are actually a test of the system's ability to extrapolate to future time periods.

Only size independent scale parameters should be used if inferences are to be extrapolated outside of the sampled time periods and areas. This study did not investigate size independence; however, statistically significant differences in classification between the standards and the test group would provide provisional evidence that size dependent scale features are a problem that can only be circumvented by sampling in proportion to abundance throughout the study areas and time periods and conducting size invariant discrimination.

1.1.3 Objective III - Stock Identification.

The standards provided to discriminate between Hudson River and non-Hudson River striped bass were taken from the Hudson, Delaware, and James Rivers. There were no problems with either accuracy or precision in establishing the standards; however, representative sampling was not accomplished for the non-Hudson standard. This was expected, and the effect may be minimal provided that the Delaware and James River stocks sufficiently represent the scale patterns of stocks produced from more southerly rivers. If this were not the case, then mixing proportion estimates applied to unknown samples would be biased towards the Hudson River component.

2.0 Methods

This section summarizes the methods used for evaluating Hudson River striped bass scales using the BioSonics Optical Pattern Recognition System (OPRS). More detailed explanations of some procedures may be found in the OPRS Data Acquisition Manual v. 1.08 and the 5-1-87 draft manual: "Standard Operating Procedures for OPRS Aging of Hudson River Striped Bass".

Methods are presented for all three study objectives:

Objective I: Classify striped bass scales by age class (0+, 1+, 2+, 3+).
Objective II: Classify striped bass scales as wild or hatchery spawned.
Objective III: Classify striped bass scales by Hudson or non-Hudson origin.

2.1 Scale Selection

Slides with scales, or acetate impressions of scales, were provided to BioSonics by Normandeau. For each slide of cleaned, dry-mounted scales, the OPRS operator selected the best scale according to the following subjective criteria:

a). Virtually perfect left/right (dorsal/ventral) symmetry. Whole scale appears bright, sharp and clean.

b). Good. Almost symmetrical with no spotting, smudges or excessive darkness.

c). Acceptable. Clearly asymmetrical but otherwise in good condition as described for quality-b. For collecting single line luminance data for Objective I, scales that were almost symmetrical but contained spots, smudges or excessive darkness in area of widely-spaced circuli were also rated quality-c.

d). Poor. Very severely asymmetrical and/or widely spaced circuli.

e). Unuseable.

All cleaned, dry-mounted scales were rated quality b, c or d. The quality ratings were appended to the data records using the Spec ID text identifier. Uncleaned dry-mounted scales and acetate impression were rated in a similar manner but more emphasis was put on the effect of occlusions on the ability to resolve circuli. Quality codes for uncleaned, dry-mounted scales and impressions ranged from b to e.

2.2 Data Acquisition

The OPRS was used in a standard configuration for all three study objectives. Scales mounted on slides, or acetate impressions of scales, were placed under a microscope fitted with a video camera and 1X, 2X or 4X lens objectives. The output of the video camera was fed to a Matrox frame grabber installed in a Compaq microcomputer loaded with the OPRS Data Acquisition Program v. 1.08.

To facilitate data acquisition, command sequences ("macros") were pre-programmed so that most steps in the OPRS program could be carried out automatically, stopping only for those actions requiring manual input for the user. The following table summarizes the study objectives, types of data collected, types of data analyzed, and the macros used. The macros are fully documented in Appendix A.

Study Objective	Data Types Collected	Data Types Analyzed	Macros Used
I. Aging	SLL	Fourier transforms of SLL	1
II. Hatchery	SLL	---	1
& Wild	RAD	Intercirculi distances	2
	SHAPE	---	3
	FD1	---	4
	FD2	---	5
III. Hudson &	SLL	---	1
non-Hudson	RAD	Intercirculi distances	2
	SHAPE	---	3
	FD1	Fourier shape descriptors	1,4
	FD2	---	5

(SLL = single line luminance, RAD = radial distance, SHAPE = shape measurement, FD1 = Fourier Descriptor 1, FD2 = Fourier Descriptor 2)

For each objective/data type, data from known scales were saved to various designated files. Data from unknown scales, or impressions, were saved to different files. Each data record within a file was uniquely identified by three text identifiers.

2.2.1 Single Line Luminance (SLL) Data Collection

For aging striped bass scales, SLL data was collected along a line where the widely-spaced circuli are well-defined. In general, this line ran from the focus to the edge of the scale along the scale's dorsal ventral axis (Figure 2-1). To standardize data collection as much as possible, it was decided to draw the SLL data line at 30 deg. counterclockwise from a reference line drawn through the "transition zone" between the widely-spaced circuli (dorsal lateral field) and closely-spaced circuli (anterior field). This method was chosen because this transition zone is a convenient scale feature that can be consistently and reliably identified across all age groups.

The procedure for collecting SLL data is fully documented in the Standard Operating Procedures 5-1-87 draft manual.

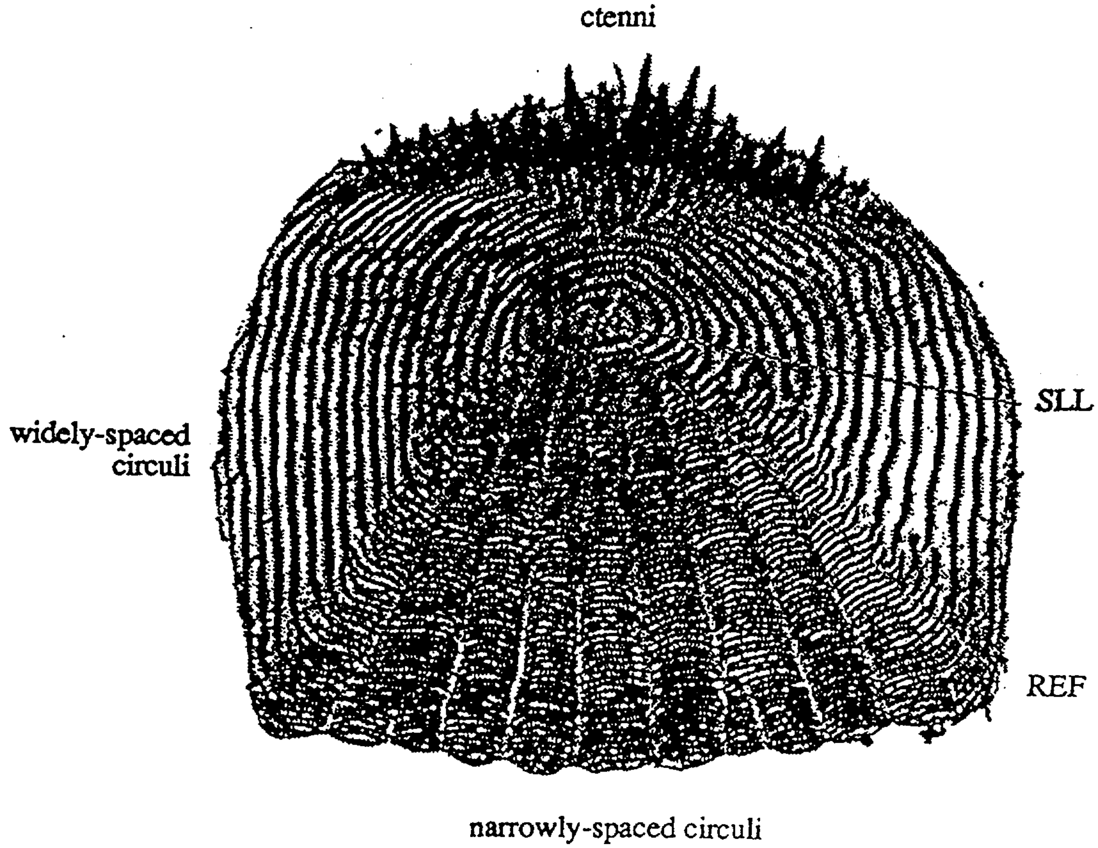
The SLL data saved to file were luminance values (L(x)) vs. distance in sampling units. Luminance values ranged from 0 (absolute black) to 255 (absolute white). Sampling units are discussed in Appendix B.

After all data had been saved to a particular SLL file (either known or unknown scales), the data were converted to an equivalent representation as a discrete Fourier transform. The conversion was accomplished by a fast Fourier transform (FFT) algorithm accessed through the OPRS Editing page. A more complete discussion of the FFT conversion and Fourier analysis can be found in Appendix A of the Standard Operating Procedures 5-1-87 draft manual.

2.2.2 Radial Distance (RAD) Data Collection

Radial distance data for Objectives II and III were collected along a line drawn exactly as described above for SLL data, except that for Objective II the angle between the reference line and radial distance extraction line was 45 deg. instead of 30 deg. The RAD operation inserted markers along the line at luminance minima corresponding to circuli. Before saving data to file, the operator inspected this line on screen to make sure that all circuli were properly marked. Some circuli may be improperly marked because the luminance-minimum criterion was based on an operator-set smoothing function for a typical scale. If a circulus was clearly visible to the eye but missed by

Figure 2-1. Hudson River striped bass scale (Age 0+, quality b) showing luminance extraction line (SLL) drawn at 30° counterclockwise from reference line (REF) drawn through transition from widely-spaced to narrowly-spaced circuli. All scales, or impressions, were displayed on video monitor with ctenni pointed up.



the OPRS program, then the operator manually added minima markers at those points. The operator could also could also delete markers at "false minima."

Data saved to RAD files were distances in sampling units from the starting point (scale's focus) to each marker. These data were then converted to distances between successive circuli using the OPRS data analysis software package. The resulting inter-circuli distances were then used for the subsequent analysis.

2.2.3 Shape Data Collection

For Objectives II and III, the boundary tracing function of the Shape sub-window on the MOR page was used to trace the scale's perimeter. This perimeter, or "shape," was then operated on using the FD1 and FD2 operators as described below. The starting and ending point for tracing the shape was at the same point where the reference line met the edge. The data collected using the SHAPE sub-window were saved to file, but not analyzed further at this time. These data were: perimeter length, area, circularity and rectangularity.

To obtain a clear and unambiguous boundary, macro sequence #3 first reduced the image to pure blacks (0) and whites (255) using a binary threshold function to alter the video input lookup table (see OPRS manual). Boundary tracing was then performed using a combination of automatic and manual tracing modes.

2.2.4 Fourier Descriptor 1 (FD1) Data Collection

The FD1 procedure can be used to analyze any shape that can be described as a single valued function about a single point (centroid). A striped bass scale fits these criteria. The coordinates of the centroid are defined as the mean x and mean y values of all points on the boundary.

Upon selecting "Normalize Coefficients" and "Perform FD1" after the shape has been traced, a radius vector extending from the centroid rotates counterclockwise around the shape at equal angular increments. This angular increment equals 360/FD Size. For Objectives II and III, the FD size was 128 so that the angular increment was 2.81 deg.. The radius R at each angular increment q was recorded resulting in a graphic output of radii outputs vs. angular input, or R(q). The function R(q) was graphed on screen, and these data were converted by an FFT to an equivalent Fourier representation similar in principle to that described above for SLL data. The macro then selected "Graph FFT" so that a periodigram showing the magnitudes of the Fourier coefficients appeared on screen. (See Standard Operating Procedures, 5-1-87 draft manual.)

2.2.5 Fourier Descriptors 2 (FD2) Data Collection

The FD2 data were collected essentially the same as the FD1 data. These data were not analyzed for this report.

2.3 Data Analysis.

The data acquisition module of the OPRS provides a considerable amount of data on each individual striped bass scale. From these data it is necessary to select a subset of variables that maximizes interclass variability and minimizes intraclass variability so that classification accuracy is optimized. There is no direct algorithm to accomplish this; however, descriptive statistics and interactive discriminant analysis provide an effective and efficient approach.

2.3.1 Feature Selection.

In practice, feature selection was accomplished iteratively. Each potential discriminating variable was subjected to an ANOVA to examine the variability among classes. The distributions were also plotted as notched box and whisker plots to elucidate differences among classes (Cook, 1987). Since the F-statistic is only vaguely related to accuracy in discriminant analysis, various combinations of variables were used until a point of diminishing returns was realized.

2.3.2 Discriminant Analysis.

Discriminant analysis was conducted with the direct density estimation procedure of Cook (1982) modified for the assumptions of the linear discriminant function (Cook, 1987). Classification arrays (Cook, 1978) were used to tabulate the results of the discriminant analyses. These statistically unbiased estimates of the accuracy of the discriminant functions were obtained with the leaving-one-out procedure (Cook, 1982; Lachenbruch, 1967).

Appraisals of the applicability of the discriminant functions were based upon the results of published simulation studies (Cook, 1983). Further appraisals to evaluate potential sampling bias were conducted by applying the discriminant functions to separate test samples (the unknowns cited in this report.)

These test samples were not required to test for accuracy of the discriminant analyses (the leaving-one-out procedure is sufficient for this). They were intended to quantify the effects of any potential bias induced by sampling the standards differently than sampling the mixed population at large. That is, differences in the classification results of the test samples that are significantly different than predicted by the results obtained by the training samples by applying the variance formulation of Pella and Robertson (1979) are most likely due to sampling bias. Of course, this is not true if the test sample is not a representative sample of the mixed population (the target population for application of the discriminant analysis). Conclusions were tempered where this was not the case, and recommendations reflect the implications of any potential sampling bias that might be encountered in practical application of the discriminant analysis.

3.0 Results and Discussion

3.1 Objective I - Aging

3.1.1 Task 2: Parameterizing system

The OPRS system was parameterized using both cleaned, dry-mounted scales, and acetate impressions of uncleaned scales. For the cleaned, dry-mounted scales, examination of FFT periodigrams indicated that Fourier component numbers 1 through 10, and 35 through 45, showed potential for discriminating between age classes. Analysis of variance (ANOVA) was used to test for significant differences in component magnitudes between age classes. Fish lengths were also tested. Fish lengths and Fourier component number 2, 3, 4, 5, 43, and 45 showed the most variance between age classes and the least variance within classes (Figures 3-1 to 3-7, Table 3-1)

Table 3-1. ANOVA results for Objective I: parameterizing system with cleaned, dry-mounted scales.

			Factor level means			
Variable	F-statistic	Sig. Level	0+	1+	2+	3+
Fish length	999.9	$P < .00001$	85	232	328	397
FFT #2	406.1	$P < .00001$	9	100	180	214
FFT #3	185.5	$P < .00001$	17	58	87	108
FFT #4	44.5	$P < .00001$	22.4	43.6	44.8	58.3
FFT #5	12.4	$P < .00001$	25.0	33.2	34.0	40.1
FFT #43	16.7	$P < .00001$	8.0	12.5	12.8	14.6
FFT #45	15.3	$P < .00001$	8.4	11.7	13.5	14.5

FIGURE 3-1 Notched Box and Whisker plot of fish length (mm) versus fish age.

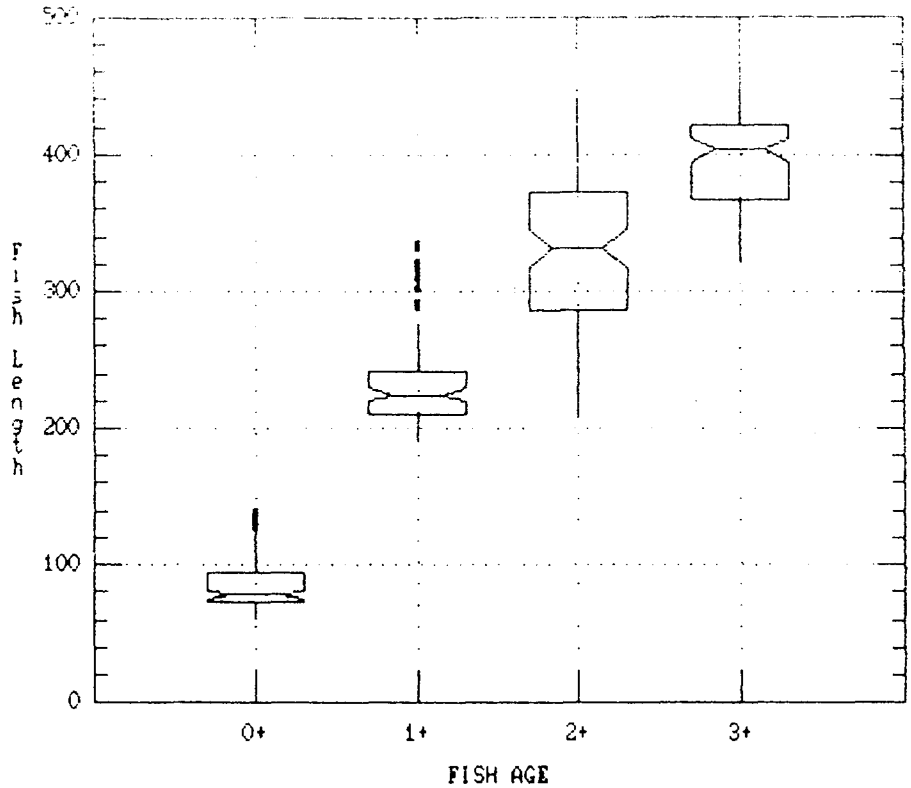


FIGURE 3-2 Notched Box and Whisker plot of FFT component #2 versus age class.

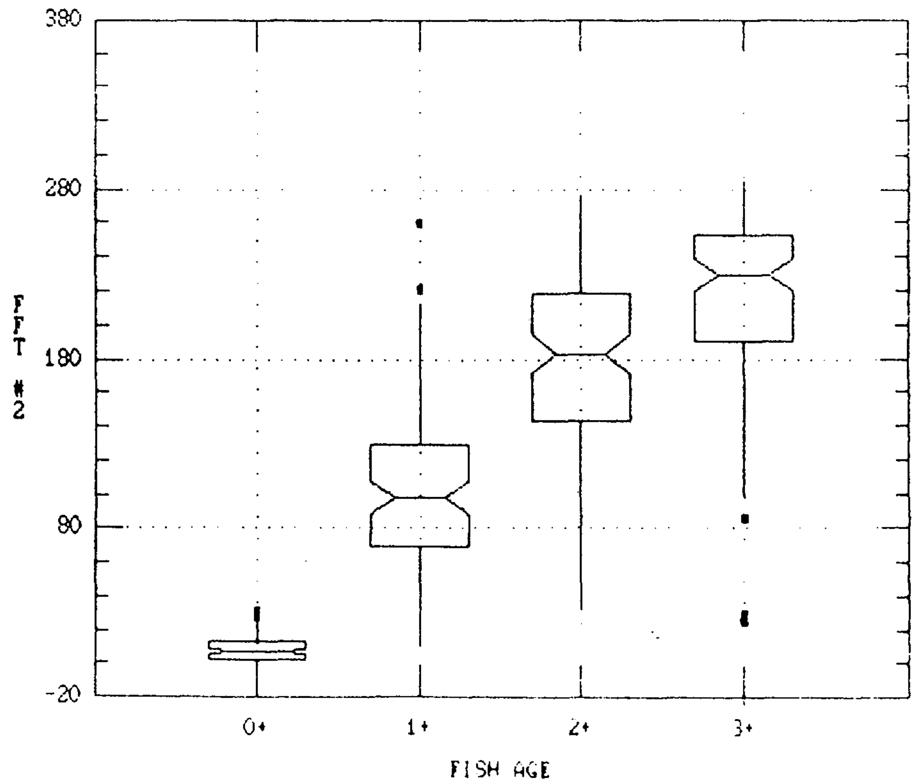


FIGURE 3-3 Notched Box and Whisker plot of FFT component #3 versus age class.

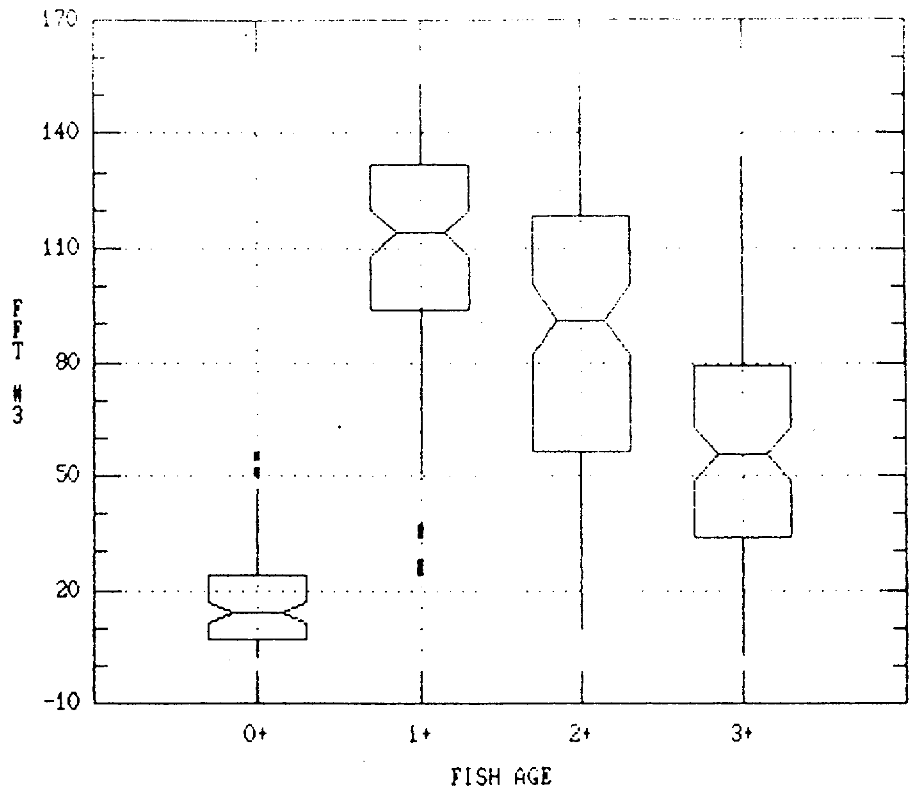


FIGURE 3-4 Notched Box and Whisker plot of FFT component #4 versus age class.

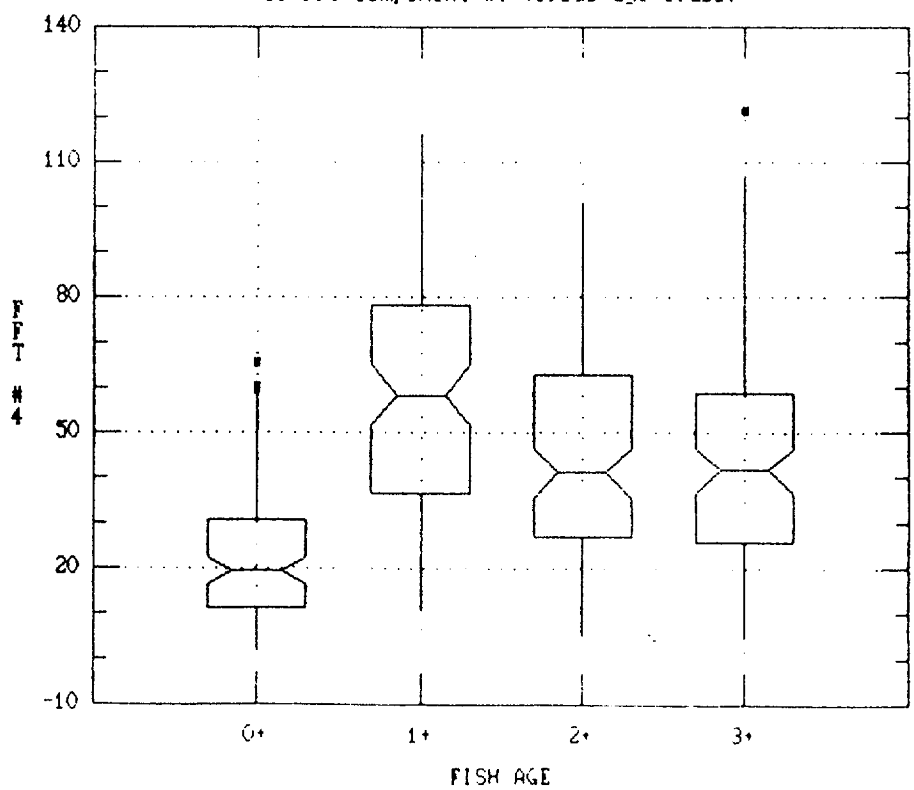


FIGURE 3-5 Notched Box and Whisker plot of FFT component #5 versus age class.

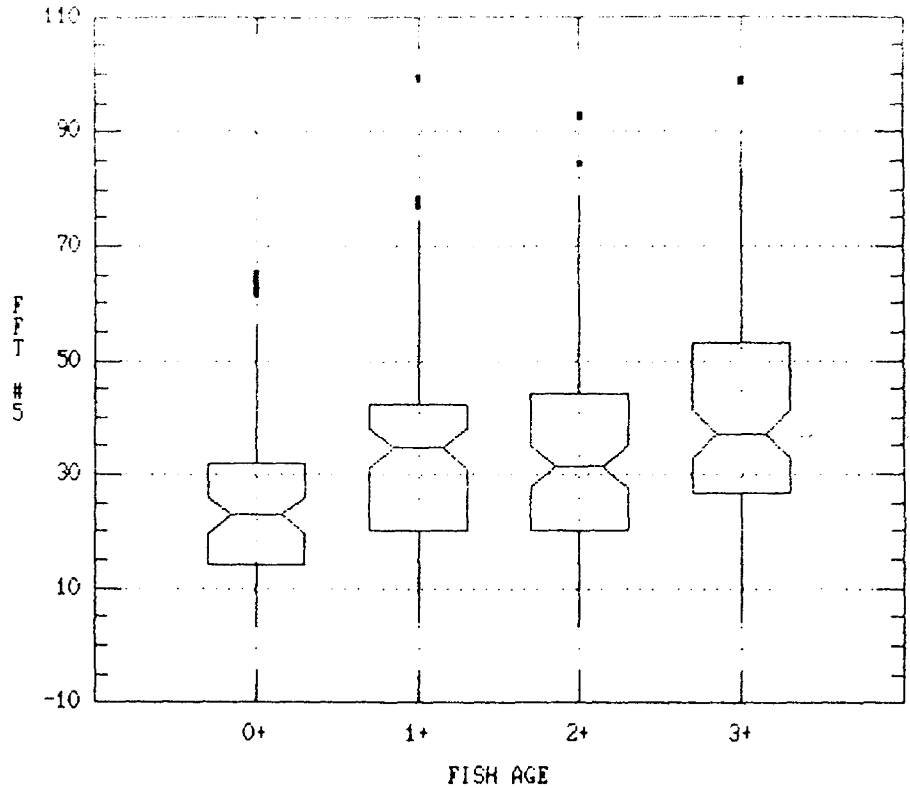


FIGURE 3-6 Notched Box and Whisker plot of FFT component #43 versus age class.

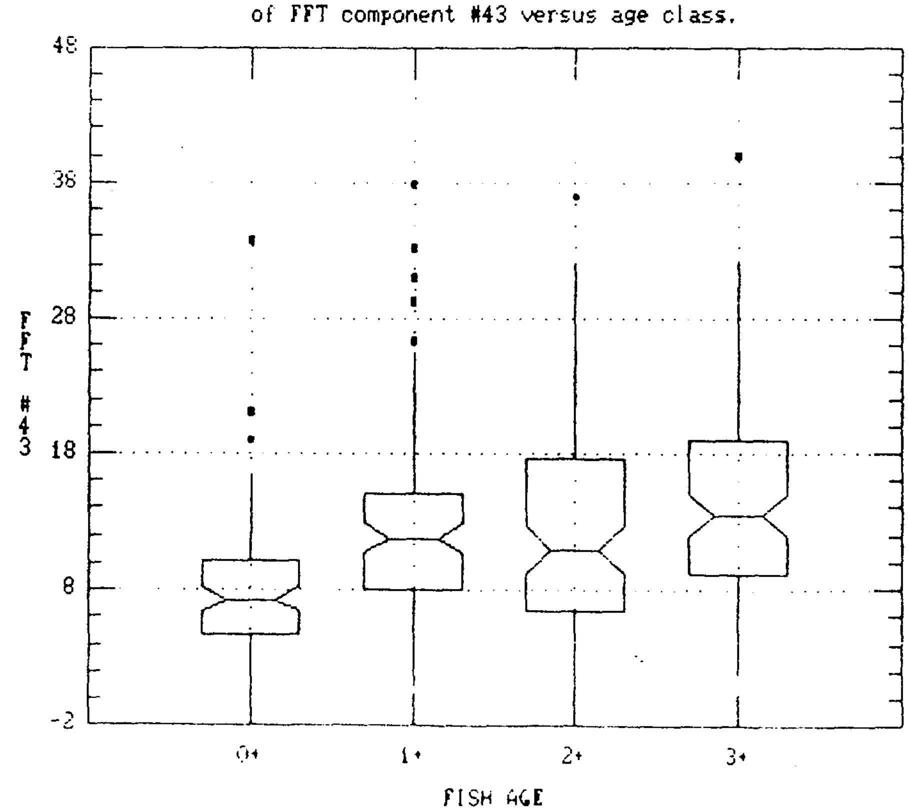
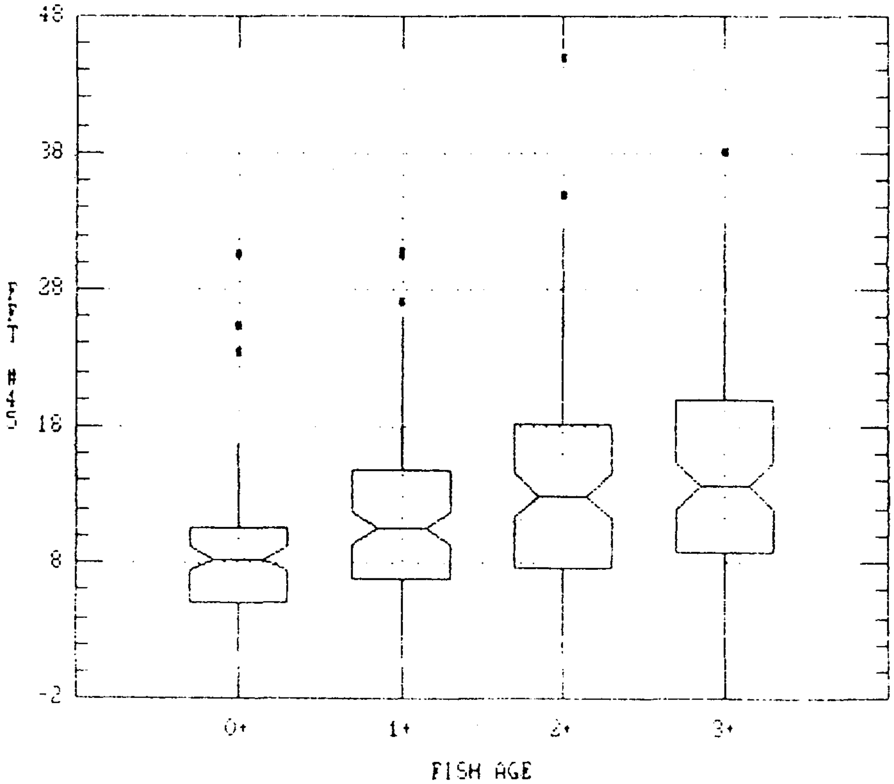


FIGURE 3-7 Notched Box and Whisker plot of FFT component #45 versus age classes.



The age assignments resulting from applying these variables to the known age scales is shown in Table 3-2. All 0+ scales were correctly aged. 92 of 100 age 1+ scales were correctly aged, 1 was incorrectly assigned to age 0+, and 7 were incorrectly assigned to age 2+. 54 of 100 age 2+ scales were correctly aged, 16 were incorrectly assigned to age 1+, and 30 were incorrectly assigned to age 3+. 80 of 100 age 3+ scales were correctly aged, and 20 were incorrectly assigned to age 2+.

Table 3-2. Numbers of cleaned, dry-mounted known age scales assigned to age classes using cleaned, dry-mounted scales to parameterize the OPRS.

To	From			
	0+	1+	2+	3+
0+	100	1	0	0
1+	0	92	16	0
2+	0	7	54	20
3+	0	0	30	80

For the acetate impressions of uncleaned scales, fish length, scale radius length, and sums of two groups of Fourier components produced the best discrimination results (Figures 3-8 to 3-11, Table 3-3). FFT component numbers 2, 3, 6, 12, 13, 14, 16, 21, 24, 29, and 39 were summed for FFT group 1, and components 3, 9, 23, 28, and 40 were summed for FFT group 2. To obtain acetate impressions of 0+ age scales, we randomly selected 50 slides from the acetate slides provided to us as unknowns for Objective II, Task 3. Since we had no fish length information for these slides, we synthesized a fish length value for each scale by adding or subtracting a random deviation to/from the average fish length (85 mm) of the 0+ age class.

FIGURE 3-8 Notched box and whisker plot of fish length (mm) versus fish age.

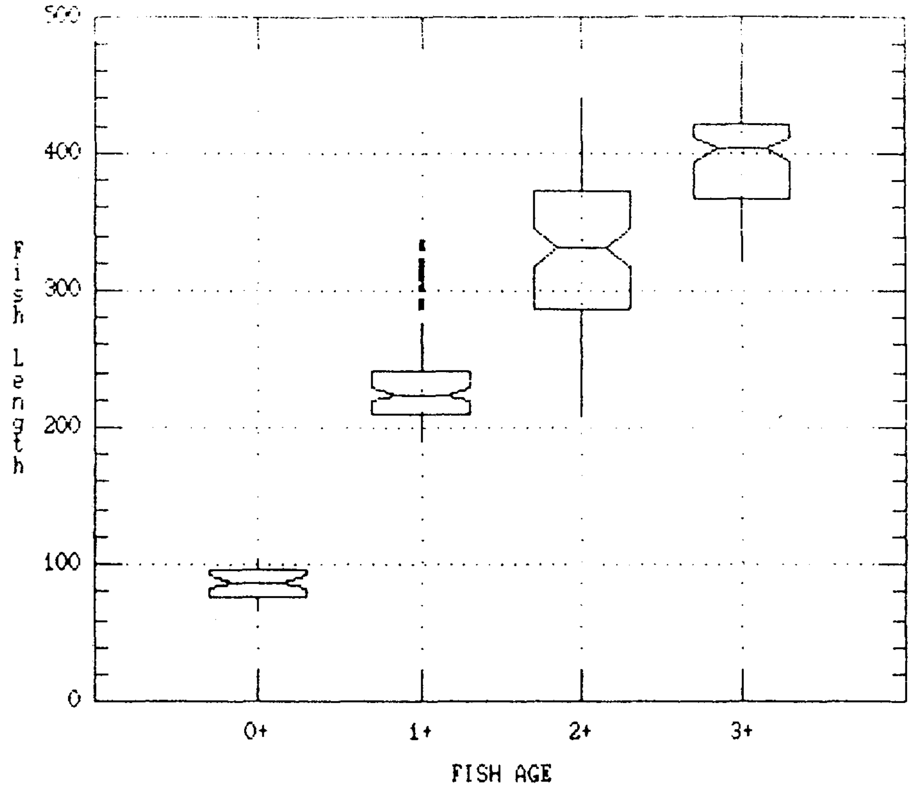


FIGURE 3-9 Notched box and whisker plot of single line radius length (m) vs.age.

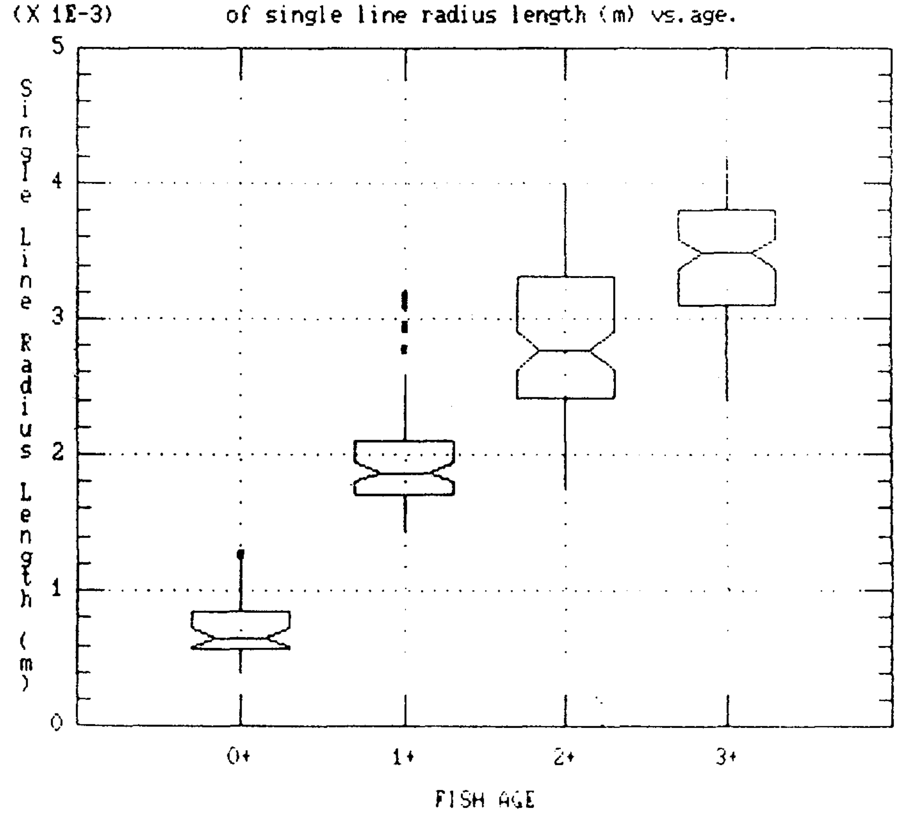


FIGURE3-10 Notched box and whisker plot of FFT component sums #1 versus fish age

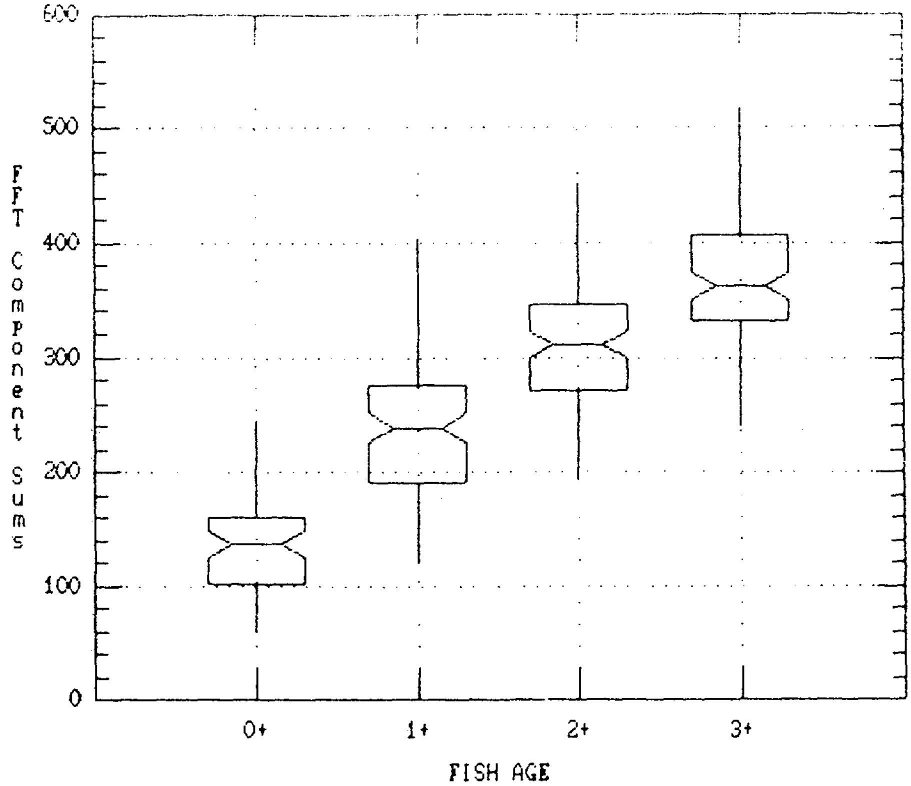


FIGURE3-11 Notched box and whisker plot of FFT component sums #2 versus fish age

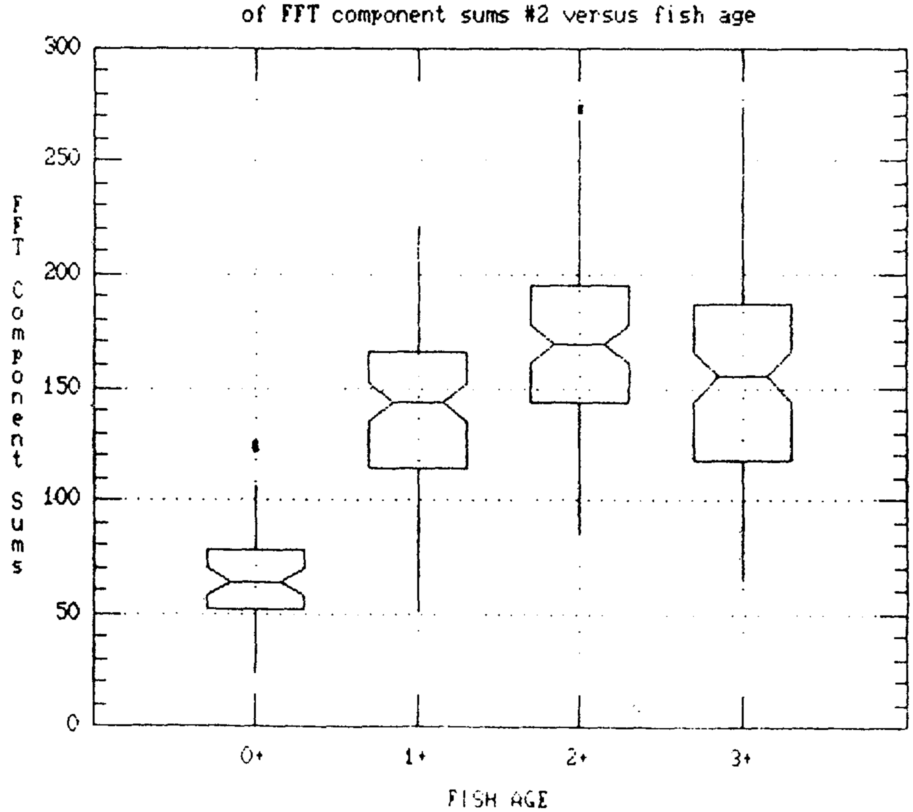


Table 3-3. ANOVA results for Objective I: parameterizing system with acetate impressions of uncleaned scales.

Variable	F-statistic	Sig. Level	0+	1+	2+	3+
			Factor level means			
Fish length	800	P < .00001	87	232	328	397
Radius length	484	P < .00001	7e-4	20e-4	28e-4	34e-4
FFT sums #1	241	P < .00001	136	239	312	368
FFT sums #2	87	P < .00001	66	141	155	170

The age assignments resulting from applying these variables to the known age scales is shown in Table 3.4. All 0+ scales were correctly aged. 90 of 100 age 1+ scales were correctly aged, and 10 were incorrectly assigned to age 2+. 61 of 100 age 2+ scales were correctly aged, 15 were incorrectly assigned to age 1+, and 23 were incorrectly assigned to age 3+. 82 of 100 age 3+ scales were correctly aged, and 18 were incorrectly assigned to age 2+.

Table 3-4. Numbers of cleaned, dry-mounted known age scales assigned to age classes using acetate impressions to parameterize the OPRS.

To	From 0+	1+	2+	3+
0+	50	0	0	0
1+	0	90	15	0
2+	0	10	61	18
3+	0	0	23	82

3.1.2 Task 3: Aging unknown cleaned glass slides

The system parameterized with cleaned, dry-mounted scales was used to assign ages to 200 scales of unknown (to BioSonics) age that had been cleaned and dry-mounted on glass slides. The OPRS Pattern Recognition software report describing the proportion of scales assigned to each age class is shown in Table 3-5, and the age assignments for individual scales is shown in Table 3-6. When OPRS age assignments were compared to Normandeau age assignments, there was 100% agreement on age 0+ scales, 90% agreement on age 1+ scales, 69% agreement on age 2+ scales, and 67% agreement on age 3+ scales. When 51 scales for which there were disagreements in age assignments between Normandeau and the New York Department of Environmental Conservation (Regions 1 and 3) were removed from the unknown test set, agreement increased to 73% for age 2+ and 68% for age 3+.

Results quantifying the precision of the OPRS age assignments by comparison of duplicate scale slides have not yet been received.

Table 3-5. Proportions of unknown age scales assigned to age classes.

```
THE A PRIORI PROBABILITIES ARE:
0.250
0.250
0.250
0.250

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 200

THE CLASSIFICATION ARRAY IS:
 100   1   0   0
   0  92  16   0
   0   7  54  20
   0   0  30  80

THE ESTIMATED CLASSIFICATION MATRIX IS:
  1.000  0.010  0.000  0.000
  0.000  0.920  0.160  0.000
  0.000  0.070  0.540  0.200
  0.000  0.000  0.300  0.800

THE NATURAL ESTIMATE IS:
0.160 Proportion AGE0+
0.290 Proportion AGE1+
0.300 Proportion AGE2+
0.250 Proportion AGE3+

THE NEARLY UNBIASED ESTIMATE IS:
0.158 Proportion AGE0+
0.232 Proportion AGE1+
0.476 Proportion AGE2+
0.134 Proportion AGE3+

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.092 0.223 Lower and Upper Bounds for AGE0+
 0.108 0.357 Lower and Upper Bounds for AGE1+
 0.214 0.737 Lower and Upper Bounds for AGE2+
 0.000 0.329 Lower and Upper Bounds for AGE3+

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.115 0.200 Lower and Upper Bounds for AGE0+
 0.151 0.314 Lower and Upper Bounds for AGE1+
 0.304 0.647 Lower and Upper Bounds for AGE2+
 0.006 0.262 Lower and Upper Bounds for AGE3+
```

Table 3-6. Individual scale age assignments for cleaned, dry-mounted scales.

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-1-404	1-b	8.3E-018	1.3E-004	1.9E-002	1.5E-002	AGE2+
hr1-1-406	1-b	5.3E-033	2.1E-013	5.7E-009	3.5E-007	AGE3+
hr1-1-409	1-b	1.7E-022	2.6E-008	1.2E-004	3.2E-003	AGE3+
hr1-1-412	2-c	5.7E-005	5.7E-004	3.6E-006	8.7E-009	AGE1+
hr1-1-414	1-b	1.0E-018	1.2E-004	1.4E-001	9.2E-002	AGE2+
hr1-1-417	1-b	5.8E-008	1.0E-002	2.2E-004	5.8E-007	AGE1+
hr1-12-422	1-b	1.8E-009	3.4E-002	3.6E-004	1.2E-006	AGE1+
hr1-12-424	2-b	4.7E-021	2.0E-007	4.4E-004	9.6E-003	AGE3+
hr1-12-433	1-b	2.2E-015	1.8E-005	2.2E-002	4.1E-002	AGE3+
hr1-12-434	1-b	8.6E-015	1.1E-004	4.0E-002	2.9E-002	AGE2+
hr1-1-440	2-b	1.6E-014	1.5E-003	1.2E-001	1.2E-002	AGE2+
hr1-1-441	2-b	9.2E-010	4.7E-002	2.6E-004	9.5E-008	AGE1+
hr1-1-442	1-b	4.5E-013	9.5E-005	8.8E-003	4.2E-003	AGE2+
hr1-1-450	2-b	3.7E-018	3.3E-004	4.5E-002	2.7E-002	AGE2+
hr1-1-452	2-b	1.3E-022	2.8E-009	3.3E-004	2.0E-002	AGE3+
hr1-1-454	1-b	4.7E-007	3.0E-002	3.3E-005	3.5E-008	AGE1+
hr1-1-457	1-b	7.5E-014	1.3E-002	2.8E-003	2.4E-006	AGE1+
hr1-12-466	1-b	3.2E-014	3.9E-006	2.7E-005	6.7E-006	AGE2+
hr1-1-470	1-b	7.2E-005	1.4E-003	5.5E-008	5.4E-012	AGE1+
hr1-12-471	2-b	2.9E-018	8.7E-005	8.8E-002	4.1E-001	AGE3+
hr1-1-474	2-b	1.3E-008	3.0E-001	1.4E-002	1.6E-005	AGE1+
hr1-1-477	1-b	3.0E-015	7.6E-003	4.1E-002	2.6E-004	AGE2+
hr1-12-481	2-b	1.3E-027	3.4E-008	3.8E-004	4.7E-003	AGE3+
hr1-12-483	1-b	3.0E-028	1.5E-008	4.1E-004	4.7E-003	AGE3+
hr1-12-485	1-b	2.5E-021	5.4E-007	8.8E-003	6.1E-002	AGE3+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-12-491	1-b	4.2E-012	1.2E-002	3.6E-002	3.5E-004	AGE2+
hr1-12-492	1-b	2.7E-020	4.0E-007	9.4E-004	3.3E-003	AGE3+
hr1-12-496	1-b	5.0E-018	7.3E-006	3.0E-002	2.0E-001	AGE3+
hr1-1-500	1-b	1.7E-025	2.0E-009	2.6E-004	4.3E-002	AGE3+
hr1-1-505	1-b	6.1E-013	3.5E-002	6.7E-003	4.0E-005	AGE1+
hr1-1-507	1-b	5.2E-013	1.1E-001	5.0E-002	7.0E-004	AGE1+
hr1-1-512	2-b	3.0E-024	7.1E-008	2.0E-003	3.7E-002	AGE3+
hr1-1-517	2-b	8.5E-014	1.1E-002	4.4E-002	9.5E-004	AGE2+
hr1-12-520	2-b	1.0E-025	1.6E-006	5.5E-003	2.2E-002	AGE3+
hr1-12-521	2-b	1.3E-019	1.2E-006	9.9E-003	8.0E-002	AGE3+
hr1-12-524	1-b	4.1E-025	8.3E-008	3.8E-004	5.1E-003	AGE3+
hr1-12-526	2-b	2.2E-009	3.5E-001	4.5E-003	2.2E-006	AGE1+
hr1-12-527	1-b	2.3E-021	5.2E-005	7.3E-002	1.5E-001	AGE3+
hr1-12-529	1-b	1.4E-019	7.4E-005	9.7E-002	2.6E-001	AGE3+
hr1-12-533	2-b	2.8E-019	2.4E-005	4.2E-002	2.8E-002	AGE2+
hr1-12-536	1-b	2.5E-016	1.2E-003	1.3E-001	2.1E-002	AGE2+
hr1-12-547	1-b	3.2E-007	1.6E-001	2.3E-003	5.9E-006	AGE1+
hr1-1-554	1-b	1.8E-013	2.0E-001	2.2E-002	4.8E-005	AGE1+
hr1-1-558	2-b	3.3E-013	4.0E-002	8.6E-002	6.7E-004	AGE2+
hr1-1-568	2-b	1.1E-017	1.1E-003	1.2E-001	1.1E-002	AGE2+
hr1-12-575	1-b	9.5E-011	7.1E-002	6.7E-002	3.5E-004	AGE1+
hr1-12-580	1-b	4.5E-014	1.0E-002	1.5E-001	5.3E-003	AGE2+
hr1-1-584	1-b	2.3E-012	2.0E-002	2.5E-004	5.9E-007	AGE1+
hr1-1-586	1-c	3.0E-011	3.6E-001	1.4E-002	1.9E-005	AGE1+
hr1-1-587	1-b	9.3E-019	2.6E-005	1.5E-002	5.5E-003	AGE2+

Table 3-6 continued

[illegible]

Site #	Drainage Code	Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-1-588	2-b	1.3E-002	8.5E-007	4.7E-011	9.4E-015	AGE0+
hr1-1-590	2-b	3.1E-016	4.7E-005	4.6E-002	1.0E-001	AGE3+
hr1-1-591	1-b	7.4E-017	1.2E-002	3.6E-001	2.2E-002	AGE2+
hr1-1-593	1-b	1.4E-015	9.7E-005	2.4E-002	4.7E-003	AGE2+
hr1-1-594	1-b	8.4E-015	5.0E-003	3.1E-002	6.4E-004	AGE2+
hr1-1-595	1-b	2.3E-016	1.6E-002	7.4E-002	1.4E-003	AGE2+
hr1-1-596	1-b	3.5E-016	2.1E-003	1.6E-003	2.7E-005	AGE1+
hr1-1-597	2-c	5.3E-013	7.7E-003	7.2E-003	1.5E-004	AGE1+
hr1-1-599	1-b	3.5E-017	4.3E-003	2.7E-001	2.5E-002	AGE2+
hr1-1-603	2-b	7.1E-013	1.9E-005	4.1E-003	3.5E-003	AGE2+
hr1-1-604	2-b	1.1E-014	4.0E-004	9.8E-002	7.6E-002	AGE2+
hr1-1-606	2-b	7.0E-028	3.5E-009	3.2E-004	1.8E-002	AGE3+
hr1-1-609	1-b	1.5E-014	1.0E-001	2.7E-001	8.3E-003	AGE2+
hr1-1-610	1-b	1.6E-021	3.5E-007	6.1E-006	1.3E-005	AGE3+
hr1-1-611	2-b	1.2E-015	2.4E-003	4.8E-001	1.8E-001	AGE2+
hr1-1-614	2-b	1.2E-018	2.1E-004	4.1E-003	3.8E-004	AGE2+
hr1-1-615	2-b	1.7E-027	8.9E-011	5.3E-007	7.2E-005	AGE3+
hr1-1-616	1-b	4.9E-017	2.8E-002	1.7E-001	9.2E-003	AGE2+
hr1-1-617	2-b	1.3E-022	3.5E-010	4.9E-005	6.3E-003	AGE3+
hr1-1-618	2-b	3.5E-013	1.1E-003	3.2E-003	2.5E-004	AGE2+
hr1-1-619	1-b	9.8E-014	9.4E-003	2.6E-001	1.7E-002	AGE2+
hr1-1-620	2-b	5.3E-004	8.5E-006	3.2E-010	1.9E-014	AGE0+
hr1-1-624	1-b	1.3E-017	1.2E-003	1.9E-002	2.9E-003	AGE2+
hr1-1-634	1-b	8.8E-012	3.3E-002	2.0E-002	7.6E-005	AGE1+
hr1-1-635	1-b	2.6E-010	1.5E-003	1.7E-004	6.1E-006	AGE1+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-1-642	1-b	1.5E-017	7.1E-003	6.7E-002	8.6E-003	AGE2+
hr1-1-640	1-b	7.7E-013	6.2E-002	3.9E-001	1.4E-002	AGE2+
hr1-1-650	2-b	3.2E-015	5.2E-003	6.6E-003	6.4E-005	AGE2+
hr1-1-651	2-b	6.6E-012	2.2E-002	2.4E-002	1.5E-004	AGE2+
hr1-1-652	1-b	1.8E-015	6.3E-004	7.4E-004	2.1E-005	AGE2+
hr1-1-653	2-b	5.9E-016	6.7E-004	3.3E-003	1.3E-004	AGE2+
hr1-1-656	2-b	1.0E-009	1.8E-001	8.9E-003	1.9E-005	AGE1+
hr1-1-658	2-b	9.2E-015	1.4E-003	1.5E-001	2.3E-002	AGE2+
hr1-1-659	1-b	1.1E-012	3.3E-002	2.8E-002	2.9E-004	AGE1+
hr1-1-661	1-b	2.1E-009	4.9E-002	6.6E-005	1.0E-008	AGE1+
hr1-1-663	1-b	1.3E-013	6.8E-003	2.2E-001	3.8E-002	AGE2+
hr1-1-665	2-b	2.2E-004	7.7E-005	1.8E-009	1.2E-013	AGE0+
hr1-1-666	2-b	8.4E-004	2.0E-005	7.1E-010	8.9E-014	AGE0+
hr1-1-668	1-b	8.5E-014	2.1E-003	2.0E-002	3.2E-004	AGE2+
hr1-1-669	2-b	1.1E-008	8.8E-004	2.4E-006	4.7E-010	AGE1+
hr1-1-670	1-b	1.1E-009	2.0E-001	3.6E-003	5.8E-006	AGE1+
hr1-1-671	1-b	1.1E-007	5.8E-005	3.4E-006	5.3E-008	AGE1+
hr1-1-672	2-b	4.8E-011	9.4E-002	1.4E-002	9.9E-005	AGE1+
hr1-1-674	1-b	3.0E-017	2.1E-002	1.7E-001	5.1E-003	AGE2+
hr1-1-675	2-b	4.0E-014	3.0E-003	7.5E-002	2.8E-003	AGE2+
hr1-1-676	1-b	4.2E-015	2.9E-004	8.5E-003	3.4E-003	AGE2+
hr1-1-679	2-b	7.6E-012	3.1E-002	2.3E-001	8.8E-003	AGE2+
hr1-1-680	1-b	2.4E-002	4.5E-005	6.4E-009	1.2E-012	AGE0+
hr1-1-681	1-b	1.5E-005	1.4E-003	5.9E-008	2.7E-012	AGE1+
hr1-1-682	1-b	2.0E-004	3.0E-004	8.3E-007	8.9E-010	AGE1+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-1-684	2-b	1.9E-017	2.2E-004	3.4E-004	1.0E-005	AGE2+
hr1-1-689	2-b	4.0E-010	2.9E-002	6.2E-003	1.3E-005	AGE1+
hr1-2-703	1-b	1.4E-021	3.4E-006	3.0E-002	1.2E-001	AGE3+
hr1-2-705	1-b	1.2E-023	1.2E-007	4.2E-004	7.3E-003	AGE3+
hr1-2-720	2-b	2.8E-023	5.9E-007	1.7E-003	6.4E-003	AGE3+
hr1-2-721	2-b	5.0E-022	4.4E-007	4.3E-003	2.4E-002	AGE3+
hr1-2-704	2-b	3.7E-012	2.2E-003	4.4E-002	1.5E-002	AGE2+
hr1-1-1011	2-b	7.3E-009	1.7E-001	8.0E-004	2.3E-007	AGE1+
hr1-1-1012	1-b	3.2E-006	1.9E-001	1.2E-004	2.5E-008	AGE1+
hr1-1-1013	2-c	6.0E-006	1.1E-001	1.4E-004	4.1E-008	AGE1+
hr1-1-1020	1-c	3.4E-008	3.0E-004	1.0E-007	9.3E-011	AGE1+
hr1-1-1021	1-b	1.3E-006	7.3E-002	6.7E-005	1.8E-008	AGE1+
hr1-1-1022	1-b	5.6E-007	3.9E-002	3.5E-005	1.3E-008	AGE1+
hr1-1-1023	1-b	1.7E-004	6.8E-003	8.0E-006	5.2E-009	AGE1+
hr1-1-1024	1-b	3.6E-006	7.4E-002	4.7E-005	8.6E-009	AGE1+
hr1-1-1025	1-b	6.2E-006	4.7E-002	7.7E-005	6.8E-008	AGE1+
hr1-1-1026	1-c	4.8E-011	8.6E-002	1.0E-003	3.6E-007	AGE1+
hr1-1-1027	1-b	1.4E-009	1.7E-001	1.7E-003	1.4E-006	AGE1+
hr1-1-1028	1-c	1.2E-005	4.7E-002	9.7E-005	9.0E-008	AGE1+
hr1-1-1029	1-c	6.1E-003	7.2E-006	6.3E-009	5.8E-012	AGE0+
hr1-3-1030	1-b	4.5E-001	4.7E-009	7.5E-014	3.8E-018	AGE0+
hr1-3-1031	1-b	1.8E-002	2.0E-005	1.4E-010	4.1E-015	AGE0+
hr1-3-1032	2-b	6.3E-001	6.4E-009	3.6E-014	7.0E-019	AGE0+
hr1-3-1033	2-b	1.1E-002	4.1E-005	3.2E-010	1.3E-014	AGE0+
hr1-3-1034	2-b	4.7E-002	1.6E-006	2.7E-011	2.1E-015	AGE0+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-3-1035	1-b	2.0E-001	4.8E-009	1.7E-013	1.0E-017	AGE0+
hr1-3-1036	2-b	1.6E-001	1.0E-006	8.4E-012	2.1E-016	AGE0+
hr1-3-1038	1-b	1.5E-002	1.0E-004	8.7E-010	2.4E-014	AGE0+
hr1-1-1039	1-c	3.0E-001	3.3E-009	8.5E-014	5.5E-018	AGE0+
hr1-2-1040	1-b	1.0E-001	8.5E-010	3.4E-014	2.2E-018	AGE0+
hr1-2-1041	1-b	2.7E-001	3.1E-006	1.0E-010	1.1E-014	AGE0+
hr1-2-1042	1-b	3.2E-002	1.5E-004	4.4E-009	4.5E-013	AGE0+
hr1-2-1043	1-b	8.9E-004	6.4E-005	4.6E-009	2.4E-013	AGE0+
hr1-2-1044	2-b	7.1E-001	8.4E-011	9.0E-017	5.5E-022	AGE0+
hr1-2-1045	1-b	5.0E-001	1.1E-007	2.2E-013	2.6E-018	AGE0+
hr1-2-1046	1-b	1.0E-002	8.6E-006	2.7E-010	1.6E-014	AGE0+
hr1-2-1048	1-c	2.4E-003	1.8E-006	3.1E-011	2.9E-015	AGE0+
hr1-2-1050	1-c	1.6E-001	1.0E-007	4.1E-012	3.0E-016	AGE0+
hr1-2-1051	1-c	2.0E-002	2.3E-006	6.2E-011	6.0E-015	AGE0+
hr1-2-1052	2-c	7.7E-002	5.3E-008	5.8E-012	8.8E-016	AGE0+
hr1-2-1053	1-b	9.5E-005	6.9E-006	3.3E-010	4.3E-014	AGE0+
hr1-2-1054	2-b	9.8E-002	1.2E-005	7.7E-010	1.8E-013	AGE0+
hr1-2-1055	2-b	7.3E-004	3.1E-007	6.3E-012	1.3E-015	AGE0+
hr1-2-1056	2-c	1.2E-017	7.4E-005	6.3E-002	1.0E-001	AGE3+
hr1-2-1057	2-b	2.5E-015	3.2E-003	2.5E-001	1.3E-001	AGE2+
hr1-3-1058	2-b	1.5E-018	3.6E-007	3.3E-003	7.7E-002	AGE3+
hr1-3-1060	2-b	2.8E-015	8.6E-005	2.3E-002	6.4E-002	AGE3+
hr1-3-1061	1-b	8.8E-021	3.8E-006	3.1E-002	3.2E-001	AGE3+
hr1-3-1062	2-c	4.3E-019	9.1E-005	9.9E-002	1.9E-001	AGE3+
hr1-3-1063	1-c	6.0E-025	8.7E-008	3.1E-003	3.1E-002	AGE3+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-2-1064	1-b	2.1E-014	3.6E-005	2.4E-003	2.0E-003	AGE2+
hr1-2-1065	2-b	5.9E-018	5.6E-007	2.6E-003	4.3E-002	AGE3+
hr1-2-1066	1-b	2.3E-018	1.2E-006	1.3E-003	1.7E-002	AGE3+
hr1-2-1067	2-b	1.0E-021	4.1E-006	5.0E-003	1.0E-002	AGE3+
hr1-2-1068	2-b	5.0E-016	6.9E-005	1.6E-002	6.2E-003	AGE2+
hr1-3-1069	1-b	8.5E-022	1.4E-006	5.7E-003	1.1E-002	AGE3+
hr1-3-1070	2-b	2.7E-017	1.5E-007	6.2E-005	4.5E-005	AGE2+
hr1-2-1071	1-b	4.5E-021	4.5E-007	1.4E-005	9.2E-006	AGE2+
hr1-2-1072	2-b	4.4E-023	2.8E-008	1.2E-004	4.5E-003	AGE3+
hr1-2-1073	1-b	5.5E-015	8.2E-005	2.1E-002	2.7E-002	AGE3+
hr1-2-1074	1-b	6.9E-019	3.9E-006	5.0E-003	1.5E-002	AGE3+
hr1-2-1076	1-b	1.8E-018	4.1E-006	9.0E-004	9.7E-004	AGE3+
hr1-2-1077	2-b	3.8E-014	1.7E-005	2.4E-003	4.9E-003	AGE3+
hr1-1-1078	1-b	4.6E-010	8.4E-002	3.1E-003	2.1E-006	AGE1+
hr1-1-1079	1-b	1.0E-007	1.2E-001	1.5E-003	1.6E-006	AGE1+
hr1-1-1080	1-c	8.9E-004	2.4E-004	6.2E-007	1.5E-009	AGE0+
hr1-1-1081	2-b	8.7E-009	1.3E-001	4.4E-004	2.1E-007	AGE1+
hr1-1-1082	2-b	9.9E-009	6.6E-002	1.2E-004	2.3E-008	AGE1+
hr1-1-1083	2-b	1.3E-006	5.7E-002	9.8E-004	4.8E-006	AGE1+
hr1-1-1084	2-b	8.2E-010	4.4E-002	1.3E-003	6.2E-007	AGE1+
hr1-1-1085	2-b	1.3E-008	2.2E-002	2.2E-005	2.7E-009	AGE1+
hr1-1-1086	2-b	2.3E-007	4.7E-002	5.2E-005	5.8E-009	AGE1+
hr1-1-1087	2-b	2.9E-007	7.3E-002	8.7E-005	2.1E-008	AGE1+
hr1-1-1088	1-c	4.4E-004	2.7E-004	9.0E-007	1.6E-009	AGE0+
hr1-1-1089	2-c	1.3E-009	4.5E-003	6.6E-005	1.0E-007	AGE1+

Table 3-6 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
hr1-1-1090	2-c	2.7E-012	5.1E-002	2.6E-004	1.3E-007	AGE1+
hr1-1-1091	2-b	2.3E-006	7.7E-002	7.9E-005	5.9E-008	AGE1+
hr1-1-1092	1-b	5.7E-005	7.0E-004	2.8E-007	1.6E-010	AGE1+
hr1-1-1093	2-c	2.6E-003	6.7E-005	4.2E-008	6.7E-011	AGE0+
hr1-1-1094	1-c	6.6E-006	1.2E-002	4.9E-006	2.9E-009	AGE1+
hr1-1-1095	2-b	5.0E-015	1.3E-003	2.0E-002	6.2E-003	AGE2+
hr1-1-1096	2-b	1.9E-013	2.5E-002	3.1E-001	1.5E-002	AGE2+
hr1-1-1097	1-b	1.5E-015	1.0E-002	8.2E-002	4.2E-003	AGE2+
hr1-1-1098	2-b	1.6E-009	1.3E-001	7.7E-003	4.1E-005	AGE1+
hr1-1-1099	2-b	1.6E-016	1.1E-003	2.5E-002	7.3E-003	AGE2+
hr1-1-1100	2-c	2.4E-014	7.9E-002	9.9E-002	1.7E-003	AGE2+
hr1-1-1101	1-b	4.8E-012	5.0E-002	4.4E-002	2.9E-003	AGE1+
hr1-2-1102	1-b	9.3E-017	1.3E-003	3.3E-002	2.4E-003	AGE2+
hr1-2-1103	2-b	1.6E-024	6.2E-007	2.6E-003	1.1E-002	AGE3+
hr1-2-1104	1-b	3.6E-018	1.5E-006	1.4E-002	1.3E-001	AGE3+
hr1-3-1105	1-b	1.4E-018	6.5E-005	4.8E-002	3.0E-002	AGE2+
hr1-2-1106	2-b	2.6E-021	6.6E-004	4.1E-002	8.5E-003	AGE2+
hr1-2-1107	1-b	1.7E-017	2.0E-005	4.7E-003	2.2E-002	AGE3+
hr1-2-1108	2-b	5.0E-018	6.4E-006	4.6E-003	4.7E-002	AGE3+
hr1-2-1109	1-c	2.5E-017	7.0E-006	1.7E-003	4.1E-003	AGE3+
hr1-3-1110	1-b	3.6E-024	1.0E-007	4.1E-004	3.7E-003	AGE3+
hr1-2-1111	2-d	2.0E-013	3.9E-004	9.5E-002	6.8E-002	AGE2+
hr1-2-1112	2-b	1.6E-010	5.7E-006	4.0E-002	3.0E-001	AGE3+
hr1-2-1113	2-b	2.2E-020	1.5E-004	6.1E-002	2.6E-002	AGE2+
hr1-2-1114	1-b	4.6E-018	1.3E-005	4.4E-003	1.2E-002	AGE3+

Table 3-6 continued

3.1.3 Task 4: Aging unknown acetate impressions

The system parameterized with cleaned, dry-mounted scales was used to assign ages to 200 scales of unknown (to BioSonics) age that had been prepared as acetate impressions of uncleaned scales. The OPRS Pattern Recognition software report describing the proportion of scales assigned to each age class is shown in Table 3.7, and the age assignments for individual scales is shown in Table 3.8. When OPRS age assignments were compared to Normandeau age assignments, there was 100% agreement on age 0+ scales, 76% agreement on age 1+ scales, 55% agreement on age 2+ scales, and 74% agreement on age 3+ scales. When 51 scales for which there were disagreements in age assignments between Normandeau and the New York Department of Environmental Conservation (Regions 1 and 3) were removed from the unknown test set, agreement decreased to 74% for age 1+, increased to 61% for age 2+ and 76% for age 3+.

The system parameterized with acetate impressions of uncleaned scales was used to assign ages to the same set of 200 unknown age scales prepared as acetate impressions. The OPRS Pattern Recognition software report describing the proportion of scales assigned to each age class is shown in Table 3-9, and the age assignments for individual scales is shown in Table 3-10.

Results quantifying the precision (reproducibility) and amount of agreement between OPRS and Normandeau age assignments have not yet been received.

Table 3-7. Proportions of unknown age scales (acetate impressions) assigned to age classes.

```
THE A PRIORI PROBABILITIES ARE:
0.250
0.250
0.250
0.250

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 200

THE CLASSIFICATION ARRAY IS:
 100   1   0   0
   0  92  16   0
   0   7  54  20
   0   0  30  80

THE ESTIMATED CLASSIFICATION MATRIX IS:
  1.000  0.010  0.000  0.000
  0.000  0.920  0.160  0.000
  0.000  0.070  0.540  0.200
  0.000  0.000  0.300  0.800

THE NATURAL ESTIMATE IS:
0.205 Proportion AGE0+
0.270 Proportion AGE1+
0.245 Proportion AGE2+
0.280 Proportion AGE3+

THE NEARLY UNBIASED ESTIMATE IS:
0.203 Proportion AGE0+
0.234 Proportion AGE1+
0.341 Proportion AGE2+
0.222 Proportion AGE3+

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.131 0.274 Lower and Upper Bounds for AGE0+
 0.121 0.347 Lower and Upper Bounds for AGE1+
 0.108 0.574 Lower and Upper Bounds for AGE2+
 0.042 0.402 Lower and Upper Bounds for AGE3+

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.156 0.250 Lower and Upper Bounds for AGE0+
 0.160 0.308 Lower and Upper Bounds for AGE1+
 0.188 0.494 Lower and Upper Bounds for AGE2+
 0.104 0.340 Lower and Upper Bounds for AGE3+
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Table 3-8. Individual age assignments for acetate impressions.

Slide #	Scale Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-12-w434	3-c	1.7E-023	2.4E-009	3.4E-008	7.9E-008	AGE3+
1-12-w433	1-c	2.9E-020	8.0E-008	1.1E-005	3.0E-005	AGE3+
1-12-w424	1-b	5.8E-020	9.6E-007	3.7E-003	7.2E-002	AGE3+
1-12-w422	3-b	8.5E-008	3.0E-001	2.4E-003	3.6E-006	AGE1+
1-1-w417	2-e	1.6E-005	1.9E-005	5.3E-007	3.7E-009	AGE1+
1-1-w414	3-b	2.6E-021	1.4E-007	2.5E-006	3.1E-006	AGE3+
1-1-w412	3-c	2.3E-008	3.0E-002	4.3E-005	3.0E-008	AGE1+
1-1-w409	1-c	2.8E-025	3.6E-007	3.0E-003	7.7E-002	AGE3+
1-1-w406	3-b	2.3E-036	3.2E-016	2.9E-012	1.1E-010	AGE3+
1-1-w404	4-e	7.0E-020	6.6E-006	2.1E-003	2.5E-003	AGE3+
1-12-w471	2-b	3.3E-020	1.3E-007	2.0E-004	1.5E-003	AGE3+
1-12-w466	1-b	7.3E-018	1.9E-003	3.0E-003	2.7E-004	AGE2+
1-1-w457	2-c	1.5E-009	1.3E-001	1.0E-002	3.2E-005	AGE1+
1-1-w454	1-e	3.0E-004	8.3E-007	4.7E-009	1.9E-011	AGE0+
1-1-w452	1-b	3.0E-024	1.2E-008	3.0E-004	1.6E-002	AGE3+
1-1-w450	4-b	4.6E-022	1.8E-004	2.1E-002	4.2E-003	AGE2+
1-1-w442	4-b	4.9E-021	7.0E-005	3.1E-004	5.3E-005	AGE2+
1-1-w441	4-b	1.1E-003	3.4E-005	8.6E-008	1.3E-010	AGE0+
1-1-w440	4-d	1.2E-013	4.1E-004	8.5E-003	7.2E-003	AGE2+
1-1-w505	2-b	1.4E-013	1.4E-002	7.6E-004	8.9E-006	AGE1+
1-1-w500	2-d	3.1E-037	2.6E-015	3.6E-011	1.0E-009	AGE3+
1-12-w496	3-c	4.0E-019	4.0E-006	3.0E-002	1.0E-001	AGE3+
1-12-w492	3-c	5.7E-021	7.4E-006	2.0E-002	1.1E-001	AGE3+
1-12-w491	3-c	7.4E-012	1.0E-002	1.0E-003	5.6E-005	AGE1+
1-12-w485	2-b	1.6E-020	3.0E-009	3.9E-005	1.6E-003	AGE3+

Table 3.8 continued

Slide #	Scale Quality Code	Relative Probability Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-12-w483	3-b	8.0E-025	1.4E-008	2.4E-004	1.5E-002	AGE3+
1-12-w481	1-c	5.7E-021	3.7E-008	1.6E-003	6.2E-002	AGE3+
1-1-w477	1-b	4.9E-012	6.4E-002	1.4E-001	2.3E-003	AGE2+
1-1-w474	2-c	5.5E-009	3.2E-001	4.1E-003	3.5E-006	AGE1+
1-12-w533	2-b	4.4E-017	1.3E-005	9.7E-003	3.2E-002	AGE3+
1-12-w529	2-c	5.8E-023	3.4E-006	6.6E-003	2.4E-002	AGE3+
1-12-w527	4-d	2.0E-024	4.1E-011	5.6E-010	1.4E-008	AGE3+
1-12-w526	1-b	1.8E-007	3.6E-002	4.0E-005	5.7E-008	AGE1+
1-12-w524	4-c	3.3E-025	1.6E-011	2.6E-008	3.1E-006	AGE3+
1-12-w521	2-c	2.2E-024	1.1E-008	1.3E-005	3.1E-004	AGE3+
1-12-w520	2-b	1.2E-025	6.0E-009	2.6E-006	3.3E-005	AGE3+
1-1-w517	2-c	2.9E-013	1.3E-001	4.3E-001	9.2E-003	AGE2+
1-1-w512	2-b	2.9E-021	1.5E-007	7.5E-003	2.6E-001	AGE3+
1-1-w507	1-b	2.2E-008	6.4E-004	4.9E-004	3.6E-005	AGE1+
1-12-w536	2-b	2.6E-013	4.6E-003	1.7E-001	3.5E-002	AGE2+
1-12-w547	4-b	1.9E-012	1.3E-003	3.2E-005	3.2E-008	AGE1+
1-1-w554	1-b	1.5E-007	1.2E-004	6.3E-006	1.6E-007	AGE1+
1-1-w558	2-c	5.6E-010	5.4E-007	5.8E-007	4.2E-008	AGE2+
1-1-w568	3-d	2.0E-010	3.8E-008	5.5E-007	1.0E-007	AGE2+
1-12-w575	3-b	1.0E-012	4.9E-003	4.6E-003	1.4E-005	AGE1+
1-12-w580	2-c	4.5E-015	1.0E-003	5.6E-003	5.2E-004	AGE2+
1-1-w584	2-e	1.5E-009	1.4E-008	1.0E-009	1.1E-010	AGE1+
1-1-w586	4-d	2.4E-009	8.6E-005	3.8E-007	7.7E-009	AGE1+
1-1-w587	2-e	5.2E-024	1.4E-005	8.5E-004	3.3E-004	AGE2+
1-1-w590	4-d	2.3E-016	7.7E-005	1.0E-002	4.6E-002	AGE3+

Table 3.8 continued

Scale Relative Probabilities

Slide #	Quality Code	Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w591	2-e	7.2E-017	2.0E-005	2.3E-004	7.8E-005	AGE2+
1-1-w593	3-d	3.3E-015	2.9E-004	4.5E-003	2.8E-003	AGE2+
1-1-w594	1-c	3.6E-015	6.2E-002	1.2E-001	5.8E-003	AGE2+
1-1-w595	2-b	4.6E-016	3.7E-003	7.9E-002	2.9E-003	AGE2+
1-1-w596	1-d	2.3E-013	4.5E-002	1.5E-001	8.4E-003	AGE2+
1-1-w597	1-c	1.2E-012	1.5E-003	2.1E-003	7.5E-005	AGE2+
1-1-w599	1-b	8.8E-015	1.4E-003	4.9E-002	7.4E-003	AGE2+
1-1-w603	1-b	1.1E-014	4.3E-003	1.7E-001	3.6E-002	AGE2+
1-1-w604	4-d	1.9E-022	3.0E-005	3.6E-004	1.8E-004	AGE2+
1-1-w606	4-c	5.3E-032	2.5E-013	5.3E-009	2.1E-006	AGE3+
1-1-w609	1-e	9.4E-017	5.1E-006	6.3E-005	9.4E-006	AGE2+
1-1-w610	1-b	8.8E-018	2.7E-003	6.4E-002	2.9E-002	AGE2+
1-1-w611	3-b	2.3E-016	1.9E-005	6.3E-004	9.2E-004	AGE3+
1-1-w614	2-c	6.0E-015	4.8E-005	1.2E-003	2.1E-004	AGE2+
1-1-w615	2-d	9.4E-035	6.0E-012	2.2E-007	8.0E-006	AGE3+
1-1-w616	3-d	1.3E-013	4.3E-003	3.3E-002	6.6E-003	AGE2+
1-1-w617	4-c	2.7E-022	1.3E-009	1.1E-004	9.3E-003	AGE3+
1-1-w618	1-b	1.3E-015	1.5E-004	9.6E-005	1.1E-005	AGE1+
1-1-w619	4-c	7.9E-015	8.9E-007	2.3E-006	2.9E-007	AGE2+
1-1-w624	1-b	2.0E-015	2.0E-006	6.7E-006	5.0E-006	AGE2+
1-1-w634	2-c	6.6E-011	5.3E-002	1.0E-003	1.1E-005	AGE1+
1-1-w635	1-c	6.6E-010	1.2E-004	9.5E-006	2.5E-007	AGE1+
1-1-w642	3-b	4.7E-014	4.7E-005	3.9E-004	7.5E-005	AGE2+
1-1-w648	1-b	1.6E-011	1.6E-002	4.9E-002	6.7E-003	AGE2+
1-1-w650	1-d	6.6E-014	4.9E-002	2.6E-002	5.6E-004	AGE1+

Table 3.8 continued

Slide #	Quality Code	Age 0+	Age 1+	Age 2+	Age 3+	Age Assignment
1-1-w652	1-d	1.9E-014	4.8E-002	1.2E-001	1.9E-003	AGE2+
1-1-w653	2-c	1.4E-014	4.4E-004	1.5E-003	2.7E-004	AGE2+
1-1-w656	3-d	4.1E-006	2.2E-004	4.8E-006	9.6E-008	AGE1+
1-1-w658	4-b	8.8E-020	1.3E-005	1.3E-004	1.7E-005	AGE2+
1-1-w659	1-b	4.4E-010	2.9E-002	6.1E-003	4.3E-005	AGE1+
1-1-w661	3-c	1.8E-008	2.2E-002	2.7E-005	1.3E-008	AGE1+
1-1-w663	1-b	7.8E-016	5.0E-008	3.3E-007	3.8E-007	AGE3+
1-1-w668	4-b	3.0E-011	1.6E-003	6.7E-004	1.6E-005	AGE1+
1-1-w669	3-c	2.3E-006	9.6E-005	1.9E-007	2.4E-010	AGE1+
1-1-w670	2-d	1.5E-009	1.0E-001	3.0E-003	5.0E-006	AGE1+
1-1-w671	3-b	6.7E-009	9.1E-004	2.7E-005	2.3E-007	AGE1+
1-1-w672	1-b	6.2E-008	2.8E-004	3.1E-005	3.8E-007	AGE1+
1-1-w674	4-c	2.5E-015	1.3E-002	2.8E-002	3.0E-003	AGE2+
1-1-w675	3-d	2.6E-012	2.0E-002	1.6E-001	1.5E-002	AGE2+
1-1-w676	4-d	2.4E-016	6.8E-004	5.7E-003	3.6E-003	AGE2+
1-1-w679	2-d	2.8E-015	4.0E-003	3.1E-003	9.4E-005	AGE1+
1-1-w682	1-c	3.6E-004	6.1E-005	1.9E-007	2.5E-010	AGE0+
1-1-w684	3-c	8.7E-017	1.2E-003	3.9E-003	2.5E-005	AGE2+
1-1-w689	1-c	3.8E-008	1.5E-004	6.6E-006	1.5E-007	AGE1+
1-1-w703	3-c	5.4E-022	1.1E-007	5.3E-004	4.2E-003	AGE3+
1-1-w705	1-c	7.6E-029	5.0E-012	5.7E-009	1.8E-007	AGE3+
1-1-w720	4-b	4.8E-020	2.1E-007	4.7E-004	5.9E-003	AGE3+
1-2-w721	3-b	1.2E-020	5.6E-007	3.9E-003	5.7E-002	AGE3+
1-2-w704	3-b	1.4E-013	9.1E-005	2.2E-003	5.0E-004	AGE2+
1-1-w1011	2-c	4.0E-005	3.5E-002	5.0E-005	7.5E-008	AGE1+

Table 3.8 continued

Relative Probability

Site #	Grid Code	Age 0+	Age 1+	Age 2+	Age 3+	Age Classification
1-1-w1013	4-b	3.8E-005	9.8E-003	5.4E-006	2.8E-009	AGE1+
1-1-w1020	1-c	1.1E-003	8.8E-003	1.9E-005	1.7E-008	AGE1+
1-1-w1021	1-c	2.1E-005	1.5E-002	5.7E-006	4.5E-009	AGE1+
1-1-w1024	3-b	7.5E-004	2.5E-002	1.6E-005	8.4E-009	AGE1+
1-1-w1026	3-b	1.1E-006	6.9E-003	1.0E-004	1.0E-007	AGE1+
1-1-w1027	4-d	1.7E-006	2.0E-004	1.0E-006	1.2E-009	AGE1+
1-1-w1028	5-c	1.6E-005	1.3E-007	8.3E-010	1.1E-012	AGE0+
1-2-w1056	1-c	4.0E-023	5.8E-009	8.6E-008	3.6E-007	AGE3+
1-2-w1057	3-b	1.9E-024	4.1E-012	1.7E-010	3.1E-010	AGE3+
1-3-w1058	3-c	9.4E-025	2.1E-008	2.9E-005	1.4E-004	AGE3+
1-2-w1060	3-b	5.9E-015	1.8E-004	2.0E-002	5.4E-002	AGE3+
1-2-w1061	3-c	1.6E-024	2.6E-007	6.0E-004	1.2E-002	AGE3+
1-2-w1062	2-c	2.2E-020	3.1E-005	5.0E-003	1.1E-002	AGE3+
1-2-w1063	2-c	1.5E-023	2.6E-008	1.3E-004	3.5E-003	AGE3+
1-2-w1064	3-c	8.3E-016	7.5E-004	3.5E-002	1.2E-002	AGE2+
1-2-w1065	2-b	6.6E-023	5.8E-007	2.1E-003	6.6E-003	AGE3+
1-2-w1066	2-b	4.3E-019	4.6E-007	3.7E-004	3.7E-003	AGE3+
1-2-w1067	2-b	2.7E-022	2.2E-009	4.3E-007	1.4E-005	AGE3+
1-2-w1068	2-b	2.3E-018	6.9E-005	9.9E-004	4.0E-004	AGE2+
1-3-w1069	3-b	5.9E-022	8.8E-006	3.6E-002	2.0E-001	AGE3+
1-3-w1070	3-b	5.0E-026	2.6E-008	2.0E-006	4.2E-006	AGE3+
1-2-w1071	1-c	1.2E-020	5.4E-006	7.9E-004	3.6E-004	AGE2+
1-2-w1072	2-c	2.4E-024	1.1E-011	1.1E-008	9.8E-007	AGE3+
1-2-w1073	4-c	3.3E-018	5.6E-004	1.3E-002	1.1E-002	AGE2+
1-2-w1074	2-c	5.0E-028	5.4E-007	5.5E-005	8.0E-005	AGE3+

Table 3.8 continued

[illegible]

[illegible] #	[illegible] Code	Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-2-w1076	2-c	5.5E-021	3.3E-006	7.7E-004	1.6E-003	AGE3+
1-2-w1077	5-b	6.7E-016	8.8E-005	3.1E-003	1.5E-003	AGE2+
1-1-w1078	1-c	1.5E-005	5.9E-003	3.5E-005	1.2E-007	AGE1+
1-1-w1079	3-b	2.3E-005	3.3E-002	5.8E-004	2.4E-006	AGE1+
1-1-w1080	1-c	6.4E-005	6.0E-005	1.5E-007	3.4E-010	AGE0+
1-1-w1081	1-c	1.7E-005	9.9E-002	4.1E-004	5.5E-007	AGE1+
1-1-w1082	1-b	1.1E-005	5.4E-002	8.2E-005	7.6E-008	AGE1+
1-1-w1083	2-b	3.1E-006	1.4E-002	1.3E-004	5.4E-007	AGE1+
1-1-w1084	4-c	5.8E-005	6.3E-003	1.6E-005	4.1E-008	AGE1+
1-1-w1085	2-c	9.3E-006	1.6E-005	7.3E-009	1.7E-011	AGE1+
1-1-w1086	1-b	4.1E-004	9.1E-004	3.9E-007	3.9E-010	AGE1+
1-1-w1087	3-c	4.2E-004	2.0E-004	2.6E-007	5.9E-010	AGE0+
1-1-w1088	1-c	8.6E-005	4.7E-005	7.7E-008	1.4E-010	AGE0+
1-1-w1089	4-b	3.4E-006	1.1E-001	7.8E-004	1.5E-006	AGE1+
1-1-w1090	1-b	4.9E-007	1.3E-002	8.1E-005	1.6E-007	AGE1+
1-1-w1091	5-c	1.7E-005	3.6E-004	8.1E-007	5.7E-010	AGE1+
1-1-w1092	3-b	3.3E-003	2.1E-006	2.7E-009	5.4E-012	AGE0+
1-1-w1093	3-b	7.8E-005	3.0E-002	1.6E-005	6.8E-009	AGE1+
1-1-w1094	4-b	1.6E-003	9.3E-004	1.6E-006	1.1E-009	AGE0+
1-3-w1105	1-b	5.0E-019	2.8E-005	2.3E-003	3.0E-003	AGE3+
1-2-w1106	1-b	1.5E-018	5.1E-004	3.6E-002	2.2E-002	AGE2+
1-2-w1107	1-b	2.7E-020	1.7E-006	2.4E-004	3.2E-004	AGE3+
1-2-w1109	2-b	3.2E-017	5.3E-006	2.5E-004	1.3E-004	AGE2+
1-3-w1110	3-b	1.7E-025	2.7E-007	3.9E-004	4.2E-003	AGE3+
1-2-w1111	3-b	1.7E-018	1.2E-006	7.0E-006	2.1E-005	AGE3+

Table 3.8 continued

[illegible] #	[illegible] Code	Age 0+	[illegible]	[illegible]	ge 3+	[illegible] assignment
1-2-w1112	2-c	3.3E²025	5.4E²008	4.3E²005	3.9E²004	AGE3+
1-2-w1113	3-b	1.3E²019	6.4E²005	9.8E²003	8.5E²003	AGE2+
1-2-w1114	3-d	7.3E²025	3.3E²010	8.4E²008	1.0E²007	AGE3+
1-1-w1095	1-b	1.4E²021	4.6E²010	1.3E²009	4.4E²010	AGE2+
1-1-w1096	1-b	6.0E²011	8.4E²003	6.2E²002	7.2E²003	AGE2+
1-1-w1097	2-c	5.4E²013	7.7E²004	1.5E²003	5.5E²004	AGE2+
1-1-w1098	3-b	9.5E²011	5.2E²001	3.4E²002	2.1E²004	AGE1+
1-1-w1099	2-b	9.2E²014	4.6E²003	3.6E²002	1.6E²002	AGE2+
1-1-w1100	3-b	1.4E²008	8.1E²003	3.8E²003	2.3E²004	AGE1+
1-1-w1101	2-b	2.5E²014	7.0E²003	4.8E²003	2.7E²004	AGE1+
1-2-w1102	1-b	7.3E²015	2.2E²003	4.7E²002	4.9E²003	AGE2+
1-2-w1103	2-b	8.2E²019	3.0E²008	1.9E²004	4.7E²003	AGE3+
1-2-w1104	3-b	5.5E²019	4.5E²006	9.3E²003	1.2E²001	AGE3+
1-2-w1108	4-b	5.3E²019	5.6E²005	4.3E²002	1.5E²001	AGE3+
1-1-w651	2-b	1.1E²010	3.5E²002	2.5E²003	2.7E²005	AGE1+
1-1-w470	2-c	1.3E²001	1.3E²007	1.4E²011	4.0E²015	AGE0+
1-1-w588	2-c	2.0E²002	6.7E²007	3.5E²011	5.6E²015	AGE0+
1-1-w665	1-b	1.8E²004	4.1E²006	1.6E²010	6.8E²015	AGE0+
1-1-w666	4-c	2.6E²002	8.7E²006	5.5E²010	1.7E²013	AGE0+
1-1-w620	1-b	6.6E²002	1.9E²005	1.6E²009	1.7E²013	AGE0+
1-1-w680	3-b	5.7E²002	3.2E²006	3.7E²010	1.3E²013	AGE0+
1-1-w681	1-c	3.3E²002	3.0E²007	1.4E²011	3.3E²015	AGE0+
1-1-w1012	1-b	3.8E²006	1.0E²004	3.1E²008	6.4E²011	AGE1+
1-1-w1022	4-d	5.4E²007	4.5E²002	2.7E²005	1.3E²008	AGE1+
1-1-w1023	5-b	2.3E²003	1.5E²005	3.0E²008	3.7E²011	AGE0+

Table 3.8 continued

Slide #	Scale & Quality Code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w1025	2-c	4.1E-007	3.1E-065	2.5E-006	5.5E-009	AGE1+
1-1-w1029	5-c	1.4E-003	1.5E-005	1.2E-008	7.6E-012	AGE0+
1-3-w1030	5-c	3.5E-001	9.1E-008	9.4E-013	3.3E-017	AGE0+
1-3-w1031	5-c	2.2E-002	6.4E-009	4.8E-014	1.6E-018	AGE0+
1-3-w1032	1-c	2.5E-001	3.5E-010	2.6E-015	4.6E-020	AGE0+
1-3-w1033	4-b	2.6E-001	9.4E-008	1.4E-012	5.7E-017	AGE0+
1-3-w1034	4-b	2.6E-001	5.0E-007	1.2E-011	7.3E-016	AGE0+
1-3-w1035	3-b	2.3E-001	3.1E-008	1.0E-012	4.6E-017	AGE0+
1-3-w1036	1-b	3.5E-001	1.1E-009	1.3E-014	4.7E-019	AGE0+
1-3-w1038	1-b	7.0E-002	4.0E-007	4.6E-012	1.3E-016	AGE0+
1-1-w1039	3-c	4.1E-001	3.3E-007	3.7E-012	1.6E-016	AGE0+
1-2-w1040	5-c	2.6E-001	1.6E-008	2.9E-013	1.6E-017	AGE0+
1-2-w1041	2-d	4.7E-002	1.9E-005	5.1E-010	2.5E-014	AGE0+
1-2-w1042	2-b	5.1E-002	1.9E-005	5.2E-010	7.8E-014	AGE0+
1-2-w1043	4-b	7.9E-003	7.7E-004	5.4E-008	7.6E-012	AGE0+
1-2-w1044	5-b	6.2E-001	2.7E-011	3.4E-017	2.0E-022	AGE0+
1-2-w1045	2-c	4.3E-001	5.4E-011	2.4E-016	3.3E-021	AGE0+
1-2-w1046	4-c	7.9E-002	5.0E-007	2.1E-011	2.0E-015	AGE0+
1-2-w1048	2-c	1.2E-001	3.8E-006	1.6E-010	1.5E-014	AGE0+
1-2-w1050	2-c	3.1E-001	4.1E-007	1.5E-011	1.5E-015	AGE0+
1-2-w1051	5-c	4.3E-002	4.2E-008	3.3E-012	2.9E-016	AGE0+
1-2-w1052	3-c	1.8E-001	2.0E-006	1.7E-010	2.7E-014	AGE0+
1-2-w1053	4-b	3.3E-002	8.8E-007	1.3E-010	6.3E-014	AGE0+
1-2-w1054	3-c	5.0E-002	1.1E-004	6.4E-009	6.6E-013	AGE0+
1-2-w1055	2-c	4.6E-002	5.3E-006	2.0E-010	5.5E-014	AGE0+

Table 3.8 continued

Table 3-9. Proportions of acetate impressions assigned to age classes.

```
THE A PRIORI PROBABILITIES ARE:
0.250
0.250
0.250
0.250

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 200

THE CLASSIFICATION ARRAY IS:
 50  0  0  0
  0 90 15  0
  0 10 61 18
  0  0 23 82

THE ESTIMATED CLASSIFICATION MATRIX IS:
  1.000  0.000  0.000  0.000
  0.000  0.900  0.152  0.000
  0.000  0.100  0.616  0.180
  0.000  0.000  0.232  0.820

THE NATURAL ESTIMATE IS:
0.150 Proportion AGE0+
0.300 Proportion AGE1+
0.295 Proportion AGE2+
0.255 Proportion AGE3+

THE NEARLY UNBIASED ESTIMATE IS:
0.150 Proportion AGE0+
0.270 Proportion AGE1+
0.375 Proportion AGE2+
0.205 Proportion AGE3+

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.087 0.213 Lower and Upper Bounds for AGE0+
 0.151 0.389 Lower and Upper Bounds for AGE1+
 0.172 0.578 Lower and Upper Bounds for AGE2+
 0.057 0.353 Lower and Upper Bounds for AGE3+

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.109 0.191 Lower and Upper Bounds for AGE0+
 0.192 0.348 Lower and Upper Bounds for AGE1+
 0.242 0.508 Lower and Upper Bounds for AGE2+
 0.108 0.302 Lower and Upper Bounds for AGE3+
```

Table 3-10. Individual age assignments for acetate impressions.

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-12-w434	3-c	2.2E-013	2.3E-003	4.5E-001	1.4E-001	AGE2+
1-12-w433	1-c	9.3E-012	2.5E-003	1.4E-001	8.3E-002	AGE2+
1-12-w424	1-b	3.3E-017	6.6E-007	1.5E-003	2.3E-002	AGE3+
1-12-w422	3-b	4.6E-005	1.9E-001	2.9E-003	1.3E-006	AGE1+
1-1-w417	2-e	6.1E-004	5.7E-001	8.7E-003	3.4E-005	AGE1+
1-1-w414	3-b	6.9E-015	7.8E-005	1.6E-002	6.9E-003	AGE2+
1-1-w412	3-c	3.5E-004	7.0E-001	8.2E-003	8.2E-006	AGE1+
1-1-w409	1-c	1.8E-019	4.7E-007	6.6E-003	3.7E-002	AGE3+
1-1-w406	3-b	3.8E-029	2.8E-013	1.1E-007	2.3E-006	AGE3+
1-1-w404	4-e	3.0E-013	2.4E-003	5.3E-001	3.1E-001	AGE2+
1-12-w471	2-b	1.2E-015	7.2E-005	8.7E-002	4.0E-001	AGE3+
1-12-w466	1-b	2.2E-011	1.1E-002	2.2E-001	1.2E-002	AGE2+
1-1-w457	2-c	4.7E-006	5.9E-001	8.5E-002	3.2E-004	AGE1+
1-1-w454	1-e	3.6E-003	1.5E-001	3.7E-004	8.0E-007	AGE1+
1-1-w452	1-b	3.3E-020	5.7E-008	1.6E-003	1.9E-001	AGE3+
1-1-w450	4-b	5.5E-014	7.2E-004	2.1E-001	1.9E-001	AGE2+
1-1-w442	4-b	1.1E-013	2.1E-004	8.0E-003	1.9E-004	AGE2+
1-1-w441	4-b	4.7E-003	3.0E-002	1.8E-005	5.7E-009	AGE1+
1-1-w440	4-d	8.1E-012	5.3E-004	1.5E-002	5.8E-003	AGE2+
1-1-w505	2-b	1.7E-006	4.1E-001	1.1E-001	4.9E-004	AGE1+
1-1-w500	2-d	1.1E-023	5.3E-009	1.3E-003	6.1E-002	AGE3+
1-12-w496	3-c	6.6E-015	3.2E-005	2.3E-002	2.1E-001	AGE3+
1-12-w492	3-c	2.0E-018	2.8E-006	1.7E-002	5.4E-002	AGE3+
1-12-w491	3-c	9.7E-009	4.7E-002	5.8E-002	1.0E-003	AGE2+
1-12-w485	2-b	7.9E-016	1.0E-006	5.1E-004	1.3E-002	AGE3+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-12-w483	3-b	3.4E-020	5.4E-008	1.3E-003	1.5E-001	AGE3+
1-12-w481	1-c	1.7E-018	5.8E-008	2.7E-004	2.9E-002	AGE3+
1-1-w477	1-b	1.1E-007	3.2E-001	4.6E-001	1.1E-002	AGE2+
1-1-w474	2-c	8.1E-005	5.5E-001	1.3E-002	1.1E-005	AGE1+
1-12-w533	2-b	2.5E-012	1.6E-004	1.0E-002	3.1E-002	AGE3+
1-12-w529	2-c	1.9E-016	5.8E-005	9.6E-002	1.1E-001	AGE3+
1-12-w527	4-d	1.5E-013	1.1E-004	2.7E-002	1.4E-001	AGE3+
1-12-w526	1-b	8.2E-004	7.6E-002	2.1E-004	7.7E-008	AGE1+
1-12-w524	4-c	2.7E-017	1.9E-006	5.8E-003	4.6E-002	AGE3+
1-12-w521	2-c	3.4E-016	5.1E-005	1.2E-001	4.2E-001	AGE3+
1-12-w520	2-b	2.2E-018	6.1E-006	3.8E-002	5.8E-002	AGE3+
1-1-w517	2-c	4.4E-009	4.6E-002	2.2E-001	1.9E-002	AGE2+
1-1-w512	2-b	1.9E-018	7.2E-008	3.1E-004	3.1E-002	AGE3+
1-1-w507	1-b	1.5E-006	1.3E-001	4.2E-002	1.5E-003	AGE1+
1-12-w536	2-b	3.3E-010	3.9E-002	8.2E-001	1.1E-001	AGE2+
1-12-w547	4-b	5.9E-006	1.8E-001	1.2E-002	3.1E-005	AGE1+
1-1-w554	1-b	2.4E-005	7.5E-002	2.8E-003	2.0E-005	AGE1+
1-1-w558	2-c	1.0E-006	1.3E-001	4.9E-002	2.8E-003	AGE1+
1-1-w568	3-d	3.0E-011	3.9E-003	1.3E-001	1.0E-001	AGE2+
1-12-w575	3-b	2.0E-008	9.7E-003	5.8E-003	5.2E-005	AGE1+
1-12-w580	2-c	7.5E-010	1.6E-002	1.6E-001	5.0E-002	AGE2+
1-1-w584	2-e	1.4E-005	1.1E-002	4.4E-004	1.2E-005	AGE1+
1-1-w586	4-d	4.1E-004	5.8E-001	1.1E-002	3.2E-005	AGE1+
1-1-w587	2-e	2.3E-015	1.5E-004	7.0E-002	2.2E-002	AGE2+
1-1-w590	4-d	5.1E-013	3.3E-004	5.6E-002	2.5E-001	AGE3+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w591	2-e	2.3E-011	1.3E-002	4.7E-001	7.4E-002	AGE2+
1-1-w593	3-d	7.6E-010	5.0E-002	7.5E-001	1.3E-001	AGE2+
1-1-w594	1-c	1.1E-010	1.1E-002	1.5E-001	2.0E-002	AGE2+
1-1-w595	2-b	3.9E-009	9.1E-002	6.0E-001	4.1E-002	AGE2+
1-1-w596	1-d	3.9E-010	2.1E-002	1.9E-001	1.4E-002	AGE2+
1-1-w597	1-c	2.7E-009	5.5E-002	1.5E-001	1.5E-003	AGE2+
1-1-w599	1-b	3.3E-010	1.8E-002	2.6E-001	7.8E-002	AGE2+
1-1-w603	1-b	4.4E-011	1.7E-002	8.3E-001	3.0E-001	AGE2+
1-1-w604	4-d	6.6E-013	3.5E-003	4.5E-001	7.3E-002	AGE2+
1-1-w606	4-c	2.9E-020	7.8E-008	2.4E-003	1.0E-001	AGE3+
1-1-w609	1-e	5.7E-013	2.6E-004	6.4E-003	1.1E-003	AGE2+
1-1-w610	1-b	3.4E-011	1.0E-002	5.7E-001	3.0E-001	AGE2+
1-1-w611	3-b	2.5E-010	1.5E-002	3.7E-001	1.6E-001	AGE2+
1-1-w614	2-c	1.7E-011	8.9E-003	3.0E-001	6.0E-002	AGE2+
1-1-w615	2-d	2.5E-021	7.4E-008	5.7E-003	3.0E-001	AGE3+
1-1-w616	3-d	4.9E-010	3.4E-002	4.7E-001	7.9E-002	AGE2+
1-1-w617	4-c	7.3E-020	3.9E-008	5.6E-004	6.8E-002	AGE3+
1-1-w618	1-b	2.2E-009	4.4E-002	2.2E-001	1.0E-002	AGE2+
1-1-w619	4-c	5.5E-009	1.0E-001	6.3E-001	6.3E-002	AGE2+
1-1-w624	1-b	9.3E-009	2.7E-002	7.8E-002	7.9E-003	AGE2+
1-1-w634	2-c	1.1E-006	2.8E-001	6.2E-002	3.7E-004	AGE1+
1-1-w635	1-c	3.8E-008	9.5E-003	6.9E-003	4.1E-004	AGE1+
1-1-w642	3-b	5.6E-011	6.0E-003	1.2E-001	4.8E-002	AGE2+
1-1-w648	1-b	5.4E-008	1.4E-001	3.7E-001	3.6E-002	AGE2+
1-1-w650	1-d	1.1E-009	6.2E-003	8.9E-003	4.1E-005	AGE2+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w652	1-d	1.9E-008	1.9E-001	6.4E-001	3.0E-002	AGE2+
1-1-w653	2-c	2.8E-009	4.5E-002	3.2E-001	5.7E-002	AGE2+
1-1-w656	3-d	4.6E-006	3.3E-001	4.9E-002	3.6E-004	AGE1+
1-1-w658	4-b	2.0E-011	9.7E-003	4.0E-001	1.3E-001	AGE2+
1-1-w659	1-b	1.4E-007	1.7E-001	1.0E-001	1.3E-003	AGE1+
1-1-w661	3-c	1.1E-003	5.2E-001	2.2E-003	7.7E-007	AGE1+
1-1-w663	1-b	1.9E-010	2.1E-002	5.2E-001	2.0E-001	AGE2+
1-1-w668	4-b	3.1E-007	1.1E-001	5.6E-002	1.4E-003	AGE1+
1-1-w669	3-c	3.9E-003	5.5E-001	2.0E-003	2.1E-006	AGE1+
1-1-w670	2-d	2.8E-006	3.1E-001	2.9E-002	4.5E-005	AGE1+
1-1-w671	3-b	9.9E-006	3.4E-001	3.6E-002	1.3E-004	AGE1+
1-1-w672	1-b	1.3E-005	5.3E-001	6.9E-002	7.0E-004	AGE1+
1-1-w674	4-c	3.2E-010	2.5E-002	2.0E-001	4.5E-003	AGE2+
1-1-w675	3-d	2.5E-010	3.6E-002	4.8E-001	2.4E-002	AGE2+
1-1-w676	4-d	3.6E-011	7.8E-003	3.2E-001	1.9E-001	AGE2+
1-1-w679	2-d	6.6E-012	3.0E-003	3.2E-002	2.7E-004	AGE2+
1-1-w682	1-c	1.2E-003	3.7E-001	1.3E-003	3.7E-007	AGE1+
1-1-w684	3-c	5.9E-010	3.6E-002	1.6E-001	2.1E-003	AGE2+
1-1-w689	1-c	1.6E-005	1.7E-001	1.1E-002	1.2E-004	AGE1+
1-1-w703	3-c	4.4E-016	3.2E-005	7.1E-002	3.7E-001	AGE3+
1-1-w705	1-c	1.2E-017	9.6E-006	5.5E-002	5.0E-001	AGE3+
1-1-w720	4-b	1.5E-015	6.7E-006	5.0E-003	6.0E-002	AGE3+
1-2-w721	3-b	3.6E-015	2.6E-005	2.1E-002	2.0E-001	AGE3+
1-2-w784	3-b	4.2E-010	3.5E-002	6.0E-001	1.3E-001	AGE2+
1-1-w1011	2-c	3.9E-003	2.4E-001	4.8E-004	2.1E-007	AGE1+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w1013	4-b	1.1E-003	3.2E-002	6.3E-005	5.1E-008	AGE1+
1-1-w1020	1-c	1.5E-003	2.8E-001	1.0E-003	8.3E-007	AGE1+
1-1-w1021	1-c	9.2E-003	4.0E-001	4.9E-004	1.4E-007	AGE1+
1-1-w1024	3-b	1.7E-002	2.4E-002	6.1E-006	1.0E-009	AGE1+
1-1-w1026	3-b	1.1E-005	1.6E-001	7.3E-003	1.8E-005	AGE1+
1-1-w1027	4-d	2.2E-004	7.9E-001	1.3E-002	1.4E-005	AGE1+
1-1-w1029	5-c	1.6E-003	2.7E-001	1.3E-003	2.4E-006	AGE1+
1-2-w1056	1-c	4.1E-014	3.1E-004	1.2E-001	2.7E-001	AGE3+
1-2-w1057	3-b	1.6E-012	5.3E-003	6.0E-001	1.9E-001	AGE2+
1-3-w1058	3-c	2.2E-018	4.1E-006	2.8E-002	1.7E-001	AGE3+
1-2-w1060	3-b	1.6E-011	3.7E-003	2.4E-001	3.0E-001	AGE3+
1-2-w1061	3-c	7.3E-018	6.0E-006	4.7E-002	7.0E-001	AGE3+
1-2-w1062	2-c	1.5E-013	1.0E-004	2.1E-002	4.5E-002	AGE3+
1-2-w1063	2-c	2.7E-021	1.3E-008	3.4E-004	5.7E-003	AGE3+
1-2-w1064	3-c	1.1E-011	1.0E-002	8.5E-001	4.1E-001	AGE2+
1-2-w1065	2-b	1.2E-019	7.2E-008	4.8E-004	9.7E-003	AGE3+
1-2-w1066	2-b	9.0E-015	4.1E-004	3.8E-001	6.6E-001	AGE3+
1-2-w1067	2-b	4.0E-017	1.9E-006	3.2E-003	5.2E-002	AGE3+
1-2-w1068	2-b	1.4E-012	4.4E-003	6.4E-001	3.8E-001	AGE2+
1-3-w1069	3-b	6.1E-018	3.1E-006	1.5E-002	1.7E-001	AGE3+
1-3-w1070	3-b	1.9E-014	1.6E-004	3.1E-002	4.7E-003	AGE2+
1-2-w1071	1-c	7.5E-015	3.0E-004	2.0E-001	3.1E-001	AGE3+
1-2-w1072	2-c	1.1E-015	2.7E-005	4.4E-002	4.4E-001	AGE3+
1-2-w1073	4-c	4.1E-012	4.5E-003	5.6E-001	4.6E-001	AGE2+
1-2-w1074	2-c	3.0E-015	2.0E-004	1.9E-001	2.7E-001	AGE3+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-2-w1076	2-c	4.6E-015	1.5E-004	1.2E-001	3.0E-001	AGE3+
1-2-w1077	5-b	5.0E-011	1.5E-002	7.6E-001	3.1E-001	AGE2+
1-1-w1078	1-c	1.4E-003	2.4E-001	1.1E-003	1.5E-006	AGE1+
1-1-w1079	3-b	6.2E-005	2.0E-001	5.9E-003	1.9E-005	AGE1+
1-1-w1080	1-c	5.1E-003	3.3E-001	9.8E-004	1.2E-006	AGE1+
1-1-w1081	1-c	3.1E-004	1.9E-001	1.8E-003	3.7E-006	AGE1+
1-1-w1082	1-b	9.0E-003	4.4E-001	9.7E-004	7.2E-007	AGE1+
1-1-w1083	2-b	2.1E-004	3.7E-001	5.7E-003	6.2E-006	AGE1+
1-1-w1084	4-c	3.5E-003	3.3E-001	1.2E-003	1.1E-006	AGE1+
1-1-w1085	2-c	2.2E-003	8.2E-002	1.7E-004	3.0E-007	AGE1+
1-1-w1086	1-b	2.3E-002	4.6E-002	1.6E-005	4.0E-009	AGE1+
1-1-w1087	3-c	2.5E-002	1.9E-001	1.5E-004	9.3E-008	AGE1+
1-1-w1088	1-c	7.3E-003	3.5E-001	7.1E-004	5.1E-007	AGE1+
1-1-w1089	4-b	1.0E-003	7.9E-001	6.9E-003	8.0E-006	AGE1+
1-1-w1090	1-b	1.8E-005	2.3E-001	8.4E-003	9.4E-006	AGE1+
1-1-w1091	5-c	1.5E-003	4.1E-001	1.8E-003	1.7E-006	AGE1+
1-1-w1092	3-b	2.3E-002	3.7E-002	1.8E-005	1.9E-008	AGE1+
1-1-w1093	3-b	7.2E-004	1.4E-001	3.8E-004	1.4E-007	AGE1+
1-1-w1094	4-b	3.0E-002	2.1E-001	1.6E-004	9.3E-008	AGE1+
1-3-w1105	1-b	4.1E-013	1.5E-003	3.4E-001	5.6E-001	AGE3+
1-2-w1106	1-b	4.8E-014	1.7E-004	3.9E-002	4.7E-002	AGE3+
1-2-w1107	1-b	7.7E-014	1.1E-003	4.0E-001	4.5E-001	AGE3+
1-2-w1109	2-b	3.4E-012	6.5E-004	5.5E-002	1.2E-001	AGE3+
1-3-w1110	3-b	1.1E-017	9.1E-006	6.1E-002	6.8E-001	AGE3+
1-2-w1111	3-b	3.7E-012	1.0E-003	3.1E-002	3.4E-003	AGE2+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-2-w1112	2-c	1.5E-016	3.9E-005	1.1E-001	6.1E-001	AGE3+
1-2-w1113	3-b	4.0E-013	1.8E-003	4.4E-001	5.8E-001	AGE3+
1-2-w1114	3-d	1.0E-014	5.2E-004	4.2E-001	5.0E-001	AGE3+
1-1-w1095	1-b	9.9E-011	1.0E-002	2.0E-001	5.1E-002	AGE2+
1-1-w1096	1-b	1.2E-008	1.5E-002	4.5E-002	1.4E-002	AGE2+
1-1-w1097	2-c	2.4E-009	8.9E-002	7.0E-001	3.6E-002	AGE2+
1-1-w1098	3-b	2.0E-006	5.4E-001	1.3E-001	6.8E-004	AGE1+
1-1-w1099	2-b	9.0E-010	8.5E-003	8.1E-002	4.6E-002	AGE2+
1-1-w1100	3-b	5.5E-009	6.0E-003	1.1E-002	1.3E-003	AGE2+
1-1-w1101	2-b	1.2E-008	1.3E-001	4.3E-001	1.0E-002	AGE2+
1-2-w1102	1-b	8.8E-012	7.9E-003	3.5E-001	5.6E-002	AGE2+
1-2-w1103	2-b	1.7E-015	2.7E-006	1.2E-003	1.9E-002	AGE3+
1-2-w1104	3-b	6.3E-015	2.6E-005	1.7E-002	1.3E-001	AGE3+
1-2-w1108	4-b	1.1E-014	1.9E-004	1.2E-001	4.8E-001	AGE3+
1-1-w651	2-b	1.2E-007	3.7E-002	1.9E-002	2.6E-004	AGE1+
1-1-w470	2-c	2.0E-001	1.2E-003	1.6E-008	1.6E-012	AGE0+
1-1-w588	2-c	3.5E-001	9.4E-003	2.4E-007	1.7E-011	AGE0+
1-1-w665	1-b	5.7E-002	4.9E-002	4.6E-006	1.9E-010	AGE0+
1-1-w666	4-c	1.7E-001	6.4E-002	5.0E-006	3.7E-010	AGE0+
1-1-w620	1-b	1.3E-001	3.5E-002	1.8E-006	7.1E-011	AGE0+
1-1-w680	3-b	2.8E-002	1.8E-002	1.5E-006	2.7E-010	AGE0+
1-1-w681	1-c	2.6E-001	1.2E-003	1.4E-008	1.1E-012	AGE0+
1-1-w1012	1-b	1.4E-002	1.8E-001	1.8E-004	1.5E-007	AGE1+
1-1-w1022	4-d	1.1E-004	4.8E-002	3.0E-004	3.6E-007	AGE1+
1-1-w1023	5-b	1.0E-002	1.7E-001	2.1E-004	2.2E-007	AGE1+

Table 3-10 continued

slide #	Scale & Quality code	Relative Probabilities Age 0+	Age 1+	Age 2+	Age 3+	Age assignment
1-1-w1025	2-c	9.1E-004	2.1E-001	6.1E-004	2.1E-007	AGE1+
1-1-w1029	5-c	3.4E-002	1.1E-001	4.7E-005	2.3E-008	AGE1+
1-3-w1030	5-c	3.5E-001	3.3E-004	9.4E-010	2.8E-014	AGE0+
1-3-w1031	5-c	5.8E-001	1.3E-003	6.9E-009	2.6E-013	AGE0+
1-3-w1032	1-c	7.7E-001	3.8E-004	5.4E-010	4.7E-015	AGE0+
1-3-w1033	4-b	6.4E-001	1.1E-003	4.6E-009	9.7E-014	AGE0+
1-3-w1034	4-b	5.6E-001	2.4E-003	1.3E-008	2.8E-013	AGE0+
1-3-w1035	3-b	5.9E-001	5.0E-003	4.7E-008	1.5E-012	AGE0+
1-3-w1036	1-b	7.2E-001	2.8E-004	4.5E-010	6.5E-015	AGE0+
1-3-w1038	1-b	6.4E-001	1.4E-003	7.1E-009	1.9E-013	AGE0+
1-1-w1039	3-c	5.9E-001	1.7E-003	9.1E-009	3.0E-013	AGE0+
1-2-w1040	5-c	3.9E-001	1.5E-003	7.2E-009	1.1E-013	AGE0+
1-2-w1041	2-d	2.4E-001	2.0E-002	6.1E-007	2.0E-011	AGE0+
1-2-w1042	2-b	3.3E-001	9.8E-003	2.3E-007	1.2E-011	AGE0+
1-2-w1043	4-b	1.3E-001	7.3E-002	6.5E-006	4.2E-010	AGE0+
1-2-w1044	5-b	3.6E-001	2.0E-006	2.3E-013	4.8E-019	AGE0+
1-2-w1045	2-c	5.5E-001	2.4E-005	9.9E-012	6.2E-017	AGE0+
1-2-w1046	4-c	3.9E-001	1.7E-002	4.6E-007	2.7E-011	AGE0+
1-2-w1048	2-c	3.5E-001	1.2E-002	2.5E-007	1.3E-011	AGE0+
1-2-w1050	2-c	5.0E-001	4.5E-003	4.9E-008	2.5E-012	AGE0+
1-2-w1051	5-c	4.0E-001	1.8E-002	4.6E-007	2.6E-011	AGE0+
1-2-w1052	3-c	3.4E-001	4.7E-003	1.0E-007	9.2E-012	AGE0+
1-2-w1053	4-b	2.1E-001	3.5E-002	2.5E-006	2.8E-010	AGE0+
1-2-w1054	3-c	3.1E-001	2.1E-002	7.6E-007	4.9E-011	AGE0+
1-2-w1055	2-c	3.5E-001	1.4E-002	4.2E-007	3.1E-011	AGE0+

3.1.4 Time required for processing

The time required to process the 200 cleaned, dry-mounted scales and 200 acetate impression of uncleaned scales was recorded. The activities required by BioSonics to process the scales were data acquisition, data editing, conversion of Single line luminance data to Fourier representation, and age assignment using a parameterized OPRS. The acetate slides were processed fairly early in the study and required a total of 19 hours to process 200 scales. The cleaned, dry-mounted slides were processed later in the study and required a total of 9.5 hours to process 200 scales. The striking difference in effort was due to the data entry technician's learning curve.

Normandeau used these values to develop estimates of the total time required to process a batch of 200 slides by both the traditional and OPRS procedures. This total time estimate included such activities as scale cleaning, slide labeling, data entry, and packing slides for shipment. Normandeau estimated that a batch of 200 acetate impressions of uncleaned scales would be processed in 33.8 hours by traditional methods and in 25.9 hours by the OPRS. The extra effort required by Normandeau to clean and dry-mount scales increased the estimated OPRS processing time for the 200 cleaned, dry-mounted scales to 34.2 hours, approximately the same as that required by Normandeau to process 200 acetate slides.

We are unable to comment on the methods, assumptions, or accuracy of the total processing time estimates as we have not yet received that information.

3.2 Objective II - Hatchery vs Wild

3.2.1 Task 2: Parameterizing system

The OPRS system was parameterized using only cleaned, dry-mounted scales. Both circuli spacing (Radial Line data) and scale shape (Fourier Descriptor 1 data) were examined for discrimination ability. Analysis of variance was used to test for significant differences between hatchery and grouped wild scales, and between river regions and collection month for the wild scales.

For circuli spacing data, only the distance from the focus of the scale to the first circulus differed between the hatchery and pooled wild scales (Figure 3-12). This scale attribute did not change significantly by month within either region 1 or region 2 of the Hudson River (Figures 3-13, 3-14) The number of circuli and total length of the radial line were significantly different between hatchery and grouped wild scales (Figures 3-15, 3-16), with the hatchery fish having fewer circuli and shorter radial line lengths (Table 3-11). Two components of the Fourier Descriptor type 1 data, component numbers 5 and 6, were significantly different between hatchery and pooled wild scales (Figures 3-17, 3-18, Table 3-11).

Table 3-11. ANOVA results for Objective II: parameterizing system with cleaned, dry-mounted scales.

Variable	F-statistic	Sig. Level	Factor level means Hatchery	Wild
First circulus	67.9	P < .00001	6.1e-5	7.3e-5
# of circuli	205.4	P < .00001	14.8	19.2
Line length	215.5	P < .00001	6.0e-4	7.8e-4
FD1 #5	200.7	P < .00001	.017	.023
FD1 #6	81.1	P < .00001	.008	.013

FIGURE 3-12 NOTCHED BOX AND WHISKER PLOT OF DISTANCE TO FIRST CIRCULUS VERSUS ORIGIN.

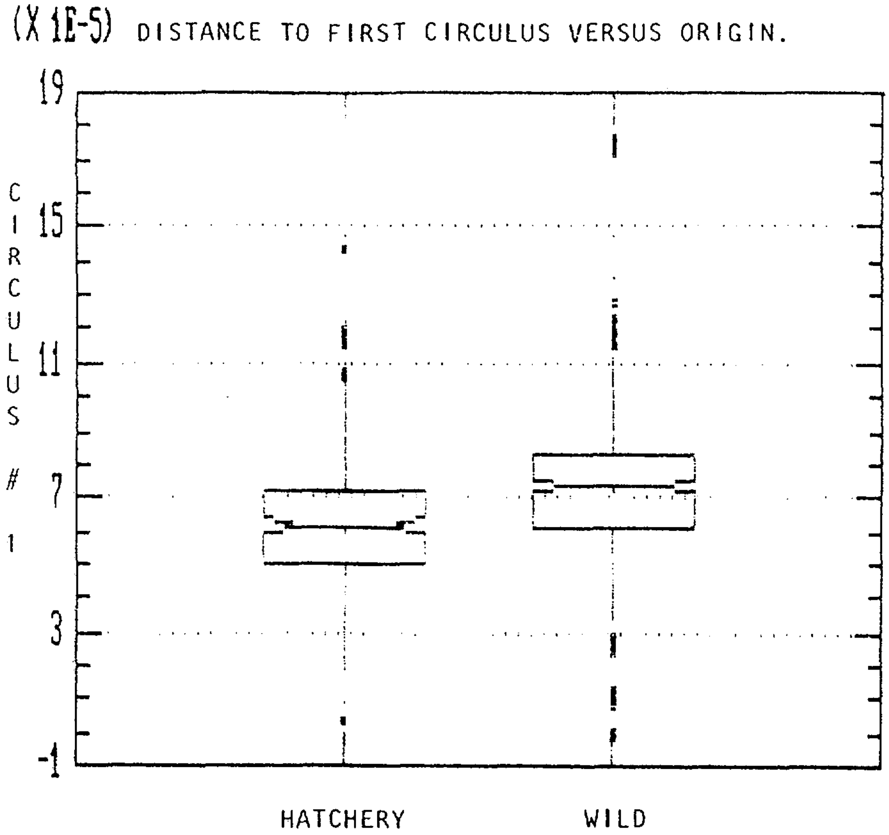


FIGURE 3-13 NOTCHED BOX AND WHISKER PLOT OF DISTANCE TO FIRST CIRCULUS FOR REGION 1 FISH BY COLLECTION MONTH.

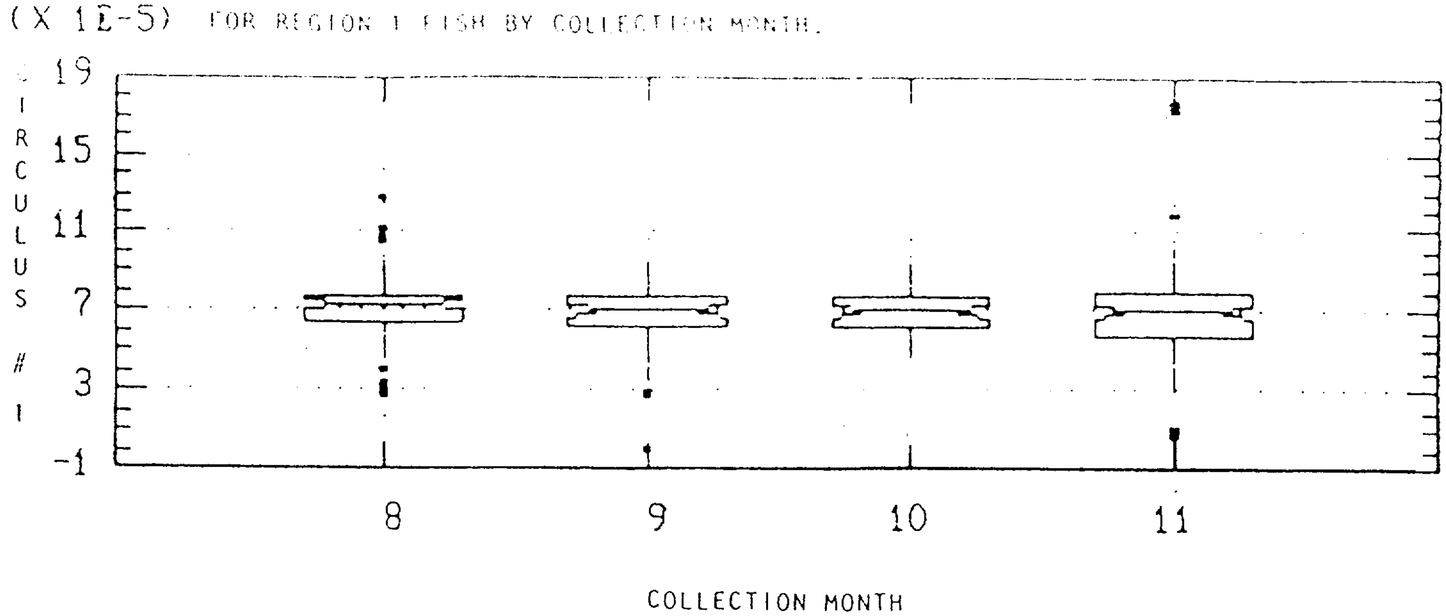


FIGURE 3-14 NOTCHED BOX AND WHISKER PLOT OF DISTANCE TO FIRST CIRCULUS FOR REGION 2 FISH BY COLLECTON MONTH.

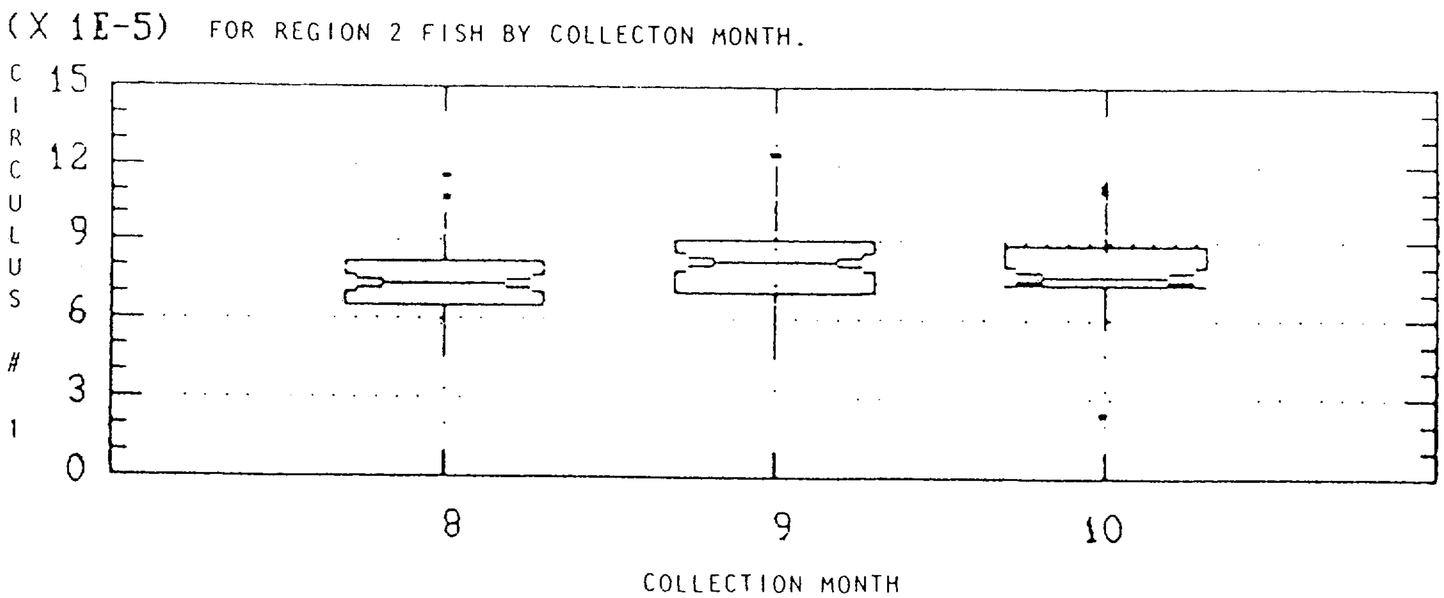


FIGURE 3-15 Notched Box and Whisker plot of total number of circuli versus origin

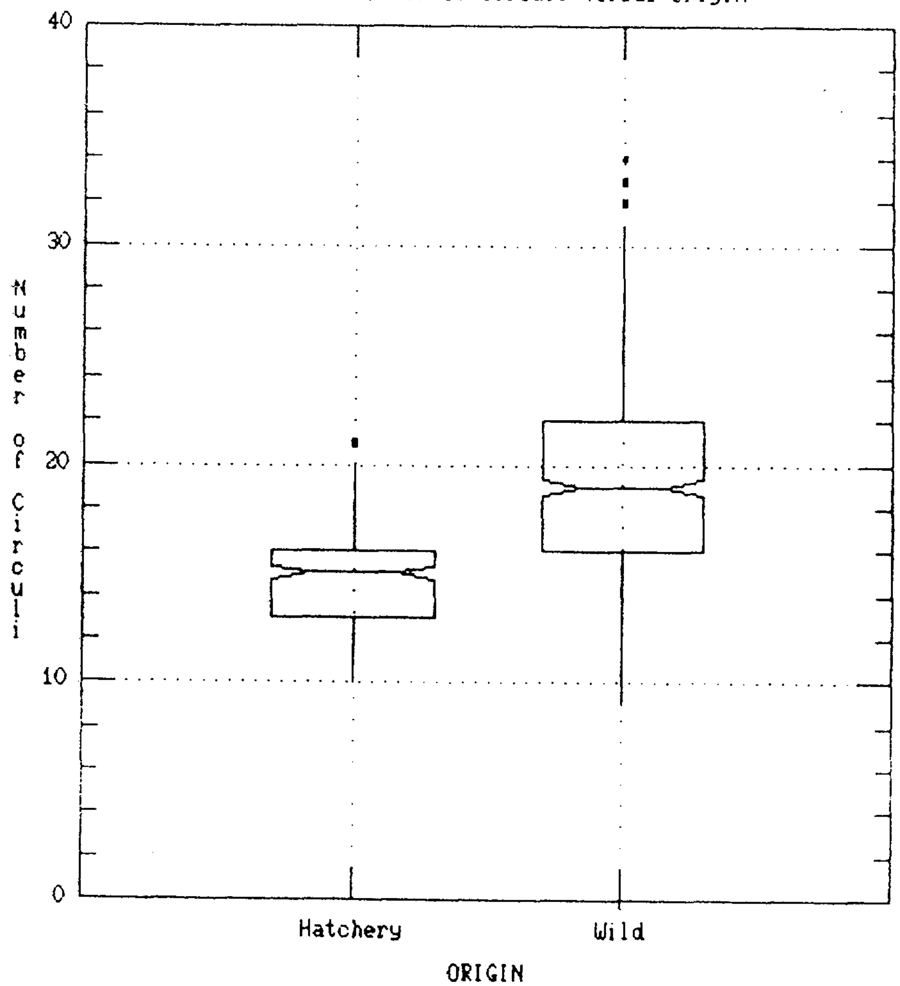


FIGURE 3-16 Notched Box and Whisker plot of Radial Line length (m) versus origin.

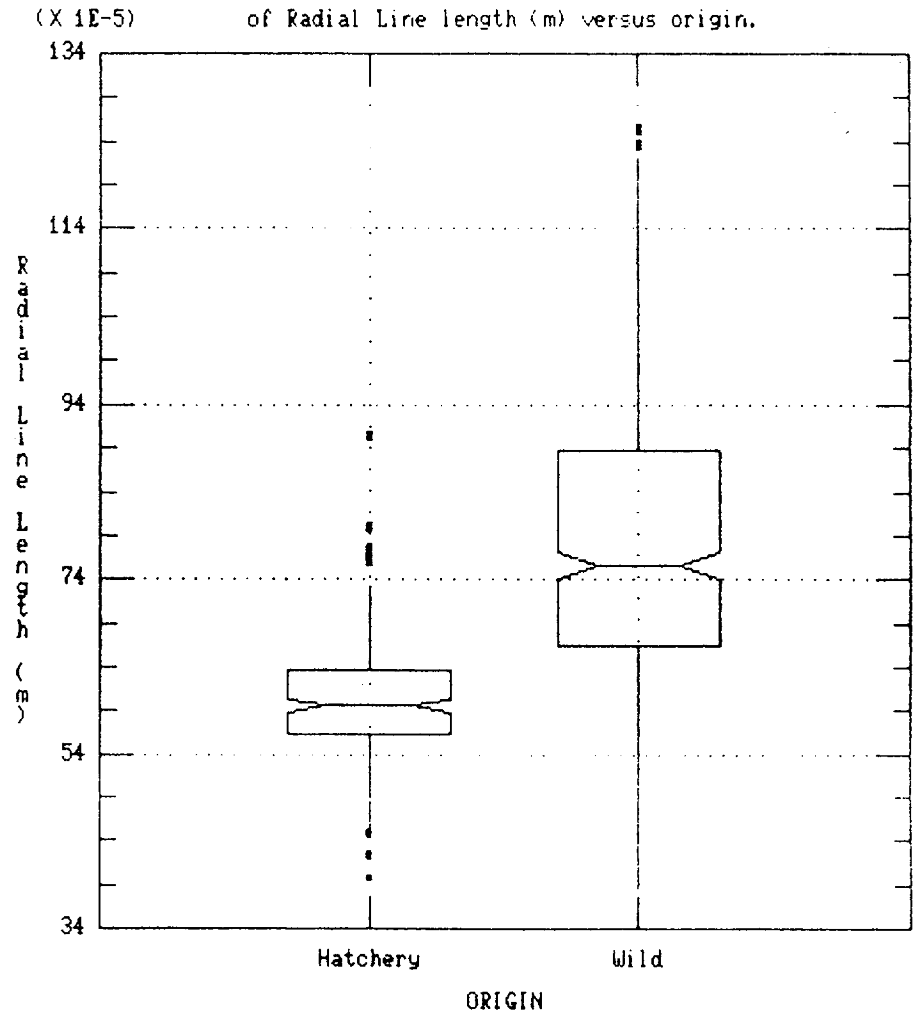


FIGURE 3-17 Notched Box and Whisker plot of FD1 component #5 versus origin.

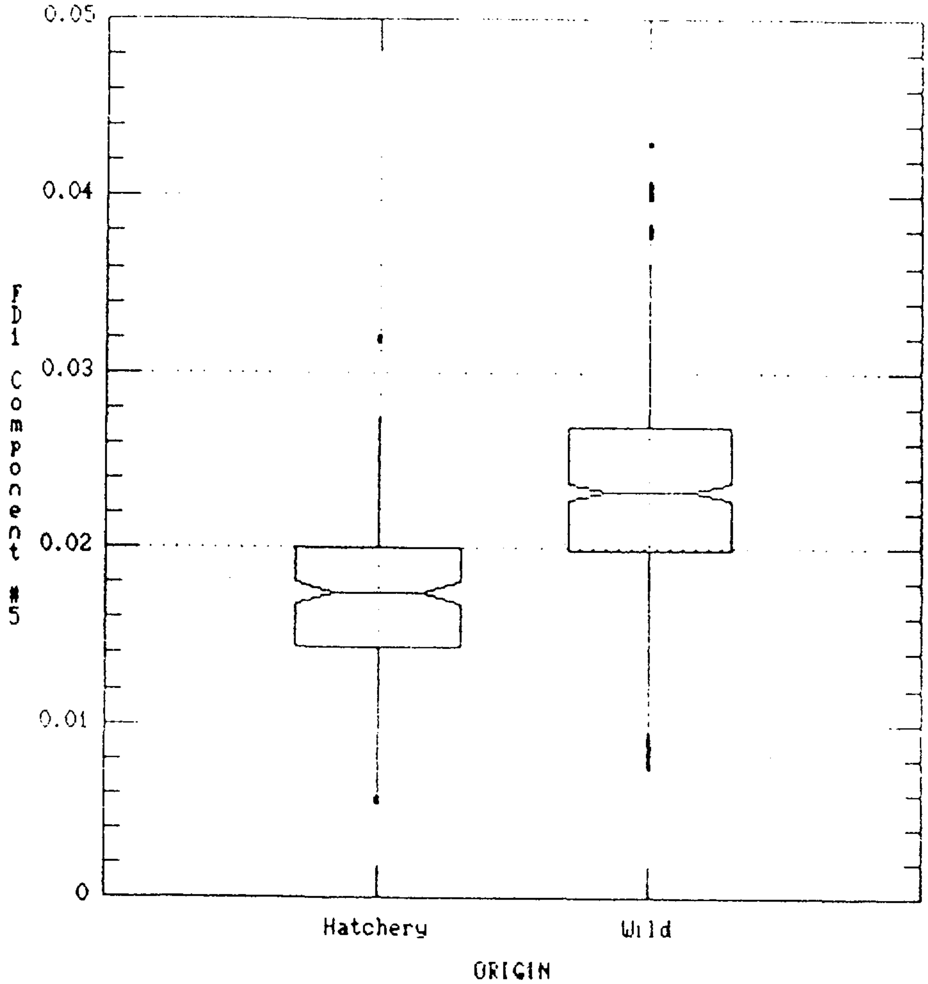
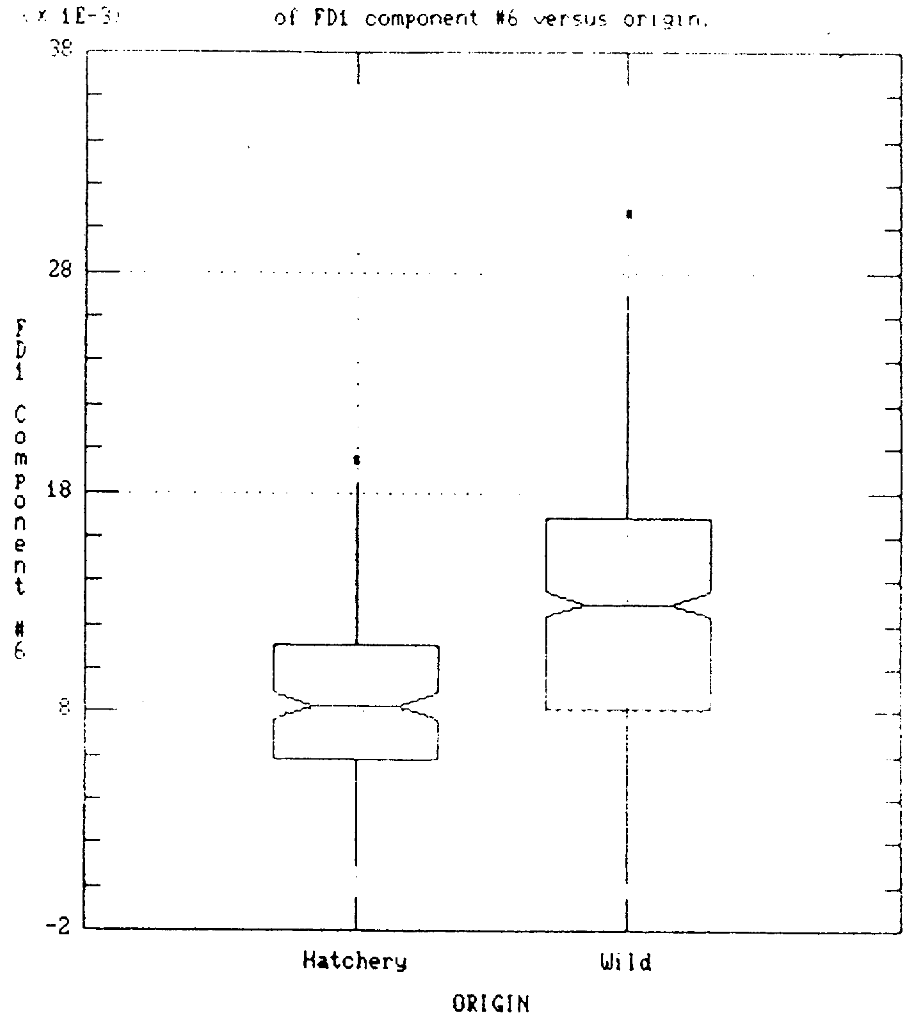


FIGURE3 18 Notched Box and Whisker plot of FD1 component #6 versus origin.



The OPRS system was parameterized twice: once with the circuli spacing information, and once with the scale shape information.

Using circuli spacing, number of circuli, and radial line length, 171 (86%) of the 200 hatchery scales were correctly assigned, and 451 (74%) of the 601 pooled wild scales were correctly assigned. Adding fish length information increases the accuracy of origin assessment; 180 (90%) of the hatchery scales, and 460 (77%) of the pooled wild scales were correctly assigned.

Applying Fourier component numbers 5 and 6 to a subset of the known origin scales produced 80% (40 of 50) correct assignment of hatchery origin, and 84% (42 of 50) correct assignment of wild origin.

Fourier scale shape descriptors should be robust features for assigning origin because they are likely to be size-invariant. We would expect much better accuracy in assigning origin when using cleaned, dry-mounted scales than when using acetate impressions because the perimeter of a scale is poorly reproduced in an impression and most of the medium to fine resolution scale shape information is missing or distorted.

3.2.2 Task 3: Discrimination using cleaned glass slides

Scales have not been delivered for this objective.

3.2.3 Task 4: Discrimination using acetate impressions

Acetate impressions of unknown origin scales were grouped by month of collection. Using the circuli spacing and size parameters, origin assignments were made for scales collected in August (Tables 3-12, 3-13), September (Tables 3-14, 3-15), October (Tables 3-16, 3-17), and November (Tables 3-18, 3-19).

Origin assignments were also made using the Fourier descriptor type I parameters for August (Tables 3-20, 3-21), September (Tables 3-22, 3-23), October (Tables 3-24, 3-25), and November (Tables 3-26, 3-27).

Although we have not yet received the precision and accuracy results for our origin assignments, the differences in assignment proportions by month between the two parameterization methods suggests that the size-dependent parameters are strongly influenced by collection month, and may not be appropriate to use for extrapolating to time periods for which known samples of both hatchery and wild origin are unavailable.

Table [illegible] Proportion of [illegible] unknown [illegible]
[illegible]

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 90

THE CLASSIFICATION ARRAY IS:
 171  150
  29  451

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.855   0.250
  0.145   0.750

THE NATURAL ESTIMATE IS:
0.767 Proportion HATCHERY
0.233 Proportion WILD

THE NEARLY UNBIASED ESTIMATE IS:
0.854 Proportion HATCHERY
0.146 Proportion WILD

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.720 0.988 Lower and Upper Bounds for HATCHERY
 0.012 0.280 Lower and Upper Bounds for WILD

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.720 0.988 Lower and Upper Bounds for HATCHERY
 0.012 0.280 Lower and Upper Bounds for WILD
```

Table 3-13. Individual August scale origin assignments using circuli spacing information.

SAMPLE ID#	SPECIMEN	HATCHERY	WILD	ORIGIN
1-8-1	3-c	6.2E^{2}001	1.3E^{2}001	HATCHERY
1-8-2	1-c	2.2E^{2}001	6.7E^{2}002	HATCHERY
1-8-3	3-c	2.6E^{2}001	3.4E^{2}002	HATCHERY
1-8-4	3-b	2.5E^{2}001	9.7E^{2}002	HATCHERY
1-8-5	3-c	1.6E^{2}002	6.9E^{2}003	HATCHERY
1-8-6	2-c	2.0E^{2}001	7.3E^{2}002	HATCHERY
1-8-7	3-c	2.1E^{2}001	7.4E^{2}001	WILD
1-8-8	4-d	1.1E^{2}001	6.2E^{2}003	HATCHERY
1-8-9	4-c	5.5E^{2}001	1.3E^{2}001	HATCHERY
1-8-10	3-c	2.1E^{2}002	1.2E^{2}003	HATCHERY
1-8-11	2-c	1.4E^{2}001	2.1E^{2}002	HATCHERY
1-8-12	2-c	1.8E^{2}001	8.6E^{2}002	HATCHERY
1-8-13	4-b	7.9E^{2}001	1.5E^{2}001	HATCHERY
1-8-14	1-d	1.4E^{2}001	5.6E^{2}002	HATCHERY
1-8-15	2-c	2.4E^{2}001	2.2E^{2}002	HATCHERY
1-8-16	2-b	8.7E^{2}002	1.3E^{2}001	WILD
1-8-17	2-c	5.6E^{2}001	1.8E^{2}001	HATCHERY
1-8-18	5-c	2.8E^{2}002	1.5E^{2}002	HATCHERY
1-8-19	5-c	3.1E^{2}001	3.9E^{2}002	HATCHERY
1-8-20	5-c	1.4E^{2}001	2.9E^{2}001	WILD
1-8-21	1-c	3.4E^{2}002	8.7E^{2}004	HATCHERY
1-8-22	2-c	1.8E^{2}001	8.7E^{2}002	HATCHERY
1-8-23	3-b	6.7E^{2}001	6.5E^{2}001	HATCHERY
1-8-24	1-c	1.2E^{2}010	3.2E^{2}009	WILD
1-8-25	4-b	1.3E^{2}001	4.0E^{2}001	WILD
1-8-26	4-c	4.1E^{2}004	7.4E^{2}004	WILD
1-8-27	2-d	3.6E^{2}002	1.7E^{2}003	HATCHERY
1-8-28	3-c	3.1E^{2}001	2.0E^{2}001	HATCHERY
1-8-29	4-c	7.2E^{2}002	9.1E^{2}002	WILD
1-8-30	3-d	5.0E^{2}001	2.9E^{2}001	HATCHERY
1-8-31	1-b	2.9E^{2}001	6.2E^{2}001	WILD
1-8-32	5-c	9.1E^{2}001	7.0E^{2}001	HATCHERY
1-8-33	1-c	6.3E^{2}002	1.4E^{2}003	HATCHERY
1-8-34	2-a	1.6E^{2}004	9.6E^{2}004	WILD
1-8-35	4-c	2.9E^{2}001	1.6E^{2}001	HATCHERY
1-8-36	4-b	1.3E^{2}001	5.2E^{2}001	WILD
1-8-37	2-c	1.2E^{2}002	6.7E^{2}002	WILD
1-8-38	1-b	1.7E^{2}001	6.6E^{2}001	WILD
1-8-39	1-d	6.0E^{2}001	2.4E^{2}001	HATCHERY
1-8-40	1-c	7.8E^{2}001	4.5E^{2}001	HATCHERY
1-8-41	3-c	2.6E^{2}001	1.7E^{2}002	HATCHERY
1-8-42	1-c	2.8E^{2}001	4.8E^{2}002	HATCHERY
1-8-43	4-c	1.7E^{2}001	8.1E^{2}002	HATCHERY
1-8-44	5-c	3.8E^{2}002	3.2E^{2}002	HATCHERY
1-8-45	2-c	9.8E^{2}002	9.8E^{2}002	WILD
1-8-46	5-c	1.3E^{2}001	4.7E^{2}002	HATCHERY
1-8-47	1-b	7.7E^{2}001	1.8E^{2}001	HATCHERY
1-8-48	1-b	1.1E^{2}001	8.0E^{2}002	HATCHERY
1-8-49	4-b	8.3E^{2}001	2.8E^{2}001	HATCHERY

TABLE 3-13 continued

SAMPLE ID#	SPECIMEN	HATCHERY	WILD	ORIGIN
1-8-50	1-c	3.4E²002	3.6E²003	HATCHERY
1-8-51	2-d	1.9E²001	1.8E²002	HATCHERY
1-8-52	2-c	7.3E²001	1.3E²001	HATCHERY
1-8-53	5-b	2.5E²001	8.0E²002	HATCHERY
1-8-54	2-b	2.1E²001	2.1E²002	HATCHERY
1-8-55	5-c	9.4E²002	7.3E²002	HATCHERY
1-8-56	1-b	1.7E²002	2.3E²001	WILD
1-8-57	1-c	1.9E²003	9.5E²004	HATCHERY
1-8-58	3-c	8.0E²002	7.6E²003	HATCHERY
1-8-59	1-c	9.8E²001	3.7E²001	HATCHERY
1-8-60	1-c	3.7E²001	7.6E²001	WILD
1-8-61	1-c	1.7E²001	8.3E²003	HATCHERY
1-8-62	1-c	6.1E²001	1.0E²001	HATCHERY
1-8-63	5-c	1.2E²002	1.7E²002	WILD
1-8-64	4-c	2.2E²002	2.7E²004	HATCHERY
1-8-65	1-c	5.4E²001	1.8E²001	HATCHERY
1-8-66	1-c	5.8E²002	4.8E²002	HATCHERY
1-8-67	6-c	5.7E²001	6.6E²002	HATCHERY
1-8-68	3-c	7.2E²001	8.8E²002	HATCHERY
1-8-69	1-b	1.1E²001	1.1E²002	HATCHERY
1-8-70	3-c	6.4E²001	1.1E²001	HATCHERY
1-8-71	2-c	6.9E²001	8.6E²002	HATCHERY
1-8-72	1-c	6.8E²001	2.6E²001	HATCHERY
1-8-73	1-b	8.5E²001	3.0E²001	HATCHERY
1-8-74	1-c	4.4E²001	1.6E²001	HATCHERY
1-8-75	2-b	9.2E²001	4.7E²001	HATCHERY
1-8-76	1-c	4.5E²001	2.5E²001	HATCHERY
1-8-77	3-b	3.0E²002	8.7E²002	WILD
1-8-78	4-b	1.7E²001	7.1E²001	WILD
1-8-79	2-c	3.0E²001	1.3E²001	HATCHERY
1-8-80	2-c	2.8E²001	3.0E²002	HATCHERY
1-8-81	2-c	2.9E²002	7.3E²002	WILD
1-8-82	1-c	7.5E²002	1.8E²003	HATCHERY
1-8-83	4-d	5.5E²001	2.7E²001	HATCHERY
1-8-84	2-b	7.1E²003	5.8E²002	WILD
1-8-85	2-c	8.9E²001	2.7E²001	HATCHERY
1-8-86	1-b	4.4E²001	7.8E²001	WILD
1-8-87	2-e	2.6E²001	2.3E²002	HATCHERY
1-8-88	3-c	4.0E²001	1.1E²001	HATCHERY
1-8-89	1-c	7.5E²001	6.3E²001	HATCHERY
1-8-90	2-d	6.5E²002	1.1E²003	HATCHERY

TABLE 3-13 continued

Table 3-14. Proportions of September unknown scales assigned to hatchery or wild origin using circuli spacing information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 90

THE CLASSIFICATION ARRAY IS:
 171  150
  29  451

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.855   0.250
  0.145   0.750

THE NATURAL ESTIMATE IS:
0.533 Proportion HATCHERY
0.467 Proportion WILD

THE NEARLY UNBIASED ESTIMATE IS:
0.469 Proportion HATCHERY
0.531 Proportion WILD

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.321 0.617 Lower and Upper Bounds for HATCHERY
 0.383 0.679 Lower and Upper Bounds for WILD

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.321 0.617 Lower and Upper Bounds for HATCHERY
 0.383 0.679 Lower and Upper Bounds for WILD
```

Table 3-15. Individual [illegible]
[illegible]

SAMPLE ID#	SPECIMEN	HATCHERY	WILD	ORIGIN
hr-9-91	1-b	2.1E²002	9.7E²002	WILD
hr-9-92	3-c	7.3E²003	4.1E²003	HATCHERY
hr-9-93	1-b	4.3E²002	1.4E²001	WILD
hr-9-94	3-c	7.4E²004	4.0E²004	HATCHERY
hr-9-95	3-c	5.4E²001	5.9E²001	WILD
hr-9-96	3-c	1.5E²001	2.3E²001	WILD
hr-9-97	3-b	5.1E²001	5.0E²001	HATCHERY
hr-9-98	2-d	3.7E²003	3.8E²004	HATCHERY
hr-9-99	5-b	3.1E²001	4.7E²001	WILD
hr-9-100	1-c	6.6E²001	7.4E²001	WILD
hr-9-101	1-c	2.3E²001	1.8E²001	HATCHERY
hr-9-102	1-c	9.5E²001	2.4E²001	HATCHERY
hr-9-103	5-c	2.0E²001	1.0E²001	HATCHERY
hr-9-104	2-c	9.1E²001	2.7E²001	HATCHERY
hr-9-105	1-b	1.3E²003	3.7E²003	WILD
hr-9-106	4-b	1.7E²002	7.1E²001	WILD
hr-9-107	2-b	6.9E²001	2.4E²001	HATCHERY
hr-9-108	4-c	1.7E²001	3.1E²002	HATCHERY
hr-9-109	2-c	4.5E²001	3.4E²001	HATCHERY
hr-9-110	1-c	7.1E²002	1.4E²001	WILD
hr-9-111	4-b	4.9E²001	5.9E²001	WILD
hr-9-112	2-c	1.0E²002	4.5E²002	WILD
hr-9-113	4-b	3.8E²001	2.0E²001	HATCHERY
hr-9-114	2-b	5.7E²002	2.6E²001	WILD
hr-9-115	3-c	8.9E²002	2.7E²001	WILD
hr-9-116	3-d	3.7E²003	3.8E²004	HATCHERY
hr-9-117	1-c	2.5E²002	6.8E²002	WILD
hr-9-118	2-c	9.4E²002	1.6E²001	WILD
hr-9-119	1-c	3.6E²001	8.3E²001	WILD
hr-9-120	1-c	3.4E²001	7.3E²002	HATCHERY
hr-9-121	4-b	[illegible]	1.3E²001	WILD
hr-9-122	4-b	1.5E²002	7.9E²002	WILD
hr-9-123	3-c	3.3E²001	4.7E²002	HATCHERY
hr-9-124	1-b	4.1E²001	6.8E²001	WILD
hr-9-125	2-c	5.6E²001	5.6E²002	HATCHERY
hr-9-126	5-b	5.2E²002	3.8E²001	WILD
hr-9-127	1-b	3.5E²004	5.9E²003	WILD
hr-9-128	4-c	5.8E²001	1.4E²001	HATCHERY
hr-9-129	3-b	5.4E²001	5.3E²001	HATCHERY
hr-9-130	1-c	1.5E²004	7.7E²004	WILD
hr-9-131	2-c	4.7E²001	5.5E²002	HATCHERY
hr-9-132	3-c	4.1E²001	2.7E²001	HATCHERY
hr-9-133	3-c	6.2E²001	7.2E²002	HATCHERY
hr-9-134	1-c	1.6E²001	1.3E²001	HATCHERY
hr-9-135	1-c	4.9E²001	4.9E²001	HATCHERY
hr-9-136	3-c	2.6E²001	1.4E²001	HATCHERY
hr-9-137	4-d	3.9E²001	3.7E²001	HATCHERY
hr-9-138	4-d	5.8E²001	3.7E²001	HATCHERY
hr-9-139	1-[illegible]	1.9E²002	1.2E²002	HATCHERY
hr-9-140	1-[illegible]	4.0E²001	5.5E²001	WILD

SAMPLE ID#	SPECIMEN	HATCHERY	WILD	ORIGIN
hr-9-141	[illegible]-b	1.7E+001	7.1E+001	WILD
hr-9-142	3-b	2.[illegible]E+004	1.6E+002	WILD
hr-9-145	5-b	2.1E+001	7.0E+001	WILD
hr-9-144	4-c	7.1E+001	9.6E+002	HATCHERY
hr-9-146	4-c	3.9E+002	2.2E+001	WILD
hr-9-147	3-c	7.5E+004	4.2E+004	HATCHERY
hr-9-148	2-b	1.1E+001	2.9E+001	WILD
hr-9-149	4-c	2.1E+004	1.4E+003	WILD
hr-9-150	4-d	3.7E+001	1.0E+001	HATCHERY
hr-9-151	2-b	6.3E+001	1.7E+001	HATCHERY
hr-9-152	4-c	1.7E+003	3.2E+003	WILD
hr-9-153	3-c	4.6E+003	2.0E+002	WILD
hr-9-154	1-c	2.6E+001	3.9E+002	HATCHERY
hr-9-155	2-c	1.4E+001	1.7E+001	WILD
hr-9-156	1-e	6.6E+001	8.2E+002	HATCHERY
hr-9-157	1-b	7.2E+001	1.7E+001	HATCHERY
hr-9-158	2-b	6.4E+003	6.3E+002	WILD
hr-9-160	2-c	4.6E+003	2.0E+003	HATCHERY
hr-9-161	1-c	7.0E+001	1.5E+001	HATCHERY
hr-9-162	4-c	6.1E+001	1.2E+001	HATCHERY
hr-9-163	2-b	7.8E+001	6.3E+001	HATCHERY
hr-9-164	2-b	6.4E+001	2.1E+001	HATCHERY
hr-9-165	1-b	9.1E+003	4.5E+002	WILD
hr-9-166	4-c	8.8E+002	2.2E+001	WILD
hr-9-167	2-c	9.6E+001	4.3E+001	HATCHERY
hr-9-168	4-c	6.1E+001	6.7E+001	WILD
hr-9-169	5-b	2.0E+001	7.4E+001	WILD
hr-9-170	3-d	2.8E+003	2.5E+002	HATCHERY
hr-9-171	[illegible]	7.1E+002	4.1E+001	HATCHERY
hr-9-172	1-c	1.7E+001	5.5E+001	WILD
hr-9-173	2-b	3.2E+001	4.7E+001	WILD
hr-9-174	5-b	2.8E+001	1.5E+001	HATCHERY
hr-9-175	2-c	1.5E+001	1.0E+002	HATCHERY
hr-9-176	1-b	6.7E+003	4.4E+002	WILD
hr-9-178	1-b	3.9E+003	2.6E+002	WILD
hr-9-179	3-b	3.2E+001	3.2E+001	HATCHERY
hr-9-180	5-c	2.5E+001	1.0E+001	HATCHERY
hr-9-181	1-d	2.9E+001	1.6E+002	HATCHERY
hr-9-143	4-d	7.5E+001	1.2E+001	HATCHERY
hr-9-159	4-d	6.1E+002	1.0E+001	WILD

TABLE 3-15 continued

Table 3-16. Proportions of October unknown scales assigned to hatchery or wild origin using circuli spacing information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 54

THE CLASSIFICATION ARRAY IS:
 171  150
  29  451

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.855  0.250
  0.145  0.750

THE NATURAL ESTIMATE IS:
0.093 Proportion HATCHERY
0.907 Proportion WILD

THE NEARLY UNBIASED ESTIMATE IS:
0.000 Proportion HATCHERY
1.000 Proportion WILD

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.000 0.117 Lower and Upper Bounds for HATCHERY
 0.883 1.000 Lower and Upper Bounds for WILD

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.000 0.117 Lower and Upper Bounds for HATCHERY
 0.883 1.000 Lower and Upper Bounds for WILD
```

Table 3-17. Individual October scale origin assignments using circuli spacing information.

hr-10-18[illegible]	1-c	3.8E-001	2.0E-00[illegible]	HATCHERY
hr-10-183	3-c	3.3E-002	1.8E-001	WILD
hr-10-184	3-c	4.4E-004	3.1E-002	WILD
hr-10-185	2-c	4.4E-003	1.4E-002	WILD
hr-10-186	2-b	4.9E-003	2.7E-002	WILD
hr-10-187	4-b	4.5E-001	7.5E-001	WILD
hr-10-188	2-e	5.4E-003	1.0E-002	WILD
hr-10-189	2-c	8.7E-006	7.2E-004	WILD
hr-10-190	2-c	3.7E-001	4.2E-001	WILD
hr-10-191	1-d	1.6E-002	2.4E-002	WILD
hr-10-192	4-c	2.4E-007	8.4E-005	WILD
hr-10-193	3-c	1.5E-002	3.7E-002	WILD
hr-10-194	4-b	1.4E-006	2.7E-004	WILD
hr-10-195	1-c	2.7E-002	1.9E-001	WILD
hr-10-196	2-c	6.0E-003	1.4E-002	WILD
hr-10-197	3-c	4.0E-001	4.8E-001	WILD
hr-10-198	4-c	1.2E-003	2.2E-002	WILD
hr-10-199	5-c	2.1E-004	5.2E-004	WILD
hr-10-200	2-c	5.7E-001	6.5E-001	WILD
hr-10-201	4-c	6.4E-006	2.1E-003	WILD
hr-10-202	1-c	2.8E-004	1.7E-002	WILD
hr-10-203	2-c	3.2E-003	7.0E-002	WILD
hr-10-204	2-e	6.4E-003	1.2E-002	WILD
hr-10-205	2-c	2.8E-004	1.6E-002	WILD
hr-10-206	3-d	2.6E-006	1.5E-004	WILD
hr-10-207	4-c	3.1E-004	1.9E-003	WILD
hr-10-208	5-c	3.3E-002	4.7E-002	WILD
hr-10-209	2-c	6.9E-004	2.5E-002	WILD
hr-10-210	4-c	2.8E-004	9.9E-003	WILD
hr-10-211	4-c	8.4E-004	1.9E-003	WILD
hr-10-212	4-b	1.2E-005	6.5E-004	WILD
hr-10-213	2-c	4.6E-002	3.7E-001	WILD
hr-10-214	4-c	1.4E-004	4.9E-003	WILD
hr-10-215	3-c	1.0E-002	6.5E-002	WILD
hr-10-216	1-d	2.6E-002	1.0E-001	WILD
hr-10-217	1-c	4.5E-001	6.4E-001	WILD
hr-10-218	1-c	1.1E-003	4.1E-002	WILD
hr-10-219	3-c	4.5E-002	8.9E-002	WILD
hr-10-220	4-b	5.7E-002	2.6E-001	WILD
hr-10-221	2-d	7.9E-001	2.6E-001	HATCHERY
hr-10-222	2-d	1.0E-002	6.3E-002	WILD
hr-10-223	3-c	3.8E-002	2.3E-001	WILD
hr-10-224	3-d	6.7E-001	2.6E-001	HATCHERY
hr-10-225	4-c	2.7E-001	5.4E-001	WILD
hr-10-227	2-d	5.6E-001	2.4E-001	HATCHERY
hr-10-226	1-c	7.8E-005	1.2E-002	WILD
hr-10-228	5-c	1.5E-001	3.4E-001	WILD
hr-10-229	1-c	1.5E-002	1.2E-001	WILD
hr-10-230	3-c	5.3E-001	6.7E-001	WILD
hr-10-231	1-c	8.2E-002	[illegible].4E-001	WILD
hr-10-232	1-c	3.9E-006	1.4E-004	WILD
hr-10-233	1-c	3.3E-004	[illegible]E-004	HATCHERY
hr-10-234	1-c	3.2E-004	1.7E-002	WILD
hr-10-235	1-c	1.2E-001	4.7E-001	WILD

Table 3-18. Proportions of November unknown scales assigned to hatchery or wild origin using circuli spacing information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 53.

THE CLASSIFICATION ARRAY IS:
 171 150
  29 451

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.855  0.250
  0.145  0.750

THE NATURAL ESTIMATE IS:
0.245 Proportion HATCHERY
0.755 Proportion WILD

THE NEARLY UNBIASED ESTIMATE IS:
0.000 Proportion HATCHERY
1.000 Proportion WILD

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.000 0.167 Lower and Upper Bounds for HATCHERY
 0.833 1.000 Lower and Upper Bounds for WILD

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.000 0.167 Lower and Upper Bounds for HATCHERY
 0.833 1.000 Lower and Upper Bounds for WILD
```

Table 3-19. Individual November scale origin assignments using circuli spacing information.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
hr-11-243	5-b	3.4E+008	1.2E+005	WILD
hr-11-244	3-c	9.3E+006	1.3E+005	WILD
hr-11-245	2-c	2.1E+003	5.2E+002	WILD
hr-11-246	3-c	4.4E+002	1.3E+001	WILD
hr-11-247	2-c	6.6E+001	4.6E+001	HATCHERY
hr-11-248	2-b	5.1E+002	3.2E+001	WILD
hr-11-249	2-c	8.4E+004	2.8E+003	WILD
hr-11-250	1-c	1.6E+001	4.5E+002	HATCHERY
hr-11-251	4-c	1.7E+001	6.3E+002	HATCHERY
hr-11-252	2-d	1.9E+003	1.6E+002	WILD
hr-11-253	3-c	7.1E+004	5.0E+003	WILD
hr-11-254	1-c	2.2E+001	6.8E+002	HATCHERY
hr-11-255	2-c	4.4E+005	1.4E+004	WILD
hr-11-256	4-c	9.9E+008	3.9E+005	WILD
hr-11-257	4-e	2.5E+002	8.6E+004	HATCHERY
hr-11-258	1-c	1.2E+001	4.1E+001	WILD
hr-11-259	4-c	1.1E+002	4.2E+002	WILD
hr-11-260	1-d	1.3E+003	2.0E+003	WILD
hr-11-261	5-c	8.3E+006	1.6E+003	WILD
hr-11-262	5-d	4.9E+002	2.4E+001	WILD
hr-11-263	2-c	3.0E+001	4.8E+001	WILD
hr-11-264	1-c	3.9E+004	1.4E+003	WILD
hr-11-265	2-c	9.9E+003	1.1E+001	WILD
hr-11-266	4-d	5.7E+001	2.1E+001	HATCHERY
hr-11-267	1-d	1.3E+002	2.8E+003	HATCHERY
hr-11-268	3-c	2.3E+004	1.6E+002	WILD
hr-11-269	2-b	1.2E+002	1.8E+001	WILD
hr-11-270	2-c	2.9E+001	2.7E+001	HATCHERY
hr-11-271	2-b	7.1E+002	1.3E+001	WILD
hr-11-272	4-c	8.9E+001	3.4E+001	HATCHERY
hr-11-273	1-c	2.5E+001	4.7E+001	WILD
hr-11-274	4-c	8.4E+001	[illegible]	HATCHERY
hr-11-275	5-c	3.0E+001	[illegible]	WILD
hr-11-276	4-c	6.9E+003	[illegible]	WILD
hr-11-277	3-c	1.1E+006	1.0E+004	WILD
hr-11-278	2-d	1.7E+001	5.3E+001	WILD
hr-11-279	3-b	1.6E+001	6.6E+001	WILD
hr-11-280	1-d	7.2E+002	5.1E+002	HATCHERY
hr-11-281	3-c	5.0E+004	1.5E+002	WILD
hr-11-282	2-c	7.3E+002	3.9E+001	WILD
hr-11-283	2-c	4.7E+006	2.0E+004	WILD
hr-11-284	2-c	3.1E+001	4.7E+001	WILD
hr-11-285	3-d	4.9E+003	2.0E+002	WILD
hr-11-286	3-c	8.2E+004	1.3E+002	WILD
hr-11-287	3-c	1.2E+001	4.3E+001	WILD
hr-11-288	4-c	2.1E+002	1.8E+001	WILD
hr-11-289	4-c	8.6E+004	2.6E+002	WILD
hr-11-290	1-c	2.7E+002	1.0E+001	WILD
hr-11-291	4-c	1.4E+001	3.7E+001	WILD
hr-11-292	3-c	3.4E+002	3.4E+001	WILD
hr-11-293	5-c	1.4E+001	6.5E+001	WILD
hr-11-294	3-e	3.0E+003	1.4E+003	HATCHERY

Table [illegible]. [illegible] hatchery or wild origin [illegible]

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 90

THE CLASSIFICATION ARRAY IS:
 40   8
 10  42

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.800  0.160
  0.200  0.840

THE NATURAL ESTIMATE IS:
0.511 Proportion WILD
0.489 Proportion HATCHERY

THE NEARLY UNBIASED ESTIMATE IS:
0.549 Proportion WILD
0.451 Proportion HATCHERY

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.381 0.716 Lower and Upper Bounds for WILD
 0.284 0.619 Lower and Upper Bounds for HATCHERY

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.381 0.716 Lower and Upper Bounds for WILD
 0.284 0.619 Lower and Upper Bounds for HATCHERY
```

Table 3-21. Individual August scale origin assignments using LDA information.

SAMPLE ID	SPECIMEN	HATCHERY	WILD	ORIGIN
1-8-1	[illegible]	[illegible]E-001	1.[illegible]E-002	WILD
1-8-2	1-[illegible]	1.1E-001	[illegible]	HATCHERY
1-8-3	3-[illegible]	4.0E-002	1.8E-001	HATCHERY
1-8-4	3-b	2.6E-002	[illegible].5E-001	HATCHERY
1-8-5	3-c	9.3E-001	8.5E-001	HATCHERY
1-8-6	2-[illegible]	6.0E-001	4.7E-002	WILD
1-8-7	3-[illegible]	2.7E-001	8.6E-001	HATCHERY
1-8-8	4-d	9.5E-003	8.8E-003	WILD
1-8-9	4-c	1.5E-002	3.2E-001	HATCHERY
1-8-10	3-c	7.9E-003	4.1E-002	HATCHERY
1-8-11	2-c	5.7E-001	3.1E-002	WILD
1-8-12	2-c	9.4E-002	4.6E-001	HATCHERY
1-8-13	4-b	7.9E-001	3.0E-001	WILD
1-8-14	1-d	3.5E-001	8.1E-001	HATCHERY
1-8-15	2-c	1.2E-002	4.2E-001	HATCHERY
1-8-16	2-b	8.8E-001	1.7E-001	WILD
1-8-17	2-c	1.6E-001	5.7E-001	HATCHERY
1-8-18	5-c	7.1E-003	2.6E-001	HATCHERY
1-8-19	5-c	6.4E-003	2.1E-001	HATCHERY
1-8-20	5-c	1.6E-001	4.1E-003	WILD
1-8-21	1-c	6.2E-001	7.8E-001	HATCHERY
1-8-22	2-c	6.3E-002	2.5E-001	HATCHERY
1-8-23	3-b	1.2E-001	6.1E-002	WILD
1-8-24	1-c	5.1E-001	9.1E-002	WILD
1-8-25	4-b	1.2E-001	2.7E-003	WILD
1-8-26	4-c	1.2E-001	8.2E-001	HATCHERY
1-8-27	2-d	4.7E-002	3.8E-002	WILD
1-8-28	3-c	5.6E-002	5.8E-002	HATCHERY
1-8-29	4-c	8.5E-001	1.2E-001	WILD
1-8-30	3-d	3.4E-002	1.1E-002	WILD
1-8-31	1-b	4.6E-001	7.9E-001	HATCHERY
1-8-32	[illegible]	[illegible].1E-001	[illegible]	WILD
1-8-33	1-[illegible]	7.1E-001	8.[illegible]E-001	HATCHERY
1-8-34	2-c	8.3E-001	7.9E-001	WILD
1-8-35	4-c	5.2E-002	1.4E-002	WILD
1-8-36	4-b	6.2E-001	6.9E-001	HATCHERY
1-8-37	2-c	8.4E-001	5.7E-001	WILD
1-8-38	1-b	6.9E-001	7.3E-001	HATCHERY
1-8-39	1-d	1.8E-001	1.4E-001	WILD
1-8-40	1-c	3.3E-003	1.6E-001	HATCHERY
1-8-41	3-c	8.1E-005	1.2E-003	HATCHERY
1-8-42	1-c	2.7E-002	5.6E-001	HATCHERY
1-8-43	4-c	6.7E-002	6.3E-001	HATCHERY
1-8-44	5-c	4.3E-001	2.3E-002	WILD
1-8-45	2-c	6.0E-001	2.9E-001	WILD
1-8-46	5-c	6.8E-003	2.9E-005	WILD
1-8-47	1-b	4.1E-001	9.1E-001	HATCHERY
1-8-48	1-b	4.4E-001	1.5E-002	WILD
1-8-49	4-b	2.3E-002	5.3E-001	HATCHERY

SAMPLE ID#	SPECIMEN	HATCHERY	WILD	ORIGIN
1-8-50	[illegible]	[illegible]	[illegible]	[illegible]
1-8-51	2-d	7.4E+005	1.3E+00[illegible]	[illegible]
1-8-52	[illegible]	[illegible]	[illegible]	[illegible]
1-8-53	[illegible]	5.6E+00[illegible]	[illegible]	[illegible]
1-8-54	2-b	5.5E+001	1.5E+00[illegible]	[illegible]
1-8-55	5-c	7.2E+001	5.7E+00[illegible]	WILD
1-8-56	1-b	7.5E+001	2.0E+00[illegible]	WILD
1-8-57	1-c	6.2E+001	5.8E+00[illegible]	WILD
1-8-58	3-c	1.3E+005	3.9E+00[illegible]	HATCHERY
1-8-59	1-c	5.2E+001	8.5E+001	HATCHERY
1-8-60	1-c	1.1E+001	3.0E+001	HATCHERY
1-8-61	1-c	7.0E+001	2.3E+001	WILD
1-8-62	1-c	6.6E+001	1.6E+001	WILD
1-8-63	5-c	7.8E+001	6.7E+002	WILD
1-8-64	4-c	2.9E+002	6.0E+001	HATCHERY
1-8-65	1-c	3.0E+004	4.8E+002	HATCHERY
1-8-66	1-c	9.3E+001	1.3E+001	WILD
1-8-67	6-c	1.6E+002	4.0E+001	HATCHERY
1-8-68	3-c	2.2E+003	9.7E+003	HATCHERY
1-8-69	1-b	3.7E+003	1.5E+001	HATCHERY
1-8-70	3-c	9.9E+001	2.1E+001	WILD
1-8-71	2-c	1.1E+003	1.2E+001	HATCHERY
1-8-72	1-c	7.1E+001	7.0E+001	WILD
1-8-73	1-b	6.0E+001	1.6E+001	WILD
1-8-74	1-c	3.1E+001	6.4E+003	WILD
1-8-75	2-b	3.8E+003	2.4E+001	HATCHERY
1-8-76	1-c	8.2E+001	5.9E+001	WILD
1-8-77	3-b	8.0E+001	9.9E+002	WILD
1-8-78	4-b	8.2E+001	5.5E+001	WILD
1-8-79	2-c	6.4E+001	4.7E+001	WILD
1-8-80	[illegible]	1.4E+001	[illegible]	HATCHERY
1-8-81	[illegible]	[illegible]	[illegible]	WILD
1-8-82	1-c	4.8E+004	[illegible]	HATCHERY
1-8-83	4-d	5.7E+001	[illegible]	WILD
1-8-84	2-b	9.9E+001	2.1E+001	WILD
1-8-85	2-c	9.0E+003	1.3E+001	HATCHERY
1-8-86	1-b	4.2E+001	4.3E+001	HATCHERY
1-8-87	2-e	1.9E+002	4.5E+003	WILD
1-8-88	3-c	6.8E+001	3.1E+001	WILD
1-8-89	1-c	6.8E+001	4.7E+001	WILD
1-8-90	2-d	1.0E+003	1.1E+001	HATCHERY

TABLE 3-21 continued

Table 3-22. Proportions of September unknown scales assigned to hatchery or wild origin using FD1 information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 93

THE CLASSIFICATION ARRAY IS:
 40  8
 10 42

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.800  0.160
  0.200  0.840

THE NATURAL ESTIMATE IS:
0.484 Proportion WILD
0.516 Proportion HATCHERY

THE NEARLY UNBIASED ESTIMATE IS:
0.506 Proportion WILD
0.494 Proportion HATCHERY

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.341 0.671 Lower and Upper Bounds for WILD
 0.329 0.659 Lower and Upper Bounds for HATCHERY

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.341 0.671 Lower and Upper Bounds for WILD
 0.329 0.659 Lower and Upper Bounds for HATCHERY
```

Table 3-23. Individual September scale origin assignments using FD1 information.

hr-9-91	1-b	4.0E-002	5.0E-003	WILD
hr-9-92	3-c	2.2E-002	5.2E-001	HATCHERY
hr-9-93	1-b	1.6E-002	1.2E-003	WILD
hr-9-94	3-c	1.8E-001	3.0E-003	WILD
hr-9-95	3-c	2.5E-001	5.1E-001	HATCHERY
hr-9-96	3-c	4.8E-001	9.0E-001	HATCHERY
hr-9-97	3-b	1.7E-001	1.8E-002	WILD
hr-9-98	2-d	2.0E-005	9.6E-003	HATCHERY
hr-9-99	5-b	5.3E-001	7.1E-001	HATCHERY
hr-9-100	1-c	2.3E-001	6.5E-001	HATCHERY
hr-9-101	1-c	6.4E-001	2.6E-001	WILD
hr-9-102	1-c	1.7E-001	9.7E-001	HATCHERY
hr-9-103	5-c	5.9E-002	7.7E-001	HATCHERY
hr-9-104	2-c	1.5E-003	1.3E-001	HATCHERY
hr-9-105	1-b	8.3E-001	8.2E-002	WILD
hr-9-106	4-b	4.4E-001	4.0E-002	WILD
hr-9-107	2-b	1.1E-001	8.0E-001	HATCHERY
hr-9-108	4-c	2.1E-003	1.8E-001	HATCHERY
hr-9-109	2-c	1.9E-001	1.1E-001	WILD
hr-9-110	1-c	5.2E-001	4.9E-001	WILD
hr-9-111	4-b	4.5E-001	1.4E-001	WILD
hr-9-112	2-c	7.9E-002	1.5E-003	WILD
hr-9-113	4-b	1.1E-001	9.0E-001	HATCHERY
hr-9-114	2-b	5.8E-001	4.6E-001	WILD
hr-9-115	3-c	3.7E-001	5.7E-001	HATCHERY
hr-9-116	3-d	6.6E-006	1.2E-003	HATCHERY
hr-9-117	1-c	1.2E-001	9.1E-001	HATCHERY
hr-9-118	2-c	8.9E-002	2.7E-003	WILD
hr-9-119	1-c	2.3E-001	9.9E-001	HATCHERY
hr-9-120	1-c	2.3E-002	5.5E-001	HATCHERY
hr-9-121	4-b	1.0E-001	4.1E-002	WILD
hr-9-122	4-b	1.1E-001	1.7E-003	WILD
hr-9-123	3-c	7.0E-003	3.2E-001	HATCHERY
hr-9-124	1-b	6.0E-001	4.1E-001	WILD
hr-9-125	2-c	1.2E-005	6.9E-003	HATCHERY
hr-9-126	5-b	1.6E-002	2.9E-001	HATCHERY
hr-9-127	1-b	1.5E-001	2.2E-002	WILD
hr-9-128	4-c	8.3E-003	3.5E-001	HATCHERY
hr-9-129	3-b	3.3E-001	1.9E-001	WILD
hr-9-131	2-c	2.1E-001	9.9E-001	HATCHERY
hr-9-132	3-c	5.1E-003	2.6E-001	HATCHERY
hr-9-133	3-c	4.6E-002	7.1E-001	HATCHERY
hr-9-134	1-c	1.9E-001	1.1E-002	WILD
hr-9-135	1-c	1.4E-001	4.6E-001	HATCHERY
hr-9-136	3-c	4.4E-001	8.4E-001	HATCHERY
hr-9-137	4-d	6.1E-002	7.3E-001	HATCHERY
hr-9-138	4-d	8.1E-002	8.4E-001	HATCHERY
hr-9-139	1-c	8.0E-002	8.0E-001	HATCHERY
hr-9-140	1-c	3.7E-001	9.6E-001	HATCHERY

Table 3-23 continued

Table 3-23 continued

hr-9-141	3-b	8.0E^{2}001	1.6E^{2}001	WILD
hr-9-142	3-b	7.9E^{2}001	3.6E^{2}001	WILD
hr-9-143	4-d	5.4E^{2}006	2.4E^{2}003	HATCHERY
hr-9-145	5-b	5.8E^{2}002	4.1E^{2}001	HATCHERY
hr-9-144	4-c	5.6E^{2}005	2.1E^{2}002	HATCHERY
hr-9-146	4-c	3.3E^{2}001	1.3E^{2}002	WILD
hr-9-147	3-c	5.0E^{2}003	2.7E^{2}001	HATCHERY
hr-9-148	2-b	4.6E^{2}001	4.4E^{2}002	WILD
hr-9-149	4-c	2.0E^{2}001	6.4E^{2}002	WILD
hr-9-150	4-d	9.4E^{2}002	6.1E^{2}001	HATCHERY
hr-9-151	2-b	8.3E^{2}001	4.7E^{2}001	WILD
hr-9-152	4-c	9.7E^{2}004	4.1E^{2}006	WILD
hr-9-153	3-c	2.8E^{2}001	8.4E^{2}002	WILD
hr-9-154	1-c	5.1E^{2}002	4.8E^{2}001	HATCHERY
hr-9-155	2-c	1.9E^{2}001	5.9E^{2}001	HATCHERY
hr-9-156	1-e	1.8E^{2}001	3.6E^{2}001	HATCHERY
hr-9-158	2-b	3.6E^{2}001	5.9E^{2}002	WILD
hr-9-159	4-d	1.3E^{2}001	2.0E^{2}003	WILD
hr-9-160	2-c	1.5E^{2}001	3.2E^{2}001	HATCHERY
hr-9-161	1-c	6.5E^{2}002	6.8E^{2}001	HATCHERY
hr-9-162	4-c	2.9E^{2}002	4.0E^{2}001	HATCHERY
hr-9-163	2-b	4.4E^{2}001	2.6E^{2}002	WILD
hr-9-164	2-b	7.8E^{2}001	3.5E^{2}001	WILD
hr-9-165	1-b	4.7E^{2}001	3.7E^{2}001	WILD
hr-9-166	4-c	8.4E^{2}001	4.0E^{2}001	WILD
hr-9-167	2-c	4.5E^{2}001	8.2E^{2}001	HATCHERY
hr-9-168	4-c	4.1E^{2}002	2.0E^{2}002	WILD
hr-9-169	5-b	2.4E^{2}002	6.3E^{2}002	HATCHERY
hr-9-170	3-d	4.6E^{2}003	2.6E^{2}001	HATCHERY
hr-9-171	5-c	6.3E^{2}002	2.5E^{2}002	WILD
hr-9-172	1-c	3.1E^{2}001	8.0E^{2}002	WILD
hr-9-173	2-b	5.7E^{2}001	5.6E^{2}002	WILD
hr-9-174	5-b	5.8E^{2}001	4.5E^{2}001	WILD
hr-9-175	2-c	3.6E^{2}003	2.3E^{2}001	HATCHERY
hr-9-176	1-b	7.4E^{2}001	5.3E^{2}002	WILD
hr-9-178	1-b	4.1E^{2}001	3.0E^{2}002	WILD
hr-9-179	3-b	5.7E^{2}004	1.7E^{2}005	WILD
hr-9-180	5-c	6.9E^{2}001	2.2E^{2}001	WILD
hr-9-181	1-d	1.8E^{2}001	9.5E^{2}001	HATCHERY
hr-9-130	1-c	4.1E^{2}001	7.5E^{2}001	HATCHERY
hr-9-142	3-b	8.0E^{2}001	4.0E^{2}001	WILD
hr-9-157	1-b	1.3E^{2}001	7.3E^{2}001	HATCHERY
hr-9-158	2-b	1.9E^{2}001	4.2E^{2}002	WILD
hr-9-163	2-b	6.0E^{2}001	4.8E^{2}002	WILD

Table 3-24. Proportions of October unknown scales assigned to hatchery or wild origin using FD1 information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 54

THE CLASSIFICATION ARRAY IS:
 40  8
 10 42

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.800  0.160
  0.200  0.840

THE NATURAL ESTIMATE IS:
0.574 Proportion WILD
0.426 Proportion HATCHERY

THE NEARLY UNBIASED ESTIMATE IS:
0.647 Proportion WILD
0.353 Proportion HATCHERY

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.445 0.849 Lower and Upper Bounds for WILD
 0.151 0.555 Lower and Upper Bounds for HATCHERY

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.445 0.849 Lower and Upper Bounds for WILD
 0.151 0.555 Lower and Upper Bounds for HATCHERY
```

Table 3-25. Individual October scale origin assignments using FD1 information.

hr-10-182	[illegible]	4.0E-00[illegible]	[illegible]-001	HATCHERY
hr-10-183	3-c	9.9E-002	3.0E-002	WILD
hr-10-184	3-c	9.4E-001	3.9E-001	WILD
hr-10-187	4-b	4.1E-002	6.2E-001	HATCHERY
hr-10-188	2-e	1.3E-001	9.3E-001	HATCHERY
hr-10-189	2-c	5.8E-002	5.7E-004	WILD
hr-10-190	2-c	9.1E-002	7.2E-001	HATCHERY
hr-10-191	1-d	4.4E-002	1.2E-001	HATCHERY
hr-10-192	4-c	2.3E-001	1.6E-002	WILD
hr-10-193	3-c	2.9E-001	7.7E-001	HATCHERY
hr-10-194	4-b	1.4E-001	1.4E-002	WILD
hr-10-195	1-c	7.7E-001	6.1E-001	WILD
hr-10-196	2-c	3.6E-001	7.8E-001	HATCHERY
hr-10-197	3-c	3.4E-001	9.8E-001	HATCHERY
hr-10-198	4-c	1.3E-004	3.6E-002	HATCHERY
hr-10-199	5-c	4.8E-001	9.7E-002	WILD
hr-10-200	2-c	2.4E-001	6.2E-001	HATCHERY
hr-10-201	4-c	3.6E-001	8.7E-003	WILD
hr-10-202	1-c	1.2E-003	8.9E-005	WILD
hr-10-203	2-c	5.3E-001	6.2E-002	WILD
hr-10-204	2-e	3.3E-003	1.9E-004	WILD
hr-10-205	2-c	1.1E-002	2.7E-004	WILD
hr-10-206	3-d	1.7E-001	2.7E-001	HATCHERY
hr-10-207	4-c	4.5E-002	6.2E-001	HATCHERY
hr-10-208	5-c	1.5E-001	4.8E-001	HATCHERY
hr-10-209	2-c	3.8E-005	3.7E-005	WILD
hr-10-210	4-c	4.8E-001	2.2E-002	WILD
hr-10-211	4-c	1.5E-001	1.8E-003	WILD
hr-10-212	4-b	1.1E-002	2.1E-005	WILD
hr-10-213	2-c	9.0E-002	8.4E-001	HATCHERY
hr-10-214	4-c	3.5E-001	8.3E-003	WILD
hr-10-215	3-c	1.9E-001	3.9E-002	WILD
hr-10-216	1-d	2.4E-001	1.1E-002	WILD
hr-10-217	1-c	2.3E-001	6.6E-001	HATCHERY
hr-10-218	1-c	3.9E-001	1.5E-002	WILD
hr-10-219	3-c	1.1E-002	8.4E-004	WILD
hr-10-220	4-b	5.2E-001	8.5E-002	WILD
hr-10-221	2-d	1.7E-001	9.6E-001	HATCHERY
hr-10-222	2-d	2.2E-001	1.1E-001	WILD
hr-10-224	3-d	4.1E-002	3.6E-001	HATCHERY
hr-10-225	4-c	2.9E-001	8.6E-001	HATCHERY
hr-10-227	2-d	6.1E-002	7.3E-001	HATCHERY
hr-10-226	1-c	2.6E-001	5.7E-003	WILD
hr-10-228	5-c	4.5E-001	5.5E-001	HATCHERY
hr-10-229	1-c	6.8E-001	1.1E-001	WILD
hr-10-230	3-c	1.5E-001	9.4E-001	HATCHERY
hr-10-231	1-c	2.5E-002	2.7E-004	WILD
hr-10-232	1-c	6.5E-003	1.7E-003	WILD
hr-10-233	1-c	2.0E-001	3.5E-003	WILD
hr-10-234	1-c	7.6F-001	1.1E-001	WILD
hr-10-235	1-c	2.0E-001	4.3E-001	HATCHERY
hr-10-185	2-c	2.7E-001	1.3E-001	WILD
hr-10-186	2-b	7.1E-001	4.1E-001	WILD
hr-10-223	3-c	1.5E-002	4.2E-001	HATCHERY

Table 3-26. Proportions of November unknown scales assigned to hatchery or wild origin using FD1 information.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 53

THE CLASSIFICATION ARRAY IS:
 40  8
 10 42

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.800  0.160
  0.200  0.840

THE NATURAL ESTIMATE IS:
0.547 Proportion WILD
0.453 Proportion HATCHERY

THE NEARLY UNBIASED ESTIMATE IS:
0.605 Proportion WILD
0.395 Proportion HATCHERY

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.402 0.808 Lower and Upper Bounds for WILD
 0.192 0.598 Lower and Upper Bounds for HATCHERY

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.402 0.808 Lower and Upper Bounds for WILD
 0.192 0.598 Lower and Upper Bounds for HATCHERY
```

Table 3-27. Individual November scale origin assignments using FD1 information.

hr-11-242	4-b	3.0E+002	2.4E+001	HATCHERY
hr-11-243	5-b	1.9E+001	2.7E+003	WILD
hr-11-244	3-c	2.1E+001	2.3E+001	HATCHERY
hr-11-245	2-c	4.8E+003	1.2E+002	HATCHERY
hr-11-246	3-c	2.1E+001	8.6E+001	HATCHERY
hr-11-247	2-c	1.6E+001	9.6E+001	HATCHERY
hr-11-248	2-b	5.7E+002	2.7E+001	HATCHERY
hr-11-249	2-c	1.9E+001	2.3E+001	HATCHERY
hr-11-250	1-c	4.2E+001	3.5E+001	WILD
hr-11-251	4-c	1.7E+002	4.9E+001	HATCHERY
hr-11-252	2-d	3.3E+003	6.4E+004	WILD
hr-11-253	3-c	2.4E+001	1.3E+002	WILD
hr-11-254	1-c	6.6E+001	7.0E+001	HATCHERY
hr-11-255	2-e	8.8E+001	3.2E+001	WILD
hr-11-256	4-c	3.2E+002	1.0E+003	WILD
hr-11-257	4-e	2.0E+001	9.4E+001	HATCHERY
hr-11-258	1-c	5.1E+001	1.9E+002	WILD
hr-11-259	4-c	6.5E+001	5.5E+001	WILD
hr-11-260	1-d	4.1E+001	7.9E+001	HATCHERY
hr-11-261	5-c	2.2E+001	6.6E+003	WILD
hr-11-262	5-d	7.6E+001	3.6E+001	WILD
hr-11-263	2-c	4.2E+001	7.8E+001	HATCHERY
hr-11-264	1-c	1.2E+001	2.2E+001	HATCHERY
hr-11-265	2-c	5.6E+001	2.8E+001	WILD
hr-11-266	4-d	1.2E+001	9.1E+001	HATCHERY
hr-11-267	1-d	1.0E+001	8.3E+001	HATCHERY
hr-11-268	3-c	1.4E+002	3.2E+003	WILD
hr-11-269	2-b	1.0E+001	7.8E+003	WILD
hr-11-270	2-c	4.2E+001	8.4E+001	HATCHERY
hr-11-271	2-b	2.7E+004	5.0E+005	WILD
hr-11-272	4-c	4.2E+001	9.4E+001	HATCHERY
hr-11-273	1-c	1.8E+003	8.2E+004	WILD
hr-11-274	4-c	9.3E+001	3.8E+001	WILD
hr-11-276	4-c	7.4E+001	9.3E+002	WILD
hr-11-275	5-c	1.3E+002	2.0E+001	HATCHERY
hr-11-277	3-c	7.9E+001	9.0E+002	WILD
hr-11-278	2-d	4.4E+001	2.1E+002	WILD
hr-11-279	3-b	6.8E+001	5.6E+001	WILD
hr-11-280	1-d	6.5E+002	5.0E+001	HATCHERY
hr-11-281	3-c	1.1E+002	2.2E+005	WILD
hr-11-282	2-c	3.3E+001	6.8E+001	HATCHERY
hr-11-283	2-c	7.3E+001	7.8E+002	WILD
hr-11-284	2-c	1.7E+002	7.0E+002	HATCHERY
hr-11-285	3-d	1.4E+001	7.3E+002	WILD
hr-11-286	3-c	6.2E+003	7.7E+004	WILD
hr-11-287	3-c	3.6E+001	9.2E+001	HATCHERY
hr-11-288	4-c	2.8E+001	5.7E+002	WILD
hr-11-289	4-c	3.1E+001	7.0E+003	WILD
hr-11-290	1-c	7.4E+001	7.0E+002	WILD
hr-11-291	4-c	2.2E+001	9.2E+001	HATCHERY
hr-11-292	3-c	3.5E+004	6.5E+002	HATCHERY
hr-11-293	5-c	6.9E+001	1.3E+001	WILD
hr-11-294	3-e	6.8E+001	1.8E+001	WILD

3.2.4 Task 5: Discrimination using age 1+ impressions

177 acetate impression of age 1+ wild and hatchery recaptured fish scales were provided by Normandeau. They were assigned to wild or hatchery origin using the Fourier descriptor type I parameters. The assignment proportions are shown in Table 3-28, and the individual origin assignments in Table 3-29.

Table 3-28. Proportions of age 1+ unknown scales assigned to hatchery or wild origin using FD1 information.

```
HE A PRIORI PROBABILITIES ARE:
.500
0.500

HE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 177

THE CLASSIFICATION ARRAY IS:
42 10
 8 40

HE ESTIMATED CLASSIFICATION MATRIX IS:
 0.840  0.200
 0.160  0.800

HE NATURAL ESTIMATE IS:
0.254 Proportion HATCHERY
.746 Proportion WILD

THE NEARLY UNBIASED ESTIMATE IS:
0.085 Proportion HATCHERY
.915 Proportion WILD

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 .000 0.242 Lower and Upper Bounds for HATCHERY
 .758 1.000 Lower and Upper Bounds for WILD

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 .000 0.242 Lower and Upper Bounds for HATCHERY
 .758 1.000 Lower and Upper Bounds for WILD

 YOU WISH TO SEE THE RESULTS FOR INDIVIDUAL SPECIMENS? (Y/N)
```

Table 3-29. Individual origin assignments for age 1+ wild or recaptured hatchery fish.

Slide number	Scale #, quality code	Relative probabilities Hatchery	Wild	Origin assignment
hr-2-295	4-c	7.7E-001	4.1E-001	HATCHERY
hr-3-296	2-c	2.3E-001	9.7E-001	WILD
hr-1-297	2-d	1.5E-001	1.6E-001	WILD
hr-3-298	5-b	2.2E-003	1.2E-001	WILD
hr-12-299	3-c	2.9E-001	3.6E-002	HATCHERY
hr-3-300	4-b	1.5E-002	2.7E-001	WILD
hr-12-302	5-c	3.9E-001	1.0E-001	HATCHERY
hr-3-303	2-b	1.2E-001	9.1E-001	WILD
hr-3-304	2-b	7.7E-003	2.9E-001	WILD
hr-3-305	3-c	9.2E-002	5.1E-001	WILD
hr-2-306	3-b	1.7E-002	1.1E-002	HATCHERY
hr-3-307	3-c	8.8E-001	3.9E-001	HATCHERY
hr-2-308	4-d	7.6E-004	2.1E-005	HATCHERY
hr-3-309	2-c	1.2E-002	4.2E-001	WILD
hr-2-310	2-c	6.6E-001	1.2E-001	HATCHERY
hr-3-311	3-c	8.5E-002	3.8E-001	WILD
hr-2-312	2-d	1.4E-002	9.5E-002	WILD
hr-2-313	1-c	4.7E-002	7.1E-001	WILD
hr-3-314	1-c	1.4E-005	8.0E-003	WILD
hr-1-315	1-d	1.1E-003	1.2E-001	WILD
hr-3-316	4-c	5.2E-001	7.3E-001	WILD
hr-3-317	1-c	1.7E-001	9.8E-001	WILD
hr-3-318	5-c	3.0E-001	3.9E-001	WILD
hr-1-319	3-d	4.0E-001	4.2E-001	WILD
hr-3-320	3-c	1.6E-002	3.1E-001	WILD
hr-1-321	3-e	1.1E-001	9.1E-001	WILD
hr-3-322	3-c	1.8E-001	9.6E-001	WILD
hr-3-324	2-c	2.7E-001	9.6E-001	WILD
hr-3-325	4-c	1.8E-004	4.4E-002	WILD
hr-3-326	2-c	2.7E-002	3.1E-001	WILD
hr-2-327	5-e	4.8E-003	6.1E-003	WILD
hr-3-328	4-e	5.8E-007	8.1E-005	WILD
hr-3-329	3-d	7.4E-003	3.4E-001	WILD
hr-12-330	3-c	8.8E-001	1.4E-001	HATCHERY
hr-3-331	4-b	1.4E-001	8.7E-001	WILD
hr-12-332	2-c	2.1E-001	4.3E-003	HATCHERY
hr-3-333	3-c	8.6E-003	3.6E-001	WILD
hr-12-334	3-c	8.7E-001	3.8E-001	HATCHERY
hr-3-335	1-b	7.2E-002	7.2E-001	WILD
hr-2-336	5-d	1.5E-001	8.6E-002	HATCHERY
hr-3-337	4-d	7.3E-002	5.7E-001	WILD
hr-2-338	5-d	1.3E-002	3.8E-001	WILD

Table 3-29 continued

Slide number	Scale #, quality code	Relative probabilities Hatchery	Wild	Origin assignment
hr-3-339	2-d	1.1E-002	3.8E-001	WILD
hr-3-340	2-c	2.1E-001	2.8E-001	WILD
hr-3-341	1-c	1.3E-002	1.5E-001	WILD
hr-2-342	4-d	8.4E-001	9.1E-002	HATCHERY
hr-3-343	4-c	5.3E-003	9.8E-002	WILD
hr-3-344	3-c	1.1E-002	3.5E-001	WILD
hr-2-345	2-c	7.3E-001	2.3E-001	HATCHERY
hr-2-346	4-d	7.7E-003	2.4E-003	HATCHERY
hr-3-347	2-e	1.9E-003	1.5E-001	WILD
hr-3-348	4-c	3.8E-003	2.4E-001	WILD
hr-3-349	4-b	1.1E-003	5.9E-002	WILD
hr-3-350	4-c	8.5E-002	1.3E-001	WILD
hr-2-351	1-c	1.9E-003	9.8E-002	WILD
hr-3-352	3-c	8.7E-002	5.6E-002	HATCHERY
hr-2-353	1-c	6.9E-002	4.0E-001	WILD
hr-2-354	3-c	4.6E-001	6.8E-001	WILD
hr-3-355	4-d	1.6E-003	1.4E-001	WILD
hr-3-356	3-c	6.6E-002	2.1E-001	WILD
hr-3-357	3-d	4.4E-002	4.4E-001	WILD
hr-3-358	3-d	3.1E-002	2.7E-001	WILD
hr-3-360	4-d	1.4E-001	1.7E-002	HATCHERY
hr-3-361	1-c	6.2E-001	3.2E-001	HATCHERY
hr-2-362	1-e	7.1E-002	6.0E-001	WILD
hr-3-364	4-c	6.8E-002	4.2E-002	HATCHERY
hr-3-365	2-c	4.5E-003	5.9E-002	WILD
hr-3-367	1-c	5.2E-001	3.1E-001	HATCHERY
hr-3-368	5-b	1.5E-001	9.6E-001	WILD
hr-3-369	3-d	5.8E-002	7.6E-001	WILD
hr-3-371	1-c	3.3E-001	9.5E-001	WILD
hr-3-372	4-b	9.1E-003	3.2E-001	WILD
hr-3-373	2-c	6.4E-003	5.0E-002	WILD
hr-3-374	1-c	7.3E-001	2.3E-001	HATCHERY
hr-3-375	4-c	6.0E-004	8.5E-002	WILD
hr-3-377	2-c	1.9E-001	8.8E-001	WILD
hr-3-378	5-e	1.1E-002	3.2E-001	WILD
hr-3-379	5-c	6.8E-003	2.3E-002	WILD
hr-3-380	1-d	4.8E-002	2.4E-001	WILD
hr-2-381	3-c	3.9E-001	2.0E-002	HATCHERY
hr-2-382	3-e	1.2E-001	1.5E-001	WILD
hr-3-383	5-c	2.2E-002	4.8E-001	WILD
hr-3-384	5-c	2.9E-001	9.9E-001	WILD
hr-3-385	4-c	9.0E-003	2.6E-001	WILD
hr-3-386	3-d	7.6E-002	4.5E-001	WILD
hr-3-387	4-e	9.6E-002	8.1E-001	WILD
hr-3-388	3-c	2.5E-002	3.8E-001	WILD

Table 3-29 continued

Slide number	Scale #, quality code	Relative probabilities Hatchery	Wild	Origin assignment
hr-3-389	3-c	7.0E-002	4.6E-001	WILD
hr-3-390	1-c	2.6E-002	4.4E-001	WILD
hr-3-391	1-c	8.9E-003	1.7E-001	WILD
hr-4-392	4-c	3.7E-002	2.1E-001	WILD
hr-3-393	3-b	4.6E-002	6.0E-001	WILD
hr-3-394	2-b	3.7E-001	3.5E-001	HATCHERY
hr-3-395	3-b	3.0E-001	7.3E-001	WILD
hr-3-397	1-b	7.2E-002	7.4E-002	WILD
hr-3-398	5-b	5.6E-001	8.5E-001	WILD
hr-3-399	2-d	5.6E-002	3.6E-002	HATCHERY
hr-1-400	3-e	2.1E-001	6.9E-002	HATCHERY
hr-3-401	3-c	1.8E-001	9.2E-001	WILD
hr-12-323	4-d	6.4E-001	1.8E-001	HATCHERY
hr-3-403	4-c	2.0E-001	9.9E-001	WILD
hr-3-405	4-b	5.9E-002	5.2E-001	WILD
hr-3-406	3-c	1.2E-003	8.7E-002	WILD
hr-3-407	4-c	5.1E-002	1.9E-001	WILD
hr-2-408	3-c	3.0E-001	2.2E-001	HATCHERY
hr-3-409	4-b	2.1E-001	5.1E-001	WILD
hr-3-410	4-c	1.6E-001	8.0E-001	WILD
hr-3-411	4-c	2.9E-002	5.2E-001	WILD
hr-3-412	3-c	5.9E-002	7.6E-001	WILD
hr-3-413	3-e	8.4E-002	7.6E-001	WILD
hr-3-414	2-b	7.8E-002	7.8E-001	WILD
hr-4-415	2-b	3.0E-001	9.9E-001	WILD
hr-3-416	3-d	5.7E-002	5.9E-002	WILD
hr-3-418	2-c	9.3E-002	6.9E-001	WILD
hr-3-419	2-c	2.2E-001	9.6E-001	WILD
hr-3-421	1-c	1.1E-002	1.1E-001	WILD
hr-3-422	5-b	8.5E-001	4.3E-001	HATCHERY
hr-3-424	1-d	2.0E-001	3.2E-003	HATCHERY
hr-3-425	3-d	5.0E-001	4.6E-001	HATCHERY
hr-3-426	1-c	8.0E-001	4.1E-001	HATCHERY
hr-3-428	2-c	9.1E-001	4.7E-001	HATCHERY
hr-3-429	1-b	1.9E-002	1.1E-001	WILD
hr-3-430	2-e	6.8E-002	5.8E-002	HATCHERY
hr-3-432	1-d	1.8E-006	1.6E-003	WILD
hr-3-433	3-b	5.4E-002	4.4E-002	HATCHERY
hr-3-434	2-b	1.1E-004	1.3E-002	WILD
hr-3-436	1-c	4.5E-002	6.1E-001	WILD
hr-2-437	3-c	2.3E-001	3.1E-001	WILD
hr-3-438	3-b	1.9E-001	3.6E-001	WILD
hr-2-439	1-e	2.6E-001	6.0E-001	WILD
hr-3-440	3-c	2.3E-002	4.1E-001	WILD
hr-12-441	3-c	3.5E-001	2.1E-002	HATCHERY

Table 3-29 continued

Slide number	Scale #, quality code	Relative probabilities Hatchery	Wild	Origin assignment
hr-3-442	3-d	1.1E-001	3.1E-001	WILD
hr-3-443	1-e	6.4E-002	2.9E-001	WILD
hr-3-444	4-c	1.1E-001	7.7E-001	WILD
hr-3-446	5-b	5.6E-002	3.0E-001	WILD
hr-3-448	2-c	2.4E-001	9.3E-001	WILD
hr-3-449	1-c	9.1E-002	4.7E-001	WILD
hr-3-450	3-c	8.9E-002	4.7E-002	HATCHERY
hr-3-452	1-b	6.5E-001	6.5E-001	WILD
hr-3-453	1-c	3.5E-003	1.4E-002	WILD
hr-3-455	1-d	9.3E-001	4.1E-001	HATCHERY
hr-3-456	4-c	7.1E-002	7.8E-001	WILD
hr-3-458	1-c	2.4E-003	1.0E-001	WILD
hr-3-457	5-d	7.6E-001	1.1E-001	HATCHERY
hr-3-459	2-e	2.1E-002	2.6E-001	WILD
hr-3-460	1-c	8.7E-001	2.6E-001	HATCHERY
hr-3-461	2-d	3.0E-002	5.3E-001	WILD
hr-3-462	3-d	3.1E-003	3.3E-003	WILD
hr-3-463	5-d	3.4E-002	3.8E-001	WILD
hr-3-464	1-b	9.3E-003	1.2E-001	WILD
hr-4-465	4-c	2.0E-001	3.4E-001	WILD
hr-3-466	5-c	4.9E-001	6.7E-001	WILD
hr-3-467	2-d	1.4E-001	2.3E-001	WILD
hr-3-468	5-e	5.8E-002	6.9E-001	WILD
hr-3-469	2-b	8.0E-003	2.5E-001	WILD
hr-3-471	2-c	6.9E-001	4.0E-001	HATCHERY
hr-3-472	3-b	3.3E-002	5.5E-001	WILD
hr-3-474	4-b	2.0E-001	7.1E-001	WILD
hr-3-477	1-b	7.3E-003	9.8E-002	WILD
hr-3-478	5-c	1.4E-004	6.9E-003	WILD
hr-3-479	1-d	1.8E-003	1.3E-001	WILD
hr-2-480	3-d	1.7E-001	5.2E-001	WILD
hr-3-481	4-b	4.0E-001	5.8E-001	WILD
hr-3-482	2-c	4.7E-001	1.0E-001	HATCHERY
hr-3-483	2-c	3.1E-001	5.5E-001	WILD
hr-3-484	1-e	3.8E-006	6.9E-004	WILD
hr-3-485	3-c	8.8E-001	1.9E-001	HATCHERY
hr-3-487	4-c	2.0E-002	5.2E-001	WILD
hr-3-486	4-e	1.4E-001	1.0E-001	HATCHERY
hr-3-488	5-b	2.5E-001	8.3E-001	WILD
hr-3-490	4-b	1.6E-001	3.2E-001	WILD
hr-3-491	4-b	3.8E-002	6.2E-001	WILD
hr-3-493	1-d	6.5E-001	6.5E-001	HATCHERY
hr-3-431	2-b	5.7E-001	4.3E-001	HATCHERY
hr-3-451	4-d	4.8E-001	1.9E-001	HATCHERY
hr-3-476	5-c	3.9E-001	9.0E-001	WILD

3.3 Objective III - Hudson vs Non-Hudson

3.3.1 Task 3: Parameterizing system

The OPRS system was parameterized using only cleaned, dry-mounted age 0+ scales. 83 slides were from the Delaware River, 120 from the James River, and a random sample of 50 wild Hudson River fish was selected from the slides provided for Objective I, Task 2. Circuli spacing (Radial Line data) and scale shape (Fourier descriptor 1 data) were examined for discrimination ability. Sums of circuli 4, 7, and 8 (Figure 3-19), 11, 12 and 13 (Figure 3-20), and sums of Fourier descriptor components 3 and 4 (figure 3-21) were used to assign Hudson or non-Hudson origin to both the known and unknown slides.

For the known slides, 73% (148 of 203) were correctly assigned to non-Hudson, and 80% (40 of 50) were correctly assigned to Hudson origin.

3.3.2 Task 4: Discrimination using uncleaned glass slides.

225 cleaned, dry-mounted slides of unknown origin were assigned to Hudson or non-Hudson origin with the parameters described above (Tables 3-30, 3-31).

FIGURE 3-19 Notched Box and Whisker plot of circuli spacing sums (#'s 4,7,3) versus Hudson River origin.

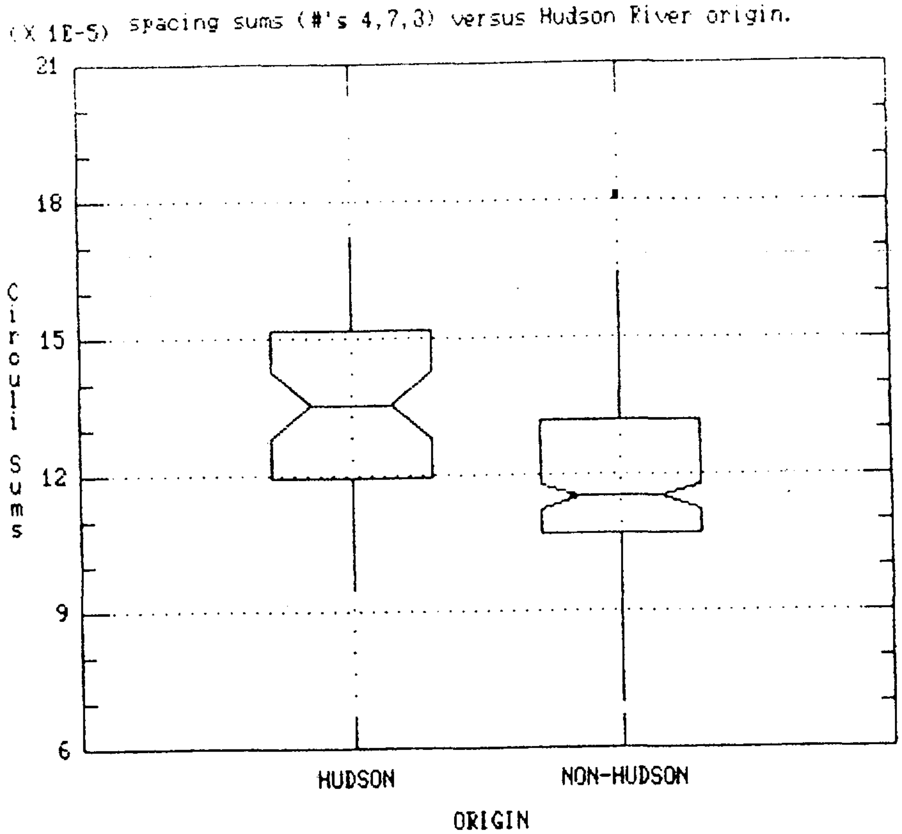


FIGURE 3-20 Notched Box and Whisker plot of circuli spacing sums (#'s 11,12,13) versus Hudson River origin.

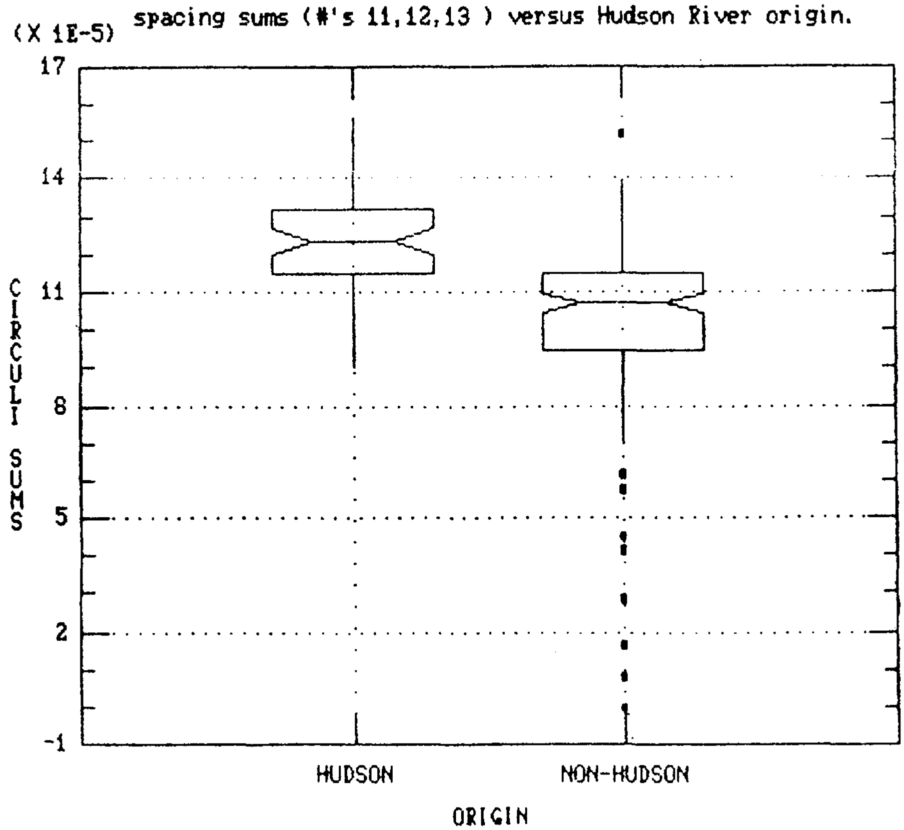


FIGURE 3-21 Notched Box and Whisker plot of Fourier component sums (#'s 3,4) versus Hudson River origin.

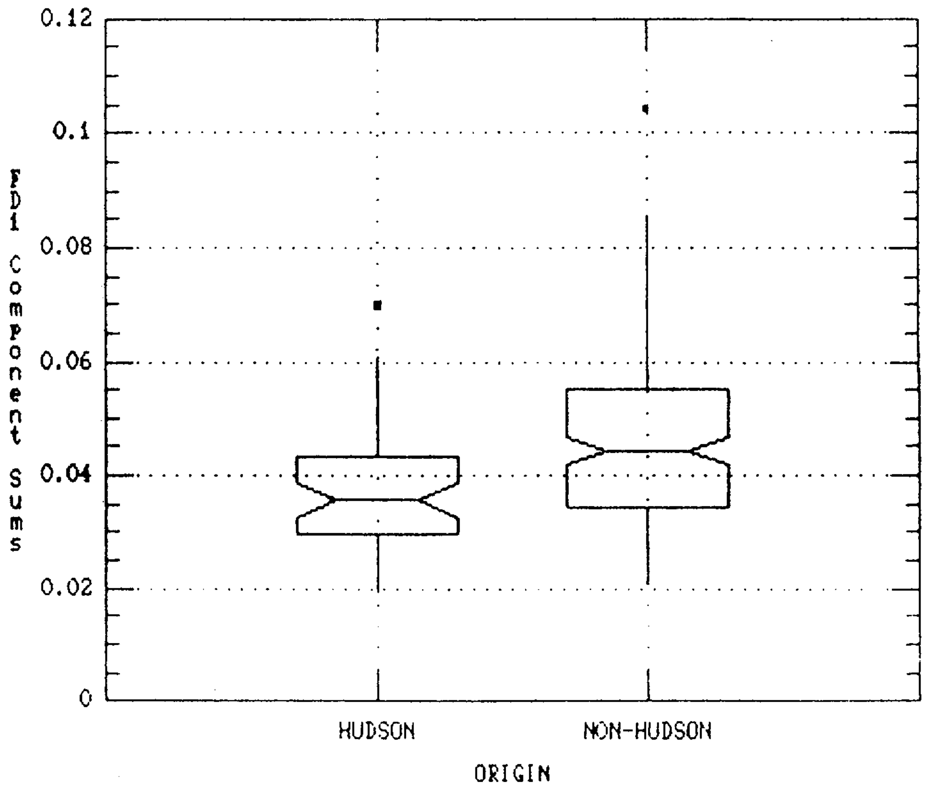


Table 3-30 Individual Hudson or non-Hudson origin assignments.

```
THE A PRIORI PROBABILITIES ARE:
0.500
0.500

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 225

THE CLASSIFICATION ARRAY IS:
 148  10
  55  40

THE ESTIMATED CLASSIFICATION MATRIX IS:
  0.729  0.200
  0.271  0.800

THE NATURAL ESTIMATE IS:
0.520 Proportion NON-HUDSON
0.480 Proportion HUDSON

THE NEARLY UNBIASED ESTIMATE IS:
0.605 Proportion NON-HUDSON
0.395 Proportion HUDSON

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:
 0.467 0.742 Lower and Upper Bounds for NON-HUDSON
 0.258 0.533 Lower and Upper Bounds for HUDSON

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:
 0.467 0.742 Lower and Upper Bounds for NON-HUDSON
 0.258 0.533 Lower and Upper Bounds for HUDSON
```

Table 3-31. Individual Hudson or non-Hudson origin assignments.

SAMPLE ID#	SPECIMEN	NON--HUDSON	HUDSON	ORIGIN
sd-8-01	1-c	6.9E^{2}001	5.2E^{2}001	NON-HUDSON
sd-8-02	1-b	1.7E^{2}001	2.2E^{2}002	NON-HUDSON
sd-8-03	3-c	7.3E^{2}001	7.4E^{2}001	HUDSON
sd-9-04	1-c	7.4E^{2}006	9.0E^{2}008	NON-HUDSON
sd-8-05	1-b	1.2E^{2}001	3.4E^{2}003	NON-HUDSON
sd-9-06	2-b	3.6E^{2}001	4.3E^{2}001	HUDSON
sd-8-07	1-c	5.3E^{2}001	5.8E^{2}002	NON-HUDSON
sd-10-08	1-e	2.8E^{2}001	3.3E^{2}001	HUDSON
sd-9-09	2-c	4.4E^{2}002	6.7E^{2}002	HUDSON
sd-10-10	2-d	1.0E^{2}001	1.7E^{2}001	HUDSON
sd-10-11	1-e	1.2E^{2}011	1.2E^{2}009	HUDSON
sd-10-12	1-b	1.7E^{2}002	1.3E^{2}001	HUDSON
sd-8-13	1-b	8.5E^{2}001	1.6E^{2}001	NON-HUDSON
sd-8-14	1-c	3.8E^{2}001	1.8E^{2}001	NON-HUDSON
sd-8-15	1-c	3.5E^{2}001	9.4E^{2}001	HUDSON
sd-10-16	1-b	6.5E^{2}002	1.5E^{2}002	NON-HUDSON
sd-8-17	1-e	2.4E^{2}001	3.6E^{2}002	NON-HUDSON
sd-9-18	1-b	3.0E^{2}001	7.9E^{2}001	HUDSON
sds-8-19	1-b	1.0E^{2}006	4.0E^{2}008	NON-HUDSON
sd-10-20	2-b	3.5E^{2}001	9.4E^{2}001	HUDSON
sd-10-21	1-d	1.9E^{2}001	4.0E^{2}002	NON-HUDSON
sd-9-22	1-c	2.7E^{2}001	2.5E^{2}002	NON-HUDSON
sd-10-23	1-b	1.0E^{2}001	6.8E^{2}001	HUDSON
sd-8-24	1-c	5.8E^{2}001	7.8E^{2}001	HUDSON
sd-9-25	1-c	3.3E^{2}001	7.3E^{2}001	HUDSON
sd-8-26	1-c	3.7E^{2}001	5.4E^{2}002	NON-HUDSON
sd-9-27	1-c	5.0E^{2}001	6.6E^{2}001	HUDSON
sd-8-28	1-b	5.3E^{2}001	7.6E^{2}001	HUDSON
sd-8-29	1-d	1.5E^{2}004	1.9E^{2}006	NON-HUDSON
sd-11-30	2-c	3.9E^{2}001	7.3E^{2}001	HUDSON
sd-10-31	1-d	7.8E^{2}001	1.3E^{2}001	NON-HUDSON
sd-8-32	1-b	4.5E^{2}001	1.1E^{2}001	NON-HUDSON
sd-10-33	2-d	2.7E^{2}001	8.9E^{2}001	HUDSON
sd-8-34	2-b	6.3E^{2}001	1.3E^{2}001	NON-HUDSON
sd-8-35	1-c	6.3E^{2}001	7.6E^{2}001	HUDSON
sd-8-36	2-d	5.6E^{2}001	4.1E^{2}001	NON-HUDSON
sd-8-37	1-c	5.8E^{2}001	7.4E^{2}002	NON-HUDSON
sd-10-38	1-d	6.6E^{2}001	3.5E^{2}001	NON-HUDSON
sd-11-39	1-c	7.1E^{2}001	3.7E^{2}001	NON-HUDSON
sd-8-40	1-d	1.1E^{2}001	1.8E^{2}002	NON-HUDSON
sd-11-41	3-c	8.6E^{2}002	1.3E^{2}001	HUDSON
sd-8-42	3-c	2.3E^{2}001	5.3E^{2}001	HUDSON

SAMPLE ID#	SPECIMEN	HUDSON	NON-HUDSON	ORIGIN
sd-10-86	2-c	5.4E+001	[illegible].4E+001	NON-H[illegible]
sd-9-87	2-d	2.2E+001	2.8E+001	HUDSON
sd-8-88	1-c	2.6E+002	5.2E+004	NON-HUDSON
sd-9-89	1-c	1.2E+001	7.1E+001	HUDSON
sd-8-90	1-d	8.7E+001	2.9E+001	NON-HUDSON
sd-9-91	1-c	6.8E+003	3.6E+004	NON-HUDSON
sd-8-92	1-d	1.2E+001	3.7E+001	HUDSON
sd-9-93	1-b	5.7E+001	5.8E+001	HUDSON
sd-8-94	2-c	5.2E+001	1.0E+001	NON-HUDSON
sd-8-95	2-d	2.3E+001	8.5E+001	HUDSON
sd-9-96	1-c	2.6E+002	[illegible].8E+002	HUDSON
sd-9-97	1-e	8.2E+003	3.7E+002	HUDSON
sd-9-98	1-b	2.1E+001	3.6E+001	HUDSON
sd-10-99	3-d	1.0E+001	2.2E+001	HUDSON
sd-9-100	2-c	3.2E+001	7.2E+001	HUDSON
sd-8-101	2-d	4.2E+001	3.5E+001	NON-HUDSON
sd-9-102	1-c	4.0E+001	7.4E+001	HUDSON
sd-10-103	3-d	1.9E+001	1.3E+002	NON-HUDSON
sd-8-104	2-b	2.3E+001	1.5E+001	NON-HUDSON
sd-9-105	2-c	2.4E+001	4.3E+001	HUDSON
sd-8-106	1-d	6.3E+001	8.7E+001	HUDSON
sd-9-107	2-c	1.2E+001	6.9E+001	HUDSON
sd-9-108	2-c	1.6E+001	8.2E+001	HUDSON
sd-8-109	3-d	7.8E+001	1.4E+001	NON-HUDSON
sd-8-110	1-c	1.6E+001	1.6E+001	NON-HUDSON
sd-8-111	2-c	6.2E+001	1.0E+001	NON-HUDSON
sd-9-112	2-c	1.9E+001	7.6E+001	HUDSON
sd-9-113	2-b	1.9E+001	7.4E+001	HUDSON
sd-9-114	1-d	8.1E+001	6.8E+001	NON-HUDSON
sd-8-115	1-c	8.6E+001	5.4E+001	NON-HUDSON
sd-9-116	1-b	3.1E+001	9.4E+001	HUDSON
sd-8-117	2-c	2.3E+001	7.1E+001	HUDSON
sd-9-118	1-b	7.6E+001	6.1E+001	NON-HUDSON
sd-8-119	2-c	2.2E+001	1.1E+001	NON-HUDSON
sd-9-120	2-c	1.4E+001	8.1E+001	HUDSON
sd-10-121	2-c	2.4E+002	3.3E+001	HUDSON
sd-9-122	1-c	1.7E+001	5.3E+001	HUDSON
sd-10-123	3-d	4.6E+001	6.3E+002	NON-HUDSON
sd-9-124	1-b	1.8E+001	3.2E+001	HUDSON
sd-8-125	1-c	8.5E+001	3.2E+001	NON-HUDSON
sd-9-126	1-c	5.7E+002	4.4E+002	NON-HUDSON
sd-9-127	1-c	6.6E+001	3.4E+001	NON-HUDSON
sd-8-128	2-c	6.4E+001	3.9E+001	NON-HUDSON

TABLE 3-31 continued

SAMPLE ID#	SPECIMEN	HUDSON	NON-HUDSON	ORIGIN
sd-8-130	2-c	5.7E^{2}001	7.8E^{2}001	HUDSON
sd-9-131	2-d	3.5E^{2}001	7.3E^{2}001	HUDSON
sd-8-132	2-d	7.8E^{2}001	7.6E^{2}001	NON-HUDSON
sd-10-133	2-c	3.7E^{2}002	2.1E^{2}001	HUDSON
sd-10-134	2-d	2.4E^{2}001	2.5E^{2}001	HUDSON
sd-10-135	2-e	7.3E^{2}001	5.1E^{2}001	NON-HUDSON
sd-9-136	1-d	5.9E^{2}001	6.5E^{2}002	NON-HUDSON
sd-11-137	1-c	4.5E^{2}002	5.1E^{2}001	HUDSON
sd-11-138	3-d	8.2E^{2}004	3.8E^{2}002	HUDSON
sd-8-139	2-d	6.5E^{2}001	1.9E^{2}001	NON-HUDSON
sd-8-140	1-c	2.1E^{2}001	1.9E^{2}001	NON-HUDSON
sd-11-141	3-c	9.8E^{2}004	2.1E^{2}002	HUDSON
sd-8-142	1-e	3.5E^{2}006	1.3E^{2}007	NON-HUDSON
sd-11-143	4-c	8.5E^{2}001	3.1E^{2}001	NON-HUDSON
sd-8-144	1-c	2.0E^{2}003	1.1E^{2}003	NON-HUDSON
sd-9-145	2-c	8.3E^{2}001	7.4E^{2}001	NON-HUDSON
sd-8-146	2-c	8.3E^{2}002	3.1E^{2}001	HUDSON
sd-8-147	1-c	7.7E^{2}001	2.0E^{2}001	NON-HUDSON
sd-11-148	2-c	3.3E^{2}001	4.1E^{2}001	HUDSON
sd-9-149	1-d	6.1E^{2}001	8.3E^{2}002	NON-HUDSON
sd-11-150	1-c	1.5E^{2}001	6.5E^{2}001	HUDSON
sd-10-151	2-d	1.6E^{2}001	9.0E^{2}002	NON-HUDSON
sd-8-152	2-c	2.2E^{2}001	7.8E^{2}001	HUDSON
sd-10-153	1-e	8.3E^{2}001	3.6E^{2}001	NON-HUDSON
sd-11-154	1-d	9.0E^{2}001	5.7E^{2}001	NON-HUDSON
sd-8-155	1-d	1.6E^{2}001	3.3E^{2}001	HUDSON
sd-8-156	1-d	7.6E^{2}001	1.2E^{2}001	NON-HUDSON
sd-10-157	1-d	1.1E^{2}002	2.6E^{2}003	NON-HUDSON
sd-11-158	2-b	3.5E^{2}001	7.1E^{2}001	HUDSON
sd-9-159	1-d	1.6E^{2}001	6.2E^{2}001	HUDSON
sd-8-160	1-d	4.2E^{2}001	1.7E^{2}001	NON-HUDSON
sd-11-161	2-c	4.3E^{2}001	1.9E^{2}001	NON-HUDSON
sd-9-162	1-b	7.5E^{2}001	6.3E^{2}001	NON-HUDSON
sd-10-163	3-d	5.0E^{2}001	1.1E^{2}001	NON-HUDSON
sd-9-165	1-d	1.9E^{2}001	8.3E^{2}001	HUDSON
sd-8-166	2-c	7.5E^{2}001	7.5E^{2}001	NON-HUDSON
sd-8-167	1-c	4.4E^{2}001	3.3E^{2}001	NON-HUDSON
sd-8-168	1-b	3.4E^{2}001	6.9E^{2}001	HUDSON
sd-9-169	2-c	8.8E^{2}002	1.6E^{2}002	NON-HUDSON
sd-11-171	2-c	3.6E^{2}001	3.5E^{2}001	NON-HUDSON
sd-11-172	2-d	7.1E^{2}002	4.7E^{2}001	HUDSON
sd-8-173	1-c	4.5E^{2}001	4.6E^{2}001	HUDSON

TABLE 3-31 continued

SAMPLE ID#	SPECIMEN	HUDSON	NON-HUDSON	ORIGIN
sd-8-174	1-b	$4.3E^2 001$	$9.4E^2 001$	HUDSON
sd-8-175	2-d	$2.1E^2 003$	$2.9E^2 002$	HUDSON
sd-10-176	2-d	$7.4E^2 001$	$2.2E^2 001$	NON-HUDSON
sd-11-177	2-d	$6.6E^2 001$	$7.5E^2 001$	HUDSON
sd-11-178	1-c	$6.0E^2 001$	$6.6E^2 001$	HUDSON
sd-10-179	1-d	$1.3E^2 001$	$2.7E^2 002$	NON-HUDSON
sd-11-181	1-c	$1.7E^2 001$	$7.3E^2 001$	HUDSON
sd-8-182	3-d	$1.2E^2 001$	$2.7E^2 002$	NON-HUDSON
sd-11-183	2-c	$2.5E^2 001$	$6.0E^2 001$	HUDSON
sd-10-184	2-c	$9.0E^2 002$	$4.6E^2 001$	HUDSON
sd-11-185	2-c	$1.7E^2 001$	$1.4E^2 001$	NON-HUDSON
sd-11-187	1-c	$8.4E^2 001$	$3.8E^2 001$	NON-HUDSON
sd-11-188	1-c	$3.9E^2 001$	$5.0E^2 001$	HUDSON
sd-11-189	2-c	$2.8E^2 001$	$5.3E^2 001$	HUDSON
sd-8-190	1-d	$6.0E^2 001$	$1.6E^2 001$	NON-HUDSON
sd-8-191	1-c	$1.1E^2 001$	$5.7E^2 002$	NON-HUDSON
sd-11-192	1-d	$4.3E^2 003$	$2.2E^2 003$	NON-HUDSON
sd-10-193	2-c	$2.5E^2 002$	$2.1E^2 003$	NON-HUDSON
sd-9-194	1-d	$2.6E^2 001$	$6.9E^2 001$	HUDSON
sd-10-195	1-d	$2.0E^2 001$	$5.3E^2 001$	HUDSON
sd-9-196	1-b	$4.1E^2 001$	$9.9E^2 001$	HUDSON
sd-8-197	1-b	$8.1E^2 001$	$3.3E^2 001$	NON-HUDSON
sd-8-198	2-b	$2.8E^2 001$	$9.4E^2 001$	HUDSON
sd-9-199	2-c	$2.3E^2 001$	$5.4E^2 001$	HUDSON
sd-8-200	1-c	$2.3E^2 001$	$6.2E^2 001$	HUDSON
sd-11-201	4-d	$3.2E^2 001$	$9.8E^2 001$	HUDSON
sd-10-202	1-d	$7.6E^2 001$	$1.5E^2 001$	NON-HUDSON
sd-9-203	1-c	$7.0E^2 001$	$8.0E^2 001$	HUDSON
sd-11-204	3-d	$6.7E^2 001$	$4.7E^2 001$	NON-HUDSON
sd-9-205	1-c	$2.6E^2 001$	$6.2E^2 002$	NON-HUDSON
sd-11-206	2-c	$4.3E^2 001$	$9.3E^2 001$	HUDSON
sd-11-207	1-d	$1.1E^2 002$	$7.3E^2 003$	NON-HUDSON
sd-10-208	2-d	$4.6E^2 001$	$2.0E^2 001$	NON-HUDSON
sd-9-209	1-d	$9.1E^2 005$	$8.2E^2 004$	HUDSON
sd-8-210	1-b	$2.3E^2 001$	$1.7E^2 001$	NON-HUDSON
sd-9-211	1-c	$7.2E^2 007$	$5.9E^2 009$	NON-HUDSON
sd-8-212	1-c	$5.6E^2 001$	$6.6E^2 002$	NON-HUDSON
sd-9-213	1-b	$2.1E^2 005$	$4.4E^2 007$	NON-HUDSON
sd-8-214	2-c	$4.5E^2 001$	$5.5E^2 001$	HUDSON
sd-10-215	1-c	$4.0E^2 002$	$4.9E^2 001$	HUDSON
sd-9-216	2-c	$2.3E^2 001$	$5.1E^2 001$	HUDSON
sd-8-217	1-d	$2.2E^2 001$	$1.9E^2 002$	NON-HUDSON

TABLE 3-31 continued

SAMPLE ID#	SPECIMEN	HUDSON	NON-HUDSON	ORIGIN
sd-10-43	2-c	3.9E-001	4.6E-001	HUDSON
sd-8-44	2-b	6.1E-001	3.0E-001	NON-HUDSON
sd-8-45	1-e	2.6E-001	7.4E-001	HUDSON
sd-10-46	1-d	1.1E-001	7.2E-001	HUDSON
sd-9-47	1-c	7.7E-001	5.8E-001	NON-HUDSON
sd-10-48	3-e	1.4E-001	9.5E-002	NON-HUDSON
sd-8-49	1-d	9.0E-001	2.0E-001	NON-HUDSON
sd-11-51	1-c	3.8E-001	8.7E-001	HUDSON
sd-10-52	1-e	8.5E-010	4.3E-007	HUDSON
sd-10-53	2-d	3.4E-001	8.1E-001	HUDSON
sd-8-54	1-e	1.8E-001	1.3E-001	NON-HUDSON
sd-10-55	1-d	5.6E-001	8.3E-002	NON-HUDSON
sd-8-56	2-b	2.8E-002	7.0E-003	NON-HUDSON
sd-11-57	2-e	1.6E-002	2.2E-001	HUDSON
sd-10-58	2-d	3.4E-002	4.1E-003	NON-HUDSON
sd-11-59	4-c	9.9E-002	1.2E-001	HUDSON
sd-9-60	2-d	5.8E-002	3.1E-001	HUDSON
sd-8-61	1-d	8.6E-002	3.1E-002	NON-HUDSON
sd-11-62	1-b	1.7E-001	2.8E-001	HUDSON
sd-8-63	2-c	5.6E-001	2.3E-001	NON-HUDSON
sd-10-64	1-c	6.4E-001	6.7E-001	HUDSON
sd-8-65	1-d	6.3E-006	6.7E-008	NON-HUDSON
sd-11-66	1-c	1.8E-001	5.0E-001	HUDSON
sd-8-67	1-c	4.9E-001	9.7E-002	NON-HUDSON
sd-8-68	1-d	7.8E-001	7.4E-001	NON-HUDSON
sd-10-69	1-b	7.0E-001	3.7E-001	NON-HUDSON
sd-9-70	2-d	2.9E-001	8.3E-001	HUDSON
sd-11-71	2-c	5.8E-002	4.3E-001	HUDSON
sd-8-72	1-d	5.3E-001	8.7E-001	HUDSON
sd-11-73	3-e	6.1E-001	[illegible].4E-001	HUDSON
sd-9-74	2-c	8.9E-001	6.7E-001	NON-HUDSON
sd-10-75	2-b	[illegible].4E-001	1.2E-001	NON-HUDSON
sd-8-76	2-c	5.8E-001	1.7E-001	NON-HUDSON
sd-11-77	2-d	5.1E-002	2.1E-001	HUDSON
sd-8-78	1-d	1.6E-007	4.6E-008	NON-HUDSON
sd-10-79	1-c	3.8E-001	9.8E-001	HUDSON
sd-8-80	2-d	2.8E-001	8.0E-001	HUDSON
sd-9-81	3-c	1.9E-001	6.4E-001	HUDSON
sd-8-82	2-c	1.6E-001	8.4E-001	HUDSON
sd-10-83	1-e	8.2E-003	5.6E-003	NON-HUDSON
sd-8-84	1-d	3.2E-001	2.0E-002	NON-HUDSON
sd-8-85	2-b	2.3E-001	7.2E-002	NON-HUDSON

TABLE 3-31 continued

SAMPLE ID#	SPECIMEN	HUDSON	NON-HUDSON	ORIGIN
sd-9-218	1-d	5.5E-001	3.8E-001	NON-HUDSON
sd-8-219	1-c	1.0E-001	2.1E-002	NON-HUDSON
sd-9-220	2-c	3.4E-001	9.4E-001	HUDSON
sd-9-221	1-c	9.5E-001	3.2E-001	NON-HUDSON
sd-8-222	1-c	2.1E-001	8.9E-002	NON-HUDSON
sd-8-223	1-c	1.6E-004	8.1E-007	NON-HUDSON
sd-8-224	2-c	2.4E-001	6.4E-001	HUDSON
sd-9-225	1-c	6.4E-001	1.4E-001	NON-HUDSON
sd-11-226	2-d	5.6E-001	4.7E-001	NON-HUDSON
sd-8-227	1-d	5.3E-001	4.9E-002	NON-HUDSON
sd-9-129	1-c	7.3E-001	8.5E-001	HUDSON
sd-8-180	1-b	5.7E-002	1.5E-001	HUDSON
sd-8-186	2-d	4.8E-001	4.8E-002	NON-HUDSON
sd-8-164	1-e	7.7E-001	5.6E-001	NON-HUDSON

TABLE 3-31 continued

4.0 Discussion and Recommendations.

The results for aging were mixed. Accuracies were excellent for age 0+ and age 1+ striped bass and these accuracies would allow precise quantitative inferences. Confidence intervals would be wider for age 2+ and age 3+ and considerably less precise inferences would be appropriate. Efficiency was very good: Acetate impressions could be processed considerably faster with the OPRS than with traditional methods with no detectable loss in accuracy. Although we have not obtained the data, we expect precision to be very high. If inferences about 2+ and 3+ fish are not needed, then the OPRS is preferred over the traditional techniques. The 2+ and 3+ training samples could be pooled and the OPRS could be reparameterized. Statistically valid age composition estimates would be obtained from unknown samples.

We cannot recommend that precise inferences about 2+ or 3+ fish be made with either the traditional methods or with the OPRS. If such inferences are of value and are needed for further quantitative analyses, then we recommend a more comprehensive study. Such a study should quantify the accuracy and precision inherent in the traditional approach (and, therefore, in the training samples), and then examine a broader set of variables for parameterizing the OPRS. The accuracies of both techniques, the relative costs, and the value of the information could then be used to form a recommendation.

The OPRS provided moderate to good accuracy for hatchery versus wild striped bass. With the levels of accuracy obtained, it is possible to apply the techniques and make valuable inferences about the contribution of hatchery stocks to the Hudson River. We would recommend that further work be done to assess the effects of size dependent scale parameters. In particular, the quantification of a "planting check" deserves attention. This would not only eliminate our reservations about size dependent bias, but improve accuracy of the technique to the point where very precise inferences and astute management decisions could be made regarding the hatchery component within the Hudson River.

Accuracy for stock identification was only moderate. With large sample sizes the presence or absence of non-Hudson striped bass in the Hudson could be strongly supported; however, percentage estimates would have wide confidence intervals. It is recommended that the data collected by this study be analyzed further to improve accuracy.

5.0 References

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Appendix A: Macro Documentation

This appendix documents the five macro sequences used to collect data for study objectives I, II and III (aging, hatchery/wild, river system). The macros were stored in three different configuration files, one for each study objective. Only macro 1 was run for for objective I. For objectives II and III, all five macros were run and the data saved to files, even though not all the data were analyzed at this time. For these objectives, the macros were designed to run in sequence. For instance, once the text identifiers for a given scale or impression were entered for macro 1, it was not necessary to enter them again (except sometimes SpecID in macro 4). Also, the shape traced in macro 3 was used by the FD1 and FD2 transformations in macros 4 and 5.

Saving data to file was always a manually executed step. In the notation below, the actual macros consist of those steps between the dashed lines.

Macro 1, SL Page, Objectives I, II, III

1. Run Macro 1

----

2. SL page
3. Lens Calibration (2X lens)
4. Acquire
5. Show File Selection Window
6. Choose SLL file
7. SampID
8. SpecID
9. Other
10. Reference Line, On
11. Draw Line
12. Amplification, Auto
13. Draw Line
14. Reference Line, Off
15. Acquire

----

16. Save to File

Macro 2, RAD Page, Objectives II, III

1. Run Macro 2

----

2. RAD page
3. Lens Calibration (2X lens)
4. Acquire
5. Show File Selection window
6. Choose RAD file
7. Reference Line, On
8. Draw Radial
9. Reference Line, Off
10. Acquire

----

11. Save to File

Macro 3, MOR Page, Shape subwindow, Objectives II, III

1. Run Macro 3

----

2. MOR page
3. Lens Calibration (4X lens)
4. Acquire
5. Show File Selection Window
6. Choose APE file
7. SpecID (change to 2X if needed)
8. FRM page
9. Binary threshold
10. Amplification, Manual
11. MOR page
12. Shape subwindow
13. Start Auto Track to trace shape

If 2X lens is used, manually perform the following steps:

13a. Set Lens Calibration to 2X
13b. Select Acquire
13c. Start Auto Track to trace shape

----

14. Save to File

Macro 4, MOR page, FD1 subwindow, Objectives II, III

1. Run Macro 4

----

2. MOR page
3. Show File Selection window
4. Choose FD1 file
5. FD1 subwindow
6. Perform FD1 Shape FFT
   >> FD Size: 128, >> Normalize Coefficients
7. Graph FFT. Inspect periodigram

----

8. Save to File

Macro 5, MOR Page, FD2 subwindow, Objectives II, III

1. Run Macro 5

----

2. MOR page
3. Show File Selection window
4. Choose FD2 file
5. FD2 subwindow
6. Perform FD2 Shape FFT
   >> FD Size: 128 >> Normalize Coefficients
   >> Normalize Position >> Normalize Orientation
7. Show Outline. Inspect shape

7a. If necessary, select Rotate: 180
8. Save to File

APPENDIX B

Pixels, Virtual Coordinates, and Sampling Units

Aspect Ratio Correction

Both American and European television standards define a non-square video image with a 4:3 aspect ratio (horizontal:vertical). Since the frame grabber digitizes the image using a grid of 512 x 512 pixels, each individual pixel represents a rectangular area with a 4:3 aspect ratio. When performing distance measurements on this non-square digitized image, it is unfeasible to perform calculations in units of pixels, since the distance represented will vary depending on the angle.

The OPRS system software corrects for this problem by mapping the non-square pixel grid onto a high resolution virtual coordinate system which has the necessary 1:1 aspect ratio.

Virtual Coordinate System

The virtual coordinate system is a square grid with 0,0 at the center of the screen. It extends approximately 16,000 units in each of the positive and negative x and y directions. All measurements are performed in virtual coordinate space. The boundary tracking bug operates in pixel space, but the resulting measurements are performed in virtual coordinates or their equivalent.

Sampling Units

When collecting luminance values along a line, the OPRS system takes measurements at fixed intervals called sampling units. A sampling unit is defined as the ratio of virtual units to pixels along a 45 diagonal line. This ratio is approximately 52 when operating in the NTSC mode; i.e. luminance samples will be taken every 52 virtual units. Along a 45 degree diagonal line, this corresponds to one sampling unit per pixel. Along non-diagonal lines, samples will be taken at intervals smaller than one pixel.

Bilinear Interpolation

Since luminance values are taken in virtual coordinate space, the point being sampled generally will not fall squarely in the center of a pixel. Bilinear interpolation is used to create a sampled luminance value which is proportional to the relative distances to the four neighboring pixels and their intensities.

Φ1429

HUDSON RIVER STRIPED BASS SCALE AGING TECHNIQUES

WORKSHOP 21-22 APRIL 1987 - SUMMARY REPORT

Submitted to

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Submitted by

NORMANDEAU ASSOCIATES INC.
25 Nashua Road
Bedford, New Hampshire 03102

R-1163/01

03 May 1988

HUDSON RIVER STRIPED BASS SCALE AGING TECHNIQUES
WORKSHOP 21-22 APRIL 1987 - SUMMARY REPORT

Participants: Normandeau Associates Inc. (NAI)

New York State Department of Environmental Conservation (NYSDEC) Region 1 and Region 3

INTRODUCTION

Determination of the age of striped bass by analysis of scale growth patterns results in some uncertainty as to which scale features are the most reliable indicators of true annual marks. This workshop was convened to compare notes on conventional aging techniques and criteria for identifying true annuli used by the various groups that regularly determine the age of Hudson River striped bass. The workshop goal was to resolve differences among groups, and agree on the best set of guidelines for accurately determining age. Through this cooperative effort we hoped to determine as closely as possible the correct age of a random sample of 207 striped bass from acetate scale impressions. This set of scale impressions was then used to test the capabilities of an Optical Pattern Recognition System (OPRS) developed by BioSonics, Inc. to determine striped bass age.

METHODS

A set of 207 striped bass scale impressions from Age 0+ to 5+ striped bass was prepared by NAI. There were 177 unique scale samples and 30 duplicate impressions among the 207 scale samples. Duplicate impressions were used to evaluate precision of age assignments. Each acetate slide was assigned a unique identification number and age was determined without reference to collection date or length. The age of these 207 scales was then independently determined by NAI and by individuals from the NYSDEC Region 1 and Region 3. True annuli were identified by conventional scale ageing techniques including 1) examining circulus spacing patterns in the anterior scale field, 2) tracing circuli to find "crossing over" in the lateral scale fields, and 3) finding dark banding which bridges the scale insertion site in the posterior scale fields.

Complete agreement was observed between all three laboratories in the assignment of age to 154 out of the 207 acetate scale impressions (Table 1, Table 2). The remaining 53 scale samples were assigned different ages by two or more groups. On 21-22 April 1987, a workshop was held between individuals from NAI, NYSDEC Region 1 and NYSDEC Region 3 to identify the reasons for disagreement in assigned age and to resolve of differences in criteria and technique by examining these 53 scale samples. An additional two scales were added to the set examined at the workshop because NAI's original age assignments for these two recaptured fish were found to be incorrect when compared to age for these fish from scale samples at the time of release.

Workshop participants were split into three work groups with representatives from each lab in each work group, with one exception; group 2 was not represented by DEC Region 3 (Table 3). Images of acetate impressions of each scale sample were projected onto a white screen using Bausch and Lomb microprojector. Ages of the 55 scales were arrived at independently by each work group member and answers were compared and discussed within groups.

RESULTS

Conventional Age Determination

It rapidly became apparent that NAI, NYSDEC Region 1 and NYSDEC Region 3 placed different emphasis on annulus identification

TABLE 1. INDEPENDENT ASSIGNMENT OF AGE TO 207 ACETATE IMPRESSIONS OF SCALES FROM HUDSON RIVER STRIPED BASS BY NAI, NYSDEC REGION 1 AND NYSDEC REGION 3 PRIOR TO STRIPED BASS SCALE AGING TECHNIQUES WORKSHOP, 21-22 APRIL 1987.

TASK CODE	SAMPLE NUMBER	FISH IDENTIFICATION	SLIDE_CD	DATE	RECAPT	LENGTH	AGREEMENT	NAI_AGE	DEC1_AGE	DEC3_AGE	BIOAGE
53	306	1	1044	02/20/87	N	68	Y	0	0	0	0
53	306	6	1045	02/20/87	N	86	Y	0	0	0	0
53	527	9	1032	03/19/87	N	97	Y	0	0	0	0
53	466	10	1036	03/12/87	N	104	Y	0	0	0	0
53	544	17	1030	03/19/87	N	111	Y	0	0	0	0
53	543	1	1031	03/19/87	N	112	Y	0	0	0	0
53	105	1	1039	01/07/87	N	113	Y	0	0	0	0
53	467	3	1038	03/12/87	N	115	Y	0	0	0	0
53	475	24	1033	03/13/87	N	116	Y	0	0	0	0
53	453	30	1034	03/12/87	N	117	Y	0	0	0	0
53	2060	3	1040	02/04/87	N	117	Y	0	0	0	0
53	433	1	1035	03/04/87	N	119	Y	0	0	0	0
53	309	13	1050	02/20/87	N	125	N	0	.	1	0
53	288	8	1041	02/19/87	N	130	Y	0	0	0	0
53	288	6	1042	02/19/87	N	134	Y	0	0	0	0
53	309	1	1048	02/20/87	N	134	Y	0	0	0	0
53	287	4	1051	02/19/87	N	135	Y	0	0	0	0
53	306	7	1046	02/20/87	N	135	Y	0	0	0	0
53	288	7	1055	02/19/87	N	137	Y	0	0	0	0
53	140	19	681	01/19/87	N	140	Y	0	0	0	0
53	314	2	1052	02/20/87	N	140	Y	0	0	0	0
53	150	14	665	01/21/87	N	141	Y	0	0	0	0
53	138	11	620	01/19/87	N	142	Y	0	0	0	0
53	164	3	588	01/28/87	N	142	Y	0	0	0	0
53	310	4	1054	02/20/87	N	142	Y	0	0	0	0
53	120	9	470	01/12/87	N	144	Y	0	0	0	0
53	150	15	666	01/21/87	N	146	Y	0	0	0	0
53	302	5	1043	02/20/87	N	146	N	0	0	1	0
53	139	1	680	01/19/87	N	148	Y	0	0	0	0
53	311	6	1053	02/20/87	N	154	Y	0	0	0	0
53	142	6	1029	01/19/87	N	180	Y	1	1	1	1
53	142	6	1093	01/19/87	N	180	Y	1	1	1	1
53	2038	61	1024	01/20/87	N	181	Y	1	1	1	1
53	2038	61	1092	01/20/87	N	181	Y	1	1	1	1
53	2038	39	1012	01/20/87	N	183	Y	1	1	1	1
53	2021	29	1021	01/09/87	N	184	Y	1	1	1	1
53	2021	29	1086	01/09/87	N	184	Y	1	1	1	1
53	2036	33	1023	01/20/87	N	188	Y	1	1	1	1
53	2036	33	1094	01/20/87	N	188	Y	1	1	1	1
53	2021	45	1013	01/09/87	N	189	Y	1	1	1	1
53	141	12	1020	01/19/87	N	190	Y	1	1	1	1
53	141	12	1087	01/19/87	N	190	Y	1	1	1	1
53	2038	3	1022	01/20/87	N	190	Y	1	1	1	1
53	2038	3	1085	01/20/87	N	190	N	1	1	2	1
53	2025	8	441	01/14/87	N	194	Y	1	1	1	1
53	2039	43	661	01/20/87	N	196	N	1	1	2	1
53	2020	39	1082	01/09/87	N	198	N	1	1	.	1
53	123	65	1080	01/13/87	N	199	Y	1	1	1	1
53	144	1	682	01/19/87	N	199	Y	1	1	1	1
53	2036	17	1025	01/20/87	N	199	Y	1	1	1	1
53	2036	17	1091	01/20/87	N	199	Y	1	1	1	1

TABLE 1. (Cont.)

TASK CODE	SAMPLE NUMBER	FISH IDENTIFICATION	SLIDE_CD	DATE	RECAPT	LENGTH	AGREEMENT	NAI_AGE	DEC1_AGE	DEC3_AGE	BIOAGE
53	156	24	669	01/21/87	N	200	N	1	1	2	1
53	2017	59	454	01/09/87	N	200	N	1	1	.	1
53	2037	1	1028	01/20/87	N	201	Y	1	1	1	1
53	2037	1	1088	01/20/87	N	201	Y	1	1	1	1
53	2036	8	1011	01/20/87	N	202	Y	1	1	1	1
53	123	61	1081	01/13/87	N	205	Y	1	1	1	1
53	144	11	1084	01/19/87	N	207	Y	1	1	1	1
53	29	12	526	12/22/86	N	209	Y	1	1	1	1
53	2021	32	1027	01/09/87	N	215	Y	1	1	1	1
53	2021	32	1089	01/09/87	N	215	Y	1	1	1	1
53	119	3	1078	01/12/87	N	217	Y	1	1	1	1
53	2020	41	1026	01/09/87	N	219	Y	1	1	1	1
53	2020	41	1090	01/09/87	N	219	Y	1	1	1	1
53	51	1	422	12/29/86	N	221	N	1	2	1	1
53	120	1	1079	01/12/87	N	224	Y	1	1	1	1
53	11	3	547	12/21/86	N	225	Y	1	1	1	1
53	144	18	1083	01/19/87	N	228	Y	1	1	1	1
53	2027	3	417	01/14/87	N	228	Y	1	1	1	1
53	145	30	689	01/19/87	N	238	N	1	2	2	1
53	147	10	656	01/21/87	N	242	Y	1	1	1	1
53	2017	25	457	01/09/87	N	246	Y	1	1	1	1
53	123	46	634	01/13/87	N	253	Y	1	1	1	1
53	132	20	554	01/16/87	N	256	Y	1	1	1	1
53	90	13	505	01/06/87	N	261	N	1	2	.	1
53	35	4	575	12/23/86	N	262	Y	1	1	1	1
53	133	89	558	01/16/87	N	275	N	1	2	1	1
53	100	1	477	01/07/87	N	284	N	1	2	1	2
53	123	4	648	01/13/87	N	299	N	1	2	2	2
53	132	6	412	01/16/87	N	210	Y	2	2	2	1
53	2010	15	474	01/08/87	N	223	Y	2	2	2	1
53	145	37	670	01/19/87	N	231	N	2	.	1	1
53	167	4	586	01/28/87	N	235	N	2	2	3	1
53	163	2	584	01/28/87	N	248	N	2	4	.	1
53	145	2	671	01/19/87	N	252	Y	2	2	2	1
53	145	2	1098	01/19/87	N	252	N	2	2	.	1
53	145	5	672	01/19/87	N	253	Y	2	2	2	1
53	155	19	659	01/21/87	N	264	Y	2	2	2	1
53	155	21	651	01/21/87	N	264	Y	2	2	2	1
53	125	15	635	01/13/87	N	269	Y	2	2	2	1
53	12	12	491	12/21/86	N	275	N	2	2	1	3
53	89	12	507	01/06/87	N	279	N	2	2	.	1
53	152	5	597	01/21/87	N	280	Y	2	2	2	2
53	144	8	684	01/19/87	N	283	Y	2	2	2	2
53	144	8	1100	01/19/87	N	283	Y	2	2	2	2
53	148	9	668	01/21/87	N	284	Y	2	2	2	1
53	155	3	650	01/21/87	N	288	Y	2	2	2	2
53	143	1	679	01/19/87	N	293	Y	2	2	2	2
53	143	1	1101	01/19/87	N	293	Y	2	2	2	2
53	153	35	652	01/21/87	N	295	Y	2	2	2	2
53	2003	2	517	01/05/87	N	295	Y	2	2	2	2
53	152	16	596	01/21/87	N	297	N	2	3	3	2

TABLE 1. (Cont.)

TASK CODE	SAMPLE NUMBER	FISH IDENTIFICATION	SLIDE_CD	DATE	RECAPT	LENGTH	AGREEMENT	NAI_AGE	DEC1_AGE	DEC3_AGE	BIOAGE
53	2051	7	609	01/27/87	Y	300	Y	2	2	2	2
53	160	12	595	01/21/87	N	303	Y	2	2	2	2
53	160	23	594	01/21/87	N	303	N	2	2	3	2
53	145	27	675	01/19/87	N	305	Y	2	2	2	2
53	145	27	1096	01/19/87	N	305	Y	2	2	2	2
53	153	11	653	01/21/87	N	307	Y	2	2	2	2
53	145	6	674	01/19/87	N	309	Y	2	2	2	2
53	145	6	1097	01/19/87	N	309	Y	2	2	2	2
53	155	14	619	01/21/87	N	310	N	2	3	2	2
53	154	14	618	01/21/87	N	311	N	2	.	3	2
53	36	3	580	12/23/86	N	312	Y	2	2	2	2
53	158	10	616	01/21/87	N	312	Y	2	2	2	2
53	134	6	624	01/16/87	N	316	Y	2	2	2	2
53	159	25	614	01/21/87	N	319	Y	2	2	2	2
53	160	29	591	01/21/87	N	320	N	2	3	2	2
53	2088	128	784	02/13/87	Y	320	N	2	3	3	2
53	2088	128	1102	02/13/87	Y	320	N	2	.	3	2
53	124	48	642	01/13/87	N	323	Y	2	2	2	2
53	160	17	593	01/21/87	Y	326	Y	2	2	2	2
53	155	6	599	01/21/87	N	328	Y	2	2	2	2
53	2037	13	663	01/20/87	N	331	Y	2	2	2	2
53	2037	13	1099	01/20/87	N	331	Y	2	2	2	2
53	149	20	658	01/21/87	N	332	Y	2	2	2	2
53	2013	14	568	01/08/87	N	332	Y	2	2	2	2
53	145	9	676	01/19/87	N	333	Y	2	2	2	2
53	145	9	1095	01/19/87	N	333	Y	2	2	2	2
53	174	1	603	01/29/87	N	337	Y	2	2	2	2
53	151	5	611	01/21/87	N	342	N	2	2	.	2
53	171	5	604	01/29/87	N	344	Y	2	2	2	2
53	2043	31	587	01/22/87	N	345	Y	2	2	2	2
53	151	16	610	01/21/87	N	349	N	2	.	2	2
53	10	21	433	12/21/86	N	359	N	2	3	2	2
53	22	4	533	12/22/86	N	364	N	2	3	3	3
53	2049	3	590	01/27/87	Y	371	N	2	3	3	3
53	46	13	471	12/29/86	N	388	N	2	4	3	3
53	10	9	492	12/21/86	N	393	Y	2	2	2	3
53	215	1	721	02/03/87	N	403	Y	2	2	2	3
53	215	1	1104	02/03/87	N	403	N	2	2	.	3
53	222	10	703	02/06/87	N	403	Y	2	2	2	3
53	223	12	705	02/06/87	N	404	N	2	2	.	3
53	223	12	1103	02/06/87	N	404	N	2	.	.	3
53	25	9	485	12/22/86	N	405	N	2	3	3	2
53	2059	2	720	02/04/87	N	409	N	2	.	.	3
53	154	2	617	01/21/87	N	439	Y	2	2	2	3
53	158	11	615	01/21/87	N	444	N	2	3	.	3
53	177	1	606	01/29/87	N	451	N	2	3	.	3
53	74	5	466	12/31/86	N	315	Y	3	3	3	2
53	2017	36	440	01/09/87	N	326	Y	3	3	3	2
53	29	20	536	12/22/86	N	328	Y	3	3	3	2
53	2022	7	442	01/09/87	N	332	N	3	3	4	2
53	343	3	1077	02/25/87	N	343	Y	3	3	3	2

TABLE 1. (Cont.)

TASK CODE	SAMPLE NUMBER	FISH IDENTIFICATION	SLIDE_CD	DATE	RECAPT	LENGTH	AGREEMENT	NAI_AGE	DEC1_AGE	DEC3_AGE	BIOAGE
53	10	10	434	12/21/86	N	345	Y	3	3	3	2
53	339	7	1068	02/25/87	N	348	N	3	.	3	2
53	339	7	1106	02/25/87	N	348	N	3	.	3	3
53	376	6	1064	02/27/87	N	348	Y	3	3	3	2
53	2107	9	1057	02/26/87	N	348	Y	3	3	3	2
53	2107	9	1111	02/26/87	N	348	Y	3	3	3	2
53	122	11	404	01/13/87	Y	352	Y	3	3	3	2
53	2020	28	450	01/09/87	Y	353	Y	3	3	3	2
53	348	3	1073	02/25/87	N	357	Y	3	3	3	2
53	358	13	1060	02/26/87	N	357	Y	3	3	3	3
53	358	13	1109	02/26/87	N	357	Y	3	3	3	3
53	355	13	1056	02/25/87	N	362	Y	3	3	3	3
53	355	13	1113	02/25/87	N	362	Y	3	3	3	3
53	2024	36	414	01/14/87	Y	362	Y	3	3	3	2
53	400	2	1070	03/02/87	N	364	Y	3	3	3	2
53	400	2	1105	03/02/87	N	364	Y	3	3	3	3
53	359	1	1071	02/26/87	N	365	Y	3	3	3	3
53	359	1	1107	02/26/87	N	365	Y	3	3	3	3
53	339	11	1076	02/25/87	N	369	Y	3	3	3	3
53	359	20	1062	02/26/87	N	378	Y	3	3	3	3
53	359	20	1114	02/26/87	N	378	Y	3	3	3	3
53	8	6	527	12/21/86	N	382	Y	3	3	3	3
53	341	3	1066	02/25/87	N	382	Y	3	3	3	3
53	341	3	1108	02/25/87	N	382	Y	3	3	3	3
53	365	2	1074	02/26/87	N	385	Y	3	3	3	3
53	27	10	529	12/22/86	N	387	Y	3	3	3	3
53	10	22	496	12/21/86	N	392	Y	3	3	3	3
53	339	14	1065	02/25/87	N	393	Y	3	3	3	3
53	339	14	1112	02/25/87	N	393	N	3	4	3	3
53	401	2	1069	03/02/87	N	396	Y	3	3	3	3
53	358	8	1067	02/26/87	N	398	Y	3	3	3	3
53	4	2	520	12/21/86	N	404	N	3	3	4	3
53	10	20	521	12/21/86	N	404	N	3	4	3	3
53	360	4	1072	02/26/87	N	406	Y	3	3	3	3
53	402	2	1058	03/02/87	N	408	Y	3	3	3	3
53	402	2	1110	03/02/87	N	408	Y	3	3	3	3
53	34	7	424	12/23/86	N	412	N	3	3	4	3
53	343	2	1061	02/25/87	N	412	Y	3	3	3	3
53	371	2	1063	02/26/87	N	421	Y	3	3	3	3
53	11	8	524	12/21/86	N	423	N	3	4	4	3
53	95	5	512	01/06/87	N	423	N	3	4	4	3
53	123	12	409	01/13/87	N	424	N	3	4	4	3
53	27	6	481	12/22/86	Y	429	Y	3	3	3	3
53	20	7	483	12/22/86	N	438	Y	3	3	3	3
53	2013	13	452	01/08/87	N	444	Y	3	3	3	3
53	124	8	406	01/13/87	N	453	Y	3	3	3	3
53	102	4	500	01/07/87	N	456	Y	3	3	3	3
53	102	5	501	01/07/87	Y	408	N	4	5	4	.
53	8	12	525	12/21/86	N	442	Y	4	4	4	.
53	177	2	605	01/29/87	N	446	Y	4	4	4	.
53	2016	14	447	01/09/87	N	448	Y	4	4	4	.

TABLE 1. (Cont.)

TASK CODE	SAMPLE NUMBER	FISH IDENTIFICATION	SLIDE_CD	DATE	RECAPT	LENGTH	AGREEMENT	NAI_AGE	DEC1_AGE	DEC3_AGE	BIOAGE
53	2017	43	448	01/09/87	N	452	N	4	5	4	.
53	124	97	405	01/13/87	N	455	N	4	5	5	.
53	18	13	482	12/22/86	Y	453	N	5	4	5	.

TABLE 1. (Cont)

LEGEND FOR TABLE 1:

TASK_CD, SAMPLE NUMBER, FISH IDENTIFICATION = Variables linking individual fish to NAI Field Sample

SLIDE_CD = unique identifying number for each acetate scale impression

DATE = Date striped bass was caught

RECAPT = Y = Yes if fish was recaptured by NAI
= N = No

LENGTH = Total length of striped bass in mm

AGREEMENT = Y = Yes if there was complete agreement in assigned age among NAI, NYSDEC Region 1 and NYSDEC Region 3 prior to the workshop
= N = No

NAI_AGE = Age assigned by NAI

DEC1_AGE = Age assigned by NYSDEC Region 1

DEC3_AGE = Age assigned by NYSDEC Region 3

BIOAGE = Age assigned by BioSonics OPRS

Notes: This table is sorted in ascending order by NAI_AGE and within each age in ascending order by length. Unassigned age is represented by ".".

TABLE 2. AGREEMENT IN AGE ASSIGNED TO 207 ACETATE IMPRESSIONS OF SCALE SAMPLES FROM THE 1986-1987 HUDSON RIVER STRIPED BASS PROGRAM, FOR SAMPLES EXAMINED BY NAI, NYSDEC REGION 1 AND NYSDEC REGION 3 PRIOR TO THE SCALE AGEING TECHNIQUES WORKSHOP, 21-22 APRIL 1987.

	NUMBER OF SCALE SAMPLES ASSIGNED THE SAME AGE AS NAI			
AGE	NAI	NYSDEC 1	NYSDEC 3	COMPLETE AGREEMENT[a]
0+	30	29	28	28 (93%)
1+	49	43	41	38 (78%)
2+	69	51	47	43 (62%)
3+	52	45	46	42 (81%)
4+	6	3	5	3 (50%)
5+	1	0	1	0 (0%)
b	0	9	13	0 (0%)
Total Agreement	207 (100%)	171 (83%)	168 (81%)	154 (74%)

[a]Complete agreement in assigned age between NAI, NYSDEC Region 1 and NYSDEC Region 3.
[b]Age not assigned.

TABLE 3. LIST OF PARTICIPANTS IN WORK GROUPS AT THE HUDSON RIVER STRIPED BASS SCALE AGING TECHNIQUES WORKSHOP, 21-22 APRIL 1987.

	PARTICIPANT		
WORK GROUP	NAI	NYSDEC 1	NYSDEC 3
1	Rich Park	Vic Vecchio	Doug Stang
2	Joe Strube Jim Reichle	Byron Young	-
3	Mike Humphreys Joan Mikolajczyk	Kim McKown	Andy Kahnle

features. Although most participants were using all of the identified aging criteria to some degree, some believed that "crossing over" of circuli in the lower lateral fields was the best indication of true annuli. Others relied more heavily on continuous abrupt disruptions in growth across the anterior field of all scales in a sample. Shading or dark banding in the posterior field, circulus spacing, and distance between annuli were also taken into consideration, but were of less importance. As a final check to resolve difficult to age scales, some individually examined the date of collection and length of fish and compared these data to scale features. Often disagreements resulted when crossing over was present in the lateral fields but disruptions in the anterior field were weak, discontinuous, or not abruptly defined. This difference in weighting of criteria resulted in some groups consistently assigning older ages to certain scale samples. Despite these differences, complete agreement within and among groups was achieved for 23 out of the 55 scales (Table 4).

In an attempt to resolve the remaining differences among work groups, we examined paired scale samples taken from striped bass at the time of initial capture and tagging, and again after recapture one or two years later. We also examined scales from verified one and two year old recaptured hatchery fish. With the knowledge that the number of additional annuli layed down after release corresponds to the number of years at large, we were able to identify true and false annuli. It became apparent that crossing over may be present on false annuli, and that careful examination of disruptions in the anterior field was less likely to result in the erroneous identification of growth checks as true annuli. Examination of scales for crossing over becomes more necessary as fish get older and annuli became more closely spaced.

Careful inspection of first year growth patterns on scales of hatchery recaptures revealed a "stocking" or "planting" check which could be mistaken as an annulus if the origin of the fish were not known. Scales from hatchery recaptures typically showed rapid early

TABLE 4. RESOLUTION OF AGE ASSIGNMENT AMONG 55 ACETATE IMPRESSIONS OF SCALES FROM HUDSON RIVER STRIPED BASS BY NAI, NYSDEC REGION 1, AND NYSDEC REGION 3, 21-22 APRIL 1987.

				ASSIGNED AGE BY GROUP			ASSIGNED AGE BY LAB AND GROUP									
							NAI			NYSDEC1			NYSDEC3			
SLIDE CODE	COLLECTION DATE	LENGTH	AGREEMENT	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	BIOAGE
1043	02/20/87	146	N	0	0	1	0	0	1	0	0	1	0	.	1	0
1050	02/20/87	125	N	0	0	.	0	0	0	0	0	0	0	.	1	0
558	01/16/87	275	Y	1	1	1	1	1	1	1	1	1	1	.	1	1
669	01/21/87	200	Y	1	1	1	1	1	1	1	1	1	1	.	1	1
1085	01/20/87	190	Y	1	1	1	1	1	1	1	1	1	1	.	1	1
661	01/20/87	196	Y	1	1	1	1	1	1	1	1	1	1	.	1	1
422	12/29/86	221	N	2	.	1	2	.	1	2	.	2	2	.	2	1
505	01/06/87	261	N	1	.	1	2	.	1	1	2	1	1	.	1	1
477	01/07/87	284	N	1	2	1	1	2	1	1	2	1	1	.	1	2
648	01/13/87	299	N	1	2	1	1	2	1	2	2	1	1	.	1	2
689	01/19/87	238	N	1	2	1	1	2	1	1	2	1	1	.	1	1
454	01/09/87	200	N	1	2	1	1	2	1	1	2	1	1	.	1	1
433	12/21/86	359	Y	2	2	2	2	2	2	2	2	2	2	.	2	2
491	12/21/86	275	Y	2	2	2	2	2	2	2	2	2	2	.	2	3
485	12/22/86	405	Y	2	2	2	2	2	2	3	2	2	2	.	2	2
507	01/06/87	279	Y	2	2	2	2	2	2	2	2	2	2	.	2	1
635	01/13/87	269	Y	2	2	2	2	2	2	2	2	2	2	.	2	1
611	01/21/87	342	Y	2	2	2	2	2	2	2	2	2	2	.	2	2
593	01/21/87	326	Y	2	2	2	2	2	2	2	2	2	2	.	2	2
594	01/21/87	303	Y	2	2	2	2	2	2	2	2	2	2	.	2	2
584	01/28/87	248	Y	2	2	2	2	2	2	2	2	2	2	.	2	1
1103	02/06/87	404	Y	2	2	2	2	2	2	3	2	2	3	.	2	3
1102	02/13/87	320	Y	3	3	3	3	3	3	3	3	3	4	.	3	2
533	12/22/86	364	N	2	3	2	2	3	2	2	3	2	2	.	3	3
471	12/29/86	388	N	4	3	.	4	3	2	4	3	3	4	.	3	3
412	01/16/87	210	N	.	2	.	2	2	2	1	2	.	1	.	.	1
670	01/19/87	231	N	1	1	2	1	1	2	1	1	2	1	.	2	1
1098	01/19/87	252	N	2	1	2	2	.	2	2	2	2	2	.	2	1
610	01/21/87	349	N	2	.	2	2	.	2	2	.	2	2	.	2	2

TABLE 4. (Cont.)

				ASSIGNED AGE BY GROUP			ASSIGNED AGE BY LAB AND GROUP								
							NAI			NYSDEC1			NYSDEC3			
SLIDE CODE	COLLECTION DATE	LENGTH	AGREEMENT	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3	BIOAGE
596	01/21/87	297	N	2	3	2	3	3	2	2	3	2	2	.	2	2
618	01/21/87	311	N	.	.	.	.	.	2	.	.	3	.	.	3	2
619	01/21/87	310	N	2	2	.	2	2	2	2	2	3	2	.	3	2
615	01/21/87	444	N	2	3	2	2	3	2	2	3	2	2	.	2	3
591	01/21/87	320	N	.	2	2	3	2	2	2	2	2	2	.	2	2
586	01/28/87	235	N	2	2	.	2	2	2	2	2	2	3	.	3	1
606	01/29/87	451	N	2	4	2	2	4	2	2	4	2	3	.	2	3
1104	02/03/87	403	N	2	.	2	2	.	2	2	2	2	2	.	2	3
590	01/27/87	371	N	2	3	2	3	3	2	3	3	2	3	.	2	3
720	02/04/87	409	N	.	3	2	2	3	2	3	3	2	2	.	2	3
784	02/13/87	320	N	.	3	.	2	3	2	.	3	3	3	.	3	2
521	12/21/86	404	Y	3	3	3	4	3	3	3	3	3	3	.	3	3
424	12/23/86	412	Y	3	3	3	3	3	3	3	3	3	3	.	3	3
409	01/13/87	424	Y	3	3	3	3	3	3	3	3	3	3	.	3	3
1106	02/25/87	348	Y	3	3	3	3	3	3	3	3	3	3	.	3	3
1112	02/25/87	393	Y	3	3	3	3	3	3	3	3	3	3	.	3	3
442	01/09/87	332	Y	3	3	3	3	3	3	3	3	3	3	.	3	2
414	01/14/87	362	Y	3	3	3	3	.	3	3	2	3	3	.	3	2
520	12/21/86	404	N	3	2	3	3	2	3	4	2	3	4	.	3	3
524	12/21/86	423	N	.	3	3	3	3	3	3	3	3	3	.	3	3
512	01/06/87	423	N	4	.	.	3	.	.	4	4	4	4	.	.	3
1068	02/25/87	348	N	.	3	3	3	3	3	2	3	3	2	.	3	2
448	01/09/87	452	Y	4	4	4	4	4	4	4	4	4	4	.	4	.
501	01/07/87	408	N	5	4	4	5	4	4	5	4	4	4	.	4	.
405	01/13/87	455	N	4	.	4	4	.	4	4	3	4	4	.	4	.
482	12/22/86	453	N	5	.	5	5	.	5	5	5	5	5	.	5	.

TABLE 4. (Cont.)

LEGEND FOR TABLE 4:

SLIDE CODE = Unique identifying number for each acetate scale impression

COLLECTION DATE = Date striped bass was caught

LENGTH = Total length of striped bass in mm

AGREEMENT = Y = Yes is all 3 groups assigned the same age
= N = No if all 3 groups did not assign the same age

ASSIGNED AGE BY GROUP = Age assigned by each of the three work groups in Table 3

ASSIGNED AGE BY LAB AND GROUP = Age assigned by persons in each work group representative of NAI, NYSDEC Region 1 and NYSDEC Region 3

BIOAGE = Age assigned by BioSonics OPRS.

NOTES: This table is sorted in ascending order by NAI_AGE (not shown) and within age in ascending order by length. An unassigned age is represented by a ".". There was no individual from NYSDEC Region 3 present in work group 2.

growth compared to wild fish of the same age. The stocking check was probably formed as a result of one or more of the following factors: 1) withholding food prior to stocking, 2) handling and tagging stress, and 3) change of diet from pellets to wild food. First year growth after stocking was typically much slower.

All participants agreed that there was a need for a set of training scales of known age to standardize techniques among laboratories. Older hatchery recaptures and internal anchor tag recaptures at large for several years are rare, however, and it may take some time to compile a good set of training scales.

BioSonics - OPRS Age Determination

A set of acetate impressions of 200 striped bass scale samples from the 207 scales was also aged by BioSonics with the OPRS, which had been parameterized (trained) using acetate slide impressions. Seven scale samples from the 207 scales were determined by NAI to be older than age 3+ and were not included in the scales examined by BioSonics. Overall agreement with NAI determined ages was 78% (Table 5). The best agreement was achieved with age 0+ and age 1+ fish (100% and 96% respectively). Age 2+ and age 3+ scales were the most difficult to age using the OPRS. When the 49 scales that NAI and NYSDEC Region 1 and Region 3 were not in complete agreement on the assigned age (Table 2) were removed from the set of 200 slides, the overall accuracy of the OPRS did not improve, and agreement of OPRS assigned ages 0+, 1+, 2+, and 3+ was 100%, 100%, 72% and 69% respectively.

Reliance by the OPRS on fish length or some other discriminating factor related to length (such as scale radius) to separate age groups of fish can be seen by examining the variables LENGTH and BIOAGE in Table 1. Since Table 1 is sorted by age and within age by length, errors due to incorrect assignment of age based on length should occur

TABLE 5. AGREEMENT BETWEEN NAI AND BIOSONICS OPRS IN AGE ASSIGNED TO ACETATE IMPRESSIONS OF SCALE SAMPLES FROM THE 1986-1987 HUDSON RIVER STRIPED BASS PROGRAM.

	NUMBER OF SCALE SAMPLES ASSIGNED THE SAME AGE AS NAI FROM THE TOTAL SET OF 200 SCALES			NUMBER OF SCALE SAMPLES ASSIGNED THE SAME AGE FROM A SET OF 151 SCALES FOR WHICH COMPLETE AGREEMENT IN AGE WAS OBSERVED[a]		
AGE	NAI	OPRS	AGREEMENT	NAI-NYSDEC	OPRS	AGREEMENT
0+	30	30	100%	28	28	100%
1+	49	47	96%	38	38	100%
2+	69	42	61%	43	31	72%
3+	52	37	71%	42	29	69%
TOTAL	200	156	78%	151	116	77%

[a]Complete agreement in age independently assigned by NAI, NYSDEC Region 1 and NYSDEC Region 3 prior to 21-22 April 1987 workshop.

most frequently when the size of fish overlap between age groups. For age 0+, 26 mmTL separated the largest age 0+ striped bass and the smallest age 1+ fish. The OPRS effectively identified age 0+ based on length alone since there was no length overlap. Age 1+ and age 2+ striped bass overlapped by 89 mmTL, and the two erroneous age assigned by the OPRS for age 1+ were to the largest age 1+ fish which were called age 2+. Age 2+ striped bass are sandwiched between two overlapping age groups. The smallest age 2+ fish overlapped with the largest age 1+ fish by 89 mmTL, and the largest age 2+ fish overlapped with the smallest age 3+ fish by 136 mmTL. All of the incorrectly assigned ages by the OPRS for age 2+ fish occurred in the upper and lower length overlaps. Small age 2+ fish were labeled age 1+ (13/14 or 93% of the underestimated age errors) and large age 2+ fish were labeled age 3+ (13/13 or 100% of the overestimated age errors). Large age 3+ fish were not incorrectly assigned to older age classes because fish older than age 3+ were not provided for training (parameterizing) the OPRS. However, all of the 15 incorrect ages assigned to age 3+ fish were due to labeling small age 3+ fish as age 2+. It was concluded that the OPRS was useful for discriminating between the age groups that are most easily separated by length. As the overlap in length between age cohorts increases with increasing age, the ability of the OPRS to discriminate age cohorts is reduced.

Precision of Conventional Ageing Techniques

Precision for conventional age determination was defined as consistently identifying the correct age for one or more pairs of scale samples from the same fish. The 30 duplicated slides within the set of 207 striped bass scale samples were used to evaluate precision of assigned age and to examine variation in assigned age both within and between laboratories (Table 6). Ten duplicated slides were provided for each of age 1+, 2+ and 3+ striped bass scales from the 1986-1987 Hudson River Striped Bass Program and were randomly mixed among the 207 scales.

TABLE 6. PRECISION OF AGE ASSIGNMENT TO 30 PAIRS OF HUDSON RIVER STRIPED BASS SCALE SAMPLES EXAMINED IN A DOUBLE BLIND TEST BY NAI, NYSDEC REGION 1 AND NYSDEC REGION 3 PRIOR TO THE SCALE AGEING TECHNIQUES WORKSHOP, 21-22 APRIL 1987.

				ASSIGNED AGE					
				NAI		NYSDEC REGION 1		NYSDEC REGION 3	
TASK CD	SAMPLE	FISH ID	SLIDE CODE NUMBERS REPLICATE 1 - REPLICATE 2	REPLICATE 1	REPLICATE 2	REPLICATE 1	REPLICATE 2	REPLICATE 1	REPLICATE 2
53	2038	3	1085 - 1022	1	1	1	1	2	1
53	2021	29	1086 - 1021	1	1	1	1	1	1
53	0141	12	1087 - 1020	1	1	1	1	1	1
53	2037	1	1088 - 1028	1	1	1	1	1	1
53	2021	32	1089 - 1027	1	1	1	1	1	1
53	2020	41	1090 - 1026	1	1	1	1	1	1
53	2036	17	1091 - 1025	1	1	1	1	1	1
53	2038	61	1092 - 1024	1	1	1	1	1	1
53	0142	6	1093 - 1029	1	1	1	1	1	1
53	2036	33	1094 - 1023	1	1	1	1	1	1
53	0145	9	1095 - 0676	2	2	2	2	2	2
53	0145	27	1096 - 0675	2	2	2	2	2	2
53	0145	6	1097 - 0674	2	2	2	2	2	2
53	0145	2	1098 - 0671	2	2	2	2	*	2
53	2037	13	1099 - 0663	2	2	2	2	2	2
53	0144	8	1100 - 0684	2	2	2	2	2	2
53	0143	1	1101 - 0679	2	2	2	2	2	2
53	2088	128	1102 - 0784	2	2	*	3	3	3
53	0223	12	1103 - 0705	2	2	*	2	*	*
53	0215	1	1104 - 0721	2	2	2	2	*	2

TABLE 6. (Cont.)

TASK CD	SAMPLE	FISH ID	SLIDE CODE NUMBERS REPLICATE 1 - REPLICATE 2	ASSIGNED AGE NAI REPLICATE 1	NAI REPLICATE 2	NYSDEC REGION 1 REPLICATE 1	NYSDEC REGION 1 REPLICATE 2	NYSDEC REGION 3 REPLICATE 1	NYSDEC REGION 3 REPLICATE 2
53	0400	2	1105 - 1070	3	3	3	3	3	3
53	0339	7	1106 - 1068	3	3	*	*	3	3
53	0359	1	1107 - 1071	3	3	3	3	3	3
53	0341	3	1108 - 1066	3	3	3	3	3	3
53	0358	13	1109 - 1060	3	3	3	3	3	3
53	0402	2	1110 - 1058	3	3	3	3	3	3
53	2107	9	1111 - 1057	3	3	3	3	3	3
53	0339	14	1112 - 1065	3	3	4	3	3	3
53	0355	13	1113 - 1056	3	3	3	3	3	3
53	0359	20	1114 - 1062	3	3	3	3	3	3

*Unresolved age

Legend:

TASK CD, SAMPLE, FISH ID = Variables identifying each fish from a NAI field sample, and
SLIDE CODE NUMBERS = pair of unique identifying numbers used to recognize Replicate 1 and Replicate 2 of the acetate scale impressions from each fish.

NAI correctly identified the age on all pairs of samples. NYSDEC Region 1 correctly identified age for all of the age 1+, 80% of the age 2+ and 80% of the age 3+ paired samples. NYSDEC Region 3 correctly identified the age for 90% of the age 1+, 60% of the age 2+ and all of the age 3+ paired scale samples.

An analysis of variance (ANOVA) was performed to quantify the within laboratory and between laboratory variation in precision of age assigned to striped bass scales. The model for this comparison was:

$$Y_{ij} = A_i + AB_{ij} + e_{k(ij)}$$

where

Y_{ij} = Arc Sine transformed, percent agreement in assigned age of age j striped bass by laboratory i

A_i = Laboratory i, i = 1 for NAI
i = 2 for NYSDEC Region 1
i = 3 for NYSDEC Region 3

B_j = assigned age of fish j, where j = 1 for age 1+
j = 2 for age 2+
j = 3 for age 3+

AB_{ij} = interaction between laboratory and assigned age

$e_{k(ij)}$ = error.

A Newman-Kuels comparison test was used to test for significant ($P\alpha$ = 0.05) differences among laboratories, assigned ages and the interaction between assigned age and laboratory since these factors were significant in the ANOVA model (Table 7). NAI was the most precise laboratory and consistently assigned the correct age to age 1+, 2+ and 3+ striped bass (100% precision and accuracy). This is not surprising since NAI prepared the test set of scales using a 100% quality control inspection plan and a Standard Operating Procedures Manual which requires individuals to consistently use the same criteria to assign

TABLE 7. ANALYSIS OF VARIANCE COMPARING PRECISION OF AGE ASSIGNED TO AGE 1+, 2+, AND 3+ HUDSON RIVER STRIPED BASS FROM THE 1986-1987 PROGRAM BY NAI, NYSDEC REGION 1 AND NYSDEC REGION 3.

SOURCE	df	SS	MS	F	SIGNIFICANCE
Laboratory	2	0.139	0.070	5.385	$P < 0.01$
Age	2	0.173	0.087	6.692	$P < 0.01$
Interaction	4	0.227	0.057	4.385	$P < 0.01$
Error	9	0.114	0.013		
Total	17	0.653			

Newman-Keuls contrast (precision as %). Factor levels connected by an underline are not significantly different at $P\alpha = 0.05$.

Factor	Contrast		
Laboratory	NAI (100%)	NYSDEC 1 (87%)	NYSDEC (83%)
Age	1+ (97%)	3+ (93%)	2+ (80%)
Interaction	NAI age 1+, 2+ and 3+ NYSDEC 1 age 1+ NYSDEC 3 age 3+ (100%) NYSDEC 3 age 1+ (90%) NYSDEC 1 age 2+ and age 3+ (80%) NYSDEC 1 age 2+ (60%)		

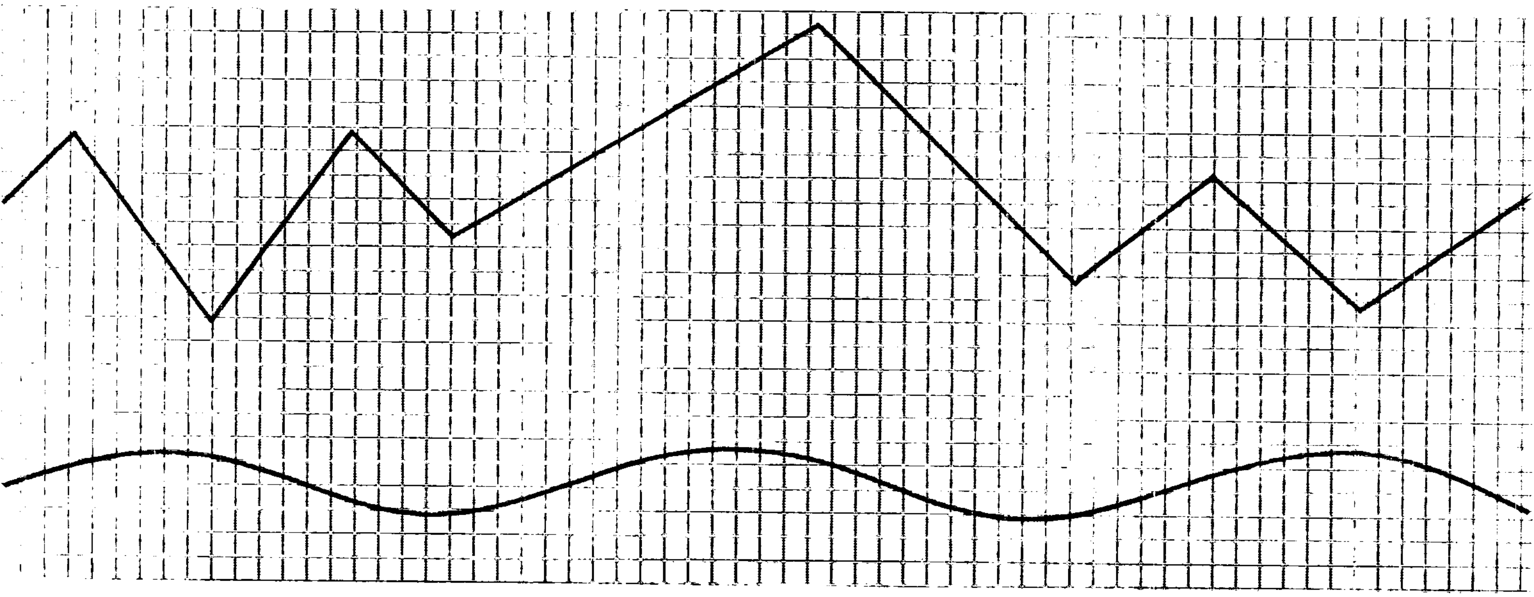
(Underlines: Laboratory — NAI (100%) alone; NYSDEC 1 (87%) and NYSDEC (83%) joined. Age — each level underlined separately.)

age. NYSDEC Region 1 and Region 3 were equally precise overall in their assignment of age to striped bass and less precise than NAI. Assignment of age to striped bass was most precise for age 0+ among all laboratories and least precise for age 2+ fish. NYSDEC Region 1 had the least precision in assigning age to age 2+ fish, and NYSDEC Region 3 was intermediate in precision. NYSDEC Region 1 remained intermediate precision when assigning age to age 3+ striped bass, while both NYSDEC Region 3 and NAI were more precise than NYSDEC Region 1 for age 3+.

Precision of BioSonics OPRS

For the BioSonics OPRS, precision was first defined as reproducibility or the ability to consistently assign the same age to both scale samples in each of the 30 pairs of striped bass scales described above. With this definition of precision, reproducibility of the OPRS was 100% for assigning age to age 1+ and age 2+ striped bass scales from acetate impressions and 80% for age 3+. For comparison with conventional ageing techniques, precision for the OPRS was also defined as the ability to correctly and consistently assign age to both scale samples in each of the 30 pairs of striped bass scales. Under the more restrictive definition of precision (which includes both accuracy and precision), the OPRS was 80% precise for assigning age to age 1+, 60% precise for age 2+ and 80% precise for age 3+ striped bass scales. These results were comparable with the precision of conventional ageing techniques and may be affected by the overlap in length between sucessive age cohorts as was described above under OPRS age determination.

HUDSON RIVER FOUNDATION



Hudson River Striped Bass Tag Recovery Program March 1987 – February 1988

John R. Waldman

HUDSON RIVER STRIPED BASS TAG RECOVERY PROGRAM

MARCH 1987 - FEBRUARY 1988

Final Report

Prepared under contract with
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New York Power Authority

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1.0 EXECUTIVE SUMMARY

* Between 1 March 1987 and February 29, 1988, the Hudson River Foundation (HRF) received 946 tags from striped bass tagged in the Hudson River Adult Striped Bass Stock Assessment. Of these, 415 tag returns were from 9,479 releases of tagged striped bass made during winter 1986-1987, 502 returns were from 18,510 releases made during winter 1985-1986, 10 returns were from 741 releases made during spring 1984, and 19 returns were unidentifiable as to release year.

* No relationship was found between recapture rate and temperature at tagging from 0 to 13^{0}C.

* Internal anchor tags continued to provide superior long-term retention in comparison with anchor tags. All 10 returns from striped bass double-tagged during 1984 resulted from the presence of internal anchor tags only. The relative retention rate of internal anchor tags vs. anchor tags over the second through fourth recapture years was 97.1% vs. 8.6%, respectively.

* Fishermen reported that 92.7% of all 1987-1988 recaptures were released in good condition. Unlike 1986-1987, there was no significant difference in the percentages of fish released in good condition between fish <600 mm and $\geq$600 mm TL. The lack of a difference may be related to changes in fishing regulations.

* Vinyl-covered internal anchor tags did not provide a higher return rate than unprotected internal anchor tags. Although vinyl sleeves prevented the abrasion of tag legends, the sleeves became opaque and allowed algal growth between the tag streamer and the sleeve, thereby reducing legibility.

* The geographic pattern of recaptures during the 1987-1988 recapture year was generally consistent with that observed in previous years of this program, with one notable exception - a return from offshore of Currituck Island, Cape Hatteras, North Carolina. Recaptures to the north ranged to the Annapolis River, Nova Scotia. One recovery was made above tidewater at Waterford, New York, north of the Federal Dam at Troy. First year recaptures of 1986-1987 releases were less widely dispersed than second year recaptures of 1985-1986 releases.

* The relationship between fish length and distance traveled from the mouth of the Hudson River for first year recaptures of striped bass tagged during 1986-1987 was significant and positive ($r=0.202$, $P=0.0014$). However, it was not as strong as for first year recaptures during 1985-1986 ($r=0.536$, $P<0.0001$), probably due to the smaller number of large fish tagged during 1986-1987.

2.0 INTRODUCTION

The Hudson River Cooling Tower Settlement Agreement (Sandler and Schoenbrod 1981) among electric utilities, government agencies, and environmental protection groups stipulated that the utilities conduct biological monitoring studies of certain Hudson River fish stocks, including striped bass *Morone saxatilis*. It also stipulated that the utilities evaluate the contribution of stocked striped bass to the Hudson River population. As a result, striped bass have been captured, examined for hatchery marks, and externally tagged and released since 1984.

The Hudson River Foundation (HRF) was contracted to process tag returns, publicize the program, and analyze the tag return data. Normandeau Associates, Inc. (NAI) performed the tagging, recaptured some striped bass, and evaluated the contribution of stocked fish.

During 1984, a study was conducted to compare three tag styles (Dunning et al. 1987) and to test fishing gear (NAI 1985). During the field portion of that study (April-June 1984), 741 Hudson River striped bass ≥300 mm total length (TL) were tagged and released. First and second year recaptures from this tagging were analyzed in HRF (1985) and HRF (1986), respectively. From November 1985-May 1986, 18,510 striped bass ≥200 mm TL were tagged and released in the lower Hudson River and adjoining waters. First year recaptures of these striped bass were reported in Waldman (1988), as were third year recaptures of fish tagged in 1984. From December 1986-May 1987, 9,479 striped bass ≥200 mm TL were tagged and released in the Hudson estuary.

This report provides an analysis of information from tags received during March 1987-February 1988 which were released through May 1987 from the first three tagging efforts. Specific topics included are: 1) the effects of fish length and release temperature on recapture rates, 2) whether there was angler selectivity for fish length, 3) recapture rate by anglers in comparison with overall recapture rate, 4) the effects of fish length on the percentage of fish reported released in good condition, 5) long-term tag retention of anchor vs. internal anchor tags, 6) whether different return rates occurred from vinyl sleeve protected vs. non-vinyl sleeve protected internal anchor tags, 7) the abrasion of information from tags, 8) the condition of fish at the tag sites, and 9) information on distribution and movement, particularly concerning the effects of fish length.

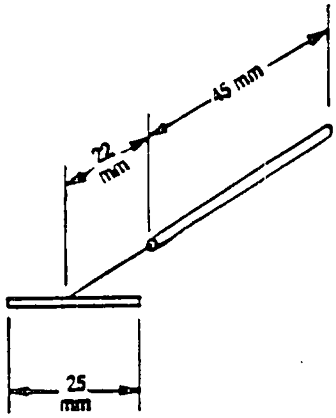
3.0 MATERIALS AND METHODS

3.1 Tagging

Detailed accounts of the materials and methods used in tagging, administration, and analysis for the 1984 and 1985-1986 programs are provided in HRF (1985) and Waldman (1988), respectively. Further information on sampling and tagging procedures appeared in NAI (1985) for the 1984 program, NAI (1986) for the 1985-1986 program, and NAI (1987) for the 1986-1987 program. In the 1984 study, striped bass ≥300 mm TL were double-tagged with Floy FD68-B anchor tags and Floy FT-69 internal anchor tags. Based on the results of the 1984 study and a holding pool study which demonstrated superior retention of the internal anchor tag in striped bass (Dunning et al. 1987), all fish marked in the 1985-1986 and 1986-1987 studies were single-tagged with internal anchor tags (Figure 1). Striped bass 200-299 mm TL were tagged with a smaller internal anchor tag than fish ≥300 mm TL during the latter two studies. All tags bore the message "RTN to HRF Box 1731 GCS, NY 10163" and a five-digit tag number and reward value on the external streamer. Reward values for the 1986-1987 program were either \$5-\$1000 or \$10-\$1000.

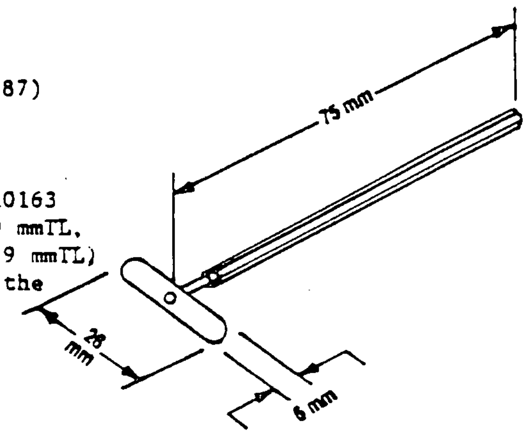
During the 1986-1987 tagging program striped bass were captured between 21 December 1986 and 8 May 1987 using 9 m and 12 m high rise trawls (NAI 1987). Sampling was concentrated in the Hudson River between river miles 0 and 14 and in Upper New York Harbor between Harbor miles 0 and 4. Trawling in the Hudson River (between river miles 23 and 39), in the East River (between East River river miles 1 and 5), in the Harlem River (at Harlem River miles 1 through 5 and 11 through 14), and in the Lower Harbor from the Verrazano-Narrows Bridge to Sandy Hook, New Jersey (Figure 2) was limited because initial efforts resulted in low striped bass catches.

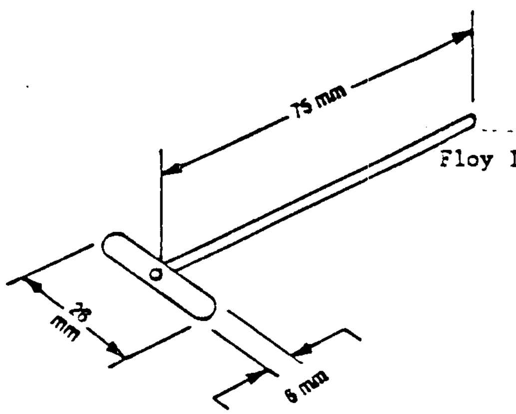
The mean length of the striped bass tagged during 1986-1987 was 301.2 mm (SD 71.8 mm) and 761 (8.0%) measured ≥400 mm (NAI 1987). The mean length of the 1985-1986 releases was 330.6 mm



Hallprint Internal Anchor-External Streamer Tag (1987-present)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No. ######

Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer





Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm X 6 mm for fish ≥300 mmTL,
RED 20 mm X 5 mm for fish 200-299 mmTL)
no legend

Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

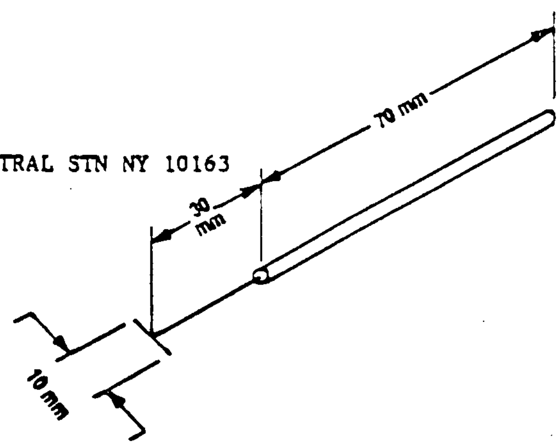


Figure 1. Internal anchor tags used in striped bass.
(From NAI Striped Bass Hatchery Evaluation Report)

(SD 105.3 mm) and 4,115 (22.2%) were ≥400 mm (NAI 1986).

Most of the tagging occurred using two vessels. The capture boat conducted the actual sampling while the tagging boat handled the catch. Captured fish were transferred directly from the trawls to a holding facility alongside the tagging boat. This procedure minimized mortality from handling (Dunning et al. 1989). All striped bass were measured (TL) and examined for external tags and tag wounds. Because the tagging program was coordinated with a study to evaluate the contribution of stocked striped bass to the Hudson River striped bass stock, all striped bass were examined for internal magnetic tags, implanted at the hatchery using a Northwest Marine Technology, Inc. tag detector.

Striped bass ≥200 mm TL, in good condition and not already externally tagged, were tagged with an internal anchor-external streamer tag. When NAI recaptured fish tagged in this program, the tag was inspected for wear. If printing on the tag was still clearly legible the fish was re-released with the tag in place; however, if information on the tag was lost or obscured by abrasion, the tag was replaced. To insert the tags, a scale midway between the vent and the distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral midline was removed. A horizontal incision approximately 5 mm long was then made through the abdominal wall. The anchor of the tag was inserted through the incision and the wound was treated with a merbromine-based topical antiseptic. Fish were released at least 400 m from active fishing gear but within one mile of the capture location.

A modification to the internal anchor tag was made during the latter part of the 1986-1987 tagging effort. Tags returned from the 1985-1986 releases began to show evidence of wear from abrasion with the substrate, which resulted in degradation of the tag legends (Waldman 1988, Mattson et al., in press). To mitigate tag abrasion, most tags used after 8 March 1987 had protective vinyl sleeves. The clear sleeve was fitted over internal anchor tags of the same size as the sleeveless versions.

An additional 65 striped bass were tagged in the Hudson River between river km 43 and 182 during spring 1987 by a sportfisherman using tagging materials and procedures similar to those of NAI.

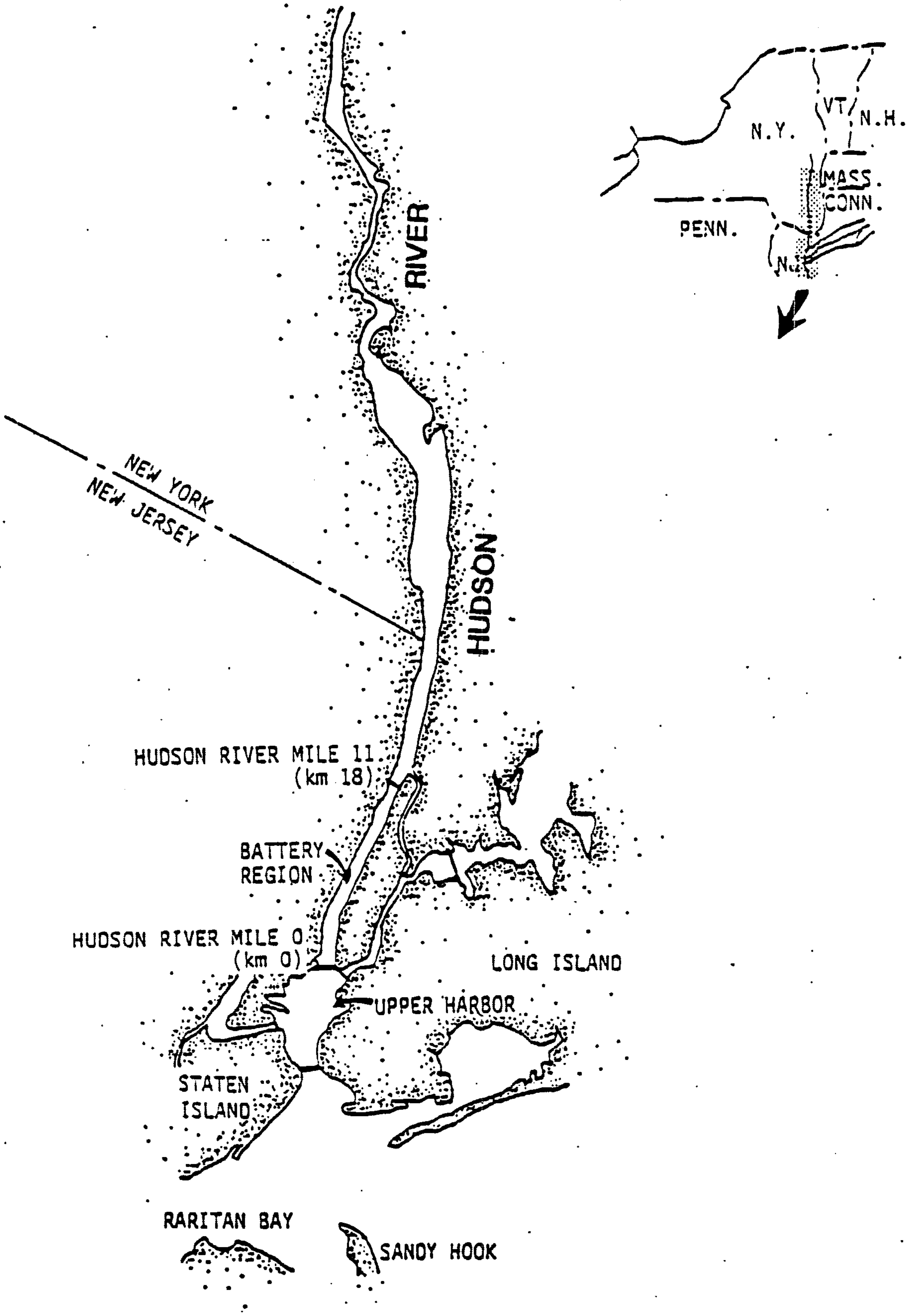


Figure 2. Areas sampled by Normandeau Associates, Inc. during 1986-1987.
(From NAI Striped Bass Hatchery Evaluation Report)

3.2 Processing of Tag Returns

When a tag was returned, the HRF issued a check for the minimum reward value displayed on the tag, either $5 or $10. The reward check and a questionnaire were then mailed to the respondent along with a stamped return envelope and a flier describing the program. If a response was not received within about six weeks, a followup questionnaire was sent. All questionnaires indicated that completion and return of the questionnaire was necessary for the respondent to be eligible for a $100 to $1000 reward.

After the completed questionnaire was received by HRF, a form was mailed to the respondent indicating where and when their fish was tagged. Early in the 1987-1988 program year the form was modified to become a "Certificate of Participation", suitable for display (Appendix 1). Respondents were also entered into a drawing.

All those who returned questionnaires by late February 1988 were included in the drawing held on February 29, 1988, once for each tag returned. In accordance with the rules of the drawing, nine tag numbers were randomly selected. The first five people whose number was drawn received $100 per tag, the next two received $500 per tag, and the final two received $1000 per tag.

A publicity campaign to create angler awareness of the program was continued by the HRF. An advertisement was displayed in the weekly Fisherman publication series (New England Fisherman, Long Island Fisherman, and New Jersey Fisherman) once per month from April through October 1987. Press releases were also issued periodically which ran in the Fisherman publications, daily newspapers, and the January 1988 issue of Salt Water Sportsman. An article summarizing the results of the 1986-1987 program was published in the Fisherman series (Waldman et al. 1988).

3.3 Data Analysis

All analyses involving fish length were performed using the lengths at time of release, which were taken using a standardized measuring procedure. For the purposes of this report, spring is defined as March - May, summer as June - August, autumn as September - November, and winter as December - February. All data associated with striped bass releases were obtained from NAI.

Recaptures here refers to recaptures of tagged fish for which the HRF was notified through return of a tag to HRF, or other form of communication such as a letter from the New York State Department of Environmental Conservation (NYSDEC) or other agency verifying recapture of a tagged fish. Tag retention refers to the continuing attachment of the tag to the fish.

Most statistical analyses were performed using the Statistical Analysis System (SAS 1987) on a personal computer. Statistical significance was sometimes determined with the Chi-square test using the procedures of Sokal and Rohlf (1969).

The relationship between fish length and distance traveled was assessed for various length classes. For recaptures outside the Hudson River (south of the Battery, at the southern tip of Manhattan Island), distance traveled was calculated from the mouth of the river to eliminate the effect of within-river differences in tagging locations. As in Waldman (1988), for recaptures in the 1986-1987 program year, two assumptions were made in calculating the minimum distance traveled (statute miles) of coastal recaptures (outside the Hudson River): (1) striped bass tagged in the Hudson River but recaptured outside the Hudson River traveled by way of the Battery and not the Harlem River, and (2) striped bass recaptured north of or within Cape Cod Bay passed through the Cape Cod Canal, but that fish recaptured east of the Elizabeth islands, near the southern entrance to the Canal, and those recaptured on the ocean side of Cape Cod, had not utilized the Canal for passage around Cape Cod.

4.0 **RESULTS**

4.1 **Recapture Rates**

Between December 1986 and May 1987, 9,479 striped bass were tagged and released in the Hudson estuary and adjacent waters (Table 1). Between 1 March 1987 and 29 February 1988, 415 of these tags were returned to HRF. Over the same period, numerous tags were returned from earlier program years, 502 tags from the 18,510 marked during the 1985-1986 program, and 10 from the 1984 tagging. An additional 19 tags were received during the 1987-1988 recovery period that were unidentifiable as to release year.

While tagging striped bass in the lower Hudson estuary during winter 1987-1988, NAI recaptured 103 tagged striped bass from the 1986-1987 tagging (NAI 1988).

Table 1.-Number of striped bass tagged and released and number of returns to HRF since beginning of Hudson River Striped Bass Tag Recovery Program.

Release year	No. tagged	No. tags returned to HRF 1984-85	1985-86	1986-87	1987-88[1]	TOTAL
1984	741	53	13	10	10	86
1984-85	0	--	--	--	--	--
1985-86	18510	--	--	717	502	1219
1986-87	9479	--	--	--	415	415
TOTAL	28730	53	13	727	927	1720

[1] Nineteen additional tags were received that were unidentifiable as to release year.

There was a highly significant difference ($P < 0.01$) among recapture rates by length classes for striped bass released from the trawls (Table 2). Return rates rose from 3.3% for 200-299 mm fish to 5.7% for 400-499 mm fish, and then fell to 4.7% for fish ≥500 mm, for an overall return rate of 3.9%. The return rate from the 65 angling releases was 6.2% (Table 3), higher than that for releases from the trawl. The number of returns from angling releases was too small to test for a statistical difference between recapture rates from angling and trawl releases.

Table 2.-Numbers released and recaptured and percent recaptured, by length class, of striped bass released from trawls during 1986-1987.

Length class (mm)	Released		Recaptured		Percent recaptured
200-299	5222	(55.5)	171	(46.3)	3.3
300-399	3492	(37.1)	159	(43.1)	4.6
400-499	593	(6.3)	34	(9.2)	5.7
≥500	107	(1.1)	5	(1.4)	4.7
TOTAL	9414	(100.0)	369	(100.0)	3.9

Table 3.-Numbers released and recaptured and percent recaptured, by length class, of striped bass released by an angler during 1986-1987.

Length class (mm)	Released		Recaptured		Percent recaptured
200-399	4	(6.2)	0	(0.0)	0.0
400-599	41	(63.1)	3	(75.0)	7.3
≥600	20	(30.8)	1	(25.0)	5.0
TOTAL	65	(100.0)	4	(100.0)	6.2

4.1.1 Gear and Temperature Effects

Recapture rates of striped bass released from trawls conducted at temperatures ranging between 0-14^{0}C showed no clear pattern, and ranged from a low of 0.9% at 6^{0}C and a high of 4.4% at 3^{0}C (Table 4). The recapture rates by temperature were not significantly different.

Table 4.-Recapture rates by temperature at release of Hudson River striped bass released from trawls during 1986-1987.

Temperature (^{0}C)	Releases	Recaptures	Percent recaptured
0-1	258	10	3.9
2	1282	48	3.7
3	2788	124	4.4
4	1849	74	4.0
5	1628	69	4.2
6	319	3	0.9
7	447	14	3.1
8	575	23	4.0
9	197	2	1.0
10-13	71	2	2.8

4.1.2 **Angling Recaptures**

Angling recaptures during 1987-1988 of 1986-1987 releases totaled 350, which comprised approximately 95% of all non-NAI recaptures. The remainder were recaptured in nets by commercial fishermen and researchers. Angling recapture rates increased from 3.1% for the 200-299 mm length class to 5.4% for the 400-499 mm length class, but declined to 2.4% for the ≥500 mm length class (Table 5). The only significant difference ($P < 0.05$) in recapture rates between successive length classes was between fish measuring 200-299 mm and 300-399 mm.

Table 5.-Numbers and percent of angling recaptures during 1987-1988 of 1986-1987 releases, by length class at release.

Length class (mm)	Number released	Number recaptured	Percent recaptured
200-299	5223	163	3.1
300-399	3495	151	4.3
400-499	595	32	5.4
≥500	166	4	2.4
TOTAL	9479	350	3.7

There were 339 angling recaptures of 1985-1986 releases, constituting 91% of non-NAI recaptures. Angling recapture rates increased from 1.4% for the 200-299 mm length class to 3.1% for fish ≥500 mm (Table 6). The only significant difference ($P < 0.05$) in recapture rates between successive length classes was between fish measuring 200-299 mm and 300-399 mm.

Table 6.-Numbers and percent of angling recaptures during 1987-1988 of 1985-1986 releases, by length class at release.

Length class (mm)	Number released	Number recaptured	Percent recaptured
200-299	9603	132	1.4
300-399	4780	97	2.0
400-499	2232	52	2.3
≥500	1860	58	3.1
TOTAL	18475[1]	339	1.8

[1] Does not include 25 striped bass tagged from gill nets and 10 fish that escaped before the tag number was recorded.

4.1.3 Long-term Tag Retention

An additional 10 internal anchor tags were returned from the 741 striped bass double-tagged with internal anchor and anchor tags in 1984 (Table 7). No anchor tags were returned during the 1987-1988 recapture period. Of the 110 recaptures by NAI of striped bass tagged in prior years, none were from 1984 releases.

Table 7.-Number of anchor (Dennison) and internal anchor tags returned per year, including NAI recoveries, from 741 striped bass double-tagged in 1984.

Recapture year	No. of fish recaptured	Number of tags recovered	
		Anchor	Internal anchor
<2/28/85	53	21	49
3/1/85 - 2/28/86	13	1	12
3/1/86 - 2/28/87	12	2	12
3/1/87 - 2/28/88	10	0	10
TOTAL	88	24	83

4.1.4 **Condition and Disposition of Recaptures**

Respondents were asked whether the tagged striped bass they caught were released in good condition. Whereas the answer yes was unambiguous, the answer no could mean either that the fish was kept or that it was released in poor condition. However, the negative response does provide an estimate of fishing-induced mortality if it is assumed that fish released in poor condition later died. When responses for 1987-1988 recaptures from 1986-1987 and 1985-1986 were pooled, the percent released in good condition ranged from a high of 94.3% for the 400-499 mm length class to a low of 84.2% for the ≥600 mm length class (Table 8). There was no significant difference among length classes in the percent of striped bass released in good condition (P>0.05).

Table 8.-Numbers and percent of striped bass released in good condition following recapture, by length class at release, of 1987-1988 recaptures from 1985-1986 and 1986-1987 releases.

Length class (mm)	Total number of responses	Number released in good condition	Percent released in good condition
200-299	299	280	93.6
300-399	244	227	93.0
400-499	88	83	94.3
500-599	47	40	85.1
≥600	19	16	84.2
TOTAL	697	646	92.7

4.2 **Physical Effects of Tagging**

4.2.1 **Abrasion of Information from Tags**

Nineteen tags were received during the 1987-1988 program year that could not be identified as to year of release due to abrasion of their serial numbers. Waldman (1988) and Mattson et al. (in press) found that cumulative abrasion of the legends of ventrally-oriented internal anchor tags may occur through contact with the substrate. Abraded tags that were recovered during the

1986-1987 program year were identifiable to recapture year because tags with a streamer length of 65 mm had been used only during the 1984 tagging period. However, during the 1987-1988 recapture year, the same-sized tags had been used over two tagging efforts, making it impossible to identify the year employed for tags with heavily abraded serial numbers.

Vinyl sleeves were fitted over tag streamers in an attempt to reduce the abrasion of information from tag legends. Return rates from these tags were compared with return rates from uncovered tags to determine whether the sleeves altered return rates. Unprotected internal anchor tags provided a return rate of 4.44% (323/7265) vs. 4.15% (92/2215) for tags with vinyl sleeves. This difference in return rates was not significant ($P>0.05$).

4.2.2 Fish Condition at Tag Sites

A smaller version of the internal anchor tag was used to mark striped bass between 200 and 299 mm than was used for striped bass 300 mm or longer. Fishermen were asked to report the condition of the tag insertion site as showing either no abrasion, some abrasion, or substantial abrasion. Based on 328 responses, abrasion rates from the two sizes of tags were very similar (Table 9).

Table 9.-Condition of tag insertion sites as reported by fishermen for small and large internal anchor tags (used in 200-299mm and ≥300mm length classes, respectively) from 1986-1987 releases.

Length class	No abrasion	Some abrasion	Substantial abrasion
200-299 mm	116 (76.8%)	29 (19.2%)	6 (4.0%)
≥300 mm	131 (74.0%)	40 (22.6%)	6 (3.4%)
TOTAL	247 (75.3%)	69 (21.0%)	12 (3.7%)

Abrasion rates were compared between first year recaptures (1986-1987) and second year recaptures (1987-1988) from 1985-1986 releases (Table 10). Despite the additional time in which the internal anchor tags remained implanted in the second year recaptures, fishermen reported abrasion rates that were almost identical to first year abrasion rates.

Table 10.-Condition of tag insertion sites for first recapture year (1986-1987) and second recapture year (1987-1988) of striped bass released during 1985-1986.

Recapture yr.	No abrasion	Some abrasion	Substantial abrasion
1986-1987	360 (73.6%)	101 (20.7%)	28 (5.7%)
1987-1988	239 (72.9%)	72 (22.1%)	17 (5.1%)
TOTAL	599 (73.3%)	173 (21.2%)	45 (5.5%)

4.3 Striped Bass Movements

4.3.1 Distribution of Recoveries

First year recaptures during 1987-1988 from 1986-1987 releases were less widely distributed on a by-state basis than second year recaptures from 1985-1986 releases (Table 11). For example, recapture proportions were greater for second year recaptures from Connecticut (9.8% vs. 5.4%), Rhode Island (6.6% vs. 0.6%), Massachusetts (5.5% vs. 1.0%), and Maine and Nova Scotia (1.9% vs. 0.0%). The proportion of second year recaptures from within the Hudson River was only about half that of first year recaptures (14.4% vs. 25.8%).

First year recaptures (1986-1987) of 1985-1986 releases are also provided for comparison with second year recaptures from the same release year (Table 11). First year recaptures of 1985-1986 releases were more widely distributed than first year recaptures from 1986-1987 releases, but less widely distributed than second year recaptures of 1985-1986 releases. The proportion of second year recaptures of 1985-1986 releases from within the Hudson River was less than half the first year recapture proportion from within the river (14.4% vs. 32.6%).

Table 11.-Numbers and percent (column) of first and second year recaptures from 1985-1986 releases and first year recaptures from 1986-1987 releases, by state, and by occurrence within or outside the Hudson River.

	Number of recaptures					
	1985-1986 Releases				1986-1987 Releases	
	1986-1987 Recaptures		1987-1988 Recaptures		1987-1988 Recaptures	
New York (in river)	188	(28.6)	62	(13.1)	110	(22.9)
New York (out river)	258	(39.3)	222	(47.0)	163	(34.0)
New Jersey (in river)	26	(4.0)	6	(1.3)	14	(2.9)
New Jersey (out river)	71	(10.8)	70	(14.8)	59	(12.3)
Connecticut	44	(6.7)	46	(9.8)	26	(5.4)
Rhode Island	37	(5.6)	31	(6.6)	3	(0.6)
Massachusetts	26	(4.0)	26	(5.5)	5	(1.0)
Maine	4	(0.6)	7	(1.5)	0	(0.0)
Virginia	2	(0.3)	0	(0.0)	0	(0.0)
Nova Scotia	1	(0.2)	2	(0.4)	0	(0.0)
TOTAL						
(in river)	214	(32.6)	68	(14.4)	124	(25.8)
(out river)	443	(67.4)	404	(85.6)	256	(74.2)
(combined)	657	(100.0)	472	(100.0)	380	(100.0)

4.3.1.1 First Year Recaptures from 1986-1987 Releases

First year recaptures with locality data from 1986-1987 releases were 380; 256 (74.2%) were from outside the Hudson River and 124 (25.8%) were from within the river (Table 11).

There were 10 recoveries during March 1987 and they were evenly divided between the river and outside of it. All of these occurred between Tarrytown and Jamaica Bay. During April and succeeding months, more recaptures were made outside the river. April recaptures within the river were concentrated below Poughkeepsie but extended to Catskill. Recaptures outside the river occurred primarily near Upper and Lower New York harbors but extended as far as Greenwich in Long Island Sound, Orient Point in eastern Long Island, and Blue Point in Great South Bay on the south shore of Long Island. During May, numerous recaptures were made in the tidal Hudson River to the Federal Dam at Troy. A single fish measuring 387 mm at release at river mile 8 was recaptured north of the Federal Dam in Lock 1 at Waterford. Recoveries were numerous in the lower estuary and in Long Island Sound, including tributaries such as the Housatonic, Connecticut, and Thames rivers. Distant recoveries occurred in Napeague Bay in eastern Long Island (2) and Falmouth Harbor, Massachusetts.

During June, the 15 recaptures made at the dam in Troy represented half of all the recaptures north of the Battery for the month. Other Hudson River locations with multiple recaptures included the Esopus Creek (2) and Rondout Creek (4) regions, Croton Bay (2), and off mid-Manhattan (2). Recoveries were also made along the length of Long Island Sound and the Housatonic and Connecticut rivers. There were four recaptures from the Connecticut River including one from near the Massachusetts border at Enfield, Connecticut. There were few recoveries from east of Connecticut: one from Pawcatuck, Rhode Island, and one each from Monomoy Island and Barnstable Harbor, Massachusetts.

In July, the number of recaptures from the Hudson River (9) fell dramatically in comparison with June. Only one recovery was made at the Federal Dam. July recaptures from outside the river were also few (17), and ranged as far east as Great Peconic Bay, Long Island, and the Quonochontaug Breachway, Rhode Island. Total recaptures with locality data in August fell to 16, with seven from the Hudson River, ranging to the dam at Troy.

Thirteen recaptures were made during September, only one of which was north of the Battery. September recoveries from outside the river were limited to the New York City area, except for one from the Connecticut River in September. October and November showed an increase in the number of recaptures, although very few of these were from the Hudson River. During October and

November, only six fish were recaptured north of the Battery, none above Kingston. October returns from outside the river were numerous around New York City, particularly in the East River and Upper New York Harbor. Distant recaptures included two from the Connecticut River and single recaptures from Newport, Rhode Island, and Revere and South Dartmouth, Massachusetts. Recaptures outside the river in November were limited to New York Harbor and adjoining waters.

The only recapture from south of Sandy Hook for the entire recapture year from this group of fish was made in December at Island Beach State Park in southern New Jersey. Other winter recaptures occurred in the lower Hudson estuary and the outflow of the power plant at Northport, New York.

4.3.1.2 Second Year Recaptures from 1985-1986 Releases

Second year tag returns with information on recapture locations, from 1985-1986 releases totaled 472; 404 (85.6%) were from outside the Hudson River and 68 (14.4%) were from within the river (Table 11).

Spring recaptures ranged as far north as the Cape Cod Canal and south to Delaware Bay, but were concentrated in the Hudson estuary region. Three striped bass were recaptured in gill nets in the ocean off Atlantic City, New Jersey. Eleven recoveries originated from the area of a power plant outflow in Northport, New York, primarily in March and early April. Late April through mid-May provided seven returns from pound nets set at Orient Point, New York. Within the river, striped bass were recaptured as far north as Rondout Creek in April and the Federal Dam at Troy by mid-May.

Most summer recaptures were from north of the New York Bight and ranged to the Annapolis River, Nova Scotia. Other recovery locations from Maine included the Androscoggin, Kennebec, Sheepscot and Saco rivers. No returns originated from south of Sandy Hook. There were a few summer recaptures from the river, mainly from tributaries or tributary mouths.

The limits of autumn recaptures were the Narraguagus River in Maine and Island Beach State Park in southern New Jersey. Recaptures from the ocean were frequent in autumn. Late autumn showed a general clustering toward, and winter, a complete restriction of recaptures to waters of the New York Harbor complex.

4.3.1.3 Fourth Year Recaptures from 1984 Releases

Two of the ten recaptures of striped bass tagged and released during 1984 were from the Hudson River - at river miles 0 and 93. The remainder ranged from Liberty Island in New York Harbor to a pair of recaptures at Cuttyhunk Island, Massachusetts. Other sites included Moriches Inlet, Long Island, Charlestown, Rhode Island, and three from western Long Island Sound.

4.3.1.4 Recaptures Unidentifiable as to Release Year

Of the nineteen tags with unidentifiable serial numbers, 16 were returned with information on recapture location. Two of these were from the Hudson River, 14 occurred outside of it. All were within the boundaries of recapture for identified tags for the 1987-1988 program year except for a single recapture from North Carolina. This fish was recaptured on 17 January 1988 approximately 1-2 miles offshore of Currituck Island, Cape Hatteras in a trawl survey and measured 678 mm TL (personal communication - Richard Bradford, US Fish & Wildlife Service). Six of the unidentified tags were recaptured by a cooperator who recorded the zip code on the tag legend instead of the serial number and then released the fish with the tags in place. It is not known how many of these six tags actually had unidentifiable serial numbers.

4.3.2 Relationship of Fish Size to Movement

The relationship between fish length and movement was examined in several ways. Because of the fewer returns from within the Hudson River (22.5% of 1987-1988 returns from 1985-1986 and 1986-1987 releases - Table 11), most of these analyses concern movement outside the river.

The proportion of recoveries by angling within the river, by length classes, of all angling recaptures was examined (Table 12). For both first year recaptures of 1986-1987 releases and second year recaptures of 1985-1986 releases, there was a clear pattern of higher proportions of recoveries within the river for shorter length classes.

Table 12.-Number and percent of angling recaptures within the Hudson River, by length class, of all angling recaptures.

Length class (mm)	1987-1988 recaptures 1985-1986 releases		1986-1987 releases	
200-299	25/132	(18.9)	55/163	(33.7)
300-399	16/97	(16.5)	43/151	(28.5)
400-499	6/52	(11.5)	6/32	(18.8)
500-599	2/43	(4.6)	0/2	(0.0)
≥600	0/15	(0.0)	1/2	(50.0)
TOTAL	49/339	(14.4)	105/350	(30.0)

The mean seasonal distances traveled from the river mouth by length class for 1987-1988 angling recaptures of 1986-1987 releases showed an increase from spring to summer for the two length classes with sufficient sample sizes, the 200-399 mm and 400-499 mm length classes (Table 13). Mean distance traveled for the 200-399 mm length class decreased in autumn to about that of the spring, while mean distance for the 400-499 mm class remained near the summer level. Summer and autumn mean distances traveled were higher for the 400-499 mm length class than for the shorter length class.

Table 13.-Mean distance in miles between the Hudson River mouth and recapture locations by length class and season for angling recaptures outside of the Hudson River during 1987-1988 of 1986-1987 releases.

Season	Mean distance (miles)					
	200-399 mm		400-499 mm		≥500 mm	
Spring 1987	16.6	(79)[1]	11.4	(8)	--	--
Summer 1987	32.1	(48)	42.6	(10)	224.0	(1)
Autumn 1987	14.5	(62)	43.6	(7)	91.0	(1)
Winter 1987-1988	14.4	(19)	--	--	--	--

[1] Sample size.

The mean seasonal distances traveled from the Battery by length class for 1986-1987 angling recaptures of 1985-1986 releases increased from spring to summer for the 200-399 mm, 400-499 mm, and ≥500 mm length classes (Table 14). These were followed by decreases in autumn for all three length classes and in winter for the first two classes. Within season mean distances tended to be higher for larger-sized fish, but not in every instance.

Table 14.-Mean distance in miles between the Hudson River mouth and recapture locations by length class and season for angling recaptures outside of the Hudson River during 1987-1988 of 1985-1986 releases.

Season	Mean distance (miles)					
	200-399 mm		400-499 mm		≥500 mm	
Spring 1987	27.7	(65)[1]	67.9	(8)	41.6	(5)
Summer 1987	48.2	(51)	151.1	(17)	97.6	(28)
Autumn 1987	34.4	(66)	34.2	(19)	82.0	(23)
Winter 1987-1988	28.0	(4)	14.0	(1)	--	--

[1] Sample size.

McLaren et al. (1981) determined the proportion of recaptures outside the Hudson River within a 31 mile (50 km) radius from the Battery for recaptures made during 1976 and 1977, and he concluded that the majority of the Hudson stock occurs within 31 miles of the river mouth. In the present study, the proportion of recaptures within 31 miles was calculated, by length class, as was the proportion from 31-123 miles (50-199 km) and ≥124 miles (≥200 km) zones (Table 15). The proportion of 1976 and 1977 recaptures within these zones by length class were determined from raw data included in TI (1979) and TI (1980). The contention of McLaren et al. (1981) that the majority of the Hudson stock is found within 31 miles of the river mouth only held true for the 200-399 mm and 400-499 mm length classes among the first year recaptures of 1986-1987 releases and the 200-399 mm length classes among the 1987-1988 and 1986-1987 recaptures from 1985-1986 releases.

Table 15.-Percent (column) and number of recaptures outside the Hudson River by length class, within 31 miles (50 km), 31-123 miles (50-199 km), and greater or equal than 124 miles (200 km) zones beyond Hudson River mouth (excluding NAI recaptures).

Recapture zone	Percent recaptures 200-399 mm		400-499 mm		≥500 mm		Total
1987-1988 (first year) recaptures of 1986-1987 releases							
<31 miles	83.0	(181)	76.9	(20)	33.3	(1)	(202)
≥31-123 miles	12.8	(28)	15.4	(4)	0.0	(0)	(32)
≥124 miles	4.1	(9)	7.7	(2)	66.7	(2)	(13)
TOTAL	100.0	(218)	100.0	(26)	100.0	(3)	(247)
1987-1988 (second year) recaptures of 1985-1986 releases							
<31 miles	65.2	(133)	44.4	(24)	27.4	(17)	(174)
≥31-123 miles	23.0	(47)	24.1	(13)	40.3	(25)	(54)
≥124 miles	11.8	(24)	31.5	(17)	32.3	(20)	(61)
TOTAL	100.0	(174)	100.0	(85)	100.0	(61)	(320)
1986-1987 (first year) recaptures of 1985-1986 releases							
<31 miles	76.2	(192)	44.6	(33)	29.0	(22)	(247)
≥31-123 miles	16.7	(42)	31.1	(23)	35.5	(27)	(92)
≥124 miles	7.1	(18)	24.3	(18)	35.5	(27)	(63)
TOTAL	100.0	(252)	100.0	(74)	100.0	(76)	(402)
First year recaptures from 1976 & 1977 releases, (TI 1979, 1980)							
<31 miles	60.0	(6)	63.2	(60)	52.6	(60)	(126)
≥31-123 miles	40.0	(4)	27.4	(26)	31.6	(36)	(66)
≥124 miles	0.0	(0)	9.5	(9)	15.8	(18)	(27)
TOTAL	100.0	(10)	100.0	(95)	100.0	(114)	(219)

Movement within the Hudson River was examined by length group for striped bass tagged off Manhattan or in the Harbor region during 1986-1987 and recaptured north of Manhattan during 1987-1988. For those fish, the mean distance from the Battery to the point of recapture was 82.2 miles (n=39) for the 200-299 mm length class, 99.8 miles (n=38) for the 300-399 mm class, and

142.5 miles (n=6) for the $\geq$400 mm class. The difference between the 200-299 mm and 300-399 mm length classes was not significant ($P<0.05$).

As in Waldman (1988), data on fish length and distance traveled was tested for correlation. There was a weak but significant correlation ($r=0.202$, $P=0.0014$) between fish length and distance traveled for 1987-1988 recaptures (excluding NAI) of 1986-1987 releases outside the Hudson River with distances calculated from the river mouth.

5.0 DISCUSSION

5.1 Recapture Rates

5.1.1 Overall

The overall recapture rate of 3.9% for first year recaptures during 1987-1988 of striped bass released from trawls was identical with the first year recapture rate during 1986-1987 (in Waldman 1988). Recapture during 1987-1988 of 502 striped bass that were tagged and released during 1985-1986, in addition to the 717 recaptured during 1986-1987 raises the overall recapture rate from 1985-1986 releases to 6.6%. This rate, together with the first year recapture rates mentioned above are on the low end of the range for Hudson River striped bass tagging studies. Although McFadden (1977) achieved only a 3.6% recapture rate during 1972-1975, McLaren et al. (1981) experienced first year recaptures of 6.5% during 1976. TI (1980) had a two year year recapture rate of 15.8% from 1978 releases and TI (1981) obtained a single year recapture rate of 11.8% from 1979 releases.

Part of the difference between the HRF and TI study recapture rates can be explained by TI's inclusion of their own recaptures and HRF's separate treatment of NAI recaptures. However, addition of the 151 NAI recaptures (NAI 1987) to the 1987-1988 recaptures of 1986-1987 releases raises the recapture rate to only 5.5%. This comparatively low recapture rate is striking in that the internal anchor tags used in the present study provide far greater relative tag retention than the anchor tags used in the TI study (Dunning et al. 1987). It appears that the combined effects of health advisories and increasingly stringent harvest regulations resulted in reduced fishing pressure on the Hudson River striped bass stock during 1986.

5.1.2 Gear and Temperature Effects

Recapture rates of striped bass released from trawls made at various water temperatures ranging between 0-14^{0}C did not vary significantly (Table 4). This was consistent with releases from trawls over a similar temperature range during 1985-1986, recaptured in 1986-1987 (Waldman 1988). The continued absence of a relationship between recapture rates and temperature at tagging and release indicates that the use of a live car as adopted by NAI (1987) and NAI (1988) permits the capture of striped bass in trawls for tagging to a water temperature of at least 14^{0}C while maintaining a low level of delayed mortality (Dunning et al. 1989).

5.1.3 Angling

Angling recapture rates by length class showed a trend toward higher rates for longer length classes for first year recaptures of 1986-1987 releases (Table 5) and second year recaptures of 1985-1986 releases (Table 6), but recapture rates differed significantly between successive length classes only for fish measuring 200-299 mm and 300-399 mm for both years. It remains unclear whether the proportionately greater catches of larger striped bass is due to targeting of larger fish by anglers or through differential migration of larger fish out of the Hudson River to regions of higher fishing pressure, as hypothesized in HRF (1985).

5.1.4 Long-Term Tag Retention

First year recaptures from 741 striped bass double-tagged in 1984 showed clearly superior relative retention for internal anchor tags (98%) vs. anchor tags (42%) (HRF 1985; Dunning et al. 1987). Cumulative recaptures since the first recapture year (Table 7) show that the difference in long-term retention between these two tag styles is even more pronounced. The relative retention rate of internal anchor tags pooled over second through fourth year recaptures was 97.1% vs. only 8.6% for anchor tags. From this, it appears that loss of internal anchor tags occurs at a very low and stable rate over the long-term, whereas anchor tags are shed, with few exceptions, within the first year following implantation.

5.1.4 Condition and Disposition of Recaptures

Because fishermen, when they made a recapture, were not aware whether they were making a first or second year recapture, 1987-1988 recaptures from 1986-1987 and 1985-1986 recaptures were treated together (Table 8). The overall percentage of fish reportedly released in good condition by fishermen of 92.7% was similar to the rate of 91.8% reported during 1986-1987 for 1985-1986 releases (Waldman 1988). The range of rates of release in good condition did not vary significantly during 1987-1988 and the range was less than during 1986-1987 when there was a significant difference between fish <600 mm and ≥600 mm. The sharp division at 600 mm was thought to reflect the 24 inch TL (610 mm) legal length minimum in New York waters in effect until early May 1986 when a total moratorium was enacted (Waldman 1988). The lower rates for both the 500-599 mm and ≥600 mm length classes in comparison with shorter length classes during 1987-1988 may be related to regulations in effect over that period. In New York, harvest of a single striped bass 18 inches TL (457 mm) or larger was permitted north of the George Washington Bridge (river mile 12) in the Hudson River. In marine waters of New York, the legal minimum for striped bass was 33 inches TL (838 mm).

5.2 Physical Effects of Tagging

5.2.1 Abrasion of Information from Tags

Internal anchor tags without protective vinyl sleeves continued to show the pattern of cumulative abrasion of information from the tag legend by the substrate observed the previous year (Waldman 1988; Mattson et al., in press). Some tags became so worn that they eventually broke along the streamer, so that only a sanded streamer stub was visible externally on the fish.

Vinyl-covered tags did not provide a higher return rate than unprotected tags. Although vinyl-covered tags prevented degradation of tag legends through cumulative abrasion, most developed a condition that lessened or negated their legibility. This condition was was the growth of a layer of what appeared to be algae between the yellow streamer and the clear vinyl covering. The algal layer particularly obscured the legend when the tag became dessicated following its removal from the fish. Legibility was further compromised by a tendency for the clear vinyl tubing to abrade and become more opaque. Abrasion was more heavily concentrated on the terminal end of the streamer in vinyl-covered tags because of their greater stiffness and reduced curvature in comparison with unprotected internal anchor tags. Many fishermen described tags in this unreadable condition as "pieces of wire" and at least one returned a fish to the water with the tag in place because of it.

5.2.2 Fish Condition at Tag Sites

There was little difference between rates of abrasion and irritation of tagging sites for internal anchor tags as reported by fishermen between the two sizes of tags used on 1986-1987 releases (Table 9) or between first year recaptures from 1986-1987 (Table 9) and 1985-1986 releases (Waldman 1988). It appears that for returns of internal anchor tags in which fishermen provide a commital response, approximately 75% report no abrasion, 20% report some abrasion, and 5% report substantial abrasion.

Tagging site condition was compared for the same group of tagged fish over two recapture years (Table 10). Abrasion rates of first and second year recaptures from 1985-1986 releases were almost identical for the two periods, suggesting that an equilibrium in the proportions of fish displaying these conditions is quickly reached. However, it is not clear how stable these conditions are. Relative loss of internal anchor tags is very low (Dunning et al. 1987), yet Mattson et al. (in press) and NAI (1987; 1988) did encounter individuals that appeared to have shed internal anchor tags or that were very likely to, given the poor condition of their tag insertion sites. Mattson et al. (in press) observed that recaptures of fish made by NAI with infected tag sites sometimes showed protrusion of the anchor of the internal anchor tag. They also believed that partial anchor protrusion is an early stage of complete protrusion and consequent tag loss. Five percent (7/134) of striped bass recaptured from previous programs by NAI during the 1987-1988 program exhibited some degree of anchor protrusion.

It would be instructive in quantifying the extent of tag loss due to a sequence of internal and external irritation, partial anchor protrusion, and tag expulsion to determine whether the sequence is unidirectional or whether some tags are retained through a build-up of scar tissue as occurs in spotted seatrout *Cynoscion nebulosus* (Vogelbein and Overstreet 1987).

5.3 STRIPED BASS MOVEMENTS

5.3.1 Distribution of Recoveries

The pattern of first year recaptures from 1986-1987 releases was consistent with first year recaptures made the previous year from 1985-1986 releases, with the exception of fewer far distant returns among the former. Again, there was a movement upriver in spring of a portion of the marked fish. Recaptures were made primarily in the lower half of the river in April, by both commercial and recreational fishermen, but by May most recaptures occurred from the sportfishery at the spillways of the Federal Dam in Troy. Returns from the Federal Dam were numerous in May and June and scarce thereafter, as were returns from the entire Hudson River. The recapture made at Lock 1, Waterford, New York is the first recapture above the Federal Dam made in this program since 1984 when a recapture was made in the lower Mohawk River (HRF 1985). Previously, Raney (1952) had reported two striped bass from the Mohawk River Barge Canal and one from Niskayuna Lake above Lock 7 in the Mohawk canal, about 140 feet above sea level. These observations suggest that passage above the Federal Dam by striped bass is a regular but minor phenomenon.

Outside the Hudson River, striped bass tagged during 1986-1987 were recaptured as far north as Massachusetts, in comparison with the previous year in which several recaptures were made in Maine and one in Nova Scotia. The great majority of recaptures from late summer through autumn occurred relatively close to New York City. Contribution of Hudson River striped bass to the population of non-native striped bass that occurs in the Connecticut River annually was again demonstrated with seven recaptures from its waters, as far north as Enfield, Connecticut, near the Massachusetts border. Migration of subadult striped bass into the Massachusetts waters of the Connecticut River occurs regularly (Kynard and Warner 1987) in the absence of a native spawning population (Merriman 1941; Marcy 1976). The Hudson River is the dominant or sole source of these fish based on analysis of mitochondrial DNA (Wirgin 1987).

There was a scarcity of returns from south of Sandy Hook, New Jersey. Only one occurred, from southern New Jersey, in December.

Second year recaptures from 1985-1986 releases were more widely dispersed than first year recaptures from 1986-1987 releases. Winter recaptures were concentrated at the outflow of the Long Island Lighting Company's power plant at Northport, New York, a location that has supported wintering aggregations of striped bass since at least winter 1975-1976 (Young 1980).

The pattern of spring returns from the Hudson River were similar to the pattern observed to other release-recapture cohorts in this program with recoveries from as far north as the central-Hudson in April and a preponderance of returns from the Troy region in May. Recoveries during spring outside the river were primarily from north and east of the river mouth, as Boreman and Lewis (1987) found, and by summer extended to as far as the Annapolis River system, Nova Scotia, the site of another recapture the previous year (Waldman 1988). As in the previous year, recaptures made in Maine were from rivers and river mouths, not from the open coast.

Although there was a higher proportion of recaptures from the Hudson River than outside of it in comparison with 1986-1987 recaptures from 1985-1986 releases (Tables 11 and 12), the difference was not significant (P>0.05). When the proportions of first year recaptures in and outside the river from 1985-1986 releases were compared with second year recaptures from those same releases (Table 11), the difference was highly significant (P<0.001). This difference is attributable to at least two factors. One is that the vast majority of striped bass tagged during 1985-1986 were tagged in the Hudson River, so that first year recaptures represented the fragmentation of a within-river tagged body of fish. Some, if not many second year recaptures of these fish may have been of individuals that were not present in the Hudson River over the winter of 1986-1987. Second, is that second year recaptures were one year older and somewhat larger than these same fish were over their first recapture year. There is a greater tendency for larger striped bass to leave the river in spring (Table 12).

The distribution of recoveries of unidentifiable tags during 1987-1988 was similar to that for identifiable tags, with one notable exception. The recapture among a large body of striped bass off Cape Hatteras in January 1988 of a striped bass tagged in this program is the first positive evidence that some Hudson River striped bass winter offshore in the Atlantic Ocean, as do larger Chesapeake Bay striped bass. The wintering aggregations of large striped bass off Cape Hatteras supported intensive commercial fisheries (Chapoton and Sykes 1961; Holland and Yelverton 1973) until the collapse of the Chesapeake striped bass stock in the late 1970's. Negative evidence that larger striped bass winter outside the Hudson River was their absence in winter samples in this tagging program and in studies by Clark (1968) and USDOT and USCOE (1984). However, both Bigelow and Schroeder (1953) and Clark (1968) cited anecdotal accounts of striped bass being taken by commercial trawlers in winter within several miles of the coast between New Jersey and Delaware. More recently, Matthiessen (1986) reported similar catches in the waters off eastern Long Island. The late autumn, winter, and early spring recaptures of Hudson River-tagged fish in this program from central and southern New Jersey may represent movement to and from southern offshore wintering grounds.

5.3.2 Relationship of Fish Size to Movement

Recaptures during 1987-1988 from 1986-1987 releases did not appear to travel as extensively outside the Hudson River as did the second year recaptures of the 1985-1986 releases. If the two tagging cohorts were treated independently, different conclusions would be reached concerning the extent of migration of Hudson

River striped bass. Whereas annual physical variations in the ocean habitat like those which are thought to influence oceanic migration of the San Francisco Bay striped bass stock (Radovich 1963) might be hypothesized to account for differences in the limits of migration of Hudson River striped bass among years, the fact that the two tagging cohorts were recaptured over the same period argues against any explanation of this kind. The most likely reason for the differences in the extent of migration between the two groups of fish is the tendency for larger striped bass to migrate farther from the river operating over the considerable difference in the number of larger fish tagged during each release year, 4115 ≥400 mm in 1985-1986 vs. only 761 ≥400 mm in 1986-1987.

Based on the results of this program, larger Hudson River striped bass are clearly more migratory than smaller ones. Larger length classes have a greater tendency to leave the Hudson River (Table 12). They also travel farther on average than do smaller striped bass. For first year recaptures of 1986-1987 releases and first and second year recaptures of 1985-1986 releases, higher proportions of longer length classes were found in most instances within the two more distant zones (Table 15).

The contention of McLaren et al. (1981) that the majority of the Hudson stock is found within 31 miles (50 km) of the river mouth only held true for some of the shorter length classes in this program (Table 15). Waldman's (1988) belief that Hudson River striped bass are currently somewhat more migratory than in earlier decades is supported by the comparisons in Table 15. More than 70% of the recaptures of striped bass ≥500 mm outside of the river during 1987-1988 and 1986-1987 from 1985-1986 releases originated from 124 miles (200 km) and beyond, in comparison with less than 50% during 1976 and 1977.

The significant positive correlation ($P<0.05$) between fish length and distance traveled from the river mouth ($r=0.536$) found for 1986-1987 recaptures of 1985-1986 releases (Waldman 1988), held true (r=0.202) for 1987-1988 recaptures of 1986-1987 releases, but less strongly. The weaker correlation is probably due to the relative paucity of larger, more highly migratory fish tagged during 1986-1987.

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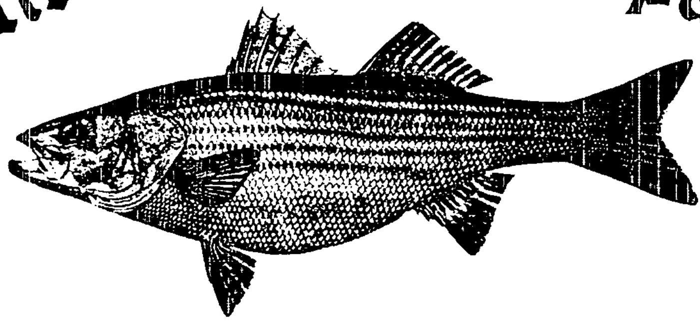
Appendix I.

Certificate of Participation



IN THE HUDSON RIVER FOUNDATION'S STRIPED BASS TAG RECOVERY PROGRAM.

AWARDED TO:

____

THE TAGGED STRIPED BASS YOU CAUGHT

AT____

ON____

WAS ORIGINALLY TAGGED

AT____

ON____

Sincerely,

PROGRAM DIRECTOR

HUDSON RIVER FOUNDATION FOR SCIENTIFIC AND ENVIRONMENTAL RESEARCH, INC.
122 EAST 42 STREET, SUITE 1901, NEW YORK, NY 10168 212-949-0028

Appendix II.

QUALITY ASSURANCE/ QUALITY CONTROL PROGRAM FOR THE HUDSON RIVER STRIPED BASS TAG RECOVERY PROGRAM

Data are entered into the Hudson River Foundation Striped Bass Tag Return Data Entry Program, developed during 1988 by Normandeau Associates, Inc. For QA/QC purposes, the program incorporates an error checking function comprised of ranges of acceptable values for each value to be entered. When a value is outside the range of acceptable values, the program asks whether the new value is correct before it accepts it into the data file. Data are keypunched from master data forms, one per return, that combine release and recapture information. The error checking function includes the following parameters:

Series: In order to quickly reference release efforts and recapture periods (March 1 to last day in February) for tag returns, each return is assigned a series number. A fish tagged and released during January 1986, the second tagging effort, and recaptured during June 1988, into the third recapture year following release would be coded as series 23. The low to high range for series is 11 to 69.

Tag Number: The range of valid tag numbers is 1 (00001) to 26000.

Release Date: The range of valid release dates is 04/13/84 to 04/22/88.

River Mile: River miles at release refer to a given station. The range of valid river miles is 1 to 76.

Release Length: Acceptable lengths at release are 195 mm to 1000 mm.

Recapture Date: Recapture dates must be no earlier than 01/01/88. When recapture information is manually copied to the master forms, the recapture date is checked to insure that it does not precede the release date.

Recapture Length: Recapture lengths, converted from inches to millimeters, should not exceed the range of lengths at release.

Recapture Gear: Acceptable recapture gear codes, from the utilities data dictionary, fall between 87 and 99.

Distance Travelled: The valid range is set at 0 to 1000 miles.

HUDSON RIVER
FOUNDATION

122 EAST 42 STREET SUITE 1901
NEW YORK, NY 10168

1988-89 HUDSON RIVER

STRIPED BASS HATCHERY EVALUATION

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Jointly financed by
Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

Submitted by

NORMANDEAU ASSOCIATES INC.
25 Nashua Road
Bedford, New Hampshire 03102

R-1250.00

January 1990

- The Program Manager for Normandeau Associates Inc. was Dr. Mark T. Mattson.

- The Program Manager for the New York Power Authority was Dr. Dennis J. Dunning.

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was 0.2% for Age 1+ fish 3.5% for Age 2+ fish, and 2.4% for Age 3+ fish among the population of striped bass caught in the lower Hudson River between 31 October 1988 and 15 April 1989.

- Mean length at Age 0+ of the 1988 hatchery cohort of striped bass was significantly larger than the mean length at Age 0+ of the 1988 wild cohort of striped bass. In previous years, mean length at Age 0+ was significantly smaller for the hatchery cohort compared to the wild cohort. This was attributed to holding the hatchery fish longer in 1988 than in previous years before stocking.

- The 1987 cohort of Age 1+ striped bass dominated the population statistics for Hudson River striped bass during the 1988-89 Hatchery Evaluation Program. The 1987 cohort represented 70% of the total catch and more than 90% of the population ≥150 mmTL.

- The estimated size of the mid-winter striped bass population ≥150 mmTL in upper New York harbor and the Battery region was 1,190,000 fish with upper and lower 95% confidence intervals of 1,021,000 - 1,427,000. Age 1+ striped bass accounted for 92% or 1,092,000 fish in the mid-winter population, Age 2+ contributed 72,000 fish, Age 3+ contributed 14,000 fish and Age >3+ contributed 12,000 fish.

- During the 1988-89 striped bass program, 25,610 fish were caught and 24,393 fish were tagged and released bringing the total number of striped bass tagged and released in these programs since 1984 to 65,351. Of the 453 fish that were recaptured, 385 were tagged and released in the present program, 48 were from 1987-88, 12 were from 1986-87, 6 were from 1985-86, and 2 fish had illegible tag numbers so release year could not be determined.

- Overall mean CPUE in the Battery region was 32.2 striped bass per ten minute tow. The catch was dominated by a strong 1987 year class of Age 1+ fish which contributed more than 70% of the total catch.

- Handling mortality was less than 1% during the 1988-89 program and was comparable to 1985-86, 1986-87 and 1987-88. No relationship between water temperature and handling mortality was observed.

1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. To address this requirement, the Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York. Fingerling striped bass produced at the hatchery have been released since 1983. The total number of hatchery striped bass that has been stocked into the Hudson River is:

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,579
1988	48,611

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program be conducted through May 1991 that includes an evaluation of mitigation measures. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery are tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally spawned striped bass. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered

CWTs. If these striped bass are tagged with an external tag and released, then their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could also be used to estimate annual survival rate of the post-juvenile stock. However, sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986). Consequently, the program focused on estimating annual survival rate for Age 1+ and Age 2+.

The April-June 1984 Adult Striped Bass Program (NAI 1985) demonstrated that it was feasible to use a 12 m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. It was also demonstrated in 1984 that striped bass could be externally tagged and released without significantly increasing the 24-hour mortality (Dunning *et al.* 1987). Finally, the 1984 program suggested those river sections in the lower Hudson River estuary that could be most efficiently fished for striped bass with each gear.

The 1985-86 Hudson River Striped Bass Program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced the highest catch of striped bass per tow. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit of effort for a 12 m trawl was greater than for a 9 m trawl, but mean catch per day was almost identical for the two trawls because more tows could be taken using the 9 m trawl in a day. The 12 m trawl was more efficient for capturing striped bass in a size range from 300-450 mm total length (TL), while the 9 m trawl was more efficient for capturing striped bass <250 mmTL. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mmTL. A total of 18,487 striped bass ≥200 mmTL were captured in trawls and seines, tagged and released. A total of 250 striped bass released during the 1985-86 program were recaptured. Two tagged fish from the 1984 program were also recaptured. However, no striped bass of any age containing CWT were detected although all fish were checked for these tags. Based on the recapture of tagged fish released during late December 1985 through February 1986, the estimated size of the mid-winter striped bass population in upper New York Harbor and the Battery region was approximately 540,000 fish ≥200 mmTL.

Data from the 1984 and 1985-86 field programs (NAI 1985, 1986) were also used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration. These options were selected because they satisfied underlying statistical assumptions and the required sampling effort for their implementation was feasible. They included:

1) sampling yearling striped bass in the mouth of the river in winter,

2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and

3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring.

The 1986-87 Hudson River Striped Bass Hatchery Evaluation was conducted in the Croton-Haverstraw, Tappan Zee, Upper Harbor, and Battery regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catch per ten minute tow for both the 9 and 12 m trawls. Use of a cod end liner (2.5 cm stretch mesh) in the 9 m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of the cod end liner in the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning *et al.* 1989). Stratified sampling to select scales for age analysis was extremely precise for estimating the proportion of Age 0+, 1+ and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.5%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mmTL.

The 1987-88 Hudson River Striped Bass Hatchery Evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River. The Battery region received most of the fishing effort (98%) and exhibited the highest catch per ten minute tow for both the 9 m trawl and 12 m trawl with a 9 m trawl cod end. The catch was dominated by the strong 1987 year class of Age 0+ fish which contributed more than one half of the catch. The 9 m trawl was more efficient than the 12 m trawl with a 9 m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning *et al.* 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6%. The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mmTL.

The 1988-89 Hudson River Striped Bass Hatchery Evaluation Program was similar to the 1986-87 and 1987-88 program and was conducted to address the following objectives:

1) determine if hatchery striped bass, stocked during any year between 1983 and 1987, can be detected in the Hudson River population as Age 1+ or older fish,

2) estimate the proportion of Age 1+ through 4+ Hudson River striped bass composed of hatchery fish,

3) tag all striped bass greater than or equal to 150 mmTL, that are in good condition, with internal anchor tags,

4) determine catch rate and handling mortality of striped bass during 1988-89, and

5) estimate the abundance of striped bass overwintering in the lower Hudson River.

Con Edison Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, N.Y. 10003

November 1, 1989

Dr. Dennis Dunning
New York Power Authority
123 Main Street
White Plains, New York 10601

Dear Dennis:

The enclosed pages outline a procedure to calculate mean length by age and its approximate variance. The procedure is based on Cochran's 1977 *Sampling Techniques*, specifically equations 12.1 and 12.24. I consider the variance to be approximate because of several simplifying assumptions I made. The effect of the assumptions should be minor, but the error would be to make the estimated variance slightly larger than it would have been otherwise. I wouldn't characterize this procedure as the best that could be achieved, but it is certainly closer to the true variance than the methods NAI has been using.

Although I haven't checked all the calculations completely, John Hamilton and I have estimated the stratified means and variances for the 1986-1987 striped bass data based on 10 mm length intervals. The means for ages 0+, 1+, and 2+ are all within 2mm of the means NAI calculated. The within stratum component of the variance appears to be similar in magnitude to NAI's variance. The among stratum component is substantially larger, as would be expected. The total variance would give 95% CI half-widths of 3 mm, 2.5 mm, and 2.7 mm for the three age groups.

I suggest that NAI use these procedures to recalculate the length statistics for the report. (Procedures, SAS code, and output for 1986-1987 data are enclosed.) The w_h values estimate the proportion of the age group within length class h, and therefore represent length frequency estimates. NAI's weighting factor (N_{hi}/N_i) must be identical, or nearly identical, to w_h, or the stratified means would not have been so close.

It would probably be worthwhile to have Doug review the methods, but I think simulation and further analytical work may not be necessary, at least for the present.

Sincerely,

John Young

John Young

cc: W. Kirk
M. Mattson
D. Heimbuch

JRY 10/31/89

Methods for Mean Length

Mean length at age, and its variance, are estimated from Cochran (1977) equations 12.1 and 12.24.

$$\bar{y}_{st} = \sum_{h=1}^{L} w_h \bar{y}_h \qquad (12.1)$$

$$v(\bar{y}_{st}) = \underbrace{\sum_{h}^{L} w_h s_h^2 \left(\frac{1}{n' \nu_h} - \frac{1}{N}\right)}_{\text{within strata variance}} + \underbrace{\frac{g'}{n'} \sum_{h}^{L} w_h \left(\bar{y}_h - \bar{y}_{st}\right)^2}_{\text{among strata variance}} \qquad (12.24)$$

where N = population size
w_h = estimate of fraction of population in stratum h
n' = total sample size used to determine w_h's
$\bar{y}_h$ = mean length within stratum h
$\bar{y}_{st}$ = estimate of mean length
ν_h = fraction of stratum h that are measured in subsample
$g' = (N-n')/(N-1)$
s_h^2 = sample variance of length within stratum h

In applying these equations, each age class will be treated separately, and we will make the following assumptions:

1) N is large
2) $N \gg n'$

Therefore $\frac{1}{N} \sim 0$ and $g' \sim 1$.

Equation 12.24 can then be simplified and terms redefined in context of the present problem.

$$v(\bar{y}_{st}) = \sum_{h}^{L} \frac{w_h s_h^2}{n' \nu_h} + \frac{1}{n'} \sum_{h}^{L} w_h \left(\bar{y}_h - \bar{y}_{st}\right)^2$$

w_h = proportion of the age class in stratum h
s_h^2 = variance of length of the age class within stratum h
$(n' \nu_h)$ = number of the age class measured within stratum h
n' = total number of the age class that were aged
$\bar{y}_h$ = mean length of the age class within stratum h
$\bar{y}_{st}$ = stratified estimate of mean length for the age class

This formula will give larger estimates of variance than the previous method because 1) the previous method estimated only the within strata component, and 2) no finite population corrections are used since our inference is to a large unknown population size.

Application of the simplified version of 12.24 would be relatively simple if subsampling for aging were done randomly. In that case, the w_h would be estimated directly as the fraction of the proper age fish that were in stratum h.

However, the Neyman allocation of the aging sample forces us to use an indirect method to estimate the w_h's. Bayes Theorum is required.

Let L denote length class and A denote age.

$$P(L_h|A) = \frac{P(L_h)\cdot P(A|L_h)}{P(A)}$$ Bayes' Theorum

where $P(L_h|A) = w_h$ for age A

$P(L_h)$ = probability that a random fish will be in stratum
= fraction of total catch in length class h

$P(A|L_h)$ = probability that a fish in length class h is age A
= fraction of aged fish in length class h that are age A

$P(A)$ = probability that a random fish is age A
= fraction of population that is age A

$P(L_h)$ is estimated from the total catch; $P(A|L_h)$ is estimated from the aging subsample; $P(A)$ is already estimated for age composition.

1986-1987 STRIPED BASS DATA
STRATIFIED MEAN LENGTH AND VARIANCE

OBS	AGE	_TYPE_	_FREQ_	VWITHIN	VAMONG	STRVAR	STRMEAN
1	0	0	14	0.51939	1.73928	2.25867	125.094
2	1	0	22	0.21173	1.37046	1.58220	223.058
3	2	0	30	0.16406	1.63460	1.79866	304.696
4	3	0	25	0.62778	6.73681	7.36459	372.053

VWITHIN: VARIANCE WITHIN STRATA

VAMONG: VARIANCE AMONG STRATA

STRVAR: TOTAL VARIANCE OF THE MEAN

STRMEAN: STRATIFIED MEAN

STRATIFIED MEAN LENGTH AND VARIANCE

FINAL DATA SET

OBS	LENCLAS	AGE	MEANLEN	VAR	N_AL	N_A	PR_A_L	N_L	PR_L	PR_A	WH	WTLEN	STMEAN	SUMN_AL	VWITHIN	VAMONG	VARST
1	6	0	68.000	8.3333	1	1	1.00000	7	0.000495	0.219	0.00226	0.1537	125.094	217	0.01884	0.03396	0.05281
2	7	0	71.000	8.3333	1	1	1.00000	39	0.002759	0.219	0.01260	0.8944	125.094	217	0.10497	0.16987	0.27484
3	8	0	87.000	2.0000	2	2	1.00000	111	0.007852	0.219	0.03585	3.1192	125.094	217	0.03585	0.23976	0.27562
4	9	0	95.250	4.2143	8	8	1.00000	183	0.012945	0.219	0.05911	5.6301	125.094	217	0.03114	0.24261	0.27375
5	10	0	103.375	7.1250	8	8	1.00000	266	0.018816	0.219	0.08592	8.8817	125.094	217	0.07652	0.18677	0.26329
6	11	0	114.222	9.2418	18	18	1.00000	466	0.032963	0.219	0.15052	17.1923	125.094	217	0.07728	0.08199	0.15927
7	12	0	123.947	6.8304	19	19	1.00000	562	0.039754	0.219	0.18152	22.4995	125.094	217	0.06526	0.00110	0.06636
8	13	0	134.980	8.4787	49	49	1.00000	726	0.051355	0.219	0.23450	31.6522	125.094	217	0.04058	0.10560	0.14617
9	14	0	144.123	6.7525	57	58	0.98276	525	0.037137	0.219	0.16665	24.0180	125.094	217	0.01974	0.27807	0.29781
10	15	0	153.053	8.5917	38	44	0.86364	185	0.013086	0.219	0.05161	7.8985	125.094	217	0.01167	0.18589	0.19756
11	16	0	162.556	3.5278	9	31	0.29032	86	0.006083	0.219	0.00806	1.3109	125.094	217	0.00316	0.05215	0.05531
12	17	0	175.500	0.5000	2	34	0.05882	146	0.010328	0.219	0.00277	0.4868	125.094	217	0.00069	0.03248	0.03317
13	18	0	184.750	14.2500	4	67	0.05970	291	0.020584	0.219	0.00561	1.0367	125.094	217	0.01999	0.09203	0.11202
14	19	0	195.000	8.3333	1	93	0.01075	473	0.033458	0.219	0.00164	0.3203	125.094	217	0.01369	0.03699	0.05068
15	14	1	143.000	8.3333	1	58	0.01724	525	0.037137	0.262	0.00244	0.3495	223.058	891	0.02037	0.01758	0.03794
16	15	1	153.000	6.4000	6	44	0.13636	185	0.013086	0.262	0.00681	1.0421	223.058	891	0.00727	0.03752	0.04478
17	16	1	166.000	8.7619	22	31	0.70968	86	0.006083	0.262	0.01648	2.7353	223.058	891	0.00656	0.06021	0.06677
18	17	1	175.452	8.3892	31	34	0.91176	146	0.010328	0.262	0.03594	6.3057	223.058	891	0.00973	0.09142	0.10114
19	18	1	185.033	8.2322	61	67	0.91045	291	0.020584	0.262	0.07153	13.2354	223.058	891	0.00965	0.11608	0.12573
20	19	1	194.674	8.2449	89	93	0.95699	473	0.033458	0.262	0.12221	23.7913	223.058	891	0.01132	0.11050	0.12182
21	20	1	204.621	8.0462	116	126	0.92063	521	0.036854	0.262	0.12950	26.4982	223.058	891	0.00898	0.04940	0.05839
22	21	1	214.644	7.6041	87	103	0.84466	511	0.036146	0.262	0.11653	25.0128	223.058	891	0.01019	0.00926	0.01944
23	22	1	224.396	7.8778	111	136	0.81618	468	0.033105	0.262	0.10313	23.1413	223.058	891	0.00732	0.00021	0.00753
24	23	1	234.194	8.9404	93	125	0.74400	489	0.034590	0.262	0.09823	23.0037	223.058	891	0.00944	0.01367	0.02311
25	24	1	243.843	8.4752	83	138	0.60145	483	0.034166	0.262	0.07843	19.1249	223.058	891	0.00801	0.03803	0.04604
26	25	1	254.197	9.4177	71	166	0.42771	588	0.041593	0.262	0.06790	17.2600	223.058	891	0.00901	0.07390	0.08290
27	26	1	263.758	11.5644	33	144	0.22917	595	0.042088	0.262	0.03681	9.7099	223.058	891	0.01290	0.06844	0.08134
28	27	1	274.200	6.0632	20	148	0.13514	661	0.046757	0.262	0.02412	6.6127	223.058	891	0.00731	0.07079	0.07811
29	28	1	283.700	7.3897	30	158	0.18987	633	0.044776	0.262	0.03245	9.2060	223.058	891	0.00799	0.13393	0.14193
30	29	1	294.083	10.2652	12	134	0.08955	621	0.043927	0.262	0.01501	4.4155	223.058	891	0.01284	0.08501	0.09785
31	30	1	305.833	5.7667	6	101	0.05941	607	0.042937	0.262	0.00974	2.9775	223.058	891	0.00936	0.07487	0.08422
32	31	1	314.500	10.8571	8	102	0.07843	546	0.038622	0.262	0.01156	3.6362	223.058	891	0.01569	0.10850	0.12419
33	32	1	322.500	3.6667	4	87	0.04598	507	0.035863	0.262	0.00629	2.0296	223.058	891	0.00577	0.06985	0.07562
34	33	1	332.000	3.3333	4	80	0.05000	413	0.029214	0.262	0.00558	1.8510	223.058	891	0.00465	0.07426	0.07891
35	35	1	357.000	8.3333	1	73	0.01370	313	0.022140	0.262	0.00116	0.4133	223.058	891	0.00965	0.02331	0.03296
36	36	1	365.000	8.0000	2	86	0.02326	308	0.021787	0.262	0.00193	0.7059	223.058	891	0.00774	0.04373	0.05146
37	17	2	177.000	8.3333	1	34	0.02941	146	0.010328	0.402	0.00076	0.1337	304.696	1303	0.00630	0.00946	0.01575
38	18	2	187.000	2.0000	2	67	0.02985	291	0.020584	0.402	0.00153	0.2858	304.696	1303	0.00153	0.01625	0.01778
39	19	2	196.333	2.3333	3	93	0.03226	473	0.033458	0.402	0.00268	0.5271	304.696	1303	0.00209	0.02420	0.02628
40	20	2	204.900	8.3222	10	126	0.07937	521	0.036854	0.402	0.00728	1.4908	304.696	1303	0.00606	0.05561	0.06167
41	21	2	215.125	11.8500	16	103	0.15534	511	0.036146	0.402	0.01397	3.0048	304.696	1303	0.01034	0.08600	0.09635
42	22	2	225.080	7.4933	25	136	0.18382	468	0.033105	0.402	0.01514	3.4072	304.696	1303	0.00454	0.07364	0.07818
43	23	2	234.875	8.6935	32	125	0.25600	489	0.034590	0.402	0.02203	5.1737	304.696	1303	0.00598	0.08241	0.08840
44	24	2	245.019	9.4525	54	138	0.39130	483	0.034166	0.402	0.03326	8.1485	304.696	1303	0.00582	0.09090	0.09672
45	25	2	254.703	7.8110	91	166	0.54819	588	0.041593	0.402	0.05672	14.4465	304.696	1303	0.00487	0.10879	0.11366
46	26	2	264.509	7.6651	110	144	0.76389	595	0.042088	0.402	0.07998	21.1546	304.696	1303	0.00557	0.09913	0.10470
47	27	2	274.540	8.8424	126	148	0.85135	661	0.046757	0.402	0.09902	27.1852	304.696	1303	0.00695	0.06911	0.07606
48	28	2	284.232	7.2925	125	158	0.79114	633	0.044776	0.402	0.08812	25.0465	304.696	1303	0.00514	0.02832	0.03346
49	29	2	294.724	9.2972	116	134	0.86567	621	0.043927	0.402	0.09459	27.8790	304.696	1303	0.00758	0.00722	0.01480
50	30	2	304.407	7.4677	86	101	0.85149	607	0.042937	0.402	0.09095	27.6845	304.696	1303	0.00790	0.00001	0.00790
51	31	2	314.314	9.1356	86	102	0.84314	546	0.038622	0.402	0.08100	25.4608	304.696	1303	0.00860	0.00575	0.01436
52	32	2	324.353	9.0079	68	87	0.78161	507	0.035863	0.402	0.06973	22.6169	304.696	1303	0.00924	0.02068	0.02991
53	33	2	333.923	7.1704	52	80	0.65000	413	0.029214	0.402	0.04724	15.7734	304.696	1303	0.00651	0.03097	0.03748
54	34	2	344.551	5.7109	49	80	0.61250	361	0.025536	0.402	0.03891	13.4055	304.696	1303	0.00453	0.04743	0.05196

STRATIFIED MEAN LENGTH AND VARIANCE
FINAL DATA SET

OBS	LENCLAS	AGE	MEANLEN	VAR	N_AL	N_A	PR_A_L	N_L	PR_L	PR_A	WH	WTLEN	STMEAN	SUMN_AL	VWITHIN	VAMONG	VARST
55	35	2	353.822	10.1495	45	73	0.61644	313	0.022140	0.402	0.03395	12.0126	304.696	1303	0.00766	0.06288	0.07054
56	36	2	363.750	6.1489	48	86	0.55814	308	0.021787	0.402	0.03025	11.0031	304.696	1303	0.00387	0.08096	0.08483
57	37	2	374.234	7.9223	47	71	0.66197	247	0.017472	0.402	0.02877	10.7670	304.696	1303	0.00485	0.10677	0.11162
58	38	2	383.886	8.2807	35	58	0.60345	219	0.015491	0.402	0.02325	8.9269	304.696	1303	0.00550	0.11192	0.11742
59	39	2	393.600	10.0421	20	47	0.42553	202	0.014289	0.402	0.01513	5.9533	304.696	1303	0.00759	0.09175	0.09934
60	40	2	404.875	5.7663	24	49	0.48980	168	0.011884	0.402	0.01448	5.8622	304.696	1303	0.00348	0.11152	0.11500
61	41	2	415.000	6.0000	12	42	0.28571	117	0.008276	0.402	0.00588	2.4411	304.696	1303	0.00294	0.05492	0.05787
62	42	2	421.667	1.8667	6	27	0.22222	92	0.006508	0.402	0.00360	1.5169	304.696	1303	0.00112	0.03777	0.03889
63	43	2	435.667	10.2667	6	29	0.20690	77	0.005447	0.402	0.00280	1.2213	304.696	1303	0.00480	0.03690	0.04170
64	44	2	442.500	4.5000	2	13	0.15385	49	0.003466	0.402	0.00133	0.5870	304.696	1303	0.00298	0.01933	0.02232
65	45	2	453.000	12.6667	4	15	0.26667	46	0.003254	0.402	0.00216	0.9778	304.696	1303	0.00684	0.03643	0.04327
66	47	2	472.500	4.5000	2	8	0.25000	29	0.002051	0.402	0.00128	0.6028	304.696	1303	0.00287	0.02757	0.03044
67	24	3	245.000	8.3333	1	138	0.00725	483	0.034166	0.092	0.00269	0.6593	372.053	324	0.02243	0.13407	0.15650
68	25	3	254.500	0.3333	4	166	0.02410	588	0.041593	0.092	0.01089	2.7725	372.053	324	0.00091	0.46463	0.46553
69	26	3	269.000	8.3333	1	144	0.00694	595	0.042088	0.092	0.00318	0.8546	372.053	324	0.02647	0.10413	0.13061
70	27	3	273.000	2.0000	2	148	0.01351	661	0.046757	0.092	0.00687	1.8749	372.053	324	0.00687	0.20798	0.21484
71	28	3	283.667	4.3333	3	158	0.01899	633	0.044776	0.092	0.00924	2.6214	372.053	324	0.01335	0.22282	0.23616
72	29	3	295.333	9.0667	6	134	0.04478	621	0.043927	0.092	0.02138	6.3140	372.053	324	0.03231	0.38838	0.42069
73	30	3	304.889	7.1111	9	101	0.08911	607	0.042937	0.092	0.04159	12.6796	372.053	324	0.03286	0.57902	0.61188
74	31	3	315.625	3.4107	8	102	0.07843	546	0.038622	0.092	0.03293	10.3922	372.053	324	0.01404	0.32358	0.33761
75	32	3	324.267	7.9238	15	87	0.17241	507	0.035863	0.092	0.06721	21.7940	372.053	324	0.03550	0.47369	0.50919
76	33	3	334.348	6.6008	23	80	0.28750	413	0.029214	0.092	0.09129	30.5240	372.053	324	0.02620	0.40058	0.42678
77	34	3	345.067	8.2023	30	80	0.37500	361	0.025536	0.092	0.10409	35.9167	372.053	324	0.02846	0.23395	0.26241
78	35	3	354.692	8.7815	26	73	0.35616	313	0.022140	0.092	0.08571	30.4020	372.053	324	0.02895	0.07973	0.10868
79	36	3	364.719	8.2087	32	86	0.37209	308	0.021787	0.092	0.08812	32.1377	372.053	324	0.02260	0.01463	0.03723
80	37	3	375.227	6.5649	22	71	0.30986	247	0.017472	0.092	0.05885	22.0806	372.053	324	0.01756	0.00183	0.01939
81	38	3	384.550	6.6816	20	58	0.34483	219	0.015491	0.092	0.05806	22.3282	372.053	324	0.01940	0.02799	0.04739
82	39	3	394.560	7.4233	25	47	0.53191	202	0.014289	0.092	0.08261	32.5958	372.053	324	0.02453	0.12917	0.15370
83	40	3	404.083	8.3406	24	49	0.48980	168	0.011884	0.092	0.06327	25.5653	372.053	324	0.02199	0.20034	0.22233
84	41	3	414.542	4.9547	24	42	0.57143	117	0.008276	0.092	0.05140	21.3094	372.053	324	0.01061	0.28642	0.29704
85	42	3	424.471	9.0147	17	27	0.62963	92	0.006508	0.092	0.04454	18.9049	372.053	324	0.02362	0.37770	0.40131
86	43	3	433.385	9.4231	13	29	0.44828	77	0.005447	0.092	0.02654	11.5018	372.053	324	0.01924	0.30812	0.32736
87	44	3	444.857	6.1429	7	13	0.53846	49	0.003466	0.092	0.02029	9.0246	372.053	324	0.01780	0.33188	0.34968
88	45	3	454.500	5.9000	6	15	0.40000	46	0.003254	0.092	0.01415	6.4299	372.053	324	0.01391	0.29681	0.31072
89	46	3	467.000	8.3333	1	2	0.50000	33	0.002334	0.092	0.01269	5.9246	372.053	324	0.10572	0.35299	0.45871
90	47	3	472.250	10.9167	4	8	0.50000	29	0.002051	0.092	0.01115	5.2650	372.053	324	0.03043	0.34545	0.37588
91	56	3	567.000	8.3333	1	2	0.50000	10	0.000707	0.092	0.00384	2.1798	372.053	324	0.03204	0.45094	0.48297

AGE MAP

2173 for random age sample

324
1303
891
217
2735

/

```
OPTIONS LS=132 PS=60 ;
 libname out 'c:\JRY' ;

*    PROGRAM TO CALCULATE MEAN LENGTH AT AGE AND VARIANCE
     FOR STRIPED BASS HATCHERY EVALUATION PROGRAM

     J. YOUNG AND J. HAMILTON  10/31/89 ;


DATA ALL;
    SET OUT.GFSHLV6;
    LENCLAS = INT(LENGTH/10);
RUN;


*   SUBSET LEVEL6 DATA TO GET AGED FISH;
DATA AGED;
    SET ALL;
        IF AGE NE .;
RUN;

PROC SORT DATA=AGED ;
 BY LENCLAS AGE ;

*   CALCULATE LENGTHCLASS-AGE TOTALS, MEAN LENGTH, AND VARIANCE ;
PROC MEANS DATA=AGED N NOPRINT MEAN VAR;
 BY LENCLAS AGE ;
 VAR LENGTH ;
 OUTPUT OUT=NLA N=N_LA MEAN=MEANLEN VAR=VAR;
 RUN;


*  CALCULATE TOTAL NUMBER AGED BY LENGTH CLASS;
PROC MEANS DATA=AGED N NOPRINT ;
 BY LENCLAS  ;
 VAR SAMPLE ;
 OUTPUT OUT=NL N=N_L ;
 RUN;

*  CALCULATE Pr(Age|Length)  ;
DATA RESULT ;
 MERGE NLA (IN=A) NL (IN=B) ;
 BY LENCLAS ;
 IF A AND B ;
  PRACONL=(N_LA/N_L) ;
RUN ;


 PROC PRINT DATA=RESULT ;
   BY LENCLAS ;
   sumby lenclas ;
   sum PRACONL N_LA ;
   ID LENCLAS ;
 RUN;

*  ESTIMATE Pr(Length) FROM ALL DATA;
data all (keep=sample lenclas age);
 set all ;
 run ;
PROC SORT DATA=all ;
 BY LENCLAS  ;

PROC MEANS DATA=All N noPRINT ;
 BY LENCLAS  ;
```

2

```
 VAR SAMPLE ;
 OUTPUT OUT=all_nlc N=n_l ;
 RUN;

PROC MEANS DATA=all N NOPRINT ;
 VAR SAMPLE ;
 OUTPUT OUT=all_n N=tot_n ;
 RUN;

DATA all_res ;
 set all_nlc ;
 if _n_=1 then set all_n ;
 retain tot_n ;
  PR_L=(n_l/tot_n) ;
RUN ;


 PROC PRINT DATA=all_res ;
   BY LENCLAS ;
   ID LENCLAS ;
 RUN;


  *  ENTER Pr(Age) DATA FROM EXISTING AGE COMPOSITION ;
   *            FROM 1986-1987 DRAFT REPORT;
  DATA PRAGE;
      INPUT AGE PR_A;
   CARDS;
   0  0.219
   1  0.262
   2  0.402
   3  0.092
   4  0.0010
   5  0.0006
   6  0.0005
   7  0.0003
   8  0.0001
 ;

 *  GET Pr(Length) DATA FROM LENGTH COMPOSITION OF ENTIRE CATCH ;
  data PRL ;
  SET  all_res;
  KEEP LENCLAS N_L PR_L;
  run;

  *  GET Pr(Age|Length) DATA FROM AGED SUBSAMPLE  ;
  data PRACONL ;
  SET RESULT ;
      N_AL = N_LA;
      N_A  = N_L ;
      PR_A_L = PRACONL;
  KEEP LENCLAS AGE N_AL N_A PR_A_L MEANLEN VAR;
  run;


  * SORT AND MERGE DATA SETS  ;

  PROC SORT DATA= PRACONL;
        BY LENCLAS;
RUN;

  PROC SORT DATA= PRL;
        BY LENCLAS;
RUN;

 DATA PRAL;
```

```
    MERGE PRALONL PRL;
       BY LENCLAS;
RUN;

 PROC SORT DATA=PRAL;
    BY AGE;
RUN;

 PROC SORT DATA=PRAGE;
    BY AGE;
RUN;

DATA FINAL;
     MERGE PRAL PRAGE;
       BY AGE;
        IF AGE NE .;
        IF AGE LE 3;

        wh = PR_L * PR_A_L / PR_A;
        WTLEN = wh * MEANLEN;
RUN;

*   PLOT LENGTH FREQUENCY BY AGE  ;
PROC PLOT DATA=FINAL ;
    PLOT wh * LENCLAS = AGE ;
  TITLE1 '1986-1987 STRIPED BASS DATA';
  TITLE2 'LENGTH FREQUENCY';
RUN;

*   CALCULATE WEIGHTED MEAN LENGTH BY AGE;
PROC MEANS DATA=FINAL NOPRINT SUM;
  BY AGE;
      VAR WTLEN N_AL;
    OUTPUT OUT=WTMEAN SUM=STMEAN SUMN_AL;
RUN;

*********;
*   CALCULATE VARIANCE OF ESTIMATED MEAN LENGTH;
DATA FINAL;
   MERGE FINAL WTMEAN;
      BY AGE;
*  ADD WITHIN STRATA VARIANCE FOR CLASSES WITH ONLY ONE OBSERVATION;
*    ASSUMES UNIFORM DISTRIBUTION WITHIN 10mm LENGTH CLASS;
     IF VAR = . THEN VAR = 100/12;

     VWITHIN = wh*VAR/N_AL ;
     VAMONG  = (wh * (MEANLEN - STMEAN)**2)/SUMN_AL;
     VARST = VWITHIN + VAMONG;
    DROP _TYPE_   _FREQ_;
RUN;

PROC MEANS DATA=FINAL SUM MAX NOPRINT;
      BY AGE;
         VAR VWITHIN VAMONG VARST STMEAN;
  OUTPUT OUT=STATS SUM=VWITHIN VAMONG STRVAR  D1 MAX=D2 D3 D4 STRMEAN;
RUN;

DATA STATS;
    SET STATS;
       DROP D1 D2 D3 D4;
RUN;

PROC PRINT DATA=STATS;
  TITLE2 '  STRATIFIED MEAN LENGTH AND VARIANCE';
RUN;
```

```
PROC SORT DATA=FINAL;
   BY AGE LENCLAS;
RUN;

PROC PRINT DATA=FINAL;
   TITLE3 'FINAL DATA SET';
RUN;
```

October 30, 1989

Dr. Dennis Dunning
New York Power Authority
123 Main Street
White Plains, New York 10601

Dear Dennis:

I'm absolutely astounded at NAI's section on identification of hatchery fish through scale analysis. The section is so naive, and wrong, that it's difficult to provide many rational comments. The paragraph proposing that estimates of hatchery proportions would be more accurate without CWTs would be laughable if it wasn't in one of our reports.

If NAI had done any analysis of the data at all, they could not possibly have come to the conclusions they did. (Table 3-17 does not constitute data analysis.) The enclosed table and figures demonstrate that scale analysis alone would produce estimates of hatchery proportion that would be many times higher than the true proportion. (This is the type of analysis I expected NAI could have thought up on their own.)

I will provide comments on the rest of the report later; however, I have given further thought to the stratified estimate problems. I am doubtful that will be necessary to spend $20K to have CES do simulation and derive analytical variance estimates. I may be able to provide a way to get reasonable variance estimates in a couple days. Please call if you have any questions about my comments or analysis.

Sincerely,

John Young

cc: W. Kirk

Con Edison Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, N.Y. 10003

FACSIMILE TRANSMISSION
FAX 212-982-8194

COVER SHEET

FROM: JOHN YOUNG
CON EDISON

TO: MARK MATTSON
NAI

FAX NO. (   ) -

TOTAL NUMBER OF PAGES INCLUDING COVER SHEET 6

NAIHTWLD.WK1

Age 0+

Estimated Probabilities

A	classified		true			
true	Hat	Wild	Total	Pr(H;H)	0.825	= 99/120
Hat	99	19	120	Pr(H;W)	0.267	= 16/60
Wild	16	43	60	Pr(W;W)	0.717	= 43/60
Total	115	62		Pr(W;H)	0.158	= 19/120

B	classified				
true	Hat	Wild	Total	Pr(H;H)	0.825
Hat	99	13	120	Pr(H;W)	0.267
Wild	16	52	60	Pr(W;W)	0.867
Total	115	65		Pr(W;H)	0.108

should total ≤ 60

C	classified				
true	Hat	Wild	Total	Pr(H;H)	0.875
Hat	105	6	120	Pr(H;W)	0.183
Wild	11	57	60	Pr(W;W)	0.950
Total	116	63		Pr(W;H)	0.050

Age 1+

A	classified		true		
true	Hat	Wild	Total	Pr(H;H)	0.744
Hat	29	10	39	Pr(H;W)	0.042
Wild	9	203	214	Pr(W;W)	0.949
Total	38	213		Pr(W;H)	0.256 ?

✓

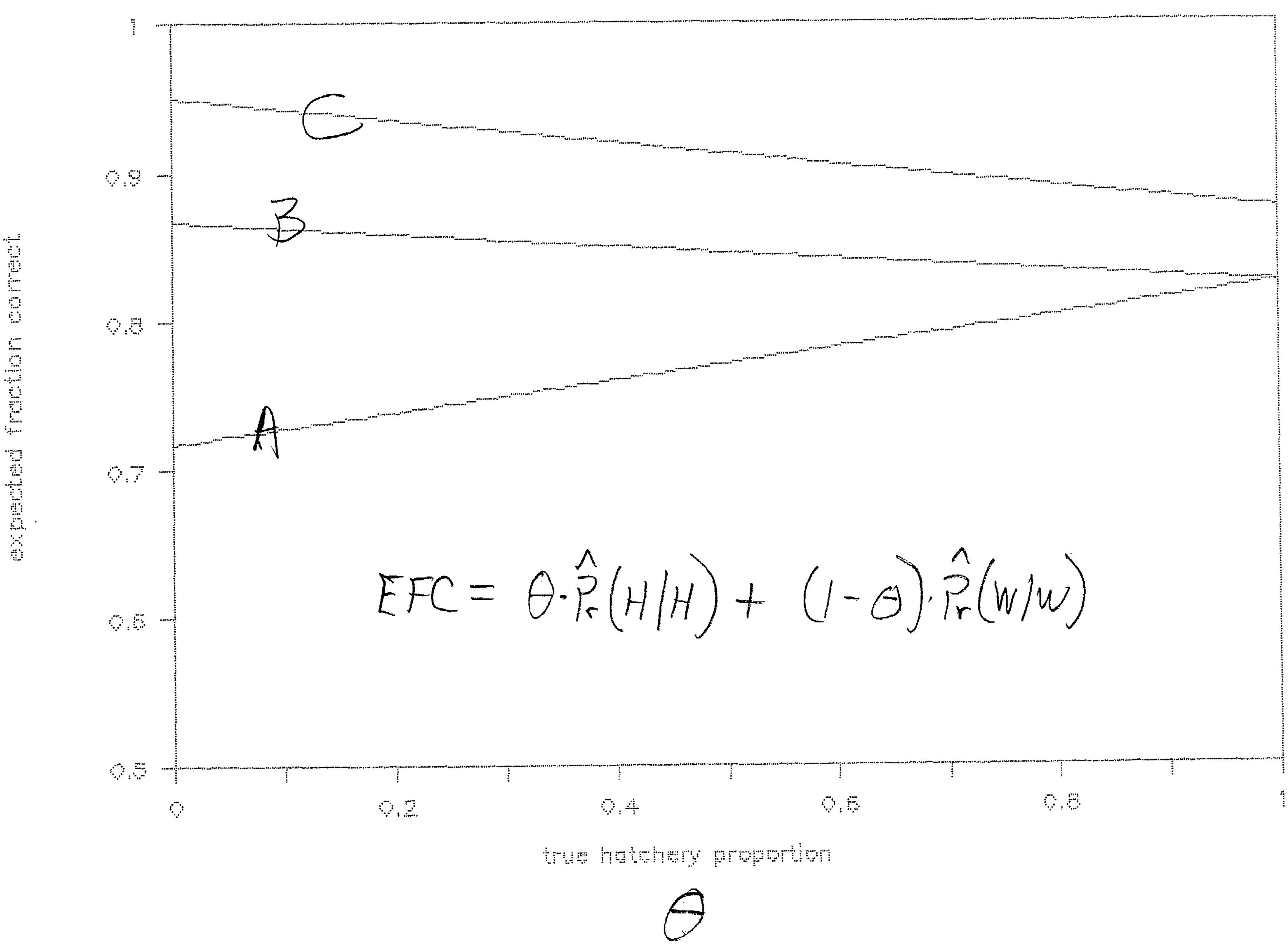
B	classified				
true	Hat	Wild	Total	Pr(H;H)	0.641
Hat	25	11	39	Pr(H;W)	0.070
Wild	15	201	214	Pr(W;W)	0.939
Total	40	212		Pr(W;H)	0.282

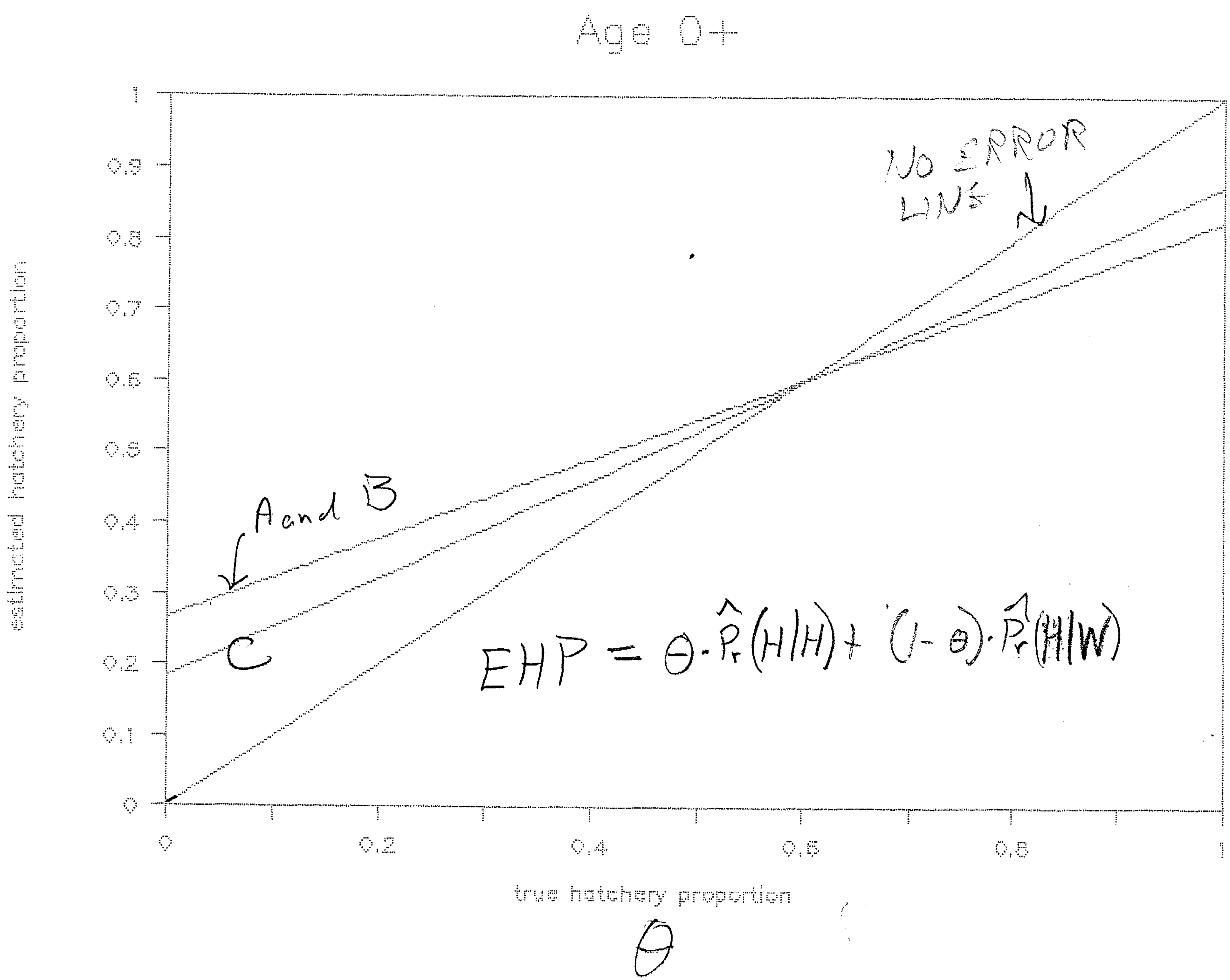
should total ≤ 214

C	classified				
true	Hat	Wild	Total	Pr(H;H)	0.769
Hat	30	3	39	Pr(H;W)	0.037
Wild	8	212	214	Pr(W;W)	0.991
Total	38	215		Pr(W;H)	0.077

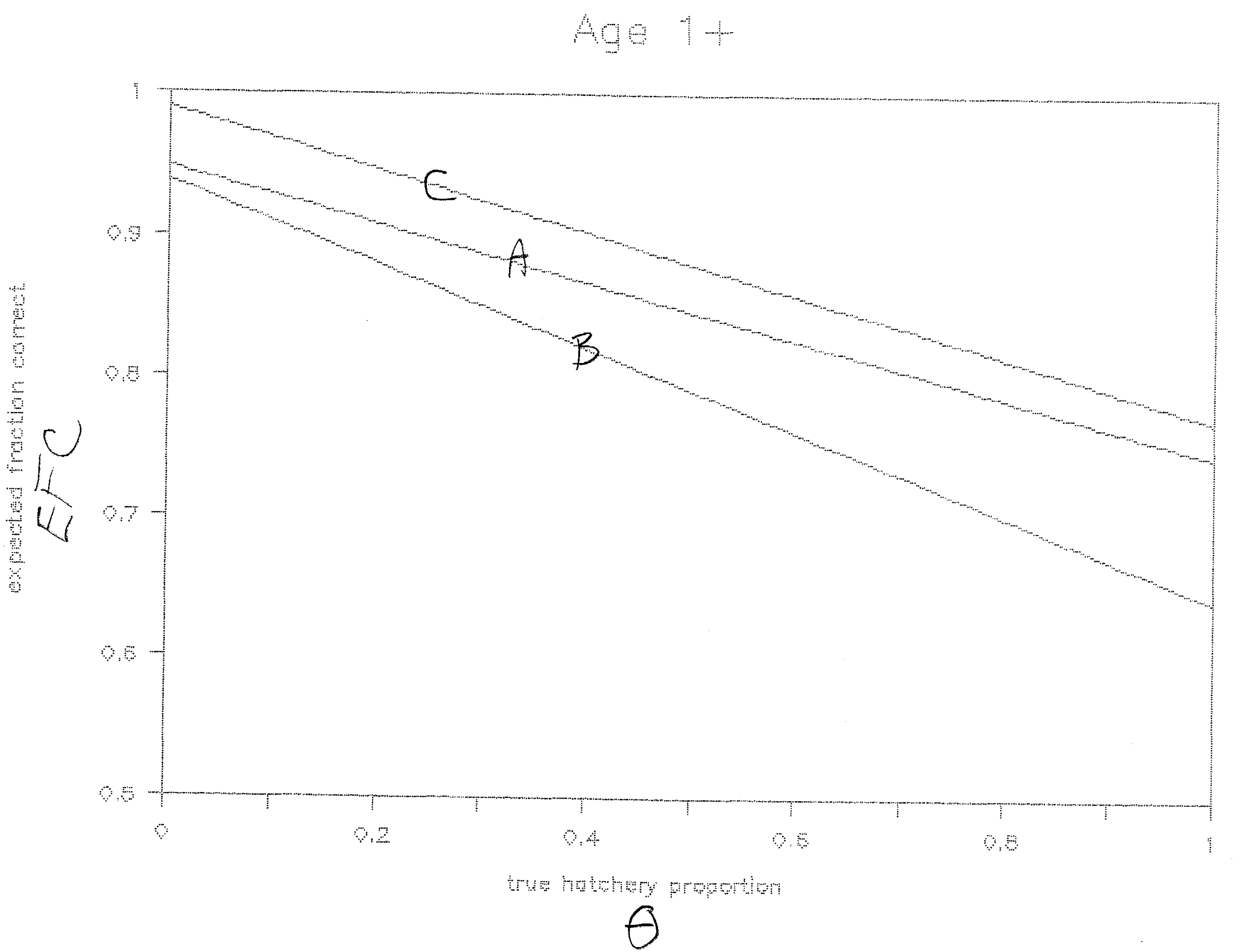
Note: Pr(H/H) = probability of identify a hatchery fish as hatchery

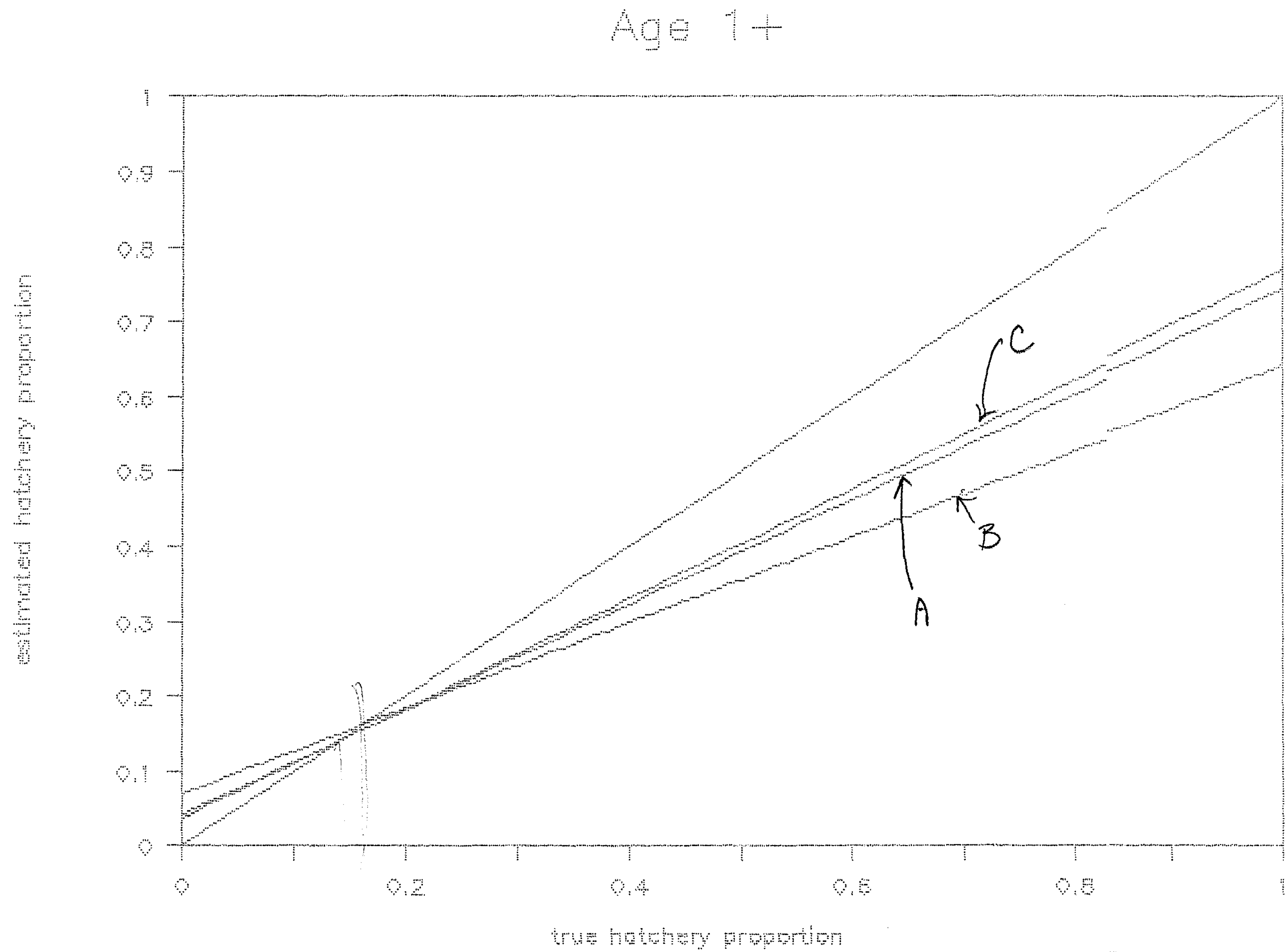
Age 0+


1
0.9
0.8
0.7
0.6
0.5
expected fraction correct
C
B
A
EFC = θ·P̂r(H|H) + (1-θ)·P̂r(W/W)
0
0.2
0.4
0.6
0.8
1
true hatchery proportion
θ



Age 0+
estimated hatchery proportion
true hatchery proportion
θ
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
NO ERROR LINE
A and B
C
EHP = θ · P̂r(H|H) + (1 − θ) · P̂r(H|W)


Age 1+
expected fraction correct
EFC
1
0.9
0.8
0.7
0.6
0.5
0
0.2
0.4
0.6
0.8
1
true hatchery proportion
θ
C
A
B


Age 1+
estimated hatchery proportion
true hatchery proportion
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.2
0.4
0.6
0.8
1
A
B
C

	H	W
	99	19
	16	43

99	13
16	52

105	6
11	57

29	10
9	203

25	11
15	201

30	3
8	212

EXAMPLE

	True Sources	Identified Source A		Identified Source B		Identified Source C		TRUE TOTAL
		Hat	Wild	Hat	Wild	Hat	Wild	
0+	Hatchery	99	19	99	13	105	6	120
	Wild	16	43	16	52	11	57	60
		115	62	115	65	116	63	180
1+	Hatchery	29	10	25	11	30	3	39
	Wild	9	203	15	201	8	212	214
		38	213	40	212	38	215	253

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1988-89 Hudson River Striped Bass Hatchery Evaluation/ Atlantic Tomcod Standard Operating Procedures (NAI 1989). The 1988-89 Hudson River Striped Bass Hatchery Evaluation Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1) with a 9 m trawl (Appendix Table A-1). Sampling locations were selected to maximize the catch per unit of effort of striped bass within the lower Hudson River, based on the results of the 1985-86, 1986-87 and 1987-88 programs (NAI 1986, 1987, 1988). Previous programs used a Scottish seine, 12 m trawl, and a 12 m trawl with a 9 m trawl cod end to collect striped bass. Only the 9 m trawl was used in the 1988-89 program based on the results of the 1987-88 program which showed that the 9 m trawl was more efficient than other gear in catching striped bass of the target ages of Age 0+ and Age 1+ (NAI 1988). Striped bass captured in each trawl were enumerated, and fish ≥150 mmTL in good condition were marked with internal anchor tags (Figure 2-2) and released. In previous years, fish ≥200 mmTL (1985-86, 1986-87 and 1987-88) or ≥300 mmTL (1984) were tagged and released (Appendix Tables D-8 through D-13).

For 24 weeks from the week of 31 October 1988 through the week of 10 April 1989, the 9 m trawl was deployed in the Upper Harbor and/or Battery regions. The 9 m trawl was fished in each of the 24 weeks in the Battery region and on selected days during 4 weeks (weeks of 7 November and 14 November 1988, and the weeks of 23 January and 27 February 1989) in the Upper Harbor region. An average of 15 tows per day were scheduled to be made with the 9 m trawl. Tow duration was 10 minutes unless sampling difficulties such as bottom obstructions required shortening the tow. Striped bass captured by the trawls received

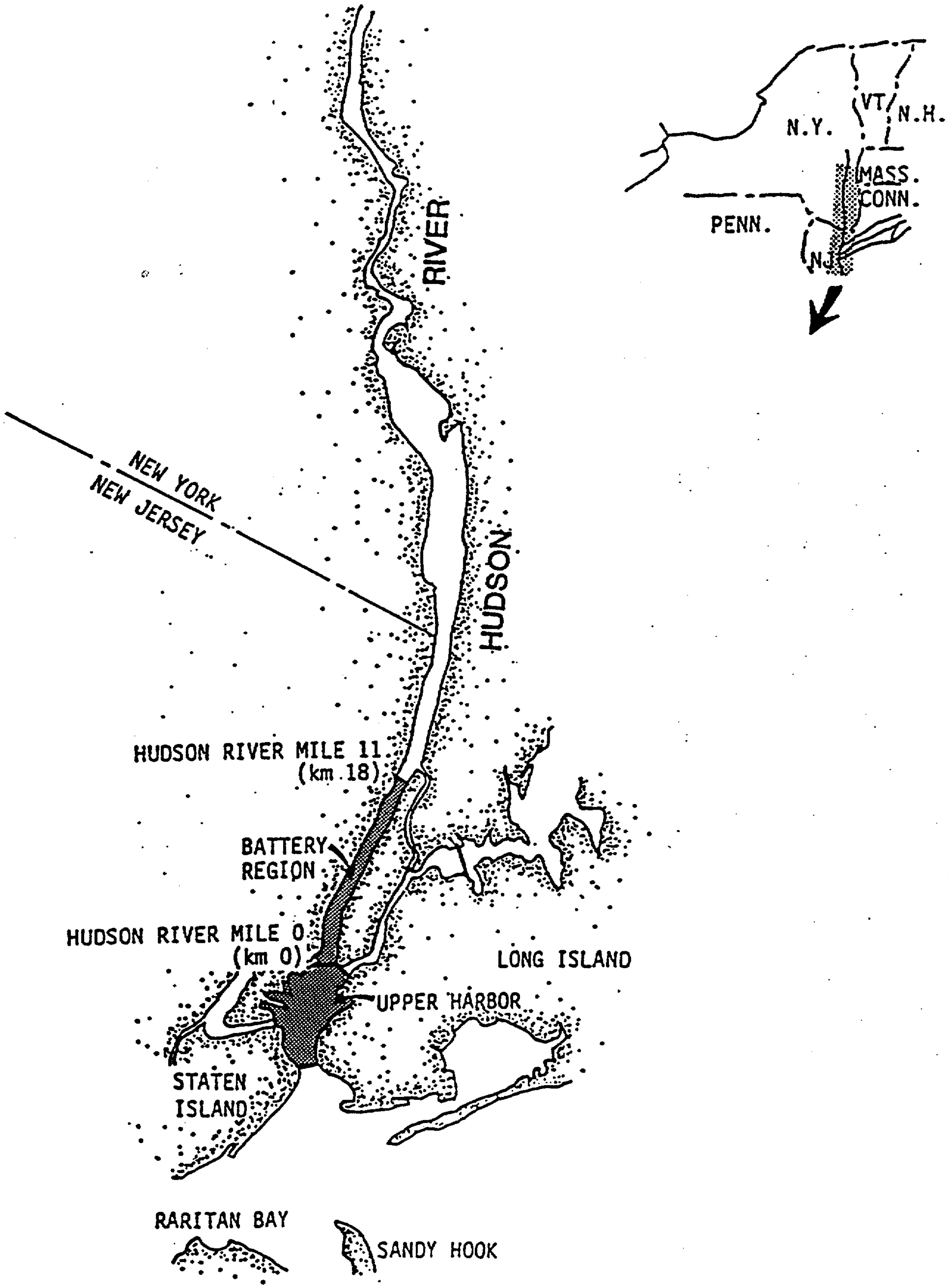
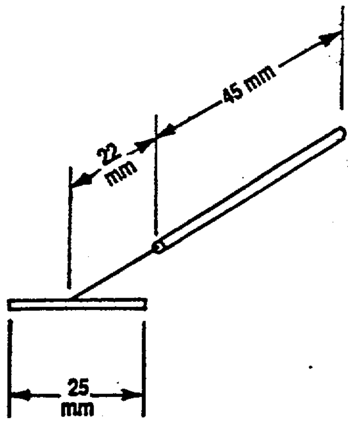
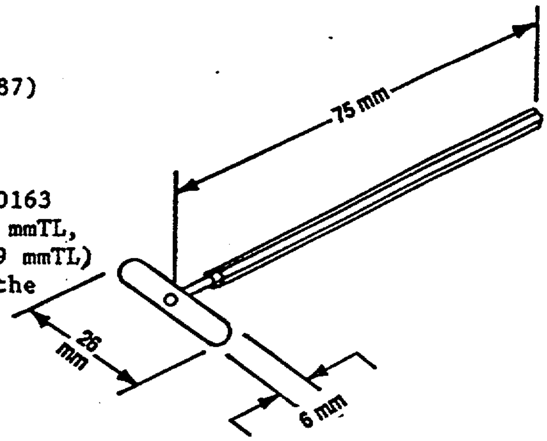


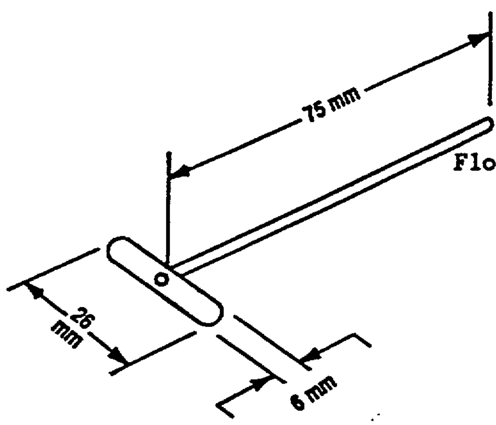
Figure 2-1. Sampling regions in the lower Hudson River, New York Harbor during the winter 1988-1989 Hudson River Striped Bass Hatchery Evaluation.



Hallprint Internal Anchor-External Streamer Tag (1987-present)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No. ######

Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the
external streamer





Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm X 6 mm for fish ≥300 mmTL,
RED 20 mm X 5 mm for fish 200-299 mmTL)
no legend

Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

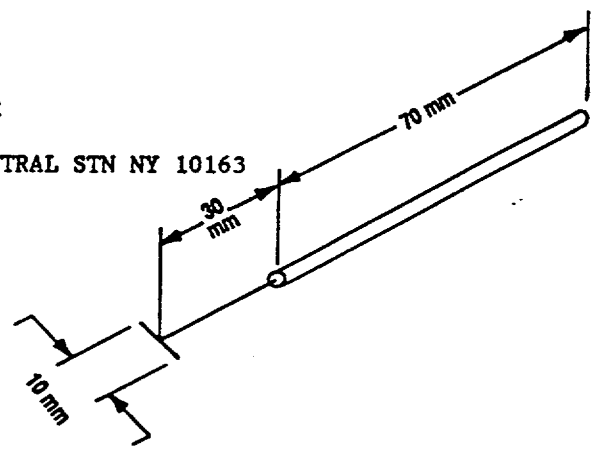


Figure 2-2. Tags used to mark striped bass during the 1984-Present Hudson River Striped Bass Hatchery Evaluation Programs.

identical handling to minimize fish stress before tagging. In general, each sampling effort required two boats. One boat conducted the actual sampling (capture boat) while the second boat (tagging boat) tended the capture boat with a holding facility for striped bass that was secured in the water alongside the tagging boat. The cod end of the net was transferred through the water from the capture boat to the holding facility alongside the tagging boat. Striped bass were then transferred from the holding facility to the tagging boat one at a time using the following procedures:

1) fish were removed from the live car using a dip net,
2) all surfaces that came in contact with the live fish were wet,
3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and
4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

All striped bass were measured (mmTL) and examined for external tags, tag wounds, and CWTs, using a magnetic tag detector. A V-shaped field detector was used throughout the study. Additionally, a more sensitive tube-shaped detector was used in tandem with the field detector on randomly selected days to evaluate the efficiency of the field detector.

All striped bass ≥150 mmTL, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

1) no bleeding from gills or body wounds,
2) no significant loss of scales, and
3) strong opercular movement.

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a hooking movement of a curved blade scalpel. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromine-based topical antiseptic. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location. Scale samples were taken from the left side from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for recaptured, tagged fish from which a scale sample was taken on the right side of the fish to avoid regenerated scales. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass was also evaluated.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, fish and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random subsample of striped bass using scales collected from the fish in the field. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mmTL length group. Expected numbers of Age 1+ striped bass in each 10 mmTL length group were calculated from age at length data obtained during the 1987-88 program (NAI 1988).

The hatching date of striped bass was assumed to be 15 May. Therefore, a yearling fish captured in April would be 23 months old and designated "Age 1+". Similarly, a young-of-the-year striped bass approaching its birth date would be 11 months old and designated "Age 0+".

Striped bass scales were pressed on 0.050 in thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined through a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were 1) changes in the relative spacing of circuli in the anterior field of the scale, 2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and 3) variations in the thickness, and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was also measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 2 samples were used for mark-recapture analysis only. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data anlyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among locations and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Of Effort

Catch Per Unit Of Effort (CPUE) for the 9 m trawl was defined as catch per ten-minute tow (Use Code = 1) and was calculated as:

$$\bar{X} = \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \times 10 \right] /n \qquad \text{Equation 1}$$

where, $\bar{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,

E_i = the tow duration of trawl i in minutes, and

n = the number of trawls.

2.3.1.2 Length-Frequency

Length-frequency histograms, with number of fish on the ordinate and total length on the abscissa were constructed to describe the catch characteristics of the 9 m trawl.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula:

$$PropD_x = D_x/T_x \qquad \text{Equation 2}$$

where, $PropD_x$ = the proportion of dead striped bass at water temperature x,

D_x = the number of dead striped bass at water temperature x, and

T_x = total number of striped bass captured at water temperature x.

PropD was calculated by sampling gear for samples collected in the Battery at both surface and bottom water temperatures. Comparisons of handling mortality among the 1988-89, 1987-88, 1986-87 and 1985-86 programs were also made using data subset by gear within the Battery region in each year.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 Estimated Number of Striped Bass in Each Age Category

A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1988-89 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mmTL length increment and the variance of the proportion of Age 1+ fish in each 10 mmTL length group. This Neyman allocation scheme is considered optimum with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish, and is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n(N_h\sqrt{p_h q_h}/\Sigma N_h\sqrt{p_h q_h}) \qquad \text{Equation 3}$$

where

n_h = number of scale samples selected for age determination from length group h,

n = number of scale samples to be selected from the total of N fish caught,

N_h = total number of fish caught in length group h,

p_h = proportion of Age 1+ fish in length group h from the laboratory sample, and

$q_h = 1 - p_h$.

The stratified sampling plan was implemented using actual age-length frequency data from 1987-88 study (NAI 1988). The stratified sampling program was designed to select approximately 16% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1987-88 were applied to the data in three lots to permit scale analysis to proceed during the study. In each lot (31 October-31 December, 1 January-26 February and 27 February-14 April) scale samples from approximately 16% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1988-89 program was estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \Sigma(N_h p_{hi}/N) \qquad \text{Equation 4}$$

where

p_{sti} = the stratified mean proportion of Age i fish,
p_{hi} = the proportion of Age i fish in length group h, and
N_h and N are as defined in Equation 3.

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N(p_{sti}) \qquad \text{Equation 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2_{p_{sti}}$) is (Cochran 1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h{}^2(N_h - n_h)/(N_h - 1)][(p_{hi}q_{hi})/(n_h - 1)]\right] \qquad \text{Equation 6}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish are calculated based on Cochran (1977) Equations 5.14 and 5.15 are:

$$95\%\ \text{CI for } p_{sti} = p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 7}$$

$$95\%\ \text{CI for } A_i = N\, p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 8}$$

where

$$s_{p_{sti}} = \sqrt{s^2{}_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 4-7.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1988-89 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} N_{hi}\, \bar{y}_{hi}\right] / N_i \qquad \text{Equation 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

N_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least two Age i fish were measured. If fewer than two Age i fish were present in length group i, the data were pooled with the next length group closest to the group containing the mean.

Variance estimates and confidence intervals for the stratified mean length of Age i fish are based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the total number of fish caught (N_{hi}). Somewhat wider confidence intervals would be obtained if this extrapolation was made to the entire population of Age striped bass in the Hudson River. However, extrapolating the variance of mean length to the entire river population requires a two-phase sampling simulation in which the total catch is the primary sample and aged fish are the secondary sample. to determine both the effects of sampling variability and mesh size selectivity on the estimated variance of mean length at age. This simulation study is beyond the present scope of work. However, a two-phase sampling plan (Cochran 1977) was used as an approximation of the wider confidence limits for mean length at age in the entire population of Hudson River striped bass.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24 with the assumption that N_i is large and substantially larger than n_i', therefore $N_i^{-1} \approx 0$ and $g_i \approx 1$):

$(N_i - n_i')/(N_i - 1)$

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L} \left[w_{hi} (S^2{hi} / n_i' \, V_{hi} \right] + (1/n_i') \sum_{h=1}^{L} w_{hi} (\bar{y}_{hi} - \bar{y}_{sti})^2 \qquad \text{Equation 10}$$

where

$S^2_{\bar{y}_{sti}}$ = Two-phase variance of the stratified mean length of striped bass of Age i,

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes Theorum presented in Equation 11,

s^2_{hi} = variance of the mean length of Age i fish measured for length in length group h of the laboratory sample,

n_i' = total number of Age i fish in the laboratory sample,

– N_i = number of Age i fish in population

V_{hi} = proportion of Age i fish in length group h, and

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9.

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes Theorum as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P\ (L_h \mid A_i) = [P\ (L_h)\ P\ (A \mid L_h)]/\ P(A_i) \qquad \text{Equation 11}$$

where

w_{hi} is as defined in Equation 10,

A_i = Age i striped bass,

$P(L_h)$ = proportion of the total catch of striped bass in length group h,

$P\ (A_i \mid L_h)$ = proportion of aged fish in length group h that are Age i, and

$P\ (A_i)$ = proportion of Age i fish in the total catch.

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ \text{CI for}\ \bar{y}_{sti} = \bar{y}_{sti} + t\ S_{\bar{y}_{sti}} \qquad \text{Equation 12}$$

where

$$S_{\bar{y}_{sti}} = s^2_{\bar{y}_{sti}}$$

t = Student's t statistic for $\alpha = 0.05$ based on $n_i' - 1$ degrees of freedom (not the effective degrees of freedom), and

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$\bar{y}_{sti}$ is as defined in Equation 9.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1988-89 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following formula (MMES 1986):

$$P_i = H_i / (H_i + W_i) \qquad \text{Equation 12}$$

where

P_i = the proportion of Age i hatchery striped bass in the population,

H_i = the number of Age i verified hatchery recaptures caught, and

W_i = the number of Age i wild striped bass caught (A_i from Equation 5).

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_i) in Equation 12, the exact binomial variance of P_i can be calculated and confidence limits are determined for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning *et al*. 1989) and non-detection of tags on an age-specific basis (Table 2-1) as follows:

$$H_{ai} = H_i / \left[(1-TAG_i)(1-NDET_i) \right] \qquad \text{Equation 13}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

H_i = the number of Age i verified hatchery recaptures caught,

TAG_i = weighted, decimal percent 48-hour magnetic tag loss for Age i hatchery striped bass determined at the time of tagging, and

$NDET_i$ = decimal percent non-detection rate for magnetic tags during the recapture program.

The adjusted number of Age *i* hatchery striped bass caught (H_{ai}) was then substituted for H_i in Equation 12. The total number of hatchery striped bass that were stocked in each year (Section 1.0) was not adjusted for handling mortality (Dunning *et al*. 1989) because different lots of fish were held between 1 and 48 hours after tagging (EA 1989), and it was not possible to calculate an accurate mortality rate for each lot.

2.3.4 Population Movement

Distance between tagging and recovery locations, days at large, and minimum rate of travel were calculated for all recaptured striped bass and used to directly evaluate movement of fish within the study area. Two groups of fish were considered: 1) fish recaptured from previous programs (cross-year) recaptures and 2) fish caught, tagged, released and recaptured within the 1988-89 program (within-year recaptures). The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few

TABLE 2-1. FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOSS (TAG_i) AND NON-DETECTION OF TAGS ($NDET_i$) DURING 1988-89.

COHORT	AGE	TAG_i	$NDET_i$
1988	0+	0.017	0.019
1987	1+	0.147	0.019
1986	2+	0.075	0.019
1985	3+	0.065	0.019
1984	4+	0.276	0.019

fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$\text{Recapture rate} = R_{ij}/M_{ij} \qquad \text{Equation 15}$$

where R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

M_{ij} = number of tagged striped bass released during time (week) period i in region j.

$$\text{Recapture Proportion } R_{ij}/C_{ij} \qquad \text{Equation 16}$$

where R_{ij} = number of tagged striped bass recaptured in time period i (week) in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period i (week) in region j.

2.3.5 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i) with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber

1982). When the squared residules ($R_i/C_i - \beta M_i$) are weighted by the catch (C_i), then N^{-1} equals the slope, ß.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$1/N = \Sigma(R_i M_i)/\Sigma(C_i M_i^2) \qquad \text{Equation 17}$$

where

N = estimated population size,
C_i = total catch during time interval i,
M_i = total number of marked fish available for recapture at the midpoint of time interval i, and
R_i = number of recaptured fish in C_i.

The variance of the recriprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\Sigma(R_i^2/C_i)-(\Sigma R_i M_i)^2/\Sigma(C_i M_i^2)}{m-1} \qquad \text{Equation 18}$$

where

S^2 = mean of squared deviations from the regression model described above,
m = the number of data points in the regression, and
C_i, M_i and R_i are as defined above in Equation 17.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_i M_i^2 \times t_{m-1} \qquad \text{Equation 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and α=0.05.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE TRAWLS

3.1.1 Catch Per Unit Of Effort

Mean striped bass catch per ten minute tow (CPUE) is presented in this section for the 9 m trawl that was fished in the lower Hudson River from 31 October 1988 to 15 April 1989. Mean CPUE was calculated for the 9 m trawl for successful (Use Code = 1) samples completed in the Upper Harbor and Battery regions (Table 2-1).

Most of the trawling effort (97%) was expended in the Battery region which exhibited almost three times the striped bass mean CPUE when compared with the Upper Harbor over all sampling weeks combined (Table 3-1). During the 4 weeks when the 9 m trawl was fished in both the Upper Harbor and Battery regions, the weekly mean CPUE in the Upper Harbor region was equal during the week of 7 November 1988, greater during the week of 14 November 1988, or lower during the weeks of 23 January and 27 February 1989 than in the Battery (Appendix Table C-1). There were four major peaks in mean CPUE for the 9 m trawl in the Battery region during the 1988-89 program. These peaks in mean CPUE occurred during the weeks of 31 October 1988, 2 January, 13 February, and 20 March 1989 (Figure 3-1; Appendix Tables C-1 and C-2). The highest weekly mean CPUE for the 9 m trawl was 61.0 striped bass per ten minute tow during the week of 2 January 1989.

Mean CPUE for the 9 m trawl in the Battery region has increased annually since 1985-86 (Table 3-2). Mean CPUE for the 9 m trawl in 1988-89 (38.9) was approximately 27% greater than the CPUE observed during 1987-88 (28.5) program for comparable time periods. Mean CPUE in the 1988-89 program was approximately three times greater than that observed in the 1986-87 program and approximately five times greater than that observed in 1985-86 program for comparable time

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

REGION	TRAWL	NUMBER OF TOWS[1]	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Upper Harbor	9 m	32	306	9.6	1.7
Battery	9 m	1,151	32,487	28.2	1.0

[1]Use Code = 1 tows only.

TABLE 3-2. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE BATTERY REGION OF THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86, 1986-87, 1987-88 AND 1988-89.

GEAR	YEAR	TOWS	MEAN CPUE	95% CI
9 m trawl	1985-86[a]	638	8.1	±1.0
	1986-87[b]	385	12.2	±1.2
	1987-88c	437	28.5	±2.5
	1988-89[d]	527	38.9	±3.3

a 9 m trawl 23 December 1985-21 March 1986

b 9 m trawl 21 December 1986-21 March 1987

c 9 m trawl 20 December 1987-19 March 1988

d 9 m trawl 19 December 1988-18 March 1989

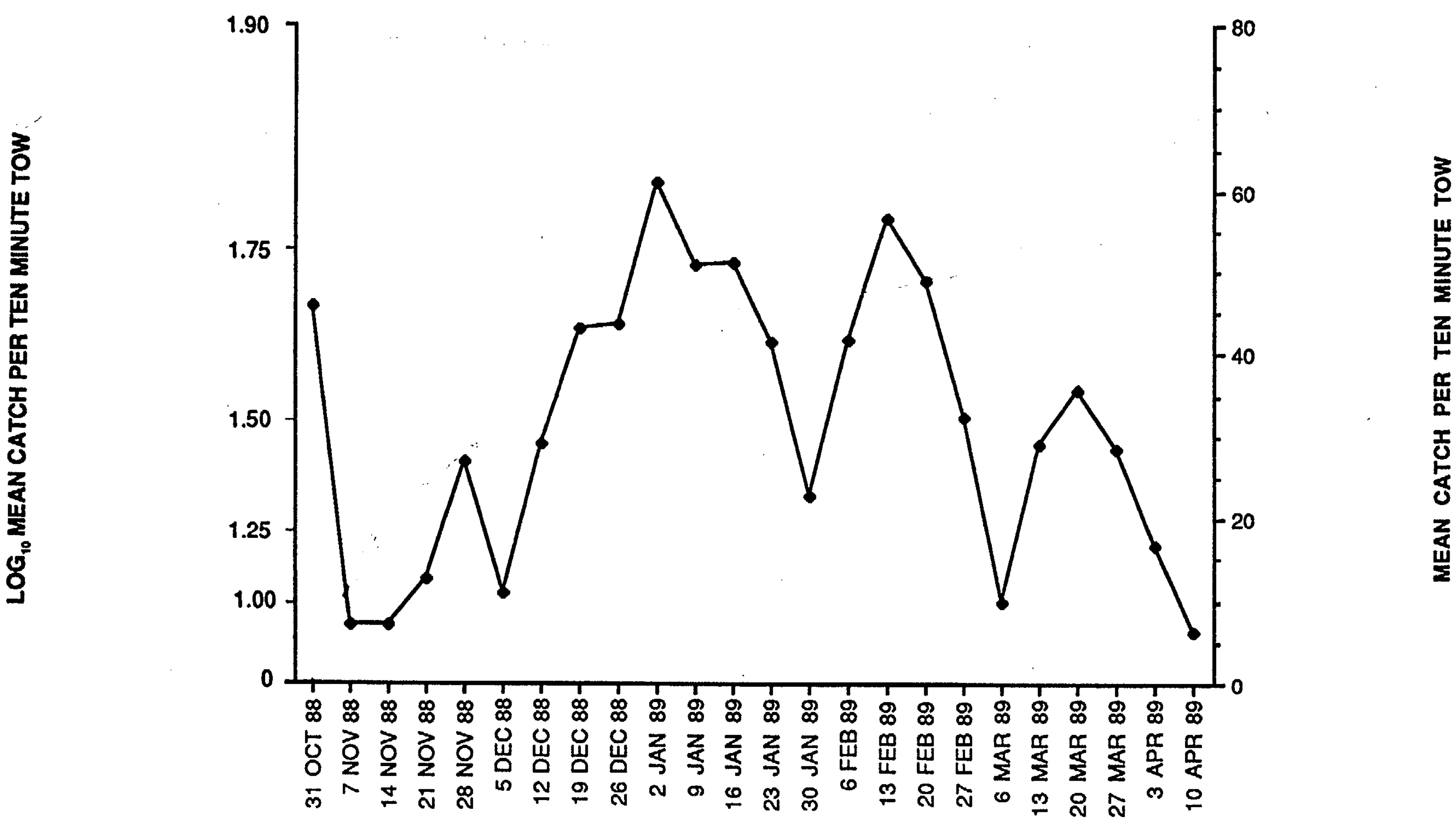

Figure 3-1. Log_{10} mean catch per ten minute tow and mean catch per ten minute tow by a 9 m trawl in the Battery region (Rm 0-11; Km 0-18) of the Hudson River, 31 October 1988 through 15 April 1989.

periods. The increased CPUE observed during the 1988-89 program may be due to the complete recruitment of the numerically dominant 1987 striped bass year class to the 9 m trawl.

3.1.2 Length-Frequency Distributions

Length-frequency distributions for striped bass caught by the 9 m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

The mean size of striped bass caught by the 9 m trawl was 208 mmTL (Table 3-3). The length-frequency distribution for the 9 m trawl was skewed right, indicating more fish were smaller than the mean length than would be expected if the length-frequency distributions were bell shaped (Table 3-3; Figure 3-2). Length-frequency distributions for the 9 m trawl were also leptokurtotic, indicating more fish were found in length groups close to the mean length than would be expected if the length-frequency distributions were bell-shaped. The length-frequency distribution of the 9 m trawl was unimodal (Figure 3-2) and the greatest percentage of the striped bass catch in the 9 m trawl occurred in the 201-250 mmTL group

Weekly mean length of striped bass caught by the 9 m trawl increased steadily from 210 mmTL during the first week of the 1988-89 program to the maximum of 240 mmTL during the weeks of 12 and 19 December 1988 (Table 3-4). This period of increase was followed by a steady decline in weekly mean length to the minimum weekly mean length of 156 mmTL during the week of 16 January 1989. Following this minimum, weekly mean length generally increased beginning the week of 23 January 1989 for the rest of the program to a post minimum high of 235 mmTL during the week of 3 April 1989.

TABLE 3-3. DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

GEAR	N	MEAN (mmTL)	S.D.	SKEWNESS (±95% C.I.)	KURTOSIS (±95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
9 m TRAWL	32,487	207.9	68.6	0.64±0.03	2.23±0.05	62	855	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Normal skewness = Skewness not significantly different from 0, which is the value obtained from a normal distribution.
Normal kurtosis = Kurtosis not significantly different from 0, which is the value obtained from a normal distribution.
Right skewness = Significant positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.
Left skewness = Significant negative skewness indicating more striped bass were larger than the mean length than would be expected from a normal distribution.
Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.
Platykurtosis = Significant negative kurtosis indicating more striped bass were both higher and lower than the mean length than would be expected from a normal distribution.

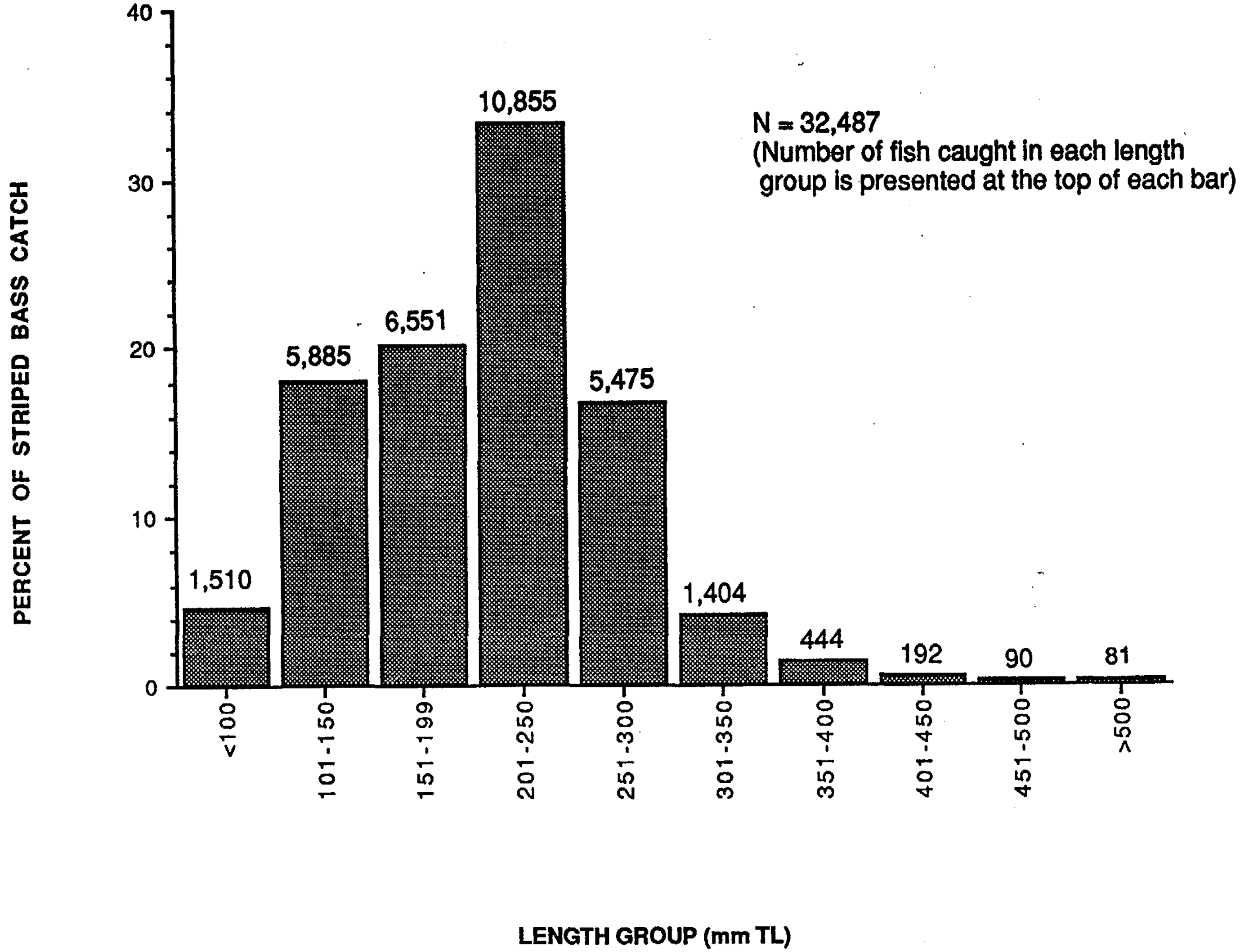

Figure 3-2. Length frequency distribution for striped bass captured by a 9 m trawl in the Battery region of the Hudson River, 31 October 1988 through 15 April 1989.

TABLE 3-4. WEEKLY MEAN LENGTH (mmTL) OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

	9 m TRAWL LENGTH (mmTL)			
WEEK	NO. FISH	MEAN	S.D.	S.E.
31OCT88	1514	210	64.75	1.66
07NOV88	402	201	96.67	4.82
14NOV88	318	208	85.16	4.78
21NOV88	660	223	88.93	3.46
28NOV88	1266	231	75.25	2.11
05DEC88	834	233	95.14	3.29
12DEC88	1544	240	76.90	1.96
19DEC88	1428	240	72.97	1.93
26DEC88	1134	220	51.21	1.52
02JAN89	1525	195	49.07	1.26
09JAN89	1738	179	62.50	1.50
16JAN89	2306	156	50.93	1.06
23JAN89	1824	187	62.99	1.47
30JAN89	1385	222	55.97	1.50
06FEB89	1805	210	58.84	1.38
13FEB89	2772	209	64.10	1.22
20FEB89	1126	184	65.60	1.95
27FEB89	1658	195	77.57	1.91
06MAR89	469	216	54.50	2.52
13MAR89	1342	190	62.03	1.69
20MAR89	2144	219	55.13	1.19
27MAR89	1716	235	52.38	1.26
03APR89	1085	225	56.31	1.71
10APR89	492	228	67.58	3.05
ALL WEEKS	32487	208	68.60	0.38

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50 mmTL length groups, exhibited no distinct seasonal pattern for the 9 m trawl (Table 3-5). The highest weekly catch per tow for the 9 m trawl was 25.1 striped bass for the 101-150 mmTL length group during the week of 16 January 1989. The highest overall catch per tow for the 9 m trawl was 9.7 striped bass for the 201-250 mmTL.

Length-frequency data from the 1988-89 program showed the influence of the numerically dominant 1987 and 1988 striped bass year classes (McKown 1989). The 1987 year class, which was Age 1+ during the program, was apparent in the length-frequency distribution of striped bass (Figure 3-2). Age 1+ fish are generally between 201 and 250 mmTL (NAI 1988; this report section 3.4.1.1) and during the 1988-89 program, the greatest percentage (33.4%) of striped bass were captured in the 201-250 mmTL length group. The numerical dominance of the 1987 year class is also shown in the catch of striped bass per tow in 50 mmTL length groups; the largest overall catches per tow were in the 201-250 mmTL length group. Comparisons of length-frequency distributions between the 1987-88 and 1988-89 programs show the influence of the 1987 year class (Figure 3-3). During the 1987-88 program, the 1987 year class was Age 0+ and was represented by the lower mode of a bimodal length frequency distribution with peak abundance occurring in the 100-150 mmTL length group (NAI 1988). The unimodal shape of the 1988-89 length frequency distribution with peak abundance in the 201-250 mmTL length group is the result of the growth in length of the 1987 year class.

The 1988 year class, which was Age 0+ during the program was apparent in the weekly mean length data during the week of 16 January. Age 0+ striped bass are generally between 100 and 150 mmTL (NAI 1988; this report Section 3.4.1.1). The smallest weekly mean length of 156 mmTL was recorded during the week of 16 January. This decrease in mean length probably represents an influx of smaller striped bass to the sampling area as CPUE remained relatively high.

TABLE 3-5. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW IN A 9 m TRAWL FOR 50 mmTL LENGTH GROUPS FROM 31 OCTOBER 1988 THROUGH 15 APRIL 1989 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mmTL LENGTH GROUPS													
		<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	>700
31OCT88	33	1.2	10.7	5.6	15.2	11.0	1.7	0.3	0.1	0.1	0.0	<0.1	0.0	0.0	0.0
07NOV88	57	0.7	2.2	0.8	1.3	1.2	0.4	0.2	0.1	<0.1	0.1	0.0	0.0	0.0	<0.1
14NOV88	45	0.9	1.6	0.6	1.7	1.6	0.6	0.2	<0.1	0.1	0.0	0.0	0.0	0.0	0.0
21NOV88	52	1.0	1.6	1.5	4.3	2.1	1.0	0.4	0.3	0.1	0.1	<0.1	<0.1	0.0	0.0
28NOV88	47	0.5	3.2	3.6	11.4	5.2	1.6	0.5	0.2	0.8	0.2	0.1	<0.1	<0.1	0.0
05DEC88	75	0.8	1.7	1.2	2.9	2.4	1.1	0.4	0.3	0.2	0.1	<0.1	<0.1	0.0	<0.1
12DEC88	53	1.6	2.2	3.8	8.6	7.7	3.4	1.0	0.6	0.1	0.1	<0.1	0.0	0.0	0.0
19DEC88	33	0.8	4.2	6.0	14.3	11.5	3.6	1.6	0.7	0.3	0.1	0.1	0.0	<0.1	0.0
26DEC88	26	0.6	4.2	8.4	19.2	9.3	1.4	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
02JAN89	25	0.4	11.6	22.7	20.3	4.1	1.1	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0
09JAN89	34	6.2	12.8	11.1	15.4	4.5	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
16JAN89	45	3.7	25.1	12.9	7.3	1.6	0.3	0.2	0.2	4.0	0.0	0.0	0.0	0.0	0.0
23JAN89	44	4.0	9.1	9.0	13.6	4.5	0.8	0.3	0.1	<0.1	0.0	0.0	0.0	0.0	0.0
30JAN89	61	0.2	1.6	6.0	9.2	4.0	1.1	0.4	0.2	<0.1	<0.1	0.0	0.0	0.0	0.0
06FEB89	43	0.9	6.2	9.3	17.1	6.3	1.6	0.3	0.1	0.1	<0.1	0.0	0.0	0.0	0.0
13FEB89	127	2.6	9.4	11.2	19.8	10.3	2.1	0.9	0.2	0.1	<0.1	0.0	0.0	0.0	0.0
20FEB89	23	4.9	13.7	8.7	14.0	6.2	1.2	0.2	<0.1	0.0	0.0	<0.1	0.0	0.0	0.0
27FEB89	51	2.4	8.6	6.2	8.2	4.5	1.5	0.5	0.3	0.2	0.1	<0.1	0.0	0.0	0.0
06MAR89	47	0.1	1.2	2.3	4.1	2.0	0.3	0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0
13MAR89	46	1.8	6.8	7.4	8.9	3.4	0.7	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
20MAR89	60	0.5	3.1	7.9	16.1	6.8	0.9	0.4	0.1	<0.1	<0.1	0.0	<0.1	0.0	<0.1
27MAR89	60	0.1	1.1	5.3	11.9	8.2	1.7	0.2	0.1	0.1	0.1	<0.1	<0.1	0.0	0.0
03APR89	65	0.1	1.6	3.7	5.7	4.2	1.1	0.2	<0.1	<0.1	0.0	<0.1	0.0	0.0	0.0
10APR89	77	0.1	0.6	1.6	2.3	1.0	0.5	0.2	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0
TOTAL TOWS	1151														
STRIPED BASS PER TOW		1.3	5.1	5.7	9.5	4.8	1.2	0.4	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1

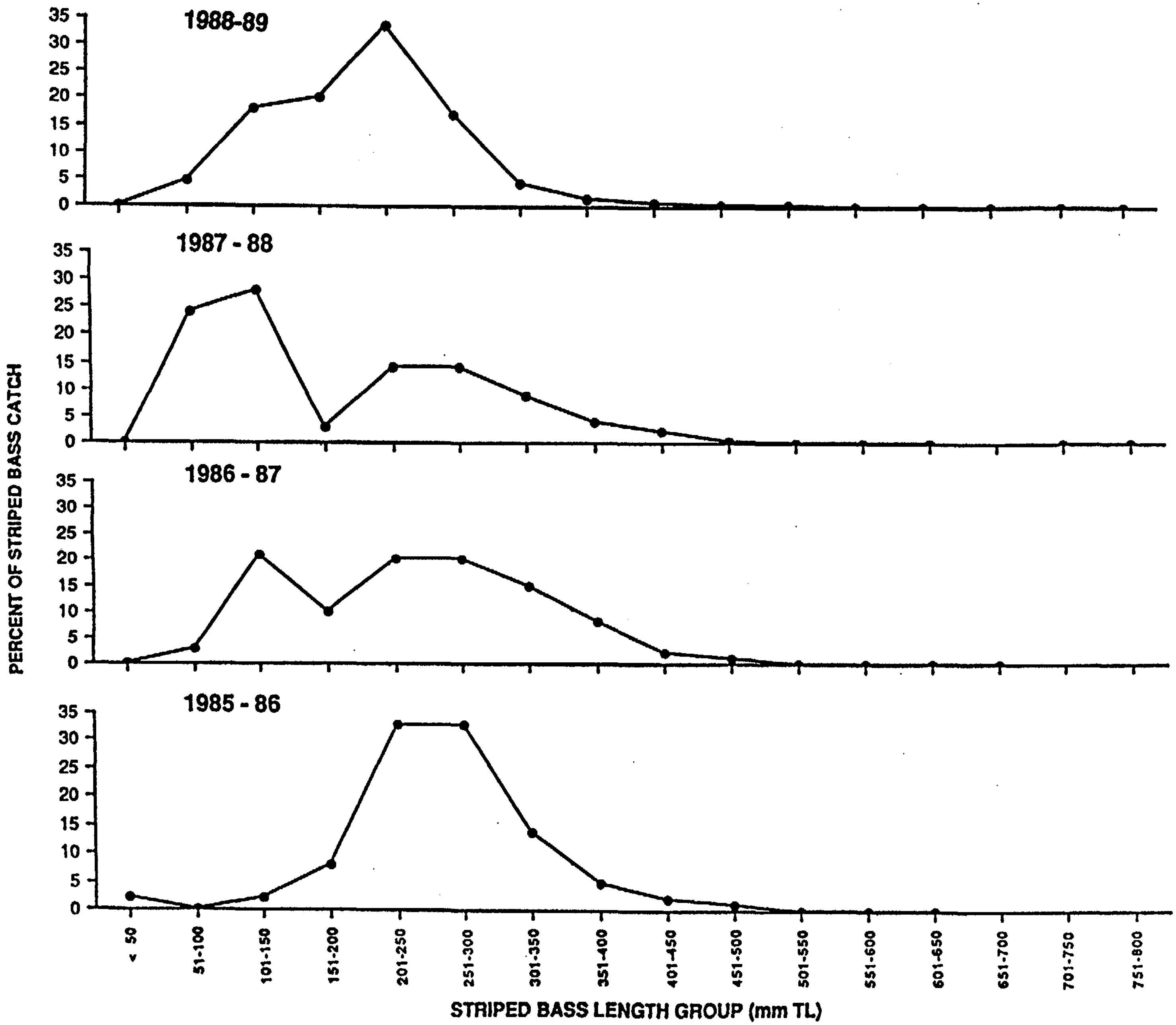

Figure 3-3. Standardized length frequency of striped bass captured by a 9 m trawl in the Battery region of the Hudson River, December through March of 1988-89, 1987-88, 1986-87 and 1985-86.

The increase in the overall mean length of striped bass caught in the 9 m trawl from 1987-88 to 1988-89 probably is a result of growth in length of the 1987 year class and more complete recruitment of this year class to the 9 m trawl. In addition, the recruitment of the dominant 1987 year class to the 9 m trawl is probably responsible for the overall increase in mean CPUE (Table 3-1).

3.1.3 Handling Mortality

Handling mortality statistics provide a basis for comparing methods of capture and for selecting techniques which minimize mortality due to the capture and tagging of striped bass. Differences in striped bass handling mortality between programs (1985-86, 1986-87, 1987-88, 1988-89) were assessed by comparing the percentage of dead fish in the catch in one degree temperature increments.

A total of 63 striped bass died out of 32,487 fish caught and handled in use code = 1 tows. Striped bass handling mortality in the 9 m trawl across all surface and bottom water temperatures was less than 1% during 1988-89 for 32,423 fish caught in use code = 1 tows that had water temperature data associated with each tow (Tables 3-6, 3-7). If all use code tows were included (Appendix Table C-3), a total of 32,975 fish were handled and no additional handling mortality was observed. The highest handling mortality of 0.4% in the 9 m trawl occurred at a bottom water temperature of 5°C. The relatively consistent, low handling mortality indicates there is no relationship between handling mortality and water temperature for the 9 m trawl over water temperatures of 0-19°C experienced in this study. As noted previously, handling mortality never exceeded 1% even at temperatures as high as 19°C. Within the range of temperatures observed, no trends in handling mortality were observed.

TABLE 3-6. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO LOWER HUDSON RIVER SURFACE WATER TEMPERATURE, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

SURFACE WATER TEMPERATURE (°C)	9 m TRAWL		
	% OF CATCH DEAD	NUMBER DEAD	TOTAL
2	<1	1	1,696
3	<1	6	6,026
4	<1	26	8,970
5	<1	12	5,292
6	<1	10	2,408
7	<1	3	2,466
8	<1	3	2,019
9	0	0	540
10	0	0	701
11	<1	1	787
12	<1	1	1,093
13	0	0	244
14	0	0	46
15	0	0	59
16	0	0	76
2-16	<1	63	32,423

TABLE 3-7. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO LOWER HUDSON RIVER BOTTOM WATER TEMPERATURE, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

BOTTOM WATER TEMPERATURE (°C)	9 m TRAWL		
	% OF CATCH DEAD	NUMBER DEAD	TOTAL
1	0	0	0
2	0	0	464
3	<1	3	5,760
4	<1	11	7,503
5	<1	27	6,826
6	<1	14	4,360
7	<1	5	1,984
8	<1	1	760
9	0	0	726
10	0	0	1,672
11	<1	1	1,042
12	<1	1	430
13	0	0	41
14	0	0	152
15	0	0	485
16	0	0	118
17	0	0	24
18	0	0	43
19	0	0	33
1-19	<1	63	32,423

3.1.3.1 Handling Mortality Discussion

Striped bass handling mortality in the 1988-89 program was uniformly low, and similar to or slightly less than mortality observed in the 1985-86, 1986-87 and 1987-88 programs, and approximately ten times less than that observed in the 1984 program. Handling mortality in the 9 m trawl was 1% in the 1985-86 and 1986-87 programs and less than 1% in the 1987-88, and 1988-89 programs (Table 3-8). The 1988-89 data was not examined for an interaction between water temperature, fish length and immediate handling mortality because this interaction was not significant in previous programs (Dunning *et al*. 1989). The findings of the 1988-89 program support those of the 1985-86, 1986-87 and 1987-88 programs; that the primary reasons for the decrease in handling mortality observed after 1984 are the use of the submerged holding facility and the increased tagging efficiency of field crews (NAI 1986). The holding facility used in the 1985-86 through 1988-89 programs permitted transfer of each catch from the cod end into the holding tank without having to lift both the net and fish out of the water, i.e., the fish remained in the water until they were individually removed and tagged. In contrast, during the 1984 program, the cod end of the net was lifted out of the water and fish were compressed by their weight in the air as they were transferred to the on-deck holding tanks. The increased tagging efficiency observed in the 1985-86 through 1988-89 programs contributed to decreased handling mortality by lessening exposure of striped bass to the air, thus reducing stress by returning tagged fish to the water quickly.

Handling mortality in the 9 m trawl was approximately 1% or less in the 1985-86 through 1988-89 programs for the common bottom water temperature range of 0-14°C (Table 3-8). Despite an additional year of experience in handling and tagging striped bass, little improvement in the already low handling mortality was observed. However, little decrease in handling mortality may be possible.

TABLE 3-8. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL DURING THE 1985-86, 1986-87, 1987-88 AND 1988-89 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAMS.

	1985-1986 9 m TRAWL		1986-1987 9 m TRAWL		1986-1987 9 m TRAWL W/LINER		1987-1988 9 m TRAWL		1988-1989 9 m TRAWL	
BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N
0				0		0/6				
1	0	0/45	5	3/65	0	0/25	3	2/64		
2	<1	4/856	1	5/773	2	7/359	<1	7/2097	0	0/464
3	1	8/1489	1	8/1297	2	13/728	1	28/4295	<1	3/5760
4	1	21/1521	<1	4/1002	<1	1/542	<1	13/3635	<1	11/7503
5	2	11/720	1	6/973	0	0/115	<1	5/1818	<1	27/6826
6	1	9/882	1	4/295	1	1/166	<1	2/886	<1	14/4360
7	2	8/403	1	4/602	0	0/40	<1	4/1503	<1	5/1984
8	1	5/423	<1	1/373	6	19/346	<1	2/1654	<1	1/760
9	3	17/521	0	0/79	0	0/61	<1	2/829	0	0/726
10	15	2/13	11	3/28	20	4/20	0	0/363	0	0/1672
11	0	0/2	0	0/66	13	4/32	1	6/449	<1	1/1042
12	3	4/130	0	0/5			0	0/160	<1	1/430
13	2	5/309					0	0/176	0	0/41
14							13	1/8	0	0/152
0-14	1	94/7314	1	38/5558	2	49/2440	<1	72/17937	<1	63/31720

n = Number dead at a temperature for use code = 1 tows.
N = Total number caught at a temperature for use code = 1 tows.

NOTE: In 1986-87 the 9 m trawl was deployed with a 3.8 cm (stretch) mesh cod end or with a 2.5 cm (stretch) mesh cod end liner.

No large increases in handling mortality with increasing temperature occurred in the 1988-89 program. This supports the findings of the 1985-86 through 1987-88 programs, that use of the in-water holding facility and increased crew experience are probably the largest factors in determining handling mortality (NAI 1986, Dunning *et al.* 1989).

3.2 STRIPED BASS AGE AND LENGTH DISTRIBUTION

3.2.1 Evaluation of Laboratory Sample Selection by the Stratified Sampling Plan

Stratified random sampling resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-9). For the allocation of 5,108 scale samples actually selected, the C.V. based on 95% confidence limits was 0.6% (±136 fish). Relatively little gain in precision would be realized compared to the cost for determining the age of more than 6% or 2,000 scale samples. For example, doubling the number of striped bass scale samples examined for age determination from 2,000 to 4,000 would only result in a 0.3% improvement in the coefficient of variation (Table 3-9). In previous years, this level of precision would require age determination for about 14% of the striped bass caught (NAI 1988). However, due to the dominance of the 1987 cohort of Age 1+ fish in most length groups caught, the estimated proportion and number of Age 1+ striped bass during the 1988-89 program was twice as precise as in the 1987-88 program. By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass out of the 32,975 fish caught could be estimated with 95% confidence limits of ± 460 fish (C.V. = 2.0%, Table 3-9).

The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mmTL length increment and the variance of the proportion of Age 1+ fish in each 10 mm TL length group. Therefore, it was expected *a priori* that

TABLE 3-9. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

		ESTIMATED NUMBER OF AGE 1+ FISH CAUGHT			
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL	LOWER 95%CI	UPPER 95%CI	C.V.(%)[a]
500	0.695	22,932	22,472	23,391	2.0
1,000	0.695	22,932	22,616	23,247	1.4
2,000	0.695	22,932	22,716	23,147	0.9
3,000	0.695	22,932	22,761	23,102	0.7
4,000	0.695	22,932	22,788	23,075	0.6
5,000	0.695	22,932	22,808	23,055	0.5
5,108[b]	0.695	22,932	22,796	23,067	0.6
6,000	0.695	22,932	22,823	23,041	0.5
7,000	0.695	22,932	22,835	23,029	0.4
8,000	0.695	22,932	22,845	23,019	0.4

[a]C.V. = coefficient of variation = 95% confidence interval (CI) half width/stratified total x 100.

[b]Results for sample size = 5,108 are based on actual allocations which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain the best (most precise and accurate) estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 3+ striped bass (Table 3-10), which collectively comprised 99.2% of the fish caught in this program. Only 257 striped bass estimated to be older than Age 3+ were caught during the 1988-89 program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The large 1987 cohort of Age 1+ striped bass was approximately 70% of the total catch during 1988-89, in contrast with 1987-88 when the 1987 cohort of Age 0+ striped bass comprised about 50% and Age 1+ fish represented about 30% of the fish caught (NAI 1988). The numbers of Age 2+ and Age 3+ striped bass were estimated with lower precision than the number of Age 1+ fish because Age 2+ and Age 3+ fish occur over a wide range of sizes, particularly in the larger length increments which had few Age 1+ fish and were not sampled intensively. The 1986 cohort of Age 2+ striped bass was only 5% of the total catch in 1988-89, while in 1987-88 Age 2+ striped bass comprised 11% of the total catch (NAI 1988). The dominant 1987 cohort of Age 1+ fish probably reduced proportions of the other cohorts caught in 1988-89.

3.2.2 Length Distribution and Associated Statistics for Each Age Cohort

The 9 m trawl mesh size in both the body and cod end was the same among the 1986-87, 1987-88 and 1988-89 programs. Therefore, the striped bass catch by this 9 m trawl was used for comparisons of mean length at age among programs to avoid any bias introduced by the size selectivity of different trawls.

Striped bass were randomly selected by the stratified random sampling plan to maximize the precision of the estimated proportion and number of Age 1+ striped bass caught (Section 3.2.1). This stratified

TABLE 3-10. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

		ESTIMATED NUMBER OF FISH CAUGHT			
AGE	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	C.V. (%)
0+	0.242	7,988	7,900	8,075	1.1
1+	0.695	22,932	22,796	23,067	0.6
2+	0.046	1,502	1,380	1,623	8.1
3+	0.009	296	220	373	25.8

[a]based on a laboratory sample of scales from 5,108 fish.

8/0 ✓ 2,5

design was also relatively precise in estimating the mean length at age for Age 0+ through Age 3+ striped bass.

Mean length at Age 0+ for the 1988 cohort (121.2 mmTL) during the 1988-89 program was greater in length than the 1987 cohort (107.6 mmTL), but smaller than the 1986 cohort (128.3 mmTL) (Table 3-11). The 1986 cohort had the largest mean length at Age 1+ (252.8 mmTL) followed by the 1987 cohort (227.0 mmTL) and the 1985 cohort (220.8 mmTL). At Age 2+, the 1986 cohort had a larger mean length than both the 1985 (317.2 mmTL) and 1984 (298.9 mmTL) cohorts. Mean lengths at Age 3+ were largest for the 1985 cohort (396.2 mmTL) followed by the 1983 (369.4 mmTL) and 1984 (367.6 mmTL) cohorts.

Mean lengths at Ages 0+, 1+, 2+, and 3+ for the 1983 through 1988 cohorts indicated that the relative ranking of mean lengths at age among cohorts may be determined by Age 0+, and this ranking persists up to at least Age 3+ (Table 3-11). The 1987 cohort was smaller at Age 0+ and Age 1+ than the 1986 cohort. Similarly, the 1986 cohort was larger at Age 1+ and Age 2+ than the 1985 cohort. Finally, the 1985 cohort was larger than the 1984 cohort at Ages 2+ and 3+. The relative ranking of mean length at age among cohorts remained the same for all cohorts at all ages examined.

The relative ranking among cohorts of mean length at age, may be inversely proportional to year class strength, particularly at Age 0+. Based on an annual August beach seine index of young-of-the-year abundance calculated by the NYSDEC (McKown 1989), the 1987 cohort of wild striped bass was the largest observed during the 1976-88 period, followed in magnitude by the 1988 cohort. The 1986 and 1985 cohorts were among the smallest observed during the period 1976-87. The 1986 wild cohort had a larger mean length at Age 0+ followed in order by the 1988 and 1987 cohorts (Table 3-11). However, this relationship did not hold true at Age 1+ where the relatively weak 1985 cohort was significantly smaller at Age 1+ than the strong 1987 cohort.

TABLE 3-11. MEAN LENGTH AT AGE AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER DURING THE 1988-89, 1987-88 AND 1986-87 STRIPED BASS HATCHERY EVALUATION PROGRAMS.

AGE	COHORT	PROGRAM	N	STRATIFIED MEAN LENGTH (mmTL)	LOWER 95% CI	LOWER 95% CI
0+	1988	1988-89	1007	121.2	117.3	125.1
	1987	1987-88	190	107.6	103.5	111.7
	1986	1986-87	83	128.3	122.6	134.0
1+	1987	1988-89	3,623	227.0	225.6	228.5
	1986	1987-88	1,503	252.8	250.5	251.1
	1985	1986-87	285	220.8	215.0	226.7
2+	1986	1988-89	361	324.5	317.5	331.4
	1985	1987-88	574	317.2	312.0	322.4
	1984	1986-87	359	298.9	292.9	305.0
3+	1985	1988-89	57	396.2	377.7	414.6
	1984	1987-88	273	367.4	359.9	375.2
	1983	1986-87	54	369.4	353.9	385.0

Standardized age frequency by length histograms, presented by 10 mmTL length groups for Age 0+ through Age 3+ striped bass (Figure 3-4) demonstrate minimal overlap between size of Age 0+ and Age 1+ striped bass caught during the 1988-89 program. Most of the fish ≤169 mmTL were Age 0+, while most of the fish between 170 and 319 mmTL were Age 1+. Age 1+ and Age 2+ striped bass overlap in size primarily between 220 and 339 mmTL. Age 3+ striped bass overlap with Age 2+ fish primarily between 300 and 439 mmTL.

3.3 STRIPED BASS HATCHERY PROPORTION

Striped bass stocked in the Hudson River from the Verplanck hatchery comprised 1.6% of the Age 0+ cohort, 0.2% of the Age 1+ cohort, 3.5% of the Age 2+ cohort, and 2.4% of the Age 3+ cohort of fish caught during the winter 1988-89 (Table 3-12). Comparing 95% confidence limits about the hatchery proportion of striped bass among cohorts indicated the proportion of Age 2+ hatchery fish was significantly higher than Age 0+ or Age 1+ but not significantly different than Age 3+. The Age 3+ hatchery cohort exhibited the next highest hatchery proportion, however due to relatively wide confidence limits, this proportion was only significantly higher than the Age 1+ hatchery proportion. Age 0+ hatchery fish were captured in significantly higher proportion than Age 1+ and in significantly lower proportion than Age 2+ fish. Age 1+ hatchery striped bass exhibited the lowest hatchery proportion; the Age 1+ hatchery cohort was captured in significantly lower proportion than Age 0+, Age 2+ or Age 3+ cohorts. The low hatchery proportion of Age 1+ striped bass from the 1987 cohort probably reflects the abundant wild cohort and not low hatchery production or poor survival of 1987 hatchery fish. Age 0+ hatchery fish are not randomly distributed in the fall following stocking (LMS 1989). Furthermore, we have no evidence that Age 0+ striped bass become randomly distributed during the first winter after stocking. Therefore, the proportion of Age 0+ is considered the least reliable estimate, and the hatchery proportion in 1988-89 for the

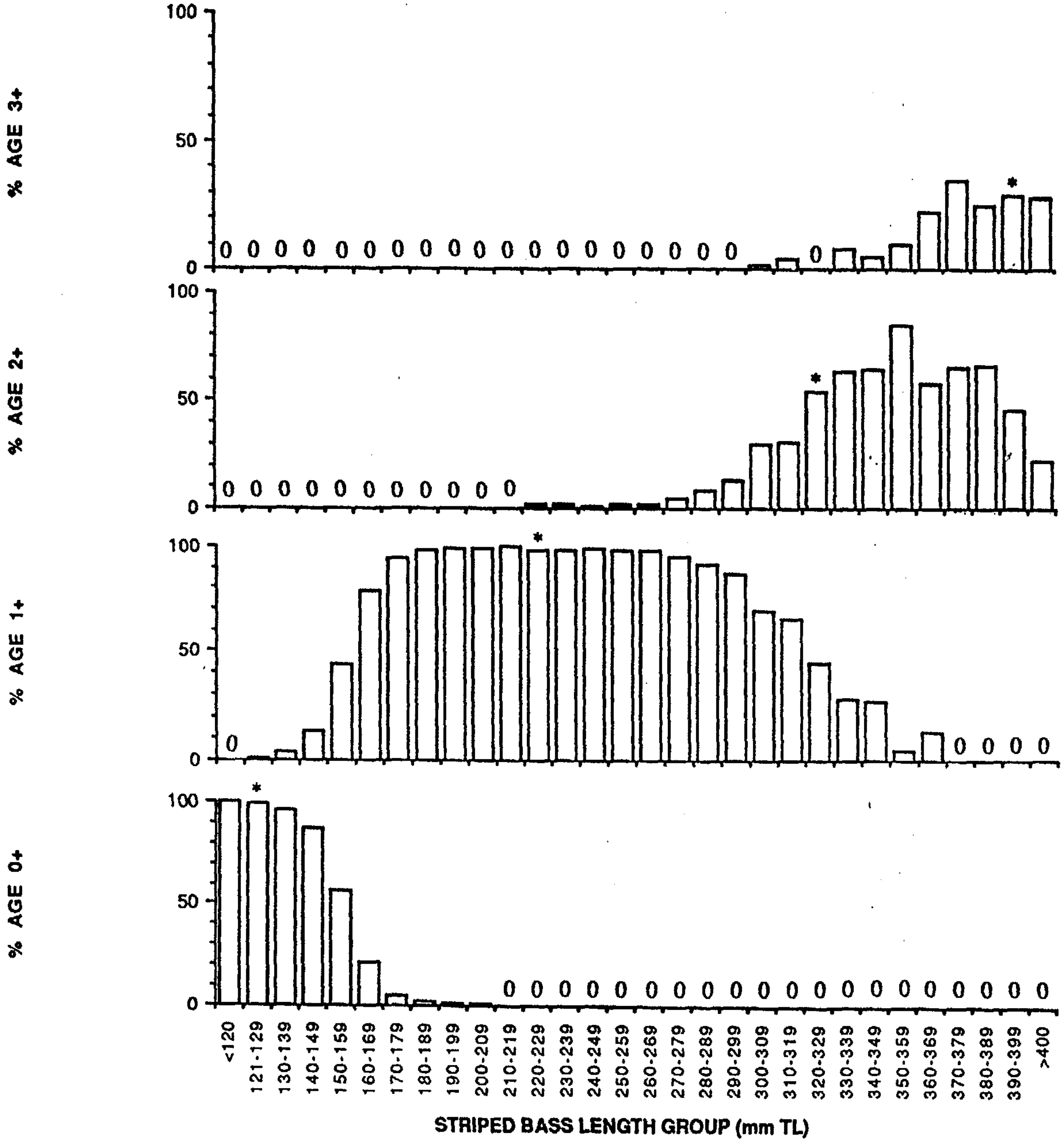

Figure 3-4. Standardized age frequency by length distribution for age 0+, 1+, and 3+ striped bass captured by a 9 m trawl in the lower Hudson River estuary, 31 October 1988 through 15 April 1989. (Note: Length group which contains the stratified mean length at age is marked with an *.)

TABLE 3-12. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

STATISTIC	COHORT			
	1988	1987	1986	1985
Age	0+	1+	2+	3+
Total Hatchery Stocking (N_i)	48,611	324,579	529,563	284,578
Hatchery Recaptures (H_i)	120	39	48	6
Adjusted Hatchery Recaptures (H_{ai})	124	47	53	7
Wild Fish Examined (W_i)	7,868	22,893	1,454	290
Estimated Hatchery Proportion ($H_{ai}/(H_{ai}+W_i)$)	0.0155	0.0020	0.0352	0.0236
Lower 95% C.I.	0.0127	0.0014	0.0245	0.0075
Upper 95% C.I.	0.0187	0.0028	0.0500	0.0646

1985, 1986 and 1987 cohorts of Age 1+, Age 2+ and Age 3+ striped bass should be considered more accurate estimates.

It is not clear at this time which age from Age 1 to Age 3+ provides the most reliable estimate of the proportion of hatchery striped bass for any year class. However, comparing estimated hatchery proportions for the 1984 through 1988 hatchery cohorts caught in 1986-87, 1987-88 and 1988-89, the data suggests that the hatchery proportion for each cohort has doubled as the cohort increases in age from Age 1+ to Age 2+ (Table 3-13). The 1985 cohort had an estimated hatchery proportion of 1.6% at Age 1+ in 1986-87 and 3.1% at Age 2+ in 1987-88. The 1986 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1987-88 and 3.5% at Age 2+ in 1988-89. In contrast with doubling between Age 1+ and Age 2+, the hatchery proportion for each cohort has remained constant as the cohort increased in age from Age 0+ to Age 1+, and from Age 2+ to Age 3+ (Table 3-13). This doubling of the hatchery proportion between Age 1+ and Age 2+ suggests 1) Age 1+ or Age 2+ hatchery striped bass may not be randomly distributed with respect to the wild population during the sampling period, 2) hatchery fish may exhibit higher survival than wild fish between Age 1+ and Age 2+, or 3) gear size selectivity may have differentially affected the catch of Age 1+ and Age 2+ hatchery and wild fish. Insufficient data presently exists to substantiate the existence of this pattern and permit evaluation of either the hypothesis that Age 1+ and Age 2+ hatchery fish may not be randomly mixed or the hypothesis of differential survival of hatchery and wild fish between Age 1+ and Age 2+. With respect to gear selectivity, comparison of the length frequency differences of the catch of striped bass in both the 9 m trawl and 9 m trawl with a fine mesh liner during the 1986-87 program (NAI 1987) indicated a significant difference existed in the catch of fish <200 mmTL (χ^2 = 26.6, P = 0.014). This difference was primarily due to fewer fish caught by the 9 m trawl in the 100-109 mmTL group, which suggests striped bass less than 110 mmTL may not be fully recruited to the 9 m trawl. However, Age 1+ and Age 2+ hatchery and wild striped bass are substantially larger than 110 mmTL.

TABLE 3-13. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY RELEASE COHORT IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER DURING WINTERS OF 1986-87, 1987-88 AND 1988-89.

COHORT	ESTIMATED PROPORTION WITH LOWER OR UPPER 95% CONFIDENCE LIMITS								
	1986-87			1987-88			1988-89		
	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER
1988							0.0127	0.0155	0.0187
1987				0.0015	0.0023	0.0033	0.0014	0.0020	0.0028
1986	0.0102	0.0142	0.0193	0.0138	0.0165	0.0196	0.0245	0.0352	0.0500
1985	0.0117	0.0159	0.0212	0.0240	0.0311	0.0399	0.0075	0.0236	0.0646
1984	0.0004	0.0012	0.0026	0.0011	0.0034	0.0081		0.0000	

In fact, no striped bass less than 129 mmTL have ever been caught among the estimated 12,708 Age 1+ and 4,554 Age 2+ fish caught in the 1985 and 1986 cohorts.

Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 0+ 1988 cohort to 0.4% for Age 1+ fish from the 1987 cohort (Table 3-14). The unusually high proportion of Age 0+ fish may be related to their non-random distribution (LMS 1989) or to stocking a portion of the fish at a larger size (EA 1989). Tracking this cohort in subsequent years may provide additional insight.

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

In this section, the size range, distribution and recapture patterns of striped bass are described. During the 1988-89 program recaptures were made of: 1) hatchery striped bass which were tagged with a CWT and 2) wild striped bass that were individually tagged with an internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

TABLE 3-14. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY RELEASE COHORT IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1986-87, 1987-88 AND 1988-89, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH.

COHORT	SCALED PROPORTION WITH LOWER OR UPPER 95% CONFIDENCE LIMITS[a]								
	1986-87			1987-88			1988-89		
	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER
1988							0.1540	0.1628	0.1722
1987				0.0031	0.0042	0.0055	0.0029	0.0038	0.0047
1986	0.0115	0.0158	0.0211	0.0157	0.0186	0.0219	0.0282	0.0366	0.0554
1985	0.0265	0.0329	0.0405	0.0526	0.0634	0.0760	0.0202	0.0484	0.1014
1984	0.0031	0.0049	0.0074	0.0080	0.0135	0.0218		0.0000	

[a]Estimated hatchery proportion scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-2, and the following formula:

$$\left[H_{ai} \times 600000/N_i\right] / \left[(H_{ai} \times 600000/N_i) + W_i\right]$$

3.4.1 Hatchery-Tagged Striped Bass

During the 1988-89 winter sampling program, 120 Age 0+, 39 Age 1+, 48 Age 2+, and 6 Age 3+ hatchery striped bass were caught. One 307 mmTL Age 2+ hatchery striped bass was recaptured on 1 April 1989 in the Battery region at River Mile 9. This fish originated from the U.S. Fish and Wildlife Service Hatchery in Virginia.

3.4.1.1 Length

Mean length of Age 1+ hatchery striped bass was significantly smaller than for wild Age 1+ striped bass, but Age 0+ hatchery striped bass were significantly larger than Age 0+ wild striped bass captured during the 1988-89 program (Table 3-15). Age 1+ (1987 cohort) hatchery striped bass averaged 20 mmTL smaller than wild striped bass, and Age 0+ (1988 cohort) hatchery striped bass averaged 20 mmTL larger than wild fish of the same cohort.

Proportional differences in mean length at age between the 1986 hatchery and wild cohorts appeared to decrease as the cohorts grew older (Table 3-16). The 1986 hatchery cohort was 16% smaller than the wild cohort at Age 0+, 13% smaller at Age 1+, and 4% smaller at Age 2+. In contrast, there was no significant difference between mean length at Age 0+ for the 1987 hatchery and wild cohorts, but when these cohorts reached Age 1+, the 1987 wild cohort was significantly (9%) larger than the hatchery cohort. The lack of a significant difference in mean length at Age 0+ between the 1987 hatchery and wild cohorts could be due to the incomplete recruitment of Age 0+ striped bass to the capture gear, since fish less than 110 mmTL are probably not completely recruited to trawls with cod end mesh larger than 2.5cm stretch (NAI 1987).

TABLE 3-15. COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+, 1+, 2+, AND 3+ WILD AND HATCHERY STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mmTL)	LOWER 95% CI	UPPER 95% CI	N	MEAN (mmTL)	LOWER 95% CI	UPPER 95% CI
0+	1988	1007	121.2	117.3	125.1	120	131.5	128.1	134.8
1+	1987	3623	227.0	225.6	228.5	39	206.9	196.4	217.4
2+	1986	361	324.5	317.5	331.4	48	311.6	301.2	322.0
3+	1985	57	396.2	377.7	414.6	6	359.3	321.8	396.9

In contrast to all other hatchery and wild cohorts, the 1988 hatchery cohort was significantly larger at Age 0+ than the wild cohort (Table 3-16). Furthermore, the 1988 hatchery cohort was significantly larger at Age 0+ than all other hatchery cohorts. This larger mean size at Age 0+ of the 1988 hatchery cohort is probably due to the different conditions under which the 1988 hatchery cohort was released to the Hudson River. Two size groups of Age 0+ hatchery striped bass were stocked into the Hudson River in 1988 (EA 1989). The Verplanck Hatchery supplied 44,799 fish with a modal size of 130 mmTL, and an additional 3,812 fish were reared from fry at the Attleboro National Fish Hatchery and stocked into the Hudson River at a modal size of 80 mmTL (EA 1989). Fish were also stocked later in the year (late September through November 1988) than in previous hatchery programs (EA 1989). Therefore, stocking of primarily large fish from the Verplanck Hatchery during 1988 probably resulted in the recapture of Age 0+ hatchery fish during 1988-89 with a larger average size than for any previous hatchery cohort. It remains to be seen if this difference in mean length at Age 0+ for the 1988 hatchery and wild cohorts will persist at older ages.

3.4.1.2 Magnetic Tag Detection Efficiency

Among the 32,975 striped bass examined by the field magnetic tag detector in the 1988-89 program, 218 fish were classified as Hudson River hatchery striped bass, 213 of these suspected hatchery recaptures were verified as having CWTs from the Verplanck hatchery present (Appendix Table D-1). Five fish were suspected of having CWTs from the Verplanck hatchery but were not verified as originating from the Verplanck hatchery. One additional fish had a CWT from a Virginia hatchery. Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson *et al.* in press).

TABLE 3-16. MEAN LENGTH AT AGE[1] FOR THE 1984, 1985, 1986, 1987 AND 1988 HATCHERY AND WILD STRIPED BASS COHORTS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER DURING 21 DECEMBER 1986 THROUGH 8 MAY 1987 (UPPER DIAGONAL), 9 NOVEMBER 1987 THROUGH 22 APRIL 1988 (MIDDLE DIAGONAL), AND 31 OCTOBER 1988 THROUGH 15 APRIL 1989 (LOWER DIAGONAL).

		MEAN LENGTH (mmTL)			
COHORT	ORIGIN	AGE 0+	AGE 1+	AGE 2+	AGE 3+
1984	HATCHERY			275.0	348.5
	WILD			298.9	367.6
1985	HATCHERY		204.6*	286.3*	359.3
	WILD		220.8*	317.2*	396.2
1986	HATCHERY	107.5*	220.3*	311.6	
	WILD	128.3*	252.8*	324.5	
1987	HATCHERY	107.8	206.9*		
	WILD	107.6	227.0*		
1988	HATCHERY	131.5*			
	WILD	121.2*			

[1]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

*Indicates a significant ($P \leq 0.05$) difference in mean length between the hatchery and wild cohorts within an age class.

To evaluate the effectiveness of the magnetic tag detectors used in the field, an extremely sensitive "tube-shaped" detector was also used in tandem with the standard "V-shaped" field detector as a quality control check on approximately 10% of the sampling days. One fish with a CWT out of 31 tagged fish escaped detection with the standard detector when 3,368 striped bass caught on randomly selected days from 31 October 1988 through 13 March 1989 were first checked with the "V-shaped" detector and then passed through the "tube" detector. On 20 March 1989, the tube detector became inoperable and from 22 March through 15 April 1989 an additional 4,796 striped bass (representing all of the fish caught in this period) were checked with two "V-shaped" detectors. All of the additional 21 suspected hatchery striped bass were detected by both detectors. Therefore, the best estimate of the non-detection rate during the 1988-89 program is 1/52 or 1.9%, which was used to adjust the number of hatchery recaptures in this study (Table 2-1). In 1986-87, 2 out of 15 CWT-tagged fish escaped detection for a nondetection rate of 13.3%. The average nondetection rate of CWTs for the studies prior to 1988-89 was 2/26 or 7.7%.

3.4.1.3 Stocking Check

Striped bass stocked from the Hudson River striped bass hatchery apparently exhibit a characteristic growth pattern that differentiates them from wild striped bass (Humphreys *et al.* in press). This growth pattern is reflected in the spacing of the circuli on their scales. Circuli on the scales of verified hatchery striped bass had thick, widely spaced circuli near the focus corresponding to rapid hatchery growth, followed by an abrupt growth check possibly resulting from handling, tagging, and adaptation to natural food sources after release to the river. Scales from wild fish showed more uniform circulus spacing corresponding to a more stable growth rate. To evaluate the use of this stocking check to distinguish hatchery from wild striped bass, three experienced scale readers were presented with ~~an unknown~~ sample of ~~mixed~~ Age 0+ through 3+ hatchery and wild striped bass from the 1988-89 Striped Bass Hatchery Evaluation Program. Scale samples from most of the verified striped bass recaptured from the Verplanck Hatchery (114 Age 0+, 38 Age 1+, 48 Age 2+ and 6 Age 3+ fish) were mixed with a simple random sample of scales from 298 wild striped bass.

The three scale readers were able to correctly identify 86-90% of the Age 0+ hatchery striped bass, 63-79% of the Age 1+ hatchery fish, 67-85% of the Age 2+ hatchery fish, and 33-100% of the Age 3+ hatchery fish in this sample (Table 3-17). The three scale readers were also able to correctly recognize 68-90% of the wild Age 0+ hatchery striped bass, 94-99% of the wild Age 1+ fish, 87-93% of the wild Age 2+ fish, and 80-100% of the wild Age 3+ fish. The three scale readers misclassified the source and called hatchery striped bass wild for 10-14% of the Age 0+ hatchery striped bass, 21-37% of the Age 1+ hatchery fish, 15-33% of the Age 2+ hatchery fish and 0-66% of the Age 3+ hatchery fish. Conversely, wild striped bass were assigned a hatchery source for 10-32% of the Age 0+ wild fish, 1-6% of the wild Age 1+ fish, 7-13% of the wild Age 2+ fish and 0-20% of the wild Age 3+ fish. For difficult to identify fish, scale reader A elected to not assign a source to one Age 0+ and one Age 2+ striped bass.

TABLE 3-17. NUMBER OF SCALES IDENTIFIED AS HATCHERY OR WILD SOURCE FOR AN UNKNOWN SAMPLE OF AGE 0+, 1+, 2+ AND 3+ STRIPED BASS EXAMINED INDEPENDENTLY BY THREE TECHNICIANS DURING THE 1988-89 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAM.

			IDENTIFIED SOURCE					
			PERSON A		PERSON B		PERSON C	
AGE	TRUE SOURCE	TRUE TOTAL	HATCHERY	WILD	HATCHERY	WILD	HATCHERY	WILD
0+	Hatchery	114	98	16	98	16	103	11
0+	Wild	63	19	43	12	51	6	57
		177	117[a]	59[a]	110	67	109	68
1+	Hatchery	38	29	9	24	14	30	8
1+	Wild	215	10	205	12	203	3	212
		253	39	214	36	217	33	220
2+	Hatchery	48	41	6	32	16	35	13
2+	Wild	15	2	13	1	14	1	14
		63	43[a]	19[a]	33	30	36	27
3+	Hatchery	6	6	0	2	4	6	0
3+	Wild	5	1	4	0	5	0	5
		11	7	4	2	9	6	5

[a]Person A did not classify one Age 0+ fish and one Age 2+ fish.

If the hatchery striped bass were not individually tagged with CWT, and stocking check recognition was used as the only method to identify the source and number of hatchery fish recaptured in each year, errors of assigning hatchery source to wild fish and vice versa would not be recognized and may be compounded when estimating the hatchery proportions. These errors may be relatively large when the true hatchery proportion is small (less than 5%) as has been observed for all hatchery cohorts recaptured since 1984 (Section 3.3). To evaluate the relationship between stocking check recognition and the true hatchery proportion, we calculated an estimated hatchery proportion for selected true hatchery proportions based on the results presented in Table 3-17. For example, the estimated probability of Person A correctly identifying an Age 1+ hatchery striped bass as an Age 1+ hatchery striped bass is 29/38 = 0.7632 (from Table 3-17). The estimated probability of Person A incorrectly identifying an Age 1+ wild striped bass as an Age 1+ hatchery striped bass is 10/215 = 0.0465. The estimated hatchery proportion for Age 1+ striped bass examined by Person A during 1989-90 if the true hatchery proportion was 4% is (0.04)(0.7632) + (0.96)(0.0465) = 0.0752 or about 8%.

The Age 1+ cohort of Hudson River hatchery striped bass was most consistently and accurately recognized by each of the three scale readers, followed by Age 2+ and Age 0+ (Table 3-18). Among the three scale readers, Person C was the most accurate in recognizing Age 0+, Age 1+ or Age 2+ hatchery fish, followed by Person A and Person B. For true hatchery proportions less than 5%, the estimated hatchery proportion of Age 0+ fish was substantially overestimated, primarily because many wild Age 0+ fish were identified as hatchery fish. Late stocking and grow-out of the 1988 (Age 0+) hatchery fish were the most likely factors contributing to the poor recognition of this hatchery cohort. Scales from hatchery fish stocked late in the year would not exhibit much growth after stocking before the first annulus was formed. Therefore, the stocking check would be formed in close proximity to the annulus and may not be consistently recognized. For true hatchery proportions less

TABLE 3-18. ESTIMATED PROPORTION OF STRIPED BASS BASED ON SCALE SAMPLES FROM AGE 0+, AGE 1+ AND AGE 2+ COHORTS CAPTURED DURING THE 1989-90 HUDSON RIVER HATCHERY EVALUATION PROGRAM AND EXAMINED FOR A STOCKING CHECK BY THREE TECHNICIANS (A, B OR C).

	ESTIMATED HATCHERY PROPORTION[a]								
TRUE HATCHERY PROPORTION	AGE 0+ A	AGE 0+ B	AGE 0+ C	AGE 1+ A	AGE 1+ B	AGE 1+ C	AGE 2+ A	AGE 2+ B	AGE 2+ C
0.01	0.31	0.20	0.10	0.05	0.06	0.02	0.14	0.07	0.07
0.02	0.31	0.20	0.11	0.06	0.07	0.03	0.15	0.08	0.08
0.03	0.32	0.21	0.12	0.07	0.07	0.04	0.15	0.08	0.09
0.04	0.32	0.22	0.13	0.08	0.08	0.05	0.16	0.09	0.09
0.05	0.33	0.22	0.14	0.08	0.08	0.05	0.17	0.10	0.10
0.10	0.36	0.26	0.18	0.12	0.11	0.09	0.21	0.13	0.13
0.15	0.39	0.29	0.22	0.15	0.14	0.13	0.24	0.16	0.17
0.20	0.41	0.32	0.26	0.19	0.17	0.17	0.28	0.19	0.20
0.30	0.47	0.39	0.34	0.26	0.22	0.25	0.35	0.25	0.27
0.40	0.52	0.46	0.42	0.33	0.29	0.32	0.42	0.31	0.33
0.50	0.58	0.53	0.50	0.40	0.34	0.40	0.49	0.37	0.40
0.64	0.66	0.62	0.61	0.51	0.42	0.51	0.59	0.45	0.50
0.76	0.73	0.70	0.71	0.59	0.50	0.60	0.68	0.52	0.58

[a]Estimated hatchery proportion = $\theta\ \hat{p}(H|H) + (1 - \theta)\ \hat{p}(H|W)$

where θ = selected true hatchery proportion,

$\hat{p}(H|H)$ = probability of a scale sample being correctly identified as originating from a hatchery fish if it was from a hatchery fish, and

$\hat{p}(H|W)$ = probability of a scale sample being incorrectly identified as originating from a hatchery fish if it was actually from a wild fish.

than 5%, Age 1+ and Age 2+ hatchery proportions were also over estimated primarily due to miss-classifying wild fish as of hatchery origin.

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1988-89 winter sampling program, 385 striped bass were recaptured out of 24,393 fish that were caught, tagged with internal anchor tags, and released. A complete description of the number of fish caught, tagged with different types of internal anchor-external streamer tags since 1984, and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 through D-13. An additional 66 striped bass were recaptured with internal anchor tags implanted during previous programs, and two fish were recaptured with illegible tag numbers. These groups of wild striped bass are described below in separate sections.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1988-89 Winter Program

The Battery region contributed nearly all (99%) of the taggable-size (≥150 mmTL) striped bass caught (25,610) and all but six of the fish tagged, released and recaptured within this study (Table 3-19, Appendix Table D-2). This is not surprising since most (97%) of the trawl sampling effort was allocated to the Battery during 1988-89 as a result of the 1985-86, 1986-87 and 1987-88 studies (NAI 1986, 1987, 1988).

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space (and/or time) frames. Recapture rates from the row totals compare the number of fish recaptured throughout the program (recaptured any time after the release date) to the number of fish released in a particular region or time period. Recapture rates from the column totals compare the number

TABLE 3-19. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

			NUMBER OF RECAPTURES[a] IN REGION		
RELEASE REGION	NUMBER MARKED (M)	STATISTIC	UPPER HARBOR (C=313)	BATTERY (C=25,297)	TOTAL (C=25,610)
UPPER HARBOR	295	R	1	5	6
		R/M	0.00339	0.01695	0.02034
		R/C	0.00319	0.00020	0.00023
BATTERY	24,098	R	0	379	379
		R/M	0.00000	0.01573	0.01573
		R/C	0.00000	0.01498	0.01480
TOTAL	24,393	R	1	384	385
		R/M	0.00004	0.01574	0.01578
		R/C	0.00319	0.01518	0.01503

[a] Excluding fish recaptured from previous sampling seasons.

LEGEND: R = number of striped bass recaptured
M = number of striped bass $\geq$150 mmTL marked and released
C = number of striped bass $\geq$150 mmTL caught and examined for tags
R/M = recapture rate
R/C = recapture proportion

of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-19, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 379/24098 or 0.01573, which also represents the recapture rate for fish tagged and released in the Battery and recaptured in all regions (row total) because fish tagged and released in the Battery were not recaptured outside of the Battery in 1988-89. The recapture rate for striped bass tagged and released throughout the study area and recaptured in the Battery (column total) was 384/24,393 or 0.01574.

In contrast, recapture proportions (R/C) from row totals compare the number of fish recaptured in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the column totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-19, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 379/25,297 or 0.01498, which also represents the recapture proportion for fish recaptured in the Battery compared to all fish examined for tags throughout the program (row total) because fish tagged and released in the Battery were not recaptured outside of the Battery in 1988-89. The recapture proportion for striped bass from the entire study area that were recaptured in the Battery (column total) was 384/25,297 or 0.01518. It is generally most informative to examine recapture rates from the row totals and recapture proportions from the column totals since these statistics best describe specific movement among regions (or time periods).

Striped bass monthly recapture rates (R/M row totals) exhibited a general decreasing trend from November 1988 through April 1989 in the combined upper New York harbor and Battery regions (Table 3-20). Monthly recapture rates declined from 0.03494 in November 1988 to 0.00520 in April 1989, but were similar in December 1988 and January 1989, and in February and March 1989. Monthly recapture proportions

TABLE 3-20. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY A 9 m TRAWL IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

RELEASE MONTH	STATISTIC	NUMBER MARKED (M)	NUMBER OF RECAPTURES IN MONTH[a] NOVEMBER (C=2,420)	DECEMBER (C=5,403)	JANUARY (C=4.595)	FEBRUARY (C=5,694)	MARCH (C=4,429)	APRIL (C=3,069)	TOTAL (C=25,610)
November	R	2,318	40	16	3	10	6	6	81
	R/M		0.01726	0.00690	0.00129	0.00431	0.00259	0.00259	0.03494
	R/C		0.01653	0.00296	0.00065	0.00185	0.00135	0.00196	0.00316
December	R	5,093		38	19	15	9	11	92
	R/M			0.00746	0.00373	0.00295	0.00177	0.00216	0.01806
	R/C			0.00703	0.00413	0.00263	0.00203	0.00358	0.00359
January	R	4,416			46	22	14	8	90
	R/M				0.01042	0.00498	0.00317	0.00181	0.02038
	R/C				0.01001	0.00386	0.00316	0.00261	0.00351
February	R	5,487				28	26	10	64
	R/M					0.00510	0.00474	0.00182	0.01166
	R/C					0.00492	0.00587	0.00326	0.00250
March	R	4,192					30	13	43
	R/M						0.00716	0.00310	0.01026
	R/C						0.00677	0.00424	0.00168
April	R	2,887						15	15
	R/M							0.00520	0.00520
	R/C							0.00489	0.00059
TOTAL	R	24,393	40	54	68	75	85	63	385
	R/M		0.00164	0.00221	0.00279	0.00307	0.00348	0.00258	0.01578
	R/C		0.01653	0.00999	0.01480	0.01317	0.01919	0.02053	0.01503

[a] Excluding recapture from previous sampling seasons.

LEGEND: R = Number of striped bass recaptured.
M = Number of striped bass ≥150 mmTL marked and released.
C = Number of striped bass ≥150 mmTL caught and examined for tags.
R/M = Recapture rate.
R/C = Recapture proportion.

(R/C column totals) generally increased from December 1988 through April 1989, and ranged between 0.00999 and 0.02053 in this period (Table 3-20). This pattern of similar monthly recapture rates in December through March and increasing monthly recapture proportions from December through April is similar to patterns in these statistics observed in the 1985-86, 1986-87 and 1987-88 studies (NAI 1986, 1987, 1988).

Striped bass tagged, and released in the combined Battery and upper New York harbor regions, and subsequently recaptured there were at large an average of 29 days and ranged in size between 150 mmTL and 486 mmTL (Table 3-21). Approximately 27% (103/385) of the striped bass were recaptured on the same day as they were tagged and released, and 67% (259/385) of the fish were recaptured within 30 days of release (Table 3-21), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 83% (318/385) of the striped bass were recaptured, and the maximum days at large was 149 days.

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1988-89 Winter Program

Among the 66 striped bass recaptured with internal anchor tags from previous programs, 59 were caught in the Battery and 7 were caught in the Upper Harbor region (Appendix Table D-3). Among these 66 recaptured striped bass were 61 fish with the external portion of the tag (streamer) present and 5 fish with tag number obtained from the anchor because no streamer was present or because the streamer legend was illegible. Among the 61 striped bass with streamers intact, 47 fish had tags with completely legible numbers, 6 fish had abraded but legible numbers, and 8 fish had the tag number abraded and partly or completely missing. (Table 3-22, Appendix Table D-4). An additional 26 fish were observed with tag wounds but no tag present (Table 3-22). Tag numbers were defined as completely illegible if one or more of the 5-digit tag number could not be read in the field. Tag abrasion was first observed

TABLE 3-21. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE LOWER HUDSON RIVER BY A 9 m TRAWL, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

STATISTIC		RELEASED WITHIN THE 1988-89 PROGRAM 9 m TRAWL
NUMBER TAGGED (≥150 mmTL)	M	24,393
NUMBER EXAMINED FOR TAGS (≥150 mmTL)	C	25,610
NUMBER RECAPTURED	R	385
SIZE RANGE OF RECAPTURED FISH (mmTL)	Min	150
	Max	486
	Mean	225
	S.D.	43
DAYS AT LARGE	Min	0
	Max	149
	Mean	28
	S.D.	36
FREQUENCY OF DAYS AT LARGE	0 Days	103
	1-5 Days	43
	6-10 Days	34
	11-20 Days	41
	21-30 Days	38
	31-40 Days	20
	41-50 Days	28
	51-60 Days	11
	61-70 Days	14
	71-80 Days	10
	81-90 Days	8
	91-100 Days	9
	101-110 Days	7
	111-120 Days	5
	121-130 Days	8
	131-140 Days	5
	≥ 141 Days	1

TABLE 3-22. INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH[a]
Tag number completely legible	Healed	34
	Infected	13
	Anchor Protruding	(5)
		47
Tag number abraded but legible	Healed	3
	Infected	3
	Anchor Protruding	(1)
		6
Tag number partly or completely missing and not legible	Healed	5
	Infected	3
	Anchor Protruding	(0)
		8
Tag wound only, tag and anchor missing	Healed	16
	Infected	0
		16
Tag wound, anchor present	Healed	9
	Infected	1
		10

[a]striped bass which could be cross-classified by degree of tag number abrasion and condition of the tag insertion site.

during 1986-87, is time dependent, and requires at least 6 months to be observed (Mattson *et al.* in press, NAI 1987, 1988). Unfortunately, without the complete tag number, it is impossible to determine in which of the previous programs the fish was released. Fortunately, only 8/68 or 11.8% of the recaptured, tagged fish that were released prior to the winter 1988-89 program had illegible tag numbers (assuming all fish with illegible tags originated from programs prior to 1988-89), although 14/68 or 20.6% of these fish exhibited some degree of tag number abrasion. The proportion of fish recaptured with illegible tag numbers was similar to the proportion observed during the 1987-88 program (NAI 1988). However, the proportion of recaptured fish with abraded tag numbers was higher than observed during the 1987-88 program (11.9% abraded, NAI 1988), and probably represents the accumulation of fish with abraided tags from several years of the program. Fortunately, fish recaptured with abraded tag numbers that had been released during and after the 1986-87 program had tag numbers printed on the anchor. By sacrificing these fish and examining the anchor, we could determine the release information for all but two fish.

The 26 striped bass observed with wounds at the tag insertion site (Table 3-22) may have originated in three ways. First, the tag could have been removed by a fisherman and mailed to the Hudson River Foundation (HRF) address on the tag legend. This may be a common method of tag loss since more than 700 tags have been mailed to the HRF annually (HRF 1985). In the 1988-89 program, all of the 26 fish with tag wounds were sacrificed, and subsequent laboratory examination revealed the anchor was present on 38% (10/26) of these fish. Second, the tag may have been shed. An indication that tag shedding can occur is seen in the incidence of fish caught with some degree of anchor protrusion. Nine percent (6/68) of the striped bass recaptured with tags from previous programs exhibited some degree of anchor protrusion (Table 3-22). Typically only the anterior edge of the internal anchor was exposed, but for two fish the entire anchor was protruding through the body wall at a point anterior to the insertion site. With the entire anchor protruding, the tag was attached to the fish by a thin loop of abdominal musculature in the body wall and could easily be caught on weeds or other material and dislodged. Finally, natural wounds can occur at the tag insertion site.

Forty-eight of the 66 striped bass recaptured during the 1988-89 program were tagged and released during 1987-88, 12 recaptured fish were tagged and released during 1986-87, and the remaining 6 fish were tagged and released during 1985-86 (Table 3-23, Appendix Table D-3). However, with the apparent time dependence of tag abrasion, it is possible that fish from the 1984 program were recaptured with illegible tag numbers and could not be identified. Among the 48 fish recaptured from 1987-88, 29 had been released from the 9 m trawl, and 19 were released from the 12 m trawl with 9 m trawl cod end. Among the 12 striped bass recaptured from 1986-87, 5 were tagged and released from the 9 m trawl, 3 from the 9 m trawl with cod-end liner, 1 from the 12 m trawl, and 3 from the 12 m trawl with cod-end liner. Among the 6 fish recaptured from 1985-86, 4 were tagged and released from the 12 m trawl and 1 was released frome ach of the 9 m trawl and Jackson seine. Recaptured fish were at large between 223 and 1,061 days, and ranged in length between 240 mmTL and 978 mmTL (Table 3-24). Mean length of recaptured striped bass was highest for fish tagged and released from the Scottish seine (one fish, 978 mmTL) and was similar for fish tagged and released among the four trawls. Recapture rates (R/M) were similar within each release year for each gear (Table 3-23).

3.5 STRIPED BASS POPULATION SIZE

One objective of the 1988-89 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. Section 3.4 indicated that the striped bass population in the Upper Harbor and Battery regions of the Hudson River was apparently closed to major immigration and emigration during most of December 1988 through April 1989. Therefore, closed population mark-recapture estimators were examined to estimate the size

TABLE 3-23. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN RELEASE YEARS PRIOR TO, AND RECAPTURED IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED(R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH			
					MIN	MAX	MEAN	S.D.
1987-88	9 m trawl	7,582	29	0.00382	240	523	346	66
	12 m trawl with 9 m trawl cod end	4,854	19	0.00391	246	410	328	48
	TOTAL	12,436	48	0.00386				
1986-87	9 m trawl	3,724	5	0.00134	342	416	379	34
	12 m trawl	1,980	1	0.00051	499	499	499	
	9 m trawl with liner	1,625	3	0.00185	325	365	338	23
	12 m trawl with liner	2,059	3	0.00146	388	419	403	16
	TOTAL	9,388	12	0.00128				
1985-86	9 m trawl	6,366	1	0.00016	410	410	410	
	12 m trawl	7,265	4	0.00055	458	498	471	19
	Jackson seine	4,856	1	0.00021	390	390	390	
	TOTAL	18,487	6	0.00032				

TABLE 3-24. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO, AND RECAPTURED IN THE LOWER HUDSON RIVER, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

		RELEASED PRIOR TO 31 OCTOBER 1988 IN GEAR					
STATISTIC		9 m TRAWL[a]	9 m TRAWL WITH LINER[b]	12 m TRAWL[c]	12 m TRAWL WITH LINER	12 m TRAWL WITH 9 m TRAWL COD END[d]	SCOTTISH SEINE[e]
TOTAL NUMBER TAGGED	M	17,672	1,625	9,245	2,059	4,854	4,856
NUMBER AGE 2+ OR OLDER EXAMINED FOR TAGS	C	2,055	2,055	2,055	2,055	2,055	2,055
NUMBER RECAPTURED	R	35	3	5	3	19	1
RECAPTURE RATE	R/M	0.00198	0.00185	0.00054	0.00146	0.00391	0.00021
RECAPTURE PROPORTION	R/C	0.01703	0.00146	0.00243	0.00146	0.00925	0.00049
LENGTH OF RECAPTURED FISH (mmTL)	Min	240	325	458	388	246	978
	Max	523	365	499	419	410	978
	Mean	350	338	477	403	328	978
	S.D.	64	23	21	16	48	-
DAYS AT LARGE	Min	223	573	786	708	240	390
	Max	1,141	677	1,061	789	480	390
	Mean	402	615	984	742	358	390
	S.D.	181	55	117	42	65	-

continued

TABLE 3-24. (Continued)

STATISTIC		RELEASED PRIOR TO 31 OCTOBER 1988 IN GEAR					
		9 m TRAWL[a]	9 m TRAWL WITH LINER[b]	12 m TRAWL[c]	12 m TRAWL WITH LINER[b]	12 m TRAWL WITH 9 m TRAWL COD END[d]	SCOTTISH SEINE[e]
FREQUENCY OF DAYS AT LARGE	151-200 Days	0				0	
	201-250 Days	2				1	
	251-300 Days	6				3	
	301-350 Days	8				2	
	351-400 Days	12				8	
	401-450 Days	1				3	
	451-500 Days	0				2	
	501-550 Days	0	0	0	0		
	551-600 Days	2	2	0	0		
	601-650 Days	0	0	0	0		
	651-700 Days	1	1	0	0		
	701-750 Days	2	0	0	2		
	751-800 Days	0	0	1	1		
	801-850 Days	0	0	0	0		
	851-900 Days	0		0			0
	901-950 Days	0		0			0
	951-1000 Days	0		1			1
	1001-1050 Days	0		0			0
	1051-1100 Days	0		3			0
	1101-1150 Days	1		0			0

[a]Contains fish tagged and released in the 1985-1986, 1986-87 and 1987-88 programs.
[b]Contains fish tagged and released in the 1986-87 program.
[c]Contains fish tagged and released in the 1985-86 and 1986-87 programs.
[d]Contains fish tagged and released in the 1987-88 program.
[e]Contains fish tagged and released in the 1985-86 program.

of the striped bass population. The estimators examined were: Petersen, Bailey's single catch, least squares, inverse sampling technique with and without replacement, Schnabel, Schumacher-Eschmeyer, inverse Schnabel, sequential Schnabel and Overton (Ricker 1985; Seber 1982; MMES 1986). The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently. This estimator was effectively used during 1985-86, 1986-87 and 1987-88 to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) mortality is negligible for tagged and untagged bass,
2) tagging does not affect bass catchability,
3) tagged bass do not lose their marks,
4) all tags are recognized and reported,
5) natural marking does not occur or is recognizable,
6) immigration, emigration, and recruitment are negligible in the study area i.e., the population is closed,
7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions, and
8) marked fish have the same probability of being caught.

With regard to Assumption 1, Dunning *et al.* (1987) observed no difference in mortality between tagged and untagged striped bass retained 1) in the Hudson River for 24 hours and 2) in holding pools for up to 180 days. For the purposes of obtaining a mark-recapture population estimate, mortality during the estimation period was assumed to be zero.

Differential vulnerability of tagged and untagged striped bass during the winter (assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1989) which would provide evidence of tag loss. QA/QC procedures (NAI 1989) and audits provide documentation that miss-identification or non-reporting of tags by field crews did not occur. Dunning *et al.* (1987) found 97.7% retention of internal anchor tags of to 180 days in holding pools. Based on a 2.3% loss rate (Dunning *et al.* 1987) and a recapture rate of 385 fish out of 24,393 tagged fish, approximately 9 fish would be expected to have lost tags in the 1988-89 program. Throughout the program, 25,610 striped bass were examined for tags and tag wounds, and 25 fish were observed with missing tags. However, 5 of these fish had the tag removed by fishermen (only the anchor was present) and these fish originated from previous programs. Therefore, it is likely that most or all of these fish with missing tags originated from previous programs since the tag wounds were all well healed. Therefore, loss of internal anchor tags for fish tagged and released during 1988-89 was considered zero in this program.

Assumption 4, the recognition and reporting of tags, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1989, Geoghegan *et al.* in press). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration (Assumption 6) was apparently negligible during most of the study period (November 1988 through April 1989) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4, NAI 1986, 1987, 1988). Examination of weekly recapture proportions plotted against the cumulative number of marked fish (Figure 3-5) reveals a strong, increasing linear trend from the week of 12 December 1988 through the week of 27 March 1989 (Appendix Table D-6). This is a longer period of stability in the winter striped bass population than was observed during 1985-86 (30 December 1985 through 21 February 1986, NAI 1986), 1986-87 (21 December 1986 through 13 March 1987, NAI 1987) and 1987-88 (21 December 1987 through 9 April 1989, NAI 1988). A significant linear regression was observed (Appendix Table D-7) which forms the basis for the Schumacher-Eschmeyer closed population estimator for striped bass in upper New York harbor and the Battery and supports the assumption of random mixing of tagged and untagged striped bass (Assumption 7). Furthermore, based on a curve fitting technique which maximizes the goodness of fit to the best model, a linear model provided the best description of these data. The population may not be closed after 3 April 1989, because studies conducted during 1985-86 indicated tagged striped bass began moving from the Battery and Upper Harbor upriver into the Tappan Zee and Croton-Haverstraw regions in late-March and April (NAI 1986). If tagged fish were not randomly mixed, recapture short-term (within one season) would indicate migration or tag loss, while long-term decreasing trends would indicate mortality (TI 1981; Ricker 1975; Seber 1982).

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally

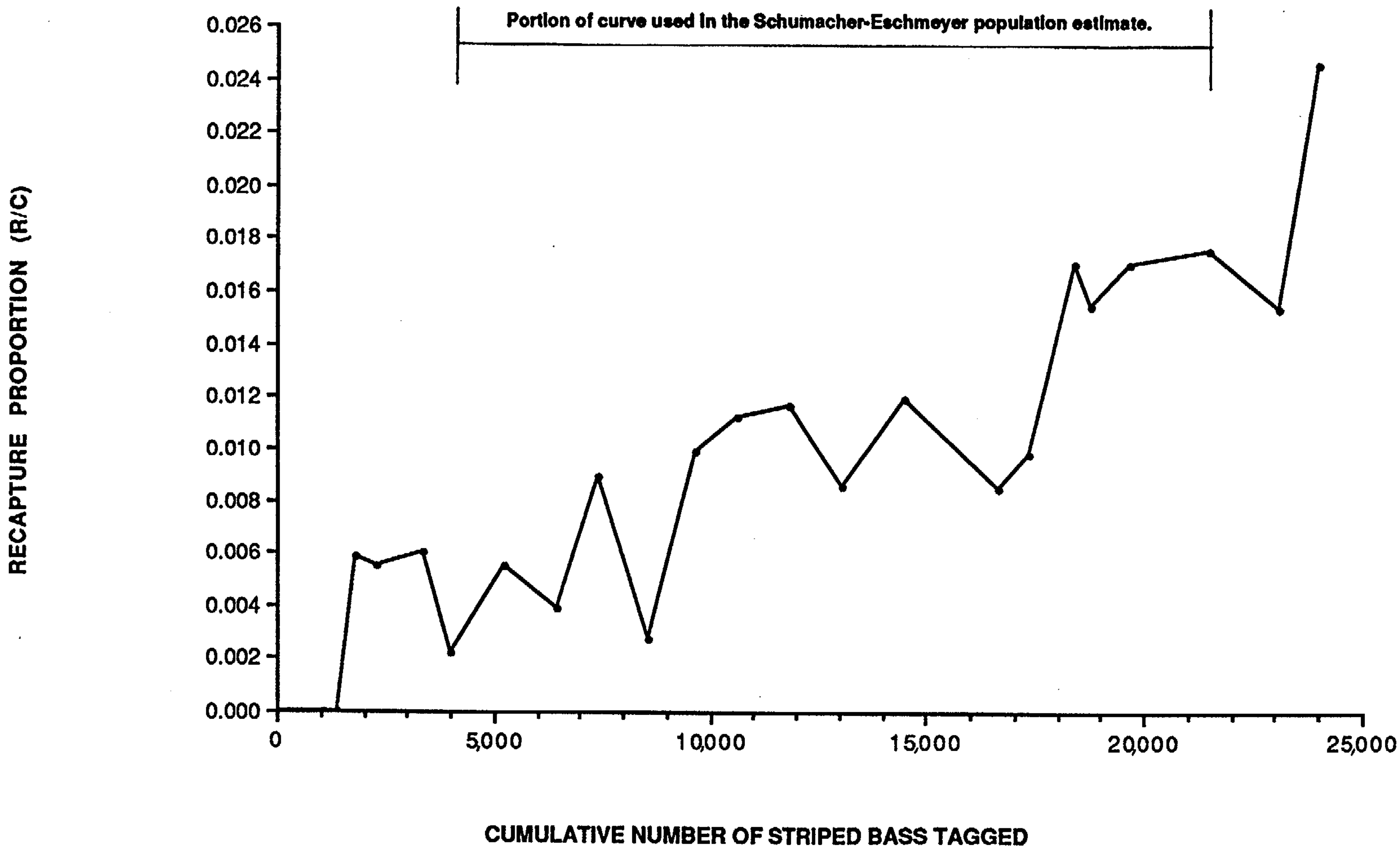

Figure 3-5. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged in the combined Upper Harbor and Battery regions of the lower Hudson River, 31 October 1988 through 15 April 1989.

applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1988-89 was 1,190,000 fish ≥ 150 mmTL, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 1,021,000 to 1,427,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25). Based on the estimated hatchery proportion of 0.2% for Age 1+ fish, 3.5% for Age 2+ fish, and 2.4% for Age 3+ fish (Section 3.3), approximately 2,000 Age 1+, and 2,500 Age 2+, and 300 Age 3+ hatchery fish were present among the striped bass overwintering in the Battery and upper New York harbor regions during winter 1988-89.

For comparison with previous surveys, the total population of striped bass ≥200 mmTL was estimated as 912,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mmTL, based on the proportion of Age 1+ and Age 2+ fish between 150 and 200 mmTL (Table 3-26). This estimate was the highest calculated since 1985-86, and compares to 295,000 fish ≥200 mmTL during the 1987-88 program (NAI 1988), 394,000 fish ≥200 mmTL during the 1986-87 program (NAI 1987), and 540,000 fish ≥200 mmTL during the 1985-86 program (NAI 1986). The abundant 1987 cohort of Age 1+ fish was the primary contributor to this relatively large estimate of Hudson River striped bass in the mid-winter population during 1988-89.

TABLE 3-25. ESTIMATED POPULATION OF STRIPED BASS ≥150 mmTL BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1988-89.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥150mmTL	PROPORTION ≥150mmTL	ESTIMATED POPULATION[a]
1+	22,932	22,756	0.9172	1,092,000
2+	1,502	1,502	0.0605	72,000
3+	296	296	0.0119	14,000
>3+	257	257	0.0104	12,000
TOTAL	24,987	24,811	1.0000	1,190,000

[a]Estimated population based on a Schumacher-Eschmeyer estimate of the number of striped bass marked, released and recaptured in the Upper Harbor and Battery regions of the Lower Hudson River from the week of 12 December 1988 through the week of 27 March 1989.

TABLE 3-26. ESTIMATED POPULATION OF STRIPED BASS ≥200 mmTL BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1988-89.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥200mmTL	PROPORTION ≥200mmTL	ESTIMATED POPULATION[a]
1+	22,932	17,108	0.8933	815,000
2+	1,502	1,489	0.0778	71,000
3+	296	296	0.0155	14,000
>3+	257	257	0.0134	12,000
TOTAL	24,987	19,150	1.0000	912,000

[a]The total population estimate based on fish ≥150 mmTL (1,190,000) was adjusted for the estimated proportion of striped bass ≥200 mmTL (19,150/24,987 = 0.7664).

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APPENDICES

APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9 m TRAWL.

	9 m TRAWL
Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6 cm (stretch) mesh polypropylene; polypropylene; 3 mm diameter twine
- cod end	3.8 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER ESTUARY DURING THE 1988-1989 STRIPED BASS PROGRAM.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY
UPPER HARBOR	07NOV88	11.88	29785	11.66	36235
	14NOV88	11.06	18395	11.16	31626
	23JAN89	4.25	35510	4.00	40192
	27FEB89	2.50	26087	3.00	38906
BATTERY	31OCT88	12.27	23759	13.14	34130
	07NOV88	11.82	23379	13.73	32372
	14NOV88	11.51	14747	11.84	28056
	21NOV88	10.11	18080	10.34	27495
	28NOV88	8.25	9924	9.57	35449
	05DEC88	7.49	20669	8.56	34658
	12DEC88	5.00	23566	6.02	34706
	19DEC88	4.34	26199	4.92	33462
	26DEC88	4.48	21913	5.04	35474
	02JAN89	3.48	23643	4.86	34571
	09JAN89	3.34	25651	3.56	30214
	16JAN89	3.92	31469	4.09	35885
	23JAN89	3.80	29950	4.05	36072
	30JAN89	4.25	21926	4.46	37613
	06FEB89	4.30	28291	4.52	31277
	13FEB89	2.90	24065	3.16	31283
	20FEB89	3.76	27708	3.80	32245
	27FEB89	2.17	17650	2.84	35253
	06MAR89	2.66	33379	2.99	36607
	13MAR89	3.43	23994	3.24	31779
	20MAR89	5.23	24231	5.17	30007
	27MAR89	6.82	11306	6.43	24344
	03APR89	7.02	13714	6.88	25115
	10APR89	8.14	5277	7.64	25811

CONDUCTIVITY IN MICRO SIEMANS PER cm^2 AT 25°C
TEMPERATURE IN °C

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER DURING WINTER, 1988-89.

STATION=UPPER HARBOR REGION

9 M TRAWL

			CPUE	
	TOWS	N	MEAN	S.E.
WEEK				
07NOV88	13	100	7.7	1.7
14NOV88	15	202	13.5	3.0
23JAN89	2	4	2.0	2.0
27FEB89	2	0	0.0	0.0
TOTAL	32	306	9.6	1.7

continued

APPENDIX TABLE C-1. (CONTINUED)

STATION=THE BATTERY REGION

9 M TRAWL

WEEK	TOWS	N	CPUE MEAN	CPUE S.E.
31OCT88	33	1514	45.9	6.8
07NOV88	57	402	7.1	1.2
14NOV88	45	318	7.1	0.8
21NOV88	52	660	12.7	1.9
28NOV88	47	1266	26.9	3.9
05DEC88	75	833	11.1	1.6
12DEC88	53	1544	29.1	4.6
19DEC88	33	1426	43.2	4.7
26DEC88	26	1134	43.6	9.0
02JAN89	25	1525	61.0	17.1
09JAN89	34	1726	50.8	4.7
16JAN89	45	2304	51.2	9.5
23JAN89	44	1821	41.4	4.4
30JAN89	61	1384	22.7	3.4
06FEB89	43	1802	41.9	4.6
13FEB89	49	2768	56.5	4.2
20FEB89	23	1126	48.9	7.2
27FEB89	51	1658	32.5	3.8
06MAR89	47	469	10.0	1.3
13MAR89	46	1340	29.1	3.7

continued

APPENDIX TABLE C-1. (CONTINUED)

STATION=THE BATTERY REGION

9 M TRAWL

			CPUE	
	TOWS	N	MEAN	S.E.
WEEK				
20MAR89	60	2144	35.7	4.2
27MAR89	60	1715	28.6	4.5
03APR89	65	1083	16.7	2.1
10APR89	77	492	6.4	0.6
TOTAL	1151	32454	28.2	1.0

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER DURING WINTER, 1988-89.

STATION=UPPER HARBOR REGION

			CPUE	
	TOWS	N	MEAN	S.E.
RIV_MILE				
2	23	235	10.2	2.2
3	9	71	7.9	2.7
TOTAL	32	306	9.6	1.7

continued

APPENDIX TABLE C-2. (CONTINUED)

STATION=THE BATTERY REGION

RIV_MILE	TOWS	N	CPUE MEAN	S.E.
1	207	6020	29.1	2.3
5	365	9206	25.2	2.1
8	305	9681	31.7	1.7
9	251	7170	28.6	1.9
10	10	349	34.9	8.6
11	13	27	2.1	0.8
TOTAL	1151	32454	28.2	1.0

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS CAPTURED AND STRIPED BASS TAGGED IN THE HUDSON RIVER CROSS-CLASSIFIED BY REGION, GEAR AND USE CODE FOR THE 9 m TRAWL, 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

REGION	GEAR	USE CODE	SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
Battery	9 m trawl	1	1,151	32,487	23,978
		2	17	171	120
		5	2	0	0
Total			1,170	32,658	24,098
Upper Harbor	9 m trawl	1	32	306	286
		2	2	11	9
		5	1	0	0
Total			35	317	295

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER DURING THE 1988-89 STRIPED BASS/ATLANTIC TOMCOD PROGRAM.

				N TOWS		NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (mm TL)											N FISH				MORTAL-ITY	
DATE	GEAR	WATER TEMP.	COND.	TOTAL	VOID	<149	150-199	200-299	300-399	400-499	500-599	600-699	700-799	800+	TOTAL	MEAN CPUE	TAG-GED	RECAP-TURED	HATCH-ERY	NOT TAGGED	N	%
31 OCT 88	9m	13.1	34130	33	0	393	185	863	68	4	1	0	0	0	1514	46	1074	33	1	13	0	0.0
7 NOV 88	9m	13.4	33079	71	0	172	47	170	61	33	17	5	2	1	508	7	322	6	0	7	1	0.2
14 NOV 88	9m	11.7	28990	65	1	142	39	231	114	40	13	2	0	0	581	9	416	5	3	12	3	0.5
21 NOV 88	9m	10.3	27495	53	0	148	79	336	73	19	5	2	0	0	662	12	491	8	3	12	0	0.0
28 NOV 88	9m	9.6	35449	47	0	177	171	778	96	31	11	2	0	0	1266	27	1043	15	8	23	0	0.0
5 DEC 88	9m	8.6	34658	79	0	192	91	406	123	31	10	1	1	0	855	11	619	9	10	25	0	0.0
12 DEC 88	9m	6.0	34706	55	0	208	202	885	236	38	8	0	0	0	1577	29	1245	12	13	94	5	0.3
19 DEC 88	9m	4.9	33462	33	1	167	198	850	172	34	6	1	0	0	1428	43	1196	21	11	29	4	0.3
26 DEC 88	9m	5.0	35474	26	0	123	219	740	50	2	0	0	0	0	1134	44	949	5	13	34	10	0.9
2 JAN 89	9m	4.9	34571	25	0	300	568	611	41	5	0	0	0	0	1525	61	1165	24	15	12	9	0.6
9 JAN 89	9m	3.6	30214	34	1	646	377	674	39	2	0	0	0	0	1738	51	1057	11	8	13	3	0.2
16 JAN 89	9m	4.1	35885	45	0	1296	580	401	22	7	0	0	0	0	2306	51	954	18	23	14	1	0.0
23 JAN 89	9m	4.0	36247	47	0	578	395	798	52	5	0	0	0	0	1828	39	1191	21	13	21	4	0.2
30 JAN 89	9m	4.5	37613	61	0	111	361	808	92	12	1	0	0	0	1385	23	1204	24	9	34	3	0.2
6 FEB 89	9m	4.5	31277	44	0	308	398	1021	81	9	2	0	0	0	1819	41	1471	17	9	12	2	0.1
13 FEB 89	9m	3.2	31283	49	0	587	548	1477	145	14	1	0	0	0	2772	57	2100	33	15	36	1	0.0
20 FEB 89	9m	3.8	32245	23	0	428	201	463	32	1	1	0	0	0	1126	49	669	10	8	9	2	0.2
27 FEB 89	9m	2.8	35388	54	0	562	318	661	103	24	3	2	0	0	1673	31	1040	22	23	25	1	0.1
6 MAR 89	9m	3.0	36607	47	0	60	109	281	17	2	0	0	0	0	469	10	382	11	1	15	0	0.0
13 MAR 89	9m	3.2	31779	47	0	393	348	575	39	4	1	0	0	0	1360	29	916	22	9	20	0	0.0
20 MAR 89	9m	5.2	30007	60	0	212	471	1371	77	7	4	1	0	1	2144	36	1826	41	11	46	8	0.4
27 MAR 89	9m	6.4	24344	61	0	74	317	1205	109	10	5	1	0	0	1721	28	1548	39	4	47	9	0.5
3 APR 89	9m	6.9	25115	65	0	114	239	648	79	4	1	0	0	0	1085	17	918	16	5	29	3	0.3
10 APR 89	9m	7.6	25811	78	0	53	121	262	52	8	3	0	0	0	499	6	412	13	4	16	1	0.2
TOTAL		6.3	32326	1202	3	7444	6582	16515	1973	346	93	17	3	2	32975	27	24208	436	219	598	70	0.2

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. RECAPTURE DATA FOR VERIFIED HATCHERY STRIPED BASS RECAPTURED DURING THE 1988-1989 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	14NOV88	BATTERY	9	121	88
0	9 M TRAWL	17NOV88	BATTERY	5	131	88
0	9 M TRAWL	21NOV88	BATTERY	5	137	88
0	9 M TRAWL	21NOV88	BATTERY	5	151	88
0	9 M TRAWL	21NOV88	BATTERY	5	137	88
0	9 M TRAWL	29NOV88	BATTERY	5	132	88
0	9 M TRAWL	29NOV88	BATTERY	5	120	88
0	9 M TRAWL	30NOV88	BATTERY	9	124	88
0	9 M TRAWL	30NOV88	BATTERY	9	115	88
0	9 M TRAWL	30NOV88	BATTERY	9	122	88
0	9 M TRAWL	30NOV88	BATTERY	9	141	88
0	9 M TRAWL	05DEC88	BATTERY	9	146	88
0	9 M TRAWL	05DEC88	BATTERY	8	123	88
0	9 M TRAWL	07DEC88	BATTERY	9	135	88
0	9 M TRAWL	08DEC88	BATTERY	1	83	88
0	9 M TRAWL	09DEC88	BATTERY	5	128	88
0	9 M TRAWL	09DEC88	BATTERY	5	125	88
0	9 M TRAWL	09DEC88	BATTERY	10	76	88
0	9 M TRAWL	09DEC88	BATTERY	9	128	88
0	9 M TRAWL	09DEC88	BATTERY	9	113	88
0	9 M TRAWL	12DEC88	BATTERY	9	148	88
0	9 M TRAWL	13DEC88	BATTERY	5	90	88
0	9 M TRAWL	14DEC88	BATTERY	5	160	88
0	9 M TRAWL	14DEC88	BATTERY	5	117	88
0	9 M TRAWL	15DEC88	BATTERY	5	145	88
0	9 M TRAWL	16DEC88	BATTERY	1	120	88
0	9 M TRAWL	20DEC88	BATTERY	1	131	88
0	9 M TRAWL	21DEC88	BATTERY	5	144	88
0	9 M TRAWL	21DEC88	BATTERY	5	123	88
0	9 M TRAWL	21DEC88	BATTERY	5	134	88
0	9 M TRAWL	22DEC88	BATTERY	1	162	88
0	9 M TRAWL	22DEC88	BATTERY	1	145	88
0	9 M TRAWL	29DEC88	BATTERY	5	120	88
0	9 M TRAWL	29DEC88	BATTERY	5	155	88
0	9 M TRAWL	29DEC88	BATTERY	5	110	88
0	9 M TRAWL	30DEC88	BATTERY	5	132	88
0	9 M TRAWL	30DEC88	BATTERY	5	137	88
0	9 M TRAWL	03JAN89	BATTERY	5	134	88
0	9 M TRAWL	03JAN89	BATTERY	5	143	88
0	9 M TRAWL	03JAN89	BATTERY	5	134	88
0	9 M TRAWL	04JAN89	BATTERY	5	171	88
0	9 M TRAWL	04JAN89	BATTERY	5	150	88
0	9 M TRAWL	04JAN89	BATTERY	5	148	88
0	9 M TRAWL	04JAN89	BATTERY	5	137	88
0	9 M TRAWL	11JAN89	BATTERY	8	78	88
0	9 M TRAWL	11JAN89	BATTERY	9	115	88
0	9 M TRAWL	12JAN89	BATTERY	8	83	88
0	9 M TRAWL	12JAN89	BATTERY	8	89	88
0	9 M TRAWL	13JAN89	BATTERY	8	140	88
0	9 M TRAWL	16JAN89	BATTERY	5	154	88
0	9 M TRAWL	16JAN89	BATTERY	5	147	88

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	16JAN89	BATTERY	5	146	88
0	9 M TRAWL	16JAN89	BATTERY	5	129	88
0	9 M TRAWL	16JAN89	BATTERY	5	142	88
0	9 M TRAWL	16JAN89	BATTERY	5	138	88
0	9 M TRAWL	16JAN89	BATTERY	5	124	88
0	9 M TRAWL	17JAN89	BATTERY	1	113	88
0	9 M TRAWL	18JAN89	BATTERY	5	134	88
0	9 M TRAWL	18JAN89	BATTERY	5	149	88
0	9 M TRAWL	18JAN89	BATTERY	5	130	88
0	9 M TRAWL	18JAN89	BATTERY	5	128	88
0	9 M TRAWL	18JAN89	BATTERY	5	128	88
0	9 M TRAWL	18JAN89	BATTERY	5	147	88
0	9 M TRAWL	18JAN89	BATTERY	5	160	88
0	9 M TRAWL	18JAN89	BATTERY	5	128	88
0	9 M TRAWL	18JAN89	BATTERY	5	135	88
0	9 M TRAWL	18JAN89	BATTERY	5	122	88
0	9 M TRAWL	23JAN89	BATTERY	5	128	88
0	9 M TRAWL	23JAN89	BATTERY	9	139	88
0	9 M TRAWL	23JAN89	BATTERY	9	162	88
0	9 M TRAWL	23JAN89	BATTERY	9	88	88
0	9 M TRAWL	24JAN89	BATTERY	8	96	88
0	9 M TRAWL	24JAN89	BATTERY	8	135	88
0	9 M TRAWL	26JAN89	BATTERY	5	148	88
0	9 M TRAWL	26JAN89	BATTERY	5	133	88
0	9 M TRAWL	26JAN89	BATTERY	5	124	88
0	9 M TRAWL	30JAN89	BATTERY	5	143	88
0	9 M TRAWL	02FEB89	BATTERY	8	127	88
0	9 M TRAWL	07FEB89	BATTERY	5	122	88
0	9 M TRAWL	09FEB89	BATTERY	5	123	88
0	9 M TRAWL	09FEB89	BATTERY	8	136	88
0	9 M TRAWL	13FEB89	BATTERY	5	153	88
0	9 M TRAWL	13FEB89	BATTERY	8	138	88
0	9 M TRAWL	13FEB89	BATTERY	9	136	88
0	9 M TRAWL	14FEB89	BATTERY	9	110	88
0	9 M TRAWL	15FEB89	BATTERY	8	130	88
0	9 M TRAWL	15FEB89	BATTERY	8	155	88
0	9 M TRAWL	15FEB89	BATTERY	8	112	88
0	9 M TRAWL	17FEB89	BATTERY	9	137	88
0	9 M TRAWL	17FEB89	BATTERY	9	140	88
0	9 M TRAWL	22FEB89	BATTERY	9	124	88
0	9 M TRAWL	22FEB89	BATTERY	9	127	88
0	9 M TRAWL	22FEB89	BATTERY	8	153	88
0	9 M TRAWL	22FEB89	BATTERY	8	134	88
0	9 M TRAWL	23FEB89	BATTERY	9	142	88
0	9 M TRAWL	27FEB89	BATTERY	5	140	88
0	9 M TRAWL	27FEB89	BATTERY	5	144	88
0	9 M TRAWL	27FEB89	BATTERY	5	139	88
0	9 M TRAWL	27FEB89	BATTERY	5	130	88
0	9 M TRAWL	28FEB89	BATTERY	5	128	88
0	9 M TRAWL	28FEB89	BATTERY	5	156	88
0	9 M TRAWL	28FEB89	BATTERY	5	151	88
0	9 M TRAWL	02MAR89	BATTERY	8	108	88
0	9 M TRAWL	03MAR89	BATTERY	9	160	88

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	03MAR89	BATTERY	8	145	88
0	9 M TRAWL	03MAR89	BATTERY	8	126	88
0	9 M TRAWL	03MAR89	BATTERY	8	117	88
0	9 M TRAWL	03MAR89	BATTERY	8	112	88
0	9 M TRAWL	03MAR89	BATTERY	8	121	88
0	9 M TRAWL	03MAR89	BATTERY	8	119	88
0	9 M TRAWL	16MAR89	BATTERY	8	130	88
0	9 M TRAWL	17MAR89	BATTERY	9	121	88
0	9 M TRAWL	20MAR89	BATTERY	8	130	88
0	9 M TRAWL	22MAR89	BATTERY	9	145	88
0	9 M TRAWL	22MAR89	BATTERY	8	138	88
0	9 M TRAWL	22MAR89	BATTERY	8	150	88
0	9 M TRAWL	05APR89	BATTERY	8	131	88
0	9 M TRAWL	06APR89	BATTERY	5	85	88
0	9 M TRAWL	12APR89	BATTERY	1	174	88
0	9 M TRAWL	13APR89	BATTERY	5	145	88
1	9 M TRAWL	18NOV88	BATTERY	1	162	87
1	9 M TRAWL	01DEC88	BATTERY	1	220	87
1	9 M TRAWL	01DEC88	BATTERY	1	180	87
1	9 M TRAWL	15DEC88	BATTERY	1	171	87
1	9 M TRAWL	21DEC88	BATTERY	5	247	87
1	9 M TRAWL	27DEC88	BATTERY	5	246	87
1	9 M TRAWL	29DEC88	BATTERY	5	174	87
1	9 M TRAWL	30DEC88	BATTERY	5	221	87
1	9 M TRAWL	03JAN89	BATTERY	5	160	87
1	9 M TRAWL	03JAN89	BATTERY	5	305	87
1	9 M TRAWL	04JAN89	BATTERY	5	199	87
1	9 M TRAWL	06JAN89	BATTERY	5	248	87
1	9 M TRAWL	09JAN89	BATTERY	5	180	87
1	9 M TRAWL	11JAN89	BATTERY	8	225	87
1	9 M TRAWL	12JAN89	BATTERY	9	202	87
1	9 M TRAWL	18JAN89	BATTERY	5	208	87
1	9 M TRAWL	19JAN89	BATTERY	5	240	87
1	9 M TRAWL	25JAN89	BATTERY	1	203	87
1	9 M TRAWL	06FEB89	BATTERY	5	220	87
1	9 M TRAWL	07FEB89	BATTERY	5	221	87
1	9 M TRAWL	08FEB89	BATTERY	10	240	87
1	9 M TRAWL	08FEB89	BATTERY	5	219	87
1	9 M TRAWL	10FEB89	BATTERY	8	170	87
1	9 M TRAWL	17FEB89	BATTERY	9	201	87
1	9 M TRAWL	17FEB89	BATTERY	9	168	87
1	9 M TRAWL	23FEB89	BATTERY	9	202	87
1	9 M TRAWL	23FEB89	BATTERY	9	205	87
1	9 M TRAWL	28FEB89	BATTERY	5	223	87
1	9 M TRAWL	01MAR89	BATTERY	8	198	87
1	9 M TRAWL	14MAR89	BATTERY	5	178	87
1	9 M TRAWL	15MAR89	BATTERY	9	165	87
1	9 M TRAWL	16MAR89	BATTERY	9	200	87
1	9 M TRAWL	23MAR89	BATTERY	8	187	87
1	9 M TRAWL	23MAR89	BATTERY	8	210	87
1	9 M TRAWL	29MAR89	BATTERY	8	200	87
1	9 M TRAWL	03APR89	BATTERY	9	247	87
1	9 M TRAWL	04APR89	BATTERY	8	194	87

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL	05APR89	BATTERY	8	160	87
1	9 M TRAWL	13APR89	BATTERY	5	270	87
2	9 M TRAWL	01NOV88	BATTERY	1	369	86
2	9 M TRAWL	07DEC88	BATTERY	1	299	86
2	9 M TRAWL	13DEC88	BATTERY	5	295	86
2	9 M TRAWL	15DEC88	BATTERY	1	333	86
2	9 M TRAWL	16DEC88	BATTERY	1	315	86
2	9 M TRAWL	16DEC88	BATTERY	1	355	86
2	9 M TRAWL	20DEC88	BATTERY	1	288	86
2	9 M TRAWL	22DEC88	BATTERY	1	310	86
2	9 M TRAWL	22DEC88	BATTERY	1	321	86
2	9 M TRAWL	27DEC88	BATTERY	5	320	86
2	9 M TRAWL	27DEC88	BATTERY	5	326	86
2	9 M TRAWL	27DEC88	BATTERY	5	375	86
2	9 M TRAWL	30DEC88	BATTERY	5	373	86
2	9 M TRAWL	04JAN89	BATTERY	5	289	86
2	9 M TRAWL	06JAN89	BATTERY	5	291	86
2	9 M TRAWL	06JAN89	BATTERY	5	310	86
2	9 M TRAWL	16JAN89	BATTERY	5	243	86
2	9 M TRAWL	17JAN89	BATTERY	1	313	86
2	9 M TRAWL	20JAN89	BATTERY	9	325	86
2	9 M TRAWL	25JAN89	BATTERY	1	355	86
2	9 M TRAWL	25JAN89	BATTERY	1	328	86
2	9 M TRAWL	25JAN89	BATTERY	1	342	86
2	9 M TRAWL	30JAN89	BATTERY	8	268	86
2	9 M TRAWL	31JAN89	BATTERY	1	305	86
2	9 M TRAWL	01FEB89	BATTERY	8	320	86
2	9 M TRAWL	01FEB89	BATTERY	8	290	86
2	9 M TRAWL	01FEB89	BATTERY	8	346	86
2	9 M TRAWL	01FEB89	BATTERY	8	265	86
2	9 M TRAWL	02FEB89	BATTERY	8	347	86
2	9 M TRAWL	08FEB89	BATTERY	10	290	86
2	9 M TRAWL	14FEB89	BATTERY	8	384	86
2	9 M TRAWL	15FEB89	BATTERY	8	203	86
2	9 M TRAWL	17FEB89	BATTERY	9	320	86
2	9 M TRAWL	23FEB89	BATTERY	9	278	86
2	9 M TRAWL	01MAR89	BATTERY	8	301	86
2	9 M TRAWL	01MAR89	BATTERY	8	306	86
2	9 M TRAWL	03MAR89	BATTERY	8	330	86
2	9 M TRAWL	03MAR89	BATTERY	8	277	86
2	9 M TRAWL	03MAR89	BATTERY	8	329	86
2	9 M TRAWL	03MAR89	BATTERY	8	295	86
2	9 M TRAWL	10MAR89	BATTERY	8	354	86
2	9 M TRAWL	16MAR89	BATTERY	8	300	86
2	9 M TRAWL	16MAR89	BATTERY	8	308	86
2	9 M TRAWL	16MAR89	BATTERY	8	285	86
2	9 M TRAWL	17MAR89	BATTERY	8	300	86
2	9 M TRAWL	20MAR89	BATTERY	1	325	86
2	9 M TRAWL	27MAR89	BATTERY	8	318	86
2	9 M TRAWL	29MAR89	BATTERY	8	236	86
3	9 M TRAWL	15DEC88	BATTERY	1	365	85
3	9 M TRAWL	22DEC88	BATTERY	1	290	85
3	9 M TRAWL	15FEB89	BATTERY	8	370	85

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
3	9 M TRAWL	20MAR89	BATTERY	1	392	85
3	9 M TRAWL	22MAR89	BATTERY	8	390	85
3	9 M TRAWL	23MAR89	BATTERY	8	349	85

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED DURING AND RECAPTURED DURING. THE 1988-1989 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE GEAR	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
01NOV88	9 M TRAWL	210	BT	1	2	01NOV88	9 M TRAWL	211	BT	1	2	0	0	0	1	258068
02NOV88	9 M TRAWL	272	BT	1	2	02NOV88	9 M TRAWL	273	BT	1	2	0	0	0	1	258275
02NOV88	9 M TRAWL	234	BT	1	2	02NOV88	9 M TRAWL	239	BT	1	2	0	0	0	1	258282
02NOV88	9 M TRAWL	220	BT	1	2	02NOV88	9 M TRAWL	228	BT	1	2	0	0	0	1	258336
02NOV88	9 M TRAWL	244	BT	1	2	02NOV88	9 M TRAWL	246	BT	1	2	0	0	0	1	258389
02NOV88	9 M TRAWL	280	BT	1	2	02NOV88	9 M TRAWL	277	BT	1	2	0	0	0	1	258409
02NOV88	9 M TRAWL	180	BT	1	2	02NOV88	9 M TRAWL	178	BT	1	2	0	0	0	1	258454
03NOV88	9 M TRAWL	202	BT	1	2	01NOV88	9 M TRAWL	201	BT	1	2	2	0	0	1	258097
03NOV88	9 M TRAWL	220	BT	1	2	02NOV88	9 M TRAWL	218	BT	1	2	1	0	0	1	258229
03NOV88	9 M TRAWL	150	BT	1	2	02NOV88	9 M TRAWL	151	BT	1	2	1	0	0	1	258257
03NOV88	9 M TRAWL	227	BT	1	2	02NOV88	9 M TRAWL	229	BT	1	2	1	0	0	1	258289
03NOV88	9 M TRAWL	230	BT	1	2	02NOV88	9 M TRAWL	228	BT	1	2	1	0	0	1	258360
03NOV88	9 M TRAWL	232	BT	1	2	02NOV88	9 M TRAWL	234	BT	1	2	1	0	0	1	258363
03NOV88	9 M TRAWL	206	BT	1	2	03NOV88	9 M TRAWL	207	BT	1	2	0	0	0	1	258485
03NOV88	9 M TRAWL	173	BT	1	2	03NOV88	9 M TRAWL	178	BT	1	2	0	0	0	1	258491
03NOV88	9 M TRAWL	291	BT	1	2	03NOV88	9 M TRAWL	295	BT	1	2	0	0	0	1	258515
03NOV88	9 M TRAWL	157	BT	1	2	03NOV88	9 M TRAWL	155	BT	1	2	0	0	0	1	258519
03NOV88	9 M TRAWL	252	BT	1	2	03NOV88	9 M TRAWL	250	BT	1	2	0	0	0	1	258529
03NOV88	9 M TRAWL	232	BT	1	2	03NOV88	9 M TRAWL	234	BT	1	2	0	0	0	1	258531
03NOV88	9 M TRAWL	305	BT	1	2	03NOV88	9 M TRAWL	309	BT	1	2	0	0	0	1	258535
04NOV88	9 M TRAWL	227	BT	5	8	04NOV88	9 M TRAWL	229	BT	5	8	0	0	0	1	257016
04NOV88	9 M TRAWL	261	BT	5	8	04NOV88	9 M TRAWL	261	BT	5	8	0	0	0	1	257034
04NOV88	9 M TRAWL	219	BT	5	8	03NOV88	9 M TRAWL	217	BT	1	2	1	4	6	1	257388
04NOV88	9 M TRAWL	236	BT	5	8	04NOV88	9 M TRAWL	236	BT	5	8	0	0	0	1	257417
04NOV88	9 M TRAWL	207	BT	5	8	04NOV88	9 M TRAWL	207	BT	5	8	0	0	0	1	257427
04NOV88	9 M TRAWL	258	BT	5	8	04NOV88	9 M TRAWL	260	BT	5	8	0	0	0	1	257430
04NOV88	9 M TRAWL	259	BT	5	8	04NOV88	9 M TRAWL	260	BT	5	8	0	0	0	1	257430
04NOV88	9 M TRAWL	182	BT	5	8	04NOV88	9 M TRAWL	185	BT	5	8	0	0	0	1	257454
04NOV88	9 M TRAWL	230	BT	5	8	04NOV88	9 M TRAWL	231	BT	5	8	0	0	0	1	257489
04NOV88	9 M TRAWL	247	BT	5	8	04NOV88	9 M TRAWL	249	BT	5	8	0	0	0	1	257492
04NOV88	9 M TRAWL	211	BT	5	8	04NOV88	9 M TRAWL	211	BT	5	8	0	0	0	1	257494
04NOV88	9 M TRAWL	206	BT	5	8	31OCT88	9 M TRAWL	206	BT	5	8	4	0	0	1	258039
04NOV88	9 M TRAWL	150	BT	5	8	04NOV88	9 M TRAWL	151	BT	5	8	0	0	0	1	258557
08NOV88	9 M TRAWL	162	BT	5	8	08NOV88	9 M TRAWL	161	BT	5	8	0	0	0	1	258771
11NOV88	9 M TRAWL	355	UH	2	3	11NOV88	9 M TRAWL	355	UH	2	3	0	0	0	1	258964
17NOV88	9 M TRAWL	222	BT	5	8	17NOV88	9 M TRAWL	225	BT	5	8	0	0	0	1	260194
22NOV88	9 M TRAWL	203	BT	1	2	22NOV88	9 M TRAWL	205	BT	1	2	0	0	0	1	260446
23NOV88	9 M TRAWL	206	BT	1	2	01NOV88	9 M TRAWL	207	BT	1	2	22	0	0	2	258071
23NOV88	9 M TRAWL	243	BT	1	2	02NOV88	9 M TRAWL	242	BT	1	2	21	0	0	1	258356
23NOV88	9 M TRAWL	208	BT	1	2	03NOV88	9 M TRAWL	210	BT	1	2	20	0	0	1	258495
29NOV88	9 M TRAWL	261	BT	5	8	03NOV88	9 M TRAWL	264	BT	1	2	26	4	6	1	257355
30NOV88	9 M TRAWL	265	BT	9	14	30NOV88	9 M TRAWL	265	BT	8	13	0	1	2	1	261079
30NOV88	9 M TRAWL	253	BT	9	14	30NOV88	9 M TRAWL	253	BT	8	13	0	1	2	1	261090
30NOV88	9 M TRAWL	258	BT	9	14	30NOV88	9 M TRAWL	258	BT	9	14	0	0	0	1	261128
30NOV88	9 M TRAWL	238	BT	9	14	30NOV88	9 M TRAWL	237	BT	9	14	0	0	0	1	261138
01DEC88	9 M TRAWL	247	BT	1	2	23NOV88	9 M TRAWL	247	BT	1	2	8	0	0	1	260744
01DEC88	9 M TRAWL	238	BT	1	2	01DEC88	9 M TRAWL	237	BT	1	2	0	0	0	1	261237

(continued)

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER
01DEC88	9 M TRAWL	219	BT	1	2	01DEC88	9 M TRAWL	220	BT	1	2	0	0	0	1	261401
02DEC88	9 M TRAWL	183	BT	1	2	02NOV88	9 M TRAWL	182	BT	1	2	30	0	0	2	258245
02DEC88	9 M TRAWL	232	BT	1	2	02NOV88	9 M TRAWL	233	BT	1	2	30	0	0	1	258459
02DEC88	9 M TRAWL	203	BT	1	2	22NOV88	9 M TRAWL	203	BT	1	2	10	0	0	1	260449
02DEC88	9 M TRAWL	199	BT	1	2	22NOV88	9 M TRAWL	199	BT	1	2	10	0	0	1	260588
02DEC88	9 M TRAWL	241	BT	1	2	01DEC88	9 M TRAWL	241	BT	1	2	1	0	0	1	261395
02DEC88	9 M TRAWL	287	BT	1	2	02DEC88	9 M TRAWL	287	BT	1	2	0	0	0	1	261693
05DEC88	9 M TRAWL	257	BT	8	13	02DEC88	9 M TRAWL	257	BT	1	2	3	7	11	1	261923
07DEC88	9 M TRAWL	253	BT	9	14	29NOV88	9 M TRAWL	253	BT	5	8	8	4	6	1	261048
07DEC88	9 M TRAWL	254	BT	11	18	07DEC88	9 M TRAWL	254	BT	11	18	0	0	0	1	262195
08DEC88	9 M TRAWL	208	BT	1	2	01DEC88	9 M TRAWL	209	BT	1	2	7	0	0	1	261230
08DEC88	9 M TRAWL	283	BT	1	2	02DEC88	9 M TRAWL	284	BT	1	2	6	0	0	1	261778
08DEC88	9 M TRAWL	329	BT	1	2	08DEC88	9 M TRAWL	327	BT	1	2	0	0	0	1	262234
09DEC88	9 M TRAWL	239	BT	5	8	06DEC88	9 M TRAWL	241	BT	9	14	3	4	6	1	262089
12DEC88	9 M TRAWL	212	BT	9	14	22NOV88	9 M TRAWL	216	BT	1	2	20	8	13	1	260642
13DEC88	9 M TRAWL	260	BT	5	8	13DEC88	9 M TRAWL	261	BT	5	8	0	0	0	1	262658
13DEC88	9 M TRAWL	298	BT	5	8	13DEC88	9 M TRAWL	300	BT	5	8	0	0	0	1	262738
14DEC88	9 M TRAWL	307	BT	5	8	30NOV88	9 M TRAWL	311	BT	8	13	14	3	5	1	261075
14DEC88	9 M TRAWL	346	BT	5	8	14DEC88	9 M TRAWL	346	BT	5	8	0	0	0	1	262847
14DEC88	9 M TRAWL	262	BT	5	8	14DEC88	9 M TRAWL	263	BT	5	8	0	0	0	1	262894
15DEC88	9 M TRAWL	287	BT	5	8	03NOV88	9 M TRAWL	285	BT	1	2	42	4	6	1	257373
15DEC88	9 M TRAWL	218	BT	1	2	14DEC88	9 M TRAWL	220	BT	5	8	1	4	6	1	262925
16DEC88	9 M TRAWL	175	BT	1	2	15DEC88	9 M TRAWL	175	BT	1	2	1	0	0	1	263129
16DEC88	9 M TRAWL	237	BT	1	2	16DEC88	9 M TRAWL	239	BT	1	2	0	0	0	1	263749
19DEC88	9 M TRAWL	298	BT	8	13	22NOV88	9 M TRAWL	301	BT	1	2	27	7	11	1	260481
20DEC88	9 M TRAWL	205	BT	1	2	02NOV88	9 M TRAWL	205	BT	1	2	48	0	0	1	258195
20DEC88	9 M TRAWL	234	BT	1	2	11NOV88	9 M TRAWL	232	UH	2	3	39	3	5	1	258912
20DEC88	9 M TRAWL	222	BT	1	2	28NOV88	9 M TRAWL	221	BT	1	2	22	0	0	1	260931
20DEC88	9 M TRAWL	260	BT	1	2	15DEC88	9 M TRAWL	258	BT	1	2	5	0	0	1	263352
20DEC88	9 M TRAWL	272	BT	1	2	20DEC88	9 M TRAWL	274	BT	1	2	0	0	0	1	264113
20DEC88	9 M TRAWL	262	BT	1	2	20DEC88	9 M TRAWL	264	BT	1	2	0	0	0	1	264139
20DEC88	9 M TRAWL	330	BT	1	2	20DEC88	9 M TRAWL	332	BT	1	2	0	0	0	1	264379
21DEC88	9 M TRAWL	240	BT	5	8	21DEC88	9 M TRAWL	244	BT	5	8	0	0	0	1	264461
21DEC88	9 M TRAWL	235	BT	5	8	21DEC88	9 M TRAWL	236	BT	5	8	0	0	0	1	264546
21DEC88	9 M TRAWL	249	BT	5	8	21DEC88	9 M TRAWL	246	BT	5	8	0	0	0	1	264616
22DEC88	9 M TRAWL	238	BT	1	2	18NOV88	9 M TRAWL	238	UH	3	5	34	4	6	1	260352
22DEC88	9 M TRAWL	205	BT	1	2	22NOV88	9 M TRAWL	206	BT	1	2	30	0	0	1	260509
22DEC88	9 M TRAWL	255	BT	1	2	20DEC88	9 M TRAWL	255	BT	1	2	2	0	0	1	264198
22DEC88	9 M TRAWL	197	BT	1	2	20DEC88	9 M TRAWL	198	BT	1	2	2	0	0	1	264445
22DEC88	9 M TRAWL	233	BT	1	2	22DEC88	9 M TRAWL	233	BT	1	2	0	0	0	1	264785
22DEC88	9 M TRAWL	220	BT	1	2	22DEC88	9 M TRAWL	220	BT	1	2	0	0	0	1	264799
22DEC88	9 M TRAWL	194	BT	1	2	22DEC88	9 M TRAWL	194	BT	1	2	0	0	0	1	264971
27DEC88	9 M TRAWL	253	BT	5	8	04NOV88	9 M TRAWL	250	BT	5	8	53	0	0	1	258576
27DEC88	9 M TRAWL	260	BT	5	8	07NOV88	9 M TRAWL	260	BT	5	8	50	0	0	1	258685
28DEC88	9 M TRAWL	206	BT	5	8	04NOV88	9 M TRAWL	206	BT	5	8	54	0	0	1	258652
28DEC88	9 M TRAWL	202	BT	5	8	16DEC88	9 M TRAWL	201	BT	1	2	12	4	6	1	263813
28DEC88	9 M TRAWL	206	BT	5	8	28DEC88	9 M TRAWL	206	BT	5	8	0	0	0	1	265388

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE						RELEASE										
DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER
03JAN89	9 M TRAWL	187	BT	5	8	04NOV88	9 M TRAWL	186	BT	5	8	60	0	0	1	257045
03JAN89	9 M TRAWL	192	BT	5	8	28DEC88	9 M TRAWL	192	BT	5	8	6	0	0	1	265437
03JAN89	9 M TRAWL	194	BT	5	8	28DEC88	9 M TRAWL	194	BT	5	8	6	0	0	1	265470
03JAN89	9 M TRAWL	175	BT	5	8	28DEC88	9 M TRAWL	174	BT	5	8	6	0	0	1	265472
03JAN89	9 M TRAWL	199	BT	5	8	28DEC88	9 M TRAWL	198	BT	5	8	6	0	0	1	265499
03JAN89	9 M TRAWL	189	BT	5	8	28DEC88	9 M TRAWL	188	BT	5	8	6	0	0	1	265517
03JAN89	9 M TRAWL	203	BT	5	8	03JAN89	9 M TRAWL	204	BT	5	8	0	0	0	1	266158
04JAN89	9 M TRAWL	201	BT	5	8	20DEC88	9 M TRAWL	204	BT	1	2	15	4	6	1	264372
04JAN89	9 M TRAWL	182	BT	5	8	28DEC88	9 M TRAWL	179	BT	5	8	7	0	0	1	265507
04JAN89	9 M TRAWL	178	BT	5	8	03JAN89	9 M TRAWL	179	BT	5	8	1	0	0	1	266060
04JAN89	9 M TRAWL	175	BT	5	8	03JAN89	9 M TRAWL	175	BT	5	8	1	0	0	1	266170
04JAN89	9 M TRAWL	150	BT	5	8	03JAN89	9 M TRAWL	150	BT	5	8	1	0	0	1	266202
04JAN89	9 M TRAWL	203	BT	5	8	03JAN89	9 M TRAWL	204	BT	5	8	1	0	0	1	266204
04JAN89	9 M TRAWL	237	BT	5	8	04JAN89	9 M TRAWL	236	BT	5	8	0	0	0	1	275002
05JAN89	9 M TRAWL	197	BT	1	2	01DEC88	9 M TRAWL	199	BT	1	2	35	0	0	1	261570
05JAN89	9 M TRAWL	215	BT	5	8	16DEC88	9 M TRAWL	216	BT	1	2	20	4	6	1	263640
05JAN89	9 M TRAWL	187	BT	5	8	03JAN89	9 M TRAWL	186	BT	5	8	2	0	0	1	266345
06JAN89	9 M TRAWL	270	BT	5	8	16DEC88	9 M TRAWL	270	BT	1	2	21	4	6	1	263589
06JAN89	9 M TRAWL	186	BT	5	8	03JAN89	9 M TRAWL	186	BT	5	8	3	0	0	1	266134
06JAN89	9 M TRAWL	325	BT	5	8	06JAN89	9 M TRAWL	305	BT	5	8	0	0	0	1	270041
06JAN89	9 M TRAWL	240	BT	5	8	04JAN89	9 M TRAWL	240	BT	5	8	2	0	0	1	275193
06JAN89	9 M TRAWL	209	BT	5	8	06JAN89	9 M TRAWL	209	BT	5	8	0	0	0	1	275463
06JAN89	9 M TRAWL	196	BT	5	8	06JAN89	9 M TRAWL	195	BT	5	8	0	0	0	1	275521
09JAN89	9 M TRAWL	262	BT	5	8	09JAN89	9 M TRAWL	261	BT	5	8	0	0	0	1	275663
09JAN89	9 M TRAWL	248	BT	5	8	09JAN89	9 M TRAWL	244	BT	5	8	0	0	0	1	275679
09JAN89	9 M TRAWL	173	BT	5	8	09JAN89	9 M TRAWL	169	BT	5	8	0	0	0	1	275693
09JAN89	9 M TRAWL	258	BT	5	8	09JAN89	9 M TRAWL	255	BT	5	8	0	0	0	1	275705
11JAN89	9 M TRAWL	187	BT	9	14	03JAN89	9 M TRAWL	186	BT	5	8	8	4	6	1	266469
12JAN89	9 M TRAWL	152	BT	8	13	10JAN89	9 M TRAWL	152	BT	8	13	2	0	0	1	275999
12JAN89	9 M TRAWL	226	BT	8	13	12JAN89	9 M TRAWL	223	BT	5	8	0	3	5	1	276314
13JAN89	9 M TRAWL	192	BT	8	13	19DEC88	9 M TRAWL	192	BT	9	14	25	1	2	1	263937
13JAN89	9 M TRAWL	182	BT	8	13	03JAN89	9 M TRAWL	181	BT	5	8	10	3	5	1	266208
13JAN89	9 M TRAWL	151	BT	9	14	13JAN89	9 M TRAWL	152	BT	8	13	0	1	2	1	276484
16JAN89	9 M TRAWL	210	BT	5	8	23NOV88	9 M TRAWL	210	BT	1	2	54	4	6	1	260688
16JAN89	9 M TRAWL	186	BT	5	8	03JAN89	9 M TRAWL	185	BT	5	8	13	0	0	1	266220
16JAN89	9 M TRAWL	205	BT	5	8	03JAN89	9 M TRAWL	204	BT	5	8	13	0	0	1	266392
16JAN89	9 M TRAWL	210	BT	5	8	03JAN89	9 M TRAWL	212	BT	5	8	13	0	0	1	266511
16JAN89	9 M TRAWL	213	BT	5	8	16JAN89	9 M TRAWL	215	BT	5	8	0	0	0	1	276787
17JAN89	9 M TRAWL	227	BT	1	2	16JAN89	9 M TRAWL	228	BT	5	8	1	4	6	2	276869
18JAN89	9 M TRAWL	168	BT	5	8	27DEC88	9 M TRAWL	168	BT	5	8	22	0	0	1	265180
18JAN89	9 M TRAWL	188	BT	5	8	28DEC88	9 M TRAWL	188	BT	5	8	21	0	0	1	265486
18JAN89	9 M TRAWL	219	BT	5	8	28DEC88	9 M TRAWL	218	BT	5	8	21	0	0	1	265506
18JAN89	9 M TRAWL	151	BT	5	8	04JAN89	9 M TRAWL	151	BT	5	8	14	0	0	1	275167
18JAN89	9 M TRAWL	222	BT	5	8	12JAN89	9 M TRAWL	221	BT	8	13	6	3	5	1	276390
18JAN89	9 M TRAWL	164	BT	5	8	16JAN89	9 M TRAWL	163	BT	5	8	2	0	0	1	276711
18JAN89	9 M TRAWL	232	BT	5	8	16JAN89	9 M TRAWL	233	BT	5	8	2	0	0	1	276841
18JAN89	9 M TRAWL	151	BT	5	8	16JAN89	9 M TRAWL	150	BT	5	8	2	0	0	1	276915

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	RELEASE DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
18JAN89	9 M TRAWL	169	BT	5	8	16JAN89	9 M TRAWL	167	BT	5	8	2	0	0	1	276976
19JAN89	9 M TRAWL	187	BT	5	8	16JAN89	9 M TRAWL	189	BT	5	8	3	0	0	1	276870
20JAN89	9 M TRAWL	188	BT	9	14	03JAN89	9 M TRAWL	187	BT	5	8	17	4	6	1	266483
23JAN89	9 M TRAWL	227	BT	8	13	27DEC88	9 M TRAWL	228	BT	5	8	27	3	5	1	265118
24JAN89	9 M TRAWL	250	BT	8	13	28DEC88	9 M TRAWL	251	BT	5	8	27	3	5	1	265293
24JAN89	9 M TRAWL	182	BT	5	8	09JAN89	9 M TRAWL	182	BT	5	8	15	0	0	1	275694
24JAN89	9 M TRAWL	170	BT	8	13	11JAN89	9 M TRAWL	168	BT	9	14	13	1	2	1	276153
24JAN89	9 M TRAWL	201	BT	8	13	11JAN89	9 M TRAWL	199	BT	8	13	13	0	0	1	276160
24JAN89	9 M TRAWL	210	BT	9	14	13JAN89	9 M TRAWL	208	BT	8	13	11	1	2	1	276583
25JAN89	9 M TRAWL	230	BT	1	2	09JAN89	9 M TRAWL	231	BT	5	8	16	4	6	1	275656
25JAN89	9 M TRAWL	171	BT	1	2	18JAN89	9 M TRAWL	172	BT	5	8	7	4	6	1	277272
25JAN89	9 M TRAWL	232	BT	1	2	23JAN89	9 M TRAWL	231	BT	9	14	2	8	13	1	277641
25JAN89	9 M TRAWL	183	BT	1	2	25JAN89	9 M TRAWL	182	BT	1	2	0	0	0	1	278160
26JAN89	9 M TRAWL	164	BT	10	16	21DEC88	9 M TRAWL	161	BT	8	13	36	2	3	1	264723
26JAN89	9 M TRAWL	209	BT	5	8	12JAN89	9 M TRAWL	208	BT	5	8	14	0	0	1	276315
27JAN89	9 M TRAWL	201	BT	1	2	23NOV88	9 M TRAWL	199	BT	1	2	65	0	0	1	260752
27JAN89	9 M TRAWL	177	BT	1	2	08DEC88	9 M TRAWL	178	BT	1	2	50	0	0	1	262412
27JAN89	9 M TRAWL	210	BT	1	2	30DEC88	9 M TRAWL	212	BT	5	8	28	4	6	1	265709
27JAN89	9 M TRAWL	173	BT	1	2	17JAN89	9 M TRAWL	174	BT	1	2	10	0	0	1	277027
27JAN89	9 M TRAWL	223	BT	1	2	26JAN89	9 M TRAWL	224	BT	5	8	1	4	6	1	278263
27JAN89	9 M TRAWL	282	BT	1	2	27JAN89	9 M TRAWL	282	BT	1	2	0	0	0	1	278306
30JAN89	9 M TRAWL	248	BT	8	13	02NOV88	9 M TRAWL	248	BT	1	2	89	7	11	1	258381
30JAN89	9 M TRAWL	160	BT	5	8	09JAN89	9 M TRAWL	156	BT	5	8	21	0	0	1	275729
30JAN89	9 M TRAWL	255	BT	5	8	16JAN89	9 M TRAWL	254	BT	5	8	14	0	0	1	276726
30JAN89	9 M TRAWL	187	BT	5	8	19JAN89	9 M TRAWL	187	BT	5	8	11	0	0	1	277425
30JAN89	9 M TRAWL	190	BT	8	13	30JAN89	9 M TRAWL	189	BT	5	8	0	3	5	1	278766
31JAN89	9 M TRAWL	172	BT	1	2	31JAN89	9 M TRAWL	174	BT	1	2	0	0	0	1	278955
31JAN89	9 M TRAWL	167	BT	1	2	31JAN89	9 M TRAWL	169	BT	1	2	0	0	0	1	278963
01FEB89	9 M TRAWL	299	BT	8	13	01NOV88	9 M TRAWL	300	BT	1	2	92	7	11	1	258141
01FEB89	9 M TRAWL	272	BT	8	13	10NOV88	9 M TRAWL	271	BT	9	14	83	1	2	1	258885
01FEB89	9 M TRAWL	263	BT	8	13	22NOV88	9 M TRAWL	264	BT	1	2	71	7	11	1	260549
01FEB89	9 M TRAWL	253	BT	8	13	20DEC88	9 M TRAWL	250	BT	1	2	43	7	11	1	264436
01FEB89	9 M TRAWL	196	BT	8	13	03JAN89	9 M TRAWL	195	BT	5	8	29	3	5	1	266501
01FEB89	9 M TRAWL	243	BT	8	13	25JAN89	9 M TRAWL	242	BT	1	2	7	7	11	1	278024
01FEB89	9 M TRAWL	175	BT	8	13	30JAN89	9 M TRAWL	177	BT	8	13	2	0	0	1	278863
01FEB89	9 M TRAWL	272	BT	8	13	01FEB89	9 M TRAWL	273	BT	8	13	0	0	0	1	279004
02FEB89	9 M TRAWL	174	BT	8	13	04JAN89	9 M TRAWL	175	BT	5	8	29	3	5	1	275180
02FEB89	9 M TRAWL	241	BT	8	13	27JAN89	9 M TRAWL	243	BT	1	2	6	7	11	1	278631
02FEB89	9 M TRAWL	211	BT	8	13	02FEB89	9 M TRAWL	210	BT	9	14	0	1	2	1	279615
03FEB89	9 M TRAWL	206	BT	9	14	16DEC88	9 M TRAWL	205	BT	1	2	49	8	13	1	263764
03FEB89	9 M TRAWL	207	BT	8	13	28DEC88	9 M TRAWL	207	BT	5	8	37	3	5	1	265400
03FEB89	9 M TRAWL	210	BT	8	13	03JAN89	9 M TRAWL	206	BT	5	8	31	3	5	1	266009
03FEB89	9 M TRAWL	178	BT	9	14	30JAN89	9 M TRAWL	178	BT	8	13	4	1	2	1	278869
06FEB89	9 M TRAWL	254	BT	8	13	03NOV88	9 M TRAWL	255	BT	1	2	95	7	11	1	257360
06FEB89	9 M TRAWL	215	BT	8	13	01DEC88	9 M TRAWL	216	BT	1	2	67	7	11	1	261537
06FEB89	9 M TRAWL	208	BT	8	13	01FEB89	9 M TRAWL	208	BT	8	13	5	0	0	1	279385
07FEB89	9 M TRAWL	191	BT	5	8	28DEC88	9 M TRAWL	191	BT	5	8	41	0	0	1	265440

continued

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE						RELEASE										
DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER
07FEB89	9 M TRAWL	290	BT	5	8	07FEB89	9 M TRAWL	289	BT	5	8	0	0	0	1	270510
07FEB89	9 M TRAWL	227	BT	5	8	07FEB89	9 M TRAWL	228	BT	5	8	0	0	0	1	270524
07FEB89	9 M TRAWL	280	BT	5	8	07FEB89	9 M TRAWL	279	BT	5	8	0	0	0	1	270532
07FEB89	9 M TRAWL	210	BT	5	8	07FEB89	9 M TRAWL	208	BT	5	8	0	0	0	1	270558
07FEB89	9 M TRAWL	208	BT	5	8	16JAN89	9 M TRAWL	210	BT	5	8	22	0	0	1	276862
08FEB89	9 M TRAWL	231	BT	10	16	01FEB89	9 M TRAWL	230	BT	8	13	7	2	3	1	279348
09FEB89	9 M TRAWL	182	BT	9	14	10JAN89	9 M TRAWL	181	BT	9	14	30	0	0	1	275814
09FEB89	9 M TRAWL	167	BT	9	14	19JAN89	9 M TRAWL	168	BT	5	8	21	4	6	1	277401
09FEB89	9 M TRAWL	256	BT	9	14	27JAN89	9 M TRAWL	257	BT	1	2	13	8	13	1	278682
09FEB89	9 M TRAWL	262	BT	9	14	01FEB89	9 M TRAWL	264	BT	8	13	8	1	2	1	279173
09FEB89	9 M TRAWL	250	BT	9	14	01FEB89	9 M TRAWL	251	BT	8	13	8	1	2	1	279177
10FEB89	9 M TRAWL	355	BT	9	14	05DEC88	9 M TRAWL	355	BT	9	14	67	0	0	1	262021
10FEB89	9 M TRAWL	204	BT	9	14	07DEC88	9 M TRAWL	204	BT	11	18	65	2	3	1	262204
13FEB89	9 M TRAWL	205	BT	9	14	25JAN89	9 M TRAWL	204	BT	1	2	19	8	13	1	277984
14FEB89	9 M TRAWL	212	BT	8	13	15DEC88	9 M TRAWL	213	BT	5	8	61	3	5	2	263453
14FEB89	9 M TRAWL	243	BT	8	13	16DEC88	9 M TRAWL	243	BT	1	2	60	7	11	1	263794
14FEB89	9 M TRAWL	205	BT	8	13	13JAN89	9 M TRAWL	207	BT	8	13	32	0	0	1	276501
14FEB89	9 M TRAWL	225	BT	9	14	03FEB89	9 M TRAWL	225	BT	9	14	11	0	0	1	279873
14FEB89	9 M TRAWL	278	BT	9	14	14FEB89	9 M TRAWL	279	BT	8	13	0	1	2	1	280978
14FEB89	9 M TRAWL	283	BT	8	13	14FEB89	9 M TRAWL	284	BT	9	14	0	1	2	1	280994
15FEB89	9 M TRAWL	261	BT	8	13	02NOV88	9 M TRAWL	263	BT	1	2	105	7	11	1	258370
15FEB89	9 M TRAWL	269	BT	8	13	02NOV88	9 M TRAWL	267	BT	1	2	105	7	11	1	258418
15FEB89	9 M TRAWL	182	BT	8	13	29NOV88	9 M TRAWL	182	BT	5	8	78	3	5	2	261024
15FEB89	9 M TRAWL	266	BT	9	14	09DEC88	9 M TRAWL	267	BT	9	14	68	0	0	1	262518
15FEB89	9 M TRAWL	213	BT	9	14	21DEC88	9 M TRAWL	211	BT	8	13	56	1	2	1	264715
15FEB89	9 M TRAWL	204	BT	9	14	03JAN89	9 M TRAWL	206	BT	5	8	43	4	6	1	266408
15FEB89	9 M TRAWL	245	BT	9	14	07FEB89	9 M TRAWL	246	BT	5	8	8	4	6	1	270499
15FEB89	9 M TRAWL	195	BT	9	14	04JAN89	9 M TRAWL	196	BT	5	8	42	4	6	1	275052
15FEB89	9 M TRAWL	215	BT	9	14	24JAN89	9 M TRAWL	215	BT	8	13	22	1	2	1	277764
15FEB89	9 M TRAWL	188	BT	8	13	01FEB89	9 M TRAWL	187	BT	8	13	14	0	0	1	279276
15FEB89	9 M TRAWL	205	BT	9	14	09FEB89	9 M TRAWL	205	BT	9	14	6	0	0	1	280143
15FEB89	9 M TRAWL	200	BT	9	14	10FEB89	9 M TRAWL	199	BT	8	13	5	1	2	1	280554
16FEB89	9 M TRAWL	294	BT	9	14	28DEC88	9 M TRAWL	292	BT	5	8	50	4	6	1	265445
16FEB89	9 M TRAWL	161	BT	8	13	13JAN89	9 M TRAWL	159	BT	8	13	34	0	0	1	276598
16FEB89	9 M TRAWL	225	BT	8	13	27JAN89	9 M TRAWL	225	BT	1	2	20	7	11	1	278640
17FEB89	9 M TRAWL	214	BT	8	13	10NOV88	9 M TRAWL	214	BT	1	2	99	7	11	2	258860
17FEB89	9 M TRAWL	206	BT	8	13	08DEC88	9 M TRAWL	205	BT	1	2	71	7	11	1	262405
17FEB89	9 M TRAWL	262	BT	8	13	30DEC88	9 M TRAWL	263	BT	5	8	49	3	5	1	265841
17FEB89	9 M TRAWL	200	BT	8	13	03JAN89	9 M TRAWL	201	BT	5	8	45	3	5	1	266079
17FEB89	9 M TRAWL	229	BT	9	14	09JAN89	9 M TRAWL	230	BT	5	8	39	4	6	1	275667
17FEB89	9 M TRAWL	184	BT	9	14	16JAN89	9 M TRAWL	186	BT	5	8	32	4	6	1	276965
17FEB89	9 M TRAWL	264	BT	9	14	14FEB89	9 M TRAWL	264	BT	8	13	3	1	2	1	280876
22FEB89	9 M TRAWL	241	BT	8	13	03NOV88	9 M TRAWL	245	BT	1	2	111	7	11	1	257393
22FEB89	9 M TRAWL	264	BT	8	13	07NOV88	9 M TRAWL	262	BT	5	8	107	3	5	1	258692
22FEB89	9 M TRAWL	226	BT	8	13	10FEB89	9 M TRAWL	228	BT	9	14	12	1	2	1	280404
22FEB89	9 M TRAWL	238	BT	9	14	14FEB89	9 M TRAWL	237	BT	9	14	8	0	0	1	281249
23FEB89	9 M TRAWL	227	BT	8	13	01FEB89	9 M TRAWL	228	BT	8	13	22	0	0	1	279192

continued

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	RECAPTURE GEAR	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE GEAR	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
23FEB89	9 M TRAWL	190	BT	9	14	10FEB89	9 M TRAWL	187	BT	9	14	13	0	0	1	280358
23FEB89	9 M TRAWL	233	BT	9	14	22FEB89	9 M TRAWL	235	BT	9	14	1	0	0	1	283143
28FEB89	9 M TRAWL	197	BT	5	8	16JAN89	9 M TRAWL	197	BT	5	8	43	0	0	1	276780
01MAR89	9 M TRAWL	294	BT	8	13	01FEB89	9 M TRAWL	295	BT	8	13	28	0	0	1	279106
01MAR89	9 M TRAWL	213	BT	8	13	14FEB89	9 M TRAWL	215	BT	8	13	15	0	0	1	281088
01MAR89	9 M TRAWL	155	BT	8	13	15FEB89	9 M TRAWL	156	BT	8	13	14	0	0	1	281718
01MAR89	9 M TRAWL	246	BT	8	13	01MAR89	9 M TRAWL	247	BT	8	13	0	0	0	1	283355
01MAR89	9 M TRAWL	154	BT	8	13	01MAR89	9 M TRAWL	153	BT	8	13	0	0	0	1	283373
02MAR89	9 M TRAWL	308	BT	8	13	02DEC88	9 M TRAWL	317	BT	1	2	90	7	11	1	261744
02MAR89	9 M TRAWL	288	BT	8	13	13DEC88	9 M TRAWL	287	BT	5	8	79	3	5	1	262697
02MAR89	9 M TRAWL	303	BT	8	13	16DEC88	9 M TRAWL	302	BT	1	2	76	7	11	1	263570
02MAR89	9 M TRAWL	351	BT	8	13	10FEB89	9 M TRAWL	350	BT	8	13	20	0	0	1	271009
02MAR89	9 M TRAWL	264	BT	8	13	14FEB89	9 M TRAWL	263	BT	8	13	16	0	0	1	280935
02MAR89	9 M TRAWL	235	BT	8	13	02MAR89	9 M TRAWL	234	BT	8	13	0	0	0	1	283620
02MAR89	9 M TRAWL	230	BT	8	13	02MAR89	9 M TRAWL	229	BT	8	13	0	0	0	1	283654
02MAR89	9 M TRAWL	210	BT	8	13	02MAR89	9 M TRAWL	210	BT	8	13	0	0	0	1	283658
02MAR89	9 M TRAWL	203	BT	9	14	02MAR89	9 M TRAWL	203	BT	8	13	0	1	2	1	283750
03MAR89	9 M TRAWL	486	BT	8	13	03MAR89	9 M TRAWL	485	BT	8	13	0	0	0	1	271486
03MAR89	9 M TRAWL	166	BT	8	13	01FEB89	9 M TRAWL	166	BT	8	13	30	0	0	1	279239
03MAR89	9 M TRAWL	257	BT	8	13	21FEB89	9 M TRAWL	256	BT	9	14	10	1	2	1	282502
03MAR89	9 M TRAWL	177	BT	8	13	03MAR89	9 M TRAWL	177	BT	8	13	0	0	0	1	283946
09MAR89	9 M TRAWL	236	BT	5	8	27JAN89	9 M TRAWL	236	BT	1	2	41	4	6	1	278482
10MAR89	9 M TRAWL	272	BT	9	14	03NOV88	9 M TRAWL	294	BT	1	2	127	8	13	2	257188
10MAR89	9 M TRAWL	312	BT	8	13	01NOV88	9 M TRAWL	313	BT	1	2	129	7	11	1	258146
10MAR89	9 M TRAWL	264	BT	9	14	22NOV88	9 M TRAWL	266	BT	1	2	108	8	13	1	260586
10MAR89	9 M TRAWL	189	BT	9	14	09FEB89	9 M TRAWL	189	BT	9	14	29	0	0	1	280154
10MAR89	9 M TRAWL	279	BT	9	14	22FEB89	9 M TRAWL	280	BT	8	13	16	1	2	1	282724
10MAR89	9 M TRAWL	222	BT	8	13	10MAR89	9 M TRAWL	222	BT	8	13	0	0	0	1	284244
11MAR89	9 M TRAWL	275	BT	1	2	15DEC88	9 M TRAWL	277	BT	1	2	86	0	0	2	263005
11MAR89	9 M TRAWL	215	BT	1	2	11MAR89	9 M TRAWL	210	BT	1	2	0	0	0	1	284330
13MAR89	9 M TRAWL	199	BT	5	8	07NOV88	9 M TRAWL	196	BT	5	8	126	0	0	1	258697
13MAR89	9 M TRAWL	193	BT	5	8	27JAN89	9 M TRAWL	193	BT	1	2	45	4	6	1	278477
14MAR89	9 M TRAWL	201	BT	8	13	30JAN89	9 M TRAWL	201	BT	5	8	43	3	5	1	278783
14MAR89	9 M TRAWL	194	BT	8	13	01FEB89	9 M TRAWL	193	BT	8	13	41	0	0	1	279255
14MAR89	9 M TRAWL	182	BT	8	13	06FEB89	9 M TRAWL	181	BT	8	13	36	0	0	1	279901
14MAR89	9 M TRAWL	156	BT	5	8	27FEB89	9 M TRAWL	157	BT	5	8	15	0	0	1	282874
15MAR89	9 M TRAWL	157	BT	9	14	07NOV88	9 M TRAWL	158	BT	1	2	128	8	13	1	258714
15MAR89	9 M TRAWL	201	BT	9	14	02DEC88	9 M TRAWL	202	BT	1	2	103	8	13	1	261860
15MAR89	9 M TRAWL	215	BT	8	13	09DEC88	9 M TRAWL	271	BT	9	14	96	1	2	1	262529
15MAR89	9 M TRAWL	166	BT	9	14	28DEC88	9 M TRAWL	165	BT	5	8	77	4	6	1	265505
15MAR89	9 M TRAWL	194	BT	9	14	09JAN89	9 M TRAWL	194	BT	5	8	65	4	6	1	275689
15MAR89	9 M TRAWL	234	BT	9	14	02MAR89	9 M TRAWL	233	BT	8	13	13	1	2	1	283786
15MAR89	9 M TRAWL	205	BT	8	13	11MAR89	9 M TRAWL	205	BT	1	2	4	7	11	1	284338
15MAR89	9 M TRAWL	196	BT	9	14	15MAR89	9 M TRAWL	195	BT	8	13	0	1	2	1	284741
16MAR89	9 M TRAWL	212	BT	8	13	01MAR89	9 M TRAWL	210	BT	8	13	15	0	0	1	283443
17MAR89	9 M TRAWL	209	BT	9	14	15FEB89	9 M TRAWL	208	BT	8	13	30	1	2	1	271104
17MAR89	9 M TRAWL	279	BT	8	13	17MAR89	9 M TRAWL	279	BT	8	13	0	0	0	1	285153

continued

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	RELEASE DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
20MAR89	9 M TRAWL	218	BT	5	8	10JAN89	9 M TRAWL	217	BT	9	14	69	4	6	1	275823
20MAR89	9 M TRAWL	188	BT	8	13	19JAN89	9 M TRAWL	188	BT	5	8	60	3	5	1	277453
20MAR89	9 M TRAWL	212	BT	1	2	02FEB89	9 M TRAWL	210	BT	9	14	46	8	13	1	279615
20MAR89	9 M TRAWL	201	BT	1	2	16FEB89	9 M TRAWL	250	BT	9	14	32	8	13	1	282085
21MAR89	9 M TRAWL	190	BT	8	13	22DEC88	9 M TRAWL	188	BT	1	2	89	7	11	1	264913
21MAR89	9 M TRAWL	168	BT	9	14	16JAN89	9 M TRAWL	171	BT	5	8	64	4	6	1	276670
21MAR89	9 M TRAWL	179	BT	9	14	09FEB89	9 M TRAWL	180	BT	9	14	40	0	0	1	280206
21MAR89	9 M TRAWL	214	BT	9	14	15FEB89	9 M TRAWL	216	BT	8	13	34	1	2	1	281684
21MAR89	9 M TRAWL	175	BT	9	14	16FEB89	9 M TRAWL	176	BT	8	13	33	1	2	1	281926
21MAR89	9 M TRAWL	178	BT	8	13	07MAR89	9 M TRAWL	181	BT	5	8	14	3	5	1	283993
21MAR89	9 M TRAWL	254	BT	9	14	21MAR89	9 M TRAWL	254	BT	9	14	0	0	0	1	285518
22MAR89	9 M TRAWL	239	BT	8	13	02NOV88	9 M TRAWL	246	BT	1	2	140	7	11	1	258389
22MAR89	9 M TRAWL	310	BT	8	13	02DEC88	9 M TRAWL	313	BT	1	2	110	7	11	1	261683
22MAR89	9 M TRAWL	192	BT	8	13	03JAN89	9 M TRAWL	194	BT	5	8	78	3	5	1	266360
22MAR89	9 M TRAWL	238	BT	8	13	07FEB89	9 M TRAWL	239	BT	5	8	43	3	5	1	270520
22MAR89	9 M TRAWL	239	BT	9	14	16JAN89	9 M TRAWL	239	BT	5	8	65	4	6	1	276675
22MAR89	9 M TRAWL	196	BT	8	13	19JAN89	9 M TRAWL	200	BT	5	8	62	3	5	1	277373
22MAR89	9 M TRAWL	182	BT	8	13	25JAN89	9 M TRAWL	183	UH	2	3	56	10	16	1	277974
22MAR89	9 M TRAWL	202	BT	8	13	02FEB89	9 M TRAWL	201	BT	8	13	48	0	0	1	279511
22MAR89	9 M TRAWL	229	BT	9	14	03FEB89	9 M TRAWL	230	BT	9	14	47	0	0	1	279865
22MAR89	9 M TRAWL	178	BT	8	13	09FEB89	9 M TRAWL	279	BT	9	14	41	1	2	1	280031
22MAR89	9 M TRAWL	242	BT	9	14	17FEB89	9 M TRAWL	240	BT	9	14	33	0	0	1	282193
22MAR89	9 M TRAWL	219	BT	8	13	01MAR89	9 M TRAWL	220	BT	8	13	21	0	0	1	283261
22MAR89	9 M TRAWL	258	BT	8	13	01MAR89	9 M TRAWL	259	BT	8	13	21	0	0	1	283340
22MAR89	9 M TRAWL	208	BT	9	14	10MAR89	9 M TRAWL	236	BT	9	14	12	0	0	1	284151
22MAR89	9 M TRAWL	162	BT	8	13	15MAR89	9 M TRAWL	161	BT	8	13	7	0	0	1	284738
22MAR89	9 M TRAWL	199	BT	8	13	22MAR89	9 M TRAWL	198	BT	8	13	0	0	0	1	285872
22MAR89	9 M TRAWL	221	BT	8	13	22MAR89	9 M TRAWL	223	BT	9	14	0	1	2	1	285915
22MAR89	9 M TRAWL	184	BT	8	13	22MAR89	9 M TRAWL	183	BT	8	13	0	0	0	1	286153
22MAR89	9 M TRAWL	238	BT	8	13	22MAR89	9 M TRAWL	237	BT	8	13	0	0	0	1	286201
23MAR89	9 M TRAWL	223	BT	8	13	07FEB89	9 M TRAWL	223	BT	5	8	44	3	5	1	270503
23MAR89	9 M TRAWL	232	BT	8	13	08FEB89	9 M TRAWL	231	BT	10	16	43	2	3	1	270789
23MAR89	9 M TRAWL	261	BT	8	13	11JAN89	9 M TRAWL	262	BT	8	13	71	0	0	1	276291
23MAR89	9 M TRAWL	246	BT	8	13	21FEB89	9 M TRAWL	242	BT	8	13	30	0	0	1	282441
23MAR89	9 M TRAWL	185	BT	8	13	28FEB89	9 M TRAWL	189	BT	5	8	23	3	5	1	282894
23MAR89	9 M TRAWL	208	BT	8	13	01MAR89	9 M TRAWL	208	BT	8	13	22	0	0	1	283513
23MAR89	9 M TRAWL	259	BT	9	14	20MAR89	9 M TRAWL	258	BT	5	8	3	4	6	1	285358
24MAR89	9 M TRAWL	185	BT	9	14	18JAN89	9 M TRAWL	185	BT	5	8	65	4	6	1	277171
24MAR89	9 M TRAWL	228	BT	5	8	27JAN89	9 M TRAWL	228	BT	1	2	56	4	6	1	278662
24MAR89	9 M TRAWL	212	BT	5	8	24MAR89	9 M TRAWL	213	BT	5	8	0	0	0	1	286935
27MAR89	9 M TRAWL	317	BT	9	14	18NOV88	9 M TRAWL	316	UH	2	3	129	11	18	1	260316
27MAR89	9 M TRAWL	297	BT	9	14	14DEC88	9 M TRAWL	300	BT	5	8	103	4	6	1	262953
27MAR89	9 M TRAWL	195	BT	9	14	19DEC88	9 M TRAWL	195	BT	5	8	98	4	6	1	263991
27MAR89	9 M TRAWL	251	BT	9	14	19DEC88	9 M TRAWL	253	BT	5	8	98	4	6	1	263992
27MAR89	9 M TRAWL	209	BT	9	14	03JAN89	9 M TRAWL	209	BT	5	8	83	4	6	1	266180
27MAR89	9 M TRAWL	328	BT	9	14	01FEB89	9 M TRAWL	327	BT	8	13	54	1	2	1	270186
27MAR89	9 M TRAWL	218	BT	9	14	08FEB89	9 M TRAWL	219	BT	10	16	47	1	2	1	270651

continued

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	GEAR	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER
27MAR89	9 M TRAWL	201	BT	9	14	09JAN89	9 M TRAWL	201	BT	5	8	77	4	6	1	275660
27MAR89	9 M TRAWL	178	BT	9	14	16FEB89	9 M TRAWL	181	BT	8	13	39	1	2	1	282057
27MAR89	9 M TRAWL	222	BT	9	14	16FEB89	9 M TRAWL	221	BT	9	14	39	0	0	1	282114
27MAR89	9 M TRAWL	196	BT	9	14	02MAR89	9 M TRAWL	198	BT	8	13	25	1	2	1	283640
27MAR89	9 M TRAWL	185	BT	9	14	02MAR89	9 M TRAWL	186	BT	8	13	25	1	2	1	283774
27MAR89	9 M TRAWL	254	BT	9	14	20MAR89	9 M TRAWL	256	BT	8	13	7	1	2	1	285455
27MAR89	9 M TRAWL	245	BT	9	14	27MAR89	9 M TRAWL	248	BT	9	14	0	0	0	1	287190
28MAR89	9 M TRAWL	270	BT	8	13	23NOV88	9 M TRAWL	269	BT	1	2	125	7	11	1	260731
28MAR89	9 M TRAWL	251	BT	8	13	23NOV88	9 M TRAWL	248	BT	1	2	125	7	11	1	260900
28MAR89	9 M TRAWL	193	BT	8	13	10FEB89	9 M TRAWL	190	BT	9	14	46	1	2	1	280496
29MAR89	9 M TRAWL	275	BT	8	13	02DEC88	9 M TRAWL	276	BT	1	2	117	7	11	1	261675
29MAR89	9 M TRAWL	209	BT	8	13	22DEC88	9 M TRAWL	210	BT	1	2	97	7	11	1	265012
29MAR89	9 M TRAWL	299	BT	8	13	14FEB89	9 M TRAWL	301	BT	8	13	43	0	0	1	271046
29MAR89	9 M TRAWL	223	BT	8	13	29MAR89	9 M TRAWL	224	BT	8	13	0	0	0	1	287788
30MAR89	9 M TRAWL	178	BT	8	13	01NOV88	9 M TRAWL	178	BT	1	2	149	7	11	2	258081
30MAR89	9 M TRAWL	200	BT	9	14	11JAN89	9 M TRAWL	200	BT	8	13	78	1	2	1	276250
30MAR89	9 M TRAWL	294	BT	8	13	30MAR89	9 M TRAWL	294	BT	8	13	0	0	0	1	288051
30MAR89	9 M TRAWL	233	BT	8	13	30MAR89	9 M TRAWL	239	BT	8	13	0	0	0	1	288058
31MAR89	9 M TRAWL	319	BT	8	13	18NOV88	9 M TRAWL	316	UH	2	3	133	10	16	1	260401
31MAR89	9 M TRAWL	341	BT	9	14	23FEB89	9 M TRAWL	342	BT	9	14	36	0	0	1	271369
31MAR89	9 M TRAWL	185	BT	8	13	04JAN89	9 M TRAWL	188	BT	5	8	86	3	5	1	275169
31MAR89	9 M TRAWL	230	BT	9	14	25JAN89	9 M TRAWL	231	BT	1	2	65	8	13	1	278081
31MAR89	9 M TRAWL	199	BT	8	13	01MAR89	9 M TRAWL	200	BT	8	13	30	0	0	1	283341
31MAR89	9 M TRAWL	246	BT	9	14	01MAR89	9 M TRAWL	243	BT	8	13	30	1	2	1	283405
31MAR89	9 M TRAWL	233	BT	8	13	23MAR89	9 M TRAWL	233	BT	8	13	8	0	0	1	286609
31MAR89	9 M TRAWL	296	BT	9	14	31MAR89	9 M TRAWL	297	BT	9	14	0	0	0	1	288253
01APR89	9 M TRAWL	205	BT	8	13	15MAR89	9 M TRAWL	204	BT	8	13	17	0	0	1	284773
03APR89	9 M TRAWL	261	BT	9	14	06JAN89	9 M TRAWL	262	BT	5	8	87	4	6	1	275560
03APR89	9 M TRAWL	217	BT	9	14	02FEB89	9 M TRAWL	217	BT	9	14	60	0	0	1	279662
03APR89	9 M TRAWL	163	BT	8	13	22MAR89	9 M TRAWL	164	BT	8	13	12	0	0	1	286380
03APR89	9 M TRAWL	246	BT	9	14	24MAR89	9 M TRAWL	248	BT	9	14	10	0	0	1	286884
03APR89	9 M TRAWL	190	BT	9	14	28MAR89	9 M TRAWL	191	BT	9	14	6	0	0	1	287621
03APR89	9 M TRAWL	221	BT	9	14	29MAR89	9 M TRAWL	222	BT	8	13	5	1	2	1	287954
03APR89	9 M TRAWL	198	BT	8	13	31MAR89	9 M TRAWL	198	BT	8	13	3	0	0	1	288202
04APR89	9 M TRAWL	227	BT	9	14	16FEB89	9 M TRAWL	229	BT	8	13	47	1	2	1	281965
04APR89	9 M TRAWL	228	BT	8	13	01MAR89	9 M TRAWL	229	BT	8	13	34	0	0	1	283551
04APR89	9 M TRAWL	197	BT	8	13	20MAR89	9 M TRAWL	199	BT	9	14	15	1	2	1	285402
04APR89	9 M TRAWL	177	BT	8	13	24MAR89	9 M TRAWL	180	BT	5	8	11	3	5	1	286940
06APR89	9 M TRAWL	219	BT	5	8	29MAR89	9 M TRAWL	220	BT	8	13	8	3	5	1	287884
06APR89	9 M TRAWL	218	BT	5	8	06APR89	9 M TRAWL	220	BT	5	8	0	0	0	1	289157
07APR89	9 M TRAWL	262	BT	5	8	13DEC88	9 M TRAWL	259	BT	5	8	115	0	0	1	262709
07APR89	9 M TRAWL	231	BT	5	8	02FEB89	9 M TRAWL	231	BT	9	14	64	4	6	1	279671
07APR89	9 M TRAWL	227	BT	5	8	01APR89	9 M TRAWL	226	BT	8	13	6	3	5	1	288358
10APR89	9 M TRAWL	269	BT	5	8	13DEC88	9 M TRAWL	268	BT	5	8	118	0	0	1	262767
10APR89	9 M TRAWL	184	BT	9	14	15MAR89	9 M TRAWL	187	BT	9	14	26	0	0	1	284859
10APR89	9 M TRAWL	226	BT	9	14	31MAR89	9 M TRAWL	227	BT	8	13	10	1	2	1	288191
11APR89	9 M TRAWL	197	BT	1	2	23JAN89	9 M TRAWL	201	BT	1	2	74	0	0	2	260752

continued

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE							RELEASE										
DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DATE	GEAR	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
11APR89	9 M TRAWL	243	BT	1	2	01DEC88	9 M TRAWL	245	BT	1	2	131	0	0	1	261451
11APR89	9 M TRAWL	197	BT	1	2	15DEC88	9 M TRAWL	199	BT	1	2	117	0	0	2	263189
11APR89	9 M TRAWL	306	BT	1	2	30MAR89	9 M TRAWL	305	BT	9	14	12	8	13	1	271625
12APR89	9 M TRAWL	156	BT	5	8	30JAN89	9 M TRAWL	156	BT	5	8	72	0	0	1	275729
13APR89	9 M TRAWL	197	BT	5	8	03JAN89	9 M TRAWL	198	BT	5	8	100	0	0	2	266114
13APR89	9 M TRAWL	216	BT	5	8	10APR89	9 M TRAWL	217	BT	5	8	3	0	0	1	288349
13APR89	9 M TRAWL	158	BT	5	8	13APR89	9 M TRAWL	157	BT	5	8	0	0	0	1	289595
14APR89	9 M TRAWL	250	BT	8	13	01DEC88	9 M TRAWL	250	BT	1	2	134	7	11	2	261490
14APR89	9 M TRAWL	205	BT	8	13	08DEC88	9 M TRAWL	206	BT	1	2	127	7	11	1	262236

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1988-1989 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE							RELEASE										
DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	COND	TAG NUMBER
03NOV88	9 M TRAWL	4	325	BT	1	2	10APR87	9 M W/L	2	248	BT	1	2	573	77	1	28884
09NOV88	9 M TRAWL	3	331	BT	9	14	31MAR88	9 M TRAWL	2	259	BT	9	14	223	72	2	259489
11NOV88	9 M TRAWL	4	365	UH	2	3	26MAR87	9 M W/L	2	262	BT	9	14	596	103	1	24936
11NOV88	9 M TRAWL	3	337	UH	2	3	04FEB88	12 M/9 M COD	2	294	BT	1	2	281	43	1	33078
11NOV88	9 M TRAWL	4	377	UH	2	3	23MAR87	9 M TRAWL	2	277	BT	9	14	599	100	1	24763
15NOV88	9 M TRAWL	4	362	UH	2	3	03DEC87	12 M/9 M COD	3	325	UH	2	3	348	37	1	29209
16NOV88	9 M TRAWL	.	498	UH	3	5	27MAR86	12 M	.	336	UH	2	3	965	162	2	21454
17NOV88	9 M TRAWL	.	268	BT	5	8	29JAN88	9 M TRAWL	.	203	BT	8	13	293	65	2	252629
18NOV88	9 M TRAWL	2	352	UH	2	3	23MAR88	12 M/9 M COD	1	267	BT	1	2	240	85	1	259634
18NOV88	9 M TRAWL	2	344	UH	2	3	04MAR88	12 M/9 M COD	1	254	BT	8	13	259	90	1	254424
22NOV88	9 M TRAWL	4	378	BT	1	2	04DEC87	9 M TRAWL	3	328	BT	1	2	354	50	1	29621
22NOV88	9 M TRAWL	4	350	BT	1	2	22DEC86	9 M TRAWL	2	242	BT	9	14	701	108	1	18670
22NOV88	9 M TRAWL	2	285	BT	1	2	04MAR88	12 M/9 M COD	1	239	BT	8	13	263	46	2	254372
23NOV88	9 M TRAWL	5	523	BT	1	2	04DEC87	9 M TRAWL	4	466	BT	1	2	355	57	1	29217
28NOV88	9 M TRAWL	.	416	BT	1	2	09APR87	9 M TRAWL	.	303	BT	1	2	599	113	2	30097
28NOV88	9 M TRAWL	5	519	BT	5	8	17NOV87	9 M TRAWL	4	497	BT	5	8	377	22	1	31243
07DEC88	9 M TRAWL	3	306	BT	9	14	06APR88	9 M TRAWL	2	244	BT	9	14	245	62	1	257776
07DEC88	9 M TRAWL	2	240	BT	9	14	10MAR88	9 M TRAWL	1	205	BT	8	13	272	35	2	255414
08DEC88	9 M TRAWL	3	458	BT	1	2	16JAN86	12 M	1	247	BT	5	8	1057	211	2	5788
16DEC88	9 M TRAWL	3	370	BT	1	2	10FEB88	9 M TRAWL	2	299	BT	8	13	310	71	1	33553
16DEC88	9 M TRAWL	4	419	BT	1	2	08JAN87	12 M W/L	1	214	BT	1	2	708	205	1	17235
19DEC88	9 M TRAWL	2	403	BT	5	8	17MAR88	9 M TRAWL	1	282	BT	8	13	277	121	2	256515
20DEC88	9 M TRAWL	3	325	BT	1	2	12FEB87	9 M W/L	2	259	BT	1	2	677	66	1	22409
20DEC88	9 M TRAWL	2	250	BT	1	2	19FEB88	12 M/9 M COD	1	225	BT	8	13	305	25	2	256379
22DEC88	9 M TRAWL	4	439	BT	1	2	26JAN88	9 M TRAWL	3	388	BT	1	2	331	51	1	252071
28DEC88	9 M TRAWL	5	390	BT	5	8	25APR86	J.SEINE	2	322	CH	36	58	978	68	1	20984
06JAN89	9 M TRAWL	2	312	BT	5	8	30MAR88	9 M TRAWL	1	210	BT	9	14	282	102	2	259273
10JAN89	9 M TRAWL	2	291	BT	9	14	13APR88	9 M TRAWL	1	209	BT	8	13	272	82	2	257943
12JAN89	9 M TRAWL	3	347	BT	9	14	09FEB88	9 M TRAWL	2	324	BT	9	14	338	23	1	36071
17JAN89	9 M TRAWL	2	357	BT	1	2	17MAR88	9 M TRAWL	1	251	BT	8	13	306	106	1	256528
18JAN89	9 M TRAWL	4	412	BT	5	8	02MAR87	9 M TRAWL	2	259	BT	9	14	688	153	1	23294
24JAN89	9 M TRAWL	2	267	BT	8	13	09MAR88	9 M TRAWL	1	233	BT	8	13	321	34	1	254959
24JAN89	9 M TRAWL	4	342	BT	9	14	16JAN87	9 M TRAWL	2	305	BT	9	14	739	37	2	25782
25JAN89	9 M TRAWL	3	366	BT	1	2	29FEB88	9 M TRAWL	2	312	BT	9	14	331	54	2	253613
25JAN89	9 M TRAWL	2	298	BT	1	2	29JAN88	9 M TRAWL	1	252	BT	9	14	362	46	1	252566
01FEB89	9 M TRAWL	2	325	BT	8	13	17DEC87	12 M/9 M COD	1	241	BT	8	13	412	84	1	30719
01FEB89	9 M TRAWL	4	362	BT	8	13	09FEB88	9 M TRAWL	3	316	BT	8	13	358	46	1	36935
03FEB89	9 M TRAWL	2	288	BT	8	13	24FEB88	9 M TRAWL	1	215	BT	1	2	345	73	2	252502
03FEB89	9 M TRAWL	.	399	BT	9	14	21APR88	9 M TRAWL	.	307	BT	9	14	288	92	1	258022
15FEB89	9 M TRAWL	4	470	BT	8	13	02APR86	12 M	1	230	BT	9	14	1050	240	1	13311
15FEB89	9 M TRAWL	2	354	BT	8	13	09FEB88	9 M TRAWL	1	253	BT	8	13	372	101	2	33362
16FEB89	9 M TRAWL	2	293	BT	9	14	05FEB88	9 M TRAWL	1	256	BT	8	13	377	37	2	33153
16FEB89	9 M TRAWL	2	349	BT	8	13	23FEB88	9 M TRAWL	1	243	BT	8	13	359	106	1	253038
17FEB89	9 M TRAWL	.	410	BT	9	14	03JAN86	9 M TRAWL	.	213	BT	5	8	1141	197	1	6602
21FEB89	9 M TRAWL	3	373	BT	8	13	06JAN88	12 M/9 M COD	2	340	BT	9	14	412	33	1	250740
21FEB89	9 M TRAWL	2	278	BT	8	13	24MAR88	9 M TRAWL	1	236	BT	1	2	334	42	1	259785
22FEB89	9 M TRAWL	3	335	BT	8	13	07MAR88	12 M/9 M COD	2	261	BT	8	13	352	74	1	254435

continued

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE							RELEASE										
DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	COND	TAG NUMBER
23FEB89	9 M TRAWL	2	334	BT	9	14	03MAR88	12 M/9 M COD	1	235	BT	8	13	357	99	2	254031
01MAR89	9 M TRAWL	2	246	BT	8	13	13JAN88	12 M/9 M COD	1	205	BT	8	13	413	41	1	251274
02MAR89	9 M TRAWL	3	372	BT	8	13	04FEB88	12 M/9 M COD	2	315	BT	1	2	392	57	2	36898
03MAR89	9 M TRAWL	3	344	BT	8	13	24FEB88	9 M TRAWL	2	287	BT	1	2	373	57	1	253057
08MAR89	9 M TRAWL	3	291	BT	5	8	10MAR88	9 M TRAWL	2	222	BT	8	13	363	69	2	255281
10MAR89	9 M TRAWL	2	249	BT	9	14	18FEB88	12 M/9 M COD	1	220	BT	1	2	386	29	2	256305
17MAR89	9 M TRAWL	3	346	BT	8	13	23NOV87	12 M/9 M COD	2	270	BT	1	2	480	76	1	30939
17MAR89	9 M TRAWL	4	410	BT	8	13	16MAR88	12 M/9 M COD	3	372	BT	8	13	366	38	1	255837
17MAR89	9 M TRAWL	2	295	BT	8	13	18MAR88	9 M TRAWL	1	240	BT	8	13	364	55	1	256667
17MAR89	9 M TRAWL	3	388	BT	8	13	18MAR87	12 M W/L	1	265	BT	8	13	730	123	1	24387
17MAR89	9 M TRAWL	3	331	BT	8	13	16DEC87	12 M/9 M COD	2	313	BT	8	13	457	18	1	30571
20MAR89	9 M TRAWL	2	326	BT	1	2	29DEC87	9 M TRAWL	1	237	BT	5	8	447	89	1	250242
21MAR89	9 M TRAWL	5	458	BT	8	13	25APR86	12 M	2	318	ER	12	19	1061	140	1	19532
23MAR89	9 M TRAWL	3	398	BT	8	13	28MAR88	12 M/9 M COD	2	341	BT	8	13	360	57	1	259880
27MAR89	9 M TRAWL	2	280	BT	9	14	28MAR88	12 M/9 M COD	1	243	BT	8	13	364	37	1	259054
27MAR89	9 M TRAWL	2	348	BT	9	14	09MAR88	9 M TRAWL	1	256	BT	8	13	383	92	1	254882
29MAR89	9 M TRAWL	2	307	BT	8	13	05APR88	12 M/9 M COD	1	227	BT	5	8	358	80	1	257702
29MAR89	9 M TRAWL	4	403	BT	8	13	30JAN87	12 M W/L	2	285	BT	1	2	789	118	1	16976
31MAR89	9 M TRAWL	5	499	BT	8	13	04FEB87	12 M	3	344	BT	9	14	786	155	1	26242

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 31 OCTOBER 1988 THROUGH 15 APRIL 1989.

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STATISTIC	NUMBER OF RECAPTURES IN WEEK																								
			31 OCT N = 1082	7 NOV N = 323	14 NOV N = 418	21 NOV N = 495	28 NOV N = 1051	5 DEC N = 629	12 DEC N = 1251	19 DEC N = 1205	26 DEC N = 957	2 JAN N = 1178	9 JAN N = 1064	16 JAN N = 973	23 JAN N = 1201	30 JAN N = 1211	6 FEB N = 1480	13 FEB N = 2115	20 FEB N = 681	27 FEB N = 1058	6 MAR N = 382	13 MAR N = 921	20 MAR N = 1831	27 MAR N = 1550	3 APR N = 922	10 APR N = 415	TOTAL N = 24393
31 OCT	1129	R	33																								33
		R/N	0.03050																								0.00135
		R/C	0.02923																								0.02923
7 NOV	336	R	0	2																							2
		R/N	0.00000	0.00619																							0.00008
		R/C	0.00000	0.00595																							0.00595
14 NOV	439	R	0	0	1																						1
		R/N	0.00000	0.00000	0.00239																						0.00004
		R/C	0.00000	0.00000	0.00228																						0.00228
21 NOV	516	R	3	0	0	1																					4
		R/N	0.00277	0.00000	0.00000	0.00202																					0.00016
		R/C	0.00581	0.00000	0.00000	0.00194																					0.00775
28 NOV	1091	R	3	0	0	3	8																				14
		R/N	0.00277	0.00000	0.00000	0.00606	0.00761																				0.00057
		R/C	0.00275	0.00000	0.00000	0.00275	0.00733																				0.01283
5 DEC	664	R	0	0	0	0	4	3																			7
		R/N	0.00000	0.00000	0.00000	0.00000	0.00381	0.00477																			0.00029
		R/C	0.00000	0.00000	0.00000	0.00000	0.00602	0.00452																			0.01054

continued

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																								
			31 OCT N = 1082	7 NOV N = 323	14 NOV N = 418	21 NOV N = 495	28 NOV N = 1051	5 DEC N = 629	12 DEC N = 1251	19 DEC N = 1205	26 DEC N = 957	2 JAN N = 1178	9 JAN N = 1064	16 JAN N = 973	23 JAN N = 1201	30 JAN N = 1211	6 FEB N = 1480	13 FEB N = 2115	20 FEB N = 681	27 FEB N = 1058	6 MAR N = 382	13 MAR N = 921	20 MAR N = 1831	27 MAR N = 1550	3 APR N = 922	10 APR N = 415	TOTAL N = 24393
12 DEC	1369	R	1	0	0	1	1	0	7																		10
		R/N	0.00092	0.00000	0.00000	0.00202	0.00095	0.00000	0.00560																		0.00041
		R/C	0.00073	0.00000	0.00000	0.00073	0.00073	0.00000	0.00511																		0.00730
19 DEC	1264	R	1	1	1	2	1	0	1	11																	18
		R/N	0.00092	0.00310	0.00239	0.00404	0.00095	0.00000	0.00080	0.00913																	0.00074
		R/C	0.00079	0.00079	0.00079	0.00158	0.00079	0.00000	0.00079	0.00870																	0.01424
26 DEC	1015	R	2	1	0	0	0	0	1	0	1																5
		R/N	0.00185	0.00310	0.00000	0.00000	0.00000	0.00000	0.00080	0.00000	0.00104																0.00020
		R/C	0.00197	0.00099	0.00000	0.00000	0.00000	0.00000	0.00099	0.00000	0.00099																0.00493
2 JAN	1234	R	1	0	0	0	1	0	2	1	6	12															23
		R/N	0.00092	0.00000	0.00000	0.00000	0.00095	0.00000	0.00160	0.00083	0.00627	0.01019															0.00094
		R/C	0.00081	0.00000	0.00000	0.00000	0.00081	0.00000	0.00162	0.00081	0.00486	0.00972															0.01864
9 JAN	1094	R	0	0	0	0	0	0	0	1	0	2	7														10
		R/N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00083	0.00000	0.00170	0.00658														0.00041
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00091	0.00000	0.00183	0.00640														0.00914
16 JAN	1014	R	0	0	0	1	0	0	0	0	3	5	1	7													17
		R/N	0.00000	0.00000	0.00000	0.00202	0.00000	0.00000	0.00000	0.00000	0.00313	0.00424	0.00094	0.00719													0.00070
		R/C	0.00000	0.00000	0.00000	0.00099	0.00000	0.00000	0.00000	0.00000	0.00296	0.00493	0.00099	0.00690													0.01677

continued

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK: 31 OCT N = 1082	7 NOV N = 323	14 NOV N = 418	21 NOV N = 495	28 NOV N = 1051	5 DEC N = 629	12 DEC N = 1251	19 DEC N = 1205	26 DEC N = 957	2 JAN N = 1178	9 JAN N = 1064	16 JAN N = 973	23 JAN N = 1201	30 JAN N = 1211	6 FEB N = 1480	13 FEB N = 2115	20 FEB N = 681	27 FEB N = 1058	6 MAR N = 382	13 MAR N = 921	20 MAR N = 1831	27 MAR N = 1550	3 APR N = 922	10 APR N = 415	TOTAL N = 24393
23 JAN	1253	R	0	0	0	1	0	1	0	1	3	0	6	2	4												18
		R/N	0.00000	0.00000	0.00000	0.00202	0.00000	0.00159	0.00000	0.00083	0.00313	0.00000	0.00564	0.00206	0.00333												0.00074
		R/C	0.00000	0.00000	0.00000	0.00080	0.00000	0.00080	0.00000	0.00080	0.00239	0.00000	0.00479	0.00160	0.00319												0.01437
30 JAN	1278	R	2	1	0	1	0	0	1	1	1	3	1	2	2	7											22
		R/N	0.00185	0.00310	0.00000	0.00202	0.00000	0.00000	0.00080	0.00083	0.00104	0.00255	0.00094	0.00206	0.00167	0.00578											0.00090
		R/C	0.00156	0.00078	0.00000	0.00078	0.00000	0.00000	0.00078	0.00078	0.00078	0.00235	0.00078	0.00156	0.00156	0.00548											0.01721
6 FEB	1517	R	1	0	0	0	1	2	0	0	1	0	1	2	1	4	4										17
		R/N	0.00092	0.00000	0.00000	0.00000	0.00095	0.00318	0.00000	0.00000	0.00104	0.00000	0.00094	0.00206	0.00083	0.00330	0.00270										0.00070
		R/C	0.00066	0.00000	0.00000	0.00000	0.00066	0.00132	0.00000	0.00000	0.00066	0.00000	0.00066	0.00132	0.00066	0.00264	0.00264										0.01121
13 FEB	2193	R	2	1	0	0	1	2	2	1	2	3	3	1	3	2	3	3									29
		R/N	0.00185	0.00310	0.00000	0.00000	0.00095	0.00318	0.00160	0.00083	0.00209	0.00255	0.00282	0.00103	0.00250	0.00165	0.00203	0.00142									0.00119
		R/C	0.00091	0.00046	0.00000	0.00000	0.00046	0.00091	0.00091	0.00046	0.00091	0.00137	0.00137	0.00046	0.00137	0.00091	0.00137	0.00137									0.01322
20 FEB	706	R	1	1	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1								7
		R/N	0.00092	0.00310	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00083	0.00135	0.00047	0.00147								0.00029
		R/C	0.00142	0.00142	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00142	0.00283	0.00142	0.00142								0.00992
27 FEB	1117	R	0	0	0	0	1	0	2	0	0	0	0	1	0	2	1	3	1	8							19
		R/N	0.00000	0.00000	0.00000	0.00000	0.00095	0.00000	0.00160	0.00000	0.00000	0.00000	0.00000	0.00103	0.00000	0.00165	0.00068	0.00142	0.00147	0.00756							0.00078
		R/C	0.00000	0.00000	0.00000	0.00000	0.00090	0.00000	0.00179	0.00000	0.00000	0.00000	0.00000	0.00090	0.00000	0.00179	0.00090	0.00269	0.00090	0.00716							0.01701

continued

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																								
			31 OCT N = 1082	7 NOV N = 323	14 NOV N = 418	21 NOV N = 495	28 NOV N = 1051	5 DEC N = 629	12 DEC N = 1251	19 DEC N = 1205	26 DEC N = 957	2 JAN N = 1178	9 JAN N = 1064	16 JAN N = 973	23 JAN N = 1201	30 JAN N = 1211	6 FEB N = 1480	13 FEB N = 2115	20 FEB N = 681	27 FEB N = 1058	6 MAR N = 382	13 MAR N = 921	20 MAR N = 1831	27 MAR N = 1550	3 APR N = 922	10 APR N = 415	TOTAL N = 24393
6 MAR	409	R	2	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	2						9
		R/N	0.00185	0.00000	0.00000	0.00202	0.00000	0.00000	0.00080	0.00000	0.00000	0.00000	0.00000	0.00000	0.00083	0.00000	0.00068	0.00000	0.00147	0.00000	0.00524						0.00037
		R/C	0.00489	0.00000	0.00000	0.00244	0.00000	0.00000	0.00244	0.00000	0.00000	0.00000	0.00000	0.00000	0.00244	0.00000	0.00244	0.00000	0.00244	0.00000	0.00489						0.02200
13 MAR	970	R	0	2	0	0	1	1	0	0	1	0	1	0	1	2	1	1	0	3	1	2					17
		R/N	0.00000	0.00619	0.00000	0.00000	0.00095	0.00159	0.00000	0.00000	0.00104	0.00000	0.00094	0.00000	0.00083	0.00165	0.00068	0.00047	0.00000	0.00284	0.00262	0.00217					0.00070
		R/C	0.00000	0.00206	0.00000	0.00000	0.00103	0.00103	0.00000	0.00000	0.00103	0.00000	0.00103	0.00000	0.00103	0.00206	0.00103	0.00103	0.00000	0.00309	0.00103	0.00206					0.01753
20 MAR	1933	R	1	0	0	0	1	0	0	1	0	1	2	5	2	3	5	4	1	4	2	1	7				40
		R/N	0.00092	0.00000	0.00000	0.00000	0.00095	0.00000	0.00000	0.00083	0.00000	0.00085	0.00188	0.00514	0.00167	0.00248	0.00338	0.00189	0.00147	0.00378	0.00524	0.00109	0.00382				0.00164
		R/C	0.00052	0.00000	0.00000	0.00000	0.00052	0.00000	0.00000	0.00052	0.00000	0.00052	0.00103	0.00259	0.00103	0.00155	0.00259	0.00207	0.00052	0.00207	0.00103	0.00052	0.00362				0.02069
27 MAR	1649	R	1	0	2	2	1	0	1	3	0	2	2	0	1	1	2	3	1	4	0	1	2	5			34
		R/N	0.00092	0.00000	0.00478	0.00404	0.00095	0.00000	0.00080	0.00249	0.00000	0.00170	0.00188	0.00000	0.00083	0.00083	0.00135	0.00142	0.00147	0.00378	0.00000	0.00109	0.00109	0.00323			0.00139
		R/C	0.00061	0.00000	0.00121	0.00121	0.00061	0.00000	0.00061	0.00182	0.00000	0.00121	0.00121	0.00000	0.00061	0.00061	0.00121	0.00182	0.00061	0.00243	0.00000	0.00061	0.00121	0.00303			0.02062
3 APR	973	R	0	0	0	0	0	0	1	0	0	1	0	0	0	2	0	1	0	1	0	0	4	5	1		16
		R/N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00080	0.00000	0.00000	0.00085	0.00000	0.00000	0.00000	0.00165	0.00000	0.00047	0.00000	0.00095	0.00000	0.00000	0.00218	0.00323	0.00108		0.00066
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00103	0.00000	0.00000	0.00103	0.00000	0.00000	0.00000	0.00206	0.00000	0.00103	0.00000	0.00103	0.00000	0.00000	0.00411	0.00514	0.00103		0.01644

continued

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	31 OCT N = 1082	7 NOV N = 323	14 NOV N = 418	21 NOV N = 495	28 NOV N = 1051	5 DEC N = 629	12 DEC N = 1251	19 DEC N = 1205	26 DEC N = 957	2 JAN N = 1178
			NUMBER OF RECAPTURES IN WEEK									
10 APR	447	R	0	0	0	1	2	1	2	0	0	1
		R/N	0.00000	0.00000	0.00000	0.00202	0.00190	0.00159	0.00160	0.00000	0.00000	0.00085
		R/C	0.00000	0.00000	0.00000	0.00224	0.00447	0.00224	0.00447	0.00000	0.00000	0.00224
TOTAL	25610	R	54	9	4	14	23	10	21	20	18	30
		R/N	0.04991	0.02786	0.00957	0.02828	0.02188	0.01590	0.01679	0.01660	0.01881	0.02547
		R/C	0.00211	0.00035	0.00016	0.00055	0.00090	0.00039	0.00082	0.00078	0.00070	0.00117

RECAPTURE PERIOD	STA-TISTIC	9 JAN N = 1064	16 JAN N = 973	23 JAN N = 1201	30 JAN N = 1211	6 FEB N = 1480	13 FEB N = 2115	20 FEB N = 681	27 FEB N = 1058	6 MAR N = 382	13 MAR N = 921	20 MAR N = 1831	27 MAR N = 1550	3 APR N = 922	10 APR N = 415	TOTAL N = 24393
10 APR	R	1	0	0	0	0	0	0	0	0	1	0	2	0	2	13
	R/N	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00109	0.00000	0.00129	0.00000	0.00482	0.00053
	R/C	0.00224	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00224	0.00000	0.00447	0.00000	0.00447	0.02908
TOTAL	R	25	20	15	24	19	16	5	20	5	5	13	12	1	2	385
	R/N	0.02350	0.02055	0.01249	0.01982	0.01284	0.00757	0.00734	0.01890	0.01309	0.00543	0.00710	0.00774	0.00108	0.00482	0.01578
	R/C	0.00098	0.00078	0.00059	0.00094	0.00074	0.00062	0.00020	0.00078	0.00020	0.00020	0.00051	0.00047	0.00004	0.00008	0.01503

LEGEND: R = number of striped bass recaptured.

N = number of striped bass $\geq$150 mmTL marked and released.

C = number of striped bass $\geq$150 mmTL caught and examined for tags.

R/N = recapture rate.

R/C = recapture proportion.

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR THE HUDSON RIVER STRIPED BASS CAPTURED WITH ABRADED TAGS THAT WERE TAGGED AND RELEASED PRIOR TO AND RECAPTURED DURING 1988-89.

RECAPTURE					RELEASE					TAG INFORMATION				TAG CONDITION					
DATE	GEAR	STATION	R-M	LENGTH (mm TL)	DATE	GEAR	STATION	R_M	LENGTH (mm TL)	M_C	REL TAG NO.	M_C	NEW TAG_NO.	TAG NO.	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	TAG COND.
3 NOV 88	9m	BT	1	325	10 APR 87	12m W/L	BT	1	248	96	* 28884	98	258542	4	1	4	P	N	1
7 NOV 88	9m	BT	5	505							* -	98	258663	1	2				2
9 NOV 88	9m	BT	9	331	31 MAR 88	9m	BT	9	259	98	259489			4	4	4		N	2
11 NOV 88	9m	UH	2	337	4 FEB 88	12mW/CE	BT	1	294	97	33078			4	4	4		N	1
11 NOV 88	9m	UH	2	377	23 MAR 87	9m	BT	9	277	97	24763			4	4	4		N	1
11 NOV 88	9m	UH	2	365	26 MAR 87	9mW/L	BT	9	262	96	* 24936	98	258928	2				N	1
15 NOV 88	9m	UH	2	362	3 DEC 87	12m	UH	2	325	96	29209			4	4	4	P	N	1
15 NOV 88	9m	UH	2	457							* -	98	260130					N	1
16 NOV 88	9m	UH	2	498	27 MAR 86	12m	UH	2	336		* 21454	98	260041	2	2	2		N	2
17 NOV 88	9m	BT	5	268	29 JAN 88	9m	BT	8	203	98	252629			4	4	4		N	2
18 NOV 88	9m	UH	2	344	4 MAR 88	12mW/CE	BT	8	254	98	254424							N	1
18 NOV 88	9m	UH	2	352	23 MAR 88	12mW/CE	BT	1	267	98	259634			4	4	4		N	1
22 NOV 88	9m	BT	1	378	4 DEC 87	9m	BT	1	328	96	29621			4	4	4	P	N	1
22 NOV 88	9m	BT	1	350	22 DEC 86	9m	BT	9	242	96	18670			4	4	4	P	N	1
22 NOV 88	9m	BT	1	285	4 MAR 88	12mW/CE	BT	8	239	98	$ 254372			4	4	4		Y	2
23 NOV 88	9m	BT	1	523	4 DEC 87	9m	BT	1	466	96	29217			4	4	4	P	N	1
28 NOV 88	9m	BT	5	519	17 NOV 87	9m	BT	5	497	96	31243			4	4	4		N	1
28 NOV 88	9m	BT	1	416	9 APR 87	9m	BT	1	303	96	* 30097	98	260921	3	1			N	1
7 DEC 88	9m	BT	9	306	6 APR 88	9m	BT	9	244	98	257776			4	4	4	A	N	1
7 DEC 88	9m	BT	9	240	10 MAR 88	9m	BT	8	205	98	255414			4	4	4	A	N	2
8 DEC 88	9m	BT	1	458	16 JAN 86	12m	BT	5	247	96	* 05788	98	262320	2	2	2	P	N	2
16 DEC 88	9m	BT	1	370	10 FEB 88	9m	BT	8	299	97	33553			4	4	4		N	1
16 DEC 88	9m	BT	1	419	8 JAN 87	12mW/L	BT	1	214	96	17235			4	4	4	P	N	2
19 DEC 88	9m	BT	5	403	17 MAR 88	9m	BT	8	282	98	256515							N	2
20 DEC 88	9m	BT	1	250	19 FEB 88	12mW/CE	BT	8	225	98	256379								2

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE DATE	GEAR	STATION	R-M	LENGTH (mm TL)	RELEASE DATE	GEAR	STATION	R_M	LENGTH (mm TL)	M_C	REL TAG NO.	M_C	NEW TAG_NO.	TAG NO.	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	TAG COND.
20 DEC 88	9m	BT	1	325	12 FEB 88	9mW/L	BT	1	259	96	* 22409	98	264280						1
22 DEC 88	9m	BT	1	439	26 JAN 88	9m	BT	1	388	98	252071			4	4	4	A	N	1
28 DEC 88	9m	BT	5	390	25 APR 86	JSeine	BT	36	322	96	* 20984	98	265391	3	1				1
6 JAN 89	9m	BT	5	312	30 APR 88	9m	BT	9	210	98	259273			4	4	4	A	N	2
10 JAN 89	9m	BT	9	291	13 APR 88	9m	BT	8	209	98	257943			4	4	4	A	N	2
12 JAN 89	9m	BT	9	347	9 FEB 88	9m	BT	9	324	97	36071								1
17 JAN 89	9m	BT	1	357	17 MAR 88	9m	BT	8	251	98	256528							N	1
18 JAN 89	9m	BT	5	412	2 MAR 87	9m	BT	9	259	96	* 23294	98	277202	2	2	3	P	N	1
24 JAN 89	9m	BT	8	267	9 MAR 88	9m	BT	8	233	98	254959			4	4	4		N	1
24 JAN 89	9m	BT	9	342	16 JAN 87	9m	BT	9	305	96	* 25782	98	270115	3	1			N	2
25 JAN 89	9m	BT	1	366	29 FEB 88	9m	BT	9	312	98	* 253613			3	3	3	A	N	2
25 JAN 89	9m	BT	1	298	29 JAN 88	9m	BT	9	252	98	252566			4	4	4	A	N	1
1 FEB 89	9m	BT	8	325	17 DEC 87	12mW/CE	BT	8	241	96	30719							N	1
1 FEB 89	9m	BT	8	362	9 FEB 88	9m	BT	8	316	97	36935			4	4	4		N	1
2 FEB 89	9m	BT	8	288	28 JAN 88	12mW/CE	BT	1	215	98	252502			4	4	4	A	Y	2
2 FEB 89	9m	BT	9	399	21 APR 88	9m	BT	9	307	98	258022			4	4	4	A	N	1
15 FEB 89	9m	BT	8	470	2 APR 86	12m	BT	9	230	96	13311			4	4	4	P	N	1
15 FEB 89	9m	BT	8	354	9 FEB 88	9m	BT	8	253	97	$ 33362			4	4	4		Y	2
16 FEB 89	9m	BT	8	349	23 FEB 88	9m	BT	8	243	98	253038			4	4	4	A	N	1
16 FEB 89	9m	BT	8	293	5 FEB 88	9m	BT	8	256	97	$ 33153			4	4	4		Y	2
17 FEB 89	9m	BT	9	410	3 JAN 86	9m	BT	5	213	96	* 06602	98	271328	3	1	2	P	N	1
21 FEB 89	9m	BT	8	278	24 MAR 88	9m	BT	1	236	98	259785			4	4	4	A	N	1
21 FEB 89	9m	BT	8	373	6 JAN 88	9m	BT	9	340	98	250740			4	4	4		N	1
22 FEB 89	9m	BT	8	335	7 MAR 88	12mW/CE	BT	8	261	98	254435			4	4	4	A	N	1
23 FEB 89	9m	BT	9	334	3 MAR 88	12mW/CE	BT	8	235	98	254031			4	4	4		N	2

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION				TAG CONDITION					
DATE	GEAR	STA-TION	R-M	LENGTH (mm TL)	DATE	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG NO.	M_C	NEW TAG_NO.	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
1 MAR 89	9m	BT	8	246	13 JAN 88	12mW/CE	BT	8	205	98	251274			4	4	4		N	1
2 MAR 89	9m	BT	8	372	4 FEB 88	12mW/CE	BT	1	315	97	$* 36898			3	3	3		Y	2
3 MAR 89	9m	BT	8	344	24 FEB 88	9m	BT	1	287	98	253057			4	4	4	A	N	1
8 MAR 89	9m	BT	5	291	10 MAR 88	9m	BT	8	222	98	255281			4	4	4	A	N	2
10 MAR 89	9m	BT	9	249	18 FEB 88	12mW/CE	BT	1	220	98	$ 256305			4	4	4		Y	2
17 MAR 89	9m	BT	8	346	23 NOV 87	12mW/CE	BT	1	270	96	30939			4	4	4	P	N	1
17 MAR 89	9m	BT	8	410	16 MAR 88	12mW/CE	BT	8	372	98	255837			4	4	4	A	N	1
17 MAR 89	9m	BT	8	295	18 MAR 88	9m	BT	8	240	98	256667			4	4	4	A	N	1
17 MAR 89	9m	BT	8	388	18 MAR 87	12 m	BT	8	265	96	24387			4	4	4	P	N	1
17 MAR 89	9m	BT	8	331	16 DEC 87	12mW/CE	BT	8	313	96	30571			4	4	4	P	N	1
21 MAR 89	9m	BT	8	458	25 APR 86	12m	BT	12	318	96	* 19532	98	271548					N	1
23 MAR 89	9m	BT	8	398	28 MAR 88	12mW/CE	BT	8	341	98	259880			4	4	4		N	1
27 MAR 89	9m	BT	9	348	9 MAR 88	9m	BT	8	256	98	254882			4	4	4	A	N	1
27 MAR 89	9m	BT	9	280	28 MAR 88	12mW/CE	BT	8	243	98	259054			4	4	4	A	N	1
29 MAR 89	9m	BT	8	307	5 APR 88	12mW/CE	BT	5	227	98	257702			4	4	4	A	N	1
29 MAR 89	9m	BT	8	403	30 JAN 87	12mW/L	BT	1	285	96	16976			4	4	4	P	N	1
31 MAR 89	9m	BT	8	499	8 JAN 87	12mW/L	BT	9	344	96	26242			4	4	4	P	N	1

(CONTINUED)

TABLE D-5. (CONTINUED)

LEGEND:

Gear

- 9m = 9m trawl
- 9m W/L = 9m trawl with 2.5cm cod end liner
- 12m = 12m trawl
- 12m W/L = 12m trawl with 2.5cm cod end liner
- 12m W/9m CE = 12m trawl with 9m cod end liner
- J. Seine = Jackson 280 Scottish seine

Station

- BT = Battery
- UH = Upper Harbor

M-C

- 96 = Floy internal anchor, external streamer (F)
- 97 = Floy internal anchor, external streamer tag with tube over external streamer tag (FT)
- 98 = Hallprint internal anchor, external streamer tag (H)

- * = Abraded tag
- $ = Anchor protrusion

TAG VARIABLE	COMMENT CODE	COMMENT DESCRIPTION
Number	1,2,3, or 4	1= Legend completely missing
Address	1,2,3, or 4	2=Abraded and partly missing
Reward	1,2,3, or 4	3=Abraded but completely legible
		4=Completely legible
Number orientation	A or P	A=Tag number facing anterior(Head)
		B=Tag number facing posterior(Tail)
Anchor protrusion	Y or N	Y=Yes
		N=No

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE LOWER HUDSON RIVER DURING WINTER 1988-89.

SAMPLING WEEK	(≥150 mTL) C TOTAL	(≥150 mmTL) M TOTAL	CUM M TOTAL	R TOTAL	R/C
12DEC88	1369	1251	3998	3	0.0022
19DEC88	1264	1205	5249	7	0.0055
26DEC88	1015	957	6454	4	0.0039
02JAN89	1234	1178	7411	11	0.0089
09JAN89	1094	1064	8589	3	0.0027
16JAN89	1014	973	9653	10	0.0099
23JAN89	1253	1201	10626	14	0.0112
30JAN89	1278	1211	11827	15	0.0117
06FEB89	1517	1480	13038	13	0.0086
13FEB89	2193	2115	14518	26	0.0119
20FEB89	706	681	16633	6	0.0085
27FEB89	1117	1058	17314	11	0.0098
06MAR89	409	382	18372	7	0.0171
13MAR89	970	921	18754	15	0.0155
20MAR89	1933	1831	19675	33	0.0171
27MAR89	1649	1550	21506	29	0.0176
TOTAL	20015	19058	139649	158	0.1196

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 12 DECEMBER 1988 THROUGH THE WEEK OF 27 MARCH 1989.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00111	0.00111	157.75	0.0001
Error	15	0.00011	0.00001		
Total	16	0.00121			

Regression Equation: R/C = (Cumulative M) X + error,

where,

X = 0.00000081 and

Standard Error of X = 0.00000006

R^2 = coefficient of determination = 0.91
df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F-ratio
p>F = probability of obtaining a larger F-ratio

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)[a]	MODIFIED INTERNAL ANCHOR (HALL)[a]	SMALL DART (HALL)[a]
1984	737	737[b]	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	--	3,958	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819[b]
TOTAL	65,484	737[b]	26,443	6,173	16,402	16,466	819[b]

[a]Hall - Hallprint.

[b]Not included in row total because fish were double tagged.

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1984 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Dennison	T-bar	Yellow PVC	$10	1
Floy Dennison	T-bar	Yellow PVC	$10-$1000	1
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	3
Floy Dennison and	T-bar	Yellow PVC	$10	414
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	35
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$10	23
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10-$1000	
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	90
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$5-$1000	5
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10-$1000	
Floy Dennison and	T-bar	Yellow PVC	$10	5
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	

(continued)

APPENDIX TABLE D-9. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	19
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	
Floy Dennison and	T-bar	Yellow PVC	$5-$1000	141
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	
1984 TOTAL:				737

*Striped bass $\geq$ 300 mmTL in good condition were double tagged and released.

APPENDIX TABLE D-10. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1985-86 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	$5-$1000	9,551
Floy Internal Anchor	Small, red, no legend	Yellow PVC	$10-$1000	16
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	$5-$1000	7,305
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	$10-$1000	1,576
1985-86 TOTAL:				18,448

*Striped bass $\geq$ 200 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-11. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1986-87 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$5-\$1000	2,095
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$10-\$1000	1,953
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	\$5-\$1000	159
Floy Internal Anchor	Small, red legend	Pink PVC with tube	\$10-\$1000	1,012
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	\$5-\$1000	109
Floy Internal Anchor	Large, blue no legend	Yellow PVC	\$10-\$1000	3,101
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$5-\$1000	639
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$10-\$1000	405
1986-87 TOTAL:				9,473

*Striped bass $\geq$ 200 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-12. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1987-88 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$5-\$1000	820
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	\$5-\$1000	162
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	\$10-\$1000	1,012
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	\$5-\$1000	778
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$5-\$1000	537
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$10-\$1000	649
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypro-pylene with exposed filament	\$5-\$1000	3,506
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypro-pylene with exposed filament	\$10-\$1000	4,969
1987-88 TOTAL:				12,433

*Striped bass $\geq$ 200 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-13. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1988-89 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	9,017
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	4,995
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with exposed filament	$5-$1000	2,936
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with exposed filament	$10-$1000	4,991
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	1,635

(continued)

APPENDIX TABLE D-13. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	595
Hallprint Internal Anchor	Large, yellow,	Yellow polypropylene with covered filament	$10-$1000	
and Hallprint dart	Small, yellow,	Yellow polypropylene with covered filament	$10-$1000	224
1988-89 TOTAL:				24,393

*Striped bass ≥ 150 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

APPENDIX E. STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 31 October 1988 and 15 April 1989 were taken to the Verplanck, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. The intention of this laboratory program was to gather incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1985-86, 1986-87 and 1987-88 programs (NAI 1986, 1987, 1988). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mmTL tomcod).

E.2.0 LABORATORY METHODS

E.2.1 <u>LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS</u>

Length, weight, sex, and sexual condition were determined for up to 10 striped bass per sampling day. Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E2-1.

TABLE E2-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS.[a]

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, les firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and stringlike, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in texture, but milt not running.

[a]From Con Edison Data Dictionary

E.2.2 STRIPED BASS STOMACH CONTENTS ANALYSIS

The same striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass predominated throughout the 1988-89 Hatchery Evaluation Program (Table E3-1). Only three female striped bass were captured in the resting stage in December and January, while seven male striped bass in the resting stage appeared in November, December and January. Six developing males were collected in February and March. No striped bass in the ripe, or ripe and running stages were examined.

The lack of ripe, or ripe and running striped bass in the 1988-89 biocharacteristics samples agrees with the findings of the 1985-86, 1986-87 and 1987-88 programs. This is not surprising because the majority of the fish captured in both programs were of pre-spawning size (< 400 mmTL) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the developing stage with time during the 1985-86, 1986-87, 1987-88 and 1988-89 programs indicates the approach of the spawning season, and that male striped bass may undergo a longer period of gonadal development prior to spawning than females. However, due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 94 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Few fish were captured in the larger (> 400 mmTL) length groups and a high percentage of stomachs were empty (54%) which made generalizations about changes in food habits with length difficult. Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and the majority of those were clupeids as incidentally noted by laboratory personnel.

Percentage of non-empty striped bass with invertebrate remains in their stomachs generally decreased with increasing length group (Table E3-2), however, invertebrates were eaten by both fish in the largest length group (401-500 mm) that had food in their stomach. This is in general agreement with the findings from the 1985-86 Hudson River Striped Bass Program where invertebrate remains were most common in striped bass ≤ 300 mmTL (NAI 1986), and with findings from the 1987-88 program where invertebrates were most common in striped bass ≤ 200 mmTL (NAI 1988). Invertebrate remains were most common in the 301-400 mmTL length group during the 1986-87 program (NAI 1987).

Twenty seven striped bass were examined with fish remains in their stomachs during the 1988-89 program. The percentage of non-empty striped bass with fish remains in their stomachs generally increased with length, as in the 1986-87 and 1985-86 programs (NAI 1987). This trend of increasing importance of fish as food items as striped bass length increases probably represents a switch in food habits to piscivory in older fish and has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). In 1987-88 too few fish were found in striped bass stomachs to delineate trends.

The percent of striped bass with empty stomachs generally decreased with length as in the 1986-87 and 1987-88 programs. In 1985-86, the percentage of striped bass with empty stomachs generally increased with length.

APPENDIX TABLE E3-1. SEXUAL CONDITION OF STRIPED BASS CAPTURED IN THE BATTERY REGION DURING THE 1988-89 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS														
	FEMALES					MALES					UNDETERMINED				
MONTH	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL
NOV	100 (1)				100 (1)	50 (1)	50 (1)			100 (2)					
DEC	82 (9)	18 (2)			100 (11)	58 (7)	42 (5)			100 (12)	100 (4)				100 (4)
JAN	90 (9)	10 (1)			100 (10)	91 (10)	9 (1)			100 (11)	100 (1)				100 (1)
FEB	100 (7)				100 (7)	67 (6)		33 (3)		100 (9)	100 (2)				100 (2)
MAR	100 (9)				100 (9)	63 (5)		38 (3)		100 (8)					
APR	100 (3)				100 (3)	100 (2)				100 (2)					
TOTAL	93 (38)	7 (3)			100 (41)	70 (31)	16 (7)	14 (6)		100 (44)	100 (7)				100 (7)

APPENDIX TABLE E3-2. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1988-89 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS					
LENGTH GROUP (mm TL)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤200	11.8 (2)	5.9 (1)	0.0 (0)	5.9 (1)	76.5 (13)	100.0 (17)
201-300	20.9 (9)	14.0 (6)	0.0 (0)	4.7 (2)	60.5 (26)	100.0 (43)
301-400	6.7 (2)	26.7 (8)	0.0 (0)	23.3 (7)	43.3 (13)	100.0 (30)
401-500	0.0 (0)	0.0 (0)	0.0 (0)	50.0 (2)	50.0 (2)	100.0 (4)
TOTAL	13.8 (13)	16.0 (15)	00.0 (0)	12.8 (12)	57.4 (54)	100.0 (94)

APPENDIX F

STRIPED BASS

DART AND INTERNAL ANCHOR TAG 30-DAY RETENTION RATE STUDY

APPENDIX F. STRIPED BASS DART AND INTERNAL ANCHOR TAG 30-DAY RETENTION RATE STUDY.

1.0 INTRODUCTION

From 1984 to present several types of tags have been used to tag striped bass during the Hudson River Striped Bass Hatchery Evaluation (Figure 2-2). Each tag type has demonstrated some tendency to be shed over time. This tag retention study was undertaken to obtain short term retention rate data for the Hallprint internal anchor tag which is currently being used, and for a new tag type, the small Hallprint dart tag.

2.0 METHODS

2.1 CAPTURE AND ACCLIMATION

On 28 March 1989, 96 live striped bass (243-422 mmTL) were captured with the 9 m trawl in the Battery Region of the lower Hudson River estuary. At the time of capture water temperature was 5.5°C and salinity was 22.6 ppt. These fish were placed in an aerated fish transport tank and taken to the Verplanck striped bass hatchery where they were placed in a 1m x 5m holding pool. Aquarium salt was added to maintain a salinity of 17 ppt in the holding pool for 16 hours after collection. For the next 24 hours, Hudson River water of 4.5°C was circulated through the holding pool and salinity was decreased to 4 ppt. For the next 24 hours, river water and quarry water were mixed and the water supply was gradually switched over to freshwater from the quarry which supplies the hatchery. This was done to improve water clarity so that tag retention observations would be con-ducted without handling the fish. During the entire 96 hour acclimation period, salinity decreased from 22.6 ppt to 0.4 ppt. Three striped bass died during the first 16 hours of acclimation. No additional mortality occurred before the remaining 93 fish were tagged on 1 April 1989.

2.2 DART AND INTERNAL ANCHOR TAG APPLICATION

Each fish received two small Hallprint dart tags or one dart tag and one Hallprint internal anchor tag. Retention of small Hallprint dart tags was evaluated at two tag insertion sites. The first dorsal fin site was on the left side of the fish three scale rows below the origin of the first dorsal fin at a point between the second and third fin rays from the posterior end of the fin. The second dorsal fin site was on the left side of the fish three scale rows below the origin of the second dorsal fin, at a point mid-way along the fin. Retention of Hallprint internal anchor tags was evaluated at the standard NAI internal anchor tag site (Section 2.1.1). Each fish received two tags in the following combinations: (1) 60 fish received a first dorsal fin dart tag and a second dorsal fin dart tag, (2) 19 fish received a first dorsal fin dart tag and an internal anchor tag, (3) 14 fish received a second dorsal fin dart tag and an internal anchor tag. All appropriate methods specified in the Standard Operating Procedures Manual for the 1988-1989 Striped Bass Hatchery Evaluation Program (NAI 1988) were used to apply the tags. To facilitate tag rention observations, fish that received an internal anchor tag and either a first or second dorsal fin dart tag were held in a separate pool from fish that received a first and a second dorsal fin dart tag.

2.3 30-DAY POST-TAGGING OBSERVATIONS

Tagged striped bass were checked daily for 30 consecutive days for evidence of tag shedding. Dead fish were removed, and the date, tag locations and condition of the tag insertion sites were recorded. The tagged striped bass were not fed, and no prophylactic measures were taken to prevent disease or infection other than the application of mer-bromine antiseptic to the tag wounds at the time of tagging. Sheets of plywood were placed over portions of the holding pools to provide cover and reduce stress.

3.0 RESULTS AND DISCUSSION

3.1 MORTALITY AND TAG RETENTION

None of the 153 dart tags or 33 internal anchor tags were shed during the 30-day post-tagging observation period (Appendix Table F3-1). Mortality of tagged fish, however, was relatively high and this significantly reduced the number of test fish. By the second day after tagging 34% of the tagged fish were dead. This high initial tagging mortality probably resulted from a combination of handling and tagging stress, and the resultant osmoregulatory dysfunction which occurs in stressed fish in freshwater. After this initial mortality, no additional mortality was observed until day 12. From day 12 through day 30 a spreading fungus infection killed all of the remaining fish but one. Despite the high mortality, these data indicate a very high short term tag retention rate for small Hallprint dart tags properly inserted below the first or second dorsal fin, and for Hallprint internal anchor tags inserted at the NAI internal anchor tag site.

APPENDIX TABLE F3-1. SURVIVAL AND TAG RETENTION FOR HUDSON RIVER STRIPED BASS TAGGED WITH DART AND/OR INTERNAL ANCHOR TAGS AND OBSERVED FOR 30 DAYS DURING APRIL 1989.

DATE	FIRST DORSAL AND SECOND DORSAL DART TAGS			FIRST DORSAL DART TAG AND INTERNAL ANCHOR TAG			SECOND DORSAL DART TAG AND INTERNAL ANCHOR TAG			TOTAL		
APRIL	N LIVE	N DEAD	% MORT	N LIVE	N DEAD	% MORT	N LIVE	N DEAD	% MORT	N LIVE	N DEAD	% MORT
1	60	0	0.0	19	0	0.0	14	0	0.0	93	0	0.0
2	-	-	-	-	-	-	-	-	-	-	-	-
3	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
4	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
5	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
6	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
7	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
8	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
9	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
10	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
11	38	22	36.7	13	6	31.6	10	4	28.6	61	32	34.4
12	37	23	38.3	12	7	36.8	10	4	28.6	59	34	36.6
13	-	-	-	-	-	-	-	-	-	-	-	-
14	34	26	43.3	11	8	42.1	9	5	35.7	54	39	41.9
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	28	32	53.3	9	10	52.6	8	6	42.9	45	48	51.6
18	26	34	56.7	9	10	52.6	6	8	57.1	41	52	55.9
19	24	36	60.0	9	10	52.6	6	8	57.1	39	54	58.1
20	17	43	71.7	9	10	52.6	4	10	71.4	30	63	67.7
21	14	46	76.7	8	11	57.9	3	11	78.6	25	68	73.1
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	10	50	83.3	5	14	73.7	2	12	85.7	17	76	81.7
25	6	54	90.0	4	15	78.9	2	12	85.7	12	81	87.1
26	6	54	90.0	2	17	89.5	2	12	85.7	10	83	89.2
27	3	57	95.0	2	17	89.5	2	12	85.7	7	86	92.5
28	1	59	98.3	0	19	100.0	1	13	92.9	2	91	97.8
29	1	59	98.3	0	19	100.0	0	14	100.0	1	92	98.9
30	1	59	98.3	0	19	100.0	0	14	100.0	1	92	98.9

3.2 RELEASE OF DOUBLE TAGGED FISH TO EVALUATE LONG-TERM TAG RETENTION

During the 1988-89 program, 819 striped bass between 238 mmTL and 564 mmTL (mean = 289 mmTL, S.D. = 41 mmTL) were released into the Battery Region of the Hudson River after being caught and tagged with both a Hallprint internal anchor tag and Hallprint small dart tag at the first dorsal fin site. These fish were caught, tagged and released in the following weeks:

27 March - 2 April 1989	344 fish,
3 April - 9 April 1989	346 fish, and
10 April - 15 April 1989	129 fish.

Three of these fish were recaptured before sampling ended on 15 April 1989; two were tagged, released and recaptured during the week of 27 March and one was tagged, released and recaptured during the week of 10 April 1989.

1989-90 HUDSON RIVER

STRIPED BASS HATCHERY EVALUATION

Prepared under contract with

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was 0.4% for Age 1+ fish and 0.1% for Age 2+ fish among the population of striped bass caught in the lower Hudson River between 30 October 1989 and 13 April 1990. No Age 3+ hatchery striped bass were caught.

- Mean length at Age 0+ of the 1989 hatchery cohort of striped bass was significantly larger than the mean length at Age 0+ of the 1989 wild cohort of striped bass. In years prior to 1988-89, mean length at Age 0+ was significantly smaller for the hatchery cohort compared to the wild cohort. The large mean length of Age 0+ hatchery striped bass from the 1988 and 1989 cohorts was attributed to holding the hatchery fish longer than in previous years before stocking.

- The 1988 cohort of Age 1+ striped bass dominated the population statistics for Hudson River striped bass during the 1989-90 Hatchery Evaluation Program. The 1988 cohort represented 65% of the total catch and more than 90% of the population ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in upper New York Harbor and the Battery region was 776,000 fish with upper and lower 95% confidence intervals of 682,000 - 900,000. Age 1+ striped bass accounted for 640,000 fish in the mid-winter population, Age 2+ contributed 123,000 fish, Age 3+ contributed 6,000 fish and Age >3+ contributed 3,000 fish.

- During the 1989-90 striped bass program, 25,861 fish ≥150 mm were caught and 24,362 fish were tagged and released bringing the total number of striped bass tagged and released in these programs since 1984 to 89,846. Of the 655 fish that were recaptured, 583 were tagged and released in the present program, 61 were from 1988-89, 10 were from 1987-88, 1 was from 1986-87, and no fish had illegible tag numbers.

- Overall mean catch per unit of effort (CPUE) in the Battery region was 45.3 striped bass per ten minute tow. The catch was dominated by a strong 1988 year class of Age 1+ fish which contributed 65% of the total catch. Overall mean CPUE has increased annually since 1985-86.

- Handling mortality remained less than 1% during the 1989-90 program and was comparable to 1985-86, 1986-87, 1987-88, and 1988-89 even though smaller fish (between 150 and 200 mm) were tagged compared to programs prior to 1988-89. No relationship between water temperature and handling mortality was observed.

1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York to address this requirement. The total number of hatchery striped bass that has been stocked into the Hudson River is:

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,579
1988	48,611
1989	202,068
Total	1,597,909

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program to evaluate mitigation measures be conducted through May 1991. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery are tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally spawned striped bass. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered CWTs. If these striped bass are tagged with an external tag and released, then their recovery may

provide valuable information on the Hudson River stock. Mark-recapture methodologies could also be used to estimate annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986). Consequently, the program focused on estimating annual survival rate for Age 1+ and Age 2+.

The April-June 1984 Adult Striped Bass Program (NAI 1985) demonstrated that it was feasible to use a 12 m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass could be externally tagged and released without significantly increasing 24-hour mortality (Dunning et al. 1987). Finally, the 1984 program suggested the lower Hudson River estuary could be efficiently fished for striped bass with each gear.

The 1985-86 Hudson River Striped Bass Program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East Rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit of effort for a 12 m trawl was greater than for a 9 m trawl, but mean catch per day was almost identical for the two trawls because more tows could be taken using the 9 m trawl in a day. The 12 m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9 m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm.

A total of 18,487 striped bass ≥200 mm were captured in trawls and seines, tagged and released during the 1985-86 program. A total of 250 of these striped bass were recaptured. Two tagged fish from the

1984 program were also recaptured. However, no striped bass of any age containing CWTs were detected although all fish were checked for these tags. The estimated size of the mid-winter striped bass population in upper New York Harbor and the Battery region was approximately 540,000 fish ≥200 mm, based on the recapture of tagged fish released during late December 1985 through February 1986.

Data from the 1984 and 1985-86 field programs (NAI 1985, 1986) were also used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimator could be satisfied and the required sampling effort for their implementation was feasible.

The 1986-87 Hudson River Striped Bass Hatchery Evaluation was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per ten minute tow for both the 9 and 12 m trawls. Use of a cod end liner (2.5 cm stretch mesh) in the 9 m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of the cod end liner in the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+ and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm.

The 1987-88 Hudson River Striped Bass Hatchery Evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per ten minute tow for both the 9 m trawl and 12 m trawl with a cod end similar to the 9 m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one half of the catch. The 9 m trawl was more efficient than the 12 m trawl with a 9 m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6%. The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm.

The 1988-89 and 1989-90 Hudson River Striped Bass Hatchery Evaluation Programs were similar to the 1986-87 and 1987-88 programs with the exception that only the 9 m trawl was used. The striped bass catch in the 9 m trawl during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990a). The minimum size of striped bass that were tagged was lowered from 200 mm to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm.

The 1989-90 Hudson River Striped Bass Hatchery Evaluation was conducted to address the following objectives:

(1) determine if hatchery striped bass, stocked during any year between 1983 and 1988, can be detected in the Hudson River population as Age 1+ or older fish,

(2) estimate the proportion of Age 1+ through 3+ Hudson River striped bass composed of hatchery fish,

(3) tag all wild striped bass greater than or equal to 150 mm, that are in good condition, with internal anchor tags,

(4) determine catch rate and handling mortality of striped bass, and

(5) estimate the abundance of striped bass overwintering in the lower Hudson River during each year.

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1989-90 Hudson River Striped Bass Hatchery Evaluation/ Atlantic Tomcod Standard Operating Procedures (NAI 1990b). The 1989-90 Hudson River Striped Bass Hatchery Evaluation Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1) with a 9 m trawl (Appendix Table A-1). Sampling locations were selected to maximize the catch per unit of effort of striped bass within the lower Hudson River, based on the results of the 1985-86, 1986-87, 1987-88 and 1988-89 programs (NAI 1986, 1987, 1988, 1990a). Previous programs used a Scottish seine, 9 m trawl, 12 m trawl, and a 12 m trawl with a 9 m trawl cod end to collect striped bass. Only the 9 m trawl was used in the 1989-90 program based on the results of the 1987-88 program which showed that the 9 m trawl was more efficient than other gear in catching striped bass of the target ages of Age 1+ and Age 2+ (NAI 1988). Striped bass captured in each trawl were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2) and released. In previous years, fish ≥200 mm (1985-86, 1986-87 and 1987-88) or ≥300 mm (1984) were tagged and released (Appendix Tables D-8 through D-14).

For 24 weeks, from the week of 30 October 1989 through the week of 9 April 1990, the 9 m trawl was deployed in the Upper Harbor and/or Battery regions. The 9 m trawl was fished in each of the 24 weeks in the Battery region and on selected days during two weeks in the Upper Harbor region (weeks of 25 December 1989 and 26 March 1990). An average of 15 tows per day were scheduled to be made with the 9 m trawl. Tow duration was 10 minutes unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawls were handled in a manner that minimized stress before tagging. The sampling effort generally required two boats. One boat

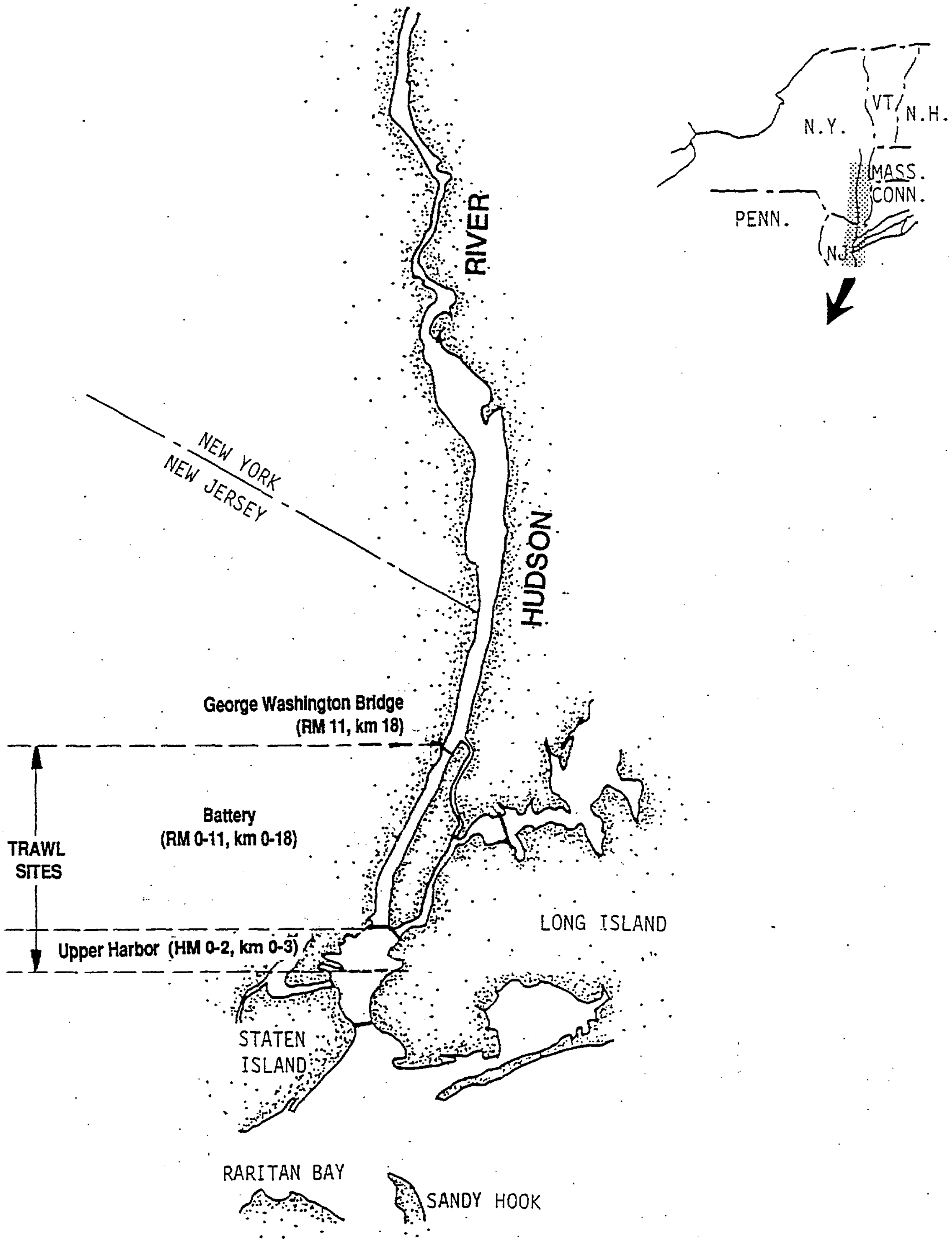
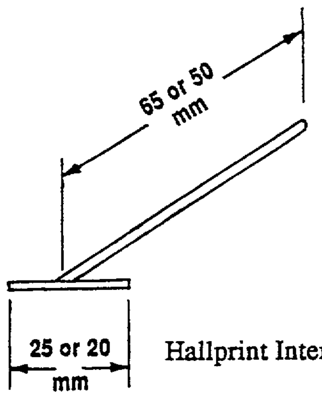
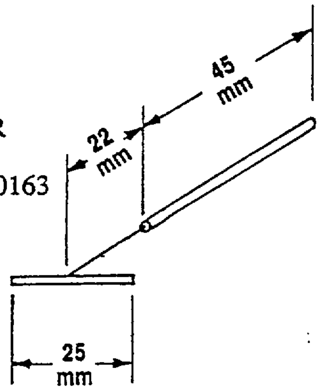


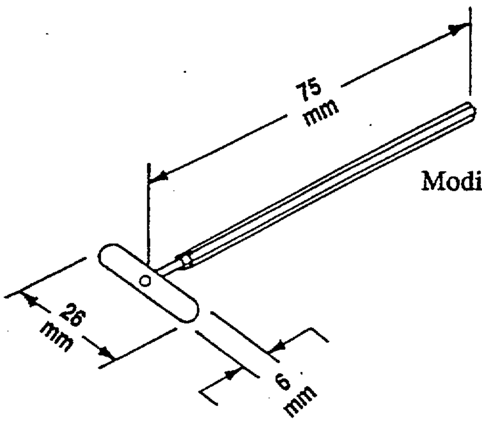
Figure 2-1. Sampling regions in the lower Hudson River and upper New York Harbor during the winter 1989-1990 Hudson River Striped Bass Hatchery Evaluation.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

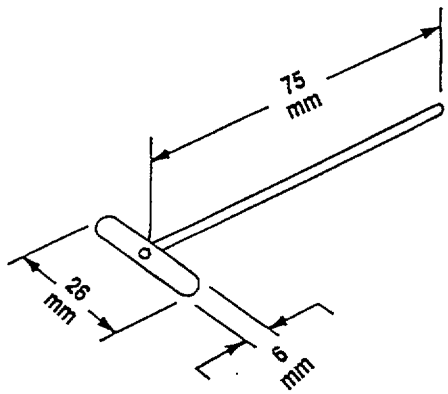
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

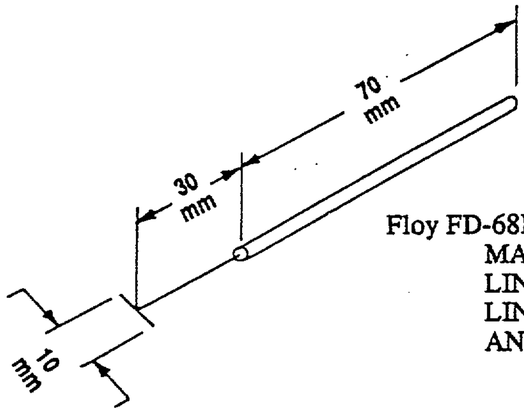




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-Present Hudson River Striped Bass Hatchery Evaluation Programs.

conducted the actual sampling (capture boat) while the second boat (tagging boat), with a holding facility for striped bass that was secured in the water alongside, tended the capture boat. The cod end of the net was transferred through the water from the capture boat to the holding facility alongside the tagging boat. Striped bass were then transferred from the holding facility to the tagging boat one at a time using the following procedures:

(1) fish were removed from the live car using a dip net,

(2) all surfaces that came in contact with the live fish were wet,

(3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and

(4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

If sampling conditions were rough (high wind and waves) or if the striped bass catch per tow was consistently less than 30 fish, field sampling was generally conducted with each boat and crew tagging its catch from its own holding facility.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for coded wire tags (CWT) using magnetic tag detectors. Two V-shaped field detectors were used in tandem throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

(1) no bleeding from gills or body wounds,
(2) no significant loss of scales, and
(3) strong opercular movement.

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a hooking movement of a curved scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromine-based topical antiseptic. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location. Scale samples were taken from the left side from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for recaptured, tagged fish from which a scale sample was taken on the right side of the fish to avoid regenerated scales. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass was also evaluated.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random subsample of striped bass using scales collected from the fish in the field. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mm length group. Expected numbers of Age 1+ striped bass in each 10 mm length group were calculated from age at length data obtained during the current and 1988-89 programs (NAI 1990a).

This program continued during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1986 and collected anywhere between November 1987 and April 1988 would be designated "Age 1+". This same fish, captured anywhere between November 1988 and April 1989, would be designated "Age 2+".

Striped bass scales were pressed on 0.050-inch thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.2.3 Stocking Check Analysis

The use of a stocking check to distinguish hatchery fish from wild striped bass was evaluated by presenting three technicians with an unknown sample of 609 mixed Age 0+ through 3+ hatchery and wild striped bass from the 1989-90 program. The origin of striped bass (hatchery or wild) and age was independently determined for these scales by the three technicians. Origin was assigned using the characteristics in Humphreys et al. (1990). Circuli on the scales of verified hatchery striped bass have thick widely spaced circuli near the focus corresponding to rapid hatchery growth followed by an abrupt growth check possibly caused by handling, tagging, and adaptation to natural food sources after release to the river.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving catch per unit effort. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data anlyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among locations and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Of Effort

Catch Per Unit of Effort (CPUE) for the 9 m trawl was defined as catch per ten-minute tow (Use Code = 1) and was calculated as

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \times 10 \right] \qquad \text{Equation 1}$$

where, $\bar{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,
E_i = the tow duration of trawl i in minutes, and
n = the number of trawls.

2.3.1.2 Length-Frequency

Length-frequency histograms, with number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9 m trawl. Length-frequency distributions for striped bass caught by the 9 m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1°C temperature interval:

$$PropD_x = D_x/T_x \qquad \text{Equation 2}$$

where, $PropD_x$ = the proportion of dead striped bass at water temperature x,
D_x = the number of dead striped bass at water temperature x, and
T_x = total number of striped bass captured at water temperature x.

PropD was calculated for samples collected in the Battery at both surface and bottom water temperatures. Comparisons of handling mortality among the 1989-90, 1988-89, 1987-88, 1986-87 and 1985-86 programs were also made using data subsetted by gear within the Battery region in each year.

Differences in striped bass handling mortality among programs (1985-86, 1986-87, 1987-88, 1988-89 and 1989-90) were assessed by comparing the percentage of dead fish in the catch in one degree temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 Estimated Number of Striped Bass in Each Age Category

A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1989-90 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mm length increment and the variance of the proportion of Age 1+ fish in each 10 mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish, and is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n(N_h\sqrt{p_h q_h}/\Sigma N_h\sqrt{p_h q_h}) \qquad \text{Equation 3}$$

where

n_h = number of scale samples selected for age determination from length group h,

n = number of scale samples to be selected from the total of N fish caught,

N_h = total number of fish caught in length group h,

p_h = proportion of Age 1+ fish in length group h from the laboratory sample, and

$q_h = 1 - p_h$

The stratified sampling plan was implemented using actual age-length frequency data from the 1988-89 study (NAI 1990a). The stratified sampling program was designed to select approximately 16% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1988-89 were applied to the data in three lots to permit scale analysis to proceed during the study. In each lot (30 October-31 December, 1 January-26 February and 27 February-13 April) scale samples from approximately 16% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1989-90 program was estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \Sigma(N_h p_{hi}/N) \qquad \text{Equation 4}$$

where

p_{sti} = the stratified mean proportion of Age i fish,

p_{hi} = the proportion of Age i fish in length group h, and

N_h and N are as defined in Equation 3.

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N(p_{sti}) \qquad \text{Equation 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2_{p_{sti}}$) was calculated by the method of Cochran (1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h^2(N_h - n_h)/(N_h - 1)][(p_{hi}q_{hi})/(n_h - 1)]\right] \qquad \text{Equation 6}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977) Equations 5.14 and 5.15:

$$95\%\ \text{CI for } p_{sti} = p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Equation 7}$$

$$95\%\ \text{CI for } A_i = N\ p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Equation 8}$$

where

$$s_{p_{sti}} = \sqrt{s^2_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 4-7.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1989-90 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi}\,\bar{y}_{hi}\right]/N_i \qquad \text{Equation 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

n_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least two Age i fish were measured. If only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean.

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling situation in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24 with the assumption that N_i is large and substantially larger than n_i, therefore $N_i^{-1} \simeq 0$ and $g'_i \simeq 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L} \left[w_{hi} (S^2_{hi} / n'_i V_{hi}) \right] + (1/n'_i) \sum_{h=1}^{L} w_{hi} (\bar{y}_{hi} - \bar{y}_{sti})^2 \qquad \text{Equation 10}$$

where

$S^2_{\bar{y}_{sti}}$ = Two-phase variance of the stratified mean length of striped bass of Age i,

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes Theorum presented in Equation 11,

S^2_{hi} = variance of the mean length of Age i fish in length group h of the laboratory sample,

n'_i = total number of Age i fish in the laboratory sample,

V_{hi} = proportion of Age i fish in length group h, and

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9.

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes Theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P(L_h \mid A_i) = [P(L_h)\, P(A \mid L_h)] / P(A_i) \qquad \text{Equation 11}$$

where

w_{hi} is as defined in Equation 10,

A_i = Age i striped bass,

$P(L_h)$ = proportion of the total catch of striped bass in length group h,

$P(A_i \mid L_h)$ = proportion of aged fish in length group h that are Age i, and

$P(A_i)$ = proportion of Age i fish in the total catch.

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ \text{CI for } \bar{y}_{sti} = \bar{y}_{sti} + t\, S_{\bar{y}_{sti}} \qquad \text{Equation 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for $\alpha = 0.05$ based on $n_i' - 1$ degrees of freedom (not the effective degrees of freedom), and

$\bar{y}_{sti}$ is as defined in Equation 9.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1989-90 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / (H_{ai} + W_{ai}) \qquad \text{Equation 13}$$

where

P_{ai} = the proportion of Age i hatchery striped bass in the population adjusted for tag loss and non-detection of tags,

H_{ai} = the number of Age i verified hatchery recaptures caught adjusted for tag loss and non-detection of tags, and

W_{ai} = the number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai}).

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and non-detection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1 - TAG_i)(1 - NDET) \right] \qquad \text{Equation 14}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

H_i = the number of Age i verified hatchery recaptures caught,

TAG_i = weighted, decimal percent 48-hour magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1), and

NDET = decimal percent non-detection rate for magnetic tags during the recapture program (calculated as follows: $= [D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected).

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Section 1.0) was not adjusted for handling mortality (Dunning et al. 1989) because different lots of fish were held between 1 and 48 hours after tagging (EA 1989), and it was not possible to calculate an accurate mortality rate for each lot.

2.3.4 Population Movement

Distance between tagging and recovery locations, days at large, and minimum rate of travel were calculated for all recaptured striped bass and used to directly evaluate movement of fish within the study area. Two groups of fish were considered: (1) fish recaptured from previous programs (cross-year recaptures) and (2) fish caught, tagged, released and recaptured within the 1989-90 program (within-year

TABLE 2-1. FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOSS (TAG_i) AND NON-DETECTION OF TAGS (NDET) DURING 1989-90.

COHORT	AGE	TAG_i	NDET
1989	0+	0.057	0.00047
1988	1+	0.017	0.00047
1987	2+	0.147	0.00047
1986	3+	0.075	0.00047
1985	4+	0.065	0.00047
1984	5+	0.276	0.00047

recaptures). The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$\text{Recapture rate} = R_{ij}/M_{ij} \qquad \text{Equation 15}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

M_{ij} = number of tagged striped bass released during time period (week) i in region j.

$$\text{Recapture Proportion} = R_{ij}/C_{ij} \qquad \text{Equation 16}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j.

2.3.5 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i) with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber

1982). When the squared residuals $(R_i/C_i - \beta M_i)$ are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$N = \Sigma(C_i M_i^2)/\Sigma(R_i M_i) \qquad \text{Equation 17}$$

where

N = estimated population size,

C_i = total catch during time interval i,

M_i = total number of marked fish available for recapture at the midpoint of time interval i, and

R_i = number of recaptured fish in C_i.

The variance of the reciprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\Sigma(R_i^2/C_i) - (\Sigma R_i M_i)^2/\Sigma(C_i M_i^2)}{m-1} \qquad \text{Equation 18}$$

where

S^2 = mean of squared deviations from the regression model described above,

m = the number of data points in the regression, and C_i, M_i and R_i are as defined above in Equation 17.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_i M_i^2 \times t_{m-1}$$ Equation 19

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and α=0.05.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.6 Stocking Check Analysis

The estimated proportion of hatchery striped bass based on scale samples from Ages 0+, 1+ and 2+ cohorts examined for a stocking check by three technicians was calculated as follows:

$$\text{Estimated hatchery proportion} = \Theta p\,(H|H) + (1 - \Theta)\, p\,(H|W)$$

where

Θ = selected true hatchery proportion,

$p\,(H|H)$ = probability of a scale sample being correctly identified as originating from a hatchery fish if it was from a hatchery fish, and

$p\,(H|W)$ = probability of a scale sample being incorrectly identified as originating from a hatchery fish if it was actually from a wild fish.

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE TRAWLS

3.1.1 Catch Per Unit Of Effort-9 m Trawl

The 9 m trawl was fished in the Upper Harbor 1% of the time and Battery regions of the lower Hudson River 99% of the time from 30 October 1989 to 13 April 1990. The mean CPUE for striped bass in the Battery region was approximately 2.5 times greater than the CPUE in the Upper Harbor region over all sampling weeks combined (Table 3-1). There were five weeks when mean CPUE exceeded 60 striped bass per ten minute tow in the Battery region: the weeks of 4 December, 18 December 1989, and 5 February, 29 January and 12 March 1990 (Figure 3-1; Appendix Tables C-1 and C-2). The highest weekly mean CPUE was 89.2 striped bass per ten minute tow during the week of 4 December 1989.

Mean CPUE for the 9 m trawl in the Battery region has increased annually since 1985-86 (Table 3-2). Mean CPUE in the 1989-90 program (45.3) was approximately 16% greater than the CPUE during the 1988-89 (38.9) program for similar time periods. Mean CPUE in the 1989-90 program was approximately 59% greater than observed in the 1987-88 program, 371% greater than observed in the 1986-87 program and 559% greater than observed in the 1985-86 program, for comparable time periods. The increased CPUE observed during the 1989-90 program may be due to the complete recruitment of the numerically dominant 1987 and 1988 striped bass year classes to the 9 m trawl (CES 1989).

3.1.2 Length-Frequency Distributions

The mean size of striped bass caught by the 9 m trawl was 203 mm (Table 3-3). The mean length of striped bass caught in the 9 m trawl decreased significantly ($p<0.001$) from 1988-89 to 1989-90. The length-

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

REGION	NUMBER OF TOWS[1]	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Upper Harbor	10	150	15.0	4.2
Battery	881	33,055	37.5	1.6

[1]Use Code = 1 tows only.

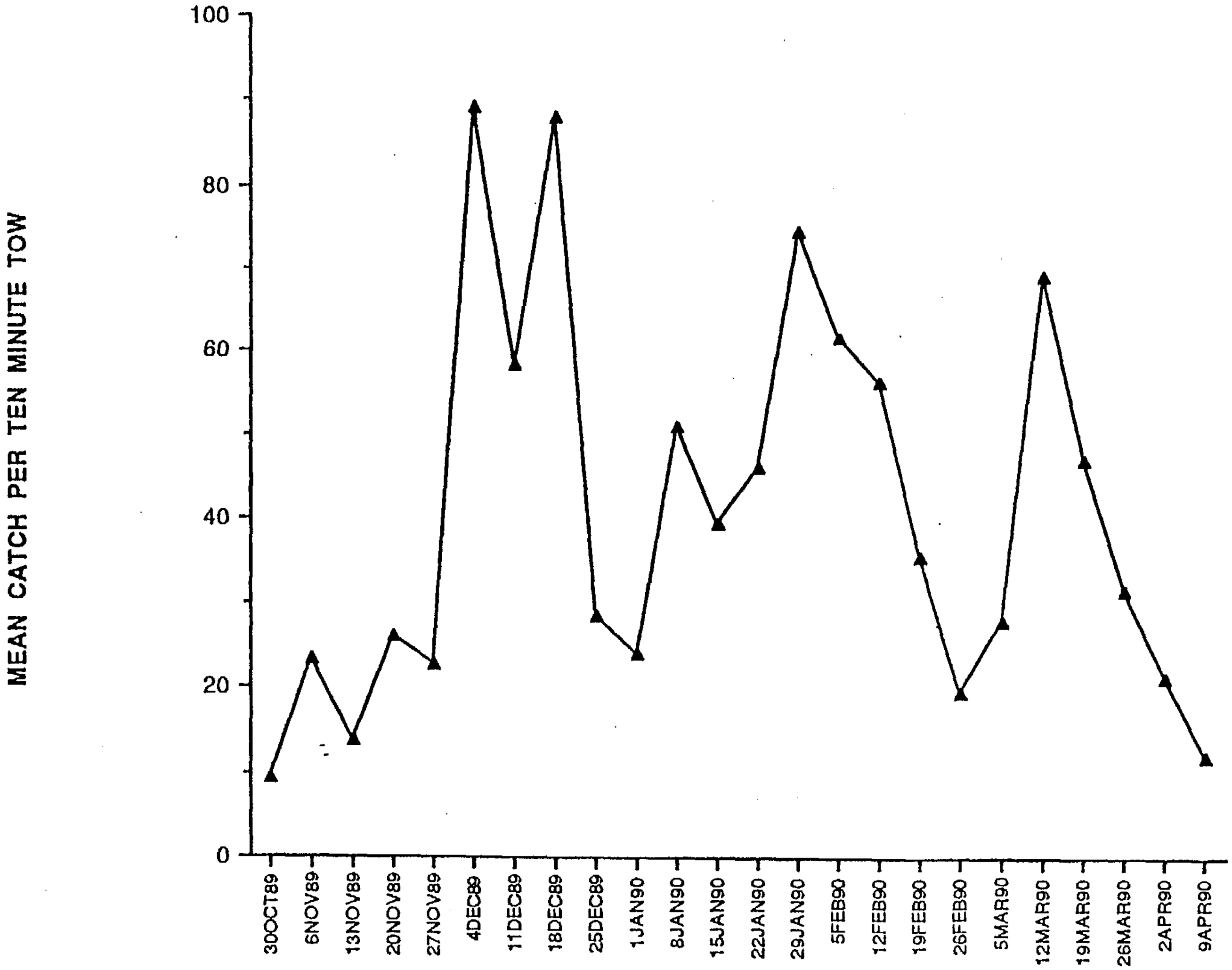


Figure 3-1. Mean catch per ten minute tow by a 9m trawl in the Battery Region of the Hudson river, 30 October 1989 through 13 April 1990.

TABLE 3-2. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE BATTERY REGION OF THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86, 1986-87, 1987-88, 1988-89, and 1989-90.

YEAR	PERIOD	TOWS	MEAN CPUE	95% CI
1985-86	12/23/85-03/21/86	638	8.1	±1.0
1986-87	12/21/86-03/21/87	385	12.2	±1.2
1987-88	12/20/87-03/19/88	437	28.5	±2.5
1988-89	12/19/88-03/18/89	527	38.9	±3.3
1989-90	12/18/89-03/16/90	458	45.3	±4.3

TABLE 3-3. DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

N	MEAN (mm)	S.D.	SKEWNESS (±95% C.I.)	KURTOSIS (±95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
33,055	203.5	70.3	0.65±0.03	2.29±0.05	52	854	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Right skewness = Significant positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.
Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.

frequency distribution for the 9 m trawl was: (1) skewed right, i.e., fish were smaller than the mean length that would be expected if the distribution was bell shaped, (2) leptokurtotic, i.e., more fish were found in length groups close to the mean length than would be expected if the distribution was bell-shaped, and (3) the length-frequency was unimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 201-250 mm length group.

The range of weekly mean lengths of striped bass caught by the 9 m trawl was 80 mm during the 1989-90 program (Table 3-4). Weekly mean length was greatest during the weeks of 11 December and 30 October 1989 (239 and 238 mm respectively). The smallest weekly mean length (159 mm) occurred during the week of 25 December 1989, two weeks after the maximum weekly mean length.

Weekly changes in length-frequency of striped bass, characterized by catch of striped bass per tow in 50 mm length groups, exhibited no distinct seasonal pattern for the 9 m trawl (Table 3-5). The highest catch per tow over all weeks was 10.8 in the 201-250 mm length group. The two highest weekly catches were 25.6 and 24.6 striped bass per two for the 201-250 and 151-200 mm length groups respectively during the week of 4 December 1989. The fish caught in these length groups were the primary constituents of the high overall catch per unit effort observed during the weeks of 4 and 18 December 1989 (Figure 3-1). Similarly, the high overall catch per unit effort observed during the weeks of 29 January and 12 March 1990 (Figure 3-1) was largely made up of fish from the 151-200 and 201-250 mm length groups (Table 3-5).

The length-frequency distribution from the 1989-90 program was dominated by the numerically strong 1988 year class. The striped bass post yolk-sac larvae index of year class strength for the 1988 year class was the fourth highest recorded (1.67: CES 1989). The 1988 year class was Age 1+ during the program. Age 1+ fish were most abundant between 201 and 250 mm (Section 3.4.1.1), and during the 1989-90 program

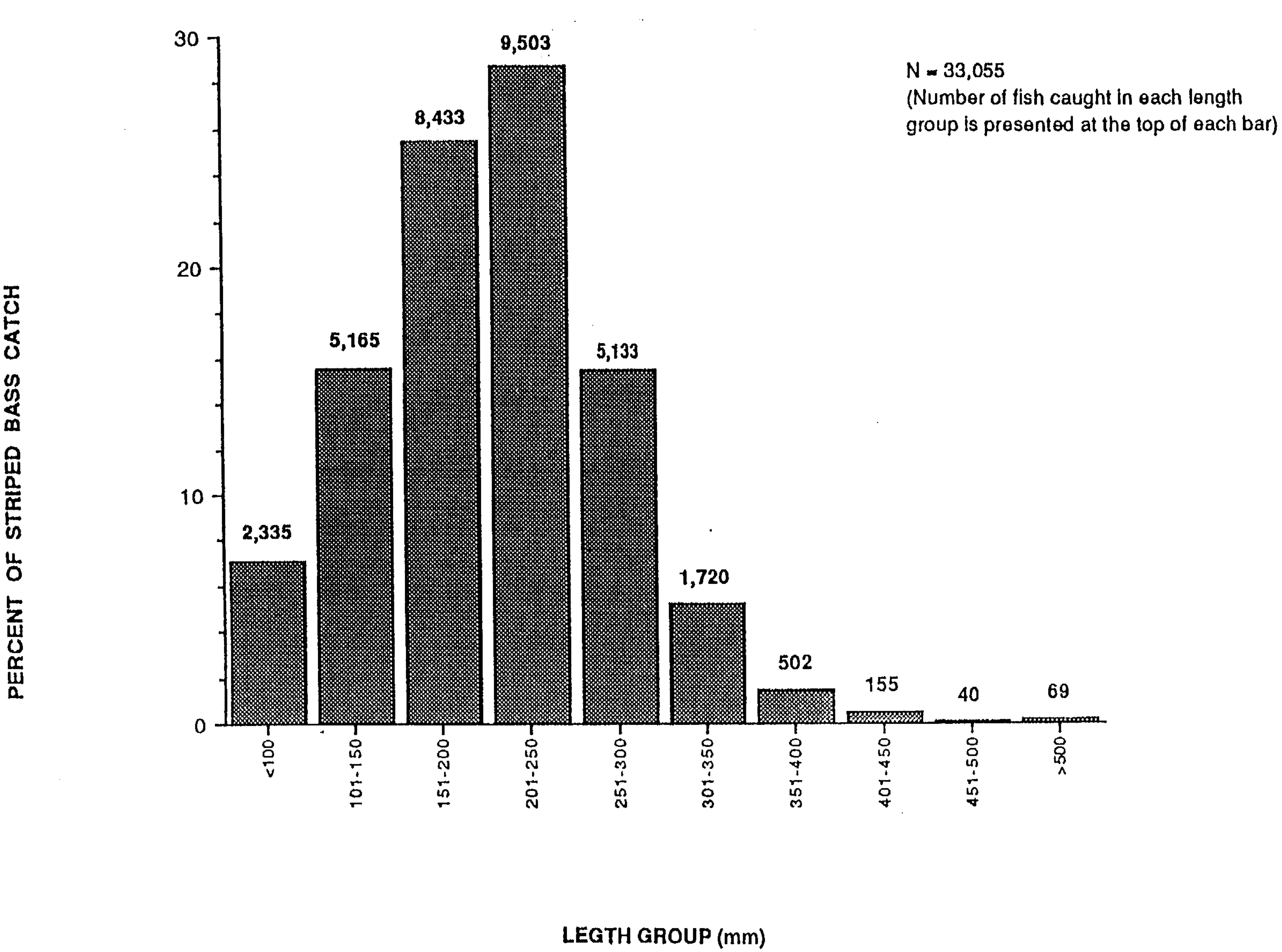


Figure 3-2. Length frequency distribution for striped bass captured by a 9m trawl in the Battery region of the Hudson River, 30 October 1989 through 13 April 1990.

TABLE 3-4. WEEKLY MEAN LENGTH (mm) OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

WEEK	NO. FISH	MEAN	S.D.	S.E.
30OCT89	284	238	66.66	3.96
06NOV89	777	228	52.13	1.87
13NOV89	383	194	83.72	4.28
20NOV89	367	191	84.46	4.41
27NOV89	1318	199	82.30	2.27
04DEC89	2498	235	66.56	1.31
11DEC89	1752	239	67.01	1.60
18DEC89	2024	214	71.91	1.60
25DEC89	512	159	73.30	3.24
01JAN90	892	196	92.41	3.09
08JAN90	1526	178	66.18	1.69
15JAN90	1533	187	61.37	1.57
22JAN90	2020	175	61.90	1.38
29JAN90	2313	190	60.00	1.25
05FEB90	1850	188	67.60	1.57
12FEB90	2018	217	58.56	1.30
19FEB90	1311	203	63.05	1.74
26FEB90	1066	170	66.72	2.04
05MAR90	1177	210	69.02	2.01
12MAR90	2493	198	65.62	1.31
19MAR90	1773	217	54.87	1.30
26MAR90	1228	226	63.99	1.83
02APR90	1023	218	74.54	2.33
19APR90	917	184	79.68	2.63
ALL WEEKS	33055	203	70.27	0.39

TABLE 3-5. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW IN A 9 m TRAWL FOR 50 mm LENGTH GROUPS FROM 30 OCTOBER 1989 THROUGH 13 APRIL 1990 IN THE BATTERY REGION OF THE HUDSON RIVER.

SAMPLING WEEK	NUMBER OF TOWS	LENGTH GROUPS <100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	>700
30OCT89	31	<0.1	0.3	2.1	3.9	1.9	0.6	0.4	0	0	0	0	0	<0.1	<0.1
06NOV89	33	0.1	1.0	5.6	10.1	4.8	1.5	0.4	0.1	<0.1	0	0	0	0	0
13NOV89	28	2.3	2.4	2.0	4.1	1.7	0.7	0.3	0.1	0	<0.1	0	<0.1	0	0
20NOV89	14	3.7	6.6	4.5	4.9	3.4	1.9	0.9	0.1	0.2	0	0	0	0	0
27NOV89	58	3.1	3.7	5.4	4.6	3.4	1.7	0.4	0.2	0.1	<0.1	<0.1	0	0	0
04DEC89	28	0.3	5.5	24.6	25.6	19.6	8.8	3.2	1.0	0.2	0.1	0.1	0.1	0	0
11DEC89	30	0.8	4.4	10.7	17.2	16.3	6.7	1.5	0.5	0	0.1	0	<0.1	0	<0.1
18DEC89	23	4.3	12.9	20.5	23.9	18.1	6.2	1.0	0.8	0.1	0.1	<0.1	<0.1	<0.1	<0.1
25DEC89	18	5.8	9.7	5.8	5.2	1.0	0.3	0.2	0.2	0.1	0.2	0.1	0	0	0
01JAN90	37	2.8	5.5	5.6	4.9	2.9	1.1	0.4	0.2	0.2	0.2	0.1	0.1	<0.1	0
08JAN90	30	7.5	11.0	13.0	12.5	5.1	1.2	0.5	0.1	0	0	0	0	0	0
15JAN90	39	3.9	7.8	10.1	11.9	4.6	0.7	0.3	0	0	0	0	0	0	0
22JAN90	44	5.5	11.3	12.8	11.5	3.8	0.9	<0.1	<0.1	<0.1	<0.1	0	0	0	0
29JAN90	31	5.1	15.5	20.2	22.4	9.5	1.5	0.3	0.2	0.1	0	0	0	0	0
05FEB90	30	6.6	11.9	16.0	17.6	6.3	2.2	0.7	0.3	<0.1	<0.1	0	0	0	0
12FEB90	36	0.8	5.1	16.8	20.0	9.5	3.1	0.6	0.2	0.1	0	0	<0.1	0	0
19FEB90	37	1.6	4.6	11.1	11.1	4.5	1.6	0.6	0.1	0	0.1	<0.1	0	0	0
26FEB90	55	3.3	5.0	4.5	4.6	1.3	0.4	0.2	0.1	<0.1	0	0	0	0	0
05MAR90	42	1.4	3.9	6.8	8.6	5.0	1.7	0.5	<0.1	0.1	0	0	<0.1	0	0
12MAR90	36	6.2	11.0	16.8	19.3	12.9	2.7	0.4	0	0	0	0	0	0	0
19MAR90	38	0.3	3.3	15.2	17.0	7.8	2.2	0.1	0.1	<0.1	<0.1	0	0	0	<0.1
26MAR90	39	0.6	2.4	7.6	10.8	6.6	2.6	0.6	0.1	0.1	0.1	0	0	0	<0.1
02APR90	48	0.5	3.1	5.4	6.5	3.4	1.5	0.7	0.2	<0.1	<0.1	0	<0.1	0	<0.1
09APR90	76	1.4	3.4	2.9	2.1	1.2	0.6	0.4	0.1	0	<0.1	<0.1	0	0	0
TOTAL TOWS	881														
STRIPED BASS PER TOW		2.7	5.9	9.6	10.8	5.8	2.0	0.6	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

the greatest percentage (28.7%) of striped bass were caught in the 201-250 mm length group. The numerical dominance of the of the 1988 year class is also apparent from the fact that the largest overall catch per tow was in the 201-250 mm length group.

The numerical dominance of the strong 1987 year class diminished between the 1987-88 and the 1989-90 programs. The 1987 year class had the third highest post yolk-sac larvae index of year class strength recorded (1.76: CES 1989). This year class was 0+ during the 1987-88 program and was represented by the lower mode of a bimodal distribution with peak abundance occurring in the 100-150 mm length group. The 100-150 mm length group made up 22% of the total catch during the 1987-88 program. One year later during the 1988-89 program, the 1987 year class was Age 1+ and was represented by a major peak in the 201-250 mm length class that made up 35% of the total catch. The 1987 year class was Age 2+ during the 1989-90 program and was not as numerically dominant as in previous programs. Age 2+ fish are generally in the 300-350 mm length group and this length group made up approximately 5% of the total catch in the 1989-90 program.

The 1989 year class had the highest post yolk-sac larvae index recorded (4.34: CES 1989) and was Age 0+ during the 1989-90 program. Age 0+ striped bass captured by the 9 m trawl were typically between 100 and 150 mm. This length class was not well represented in the weekly mean catch by length group (Table 3-5), and made a smaller contribution to the entire catch (Figure 3-3) when compared to the weaker 1987 year class.

3.1.3 Handling Mortality

Striped bass handling mortality in the 9 m trawl at surface water temperatures from 0 to 17°C (Table 3-6) and bottom water temperatures from 0 to 18°C was less than 1% during 1989-90 (Table 3-7). A total of 39 striped bass died out of 32,900 fish caught in Use Code = 1

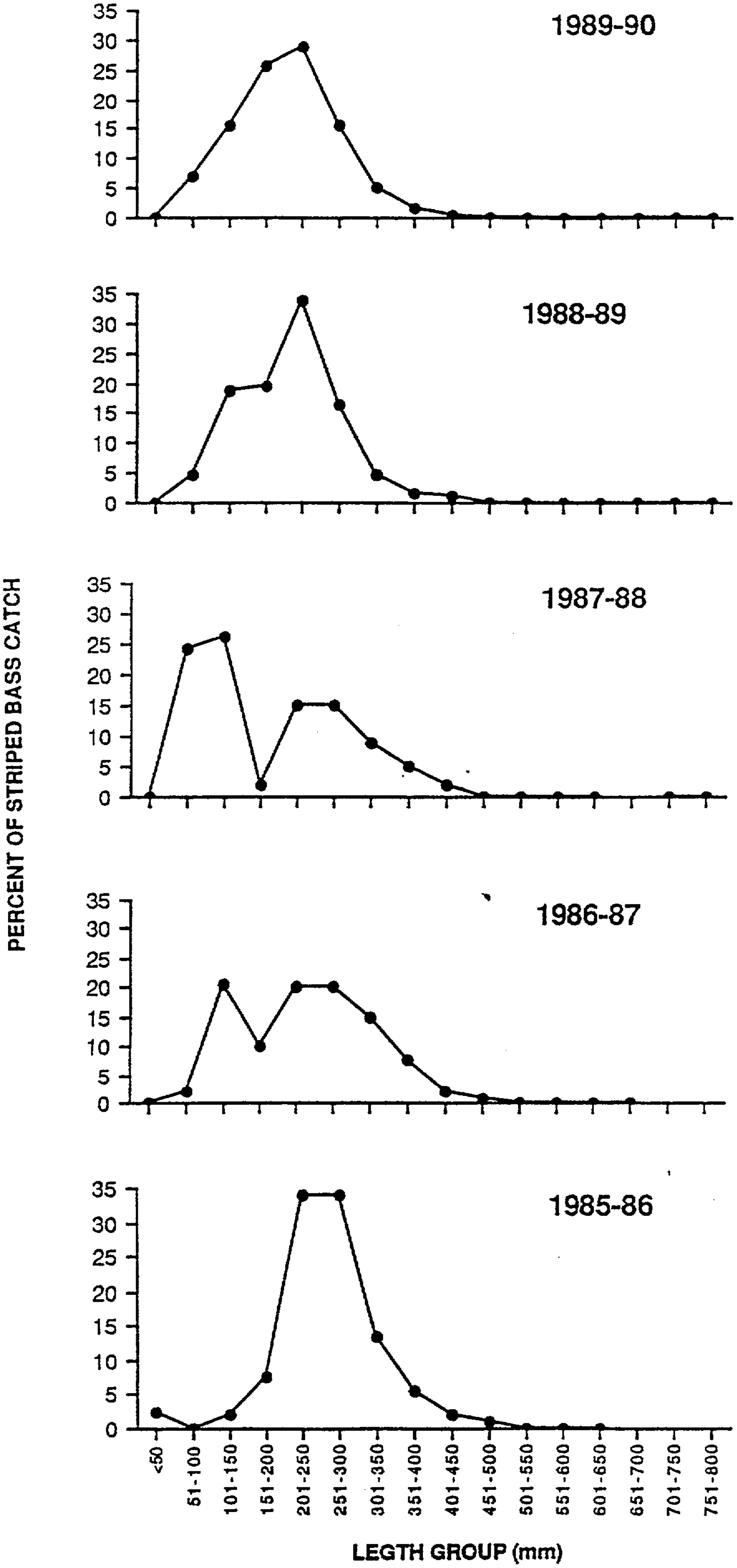


Figure 3-3. Standardized length frequency of striped bass captured by a 9m trawl in the Battery region of the Hudson River, December through March of 1989-1990, 1988-89, 1987-88, 1986-87 and 1985-86.

tows that had water temperature data associated with each tow. If all tows were included regardless of Use Code (Appendix Table C-3), a total of 33,055 fish were handled and no additional handling mortality was observed. The highest handling mortality of 0.8% (6/775) in the 9 m trawl occurred at a bottom water temperature of 14°C. The relatively consistent, low handling mortality indicates there was no relationship between handling mortality and water temperature for the 9 m trawl over water temperatures of 0-18°C experienced in this study. The 1989-90 data were not examined for an interaction between water temperature, fish length and immediate handling mortality because this interaction was not significant in previous programs (Dunning et al. 1989).

Striped bass handling mortality in the 1989-90 program was uniformly low, and not significantly different from the mortality observed in the 1985-86, 1986-87, 1987-88, and 1988-89 programs, and approximately ten times less than that observed in the 1984 program (Table 3-8). Handling mortality in 1989-90 was low, even though striped bass between 150 and 200 mm were tagged for the first time. The findings of the 1989-90 program support those of the 1985-86, 1986-87, 1987-88, and 1988-89 programs: the primary reasons for the decrease in handling mortality observed after 1984 are the use of a submerged holding facility and the increased tagging efficiency of field crews (Dunning et al. 1989). The holding facility used in the 1985-86 through 1989-90 programs permitted transfer of each catch from the cod end into the holding tank without having to lift both the net and fish out of the water, i.e., the fish remained in the water until they were individually removed and tagged. In contrast, during the 1984 program, the cod end of the net was lifted out of the water and fish were compressed by their weight in the air as they were transferred to the on-deck holding tanks. The increased tagging efficiency observed in the 1985-86 through 1989-90 programs contributed to decreased handling mortality by lessening exposure of striped bass to the air, thus reducing stress by returning tagged fish to the water quickly.

TABLE 3-6. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO LOWER HUDSON RIVER SURFACE WATER TEMPERATURE, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

SURFACE WATER TEMPERATURE (°C)	% OF CATCH DEAD	NUMBER DEAD	TOTAL
0	0.0	0	142
1	0.3	6	1,854
2	0.1	3	2,954
3	0.2	10	4,952
4	0.1	4	7,378
5	0.1	3	4,314
6	0.0	0	3,479
7	0.1	2	3,034
8	0.2	4	2,415
9	0.1	1	788
10	0.0	0	76
11	0.0	0	70
12	0.0	0	140
13	0.6	3	507
14	0.5	3	596
15	0.0	0	183
16	0.0	0	6
17	0.0	0	12
0-17	0.1	39	32,900

TABLE 3-7. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO LOWER HUDSON RIVER BOTTOM WATER TEMPERATURE, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	NUMBER DEAD	TOTAL
1	0.0	0	516
2	0.1	2	1,696
3	0.3	11	3,721
4	0.1	1	692
5	0.1	3	3,918
6	0.1	7	7,284
7	0.0	0	2,543
8	<0.1	1	3,380
9	0.1	1	1,849
10	0.1	1	1,455
11	0.1	1	707
12	0.0	0	447
13	0.1	1	1,012
14	0.8	6	775
15	0.1	1	1,088
16	0.2	2	1,173
17	0.2	1	543
18	0.0	0	101
1-18	0.1	39	32,900

TABLE 3-8. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86, 1986-87, 1987-88, 1988-89, AND 1989-90 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAMS.

	1985-1986 9 m TRAWL		1986-1987 9 m TRAWL		1986-1987 9 m TRAWL W/LINER		1987-1988 9 m TRAWL		1988-1989 9 m TRAWL		1989-1990 9 m TRAWL	
BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N
0				0	0.0	0/6						
1	0.0	0/45	4.6	3/65	0.0	0/25	3.1	2/64			0.0	0/516
2	0.5	4/856	0.6	5/773	1.9	7/359	0.3	7/2097	0.0	0/464	0.1	2/1696
3	0.5	8/1489	0.6	8/1297	1.8	13/728	0.7	28/4295	0.1	3/5760	0.3	11/3721
4	1.4	21/1521	0.4	4/1002	0.2	1/542	0.4	13/3635	0.1	11/7503	0.1	1/692
5	1.5	11/720	0.6	6/973	0.0	0/115	0.3	5/1818	0.4	27/6826	0.1	3/3918
6	1.0	9/882	1.4	4/295	0.6	1/166	0.2	2/886	0.4	14/4360	0.1	7/7284
7	2.0	8/403	0.7	4/602	0.0	0/40	0.3	4/1503	0.3	5/1984	0.0	0/2543
8	1.2	5/423	0.3	1/373	5.5	19/346	0.1	2/1654	0.1	1/760	<0.1	1/3380
9	3.3	17/521	0.0	0/79	0.0	0/61	0.2	2/829	0.0	0/726	0.1	1/1849
10	15.4	2/13	10.7	3/28	20.0	4/20	0.0	0/363	0.0	0/1672	0.1	1/1455
11	0.0	0/2	0.0	0/66	12.5	4/32	1.3	6/449	0.1	1/1042	0.1	1/707
12	3.1	4/130	0.0	0/5			0.0	0/160	0.2	1/430	0.0	0/447
13	1.6	5/309					0.0	0/176	0.0	0/41	0.1	1/1012
14							12.5	1/8	0.0	0/152	0.8	6/775
0-14	1.3	94/7314	0.7	38/5558	2.0	49/2440	0.4	72/17937	0.2	63/31720	0.1	35/29995

n = Number dead at a temperature for use code = 1 tows.
N = Total number caught at a temperature for use code = 1 tows.

NOTE: In 1986-87 the 9 m trawl was deployed with a 3.8 cm (stretch) mesh cod end or with a 2.5 cm (stretch) mesh cod end liner.

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

The 9 m trawl with 7.6 cm (stretch) mesh in the body and 3.8 cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87, 1987-88, 1988-89, and 1989-90 programs. Therefore, the striped bass catch by this 9 m trawl was used for comparisons of mean length at age among programs. At Age 0+, mean length for the 1987 (108 mm) and 1989 (112 mm) cohorts during the 1989-90 program was smaller than for the 1986 (128 mm) and 1988 cohorts (121 mm) (Table 3-9). At Age 1+ the 1986 cohort had the largest mean length (253 mm) and the 1988 cohort (214 mm) had the smallest mean length. Mean length of the 1985 cohort (221 mm) was similar to the mean length of the 1987 cohort (227 mm). At Age 2+ the 1985 cohort (317 mm) and 1986 cohort (325 m) had the largest mean lengths than either the 1984 (299 mm) and 1987 cohort (298 mm).

There does not appear to be a consistent relationship among the 1983-88 cohorts in the relative ranking of mean length at Age 0+ and length at subsequent ages. Data from previous programs suggested that the relative ranking of mean lengths at Ages 0+, 1+, 2+, and 3+ for the 1983 through 1987 cohorts may be determined at Age 0+, and this ranking may persist as late as Age 3+ (NAI 1990a). However, data collected during the 1989-90 program do not completely support this hypothesis. The 1988 cohort was estimated to have a larger mean length than the 1987 cohort at Age 0+ (Table 3-9). However at Age 1+, these cohorts had reversed their relative rankings of mean length at age.

There was no strong correlation between year class strength and mean length at Age 0+ and 1+ for the 1985 through 1989 cohorts. Data collected from previous programs indicated that an inverse relationship existed between post yolk-sac larvae abundance and mean length at Age 0+ and 1+ (NAI 1990a). However, data collected during the 1989-90 program indicated that this relationship was not strong. The 1989

TABLE 3-9. MEAN LENGTH AT AGE AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER DURING THE 1989-90, 1988-89, 1987-88 AND 1986-87 STRIPED BASS HATCHERY EVALUATION PROGRAMS.

AGE	COHORT	YEAR CLASS STRENGTH INDEX[a]	PROGRAM	n[b]	STRATIFIED MEAN LENGTH (mm)	LOWER 95% CONFIDENCE INTERVAL	UPPER 95% CONFIDENCE INTERVAL
0+	1989	4.3	1989-90	368	111.8	108.7	115.0
	1988	1.7	1988-89	1007	121.2	117.3	125.1
	1987	1.8	1987-88	190	107.6	103.5	111.7
	1986	0.7	1986-87	83	128.3	122.6	134.0
1+	1988	1.7	1989-90	3,514	213.9	212.5	215.3
	1987	1.8	1988-89	3,623	227.0	225.6	228.5
	1986	0.7	1987-88	1,503	252.8	250.5	251.1
	1985	0.4	1986-87	285	220.8	215.0	226.7
2+	1987	1.8	1989-90	1,216	297.5	294.5	300.5
	1986	0.7	1988-89	361	324.5	317.5	331.4
	1985	0.4	1987-88	574	317.2	312.0	322.4
	1984	0.9	1986-87	359	298.9	292.9	305.0
3+	1986	0.7	1989-90	55	382.3	362.0	402.6
	1985	0.4	1988-89	57	396.2	377.7	414.6
	1984	0.9	1987-88	273	367.4	359.9	375.2
	1983	0.6	1986-87	54	369.4	353.9	385.0

[a]CES (1989)
[b]Number of fish aged

year class was the strongest observed during the 1985-1989 period. Based on previous data, it was expected that mean length at Age 0+ would be less than previous programs. Mean length at Age 0+ for the 1989 cohort was significantly smaller than the weak 1986 cohort, but was not significantly different from the strong 1987 cohort (Table 3-9). Similarly, it was expected that the mean length of the 1988 year class at Age 1+ would be greater than the 1987 year class, however the relative rankins were reversed.

Standardized age frequency by length histograms, presented by 10 mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-4) demonstrate minimal overlap between size of Age 0+ and Age 1+ striped bass caught during the 1989-90 program. Most of the fish in each length group ≤139 mm were Age 0+, while most of the fish in length groups between 140 and 299 mm were Age 1+. Age 1+ and Age 2+ striped bass overlap in size primarily between 220 and 339 mm. Age 3+ striped bass overlap with Age 2+ fish primarily between 350 and 449 mm.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-10). For the allocation of 5,195 scale samples actually selected, the precision based on 95% confidence limits was 0.8% corresponding to an error term of ±175 fish.

Relatively little gain in precision would be realized compared to the cost when age is determined for more than 6% of the total sample (33,386 fish in 1989-90). For example, doubling the number of striped bass scale samples examined for age determination from 2,000 to 4,000 would only result in a 0.4% improvement in the precision (Table 3-10). In years prior to 1988-89, this level of precision would require age determination for about 14% of the striped bass caught (NAI 1988). However, due to the dominance of the 1987 cohort of Age 1+ fish in most

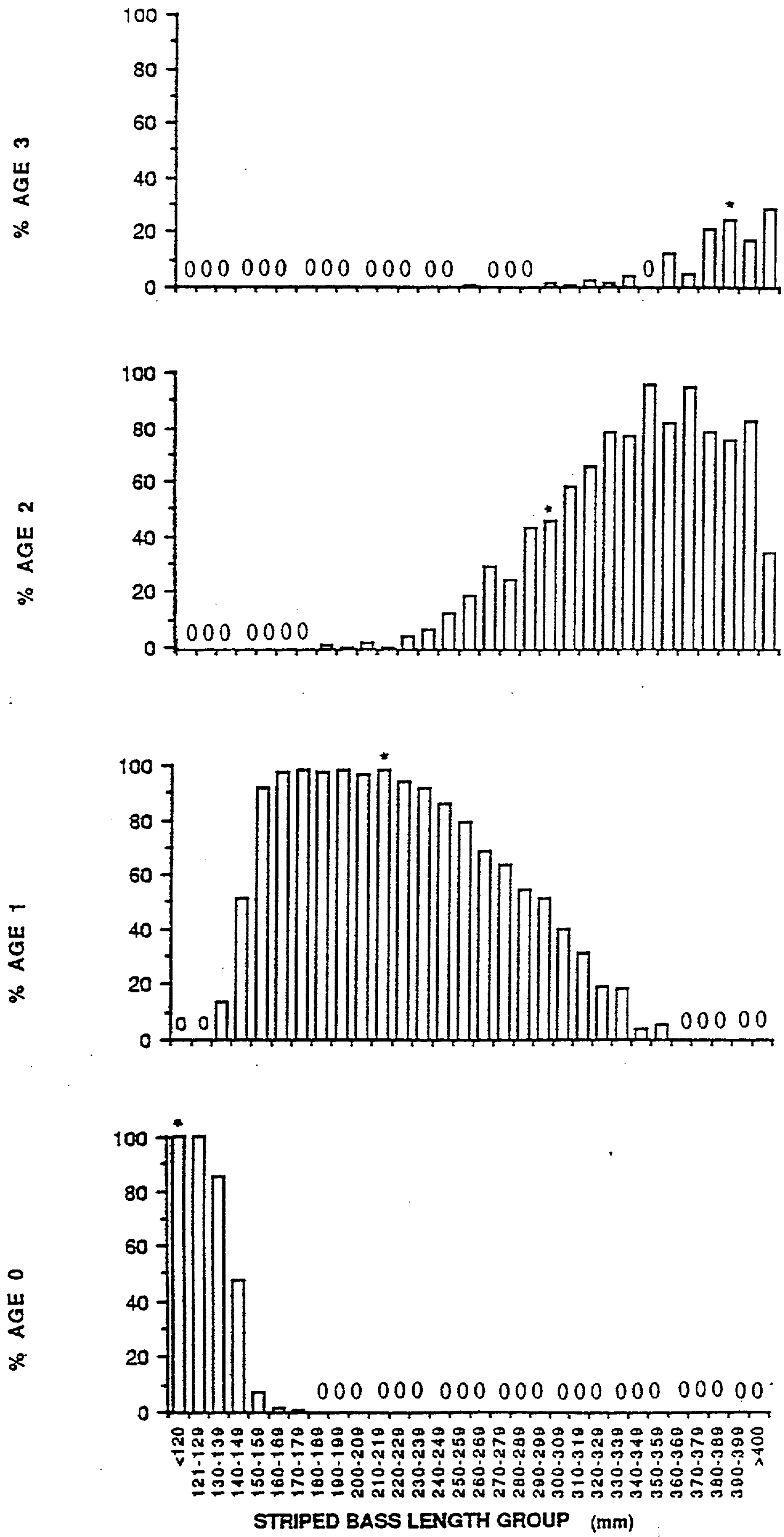


Figure 3-4. Standardized age frequency by length distribution for age 0+, 1+, and 3+ striped bass captured by a 9m trawl in the lower Hudson River estuary, 30 October 1989 through 13 April 1990. (Note: Length group which contains the stratified mean length at age is marked with an *.)

TABLE 3-10. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

		ESTIMATED NUMBER OF AGE 1+ FISH CAUGHT			
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL	LOWER 95%CI	UPPER 95%CI	PRECISION (%)[a]
500	0.651	21,725	21,113	22,337	2.8
1,000	0.651	21,725	21,307	22,143	1.9
2,000	0.651	21,725	21,439	22,011	1.3
3,000	0.651	21,725	21,499	21,951	1.0
4,000	0.651	21,725	21,535	21,915	0.9
5,000	0.651	21,725	21,561	21,890	0.8
5,195[b]	0.651	21,725	21,550	21,900	0.8
6,000	0.651	21,725	21,580	21,870	0.7
7,000	0.651	21,725	21,596	21,855	0.6
8,000	0.651	21,725	21,609	21,842	0.5

[a] Precision = 95% confidence interval (CI) half width/stratified total x 100.

[b] Results for sample size = 5,195 are based on actual allocations which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

length groups caught during 1988-89 (NAI 1990a) and the dominance of the 1988 cohort of Age 1+ fish in most length groups caught during 1989-90, the estimated proportions and numbers of Age 1+ striped bass during the 1988-89 and 1989-90 programs were more precise than in the 1987-88 program. By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass out of the 33,386 fish caught during 1989-90 could be estimated with 95% confidence limits of ± 612 fish (precision = 2.8%, Table 3-10).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10 mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 2+ striped bass (Table 3-10), which collectively comprised 99.1% of the fish caught in this program. Only 205 striped bass were estimated to be Age 3+ and 103 fish were older than Age 3+ in the 1989-90 program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The large 1988 cohort of Age 1+ striped bass was approximately 65% of the total catch during 1989-90. The numbers of Age 2+ and Age 3+ striped bass were estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ and Age 3+ was wider. The 1987 cohort of Age 2+ striped bass was about 12% of the total catch in 1989-90. The 1986 cohort of Age 3+ striped bass was about 6% of the total catch in 1989-90.

TABLE 3-11. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

			ESTIMATED NUMBER OF FISH CAUGHT			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	PRECISION (%)
0+	1989	21.7	7,240	7,174	7,306	0.9
1+	1988	65.3	21,725	21,550	21,900	0.8
2+	1987	12.4	4,113	3,945	4,280	4.1
3+	1986	5.6	205	159	250	22.2

[a]based on a laboratory sample of scales from 5,195 fish.

3.3 STRIPED BASS HATCHERY PROPORTION

Striped bass stocked in the Hudson River from the Verplanck hatchery accounted for 0.7% of the Age 0+ cohort, 0.4% of the Age 1+ cohort, and 0.1% of the Age 2+ cohort of fish caught during the winter of 1989-90 (Table 3-12). Comparing 95% confidence limits about the hatchery proportion of striped bass among cohorts indicated the proportion of Age 0+ and Age 1+ hatchery fish was significantly higher than Age 2+. The 1987, 1988, and 1989 wild cohorts were each relatively strong (CES 1989) and this probably resulted in dilution of the hatchery proportion for Age 0+, 1+, and 2+ striped bass during the 1989-1990 study. Age 0+ hatchery fish are not randomly distributed in the fall following stocking (Wells et al. in press). Furthermore, we have no evidence that Age 0+ striped bass become randomly distributed during the first winter after stocking. Therefore, the proportion of Age 0+ is considered the least reliable estimate, and the hatchery proportion in 1989-90 for the 1987 and 1988 cohorts of Age 1+ and Age 2+ striped bass should be considered more accurate estimates.

Comparson of estimated hatchery proportions for the 1984 through 1989 hatchery cohorts caught in 1986-87, 1987-88 and 1988-89 suggested that the hatchery proportion for each cohort caught prior to the current program doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; this report Table 3-13). However, this trend was not continued in 1989-90; the 1987 cohort had an estimated hatchery proportion of 0.2% at Age 1+ in 1988-89 and was reduced significantly to 0.1% at Age 2+ in 1989-90. In prior programs, the 1985 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1986-87 and 3.1% at Age 2+ in 1987-88. The 1986 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1987-88 and 3.5% at Age 2+ in 1988-89. Prior to the 1989-90 program, the hatchery proportion for each cohort has remained constant as the cohort increased in age from Age 0+ to Age 1+, and from Age 2+ to Age 3+ (Table 3-13). However, during the 1989-90 program, the hatchery proportion decreased significantly for the 1988 cohort from 1.6% at Age 0+ during 1988-89 to 0.5% at Age 1+ in 1989-90

TABLE 3-12. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

STATISTIC	COHORT 1989	1988	1987
Age	0+	1+	2+
Total Hatchery Stocking (N_i)	202,068	48,611	324,579
Hatchery Recaptures (H_i)	46	92	3
Adjusted Hatchery Recaptures (H_{ai})	49	94	4
Wild Fish Examined (W_{ai})	7,191	21,631	4,109
Estimated Hatchery Proportion ($H_{ai}/H_{ai}+W_{ai}$))	0.0068	0.0043	0.0010
Lower 95% C.I.	0.0049	0.0034	0.0002
Upper 95% C.I.	0.0091	0.0054	0.0027

TABLE 3-13. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER DURING WINTERS OF 1986-87, 1987-88, 1988-89, AND 1989-90.

COHORT	NUMBER STOCKED	ESTIMATED PROPORTION WITH LOWER OR UPPER 95% CONFIDENCE LIMITS											
		1986-87			1987-88			1988-89			1989-90		
		LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER
1989	202,068										0.0049	0.0068 (46)	0.0091
1988	48,611							0.0127	0.0155 (120)	0.0187	0.0034	0.0043 (92)	0.0054
1987	324,579				0.0015	0.0023 (25)	0.0033	0.0014	0.0020 (39)	0.0027	0.0002	0.0010 (3)	0.0027
1986	529,563	0.0110	0.0152 (38)	0.0204	0.0137	0.0165 (127)	0.0196	0.0245	0.0353 (48)	0.0500			
1985	284,578	0.0126	0.0170 (51)	0.0225	0.0240	0.0311 (82)	0.0399	0.0075	0.0236 (6)	0.0645			
1984	147,153	0.0005	0.0014 (5)	0.0029	0.0011	0.0034 (4)	0.0081	0.0000	0.0056 (0)	0.0514			

(Table 3-13). No Age 3+ hatchery striped bass were caught during 1989-90. Therefore, the hatchery proportions estimated for the 1987 cohort during the 1988-89 and 1989-90 programs did not substantiate the pattern of doubling that was observed for the 1985 and 1986 cohorts between Age 1+ and Age 2+.

Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 0+ 1988 cohort to 0.2% for Age 2+ fish from the 1987 cohort (Table 3-14). The unusually high proportion of Age 0+ fish in 1988-89 may be related to their non-random distribution (LMS 1989) or to stocking most of the fish at a larger size (EA 1989) that is better recruited to the 9 m trawl (NAI 1990a). Additional insight is provided by analysis of the mean length of summer and fall stocked Age 0+ hatchery striped bass (Section 3.4.1.1).

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

In this section, the size range, distribution and recapture patterns of striped bass are described. During the 1989-90 program recaptures were made of 141 hatchery striped bass which were tagged with a CWT and 655 wild striped bass that were individually tagged with our internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

TABLE 3-14. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1986-87, 1987-88, 1988-89, AND 1989-90 SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH.

		SCALED PROPORTION[a] WITH LOWER OR UPPER 95% CONFIDENCE LIMITS											
			1986-87			1987-88			1988-89			1989-90	
COHORT	NUMBER STOCKED	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER
1989	202,068										0.0165	0.0198 (46)	0.0235
1988	48,611							0.1541	0.1630 (120)	0.1723	0.0477	0.0509 (92)	0.0543
1987	324,579				0.0031	0.0042 (25)	0.0055	0.0030	0.0038 (39)	0.0048	0.0006	0.0017 (3)	0.0037
1986	529,563	0.0126	0.0171 (38)	0.0226	0.0158	0.0187 (127)	0.0220	0.0282	0.0398 (48)	0.0554			
1985	284,578	0.0286	0.0353 (51)	0.0432	0.0526	0.0634 (82)	0.0761	0.0221	0.0493 (6)	0.1062			
1984	147,153	0.0038	0.0058 (5)	0.0084	0.0080	0.0135 (4)	0.0218	0.0043	0.0222 (0)	0.0913			

[a] Estimated hatchery proportion scaled up to the proportion expected of 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula:

$$\left[H_{ai} \times 600000/N_i\right] / \left[(H_{ai} \times 600000/N_i) + W_i\right]$$

3.4.1 Hatchery-Tagged Striped Bass

During the 1989-90 winter sampling program, 46 Age 0+, 92 Age 1+, and 3 Age 2+ hatchery striped bass were caught. No Age 3+ hatchery striped bass were caught. One 365 mm hatchery striped bass was recaptured on 28 March 1990 in the Battery region at River Mile 2. This fish originated from the U.S. Fish and Wildlife Service Hatchery in Virginia.

3.4.1.1 Length

Mean length of the 1989 hatchery cohort was significantly larger than the wild cohort at Age 0+ (Table 3-15). This size difference is probably due to the larger size of hatchery fish compared to wild fish at the time of stocking. Three different groups of hatchery fish were stocked at three separate periods in 1989 (Table 3-16). The first group of 179,219 fish from the Verplanck Hatchery was stocked between 15 August and 7 September (summer fish). Weekly mean length of a subsample of these fish stocked between 21 August and 5 September ranged from 97 to 112 mm. These summer stocked fish were significantly larger ($p<0.001$) than wild fish in each of the stocking weeks (Table 3-16). The second group of 21,196 fish from the Verplanck Hatchery was stocked between 26 October and 3 November. Mean length of a subsample of these fish stocked on 27 October was 152 mm. These fall stocked fish were signficantly larger ($p<0.001$) than the wild fish at the time of stocking. A group of 1,653 fish from the Attleboro National Fish Hatchery with a modal length between 92 and 96 mm (mean lengths not available) was stocked on 3 November.

Striped bass stocked from the Verplanck Hatchery in the fall exhibited higher recapture rates at Age 0+ during the 1989-90 program than fish stocked during the summer. A total of 46 Age 0+ hatchery striped bass were recaptured during the 1989-90 program. Of these 46 fish, 13 were stocked between 15 August and 1 September (summer) and 33 were stocked between 26 October and 3 November (fall). Summer- and fall-stocked striped bass composed 88.7% and 10.5% respectively of the

TABLE 3-15. COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+, 1+, 2+, AND 3+ WILD AND HATCHERY STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER 95% CI	UPPER 95% CI	N	MEAN (mm)	LOWER 95% CI	UPPER 95% CI
0+	1989	368	111.8	108.6	115.0	46	137.8	133.7	141.9
1+	1988	3,514	213.9	212.5	215.3	92	219.1	211.7	226.5
2+	1987	1,216	297.5	294.5	300.5	3	289.7	238.8	340.5
3+	1986	55	382.3	362.2	402.4	0			

TABLE 3-16. DIFFERENCES IN MEAN LENGTH AT TIME OF STOCKING FOR HATCHERY AND WILD STRIPED BASS IN THE LOWER HUDSON RIVER, 1987, 1988 AND 1989 COHORTS.

		HATCHERY FISH			WILD FISH			
COHORT	DATE	n	MEAN LENGTH	STANDARD DEVIATION	n	MEAN LENGTH	STANDARD DEVIATION	P
1989	20-26 Aug	248	97	8.8	152	68.1	12.0	<0.001
	27 Aug-2 Sep	393	105	11.0	110	73.3	12.3	<0.001
	3-9 Sep	298	112	11.9	140	71.2	11.5	<0.001
	22-28 Oct	100	152	10.9	54	90.2	15.7	<0.001
1988	23-29 Oct	68	139.3	14.8	101	89.2	168.0	<0.001
1987	9-15 Aug	46	77.2	4.6	151	59.5	11.9	<0.001

total number of striped bass stocked. However, summer and fall stocked striped bass made up 28.3% and 71.7% respectively of the hatchery recaptures. The disproportionate recapture of fall stocked striped bass could either be due to gear selection, differential distribution, or differential survival of the two stocking groups. Fall stocked striped bass were significantly larger than summer stocked striped bass when recaptured at Age 0+ (summer: mean=124.0, standard error=1.99; fall: mean=143.2, standard error=2.39). The 9 m trawl used in this program does not effectively capture fish less than 110 mm (NAI 1990a) and the preferential capture of fall stocked fish may be due to their larger size. If the two stocking groups had a different distribution in the lower estuary, it is possible that the fall stocked striped bass inhabited an area where the majority of our sampling effort was concentrated. If survival was significantly lower for the summer-stocked striped bass compared to the fall-stocked striped bass, a proportionally greater number of fall stocked striped bass would be available for capture in the winter of 1989-90. All of these hypotheses are better evaluated when the 1989 hatchery cohort is fully recruited to the gear at Age 1+.

The 1988 hatchery cohort was significantly larger at Ages 0+ and 1+ than the wild cohort (Table 3-17). These size differences are probably due to the larger size of hatchery fish compared to wild fish at the time of stocking. Two groups of hatchery striped bass were stocked between 30 September and 4 November 1988. The first group of 38,554 fish were stocked from the Verplanck Hatchery between 30 September and 4 November at a mean length of 139 mm. These fish were significantly larger than wild fish at the time of stocking (Table 3-16). The second group of 10,057 fish were from the Attleboro Hatchery and were stocked to the Hudson River at a modal size of 80 mm (mean lengths not available) between 28 October and 4 November. Both of these groups were stocked to the Hudson River later in the year and at a larger size than previous hatchery cohorts.

TABLE 3-17. MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1989 HATCHERY AND WILD STRIPED BASS COHORTS CAPTURED BY A 9 m TRAWL IN THE LOWER HUDSON RIVER DURING 21 DECEMBER 1986 THROUGH 8 MAY 1987, 9 NOVEMBER 1987 THROUGH 22 APRIL 1988, 31 OCTOBER THROUGH 15 APRIL 1989, AND 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH(mm)	S.D.	n	MEAN LENGTH(mm)	S.D.	n	MEAN LENGTH(mm)	S.D.	n	MEAN LENGTH(mm)	S.D.
1984	Hatchery							5	280	46.7	2	349	44.5
	Wild							359	299	3.1	273	367	3.9
1985	Hatchery				51	205*	21.2	58	286*	41.4	6	364	39.0
	Wild				285	221*	3.0	514	317*	2.7	57	396	4.4
1986	Hatchery	38	108*	15.1	96	220*	26.6	48	315	36.2	0		
	Wild	83	128*	2.9	1,503	253*	1.2	361	325	0.5	55	382	10.1
1987	Hatchery	20	108	27.9	39	209*	32.5	3	290[b]	27.7			
	Wild	190	108	2.1	3,623	227*	0.1	1,216	298[b]	1.5			
1988	Hatchery	120	133*	19.1	92	219*	35.4						
	Wild	1007	121*	0.9	3,514	214*	0.7						
1989	Hatchery	46	138*	13.8									
	Wild	368	112*	1.6									

[a] Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.
[b] Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for Age 2+ hatchery striped bass.
* Indicates a significant ($p<0.05$) difference in mean length between the hatchery and wild cohorts within an age class.

Mean length of the 1987 hatchery cohort was not significantly different from the wild cohort at Age 0+. However, at Age 1+ the wild cohort was significantly larger (Table 3-17). This pattern contrasts with the length relationships at the time of stocking. A total of 324,800 fish were stocked from the Verplanck hatchery between 31 July and 25 September 1987. The mean length of a subsample of the hatchery fish at the time of stocking on 10 August was 77 mm. The mean length of wild fish during the week of 10 August was significantly smaller than the hatchery fish at the time of stocking (Table 3-16). This growth pattern would be expected if growth of summer stocked fish is slower than wild fish.

The 1986 hatchery cohort was significantly smaller at Age 0+ and 1+ compared to the wild cohorts at the same ages and the 1985 hatchery cohort was smaller at Ages 1+ and 2+ compared to the wild cohort (Table 3-17). No data are available on the mean lengths of the 1986 and 1985 hatchery cohorts at the time of stocking.

3.4.1.2 <u>Magnetic Tag Detection Efficiency</u>

During the 1989-90 program, 33,386 striped bass were examined using the field magnetic tag detectors. Of these fish, 148 were classified as suspected Hudson River hatchery striped bass and 141 were verified as having CWTs from the Verplanck hatchery present (Appendix Table D-1). Seven fish suspected of having CWTs from the Verplanck hatchery did not have CWTs. One additional fish had a CWT from a Virginia hatchery. Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990).

To evaluate the effectiveness of the magnetic tag detectors used in the field, previous studies used an extremely sensitive "tube-shaped" detector in tandem with the standard "V-shaped" field detector as a quality control check on approximately 10% of the sampling days (NAI 1990a). On 20 March 1989, the "tube-shaped" detector became inoperable (NAI 1990a), and due to its unreliability as a field instrument, was no longer used. Therefore, striped bass caught during the 1989-90 program were double-checked for CWTs with two "V-shaped" detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Striped bass that did elicit a response from the first detector were not passed through the second detector. Three fish with CWTs out of 141 tagged fish escaped detection with the first detector. Therefore, the best estimate of the non-detection rate during the 1989-90 program is $(3/138)^2$ or 0.047%, which was used to adjust the number of hatchery recaptures. In 1988-89, the nondetection rate was 1.9% (NAI 1990a). In 1986-87, 2 out of 15 CWT-tagged fish escaped detection for a nondetection rate of 13.3%. No fish escaped detection in 1987-88. The average nondetection rate of CWTs for the studies prior to 1988-89 was 2/26 or 7.7%.

3.4.1.3 Stocking Check

Striped bass stocked from the Hudson River striped bass hatchery exhibit a characteristic growth pattern and can be differentiated from wild striped bass based on the formation of a stocking check on their scales (Humphreys et al. 1990). To evaluate the use of this stocking check to distinguish hatchery from wild striped bass, three experienced scale readers were presented with an unknown sample of mixed Age 0+ through 3+ hatchery and wild striped bass from the 1989-90 Striped Bass Hatchery Evaluation Program.

The three scale readers were able to correctly identify the source of origin for 79-94% of the Age 0+ hatchery striped bass, 51-90% of the Age 1+ hatchery fish, and 50-100% of the Age 2+ hatchery fish in this sample (Table 3-18). The three scale readers were also able to correctly recognize the source of origin for 58-97% of the wild Age 0+ striped bass, 95-99% of the wild Age 1+ fish, and 91-98% of the wild Age 2+ fish. The three scale readers misclassified the source and called hatchery striped bass wild for 6-21% of the Age 0+ hatchery striped bass, 10-49% of the Age 1+ hatchery fish, and 0-50% of the Age 2+ hatchery fish. Conversely, wild striped bass were assigned a hatchery source for 3-42% of the Age 0+ wild fish, 1-5% of the wild Age 1+ fish, and 2-9% of the wild Age 2+ fish.

If the hatchery striped bass were not individually tagged with CWT, and stocking check recognition was used as the only method to identify the source and number of hatchery fish recaptured in each year, errors of assigning hatchery source to wild fish and vice versa would not be recognized and may bias estimates of the hatchery proportions. These errors may be relatively large when the true hatchery proportion is small (less than 5%) as has been observed for all hatchery cohorts recaptured since 1984 (Section 3.3). To evaluate the relationship between stocking check recognition and the true hatchery proportion, we calculated an estimated hatchery proportion for selected true hatchery proportions based on the results presented in Table 3-18. For example, the estimated probability of Person A correctly identifying an Age 1+ hatchery striped bass as an Age 1+ hatchery striped bass is 46/90 = 0.51 (from Table 3-18). The estimated probability of Person A incorrectly identifying an Age 1+ wild striped bass as an Age 1+ hatchery striped bass is 2/327 = 0.01. The estimated hatchery proportion for Age 1+ striped bass examined by Person A during 1989-90 if the true hatchery proportion was 4% is (0.04)(0.51) + (0.96)(0.01) = 0.03 or about 3%.

The Age 1+ and Age 2+ cohorts of Hudson River hatchery striped bass were most consistently and accurately recognized by each of the three scale readers, followed by Age 0+ (Figure 3-5). Among the three scale readers, Person B was the most accurate in recognizing Age 0+, Age 1+ and Age 2+ hatchery fish, followed by Person A and Person C. Person C was generally quite accurate in assigning origin to Age 1+ and Age 2+ fish, but overestimated the proportion of Age 0+ hatchery striped bass. For true hatchery proportions less than 5%, the estimated hatchery proportion of Age 0+ fish was substantially overestimated by persons A and C, primarily because many wild Age 0+ fish were identified as hatchery fish. Persons B and C overestimated the hatchery proportion

TABLE 3-18. NUMBER OF SCALES IDENTIFIED AS HATCHERY OR WILD SOURCE FOR AN UNKNOWN SAMPLE OF AGE 0+, 1+, AND 2+ STRIPED BASS EXAMINED INDEPENDENTLY BY THREE TECHNICIANS DURING THE 1989-90 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAM.

				PERSON A			PERSON B			PERSON C		
AGE	COHORT	TRUE SOURCE	TRUE TOTAL	HATCHERY	WILD	PERCENT PROPERLY CLASSIFIED	HATCHERY	WILD	PERCENT PROPERLY CLASSIFIED	HATCHERY	WILD	PERCENT PROPERLY CLASSIFIED
0+	1989	Hatchery	34	27	7	79.4	32	2	94.1	31	3	91.2
0+	1989	Wild	98	17	81	82.7	3	95	96.9	41	57	58.2
			132	44	88		35	97		72	60	
1+	1988	Hatchery	90	46	44	51.1	81	9	90.0	57	33	63.3
1+	1988	Wild	327	2	325	99.4	15	312	95.4	13	314	96.0
			417	48	369		96	321		70	347	
2+	1987	Hatchery	2	2	0	100.0	1	1	50.0	2	0	100
2+	1987	Wild	58	1	57	98.3	5	53	91.4	2	56	96.6
			60	3	57		6	54		4	56	

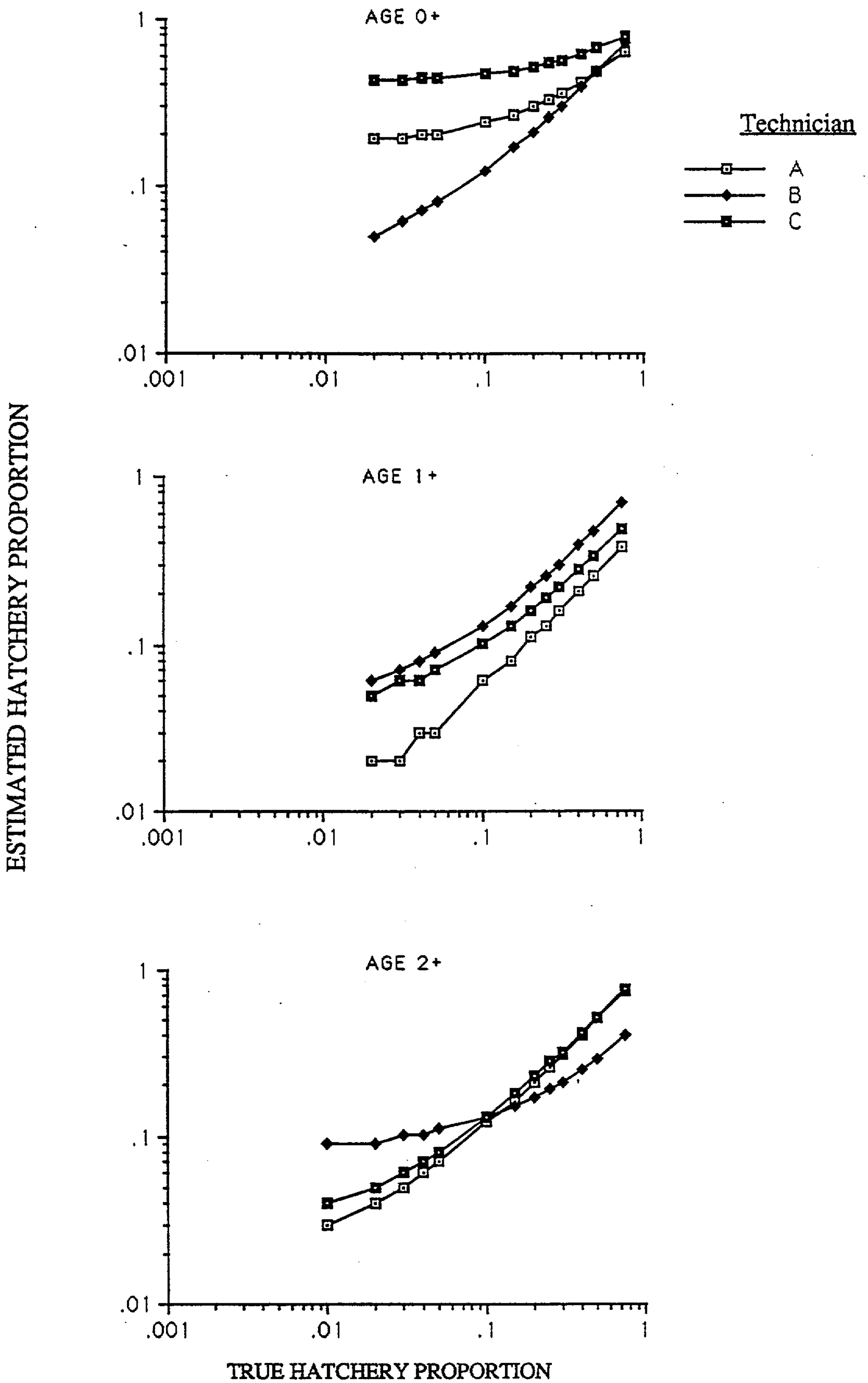


Figure 3-5. Estimated proportion of striped bass based on scale samples from Age 0+, Age 1+ and Age 2+ cohorts captured during the 1989-90 Hudson River Hatchery Evaluation Program and examined for a stocking check by three technicians (A, B or C).

for Age 1+ and Age 2+ at low hatchery proportions. For true hatchery proportions less than 5%, Age 1+ and Age 2+ hatchery proportions were overestimated primarily due to misclassification of wild fish as hatchery.

A relatively high recapture rate for fish in the 1988 cohort (Age 1+) and rapid growth of the 1989 (Age 0+) hatchery fish were the most likely factors contributing to the poor recognition of these hatchery cohorts. Scales from hatchery fish stocked late in the year would not exhibit much growth after stocking before the first annulus was formed. Therefore, the stocking check would be formed in close proximity to the annulus and may not be consistently recognized. Additionally, a higher proportion of the late stocked Age 0+ fish were caught.

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1989-90 winter sampling program, 583 striped bass were recaptured out of 24,362 fish that were caught, tagged with internal anchor tags, and released. A complete description of the number of fish caught, tagged with different types of internal anchor-external streamer tags since 1984, and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 through D-14. Both internal anchor and dart tags were applied to 659 fish during the 1989-90 program. Nine of these striped bass were recaptured with both tag types present and two fish were recaptured with the dart tag wounds. It appeared that the dart tags were shed or the anchors were removed by anglers, because anchors were not found in the wound musculature.

An additional 72 striped bass were recaptured with internal anchor tags implanted during previous programs, six fish were recaptured with suspected tag wounds, three fish were recaptured with illegible tag numbers, two fish were recaptured with dart tag wounds in addition to the internal anchor tag, one fish was recaptured with a dart tag and no internal anchor tag, and three fish were recaptured with tags from other tagging studies. These groups of wild striped bass are described below in separate sections.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1989-90 Winter Program

Nearly all (99%) of the taggable-size (≥150 mm) striped bass (25,861) were caught in the Battery region as were all but two of the 583 fish tagged, released and recaptured during this study (Table 3-19, Appendix Table D-2). This is not surprising since most (97%) of the trawl sampling effort was allocated to the Battery during 1989-90 based on the high CPUE in this region during previous programs (NAI 1986, 1987, 1988, 1990a).

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals compare the number of fish recaptured throughout the program (recaptured any time after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-19, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 580/24,257 or 0.02391. The recapture rate for striped bass tagged and released in the Battery and recaptured throughout the study area (column total) was 582/24,257 or 0.02399.

In contrast, recapture proportions (R/C) from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example,

TABLE 3-19. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	NUMBER OF RECAPTURES* FROM RELEASE REGION: UPPER HARBOR (M=105)	BATTERY (M=24,257)	TOTAL (M=24,362)
UPPER HARBOR	111	R	0	2	2
		R/M	0.00000	0.00008	0.00008
		R/C	0.00000	0.01802	0.01802
BATTERY	25,750	R	1	580	581
		R/M	0.00952	0.02391	0.02385
		R/C	0.00004	0.02252	0.02256
TOTAL	25,861	R	1	582	583
		R/M	0.00952	0.02399	0.02393
		R/C	0.00004	0.02250	0.02254

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/ M = recapture rate.
R/ C = recapture proportion.

in Table 3-19, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 580/25,750 or 0.02252. The recapture proportion for striped bass from the entire study area that were recaptured in the Battery (row total) was 581/25,750 or 0.02256. It is generally most informative to examine recapture rates from the column totals and recapture proportions from the row totals since these statistics best describe specific movement among regions (or time periods).

Examination of monthly recapture rates (R/M) and recapture proportions (R/C) can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (R/M column totals; Table 3-20) were highest for fish tagged in November 1989 at 0.04755, and were similar for fish tagged from December 1989 to April 1990. Monthly recapture proportions (R/C row totals) increased from January 1990 through April 1990, and ranged between 0.01246 and 0.04918 in this period (Table 3-20). This pattern of similar monthly recapture rates for fish tagged in December through March and increasing monthly recapture proportions from January through April is similar to patterns in these statistics observed in the 1985-86, 1986-87, 1987-88, and 1989-90 studies (NAI 1986, 1987, 1988, 1990a).

Striped bass tagged and released in the combined Battery and upper New York harbor regions, and subsequently recaptured in those regions were at large an average of 25 days and ranged in size between 151 mm and 412 mm (Table 3-21). Approximately 44% (255/583) of the striped bass were recaptured on the same day as they were tagged and released, and 68% (399/583) of the fish were recaptured within 30 days of release (Table 3-21), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 85% (496/583) of the striped bass were recaptured, and the maximum days at large was 150 days. Days at large

TABLE 3-20. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 30 OCTOBER 1989 TO 13 APRIL 1990.

			NUMBER OF RECAPTURES FROM RELEASE MONTH*						
RECAPTURE MONTH	NUMBER CAUGHT (C)	STATISTIC	NOV M = 2294	DEC M = 5574	JAN M = 3811	FEB M = 6168	MAR M = 5244	APR M = 1271	TOTAL M = 24362
NOVEMBER	2423	R	50						50
		R/M	0.02180						0.00205
		R/C	0.02064						0.02064
DECEMBER	5832	R	17	77					94
		R/M	0.00741	0.01381					0.00386
		R/C	0.00291	0.01320					0.01612
JANUARY	4014	R	7	14	29				50
		R/M	0.00305	0.00251	0.00761				0.00205
		R/C	0.00174	0.00349	0.00722				0.01246
FEBRUARY	6507	R	14	21	23	91			149
		R/M	0.00610	0.00377	0.00604	0.01475			0.00612
		R/C	0.00215	0.00323	0.00353	0.01398			0.02290
MARCH	5682	R	13	26	18	50	64		171
		R/M	0.00567	0.00466	0.00472	0.00811	0.01220		0.00702
		R/C	0.00229	0.00458	0.00317	0.00880	0.01126		0.03010
APRIL	1403	R	8	6	2	9	12	32	69
		R/M	0.00349	0.00108	0.00052	0.00146	0.00229	0.02518	0.00283
		R/C	0.00570	0.00428	0.00143	0.00641	0.00855	0.02281	0.04918
TOTAL	25861	R	109	144	72	150	76	32	583
		R/M	0.04755	0.02584	0.01890	0.02433	0.01450	0.02518	0.02394
		R/C	0.00422	0.00557	0.00279	0.00580	0.00294	0.00124	0.02255

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

TABLE 3-21. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE LOWER HUDSON RIVER BY A 9 m TRAWL, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

STATISTIC	RELEASED WITHIN THE 1989-90 PROGRAM	
NUMBER TAGGED (≥150 mm)	M	24,362
NUMBER EXAMINED FOR TAGS (≥150 mm)	C	25,861
NUMBER RECAPTURED	R	583
SIZE RANGE OF RECAPTURED FISH (mm)	Min	150
	Max	412
	Mean	219
	S.D.	43
DAYS AT LARGE	Min	0
	Max	150
	Mean	25
	S.D.	36
FREQUENCY OF DAYS AT LARGE	0 Days	255
	1-5 Days	67
	6-10 Days	18
	11-20 Days	29
	21-30 Days	30
	31-40 Days	39
	41-50 Days	31
	51-60 Days	27
	61-70 Days	14
	71-80 Days	9
	81-90 Days	10
	91-100 Days	13
	101-110 Days	16
	111-120 Days	8
	121-130 Days	5
	131-140 Days	6
	141-150 Days	6

and recapture length data for the 1989-90 program were similar to previous years (NAI 1987, 1988, 1990).

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1989-90 Winter Program

All of the 72 striped bass recaptured with internal anchor tags from previous programs were caught in the Battery region (Appendix Table D-3). All of these 72 recaptured striped bass had the external portion of the tag (streamer) present. Among the 72 striped bass with streamers intact, nearly all (69) fish had tags with completely legible numbers. Only three fish were observed with abraded but legible tags, and no fish had partly or completely missing tag numbers due to abrasion (Table 3-22, Appendix Table D-5). An additional six fish were observed with tag wounds but no tag present (Table 3-22). Tag numbers were defined as completely illegible if one or more of the 5-digit tag number could not be read in the field. Tag abrasion was first observed during 1986-87, is time dependent, and requires at least 6 months to be observed (Mattson et al. 1990). Unfortunately, without the complete tag number, it is impossible to determine exactly when the fish was released; however the year of release may be identified by tag style. Although no illegible tags were observed in the 1989-90 program, in previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged at large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990a).

Changes in tag design since 1986-87 have reduced tag abrasion. Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used: abrasion was observed in 28% of the recaptured fish at large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type

TABLE 3-22. INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 1988-89 AND 1989-90 PROGRAMS.

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH[a] 1988-89	NUMBER OF FISH[a] 1989-90
Tag number completely legible	Healed	34	63
	Infected	13	6
	Anchor Protruding	(0)	(0)
		47	69
Tag number abraded but legible	Healed	3	2
	Infected	0	1
	Anchor Protruding	(0)	(0)
		6	3
Tag number partly or completely missing and not legible	Healed	0	0
	Infected	0	0
	Anchor Protruding	(0)	(0)
		0	0
Tag wound only, tag and anchor missing	Healed	4	6
	Infected	0	0
		4	6
Tag wound, anchor present	Healed	2	0
	Infected	0	0
		2	0

[a]striped bass which could be cross-classified by degree of tag number abrasion and condition of the tag insertion site.

tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor. Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but short length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag would site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990a). Apparently, the monofilament strand cut through the ventral body wall of the fish as continuous force was applied to the tag during swimming. The tag cut through the ventral body wall, forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was displaced out of the fish and shed.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a shedding rate for the original Hallprint tag with an exposed filament of 22/94 or 23%. Among the six fish with suspected tag wounds caught during the 1989-90 program, five fish had a longitudinal scar suggesting they may have shed a tag, and none of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. For fish released during 1988-89 and recaptured during the 1989-90 program, the recapture rate for fish with modified Hallprint tags with extended streamers was

0.24% (19/7,927), compared to a recapture rate of 0.26% (42/16,466) for the original Hallprint tag with exposed filament. Changing to the Hallprint tag in 1987-88 has eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has virtually eliminated tag loss due to shedding.

Sixty-one of the 72 striped bass recaptured during the 1989-90 program were tagged and released during 1988-89, 10 recaptured fish were tagged and released during 1987-88, and the remaining one fish was tagged and released during 1986-87 (Table 3-23, Appendix Table D-3). All 61 fish recaptured from 1988-89 had been released from the 9 m trawl, which was the only gear used in that program. Among the 10 striped bass recaptured from 1987-88, 9 were tagged and released from the 9 m trawl, and one fish was from the 12 m trawl with 9 m trawl cod-end. The one fish recaptured from 1986-87 was tagged and released from the 9 m trawl. Recaptured fish were at large between 255 and 1,109 days, and ranged in length between 225 mm and 565 mm (Table 3-24).

Three striped bass were recaptured during 1989-90 with evidence of being double tagged with both an internal anchor tag and a dart tag (Appendix Table D-3). One 557 mm fish was released 5 April 1989 and recaptured 2 January 1990 in the Battery region with an internal anchor tag present but a wound was observed at the dart tag insertion site. A second fish was recaptured with an internal anchor tag and a wound at the dart tag insertion site. This 285 mm fish was released on 3 April 1989 and recaptured on 11 January 1990. A third 280 mm fish was released on 13 April 1989 and recaptured on 8 March 1990 with only a dart tag present. The internal anchor tag had been removed by a fisherman. These three fish were among the 819 double tagged striped bass released during the 1988-89 program, and exhibited a recapture rate of 0.37% (3/819).

TABLE 3-23. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN RELEASE YEARS PRIOR TO, AND RECAPTURED IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED(R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH			
					MIN	MAX	MEAN	S.D.
1988-89	9 m trawl	24,393	61	0.00250	225	565	300	55
1987-88	9 m trawl	7,582	9	0.00119	353	554	432	68
	12 m trawl with 9 m trawl cod end	4,854	1	0.00021	363	363	363	
	TOTAL	12,436	10	0.00080				
1986-87	9 m trawl	3,724	1	0.00027	393	393	393	
	12 m trawl	1,980	0	0.00000				
	9 m trawl with liner	1,625	0	0.00000				
	12 m trawl with liner	2,059	0	0.00000				
	TOTAL	9,388	1	0.00011				

TABLE 3-24. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN THE LOWER HUDSON RIVER PRIOR TO, AND RECAPTURED DURING THE PRESENT PROGRAM, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

STATISTIC		RELEASED PRIOR TO 30 OCTOBER 1989 IN GEAR: 9 m TRAWL[a]	RELEASED PRIOR TO 30 OCTOBER 1989 IN GEAR: 12 m TRAWL WITH 9 m TRAWL COD END[b]
TOTAL NUMBER TAGGED	M	42,065	4,854
NUMBER AGE 2+ OR OLDER EXAMINED FOR TAGS	C	4,421	4,113
NUMBER RECAPTURED	R	71	1
RECAPTURE RATE	R/M	0.00169	0.00021
RECAPTURE PROPORTION	R/C	0.01726	0.00024
LENGTH OF RECAPTURED FISH (mm)	Min	225	363
	Max	565	363
	Mean	318	363
	S.D.	72	--
DAYS AT LARGE	Min	255	628
	Max	1,109	628
	Mean	410	628
	S.D.	163	--
FREQUENCY OF DAYS AT LARGE	151-200 Days	0	
	201-250 Days	0	
	251-300 Days	17	
	301-350 Days	16	
	351-400 Days	12	
	401-450 Days	9	
	451-500 Days	7	
	501-550 Days	0	0
	551-600 Days	0	0
	601-650 Days	1	1
	651-700 Days	3	0
	701-750 Days	2	0
	751-800 Days	2	0
	801-850 Days	1	0
	851-900 Days	0	
	901-950 Days	0	
	951-1000 Days	0	
	1001-1050 Days	0	
	1051-1100 Days	0	
	1101-1150 Days	1	

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, and 1988-89 programs.
[b]Contains fish tagged and released in the 1986-87 program.

Three striped bass were recaptured in 1989-90 with tags originating from other tagging programs (Table 3-25). Two fish were recaptured with U.S. Fish and Wildlife Service internal anchor tags and one fish was recaptured with a Littoral Society spaghetti tag.

3.5 STRIPED BASS POPULATION SIZE

One of the objectives of the 1989-90 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. Section 3.4.2.1 indicated that the striped bass population in the Upper Harbor and Battery regions of the Hudson River was apparently closed to major immigration and emigration during most of December 1989 through April 1990. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently. This estimator was used during 1985-86, 1986-87, 1987-88, and 1988-89 to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990a).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) mortality is not different for tagged and untagged bass,

2) tagging does not affect bass catchability,

3) tagged bass do not lose their marks,

4) all tags are recognized and reported,

5) natural marking does not occur or is recognizable,

6) immigration, emigration, and recruitment are negligible in the study area i.e., the population is closed,

TABLE 3-25. DATA FOR TAGGED STRIPED BASS ORIGINATING FROM THE U.S. FISH AND WILDLIFE SERVICE (USFWS), AND LITTORAL SOCIETY (LS) TAGGING PROGRAMS AND RECAPTURED BY A 9 M TRAWL IN THE LOWER HUDSON RIVER, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

RECAPTURE DATE	LOCATION	LENGTH (mm)	TAG NUMBER	TAGGING PROGRAM	TAG INSERTION SITE
16 Feb 1990	Battery RM 1	257	100675	USFWS	Good condition
7 Mar 1990	Battery RM 5	232	101560	USFWS	Good condition
23 Mar 1990	Battery RM 1	342	209771	LS	Good condition

7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions, and

8) marked fish have the same probability of being caught.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained 1) in the Hudson River for 24 hours and 2) in holding pools for up to 180 days. For the purposes of obtaining a mark-recapture population estimate, differential mortality during the estimation period was assumed to be zero.

Differential vulnerability of tagged and untagged striped bass during the winter (assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1989) which would provide evidence of tag loss. QA/QC procedures (NAI 1989) and audits provide documentation that incorrect identification or non-reporting of tags by field crews did not occur. Dunning et al. (1987) found 97.7% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and a recapture rate of 583 fish out of 24,362 tagged fish, approximately 13 fish would be expected to have lost tags in the 1989-90 program. Throughout the 1989-90 program, 25,861 striped bass were examined for tags and tag wounds, and only 6 fish were observed with tag wounds. However, 5 of these fish exhibited a longitudinal scar, suggesting the scar originated from shed Hallprint tags. Since these longitudinal scars have been shown to originate from shed Hallprint tags with exposed filaments at the base of the external streamer (Section 3.4.2.2), these fish probably originated from previous programs. The exposed filament tag was not used during the 1989-90 program. The remaining fish exhibited an atypical wound at the insertion site suggesting it may have a natural origin and not be from a shed tag. Therefore, loss of internal anchor tags for fish tagged and released during 1989-90 was considered zero. This assumption provides a conservative estimate of abundance. If tag loss did occur, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1990b, Geoghegan et al. 1990). Since this program provided both marking and recapture efforts, nonreporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tags used in this study.

Immigration and emigration (Assumption 6) was apparently negligible during most of the study period (November 1989 through April 1990) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4, NAI 1986, 1987, 1988, 1990a). A regression of weekly recapture proportions (R/C) on cumulative number of marked fish (Figure 3-6) was significant and positive for the week of 22 January 1990 through the week of 9 April 1990 (Appendix Tables D-6 and D-7). Recapture rates (R/M) varied less during the weeks of 22 January through 9 April than any other 12 week period during the program.

A period of increasing recapture proportions and relatively stable recapture rates suggests little movement of a marked population (Cormack 1968; Schaefer 1951). This period of little movement by the winter striped bass population occurred later in the program than was observed during 1985-86 (30 December 1985 through 21 February 1986, NAI

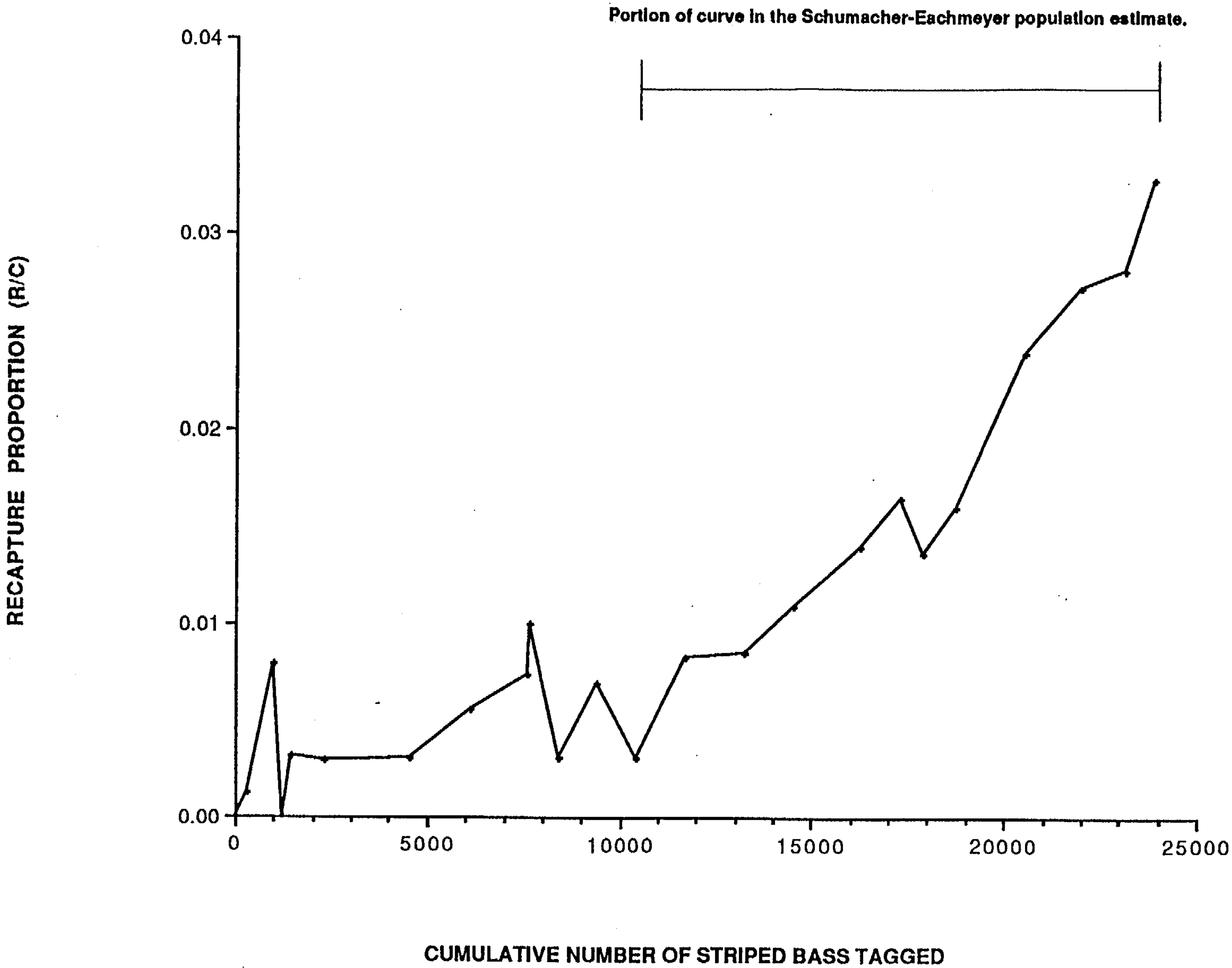


Figure 3-6. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged in the combined Upper Harbor and Battery regions of the lower Hudson River, 30 October 1989 through 13 April 1990.

1986), 1986-87 (21 December 1986 through 13 March 1987, NAI 1987), 1987-88 (21 December 1987 through 9 April 1989, NAI 1988), and 1988-89 (12 December 1988 through 2 April 1989, NAI 1990a). The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass (Assumption 7). Furthermore, polynomial regressions did not significantly improve goodness of fit, which indicated a linear regression was appropriate. The population may not be closed after 13 April 1990, because studies conducted during 1985-86 indicated tagged striped bass began moving from the Battery and Upper Harbor upriver into the Tappan Zee and Croton-Haverstraw regions in late-March or early April (NAI 1986).

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1989-90 was 776,000 fish $\geq$ 150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 682,000 to 900,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-26). Based on the estimated hatchery proportion of 0.4% for Age 1+ fish and 0.1% for Age 2+ fish, (Section 3.3), about 2,600 Age 1+ and 100 Age 2+ hatchery fish were present among the striped bass overwintering in the Battery and upper New York harbor regions during winter 1989-90.

For comparison with previous programs, the total population of striped bass ≥200 mm was estimated as 528,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ and Age 2+ fish between 150 and 200 mm (Table 3-27). This estimate was the third highest calculated annually since 1985-86 (Table 3-28). The abundant 1988 cohort of Age 1+ fish was the primary contributor to this relatively large estimate of Hudson River striped bass in the mid-winter population during 1989-90.

TABLE 3-26. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1989-90.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥150mm	PROPORTION ≥150mm	ESTIMATED POPULATION[a]
1+	21,725	21,331	0.8248	640,000
2+	4,113	4,113	0.1591	123,000
3+	205	205	0.0079	6,000
>3+	103	103	0.0040	3,000
TOTAL	26,146	25,752	0.9958	772,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of striped bass ≥150 mm marked, released and recaptured in the Upper Harbor and Battery regions of the Lower Hudson River from the week of 22 January 1990 through the week of 9 April 1990. Age 0+ striped bass were an additional 0.42% of the population ≥150 mm.

TABLE 3-27. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1989-90.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥200mm	PROPORTION ≥200mm	ESTIMATED POPULATION[a]
1+	21,725	13,213	0.7516	397,000
2+	4,113	4,059	0.2309	122,000
3+	205	205	0.0117	6,000
>3+	103	103	0.0058	3,000
TOTAL	26,146	17,580	1.0000	528,000

[a]The total population estimate based on fish ≥150 mm (776,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (17,580/25,861 = 0.6798).

TABLE 3-28. ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER OFF MANHATTAN DURING THE WINTERS OF 1985-86 THROUGH 1989-90.

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged and no population estimate is possible for the 1987-88, 1986-87 and 1985-86 programs.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9 m TRAWL.

	9 m TRAWL
Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6 cm (stretch) mesh polypropylene; polypropylene; 3 mm diameter twine
- cod end	3.8 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER ESTUARY DURING THE 1989-90 STRIPED BASS PROGRAM.

REGION	WEEK	SURFACE WATER TEMPERATURE[a]	SURFACE WATER CONDUCTIVITY[b]	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY
UPPER HARBOR	25DEC89	1.46	32293	2.00	38329
	26MAR90	7.20	23563	17.00	27018
BATTERY	30OCT89	14.72	15376	15.08	30452
	06NOV89	13.25	16207	13.74	31842
	13NOV89	12.60	14550	12.71	24079
	20NOV89	9.31	9362	10.39	25112
	27NOV89	7.73	22016	8.26	30981
	04DEC89	4.90	23500	5.85	33693
	11DEC89	4.11	29629	4.94	36942
	18DEC89	1.28	21685	3.19	38528
	25DEC89	1.06	28276	1.79	33069
	01JAN90	1.21	25719	1.40	33789
	08JAN90	2.62	30228	2.71	33996
	15JAN90	2.84	22459	3.18	36412
	22JAN90	3.81	20281	5.64	34779
	29JAN90	3.93	14640	5.70	26871
	05FEB90	4.10	18957	7.15	30612
	12FEB90	3.92	10124	5.71	31400
	19FEB90	3.96	16617	6.22	35321
	26FEB90	3.36	15577	8.20	24681
	05MAR90	2.82	14752	9.87	27924
	12MAR90	5.82	12194	9.90	23100
	19MAR90	6.26	6104	8.91	28096
	26MAR90	7.50	17549	14.91	24508
	02APR90	7.51	10572	13.85	23526
	09APR90	8.24	7121	12.78	20641

[a] Water temperature in °C
[b] Conductivity in µS/cm^2

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER DURING WINTER, 1989-90.

STATION	WEEK	TOWS	N	CPUE MEAN	S.E.
UPPER HARBOR REGION					
	25DEC89	5	59	11.8	6.1
	26MAR90	5	91	18.2	6.2
	TOTAL	10	150	15.0	4.2
THE BATTERY REGION					
	30OCT89	31	284	9.2	2.9
	06NOV89	33	777	23.5	5.6
	13NOV89	28	383	13.7	3.7
	20NOV89	14	367	26.2	7.1
	27NOV89	58	1318	22.7	3.5
	04DEC89	28	2498	89.2	24.8
	11DEC89	30	1752	58.4	6.8
	18DEC89	23	2024	88.0	13.6
	25DEC89	18	512	28.4	3.3
	01JAN90	37	892	24.1	2.2
	08JAN90	30	1526	50.9	7.0
	15JAN90	39	1533	39.3	8.0
	22JAN90	44	2020	45.9	7.0
	29JAN90	31	2313	74.6	10.4
	05FEB90	30	1850	61.7	12.7
	12FEB90	36	2018	56.1	5.4
	19FEB90	37	1311	35.4	4.4
	26FEB90	55	1066	19.4	3.3
	05MAR90	42	1177	28.0	8.3
	12MAR90	36	2493	69.2	8.4
	19MAR90	38	1773	46.7	6.1
	26MAR90	39	1228	31.5	3.7
	02APR90	48	1023	21.3	2.4
	09APR90	76	917	12.1	1.1
	TOTAL	881	33055	37.5	1.6

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER DURING WINTER, 1989-90.

STATION	RIV_MILE	TOWS	N	CPUE MEAN	S.E.
UPPER HARBOR REGION					
	2	10	150	15.0	4.2
	TOTAL	10	150	15.0	4.2
THE BATTERY REGION					
	1	407	19187	47.1	2.8
	5	167	3611	21.6	2.1
	6	1	1	1.0	
	8	154	5653	36.7	3.8
	9	151	4595	30.4	2.8
	10	1	8	8.0	
	TOTAL	881	33055	37.5	1.6

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS CAPTURED AND STRIPED BASS TAGGED IN THE HUDSON RIVER CROSS-CLASSIFIED BY REGION, GEAR AND USE CODE FOR THE 9 m TRAWL, 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

REGION	GEAR	USE CODE	SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
Battery	9 m trawl	1	881	33,055	24,116
		2	11	181	141
		5	5	0	0
Total			897	33,236	24,257
Upper Harbor	9 m trawl	1	10	150	105
		2	0	0	0
		5	0	0	0
Total			10	150	105

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER DURING THE 1989-90 STRIPED BASS/ATLANTIC TOMCOD PROGRAM.

				N TOWS		NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (mm)											NUMBER OF FISH				MORTALITY	
DATE	GEAR	WATER TEMP.	COND.	TOTAL	VOID	<150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	801+	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	N	%
30 OCT 89	9m	15.1	30452	31	0	10	64	178	30	0	0	1	1	0	284	9	270	3	1	0	0	0.0
6 NOV 89	9m	13.7	31842	33	0	36	184	492	61	4	0	0	0	0	777	24	708	14	2	11	6	0.8
13 NOV 89	9m	12.7	24079	28	1	130	57	162	28	4	1	1	0	0	383	14	241	4	4	4	0	0.0
20 NOV 89	9m	10.4	25112	14	0	144	63	117	38	5	0	0	0	0	367	26	216	1	4	1	1	0.3
27 NOV 89	9m	8.3	30981	59	0	396	314	464	127	21	3	0	0	0	1325	22	870	37	4	17	1	0.1
4 DEC 89	9m	5.9	33693	28	0	163	690	1268	335	33	7	2	0	0	2498	89	2267	48	11	8	1	0.0
11 DEC 89	9m	4.9	36942	30	0	158	321	1005	248	16	2	1	0	1	1752	58	1544	30	3	17	0	0.0
18 DEC 89	9m	3.1	38528	23	0	394	471	966	166	20	4	2	1	0	2024	88	1536	34	12	43	5	0.2
25 DEC 89	9m	1.8	34121	25	0	337	113	132	12	4	5	2	0	0	605	24	248	5	8	5	2	0.3
1 JAN 90	9m	1.4	33789	39	0	309	220	295	55	16	10	5	0	0	910	23	561	16	7	17	0	0.0
8 JAN 90	9m	2.7	33996	30	1	555	391	528	49	3	0	0	0	0	1526	51	925	6	9	28	3	0.2
15 JAN 90	9m	3.2	36412	40	0	461	416	696	40	1	0	0	0	0	1614	40	1083	25	5	35	5	0.3
22 JAN 90	9m	5.6	34779	44	0	740	563	672	41	3	0	0	0	1	2020	46	1222	15	8	33	2	0.1
29 JAN 90	9m	5.7	26871	32	0	637	626	991	55	6	0	0	0	0	2315	72	1584	29	14	49	2	0.1
5 FEB 90	9m	7.2	30612	30	1	557	479	716	87	10	1	0	0	0	1850	62	1234	27	5	26	1	0.1
12 FEB 90	9m	5.7	31400	37	0	211	610	1074	134	9	2	1	0	0	2041	55	1724	55	11	36	4	0.2
19 FEB 90	9m	6.2	35321	37	0	231	412	579	83	3	3	0	0	0	1311	35	1026	33	10	10	1	0.1
26 FEB 90	9m	8.2	24681	56	0	463	248	325	31	4	0	0	0	0	1071	19	573	15	8	12	0	0.0
5 MAR 90	9m	9.9	27924	42	0	224	286	569	91	5	0	2	0	0	1177	28	895	20	7	30	1	0.1
12 MAR 90	9m	9.9	23100	36	1	620	604	1158	111	0	0	0	0	0	2493	69	1750	43	5	73	2	0.1
19 MAR 90	9m	8.9	28096	38	0	138	578	942	110	3	1	0	1	0	1773	47	1456	72	4	103	0	0.0
26 MAR 90	9m	15.1	24787	45	0	119	303	735	158	10	3	0	1	1	1330	30	1130	51	2	28	0	0.0
2 APR 90	9m	13.9	23526	49	1	170	259	475	102	12	2	2	0	1	1023	21	782	42	2	27	0	0.0
9 APR 90	9m	12.8	20641	76	0	369	218	245	72	10	3	0	0	0	917	12	485	30	3	29	1	0.1
TOTAL		8.0	30070	902	5	7572	8490	14784	2264	202	47	19	4	4	33386	37	24330	655	149	642	38	0.1

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. RECAPTURE DATA FOR VERIFIED HATCHERY STRIPED BASS RECAPTURED DURING THE 1989-1990 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	11/14/89	BATTERY	1	122	1989
0	9 M TRAWL	11/17/89	BATTERY	9	140	1989
0	9 M TRAWL	11/17/89	BATTERY	9	161	1989
0	9 M TRAWL	11/20/89	BATTERY	5	125	1989
0	9 M TRAWL	11/20/89	BATTERY	5	112	1989
0	9 M TRAWL	11/28/89	BATTERY	8	146	1989
0	9 M TRAWL	11/29/89	BATTERY	8	148	1989
0	9 M TRAWL	11/29/89	BATTERY	8	135	1989
0	9 M TRAWL	11/29/89	BATTERY	8	132	1989
0	9 M TRAWL	12/06/89	BATTERY	1	115	1989
0	9 M TRAWL	12/07/89	BATTERY	1	140	1989
0	9 M TRAWL	12/14/89	BATTERY	1	131	1989
0	9 M TRAWL	12/18/89	BATTERY	8	126	1989
0	9 M TRAWL	12/18/89	BATTERY	9	147	1989
0	9 M TRAWL	12/20/89	BATTERY	1	147	1989
0	9 M TRAWL	12/20/89	BATTERY	1	153	1989
0	9 M TRAWL	12/28/89	BATTERY	9	135	1989
0	9 M TRAWL	12/29/89	BATTERY	1	149	1989
0	9 M TRAWL	01/02/90	BATTERY	1	155	1989
0	9 M TRAWL	01/05/90	BATTERY	8	127	1989
0	9 M TRAWL	01/05/90	BATTERY	9	137	1989
0	9 M TRAWL	01/08/90	BATTERY	8	126	1989
0	9 M TRAWL	01/10/90	BATTERY	8	154	1989
0	9 M TRAWL	01/11/90	BATTERY	8	121	1989
0	9 M TRAWL	01/11/90	BATTERY	8	145	1989
0	9 M TRAWL	01/12/90	BATTERY	9	115	1989
0	9 M TRAWL	01/16/90	BATTERY	1	169	1989
0	9 M TRAWL	01/17/90	BATTERY	1	132	1989
0	9 M TRAWL	01/22/90	BATTERY	9	124	1989
0	9 M TRAWL	01/27/90	BATTERY	5	128	1989
0	9 M TRAWL	01/30/90	BATTERY	8	138	1989
0	9 M TRAWL	01/30/90	BATTERY	8	159	1989
0	9 M TRAWL	02/09/90	BATTERY	1	152	1989
0	9 M TRAWL	02/13/90	BATTERY	1	117	1989
0	9 M TRAWL	02/13/90	BATTERY	1	157	1989
0	9 M TRAWL	02/22/90	BATTERY	5	130	1989
0	9 M TRAWL	02/23/90	BATTERY	5	140	1989
0	9 M TRAWL	02/23/90	BATTERY	5	124	1989
0	9 M TRAWL	02/27/90	BATTERY	9	132	1989
0	9 M TRAWL	02/28/90	BATTERY	5	132	1989
0	9 M TRAWL	02/28/90	BATTERY	5	162	1989
0	9 M TRAWL	03/01/90	BATTERY	5	148	1989
0	9 M TRAWL	03/09/90	BATTERY	8	141	1989
0	9 M TRAWL	03/09/90	BATTERY	8	140	1989
0	9 M TRAWL	04/12/90	BATTERY	9	135	1989
0	9 M TRAWL	04/13/90	BATTERY	9	135	1989

(continued)

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL	11/03/89	BATTERY	1	188	1988
1	9 M TRAWL	11/06/89	BATTERY	5	211	1988
1	9 M TRAWL	11/08/89	BATTERY	1	243	1988
1	9 M TRAWL	11/14/89	BATTERY	1	190	1988
1	9 M TRAWL	11/22/89	BATTERY	9	157	1988
1	9 M TRAWL	11/22/89	BATTERY	9	197	1988
1	9 M TRAWL	12/04/89	BATTERY	1	255	1988
1	9 M TRAWL	12/04/89	BATTERY	1	279	1988
1	9 M TRAWL	12/04/89	BATTERY	1	219	1988
1	9 M TRAWL	12/05/89	BATTERY	1	198	1988
1	9 M TRAWL	12/06/89	BATTERY	1	233	1988
1	9 M TRAWL	12/06/89	BATTERY	1	215	1988
1	9 M TRAWL	12/07/89	BATTERY	1	213	1988
1	9 M TRAWL	12/14/89	BATTERY	1	244	1988
1	9 M TRAWL	12/18/89	BATTERY	9	276	1988
1	9 M TRAWL	12/19/89	BATTERY	1	225	1988
1	9 M TRAWL	12/19/89	BATTERY	1	218	1988
1	9 M TRAWL	12/19/89	BATTERY	1	261	1988
1	9 M TRAWL	12/19/89	BATTERY	1	247	1988
1	9 M TRAWL	12/20/89	BATTERY	1	222	1988
1	9 M TRAWL	12/20/89	BATTERY	1	231	1988
1	9 M TRAWL	12/27/89	BATTERY	8	214	1988
1	9 M TRAWL	12/28/89	BATTERY	9	172	1988
1	9 M TRAWL	12/28/89	BATTERY	9	231	1988
1	9 M TRAWL	12/29/89	UPPER HARBOR	2	285	1988
1	9 M TRAWL	12/29/89	BATTERY	1	245	1988
1	9 M TRAWL	12/29/89	BATTERY	1	193	1988
1	9 M TRAWL	01/02/90	BATTERY	1	205	1988
1	9 M TRAWL	01/02/90	BATTERY	1	301	1988
1	9 M TRAWL	01/02/90	BATTERY	1	205	1988
1	9 M TRAWL	01/04/90	BATTERY	1	248	1988
1	9 M TRAWL	01/10/90	BATTERY	9	244	1988
1	9 M TRAWL	01/10/90	BATTERY	8	239	1988
1	9 M TRAWL	01/12/90	BATTERY	8	197	1988
1	9 M TRAWL	01/12/90	BATTERY	9	206	1988
1	9 M TRAWL	01/16/90	BATTERY	1	225	1988
1	9 M TRAWL	01/16/90	BATTERY	1	234	1988
1	9 M TRAWL	01/18/90	BATTERY	1	290	1988
1	9 M TRAWL	01/26/90	BATTERY	1	226	1988
1	9 M TRAWL	01/26/90	BATTERY	5	267	1988
1	9 M TRAWL	01/27/90	BATTERY	5	193	1988
1	9 M TRAWL	01/27/90	BATTERY	5	215	1988
1	9 M TRAWL	01/27/90	BATTERY	5	207	1988
1	9 M TRAWL	01/27/90	BATTERY	5	208	1988
1	9 M TRAWL	01/29/90	BATTERY	5	146	1988
1	9 M TRAWL	01/29/90	BATTERY	5	219	1988
1	9 M TRAWL	01/29/90	BATTERY	5	177	1988
1	9 M TRAWL	01/29/90	BATTERY	5	212	1988

(continued)

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL	01/29/90	BATTERY	5	216	1988
1	9 M TRAWL	01/31/90	BATTERY	1	195	1988
1	9 M TRAWL	02/01/90	BATTERY	1	171	1988
1	9 M TRAWL	02/01/90	BATTERY	1	205	1988
1	9 M TRAWL	02/01/90	BATTERY	1	203	1988
1	9 M TRAWL	02/02/90	BATTERY	1	278	1988
1	9 M TRAWL	02/05/90	BATTERY	1	161	1988
1	9 M TRAWL	02/05/90	BATTERY	1	212	1988
1	9 M TRAWL	02/05/90	BATTERY	1	249	1988
1	9 M TRAWL	02/07/90	BATTERY	1	178	1988
1	9 M TRAWL	02/12/90	BATTERY	1	166	1988
1	9 M TRAWL	02/13/90	BATTERY	1	199	1988
1	9 M TRAWL	02/13/90	BATTERY	1	222	1988
1	9 M TRAWL	02/13/90	BATTERY	1	245	1988
1	9 M TRAWL	02/13/90	BATTERY	1	197	1988
1	9 M TRAWL	02/15/90	BATTERY	1	244	1988
1	9 M TRAWL	02/16/90	BATTERY	1	197	1988
1	9 M TRAWL	02/20/90	BATTERY	1	224	1988
1	9 M TRAWL	02/20/90	BATTERY	1	161	1988
1	9 M TRAWL	02/20/90	BATTERY	1	232	1988
1	9 M TRAWL	02/21/90	BATTERY	1	162	1988
1	9 M TRAWL	02/22/90	BATTERY	5	213	1988
1	9 M TRAWL	02/23/90	BATTERY	5	207	1988
1	9 M TRAWL	02/23/90	BATTERY	5	221	1988
1	9 M TRAWL	02/28/90	BATTERY	5	149	1988
1	9 M TRAWL	03/01/90	BATTERY	5	169	1988
1	9 M TRAWL	03/01/90	BATTERY	5	180	1988
1	9 M TRAWL	03/02/90	BATTERY	1	211	1988
1	9 M TRAWL	03/05/90	BATTERY	1	274	1988
1	9 M TRAWL	03/08/90	BATTERY	8	238	1988
1	9 M TRAWL	03/09/90	BATTERY	9	279	1988
1	9 M TRAWL	03/09/90	BATTERY	8	201	1988
1	9 M TRAWL	03/13/90	BATTERY	9	310	1988
1	9 M TRAWL	03/16/90	BATTERY	5	196	1988
1	9 M TRAWL	03/16/90	BATTERY	5	207	1988
1	9 M TRAWL	03/16/90	BATTERY	5	216	1988
1	9 M TRAWL	03/16/90	BATTERY	5	271	1988
1	9 M TRAWL	03/20/90	BATTERY	1	180	1988
1	9 M TRAWL	03/20/90	BATTERY	1	264	1988
1	9 M TRAWL	03/22/90	BATTERY	1	281	1988
1	9 M TRAWL	03/23/90	BATTERY	1	187	1988
1	9 M TRAWL	03/26/90	BATTERY	1	232	1988
1	9 M TRAWL	04/02/90	BATTERY	1	208	1988
1	9 M TRAWL	04/05/90	BATTERY	9	216	1988
2	9 M TRAWL	12/06/89	BATTERY	1	286	1987
2	9 M TRAWL	02/13/90	BATTERY	1	319	1987
2	9 M TRAWL	03/07/90	BATTERY	5	264	1987

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED DURING AND RECAPTURED DURING THE 1989-90 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER	DART TAG_N
03NOV89	235	BT	1	2	03NOV89	235	BT	1	2	0	0	0	1	289775	
03NOV89	219	BT	1	2	03NOV89	219	BT	1	2	0	0	0	1	289797	
07NOV89	200	BT	1	2	03NOV89	201	BT	1	2	4	0	0	1	289904	
07NOV89	208	BT	1	2	07NOV89	209	BT	1	2	0	0	0	1	289984	
07NOV89	263	BT	1	2	07NOV89	263	BT	1	2	0	0	0	1	290104	
08NOV89	218	BT	1	2	07NOV89	217	BT	1	2	1	0	0	1	290013	
08NOV89	167	BT	1	2	07NOV89	168	BT	1	2	1	0	0	1	290060	
08NOV89	199	BT	1	2	07NOV89	176	BT	1	2	1	0	0	1	290075	
08NOV89	225	BT	1	2	07NOV89	225	BT	1	2	1	0	0	1	290150	
08NOV89	249	BT	1	2	08NOV89	249	BT	1	2	0	0	0	1	290262	
08NOV89	232	BT	1	2	08NOV89	231	BT	1	2	0	0	0	1	290268	
08NOV89	243	BT	1	2	08NOV89	237	BT	1	2	0	0	0	1	290298	
08NOV89	256	BT	1	2	08NOV89	259	BT	1	2	0	0	0	1	290303	
14NOV89	244	BT	1	2	07NOV89	251	BT	1	2	7	0	0	1	271955	
14NOV89	266	BT	1	2	03NOV89	276	BT	1	2	11	0	0	1	289843	
14NOV89	214	BT	1	2	14NOV89	214	BT	1	2	0	0	0	1	290512	
27NOV89	175	BT	9	14	27NOV89	175	BT	9	14	0	0	0	1	290916	
27NOV89	195	BT	9	14	27NOV89	195	BT	9	14	0	0	0	1	290933	
27NOV89	234	BT	8	13	27NOV89	234	BT	9	14	0	1	2	1	290942	
29NOV89	332	BT	9	14	29NOV89	329	BT	9	14	0	0	0	1	272102	
29NOV89	289	BT	9	14	22NOV89	191	BT	9	14	7	0	0	1	290785	
30NOV89	217	BT	1	2	07NOV89	220	BT	1	2	23	0	0	1	290070	
30NOV89	251	BT	1	2	30NOV89	252	BT	1	2	0	0	0	1	291172	300602
30NOV89	270	BT	1	2	30NOV89	272	BT	1	2	0	0	0	1	291187	300619
30NOV89	333	BT	1	2	30NOV89	234	BT	1	2	0	0	0	1	291198	
01DEC89	195	BT	1	2	07NOV89	198	BT	1	2	24	0	0	1	290006	
01DEC89	211	BT	1	2	30NOV89	211	BT	1	2	1	0	0	1	291226	
01DEC89	212	BT	1	2	30NOV89	212	BT	1	2	1	0	0	1	291233	
01DEC89	213	BT	1	2	30NOV89	215	BT	1	2	1	0	0	1	291274	
01DEC89	165	BT	1	2	30NOV89	167	BT	1	2	1	0	0	1	291335	
01DEC89	180	BT	1	2	30NOV89	180	BT	1	2	1	0	0	1	291353	
01DEC89	269	BT	1	2	01DEC89	269	BT	1	2	0	0	0	1	291384	
01DEC89	280	BT	1	2	01DEC89	288	BT	1	2	0	0	0	1	291386	
01DEC89	217	BT	1	2	01DEC89	218	BT	1	2	0	0	0	1	291393	
01DEC89	237	BT	1	2	01DEC89	235	BT	1	2	0	0	0	1	291404	
01DEC89	218	BT	1	2	01DEC89	218	BT	1	2	0	0	0	1	291413	
01DEC89	215	BT	1	2	01DEC89	216	BT	1	2	0	0	0	1	291415	
01DEC89	273	BT	1	2	01DEC89	275	BT	1	2	0	0	0	1	291416	
01DEC89	207	BT	1	2	01DEC89	209	BT	1	2	0	0	0	1	291417	
01DEC89	259	BT	1	2	01DEC89	258	BT	1	2	0	0	0	1	291419	
01DEC89	215	BT	1	2	01DEC89	216	BT	1	2	0	0	0	1	291421	
01DEC89	182	BT	1	2	01DEC89	182	BT	1	2	0	0	0	1	291424	
01DEC89	162	BT	1	2	01DEC89	163	BT	1	2	0	0	0	1	291426	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
01DEC89	279	BT	1	2	01DEC89	281	BT	1	2	0	0	0	1	291438	
01DEC89	213	BT	1	2	01DEC89	214	BT	1	2	0	0	0	1	291459	
01DEC89	255	BT	1	2	01DEC89	255	BT	1	2	0	0	0	1	291467	
01DEC89	189	BT	1	2	01DEC89	188	BT	1	2	0	0	0	1	291493	
01DEC89	170	BT	1	2	01DEC89	171	BT	1	2	0	0	0	1	291499	
01DEC89	206	BT	1	2	01DEC89	204	BT	1	2	0	0	0	1	291508	
01DEC89	272	BT	1	2	01DEC89	272	BT	1	2	0	0	0	1	280288	
04DEC89	307	BT	1	2	04DEC89	308	BT	1	2	0	0	0	1	272218	
04DEC89	386	BT	1	2	04DEC89	386	BT	1	2	0	0	0	1	272237	
04DEC89	258	BT	1	2	04DEC89	258	BT	1	2	0	0	0	1	291717	
04DEC89	215	BT	1	2	04DEC89	218	BT	1	2	0	0	0	1	291742	
04DEC89	287	BT	1	2	04DEC89	288	BT	1	2	0	0	0	1	291761	
04DEC89	288	BT	1	2	04DEC89	290	BT	1	2	0	0	0	1	291790	
04DEC89	218	BT	1	2	04DEC89	228	BT	1	2	0	0	0	1	291807	
05DEC89	177	BT	1	2	30NOV89	177	BT	1	2	5	0	0	1	291320	
05DEC89	194	BT	1	2	30NOV89	190	BT	1	2	5	0	0	1	291360	
05DEC89	205	BT	1	2	05DEC89	200	BT	1	2	0	0	0	1	292028	
05DEC89	210	BT	1	2	05DEC89	210	BT	1	2	0	0	0	1	292050	
05DEC89	195	BT	1	2	05DEC89	197	BT	1	2	0	0	0	1	292074	
06DEC89	318	BT	1	2	06DEC89	317	BT	1	2	0	0	0	1	272454	
06DEC89	178	BT	1	2	07NOV89	178	BT	1	2	29	0	0	1	290010	
06DEC89	200	BT	1	2	07NOV89	204	BT	1	2	29	0	0	1	290176	
06DEC89	192	BT	1	2	30NOV89	192	BT	1	2	6	0	0	1	291197	
06DEC89	169	BT	1	2	01DEC89	169	BT	1	2	5	0	0	1	291557	
06DEC89	183	BT	1	2	01DEC89	184	BT	1	2	5	0	0	1	291597	
06DEC89	208	BT	1	2	05DEC89	210	BT	1	2	1	0	0	1	291942	
06DEC89	160	BT	1	2	05DEC89	160	BT	1	2	1	0	0	1	291968	
06DEC89	200	BT	1	2	05DEC89	198	BT	1	2	1	0	0	1	291993	
06DEC89	193	BT	1	2	05DEC89	194	BT	1	2	1	0	0	1	292047	
06DEC89	197	BT	1	2	05DEC89	196	BT	1	2	1	0	0	1	292317	
06DEC89	197	BT	1	2	06DEC89	196	BT	1	2	0	0	0	1	292332	
06DEC89	180	BT	1	2	06DEC89	182	BT	1	2	0	0	0	1	292386	
06DEC89	199	BT	1	2	06DEC89	197	BT	1	2	0	0	0	1	292413	
06DEC89	206	BT	1	2	06DEC89	209	BT	1	2	0	0	0	1	292414	
06DEC89	184	BT	1	2	06DEC89	192	BT	1	2	0	0	0	1	292453	
07DEC89	308	BT	1	2	07DEC89	307	BT	1	2	0	0	0	1	272496	
07DEC89	199	BT	1	2	06DEC89	198	BT	1	2	1	0	0	1	292477	
07DEC89	200	BT	1	2	06DEC89	198	BT	1	2	1	0	0	1	292602	
07DEC89	217	BT	1	2	07DEC89	217	BT	1	2	0	0	0	1	293055	
07DEC89	168	BT	1	2	07DEC89	167	BT	1	2	0	0	0	1	293058	
07DEC89	211	BT	1	2	07DEC89	212	BT	1	2	0	0	0	1	293063	
07DEC89	205	BT	1	2	07DEC89	206	BT	1	2	0	0	0	1	293076	
07DEC89	215	BT	1	2	07DEC89	214	BT	1	2	0	0	0	1	293156	
08DEC89	187	BT	1	2	06DEC89	185	BT	1	2	2	0	0	1	292593	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
08DEC89	201	BT	1	2	08DEC89	200	BT	1	2	0	0	0	1	293380	
08DEC89	283	BT	1	2	08DEC89	283	BT	1	2	0	0	0	1	293383	
08DEC89	193	BT	1	2	08DEC89	193	BT	1	2	0	0	0	1	293397	
08DEC89	182	BT	1	2	08DEC89	182	BT	1	2	0	0	0	1	293486	
12DEC89	211	BT	1	2	08NOV89	211	BT	1	2	34	0	0	1	290414	
12DEC89	170	BT	1	2	07DEC89	169	BT	1	2	5	0	0	1	293298	
12DEC89	232	BT	1	2	12DEC89	234	BT	1	2	0	0	0	1	293724	
12DEC89	280	BT	1	2	12DEC89	281	BT	1	2	0	0	0	1	293740	
12DEC89	232	BT	1	2	12DEC89	231	BT	1	2	0	0	0	1	293749	
12DEC89	261	BT	1	2	12DEC89	263	BT	1	2	0	0	0	1	293821	
14DEC89	340	BT	1	2	14DEC89	341	BT	1	2	0	0	0	1	272657	
14DEC89	310	BT	1	2	14DEC89	311	BT	1	2	0	0	0	1	272758	300661
14DEC89	412	BT	1	2	14DEC89	415	BT	1	2	0	0	0	1	272759	300662
14DEC89	257	BT	1	2	14DEC89	258	BT	1	2	0	0	0	1	272808	
14DEC89	287	BT	1	2	14DEC89	287	BT	1	2	0	0	0	1	272813	
14DEC89	219	BT	1	2	07NOV89	220	BT	1	2	37	0	0	1	289974	
14DEC89	226	BT	1	2	14NOV89	225	BT	1	2	30	0	0	1	290561	
14DEC89	203	BT	1	2	07DEC89	222	BT	1	2	7	0	0	1	293090	
14DEC89	230	BT	1	2	14DEC89	225	BT	1	2	0	0	0	1	294209	
14DEC89	257	BT	1	2	14DEC89	288	BT	1	2	0	0	0	1	294219	
14DEC89	233	BT	1	2	14DEC89	234	BT	1	2	0	0	0	1	294281	
14DEC89	255	BT	1	2	14DEC89	255	BT	1	2	0	0	0	1	294299	
14DEC89	233	BT	1	2	14DEC89	233	BT	1	2	0	0	0	1	294306	
14DEC89	221	BT	1	2	14DEC89	220	BT	1	2	0	0	0	1	294307	
14DEC89	260	BT	1	2	14DEC89	262	BT	1	2	0	0	0	1	294322	
14DEC89	288	BT	1	2	14DEC89	287	BT	1	2	0	0	0	1	294338	
14DEC89	277	BT	1	2	14DEC89	276	BT	1	2	0	0	0	1	294602	
18DEC89	207	BT	9	14	06DEC89	206	BT	1	2	12	8	13	1	292723	
18DEC89	276	BT	9	14	18DEC89	277	BT	8	13	0	1	2	1	294745	
19DEC89	281	BT	1	2	14DEC89	279	BT	1	2	5	0	0	1	272874	
19DEC89	277	BT	1	2	19DEC89	278	BT	1	2	0	0	0	1	273021	
19DEC89	206	BT	1	2	19DEC89	206	BT	1	2	0	0	0	1	273087	
19DEC89	222	BT	1	2	19DEC89	222	BT	1	2	0	0	0	1	273089	
19DEC89	265	BT	1	2	19DEC89	266	BT	1	2	0	0	0	1	273126	
19DEC89	276	BT	1	2	19DEC89	277	BT	1	2	0	0	0	1	273142	
19DEC89	222	BT	1	2	19DEC89	221	BT	1	2	0	0	0	1	273186	
19DEC89	225	BT	1	2	19DEC89	227	BT	1	2	0	0	0	1	273188	
19DEC89	311	BT	1	2	19DEC89	311	BT	1	2	0	0	0	1	273225	
19DEC89	251	BT	1	2	19DEC89	250	BT	1	2	0	0	0	1	273257	
19DEC89	187	BT	1	2	19DEC89	186	BT	1	2	0	0	0	1	273270	
19DEC89	322	BT	1	2	19DEC89	322	BT	1	2	0	0	0	1	273318	
19DEC89	225	BT	1	2	13DEC89	223	BT	8	13	6	7	11	1	294135	
20DEC89	203	BT	1	2	19DEC89	202	BT	1	2	1	0	0	1	273346	
20DEC89	216	BT	1	2	20DEC89	215	BT	1	2	0	0	0	1	273450	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
20DEC89	278	BT	1	2	20DEC89	280	BT	1	2	0	0	0	1	273494	
20DEC89	231	BT	1	2	20DEC89	231	BT	1	2	0	0	0	1	273574	
20DEC89	225	BT	1	2	20DEC89	222	BT	1	2	0	0	0	1	273583	
20DEC89	207	BT	1	2	07NOV89	212	BT	1	2	43	0	0	1	290049	
21DEC89	160	BT	1	2	20DEC89	159	BT	1	2	1	0	0	1	273668	
21DEC89	209	BT	1	2	02NOV89	205	BT	1	2	49	0	0	1	289710	
21DEC89	211	BT	1	2	08NOV89	212	BT	1	2	43	0	0	1	290342	
21DEC89	198	BT	1	2	05DEC89	199	BT	1	2	16	0	0	1	292238	
21DEC89	180	BT	1	2	18DEC89	180	BT	9	14	3	8	13	1	294960	
22DEC89	189	BT	1	2	07NOV89	188	BT	1	2	45	0	0	1	289953	
22DEC89	205	BT	1	2	30NOV89	202	BT	1	2	22	0	0	1	291195	
27DEC89	205	BT	1	2	07NOV89	207	BT	1	2	50	0	0	1	271942	
27DEC89	182	BT	9	14	01DEC89	181	BT	1	2	26	8	13	1	291512	
02JAN90	288	BT	1	2	02JAN90	290	BT	1	2	0	0	0	1	305163	
02JAN90	228	BT	1	2	02JAN90	228	BT	1	2	0	0	0	1	305244	
03JAN90	197	BT	1	2	21DEC89	196	BT	1	2	13	0	0	1	274066	
03JAN90	238	BT	1	2	06DEC89	237	BT	1	2	28	0	0	1	292738	
03JAN90	241	BT	1	2	14DEC89	240	BT	1	2	20	0	0	1	294670	
03JAN90	239	BT	1	2	02JAN90	240	BT	1	2	1	0	0	1	305114	
03JAN90	239	BT	1	2	03JAN90	239	BT	1	2	0	0	0	1	305284	
04JAN90	165	BT	9	14	12DEC89	165	BT	1	2	23	8	13	1	294042	
04JAN90	190	BT	1	2	02JAN90	190	BT	1	2	2	0	0	1	305206	
05JAN90	195	BT	8	13	22NOV89	195	BT	8	13	44	0	0	1	290904	
05JAN90	197	BT	9	14	06DEC89	197	BT	1	2	30	8	13	1	292446	
08JAN90	368	BT	8	13	04DEC89	368	BT	1	2	35	7	11	1	272195	
10JAN90	255	BT	9	14	22NOV89	252	BT	9	14	49	0	0	1	290822	300576
11JAN90	240	BT	8	13	11JAN90	240	BT	9	14	0	1	2	1	306059	
12JAN90	265	BT	8	13	08DEC89	267	BT	1	2	35	7	11	1	293501	
16JAN90	282	BT	1	2	16JAN90	282	BT	1	2	0	0	0	1	274477	
16JAN90	249	BT	1	2	16JAN90	251	BT	1	2	0	0	0	1	274486	
16JAN90	177	BT	1	2	07DEC89	176	BT	1	2	40	0	0	1	293096	
16JAN90	266	BT	1	2	13DEC89	265	BT	9	14	34	8	13	1	294180	
16JAN90	222	BT	1	2	16JAN90	221	BT	1	2	0	0	0	1	306511	
16JAN90	237	BT	1	2	16JAN90	236	BT	1	2	0	0	0	1	306601	
16JAN90	185	BT	1	2	16JAN90	183	BT	1	2	0	0	0	1	306631	
16JAN90	208	BT	1	2	16JAN90	207	BT	1	2	0	0	0	1	306727	
17JAN90	258	BT	1	2	28NOV89	255	BT	8	13	50	7	11	1	291098	
17JAN90	168	BT	1	2	17JAN90	167	BT	1	2	0	0	0	1	306913	
18JAN90	238	BT	1	2	22DEC89	235	BT	1	2	27	0	0	1	274099	
18JAN90	246	BT	1	2	06DEC89	245	BT	1	2	43	0	0	1	292626	
18JAN90	252	BT	1	2	18JAN90	252	BT	1	2	0	0	0	1	307083	
18JAN90	212	BT	1	2	18JAN90	212	BT	1	2	0	0	0	1	307118	
18JAN90	210	BT	1	2	18JAN90	210	BT	1	2	0	0	0	1	307127	
18JAN90	214	BT	1	2	18JAN90	215	BT	1	2	0	0	0	1	307128	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
18JAN90	176	BT	1	2	18JAN90	177	BT	1	2	0	0	0	1	307129	
19JAN90	264	BT	8	13	18DEC89	276	BT	9	14	32	1	2	1	272942	
19JAN90	244	BT	8	13	22NOV89	241	BT	8	13	58	0	0	1	290887	
19JAN90	185	BT	8	13	27NOV89	182	BT	9	14	53	1	2	1	290952	
19JAN90	226	BT	8	13	19JAN90	226	BT	8	13	0	0	0	1	307214	
19JAN90	252	BT	9	14	19JAN90	254	BT	8	13	0	1	2	1	307216	
19JAN90	232	BT	8	13	19JAN90	233	BT	8	13	0	0	0	1	307221	
22JAN90	200	BT	9	14	07NOV89	203	BT	1	2	76	8	13	1	289977	
23JAN90	240	BT	5	8	12DEC89	239	BT	1	2	42	4	6	1	293934	
23JAN90	201	BT	5	8	23JAN90	201	BT	5	8	0	0	0	1	307630	
25JAN90	276	BT	1	2	08NOV89	277	BT	1	2	78	0	0	1	290372	
25JAN90	191	BT	1	2	22JAN90	191	BT	9	14	3	8	13	1	307491	
26JAN90	157	BT	1	2	05DEC89	157	BT	1	2	52	0	0	1	292241	
26JAN90	233	BT	1	2	26JAN90	232	BT	1	2	0	0	0	1	308277	
26JAN90	157	BT	1	2	26JAN90	156	BT	1	2	0	0	0	1	308286	
27JAN90	177	BT	5	8	27JAN90	177	BT	5	8	0	0	0	1	308450	
27JAN90	167	BT	5	8	27JAN90	166	BT	5	8	0	0	0	1	308477	
27JAN90	222	BT	5	8	27JAN90	222	BT	5	8	0	0	0	1	308573	
27JAN90	259	BT	5	8	27JAN90	260	BT	5	8	0	0	0	1	308586	
29JAN90	220	BT	5	8	20NOV89	219	BT	5	8	70	0	0	1	290743	
29JAN90	240	BT	5	8	19JAN90	240	BT	8	13	10	3	5	1	307425	
30JAN90	203	BT	8	13	08NOV89	203	BT	1	2	83	7	11	1	290389	
30JAN90	177	BT	8	13	05DEC89	178	BT	1	2	56	7	11	1	292228	
30JAN90	265	BT	9	14	03JAN90	263	BT	1	2	27	8	13	1	305279	
31JAN90	210	BT	1	2	20DEC89	208	BT	1	2	42	0	0	1	273512	
31JAN90	320	BT	1	2	31JAN90	320	BT	1	2	0	0	0	1	274644	
31JAN90	171	BT	1	2	07DEC89	172	BT	1	2	55	0	0	1	293088	
31JAN90	165	BT	1	2	31JAN90	165	BT	1	2	0	0	0	1	309055	
01FEB90	191	BT	1	2	21DEC89	189	BT	1	2	42	0	0	1	274013	
01FEB90	165	BT	1	2	25JAN90	167	BT	1	2	7	0	0	1	308117	
01FEB90	177	BT	1	2	29JAN90	181	BT	5	8	3	4	6	1	308766	
01FEB90	262	BT	1	2	01FEB90	262	BT	1	2	0	0	0	1	309417	
01FEB90	285	BT	1	2	01FEB90	288	BT	1	2	0	0	0	1	309437	
01FEB90	196	BT	1	2	01FEB90	196	BT	1	2	0	0	0	1	309464	
01FEB90	215	BT	1	2	01FEB90	215	BT	1	2	0	0	0	1	309504	
01FEB90	192	BT	1	2	01FEB90	192	BT	1	2	0	0	0	1	309607	
01FEB90	257	BT	1	2	01FEB90	260	BT	1	2	0	0	0	1	309640	
01FEB90	161	BT	1	2	01FEB90	162	BT	1	2	0	0	0	1	309648	
01FEB90	243	BT	1	2	01FEB90	247	BT	1	2	0	0	0	1	309703	
01FEB90	194	BT	1	2	01FEB90	195	BT	1	2	0	0	0	1	309753	
02FEB90	262	BT	1	2	19DEC89	265	BT	1	2	45	0	0	1	273311	
02FEB90	230	BT	1	2	03NOV89	234	BT	1	2	91	0	0	1	289790	
02FEB90	212	BT	1	2	05DEC89	212	BT	1	2	59	0	0	1	291919	
02FEB90	220	BT	1	2	11DEC89	220	BT	8	13	53	7	11	1	293619	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER	DART TAG_N
02FEB90	172	BT	1	2	19JAN90	172	BT	8	13	14	7	11	1	307408	
02FEB90	246	BT	1	2	02FEB90	246	BT	1	2	0	0	0	1	309987	
02FEB90	218	BT	1	2	02FEB90	270	BT	1	2	0	0	0	1	309997	
05FEB90	256	BT	1	2	07DEC89	258	BT	1	2	60	0	0	1	293337	
05FEB90	176	BT	1	2	14DEC89	174	BT	1	2	53	0	0	1	294440	
05FEB90	150	BT	1	2	19JAN90	151	BT	8	13	17	7	11	1	307328	
05FEB90	209	BT	1	2	30JAN90	209	BT	9	14	6	8	13	1	308855	
05FEB90	264	BT	1	2	05FEB90	265	BT	1	2	0	0	0	1	310193	
05FEB90	208	BT	1	2	05FEB90	210	BT	1	2	0	0	0	1	310194	
05FEB90	181	BT	1	2	05FEB90	177	BT	1	2	0	0	0	1	310195	
05FEB90	206	BT	1	2	05FEB90	204	BT	1	2	0	0	0	1	310238	
05FEB90	162	BT	1	2	05FEB90	161	BT	1	2	0	0	0	1	310241	
05FEB90	185	BT	1	2	05FEB90	185	BT	1	2	0	0	0	1	310250	
05FEB90	165	BT	1	2	05FEB90	172	BT	1	2	0	0	0	1	310260	
05FEB90	187	BT	1	2	05FEB90	189	BT	1	2	0	0	0	1	310261	
05FEB90	180	BT	1	2	05FEB90	177	BT	1	2	0	0	0	1	310262	
05FEB90	206	BT	1	2	05FEB90	209	BT	1	2	0	0	0	1	310343	
06FEB90	215	BT	1	2	01FEB90	215	BT	1	2	5	0	0	1	309504	
07FEB90	219	BT	1	2	07NOV89	226	BT	1	2	92	0	0	1	289982	
07FEB90	230	BT	1	2	01DEC89	232	BT	1	2	68	0	0	1	291470	
07FEB90	174	BT	1	2	07FEB90	175	BT	1	2	0	0	0	1	310778	
09FEB90	265	BT	1	2	07NOV89	269	BT	1	2	94	0	0	1	290130	
09FEB90	180	BT	1	2	24JAN90	182	BT	5	8	16	4	6	1	307780	
09FEB90	167	BT	1	2	25JAN90	170	BT	1	2	15	0	0	1	308116	
09FEB90	268	BT	1	2	31JAN90	273	BT	1	2	9	0	0	1	309086	
09FEB90	212	BT	1	2	09FEB90	215	BT	1	2	0	0	0	1	311103	
09FEB90	216	BT	1	2	09FEB90	221	BT	1	2	0	0	0	1	311135	
12FEB90	312	BT	1	2	14DEC89	316	BT	1	2	60	0	0	1	272656	
12FEB90	211	BT	1	2	16JAN90	275	BT	1	2	27	0	0	1	274499	
12FEB90	210	BT	1	2	01FEB90	209	BT	1	2	11	0	0	1	309696	
12FEB90	175	BT	1	2	05FEB90	177	BT	1	2	7	0	0	1	310256	
13FEB90	186	BT	1	2	07DEC89	187	BT	1	2	68	0	0	1	293215	
13FEB90	228	BT	1	2	07DEC89	227	BT	1	2	68	0	0	1	293233	
13FEB90	182	BT	1	2	12DEC89	184	BT	1	2	63	0	0	1	293796	
13FEB90	209	BT	1	2	12JAN90	210	BT	9	14	32	8	13	1	306259	
13FEB90	203	BT	1	2	22JAN90	205	BT	9	14	22	8	13	1	307486	
13FEB90	240	BT	1	2	23JAN90	242	BT	5	8	21	4	6	1	307652	
13FEB90	227	BT	1	2	13FEB90	227	BT	1	2	0	0	0	1	311671	
13FEB90	150	BT	1	2	13FEB90	151	BT	1	2	0	0	0	1	311719	
13FEB90	190	BT	1	2	13FEB90	188	BT	1	2	0	0	0	1	311724	
13FEB90	215	BT	1	2	13FEB90	216	BT	1	2	0	0	0	1	311741	
13FEB90	196	BT	1	2	13FEB90	196	BT	1	2	0	0	0	1	311761	
13FEB90	204	BT	1	2	13FEB90	204	BT	1	2	0	0	0	1	311789	
13FEB90	245	BT	1	2	13FEB90	247	BT	1	2	0	0	0	1	311800	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
13FEB90	175	BT	1	2	13FEB90	177	BT	1	2	0	0	0	1	311806	
13FEB90	219	BT	1	2	13FEB90	217	BT	1	2	0	0	0	1	311835	
13FEB90	177	BT	1	2	13FEB90	176	BT	1	2	0	0	0	1	311860	
13FEB90	263	BT	1	2	13FEB90	264	BT	1	2	0	0	0	1	311864	
13FEB90	243	BT	1	2	13FEB90	240	BT	1	2	0	0	0	1	311892	
13FEB90	175	BT	1	2	13FEB90	175	BT	1	2	0	0	0	1	311941	
13FEB90	177	BT	1	2	13FEB90	178	BT	1	2	0	0	0	1	311956	
14FEB90	210	BT	1	2	08NOV89	215	BT	1	2	98	0	0	1	290300	
14FEB90	209	BT	1	2	30NOV89	211	BT	1	2	76	0	0	1	291199	
14FEB90	186	BT	1	2	30NOV89	190	BT	1	2	76	0	0	1	291205	
14FEB90	248	BT	1	2	24JAN90	251	BT	5	8	21	4	6	1	307885	
14FEB90	208	BT	1	2	12FEB90	209	BT	1	2	2	0	0	1	311397	
14FEB90	222	BT	1	2	12FEB90	227	BT	1	2	2	0	0	1	311469	
14FEB90	186	BT	1	2	14FEB90	188	BT	1	2	0	0	0	1	312037	
14FEB90	200	BT	1	2	14FEB90	199	BT	1	2	0	0	0	1	312068	
14FEB90	157	BT	1	2	14FEB90	155	BT	1	2	0	0	0	1	312114	
14FEB90	231	BT	1	2	14FEB90	230	BT	1	2	0	0	0	1	312193	
14FEB90	272	BT	1	2	14FEB90	277	BT	1	2	0	0	0	1	312220	301203
15FEB90	217	BT	1	2	22DEC89	220	BT	1	2	55	0	0	1	274102	
15FEB90	223	BT	1	2	03NOV89	223	BT	1	2	104	0	0	1	289864	
15FEB90	233	BT	1	2	07NOV89	233	BT	1	2	100	0	0	1	290011	
15FEB90	173	BT	1	2	01DEC89	177	BT	1	2	76	0	0	1	291587	
15FEB90	235	BT	1	2	10JAN90	239	BT	8	13	36	7	11	1	305985	
15FEB90	203	BT	1	2	12FEB90	201	BT	1	2	3	0	0	1	311612	
15FEB90	180	BT	1	2	15FEB90	180	BT	1	2	0	0	0	1	312367	
15FEB90	180	BT	1	2	15FEB90	180	BT	1	2	0	0	0	1	312380	
15FEB90	215	BT	1	2	15FEB90	215	BT	1	2	0	0	0	1	312529	
15FEB90	296	BT	1	2	15FEB90	294	BT	1	2	0	0	0	1	312585	
16FEB90	193	BT	1	2	08FEB90	193	BT	8	13	8	7	11	1	310981	
16FEB90	222	BT	1	2	16FEB90	224	BT	1	2	0	0	0	1	312741	
16FEB90	204	BT	1	2	16FEB90	203	BT	1	2	0	0	0	1	312787	
16FEB90	282	BT	1	2	16FEB90	284	BT	1	2	0	0	0	1	312803	
16FEB90	210	BT	1	2	16FEB90	212	BT	1	2	0	0	0	1	312824	
16FEB90	200	BT	1	2	16FEB90	203	BT	1	2	0	0	0	1	312840	
20FEB90	230	BT	1	2	21DEC89	232	BT	1	2	61	0	0	1	274063	
20FEB90	180	BT	1	2	28DEC89	181	BT	9	14	54	8	13	1	274269	
20FEB90	234	BT	1	2	12DEC89	236	BT	1	2	70	0	0	2	293765	
20FEB90	160	BT	1	2	04JAN90	160	BT	9	14	47	8	13	1	305474	
20FEB90	236	BT	1	2	27JAN90	238	BT	5	8	24	4	6	1	308598	
20FEB90	160	BT	1	2	06FEB90	162	BT	1	2	14	0	0	1	310755	
20FEB90	191	BT	1	2	14FEB90	190	BT	1	2	6	0	0	1	312120	
20FEB90	160	BT	1	2	16FEB90	158	BT	1	2	4	0	0	1	312725	
20FEB90	199	BT	1	2	20FEB90	199	BT	1	2	0	0	0	1	312980	
20FEB90	239	BT	1	2	20FEB90	240	BT	1	2	0	0	0	1	312998	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER	DART TAG_N
20FEB90	204	BT	1	2	20FEB90	203	BT	1	2	0	0	0	1	313041	
20FEB90	207	BT	1	2	20FEB90	207	BT	1	2	0	0	0	1	313046	
20FEB90	163	BT	1	2	20FEB90	163	BT	1	2	0	0	0	1	313047	
20FEB90	184	BT	1	2	20FEB90	184	BT	1	2	0	0	0	1	313051	
20FEB90	260	BT	1	2	20FEB90	261	BT	1	2	0	0	0	1	313064	
20FEB90	180	BT	1	2	20FEB90	182	BT	1	2	0	0	0	1	313086	
20FEB90	161	BT	1	2	20FEB90	160	BT	1	2	0	0	0	1	313120	
21FEB90	357	BT	1	2	22DEC89	362	BT	1	2	61	0	0	1	274150	
21FEB90	228	BT	1	2	07NOV89	230	BT	1	2	106	0	0	1	290245	
21FEB90	215	BT	1	2	12JAN90	217	BT	8	13	40	7	11	1	306410	
21FEB90	169	BT	1	2	31JAN90	173	BT	1	2	21	0	0	1	309072	
21FEB90	242	BT	1	2	21FEB90	245	BT	1	2	0	0	0	1	313301	
21FEB90	241	BT	1	2	21FEB90	242	BT	1	2	0	0	0	1	313321	
21FEB90	229	BT	1	2	21FEB90	232	BT	1	2	0	0	0	1	313346	
21FEB90	208	BT	1	2	20FEB90	207	BT	1	2	1	0	0	1	313405	
21FEB90	205	BT	1	2	20FEB90	204	BT	1	2	1	0	0	1	313428	
22FEB90	200	BT	5	8	02NOV89	200	BT	1	2	112	4	6	1	289712	
22FEB90	286	BT	5	8	25JAN90	290	BT	5	8	28	0	0	1	308128	
22FEB90	200	BT	5	8	27JAN90	201	BT	5	8	26	0	0	1	308584	
22FEB90	210	BT	5	8	22FEB90	209	BT	5	8	0	0	0	1	313607	
22FEB90	155	BT	5	8	22FEB90	156	BT	5	8	0	0	0	1	313615	
23FEB90	203	BT	5	8	23FEB90	204	BT	5	8	0	0	0	1	313776	
23FEB90	194	BT	5	8	23FEB90	195	BT	5	8	0	0	0	1	313798	
27FEB90	227	BT	9	14	04DEC89	231	BT	1	2	85	8	13	1	291689	
27FEB90	233	BT	8	13	14DEC89	236	BT	1	2	75	7	11	1	294707	
27FEB90	257	BT	9	14	10JAN90	227	BT	9	14	48	0	0	1	305689	
27FEB90	192	BT	9	14	19JAN90	193	BT	8	13	39	1	2	1	307385	
27FEB90	166	BT	9	14	25JAN90	168	BT	1	2	33	8	13	1	307980	
27FEB90	163	BT	9	14	09FEB90	164	BT	1	2	18	8	13	1	311239	
27FEB90	217	BT	9	14	22FEB90	215	BT	5	8	5	4	6	1	313696	
28FEB90	255	BT	5	8	08DEC89	257	BT	1	2	82	4	6	1	293541	
01MAR90	184	BT	5	8	26JAN90	187	BT	5	8	34	0	0	1	308381	
01MAR90	281	BT	5	8	01MAR90	280	BT	5	8	0	0	0	1	314208	
01MAR90	202	BT	5	8	01MAR90	200	BT	5	8	0	0	0	1	314322	
02MAR90	195	BT	1	2	08JAN90	197	BT	8	13	53	7	11	1	305589	
02MAR90	237	BT	1	2	02MAR90	235	BT	1	2	0	0	0	1	314466	
05MAR90	196	BT	1	2	18DEC89	197	BT	9	14	77	8	13	1	294788	
05MAR90	184	BT	1	2	02FEB90	185	BT	1	2	31	0	0	1	310086	
05MAR90	169	BT	1	2	09FEB90	170	BT	1	2	24	0	0	1	311091	
05MAR90	192	BT	1	2	14FEB90	193	BT	1	2	19	0	0	1	312201	
05MAR90	242	BT	1	2	27FEB90	240	BT	9	14	6	8	13	1	313985	
05MAR90	211	BT	1	2	05MAR90	213	BT	1	2	0	0	0	1	314593	
06MAR90	195	BT	5	8	13FEB90	195	BT	1	2	21	4	6	1	311840	
07MAR90	190	BT	5	8	26JAN90	192	BT	5	8	40	0	0	1	308420	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER	DART TAG_N
07MAR90	226	BT	5	8	02MAR90	225	BT	1	2	5	4	6	1	314500	
09MAR90	201	BT	8	13	28NOV89	202	BT	8	13	101	0	0	1	291068	
09MAR90	179	BT	8	13	29JAN90	180	BT	5	8	39	3	5	1	308661	
09MAR90	185	BT	8	13	31JAN90	185	BT	1	2	37	7	11	1	309145	
09MAR90	158	BT	8	13	05FEB90	159	BT	1	2	32	7	11	1	310305	
09MAR90	198	BT	9	14	21FEB90	200	BT	1	2	16	8	13	1	313281	
09MAR90	174	BT	8	13	05MAR90	176	BT	1	2	4	7	11	1	314517	
12MAR90	231	BT	8	13	07NOV89	235	BT	1	2	125	7	11	1	271951	
12MAR90	215	BT	8	13	19DEC89	215	BT	1	2	83	7	11	1	273035	
12MAR90	318	BT	8	13	20DEC89	316	BT	1	2	82	7	11	1	273839	
12MAR90	250	BT	8	13	04DEC89	255	BT	1	2	98	7	11	1	291707	
12MAR90	201	BT	8	13	17JAN90	203	BT	1	2	54	7	11	1	307004	
12MAR90	197	BT	8	13	25JAN90	200	BT	1	2	46	7	11	1	308031	
12MAR90	172	BT	8	13	25JAN90	175	BT	1	2	46	7	11	1	308055	
12MAR90	191	BT	8	13	27JAN90	191	BT	5	8	44	3	5	1	308616	
12MAR90	271	BT	8	13	07FEB90	272	BT	1	2	33	7	11	1	310832	--[a]
12MAR90	277	BT	8	13	09FEB90	276	BT	1	2	31	7	11	1	311146	--[a]
12MAR90	284	BT	8	13	12MAR90	283	BT	8	13	0	0	0	1	315409	
12MAR90	256	BT	8	13	12MAR90	258	BT	8	13	0	0	0	1	315491	
13MAR90	233	BT	9	14	06DEC89	239	BT	1	2	97	8	13	1	292771	
13MAR90	217	BT	9	14	09FEB90	216	BT	1	2	32	8	13	1	311310	
13MAR90	165	BT	8	13	12MAR90	165	BT	8	13	1	0	0	1	315813	
13MAR90	244	BT	9	14	13MAR90	243	BT	9	14	0	0	0	1	315822	
13MAR90	205	BT	9	14	13MAR90	224	BT	9	14	0	0	0	1	315875	
14MAR90	224	BT	8	13	10JAN90	225	BT	9	14	63	1	2	1	305848	
14MAR90	152	BT	8	13	16JAN90	152	BT	1	2	57	7	11	1	306550	
14MAR90	215	BT	8	13	18JAN90	207	BT	1	2	55	7	11	1	307033	
14MAR90	278	BT	8	13	01FEB90	280	BT	1	2	41	7	11	1	309548	
14MAR90	212	BT	8	13	02FEB90	214	BT	1	2	40	7	11	1	309965	
14MAR90	197	BT	8	13	23FEB90	198	BT	5	8	19	3	5	1	313836	
14MAR90	165	BT	8	13	23FEB90	165	BT	5	8	19	3	5	1	313838	
14MAR90	177	BT	8	13	23FEB90	176	BT	5	8	19	3	5	1	313870	
14MAR90	177	BT	8	13	14FEB90	177	BT	5	8	28	3	5	1	313870	
15MAR90	208	BT	8	13	20DEC89	208	BT	1	2	85	7	11	1	273447	
15MAR90	170	BT	8	13	01DEC89	175	BT	1	2	104	7	11	1	291585	
15MAR90	266	BT	8	13	15MAR90	267	BT	8	13	0	0	0	1	316486	301303
16MAR90	200	BT	5	8	20DEC89	202	BT	1	2	86	4	6	1	273783	
16MAR90	263	BT	5	8	14NOV89	268	BT	1	2	122	4	6	1	290567	
16MAR90	216	BT	5	8	30NOV89	214	BT	1	2	106	4	6	1	291183	
16MAR90	186	BT	5	8	26JAN90	181	BT	1	2	49	4	6	1	308178	
16MAR90	193	BT	5	8	27JAN90	193	BT	5	8	48	0	0	1	308512	
16MAR90	201	BT	5	8	21FEB90	199	BT	1	2	23	4	6	1	313462	
16MAR90	174	BT	5	8	22FEB90	174	BT	5	8	22	0	0	1	313631	
16MAR90	213	BT	5	8	16MAR90	213	BT	5	8	0	0	0	1	316740	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER	DART TAG_N
16MAR90	186	BT	5	8	16MAR90	187	BT	5	8	0	0	0	1	316964	
16MAR90	202	BT	5	8	16MAR90	203	BT	5	8	0	0	0	1	317026	
16MAR90	268	BT	5	8	16MAR90	267	BT	5	8	0	0	0	1	317027	
19MAR90	210	BT	1	2	03NOV89	206	BT	1	2	136	0	0	1	289793	
19MAR90	233	BT	1	2	06DEC89	232	BT	1	2	103	0	0	1	292810	
19MAR90	236	BT	1	2	12DEC89	233	BT	1	2	97	0	0	1	293802	
19MAR90	265	BT	1	2	17JAN90	265	BT	1	2	61	0	0	1	306788	
19MAR90	204	BT	1	2	05FEB90	206	BT	1	2	42	0	0	1	310217	
19MAR90	179	BT	1	2	06FEB90	177	BT	1	2	41	0	0	1	310702	
19MAR90	187	BT	1	2	08FEB90	184	BT	9	14	39	8	13	1	310882	
19MAR90	245	BT	1	2	13FEB90	243	BT	1	2	34	0	0	1	311804	
19MAR90	180	BT	1	2	20FEB90	180	BT	1	2	27	0	0	1	313206	
19MAR90	257	BT	1	2	19MAR90	257	BT	1	2	0	0	0	1	317176	
19MAR90	198	BT	1	2	19MAR90	198	BT	1	2	0	0	0	1	317310	
20MAR90	203	BT	1	2	11DEC89	203	BT	8	13	99	7	11	1	293636	
20MAR90	209	BT	1	2	14FEB90	208	BT	1	2	34	0	0	1	312093	
20MAR90	247	BT	1	2	20FEB90	243	BT	1	2	28	0	0	1	313134	
20MAR90	191	BT	1	2	19MAR90	190	BT	1	2	1	0	0	1	317319	
20MAR90	197	BT	1	2	19MAR90	195	BT	1	2	1	0	0	1	317391	
20MAR90	166	BT	1	2	20MAR90	164	BT	1	2	0	0	0	1	317581	
20MAR90	232	BT	1	2	20MAR90	231	BT	1	2	0	0	0	1	317653	
20MAR90	208	BT	1	2	20MAR90	211	BT	1	2	0	0	0	1	317695	
21MAR90	216	BT	1	2	21DEC89	216	BT	1	2	90	0	0	1	273904	
21MAR90	214	BT	1	2	08DEC89	214	BT	1	2	103	0	0	1	293389	
21MAR90	276	BT	1	2	08DEC89	277	BT	1	2	103	0	0	1	293523	
21MAR90	178	BT	1	2	13DEC89	178	BT	9	14	98	8	13	1	294177	
21MAR90	235	BT	1	2	29DEC89	235	UH	2	3	82	3	5	1	305008	
21MAR90	235	BT	1	2	21MAR90	235	BT	1	2	0	0	0	1	305008	
21MAR90	213	BT	1	2	23JAN90	212	BT	1	2	57	0	0	2	307584	
21MAR90	205	BT	1	2	24JAN90	205	BT	5	8	56	4	6	1	307720	
21MAR90	225	BT	1	2	31JAN90	226	BT	1	2	49	0	0	1	309169	
21MAR90	224	BT	1	2	21MAR90	225	BT	1	2	0	0	0	1	309169	
21MAR90	151	BT	1	2	05FEB90	154	BT	1	2	44	0	0	1	310263	
21MAR90	181	BT	1	2	08FEB90	179	BT	9	14	41	8	13	1	310888	
21MAR90	214	BT	1	2	12FEB90	210	BT	1	2	37	0	0	1	311484	
21MAR90	166	BT	1	2	12FEB90	164	BT	1	2	37	0	0	1	311576	
21MAR90	238	BT	1	2	14FEB90	235	BT	1	2	35	0	0	1	312163	
21MAR90	162	BT	1	2	05MAR90	159	BT	1	2	16	0	0	1	314578	
21MAR90	203	BT	1	2	12MAR90	202	BT	8	13	9	7	11	1	315710	
21MAR90	167	BT	1	2	20MAR90	167	BT	1	2	1	0	0	1	317556	
21MAR90	176	BT	1	2	20MAR90	178	BT	1	2	1	0	0	1	317575	
21MAR90	179	BT	1	2	20MAR90	179	BT	1	2	1	0	0	1	317693	
21MAR90	219	BT	1	2	20MAR90	218	BT	1	2	1	0	0	1	317760	
21MAR90	257	BT	1	2	21MAR90	259	BT	1	2	0	0	0	1	317827	301357

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
21MAR90	195	BT	1	2	21MAR90	196	BT	1	2	0	0	0	1	317881	
21MAR90	206	BT	1	2	21MAR90	205	BT	1	2	0	0	0	1	317991	
21MAR90	235	BT	1	2	21MAR90	235	BT	1	2	0	0	0	1	318008	
22MAR90	161	BT	1	2	08NOV89	162	BT	1	2	134	0	0	1	290435	
22MAR90	263	BT	1	2	06DEC89	266	BT	1	2	106	0	0	1	292943	
22MAR90	186	BT	1	2	20FEB90	185	BT	1	2	30	0	0	1	313451	
22MAR90	202	BT	1	2	09MAR90	201	BT	8	13	13	7	11	1	315364	
22MAR90	226	BT	1	2	19MAR90	227	BT	1	2	3	0	0	1	317367	
22MAR90	235	BT	1	2	21MAR90	234	BT	1	2	1	0	0	1	318015	
22MAR90	201	BT	1	2	21MAR90	202	BT	1	2	1	0	0	1	318020	
23MAR90	184	BT	1	2	21DEC89	185	BT	1	2	92	0	0	1	273999	
23MAR90	182	BT	1	2	12JAN90	181	BT	8	13	70	7	11	1	306324	
23MAR90	188	BT	1	2	02FEB90	190	BT	1	2	49	0	0	1	310116	
23MAR90	218	BT	1	2	05FEB90	219	BT	1	2	46	0	0	1	310378	
23MAR90	173	BT	1	2	09FEB90	173	BT	1	2	42	0	0	1	311304	
23MAR90	172	BT	1	2	13FEB90	172	BT	1	2	38	0	0	1	311845	
23MAR90	244	BT	1	2	14FEB90	245	BT	1	2	37	0	0	1	312311	
23MAR90	179	BT	1	2	20FEB90	183	BT	1	2	31	0	0	1	313023	
23MAR90	305	BT	1	2	20MAR90	303	BT	1	2	3	0	0	1	317733	
23MAR90	181	BT	1	2	21MAR90	183	BT	1	2	2	0	0	1	317970	
23MAR90	162	BT	1	2	22MAR90	161	BT	1	2	1	0	0	1	318099	
23MAR90	237	BT	1	2	22MAR90	235	BT	1	2	1	0	0	1	318207	
23MAR90	269	BT	1	2	23MAR90	268	BT	1	2	0	0	0	1	318351	
23MAR90	256	BT	1	2	23MAR90	248	BT	1	2	0	0	0	1	318358	
23MAR90	213	BT	1	2	23MAR90	213	BT	1	2	0	0	0	1	318366	
23MAR90	214	BT	1	2	23MAR90	212	BT	1	2	0	0	0	1	318425	
23MAR90	205	BT	1	2	23MAR90	207	BT	1	2	0	0	0	1	318466	
23MAR90	360	BT	1	2	23MAR90	361	BT	1	2	0	0	0	1	318490	
26MAR90	375	BT	1	2	01DEC89	382	BT	1	2	115	0	0	1	272167	
26MAR90	284	BT	1	2	08NOV89	284	BT	1	2	138	0	0	1	290286	
26MAR90	190	BT	1	2	30NOV89	192	BT	1	2	116	0	0	1	291354	
26MAR90	217	BT	1	2	06DEC89	218	BT	1	2	110	0	0	1	292920	
26MAR90	336	BT	1	2	12DEC89	236	BT	1	2	104	0	0	1	293721	
26MAR90	176	BT	1	2	03JAN90	178	BT	1	2	82	0	0	1	305375	
26MAR90	191	BT	1	2	30JAN90	192	BT	8	13	55	7	11	1	308912	
26MAR90	177	BT	1	2	14FEB90	175	BT	1	2	40	0	0	1	312204	
26MAR90	204	BT	1	2	20FEB90	210	BT	1	2	34	0	0	1	313221	
26MAR90	212	BT	1	2	20MAR90	217	BT	1	2	6	0	0	1	317494	
26MAR90	265	BT	1	2	23MAR90	264	BT	1	2	3	0	0	1	318530	
26MAR90	236	BT	1	2	26MAR90	238	BT	1	2	0	0	0	1	318661	
26MAR90	228	BT	1	2	26MAR90	230	BT	1	2	0	0	0	1	318725	
27MAR90	222	BT	1	2	20DEC89	222	BT	1	2	97	0	0	1	273605	
27MAR90	172	BT	1	2	14DEC89	175	BT	1	2	103	0	0	1	294637	
27MAR90	192	BT	5	8	24JAN90	192	BT	5	8	62	0	0	1	307831	

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APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
27MAR90	198	BT	1	2	27JAN90	200	BT	5	8	59	4	6	1	308494	
27MAR90	170	BT	1	2	31JAN90	171	BT	1	2	55	0	0	1	309142	
27MAR90	213	BT	1	2	05FEB90	214	BT	1	2	50	0	0	1	310478	
27MAR90	279	BT	1	2	20FEB90	178	BT	1	2	35	0	0	1	313079	
27MAR90	244	BT	1	2	22MAR90	243	BT	1	2	5	0	0	1	318254	
27MAR90	243	BT	1	2	27MAR90	244	BT	1	2	0	0	0	1	318254	
27MAR90	162	BT	1	2	23MAR90	162	BT	1	2	4	0	0	1	318600	
27MAR90	308	BT	1	2	27MAR90	307	BT	1	2	0	0	0	1	318946	
28MAR90	336	UH	2	3	30NOV89	334	BT	1	2	118	3	5	2	272153	
28MAR90	290	UH	2	3	12DEC89	292	BT	1	2	106	3	5	1	293838	
28MAR90	188	BT	1	2	17JAN90	190	BT	1	2	70	0	0	1	306790	
28MAR90	215	BT	1	2	16FEB90	212	BT	1	2	40	0	0	1	312729	
28MAR90	230	BT	1	2	16FEB90	230	BT	1	2	40	0	0	1	312882	
28MAR90	187	BT	1	2	14MAR90	190	BT	9	14	14	8	13	1	316351	
28MAR90	396	BT	1	2	28MAR90	398	BT	1	2	0	0	0	1	319344	
28MAR90	395	BT	1	2	28MAR90	396	BT	1	2	0	0	0	1	319344	
28MAR90	166	BT	1	2	28MAR90	165	BT	1	2	0	0	0	1	319354	
28MAR90	257	BT	1	2	28MAR90	258	BT	1	2	0	0	0	1	319373	
28MAR90	287	BT	1	2	28MAR90	286	BT	1	2	0	0	0	1	319385	
29MAR90	215	BT	1	2	19DEC89	215	BT	1	2	100	0	0	1	273416	
29MAR90	198	BT	1	2	07NOV89	203	BT	1	2	142	0	0	1	289986	
29MAR90	203	BT	1	2	05DEC89	200	BT	1	2	114	0	0	1	292095	
29MAR90	208	BT	1	2	29MAR90	209	BT	1	2	0	0	0	1	320069	
29MAR90	260	BT	1	2	29MAR90	263	BT	1	2	0	0	0	1	320079	
29MAR90	255	BT	1	2	29MAR90	254	BT	1	2	0	0	0	1	320088	
29MAR90	215	BT	1	2	29MAR90	215	BT	1	2	0	0	0	1	320111	
30MAR90	225	BT	5	8	07NOV89	227	BT	1	2	143	4	6	1	290215	
30MAR90	246	BT	5	8	11DEC89	242	BT	8	13	109	3	5	1	293604	
30MAR90	272	BT	5	8	13DEC89	222	BT	8	13	107	3	5	1	294072	
30MAR90	186	BT	5	8	01FEB90	185	BT	1	2	57	4	6	1	309641	
30MAR90	253	BT	5	8	30MAR90	253	BT	5	8	0	0	0	1	320217	
02APR90	186	BT	1	2	03NOV89	185	BT	1	2	150	0	0	1	289827	
02APR90	216	BT	1	2	07NOV89	221	BT	1	2	146	0	0	1	289956	
02APR90	222	BT	1	2	08NOV89	223	BT	1	2	145	0	0	1	290445	
02APR90	207	BT	1	2	22NOV89	204	BT	8	13	131	7	11	1	290864	
02APR90	188	BT	1	2	05DEC89	190	BT	1	2	118	0	0	1	291884	
02APR90	214	BT	1	2	14DEC89	213	BT	1	2	109	0	0	1	294646	
02APR90	250	BT	1	2	12JAN90	252	BT	9	14	80	8	13	1	306232	
02APR90	205	BT	1	2	31JAN90	206	BT	1	2	61	0	0	1	309234	
02APR90	260	BT	1	2	21FEB90	258	BT	1	2	40	0	0	1	313456	
02APR90	162	BT	1	2	21FEB90	160	BT	1	2	40	0	0	1	313473	
02APR90	207	BT	1	2	12MAR90	210	BT	8	13	21	7	11	1	315689	
02APR90	232	BT	1	2	20MAR90	233	BT	1	2	13	0	0	1	317516	
02APR90	212	BT	1	2	22MAR90	211	BT	1	2	11	0	0	1	318321	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
02APR90	206	BT	1	2	02APR90	205	BT	1	2	0	0	0	1	320289	
02APR90	165	BT	1	2	02APR90	165	BT	1	2	0	0	0	1	320338	
04APR90	275	BT	1	2	30NOV89	277	BT	1	2	125	0	0	1	291215	
04APR90	215	BT	1	2	06DEC89	215	BT	1	2	119	0	0	1	292345	
04APR90	195	BT	1	2	08DEC89	195	BT	1	2	117	0	0	1	293433	
04APR90	177	BT	1	2	09FEB90	178	BT	1	2	54	0	0	1	311357	
04APR90	274	BT	1	2	21FEB90	274	BT	1	2	42	0	0	1	313453	
04APR90	202	BT	1	2	23MAR90	204	BT	1	2	12	0	0	1	318448	
04APR90	175	BT	1	2	23MAR90	177	BT	1	2	12	0	0	1	318515	
04APR90	240	BT	1	2	04APR90	341	BT	1	2	0	0	0	1	319548	
04APR90	216	BT	1	2	02APR90	217	BT	1	2	2	0	0	1	320255	
04APR90	230	BT	1	2	02APR90	232	BT	1	2	2	0	0	1	320274	
04APR90	162	BT	1	2	04APR90	163	BT	1	2	0	0	0	1	320541	
04APR90	298	BT	1	2	04APR90	298	BT	1	2	0	0	0	1	320550	
04APR90	206	BT	1	2	04APR90	207	BT	1	2	0	0	0	1	320566	
04APR90	297	BT	1	2	04APR90	298	BT	1	2	0	0	0	1	320573	
04APR90	285	BT	1	2	04APR90	284	BT	1	2	0	0	0	1	320611	
05APR90	153	BT	8	13	16JAN90	158	BT	1	2	79	7	11	2	306625	
05APR90	290	BT	9	14	20MAR90	196	BT	1	2	16	8	13	1	317664	
05APR90	165	BT	8	13	05APR90	163	BT	9	14	0	1	2	1	320743	
06APR90	183	BT	1	2	13FEB90	182	BT	1	2	52	0	0	1	293796	
06APR90	167	BT	1	2	20MAR90	170	BT	1	2	17	0	0	1	317583	
06APR90	220	BT	1	2	04APR90	217	BT	1	2	2	0	0	1	320615	
06APR90	168	BT	1	2	04APR90	168	BT	1	2	2	0	0	1	320711	
06APR90	254	BT	1	2	06APR90	227	BT	1	2	0	0	0	1	320799	
06APR90	202	BT	1	2	06APR90	205	BT	1	2	0	0	0	1	320807	
06APR90	212	BT	1	2	06APR90	213	BT	1	2	0	0	0	1	320833	
06APR90	272	BT	1	2	06APR90	270	BT	1	2	0	0	0	1	320843	
09APR90	170	BT	8	13	13FEB90	170	BT	1	2	55	7	11	2	311740	
09APR90	181	BT	9	14	26MAR90	181	BT	1	2	14	8	13	1	318775	
09APR90	207	BT	9	14	04APR90	208	BT	1	2	5	8	13	1	320648	
09APR90	206	BT	8	13	09APR90	205	BT	8	13	0	0	0	1	320961	
10APR90	195	BT	8	13	22MAR90	196	BT	1	2	19	7	11	1	318319	
10APR90	302	BT	9	14	10APR90	301	BT	9	14	0	0	0	1	319663	
10APR90	192	BT	8	13	05APR90	193	BT	8	13	5	0	0	1	320763	
10APR90	184	BT	9	14	10APR90	184	BT	9	14	0	0	0	1	321002	
11APR90	248	BT	1	2	14NOV89	255	BT	1	2	148	0	0	1	290590	
11APR90	210	BT	1	2	04DEC89	208	BT	1	2	128	0	0	1	291855	
11APR90	207	BT	1	2	06DEC89	209	BT	1	2	126	0	0	1	292673	
11APR90	297	BT	1	2	14FEB90	295	BT	1	2	56	0	0	1	312187	301196
11APR90	168	BT	1	2	08MAR90	272	BT	8	13	34	7	11	1	314969	
11APR90	275	BT	1	2	12MAR90	275	BT	8	13	30	7	11	1	315595	
11APR90	188	BT	1	2	23MAR90	186	BT	1	2	19	0	0	1	318512	
11APR90	194	BT	1	2	02APR90	194	BT	1	2	9	0	0	1	320279	

(continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER	DART TAG_N
11APR90	291	BT	1	2	04APR90	289	BT	1	2	7	0	0	1	320563	
11APR90	204	BT	1	2	10APR90	205	BT	8	13	1	7	11	1	321031	
11APR90	233	BT	1	2	11APR90	234	BT	1	2	0	0	0	1	321056	
11APR90	291	BT	1	2	11APR90	291	BT	1	2	0	0	0	1	321064	
11APR90	244	BT	1	2	11APR90	244	BT	1	2	0	0	0	1	321098	
11APR90	171	BT	1	2	11APR90	170	BT	1	2	0	0	0	1	321113	
12APR90	174	BT	8	13	28NOV89	177	BT	9	14	135	1	2	1	291031	
13APR90	211	BT	8	13	28NOV89	210	BT	8	13	136	0	0	1	291016	
13APR90	182	BT	8	13	13FEB90	181	BT	1	2	59	7	11	1	311906	
13APR90	180	BT	8	13	04APR90	179	BT	1	2	9	7	11	1	320713	
13APR90	155	BT	8	13	10APR90	156	BT	9	14	3	1	2	1	320994	
13APR90	170	BT	8	13	12APR90	170	BT	8	13	1	0	0	1	321235	

[a]Fish were released with both anchor and dart tags, but were recaptured only with anchor tags.

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1989-1990 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE							RELEASE											
DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER	DART TAG_N
03NOV89	9 M TRAWL	2	315	BT	1	2	15DEC88	9 M TRAWL	1	230	BT	1	2	323	85	1	263050	
06NOV89	9 M TRAWL	2	274	BT	9	14	15FEB89	9 M TRAWL	1	164	BT	8	13	264	110	1	281451	
08NOV89	9 M TRAWL	2	354	BT	1	2	04JAN89	9 M TRAWL	1	177	BT	5	8	308	177	1	275051	
08NOV89	9 M TRAWL	2	288	BT	1	2	02FEB89	9 M TRAWL	1	226	BT	8	13	279	62	1	279532	
15NOV89	9 M TRAWL	2	286	BT	9	14	10JAN89	9 M TRAWL	1	216	BT	8	13	309	70	1	275958	
20NOV89	9 M TRAWL	2	240	BT	5	8	03JAN89	9 M TRAWL	1	194	BT	5	8	321	46	1	266117	
28NOV89	9 M TRAWL	2	285	BT	8	13	14MAR89	9 M TRAWL	1	197	BT	8	13	259	88	2	284593	
30NOV89	9 M TRAWL	2	273	BT	1	2	15DEC88	9 M TRAWL	1	244	BT	1	2	350	29	1	263183	
01DEC89	9 M TRAWL	2	272	BT	1	2	09FEB89	9 M TRAWL	1	187	BT	8	13	295	85	1	280288	
04DEC89	9 M TRAWL	3	363	BT	1	2	16MAR88	12 M/9 M COD	2	287	BT	8	13	628	76	1	255853	
04DEC89	9 M TRAWL	4	474	BT	1	2	02DEC88	9 M TRAWL	3	456	BT	1	2	367	18	1	261731	
04DEC89	9 M TRAWL	2	281	BT	1	2	15FEB89	9 M TRAWL	1	214	BT	9	14	292	67	1	281305	
06DEC89	9 M TRAWL	2	293	BT	1	2	01FEB89	9 M TRAWL	1	218	BT	8	13	308	75	1	279156	
07DEC89	9 M TRAWL	.	554	BT	1	2	16NOV87	9 M TRAWL	.	306	BT	1	2	752	248	1	31077	
08DEC89	9 M TRAWL	4	353	BT	1	2	14JAN88	9 M TRAWL	3	274	BT	8	13	694	79	1	251477	
08DEC89	9 M TRAWL	2	295	BT	1	2	31JAN89	9 M TRAWL	1	207	BT	1	2	311	88	1	278978	
12DEC89	9 M TRAWL	2	286	BT	1	2	20DEC88	9 M TRAWL	1	199	BT	1	2	357	87	1	264386	
12DEC89	9 M TRAWL	2	364	BT	1	2	21FEB89	9 M TRAWL	1	286	BT	8	13	294	78	2	282452	
14DEC89	9 M TRAWL	2	235	BT	1	2	16DEC88	9 M TRAWL	1	173	BT	1	2	363	62	1	263665	
14DEC89	9 M TRAWL	2	323	BT	1	2	01FEB89	9 M TRAWL	1	210	BT	8	13	316	113	1	279502	
14DEC89	9 M TRAWL	2	259	BT	1	2	15FEB89	9 M TRAWL	1	217	BT	9	14	302	42	1	281286	
14DEC89	9 M TRAWL	2	273	BT	1	2	20MAR89	9 M TRAWL	1	204	BT	9	14	269	69	1	285410	
14DEC89	9 M TRAWL	2	277	BT	1	2	03APR89	9 M TRAWL	1	184	BT	9	14	255	93	1	288693	
19DEC89	9 M TRAWL	4	403	BT	1	2	21MAR88	9 M TRAWL	2	293	BT	8	13	638	110	1	256733	
20DEC89	9 M TRAWL	2	283	BT	1	2	21FEB89	9 M TRAWL	1	165	BT	5	8	302	118	1	282410	
20DEC89	9 M TRAWL	2	274	BT	1	2	20MAR89	9 M TRAWL	1	212	BT	8	13	275	62	1	285432	
21DEC89	9 M TRAWL	2	280	BT	1	2	28DEC88	9 M TRAWL	1	152	BT	5	8	358	128	1	265511	
21DEC89	9 M TRAWL	2	260	BT	1	2	13JAN89	9 M TRAWL	1	190	BT	8	13	342	70	1	276490	
21DEC89	9 M TRAWL	3	355	BT	1	2	02MAR89	9 M TRAWL	1	263	BT	8	13	294	92	1	283676	
28DEC89	9 M TRAWL	3	480	BT	9	14	29JAN88	9 M TRAWL	3	353	BT	8	13	699	127	1	252605	
28DEC89	9 M TRAWL	2	381	BT	9	14	20MAR89	9 M TRAWL	1	234	BT	8	13	283	147	1	285426	
29DEC89	9 M TRAWL	3	402	BT	1	2	15DEC87	9 M TRAWL	1	277	BT	5	8	745	125	1	34025	
02JAN90	9 M TRAWL	4	515	BT	1	2	10FEB88	9 M TRAWL	2	324	BT	8	13	692	191	1	36108	
02JAN90	9 M TRAWL	5	565	BT	1	2	05APR89	9 M TRAWL	4	557	BT	8	13	272	8	1	271826	---[a]
02JAN90	9 M TRAWL	2	281	BT	1	2	20MAR89	9 M TRAWL	1	246	BT	1	2	288	35	1	285245	
02JAN90	9 M TRAWL	2	320	BT	1	2	23MAR89	9 M TRAWL	1	259	BT	8	13	285	61	1	286659	
03JAN90	9 M TRAWL	2	319	BT	1	2	13DEC88	9 M TRAWL	1	210	BT	5	8	386	109	2	262663	
08JAN90	9 M TRAWL	2	330	BT	8	13	22MAR89	9 M TRAWL	1	265	BT	9	14	292	65	1	285840	
11JAN90	9 M TRAWL	2	285	BT	9	14	03APR89	9 M TRAWL	1	251	BT	9	14	283	34	1	288511	---[a]
16JAN90	9 M TRAWL	2	298	BT	1	2	03JAN89	9 M TRAWL	1	214	BT	5	8	378	84	1	266427	
17JAN90	9 M TRAWL	2	328	BT	1	2	27JAN89	9 M TRAWL	1	218	BT	1	2	355	110	1	278572	
23JAN90	9 M TRAWL	2	294	BT	5	8	07FEB89	9 M TRAWL	1	216	BT	5	8	350	78	1	270629	
24JAN90	9 M TRAWL	2	288	BT	5	8	04JAN89	9 M TRAWL	1	202	BT	5	8	385	86	1	275209	
27JAN90	9 M TRAWL	2	268	BT	5	8	13APR89	9 M TRAWL	1	218	BT	5	8	289	50	1	289585	

(continued)

APPENDIX TABLE D-3. (Continued)

RECAPTURE							RELEASE											
DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER	DART TAG_N
01FEB90	9 M TRAWL	2	266	BT	1	2	03JAN89	9 M TRAWL	1	182	BT	5	8	394	84	1	266282	
05FEB90	9 M TRAWL	2	225	BT	1	2	22DEC88	9 M TRAWL	1	188	BT	1	2	410	37	1	264821	
08FEB90	9 M TRAWL	2	397	BT	8	13	02MAR89	9 M TRAWL	1	273	BT	8	13	343	124	1	283821	
09FEB90	9 M TRAWL	2	297	BT	1	2	10FEB89	9 M TRAWL	1	201	BT	9	14	364	96	1	280491	
13FEB90	9 M TRAWL	2	393	BT	1	2	31JAN87	9 M TRAWL	1	272	BT	1	2	1E3	121	1	17673	
13FEB90	9 M TRAWL	2	305	BT	1	2	02NOV88	9 M TRAWL	1	240	BT	1	2	468	65	2	258422	
15FEB90	9 M TRAWL	2	283	BT	1	2	31JAN89	9 M TRAWL	1	197	BT	1	2	380	86	1	278979	
15FEB90	9 M TRAWL	2	321	BT	1	2	03APR89	9 M TRAWL	1	246	BT	9	14	318	75	1	288701	
28FEB90	9 M TRAWL	2	310	BT	5	8	11JAN89	9 M TRAWL	1	210	BT	8	13	413	100	1	276287	
02MAR90	9 M TRAWL	2	250	BT	1	2	02NOV88	9 M TRAWL	1	181	BT	1	2	485	69	2	258323	
05MAR90	9 M TRAWL	.	379	BT	1	2	23NOV87	9 M TRAWL	1	252	BT	1	2	833	127	2	20218	
05MAR90	9 M TRAWL	4	408	BT	1	2	24MAR88	9 M TRAWL	2	277	BT	1	2	711	131	1	259742	
08MAR90	9 M TRAWL	2	276	BT	8	13	19DEC88	9 M TRAWL	1	196	BT	8	13	444	80	1	263893	
08MAR90	9 M TRAWL	2	360	BT	8	13	13APR89	9 M TRAWL	1	280	BT	5	8	329	80	1		304520[b]
09MAR90	9 M TRAWL	2	344	BT	8	13	22MAR89	9 M TRAWL	1	241	BT	8	13	352	103	1	286426	
12MAR90	9 M TRAWL	2	252	BT	8	13	15DEC88	9 M TRAWL	1	195	BT	1	2	452	57	2	263080	
13MAR90	9 M TRAWL	2	263	BT	9	14	31MAR89	9 M TRAWL	1	204	BT	9	14	347	59	1	288255	
16MAR90	9 M TRAWL	2	288	BT	5	8	19JAN89	9 M TRAWL	1	173	BT	5	8	421	115	1	277376	
20MAR90	9 M TRAWL	2	302	BT	1	2	08DEC88	9 M TRAWL	1	212	BT	1	2	467	90	1	262363	
21MAR90	9 M TRAWL	2	272	BT	1	2	26JAN89	9 M TRAWL	1	200	BT	10	16	419	72	1	278437	
23MAR90	9 M TRAWL	1	250	BT	1	2	18JAN89	9 M TRAWL	1	206	BT	5	8	429	44	1	277315	
26MAR90	9 M TRAWL	2	340	BT	1	2	02DEC88	9 M TRAWL	1	249	BT	1	2	479	91	1	261813	
26MAR90	9 M TRAWL	2	228	BT	1	2	15DEC88	9 M TRAWL	0	157	BT	1	2	466	71	1	263035	
26MAR90	9 M TRAWL	2	269	BT	1	2	16FEB89	9 M TRAWL	1	167	BT	8	13	403	102	1	281980	
28MAR90	9 M TRAWL	2	302	UH	2	3	30NOV88	9 M TRAWL	1	247	BT	9	14	483	55	1	261135	
06APR90	9 M TRAWL	3	396	BT	1	2	10MAR88	9 M TRAWL	1	329	BT	8	13	757	67	1	255291	
10APR90	9 M TRAWL	2	297	BT	8	13	16JAN89	9 M TRAWL	1	200	BT	5	8	449	97	1	276756	
10APR90	9 M TRAWL	2	274	BT	9	14	27JAN89	9 M TRAWL	1	188	BT	1	2	438	86	1	278725	

[a]Fish were released with both anchor and dart tags, but were recaptured only with anchor tags.

[b]Fish was released with both anchor and dart tags, but was recaptured only with dart tag. Anchor tag appeared to have been removed by an angler.

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 30 OCTOBER 1989 THROUGH 13 APRIL 1990.

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STATISTIC	NUMBER OF RECAPTURES IN WEEK: 30 OCT N = 271	6 NOV N = 686	13 NOV N = 243	20 NOV N = 219	27 NOV N = 873	4 DEC N = 2271	11 DEC N = 1345	18 DEC N = 1507	25 DEC N = 251	1 JAN N = 564	8 JAN N = 933	15 JAN N = 1085	22 JAN N = 1220	29 JAN N = 1566	5 FEB N = 1242	12 FEB N = 1730	19 FEB N = 1032	26 FEB N = 378	5 MAR N = 898	12 MAR N = 1734	19 MAR N = 1459	26 MAR N = 1133	2 APR N = 781	9 APR N = 490	TOTAL N = 24362
30 OCT	275	R	2																								2
		R/N	0.00738																								0.00008
		R/C	0.00727																								0.00727
6 NOV	741	R	1	10																							11
		R/N	0.00369	0.01458																							0.00045
		R/C	0.00135	0.01350																							0.01484
13 NOV	253	R	1	1	1																						3
		R/N	0.00369	0.00146	0.00412																						0.00012
		R/C	0.00395	0.00395	0.00395																						0.01186
20 NOV	224	R	0	0	0	0																					0
		R/N	0.00000	0.00000	0.00000	0.00000																					0.00000
		R/C	0.00000	0.00000	0.00000	0.00000																					0.00000
27 NOV	930	R	0	2	0	1	31																				34
		R/N	0.00000	0.00292	0.00000	0.00457	0.03551																				0.00140
		R/C	0.00000	0.00215	0.00000	0.00108	0.03333																				0.03656
4 DEC	2337	R	0	2	0	0	5	34																			41
		R/N	0.00000	0.00292	0.00000	0.00000	0.00573	0.01497																			0.00168
		R/C	0.00000	0.00086	0.00000	0.00000	0.00214	0.01455																			0.01754

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																								
			30 OCT M = 271	6 NOV M = 686	13 NOV M = 243	20 NOV M = 219	27 NOV M = 877	4 DEC M = 2271	11 DEC M = 1545	18 DEC M = 1507	25 DEC M = 251	1 JAN M = 564	8 JAN M = 933	15 JAN M = 1085	22 JAN M = 1228	29 JAN M = 1588	5 FEB M = 1242	12 FEB M = 1730	19 FEB M = 1032	26 FEB M = 578	5 MAR M = 898	12 MAR M = 1734	19 MAR M = 1459	26 MAR M = 1133	2 APR M = 781	9 APR M = 400	TOTAL M = 24382
11 DEC	1594	R	0	2	1	0	0	2	18																		23
		R/M	0.00000	0.00292	0.00412	0.00000	0.00000	0.00088	0.01165																		0.00094
		R/C	0.00000	0.00125	0.00063	0.00000	0.00000	0.00125	0.01129																		0.01443
18 DEC	1631	R	1	3	0	0	1	2	2	19																	28
		R/M	0.00369	0.00437	0.00000	0.00000	0.00114	0.00088	0.00129	0.01261																	0.00115
		R/C	0.00061	0.00184	0.00000	0.00000	0.00061	0.00123	0.00123	0.01165																	0.01717
25 DEC	270	R	0	1	0	0	1	0	0	0	0																2
		R/M	0.00000	0.00146	0.00000	0.00000	0.00114	0.00000	0.00000	0.00000	0.00000																0.00008
		R/C	0.00000	0.00370	0.00000	0.00000	0.00370	0.00000	0.00000	0.00000	0.00000																0.00741
1 JAN	602	R	0	0	0	1	0	2	2	1	0	5															11
		R/M	0.00000	0.00000	0.00000	0.00457	0.00000	0.00088	0.00129	0.00066	0.00000	0.00887															0.00045
		R/C	0.00000	0.00000	0.00000	0.00166	0.00000	0.00332	0.00332	0.00166	0.00000	0.00831															0.01827
8 JAN	975	R	0	0	0	1	0	2	0	0	0	0	1														4
		R/M	0.00000	0.00000	0.00000	0.00457	0.00000	0.00088	0.00000	0.00000	0.00000	0.00000	0.00107														0.00016
		R/C	0.00000	0.00000	0.00000	0.00103	0.00000	0.00205	0.00000	0.00000	0.00000	0.00000	0.00103														0.00410
15 JAN	1154	R	0	0	0	1	2	2	1	2	0	0	0	15													23
		R/M	0.00000	0.00000	0.00000	0.00457	0.00228	0.00088	0.00065	0.00133	0.00000	0.00000	0.00000	0.01382													0.00094
		R/C	0.00000	0.00000	0.00000	0.00087	0.00173	0.00173	0.00087	0.00173	0.00000	0.00000	0.00000	0.01300													0.01993

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK 30 OCT M = 271	6 NOV M = 686	13 NOV M = 243	20 NOV M = 219	27 NOV M = 875	4 DEC M = 2271	11 DEC M = 1545	18 DEC M = 1507	25 DEC M = 251	1 JAN M = 564	8 JAN M = 933	15 JAN M = 1085	22 JAN M = 1229	29 JAN M = 1586	5 FEB M = 1242	12 FEB M = 1730	19 FEB M = 1032	26 FEB M = 578	5 MAR M = 898	12 MAR M = 1754	19 MAR M = 1459	26 MAR M = 1133	2 APR M = 781	9 APR M = 490	TOTAL M = 24362
22 JAN	1283	R	0	2	0	0	0	1	1	0	0	0	0	0	8												12
		R/M	0.00000	0.00292	0.00000	0.00000	0.00000	0.00044	0.00065	0.00000	0.00000	0.00000	0.00000	0.00000	0.00651												0.00049
		R/C	0.00000	0.00156	0.00000	0.00000	0.00000	0.00078	0.00078	0.00000	0.00000	0.00000	0.00000	0.00000	0.00624												0.00935
29 JAN	1682	R	1	1	0	1	0	3	1	3	0	1	0	2	1	14											28
		R/M	0.00369	0.00146	0.00000	0.00457	0.00000	0.00132	0.00065	0.00199	0.00000	0.00177	0.00000	0.00184	0.00081	0.00883											0.00115
		R/C	0.00059	0.00059	0.00000	0.00059	0.00000	0.00178	0.00059	0.00178	0.00000	0.00059	0.00000	0.00119	0.00059	0.00832											0.01665
5 FEB	1300	R	0	2	0	0	1	1	1	0	0	0	0	1	2	3	13										24
		R/M	0.00000	0.00292	0.00000	0.00000	0.00114	0.00044	0.00065	0.00000	0.00000	0.00000	0.00000	0.00092	0.00163	0.00189	0.01047										0.00099
		R/C	0.00000	0.00154	0.00000	0.00000	0.00077	0.00077	0.00077	0.00000	0.00000	0.00000	0.00000	0.00077	0.00154	0.00231	0.01000										0.01846
12 FEB	1834	R	1	2	0	0	3	2	2	1	0	0	2	1	3	1	2	31									51
		R/M	0.00369	0.00292	0.00000	0.00000	0.00343	0.00088	0.00129	0.00066	0.00000	0.00000	0.00214	0.00092	0.00244	0.00063	0.00161	0.01792									0.00209
		R/C	0.00055	0.00109	0.00000	0.00000	0.00164	0.00109	0.00109	0.00055	0.00000	0.00000	0.00109	0.00055	0.00164	0.00055	0.00109	0.01690									0.02781
19 FEB	1082	R	1	1	0	0	0	0	1	2	1	1	1	0	3	1	1	2	18								33
		R/M	0.00369	0.00146	0.00000	0.00000	0.00000	0.00000	0.00065	0.00133	0.00398	0.00177	0.00107	0.00000	0.00244	0.00063	0.00081	0.00116	0.01744								0.00135
		R/C	0.00092	0.00092	0.00000	0.00000	0.00000	0.00000	0.00092	0.00185	0.00092	0.00092	0.00092	0.00000	0.00277	0.00092	0.00092	0.00185	0.01664								0.03050
26 FEB	609	R	0	0	0	0	0	2	1	0	0	0	2	1	2	0	1	0	1	3							13
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00088	0.00065	0.00000	0.00000	0.00000	0.00214	0.00092	0.00163	0.00000	0.00081	0.00000	0.00097	0.00519							0.00053
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00328	0.00164	0.00000	0.00000	0.00000	0.00328	0.00164	0.00328	0.00000	0.00164	0.00000	0.00164	0.00493							0.02135

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS TRAWLS (C)	STA- TISTIC	NUMBER OF RECAPTURES IN WEEK																							
			30 OCT	6 NOV	13 NOV	20 NOV	27 NOV	4 DEC	11 DEC	18 DEC	25 DEC	1 JAN	8 JAN	15 JAN	22 JAN	29 JAN	5 FEB	12 FEB	19 FEB	26 FEB	5 MAR	12 MAR	19 MAR	26 MAR	2 APR	9 APR	TOTAL
			M = 271	M = 686	M = 243	M = 219	M = 875	M = 2271	M = 1545	M = 1507	M = 251	M = 564	M = 933	M = 1085	M = 1229	M = 1584	M = 1242	M = 1730	M = 1032	M = 570	M = 898	M = 1734	M = 1459	M = 1133	M = 781	M = 490	M = 24362
5 MAR	954	R	0	0	0	0	1	0	0	1	0	0	0	0	1	3	2	2	1	2	1	2	2				15
		R/M	0.00000	0.00000	0.00000	0.00000	0.00114	0.00000	0.00000	0.00066	0.00000	0.00000	0.00000	0.00000	0.00081	0.00189	0.00161	0.00116	0.00097	0.00116	0.00097	0.00346	0.00225				0.00062
		R/C	0.00000	0.00000	0.00000	0.00000	0.00105	0.00000	0.00000	0.00105	0.00000	0.00000	0.00000	0.00000	0.00105	0.00314	0.00210	0.00210	0.00105	0.00210	0.00105	0.00210	0.00210				0.01572
12 MAR	1877	R	0	1	1	0	2	2	0	4	0	0	1	3	5	2	3	1	5	5	0	0	10				40
		R/M	0.00000	0.00146	0.00412	0.00000	0.00229	0.00088	0.00000	0.00265	0.00000	0.00000	0.00107	0.00276	0.00407	0.00126	0.00242	0.00058	0.00484	0.00484	0.00000	0.00000	0.00570				0.00164
		R/C	0.00000	0.00053	0.00053	0.00000	0.00107	0.00107	0.00000	0.00213	0.00000	0.00000	0.00053	0.00160	0.00266	0.00107	0.00160	0.00053	0.00266	0.00266	0.00000	0.00000	0.00533				0.02131
19 MAR	1637	R	1	1	0	0	0	4	3	2	1	0	1	1	2	2	7	7	4	0	2	1	30				49
		R/M	0.00369	0.00369	0.00000	0.00000	0.00000	0.01476	0.01107	0.00738	0.00369	0.00000	0.00369	0.00369	0.00738	0.00738	0.02583	0.02583	0.01476	0.00000	0.00738	0.00369	0.11070				0.00283
		R/C	0.00061	0.00061	0.00000	0.00000	0.00000	0.00244	0.00183	0.00122	0.00061	0.00000	0.00061	0.00061	0.00122	0.00122	0.00428	0.00428	0.00244	0.00000	0.00122	0.00061	0.01833				0.04215
26 MAR	1214	R	0	3	0	0	3	2	5	2	0	1	0	1	2	3	1	3	2	0	0	1	4	14			47
		R/M	0.00000	0.00437	0.00000	0.00000	0.00343	0.00088	0.00324	0.00133	0.00000	0.00177	0.00000	0.00092	0.00163	0.00189	0.00081	0.00173	0.00194	0.00000	0.00000	0.00057	0.00274	0.01236			0.00193
		R/C	0.00000	0.00247	0.00000	0.00000	0.00247	0.00165	0.00412	0.00165	0.00000	0.00082	0.00000	0.00082	0.00165	0.00247	0.00082	0.00247	0.00165	0.00000	0.00000	0.00082	0.00329	0.01153			0.03871
2 APR	854	R	1	2	0	1	1	3	1	0	0	0	1	1	0	1	1	1	3	0	0	1	6	0	17		41
		R/M	0.00369	0.00292	0.00000	0.00457	0.00114	0.00132	0.00065	0.00000	0.00000	0.00000	0.00107	0.00092	0.00000	0.00063	0.00081	0.00058	0.00291	0.00000	0.00000	0.00057	0.00411	0.00000	0.02177		0.00168
		R/C	0.00117	0.00234	0.00000	0.00117	0.00117	0.00351	0.00117	0.00000	0.00000	0.00000	0.00117	0.00117	0.00000	0.00117	0.00117	0.00117	0.00351	0.00000	0.00000	0.00117	0.00703	0.00000	0.01991		0.04801
9 APR	549	R	0	0	1	0	2	2	0	0	0	0	0	0	0	0	0	3	0	0	1	1	2	1	5	10	28
		R/M	0.00000	0.00000	0.00412	0.00000	0.00229	0.00088	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00173	0.00000	0.00000	0.00111	0.00057	0.00364	0.00088	0.00640	0.02041	0.00115
		R/C	0.00000	0.00000	0.00182	0.00000	0.00364	0.00364	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00546	0.00000	0.00000	0.00182	0.00182	0.00364	0.00182	0.00911	0.01821	0.05100
TOTAL	25861	R	10	34	4	6	53	44	39	37	2	8	9	26	29	30	31	50	34	5	5	14	42	15	22	10	603
		R/M	0.03690	0.05248	0.01646	0.02740	0.06057	0.01906	0.02524	0.02455	0.00797	0.01418	0.00965	0.02396	0.02360	0.01892	0.02496	0.02890	0.03295	0.00845	0.00557	0.00798	0.02879	0.01324	0.02817	0.02041	0.02393
		R/C	0.00039	0.00139	0.00015	0.00023	0.00205	0.00255	0.00151	0.00143	0.00008	0.00031	0.00035	0.00101	0.00112	0.00116	0.00120	0.00193	0.00131	0.00019	0.00019	0.00054	0.00162	0.00058	0.00085	0.00039	0.02254

R = number of striped bass recaptured.

M = number of striped bass > 350 mmTL marked and released.

C = number of striped bass > mmTL marked and released.

R/M = recapture rate.

R/C = recapture proportion.

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR THE HUDSON RIVER STRIPED BASS CAPTURED WITH ABRADED TAGS THAT WERE TAGGED AND RELEASED PRIOR TO AND RECAPTURED DURING 1989-90.

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STATION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STATION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	TAG COND
3 NOV 89	9m	BT	1	315	15 DEC 88	9m	BT	1	230	98	263050				4	4	4	A	N	1
6 NOV 89	9m	BT	9	274	15 FEB 89	9m	BT	8	164	98	281451				4	4	4		N	1
8 NOV 89	9m	BT	1	288	2 FEB 89	9m	BT	8	226	98	279532								N	1
8 NOV 89	9m	BT	1	354	4 JAN 89	9m	BT	5	177	98	275051				4	4	4		N	1
15 NOV 89	9m	BT	9	286	10 JAN 89	9m	BT	8	216	98	275958								N	1
20 NOV 89	9m	BT	5	240	3 JAN 89	9m	BT	5	194	98	266117				4	4	4		N	1
28 NOV 89	9m	BT	8	285	14 MAR 89	9m	BT	8	197	98	284593								N	1
30 NOV 89	9m	BT	1	273	15 DEC 88	9m	BT	1	244	98	263183								N	2
1 DEC 89	9m	BT	1	272	9 FEB 89	9m	BT	8	187	98	280288								N	1
4 DEC 89	9m	BT	1	281	15 FEB 89	9m	BT	9	214	98	281305				4	4	4		N	1
4 DEC 89	9m	BT	1	363	16 MAR 88	12m	BT	8	287	98	255853				4	4	4		N	1
4 DEC 89	9m	BT	1	474	2 DEC 88	9m	BT	1	456	98	261731				4	4	4		N	1
6 DEC 89	9m	BT	1	293	1 FEB 89	9m	BT	8	218	98	279156								N	1
7 DEC 89	9m	BT	1	554	16 NOV 87	9m	BT	1	306	96	31077								N	1
8 DEC 89	9m	BT	1	295	31 JAN 89	9m	BT	1	207	98	278978				4	4	4		N	1
8 DEC 89	9m	BT	1	353	14 JAN 88	9m	BT	8	274	98	251477				4	4	4	A	N	1
12 DEC 89	9m	BT	1	286	20 DEC 88	9m	BT	1	199	98	264386				4	4	4		N	1
12 DEC 89	9m	BT	1	364	21 FEB 89	9m	BT	8	286	98	282452				4	4	4		N	2
14 DEC 89	9m	BT	1	235	16 DEC 88	9m	BT	1	173	98	263665								N	1
14 DEC 89	9m	BT	1	277	3 APR 89	9m	BT	9	184	98	288693								N	1
14 DEC 89	9m	BT	1	259	15 FEB 89	9m	BT	9	217	98	281286								N	1
14 DEC 89	9m	BT	1	273	20 MAR 89	9m	BT	9	204	98	285410				4	4	4	A	N	1
14 DEC 89	9m	BT	1	323	1 FEB 89	9m	BT	8	210	98	279502				4	4	4	A	N	1
19 DEC 89	9m	BT	1	403	21 MAR 88	9m	BT	8	293	98	256733				4	4	4	A	N	1
20 DEC 89	9m	BT	1	283	21 FEB 89	9m	BT	5	165	98	282410				4	4	4		N	1
20 DEC 89	9m	BT	1	274	20 MAR 89	9m	BT	8	212	98	285432				4	4	4		N	1
21 DEC 89	9m	BT	1	280	28 DEC 88	9m	BT	5	152	98	265511				4	4	4	A	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA- TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA- TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN- TATION	ANCHOR PROTRUSION	TAG COND.
21 DEC 89	9m	BT	1	260	13 JAN 89	9m	BT	8	190	98	276490				4	4	4	A	N	1
21 DEC 89	9m	BT	1	355	2 MAR 89	9m	BT	8	263	98	283676				4	4	4	A	N	1
28 DEC 89	9m	BT	8	480	29 JAN 88	9m	BT	8	353	98	252605				4	4	4	A	N	1
28 DEC 89	9m	BT	8	381	20 MAR 89	9m	BT	8	234	98	285426				4	4	4	A	N	1
29 DEC 89	9m	BT	1	402	15 DEC 87	9m	BT	5	277	98	34025				4	4	4	P	N	1
2 JAN 90	9m	BT	1	320	23 MAR 89	9m	BT	8	259	98	286659								N	1
2 JAN 90	9m	BT	1	565	5 APR 89	9m	BT	8	557	98	271826			300798	4	4	4		N	1
2 JAN 90	9m	BT	1	281	20 MAR 89	9m	BT	1	246	98	285245				4	4	4		N	1
2 JAN 90	9m	BT	1	515	10 FEB 88	12m	BT	8	378	97 *	36108	98	274391		3	1	1		N	1
3 JAN 90	9m	BT	1	319	12 DEC 88	9m	BT	5	251	98	262663				4	4	4	A	N	2
8 JAN 90	9m	BT	8	330	22 MAR 89	9m	BT	9	265	98	285840								N	1
11 JAN 90	9m	BT	9	285	3 APR 89	9m	BT	9	251	98	288511				4	4	4		N	1
16 JAN 90	9m	BT	1	298	3 JAN 89	9m	BT	5	214	98	266427								N	1
17 JAN 90	9m	BT	1	328	27 JAN 89	9m	BT	1	218	98	278572				4	4	4	A	N	1
23 JAN 90	9m	BT	5	294	7 FEB 88	9m	BT	5	216	98	270629				4	4	4		N	1
24 JAN 90	9m	BT	5	288	4 JAN 89	9m	BT	5	202	98	275209								N	1
27 JAN 90	9m	BT	5	268	13 APR 89	9m	BT	5	218	98	289585				4	4	4	A	N	1
1 FEB 90	9m	BT	1	266	3 JAN 89	9m	BT	5	182	98	266282				4	4	4		N	1
5 FEB 90	9m	BT	1	225	22 DEC 88	9m	BT	1	188	98	264821				4	4	4	A	N	1
9 FEB 90	9m	BT	1	297	10 FEB 89	9m	BT	9	201	98	280491				4	4	4		N	1
13 FEB 90	9m	BT	1	393	31 JAN 87	9m	BT	1	272	96 *	17673	98	274841		3	3	3		N	1
13 FEB 90	9m	BT	1	305	2 NOV 88	9m	BT	1	240	98	258422				4	4	4		N	2
15 FEB 90	9m	BT	1	321	3 APR 89	9m	BT	9	246	98	288701				4	4	4	A	N	1
15 FEB 90	9m	BT	1	283	31 JAN 89	9m	BT	1	197	98	278979				4	4	4	A	N	1
28 FEB 90	9m	BT	5	310	11 JAN 89	9m	BT	8	210	98	276287				4	4	4		N	1
2 MAR 90	9m	BT	1	250	2 NOV 88	9m	BT	1	181	98	258323				4	4	4	A	N	2
5 MAR 90	9m	BT	1	379	23 NOV 87	9m	BT	1	252	96 *	20218	98	314582		2	3	2	P		2
5 MAR 90	9m	BT	1	408	24 MAR 88	9m	BT	1	277	98	259742				4	4	4		N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
8 MAR 90	9m	BT	8	360	13 APR 89	9m	BT	5	280	98	289577			304520	4	4	4		N	1
8 MAR 90	9m	BT	8	276	19 DEC 88	9m	BT	8	196	98	263893				4	4	4	A	N	1
9 MAR 90	9m	BT	8	344	22 MAR 89	9m	BT	8	241	98	286426				4	4	4	A	N	1
12 MAR 90	9m	BT	8	252	15 DEC 88	9m	BT	1	195	98	263080				4	4	4		N	1
13 MAR 90	9m	BT	9	263	31 MAR 89	9m	BT	9	204	98	288255				4	4	4		N	1
16 MAR 90	9m	BT	5	288	19 JAN 89	9m	BT	5	173	98	277376				4	4	4	A	N	1
20 MAR 90	9m	BT	1	302	8 DEC 88	9m	BT	1	212	98	262363				4	4	4		N	1
21 MAR 90	9m	BT	1	272	26 JAN 89	9m	BT	10	200	98	278437				4	4	4	A	N	1
23 MAR 90	9m	BT	1	250	18 JAN 89	9m	BT	5	206	98	277315				4	4	4		N	1
26 MAR 90	9m	BT	1	269	16 FEB 89	9m	BT	8	167	98	281980				4	4	4	A	N	1
26 MAR 90	9m	BT	1	340	2 DEC 88	9m	BT	1	249	98	261813				4	4	4		N	1
26 MAR 90	9m	BT	1	228	15 DEC 88	9m	BT	1	157	98	263035				4	4	4		N	1
28 MAR 90	9m	UH	2	302	30 NOV 88	9m	BT	1	247	98	261135				4	4	4		N	1
6 APR 90	9m	BT	1	396	10 MAR 88	9m	BT	8	329	98	255291				4	4	4		N	1
10 APR 90	9m	BT	9	274	27 JAN 89	9m	BT	1	188	98	278725				4	4	4		N	1
10 APR 90	9m	BT	8	297	16 JAN 89	9m	BT	5	200	98	276756				4	4	4		N	1

(CONTINUED)

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE LOWER HUDSON RIVER DURING WINTER 1989-90.

SAMPLING WEEK	(≥150 m) C TOTAL	(≥150 mm) M TOTAL	CUM M TOTAL	R TOTAL	R/C
22JAN90	83	1229	0	0	0.0000
29JAN90	1682	1586	1229	1	0.0006
05FEB90	1300	1242	2815	5	0.0038
12FEB90	1834	1730	4057	6	0.0033
19FEB90	1082	1032	5787	7	0.0065
26FEB90	609	578	6819	4	0.0066
05MAR90	954	898	7397	11	0.0115
12MAR90	1877	1754	8295	16	0.0085
20MAR90	1637	1459	10049	25	0.0153
26MAR90	1214	1133	11508	16	0.0132
02APR90	854	781	12641	13	0.0152
09APR90	549	490	13422	13	0.0237
TOTAL	14875	13912	84019	117	0.1082

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 22 JANUARY 1990 THROUGH THE WEEK OF 9 APRIL 1990.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00145	0.00145	238.08	0.0001
Error	11	0.00007	0.00001		
Total	12	0.00152			

Regression Equation: R/C = (Cumulative M) X + error,

where,

$X = 0.00000134$ and

Standard Error of $X = 0.00000009$

R^2 = coefficient of determination = 0.96
df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F-ratio
p>F = probability of obtaining a larger F-ratio

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)[a]	MODIFIED INTERNAL ANCHOR (HALL)[a]	SMALL DART (HALL)[a]
1984	737	737[b]	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819[b]
1989-1990	24,362	--	--	--	--	24,362	659[b]
TOTAL	89,846	737[b]	28,041	4,575	16,402	40,828	1,478[b]

[a]Hall - Hallprint.

[b]Not included in row total because fish were double tagged.

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1984 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Dennison	T-bar	Yellow PVC	$10	1
Floy Dennison	T-bar	Yellow PVC	$10-$1000	1
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	3
Floy Dennison and	T-bar	Yellow PVC	$10	414
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	35
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$10	23
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10-$1000	
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	90
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10	
Floy Dennison and	T-bar	Yellow PVC	$5-$1000	5
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$10-$1000	
Floy Dennison and	T-bar	Yellow PVC	$10	5
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	

(continued)

APPENDIX TABLE D-9. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Dennison and	T-bar	Yellow PVC	$10-$1000	19
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	
Floy Dennison and	T-bar	Yellow PVC	$5-$1000	141
Floy Internal Anchor	Large blue, no legend	Yellow PVC	$5-$1000	
1984 TOTAL:				737

*Striped bass ≥ 300 mm in good condition were double tagged and released.

APPENDIX TABLE D-10. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1985-86 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$5-\$1000	9,551
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$10-\$1000	16
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	\$5-\$1000	7,305
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	\$10-\$1000	1,576
1985-86 TOTAL:				18,448

*Striped bass $\geq$ 200 mm and < 300 mm in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mm in good condition were tagged with large anchor (25 mm) tags and released.

NOTE: Differences between the 1985-86 total number of fish tagged and released of 18,448 and the number of 18,487 reported in NAI (1986) are explained as follows:

18,487 fish reported as tagged and released in 1985-86 program

+ 23 fish tagged and released during 1985-86 hatchery broodfish capture effort (EA)

+ 1 fish with tag number verified by recapture

- 63 fish released with missing tag numbers, or with missing alive/dead status code

TOTAL: 18,448

APPENDIX TABLE D-11. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1986-87 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	$5-$1000	2,095
Floy Internal Anchor	Small, red, no legend	Yellow PVC	$10-$1000	1,953
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	$5-$1000	159
Floy Internal Anchor	Small, red legend	Pink PVC with tube	$10-$1000	1,012
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	$5-$1000	109
Floy Internal Anchor	Large, blue no legend	Yellow PVC	$10-$1000	3,101
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	$5-$1000	639
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	$10-$1000	405
1986-87 TOTAL:				9,473

*Striped bass ≥ 200 mm and < 300 mm in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mm in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-11. (CONTINUED)

NOTE: Differences between the 1986-87 total number of fish tagged and released of 9,473 and the number of 9,388 reported in NAI (1987) are explained as follows:

9,388

+65 fish tagged and released by a sport fisherman (Tom Lake)

+27 fish discovered with the wrong alive/dead status

+2 fish with status changed due to recapture information

- 9 fish with mising tag numbers

TOTAL: 9,473

APPENDIX TABLE D-12. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1987-88 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Floy Internal Anchor	Small, red, no legend	Yellow PVC	\$5-\$1000	820
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	\$5-\$1000	162
Floy Internal Anchor	Small, red, legend	Pink PVC with tube	\$10-\$1000	1,012
Floy Internal Anchor	Large, blue, no legend	Yellow PVC	\$5-\$1000	778
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$5-\$1000	537
Floy Internal Anchor	Large, blue, legend	Pink PVC with tube	\$10-\$1000	649
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypro-pylene with exposed filament	\$5-\$1000	3,507
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypro-pylene with exposed filament	\$10-\$1000	4,968
1987-88 TOTAL:				12,433

*Striped bass $\geq$ 200 mm and < 300 mm in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mm in good condition were tagged with large anchor (25 mm) tags and released.

NOTE: Three fish were tagged and released without the tag number recorded and could not be classified by tag type or reward value.

APPENDIX TABLE D-13. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1988-89 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	\$5-\$1000	9,017
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	\$10-\$1000	4,995
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with exposed filament	\$5-\$1000	2,936
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with exposed filament	\$10-\$1000	4,991
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	\$10-\$1000	1,635

(continued)

APPENDIX TABLE D-13. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	38
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	557
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	33
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	

(continued)

APPENDIX TABLE D-13. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	191
1988-89 TOTAL:				24,393

*Striped bass ≥ 150 mm and < 300 mm in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mm in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-14. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1989-90 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	6,362
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	9,851
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	7,490
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	234

(continued)

APPENDIX TABLE D-14. (CONTINUED)

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	103
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	
and Hallprint dart	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	322
1989-90 TOTAL:				24,362

*Striped bass $\geq$ 150 mm and < 300 mm in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass $\geq$ 300 mm in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 30 October 1989 and 13 April 1990 were taken to the Verplanck, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1985-86, 1986-87, 1987-88, and 1988-89 programs (NAI 1986, 1987, 1988, 1990a). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS

Length, weight, sex, and sexual condition were determined for all striped bass that died during sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E2-1.

E.2.2 STRIPED BASS STOMACH CONTENTS ANALYSIS

The same striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass predominated in the biocharacteristics samples throughout the 1989-90 Hatchery Evaluation Program (Table E3-1). All female striped bass captured were in the immature stage, while all but three male striped bass were in the immature stage. Three resting males were collected during November through February. No striped bass in the ripe, or ripe and running stages were examined.

The lack of ripe, or ripe and running striped bass in the 1989-90 biocharacteristics samples agrees with the findings of the 1985-86 through 1988-89 programs. This is not surprising because the majority of the fish captured in both programs were of pre-spawning size (< 400 mm) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the developing stage with time during the 1985-86, 1986-87, 1987-88 and 1988-89 programs indicated the approach of the spawning season, and that male striped bass may undergo a longer period of gonadal development prior to spawning than females. However, during the 1989-90 program, no striped bass of either sex in the developing stage were collected. Due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature or resting.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 44 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Only one fish was captured in the larger (> 400 mm) length groups and a high percentage of stomachs were empty (48%) which made generalizations about changes in food habits with length difficult. Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and the majority of those were clupeids, or Morone sp. as incidentally noted by laboratory personnel.

Percentage of non-empty striped bass with invertebrate remains in their stomachs decreased with increasing length group (Table E3-2), however, invertebrates were present in the stomach of the one fish in the next to largest length group (301-400 mm). This is in general agreement with the findings from the 1985-86 Hudson River Striped Bass Program where invertebrate remains were most common in striped bass ≤ 300 mm (NAI 1986), and with findings from the 1987-88 program where invertebrates were most common in striped bass ≤ 200 mm (NAI 1988). Invertebrate remains were most common in the 301-400 mm length group during the 1986-87 program (NAI 1987).

Only three fish were examined with fish remains in their stomachs during the 1989-90 program. These fish were all greater than 301 mm and also had invertebrates present in their stomachs. Based on these three fish, the percentage of non-empty striped bass with fish remains in their stomachs increased with length, as in the 1986-87 and 1985-86 programs (NAI 1987). This trend of increasing importance of fish as food items as striped bass length increases probably represents a switch in food habits to piscivory in older fish and has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). In 1987-88 too few fish were found in striped bass stomachs to delineate trends.

TABLE E2-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS.[a]

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, less firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and stringlike, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in texture, but milt not running.

[a]From Con Edison Data Dictionary

APPENDIX TABLE E3-1. SEXUAL CONDITION OF STRIPED BASS CAPTURED IN THE BATTERY REGION DURING THE 1988-89 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS														
	FEMALES					MALES					UNDETERMINED				
MONTH	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL	IMMATURE	REST-ING	DE-VELOP-ING	RIPE	TOTAL
NOV	100 (4)				100 (4)	80 (4)	20 (1)			100 (5)					
DEC	100 (3)				100 (3)	66 (2)	33 (1)			100 (3)	100 (1)				100 (1)
JAN	100 (6)				100 (6)	100 (5)				100 (5)	100 (1)				100 (1)
FEB	100 (3)				100 (3)	100 (1)				100 (1)	100 (3)				100 (3)
MAR	100 (3)				100 (3)	100 (2)				100 (2)	100 (1)				100 (1)
APR	100 (1)				100 (1)	100 (2)				100 (2)					
TOTAL	100 (20)				100 (20)	83 (15)	17 (3)			100 (18)	100 (6)				100 (6)

APPENDIX TABLE E3-2. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1989-90 HUDSON RIVER STRIPED BASS PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS					
LENGTH GROUP (mm)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤200	59.3 (16)	0.0 (0)	0.0 (0)	0.0 (0)	40.7 (11)	100.0 (27)
201-300	25.0 (3)	0.0 (0)	0.0 (0)	0.0 (0)	75.0 (9)	100.0 (12)
301-400	25.0 (1)	0.0 (0)	0.0 (0)	50.0 (2)	25.0 (1)	100.0 (4)
401-500	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (1)	0.0 (0)	100.0 (1)
TOTAL	45.5 (20)	0.0 (0)	00.0 (0)	6.8 (3)	47.7 (21)	100.0 (44)

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

HUDSON RIVER STRIPED BASS HATCHERY

EVALUATION/MONITORING PROGRAM

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was 0.2% for Age 1+ and 2+ fish and 0.1% for Age 3+ fish among the same age cohorts of striped bass caught in the Hudson River between 12 November 1990 and 20 April 1991.

- Mean length at Age 1+ of the 1989 hatchery cohort of striped bass was significantly larger than the mean length at Age 1+ of the 1989 wild cohort of striped bass. The large mean length of Age 1+ hatchery striped bass from the 1989 cohort was attributed to holding the hatchery fish longer than in previous years before stocking.

- The 1989 cohort of Age 1+ striped bass and the 1988 cohort of Age 2+ fish dominated the population statistics for Hudson River striped bass during the 1990-91 Stock Assessment. The 1989 and 1988 cohorts represented 42% and 40% respectively of the total catch and 48% and 47% respectively of the population ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in upper New York Harbor and the Battery region was 858,000 fish with upper and lower 95% confidence limits of 772,000 and 964,000. Age 0+ striped bass accounted for 7,000 fish in the mid-winter population, Age 1+ contributed 416,000 fish, Age 2+ contributed 406,000 fish, Age 3+ contributed 27,000 fish, and Age >3+ contributed 2,000 fish.

- During the 1990-91 striped bass program, 24,964 fish ≥150 mm were caught and 22,406 fish were tagged and released bringing the total number of striped bass tagged and released in these programs since 1984 to 112,252. Of the 865 fish that were recaptured, 635 were tagged and released in the present program, 209 were from 1989-90, 20 were from 1988-89, 1 was from 1987-88, and no fish had illegible tag numbers.

- Overall mean catch per unit of effort (CPUE) in the Battery region was 40.7 striped bass per ten minute tow. The catch was dominated by a strong 1988 year class of Age 1+ fish and 1989 year class of Age 2+ fish. Overall mean CPUE has increased annually since 1985-86 to a peak of 45.3 in the 1989-90 program and decreased slightly in the 1990-91 program.

- Handling mortality remained less than 1% and was comparable to 1985-86 through 1989-90 even though smaller fish (between 150 and 200 mm) were tagged compared to programs prior to 1988-89. No relationship between water temperature and handling mortality was observed.

1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York to address this requirement. The total number of hatchery striped bass that were stocked into the Hudson River is:

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,579
1988	48,611
1989	202,068
1990	234,387
Total	1,832,296

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program to evaluate mitigation measures be conducted through May 1991. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally spawned striped bass. Striped bass produced and stocked during 1990 were not tagged. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive

after capture, after they are examined for hatchery-administered CWTs. If these striped bass are tagged with an external tag and released, then their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could also be used to estimate annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986). Consequently, the hatchery evaluation program focused on estimating annual survival rate for Age 1+ and Age 2+.

The April-June 1984 Adult Striped Bass Program (NAI 1985) demonstrated that it was feasible to use a 12 m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass could be externally tagged and released without significantly increasing 24-hour mortality (Dunning et al. 1987). Finally, the 1984 program revealed that the lower Hudson River estuary could be efficiently fished for striped bass with each gear.

The 1985-86 Hudson River Striped Bass Program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East Rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit of effort for a 12 m trawl was greater than for a 9 m trawl, but mean catch per day was almost identical for the two trawls because more tows could be taken using the 9 m trawl in a day. The 12 m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9 m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm.

A total of 18,487 striped bass ≥200 mm were captured in trawls and seines, tagged and released during the 1985-86 program. A total of 250 of these striped bass were recaptured. Two tagged fish from the 1984 program were also recaptured. However, no striped bass of any age containing CWTs were detected although all fish were checked for these tags. The estimated size of the mid-winter striped bass population in upper New York Harbor and the Battery region was approximately 540,000 fish ≥200 mm, based on the recapture of tagged fish released during late December 1985 through February 1986.

Data from the 1984 and 1985-86 field programs (NAI 1985, 1986) were also used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimator could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River Striped Bass Hatchery Evaluation was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per ten minute tow for both the 9 and 12 m trawls. Use of a cod end liner (2.5 cm stretch mesh) in the 9 m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of the cod end liner in the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+ and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm.

The 1987-88 Hudson River Striped Bass Hatchery Evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per ten minute tow for both the 9 m trawl and 12 m trawl with a cod end similar to the 9 m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one half of the catch. The 9 m trawl was more efficient than the 12 m trawl with a 9 m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6%. The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm.

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990a). The minimum size of striped bass that were tagged was lowered from 200 mm to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm.

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort of Age 1+ fish (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). Handling mortality was low (<1%). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm.

Objectives of the 1990-91 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program were to:

1. tag all wild striped bass greater than or equal to 150 mm, that are in good condition, with internal anchor tags,
2. determine the catch rate and handling mortality of striped bass,
3. estimate the abundance of striped bass overwintering in the lower Hudson River,
4. describe the age composition of the overwintering population of striped bass,
5. determine if hatchery striped bass, stocked during any year between 1983 and 1989, can be caught in the Hudson River population as Age 1+ or older fish, and
6. estimate the proportion of hatchery fish among the Age 1+ through Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1990-91 Hudson River Striped Bass Hatchery Evaluation/ Atlantic Tomcod Standard Operating Procedures (NAI 1990b). The 1990-91 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1) with a 9 m trawl (Appendix Table A-1). Sampling locations were selected to maximize the catch per unit of effort of striped bass within the lower Hudson River, based on the results of the 1985-86 through 1989-90 programs (NAI 1986, 1987, 1988, 1990a, 1991). Previous programs used a Scottish seine, 9 m trawl, 12 m trawl, and a 12 m trawl with a 9 m trawl cod end to catch striped bass. Only the 9 m trawl was used in the 1990-91 program based on the results of the 1987-88 program which showed that the 9 m trawl was more efficient than other gear in catching striped bass of the target ages of Age 1+ and Age 2+ (NAI 1988). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2) and released. We began tagging striped bass ≥150 mm in the 1988-89 and 1989-90 programs so that the minimum length of fish tagged more closely matched the minimum length of Age 1+ fish (NAI 1990a). Prior to the 1988-89 program, fish ≥200 mm (1985-86, 1986-87 and 1987-88) or ≥300 mm (1984) were tagged and released (Appendix Tables D-8 and D-9).

For 23 weeks, from the week of 12 November 1990 through the week of 15 April 1991, the 9 m trawl was deployed in the Upper Harbor or Battery regions. The 9 m trawl was fished in each of the 23 weeks in the Battery region and on selected days during four weeks in the Upper Harbor region (weeks of 7-21 January 1991 and 4 March 1991). Tow duration was 10 minutes unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by

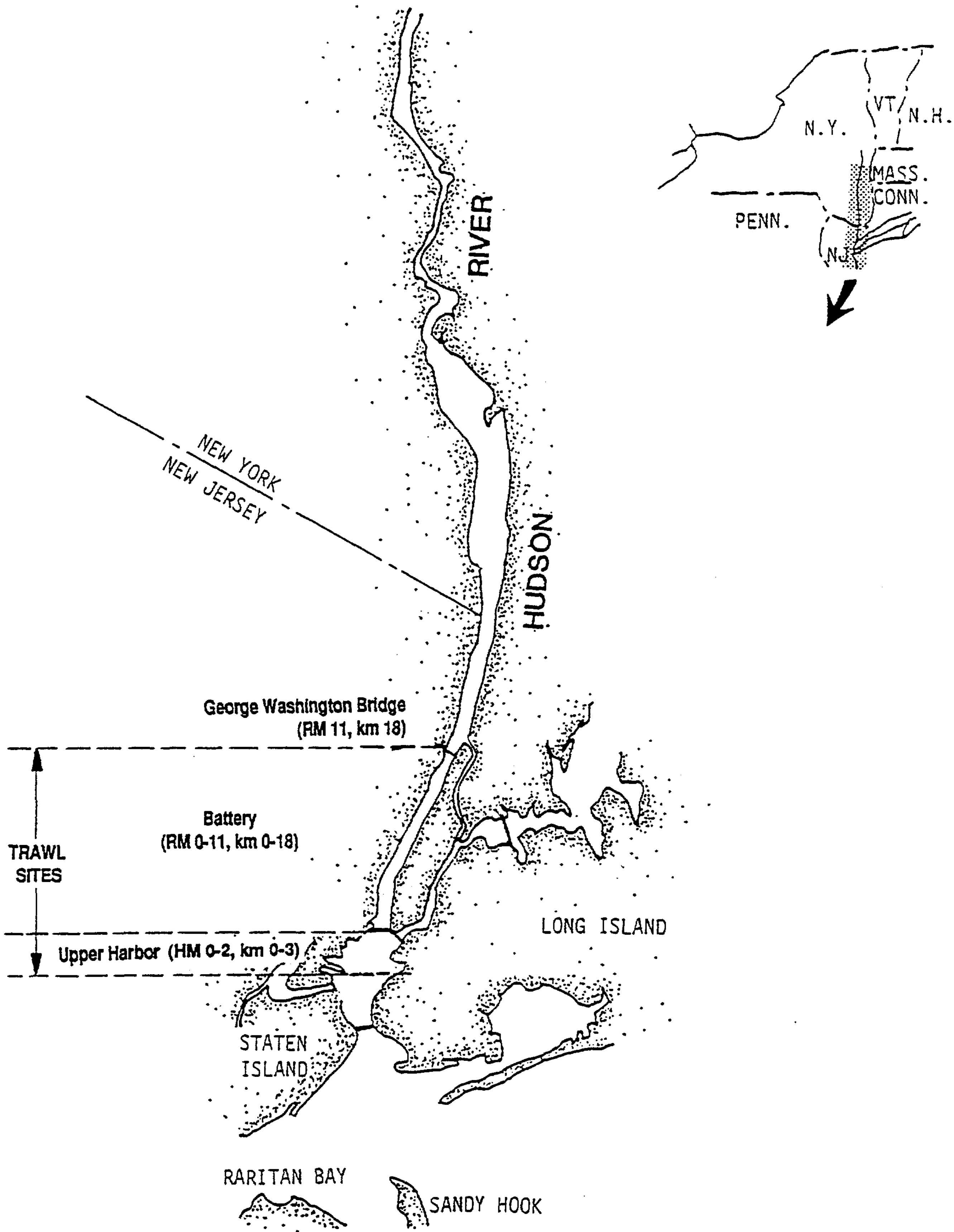
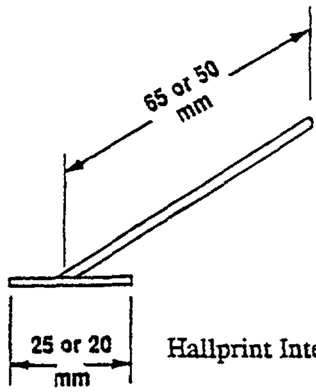
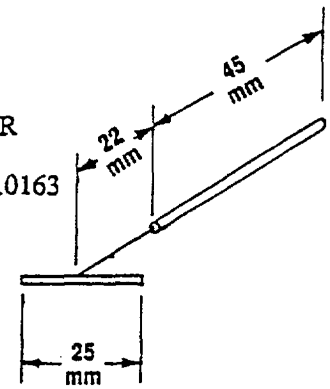


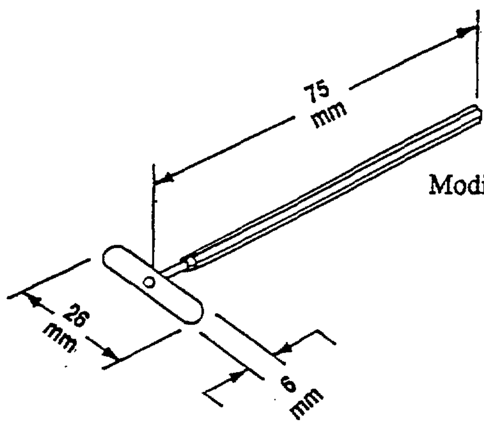
Figure 2-1. Sampling regions in the lower Hudson River and New York Harbor during the winter 1990-91 Hudson River Striped Bass Hatchery Evaluation/Monitoring Progam.

Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######



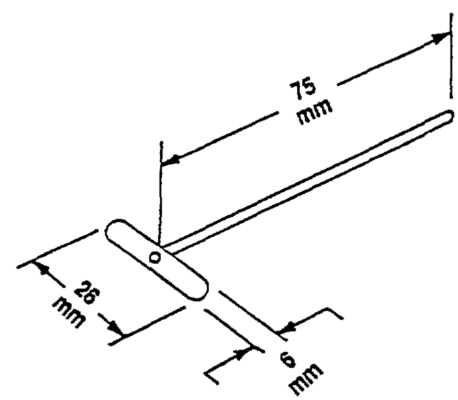
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

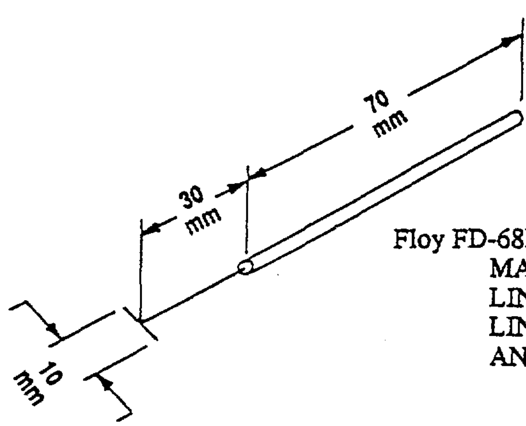




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-Present Hudson River Striped Bass Hatchery Evaluation Programs.

the trawl were handled in a manner that minimized stress before tagging. The sampling effort generally required two boats. One boat conducted the actual sampling (capture boat) while the second boat (tagging boat), with a holding facility for striped bass that was secured in the water alongside, tended the capture boat. The cod end of the net was transferred through the water from the capture boat to the holding facility alongside the tagging boat. Striped bass were then transferred from the holding facility to the tagging boat one at a time using the following procedures:

(1) fish were removed from the live car using a dip net,

(2) all surfaces that came in contact with the live fish were wet,

(3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and

(4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

If sampling conditions were rough (high wind and waves) or if the striped bass catch per tow was consistently less than 30 fish, field sampling was generally conducted with each boat and crew tagging its catch from its own holding facility.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for coded wire tags (CWT) using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

(1) no bleeding from gills or body wounds,
(2) no significant loss of scales, and
(3) strong opercular movement.

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a hooking movement of a curved scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromin-based topical antiseptic. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location. Scale samples were taken from the left side from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass was also evaluated.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random subsample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mm length group. Expected numbers of Age 1+ striped bass in each 10 mm length group were calculated from age at length data obtained during the current and 1989-90 programs (NAI 1990a).

This program continued during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1989 and collected anywhere between November 1990 and April 1991 would be designated "Age 1+". This same fish, captured anywhere between November 1991 and April 1992, would be designated "Age 2+".

Striped bass scales were pressed on 0.050-inch thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving catch per unit of effort. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row. This is because the intermediate values (e.g. marked fish adjusted for bird predation losses) are rounded to the nearest whole fish for display in the table but the sum (e.g. all species combined) was calculated from the exact (unrounded) values.

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among locations and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Of Effort

Catch Per Unit of Effort (CPUE) for the 9 m trawl was defined as catch per ten-minute tow (Use Code = 1) and was calculated as

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{C_i}{E_i} \times 10 \right] \qquad \text{Equation 1}$$

where, $\bar{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,

E_i = the tow duration of trawl i in minutes, and

n = the number of trawls.

2.3.1.2 Length-Frequency

Length-frequency histograms, with number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9 m trawl. Length-frequency distributions for striped bass caught by the 9 m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1°C temperature interval:

$$PropD_x = D_x/T_x \qquad \text{Equation 2}$$

where, $PropD_x$ = the proportion of dead striped bass at water temperature x,

D_x = the number of dead striped bass at water temperature x, and

T_x = total number of striped bass captured at water temperature x.

PropD was calculated for samples collected in the Battery at both surface and bottom water temperatures. Comparisons of handling mortality among the 1985-86 through 1990-91 programs were also made using data subsetted to include the same sampling gear deployed during comparable time periods within the Battery region in each year. Differences in striped bass handling mortality among programs (1985-86 through 1990-91) were assessed by comparing the percentage of dead fish in the catch in one degree temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 Estimated Number of Striped Bass in Each Age Category

A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1990-91 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mm length increment and the variance of the proportion of Age 1+ fish in each 10 mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish, and is based on the following formula (Cochran 1977, Equation 5.60):

Equation 3

$$n_h = n\left(N_h\sqrt{p_h q_h} / \sum N_h\sqrt{p_h q_h}\right)$$

where

- n_h = number of scale samples selected for age determination from length group h,
- n = number of scale samples to be selected from the total of N fish caught,
- N_h = total number of fish caught in length group h,
- p_h = proportion of Age 1+ fish in length group h from the laboratory sample, and
- $q_h = 1 - p_h$

The stratified sampling plan was implemented using actual age-length frequency data from the 1989-90 study (NAI 1991). The stratified sampling program was designed to select approximately 15% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1989-90 were applied to the 1990-91 length-frequency data in three lots to permit scale analysis to proceed during the study. In each lot (12 November-30 December, 31 December-2 February and 2 February-20 April) scale samples from approximately 15% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1990-91 program was estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \Sigma(N_h p_{hi}/N) \qquad \text{Equation 4}$$

where

p_{sti} = the stratified mean proportion of Age i fish,
p_{hi} = the proportion of Age i fish in length group h, and
N_h and N are as defined in Equation 3.

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N(p_{sti}) \qquad \text{Equation 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch (s^2p_{sti}) was calculated by the method of Cochran (1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h^2(N_h - n_h)/(N_h - 1)][(p_{hi}q_{hi})/(n_h - 1)]\right] \quad \text{Equation 6}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977) Equations 5.14 and 5.15:

$$95\% \text{ CI for } p_{sti} = p_{sti} \pm t\, s_{p_{sti}} \quad \text{Equation 7}$$

$$95\% \text{ CI for } A_i = N\, p_{sti} \pm t\, s_{p_{sti}} \quad \text{Equation 8}$$

where

$$s_{p_{sti}} = \sqrt{s^2{}_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 4-7.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1990-91 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi} \, \bar{y}_{hi} \right] / N_i \qquad \text{Equation 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

n_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least two Age i fish were measured. If only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean.

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24 with the assumption that N_i is large and substantially larger than n_i, therefore $N_i^{-1} \simeq 0$ and $g'_i \simeq 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L} \left[w_{hi} (S^2_{hi} / n'_i V_{hi}) \right] + (1/n'_i) \sum_{h=1}^{L} w_{hi} (\bar{y}_{hi} - \bar{y}_{sti})^2 \qquad \text{Equation 10}$$

where

$S^2_{\bar{y}_{sti}}$ = Two-phase variance of the stratified mean length of striped bass of Age i,

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes Theorum presented in Equation 11,

S^2_{hi} = variance of the mean length of Age i fish in length group h of the laboratory sample,

n'_i = total number of Age i fish in the laboratory sample,

V_{hi} = proportion of Age i fish in length group h, and

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9.

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes Theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P(L_h \mid A_i) = [P(L_h)\, P(A \mid L_h)] / P(A_i) \qquad \text{Equation 11}$$

where

w_{hi} is as defined in Equation 10,

A_i = Age i striped bass,

$P(L_h)$ = proportion of the total catch of striped bass in length group h,

$P(A_i \mid L_h)$ = proportion of aged fish in length group h that are Age i, and

$P(A_i)$ = proportion of Age i fish in the total catch.

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ \text{CI for}\ \bar{y}_{sti} = \bar{y}_{sti} \pm t\, S_{\bar{y}_{sti}} \qquad \text{Equation 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2 \bar{y}_{sti}}$$

t = Student's t statistic for $\alpha = 0.05$ based on $n_i' - 1$ degrees of freedom (not the effective degrees of freedom), and

$\bar{y}_{sti}$ is as defined in Equation 9.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1990-91 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / (H_{ai} + W_{ai}) \qquad \text{Equation 13}$$

where

P_{ai} = the proportion of Age i hatchery striped bass in the population adjusted for tag loss and non-detection of tags,

H_{ai} = the number of Age i verified hatchery recaptures caught adjusted for tag loss and non-detection of tags, and

W_{ai} = the number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai}).

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and non-detection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1-TAG_i)(1-NDET) \right] \qquad \text{Equation 14}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

H_i = the number of Age i verified hatchery recaptures caught,

TAG_i = weighted, decimal percent 48-hour magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1), and

NDET = decimal percent non-detection rate for magnetic tags during the recapture program,

TABLE 2-1. FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOSS (TAG_i) AND NON-DETECTION OF TAGS (NDET) DURING 1990-91.[1]

COHORT	AGE	TAG_i	NDET
1990	0+	[a]	[a]
1989	1+	0.057	0.00038
1988	2+	0.017	0.00038
1987	3+	0.147	0.00038
1986	4+	0.075	0.00038
1985	5+	0.065	0.00038
1984	6+	0.276	0.00038

[a]Hatchery fish were not tagged prior to release in 1990.

= $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected.

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Section 1.0) was not adjusted for handling mortality (Dunning et al. 1989) because different lots of fish were held between 1 and 48 hours after tagging (EA 1989), and it was not possible to calculate an accurate mortality rate for each lot.

2.3.4 Population Movement

Two groups of fish were considered: (1) fish recaptured from previous programs (cross-year recaptures) and (2) fish caught, tagged, released and recaptured within the 1990-91 program (within-year recaptures). The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

Recapture rate = R_{ij}/M_{ij} Equation 15

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

M_{ij} = number of tagged striped bass released during time period (week) i in region j.

Recapture Proportion = R_{ij}/C_{ij} Equation 16

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j.

2.3.5 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i) with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals $(R_i/C_i - \beta M_i)$ are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$N = \Sigma(C_i M_i^2)/\Sigma(R_i M_i) \qquad \text{Equation 17}$$

where

N = estimated population size,

C_i = total catch during time interval i,

M_i = total number of marked fish available for recapture at the midpoint of time interval i, and

R_i = number of recaptured fish in C_i.

The variance of the reciprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\Sigma(R_i^2/C_i)-(\Sigma R_iM_i)^2/\Sigma(C_iM_i^2)}{m-1} \qquad \text{Equation 18}$$

where

S^2 = mean of squared deviations from the regression model described above,

m = the number of data points in the regression, and C_i, M_i and R_i are as defined above in Equation 17.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_iM_i^2 \times t_{m-1} \qquad \text{Equation 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and α=0.05.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.6 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish at-large one or two years was compared within cohort to growth from scale samples taken at the time of tagging (untagged fish) in the 1988-89, 1989-90 and 1990-91 programs.

We measured growth as the distance from the focus to each annulus along a radial line originating at the focus and running perpedicular to the anterior edge of the scale (radius measurement).

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9 M TRAWL

3.1.1 Catch Per Unit Of Effort

The 9 m trawl was fished in the Upper Harbor 3% of the time and in the Battery region of the lower Hudson River 97% of the time between 12 November 1990 and 20 April 1991. The mean CPUE for striped bass in the Upper Harbor region was approximately 2.1 times greater than the CPUE in the Battery region over all sampling weeks combined (Table 3-1). However, the standard error of the mean CPUE was greater in the Upper Harbor region due to small sample size and greater variability in catches. Mean CPUE exceeded 60 striped bass per ten minute tow during the week of 14 January 1991 in the Upper Harbor region and during the weeks of 24 December 1990 and 4 February 1991 in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 84.6 striped bass per ten minute tow in the Battery region during the week of 4 February 1991.

The highest CPUE was at river mile 3 of the Upper Harbor region (Appendix Table C-2). However, catches at this location were variable. Consistent high catches occurred at river miles 1 and 8 of the Battery region where 61% of the sampling took place.

Mean CPUE for the 9 m trawl in the Battery region increased annually between 1985-86 and 1989-90, and was comparable to 1988-89 in 1990-91 (Table 3-2). Mean CPUE in the 1989-90 program (45.3) was approximately 16% greater than the CPUE during the 1988-89 (38.9) program and 11% greater than in the 1990-91 (40.7) for similar time periods. Mean CPUE in the 1990-91 program was approximately 1.43 times the CPUE observed in the 1987-88 program, 3.35 times that observed in the 1986-87 program and 5.02 times that observed in the 1985-86 program, for comparable time periods. The increased CPUE observed during the 1988-89, 1989-90, and 1990-91 programs may be due to the complete recruitment

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

REGION	NUMBER OF TOWS[1]	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Upper Harbor	31	1,834	59.2	17.9
Battery	940	27,037	28.8	1.1

[1]Use Code = 1 tows only.

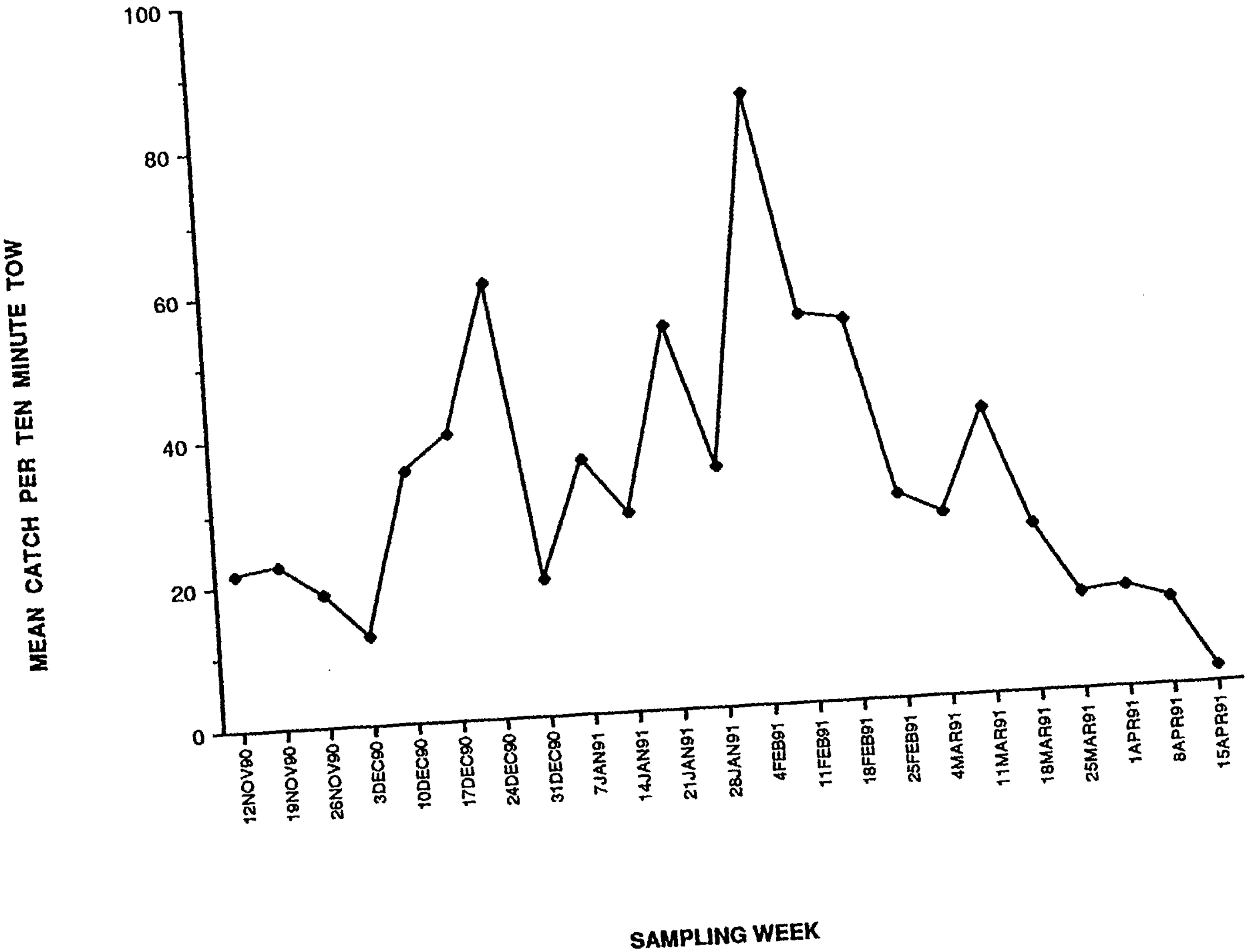


Figure 3-1. Mean catch per ten minute tow by a 9 m trawl in the Battery region of the Hudson River, 12 November 1990 through 20 April 1991.

TABLE 3-2. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1990-91.

YEAR	PERIOD	TOWS	MEAN CPUE	95% CI
1985-86	23 DEC 85 - 21 MAR 86	638	8.1	±1.0
1986-87	21 DEC 86 - 21 MAR 87	385	12.2	±1.2
1987-88	20 DEC 87 - 19 MAR 88	437	28.5	±2.5
1988-89	19 DEC 88 - 18 MAR 89	527	38.9	±3.3
1989-90	18 DEC 89 - 16 MAR 90	458	45.3	±4.3
1990-91	17 DEC 90 - 15 MAR 91	477	40.7	±3.5

of the numerically dominant 1987 and 1988 striped bass year classes to the 9 m trawl (CES 1989).

3.1.2 Length-Frequency Distributions

The mean length of striped bass caught by the 9 m trawl was 258 mm (Table 3-3). The mean length of striped bass caught in the 9 m trawl increased significantly ($p<0.001$) from 1989-90 to 1990-91. The length-frequency distribution for the 9 m trawl was: (1) skewed left, i.e., more fish were larger than the mean length than would be expected if the distribution was bell shaped, (2) leptokurtotic, i.e., more fish were found in length groups close to the mean length than would be expected if the distribution was bell-shaped, and (3) the length-frequency was bimodal with peaks in the 101-150 mm and 251-300 mm length groups (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 251-300 mm length group.

Weekly mean length of striped bass caught by the 9-m trawl was greater during the 18 week period beginning the week of 10 December 1990 and ending the week of 8 April 1991 than during the first four weeks and last week of the program (Appendix Table C-5). Weekly mean length was greatest during the week of 24 December 1990 (301 mm) and was smallest during the week of 15 April 1991 (183 mm).

Weekly changes in length frequency of striped bass, characterized by catch of striped bass per ten minute tow, indicated that fish less than 150 mm predominated early in the program and fish in the 201 through 350 mm length classes predominated after 10 December 1990 (Figure 3-3). During the weeks of 12 and 19 November, and 3 December 1991, the highest catch per tow occurred in length groups less than 150 mm. By the week of 10 December 1990 and continuing to the week of 8 April 1991, the highest catch per tow was in the 201 through 350 mm length

TABLE 3-3. DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

N	MEAN (mm)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
27,036	258	88.2	-0.04±0.03	0.61±0.06	57	916	Left skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Left skewness = Significant negative skewness indicating more striped bass were larger than the mean length than would be expected from a normal distribution.

Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.

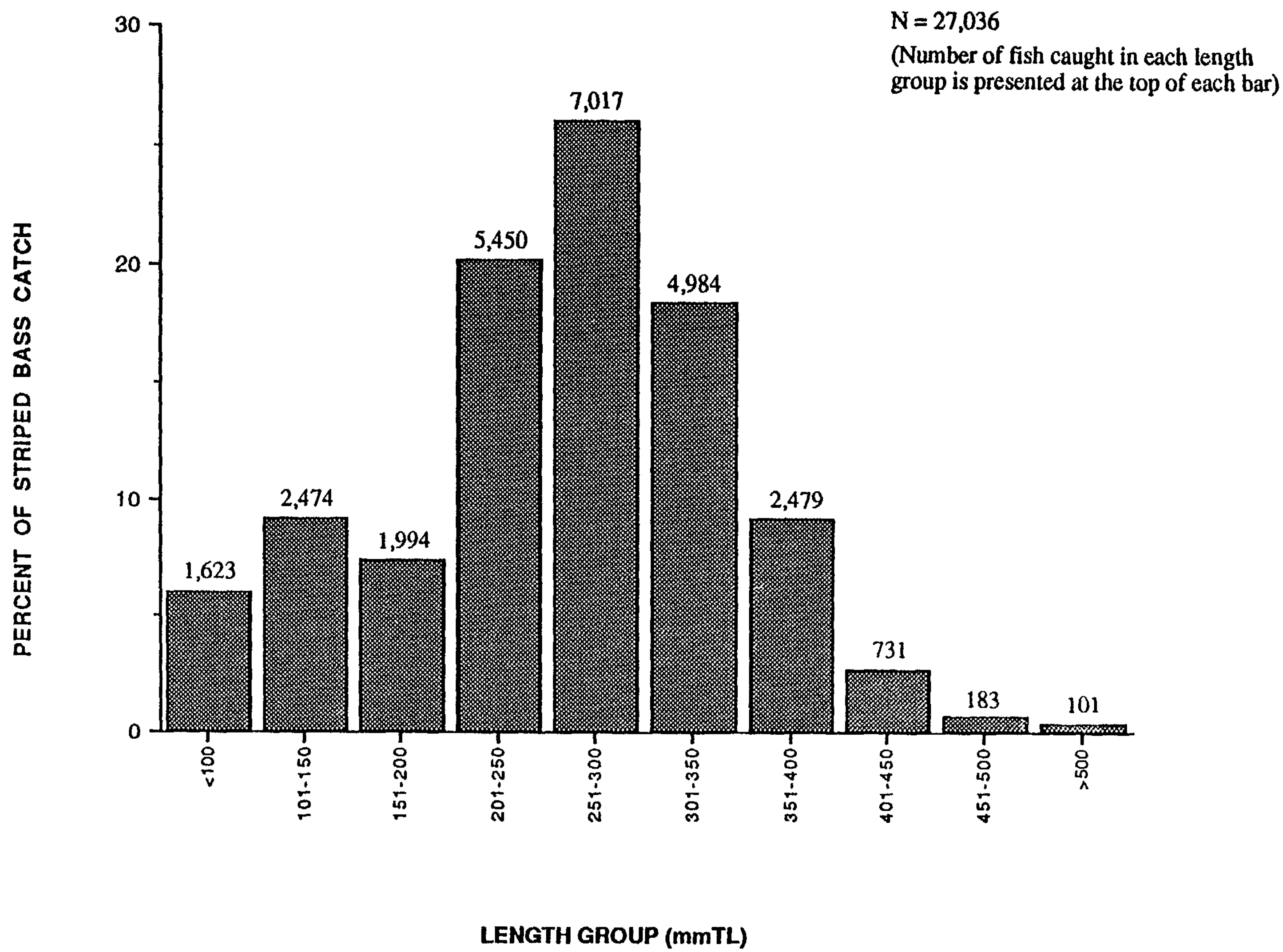


Figure 3-2. Length frequency distribution for striped bass captured by a 9m trawl in the Battery region of the Hudson River, 15 November 1990 through 19 April 1991.

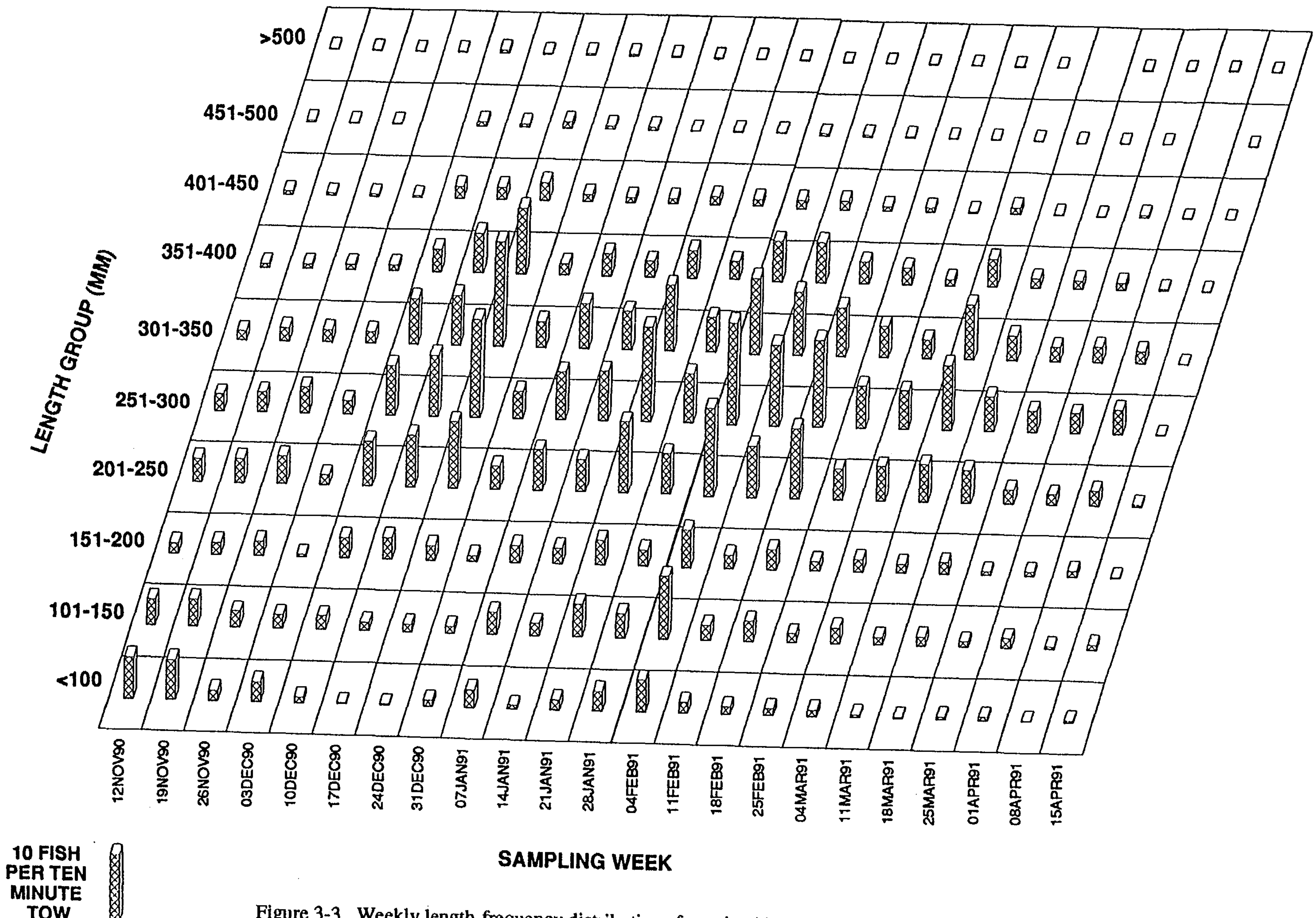


Figure 3-3. Weekly length-frequency distributions for striped bass caught per ten minute tow in a 9 m trawl in the Battery region of the Hudson River, 12 November 1990 through 20 April 1991.

groups. The highest catch per tow over all weeks was 16.3 in the 301-350 mm length group during the week of 24 December 1990. Fish in the 201 through 350 mm length classes were the primary constituents of the high overall catch per unit of effort observed during the weeks of 24 December 1990 and 4 February 1991.

The standardized length-frequency of striped bass captured during the winter of 1990-91 was bimodal with a minor peak in the 101-150 length group and the major peak in the 251-300 mm length group (Figure 3-4). Bimodal length frequencies previously occurred during the winters of 1987-88 and 1986-87. The smaller peak in the 101-150 mm length group probably represents the 1990 year class at age 0+ and the major peak at 251-300 probably represents the 1989 and 1988 year classes at ages 1+ and 2+ respectively.

3.1.3 Handling Mortality

Striped bass handling mortality in the 9 m trawl at bottom water temperatures from 3 to 16°C was less than 1% during 1990-91 (Table 3-4). A total of 61 striped bass died out of 26,378 fish caught in Use Code = 1 tows that had water temperature data associated with each tow. The highest handling mortality of 0.5% (9/1705) occurred at a bottom water temperature of 9°C. The relatively consistent, low handling mortality indicates there was no relationship between handling mortality and water temperature for the 9 m trawl over water temperatures of 3-16°C experienced in this study. The 1990-91 data were not examined for an interaction between water temperature, fish length and immediate handling mortality because this interaction was not significant in previous programs (Dunning et al. 1989).

Striped bass handling mortality in the 1990-91 program was uniformly low, and not significantly different from the mortality

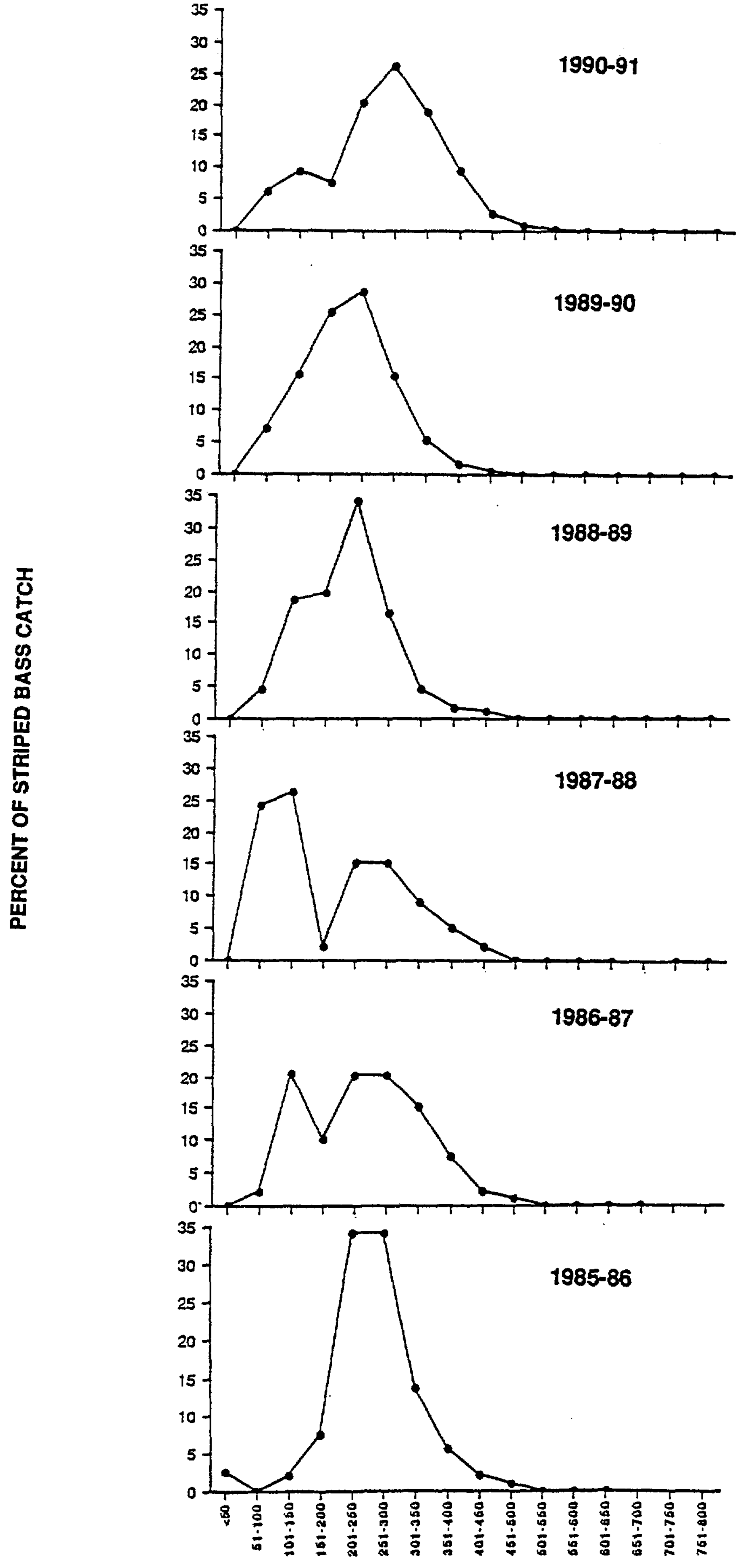


Figure 3-4. Standardized length frequency of striped bass captured by a 9 m trawl in the Battery region of the Hudson River, December through March of 1990-91, 1989-90, 1988-89, 1987-88, 1986-87 and 1985-86.

TABLE 3-4. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS IN A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO HUDSON RIVER BOTTOM WATER TEMPERATURE, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	NUMBER DEAD	TOTAL
3	0.0	0	219
4	0.1	1	1,802
5	0.1	6	6,816
6	0.1	7	5,076
7	0.5	22	4,750
8	0.5	10	2,141
9	0.5	9	1,705
10	0.2	2	1,312
11	0.3	3	919
12	0.1	1	823
13	0.0	0	299
14	0.0	0	313
15	0.0	0	53
16	0.0	0	150
3-16	0.2	61	26,378

observed in the 1985-86 through 1990-91 programs (Table 3-5), and approximately ten times less than that observed in the 1984 program (NAI 1985). The primary reasons for the decrease in handling mortality observed after 1984 are the use of a submerged holding facility and the increased tagging efficiency of field crews (Dunning et al. 1989). The holding facility used in the 1985-86 through 1990-91 programs permitted transfer of each catch from the cod end into the holding tank without having to lift both the net and fish out of the water, i.e., the fish remained in the water until they were individually removed and tagged. In contrast, during the 1984 program, the cod end of the net was lifted out of the water and fish were compressed by their weight in the air as they were transferred to the on-deck holding tanks. The increased tagging efficiency observed in the 1985-86 through 1990-91 programs contributed to decreased handling mortality by lessening exposure of striped bass to the air, thus reducing stress by returning tagged fish to the water quickly.

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

The 9 m trawl with 7.6 cm (stretch) mesh in the body and 3.8 cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1990-91 programs. Therefore, the striped bass catch by this 9 m trawl was used for comparisons of mean lengths at age among programs. At Age 0+, mean lengths for the 1987 (108 mm) and 1989 (112 mm) cohorts were smaller than for the 1986 (128 mm), 1988 (121 mm), and 1990 cohorts (119 mm) (Table 3-6; Appendix Table C-7). At Age 1+ the 1986 cohort had the largest mean length (253 mm) and the 1988 cohort (214 mm) had the smallest mean length. Mean lengths ranged between those values for the 1985 cohort (221), the 1987 cohort (227 mm), and the 1989 cohort (239 mm). At Age 2+ the 1985 cohort (317 mm), the 1986 cohort (325 mm), and the 1988 cohort (321 mm) had larger mean lengths than either the 1984 (299 mm) or the 1987 cohort (298 mm).

TABLE 3-5. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86, 1986-87 THROUGH 1990-91 HUDSON RIVER STRIPED BASS PROGRAMS.

	1985-1986		1986-1987		1987-1988		1988-1989		1989-1990		1990-1991	
BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N
0												
1	0.0	0/45	4.6	3/65	3.1	2/64			0.0	0/516		
2	0.5	4/856	0.6	5/773	0.3	7/2097	0.0	0/464	0.1	2/1696		
3	0.5	8/1489	0.6	8/1297	0.7	28/4295	0.1	3/5760	0.3	11/3721	0.0	0/219
4	1.4	21/1521	0.4	4/1002	0.4	13/3635	0.1	11/7503	0.1	1/692	0.1	1/1802
5	1.5	11/720	0.6	6/973	0.3	5/1818	0.4	27/6826	0.1	3/3918	0.1	6/6816
6	1.0	9/882	1.4	4/295	0.2	2/886	0.4	14/4360	0.1	7/7284	0.1	7/5076
7	2.0	8/403	0.7	4/602	0.3	4/1503	0.3	5/1984	0.0	0/2543	0.5	22/4750
8	1.2	5/423	0.3	1/373	0.1	2/1654	0.1	1/760	<0.1	1/3380	0.5	10/2141
9	3.3	17/521	0.0	0/79	0.2	2/829	0.0	0/726	0.1	1/1849	0.5	9/1705
10	15.4	2/13	10.7	3/28	0.0	0/363	0.0	0/1672	0.1	1/1455	0.2	2/1312
11	0.0	0/2	0.0	0/66	1.3	6/449	0.1	1/1042	0.1	1/707	0.3	3/919
12	3.1	4/130	0.0	0/5	0.0	0/160	0.2	1/430	0.0	0/447	0.1	1/823
13	1.6	5/309			0.0	0/176	0.0	0/41	0.1	1/1012	0.0	0/299
14					12.5	1/8	0.0	0/152	0.8	6/775	0.0	0/313
0-14	1.3	94/7314	0.7	38/5558	0.4	72/17937	0.2	63/31720	0.1	35/29995	0.2	61/26175

n = Number dead at a temperature for use code = 1 tows.
N = Total number caught at a temperature for use code = 1 town.

TABLE 3-6. MEAN LENGTH AT AGE FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS OF THE 1983 THROUGH 1990 COHORTS CAUGHT IN A 9 m TRAWL IN THE HUDSON RIVER, 1986-87 THROUGH 1990-91.

	STRATIFIED MEAN LENGTH (mm) AT AGE (±95% CONFIDENCE INTERVAL HALF-WIDTH)			
COHORT	0+	1+	2+	3+
1990[a]	119 (±3)			
1989	112 (±3)	239 (±2)		
1988	121 (±4)	214 (±1)	321 (±4)	
1987	108 (±4)	227 (±2)	298 (±3)	381 (±20)
1986	128 (±6)	253 (±2)	325 (±6)	382 (±20)
1985		221 (±6)	317 (±5)	396 (±18)
1984			299 (±6)	367 (± 8)
1983				369 (±16)

[a]Stratified mean length for the 1990 wild cohort of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be differentiated from wild fish.

There does not appear to be a consistent relationship among the 1984-89 cohorts in the relative ranking of mean length at Age 0+ and length at subsequent ages. Data from previous programs suggested that the relative ranking of mean lengths at Ages 0+, 1+, 2+, and 3+ for the 1983 through 1987 cohorts may be determined at Age 0+, and this ranking may persist as late as Age 3+ (NAI 1990a). However, data collected during the 1990-91 program do not completely support this hypothesis. The 1988 cohort was estimated to have a larger mean length than the 1987 cohort at Age 0+ (Table 3-6). However at Age 1+, these cohorts had reversed their relative rankings of mean length at age. The relationship reversed again by Age 2+, when the 1988 cohort again had a greater mean length than the 1987 cohort. The 1989 cohort had a shorter mean length at Age 0+ than the 1988 cohort, but at Age 1+ the 1989 cohort's mean length was much greater than that of the 1988 cohort.

Age-length frequency histograms, presented by 10 mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5) demonstrate minimal overlap in size of Age 0+ and Age 1+ striped bass caught during the 1990-91 program. Most of the fish in each length group ≤149 mm were Age 0+, while most of the fish in length groups between 150 and 269 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size primarily between 220 and 339 mm. Age 3+ striped bass overlapped with Age 2+ fish primarily between 350 and 449 mm.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-7). For the allocation of 4,558 scale samples actually selected, the precision based on 95% confidence limits was 1.7% corresponding to an error term of ±208 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than 10% of the total sample

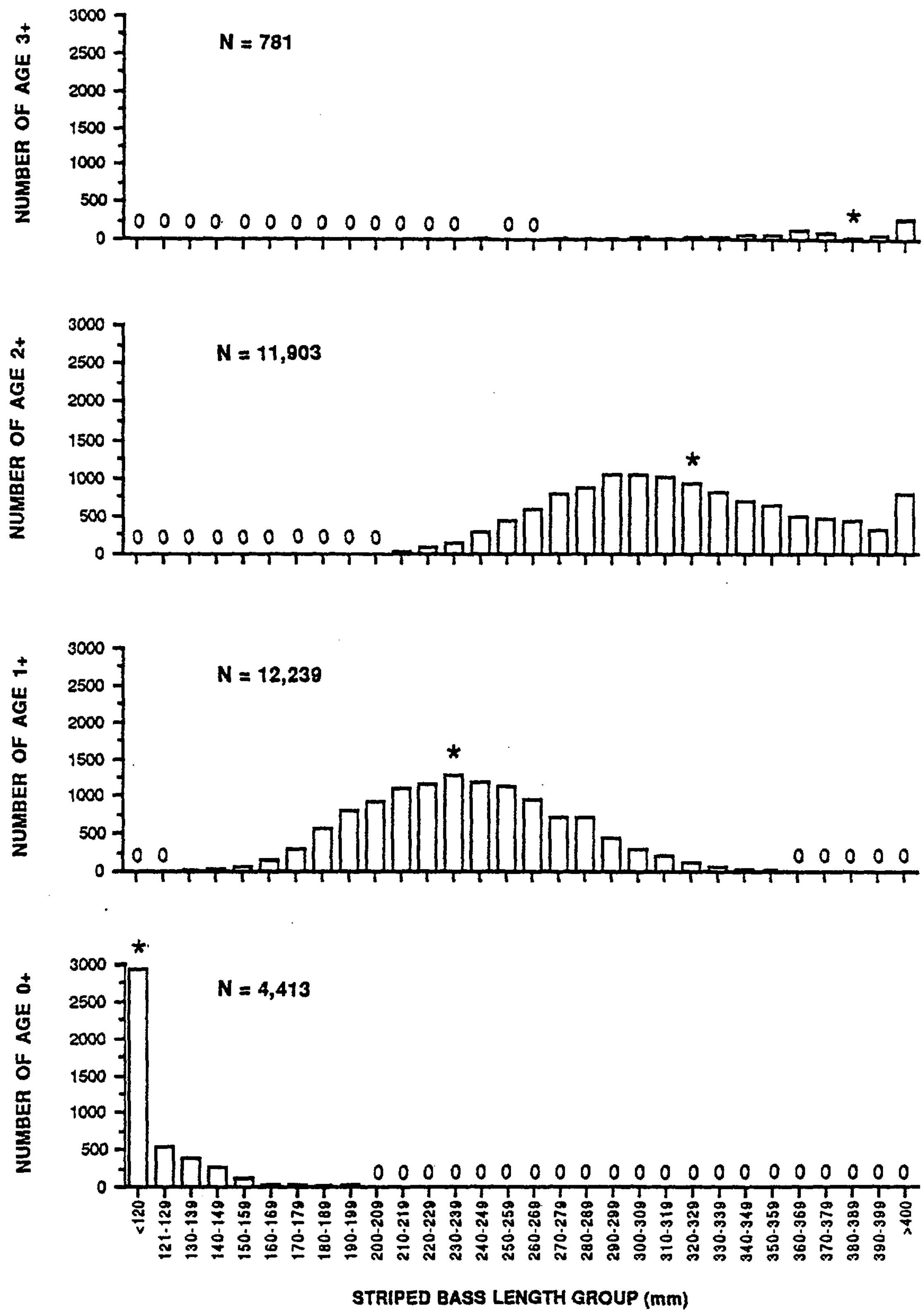


Figure 3-5. Length-frequency distributions for Age 0+, 1+, 2+ and 3+ striped bass captured by a 9 m trawl in the Hudson River, 12 November 1990 through 20 April 1991.

(Note: Length group which contains the stratified mean length at age is marked with an *.)

TABLE 3-7. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

		ESTIMATED NUMBER OF AGE 1+ FISH CAUGHT			
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL	LOWER 95%CI	UPPER 95%CI	PRECISION (%)[a]
500	0.417	12,239	11,562	12,915	5.5
1,000	0.417	12,239	11,772	12,705	3.8
2,000	0.417	12,239	11,920	12,557	2.6
3,000	0.417	12,239	11,986	12,491	2.1
4,000	0.417	12,239	12,027	12,450	1.7
4,558[b]	0.417	12,239	12,031	12,446	1.7
5,000	0.417	12,239	12,056	12,421	1.5
6,000	0.417	12,239	12,078	12,400	1.3

[a] Precision = 95% confidence interval (CI) half width/stratified total x 100.

[b] Results for sample size = 4,558 are based on actual allocations which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

(29,346 fish in 1990-91). For example, doubling the number of striped bass scale samples examined for age determination from 2,000 to 4,000 would only result in 1.4% improvement in the precision (Table 3-7). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (12,239) out of the 29,346 fish caught during 1990-91 could be estimated with 95% confidence limits of ± 677 fish (precision = 5.5%, Table 3-7).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10 mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 2+ striped bass (Table 3-8), which collectively comprised 97.1% of the fish caught in this program. Only 781 of the striped bass caught were estimated to be Age 3+ and 74 of the fish caught were older than Age 3+ in the 1990-91 program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1989 cohort of Age 1+ striped bass was approximately 42% of the total catch during 1990-91. The numbers of Age 2+ and Age 3+ striped bass were estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ and Age 3+ was wider, and the sample size was smaller for these fish. The large 1988 cohort of Age 2+ striped bass was about 41% of the total catch in 1990-91 and was the highest proportion of Age 2+ observed in any striped bass program to date. The 1987 cohort of Age 3+ striped bass was about 3% of the total catch in 1990-91.

TABLE 3-8. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

			ESTIMATED NUMBER OF FISH CAUGHT			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	PRECISION (%)
0+	1990	0.148	4,349	4,285	4,413	1.5
1+	1989	0.417	12,239	12,031	12,446	1.7
2+	1988	0.406	11,903	11,607	12,198	2.5
3+	1987	0.027	781	571	992	26.9

[a]based on a laboratory sample of scales from 4,558 fish.

3.3 STRIPED BASS HATCHERY PROPORTION

Striped bass stocked in the Hudson River from the Verplanck hatchery accounted for 0.2% of the Age 1+ and Age 2+ cohorts, and 0.1% of the Age 3+ cohort of fish caught during the winter of 1990-91 (Table 3-9). Comparing 95% confidence limits about the hatchery proportion of striped bass among cohorts indicated the proportion of Age 1+ hatchery fish was not significantly higher than Age 2+. The proportion of Age 2+ was not significantly higher than Age 3+. The 1987, 1988, and 1989 wild cohorts were each relatively strong (CES 1989, 1991 draft) and this probably resulted in the relatively low hatchery proportion for Age 1+, 2+, and 3+ striped bass during the 1990-91 study. Hatchery fish were not tagged in 1990.

Comparison of estimated hatchery proportions for the 1985 through 1988 hatchery cohorts caught in 1986-87 through 1990-91 suggested that the hatchery proportion for each cohort caught prior to the 1989-90 program doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990a; this report Table 3-10). However, this trend was not continued in 1989-90 or 1990-91; the 1987 cohort had an estimated hatchery proportion of 0.2% at Age 1+ in 1988-89 and was reduced significantly to 0.1% at Age 2+ in 1989-90. Similarly, the 1988 cohort had an estimated hatchery proportion of 0.4% at Age 1+ in 1989-90 and was reduced significantly to 0.2% at Age 2+ in 1990-91. In prior programs, the 1985 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1986-87 and 3.1% at Age 2+ in 1987-88. The 1986 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1987-88 and 3.5% at Age 2+ in 1988-89.

The hatchery proportions estimated for the 1987 and 1988 cohorts during the 1988-89, 1989-90, and 1990-91 programs did not substantiate the pattern of doubling that was observed for the 1985 and 1986 cohorts between Age 1+ and Age 2+. Prior to the 1989-90 program, the hatchery proportion for each cohort remained constant as the cohort

TABLE 3-9. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

STATISTIC	COHORT		
	1989	1988	1987
Age	1+	2+	3+
Total Hatchery Stocking (N_i)	202,068	48,611	324,579
Hatchery Recaptures (H_i)	27	24	1
Adjusted Hatchery Recaptures (H_{ai})	29	24	1
Wild Fish Examined (W_{ai})	12,210	11,879	780
Estimated Hatchery Proportion ($H_{ai}/(H_{ai}+W_{ai})$)	0.0024	0.0020	0.0013
Lower 95% C.I.	0.0015	0.0012	0.0000
Upper 95% C.I.	0.0035	0.0031	0.0098

increased in age from Age 0+ to Age 1+, and from Age 2+ to Age 3+ (Table 3-10). No Age 3+ hatchery striped bass were caught during 1989- 90. However, during 1990-91, the 1987 cohort of hatchery fish increased between Age 2+ and Age 3+ (Table 3-10). Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 1+ 1988 cohort to 0.2% for Age 3+ fish from the 1987 cohort (Table 3-11).

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

In this section, the size range, distribution and recapture patterns of recaptured striped bass are described. During the 1990-91 program, recaptures were made of 52 hatchery striped bass which were tagged with a CWT and 865 wild striped bass that were individually tagged with our internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1990-91 winter sampling program, 27 Age 1+, 24 Age 2+ and 1 Age 3+ hatchery striped bass were caught. The 1990 cohort of Age 0+ hatchery striped bass were not tagged. One hatchery striped bass 365 mm long was recaptured on 28 March 1991 in the Battery region at River Mile 2. This fish was tagged at the U.S. Fish and Wildlife Service Hatchery in Virginia.

TABLE 3-10. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1990-91.

		ESTIMATED PROPORTION WITH LOWER OR UPPER 95% CONFIDENCE LIMITS														
			1986-87			1987-88			1988-89			1989-90			1990-91	
COHORT	NUMBER STOCKED	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER	LOWER	ESTIMATE	UPPER
1989	202,068										0.0049	0.0068 (46)	0.0091	0.0015	0.0024 (27)	0.0035
1988	48,611							0.0127	0.0155 (120)	0.0187	0.0034	0.0043 (92)	0.0054	0.0012	0.0020 (24)	0.0031
1987	324,579				0.0015	0.0023 (25)	0.0033	0.0014	0.0020 (39)	0.0027	0.0002	0.0010 (3)	0.0027	0.0000	0.0013 (1)	0.0098
1986	529,563	0.0110	0.0152 (38)	0.0204	0.0137	0.0165 (127)	0.0196	0.0245	0.0353 (48)	0.0500						
1985	284,578	0.0126	0.0170 (51)	0.0225	0.0240	0.0311 (82)	0.0399	0.0075	0.0236 (6)	0.0645						
1984	147,153	0.0005	0.0014 (5)	0.0029	0.0011	0.0034 (4)	0.0081	0.0000	0.0056 (0)	0.0514						

TABLE 3-11. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1990-91, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH.

		ESTIMATED PROPORTION WITH LOWER OR UPPER 95% CONFIDENCE LIMITS														
COHORT	NUMBER STOCKED	LOWER	1986-87 ESTIMATE	UPPER	LOWER	1987-88 ESTIMATE	UPPER	LOWER	1988-89 ESTIMATE	UPPER	LOWER	1989-90 ESTIMATE	UPPER	LOWER	1990-91 ESTIMATE	UPPER
1989	202,068										0.0165	0.0198 (46)	0.0235	0.0055	0.0070 (27)	0.0088
1988	48,611							0.1541	0.1630 (120)	0.1723	0.0477	0.0509 (92)	0.0543	0.0211	0.0243 (24)	0.0279
1987	324,579				0.0031	0.0042 (25)	0.0055	0.0030	0.0038 (39)	0.0048	0.0006	0.0017 (3)	0.0037	0.0002	0.0026 (1)	0.0127
1986	529,563	0.0126	0.0171 (38)	0.0226	0.0158	0.0187 (127)	0.0220	0.0282	0.0398 (48)	0.0554						
1985	284,578	0.0286	0.0353 (51)	0.0432	0.0526	0.0634 (82)	0.0761	0.0221	0.0493 (6)	0.1062						
1984	147,153	0.0038	0.0058 (5)	0.0084	0.0080	0.0135 (4)	0.0218	0.0043	0.0222 (0)	0.0913						

[a]Estimated hatchery proportion scaled up to the proportion expected of 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula:

$$\left[H_{ai} \times 600000/N_i\right] / \left[(H_{ai} \times 600000/N_i) + W_i\right]$$

3.4.1.1 Length

The 1990 hatchery cohort was not tagged prior to stocking. Therefore, it is not possible to compare mean length at age between the hatchery and wild 1990 cohorts, and the stratified mean length presented for wild fish in Table 3-12 represents hatchery and wild fish combined.

The 1989 hatchery cohort when recaptured at Age 0+ during the 1989-90 program was significantly larger than the 1989 wild cohort (NAI 1991). Hatchery striped bass stocked in the fall were significantly larger than fish stocked in the summer, and a disproportionate number of fall-stocked striped bass were recaptured compared to summer-stocked fish (NAI 1991). Age 0+ striped bass were not fully recruited to the 9 m trawl used in this program. Because of incomplete recruitment to the sampling gear, these observations were better evaluated for the 1989 cohort of Age 1+ fish caught during 1990-91.

At Age 1+, this trend continued as mean length for recaptured striped bass from the 1989 hatchery cohort was significantly larger than mean length for the 1989 wild cohort (Table 3-12). Fall-stocked striped bass from the 1989 hatchery cohort were significantly larger than summer stocked striped bass when recaptured, and fall-stocked striped bass were preferentially recaptured (Table 3-13). The larger mean length of the 1989 hatchery cohort compared to the wild cohort at Ages 0+ and 1+ was probably due to the larger size of the hatchery fish at the time of stocking (Table 3-14). The larger size and recovery proportions for the fall-stocked fish when recaptured at Ages 0+ and 1+ may be due to the large size at which these fish were stocked. Fall-stocked fish from the 1989 hatchery cohort were the largest striped bass stocked in the Hudson River from the Verplanck Hatchery.

Differential survival or differential behavior of stocking groups best explains the disproportionally large numbers of fall-stocked 1989 hatchery striped bass captured at Ages 0+ and 1+. If survival was significantly lower for the summer-stocked striped bass compared to the

TABLE 3-12. COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+, 1+, 2+, AND 3+ WILD AND HATCHERY STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER 95% CI	UPPER 95% CI	N	MEAN (mm)	LOWER 95% CI	UPPER 95% CI
0+	1990[a]	206	118.7	115.8	121.6	-	-	-	-
1+	1989	2,174	238.9	237.2	240.6	27	245.4	229.5	261.3
2+	1988	2,109	320.8	317.3	324.3	24	310.9	290.4	331.4
3+	1987	69	380.6	359.9	401.3	1	350.0	-	-

[a] The stratified mean length for the 1990 wild cohort of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be differentiated from wild fish.

TABLE 3-13. MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM, WINTERS OF 1988-89, 1989-90 AND 1990-91.

		RECAPTURE STATISTICS FOR HATCHERY STRIPED BASS AT AGE								
		AGE 0+			AGE 1+			AGE 2+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_2)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_2)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_2)	MEAN LENGTH (mm)	RECOVER PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052
1989	Verplanck Fall[3]	13	124	0.00007	5	215	0.00003			
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104			

[1]1988 Attleboro fall number stocked (H_1) = 10,057 at 80-84 mm modal length class.
[2]1988 Verplanck fall number stocked (H_1) = 38,554 at 139 mm mean length.
[3]1989 Verplanck summer number stocked (H_1) = 179,219 at 105 mm mean length.
[4]1989 Verplanck fall number stocked (H_1) = 21,196 at 152 mm mean length.

TABLE 3-14. DIFFERENCES IN MEAN LENGTH AT TIME OF STOCKING FOR SAMPLES OF THE 1987, 1988 AND 1989 HATCHERY AND WILD STRIPED BASS COHORTS IN THE HUDSON RIVER.

		HATCHERY FISH			WILD FISH			
COHORT	DATE	n	MEAN LENGTH	STANDARD DEVIATION	n	MEAN LENGTH	STANDARD DEVIATION	p
1989	20-26 Aug	248	97	8.8	152	68	12.0	<0.001
	27 Aug-2 Sep	393	105	11.0	110	73	12.3	<0.001
	3-9 Sep	298	112	11.9	140	71	11.5	<0.001
	22-28 Oct	100	152	10.9	54	90	15.7	<0.001
1988	23-29 Oct	68	139	14.8	101	89	16.8	<0.001
1987	9-15 Aug	92	77	4.6	151	60	11.9	<0.001

fall-stocked striped bass, a proportionally greater number of fall stocked striped bass would be available for capture during the winter of 1990-91. If the two stocking groups had a different distribution in the lower estuary at Ages 0+ and 1+, it is possible that the fall-stocked striped bass inhabited an area where the majority of our sampling effort was concentrated.

Gear selectivity does not explain the disproportionally large numbers of recaptured, fall-stocked striped bass at Age 1+. Striped bass greater than 110 mm are fully recruited to the 9 m trawl used in this program (NAI 1990a). Mean lengths and their lower 95% confidence intervals of all hatchery and wild cohorts were significantly greater than 110 mm at Age 1+ (Table 3-15).

The 1988 hatchery cohort was significantly larger at Ages 0+ and 1+ than the wild cohort at the time of recapture (Table 3-15). At Age 2+, the 1988 wild cohort was significantly larger at the time of recapture. The size differences between wild and hatchery fish at the time of recapture at Ages 0+ and 1+ are probably due to the high recovery proportion of Verplanck hatchery fish which were larger than wild fish at the time of stocking (Table 3-13 and 3-14). Two groups of hatchery striped bass were stocked between 30 September and 4 November 1988. The first group of 38,554 fish were spawned and reared at the Verplanck Hatchery and stocked into the Hudson River between 30 September and 4 November at a mean length of 139 mm (Table 3-13). These fish were significantly larger ($p<0.001$) than wild fish at the time of stocking (Table 3-14). The second group of 10,057 fish were spawned at the Verplanck Hatchery and reared in outdoor pools at the Attleboro Hatchery. These Attleboro Hatchery fish were stocked to the Hudson River at a modal size of 80-84 mm (mean length not available) between 28 October and 4 November, which was smaller than the wild cohort at the time of stocking. The significantly smaller mean length at recapture of Age 2+ hatchery fish compared to wild fish of the 1988 cohort maybe due to recovery of a higher proportion of small Age 2+ fish from the Attleboro fall stocking group compared to Age 2+ fish from the Verplanck

TABLE 3-15. MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1990 HATCHERY AND WILD STRIPED BASS COHORTS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER.

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	S.D.	n	MEAN LENGTH (mm)	S.D.	n	MEAN LENGTH (mm)	S.D.	n	MEAN LENGTH	S.D.
1984	Hatchery							5	280	46.7	2[b]	349	44.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				51	205*	21.2	58	286*	41.4	6	364	39.0
	Wild				285	221*	3.0	514	317*	2.7	57	396	4.4
1986	Hatchery	38	108*	15.1	96	220*	26.6	48	315	36.2	--		
	Wild	83	128*	2.9	1,503	253*	1.2	361	325	0.5	55	382	10.1
1987	Hatchery	20	108	27.9	39	207*	32.6	3	290[b]	27.7	1[b]	350	--
	Wild	190	108	2.1	3,623	227*	0.1	1,216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	19.1	92	219*	35.4	24	311*	48.7			
	Wild	100	121*	0.9	3,514	214*	0.7	2,109	321*	1.8			
1989	Hatchery	46	138*	13.8	26	245*	40.4						
	Wild	368	112*	1.6	2,174	239*	0.9						
1990[c]	Hatchery	--											
	Wild	206	119	1.5									

*Indicates a significant ($p < 0.05$) difference in mean length between the hatchery and wild cohorts within an age class.
[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.
[b]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size hatchery striped bass.
[c]The mean length reported for the 1990 wild cohort of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be differentiated from wild fish.

fall stocking group. For the striped bass recovered from the 1988 hatchery cohort, 7.5% (9/120) of the Age 0+ and 6.5% (6/92) of the Age 1+ fish were from the Attleboro fall stocking group, compared to 16.7% (4/24) of the Age 2+ fish (Table 3-13).

Mean length of the 1987 hatchery cohort was not significantly different from the wild cohort at Age 0+. However, at Age 1+ the wild cohort was significantly larger (Table 3-15). This pattern contrasts with the length relationships at the time of stocking. A total of 324,579 fish were stocked from the Verplanck hatchery between 31 July and 25 September 1987. The mean length of a subsample of hatchery fish at the time of stocking on 10 August was 77 mm. The mean length of wild fish during the week of 10 August was significantly smaller than the hatchery fish at the time of stocking (Table 3-14). This growth pattern would be expected if growth of summer stocked fish is slower than wild fish.

The 1986 hatchery cohort was significantly smaller at Age 0+ and 1+ compared to the wild cohorts at the same ages and the 1985 hatchery cohort was smaller at Ages 1+ and 2+ compared to the wild cohort (Table 3-15). No data are available on the mean lengths of the 1986 and 1985 hatchery cohorts at the time of stocking.

3.4.1.2 Magnetic Tag Detection Efficiency

During the 1990-91 program, 29,346 striped bass were examined using the field magnetic tag detectors. Of these fish, 61 were classi-ied as suspected Hudson River hatchery striped bass and 52 were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Eight fish suspected of having CWTs from the Verplanck hatchery did not have CWTs. One additional fish had a CWT from a Virginia hatchery. Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990).

Striped bass caught during the 1990-91 program were double-checked for CWTs with two "V-shaped" detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Striped bass that did elicit a response from the first detector were not passed through the second detector. One fish with a CWT out of 52 tagged fish escaped detection with the first detector. Therefore, the best estimate of the non-detection rate during the 1990-91 program is $(1/51)^2$ or 0.038%, which was used to adjust the number of hatchery recaptures. In 1989-90, the nondetection rate was 0.047% (NAI 1991). In 1988-89, the non-detection rate was 1.9% based on the use of a "tube" shaped detector in series with a V-shaped detector on about 10% of the sampling days. In 1986-87, 2 out of 15 CWT-tagged fish escaped detection for a nondetection rate of 13.3%. No fish escaped detection in 1987-88. The average nondetection rate of CWTs for the studies prior to 1988-89 was 2/26 or 7.7%. The tube-shaped detector was not used after 1988-89 because we found it to be unreliable as a field instrument (NAI 1991).

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1990-91 winter sampling program, 635 striped bass were recaptured out of 22,406 fish that were caught, tagged with internal anchor tags, and released. A complete description of the number of fish caught, tagged with different types of internal anchor-external streamer tags since 1984, and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchors were applied during the 1990-91 program.

An additional 230 striped bass were recaptured with internal anchor tags implanted during previous programs, 81 fish were recaptured with suspected tag wounds, 3 fish were recaptured with illegible tag numbers, and 19 fish were recaptured with tags from other tagging studies. These groups of wild striped bass are described below in separate sections.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1990-91 Winter Program

Nearly all (92%) of the taggable-size (≥150 mm) striped bass (25,183) were caught in the Battery region as were all but 21 of the 635 fish tagged, released and recaptured during this study (Table 3-16, Appendix Table D-2). This is not surprising since most (97%) of the trawl sampling effort was allocated to the Battery during 1990-91 based on the high CPUE in this region during previous programs (NAI 1986, 1987, 1988, 1990a, 1991).

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-16, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 576/20,614 or 0.02794. The recapture rate for striped bass tagged and released throughout the study area and recaptured in the Battery (column total) was 587/22,406 or 0.02620.

In contrast, recapture proportions (R/C) from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-16, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 576/23,279 or 0.02474. The recapture proportion for striped bass from the entire study area that were recaptured in the Battery (row total) was 614/23,279 or 0.02638. It is generally

TABLE 3-16. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

			NUMBER OF RECAPTURES* FROM RELEASE REGION		
RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	UPPER HARBOR (M=1,792)	BATTERY (M=20,614)	TOTAL (M=22,406)
UPPER HARBOR	1,904	R	10	11	21
		R/M	0.00558	0.00053	0.00094
		R/C	0.00525	0.00578	0.01103
BATTERY	23,279	R	38	576	614
		R/M	0.02121	0.02794	0.02740
		R/C	0.00163	0.02474	0.02638
TOTAL	25,183	R	48	587	635
		R/M	0.02679	0.02848	0.02834
		R/C	0.00191	0.02331	0.02522

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

most informative to examine recapture rates from the column totals and recapture proportions from the row totals since these statistics best describe specific movement among regions (or time periods).

Examination of monthly recapture rates (R/M) and recapture proportions (R/C) can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (R/M column totals; Table 3-17) were highest for fish tagged in November 1991 at 0.10856, and decreased monthly throughout the program to a low of 0.00625 in April 1991. Monthly recapture proportions (R/C row totals) decreased between November and December 1990, remained stable between December 1990 and March 1991, and increased between March and April 1991 (Table 3-17). This pattern of decreasing monthly recapture rates and stable monthly recapture proportions from December through March contrasts to the patterns in these statistics observed in the 1985-86, 1986-87, 1987-88, 1988-89, and 1989-90 studies (NAI 1986, 1987, 1988, 1990a, 1991), and suggests a different temporal pattern of movement compared with previous years.

Striped bass tagged and released in the combined Battery and upper New York harbor regions, and subsequently recaptured in those regions were at large an average of 22 days and ranged in size between 142 mm and 470 mm (Table 3-18). Approximately 31% (195/635) of the striped bass were recaptured on the same day as they were tagged and released, and 70% (445/635) of the fish were recaptured within 30 days of release (Table 3-18), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 97% (615/635) of the striped bass were recaptured, and the maximum days at large was 144 days. Days at large and recapture length data for the 1990-91 program were similar to previous years (NAI 1987, 1988, 1990a, 1991).

TABLE 3-17. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

			NUMBER OF RELEASES IN MONTH*						
RECAPTURE MONTH	NUMBER CAUGHT (C)	STATISTIC	NOV M = 1586	DEC M = 2969	JAN M = 6675	FEB M = 6913	MAR M = 3303	APR M = 960	TOTAL M = 22406
NOVEMBER	1780	R	100						100
		R/M	0.06305						0.06305
		R/C	0.05618						0.05618
DECEMBER	3365	R	25	63					88
		R/M	0.01576	0.02122					0.01932
		R/C	0.00743	0.01872					0.02615
JANUARY	7253	R	22	27	107				156
		R/M	0.01387	0.00909	0.01603				0.01389
		R/C	0.00303	0.00372	0.01475				0.02151
FEBRUARY	7685	R	13	21	57	66			157
		R/M	0.00820	0.00707	0.00854	0.00955			0.00865
		R/C	0.00169	0.00273	0.00742	0.00859			0.02043
MARCH	3950	R	7	11	30	27	17		92
		R/M	0.00441	0.00370	0.00449	0.00391	0.00515		0.00429
		R/C	0.00177	0.00278	0.00759	0.00684	0.00430		0.02329
APRIL	1150	R	5	2	8	15	6	6	42
		R/M	0.00315	0.00067	0.00120	0.00217	0.00182	0.00625	0.00187
		R/C	0.00435	0.00174	0.00696	0.01304	0.00522	0.00522	0.03652
TOTAL	25183	R	172	124	202	108	23	6	635
		R/M	0.10845	0.04176	0.03026	0.01562	0.00696	0.00625	0.02834
		R/C	0.00683	0.00492	0.00802	0.00429	0.00091	0.00024	0.02522

*Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

TABLE 3-18. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE HUDSON RIVER BY A 9 m TRAWL, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

STATISTIC		RELEASED WITHIN THE 1990-91 PROGRAM 9 m TRAWL
NUMBER TAGGED (≥150 mm)	M	22,406
NUMBER EXAMINED FOR TAGS (≥150 mm)	C	25,183
NUMBER RECAPTURED	R	635
SIZE RANGE OF RECAPTURED FISH (mm)	Min	142
	Max	470
	Mean	262
	S.D.	55
DAYS AT LARGE	Min	0
	Max	144
	Mean	22
	S.D.	29
FREQUENCY OF DAYS AT LARGE	0 Days	195
	1-5 Days	96
	6-10 Days	49
	11-20 Days	57
	21-30 Days	48
	31-40 Days	49
	41-50 Days	40
	51-60 Days	33
	61-70 Days	16
	71-80 Days	19
	81-90 Days	10
	91-100 Days	8
	101-110 Days	3
	111-120 Days	6
	121-130 Days	2
	131-140 Days	3
	141-150 Days	1

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1990-91 Winter Program

Among the 230 striped bass recaptured during 1990-91 with internal anchor tags identified from previous programs, 16 were caught in the Upper Harbor and 214 were caught in the Battery region (Appendix Table D-3). The 230 striped bass recaptured from previous programs is the highest total number observed to date, and probably represents accumulation of a large number of fish tagged in recent years. In 1988-89, 53 striped bass from previous programs were recaptured (NAI 1990a), while in 1989-90 (NAI 1991) 72 fish from previous programs were recaptured. All of these 230 recaptured striped bass had the external portion of the tag (streamer) present. Among the 230 striped bass with streamers intact, nearly all (228) fish had tags with completely legible numbers (Table 3-19). Only two fish were observed with abraded but legible tags, and an additional fish had partly or completely missing tag numbers due to abrasion (Table 3-19, Appendix Table D-5). The three fish with abraded tags all had the Floy internal anchor tag (MARK_CD=96, Figure 2-2) that was used prior to 1988-89 (Appendix Table D-8). An additional 81 fish were observed with suspected tag wounds but no tag present (Table 3-19). Nine of these fish with suspected tag wounds had Hallprint (MARK_CD=98) anchors containing the tag number. The remaining 72 fish either had the tag and anchor removed by sportsmen, had wounds unrelated to tagging, or had shed the tag.

Tag numbers were defined as completely illegible if one or more of the 5-digit tag number could not be read in the field. Tag abrasion was first observed during 1986-87, is time dependent, and requires at least six months to be observed (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged at large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990a). Changes in tag design since 1986-87 have virtually eliminated tag abrasion. Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used: abrasion was observed in 28% of the recaptured fish at large for at least six months (Mattson et al. 1990). During the

TABLE 3-19. INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH* 1988-89	1989-90	1990-91
Tag number completely legible	Healed	34	63	206
	Infected	13	6	22
	Anchor Protruding	(5)	(0)	(6)
		47	69	228
Tag number abraded but legible	Healed	3	2	2
	Infected	3	1	0
	Anchor Protruding	(1)	(0)	(0)
		6	3	2
Tag number partly or completely missing and not legible	Healed	0	0	1
	Infected	0	0	0
	Anchor Protruding	(0)	(0)	(0)
		0	0	1
Suspected tag wound, tag and anchor missing	Healed	4	6	69
	Infected	0	0	3
		4	6	72
Suspected tag wound, anchor present	Healed	2	0	9
	Infected	0	0	0
		2	0	9

*striped bass which could be cross-classified by degree of tag number, abraision and condition of the tag insertion site.

1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but short length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990a). Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was displaced out of the fish and shed.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a shedding rate for the original Hallprint tag with an exposed filament of 22/94 or 23%. Among the 81 fish with suspected tag wounds caught during the 1990-91 program, six fish had a longitudinal scar suggesting they may have shed a tag, and none of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has virtually eliminated tag loss due to shedding.

Among the 230 striped bass recaptured from previous programs during 1990-91 were 209 fish that had been tagged and released during 1989-90, 20 recaptured fish were tagged and released during 1988-89, and the remaining one fish was tagged and released during 1987-88 (Table 3-20, Appendix Table D-3). All fish released during 1988-89, and 1989-90 were from the 9 m trawl, which was the only gear used. The one striped bass recaptured from 1987-88, was released from the 12 m trawl with 9 m trawl cod-end. Recaptured fish were at large between 233 and 1,169 days, and ranged in length between 208 mm and 531 mm (Table 3-21). Two striped bass that were double tagged with both an internal anchor tag and a dart tag were recaptured during 1990-91. Three fish that were double tagged were recaptured with the dart tag missing.

Nineteen striped bass were recaptured in 1990-91 with tags originating from other tagging programs (Table 3-22). Four fish were recaptured with U.S. Fish and Wildlife Service internal anchor tags and 15 fish were recaptured with Littoral Society spaghetti tags. One of these Littoral Society recaptures had an illegible tag number and we removed the tag. The remaining 18 fish were returned to the river without removing the tag.

3.4.2.3 Effects of the Internal Anchor Tag on Striped Bass Growth

Growth based on focus to annulus (radius) measurements for scale samples from tagged striped bass that had been at-large one or two

TABLE 3-20. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED(R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH			
					MIN	MAX	MEAN	S.D.
1989-90	9 m trawl	24,362	209	0.00858	208	442	301	42
1988-89	9 m trawl	24,393	20	0.00082	273	531	393	64
1987-88	9 m trawl	7,582	0	0.00000				
	12 m trawl with 9 m trawl cod end	4,854	1	0.00021	460	460	460	
1987-88	TOTAL	12,436	1	0.00008				

TABLE 3-21. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED BY GEAR PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

STATISTIC		RELEASED PRIOR TO 12 NOVEMBER 1990 IN GEAR	
		9 m TRAWL[a]	12 m TRAWL WITH 9 m TRAWL COD END[b]
TOTAL NUMBER TAGGED	M	66,427	4,854
NUMBER AGE 2+ OR OLDER EXAMINED FOR TAGS	C	12,758	12,758
NUMBER RECAPTURED	R	229	1
RECAPTURE RATE	R/M	0.00345	0.00021
RECAPTURE PROPORTION	R/C	0.01795	0.00008
LENGTH OF RECAPTURED FISH (mm)	Min	208	460
	Max	531	460
	Mean	309	460
	S.D.	51	
DAYS AT LARGE	Min	233	1,169
	Max	875	1,169
	Mean	380	1,169
	S.D.	120	
FREQUENCY OF DAYS AT LARGE	151-200 Days	0	
	201-250 Days	15	
	251-300 Days	30	
	301-350 Days	66	
	351-400 Days	59	
	401-450 Days	28	
	451-500 Days	11	
	501-550 Days	0	
	551-600 Days	0	
	601-650 Days	1	
	651-700 Days	8	
	701-750 Days	7	
	751-800 Days	3	
	801-850 Days	0	
	851-900 Days	1	
	901-950 Days	0	0
	951-1000 Days	0	0
	1001-1050 Days	0	0
	1051-1100 Days	0	0
	1101-1150 Days	0	0
	1151-1200 Days	0	1
	1201-1250 Days	0	0

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, and 1989-90 programs.
[b]Contains fish tagged and released in the 1986-87 program.

TABLE 3-22. STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHER AGENCY TAGS, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

			TAG CONDITION					RECAPTURE		
AGENCY	NUMBER	TAG SITE	NUMBER	TAG ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
LITTORAL SOCIETY	212468	1						21 NOV 90	1	322
LITTORAL SOCIETY		1						08 JAN 91	1	357
U S F & W	145996	1	4	4	4		N	21 JAN 91	8	452
LITTORAL SOCIETY	205858	1						21 JAN 91	9	431
LITTORAL SOCIETY	237195	1	4	4	4		N	24 JAN 91	1	317
LITTORAL SOCIETY	220636	2	4	4	4		N	31 JAN 91	8	370
LITTORAL SOCIETY	246303	1	4	4	4			01 FEB 91	8	290
LITTORAL SOCIETY	225433	1	4	4	4			04 FEB 91	7	326
U S F & W	139633	1	4	4	4	P	N	05 FEB 91	7	513
LITTORAL SOCIETY	259011	1	4	4	4	A	N	12 FEB 91	7	456
LITTORAL SOCIETY	237108	1	4	4	4			15 FEB 91	9	310
LITTORAL SOCIETY	198569	1						15 MAR 91	10	275
LITTORAL SOCIETY	212643	1	4	4	4		N	18 MAR 91	9	330
LITTORAL SOCIETY	237102	1						21 MAR 91	8	269
LITTORAL SOCIETY	7732	2						22 MAR 91	8	364
LITTORAL SOCIETY	156464	1						05 APR 91	10	390
LITTORAL SOCIETY	240065	1						08 APR 91	5	300
U S F & W	100919	1	4	2	1	A	N	10 APR 91	11	297
U S F & W	100391	2					Y	11 DEC 90	1	500

TAG VARIABLE	TAG CONDITION	TAG SITE
Number	1 = Legend completely missing	1 = Tag present, wound healed
Address	2 = Abraded and partly missing	2 = Tag present, wound poorly healed, evidence of infection or swelling.
Reward	3 = Abraded but completely legible	
	4 = Completely legible	
Number orientation	A = Tag number facing anterior(Head)	
	P = Tag number facing posterior(Tail)	
Anchor protrusion	Y = Yes	
	N = No	

years was compared within cohort to growth from a corresponding set of scales taken from untagged fish of the same cohort at the time of tagging (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. We selected scale radius measurements rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

Mean radius measurements for each annulus were obtained from the 1985, 1986, 1987 and 1988 cohorts of striped bass recaptured during the 1988-89, 1989-90 and 1990-91 programs (Table 3-23). A complementary set of scale samples was selected from the time of release for each cohort and program to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X +1 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus.

Tagged striped bass from the 1987 cohort that were at-large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way ANOVA comparisons of mean scale radius measurements (Table 3-23). Similar growth between tagged and untagged fish was also observed for Age 3+ fish from the 1985 cohort. Tagged striped bass from both the 1986 and 1988 cohorts of Age 2+ fish exhibited significantly larger scale radius measurements than untagged fish after being at-large for one year (Table 3-23). There is no evidence in the literature that suggests tags can stimulate growth. Since both the tagged and untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. If small, tagged striped bass have higher mortality rates than large, tagged fish, and untagged fish of the same cohort have similar mortality rates regardless of size, then it may appear that the tagged fish have grown larger between annulus 1 and annulus 2. This

TABLE 3-23. ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT-LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE, 1988-89, 1989-90 AND 1990-91 PROGRAMS.

						SCALE SAMPLE MEASUREMENT		
RECAPTURE PROGRAM	COHORT	AGE	YEARS AT-LARGE	TAG STATUS	N	MEAN RADIUS	S.E.	Pr>f[a]
1988-89	1985	3+	1	Tagged	11	145.6	6.9	0.7708
			0	Untagged	48	147.6	1.4	
1988-89	1986	2+	1	Tagged	24	124.2	3.5	0.0002
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	49	100.4	2.3	0.7412
			0	Untagged	1,138	101.2	0.5	
1990-91	1987	3+	1	Tagged	20	153.2	5.1	0.1076
			2	Tagged	13	153.8	7.1	0.1577
			0	Untagged	53	143.4	3.2	
1990-91	1988	2+	1	Tagged	149	104.8	1.2	0.0001
			0	Untagged	1,844	97.0	0.4	

[a]Probability of finding that the mean radius is different by chance alone, under a least squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

would occur because proportionally more large tagged fish would survive and be recaptured compared to untagged fish of the same cohort. However, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit retarded growth during one or two years at-large.

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1990-91 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently. This estimator was used during 1985-86, 1986-87, 1987-88, 1988-89, and 1989-90 to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990a, 1991).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) mortality is not different for tagged and untagged bass,

2) tagging does not affect bass catchability,

3) tagged bass do not lose their marks,

4) all tags are recognized and reported,

5) natural marking does not occur or is recognizable,

6) immigration, emigration, and recruitment are negligible in the study area i.e., the population is closed,

7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions, and

8) marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hours and (2) in holding pools for up to 180 days.

However, in late February 1991, field crews discovered a tag streamer protruding from an accumulation of bird droppings on a wood piling attached to a pier on the west side of the Hudson River at river mile 1. A second tag was found on the same piling upon further inspection. These pilings are commonly used as roosting sites by herring gulls (*Larus argentatus*) or cormorants (*Phalacrocorax carbo carbo*). A more thorough search of the pilings and other accessable roosting areas among the piers and bulkheads between Hudson River miles 1 and 9 over the next several weeks produced 63 tags (Appendix Table D-10).

Most striped bass sound immediately after they are tagged and released into the water, while others linger at the surface and may be exposed to bird (gull) predation. We do not know over what period the 63 tags had accumulated, however they represent fish that were released between December 1989 and March 1991 (Appendix Table D-10). Without an estimate of the time period represented by the 63 tags, or a measure of the adequacy of the sample, an accurate estimate of bird predation rates on tagged striped bass could not be calculated. Therefore, effective 12 March 1991 we added an extra crew member with the primary purpose of observing and recording the frequency of bird predation on tagged striped bass. Tagged fish were released in lots of 6-10 to facilitate quantification. Results indicated bird predation on tagged striped bass varied from 0 to 9 fish per day, and we observed a total of 72 tagged fish removed from the water surface by birds out of 2,969 tagged fish released between 12 March and 12 April 1991 (Table 3-24). We applied these data to the entire 1990-91 time period used for the mark-recapture estimate, and adjusted the number of tagged fish at-large downward by

TABLE 3-24 DAILY OBSERVATIONS OF BIRD PREDATION ON HUDSON RIVER STRIPED BASS THAT WERE CAUGHT BY A 9 M TRAWL, TAGGED AND RELEASED IN THE BATTERY REGION, 12 MARCH THROUGH 12 APRIL 1991.

1991 DATE	TOTAL CATCH	TOTAL PREDATION	NUMBER TAGGED	TAGGED FISH PREDATION
12 MAR	176	0	145	0
13 MAR	292	9	221	9
14 MAR	387	5	331	4
15 MAR	239	8	171	3
18 MAR	229	8	155	6
19 MAR	85	6	68	6
20 MAR	268	12	204	9
21 MAR	289	7	202	3
22 MAR	179	5	139	5
25 MAR	157	3	112	3
26 MAR	88	3	66	3
27 MAR	174	1	134	0
28 MAR	28	3	23	3
29 MAR	137	2	84	2
1 APR	161	1	112	1
2 APR	141	2	76	1
3 APR	123	2	80	2
4 APR	203	5	157	4
5 APR	80	1	42	1
8 APR	181	4	141	4
9 APR	137	2	118	2
10 APR	131	1	115	1
11 APR	24	0	19	0
12 APR	73	0	54	0
TOTAL	3,982	90	2,969	72

the observed predation rate of 2.4% (72/2,969). We intentionally did not modify our field tagging procedures in 1990-91 so that we could obtain an accurate estimate of the bird predation rate. However, modifications of the fish release procedures by using a release pen should be considered as part of future programs along with continued observations of predation incidents.

The 2.4% estimate of bird predation was only applied to adjust the number of tagged fish at-large during the release period used for the mark-recapture population estimate in the 1990-91 program. Adjustments were not made to previous years data. In 1990-91, the tagging vessel was generally moored at abandoned piers near the location where the capture vessel completed a tow. Released fish drifted away from the stationary tagging vessel before sounding, where they were exposed to predation by birds roosting in the vicinity of abandoned piers. In programs before 1990-91, the tagging vessel generally drifted as the fish were tagged and released, providing cover until the fish sounded. Therefore, the estimated bird predation rate of 2.4% for 1990-91 was probably high and not relevant for use in previous programs.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1990b) which would provide evidence of tag loss. QA/QC procedures (NAI 1990b) and audits provide documentation that incorrect identification or non-reporting of tags by field crews did not occur. Dunning et al. (1987) found 97.7% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 635 fish out of 21,863 tagged fish (adjusted for bird predation), approximately 15 fish would be expected to have lost tags in the 1990-91 program. However, the tag loss rate from Dunning *et al.* (1987) was based on Floy style tags which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1990-91 program, 25,183 striped bass were examined for tags and tag wounds, and 81 fish were observed with tag wounds. Nine of these fish had anchors present without streamers indicating the streamer was cut and removed by fishermen. Only six of these fish exhibited a longitudinal scar, suggesting the scar originated from shed Hallprint tags. Since these longitudinal scars have been shown to originate from shed Hallprint tags with exposed filaments at the base of the external streamer (Section 3.4.2.2), these fish probably originated from previous programs. The exposed filament tag was not used during the 1990-91 program. The remaining fish exhibited atypical wounds at the insertion site suggesting they may have a natural origin and may not be from a shed tag. Therefore, loss of internal anchor tags for fish tagged and released during 1990-91 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and we adjusted for it, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1990a, Geoghegan et al. 1990). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tags used in this study.

Immigration and emigration (Assumption 6) was apparently negligible during most of the study period (November 1990 through April 1991) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4, NAI 1986, 1987, 1988, 1990a). A linear regression of weekly recapture proportions (R/C) on cumulative number of marked fish (Figure 3-6) was significant and positive for the weeks of 3 December 1990 through the week of 11 March 1991 (Appendix Tables D-6 and D-7). Recapture rates (R/M) varied less during the weeks of 3 December 1990 through 11 March 1991 than any other 15 week period during the program. This 15 week period for the population estimator is one month earlier than the period used in 1989-90 (NAI 1991) and similar to the period used in 1988-89, 1987-88, 1986-87, and 1985-86 for the population estimator (NAI 1986, 1987, 1988, 1990a). During 1989-90, the period used for the Schumacher-Eschmeyer population estimate was 22 January through 9 April 1990. In 1985-86, 30 December 1985 through 21 February 1986 was used, in 1986-87 21 December 1986 through 13 March 1987 was used, in 1987-88 21 December 1987 through 9 April 1989 was used, and in 1988-89 12 December 1988 through 2 April 1989 was used to estimate the size of the midwinter striped bass population in the combined Battery and Upper Harbor regions of the Hudson River. The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass (Assumption 7). Further-more, stepwise polynomial regressions did not significantly improve goodness of fit, which indicated a linear model was appropriate.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied for the 3 December 1990 through 11 March 1991 period in this study. Therefore, a Schumacher-

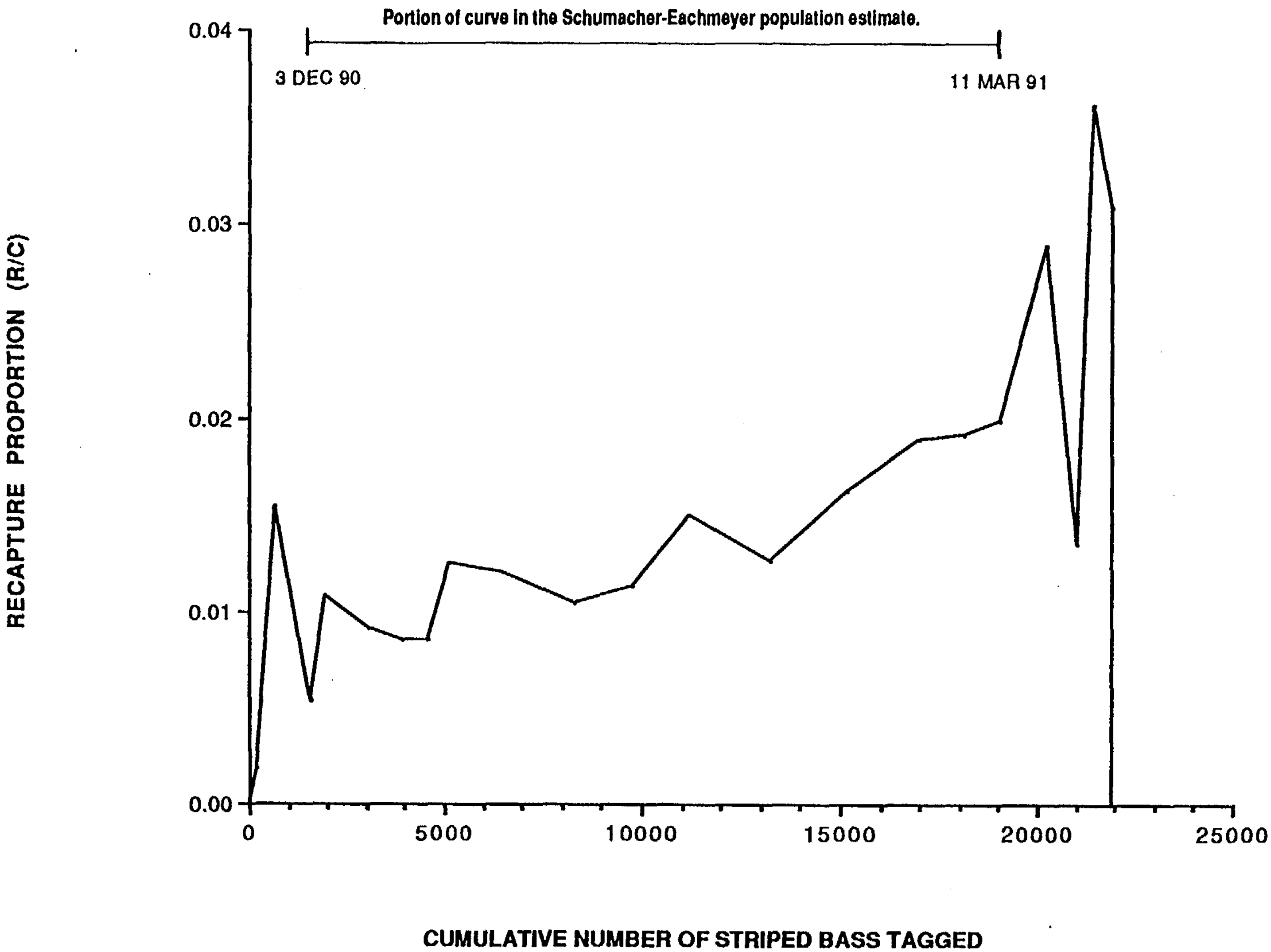


Figure 3-6. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged in the combined Upper Harbor and Battery regions of the lower Hudson River, 12 November 1990 through 20 April 1991.

Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1990-91 was 858,000 fish ≥ 150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 772,000 to 964,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25). Based on the estimated hatchery proportion of 0.2% for Age 1+ and Age 2+ fish, (Section 3.3), about 1,000 Age 1+ and 1,000 Age 2+ hatchery fish were present among the striped bass overwintering in the Battery and upper New York harbor regions during winter 1990-91.

For comparison with previous programs, the total population of striped bass ≥200 mm was estimated as 786,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This estimate was the second highest calculated annually since 1985-86 (Table 3-27). The abundant 1988 cohort of Age 2+ fish was the primary contributor to this relatively large estimate of Hudson River striped bass in the mid-winter population during 1990-91. Age 1+ fish from the 1989 cohort also exhibited a relatively strong contribution to the 1990-91 mid-winter population.

TABLE 3-25. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1990-91.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥150 mm	PROPORTION ≥150 mm	ESTIMATED POPULATION[a]
1+	12,239	12,206	0.4847	416,000
2+	11,903	11,903	0.4727	406,000
3+	781	781	0.0310	27,000
>3+	74	74	0.0029	2,000
TOTAL	24,997	24,964	1.9913	851,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 3 December 1990 through the week of 11 March 1991. Age 0+ striped bass were 0.87% (7,000 fish) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 858,000 fish.

TABLE 3-26. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1990-91.

AGE	TOTAL NUMBER CAUGHT	TOTAL NUMBER ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	12,239	10,320	0.4472	352,000
2+	11,903	11,903	0.5158	405,000
3+	781	781	0.0338	27,000
>3+	74	74	0.0032	2,000
TOTAL	24,997	23,078	1.0000	786,000

[a]The total population estimate is based on fish ≥150 mm (858,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (23,078/25,183 = 0.9164).

TABLE 3-27. ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER OFF MANHATTAN DURING THE WINTERS OF 1985-86 THROUGH 1990-91.

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged and no population estimate is possible for the 1987-88, 1986-87 and 1985-86 programs.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9 m TRAWL.

	9 m TRAWL
Head rope length	6.9 m
Foot rope length (Sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6 cm (stretch) mesh polypropylene; polypropylene; 3 mm diameter twine
- cod end	3.8 cm (stretch) mesh, knotless polypropylene; 3 mm diameter twine
Roller Gear	25.4 cm rollers spaced with 5 cm cookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991

REGION	WEEK	SURFACE WATER TEMPERATURE[a]	SURFACE WATER CONDUCTIVITY[b]	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY
UPPER HARBOR	07JAN91	3.75	15071	5.04	29094
	14JAN91	4.19	25514	4.69	33434
	21JAN91	3.45	30122	4.70	39059
	04MAR91	5.50	13070	6.90	23879
BATTERY	12NOV90	13.24	22933	13.74	36201
	19NOV90	9.05	12103	10.72	31355
	26NOV90	11.01	19554	12.53	32508
	03DEC90	8.80	20139	9.99	29093
	10DEC90	7.11	15893	9.05	30948
	17DEC90	7.43	19236	8.81	32593
	24DEC90	4.75	11773	7.25	29981
	31DEC90	5.15	17369	8.03	26748
	07JAN91	3.18	11269	5.11	29078
	14JAN91	4.40	25367	5.00	34560
	21JAN91	3.29	21501	4.52	31809
	28JAN91	3.72	21534	4.63	27348
	04FEB91	3.63	9543	4.50	23036
	11FEB91	4.30	18009	6.09	26425
	18FEB91	4.06	15470	5.16	23951
	25FEB91	4.95	17225	6.07	23530
	04MAR91	5.29	8456	6.16	20105
	11MAR91	4.64	14021	6.44	27579
	18MAR91	6.08	15666	6.90	21786
	25MAR91	6.77	12893	7.01	21424
	01APR91	7.46	8949	7.73	23085
	08APR91	10.33	8596	9.15	26995
	15APR91	9.87	19254	10.60	25329

[a]Water temperature in °C.
[b]Conductivity in μS/cm^2 at 25°C.

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

		CPUE			
STATION	WEEK	TOWS	N	MEAN	S.E.
UPPER HARBOR					
	07JAN91	9	606	67.3	23.7
	14JAN91	16	1184	74.0	31.4
	21JAN91	2	18	9.0	4.0
	04MAR91	4	26	6.5	4.5
	TOTAL	31	1834	59.2	17.9
BATTERY					
	12NOV90	16	346	21.6	6.4
	19NOV90	43	966	22.5	2.8
	26NOV90	71	1299	18.3	1.7
	03DEC90	51	631	12.4	1.8
	10DEC90	40	1391	34.8	3.6
	17DEC90	26	1030	39.6	10.1
	24DEC90	12	724	60.3	23.6
	31DEC90	35	665	19.0	1.4
	07JAN91	29	1022	35.2	4.0
	14JAN91	30	826	27.5	3.0
	21JAN91	32	1698	53.1	7.5
	28JAN91	60	1992	33.2	3.6
	04FEB91	33	2792	84.6	10.1
	11FEB91	43	2300	53.5	6.8
	18FEB91	42	2214	52.7	4.3
	25FEB91	52	1471	28.3	4.4
	04MAR91	44	1120	25.5	3.3
	11MAR91	39	1539	39.5	6.2
	18MAR91	45	1050	23.3	2.6
	25MAR91	44	584	13.3	2.5
	01APR91	51	708	13.9	1.2
	08APR91	45	543	12.1	1.9
	15APR91	57	126	2.2	0.6
	TOTAL	940	27037	28.8	1.1

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

		CPUE			
STATION	RIVER MILE	TOWS	N	MEAN	S.E.
UPPER HARBOR					
	2	5	78	15.6	8.9
	3	26	1756	67.5	20.9
	TOTAL	31	1834	59.2	17.9
BATTERY					
	1	445	11331	25.5	1.4
	2	2	18	9.0	1.0
	5	122	1362	11.2	1.5
	7	86	2816	32.7	4.2
	8	152	6282	41.3	3.4
	9	83	3192	38.5	3.5
	10	44	1926	43.8	5.6
	11	6	110	18.3	5.6
	TOTAL	940	27037	28.8	1.1

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS CAPTURED AND STRIPED BASS TAGGED IN THE HUDSON RIVER CROSS-CLASSIFIED BY REGION, GEAR AND USE CODE FOR THE 9 m TRAWL, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

REGION	GEAR	USE CODE	SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
Battery	9 m trawl	1	940	27,040	20,334
		2	20	383	280
		5	5	0	0
Total			965	27,423	20,614
Upper Harbor	9 m trawl	1	31	1,834	1,710
		2	2	89	82
		5	0	0	0
Total			33	1,923	1,792

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

				N TOWS		NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (mm TL)											NUMBER OF FISH				MORTALITY	
DATE	GEAR	WATER TEMP.	COND.	TOTAL	VOID	<150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	801+	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	N	%
12 NOV 90	9m	13.7	36201	17	0	168	27	105	35	13	1	2	0	0	351	21	168	9	3	171	0	0.0
19 NOV 90	9m	10.7	31355	44	0	442	83	321	134	23	4	0	0	0	1007	23	520	33	1	453	0	0.0
26 NOV 90	9m	12.5	32508	73	0	294	165	619	195	40	7	2	0	0	1322	18	898	99	0	323	2	0.2
3 DEC 90	9m	9.9	29093	53	0	265	20	189	143	16	3	1	0	0	637	12	329	13	2	291	2	0.3
10 DEC 90	9m	9.1	30948	41	1	117	129	610	428	104	15	4	1	1	1409	34	1128	64	2	208	7	0.5
17 DEC 90	9m	8.8	32593	27	1	43	89	470	365	62	3	1	1	0	1034	38	866	36	2	120	10	1.0
24 DEC 90	9m	7.3	29981	12	0	16	27	314	318	45	2	2	0	0	724	60	646	13	3	62	0	0.0
31 DEC 90	9m	8.0	26748	35	1	73	33	283	208	55	10	2	0	0	664	19	546	23	0	95	0	0.0
7 JAN 91	9m	5.1	29082	40	0	186	96	863	484	69	5	2	0	1	1706	43	1418	41	2	243	2	0.1
14 JAN 91	9m	4.9	34168	46	0	92	223	1146	493	52	2	2	0	0	2010	44	1766	61	6	175	2	0.1
21 JAN 91	9m	4.5	32224	35	0	221	129	950	495	48	4	0	0	0	1847	53	1466	43	7	327	4	0.2
28 JAN 91	9m	4.6	27348	62	0	416	156	867	495	72	1	0	1	0	2008	32	1479	51	3	473	2	0.1
4 FEB 91	9m	4.5	23036	34	1	585	234	1187	715	70	2	0	0	0	2793	82	1999	67	3	724	0	0.0
11 FEB 91	9m	6.1	26425	44	0	205	115	1084	831	82	6	0	0	0	2323	53	1925	64	9	322	3	0.1
18 FEB 91	9m	5.2	23951	43	0	261	171	1270	548	45	3	0	0	1	2299	53	1828	51	11	406	3	0.1
25 FEB 91	9m	6.1	23530	53	0	159	94	718	459	48	1	0	0	0	1479	28	1161	36	3	279	0	0.0
4 MAR 91	9m	6.2	20483	51	0	183	109	630	236	21	1	0	0	0	1180	23	875	26	1	274	4	0.3
11 MAR 91	9m	6.4	27579	39	0	74	68	754	592	49	2	0	0	0	1539	39	1241	45	3	248	2	0.1
18 MAR 91	9m	6.9	21786	45	0	82	99	570	285	14	0	0	0	0	1050	23	768	38	0	239	5	0.5
25 MAR 91	9m	7.0	21424	44	0	65	30	296	182	9	0	0	2	0	584	13	419	8	0	149	8	1.4
1 APR 91	9m	7.7	23085	51	0	127	43	291	216	30	1	0	0	0	708	14	467	32	0	201	8	1.1
8 APR 91	9m	9.2	26995	46	1	28	52	342	115	3	1	0	3	2	546	12	447	24	0	70	5	0.9
15 APR 91	9m	10.6	25329	58	0	75	9	25	9	6	1	0	0	1	126	2	46	0	1	79	0	0.0
TOTAL		7.6	27647	993	5	4177	2201	13904	7981	976	75	18	8	6	29346	30	22406	877	62	5932	69	0.2

SAMPLING WEEK Date beginning Monday of each week

GEAR 9m = 9m trawl (GEAR = 49)

WATER TEMP = mean river bottom water temperature in degrees Celcius

COND = mean river bottom conductivity (adjusted to 25°C) in microseimans per centimeter

N TOWS TOTAL = total number of tows by the specified gear in the specific week (USE_CODE = 1 and 2 combined)

VOID = total number of void (USE_CODE = 5) tows by the specified gear in the specific week

N FISH: TAGGED = number of striped bass tagged and released

RECAPTURED = number of striped bass recaptured from previous programs
LAB = number of fish taken to the laboratory for biocharacteristics and/or stomach analyses
HATCHERY = number of striped bass suspected to be hatchery recaptures
NOT TAGGED = number of striped bass ≥150 mm TL judged in poor condition or not tagged

MORTALITY = initial handling mortality
N = number of dead fish in sample
% = percent of dead fish in sample = number of dead fish/total number of fish x 100

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (mm) OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

	9 m TRAWL			
WEEK	NO. FISH	MEAN LENGTH (mm)	S.D.	S.E.
12NOV90	346	187	106.9	5.8
19NOV90	966	190	98.6	3.2
26NOV90	1299	230	90.7	2.5
03DEC90	630	213	109.4	4.4
10DEC90	1391	279	92.8	2.5
17DEC90	1030	287	78.1	2.4
24DEC90	724	301	71.5	2.7
31DEC90	664	282	96.5	3.8
07JAN91	1026	255	94.8	3.0
14JAN91	826	268	77.2	2.7
21JAN91	1698	260	79.8	1.9
28JAN91	1991	245	93.6	2.1
04FEB91	2792	244	89.0	1.7
11FEB91	2299	278	79.4	1.7
18FEB91	2214	260	75.0	1.6
25FEB91	1471	268	80.6	2.1
04MAR91	1120	241	77.6	2.3
11MAR91	1539	286	68.3	1.7
18MAR91	1050	260	68.6	2.1
25MAR91	584	266	80.8	3.3
01APR91	708	260	89.4	3.4
08APR91	543	264	78.8	3.4
15APR91	125	183	120.8	10.8
ALL WEEKS	27,036	258	88.2	0.5

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW IN A 9 m TRAWL FOR 50 mm LENGTH GROUPS IN THE BATTERY REGION OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

STRIPED BASS CATCH PER TEN MINUTE TOW IN 50 mm LENGTH GROUPS

SAMPLING WEEK	NUMBER OF TOWS	<100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800	>800
12NOV90	16	6.4	4.1	1.7	3.7	2.7	1.5	0.6	0.6	0.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0
19NOV90	43	6.1	4.2	1.9	3.8	3.2	2.1	0.7	0.4	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
26NOV90	71	1.6	2.5	2.3	4.4	4.2	1.9	0.8	0.4	0.2	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0
03DEC90	51	3.1	2.1	0.4	1.5	2.2	1.8	0.9	0.3	0.0	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0
10DEC90	40	0.9	2.1	3.2	7.1	8.0	7.1	3.5	1.9	0.7	0.3	0.1	0.1	0.1	<0.1	0.0	<0.1
17DEC90	26	0.2	1.3	3.4	8.3	9.8	7.8	6.2	1.9	0.5	0.1	0.0	<0.1	0.0	<0.1	0.0	0.0
24DEC90	12	0.2	1.2	2.3	10.6	15.6	16.3	10.2	2.8	1.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0
31DEC90	35	1.0	1.1	0.9	3.7	4.4	4.1	1.8	1.1	0.5	0.2	0.1	0.0	0.1	0.0	0.0	0.0
07JAN91	29	2.8	3.5	2.7	6.5	7.7	7.0	3.5	0.8	0.5	0.1	0.0	<0.1	0.0	0.0	0.0	0.0
14JAN91	30	0.6	1.9	2.5	5.1	8.0	6.0	2.5	0.8	0.1	0.0	0.0	<0.1	0.0	0.0	0.0	0.0
21JAN91	32	1.6	5.2	3.8	11.3	15.1	10.2	4.3	1.3	0.2	<0.1	0.1	0.0	0.0	0.0	0.0	0.0
28JAN91	60	3.1	3.8	2.5	6.4	7.9	5.4	2.8	1.0	0.2	0.0	<0.1	0.0	0.0	<0.1	0.0	0.0
04FEB91	33	5.8	11.9	7.1	16.7	19.3	14.1	7.5	1.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
11FEB91	43	2.0	2.8	2.6	9.7	15.3	11.8	7.4	1.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
18FEB91	42	1.4	3.8	3.8	13.2	16.4	9.0	4.0	0.9	0.2	0.0	0.1	0.0	0.0	0.0	0.0	<0.1
25FEB91	52	1.3	1.7	1.8	5.7	8.1	5.8	3.1	0.8	0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0
04MAR91	44	1.2	2.9	2.4	6.4	7.4	3.5	1.2	0.3	0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0
11MAR91	39	0.5	1.4	1.7	7.0	12.3	10.1	5.1	1.2	0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0
18MAR91	45	0.3	1.6	2.2	6.1	6.6	4.6	1.7	0.3	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25MAR91	44	0.5	1.0	0.7	2.6	4.1	2.7	1.5	0.2	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	0.0
01APR91	51	0.7	1.8	0.8	1.9	3.8	2.9	1.3	0.5	0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0
08APR91	45	0.1	0.5	1.2	2.8	4.7	2.3	0.3	0.1	0.0	0.0	<0.1	0.0	0.0	<0.1	<0.1	<0.1
15APR91	57	0.4	0.9	0.2	0.3	0.1	0.1	0.1	0.1	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1
ALL WEEKS	940	1.7	2.6	2.1	5.8	7.5	5.3	2.6	0.8	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

APPENDIX TABLE C-7. MEAN LENGTH AT AGE AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER DURING THE 1990-91, 1989-90, 1988-89, 1987-88 AND 1986-87 STRIPED BASS PROGRAMS.

AGE	COHORT	PROGRAM	n[a]	STRATIFIED MEAN LENGTH (mm)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1990	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1,007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1989	1990-91	2,174	239	237	241
	1988	1989-90	3,514	214	213	215
	1987	1988-89	3,623	227	226	229
	1986	1987-88	1,503	253	251	255
	1985	1986-87	285	221	215	227
2+	1988	1990-91	2,109	321	317	324
	1987	1989-90	1,216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

[a] number of fish aged

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HATCHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
1	9 M TRAWL	11/16/90	BATTERY	1	186	89
1	9 M TRAWL	11/16/90	BATTERY	1	194	89
1	9 M TRAWL	12/04/90	BATTERY	1	280	89
1	9 M TRAWL	12/07/90	BATTERY	1	209	89
1	9 M TRAWL	12/19/90	BATTERY	1	195	89
1	9 M TRAWL	01/11/91	UPPER HARBOR	3	230	89
1	9 M TRAWL	01/14/91	UPPER HARBOR	3	267	89
1	9 M TRAWL	01/15/91	UPPER HARBOR	3	247	89
1	9 M TRAWL	01/17/91	BATTERY	1	230	89
1	9 M TRAWL	01/23/91	BATTERY	1	239	89
1	9 M TRAWL	01/24/91	BATTERY	1	222	89
1	9 M TRAWL	01/25/91	BATTERY	1	306	89
1	9 M TRAWL	01/30/91	BATTERY	9	204	89
1	9 M TRAWL	02/08/91	BATTERY	8	203	89
1	9 M TRAWL	02/12/91	BATTERY	8	198	89
1	9 M TRAWL	02/12/91	BATTERY	8	280	89
1	9 M TRAWL	02/13/91	BATTERY	8	308	89
1	9 M TRAWL	02/14/91	BATTERY	9	255	89
1	9 M TRAWL	02/22/91	BATTERY	5	242	89
1	9 M TRAWL	02/22/91	BATTERY	5	311	89
1	9 M TRAWL	02/22/91	BATTERY	5	255	89
1	9 M TRAWL	02/22/91	BATTERY	5	213	89
1	9 M TRAWL	02/27/91	BATTERY	1	265	89
1	9 M TRAWL	03/07/91	BATTERY	1	240	89
1	9 M TRAWL	03/12/91	BATTERY	7	314	89
1	9 M TRAWL	03/15/91	BATTERY	9	309	89
1	9 M TRAWL	04/15/91	BATTERY	5	224	89
2	9 M TRAWL	11/16/90	BATTERY	1	295	88
2	9 M TRAWL	11/24/90	BATTERY	1	215	88
2	9 M TRAWL	12/14/90	BATTERY	1	267	88
2	9 M TRAWL	12/26/90	BATTERY	1	400	88
2	9 M TRAWL	01/09/91	BATTERY	1	337	88
2	9 M TRAWL	01/15/91	UPPER HARBOR	3	235	88
2	9 M TRAWL	01/23/91	BATTERY	1	236	88
2	9 M TRAWL	01/30/91	BATTERY	8	369	88
2	9 M TRAWL	01/30/91	BATTERY	8	279	88
2	9 M TRAWL	02/04/91	BATTERY	7	261	88
2	9 M TRAWL	02/08/91	BATTERY	8	308	88
2	9 M TRAWL	02/12/91	BATTERY	7	343	88
2	9 M TRAWL	02/13/91	BATTERY	7	341	88
2	9 M TRAWL	02/13/91	BATTERY	7	412	88
2	9 M TRAWL	02/14/91	BATTERY	8	323	88
2	9 M TRAWL	02/15/91	BATTERY	9	305	88
2	9 M TRAWL	02/20/91	BATTERY	8	340	88
2	9 M TRAWL	02/21/91	BATTERY	1	333	88
2	9 M TRAWL	02/21/91	BATTERY	7	315	88
2	9 M TRAWL	02/22/91	BATTERY	5	273	88
2	9 M TRAWL	02/22/91	BATTERY	5	334	88
2	9 M TRAWL	02/28/91	BATTERY	10	318	88
2	9 M TRAWL	02/28/91	BATTERY	10	328	88
2	9 M TRAWL	03/12/91	BATTERY	7	294	88
3	9 M TRAWL	01/25/91	BATTERY	1	350	87

APPENDIX TABLE D-2. STRIPED BASS MARKED, RELEASED AND RECPATURED IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER
16NOV90	381	BT	1	2	16NOV90	382	BT	1	2	0	0	0	1	321344
16NOV90	329	BT	1	2	16NOV90	330	BT	1	2	0	0	0	1	321346
16NOV90	417	BT	1	2	16NOV90	419	BT	1	2	0	0	0	1	321353
16NOV90	271	BT	1	2	16NOV90	271	BT	1	2	0	0	0	1	321424
16NOV90	316	BT	1	2	16NOV90	217	BT	1	2	0	0	0	1	321427
20NOV90	321	BT	1	2	20NOV90	320	BT	1	2	0	0	0	1	319713
21NOV90	457	BT	1	2	21NOV90	454	BT	1	2	0	0	0	1	319759
21NOV90	337	BT	1	2	21NOV90	337	BT	1	2	0	0	0	1	319777
21NOV90	223	BT	1	2	21NOV90	225	BT	1	2	0	0	0	1	321659
21NOV90	226	BT	1	2	21NOV90	225	BT	1	2	0	0	0	1	321694
24NOV90	331	BT	1	2	24NOV90	330	BT	1	2	0	0	0	1	319814
24NOV90	280	BT	1	2	16NOV90	279	BT	1	2	8	0	0	1	321399
24NOV90	216	BT	1	2	20NOV90	217	BT	1	2	4	0	0	1	321610
24NOV90	241	BT	1	2	21NOV90	240	BT	1	2	3	0	0	1	321705
24NOV90	190	BT	1	2	24NOV90	191	BT	1	2	0	0	0	1	321758
24NOV90	253	BT	1	2	24NOV90	252	BT	1	2	0	0	0	1	321769
24NOV90	205	BT	1	2	24NOV90	204	BT	1	2	0	0	0	1	321813
24NOV90	200	BT	1	2	24NOV90	197	BT	1	2	0	0	0	1	321824
24NOV90	209	BT	1	2	24NOV90	208	BT	1	2	0	0	0	1	321831
24NOV90	185	BT	1	2	24NOV90	184	BT	1	2	0	0	0	1	321832
26NOV90	350	BT	1	2	26NOV90	350	BT	1	2	0	0	0	1	319829
26NOV90	372	BT	1	2	26NOV90	372	BT	1	2	0	0	0	1	319833
26NOV90	300	BT	1	2	26NOV90	300	BT	1	2	0	0	0	1	319844
26NOV90	262	BT	1	2	20NOV90	262	BT	1	2	6	0	0	1	321557
26NOV90	279	BT	1	2	20NOV90	276	BT	1	2	6	0	0	1	321575
26NOV90	217	BT	1	2	21NOV90	218	BT	1	2	5	0	0	1	321674
26NOV90	201	BT	1	2	24NOV90	201	BT	1	2	2	0	0	1	321794
26NOV90	247	BT	1	2	24NOV90	247	BT	1	2	2	0	0	1	321827
26NOV90	159	BT	1	2	24NOV90	159	BT	1	2	2	0	0	1	321879
26NOV90	273	BT	1	2	26NOV90	273	BT	1	2	0	0	0	1	321903
26NOV90	274	BT	1	2	26NOV90	276	BT	1	2	0	0	0	1	321904
26NOV90	240	BT	1	2	26NOV90	240	BT	1	2	0	0	0	1	321912
26NOV90	195	BT	1	2	26NOV90	196	BT	1	2	0	0	0	1	321925
26NOV90	200	BT	1	2	26NOV90	200	BT	1	2	0	0	0	1	321931
26NOV90	168	BT	1	2	26NOV90	170	BT	1	2	0	0	0	1	321933
26NOV90	211	BT	1	2	26NOV90	212	BT	1	2	0	0	0	1	321946
26NOV90	200	BT	1	2	26NOV90	201	BT	1	2	0	0	0	1	321965
27NOV90	309	BT	1	2	26NOV90	300	BT	1	2	1	0	0	1	319844
27NOV90	327	BT	1	2	27NOV90	326	BT	1	2	0	0	0	1	319885
27NOV90	291	BT	1	2	27NOV90	392	BT	1	2	0	0	0	1	319892
27NOV90	322	BT	1	2	27NOV90	323	BT	1	2	0	0	0	1	319908
27NOV90	300	BT	1	2	27NOV90	301	BT	1	2	0	0	0	1	319911
27NOV90	237	BT	1	2	16NOV90	239	BT	1	2	11	0	0	1	321451
27NOV90	273	BT	1	2	21NOV90	272	BT	1	2	6	0	0	1	321719
27NOV90	175	BT	1	2	24NOV90	178	BT	1	2	3	0	0	1	321786
27NOV90	200	BT	1	2	24NOV90	201	BT	1	2	3	0	0	1	321794
27NOV90	185	BT	1	2	24NOV90	186	BT	1	2	3	0	0	1	321835

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
27NOV90	195	BT	1	2	26NOV90	193	BT	1	2	1	0	0	1	321900
27NOV90	199	BT	1	2	26NOV90	198	BT	1	2	1	0	0	1	321929
27NOV90	233	BT	1	2	26NOV90	233	BT	1	2	1	0	0	1	321948
27NOV90	195	BT	1	2	26NOV90	195	BT	1	2	1	0	0	1	321955
27NOV90	184	BT	1	2	26NOV90	184	BT	1	2	1	0	0	1	321960
27NOV90	190	BT	1	2	26NOV90	191	BT	1	2	1	0	0	1	321966
27NOV90	190	BT	1	2	26NOV90	189	BT	1	2	1	0	0	1	321972
27NOV90	271	BT	1	2	26NOV90	268	BT	1	2	1	0	0	1	321977
27NOV90	236	BT	1	2	26NOV90	235	BT	1	2	1	0	0	1	322023
27NOV90	214	BT	1	2	26NOV90	216	BT	1	2	1	0	0	1	322025
27NOV90	286	BT	1	2	27NOV90	285	BT	1	2	0	0	0	1	322047
27NOV90	182	BT	1	2	27NOV90	182	BT	1	2	0	0	0	1	322050
27NOV90	292	BT	1	2	27NOV90	291	BT	1	2	0	0	0	1	322051
27NOV90	222	BT	1	2	27NOV90	223	BT	1	2	0	0	0	1	322070
27NOV90	240	BT	1	2	27NOV90	240	BT	1	2	0	0	0	1	322119
27NOV90	295	BT	1	2	27NOV90	296	BT	1	2	0	0	0	1	322133
27NOV90	280	BT	1	2	27NOV90	281	BT	1	2	0	0	0	1	322154
27NOV90	283	BT	1	2	27NOV90	286	BT	1	2	0	0	0	1	322194
28NOV90	325	BT	1	2	28NOV90	324	BT	1	2	0	0	0	1	319943
28NOV90	198	BT	1	2	16NOV90	199	BT	1	2	12	0	0	1	321474
28NOV90	261	BT	1	2	27NOV90	263	BT	1	2	1	0	0	1	322087
28NOV90	160	BT	1	2	27NOV90	160	BT	1	2	1	0	0	1	322128
28NOV90	187	BT	1	2	27NOV90	183	BT	1	2	1	0	0	1	322183
28NOV90	221	BT	1	2	27NOV90	223	BT	1	2	1	0	0	1	322186
28NOV90	212	BT	1	2	28NOV90	210	BT	1	2	0	0	0	1	322272
28NOV90	262	BT	1	2	28NOV90	263	BT	1	2	0	0	0	1	322279
28NOV90	226	BT	1	2	28NOV90	226	BT	1	2	0	0	0	1	322300
28NOV90	234	BT	1	2	28NOV90	234	BT	1	2	0	0	0	1	322305
28NOV90	242	BT	1	2	28NOV90	243	BT	1	2	0	0	0	1	322312
29NOV90	217	BT	1	2	26NOV90	216	BT	1	2	3	0	0	1	322001
29NOV90	217	BT	1	2	27NOV90	216	BT	1	2	2	0	0	1	322189
29NOV90	186	BT	1	2	28NOV90	185	BT	1	2	1	0	0	1	322319
29NOV90	247	BT	1	2	29NOV90	247	BT	1	2	0	0	0	1	322356
29NOV90	255	BT	1	2	29NOV90	256	BT	1	2	0	0	0	1	322369
29NOV90	250	BT	1	2	29NOV90	250	BT	1	2	0	0	0	1	322384
30NOV90	204	BT	1	2	16NOV90	205	BT	1	2	14	0	0	1	321445
30NOV90	289	BT	1	2	21NOV90	288	BT	1	2	9	0	0	1	321663
30NOV90	265	BT	1	2	24NOV90	265	BT	1	2	6	0	0	1	321721
30NOV90	250	BT	1	2	24NOV90	255	BT	1	2	6	0	0	1	321795
30NOV90	222	BT	1	2	28NOV90	219	BT	1	2	2	0	0	1	322234
30NOV90	192	BT	1	2	28NOV90	190	BT	1	2	2	0	0	1	322242
30NOV90	189	BT	1	2	29NOV90	188	BT	1	2	1	0	0	1	322372
30NOV90	230	BT	1	2	29NOV90	227	BT	1	2	1	0	0	1	322403
30NOV90	265	BT	1	2	30NOV90	267	BT	1	2	0	0	0	1	322452
30NOV90	216	BT	1	2	30NOV90	217	BT	1	2	0	0	0	1	322459
30NOV90	278	BT	1	2	30NOV90	275	BT	1	2	0	0	0	1	322474
30NOV90	191	BT	1	2	30NOV90	188	BT	1	2	0	0	0	1	322484

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE RIVER REGION	RELEASE RIVER MILE	RELEASE RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
30NOV90	212	BT	1	2	30NOV90	212	BT	1	2	0	0	0	1	322485
30NOV90	283	BT	1	2	30NOV90	283	BT	1	2	0	0	0	1	322486
30NOV90	206	BT	1	2	30NOV90	204	BT	1	2	0	0	0	1	322491
30NOV90	267	BT	1	2	30NOV90	267	BT	1	2	0	0	0	1	322520
30NOV90	247	BT	1	2	30NOV90	247	BT	1	2	0	0	0	1	322522
30NOV90	298	BT	1	2	30NOV90	299	BT	1	2	0	0	0	1	322531
03DEC90	316	BT	1	2	21NOV90	317	BT	1	2	12	0	0	1	319794
03DEC90	184	BT	1	2	19NOV90	186	BT	9	14	14	8	13	1	321529
03DEC90	256	BT	1	2	03DEC90	256	BT	1	2	0	0	0	1	322574
03DEC90	306	BT	1	2	03DEC90	308	BT	1	2	0	0	0	1	330066
04DEC90	295	BT	1	2	03DEC90	292	BT	1	2	1	0	0	1	322615
04DEC90	282	BT	1	2	03DEC90	281	BT	1	2	1	0	0	1	322618
05DEC90	311	BT	1	2	05DEC90	312	BT	1	2	0	0	0	1	330130
10DEC90	214	BT	1	2	27NOV90	216	BT	1	2	13	0	0	1	322124
10DEC90	273	BT	1	2	10DEC90	271	BT	1	2	0	0	0	1	322769
10DEC90	274	BT	1	2	10DEC90	274	BT	1	2	0	0	0	1	322818
10DEC90	327	BT	1	2	10DEC90	326	BT	1	2	0	0	0	1	330198
10DEC90	301	BT	1	2	10DEC90	302	BT	1	2	0	0	0	1	330201
10DEC90	316	BT	1	2	10DEC90	316	BT	1	2	0	0	0	1	330209
10DEC90	308	BT	1	2	10DEC90	310	BT	1	2	0	0	0	1	330211
11DEC90	306	BT	1	2	26NOV90	306	BT	1	2	15	0	0	1	319830
11DEC90	380	BT	1	2	28NOV90	278	BT	1	2	13	0	0	1	322322
11DEC90	205	BT	1	2	29NOV90	206	BT	1	2	12	0	0	1	322389
11DEC90	203	BT	1	2	30NOV90	202	BT	1	2	11	0	0	1	322502
11DEC90	271	BT	1	2	06DEC90	270	BT	1	2	5	0	0	1	322689
11DEC90	269	BT	1	2	11DEC90	270	BT	1	2	0	0	0	1	322887
11DEC90	252	BT	1	2	11DEC90	254	BT	1	2	0	0	0	1	322897
11DEC90	223	BT	1	2	11DEC90	223	BT	1	2	0	0	0	1	322898
11DEC90	273	BT	1	2	11DEC90	276	BT	1	2	0	0	0	1	322901
11DEC90	325	BT	1	2	11DEC90	224	BT	1	2	0	0	0	1	322910
11DEC90	180	BT	1	2	11DEC90	178	BT	1	2	0	0	0	1	322931
11DEC90	234	BT	1	2	11DEC90	234	BT	1	2	0	0	0	1	322945
11DEC90	223	BT	1	2	11DEC90	225	BT	1	2	0	0	0	1	322949
11DEC90	228	BT	1	2	11DEC90	228	BT	1	2	0	0	0	1	322973
11DEC90	325	BT	1	2	11DEC90	225	BT	1	2	0	0	0	1	322992
11DEC90	257	BT	1	2	11DEC90	257	BT	1	2	0	0	0	1	323012
11DEC90	427	BT	1	2	11DEC90	325	BT	1	2	0	0	0	1	330288
11DEC90	329	BT	1	2	11DEC90	330	BT	1	2	0	0	0	1	330310
11DEC90	347	BT	1	2	11DEC90	346	BT	1	2	0	0	0	1	330322
12DEC90	312	BT	1	2	29NOV90	310	BT	1	2	13	0	0	1	319997
12DEC90	213	BT	1	2	30NOV90	212	BT	1	2	12	0	0	1	322481
12DEC90	266	BT	1	2	10DEC90	267	BT	1	2	2	0	0	1	322763
12DEC90	227	BT	1	2	11DEC90	229	BT	1	2	1	0	0	1	322894
12DEC90	197	BT	1	2	11DEC90	195	BT	1	2	1	0	0	1	322916
12DEC90	226	BT	1	2	11DEC90	225	BT	1	2	1	0	0	1	322918
12DEC90	249	BT	1	2	11DEC90	251	BT	1	2	1	0	0	1	323014
12DEC90	280	BT	1	2	11DEC90	280	BT	1	2	1	0	0	1	323047

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
12DEC90	252	BT	1	2	11DEC90	253	BT	1	2	1	0	0	1	323078
12DEC90	201	BT	1	2	11DEC90	201	BT	1	2	1	0	0	1	323085
12DEC90	280	BT	1	2	12DEC90	281	BT	1	2	0	0	0	1	323095
12DEC90	280	BT	1	2	12DEC90	280	BT	1	2	0	0	0	1	323102
12DEC90	210	BT	1	2	12DEC90	210	BT	1	2	0	0	0	1	323105
12DEC90	289	BT	1	2	12DEC90	289	BT	1	2	0	0	0	1	323115
12DEC90	228	BT	1	2	12DEC90	227	BT	1	2	0	0	0	1	323145
12DEC90	305	BT	1	2	12DEC90	304	BT	1	2	0	0	0	1	330392
13DEC90	187	BT	1	2	24NOV90	191	BT	1	2	19	0	0	1	321758
13DEC90	300	BT	1	2	26NOV90	296	BT	1	2	17	0	0	1	321937
13DEC90	290	BT	1	2	03DEC90	289	BT	1	2	10	0	0	1	322577
14DEC90	234	BT	1	2	16NOV90	231	BT	1	2	28	0	0	1	321412
14DEC90	208	BT	1	2	27NOV90	207	BT	1	2	17	0	0	1	322105
14DEC90	179	BT	1	2	30NOV90	178	BT	1	2	14	0	0	1	322464
17DEC90	212	BT	1	2	21NOV90	212	BT	1	2	26	0	0	1	321685
17DEC90	194	BT	1	2	21NOV90	194	BT	1	2	26	0	0	1	321697
17DEC90	221	BT	1	2	12DEC90	221	BT	1	2	5	0	0	1	323109
17DEC90	198	BT	1	2	17DEC90	198	BT	1	2	0	0	0	1	323470
17DEC90	354	BT	1	2	17DEC90	353	BT	1	2	0	0	0	1	330691
18DEC90	267	BT	1	2	13DEC90	267	BT	1	2	5	0	0	1	323287
18DEC90	272	BT	1	2	18DEC90	272	BT	1	2	0	0	0	1	323491
18DEC90	309	BT	1	2	17DEC90	309	BT	1	2	1	0	0	1	330748
18DEC90	391	BT	1	2	18DEC90	391	BT	1	2	0	0	0	1	330797
19DEC90	208	BT	1	2	21NOV90	213	BT	1	2	28	0	0	2	321692
19DEC90	251	BT	1	2	17DEC90	250	BT	1	2	2	0	0	1	323466
19DEC90	256	BT	1	2	19DEC90	257	BT	1	2	0	0	0	1	323564
19DEC90	238	BT	1	2	19DEC90	246	BT	1	2	0	0	0	1	323594
20DEC90	191	BT	1	2	26NOV90	291	BT	1	2	24	0	0	1	322026
20DEC90	283	BT	1	2	30NOV90	283	BT	1	2	20	0	0	1	322510
20DEC90	280	BT	1	2	19DEC90	281	BT	1	2	1	0	0	1	323641
21DEC90	251	BT	1	2	20NOV90	252	BT	1	2	31	0	0	1	321592
21DEC90	240	BT	1	2	20NOV90	240	BT	1	2	31	0	0	1	321617
21DEC90	228	BT	1	2	17DEC90	230	BT	1	2	4	0	0	1	323486
21DEC90	215	BT	1	2	19DEC90	216	BT	1	2	2	0	0	1	323666
21DEC90	200	BT	1	2	20DEC90	200	BT	1	2	1	0	0	1	323788
21DEC90	320	BT	1	2	21DEC90	220	BT	1	2	0	0	0	1	323798
21DEC90	282	BT	1	2	21DEC90	284	BT	1	2	0	0	0	1	323833
21DEC90	308	BT	1	2	20DEC90	306	BT	1	2	1	0	0	1	331008
26DEC90	200	BT	1	2	29NOV90	197	BT	1	2	27	0	0	1	322416
26DEC90	197	BT	1	2	11DEC90	199	BT	1	2	15	0	0	1	323016
27DEC90	216	BT	1	2	26NOV90	315	BT	1	2	31	0	0	1	319872
27DEC90	470	BT	1	2	28NOV90	469	BT	1	2	29	0	0	1	319967
27DEC90	273	BT	1	2	26NOV90	277	BT	1	2	31	0	0	1	321951
27DEC90	205	BT	1	2	11DEC90	205	BT	1	2	16	0	0	1	323028
27DEC90	239	BT	1	2	26DEC90	236	BT	1	2	1	0	0	1	324042
27DEC90	245	BT	1	2	27DEC90	247	BT	1	2	0	0	0	1	324059
27DEC90	212	BT	1	2	27DEC90	212	BT	1	2	0	0	0	1	324091

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER
03JAN91	204	BT	1	2	30NOV90	202	BT	1	2	34	0	0	1	322482
03JAN91	340	BT	1	2	31DEC90	342	BT	1	2	3	0	0	1	331437
03JAN91	344	BT	1	2	03JAN91	349	BT	1	2	0	0	0	1	331516
04JAN91	250	BT	1	2	20NOV90	252	BT	1	2	45	0	0	1	321592
04JAN91	299	BT	1	2	26NOV90	299	BT	1	2	39	0	0	1	322003
04JAN91	235	BT	1	2	27NOV90	234	BT	1	2	38	0	0	1	322045
04JAN91	264	BT	1	2	04JAN91	265	BT	1	2	0	0	0	1	324389
04JAN91	231	BT	1	2	04JAN91	231	BT	1	2	0	0	0	1	324392
04JAN91	208	BT	1	2	04JAN91	208	BT	1	2	0	0	0	1	324409
04JAN91	270	BT	1	2	04JAN91	270	BT	1	2	0	0	0	1	324422
04JAN91	241	BT	1	2	04JAN91	241	BT	1	2	0	0	0	1	324451
04JAN91	306	BT	1	2	11DEC90	385	BT	1	2	24	0	0	1	330363
04JAN91	301	BT	1	2	04JAN91	300	BT	1	2	0	0	0	1	331599
07JAN91	309	BT	8	13	27NOV90	308	BT	1	2	41	7	11	1	319918
07JAN91	240	BT	9	14	17DEC90	242	BT	1	2	21	8	13	1	323478
07JAN91	142	BT	9	14	07JAN91	242	BT	9	14	0	0	0	1	324517
07JAN91	251	BT	9	14	07JAN91	250	BT	9	14	0	0	0	1	324530
07JAN91	300	BT	8	13	07JAN91	298	BT	8	13	0	0	0	1	324565
07JAN91	363	BT	8	13	28DEC90	366	BT	1	2	10	7	11	1	331378
08JAN91	318	BT	1	2	28NOV90	317	BT	1	2	41	0	0	1	319958
08JAN91	242	BT	1	2	20NOV90	240	BT	1	2	49	0	0	1	321569
08JAN91	270	BT	1	2	26NOV90	277	BT	1	2	43	0	0	1	321951
09JAN91	191	BT	1	2	26NOV90	291	BT	1	2	44	0	0	1	322026
09JAN91	267	BT	1	2	28NOV90	267	BT	1	2	42	0	0	1	322208
09JAN91	277	BT	1	2	13DEC90	279	BT	1	2	27	0	0	1	323339
09JAN91	202	BT	1	2	19DEC90	201	BT	1	2	21	0	0	1	323647
09JAN91	171	BT	1	2	21DEC90	170	BT	1	2	19	0	0	1	323854
09JAN91	226	BT	1	2	27DEC90	226	BT	1	2	13	0	0	2	324050
09JAN91	203	BT	1	2	27DEC90	203	BT	1	2	13	0	0	1	324060
09JAN91	277	BT	1	2	07JAN91	277	BT	9	14	2	8	13	1	324520
09JAN91	299	BT	1	2	07JAN91	298	BT	8	13	2	7	11	1	324560
09JAN91	330	BT	1	2	11DEC90	335	BT	1	2	29	0	0	1	330361
10JAN91	202	BT	1	2	19DEC90	206	BT	1	2	22	0	0	1	323600
10JAN91	230	UH	3	5	04JAN91	231	BT	1	2	6	4	6	1	324425
10JAN91	248	BT	1	2	09JAN91	248	BT	1	2	1	0	0	1	324895
10JAN91	252	UH	3	5	10JAN91	254	UH	3	5	0	0	0	1	324962
10JAN91	275	UH	3	5	10JAN91	275	UH	3	5	0	0	0	1	325086
10JAN91	355	UH	3	5	09JAN91	353	BT	1	2	1	4	6	1	331864
11JAN91	235	UH	3	5	03DEC90	237	BT	1	2	39	4	6	1	322592
11JAN91	252	UH	3	5	31DEC90	252	BT	1	2	11	4	6	1	324198
11JAN91	236	UH	3	5	04JAN91	236	BT	1	2	7	4	6	1	324458
14JAN91	218	UH	3	5	10JAN91	218	UH	3	5	4	0	0	1	324946
14JAN91	292	UH	3	5	10JAN91	291	UH	3	5	4	0	0	1	325077
14JAN91	310	UH	3	5	12DEC90	311	BT	1	2	33	4	6	1	330397
14JAN91	304	UH	3	5	11JAN91	302	UH	3	5	3	0	0	1	332153
15JAN91	186	UH	3	5	29NOV90	187	BT	1	2	47	4	6	1	322417
15JAN91	217	UH	3	5	03DEC90	218	BT	1	2	43	4	6	1	322586

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
15JAN91	188	UH	3	5	26DEC90	187	BT	1	2	20	4	6	1	324037
15JAN91	202	UH	3	5	09JAN91	203	BT	1	2	6	4	6	1	324794
15JAN91	200	UH	3	5	11JAN91	202	UH	3	5	4	0	0	1	325197
15JAN91	226	UH	3	5	11JAN91	226	UH	3	5	4	0	0	1	325380
15JAN91	233	UH	3	5	15JAN91	235	UH	3	5	0	0	0	1	325768
15JAN91	233	UH	3	5	15JAN91	231	UH	3	5	0	0	0	1	325901
15JAN91	310	BT	1	2	10JAN91	309	UH	3	5	5	4	6	1	332075
16JAN91	302	BT	1	2	28NOV90	300	BT	1	2	49	0	0	1	319952
16JAN91	201	BT	1	2	29NOV90	206	BT	1	2	48	0	0	1	322389
16JAN91	206	BT	1	2	11DEC90	206	BT	1	2	36	0	0	1	323029
16JAN91	210	BT	1	2	27DEC90	212	BT	1	2	20	0	0	1	324092
16JAN91	236	BT	1	2	04JAN91	235	BT	1	2	12	0	0	1	324463
16JAN91	205	BT	1	2	09JAN91	205	BT	1	2	7	0	0	1	324875
16JAN91	225	BT	1	2	14JAN91	227	UH	3	5	2	4	6	1	325415
16JAN91	239	BT	1	2	14JAN91	238	UH	3	5	2	4	6	1	325462
16JAN91	197	BT	1	2	15JAN91	197	UH	3	5	1	4	6	1	325828
16JAN91	155	BT	1	2	15JAN91	157	UH	3	5	1	4	6	1	325890
16JAN91	273	BT	1	2	16JAN91	271	BT	1	2	0	0	0	1	326289
16JAN91	273	BT	1	2	16JAN91	271	BT	1	2	0	0	0	1	326289
16JAN91	214	BT	1	2	16JAN91	215	BT	1	2	0	0	0	1	326330
16JAN91	246	BT	1	2	16JAN91	344	BT	1	2	0	0	0	1	332414
16JAN91	312	BT	1	2	16JAN91	311	BT	1	2	0	0	0	1	332419
16JAN91	410	BT	1	2	16JAN91	410	BT	1	2	0	0	0	1	332440
16JAN91	341	BT	1	2	16JAN91	342	BT	1	2	0	0	0	1	332457
17JAN91	240	BT	1	2	27NOV90	239	BT	1	2	51	0	0	1	322049
17JAN91	262	UH	2	3	10DEC90	261	BT	1	2	38	3	5	1	322853
17JAN91	298	BT	1	2	09JAN91	296	BT	1	2	8	0	0	1	324889
17JAN91	238	UH	2	3	11JAN91	241	UH	3	5	6	1	2	1	325352
17JAN91	267	BT	1	2	15JAN91	268	UH	3	5	2	4	6	1	325770
17JAN91	256	BT	1	2	15JAN91	258	UH	3	5	2	4	6	1	325956
18JAN91	266	BT	1	2	12DEC90	265	BT	1	2	37	0	0	1	323187
18JAN91	293	BT	1	2	26DEC90	291	BT	1	2	23	0	0	1	324001
18JAN91	192	BT	1	2	15JAN91	290	BT	1	2	3	0	0	1	325635
18JAN91	270	BT	1	2	15JAN91	271	UH	3	5	3	4	6	1	325853
18JAN91	260	BT	1	2	18JAN91	258	BT	1	2	0	0	0	1	326572
18JAN91	288	BT	1	2	18JAN91	290	BT	1	2	0	0	0	1	326580
18JAN91	354	BT	1	2	18JAN91	357	BT	1	2	0	0	0	1	332617
18JAN91	370	BT	1	2	18JAN91	371	BT	1	2	0	0	0	1	332622
18JAN91	328	BT	1	2	18JAN91	327	BT	1	2	0	0	0	1	332641
21JAN91	267	BT	9	14	11DEC90	266	BT	1	2	41	8	13	1	322990
21JAN91	237	BT	8	13	18DEC90	239	BT	1	2	34	7	11	1	323508
21JAN91	226	BT	9	14	21JAN91	226	BT	9	14	0	0	0	1	326670
22JAN91	214	BT	1	2	07JAN91	218	BT	8	13	15	7	11	1	324589
22JAN91	276	BT	1	2	15JAN91	275	UH	3	5	7	4	6	1	325970
22JAN91	269	BT	1	2	22JAN91	271	BT	1	2	0	0	0	1	326804
22JAN91	237	BT	1	2	22JAN91	235	BT	1	2	0	0	0	1	326877
22JAN91	336	BT	1	2	14JAN91	337	UH	3	5	8	4	6	1	332275

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	TAG NUMBER
23JAN91	162	BT	1	2	26NOV90	163	BT	1	2	58	0	0	1	321990
23JAN91	220	BT	1	2	27NOV90	217	BT	1	2	57	0	0	1	322178
23JAN91	225	BT	1	2	28NOV90	223	BT	1	2	56	0	0	1	322224
23JAN91	249	BT	1	2	16JAN91	249	BT	1	2	7	0	0	1	326379
23JAN91	238	BT	1	2	17JAN91	237	BT	1	2	6	0	0	1	326492
23JAN91	260	BT	1	2	21JAN91	257	BT	9	14	2	8	13	1	326717
23JAN91	219	BT	1	2	22JAN91	218	BT	1	2	1	0	0	1	326858
23JAN91	222	BT	1	2	23JAN91	221	BT	1	2	0	0	0	1	327080
23JAN91	230	BT	1	2	23JAN91	230	BT	1	2	0	0	0	1	327124
23JAN91	215	BT	1	2	23JAN91	213	BT	1	2	0	0	0	1	327127
23JAN91	270	BT	1	2	23JAN91	270	BT	1	2	0	0	0	1	327152
23JAN91	194	BT	1	2	23JAN91	194	BT	1	2	0	0	0	1	327164
23JAN91	265	BT	1	2	23JAN91	265	BT	1	2	0	0	0	1	327171
23JAN91	304	BT	1	2	07JAN91	305	BT	8	13	16	7	11	1	331672
24JAN91	195	BT	1	2	28NOV90	198	BT	1	2	57	0	0	1	322292
24JAN91	210	BT	1	2	15JAN91	211	UH	3	5	9	4	6	1	326131
24JAN91	267	BT	1	2	24JAN91	268	BT	1	2	0	0	0	1	327336
24JAN91	369	BT	1	2	24JAN91	367	BT	1	2	0	0	0	1	332888
24JAN91	367	BT	1	2	24JAN91	368	BT	1	2	0	0	0	1	332902
25JAN91	305	BT	1	2	20NOV90	304	BT	1	2	66	0	0	1	319730
25JAN91	263	BT	1	2	18DEC90	265	BT	1	2	38	0	0	1	323495
25JAN91	220	BT	1	2	27DEC90	224	BT	1	2	29	0	0	1	324087
25JAN91	284	BT	1	2	23JAN91	285	BT	1	2	2	0	0	1	327145
25JAN91	306	BT	1	2	17JAN91	302	UH	2	3	8	3	5	1	332543
28JAN91	230	BT	1	2	16NOV90	232	BT	1	2	73	0	0	1	321473
28JAN91	221	BT	1	2	28JAN91	221	BT	1	2	0	0	0	1	327632
28JAN91	215	BT	1	2	28JAN91	214	BT	1	2	0	0	0	1	327659
28JAN91	268	BT	1	2	28JAN91	265	BT	1	2	0	0	0	1	327685
28JAN91	197	BT	1	2	28JAN91	197	BT	1	2	0	0	0	1	327716
28JAN91	332	BT	1	2	24JAN91	329	BT	1	2	4	0	0	1	332967
28JAN91	413	BT	1	2	28JAN91	417	BT	1	2	0	0	0	1	333200
29JAN91	158	BT	1	2	10DEC90	160	BT	1	2	50	0	0	1	322785
29JAN91	238	BT	1	2	11JAN91	238	UH	3	5	18	4	6	1	325187
29JAN91	231	BT	1	2	29JAN91	230	BT	1	2	0	0	0	1	327741
29JAN91	218	BT	1	2	29JAN91	218	BT	1	2	0	0	0	1	327809
29JAN91	297	BT	1	2	29JAN91	298	BT	1	2	0	0	0	1	327818
29JAN91	239	BT	1	2	29JAN91	239	BT	1	2	0	0	0	1	327825
29JAN91	213	BT	1	2	29JAN91	215	BT	1	2	0	0	0	1	327847
29JAN91	287	BT	1	2	29JAN91	388	BT	1	2	0	0	0	1	333221
29JAN91	318	BT	1	2	29JAN91	318	BT	1	2	0	0	0	1	333239
30JAN91	285	BT	9	14	24JAN91	284	BT	1	2	6	8	13	1	327271
30JAN91	258	BT	8	13	30JAN91	259	BT	9	14	0	1	2	1	327954
30JAN91	250	BT	8	13	30JAN91	252	BT	9	14	0	1	2	1	327969
30JAN91	250	BT	8	13	30JAN91	250	BT	8	13	0	0	0	1	327989
30JAN91	357	BT	9	14	25JAN91	359	BT	1	2	5	8	13	1	333009
30JAN91	354	BT	8	13	30JAN91	355	BT	8	13	0	0	0	1	333343
31JAN91	226	BT	8	13	12DEC90	226	BT	1	2	50	7	11	1	323210

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
31JAN91	278	BT	8	13	31DEC90	289	BT	1	2	31	7	11	1	324226
31JAN91	210	BT	9	14	07JAN91	211	BT	8	13	24	1	2	1	324604
31JAN91	247	BT	8	13	14JAN91	246	UH	3	5	17	11	18	1	325525
31JAN91	284	BT	8	13	15JAN91	285	UH	3	5	16	11	18	1	325675
31JAN91	306	BT	8	13	02JAN91	307	BT	1	2	29	7	11	1	331455
31JAN91		BT	8	13	18JAN91	372	BT	1	2	13	7	11	1	332592
31JAN91	418	BT	8	13	28JAN91	417	BT	1	2	3	7	11	1	333200
31JAN91	400	BT	8	13	31JAN91	400	BT	8	13	0	0	0	1	333427
01FEB91	268	BT	8	13	19NOV90	269	BT	9	14	74	1	2	1	321507
01FEB91	188	BT	8	13	30NOV90	188	BT	1	2	63	7	11	1	322484
01FEB91	185	BT	8	13	11DEC90	188	BT	1	2	52	7	11	1	323003
01FEB91	216	BT	8	13	10JAN91	216	UH	3	5	22	11	18	1	325072
01FEB91	288	BT	8	13	01FEB91	290	BT	8	13	0	0	0	1	328358
01FEB91	322	BT	8	13	14DEC90	322	BT	1	2	49	7	11	1	330657
01FEB91	347	BT	8	13	01FEB91	348	BT	8	13	0	0	0	1	333609
04FEB91	232	BT	7	11	31DEC90	231	BT	1	2	35	6	10	1	324217
04FEB91	208	BT	7	11	15JAN91	209	UH	3	5	20	10	16	1	325900
04FEB91	254	BT	7	11	17JAN91	256	BT	1	2	18	6	10	1	326460
04FEB91	305	BT	7	11	12DEC90	309	BT	1	2	54	6	10	1	330380
05FEB91	335	BT	8	13	26NOV90	333	BT	1	2	71	7	11	1	319828
05FEB91	152	BT	8	13	27DEC90	153	BT	1	2	40	7	11	1	324127
05FEB91	235	BT	8	13	08JAN91	235	BT	1	2	28	7	11	1	324703
05FEB91	271	BT	8	13	22JAN91	272	BT	1	2	14	7	11	1	326871
05FEB91	232	BT	9	14	24JAN91	234	BT	1	2	12	8	13	1	327293
05FEB91	288	BT	7	11	28JAN91	288	BT	1	2	8	6	10	1	327694
05FEB91	291	BT	8	13	30JAN91	292	BT	7	11	6	1	2	1	328068
05FEB91	296	BT	8	13	05FEB91	299	BT	9	14	0	1	2	1	329079
05FEB91	315	BT	8	13	19DEC90	320	BT	1	2	48	7	11	1	330874
05FEB91	300	BT	8	13	10JAN91	301	BT	1	2	26	7	11	1	331941
06FEB91	317	BT	8	13	28NOV90	317	BT	1	2	70	7	11	2	319958
06FEB91	218	BT	8	13	21NOV90	219	BT	1	2	77	7	11	1	321676
06FEB91	298	BT	8	13	26NOV90	297	BT	1	2	72	7	11	1	321938
06FEB91	277	BT	8	13	26DEC90	279	BT	1	2	42	7	11	1	323945
06FEB91	240	BT	8	13	15JAN91	238	UH	3	5	22	11	18	1	326147
06FEB91	214	BT	8	13	23JAN91	213	BT	1	2	14	7	11	1	327125
06FEB91	276	BT	8	13	25JAN91	275	BT	1	2	12	7	11	1	327624
06FEB91	258	BT	8	13	04FEB91	256	BT	7	11	2	1	2	1	328796
06FEB91	224	BT	7	11	06FEB91	225	BT	8	13	0	1	2	1	329188
06FEB91	301	BT	7	11	13DEC90	303	BT	1	2	55	6	10	1	330550
06FEB91	356	BT	7	11	25JAN91	357	BT	1	2	12	6	10	1	333034
06FEB91	316	BT	9	14	05FEB91	316	BT	8	13	1	1	2	1	334002
06FEB91	408	BT	9	14	06FEB91	406	BT	8	13	0	1	2	1	334112
06FEB91	337	BT	9	14	06FEB91	334	BT	7	11	0	2	3	1	334121
08FEB91	204	BT	8	13	13DEC90	205	BT	1	2	57	7	11	1	323280
08FEB91	244	BT	8	13	04JAN91	246	BT	1	2	35	7	11	1	324448
08FEB91	284	BT	8	13	04JAN91	282	BT	1	2	35	7	11	1	324449
08FEB91	290	BT	8	13	09JAN91	290	BT	1	2	30	7	11	1	324892

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
08FEB91	222	BT	8	13	23JAN91	223	BT	1	2	16	7	11	1	327010
08FEB91	278	BT	8	13	30JAN91	278	BT	8	13	9	0	0	1	327979
08FEB91	162	BT	8	13	01FEB91	161	BT	8	13	7	0	0	1	328377
08FEB91	224	BT	8	13	06FEB91	223	BT	8	13	2	0	0	1	329347
08FEB91	220	BT	8	13	08FEB91	213	BT	8	13	0	0	0	1	329528
08FEB91	234	BT	8	13	08FEB91	235	BT	8	13	0	0	0	1	329549
08FEB91	213	BT	8	13	08FEB91	214	BT	8	13	0	0	0	1	329550
08FEB91	219	BT	8	13	08FEB91	219	BT	8	13	0	0	0	1	329556
08FEB91	174	BT	8	13	08FEB91	175	BT	8	13	0	0	0	1	329580
08FEB91	293	BT	8	13	08FEB91	295	BT	8	13	0	0	0	1	329597
08FEB91	377	BT	8	13	03DEC90	379	BT	1	2	67	7	11	1	330071
08FEB91	328	BT	8	13	31DEC90	331	BT	1	2	39	7	11	1	331447
08FEB91	313	BT	8	13	08JAN91	315	BT	1	2	31	7	11	1	331753
08FEB91	304	BT	8	13	31JAN91	305	BT	8	13	8	0	0	1	333520
08FEB91	367	BT	8	13	08FEB91	366	BT	8	13	0	0	0	1	334267
11FEB91	288	BT	8	13	07DEC90	288	BT	1	2	66	7	11	1	322736
11FEB91	269	BT	8	13	12DEC90	268	BT	1	2	61	7	11	1	323189
11FEB91		BT	7	11	17JAN91	275	BT	1	2	25	6	10	1	326486
11FEB91	223	BT	8	13	01FEB91	224	BT	8	13	10	0	0	1	328303
11FEB91	271	BT	8	13	05FEB91	272	BT	7	11	6	1	2	1	328900
11FEB91	245	BT	8	13	06FEB91	247	BT	7	11	5	1	2	1	329163
11FEB91	265	BT	8	13	08FEB91	265	BT	8	13	3	0	0	1	329536
11FEB91	357	BT	9	14	14DEC90	357	BT	1	2	59	8	13	1	330659
11FEB91	306	BT	7	11	18DEC90	306	BT	1	2	55	6	10	1	330827
11FEB91	355	BT	8	13	08FEB91	356	BT	8	13	3	0	0	1	334269
11FEB91	312	BT	7	11	11FEB91	315	BT	8	13	0	1	2	1	334504
11FEB91	386	BT	7	11	11FEB91	387	BT	8	13	0	1	2	1	334573
11FEB91	389	BT	7	11	11FEB91	386	BT	8	13	0	1	2	1	334605
11FEB91	309	BT	7	11	11FEB91	307	BT	8	13	0	1	2	1	334621
12FEB91	229	BT	7	11	14DEC90	228	BT	1	2	60	6	10	1	323373
12FEB91	277	BT	7	11	10JAN91	279	UH	3	5	33	10	16	1	325051
12FEB91	281	BT	8	13	15JAN91	280	UH	3	5	28	11	18	1	325701
12FEB91	317	BT	7	11	09JAN91	320	BT	1	2	34	6	10	1	331906
12FEB91	369	BT	8	13	12FEB91	368	BT	7	11	0	1	2	1	334772
12FEB91	218	BT	7	11	12FEB91	217	BT	8	13	0	1	2	1	335134
13FEB91	273	BT	8	13	10DEC90	272	BT	1	2	65	7	11	2	322805
13FEB91	264	BT	8	13	23JAN91	265	BT	1	2	21	7	11	1	327193
13FEB91	200	BT	7	11	04FEB91	199	BT	7	11	9	0	0	1	328601
13FEB91	238	BT	7	11	11FEB91	235	BT	8	13	2	1	2	1	329937
13FEB91	308	BT	7	11	05FEB91	310	BT	8	13	8	1	2	1	333962
13FEB91	362	BT	8	13	13FEB91	364	BT	8	13	0	0	0	1	334845
13FEB91	262	BT	8	13	13FEB91	262	BT	8	13	0	0	0	1	335196
13FEB91	277	BT	7	11	13FEB91	278	BT	7	11	0	0	0	1	335280
14FEB91	320	BT	7	11	27NOV90	318	BT	1	2	79	6	10	1	319906
14FEB91	196	BT	7	11	26NOV90	196	BT	1	2	80	6	10	1	321956
14FEB91	217	BT	8	13	26NOV90	216	BT	1	2	80	7	11	2	322001
14FEB91	228	BT	8	13	19DEC90	230	BT	1	2	57	7	11	1	323550

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
14FEB91	317	BT	8	13	04JAN91	317	BT	1	2	41	7	11	1	331564
14FEB91	371	BT	7	11	12FEB91	371	BT	7	11	2	0	0	1	334664
14FEB91	330	BT	8	13	12FEB91	328	BT	7	11	2	1	2	1	334803
14FEB91	245	BT	8	13	14FEB91	245	BT	9	14	0	1	2	1	335472
14FEB91	402	BT	7	11	14FEB91	404	BT	8	13	0	1	2	2	335550
14FEB91	272	BT	7	11	14FEB91	273	BT	8	13	0	1	2	1	335561
14FEB91	387	BT	8	13	14FEB91	389	BT	8	13	0	0	0	1	335618
14FEB91	236	BT	7	11	14FEB91	236	BT	7	11	0	0	0	1	335733
15FEB91	306	BT	9	14	21NOV90	307	BT	1	2	86	8	13	2	319780
15FEB91	277	BT	9	14	28NOV90	276	BT	1	2	79	8	13	2	322329
15FEB91	213	BT	9	14	24JAN91	217	BT	1	2	22	8	13	1	327326
15FEB91	212	BT	10	16	08FEB91	213	BT	8	13	7	2	3	1	329537
15FEB91	247	BT	9	14	15FEB91	249	BT	10	16	0	1	2	1	335787
19FEB91	212	BT	8	13	21DEC90	212	BT	1	2	60	7	11	1	323841
19FEB91	235	BT	10	16	16JAN91	236	BT	1	2	34	9	14	1	326386
19FEB91	248	BT	10	16	25JAN91	247	BT	1	2	25	9	14	1	327436
19FEB91	282	BT	9	14	28JAN91	279	BT	1	2	22	8	13	1	327711
19FEB91	307	BT	9	14	07DEC90	312	BT	1	2	74	8	13	1	330171
19FEB91	330	BT	9	14	22JAN91	334	BT	1	2	28	8	13	1	332787
19FEB91	315	BT	9	14	13FEB91	316	BT	7	11	6	2	3	1	334885
19FEB91	357	BT	10	16	13FEB91	357	BT	7	11	6	3	5	1	334948
20FEB91	265	BT	8	13	07JAN91	265	BT	8	13	44	0	0	1	324500
20FEB91	277	BT	8	13	24JAN91	278	BT	1	2	27	7	11	1	327272
20FEB91	200	BT	8	13	05FEB91	200	BT	8	13	15	0	0	1	329001
20FEB91	194	BT	8	13	06FEB91	193	BT	9	14	14	1	2	1	329248
20FEB91	208	BT	8	13	08FEB91	211	BT	8	13	12	0	0	1	329473
20FEB91	316	BT	8	13	03JAN91	316	BT	1	2	48	7	11	1	331527
20FEB91	350	BT	8	13	28JAN91	350	BT	1	2	23	7	11	1	333182
20FEB91	240	BT	8	13	15FEB91	240	BT	9	14	5	1	2	1	335964
20FEB91	349	BT	8	13	20FEB91	350	BT	8	13	0	0	0	1	336679
20FEB91	210	BT	8	13	20FEB91	211	BT	8	13	0	0	0	1	336687
21FEB91	198	BT	1	2	11DEC90	199	BT	1	2	72	0	0	1	323035
21FEB91	207	BT	1	2	31DEC90	207	BT	1	2	52	0	0	1	324210
21FEB91	255	BT	1	2	10JAN91	257	UH	3	5	42	4	6	1	324985
21FEB91	290	BT	7	11	11JAN91	291	UH	3	5	41	10	16	1	325291
21FEB91	284	BT	1	2	14JAN91	287	UH	3	5	38	4	6	1	325500
21FEB91	295	BT	1	2	30JAN91	297	BT	9	14	22	8	13	1	327926
21FEB91	226	BT	7	11	30JAN91	226	BT	7	11	22	0	0	1	328075
21FEB91	250	BT	1	2	04FEB91	252	BT	7	11	17	6	10	1	328808
21FEB91	217	BT	7	11	08FEB91	217	BT	8	13	13	1	2	1	329760
21FEB91	370	BT	7	11	20DEC90	370	BT	1	2	63	6	10	1	331024
21FEB91	303	BT	7	11	23JAN91	305	BT	1	2	29	6	10	1	332850
21FEB91	249	BT	1	2	14FEB91	250	BT	8	13	7	7	11	1	335633
21FEB91	227	BT	1	2	14FEB91	227	BT	8	13	7	7	11	1	335693
21FEB91	310	BT	1	2	15FEB91	312	BT	9	14	6	8	13	1	335986
21FEB91	298	BT	1	2	21FEB91	298	BT	1	2	0	0	0	1	337342
22FEB91	249	BT	5	8	10DEC90	249	BT	1	2	74	4	6	1	322845

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
22FEB91	188	BT	5	8	01FEB91	187	BT	8	13	21	3	5	1	328513
22FEB91	296	BT	5	8	15FEB91	294	BT	9	14	7	4	6	1	336079
22FEB91	267	BT	5	8	21FEB91	266	BT	1	2	1	4	6	1	337313
22FEB91	254	BT	5	8	22FEB91	254	BT	5	8	0	0	0	1	337729
22FEB91	189	BT	5	8	22FEB91	188	BT	5	8	0	0	0	1	337741
25FEB91	379	BT	8	13	24JAN91	382	BT	1	2	32	7	11	1	332949
25FEB91	385	BT	8	13	31JAN91	382	BT	8	13	25	0	0	1	333565
26FEB91	339	BT	7	11	05DEC90	337	BT	1	2	83	6	10	2	330123
26FEB91	190	BT	7	11	22FEB91	189	BT	5	8	4	2	3	1	337925
27FEB91	192	BT	9	14	30NOV90	191	BT	1	2	89	8	13	1	322514
27FEB91	346	BT	9	14	26DEC90	354	BT	1	2	63	8	13	1	331204
27FEB91	356	BT	9	14	25FEB91	357	BT	8	13	2	1	2	1	338114
28FEB91	190	BT	10	16	16NOV90	192	BT	1	2	104	9	14	1	321475
28FEB91	296	BT	10	16	10JAN91	296	UH	3	5	49	13	21	1	325038
28FEB91	254	BT	10	16	30JAN91	255	BT	8	13	29	2	3	1	328008
28FEB91	154	BT	10	16	01FEB91	152	BT	8	13	27	2	3	1	328568
28FEB91	230	BT	10	16	01FEB91	230	BT	8	13	27	2	3	1	328569
28FEB91	249	BT	10	16	06FEB91	251	BT	8	13	22	2	3	1	329338
28FEB91	325	BT	10	16	02JAN91	325	BT	1	2	57	9	14	1	331469
28FEB91	340	BT	10	16	11FEB91	341	BT	8	13	17	2	3	1	334592
28FEB91	294	BT	10	16	20FEB91	293	BT	8	13	8	2	3	1	336982
28FEB91	205	BT	10	16	22FEB91	205	BT	5	8	6	5	8	1	337950
01MAR91	216	BT	10	16	26NOV90	215	BT	1	2	95	9	14	1	321961
01MAR91	294	BT	10	16	27NOV90	293	BT	1	2	94	9	14	1	322179
01MAR91	216	BT	10	16	11JAN91	214	UH	3	5	49	13	21	1	325261
01MAR91	296	BT	10	16	15JAN91	295	UH	3	5	45	13	21	1	325703
01MAR91	285	BT	10	16	15JAN91	287	UH	3	5	45	13	21	1	325724
01MAR91	223	BT	10	16	23JAN91	223	BT	1	2	37	9	14	1	326984
01MAR91	236	BT	10	16	12FEB91	236	BT	7	11	17	3	5	1	335177
01MAR91	240	BT	10	16	21FEB91	239	BT	1	2	8	9	14	1	337073
01MAR91	255	BT	10	16	21FEB91	255	BT	1	2	8	9	14	1	337378
04MAR91	242	BT	8	13	10DEC90	241	BT	1	2	84	7	11	2	322797
04MAR91	266	BT	8	13	20DEC90	266	BT	1	2	74	7	11	1	323754
04MAR91	238	BT	9	14	11JAN91	239	UH	3	5	52	12	19	1	325198
04MAR91	251	BT	9	14	30JAN91	257	BT	9	14	33	0	0	1	327931
04MAR91	289	BT	9	14	30JAN91	288	BT	9	14	33	0	0	1	328053
04MAR91	316	BT	8	13	08JAN91	315	BT	1	2	55	7	11	2	331713
04MAR91	197	BT	8	13	15FEB91	197	BT	9	14	17	1	2	1	336004
04MAR91	327	BT	8	13	28FEB91	326	BT	10	16	4	2	3	1	338624
05MAR91	278	BT	8	13	26DEC90	280	BT	1	2	69	7	11	1	323935
05MAR91	222	BT	5	8	10JAN91	222	UH	3	5	54	8	13	1	324945
05MAR91	227	BT	5	8	15JAN91	232	UH	3	5	49	8	13	1	326006
05MAR91	277	BT	5	8	14FEB91	276	BT	7	11	19	2	3	1	335657
05MAR91	265	BT	5	8	04MAR91	265	BT	9	14	1	4	6	1	339304
06MAR91	226	BT	1	2	13DEC90	227	BT	1	2	83	0	0	1	323262
06MAR91	205	BT	1	2	31JAN91	205	BT	8	13	34	7	11	1	328208
07MAR91	210	BT	1	2	08JAN91	210	BT	1	2	58	0	0	1	324693

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER
07MAR91	236	BT	1	2	11JAN91	237	UH	3	5	55	4	6	1	325211
07MAR91	190	BT	1	2	12FEB91	189	BT	7	11	23	6	10	1	335047
07MAR91	416	BT	1	2	07MAR91	416	BT	1	2	0	0	0	1	339836
08MAR91	223	BT	8	13	21FEB91	222	BT	1	2	15	7	11	1	337087
08MAR91	294	BT	9	14	22FEB91	291	BT	5	8	14	4	6	1	337726
08MAR91	354	BT	7	11	08MAR91	350	BT	7	11	0	0	0	1	339977
11MAR91	276	BT	8	13	19NOV90	284	BT	9	14	112	1	2	1	321527
11MAR91	248	BT	8	13	23JAN91	250	BT	1	2	47	7	11	1	326945
11MAR91	189	BT	8	13	25JAN91	190	BT	1	2	45	7	11	1	327451
11MAR91	292	BT	7	11	30JAN91	292	BT	8	13	40	1	2	1	327983
11MAR91	182	BT	8	13	30JAN91	182	BT	8	13	40	0	0	1	328045
11MAR91	224	BT	8	13	06FEB91	227	BT	8	13	33	0	0	1	329199
11MAR91	221	BT	8	13	13FEB91	224	BT	7	11	26	1	2	1	335331
11MAR91	230	BT	7	11	21FEB91	229	BT	7	11	18	0	0	1	337516
11MAR91	353	BT	8	13	25FEB91	355	BT	8	13	14	0	0	1	338119
11MAR91	258	BT	8	13	01MAR91	257	BT	10	16	10	2	3	1	339202
12MAR91	188	BT	7	11	18JAN91	188	BT	1	2	53	6	10	1	326636
12MAR91	249	BT	7	11	21JAN91	253	BT	9	14	50	2	3	2	326722
12MAR91	346	BT	8	13	15JAN91	337	UH	3	5	56	11	18	1	332361
12MAR91	233	BT	7	11	12MAR91	233	BT	7	11	0	0	0	1	340456
13MAR91	237	BT	8	13	14JAN91	244	UH	3	5	58	11	18	2	325401
13MAR91	277	BT	8	13	25JAN91	277	BT	1	2	47	7	11	1	327463
13MAR91	208	BT	9	14	01FEB91	210	BT	8	13	40	1	2	1	328337
13MAR91	244	BT	9	14	07FEB91	244	BT	8	13	34	1	2	1	329436
13MAR91	326	BT	9	14	13FEB91	326	BT	7	11	28	2	3	1	334896
13MAR91	194	BT	8	13	14FEB91	193	BT	7	11	27	1	2	1	335772
13MAR91	245	BT	10	16	15FEB91	247	BT	9	14	26	1	2	1	335893
13MAR91	223	BT	8	13	13MAR91	219	BT	9	14	0	1	2	1	340604
14MAR91	260	BT	10	16	19DEC90	262	BT	1	2	85	9	14	1	323604
14MAR91	232	BT	10	16	15JAN91	232	UH	3	5	58	13	21	2	325963
14MAR91	304	BT	10	16	16JAN91	303	BT	1	2	57	9	14	1	332483
14MAR91	272	BT	10	16	19FEB91	272	BT	10	16	23	0	0	1	336337
14MAR91	288	BT	7	11	11MAR91	285	BT	7	11	3	0	0	1	340349
14MAR91	226	BT	7	11	14MAR91	226	BT	10	16	0	3	5	1	340806
15MAR91	257	BT	10	16	15JAN91	251	UH	3	5	59	13	21	2	325706
15MAR91	291	BT	10	16	05FEB91	290	BT	9	14	38	1	2	1	329077
15MAR91	286	BT	7	11	08FEB91	295	BT	8	13	35	1	2	1	329812
15MAR91	252	BT	9	14	03DEC90	252	BT	1	2	102	8	13	2	330064
15MAR91	331	BT	9	14	05FEB91	333	BT	8	13	38	1	2	2	334038
18MAR91	274	BT	8	13	27NOV90	272	BT	1	2	111	7	11	1	322203
18MAR91	218	BT	8	13	08FEB91	218	BT	8	13	38	0	0	1	329489
18MAR91	177	BT	9	14	12MAR91	176	BT	7	11	6	2	3	1	340470
19MAR91	256	BT	1	2	20NOV90	268	BT	1	2	119	0	0	1	321602
19MAR91	210	BT	1	2	26NOV90	211	BT	1	2	113	0	0	1	321995
19MAR91	287	BT	1	2	17DEC90	290	BT	1	2	92	0	0	1	323398
19MAR91	237	BT	1	2	15FEB91	237	BT	9	14	32	8	13	1	336118
20MAR91	240	BT	8	13	28NOV90	239	BT	1	2	112	7	11	1	322326

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	COND	TAG NUMBER
20MAR91	218	BT	8	13	17DEC90	217	BT	1	2	93	7	11	1	323463
20MAR91	207	BT	8	13	26DEC90	209	BT	1	2	84	7	11	2	324033
20MAR91	298	BT	8	13	08JAN91	298	BT	1	2	71	7	11	1	324647
20MAR91	253	BT	8	13	08JAN91	254	BT	1	2	71	7	11	1	324704
20MAR91	284	BT	8	13	10JAN91	284	UH	3	5	69	11	18	2	325108
20MAR91	263	BT	8	13	15JAN91	263	UH	3	5	64	11	18	1	326243
20MAR91	335	BT	8	13	09JAN91	340	BT	1	2	70	7	11	1	331873
20MAR91	337	BT	8	13	11FEB91	338	BT	8	13	37	0	0	1	334590
20MAR91	214	BT	8	13	14FEB91	212	BT	8	13	34	0	0	1	335576
20MAR91	302	BT	8	13	06MAR91	304	BT	1	2	14	7	11	1	339808
20MAR91	319	BT	8	13	14MAR91	312	BT	10	16	6	2	3	1	345270
21MAR91	198	BT	8	13	29NOV90	196	BT	1	2	112	7	11	1	322359
21MAR91	204	BT	8	13	08FEB91	203	BT	8	13	41	0	0	1	329499
21MAR91	240	BT	8	13	08FEB91	241	BT	8	13	41	0	0	1	329776
21MAR91	295	BT	8	13	22FEB91	295	BT	5	8	27	3	5	1	337940
21MAR91	200	BT	8	13	05MAR91	198	BT	5	8	16	3	5	1	339616
21MAR91	234	BT	8	13	18MAR91	234	BT	8	13	3	0	0	1	340961
21MAR91	257	BT	8	13	20MAR91	257	BT	8	13	1	0	0	1	341181
22MAR91	256	BT	8	13	23JAN91	265	BT	1	2	58	7	11	1	327193
22MAR91	314	BT	8	13	17DEC90	313	BT	1	2	95	7	11	2	330695
22MAR91	198	BT	7	11	04MAR91	199	BT	9	14	18	2	3	1	339317
22MAR91	234	BT	8	13	12MAR91	233	BT	7	11	10	1	2	1	340538
25MAR91	272	BT	7	11	24NOV90	269	BT	1	2	121	6	10	1	321741
27MAR91	299	BT	7	11	18JAN91	299	BT	1	2	68	6	10	2	326642
27MAR91	338	BT	9	14	20DEC90	339	BT	1	2	97	8	13	1	331018
27MAR91	268	BT	10	16	20MAR91	269	BT	8	13	7	2	3	1	341193
28MAR91	307	BT	10	16	21FEB91	306	BT	7	11	35	3	5	1	337475
29MAR91	280	BT	1	2	04JAN91	278	BT	1	2	84	0	0	2	324444
29MAR91	183	BT	7	11	21MAR91	186	BT	8	13	8	1	2	1	341317
01APR91	252	BT	5	8	16NOV90	253	BT	1	2	136	4	6	1	321347
02APR91	186	BT	7	11	29NOV90	184	BT	1	2	124	6	10	1	322377
02APR91	279	BT	8	13	11FEB91	280	BT	8	13	50	0	0	2	329986
02APR91	317	BT	8	13	14JAN91	325	UH	3	5	78	11	18	1	332253
02APR91	297	BT	8	13	20FEB91	297	BT	8	13	41	0	0	1	336892
03APR91	246	BT	1	2	13FEB91	245	BT	8	13	49	7	11	1	335216
03APR91	234	BT	1	2	15FEB91	231	BT	9	14	47	8	13	2	335873
03APR91	310	BT	5	8	19FEB91	308	BT	10	16	43	5	8	1	336413
03APR91	216	BT	1	2	01MAR91	215	BT	10	16	33	9	14	1	339109
03APR91	313	BT	5	8	05MAR91	312	BT	9	14	29	4	6	1	339574
03APR91	291	BT	5	8	03APR91	293	BT	5	8	0	0	0	1	342006
04APR91	297	BT	1	2	16NOV90	292	BT	1	2	139	0	0	1	321442
04APR91	288	BT	1	2	24NOV90	285	BT	1	2	131	0	0	1	321762
04APR91	222	BT	1	2	08JAN91	226	BT	1	2	86	0	0	1	324749
04APR91	295	BT	1	2	22JAN91	300	BT	1	2	72	0	0	1	332824
04APR91	229	BT	1	2	12FEB91	231	BT	7	11	51	6	10	1	335048
04APR91	191	BT	1	2	04MAR91	193	BT	9	14	31	8	13	1	339263
04APR91	326	BT	1	2	21MAR91	326	BT	8	13	14	7	11	1	341328

APPENDIX TABLE D-2. (CONTINUED).

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
04APR91	260	BT	1	2	01APR91	260	BT	8	13	3	7	11	1	341908
04APR91	280	BT	1	2	04APR91	280	BT	1	2	0	0	0	1	342044
05APR91	202	BT	9	14	28DEC90	203	BT	1	2	98	8	13	1	324167
05APR91	301	BT	10	16	25JAN91	302	BT	1	2	70	9	14	1	333155
05APR91	267	BT	8	13	26FEB91	268	BT	5	8	38	3	5	1	338294
05APR91	185	BT	9	14	04MAR91	185	BT	10	16	32	1	2	1	339249
08APR91	191	BT	1	2	15NOV90	195	BT	1	2	144	0	0	2	321328
08APR91	273	BT	5	8	08JAN91	279	BT	1	2	90	4	6	2	324721
08APR91	345	BT	1	2	19DEC90	345	BT	1	2	110	0	0	1	330906
08APR91	225	BT	1	2	14FEB91	225	BT	7	11	53	6	10	2	335773
08APR91	297	BT	5	8	15FEB91	297	BT	9	14	52	4	6	1	335928
08APR91	193	BT	5	8	26FEB91	190	BT	5	8	41	0	0	1	338268
08APR91	288	BT	5	8	04MAR91	285	BT	8	13	35	3	5	1	339477
08APR91	295	BT	1	2	08APR91	293	BT	1	2	0	0	0	1	342172
09APR91	279	BT	7	11	23JAN91	280	BT	1	2	76	6	10	1	327022
09APR91	296	BT	5	8	15FEB91	297	BT	9	14	53	4	6	1	335928
09APR91	341	BT	5	8	21FEB91	342	BT	7	11	47	2	3	1	337468
09APR91	227	BT	7	11	09APR91	228	BT	7	11	0	0	0	1	342264
10APR91	325	BT	11	18	25JAN91	325	BT	1	2	75	10	16	1	333074
10APR91	293	BT	11	18	15FEB91	288	BT	9	14	54	2	3	2	335959
10APR91	275	BT	11	18	04APR91	275	BT	1	2	6	10	16	1	342079
12APR91	193	BT	1	2	03JAN91	196	BT	1	2	99	0	0	1	324334
12APR91	293	BT	5	8	08FEB91	294	BT	8	13	63	3	5	1	329852
12APR91	282	BT	5	8	05MAR91	283	BT	5	8	38	0	0	1	339654

\PPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1990-1991 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE							RELEASE										
DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
16NOV90	9 M TRAWL	3	392	BT	1	2	02NOV88	9 M TRAWL	1	213	BT	1	2	744	179	1	258298
16NOV90	9 M TRAWL	3	351	BT	1	2	21DEC89	9 M TRAWL	2	245	BT	1	2	330	106	1	274033
16NOV90	9 M TRAWL	2	332	BT	1	2	07NOV89	9 M TRAWL	1	237	BT	1	2	374	95	1	290054
16NOV90	9 M TRAWL	2	261	BT	1	2	13FEB90	9 M TRAWL	1	192	BT	1	2	276	69	1	311787
20NOV90	9 M TRAWL	2	250	BT	1	2	14NOV89	9 M TRAWL	1	209	BT	1	2	371	41	1	290514
20NOV90	9 M TRAWL	2	325	BT	1	2	05DEC89	9 M TRAWL	1	216	BT	1	2	350	109	1	292304
20NOV90	9 M TRAWL	2	293	BT	1	2	01FEB90	9 M TRAWL	1	217	BT	1	2	292	76	1	309389
21NOV90	9 M TRAWL	2	244	BT	1	2	20DEC89	9 M TRAWL	1	168	BT	1	2	336	76	1	273629
21NOV90	9 M TRAWL	2	276	BT	1	2	06DEC89	9 M TRAWL	1	228	BT	1	2	350	48	1	292418
21NOV90	9 M TRAWL	2	272	BT	1	2	16JAN90	9 M TRAWL	1	193	BT	1	2	309	79	1	306741
21NOV90	9 M TRAWL	2	235	BT	1	2	05FEB90	9 M TRAWL	1	169	BT	1	2	289	66	1	310360
21NOV90	9 M TRAWL	2	324	BT	1	2	23MAR90	9 M TRAWL	1	234	BT	1	2	243	90	1	318494
21NOV90	9 M TRAWL	2	332	BT	1	2	26MAR90	9 M TRAWL	1	334	BT	1	2	240	.	1	318754
21NOV90	9 M TRAWL	2	316	BT	1	2	02APR90	9 M TRAWL	1	230	BT	1	2	233	86	1	320398
24NOV90	9 M TRAWL	3	416	BT	1	2	28NOV89	9 M TRAWL	2	333	BT	9	14	361	83	1	272075
24NOV90	9 M TRAWL	2	242	BT	1	2	20DEC89	9 M TRAWL	1	168	BT	1	2	339	74	1	273629
24NOV90	9 M TRAWL	2	276	BT	1	2	16JAN90	9 M TRAWL	1	193	BT	1	2	312	83	1	306741
24NOV90	9 M TRAWL	2	313	BT	1	2	01FEB90	9 M TRAWL	1	233	BT	1	2	296	80	1	309375
24NOV90	9 M TRAWL	2	277	BT	1	2	26MAR90	9 M TRAWL	1	211	BT	1	2	243	66	1	318753
24NOV90	9 M TRAWL	2	295	BT	1	2	26MAR90	9 M TRAWL	1	208	BT	1	2	243	87	1	318864
26NOV90	9 M TRAWL	3	348	BT	1	2	20MAR90	9 M TRAWL	2	302	BT	1	2	251	46	1	262363
26NOV90	9 M TRAWL	2	260	BT	1	2	26MAR90	9 M TRAWL	1	227	BT	1	2	245	33	1	318825
26NOV90	9 M TRAWL	2	264	BT	1	2	27MAR90	9 M TRAWL	1	193	BT	1	2	244	71	1	319050
27NOV90	9 M TRAWL	2	271	BT	1	2	07NOV89	9 M TRAWL	1	201	BT	1	2	385	70	1	290047
27NOV90	9 M TRAWL	2	261	BT	1	2	05FEB90	9 M TRAWL	1	193	BT	1	2	295	68	1	310242
27NOV90	9 M TRAWL	2	260	BT	1	2	07FEB90	9 M TRAWL	.	178	BT	1	2	293	82	1	310829
27NOV90	9 M TRAWL	2	318	BT	1	2	13FEB90	9 M TRAWL	1	225	BT	1	2	287	93	1	311732
27NOV90	9 M TRAWL	2	264	BT	1	2	13FEB90	9 M TRAWL	1	159	BT	1	2	287	105	1	311861
27NOV90	9 M TRAWL	2	296	BT	1	2	15FEB90	9 M TRAWL	1	197	BT	1	2	285	99	1	312493
27NOV90	9 M TRAWL	2	292	BT	1	2	21MAR90	9 M TRAWL	1	185	BT	1	2	251	107	1	318061
27NOV90	9 M TRAWL	2	240	BT	1	2	22MAR90	9 M TRAWL	1	169	BT	1	2	250	71	1	318281
28NOV90	9 M TRAWL	2	234	BT	1	2	04DEC89	9 M TRAWL	1	176	BT	1	2	359	58	1	291798
28NOV90	9 M TRAWL	2	267	BT	1	2	15FEB90	9 M TRAWL	1	194	BT	1	2	286	73	1	312402
28NOV90	9 M TRAWL	2	268	BT	1	2	15FEB90	9 M TRAWL	1	194	BT	1	2	286	74	1	312402
28NOV90	9 M TRAWL	2	327	BT	1	2	29MAR90	9 M TRAWL	2	230	BT	1	2	244	97	1	320038
28NOV90	9 M TRAWL	2	277	BT	1	2	29MAR90	9 M TRAWL	1	200	BT	1	2	244	77	1	320075
29NOV90	9 M TRAWL	3	373	BT	1	2	30NOV89	9 M TRAWL	2	332	BT	1	2	364	41	1	272133
29NOV90	9 M TRAWL	2	349	BT	1	2	30NOV89	9 M TRAWL	1	220	BT	1	2	364	129	1	291177
29NOV90	9 M TRAWL	2	208	BT	1	2	26MAR90	9 M TRAWL	1	178	BT	1	2	248	30	1	318675
29NOV90	9 M TRAWL	2	255	BT	1	2	27MAR90	9 M TRAWL	1	174	BT	1	2	247	81	1	319101
03DEC90	9 M TRAWL	2	296	BT	1	2	16FEB90	9 M TRAWL	1	186	BT	1	2	290	110	1	312973
03DEC90	9 M TRAWL	2	238	BT	1	2	22MAR90	9 M TRAWL	1	190	BT	1	2	256	48	1	318303
03DEC90	9 M TRAWL	2	274	BT	1	2	11APR90	9 M TRAWL	1	191	BT	1	2	236	83	1	321159
04DEC90	9 M TRAWL	2	255	BT	1	2	30NOV89	9 M TRAWL	1	207	BT	1	2	369	48	1	291222
06DEC90	9 M TRAWL	2	295	BT	1	2	23MAR90	9 M TRAWL	1	211	BT	1	2	258	84	1	318487
07DEC90	9 M TRAWL	2	290	BT	1	2	02APR90	9 M TRAWL	1	187	BT	1	2	249	103	1	320317
10DEC90	9 M TRAWL	2	348	BT	1	2	26JAN90	9 M TRAWL	1	187	BT	1	2	318	161	1	308259

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
10DEC90	9 M TRAWL	2	346	BT	1	2	26JAN90	9 M TRAWL	1	187	BT	1	2	318	159	1	308259
10DEC90	9 M TRAWL	2	286	BT	1	2	05MAR90	9 M TRAWL	1	188	BT	1	2	280	98	1	314649
10DEC90	9 M TRAWL	2	350	BT	1	2	20MAR90	9 M TRAWL	1	267	BT	1	2	265	83	1	317758
11DEC90	9 M TRAWL	2	302	BT	1	2	06DEC89	9 M TRAWL	1	190	BT	1	2	370	112	1	292586
11DEC90	9 M TRAWL	2	388	BT	1	2	22FEB90	9 M TRAWL	1	203	BT	5	8	292	185	1	313538
11DEC90	9 M TRAWL	3	382	BT	1	2	26MAR90	9 M TRAWL	2	332	BT	1	2	260	50	1	318635
11DEC90	9 M TRAWL	2	283	BT	1	2	04APR90	9 M TRAWL	1	210	BT	1	2	251	73	1	320668
12DEC90	9 M TRAWL	2	372	BT	1	2	14DEC89	9 M TRAWL	1	237	BT	1	2	363	135	1	294475
12DEC90	9 M TRAWL	2	300	BT	1	2	10JAN90	9 M TRAWL	1	210	BT	9	14	336	90	1	305752
12DEC90	9 M TRAWL	2	269	BT	1	2	25JAN90	9 M TRAWL	1	193	BT	1	2	321	76	1	307973
12DEC90	9 M TRAWL	3	347	BT	1	2	05FEB90	9 M TRAWL	2	249	BT	1	2	310	98	1	310283
12DEC90	9 M TRAWL	2	239	BT	1	2	05MAR90	9 M TRAWL	1	166	BT	1	2	282	73	1	314569
12DEC90	9 M TRAWL	2	300	BT	1	2	11APR90	9 M TRAWL	1	218	BT	1	2	245	82	1	321081
13DEC90	9 M TRAWL	2	255	BT	1	2	13MAR90	9 M TRAWL	1	187	BT	9	14	275	68	1	315842
14DEC90	9 M TRAWL	3	510	BT	1	2	01DEC88	9 M TRAWL	1	264	BT	1	2	743	246	1	261410
14DEC90	9 M TRAWL	3	442	BT	1	2	30NOV89	9 M TRAWL	2	360	BT	1	2	379	82	1	272126
14DEC90	9 M TRAWL	3	465	BT	1	2	15FEB89	9 M TRAWL	1	243	BT	9	14	667	222	1	281269
17DEC90	9 M TRAWL	2	318	BT	1	2	26MAR90	9 M TRAWL	1	217	BT	1	2	266	101	1	292920
17DEC90	9 M TRAWL	2	259	BT	1	2	06FEB90	9 M TRAWL	1	194	BT	1	2	314	65	1	310748
18DEC90	9 M TRAWL	3	352	BT	1	2	05DEC89	9 M TRAWL	2	275	BT	1	2	378	77	1	292038
19DEC90	9 M TRAWL	3	400	BT	1	2	13FEB89	9 M TRAWL	1	214	BT	9	14	674	186	1	281054
19DEC90	9 M TRAWL	2	283	BT	1	2	30NOV89	9 M TRAWL	1	206	BT	1	2	384	77	1	291285
19DEC90	9 M TRAWL	2	320	BT	1	2	05DEC89	9 M TRAWL	1	208	BT	1	2	379	112	1	292182
19DEC90	9 M TRAWL	2	364	BT	1	2	31JAN90	9 M TRAWL	1	227	BT	1	2	322	137	1	308985
19DEC90	9 M TRAWL	2	303	BT	1	2	31JAN90	9 M TRAWL	1	237	BT	1	2	322	66	2	308997
19DEC90	9 M TRAWL	2	238	BT	1	2	12FEB90	9 M TRAWL	1	174	BT	1	2	310	64	2	311563
20DEC90	9 M TRAWL	2	335	BT	1	2	05FEB90	9 M TRAWL	1	238	BT	1	2	318	97	1	310287
21DEC90	9 M TRAWL	2	342	BT	1	2	01FEB90	9 M TRAWL	1	240	BT	1	2	323	102	1	309476
21DEC90	9 M TRAWL	3	360	BT	1	2	13MAR90	9 M TRAWL	2	308	BT	9	14	283	52	1	315981
26DEC90	9 M TRAWL	2	298	BT	1	2	25JAN90	9 M TRAWL	1	201	BT	1	2	335	97	1	308107
26DEC90	9 M TRAWL	2	315	BT	1	2	02FEB90	9 M TRAWL	1	186	BT	1	2	327	129	1	310149
26DEC90	9 M TRAWL	2	334	BT	1	2	14MAR90	9 M TRAWL	1	240	BT	8	13	287	94	1	316275
28DEC90	9 M TRAWL	2	287	BT	1	2	06DEC89	9 M TRAWL	1	247	BT	1	2	387	40	1	293018
31DEC90	9 M TRAWL	3	370	BT	1	2	14DEC89	9 M TRAWL	2	287	BT	1	2	382	83	1	294460
31DEC90	9 M TRAWL	2	355	BT	1	2	02FEB90	9 M TRAWL	1	235	BT	1	2	332	120	1	310175
31DEC90	9 M TRAWL	2	266	BT	1	2	12FEB90	9 M TRAWL	1	175	BT	1	2	322	91	1	311613
02JAN91	9 M TRAWL	2	334	BT	1	2	28DEC89	9 M TRAWL	1	250	BT	8	13	370	84	1	274323
02JAN91	9 M TRAWL	2	310	BT	1	2	26MAR90	9 M TRAWL	1	212	BT	1	2	282	98	1	318756
03JAN91	9 M TRAWL	2	308	BT	1	2	21DEC89	9 M TRAWL	1	210	BT	1	2	378	98	1	274008
03JAN91	9 M TRAWL	2	355	BT	1	2	20MAR89	9 M TRAWL	1	244	BT	5	8	654	111	1	285359
03JAN91	9 M TRAWL	2	275	BT	1	2	25JAN90	9 M TRAWL	1	220	BT	1	2	343	55	1	308069
04JAN91	9 M TRAWL	2	294	BT	1	2	11DEC89	9 M TRAWL	1	207	BT	8	13	389	87	2	293611
04JAN91	9 M TRAWL	2	290	BT	1	2	09FEB90	9 M TRAWL	1	205	BT	1	2	329	85	2	311349
07JAN91	9 M TRAWL	2	320	BT	9	14	01FEB90	9 M TRAWL	1	228	BT	1	2	340	92	1	309439
08JAN91	9 M TRAWL	2	329	BT	1	2	26JAN90	9 M TRAWL	1	166	BT	5	8	347	163	1	308394
08JAN91	9 M TRAWL	2	301	BT	1	2	27MAR90	9 M TRAWL	1	218	BT	1	2	287	83	1	319059
08JAN91	9 M TRAWL	2	370	BT	1	2	28MAR90	9 M TRAWL	1	263	BT	1	2	286	107	1	319361

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	GROWTH IN MM	COND	TAG NUMBER
10JAN91	9 M TRAWL	5	531	UH	3	5	04APR89	9 M TRAWL	3	420	BT	8	13	646	111	1	271815[a]
10JAN91	9 M TRAWL	3	426	UH	3	5	14FEB89	9 M TRAWL	1	231	BT	9	14	695	195	1	280790
10JAN91	9 M TRAWL	2	307	UH	3	5	05FEB90	9 M TRAWL	1	220	BT	1	2	339	87	2	310662
10JAN91	9 M TRAWL	2	318	UH	3	5	20FEB90	9 M TRAWL	1	168	BT	1	2	324	150	1	313207
10JAN91	9 M TRAWL	3	319	UH	3	5	21FEB90	9 M TRAWL	2	241	BT	1	2	323	78	1	313326
10JAN91	9 M TRAWL	2	288	BT	1	2	06MAR90	9 M TRAWL	1	202	BT	5	8	310	86	1	314737
11JAN91	9 M TRAWL	3	344	UH	3	5	09FEB90	9 M TRAWL	2	297	BT	1	2	336	47	2	311056[b]
11JAN91	9 M TRAWL	2	315	UH	3	5	13FEB90	9 M TRAWL	1	216	BT	1	2	332	99	1	311753
14JAN91	9 M TRAWL	3	312	UH	3	5	30JAN89	9 M TRAWL	1	183	BT	5	8	714	129	1	278836
14JAN91	9 M TRAWL	2	299	UH	3	5	08NOV89	9 M TRAWL	1	220	BT	1	2	432	79	1	290332
14JAN91	9 M TRAWL	2	284	UH	3	5	04DEC89	9 M TRAWL	1	208	BT	1	2	406	76	1	291828
14JAN91	9 M TRAWL	3	338	UH	3	5	01FEB90	9 M TRAWL	2	256	BT	1	2	347	82	1	309673
14JAN91	9 M TRAWL	2	350	UH	3	5	05FEB90	9 M TRAWL	1	204	BT	1	2	343	146	1	310670
15JAN91	9 M TRAWL	3	391	UH	3	5	07FEB90	9 M TRAWL	2	327	BT	1	2	342	64	1	274717[c]
15JAN91	9 M TRAWL	2	272	UH	3	5	08NOV89	9 M TRAWL	1	205	BT	1	2	433	67	1	290451
15JAN91	9 M TRAWL	2	267	BT	1	2	07DEC89	9 M TRAWL	1	173	BT	1	2	404	94	1	293181
15JAN91	9 M TRAWL	2	324	UH	3	5	08DEC89	9 M TRAWL	1	222	BT	1	2	403	102	1	293543
15JAN91	9 M TRAWL	2	322	BT	1	2	12FEB90	9 M TRAWL	1	234	BT	1	2	337	88	1	311476
16JAN91	9 M TRAWL	3	375	BT	1	2	20MAR89	9 M TRAWL	1	181	BT	8	13	667	194	1	285400
16JAN91	9 M TRAWL	2	280	BT	1	2	01DEC89	9 M TRAWL	1	194	BT	1	2	411	86	1	291562
16JAN91	9 M TRAWL	2	284	BT	1	2	12FEB90	9 M TRAWL	1	175	BT	1	2	338	109	1	311480
17JAN91	9 M TRAWL	3	353	BT	1	2	01MAR89	9 M TRAWL	1	167	BT	8	13	687	186	1	283540
18JAN91	9 M TRAWL	2	243	BT	1	2	20FEB90	9 M TRAWL	1	172	BT	1	2	332	71	1	313005
18JAN91	9 M TRAWL	2	333	BT	1	2	20MAR90	9 M TRAWL	1	221	BT	1	2	304	112	1	317512
21JAN91	9 M TRAWL	2	310	BT	9	14	15MAR90	9 M TRAWL	1	195	BT	9	14	312	115	1	316549
22JAN91	9 M TRAWL	2	252	BT	1	2	28DEC89	9 M TRAWL	1	197	BT	1	2	390	55	1	274347
22JAN91	9 M TRAWL	3	346	BT	1	2	22FEB90	9 M TRAWL	2	265	BT	5	8	334	81	1	313642
22JAN91	9 M TRAWL	4	440	BT	1	2	05MAR90	9 M TRAWL	.	379	BT	1	2	323	61	1	314582
23JAN91	9 M TRAWL	2	309	BT	1	2	22FEB90	9 M TRAWL	1	205	BT	5	8	335	104	1	313626
24JAN91	9 M TRAWL	2	290	BT	1	2	01DEC89	9 M TRAWL	2	220	BT	1	2	419	70	1	291478
25JAN91	9 M TRAWL	3	391	BT	1	2	13FEB90	9 M TRAWL	2	248	BT	1	2	346	143	1	311872
25JAN91	9 M TRAWL	2	320	BT	1	2	06MAR90	9 M TRAWL	1	198	BT	5	8	325	122	2	314704
25JAN91	9 M TRAWL	2	295	BT	1	2	23MAR90	9 M TRAWL	1	211	BT	1	2	308	84	1	318487
29JAN91	9 M TRAWL	3	373	BT	1	2	05DEC89	9 M TRAWL	2	312	BT	1	2	420	61	1	272357
30JAN91	9 M TRAWL	3	322	BT	9	14	27FEB89	9 M TRAWL	1	193	BT	5	8	702	129	1	282851
31JAN91	9 M TRAWL	2	325	BT	8	13	05FEB90	9 M TRAWL	1	250	BT	1	2	360	75	1	310517
31JAN91	9 M TRAWL	.	285	BT	8	13	20FEB90	9 M TRAWL	.	193	BT	1	2	345	92	1	313002
01FEB91	9 M TRAWL	3	395	BT	8	13	12JAN90	9 M TRAWL	2	329	BT	8	13	385	66	1	274467
01FEB91	9 M TRAWL	2	285	BT	8	13	06DEC89	9 M TRAWL	1	231	BT	1	2	422	54	1	292957
01FEB91	9 M TRAWL	2	287	BT	8	13	05FEB90	9 M TRAWL	1	201	BT	1	2	361	86	1	310630
01FEB91	9 M TRAWL	2	236	BT	8	13	14MAR90	9 M TRAWL	1	194	BT	8	13	324	42	2	316296
01FEB91	9 M TRAWL	2	247	BT	8	13	10APR90	9 M TRAWL	1	195	BT	8	13	297	52	1	318319
04FEB91	9 M TRAWL	3	385	BT	7	11	27MAR89	9 M TRAWL	1	230	BT	9	14	679	155	1	287266
04FEB91	9 M TRAWL	2	290	BT	7	11	11JAN90	9 M TRAWL	1	189	BT	8	13	389	101	1	306129
04FEB91	9 M TRAWL	2	264	BT	7	11	31JAN90	9 M TRAWL	1	202	BT	1	2	369	62	1	309004
04FEB91	9 M TRAWL	.	272	BT	7	11	14FEB90	9 M TRAWL	.	185	BT	1	2	355	87	1	312070
04FEB91	9 M TRAWL	2	256	BT	7	11	14FEB90	9 M TRAWL	1	184	BT	1	2	355	72	1	312105

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	COND	TAG NUMBER
04FEB91	9 M TRAWL	2	320	BT	7	11	28MAR90	9 M TRAWL	1	275	UH	2	3	313	45	1	319329
05FEB91	9 M TRAWL	2	265	BT	7	11	15FEB90	9 M TRAWL	1	223	BT	1	2	355	42	1	289864
05FEB91	9 M TRAWL	2	290	BT	7	11	07NOV89	9 M TRAWL	1	204	BT	1	2	455	86	1	290179
05FEB91	9 M TRAWL	2	218	BT	8	13	01DEC89	9 M TRAWL	1	154	BT	1	2	431	64	1	291567
05FEB91	9 M TRAWL	2	356	BT	7	11	15FEB90	9 M TRAWL	1	247	BT	1	2	355	109	1	312473
06FEB91	9 M TRAWL	.	480	BT	8	13	14FEB89	9 M TRAWL	2	293	BT	8	13	722	187	2	281078
06FEB91	9 M TRAWL	2	272	BT	7	11	08DEC89	9 M TRAWL	1	187	BT	1	2	425	85	1	293552
08FEB91	9 M TRAWL	2	346	BT	8	13	07NOV89	9 M TRAWL	1	244	BT	1	2	458	102	2	290025
08FEB91	9 M TRAWL	3	380	BT	8	13	09FEB90	9 M TRAWL	2	276	BT	1	2	364	104	1	311264[d]
08FEB91	9 M TRAWL	2	335	BT	8	13	16FEB90	9 M TRAWL	1	234	BT	1	2	357	101	1	312708
08FEB91	9 M TRAWL	2	315	BT	8	13	22MAR90	9 M TRAWL	1	216	BT	1	2	323	99	1	318184
08FEB91	9 M TRAWL	2	268	BT	8	13	22MAR90	9 M TRAWL	1	190	BT	1	2	323	78	2	318206
11FEB91	9 M TRAWL	2	323	BT	8	13	26JAN90	9 M TRAWL	1	219	BT	1	2	381	104	1	308274
12FEB91	9 M TRAWL	3	390	BT	7	11	09JAN89	9 M TRAWL	1	246	BT	5	8	764	144	1	275671
12FEB91	9 M TRAWL	2	275	BT	7	11	22JAN90	9 M TRAWL	1	210	BT	9	14	386	65	1	307529
12FEB91	9 M TRAWL	2	365	BT	7	11	02FEB90	9 M TRAWL	1	216	BT	1	2	375	149	2	309832
12FEB91	9 M TRAWL	.	254	BT	7	11	09FEB90	9 M TRAWL	2	298	BT	1	2	368	.	2	311342[e]
12FEB91	9 M TRAWL	.	254	BT	8	13	09FEB90	9 M TRAWL	2	298	BT	1	2	368	.	2	311342[e]
12FEB91	9 M TRAWL	2	301	BT	7	11	16FEB90	9 M TRAWL	1	215	BT	1	2	361	86	1	312735
13FEB91	9 M TRAWL	2	289	BT	7	11	04APR90	9 M TRAWL	1	212	BT	1	2	315	77	2	320702
14FEB91	9 M TRAWL	2	232	BT	8	13	17JAN90	9 M TRAWL	1	170	BT	1	2	393	62	1	306902
14FEB91	9 M TRAWL	2	359	BT	7	11	18JAN90	9 M TRAWL	1	212	BT	1	2	392	147	1	307101
14FEB91	9 M TRAWL	2	286	BT	7	11	01FEB90	9 M TRAWL	1	200	BT	1	2	378	86	1	309555
14FEB91	9 M TRAWL	2	335	BT	8	13	01FEB90	9 M TRAWL	1	237	BT	1	2	378	98	1	309766
15FEB91	9 M TRAWL	2	253	BT	9	14	28DEC89	9 M TRAWL	1	200	BT	9	14	414	53	1	274292
15FEB91	9 M TRAWL	3	394	BT	9	14	15MAR89	9 M TRAWL	1	184	BT	8	13	702	210	1	284715
15FEB91	9 M TRAWL	2	348	BT	9	14	18DEC89	9 M TRAWL	1	208	BT	9	14	424	140	1	294821
15FEB91	9 M TRAWL	2	292	BT	9	14	01FEB90	9 M TRAWL	1	174	BT	1	2	379	118	1	309547
15FEB91	9 M TRAWL	2	297	BT	9	14	09MAR90	9 M TRAWL	1	246	BT	8	13	343	51	1	315116
15FEB91	9 M TRAWL	2	303	BT	9	14	19MAR90	9 M TRAWL	1	219	BT	1	2	333	84	1	317304
15FEB91	9 M TRAWL	.	285	BT	9	14	21MAR90	9 M TRAWL	.	213	BT	1	2	331	72	1	317961
19FEB91	9 M TRAWL	2	317	BT	10	16	20DEC89	9 M TRAWL	1	242	BT	1	2	426	75	1	273647
19FEB91	9 M TRAWL	2	245	BT	8	13	15FEB90	9 M TRAWL	1	190	BT	1	2	369	55	2	312540
20FEB91	9 M TRAWL	.	375	BT	8	13	09FEB89	9 M TRAWL	1	160	BT	9	14	741	215	1	280212
20FEB91	9 M TRAWL	2	301	BT	8	13	02MAR90	9 M TRAWL	1	208	BT	1	2	355	93	1	314448
20FEB91	9 M TRAWL	2	310	BT	8	13	02APR90	9 M TRAWL	1	200	BT	1	2	324	110	1	320319
21FEB91	9 M TRAWL	2	340	BT	1	2	06DEC89	9 M TRAWL	1	220	BT	1	2	442	120	1	292722
21FEB91	9 M TRAWL	2	270	BT	7	11	31JAN90	9 M TRAWL	.	207	BT	1	2	386	63	1	309109
21FEB91	9 M TRAWL	2	258	BT	1	2	20MAR90	9 M TRAWL	.	190	BT	1	2	338	68	1	317768
21FEB91	9 M TRAWL	2	290	BT	1	2	11APR90	9 M TRAWL	1	176	BT	1	2	316	114	1	321160
22FEB91	9 M TRAWL	2	280	BT	5	8	11JAN90	9 M TRAWL	1	203	BT	8	13	407	77	1	306176
22FEB91	9 M TRAWL	2	275	BT	5	8	02APR90	9 M TRAWL	.	182	BT	1	2	326	93	1	320261
26FEB91	9 M TRAWL	2	285	BT	7	11	05MAR90	9 M TRAWL	1	188	BT	1	2	358	97	1	314649
28FEB91	9 M TRAWL	4	393	BT	10	16	01APR89	9 M TRAWL	2	293	BT	8	13	698	100	1	288372
28FEB91	9 M TRAWL	2	274	BT	10	16	10NOV89	9 M TRAWL	1	201	BT	1	2	475	73	1	290490
28FEB91	9 M TRAWL	2	299	BT	10	16	18JAN90	9 M TRAWL	1	198	BT	1	2	406	101	1	307035
28FEB91	9 M TRAWL	2	340	BT	10	16	20FEB90	9 M TRAWL	1	240	BT	1	2	373	100	2	313141

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE							RELEASE										
DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DATE	GEAR	AGE	TOTAL LENGTH IN MM	REGION	RIVER MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
28FEB91	9 M TRAWL	2	281	BT	10	16	26MAR90	9 M TRAWL	1	216	BT	1	2	339	65	1	318899
28FEB91	9 M TRAWL	2	260	BT	10	16	06APR90	9 M TRAWL	1	182	BT	1	2	328	78	1	320907
01MAR91	9 M TRAWL	2	297	BT	10	16	07NOV89	9 M TRAWL	1	226	BT	1	2	479	71	1	271931
01MAR91	9 M TRAWL	2	265	BT	10	16	06DEC89	9 M TRAWL	1	180	BT	1	2	450	85	1	292389
01MAR91	9 M TRAWL	2	235	BT	10	16	18DEC89	9 M TRAWL	1	176	BT	9	14	438	59	1	294962
04MAR91	9 M TRAWL	2	317	BT	8	13	20FEB90	9 M TRAWL	1	168	BT	1	2	377	149	1	313207
05MAR91	9 M TRAWL	2	327	BT	8	13	26JAN90	9 M TRAWL	1	166	BT	5	8	403	161	1	308394
05MAR91	9 M TRAWL	2	243	BT	5	8	06MAR90	9 M TRAWL	1	170	BT	5	8	364	73	1	314776
07MAR91	9 M TRAWL	.	353	UH	3	5	20FEB90	9 M TRAWL	.	241	BT	1	2	380	112	1	313153
07MAR91	9 M TRAWL	2	321	BT	1	2	28MAR90	9 M TRAWL	1	210	BT	1	2	344	111	1	319450
08MAR91	9 M TRAWL	2	273	BT	8	13	11JAN89	9 M TRAWL	1	220	BT	8	13	786	53	2	276216
11MAR91	9 M TRAWL	2	307	BT	8	13	07NOV89	9 M TRAWL	1	210	BT	1	2	489	97	1	290119
11MAR91	9 M TRAWL	2	332	BT	7	11	02JAN90	9 M TRAWL	1	174	BT	1	2	433	158	1	305080
11MAR91	9 M TRAWL	2	339	BT	8	13	09APR90	9 M TRAWL	1	167	BT	9	14	336	172	1	320941
12MAR91	9 M TRAWL	2	252	BT	7	11	12APR90	9 M TRAWL	1	178	BT	8	13	334	74	1	321250
13MAR91	9 M TRAWL	2	289	BT	10	16	19JAN90	9 M TRAWL	1	180	BT	8	13	418	109	1	307428
13MAR91	9 M TRAWL	2	304	BT	8	13	23FEB90	9 M TRAWL	1	210	BT	5	8	383	94	1	313816
13MAR91	9 M TRAWL	2	280	BT	10	16	12MAR90	9 M TRAWL	1	193	BT	8	13	366	87	1	315528
13MAR91	9 M TRAWL	2	251	BT	9	14	09APR90	9 M TRAWL	1	174	BT	9	14	338	77	2	320949
14MAR91	9 M TRAWL	.	460	BT	10	16	31DEC87	12 M/9 M COD	.	255	BT	9	14	1169	205	1	250420
14MAR91	9 M TRAWL	3	325	BT	10	16	20DEC89	9 M TRAWL	2	326	BT	1	2	449	.	1	273819
15MAR91	9 M TRAWL	3	348	BT	10	16	01FEB90	9 M TRAWL	2	295	BT	1	2	407	53	1	309542
18MAR91	9 M TRAWL	2	340	BT	8	13	29NOV89	9 M TRAWL	1	215	BT	8	13	474	125	1	291147
20MAR91	9 M TRAWL	2	263	BT	9	14	08FEB90	9 M TRAWL	1	168	BT	8	13	405	95	1	310972
20MAR91	9 M TRAWL	2	251	BT	8	13	12FEB90	9 M TRAWL	1	193	BT	1	2	401	58	2	311657
21MAR91	9 M TRAWL	2	274	BT	8	13	07NOV89	9 M TRAWL	1	195	BT	1	2	499	79	1	290045
22MAR91	9 M TRAWL	2	284	BT	8	13	06APR90	9 M TRAWL	1	214	BT	1	2	350	70	2	320824
25MAR91	9 M TRAWL	2	341	BT	8	13	27FEB90	9 M TRAWL	1	236	BT	9	14	391	105	1	314008
28MAR91	9 M TRAWL	2	291	BT	10	16	01FEB90	9 M TRAWL	1	207	BT	1	2	420	84	2	309455
01APR91	9 M TRAWL	3	367	BT	9	14	21FEB89	9 M TRAWL	1	208	BT	8	13	769	159	2	282433
01APR91	9 M TRAWL	2	267	BT	9	14	13DEC89	9 M TRAWL	1	185	BT	8	13	474	82	2	294131
04APR91	9 M TRAWL	3	353	BT	1	2	10NOV88	9 M TRAWL	1	177	BT	1	2	875	176	1	258863
04APR91	9 M TRAWL	2	325	BT	1	2	14DEC89	9 M TRAWL	1	187	BT	1	2	476	138	1	294295
04APR91	9 M TRAWL	2	318	BT	1	2	28MAR90	9 M TRAWL	1	240	BT	1	2	372	78	1	319364
04APR91	9 M TRAWL	2	280	BT	2	3	29MAR90	9 M TRAWL	1	200	BT	1	2	371	80	1	320075
04APR91	9 M TRAWL	2	268	BT	1	2	04APR90	9 M TRAWL	1	191	BT	1	2	365	77	1	320578
05APR91	9 M TRAWL	.	275	BT	8	13	09APR90	9 M TRAWL	.	187	BT	8	13	361	88	1	320965
08APR91	9 M TRAWL	2	317	BT	5	8	15FEB90	9 M TRAWL	1	223	BT	1	2	417	94	1	312365
08APR91	9 M TRAWL	2	281	BT	5	8	12MAR90	9 M TRAWL	1	189	BT	8	13	392	92	2	315516
09APR91	9 M TRAWL	2	269	BT	5	8	01DEC89	9 M TRAWL	1	182	BT	1	2	494	87	1	291477
09APR91	9 M TRAWL	2	312	BT	5	8	09MAR90	9 M TRAWL	1	221	BT	8	13	396	91	1	315264
10APR91	9 M TRAWL	2	267	BT	11	18	07DEC89	9 M TRAWL	1	169	BT	1	2	489	98	2	293174

[a] Recaptured without Dart Tag number 300774

[b] Recaptured without Dart Tag number 301056

[c] Recaptured with Dart Tag number 300746

[d] Recaptured with Dart Tag number 301107

[e] Recaptured without Dart Tag number 301142

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

			NUMBER OF RECAPTURES IN WEEK																								
RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	12 NOV M = 168	19 NOV M = 520	26 NOV M = 898	3 DEC M = 329	10 DEC M = 1128	17 DEC M = 866	24 DEC M = 646	31 DEC M = 546	7 JAN M = 1418	14 JAN M = 1766	21 JAN M = 1466	28 JAN M = 1479	4 FEB M = 1999	11 FEB M = 1925	18 FEB M = 1828	25 FEB M = 1161	4 MAR M = 875	11 MAR M = 1241	18 MAR M = 768	25 MAR M = 419	1 APR M = 467	8 APR M = 447	15 APR M = 46	TOTAL M = 22406
12 NOV	183	R	5																							5
		R/M	0.02976																							0.02976
		R/C	0.02732																							0.02732
19 NOV	567	R	1	14																						15
		R/M	0.00595	0.02692																						0.02180
		R/C	0.00176	0.02469																						0.02646
26 NOV	1030	R	3	13	64																					80
		R/M	0.01786	0.02500	0.07127																					0.05044
		R/C	0.00291	0.01262	0.06214																					0.07767
3 DEC	373	R	0	2	0	5																				7
		R/M	0.00000	0.00385	0.00000	0.01520																				0.00366
		R/C	0.00000	0.00536	0.00000	0.01340																				0.01877
10 DEC	1293	R	1	1	10	2	34																			48
		R/M	0.00595	0.00192	0.01114	0.00608	0.03014																			0.01577
		R/C	0.00077	0.00077	0.00773	0.00155	0.02630																			0.03712
17 DEC	991	R	0	5	2	0	2	15																		24
		R/M	0.00000	0.00962	0.00223	0.00000	0.00177	0.01732																		0.00614
		R/C	0.00000	0.00505	0.00202	0.00000	0.00202	0.01514																		0.02422

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK 12 NOV M = 168	19 NOV M = 520	26 NOV M = 898	3 DEC M = 329	10 DEC M = 1128	17 DEC M = 866	24 DEC M = 646	31 DEC M = 548	7 JAN M = 1418	14 JAN M = 1766	21 JAN M = 1466	28 JAN M = 1554	4 FEB M = 2019	11 FEB M = 1925	18 FEB M = 1828	25 FEB M = 1086	4 MAR M = 855	11 MAR M = 1241	18 MAR M = 770	25 MAR M = 409	1 APR M = 467	8 APR M = 447	15 APR M = 45	TOTAL M = 22397
24 DEC	708	R	0	0	4	0	2	0	3																	9
		R/M	0.00000	0.00000	0.00445	0.00000	0.00177	0.00000	0.00464																	0.00198
		R/C	0.00000	0.00000	0.00565	0.00000	0.00282	0.00000	0.00424																	0.01271
31 DEC	591	R	0	1	3	0	1	0	0	8																13
		R/M	0.00000	0.00192	0.00334	0.00000	0.00089	0.00000	0.00000	0.01485																0.00255
		R/C	0.00000	0.00169	0.00508	0.00000	0.00169	0.00000	0.00000	0.01354																0.02200
7 JAN	1522	R	0	1	5	1	2	4	3	3	9															28
		R/M	0.00000	0.00192	0.00557	0.00304	0.00177	0.00462	0.00464	0.00549	0.00635															0.00430
		R/C	0.00000	0.00066	0.00329	0.00066	0.00131	0.00263	0.00197	0.00197	0.00591															0.01840
14 JAN	1918	R	0	0	4	1	4	0	3	1	10	22														45
		R/M	0.00000	0.00000	0.00445	0.00304	0.00355	0.00000	0.00464	0.00183	0.00705	0.01246														0.00543
		R/C	0.00000	0.00000	0.00209	0.00052	0.00209	0.00000	0.00156	0.00052	0.00521	0.01147														0.02346
21 JAN	1628	R	0	1	4	0	1	2	1	0	2	6	15													32
		R/M	0.00000	0.00192	0.00445	0.00000	0.00089	0.00231	0.00155	0.00000	0.00141	0.00340	0.01023													0.00328
		R/C	0.00000	0.00061	0.00246	0.00000	0.00061	0.00123	0.00061	0.00000	0.00123	0.00369	0.00921													0.01966
28 JAN	1594	R	1	1	1	0	4	0	0	2	3	3	3	20												38
		R/M	0.00595	0.00192	0.00111	0.00000	0.00355	0.00000	0.00000	0.00366	0.00212	0.00170	0.00205	0.01352												0.00336
		R/C	0.00063	0.00063	0.00063	0.00000	0.00251	0.00000	0.00000	0.00125	0.00188	0.00188	0.00188	0.01255												0.02384

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA- TISTIC	NUMBER OF RECAPTURES IN WEEK 12 NOV M = 168	19 NOV M = 520	26 NOV M = 898	3 DEC M = 329	10 DEC M = 1128	17 DEC M = 866	24 DEC M = 646	31 DEC M = 546	7 JAN M = 1418	14 JAN M = 1766	21 JAN M = 1466	28 JAN M = 1554	4 FEB M = 2019	11 FEB M = 1925	18 FEB M = 1828	25 FEB M = 1086	4 MAR M = 855	11 MAR M = 1241	18 MAR M = 770	25 MAR M = 409	1 APR M = 467	8 APR M = 447	15 APR M = 45	TOTAL M = 22397
4 FEB	2208	R	0	1	3	1	3	1	2	4	4	3	6	5	14											47
		R/M	0.00000	0.00192	0.00334	0.00304	0.00266	0.00115	0.00310	0.00733	0.00282	0.00170	0.00409	0.00338	0.00700											0.00353
		R/C	0.00000	0.00045	0.00136	0.00045	0.00136	0.00045	0.00091	0.00181	0.00181	0.00136	0.00272	0.00226	0.00634											0.02129
11 FEB	2118	R	0	1	4	1	4	2	0	1	2	2	2	1	7	18										45
		R/M	0.00000	0.00192	0.00445	0.00304	0.00355	0.00231	0.00000	0.00183	0.00141	0.00113	0.00136	0.00068	0.00350	0.00935										0.00205
		R/C	0.00000	0.00047	0.00189	0.00047	0.00189	0.00094	0.00000	0.00047	0.00094	0.00094	0.00094	0.00047	0.00331	0.00850										0.02125
18 FEB	2039	R	0	0	0	1	2	2	0	2	3	2	4	5	5	7	6									39
		R/M	0.00000	0.00000	0.00000	0.00304	0.00177	0.00231	0.00000	0.00366	0.00212	0.00113	0.00273	0.00338	0.00250	0.00364	0.00328									0.00228
		R/C	0.00000	0.00000	0.00000	0.00049	0.00098	0.00098	0.00000	0.00098	0.00147	0.00098	0.00196	0.00245	0.00245	0.00343	0.00294									0.01913
25 FEB	1320	R	1	0	3	1	0	0	1	1	2	2	2	4	1	2	5	1								26
		R/M	0.00595	0.00000	0.00334	0.00304	0.00000	0.00000	0.00155	0.00183	0.00141	0.00113	0.00136	0.00270	0.00050	0.00104	0.00274	0.00086								0.00143
		R/C	0.00076	0.00000	0.00227	0.00076	0.00000	0.00000	0.00076	0.00076	0.00152	0.00152	0.00152	0.00303	0.00076	0.00152	0.00379	0.00076								0.01970
4 MAR	997	R	0	0	0	0	2	1	1	0	5	1	0	3	0	3	2	1	3							22
		R/M	0.00000	0.00000	0.00000	0.00000	0.00177	0.00115	0.00155	0.00000	0.00353	0.00057	0.00000	0.00203	0.00000	0.00156	0.00109	0.00086	0.00343							0.00116
		R/C	0.00000	0.00000	0.00000	0.00000	0.00201	0.00100	0.00100	0.00000	0.00502	0.00100	0.00000	0.00301	0.00000	0.00301	0.00201	0.00100	0.00301							0.02207
11 MAR	1466	R	0	1	0	1	0	1	0	0	0	6	4	3	5	4	2	2	0	4						33
		R/M	0.00000	0.00192	0.00000	0.00304	0.00000	0.00115	0.00000	0.00000	0.00000	0.00340	0.00273	0.00203	0.00250	0.00208	0.00109	0.00172	0.00000	0.00322						0.00163
		R/C	0.00000	0.00068	0.00000	0.00068	0.00000	0.00068	0.00000	0.00000	0.00000	0.00409	0.00273	0.00205	0.00341	0.00273	0.00136	0.00136	0.00000	0.00273						0.02251

(continued)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK: 12 NOV M = 168	19 NOV M = 520	28 NOV M = 898	3 DEC M = 329	10 DEC M = 1128	17 DEC M = 866	24 DEC M = 646	31 DEC M = 546	7 JAN M = 1418	14 JAN M = 1766	21 JAN M = 1468	28 JAN M = 1554
18 MAR	968	R	0	1	4	0	0	3	1	0	4	1	1	0
		R/M	0.00000	0.00192	0.00445	0.00000	0.00000	0.00346	0.00155	0.00000	0.00282	0.00057	0.00068	0.00000
		R/C	0.00000	0.00103	0.00413	0.00000	0.00000	0.00310	0.00103	0.00000	0.00413	0.00103	0.00103	0.00000
25 MAR	519	R	0	1	0	0	0	1	0	1	0	1	0	0
		R/M	0.00000	0.00192	0.00000	0.00000	0.00000	0.00115	0.00000	0.00183	0.00000	0.00057	0.00000	0.00000
		R/C	0.00000	0.00193	0.00000	0.00000	0.00000	0.00193	0.00000	0.00193	0.00000	0.00193	0.00000	0.00000
1 APR	581	R	2	1	1	0	0	0	1	0	1	1	2	0
		R/M	0.01190	0.00595	0.00595	0.00000	0.00000	0.00000	0.00595	0.00000	0.00595	0.00595	0.01190	0.00000
		R/C	0.00344	0.00172	0.00172	0.00000	0.00000	0.00000	0.00172	0.00000	0.00172	0.00172	0.00344	0.00000
8 APR	518	R	1	0	0	0	0	1	0	1	1	0	2	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00193	0.00000	0.00000	0.00000	0.00000	0.00193	0.00000	0.00193	0.00193	0.00000	0.00386	0.00000
15 APR	51	R	0	0	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TOTAL	25183	R	15	45	112	14	61	33	16	24	46	50	41	41
		R/M	0.08929	0.08654	0.12472	0.04255	0.05408	0.03811	0.02477	0.04396	0.03244	0.02831	0.02797	0.02772
		R/C	0.00060	0.00179	0.00445	0.00056	0.00242	0.00131	0.00064	0.00095	0.00183	0.00199	0.00163	0.00163

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS TRAWLS (C)	STA-TISTIC	4 FEB M = 2019	11 FEB M = 1925	18 FEB M = 1828	25 FEB M = 1086	4 MAR M = 855	11 MAR M = 1241	18 MAR M = 770	25 MAR M = 408	1 APR M = 467	8 APR M = 447	15 APR M = 45	TOTAL M = 22387
18 MAR	968	R	3	3	1	0	3	3	2					30
		R/M	0.00150	0.00156	0.00055	0.00000	0.00343	0.00242	0.00260					0.00143
		R/C	0.00310	0.00310	0.00103	0.00000	0.00310	0.00310	0.00207					0.03089
25 MAR	519	R	0	0	1	0	0	0	2	0				7
		R/M	0.00000	0.00000	0.00055	0.00000	0.00000	0.00000	0.00260	0.00000				0.00033
		R/C	0.00000	0.00000	0.00193	0.00000	0.00000	0.00000	0.00385	0.00000				0.01349
1 APR	581	R	0	4	2	2	3	0	1	0	3			24
		R/M	0.00000	0.02381	0.01190	0.01190	0.01786	0.00000	0.00595	0.00000	0.01786			0.00110
		R/C	0.00000	0.00688	0.00344	0.00344	0.00516	0.00000	0.00172	0.00000	0.00516			0.04131
8 APR	518	R	1	4	1	1	2	0	0	0	1	2		18
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00081
		R/C	0.00193	0.00772	0.00193	0.00193	0.00386	0.00000	0.00000	0.00000	0.00193	0.00386		0.03475
15 APR	51	R	0	0	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TOTAL	25183	R	36	45	20	7	11	7	5	0	4	2	0	635
		R/M	0.01801	0.02338	0.01094	0.00603	0.01257	0.00564	0.00651	0.00000	0.00857	0.00447	0.00000	0.02834
		R/C	0.00143	0.00179	0.00079	0.00028	0.00044	0.00028	0.00020	0.00000	0.00016	0.00008	0.00000	0.02522

R = number of striped bass recaptured.
M = number of striped bass > 150 mmTL marked and released.
C = number of striped bass > mmTL marked and released.
R/M = recapture rate.
R/C = recapture proportion.

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR STRIPED BASS CAPTURED WITH ABRADED TAGS IN THE HUDSON RIVER, 12 NOVEMBER 1990 THROUGH 20 APRIL 1991.

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STATION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STATION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	TAG COND.
16 NOV 90	9m	BT	1	392	2 NOV 88	9m	BT	1	213	98	258298				4	4	4		N	1
16 NOV 90	9m	BT	1	332	7 NOV 89	9m	BT	1	237	98	290054				4	4	4		N	1
16 NOV 90	9m	BT	1	261	13 FEB 90	9m	BT	1	192	98	311787				4	4	4		N	1
16 NOV 90	9m	BT	1	351	21 DEC 89	9m	BT	1	245	98	274033				4	4	4		N	1
20 NOV 90	9m	BT	1	293	1 FEB 90	9m	BT	1	217	98	* 309389				2	3	3	A	N	1
20 NOV 90	9m	BT	1	325	5 DEC 89	9m	BT	1	216	98	292304				4	4	4		N	1
20 NOV 90	9m	BT	1	250	14 NOV 89	9m	BT	1	209	98	290514				4	4	4		N	1
21 NOV 90	9m	BT	1	272	16 JAN 90	9m	BT	1	193	98	* 306741				3	3	3		N	1
21 NOV 90	9m	BT	1	276	6 DEC 89	9m	BT	1	228	98	292418				4	4	4		N	1
21 NOV 90	9m	BT	1	332	26 MAR 90	9m	BT	1	334	98	318754				4	4	4		N	1
21 NOV 90	9m	BT	1	324	23 MAR 90	9m	BT	1	234	98	318494				4	4	4		N	1
21 NOV 90	9m	BT	1	316	2 MAR 90	9m	BT	1	230	98	320398				4	4	4		N	1
21 NOV 90	9m	BT	1	235	5 FEB 90	9m	BT	1	169	98	310360				4	4	4		N	1
21 NOV 90	9m	BT	1	244	20 DEC 89	9m	BT	1	168	96	273629				4	4	4		N	1
24 NOV 90	9m	BT	1	295	26 MAR 90	9m	BT	1	208	98	318864				4	4	4		N	1
24 NOV 90	9m	BT	1	313	1 FEB 90	9m	BT	1	233	98	309375				4	4	4		N	1
24 NOV 90	9m	BT	1	416	28 NOV 89	9m	BT	9	333	98	272075				4	4	4		N	1
24 NOV 90	9m	BT	1	276	16 JAN 90	9m	BT	1	193	98	306741				4	4	4		N	1
24 NOV 90	9m	BT	1	277	26 MAR 90	9m	BT	1	211	98	318753				4	4	4		N	1
24 NOV 90	9m	BT	1	242	20 DEC 90	9m	BT	1	168	98	273629				4	4	4		N	1
26 NOV 90	9m	BT	1	264	27 MAR 90	9m	BT	1	193	98	319050				4	4	4		N	1
26 NOV 90	9m	BT	1	348	8 DEC 88	9m	BT	1	212	98	262363				4	4	4		N	1
26 NOV 90	9m	BT	1	260	26 MAR 90	9m	BT	1	227	98	318825				4	4	4		N	1
27 NOV 90	9m	BT	1	318	13 FEB 90	9m	BT	1	225	98	311732				4	4	4		N	1
27 NOV 90	9m	BT	1	261	5 FEB 90	9m	BT	1	193	98	310242				4	4	4		N	1
27 NOV 90	9m	BT	1	292	21 MAR 90	9m	BT	1	185	98	318061				4	4	4		N	1
27 NOV 90	9m	BT	1	264	13 FEB 90	9m	BT	1	159	98	311861				4	4	4		N	1
27 NOV 90	9m	BT	1	271	7 NOV 89	9m	BT	1	201	98	290047				4	4	4		N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
27 NOV 90	9m	BT	1	296	15 FEB 90	9m	BT	1	197	98	312493				4	4	4		N	1
27 NOV 90	9m	BT	1	240	22 MAR 90	9m	BT	1	169	98	318281				4	4	4		N	1
28 NOV 90	9m	BT	1	277	29 MAR 90	9m	BT	1	200	98	320075									1
28 NOV 90	9m	BT	1	267	15 FEB 90	9m	BT	1	194	98 *	312402									1
28 NOV 90	9m	BT	1	234	4 DEC 89	9m	BT	1	176	98	291798									1
28 NOV 90	9m	BT	1	268	15 FEB 90	9m	BT	1	194	98 *	312402									1
28 NOV 90	9m	BT	1	327	29 MAR 90	9m	BT	1	234	98	320038									1
29 NOV 90	9m	BT	1	208	26 MAR 90	9m	BT	1	178	98	318675				4	4	4		N	1
29 NOV 90	9m	BT	1	373	30 NOV 89	9m	BT	1	332	98	272133				4	4	4		N	1
29 NOV 90	9m	BT	1	255	27 MAR 90	9m	BT	1	174	98	319101				4	4	4		N	1
29 NOV 90	9m	BT	1	349	30 NOV 89	9m	BT	1	220	98	291177				4	4	4		N	1
3 DEC 90	9m	BT	1	296	16 FEB 90	9m	BT	1	186	98	312973				4	4	4		N	1
3 DEC 90	9m	BT	1	274	11 APR 90	9m	BT	1	191	98	321159				4	4	4		N	1
3 DEC 90	9m	BT	1	238	22 MAR 90	9m	BT	1	190	98	318303				4	4	4		N	1
4 DEC 90	9m	BT	1	255	30 NOV 89	9m	BT	1	207	98	291222				4	4	4		N	1
6 DEC 90	9m	BT	1	295	23 MAR 90	9m	BT	1	211	98	318487				4	4	4	A	N	1
7 DEC 90	9m	BT	1	290	2 APR 90	9m	BT	1	187	98	320317				4	4	4	P	N	1
10 DEC 90	9m	BT	1	286	5 MAR 90	9m	BT	1	188	98	314649				4	4	4	A	N	1
10 DEC 90	9m	BT	1	348	26 JAN 90	9m	BT	1	187	98	308259				4	4	4	P	N	1
10 DEC 90	9m	BT	1	350	20 MAR 90	9m	BT	1	267	98	317758				4	4	4	A	N	1
10 DEC 90	9m	BT	1	346	26 JAN 90	9m	BT	1	187	98	308259				4	4	4	A	N	1
11 DEC 90	9m	BT	1	283	4 APR 90	9m	BT	1	210	98	320668				4	4	4	A	N	1
11 DEC 90	9m	BT	1	388	22 FEB 90	9m	BT	5	203	98	313538				4	4	4	P	N	1
11 DEC 90	9m	BT	1	302	6 DEC 89	9m	BT	1	190	98 &	292586				4	4	4	P	Y	1
11 DEC 90	9m	BT	1	382	26 MAR 89	9m	BT	1	332	98	318635				4	4	4	A	N	1
12 DEC 90	9m	BT	1	269	25 JAN 90	9m	BT	1	193	98	307973				4	4	4	A	N	1
12 DEC 90	9m	BT	1	300	11 APR 90	9m	BT	1	218	98	321081				4	4	4	P	N	1
12 DEC 90	9m	BT	1	239	5 MAR 90	9m	BT	1	166	98	314569				4	4	4	A	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
19 DEC 90	9m	BT	1	283	30 NOV 89	9m	BT	1	206	98	291285				4	4	4	P	N	1
19 DEC 90	9m	BT	1	400	13 FEB 89	9m	BT	9	214	98	281054				4	4	4	A	N	1
20 DEC 90	9m	BT	1	335	5 FEB 90	9m	BT	1	238	98	310287				4	4	4	A	N	1
21 DEC 90	9m	BT	1	360	3 MAR 90	9m	BT	9	308	98	315981				4	4	4	A	N	1
21 DEC 90	9m	BT	1	342	1 FEB 90	9m	BT	1	240	98	309476				4	4	4	A	N	1
26 DEC 90	9m	BT	1	334	14 MAR 90	9m	BT	8	240	98	316275				4	4	4	A	N	1
26 DEC 90	9m	BT	1	315	2 FEB 90	9m	BT	1	186	98	310149				4	4	4	A	N	1
26 DEC 90	9m	BT	1	298	25 JAN 90	9m	BT	1	201	98	308107				4	4	4	A	N	1
28 DEC 90	9m	BT	1	287	6 DEC 89	9m	BT	1	247	98	293018				4	4	4	A	N	1
31 DEC 90	9m	BT	1	355	2 FEB 90	9m	BT	1	235	98	310175				4	4	4	A	N	1
31 DEC 90	9m	BT	1	266	12 FEB 90	9m	BT	1	175	98	311613				4	4	4	P	N	1
31 DEC 90	9m	BT	1	370	14 DEC 89	9m	BT	1	287	98	294460				4	4	4	P	N	1
2 JAN 91	9m	BT	1	310	26 MAR 90	9m	BT	1	212	98	318756				4	4	4	P	N	1
2 JAN 91	9m	BT	1	334	28 DEC 89	9m	BT	8	250	98	274323				4	4	4	A	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE DATE (MM/DD/YY	RECAPTURE GEAR	RECAPTURE STA-TION	RECAPTURE R_M	RECAPTURE LENGTH (mm TL)	RELEASE DATE (MM/DD/YY	RELEASE GEAR	RELEASE STA-TION	RELEASE R_M	RELEASE LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
3 JAN 91	9m	BT	1	308	21 DEC 89	9m	BT	1	210	98	274008				4	4	4	A	N	1
3 JAN 91	9m	BT	1	275	25 JAN 90	9m	BT	1	220	98	308069				4	4	4	P	N	1
3 JAN 91	9m	BT	1	355	20 MAR 89	9m	BT	5	244	98	285359				4	4	4	A	N	1
4 JAN 91	9m	BT	1	290	9 FEB 90	9m	BT	1	205	98	311349				4	4	4	A	N	2
4 JAN 91	9m	BT	1	294	11 DEC 89	9m	BT	8	207	98	293611				4	4	4	P	N	2
7 JAN 91	9m	BT	9	320	1 FEB 90	9m	BT	1	228	98	309439				4	4	4	A	N	1
8 JAN 91	9m	BT	1	329	26 JAN 90	9m	BT	5	166	98	308394				4	4	4	A	N	1
8 JAN 91	9m	BT	1	370	28 MAR 90	9m	BT	1	263	98	319361				4	4	4	A	N	1
8 JAN 91	9m	BT	1	301	27 MAR 90	9m	BT	1	218	98	319059				4	4	4	A	N	1
10 JAN 91	9m	BT	1	288	6 MAR 90	9m	BT	5	202	98	314737				4	4	4	A	N	1
10 JAN 91	9m	BT	3	531	4 APR 89	9m	BT	8	420	98	271815			# 300774	4	4	4	A	N	1
10 JAN 91	9m	BT	3	318	20 FEB 90	9m	BT	1	168	98	313207				4	4	4	A	N	1
10 JAN 91	9m	BT	3	426	14 FEB 89	9m	BT	9	231	98	280790				4	4	4	P	N	1
10 JAN 91	9m	BT	3	319	21 FEB 90	9m	BT	1	241	98	313326				4	4	4	A	N	1
10 JAN 91	9m	BT	3	307	5 FEB 90	9m	BT	1	220	98 &	310662				4	4	4	P	Y	2
11 JAN 91	9m	BT	3	315	13 FEB 90	9m	BT	1	216	98	311753				4	4	4	A	N	1
11 JAN 91	9m	BT	3	344	9 FEB 90	9m	BT	1	297	98	311056			# 301056	4	4	4	P	N	2
14 JAN 91	9m	BT	3	338	1 FEB 90	9m	BT	1	256	98	309673				4	4	4	P	N	1
14 JAN 91	9m	BT	3	350	5 FEB 90	9m	BT	1	204	98	310670				4	4	4	P	N	1
14 JAN 91	9m	BT	3	312	30 JAN 89	9m	BT	5	183	98	278836				4	4	4	P	N	1
14 JAN 91	9m	BT	3	284	4 DEC 89	9m	BT	1	208	98	291828				4	4	4	A	N	1
14 JAN 91	9m	BT	3	299	8 NOV 89	9m	BT	1	220	98	290332				4	4	4	P	N	1
15 JAN 91	9m	BT	1	322	12 FEB 90	9m	BT	1	234	98	311476				4	4	4	P	N	1
15 JAN 91	9m	BT	1	267	7 DEC 89	9m	BT	1	173	98	293181				4	4	4	P	N	1
15 JAN 91	9m	BT	3	324	8 DEC 89	9m	BT	1	222	98	293543				4	4	4	P	N	1
15 JAN 91	9m	BT	3	272	8 NOV 89	9m	BT	1	205	98	290451				4	4	4	P	N	1
15 JAN 91	9m	BT	3	391	7 FEB 90	9m	BT	1	327	98	274717			300746	4	4	4	A	N	1
16 JAN 91	9m	BT	1	280	1 DEC 89	9m	BT	1	194	98	291562				4	4	4	P	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA- TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA- TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN- TATION	ANCHOR PROTRUSION	TAG COND.
16 JAN 91	9m	BT	1	284	12 FEB 90	9m	BT	1	175	98	311480				4	4	4	A	N	1
16 JAN 91	9m	BT	1	375	20 MAR 89	9m	BT	8	181	98	285400				4	4	4	P	N	1
17 JAN 91	9m	BT	1	353	1 MAR 89	9m	BT	8	167	98	283540				4	4	4	A	N	1
18 JAN 91	9m	BT	1	243	20 FEB 90	9m	BT	1	172	98 &	313005				4	4	4	P	Y	1
18 JAN 91	9m	BT	1	333	20 MAR 90	9m	BT	1	221	98	317512				4	4	4	A	N	1
21 JAN 91	9m	BT	9	310	15 MAR 90	9m	BT	9	195	98	316549				4	4	4	P	N	1
22 JAN 91	9m	BT	1	346	22 FEB 90	9m	BT	5	265	98	313642				4	4	4	A	N	1
22 JAN 91	9m	BT	1	440	5 MAR 90	9m	BT	1	379	98	314582				4	4	4	A	N	1
22 JAN 91	9m	BT	1	252	28 DEC 89	9m	BT	1	197	98	274347				4	4	4	A	N	1
23 JAN 91	9m	BT	1	309	22 FEB 90	9m	BT	5	205	98	313626				4	4	4	A	N	1
24 JAN 91	9m	BT	1	290	1 DEC 89	9m	BT	1	220	98	291478				4	4	4	P	N	1
25 JAN 91	9m	BT	1	320	6 MAR 90	9m	BT	5	198	98	314704				4	4	4	P	N	2
25 JAN 91	9m	BT	1	391	13 FEB 90	9m	BT	1	248	98	311872				4	4	4	A	N	1
25 JAN 91	9m	BT	1	295	23 MAR 90	9m	BT	1	211	98	318487				4	4	4	P	N	1
28 JAN 91	9m	BT	1	719								98	333206		1	4	4	A	N	1
29 JAN 91	9m	BT	1	373	5 DEC 89	9m	BT	1	312	98	272357				4	4	4	P	N	1
30 JAN 91	9m	BT	9	322	27 FEB 89	9m	BT	5	193	98	282851				4	4	4	A	N	1
31 JAN 91	9m	BT	8	325	5 FEB 90	9m	BT	1	250	98	310517				4	4	4	A	N	1
1 FEB 91	9m	BT	8	236	14 MAR 90	9m	BT	8	194	98	316296				4	4	4	P	N	2
1 FEB 91	9m	BT	8	247	22 MAR 90	9m	BT	1	196	98	318319				4	4	4	P	N	1
1 FEB 91	9m	BT	8	287	5 FEB 90	9m	BT	1	201	98	310630				4	4	4	P	N	1
1 FEB 91	9m	BT	8	285	6 DEC 89	9m	BT	1	231	98	292957				4	4	4	A	N	1
1 FEB 91	9m	BT	8	395	12 JAN 90	9m	BT	8	329	98	274467				4	4	4	A	N	1
4 FEB 91	9m	BT	7	385	27 MAR 89	9m	BT	9	230	98	287266				4	4	4	P	N	1
4 FEB 91	9m	BT	7	256	14 FEB 90	9m	BT	1	184	98	312105				4	4	4	P	N	1
4 FEB 91	9m	BT	7	264	31 JAN 90	9m	BT	1	202	98 &	309004				4	4	4	A	Y	1
4 FEB 91	9m	BT	7	320	28 MAR 90	9m	BT	2	275	98	319329				4	4	4	P	N	1
4 FEB 91	9m	BT	7	290	11 JAN 90	9m	BT	8	189	98	306129				4	4	4	A	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
5 FEB 91	9m	BT	7	356	15 FEB 90	9m	BT	1	247	98	312473				4	4	4	A	N	1
5 FEB 91	9m	BT	7	265	3 NOV 89	9m	BT	1	223	98	289864				4	4	4	A	N	1
5 FEB 91	9m	BT	7	290	7 NOV 89	9m	BT	1	204	98	290179				4	4	4	P	N	1
5 FEB 91	9m	BT	7	218	1 DEC 89	9m	BT	1	154	98	291567				4	4	4	P	N	1
6 FEB 91	9m	BT	7	272	8 DEC 89	9m	BT	1	187	98	293552				4	4	4	A	N	1
6 FEB 91	9m	BT	8	480	14 FEB 89	9m	BT	8	293	98	281078	98	334164		2	4	4	A	N	1
8 FEB 91	9m	BT	8	315	22 MAR 90	9m	BT	1	216	98	318184				4	4	4	A	N	1
8 FEB 91	9m	BT	8	268	22 MAR 90	9m	BT	1	190	98	318206				4	4	4	P	N	2
8 FEB 91	9m	BT	8	335	16 FEB 90	9m	BT	1	234	98	312708				4	4	4	P	N	1
8 FEB 91	9m	BT	8	346	7 NOV 89	9m	BT	1	244	98	290025				4	4	4	A	N	2
8 FEB 91	9m	BT	8	380	9 FEB 90	9m	BT	1	276	98	311264			301107	4	4	4	A	N	1
11 FEB 91	9m	BT	8	323	26 JAN 90	9m	BT	1	219	98	308274				4	4	4	A	N	1
12 FEB 91	9m	BT	7	365	2 FEB 90	9m	BT	1	216	98	309832				4	4	4	A	N	2
12 FEB 91	9m	BT	7	254	9 FEB 90	9m	BT	1	298	98	311342			# 301142	4	4	4	A	N	2
12 FEB 91	9m	BT	7	275	22 JAN 90	9m	BT	9	210	98	307529				4	4	4	A	N	1
12 FEB 91	9m	BT	7	301	12 MAR 90	9m	BT	1	215	98	312735				4	4	4	A	N	1
12 FEB 91	9m	BT	7	254	9 FEB 90	9m	BT	1	298	98	311342			# 301142	4	4	4	A	N	2
12 FEB 91	9m	BT	7	390	9 JAN 89	9m	BT	5	246	98	275671				1	1	2		N	1
13 FEB 91	9m	BT	7	289	4 APR 90	9m	BT	1	212	98	320702				4	4	4	A	N	1
14 FEB 91	9m	BT	8	335	1 FEB 90	9m	BT	1	237	98	309766				4	4	4	A	N	1
14 FEB 91	9m	BT	8	232	17 JAN 90	9m	BT	1	170	98	306902				4	4	4	A	N	1
14 FEB 91	9m	BT	8	286	1 FEB 90	9m	BT	1	200	98	309555				4	4	4	P	N	1
14 FEB 91	9m	BT	8	359	18 JAN 90	9m	BT	1	212	98	307101				4	4	4	A	N	1
15 FEB 91	9m	BT	9	292	1 FEB 90	9m	BT	1	174	98	309547				4	4	4	A	N	1
15 FEB 91	9m	BT	9	348	18 DEC 89	9m	BT	9	208	98	294821				4	4	4	A	N	1
15 FEB 91	9m	BT	9	297	9 MAR 90	9m	BT	8	246	98	315116				4	4	4	A	N	1
15 FEB 91	9m	BT	9	253	28 DEC 89	9m	BT	9	200	98	274292				4	4	4	P	N	1
15 FEB 91	9m	BT	9	303	19 MAR 90	9m	BT	1	219	98	317304				4	4	4	P	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	RELEASE DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	TAG INFORMATION M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG CONDITION TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
15 FEB 91	9m	BT	9	394	15 MAR 89	9m	BT	8	184	98	284715				4	4	4	P	N	1
19 FEB 91	9m	BT	8	245	15 FEB 90	9m	BT	1	190	98	312540				4	4	4	P	N	2
19 FEB 91	9m	BT	10	317	20 DEC 89	9m	BT	1	242	98	273647				4	4	4	P	N	1
20 FEB 91	9m	BT	8	375	9 FEB 89	9m	BT	9	160	98	280212				4	4	4	A	N	1
20 FEB 91	9m	BT	8	301	2 MAR 90	9m	BT	1	208	98	314448				4	4	4	P	N	1
20 FEB 91	9m	BT	8	310	2 APR 90	9m	BT	1	200	98	320319				4	4	4	A	N	1
21 FEB 91	9m	BT	1	340	14 DEC 89	9m	BT	1	297	98	292722				4	4	4	P	N	1
21 FEB 91	9m	BT	1	290	11 APR 90	9m	BT	1	176	98	321160				4	4	4	P	N	1
21 FEB 91	9m	BT	7	270	31 JAN 90	9m	BT	1	207	98	309109	98	337564		2				N	1
22 FEB 91	9m	BT	5	280	1 NOV 90	9m	BT	8	203	98	306176				4	4	4	A	N	1
26 FEB 91	9m	BT	7	285	5 MAR 90	9m	BT	1	188	98	314649				4	4	4	A	N	1
28 FEB 91	9m	BT	10	260	6 APR 90	9m	BT	1	182	98	320907				4	4	4	P	N	1
28 FEB 91	9m	BT	10	299	18 JAN 90	9m	BT	1	198	98 &	307035				4	4	4	P	Y	1
28 FEB 91	9m	BT	10	393	1 APR 89	9m	BT	8	293	98	288372				4	4	4	P	N	1
28 FEB 91	9m	BT	10	281	26 MAR 90	9m	BT	1	216	98	318899				4	4	4	P	N	1
28 FEB 91	9m	BT	10	340	20 FEB 90	9m	BT	1	240	98	313141				4	4	4	A	N	2
28 FEB 91	9m	BT	10	274	10 NOV 89	9m	BT	1	201	98	290490				4	4	4	A	N	1
1 MAR 91	9m	BT	10	297	7 NOV 89	9m	BT	1	226	98	271931				4	4	4	A	N	1
1 MAR 91	9m	BT	10	265	6 DEC 89	9m	BT	1	180	98	292389				4	4	4	A	N	1
1 MAR 91	9m	BT	10	235	18 DEC 89	9m	BT	9	176	98	294962				4	4	4	A	N	1
4 MAR 91	9m	BT	8	317	20 FEB 90	9m	BT	1	168	98	313207				4	4	4	A	N	1
5 MAR 91	9m	BT	8	327	26 JAN 90	9m	BT	5	166	98	308394				4	4	4	A	N	1
5 MAR 91	9m	BT	5	243	6 MAR 90	9m	BT	5	170	98	314776				4	4	4	P	N	1
7 MAR 91	9m	BT	1	321	28 MAR 90	9m	BT	1	210	98	319450				4	4	4	A	N	1
8 MAR 91	9m	BT	8	273	11 JAN 89	9m	BT	8	220	98 &	276216				4	4	4	P	Y	2
11 MAR 91	9m	BT	7	332	2 JAN 90	9m	BT	1	174	98 &	305080				4	4	4	A	Y	1
11 MAR 91	9m	BT	8	307	7 NOV 89	9m	BT	1	210	98	290119				4	4	4	A	N	1
11 MAR 91	9m	BT	8	339	9 APR 90	9m	BT	9	167	98	320941				4	4	4	A	N	1

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

RECAPTURE					RELEASE					TAG INFORMATION					TAG CONDITION					
DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	DATE (MM/DD/YY	GEAR	STA-TION	R_M	LENGTH (mm TL)	M_C	REL TAG_N	M_C	NEW TAG_N	DART TAG_N	TAG NO.	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG COND.
12 MAR 91	9m	BT	7	252	12 APR 90	9m	BT	8	178	98	321250				4	4	4	P	N	1
13 MAR 91	9m	BT	10	280	12 MAR 90	9m	BT	8	193	98	315528				4	4	4	P	N	1
13 MAR 91	9m	BT	9	251	9 APR 90	9m	BT	9	174	98	320949				4	4	4	P	N	2
13 MAR 91	9m	BT	8	304	23 FEB 90	9m	BT	5	210	98	313816				4	4	4	P	N	1
14 MAR 91	9m	BT	10	325	20 DEC 89	9m	BT	1	326	98	273819				4	4	4	A	N	1
14 MAR 91	9m	BT	10	289	19 JAN 90	9m	BT	8	180	98	307428				4	4	4	A	N	1
15 MAR 91	9m	BT	10	348	1 FEB 90	9m	BT	1	295	98	309542				4	4	4	A	N	1
18 MAR 91	9m	BT	8	340	29 NOV 89	9m	BT	8	215	98	291147				4	4	4	A	N	1
20 MAR 91	9m	BT	9	263	8 FEB 90	9m	BT	8	168	98	310972				4	4	4	A	N	1
20 MAR 91	9m	BT	8	251	12 FEB 90	9m	BT	1	193	98	311657				4	4	4	P	N	2
21 MAR 91	9m	BT	8	274	7 NOV 89	9m	BT	1	195	98	290045				4	4	4	P	N	1
22 MAR 91	9m	BT	8	284	4 APR 90	9m	BT	1	214	98	320824				4	4	4	P	N	2
25 MAR 91	9m	BT	8	341	27 FEB 90	9m	BT	9	236	98	314008				4	4	4	P	N	1
28 MAR 91	9m	BT	10	291	1 FEB 90	9m	BT	1	207	98	309455				4	4	4	P	N	2
1 APR 91	9m	BT	9	367	21 FEB 89	9m	BT	8	208	98	282433				4	4	4	P	N	2
1 APR 91	9m	BT	9	267	13 DEC 89	9m	BT	8	185	98	294131				4	4	4	P	N	2
4 APR 91	9m	BT	1	353	10 NOV 88	9m	BT	1	177	98	258863				4	4	4	P	N	1
4 APR 91	9m	BT	1	318	28 MAR 90	9m	BT	1	240	98	319364				4	4	4	P	N	1
4 APR 91	9m	BT	1	325	14 DEC 89	9m	BT	1	187	98	294295				4	4	4	P	N	1
4 APR 91	9m	BT	1	268	4 APR 90	9m	BT	1	191	98	320578				4	4	4	A	N	1
4 APR 91	9m	BT	2	280	29 MAR 90	9m	BT	1	200	98	320075				4	4	4	P	N	1
8 APR 91	9m	BT	5	281	12 MAR 90	9m	BT	8	189	98	315516				4	4	4	A	N	1
8 APR 91	9m	BT	5	317	15 FEB 90	9m	BT	1	223	98	312365				4	4	4	P	N	1
9 APR 91	9m	BT	5	312	9 MAR 90	9m	BT	8	221	98	315264				4	4	4	P	N	1
9 APR 91	9m	BT	5	269	1 DEC 90	9m	BT	1	182	98	291477				4	4	4	A	N	1
10 APR 91	9m	BT	11	267	7 DEC 89	9m	BT	1	169	98	293174				4	4	4	A	N	2

(CONTINUED)

APPENDIX TABLE D-5. (CONTINUED)

LEGEND: Gear 9m = 9m trawl

Station BT = Battery
NY = Upper Harbor

M_C 98 = Hallprint internal anchor, external streamer tag

* = Abraded tag
& = Anchor protrusion
# = Dart tag not present

TAG VARIABLE	COMMENT CODE	COMMENT DESCRIPTION
Number	1,2,3, or 4	1 = Legend completely missing
Address	1,2,3, or 4	2 = Abraded and partly missing
Reward	1,2,3, or 4	3 = Abraded but completely legible
		4 = Completely legible
Number orientation	A or P	A = Tag number facing anterior(Head)
		P = Tag number facing posterior(Tail)
Anchor protrusion	Y or N	Y = Yes
		N = No

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1990-91.

SAMPLING WEEK	(≥150 mm) C TOTAL	(≥150 mm) M TOTAL	ADJUSTED[a] M TOTAL	ADJUSTED[a] CUM M TOTAL	R TOTAL	R/C
3 Dec 90	373	329	321	0	0	0.0000
10 Dec 90	1293	1128	1101	321	2	0.0015
17 Dec 90	991	866	845	1422	2	0.0020
24 Dec 90	708	646	630	2267	2	0.0028
31 Dec 90	591	546	533	2897	1	0.0017
7 Jan 91	1522	1418	1384	3430	13	0.0085
14 Jan 91	1918	1766	1723	4814	19	0.0099
21 Jan 91	1628	1466	1430	6537	12	0.0074
28 Jan 91	1594	1479	1443	7967	15	0.0094
4 Feb 91	2208	1999	1951	9410	29	0.0131
11 Feb 91	2118	1925	1878	11361	22	0.0104
18 Feb 91	2039	1828	1784	13239	33	0.0162
25 Feb 91	1320	1161	1133	15023	21	0.0159
4 Mar 91	997	875	854	16156	19	0.0191
11 Mar 91	1466	1241	1211	17010	28	0.0191
TOTAL	20766	18,673	18221	111854	218	0.0105

[a]Adjusted for bird predation (m_total*0.97575)

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 22 JANUARY 1990 THROUGH THE WEEK OF 9 APRIL 1990.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00054	0.00054	138.22	0.0001
Error	13	0.00005	0.00004		
Total	14	0.00059			

Regression Equation: R/C = (Cumulative M) X + error,

where,

X = 0.00125789 and

Standard Error of X = 0.00000105

R^2 = coefficient of determination = 0.911

df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F-ratio
p>F = probability of obtaining a larger F-ratio

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS HATCHERY EVALUATION PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)[a]	MODIFIED INTERNAL ANCHOR (HALL)[a]	SMALL DART (HALL)[a]
1984	737	737[b]	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819[b]
1989-1990	24,362	--	--	--	--	24,362	659[b]
1990-1991	22,406	--	--	--	--	22,406	--
TOTAL	112,252	737[b]	28,041	4,575	16,402	63,234	1,478[b]

[a]Hall - Hallprint.

[b]Not included in row total because fish were double tagged.

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1990-91 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	6,192
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	9,992
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	4,998
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	1,224
1990-91 TOTAL:				22,406

*Striped bass ≥ 150 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

APPENDIX TABLE D-10. HUDSON RIVER STRIPED BASS INTERNAL ANCHOR TAGS RETRIEVED FROM PIERS IN 1990-91.

RECAPTURE					RELEASE		
TASK CODE	SAMPLE	FISH-ID	LENGTH	TAG-N	DATE	RIVER MILE	REGION
53	3944	17	197	274105	DEC 22 89	1	BT
53	3006	13	220	276216	JAN 11 89	8	BT
53	3928	46	176	294962	DEC 18 89	9	BT
53	4316	42	208	314448	MAR 2 90	1	BT
53	4512	26	212	320702	APR 4 90	1	BT
53	4816	33	188	323003	DEC 11 90	1	BT
53	4901	1	234	324309	JAN 3 91	1	BT
53	4926	45	250	324581	JAN 7 91	8	BT
53	4999	57	162	326576	JAN 18 91	1	BT
53	5066	38	215	327885	JAN 30 91	9	BT
53	5069	22	259	327954	JAN 30 91	9	BT
53	5069	34	264	327966	JAN 30 91	8	BT
53	5072	40	183	328046	JAN 30 91	8	BT
53	5084	99	288	328141	JAN 31 91	8	BT
53	5084	106	240	328147	JAN 31 91	8	BT
53	5100	38	262	328461	FEB 1 91	8	BT
53	5100	127	168	328519	FEB 1 91	8	BT
53	5112	137	212	328827	FEB 4 91	7	BT
53	5120	71	190	329102	FEB 5 91	9	BT
53	5121	68	203	329144	FEB 5 91	8	BT
53	5121	70	176	329346	FEB 5 91	8	BT
53	5132	98	279	329392	FEB 6 91	8	BT
53	5137	148	200	329686	FEB 8 91	8	BT
53	5141	8	240	329890	FEB 11 91	9	BT
53	5142	78	285	329920	FEB 11 91	8	BT
53	5144	12	166	329972	FEB 12 91	8	BT

(continued)

APPENDIX TABLE D-10. (Continued)

RECAPTURE					RELEASE		
TASK CODE	SAMPLE	FISH-ID	LENGTH	TAG-N	DATE	RIVER MILE	REGION
53	4913	7	374	331578	JAN 4 91	1	BT
53	5141	19	317	334427	FEB 11 91	9	BT
53	5149	157	320	334760	FEB 12 91	7	BT
53	5149	94	283	335069	FEB 12 91	7	BT
53	5150	29	266	335133	FEB 12 91	8	BT
53	5163	28	245	335378	FEB 12 91	9	BT
53	5187	17	295	336370	FEB 19 91	10	BT
53	5188	96	327	336534	FEB 19 91	9	BT
53	5202	62	246	336985	FEB 20 91	8	BT
53	5222	29	242	337814	FEB 22 91	5	BT
53	5225	17	266	337946	FEB 22 91	5	BT
53	5225	31	197	337960	FEB 22 91	5	BT
53	5225	48	235	337975	FEB 22 91	5	BT
53	5264	103	180	338655	FEB 28 91	10	BT
53	5265	73	292	338736	FEB 28 91	10	BT
53	5266	12	317	338835	FEB 28 91	10	BT
53	5286	22	234	339312	MAR 4 91	9	BT
53	5289	1	275	339406	MAR 4 91	8	BT
53	5306	20	176	339881	MAR 7 91	1	BT
53	5316	9	232	339949	MAR 7 91	5	BT
53	5318	12	211	339970	MAR 7 91	5	BT
53	5326	6	221	340011	MAR 8 91	7	BT
53	5329	6	185	340030	MAR 8 91	10	BT
53	5333	2	354	340141	MAR 11 91	8	BT
53	5348	6	290	340573	MAR 13 91	9	BT
53	5348	7	296	340574	MAR 13 91	9	BT

(continued)

APPENDIX TABLE D-10. (Continued)

RECAPTURE					RELEASE		
TASK CODE	SAMPLE	FISH-ID	LENGTH	TAG-N	DATE	RIVER MILE	REGION
53	5402	18	284	341360	MAR 21 91	8	BT
53	5402	33	240	341375	MAR 21 91	8	BT
53	5391	6	370	341752	MAR 20 91	8	BT
53	5487	10	246	342019	APR 3 91	5	BT
53	5346	64	310	345080	MAR 13 91	10	BT
53	5348	3	365	345108	MAR 13 91	9	BT
53	5348	8	302	345111	MAR 13 91	9	BT

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 12 November 1990 and 19 April 1991 were taken to the Verplanck, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1985-86 through 1989-90 programs (NAI 1986, 1987, 1988, 1990, 1991). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS

Length, weight, sex, and sexual condition were determined for all striped bass that died during sample processing (Table E-1). Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-2.

APPENDIX TABLE E-1. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1990-91 PROGRAM.

LENGTH	WEIGHT	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
128	16.4	03DEC90	BATTERY	1	UNDETERMINED	IMMATURE	EMPTY
166	37.3	30JAN91	BATTERY	9	MALE	IMMATURE	INVERTS
175	49.6	27NOV90	BATTERY	1	FEMALE	IMMATURE	EMPTY
183	60.2	22JAN91	BATTERY	1	FEMALE	IMMATURE	EMPTY
184	49.6	08MAR91	BATTERY	7	MALE	IMMATURE	EMPTY
186	59.0	21FEB91	BATTERY	1	MALE	IMMATURE	EMPTY
187	60.0	08MAR91	BATTERY	7	FEMALE	IMMATURE	INVERTS
190	56.0	27NOV90	BATTERY	1	MALE	IMMATURE	EMPTY
191	67.8	20FEB91	BATTERY	9	FEMALE	IMMATURE	EMPTY
199	80.9	08FEB91	BATTERY	8	FEMALE	IMMATURE	INVERTS
202	78.8	11MAR91	BATTERY	7	FEMALE	IMMATURE	EMPTY
206	90.7	04APR91	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
208	83.3	21NOV90	BATTERY	1	MALE	IMMATURE	INVERTS
210	83.2	20MAR91	BATTERY	8	FEMALE	IMMATURE	INVERTS AND VERTS
216	76.5	18JAN91	BATTERY	1	MALE	IMMATURE	EMPTY
216	100.1	09APR91	BATTERY	5	FEMALE	IMMATURE	INVERTS
217	102.8	12DEC90	BATTERY	1	FEMALE	IMMATURE	INVERTS
218	97.5	01APR91	BATTERY	9	FEMALE	IMMATURE	INVERTS
218	88.2	08APR91	BATTERY	5	MALE	IMMATURE	EMPTY
223	108.3	22FEB91	BATTERY	5	MALE	IMMATURE	INVERTS AND VERTS
226	103.5	06MAR91	BATTERY	1	MALE	IMMATURE	EMPTY
227	113.8	14JAN91	UPPER HARBOR	3	MALE	IMMATURE	INVERTS
231	122.5	21MAR91	BATTERY	8	MALE	IMMATURE	EMPTY
233	137.4	18DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
233	120.7	21FEB91	BATTERY	1	MALE	IMMATURE	EMPTY
236	120.8	08APR91	BATTERY	5	MALE	IMMATURE	INVERTS
242	138.2	17DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
243	141.4	28FEB91	BATTERY	10	MALE	IMMATURE	INVERTS
244	146.3	25MAR91	BATTERY	5	FEMALE	IMMATURE	EMPTY
245	131.3	12DEC90	BATTERY	1	FEMALE	IMMATURE	INVERTS
246	137.5	18DEC90	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
247	144.7	08APR91	BATTERY	5	FEMALE	IMMATURE	INVERTS
248	136.8	13DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
248	162.3	13MAR91	BATTERY	10	FEMALE	IMMATURE	EMPTY
249	143.2	04DEC90	BATTERY	1	MALE	IMMATURE	INVERTS
249	122.1	19DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
250	144.3	06DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
250	168.1	14JAN91	UPPER HARBOR	3	FEMALE	IMMATURE	VERTEBRATES
250	159.1	01MAR91	BATTERY	10	MALE	RESTING	INVERTS
252	147.8	11DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
252	167.3	31DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
252	151.5	20FEB91	BATTERY	8	MALE	RESTING	EMPTY
254	169.5	10JAN91	BATTERY	1	FEMALE	IMMATURE	VERTEBRATES
257	156.5	15FEB91	BATTERY	9	MALE	IMMATURE	EMPTY
257	167.1	25MAR91	BATTERY	5	FEMALE	IMMATURE	EMPTY
258	187.5	21FEB91	BATTERY	1	MALE	IMMATURE	EMPTY
258	183.9	11MAR91	BATTERY	8	FEMALE	IMMATURE	EMPTY
260	172.3	27NOV90	BATTERY	1	MALE	IMMATURE	EMPTY
260	172.7	23JAN91	BATTERY	1	FEMALE	IMMATURE	INVERTS
260	184.1	24JAN91	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
263	176.2	25MAR91	BATTERY	5	FEMALE	IMMATURE	INVERTS
264	176.9	18DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
266	178.8	28FEB91	BATTERY	10	FEMALE	IMMATURE	INVERTS

APPENDIX TABLE E-1. (Continued)

LENGTH	WEIGHT	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
267	191.1	15FEB91	BATTERY	9	FEMALE	IMMATURE	EMPTY
267	188.7	22MAR91	BATTERY	8	MALE	IMMATURE	EMPTY
268	193.7	15FEB91	BATTERY	9	FEMALE	IMMATURE	VERTEBRATES
272	194.8	25JAN91	BATTERY	1	MALE	IMMATURE	INVERTS
272	177.5	04FEB91	BATTERY	7	FEMALE	IMMATURE	EMPTY
272	218.0	22FEB91	BATTERY	5	FEMALE	IMMATURE	INVERTS
272	187.4	25MAR91	BATTERY	5	FEMALE	IMMATURE	INVERTS
273	203.5	15FEB91	BATTERY	9	FEMALE	IMMATURE	INVERTS
274	202.5	17JAN91	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
275	191.2	02JAN91	BATTERY	1	MALE	IMMATURE	INVERTS
276	203.8	28FEB91	BATTERY	10	MALE	RESTING	INVERTS
277	204.2	18JAN91	BATTERY	1	FEMALE	IMMATURE	INVERTS
280	219.9	18DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
280	234.8	22FEB91	BATTERY	5	MALE	RESTING	INVERTS
280	207.8	01APR91	BATTERY	9	MALE	RESTING	INVERTS
281	212.2	21FEB91	BATTERY	7	FEMALE	IMMATURE	VERTEBRATES
281	218.3	05APR91	BATTERY	9	FEMALE	IMMATURE	EMPTY
281	225.4	08APR91	BATTERY	5	MALE	RESTING	INVERTS
282	234.4	21DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
282	234.8	08FEB91	BATTERY	8	MALE	IMMATURE	INVERTS AND VERTS
284	218.0	22JAN91	BATTERY	1	MALE	IMMATURE	EMPTY
284	231.6	25JAN91	BATTERY	1	MALE	IMMATURE	EMPTY
284	213.1	12MAR91	BATTERY	8	FEMALE	IMMATURE	EMPTY
285	231.3	31JAN91	BATTERY	8	MALE	IMMATURE	INVERTS
285	233.1	15FEB91	BATTERY	9	MALE	IMMATURE	EMPTY
285	262.5	15MAR91	BATTERY	10	MALE	IMMATURE	VERTEBRATES
290	211.1	28DEC90	BATTERY	1	MALE	RESTING	VERTEBRATES
290	309.9	22JAN91	BATTERY	1	MALE	RESTING	VERTEBRATES
291	236.7	28FEB91	BATTERY	10	MALE	RESTING	EMPTY
293	244.0	11FEB91	BATTERY	8	MALE	IMMATURE	INVERTS
296	250.2	20MAR91	BATTERY	8	MALE	IMMATURE	EMPTY
297	241.3	04APR91	BATTERY	1	FEMALE	IMMATURE	VERTEBRATES
298	252.3	28NOV90	BATTERY	1	MALE	IMMATURE	INVERTS
298	257.8	13DEC90	BATTERY	1	MALE	RESTING	INVERTS
299	240.1	18DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
299	272.0	10JAN91	UPPER HARBOR	3	MALE	IMMATURE	INVERTS AND VERTS
300	287.6	08JAN91	BATTERY	1	MALE	IMMATURE	INVERTS
305	241.1	20MAR91	BATTERY	8	FEMALE	IMMATURE	EMPTY
306	363.2	24JAN91	BATTERY	1	FEMALE	IMMATURE	EMPTY
308	270.9	18DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
310	288.2	30NOV90	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
311	322.3	04APR91	BATTERY	1	FEMALE	IMMATURE	INVERTS
312	288.7	18DEC90	BATTERY	1	MALE	RESTING	VERTEBRATES
313	319.5	20MAR91	BATTERY	8	MALE	RESTING	INVERTS
315	299.0	04JAN91	BATTERY	1	MALE	IMMATURE	EMPTY
315	302.5	16JAN91	BATTERY	1	MALE	IMMATURE	EMPTY
315	313.8	04APR91	BATTERY	1	FEMALE	IMMATURE	EMPTY
316	329.3	08FEB91	BATTERY	8	MALE	RESTING	EMPTY
317	313.8	09JAN91	BATTERY	1	FEMALE	IMMATURE	VERTEBRATES
320	318.7	12DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
320	402.9	24JAN91	BATTERY	1	MALE	RESTING	EMPTY
320	334.3	12FEB91	BATTERY	7	FEMALE	IMMATURE	INVERTS AND VERTS
323	330.5	28FEB91	BATTERY	10	MALE	RESTING	EMPTY

APPENDIX TABLE E-1. (Continued)

LENGTH	WEIGHT	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
325	331.8	04APR91	BATTERY	1	FEMALE	IMMATURE	EMPTY
325	360.8	04APR91	BATTERY	2	MALE	DEVELOPING	EMPTY
326	333.5	21NOV90	BATTERY	1	MALE	RESTING	INVERTS
330	340.7	04MAR91	BATTERY	8	FEMALE	IMMATURE	EMPTY
333	371.7	30JAN91	BATTERY	9	MALE	IMMATURE	VERTEBRATES
337	475.3	18DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
340	430.4	12DEC90	BATTERY	1	MALE	RESTING	VERTEBRATES
341	445.1	25MAR91	BATTERY	8	MALE	RESTING	EMPTY
342	479.2	08FEB91	BATTERY	8	MALE	RESTING	INVERTS
343	430.8	11FEB91	BATTERY	8	MALE	RESTING	VERTEBRATES
345	424.2	04MAR91	BATTERY	9	FEMALE	IMMATURE	INVERTS
350	445.6	18DEC90	BATTERY	1	MALE	RESTING	EMPTY
353	475.8	07MAR91	UPPER HARBOR	3	MALE	DEVELOPING	VERTEBRATES
353	457.5	14MAR91	BATTERY	10	MALE	IMMATURE	VERTEBRATES
359	521.0	30NOV90	BATTERY	1	MALE	IMMATURE	EMPTY
359	532.0	17DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
360	533.0	11FEB91	BATTERY	8	FEMALE	IMMATURE	EMPTY
362	493.9	10DEC90	BATTERY	1	MALE	RESTING	INVERTS
366	487.9	28DEC90	BATTERY	1	FEMALE	IMMATURE	EMPTY
368	488.4	19DEC90	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
373	590.0	27DEC90	BATTERY	1	MALE	IMMATURE	EMPTY
385	579.0	25FEB91	BATTERY	8	FEMALE	IMMATURE	EMPTY
390	638.0	30JAN91	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
390	658.0	12FEB91	BATTERY	7	MALE	IMMATURE	EMPTY
395	660.0	02JAN91	BATTERY	1	MALE	IMMATURE	INVERTS
397	726.0	20FEB91	BATTERY	8	FEMALE	IMMATURE	VERTEBRATES
402	712.0	14FEB91	BATTERY	7	MALE	IMMATURE	EMPTY
407	716.0	11FEB91	BATTERY	8	FEMALE	IMMATURE	EMPTY
434	848.0	01FEB91	BATTERY	8	MALE	RESTING	EMPTY
460	943.0	14MAR91	BATTERY	10	MALE	DEVELOPING	INVERTS AND VERTS

TABLE E-2. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS[a].

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, less firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and stringlike, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in texture, but milt not running.

[a]From Con Edison Data Dictionary

E.2.2 STRIPED BASS STOMACH CONTENTS ANALYSIS

The same striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass predominated in the biocharacteristics samples throughout the 1990-91 Hatchery Evaluation Program (Table E-3). All female striped bass captured were in the immature stage, while all but three male striped bass were in the immature or resting stages. Three developing males were collected during March and April. No striped bass in the ripe, or ripe and running stages were examined.

The lack of ripe, or ripe and running striped bass in the 1990-91 biocharacteristics samples agrees with the findings of the 1985-86 through 1989-90 programs. This is not surprising because the majority of the fish captured in both programs were of pre-spawning size (< 400 mm) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the developing stage with time during the 1985-86 through 1990-91 programs indicated the approach of the spawning season, and that male

APPENDIX TABLE E-3. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1990-91 PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS														
						MALES					UNDETERMINED				
MONTH	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL
NOV	100(1)				100(1)	86(6)	14(1)			100(7)					
DEC	100(10)				100(10)	66(12)	33(6)			100(18)	100(1)				100(1)
JAN	100(8)				100(8)	89(16)	11(2)			100(18)					
FEB	100(14)				100(14)	55(11)	45(9)			100(20)					
MAR	100(13)				100(13)	58(7)	25(3)	17(2)		100(12)					
APR	100(8)				100(8)	50(3)	33(2)	17(1)		100(6)					
TOTAL	100(54)				100(54)	68(55)	28(23)	4(3)		100(81)	100(1)				100(1)

striped bass may undergo a longer period of gonadal development prior to spawning than females. Due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature or resting.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 136 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Only four fish were captured in the larger (> 400 mm) length groups and a high percentage of stomachs were empty (50%) which made generalizations about changes in food habits with length difficult. Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and the majority of those were clupeids, or Morone sp. as incidentally noted by laboratory personnel.

Percentage of non-empty striped bass with invertebrate remains in their stomachs generally decreased with increasing length group (Table E-4). This is in general agreement with the findings from the 1985-86 Hudson River Striped Bass Program where invertebrate remains were most common in striped bass ≤ 300 mm (NAI 1986), and with findings from the 1987-88 and 1989-90 program where invertebrates were most common in striped bass ≤ 200 mm (NAI 1988). Invertebrate remains were most common in the 301-400 mm length group during the 1986-87 program (NAI 1987).

Twenty-nine fish were examined with fish remains in their stomachs during the 1989-90 program. These fish were all greater than 200 mm and thirteen also had invertebrates present in their stomachs.

The percentage of non-empty striped bass with fish remains in their stomachs increased with length in the 1986-87 and 1985-86 programs (NAI 1987). However, the majority of fish examined in the 1990-91 program were less than 301 mm which makes interpretation of food habit trends with length difficult. The trend of increasing importance of fish as food items as striped bass length increases observed in previous programs probably represents a switch in food habits to piscivory in older fish and has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). In 1990-91 too few large fish were examined to delineate trends.

APPENDIX TABLE E-4. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1990-91 PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS					
LENGTH GROUP (mm TL)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤200	30.0(3)	0.0(0)	0.0(0)	0.0(0)	70.0(7)	100.0(10)
201-300	36.2(29)	10.0(8)	0.0(0)	10.0(8)	43.7(35)	100.0(80)
301-400	16.7(7)	19.0(8)	0.0(0)	9.5(4)	54.8(23)	100.0(42)
401-500	0.0(0)	0.0(0)	0.0(0)	25.0(1)	75.0(3)	100.0(4)
TOTAL	28.7(39)	11.8(16)	00.0(0)	9.6(13)	50(68)	100.0(136)

HUDSON RIVER STRIPED BASS STOCK

ASSESSMENT PROGRAM

NOVEMBER 1992 - APRIL 1993

Prepared under contract with

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was 3.0% for Age 0+ and 0.02% for Age 3+ fish among the same age cohorts of striped bass caught in the Hudson River between 2 November 1992 and 16 April 1993.

- We caught only two Age 3+ hatchery striped bass, and did not statistically compare the mean length of hatchery and wild fish from the 1989 cohort due to this small sample. Hatchery striped bass of the 1990 and 1991 cohorts were not tagged prior to their release, and therefore could not be distinguished from wild fish. The mean length of Age 0+ hatchery and wild striped bass from the 1992 cohort were not significantly different based on overlapping 95% confidence limits.

- The 1991 cohort of Age 1+ striped bass and the 1992 cohort of Age 0+ fish dominated the catch of Hudson River striped bass during the 1992-93 program, while the Age 1+ and Age 2+ cohorts dominated the population statistics. The 1991 and 1992 cohorts represented 58% and 22% respectively of the total catch, while Age 1+ and Age 2+ fish represented 73% and 20% respectively of the population ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in upper New York Harbor and the Battery region was 920,000 fish with lower and upper 95% confidence limits of 677,000 and 1,435,000. Age 0+ striped bass accounted for 7,000 fish in the mid-winter population, Age 1+ contributed 671,000 fish, Age 2+ contributed 180,000 fish, Age 3+ contributed 39,000 fish, and Age >3+ contributed 24,000 fish.

- During the 1992-93 striped bass program, 22,996 fish ≥150 mm were caught and 20,847 fish in good condition were tagged and released bringing the total number of striped bass tagged and released in these programs since 1984 to 156,613. An additional 899 fish with one or more gross external injuries were tagged and released in 1992-93, bring the total number of these fish tagged and released to 1,692. Of the 494 fish that were recaptured, 345 were tagged and released in the present program, 115 were from 1991-92, 24 were from 1990-91, 3 were from 1989-90, 5 were from 1988-89, and one fish was from each of the 1987-88 and 1986-87 programs.

- Overall mean catch per unit of effort (CPUE) in the Battery region was 31.9 striped bass per ten minute tow. Mean CPUE during mid-December through mid-March increased annually from 1985-86 to a peak of 45.3 in the 1989-90 program. Mean CPUE decreased following 1989-90 to 40.7 in the 1990-91 program, 35.5 in the 1991-92 program, and 32.7 in the 1992-93 program.

- Handling mortality was less than 2% and was comparable to previous programs even though smaller fish (between 150 and 200 mm) were tagged compared to programs prior to 1988-89. No relationship between water temperature and handling mortality was observed.

1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York to address this requirement. Hatchery production and stocking continued in 1991 and 1992 under an agreement between the Hudson River utilities and the regulatory agencies. The total number of hatchery striped bass that were stocked into the Hudson River in each year is (EA 1993):

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,800
1988	48,611
1989	202,068
1990	234,387
1991	256,631
1992	210,746
Total	2,299,894

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program to evaluate mitigation measures be conducted through May 1991. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally-spawned striped bass. Striped bass produced and stocked during 1990 and 1991 were not tagged, however tagging of hatchery-reared striped bass resumed in 1992. The identification of hatchery-released striped bass is essential for determin-

ing the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered CWTs. If these striped bass are tagged with an external tag and released, then their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could also be used to estimate annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986). Consequently, the hatchery evaluation program focused on estimating annual survival rate for Age 1+ and Age 2+.

The Hudson River striped bass program began in 1984 as an evaluation of fishing gear and techniques that were most efficient and effective to catch and handle striped bass. The best locations, times, and fishing gear were evaluated in the 1984 through 1987-88 programs to maximize total catch and catch per unit of effort of Age 1+ and Age 2+ striped bass. The Battery region of the Hudson River adjacent to Manhattan, and upper New York Harbor in the vicinity of Liberty Island provided the most consistent catches of Age 1+ and Age 2+ striped bass during the November through March period. The 9-m trawl was the most effective gear for capturing Age 1+ and Age 2+ striped bass, and has been the only gear used from 1988-89 through the present program (Table 1-1). Concurrent with these gear evaluations, handling techniques were improved to increase the survival of striped bass that were caught, tagged, scanned for hatchery-administered magnetic tags, and released (Dunning et. al. 1987, 1989). As the Verplanck hatchery increased the annual production of fish, and more striped bass were recaptured with hatchery-administered tags, we also quantified magnetic tag detection efficiency (Mattson et al. 1989) and improved the internal anchor-external streamer tag design (Mattson et al. 1989; Waldman et al. 1990).

The Hudson River striped bass program from 1988-89 to the present has become primarily a stock assessment program. We have emphasized consistency of sampling gear and procedures, and the refinement of laboratory techniques for scale examination to accurately determine age (eg. Humphreys et al. 1989). Mark-recapture estimates are calculated for the total population and for the Age 1+ and Age 2+ sub-populations of striped bass found in the combined

TABLE 1-1. COMPARISON OF SAMPLING DESIGNS AND SELECTED RESULTS OF THE 1984 THROUGH 1991-92 HUDSON RIVER STRIPED BASS PROGRAMS.

				CATCH STATISTICS							POPULATION ESTIMATES		
PROGRAM	GEAR	DATES	SAMPLING REGIONS	N-TOWS	CPUE	N-TOTAL	N-TAGGED	N-RECAPTURED	N-HATCHERY	HANDLING MORTALITY (%)	TOTAL (≥200 mm)	AGE 1+	HATCHERY PROPORTION AGE 1+ (%)
1984	12 m trawl	9Apr-7Jun	TZ,CH,IP, WP,CW,PK	200	2.8		345[a]		0	18	--	--	
	Scottish seine	9Apr-7Jun	TZ,CH,CW	139	2.2		392[a]		0	16	--	--	
	Total			339	2.6	1,620	737	0	0	17	--	--	0
1985-86	9 m trawl	11Nov-18May	BT	900	8.2		6,366		0	1			
	12 m trawl	11Nov-18May	BT,HR,ER,LH	346	20.7		7,265		0	2			
	Scottish seine	31Mar-18May	TZ,CH	226	19.4		4,856		0	1			
	Total			1,472	12.9	20,820	18,487	171	0	1	540,000	239,000	0
1986-87	9 m trawl	21Dec-9May	BT	845	9.8		5,349		74	1			
	12 m trawl	21Dec-9May	BT	219	24.1		4,039		20	1			
	Total		BT	1,064	12.7	14,136	9,388	261	94	1	394,000	108,000	1.7
1987-88	9 m trawl	9Nov-22Apr	BT	896	20.0	18,075	7,582		176	<1			
	12 m trawl	9Nov-22Apr	BT	296	33.9	10,117	4,854		62	<1			
	Total		BT	1,192	23.5	28,192	12,436	465	238	<1	295,000	181,000	1.6
1988-89	9 m trawl	31Oct-15Apr	BT	1,151	28.5	32,975	24,393	453	213	<1	890,000	794,000	0.2
1989-90	9 m trawl	31Oct-15Apr	BT	891	37.3	33,386	24,362	655	141	<1	528,000	397,000	0.4
1990-91	9 m trawl	12Nov-20Apr	BT	971	29.7	29,346	22,406	865	52	<1	786,000	352,000	0.2
1991-92	9 m trawl	4Nov-7May	BT	1,169	29.3	34,202	25,710	631	17	<1	967,000	709,000	[a]

SAMPLING REGIONS: BT = Battery and Upper New York Harbor, Hudson River Miles 0-11 (km 0-18) and Upper New York Harbor. TZ + Tappan Zee, Hudson River Miles 24-33 (km 38-53).53). CH = Croton-Haverstraw, Hudron River Miles 34-38 (km 54-61). IP = Indian Point, Hudson River Miles 39-46 (km 62-74). CW = Cornwall, Hudson River Miles 56-61 (km 90-98). PK = Poughkeepsie, Hudson river miles 62-76 (km 99-122). HR = Harlem River. ER = East River. LH = Lower New York Harbor.

[a]Hatchery striped bass were not tagged before release in 1990 or 1991. Therefore an Age 1+ hatchery proportion was not computed.

Battery and upper New York Harbor regions during the winter. Program consistency is documented through the use of Standard Operating Procedures and a quality control/quality assurance system that has helped improve data quality (Geoghegan et al. 1989).

The April-June 1984 adult striped bass program (NAI 1985) demonstrated that it was effective to use a 12 m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass ≥300 mm (total length) could be externally tagged and released without significantly increasing 24-hour mortality (Dunning et al. 1987). No hatchery-tagged striped bass were recaptured during the 1984 program, and population estimates were not calculated from the relatively small sample of 737 external-tagged fish that were released (Table 1-1).

The 1985-86 Hudson River striped bass program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East Rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit of effort for a 12 m trawl was greater than for a 9 m trawl, but total catch and mean catch per day were similar for the two trawls because more tows could be taken with the 9 m trawl in a day. The 12 m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9 m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm. Striped bass handling mortality was reduced from 17% in 1984 to 1% of less in programs from 1985-86 to present by using an in-water live car to hold the fish prior to tagging (Dunning et. al. 1989). No hatchery-tagged fish were recaptured during the 1985-86 program among the 20,820 striped bass examined for magnetic tags. The mid-winter population of striped bass ≥200 mm was estimated to be 540,000 fish in the Battery and Upper New York Harbor, and 239,000 of these fish were estimated to be Age 1+ (Table 1-1).

Data from the 1984 and 1985-86 programs (NAI 1985, 1986) were used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimator could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River striped bass program was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per ten minute tow for both the 9 and 12 m trawls. Use of a cod end liner (2.5 cm stretch mesh) in the 9 m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of a cod end liner in the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+ and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm, and 108,000 of these fish were Age 1+ (Table 1-1).

The 1987-88 Hudson River striped bass hatchery evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per ten minute tow for both the 9 m trawl and 12 m trawl with a cod end similar to the 9 m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one half of the catch. The 9 m trawl was more efficient than the 12 m trawl with a 9 m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6%. The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm, and 181,000 of these fish were estimated to be Age 1+ (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990). The minimum size of striped bass that were tagged was lowered from 200 mm to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm, and an estimated 794,000 of the fish ≥200 mm were from the strong 1987 Age 1+ cohort (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort of Age 1+ fish (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm, and an estimated 397,000 of the fish ≥200 mm were from the strong 1988 Age 1+ cohort (Table 1-1).

The striped bass population over-wintering in the Battery and Upper Harbor during 1990-91 was estimated as 858,000 fish ≥150 mm or 786,000 fish ≥200 mm (Table 1-1). About 352,000 striped bass ≥200 mm were Age 1+ (NAI 1992). The 1989 cohort of Age 1+ hatchery fish was 0.2% of the Age 1+ catch.

The 1990 cohort of Age 1+ striped bass and the 1991 cohort of Age 0+ fish dominated the population statistics for fish caught in the Battery and Upper Harbor during the winter of 1991-92 (NAI 1994). The estimated size of the mid-winter striped bass population was 1,163,000 fish ≥150 mm or 967,000 fish ≥200 mm (Table 1-1). Age 1+ striped bass represented 791,000 fish among the population ≥150 mm and 709,000 fish ≥200 mm. Age 2+ and Age 3+

hatchery striped bass were each about 0.3% of the respective cohort's catch. Age 0+ and Age 1+ hatchery striped bass were not tagged with CWT's and could not be differentiated from wild fish of the same cohort.

Objectives of the 1992-93 Hudson River striped bass stock assessment program were to:

1. tag all wild striped bass greater than or equal to 150 mm, that are in good condition, with internal anchor tags,
2. determine the catch rate and handling mortality of striped bass,
3. estimate the abundance of striped bass overwintering in the lower Hudson River,
4. describe the age composition of the overwintering population of striped bass,
5. determine if hatchery striped bass, stocked during any year between 1983 and 1989, can be caught in the Hudson River population as Age 3+ or older fish, and
6. estimate the proportion of hatchery fish among the Age 0+ and Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1992-93 Hudson River Striped Bass and Atlantic Tomcod Programs Standard Operating Procedures (NAI 1993). These procedures have remained essentially unchanged since the start of the 1988-89 program. The 1992-93 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1) with a 9 m trawl (Appendix Table A-1). Sampling locations were selected to maximize the catch per unit of effort of striped bass in the lower Hudson River, based on the results of the 1985-86 through 1990-91 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992). A 9 m trawl was used in the 1992-93 program to catch striped bass because the results of the 1987-88 program showed that the 9 m trawl was more efficient than other gear in catching striped bass of the target ages of Age 1+ and Age 2+ (NAI 1988). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2) and released.

For 24 weeks, from the week of 2 November 1992 through the week of 12 April 1993, the 9 m trawl was deployed in the Upper Harbor or Battery regions. The 9 m trawl was fished in each of the 24 weeks in the Battery region and on selected days during 8 weeks in the Upper Harbor region (Appendix Table C-1). Tow duration was 10 minutes unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawl were handled in a manner that minimized stress before tagging. The cod end of the net was transferred while remaining in the water to the holding facility alongside the boat. Fish were then released from the cod end into the holding facility. Striped bass were then removed from the holding facility for processing using the following procedures:

(1) fish were removed from the live car using a dip net,

(2) all surfaces that came in contact with the live fish were wet,

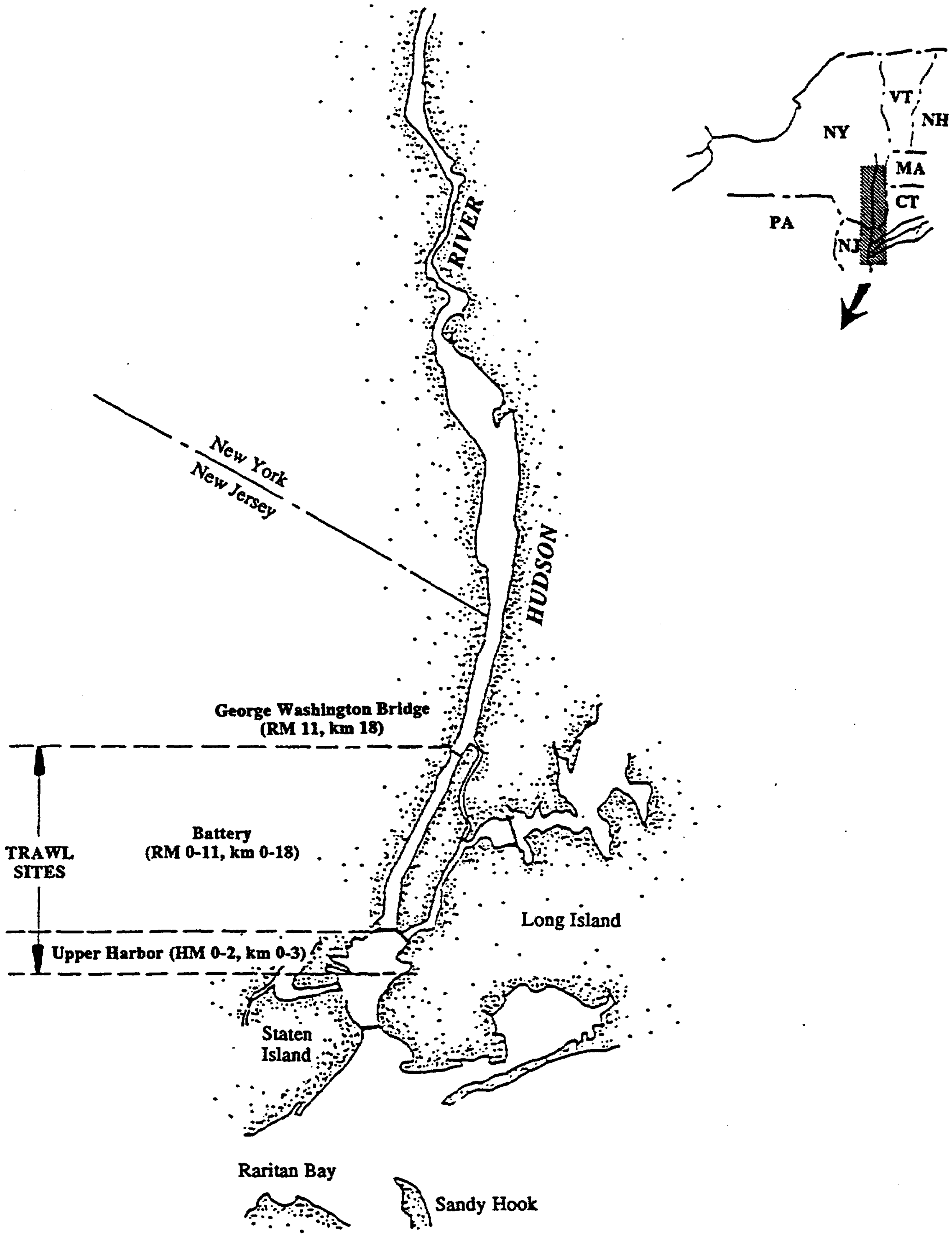
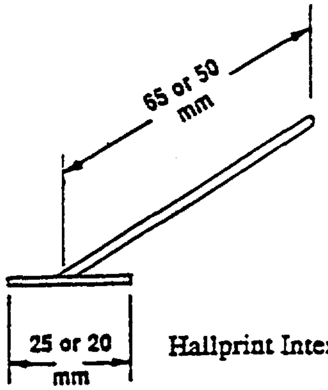
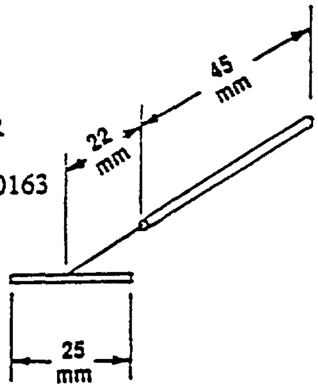


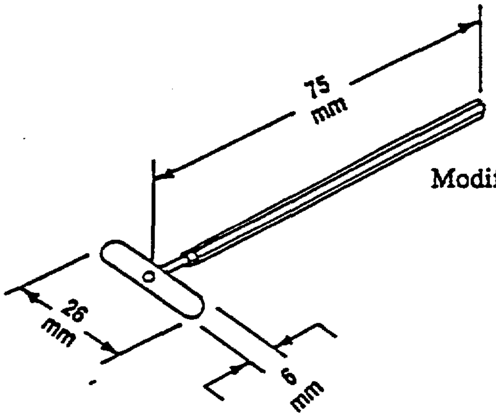
Figure 2-1. Sampling regions in the lower Hudson River and NewYork Harbor during the winter 1992-93 Hudson River Striped Bass Program.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

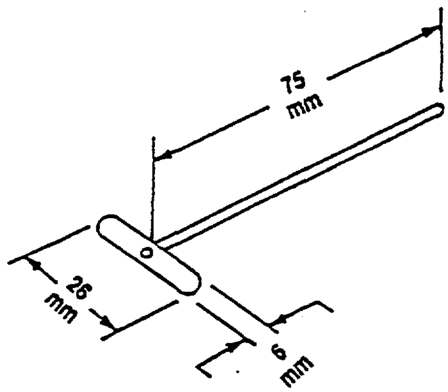
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

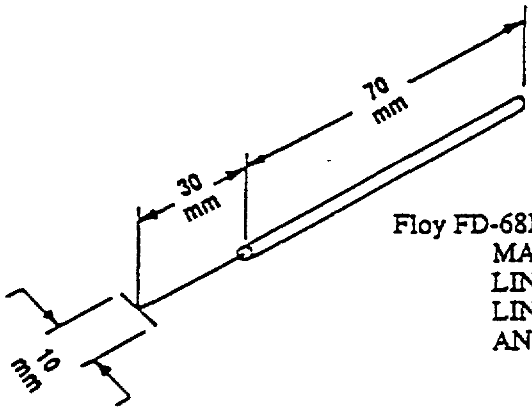




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-present Hudson River Striped Bass Programs.

(3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and

(4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for coded wire tags (CWT) using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

(1) no bleeding from gills or body wounds,
(2) no significant loss of scales,
(3) strong opercular movement, and
(4) no obvious external abnormalities such as blindness, fin rot or skeletal abnormalities.

The 1991-92 program was the first program in which we also tagged striped bass that were not in good condition, and we continued tagging these fish in the 1992-93 program to determine if the presence of certain gross anatomical abnormalities (such as blindness or bacterial infection) affected their survival. The nature of the particular abnormality of each striped bass was recorded prior to release. In previous programs, only striped bass in good condition were tagged.

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a hooking movement of a curved scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromin-based topical antiseptic.

Scale samples were taken from the left side from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Fish less than 100 mm were considered Age 0+. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs.

Condition of the tag and tag insertion site of recaptured striped bass were also evaluated.

After processing, striped bass were released into a recovery pen deployed alongside the tagging vessel. The pen was enclosed with netting on four sides, open on the top and bottom, and provided a refuge where striped bass could recover from processing without being preyed on by gulls. Bird predation was estimated to remove about 2.4% of the tagged fish released during the 1990-91 program (NAI 1992), so we began using this recovery pen to reduce this predation. Any fish remaining in the recovery pen at the end of sample processing were considered dead. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C for presentation in this report. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random sample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mm length group. Expected numbers of Age 1+ striped bass in each 10 mm length group were calculated from age at length data obtained during the current and 1991-92 programs (NAI 1994).

This program was conducted during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1990 and collected anywhere between November 1991 and May 1992 would be designated "Age 1+". This same fish, captured anywhere between November 1992 and May 1993, would be designated "Age 2+".

Striped bass scales were pressed on 0.050-inch thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving catch per unit of effort. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among locations and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Of Effort

Catch Per Unit of Effort (CPUE) for the 9 m trawl was defined as catch per ten-minute tow (Use Code = 1) and was calculated as

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{C_i}{E_i} x\ 10 \right] \qquad \text{Equation 1}$$

where, $\overline{X}$ = The mean trawl catch per ten minute tow,

C_i = total number of fish captured in trawl i,

E_i = the tow duration of trawl i in minutes, and

n = the number of trawls.

2.3.1.2 Length-Frequency

Length-frequency histograms, with the number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9 m trawl (Use Code = 1 tows). Length-frequency distributions for striped bass caught by the 9 m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1°C temperature interval:

$$PropD_x = D_x/T_x \qquad \text{Equation 2}$$

where,
$PropD_x$ = the proportion of dead striped bass at bottom water temperature x,
D_x = the number of dead striped bass at bottom water temperature x, and
T_x = total number of striped bass captured at bottom water temperature x.

Comparisons of handling mortality among the 1985-86 through 1992-93 programs were also made using data subsetted to include the same sampling gear deployed during comparable water temperature ranges within the Battery region in each year. Differences in striped bass handling mortality among programs (1985-86 through 1992-93) were assessed by comparing the percentage of dead fish in the catch in one degree bottom water temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 Estimated Number of Striped Bass in Each Age Category

A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1992-93 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10 mm length increment and the variance of the proportion of Age 1+ fish in each 10 mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish, and is based on the following formula (Cochran 1977, Equation 5.60):

Equation 3

$$n_h = n(N_h\sqrt{p_h q_h} / \sum N_h\sqrt{p_h q_h})$$

where

n_h = number of scale samples selected for age determination from length group h,
n = number of scale samples to be selected from the total of N fish caught,
N_h = total number of fish caught in length group h,

p_h = proportion of Age 1+ fish in length group h from the laboratory sample, and

$q_h = 1 - p_h$.

The stratified sampling plan was designed to select approximately 15% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1991-92 (NAI 1994) were applied to the first of three lots of 1992-93 length-frequency data to permit scale analysis to proceed during the study. Age and length-frequency data from analysis of the first lot of striped bass scales in 1992-93 were then applied to the remaining two lots of 1992-93 scale samples. In each lot (2 November-31 December, 1 January-28 February, and 1 March-16 April) scale samples from approximately 15% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1992-93 program was estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \Sigma(N_h p_{hi}/N) \qquad \text{Equation 4}$$

where

p_{sti} = the stratified mean proportion of Age i fish,

p_{hi} = the proportion of Age i fish in length group h, and

N_h and N are as defined in Equation 3.

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N(p_{sti}) \qquad \text{Equation 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2 p_{sti}$) was calculated by the method of Cochran (1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h^2 \ (N_h - n_h)/(N_h - 1)][p_{hi} q_{hi})/(n_h - 1)] \right] \qquad \text{Equation 6}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977) Equations 5.14 and 5.15:

$$95\% \text{ CI for } p_{sti} = p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 7}$$

$$95\% \text{ CI for } A_i = N\, p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 8}$$

where

$$s_{p_{sti}} = \sqrt{s^2_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 4-7.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1992-93 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi}\, \bar{y}_{hi} \right] / N_i \qquad \text{Equation 9}$$

where $\overline{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\overline{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

n_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least two Age i fish were measured. If only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean.

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24 with the assumption that N_i is large and substantially larger than n_i, therefore $N_i^{-1} \approx 0$ and $g'_i \approx 1$):

$$S^2_{\bar{y}_{st}} = \sum_{h=1}^{L} \left[w_{hi} (S^2_{hi} / n_i V_{hi}) \right] + (1/n'_i) \sum_{h=1}^{L} w_{hi} (\bar{y}_{hi} - \bar{y}_{sti})^2$$

Equation 10

where

$S^2_{\bar{y}_{sti}}$ = Two-phase variance of the stratified mean length of striped bass of Age i,

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes Theorum presented in Equation 11,

S^2_{hi} = variance of the mean length of Age i fish in length group h of the laboratory sample,

n'_i = total number of Age i fish in the laboratory sample,

V_{hi} = proportion of Age i fish in length group h, and

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9.

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes Theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P(L_h \mid A_i) = [P(L_h)\, P(A \mid L_h)] / P(A_i) \qquad \text{Equation 11}$$

where

w_{hi} is as defined in Equation 10,

A_i = Age i striped bass,

$P(L_h)$ = proportion of the total catch of striped bass in length group h,

$P(A_i \mid L_h)$ = proportion of aged fish in length group h that are Age i, and

$P(A_i)$ = proportion of Age i fish in the total catch.

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ \text{CI for } \bar{y}_{sti} = \bar{y}_{sti} \pm t\, S_{\bar{y}_{sti}} \qquad \text{Equation 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for $\alpha = 0.05$ based on $n_i' - 1$ degrees of freedom (not the effective degrees of freedom), and

$\bar{y}_{sti}$ is as defined in Equation 9.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1992-93 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / (H_{ai} + W_{ai}) \qquad \text{Equation 13}$$

where

P_{ai} = the proportion of Age i hatchery striped bass in the population adjusted for tag loss and non-detection of tags,

H_{ai} = the number of Age i verified hatchery recaptures caught adjusted for tag loss and non-detection of tags, and

W_{ai} = the number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai}).

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and non-detection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1\text{-}TAG_i)(1\text{-}NDET)\right]$$ Equation 14

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

H_i = the number of Age i verified hatchery recaptures caught,

TAG_i = decimal percent 24-hour magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1), and

NDET = decimal percent non-detection rate for magnetic tags during the recapture program,

= $[D_2/(H\text{-}D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected.

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Section 1.0) was not adjusted for handling mortality (Dunning et al. 1989) because handling mortality was minimal (<1%) and could not be associated with each lot of tagged fish stocked into the Hudson River (EA 1993).

2.3.4 Recaptured Striped Bass

Three groups of recaptured, internal anchor-tagged striped bass were considered: (1) fish recaptured from our previous programs (cross-year recaptures), (2) fish caught, tagged, released and recaptured within the current (1992-93) program (within-year recaptures), and (3) fish recaptured with external streamer tags from other programs (other recaptures). All cross-year recaptures were examined to determine the condition of the tag legend and insertion site, recapture rate, mean length, and days at-large. We also determined the age and growth for

TABLE 2-1. FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOSS (TAG_i) AND NON-DETECTION OF TAGS (NDET) DURING 1992-93.

COHORT	AGE	TAG_i	NDET
1992	0+	0.029[a]	0.01384[b]
1991	1+	c	c
1990	2+	c	c
1989	3+	0.057	0.01384
1988	4+	0.017	0.01384
1987	5+	0.147	0.01384
1986	6+	0.075	0.01384
1985	7+	0.065	0.01384
1984	8+	0.276	0.01384

[a]Decimal percent 24-hour magnetic tag loss for Age *i* hatchery striped bass determined at the time of tagging (EA 1993).

[b]Weighted non-detection rate based on a non-detection rate of 0.00000 for 82 hatchery recatpures checked with two detectors prior to 29 March 1993, and a non-detection rate of 0.03078 for 67 hatchery recaptures checked with two detectors on and after 29 March 1993: (0.00000 x 82/149) + (0.03078 x 67/149) = 0.01384.

[c]Hatchery fish were not tagged prior to release in 1990 or 1991.

cross-year recaptures by examining the scale samples taken at the time of release and time of recapture. Within-year recaptures consisted of two groups of striped bass: fish that were in good condition at the time they were tagged and released (REL_REC = 1), and fish that were tagged and released but exhibited one or more gross anatomical abnormalities (REL_REC = 6). Both groups of within-year recaptures were examined to determine the tag condition, recapture rate, mean length and days at-large. Within-year recaptures that were in good condition at the time of release were also used for a mark-recapture estimate of population size (Section 2.3.6). We obtained release and recapture information and observed the condition of the tag streamer and insertion site for other agency recaptures.

2.3.5 Population Movement

The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$\text{Recapture rate} = R_{ij}/M_{ij} \qquad \text{Equation 15}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

M_{ij} = number of tagged striped bass released during time period (week) i in region j.

$$\text{Recapture Proportion} = R_{ij}/C_{ij} \qquad \text{Equation 16}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j.

2.3.6 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i) with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals (R_i/C_i-βM_i) are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$N = \Sigma(C_i M_i^2)/\Sigma(R_i M_i) \qquad \text{Equation 17}$$

where

N = estimated population size,

C_i = total catch during time interval i,

M_i = total number of marked fish tagged and released in good condition and available for recapture at the midpoint of time interval i, and

R_i = number of recaptured fish in C_i.

The variance of the reciprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$s^2 = \frac{\Sigma(R_i^2/C_i) - (\Sigma R_i M_i)^2/\Sigma(C_i M_i)}{m-1} \qquad \text{Equation 18}$$

where

S^2 = mean of squared deviations from the regression model described above,

m = the number of data points in the regression, and C_i, M_i and R_i are as defined above in Equation 17.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_i M_i^2 \times t_{m-1} \qquad \text{Equation 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and α=0.05.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.7 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish at-large one or two years was compared within cohort to growth from scale samples taken at the time of tagging (untagged fish) in the 1988-89 through 1992-93 programs. We measured growth as the distance from the focus to each annulus along a radial line originating at the focus and running perpendicular to the anterior edge of the scale (radius measurement).

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9 M TRAWL

3.1.1 Catch Per Unit Of Effort

A total of 771 ten minute tows (use code = 1) were taken with the 9 m trawl in the Battery region, and 47 tows were taken in the Upper Harbor region of the lower Hudson River between 2 November 1992 and 16 April 1993. The mean CPUE for striped bass in the Upper Harbor region was about twice as large as the CPUE in the Battery region over all sampling weeks combined (Table 3-1). Prior to 25 January 1993, the mean CPUE was consistently higher in the Upper Harbor region compared to the Battery region. After 25 January, mean CPUE was higher in the Battery region and most sampling effort was concentrated in that region (Appendix Table C-1). Among weeks when a significant number of samples were collected, mean CPUE exceeded 50 striped bass per ten minute tow during the weeks of 14 December and 4 January in the Upper Harbor region and during the weeks of 30 November, 25 January and 5 April in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 178.0 striped bass per ten minute tow during the week of 30 November in the Upper Harbor region. However, this mean was based on only one tow. The next highest weekly mean CPUE occurred during the week of 18 January in the Upper Harbor region when an average of 122.8 striped bass were collected in 12 tows. The highest CPUE was at river mile 3 of the Upper Harbor region (Appendix Table C-2). However, catches at this location were variable. Consistent high catches occurred at river miles 1 and 8 through 10 of the Battery region where 64% of the sampling took place.

Mean CPUE for the 9 m trawl in the Battery region increased in each program from 8.1 in 1985-86 to a peak of 45.3 striped bass per ten minute tow in 1989-90 (Table 3-2). After the peak CPUE in the 1989-90 program, CPUE decreased to the present level of 32.7 striped bass per ten minute tow for the 1992-93 program. The increased CPUE observed during the 1988-89 and 1989-90 programs may be due to the complete recruitment of the numerically dominant 1987 and 1988 year classes to the 9 m trawl (CES 1989). The decrease in CPUE observed after

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

REGION	NUMBER OF TOWS[1]	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Battery	771	24,614	31.9	1.1
Upper Harbor	47	3,164	67.3	16.8

[1]Use Code = 1 tows only.

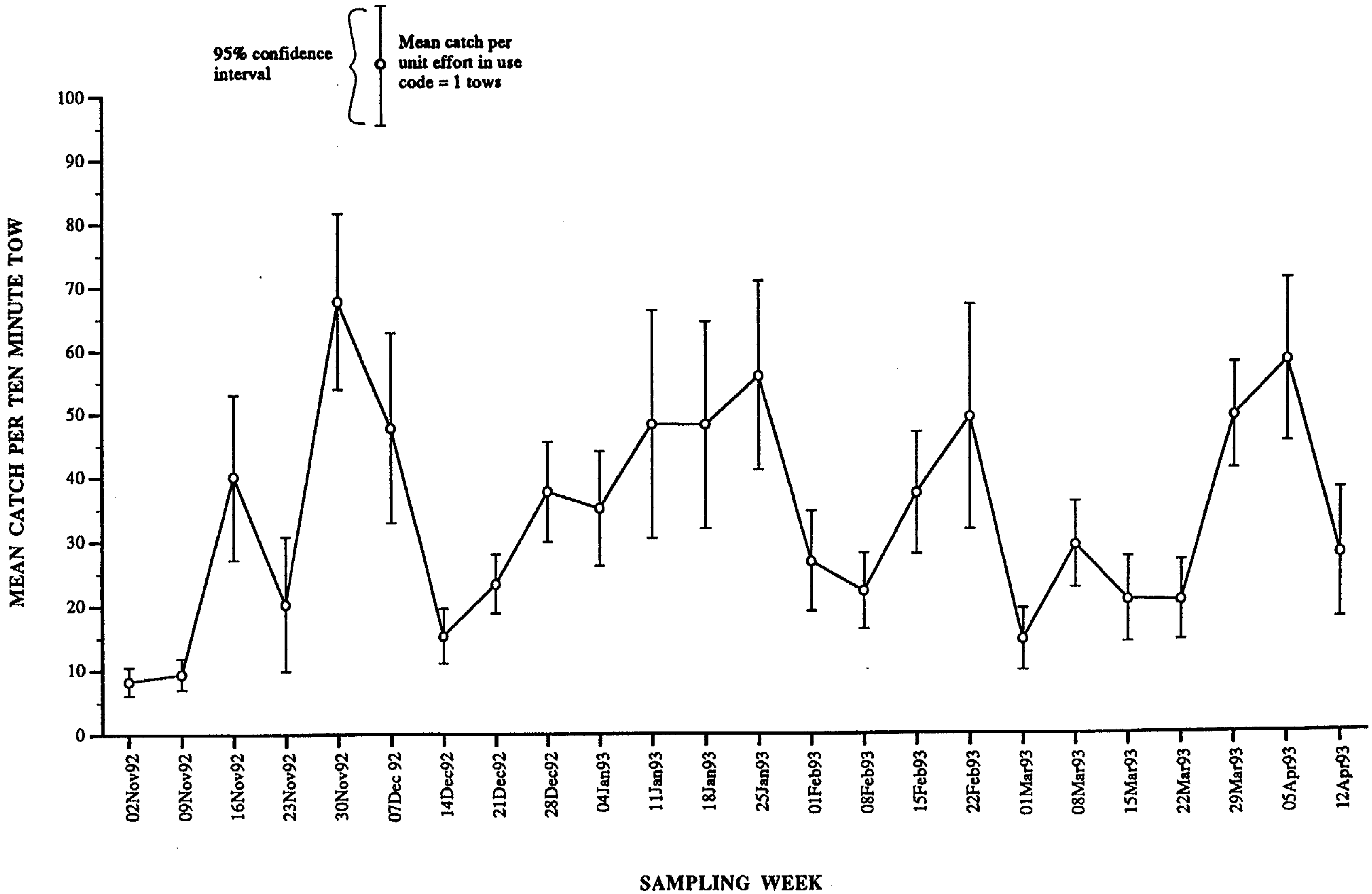


Figure 3-1. Weekly mean catch per ten minute tow by a 9m trawl in the Battery region of the Hudson River, 2 November 1992 through 16 April 1993.

TABLE 3-2. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1992-93.

YEAR	PERIOD	TOWS	MEAN CPUE	95% CI
1985-86	23 DEC 85 - 21 MAR 86	638	8.1	±1.0
1986-87	21 DEC 86 - 21 MAR 87	385	12.2	±1.2
1987-88	20 DEC 87 - 19 MAR 88	437	28.5	±2.5
1988-89	19 DEC 88 - 18 MAR 89	527	38.9	±3.3
1989-90	18 DEC 89 - 16 MAR 90	458	45.3	±4.3
1990-91	17 DEC 90 - 15 MAR 91	477	40.7	±3.5
1991-92	23 DEC 91 - 21 MAR 92	578	35.5	±2.2
1992-93	21 DEC 92 - 20 MAR 93	397	32.7	±2.9

the 1989-90 program may be due to migration or mortality of the 1987 and 1988 year classes and lower abundance of the 1989 through 1991 year classes.

3.1.2 Length-Frequency Distributions

The overall mean length of striped bass caught by the 9 m trawl in the Battery region was 220 mm during the 1992-93 program (Table 3-3). The length-frequency distribution for the 9 m trawl was: (1) skewed right i.e., more fish were smaller than the mean length than would be expected if the distribution was bell-shaped, (2) leptokurtotic, i.e., more fish were found in length groups close to the mean length than would be expected if the distribution was bell-shaped, and (3) the length-frequency was unimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 201-250 mm length group.

Weekly mean length of striped bass caught by the 9 m trawl was largest early in the program and then generally declined for the next 10 weeks, increased slightly, and then continued to decline for the rest of the program (Appendix Table C-5). Mean length was highest (318 mm) during the week of 9 November 1992 and generally declined until the week of 18 January 1993 when weekly mean length was 171 mm. Weekly mean length then increased to 253 mm during the week of 25 January 1993 and declined steadily to the lowest weekly mean length of 161 mm during the week of 22 March 1993. This pattern was similar to the pattern observed in the 1991-92 program when weekly mean lengths were largest during the first nine weeks of the program.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50 mm length classes, indicated that fish in the 151-400 mm length classes predominated prior to 14 December 1992 (Figure 3-3). Beginning during the week of 14 December catches of smaller length classes (<100 and 101-150 mm length classes) increased, until the week of 25 January when catches in the 201-400 mm length classes predominated, similar to the early weeks of the program. After the week of 25 January, catches in the length classes between 101 and 300 mm predominated. The highest catch per

TABLE 3-3. DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

N	MEAN (MM)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
24,614	220	88.6	0.60 ±0.03	0.58 ±0.06	62	792	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I. = 95% confidence interval

Right skewness = Significant positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.

Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.

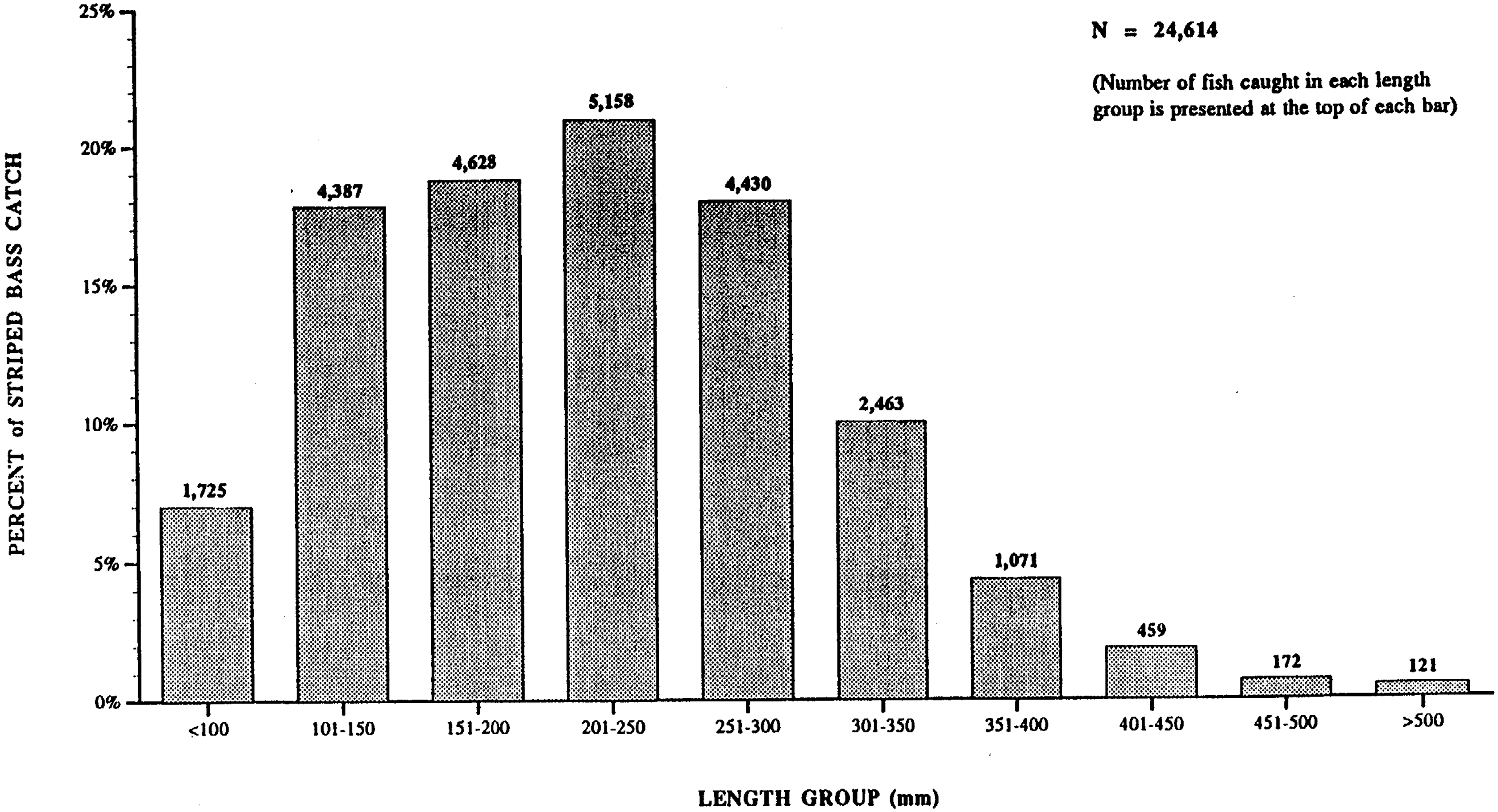


Figure 3-2. Length-frequency distribution for striped bass captured by a 9m trawl in the Battery region of the Hudson River, 2 November 1992 through 16 April 1993.

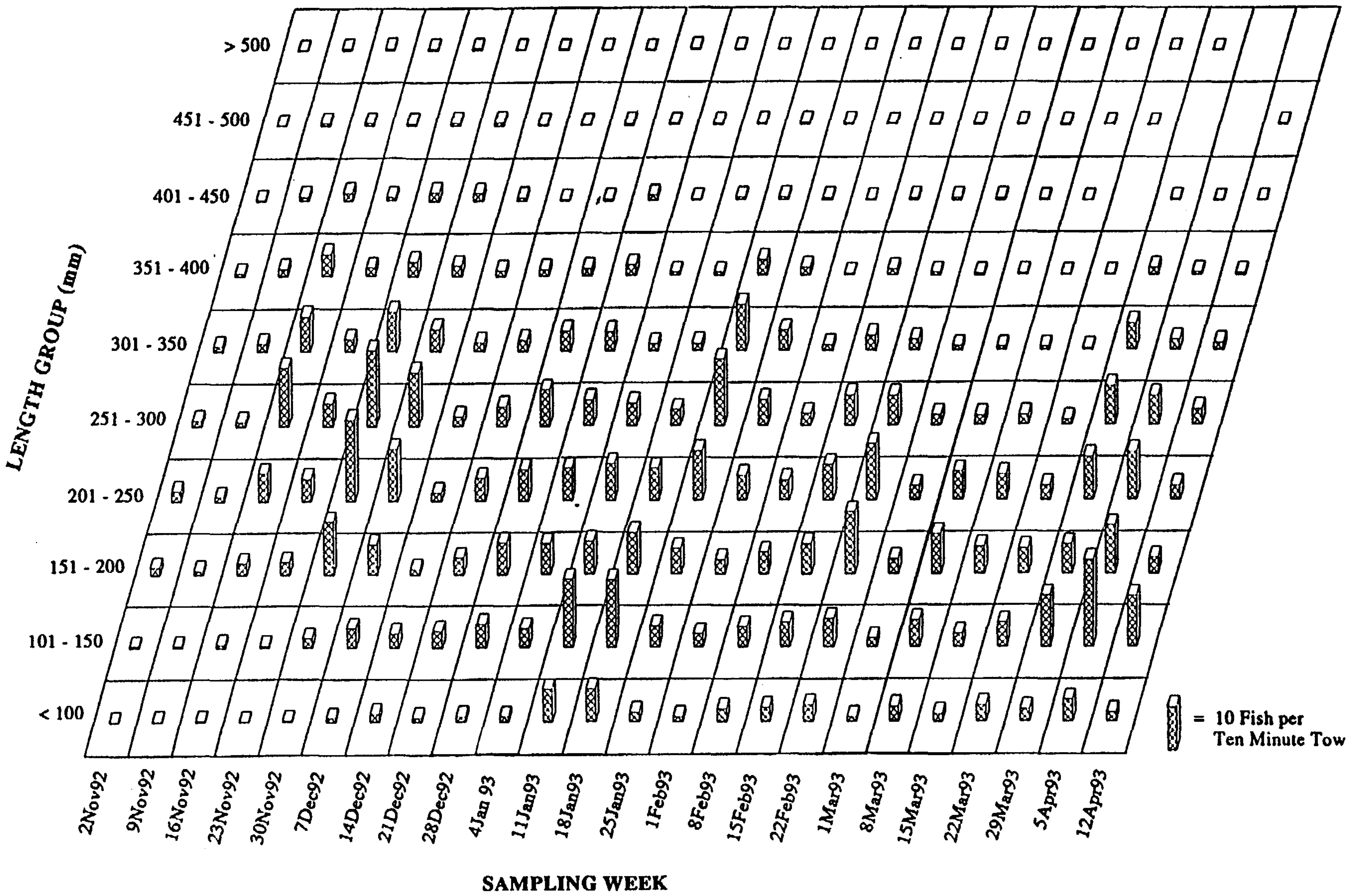


Figure 3-3. Weekly length-frequency distributions for striped bass caught per ten minute tow in a 9m trawl in the Battery region of the Hudson River, 2 November 1992 through 16 April 1993.

tow over all weeks was 20.7 striped bass in the 101-150 mm length class during the week of 5 April 1993.

The standardized length-frequency of striped bass captured during the winter of 1992-93 was unimodal with a peak in the 201-250 mm length group (Figure 3-4). Unimodal length-frequencies previously occurred during the winters of 1989-90, 1988-87, and 1985-86. The peak in the 201 to 250 mm length group probably represents the 1991 year classes at age 1+.

3.1.3 Handling Mortality

Striped bass handling mortality in the 9 m trawl was less than 2% during 1992-93 at bottom water temperatures from 2 to 13°C (Table 3-4). A total of 384 striped bass died out of 24,614 fish caught in Use Code = 1 tows that had river bottom water temperature data associated with each tow. The highest handling mortality of 3.5% (107/3,090) occurred at a bottom water temperature of 4°C. The relatively consistent, low handling mortality indicated there was no relationship between handling mortality and water temperature for the 9 m trawl over bottom water temperatures of 2 to 13°C experienced in this study. The 1992-93 data were not examined for an interaction between water temperature, fish length and immediate handling mortality because this interaction was not significant in previous programs (Dunning et al. 1989).

Striped bass handling mortality in the 1992-93 program was less than 2%, but was approximately five times higher than the pooled mortality for the 1985-86 through 1990-91 programs (Table 3-5). The apparent increase in handling mortality observed in the 1992-93 program was probably due to an underestimate of handling mortality during the 1985-86 through 1990-91 programs. During the 1985-86 through 1990-91 programs, bird predation on released striped bass was not considered to be a significant problem and little effort was made to quantify the bird predation rate. All striped bass that were not immediately identified as dead upon release were assumed to have survived. However, at the end of the 1990-91 program it became apparent that bird predation on released striped bass was significant. Approximately 2.4% of the 2,969 tagged striped bass released between 12 March and 12 April 1991 were removed from the

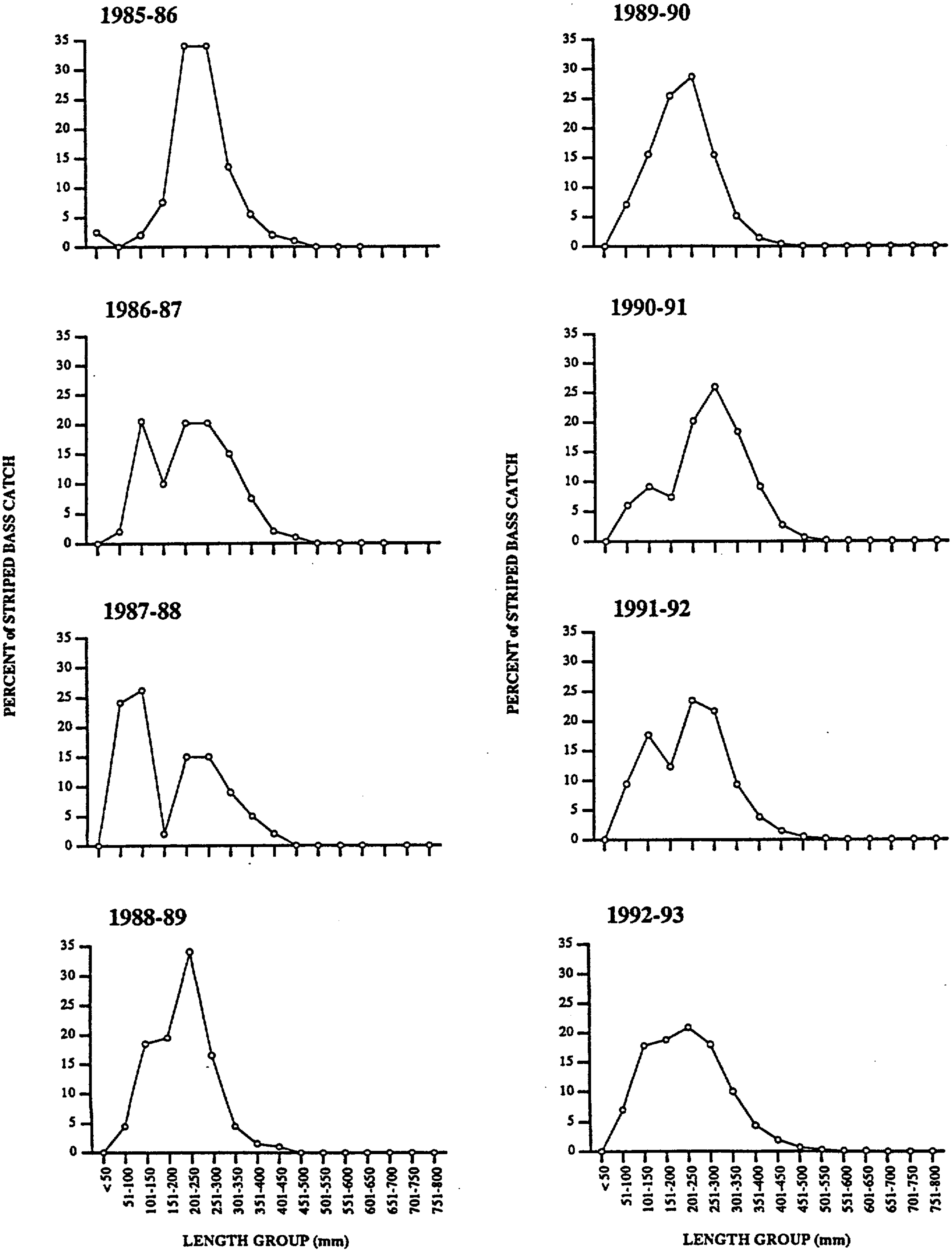


Figure 3-4. Standardized length-frequency of striped bass captured by a 9m trawl in the Battery region of the Hudson River, 1985-86 through 1992-93.

TABLE 3-4. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS IN A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO HUDSON RIVER BOTTOM WATER TEMPERATURE, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	NUMBER DEAD	TOTAL
2	0.6	6	929
3	1.4	80	5,940
4	3.5	107	3,090
5	2.2	86	3,858
6	1.8	44	2,380
7	1.2	16	1,347
8	2.2	17	756
9	0.2	3	1,361
10	0.7	6	809
11	0.5	17	3,406
12	0.2	1	434
13	0.3	1	304
2-13	1.6	384	24,614

TABLE 3-5. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1992-93 HUDSON RIVER STRIPED BASS PROGRAMS.

	1985-86 THROUGH 1990-91		1991-92		1992-93	
BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N
3	0.3	58/ 16,781	1.3	20/ 1,557	1.4	80/ 5,940
4	0.3	51/ 16,155	0.5	45/ 9,685	3.5	107/ 3,090
5	0.3	58/ 21,071	0.2	13/ 5,419	2.2	86/ 3,858
6	0.2	43/ 18,783	1.5	98/ 6,438	1.8	44/ 2,380
7	0.4	43/ 11,785	1.0	26/ 2,728	1.2	16/ 1,347
8	0.2	20/ 8,731	1.4	29/ 2,135	2.2	17/ 756
9	0.5	29/ 5,709	0.9	10/ 1,133	0.2	3/ 1,361
10	0.2	8/ 4,843	1.1	21/ 1,897	0.7	6/ 806
11	0.3	11/ 3,185	0.6	5/ 879	0.5	17/ 3,406
12	0.3	6/ 1,995	0.5	1/ 187	0.2	1/ 434
3-12°C	0.3	327/109,038	0.8	268/32,058	1.6	377/24,307

n = Number dead at a temperature for use code = 1 tows.
N = Total number caught at a temperature for use code = 1 tows.

water by gulls (NAI 1992). Therefore, handling mortality in the 1985-86 through 1990-91 programs may have been underestimated.

Field procedures were modified during the 1991-92 and 1992-93 programs to both quantify and minimize gull predation. After tagging, fish were released into a recovery pen that was deployed in the water alongside the boat. The pen was a 1 m x 2 m x 1 m deep enclosure with 0.9 cm mesh netting on four sides, open on the top and bottom, with the top of the frame suspended at the water surface. Striped bass released into the pen were provided a refuge alongside the boat where they could recover from handling stress without drifting away from the boat during recovery and possibly being preyed on by gulls. Fish in good condition typically escaped from the pen through the bottom. Stunned fish typically remained at the surface for several minutes until they recovered and escaped through the bottom of the pen. Any fish remaining in the recovery pen at the end of sample processing were considered dead and were removed and taken to the lab. A field technician also observed fish as they escaped from the recovery pen and recorded instances of gull predation. These procedures both minimized gull predation and accurately recorded handling mortality.

Quantitative comparison of the difference in handling mortality between the 1985-86 through 1990-91 programs and the 1991-92 or 1992-93 programs are probably not meaningful due to our change in field procedures. Striped bass handling mortality statistics from the 1991-92 and 1992-93 programs are probably more accurate than previous programs because use of the observer and the recovery pen allowed more assessment of accurate bird predation data. Handling mortality during the 1991-92 and 1992-93 programs was probably lower than handling mortality recorded for previous programs because the recovery pen provided a refuge against gull predation.

Handling mortality in all programs conducted after the 1985-86 program was approximately ten times less than that observed in the 1984 program (NAI 1992). The primary reason for the decrease in handling mortality observed after 1984 was the use of a submerged holding facility and the increased tagging efficiency of field crews (Dunning et al. 1989).

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

Age-length frequency histograms, presented by 10 mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5) demonstrate minimal overlap in size of Age 0+ and Age 1+ striped bass caught during the 1992-93 program. Most of the fish in each length group ≤150 mm were Age 0+, while most of the fish in length groups between 150 and 329 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size primarily between 250 and 329 mm. Age 3+ striped bass overlapped with Age 2+ fish primarily between 330 and 449 mm.

The 9 m trawl with 7.6 cm (stretch) mesh in the body and 3.8 cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1992-93 programs. Therefore, the striped bass catch by this 9 m trawl was used for comparisons of mean length at age among programs. Overlap of the 95% confidence intervals about the estimated mean length of each age cohort was used for the comparison of mean length at age.

The 1992 cohort at Age 0+ was similar in mean length to the 1988, 1989 and 1990 cohorts (Figure 3-6, Appendix Table C-7). The 1987 cohort was significantly smaller and the 1986 and 1991 cohorts were significantly larger at Age 0+. At Age 1+ the 1986 cohort had the largest mean length and the 95% confidence intervals did not overlap with any other cohort. The 1991, 1990, 1989, 1987 and 1985 cohorts at Age 1+ were intermediate in mean length and the 1988 cohort was the smallest. At Age 2+, the 95% confidence intervals for the 1990, 1989, 1988, 1986 and 1985 cohorts overlapped indicating similarity among the estimated mean lengths. Estimated mean lengths of the 1984 and 1987 cohorts were the smallest of the Age 2+ cohorts examined. Confidence intervals about the estimated mean lengths at Age 3+ were wide and overlapped among the 1983 through 1988 cohorts. However, the estimated mean length at Age 3+ of the 1989 cohort ranked largest followed by the 1985, 1988, 1986, 1987, 1983 and 1984 cohorts. The 1986 cohort remained the largest cohort at Ages 0+ and 1+ (Figure 3-6). However, the 1990 cohort was largest at Age 2+. The relative ranking of the 1988, 1989, and 1987 cohorts were not consistent among Ages 0+, 1+ and 2+.

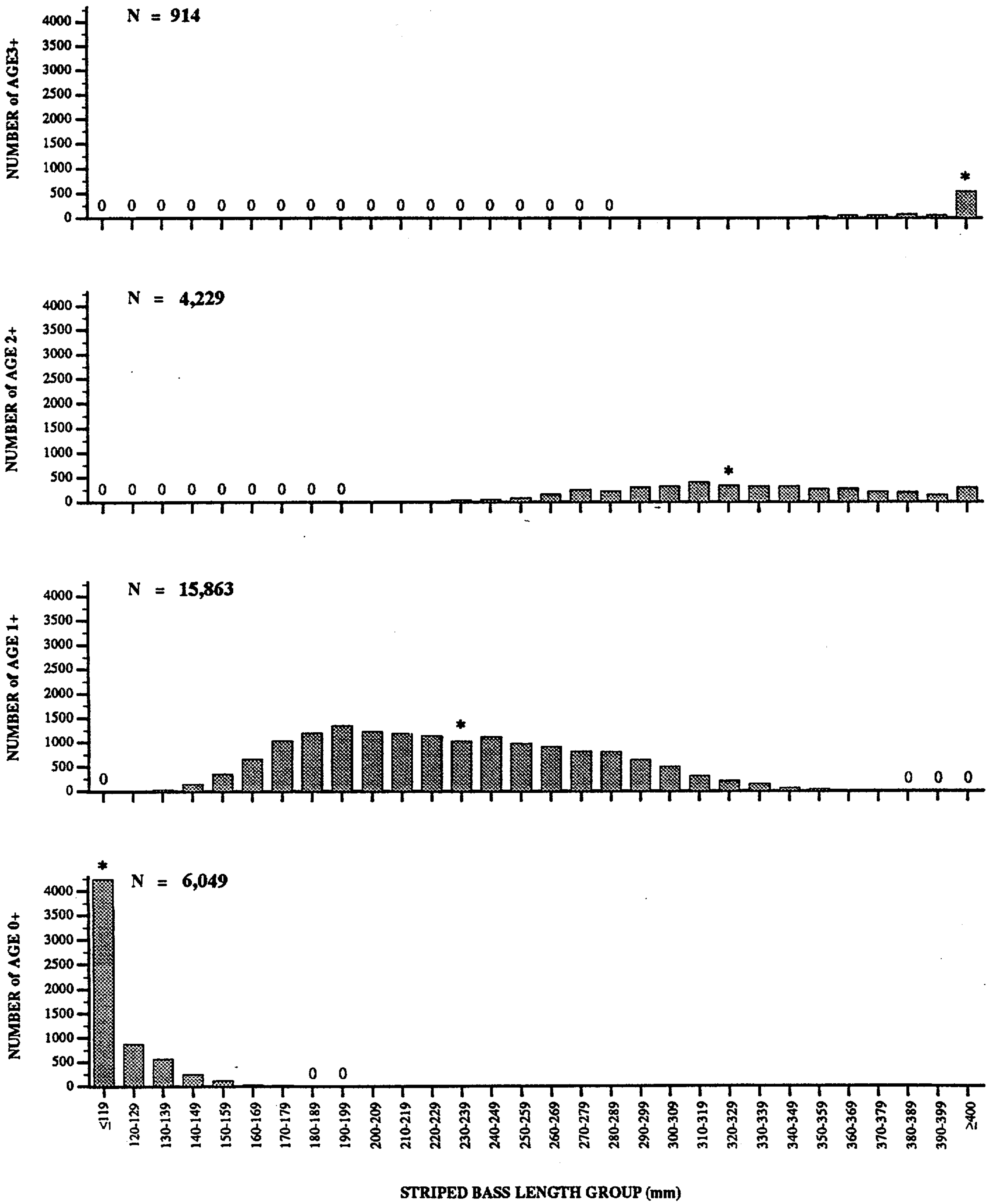


Figure 3-5. Length-frequency distributions for age 0+, 1+, 2+ and 3+ striped bass captured by a 9m trawl in the Hudson River, 2 November 1992 through 16 April 1993.

(Note: Length group which contains the stratified mean length at age is marked with an *.)

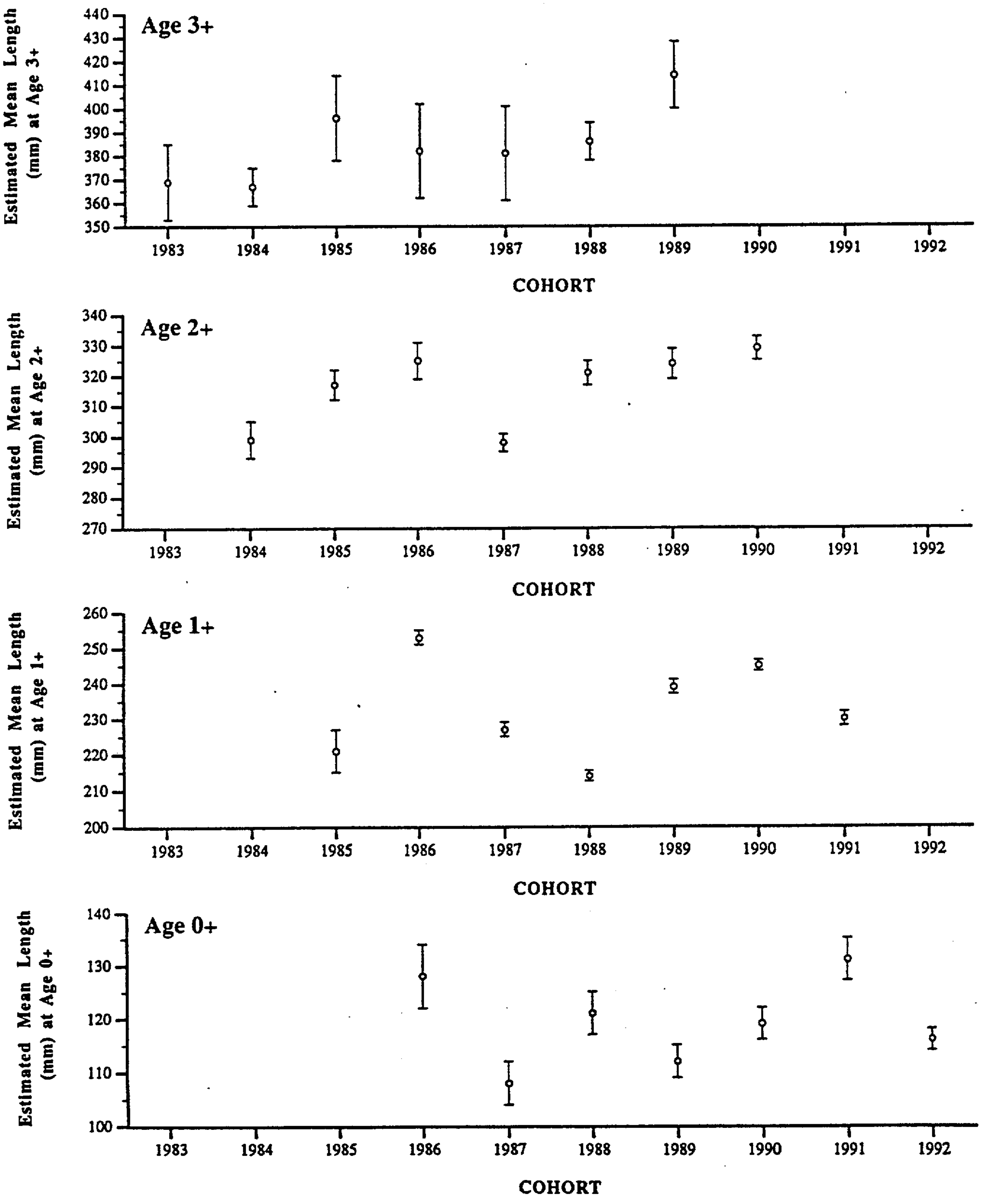


Figure 3-6. Mean length at age (and 95% confidence interval) for Age 0+ through Age 3+ wild striped bass of the 1983 through 1992 cohorts caught in a 9m trawl in the Hudson River.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling of about 15% of the scale samples resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-6). For the allocation of 5,946 scale samples actually selected, the precision based on 95% confidence limits was 0.8% corresponding to an error term of ± 106 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than about 10% of the total sample (27,778 fish in 1992-93). For example, doubling the number of striped bass scale samples examined for age determination from 3,000 to 6,000 would result in an improvement in the precision from 1.1% to 0.7% (Table 3-6). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (15,983) out of the 27,778 fish caught in use code = 1 samples during 1992-93 could be estimated with 95% confidence limits of ±474 fish (precision = 3.0%, Table 3-6).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10 mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 2+ striped bass (Table 3-7), which collectively comprised 94.7% of the fish caught in this program. Only 914 of the 27,778 striped bass caught in use code = 1 samples were estimated to be Age 3+, and 558 of the fish caught were older than Age 3+ in the 1992-93 program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1991 cohort of Age 1+ striped bass was approximately 60% of the total catch during 1992-93. The number of Age 2+ striped bass (1990 cohort) was estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ was wider, and the sample size was smaller for these fish.

TABLE 3-6. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

	ESTIMATED NUMBER OF AGE 1+ FISH CAUGHT				
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL[b]	LOWER 95%CI	UPPER 95%CI	PRECISION (%)[a]
500	0.575	15,983	15,509	16,456	3.0
1,000	0.575	15,983	15,658	16,308	2.0
2,000	0.575	15,983	15,763	16,203	1.4
3,000	0.575	15,983	15,810	16,155	1.1
4,000	0.575	15,983	15,840	16,125	0.9
5,000	0.575	15,983	15,861	16,104	0.8
5,946[c]	0.575	15,983	15,877	16,088	0.8
6,000	0.575	15,983	15,863	16,103	0.7
7,000	0.575	15,983	15,891	16,075	0.6

[a]Precision = 95% confidence interval (CI) half width/stratified total x 100.

[b]Based on 27,778 striped bass caught in use code = 1 samples.

[c]Results for sample size = 5,946 are based on actual allocations from use code = 1 samples which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

TABLE 3-7. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

			ESTIMATED NUMBER OF FISH CAUGHT			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	PRECISION (%)
0+	1992	0.219	6,094	6,049	6,139	0.7
1+	1991	0.575	15,983	15,863	16,183	0.8
2+	1990	0.152	4,229	4,038	4,421	4.5
3+	1989	0.033	914	732	1,096	19.9

[a]Based on a laboratory sample of scales from 5,946 striped bass selected by stratified random sampling from 27,778 fish caught in use code = 1 samples.

3.3 STRIPED BASS HATCHERY PROPORTION

Striped bass stocked in the Hudson River from the Verplanck hatchery in 1989 were about 0.2% of the Age 3+ cohort of fish caught during the winter of 1992-93 (Table 3-8). The 1989 wild cohort was relatively strong (CES 1989, 1991 draft) and this probably resulted in the relatively low hatchery proportion for Age 3+ striped bass during the 1992-93 study. Hatchery fish were not tagged in 1990 or 1991 and were therefore not detected among the Age 1+ or Age 2+ fish. Age 0+ hatchery fish represented 3% of the catch during 1992-93, but the reliability of this proportion is unknown because fish of the size range observed for the Age 0+ cohort are probably not fully recruited to the 9 m trawl.

Comparison of the estimated hatchery proportions for the 1985 and 1986 hatchery cohorts caught in 1986-87 through 1988-89 suggested that the hatchery proportion for each cohort doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; this report Table 3-9). However, this trend did not continue for the more recent hatchery cohorts. The 1987 cohort had an estimated hatchery proportion of 0.2% at Age 1+ in 1988-89 and was reduced significantly to 0.1% at Age 2+ in 1989-90. Similarly, the 1988 cohort had an estimated hatchery proportion of 0.4% at Age 1+ in 1989-90 and was reduced significantly to 0.2% at Age 2+ in 1990-91. The 1989 cohort had an estimated hatchery proportion of 0.2% at Age 1+ in 1990-91, and was of a similar proportion at Age 2+ in 1991-92 and at Age 3+ in 1992-93 (0.3% and 0.2%, respectively, Table 3-9). In prior programs, the 1985 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1986-87 and 3.1% at Age 2+ in 1987-88. The 1986 cohort had an estimated hatchery proportion of 1.7% at Age 1+ in 1987-88 and 3.5% at Age 2+ in 1988-89. Therefore, the hatchery proportions estimated for the 1987, 1988, and 1989 cohorts during the 1988-89 through 1991-92 programs did not substantiate the pattern of doubling that was observed for the 1985 and 1986 cohorts between Age 1+ and Age 2+. Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 1+ 1988 cohort to 0.2% for Age 3+ fish from the 1987 cohort (Table 3-10).

TABLE 3-8. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

STATISTIC	COHORT	
	1992	1989
Age	0+	3+
Total Hatchery Stocking (N_i)	210,746	202,068
Hatchery Recaptures (H_i)	188	2
Adjusted Hatchery Recaptures (H_{ai})	197[a]	2[b]
Wild Fish Examined (W_{ai})	6,378	993
Estimated Hatchery Proportion ($H_{ai}/(H_{ai}+W_{ai})$)	0.0300	0.0020
Lower 95% C.I.	0.0258	0.0001
Upper 95% C.I.	0.0347	0.0091

[a]Based on a non-detection rate of 0.00000 for 80 Age 0+ hatchery recaptures prior to 29 March 1993, and a non-detection rate of 0.03078 for 108 Age 0+ hatchery recaptures on and after 29 March 1993.

[b]Based on a non-detection rate of 0.0000 for 2 Age 3+ hatchery recaptures prior to 29 March 1993, and 0 recpatures of Age 3+ hatchery fish on and after 29 March 1993.

TABLE 3-9. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1992-93.

COHORT	1992	1989	1988	1987	1986	1985	1984
NUMBER STOCKED	210,746	202,068	48,611	324,579	529,563	284,578	147,153
1986-87							
N					38	51	5
Lower 95% C.I.					0.0110	0.0126	0.0005
Proportion					0.0152	0.0170	0.0014
Upper 95% C.I.					0.0204	0.0225	0.0029
1987-88							
N				25	127	82	4
Lower 95% C.I.				0.0015	0.0137	0.0240	0.0011
Proportion				0.0023	0.0165	0.0311	0.0034
Upper 95% C.I.				0.0033	0.0196	0.0399	0.0081
1988-89							
N			120	39	48	6	0
Lower 95% C.I.			0.0127	0.0014	0.0245	0.0075	0.0000
Proportion			0.0155	0.0020	0.0353	0.0236	0.0056
Upper 95% C.I.			0.0187	0.0027	0.0500	0.0645	0.0514
1989-90							
N		46	92	3			
Lower 95% C.I.		0.0049	0.0034	0.0002			
Proportion		0.0068	0.0043	0.0010			
Upper 95% C.I.		0.0091	0.0054	0.0027			
1990-91							
N		27	24	1			
Lower 95% C.I.		0.0015	0.0012	0.0000			
Proportion		0.0024	0.0020	0.0013			
Upper 95% C.I.		0.0035	0.0031	0.0098			
1991-92							
N		13	4				
Lower 95% C.I.		0.0015	0.0012				
Proportion		0.0032	0.0035				
Upper 95% C.I.		0.0045	0.0048				
1992-93							
N	197	2					
Lower 95% C.I.	0.0258	0.0001					
Proportion	0.0300	0.0020					
Upper 95% C.I.	0.0347	0.0091					

TABLE 3-10. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1992-93, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH.

COHORT	1992	1989	1988	1987	1986	1985	1984
NUMBER STOCKED	210,746	202,068	48,611	324,579	529,563	284,578	147,153
1986-87							
N					38	51	5
Lower					0.0126	0.0286	0.0038
Estimate					0.0171	0.0353	0.0058
Upper					0.0226	0.0432	0.0084
1987-88							
N				25	127	82	4
Lower				0.0031	0.0158	0.0526	0.0080
Estimate				0.0042	0.0187	0.0634	0.0135
Upper				0.0055	0.0220	0.0761	0.0218
1988-89							
N			120	39	48	4	0
Lower			0.1541	0.0030	0.0282	0.0221	0.0043
Estimate			0.1630	0.0038	0.0398	0.0493	0.0222
Upper			0.1723	0.0048	0.0554	0.1062	0.0913
1989-90							
N		46	92	3			
Lower		0.0165	0.0477	0.0006			
Estimate		0.0198	0.0509	0.0017			
Upper		0.0235	0.0543	0.0037			
1990-91							
N		27	24	1			
Lower		0.0055	0.0211	0.0002			
Estimate		0.0070	0.0243	0.0026			
Upper		0.0088	0.0279	0.0127			
1991-92							
N		13	4				
Lower		0.0091	0.0397				
Estimate		0.0095	0.0411				
Upper		0.0099	0.0430				
1992-93							
N	197	2					
Lower	0.0739	0.0017					
Estimate	0.0808	0.0059					
Upper	0.0882	0.0163					

[a]Estimated hatchery proportion scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula:

$$\left[H_{ai} \times 600000/N_i\right] / \left[(H_a i \times 600000/N_i) + W_i\right]$$

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

During the 1992-93 program, recaptures were made of 190 hatchery striped bass which were tagged with a CWT and 494 wild striped bass that were individually tagged with our internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin, except for 794 fish during the week of 5 April 1993 when one detector became inoperable. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1992-93 winter sampling program, 188 Age 0+ (1992 cohort) and 2 Age 3+ (1989 cohort) hatchery striped bass were caught. The 1990 and 1991 cohorts of hatchery striped bass were not tagged.

3.4.1.1 Length

A total of 210,746 hatchery striped bass were tagged with magnetic tags and stocked to the Hudson River between 16 September and 25 November 1992. The mean length of the 1992 cohort of wild fish was not significantly different from the hatchery cohort at Age 0+, based on overlapping 95% confidence intervals. It was not possible to compare mean length at age between the hatchery and wild 1990 and 1991 cohorts because these cohorts were not tagged prior to release from the hatchery. Therefore, the stratified mean lengths presented for the 1990 and 1991 cohorts of wild fish in Table 3-11 represent hatchery and wild fish combined.

TABLE 3-11. COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+, 1+, 2+, AND 3+ WILD AND HATCHERY STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER[a] 95% CI	UPPER[a] 95% CI	N	MEAN (mm)	LOWER 95% CI	UPPER 95% CI
0+	1992		116	114	118	188	127	102	152
1+	1991[b]		231	229	232	-	-	-	-
2+	1990[b]		329	325	333	-	-	-	-
3+	1989	125	414	400	428	2	423	-	-

[a] A t statistic of 2.00 was used to calculate the confidence intervals about the stratified mean for of wild fish.

[b] The stratified mean lengths for the 1990 and 1991 wild cohorts of striped bass represent hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

The 1989 hatchery cohort was tagged prior to stocking. Two separate groups of fish were stocked in 1989: 179,219 fish were stocked in August 1989 (summer-stocked); and 21,196 were stocked in October (fall-stocked). The fall-stocked fish were significantly larger than the summer stocked fish at the time of stocking. When recaptured at Ages 0+ and 1+, the 1989 hatchery cohort (summer and fall-stocked fish combined) was significantly larger than wild fish, fall-stocked fish were significantly larger than summer-stocked fish, and fall-stocked fish were preferentially recaptured compared to summer-stocked fish (NAI 1992). The larger size and preferential recapture of fall-stocked hatchery fish at Age 0+ and 1+ was attributed to either differential survival or differential behavior of the stocking groups. The 1989 hatchery cohort at Age 2+ was significantly smaller than the wild cohort (Table 3-12). However, similar to Ages 0+ and 1+, fall-stocked fish were preferentially recaptured as they comprised 79% (11/14) of the hatchery recaptures of these cohorts but only 11% of the fish stocked. Too few members of the 1989 hatchery cohort (2) were recaptured at Age 3+ to make significant comparisons with the 1989 wild cohort. However, both of the 1989 hatchery fish were from the fall-stocked group, and no members of the more numerous summer-stocked group were recaptured (Table 3-12).

No members of the 1988 or earlier hatchery cohorts were recaptured. Comparisons between estimated mean lengths between the hatchery and wild cohorts for the 1988 and previous year classes are found in NAI (1992) and Table 3-13.

3.4.1.2 Magnetic Tag Detection Efficiency

During the 1992-93 program, 29,607 striped bass were examined using the field magnetic tag detectors. Of these fish, 198 were classified as suspected Hudson River hatchery striped bass and 190 were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Eight fish suspected of having CWTs from the Verplanck hatchery did not have CWTs. Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990), and five of the eight fish without tags in this program had fish hooks present.

TABLE 3-12. MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM, WINTERS OF 1988-89 THROUGH 1992-93.

		RECAPTURE STATISTICS FOR HATCHERY STRIPED BASS AT AGE											
		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVER PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVER PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040	0	--	0.00000
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052	4	380	0.00010
1989	Verplanck Summer[3]	13	124	0.00007	5	215	0.00003	2	330	0.00001	0	--	0.00000
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104	11	300	0.00052	2	423	0.00009

[1] 1988 Attleboro fall number stocked (H_2) = 10,057 at 80-84 mm modal length class.

[2] 1988 Verplanck fall number stocked (H_2) = 38,554 at 139 mm mean length.

[3] 1989 Verplanck summer number stocked (H_2) = 179,219 at 105 mm mean length.

[4] 1989 Verplanck fall number stocked (H_2) = 21,196 at 152 mm mean length.

TABLE 3-13. MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1992 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER.

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1984	Hatchery							3	275[c]	37.5	2[c]	349	31.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				26	205*	3.8	58	286	41.4	6	364	15.9
	Wild				285	221*	3.0	574	317	2.6	57	396	9.2
1986	Hatchery	22	107*	3.8	96	220*	2.7	48	315	5.2	--		
	Wild	83	128*	2.9	1,503	253*	1.2	361	324	3.5	55	382	10.1
1987	Hatchery	20	108	6.2	39	209*	5.2	3	290[c]	16.0	1[c]	350	--
	Wild	190	108	2.1	3,623	227*	0.8	1,216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	1.7	92	219	3.7	24	311	9.9	4[c]	380	18.8
	Wild	1,007	121*	2.0	3,514	214	0.7	2,109	321	1.8	156	386	6.2
1989	Hatchery	46	138*	2.0	27	245	7.8	13	305	12.3	2[c]	423	46.0
	Wild	368	112*	1.6	2,174	239	0.9	961	324	2.3	125	414	7.2
1990[d]	Hatchery	--			--			--					
	Wild	206	119	1.5	3,675	245	0.6	1,378	329	1.9			
1991[d]	Hatchery	--			--								
	Wild	818	131	1.9	3,899	231	0.8						
1992	Hatchery	188	127	0.9									
	Wild	473	116	1.0									

*Indicates a significant ($p < 0.05$) difference in mean length between the hatchery and wild cohorts within an age class. Non-overlapping confidence intervals of mean lengths of hatchery and wild fish were used to indicate significance.

[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

[b]A t statistic of 2.00 was used to calculate the confidence intervals about the stratified means of wild fish.

[c]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for hatchery striped bass.

[d]The mean length reported for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

Striped bass caught during the 1992-93 program were double-checked for CWTs with two "V-shaped" detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Two magnetic tag detectors were used on all sampling days during the first 21 weeks of the 1992-93 program, and no fish escaped detection with the first magnetic tag detector out of 82 verified hatchery fish found. During the weeks of 29 March through 2 April 1993, eight fish escaped detection by the primary detector but were caught by the secondary detector out of 11 hatchery recaptures. During the weeks of 5 April through 9 April, the primary detector became inoperable and was removed from service on 8 April 1993. The field crew checked 794 fish with one detector on 8 and 9 April, and a back-up detector was placed into service on 12 April 1993. Because the reliability of the primary detector was not questioned prior to 29 March, and this detector's operation was questionable after 29 March, we stratified calculation of the non-detection rate into pre- and post- 29 March 1993 periods. A non-detection rate of 0.0000 was applied to all verified hatchery recaptures caught prior to 29 March, including two Age 3+ fish from the 1989 hatchery cohort and 80 Age 0+ fish from the 1992 hatchery cohort. A non-detection rate 0.03078 was applied to 108 Age 0+ verified hatchery recaptures caught during the last three weeks of the program (29 March through 16 April 1993), based on 10 fish escaping detection out of 67 verified hatchery recaptures checked with two tag detectors during this period. An additional 41 Age 0+ hatchery recaptures were caught among the 794 fish checked with only one detector. For comparison with previous programs, a weighted non-detection rate of 0.0138 was calculated (Table 3-14).

The weighted hatchery striped bass nondetection rate of 0.0138 for 1992-93 represented the third lowest magnetic tag detection efficiency (third highest non-detection rate) observed in the program since hatchery fish were first detected in 1986-87 (Table 3-14). The nondetection rate of 0.0459 for 1991-92 and 0.0237 in 1986-87 were comparable to the 1992-93 rate. Between 1987-88 and 1990-91, the nondetection rate varied between 0.0000 and 0.0005, about two orders of magnitude better in detection efficiency than in 1986-87 or 1991-92. The nondetection statistic does not take into account the large number of fish monitored, and as a ratio, is most sensitive to small numbers of verified hatchery fish examined. It appears that when all of the fish are checked with two detectors, as in 1989-90 through 1992-93, between one and three fish escape detection by the first detector unless specific operational problems occur as in 1992-93 (Table 3-14). The consequences of this relatively high non-detection rate were small in

TABLE 3-14. MAGNETIC TAG DETECTION EFFICIENCY OBSERVED FOR HUDSON RIVER HATCHERY STRIPED BASS DURING THE 1986-87 THROUGH 1992-93 WINTER PROGRAMS.

	DETECTOR TYPE		TOTAL NUMBER OF FISH			HATCHERY-TAGGED FISH DETECTED BY			
PROGRAM	PRIMARY	SECONDARY	MONITORED BY PRIMARY DETECTOR	MONITORED BY BOTH DETECTORS	VERIFIED RECAPTURES	PRIMARY	PRIMARY AND SECONDARY	MISSED BY PRIMARY	NON-DETECTION RATE[a]
1986-87	V-shaped	Tube	14,136	2,138	94	13	15	2	0.0237
1987-88	V-shaped	Tube	28,192	1,611	238	11	11	0	0.0000
1988-87	V-shaped	Tube/ V-shaped[b]	32,975	8,164[b]	213	51	52	1	0.0004
1989-90	V-shaped	V-shaped	33,386	33,386	141	138	141	3	0.0005
1990-91	V-shaped	V-shaped	29,346	29,346	52	51	52	1	0.0004
1991-92	V-shaped	V-shaped	35,072	35,072	17	14	17	3	0.0459
1992-93	V-shaped	V-shaped	29,607	28,813	190	139	149	10	0.0138[c]

[a]Non-Detection Rate = $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected when both detectors were used.

[b]3,368 fish on randomly selected days between 31 October 1988 and 13 March 1989 were first monitored with a V-shaped field detector and then with a Tube-shaped detector. The Tube-shaped detector became inoperable on 20 March 1989 and 4,796 fish representing the entire catch were monitored with both a primary and secondary V-shaped field detector until the end of field sampling on 15 April 1989.

[c]One tag detector became inoperable during the week of 29 March 1993; 10 hatchery fish were missed by this detector when two detectors were used. An additional 794 fish were checked with only one tag detector and 41 age 0+ hatchery fish were detected on that week. We applied a non-detection rate of 0.00000 to 82 hatchery recaptures prior to 29 March 1993 and a non-detection rate of 0.03078 for 67 hatchery recaptures on and after 29 March 1993. This value represents the weighted non-detection rate.

1991-92, resulting in one fish being added to adjust the 1989 cohort of 13 Age 2+ hatchery striped bass, and no fish were added to the 1988 cohort of four Age 3+ hatchery fish (NAI 1994). In 1992-93, the non-detection rate did not affect the 1989 cohort of Age 3+ fish, and added only nine fish to the Age 0+ hatchery cohort.

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1992-93 winter sampling program, 345 striped bass were recaptured out of 20,847 fish that were caught, tagged with internal anchor tags, and released in good condition. An additional 889 striped bass with external abnormalities were caught, tagged and released during the 1992-93 program, and we recaptured 17 of these fish. We also recaptured 149 striped bass with internal anchor tags implanted during previous programs, 82 fish were recaptured with suspected tag wounds, 3 fish were recaptured with illegible tag numbers, and 8 fish were recaptured with tags from other tagging studies. These groups of wild striped bass are described below in separate sections. A complete description of the number of fish caught, tagged with different types of internal anchor-external streamer tags since 1984, and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchor tags were used during the 1992-93 program.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1992-93 Winter Program

The majority (19,375 or 84%) of the taggable-size (≥150 mm) striped bass (22,996) were caught in the Battery region as were 278 or 81% of the 345 fish tagged, released and recaptured during this study (Table 3-15, Appendix Table D-2). This is not surprising since most (94%) of the trawl sampling effort was allocated to the Battery during 1992-93 based on the high CPUE in this region during the current and previous programs (NAI 1986, 1987, 1988, 1990, 1992, 1994).

TABLE 3-15. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND REACPTURE REGION IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	NUMBER OF RECAPTURES* FROM RELEASE REGION		
			UPPER HARBOR M = 3,325	BATTERY M = 17,522	TOTAL M = 20,847
UPPER HARBOR	3,621	R	7	23	30
		R/M	0.00211	0.00131	0.00144
		R/C	0.00193	0.00635	0.00829
BATTERY	19,375	R	37	278	315
		R/M	0.01113	0.01587	0.01511
		R/C	0.00191	0.01435	0.01626
TOTAL	22,996	R	44	301	345
		R/M	0.01323	0.01718	0.01655
		R/C	0.00191	0.01309	0.01500

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-15, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 278/17,522 or 0.01587. The recapture rate for striped bass tagged and released in the Battery and recaptured throughout the study area (column total) was 301/17,522 or 0.01718.

In contrast, recapture proportions (R/C) from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-15, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 278/19,375 or 0.01435. It is generally most informative to examine recapture rates from the column totals and recapture proportions from the row totals since these statistics best describe specific movement among regions (or time periods).

Examination of monthly recapture rates (R/M) and recapture proportions (R/C) can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (R/M column totals; Table 3-16) were generally stable for the December 1992 through February 1993 period and decreased in March and April 1993. Monthly recapture proportions (R/C row totals) were also relatively stable from November 1992 through April 1993. This pattern of stable monthly recapture rates and recapture proportions suggests that December 1992 through February 1993 was a period of little movement of the striped bass population in the lower Hudson River.

TABLE 3-16. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

			NUMBER OF RECAPTURES* FROM RELEASE MONTH						
RECAPTURE MONTH	STATISTIC	NUMBER CAUGHT (C)	NOV M = 2,787	DEC M = 5,559	JAN M = 4,424	FEB M = 3,157	MAR M = 3,439	APR M = 1,481	TOTAL M = 20,847
NOVEMBER	R	3,028	53						53
	R/M		0.01902						0.01902
	R/C		0.01750						0.01750
DECEMBER	R	6,026	17	49					66
	R/M		0.00610	0.00881					0.00791
	R/C		0.00282	0.00813					0.01095
JANUARY	R	4,835	6	22	50				78
	R/M		0.00215	0.00396	0.01130				0.00611
	R/C		0.00124	0.00455	0.01034				0.01613
FEBRUARY	R	3,533	3	11	26	17			57
	R/M		0.00108	0.00198	0.00588	0.00538			0.00358
	R/C		0.00085	0.00311	0.00736	0.00481			0.01613
MARCH	R	3,907	7	6	16	15	18		62
	R/M		0.00251	0.00108	0.00362	0.00475	0.00523		0.00320
	R/C		0.00179	0.00154	0.00410	0.00384	0.00461		0.01587
APRIL	R	1,667	4	8	5	5	5	2	29
	R/M		0.00144	0.00144	0.00113	0.00158	0.00145	0.00135	0.00139
	R/C		0.00240	0.00480	0.00300	0.00300	0.00300	0.00120	0.01740
TOTAL	R	22,996	90	96	97	37	23	2	345
	R/M		0.03229	0.01727	0.02193	0.01172	0.00669	0.00135	0.01655
	R/C		0.00391	0.00417	0.00422	0.00161	0.00100	0.00009	0.01500

*Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

Striped bass tagged and released in the combined Battery and upper New York harbor regions, and subsequently recaptured in those regions were at-large an average of 26 days and ranged in size between 153 mm and 583 mm (Table 3-17). Approximately 25% (87/345) of the striped bass were recaptured on the same day as they were tagged and released, and 69% (238/345) of the fish were recaptured within 30 days of release (Table 3-17), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 86% (297/345) of the striped bass were recaptured, and the maximum days at-large was 147 days. Days at-large and recapture length data for the 1992-93 program were similar to previous years (NAI 1987, 1988, 1990, 1991, 1992, 1994).

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1992-93 Winter Program

A total of 149 striped bass were recaptured during 1992-93 with internal anchor tags identified from previous programs (Appendix Table D-3). Most (134 or 90%) of these 149 recaptured striped bass had the external portion of the tag (streamer) present. Among the 134 striped bass with streamers intact, all but one fish had tags with completely legible numbers (Table 3-18). One fish was recaptured with an abraded but legible Floy internal anchor tag (MARK_CD=96) and was released on 24 February 1987 (Table 3-18, Appendix Table D-5). An additional 82 fish were observed with suspected tag wounds but no tag streamer present (Table 3-18). Fifteen of these fish with suspected tag wounds had Hallprint (MARK_CD=98) anchors in the abdominal cavity containing the tag number. The remaining 67 fish either had the tag and anchor removed by sportsmen, had wounds unrelated to tagging, or had shed the tag.

Tag numbers were defined as completely illegible if one or more of the 5-digit tag number could not be read in the field. Tag abrasion was first observed during 1986-87, is time dependent, and the tagged fish must be at-large for at least six months for abrasion to affect the legibility of the legend on the external streamer (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged at-largeat least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990). Changes in tag design since 1986-87 have virtually eliminated tag abrasion. Prior to the 1986-87

TABLE 3-17. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE HUDSON RIVER BY A 9 m TRAWL, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

NUMBER TAGGED (≥150 mm)	M	20,847
NUMBER EXAMINED FOR TAGS (≥150 mm)	C	22,996
NUMBER RECAPTURED	R	345
SIZE RANGE OF RECAPTURED FISH (mm)	Min	153
	Max	583
	Mean	252
	S.D.	58
DAYS AT-LARGE	Min	0
	Max	147
	Mean	26
	S.D.	35
FREQUENCY OF DAYS AT-LARGE	0 Days	87
	1- 5 Days	58
	6- 10 Days	31
	11- 20 Days	32
	21- 30 Days	30
	31- 40 Days	15
	41- 50 Days	21
	51- 60 Days	23
	61- 70 Days	8
	71- 80 Days	8
	81- 90 Days	6
	91-100 Days	5
	101-110 Days	5
	111-120 Days	3
	121-130 Days	9
	131-140 Days	3
	141-150 Days	1

TABLE 3-18. INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR HUDSON RIVER STRIPED BASS THAT WERE AT LARGE AT LEAST ONE YEAR PRIOR TO THEIR RECAPTURE DURING THE 1988-89 THROUGH 1992-93 PROGRAMS.

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH RECAPTURED DURING PROGRAM* 1988-89	1989-90	1990-91	1991-92	1992-93
Tag number completely legible	Healed	34	63	206	102	118
	Infected	13	6	22	15	14
		47	69	228	117	132
	(Anchor Protruding)	(5)	(0)	(6)	(1)	(0)
Tag number abraded but legible	Healed	3	2	2	0	1
	Infected	3	1	0	1	0
		6	3	2	1	1
	(Anchor Protruding)	(1)	(0)	(0)	(0)	(0)
Tag number partly or completely missing and not legible	Healed	0	0	1	2	0
	Infected	0	0	0	0	0
		0	0	1	2	0
	(Anchor Protruding)	(0)	(0)	(0)	(0)	(0)
Suspected tag wound, tag and anchor missing	Healed	4	6	69	43	57
	Infected	0	0	3	4	7
		4	6	72	47	64
Suspected tag wound, anchor present	Healed	2	0	9	10	12
	Infected	0	0	0	0	3
		2	0	9	10	15

*Striped bass that were tagged and released prior to the program which could be cross-classified by degree of tag number abrasion and condition of the tag insertion site.

program, Floy internal anchor-external streamer tags were used: abrasion was observed in 28% of the recaptured fish at-large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but short length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990). Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was displaced out of the fish and shed.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a long-term shedding rate for the original Hallprint tag with an exposed filament of 22/94 or 23%. Among the 67 fish with suspected tag wounds (and no anchor found) caught during the 1992-93 program, 45 fish had a longitudinal scar suggesting they may have shed a tag and 22 fish had wounds that were judged to be not related to tagging. None of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has virtually eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has reduced tag loss due to shedding.

Among the 149 striped bass recaptured from previous programs during 1992-93 were 115 fish that had been tagged and released during 1991-92, 24 fish that had been tagged and released during 1990-91, 3 recaptured fish were tagged and released during 1989-90, 5 recaptured fish were from 1988-89, one recaptured fish was from 1987-88, and the remaining one fish was tagged and released during 1986-87 (Table 3-19, Appendix Table D-3). All recaptured fish from the 1988-89 through 1991-92 programs were caught, tagged and released from the 9 m trawl, which was the only gear used. The one striped bass recaptured from 1987-88 was released from the 12 m trawl, even though a 9 m trawl was also deployed (NAI 1988). The one striped bass recaptured from 1986-87 was also released from a 12 m trawl even though a 9 m trawl was also used (NAI 1987). Recaptured fish were at-large between 206 and 2,194 days, and ranged in length between 206 mm and 587 mm (Table 3-20). No striped bass were recaptured with both an internal anchor tag and a dart tag during 1992-93, and no striped bass were observed to have shed a dart tag.

Eight striped bass were recaptured in 1992-93 with tags originating from other tagging programs (Table 3-21). Three fish were recaptured with U.S. Fish and Wildlife Service internal anchor tags and five fish were recaptured with Littoral Society spaghetti tags. All eight striped bass with other agency tags were returned to the river without removing the tag.

3.4.2.3 Effects of the Internal Anchor Tag on Striped Bass Growth

Growth based on focus to annulus (radius) measurements for scale samples from tagged striped bass that had been at-large one or two years was compared within cohort to growth from a corresponding set of scales taken from untagged fish of the same cohort at the

TABLE 3-19. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED(R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH (mm)			
					MIN	MAX	MEAN	S.D.
1991-92	9 m trawl	23,514	115	0.00489	206	512	321	51
1990-91	9 m trawl	22,406	24	0.00107	314	485	388	46
1989-90	9 m trawl	24,362	3	0.00012	432	556	483	65
1988-89	9 m trawl	24,393	5	0.00020	383	587	459	93
1987-88	12 m trawl[a]	4,854	1	0.00021	560	560	560	
1986-87	12 m trawl[b]	2,059	1	0.00049	570	570	570	

[a]12 m trawl with 9 m trawl cod end.

[b]12 m trawl with 2.5 cm stretch liner.

TABLE 3-20. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO NOVEMBER 1992, AND RECAPTURED IN THE HUDSON RIVER BY A 9 m TRAWL, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

TOTAL NUMBER TAGGED	M	112,347
NUMBER AGE 2+ OR OLDER EXAMINED FOR TAGS	C	6,053
NUMBER RECAPTURED	R	149
RECAPTURE RATE R/M	0.00133	
RECAPTURE PROPORTION	R/C	0.02462
LENGTH OF RECAPTURED FISH (mm)	Min	206
	Max	587
	Mean	343
	S.D.	70
DAYS AT-LARGE	Min	206
	Max	2,194
	Mean	458
	S.D.	311
FREQUENCY OF DAYS AT LARGE	201-250 Days	12
	251-300 Days	25
	301-350 Days	47
	351-400 Days	22
	401-450 Days	7
	451-500 Days	2
	501-550 Days	0
	551-600 Days	1
	601-650 Days	4
	651-700 Days	4
	701-750 Days	7
	751-800 Days	8
	801-850 Days	0
	851-900 Days	0
	901-950 Days	0
	951-1000 Days	0
	1001-1050 Days	3
	1051-1100 Days	0
	1101-1150 Days	0
	1151-1200 Days	0
	1201-1250 Days	0
	1251-1300 Days	0
	1301-1350 Days	1
	1351-1400 Days	0
	1401-1450 Days	3
	1451-1500 Days	1
	>1500 Days	2

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, 1989-90, 1990-91, and 1991-92 programs.

TABLE 3-21. STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHER AGENCY TAGS, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

		TAG CONDITION						RECAPTURE		
AGENCY	TAG NUMBER	SITE	TAG NO.	ADDRESSS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
LITTORAL SOCIETY	294222	2	4	4	4			1 DEC 92	2	598
LITTORAL SOCIETY	-		1					17 DEC 92	1	504
LITTORAL SOCIETY	132699	2	4	4	4	2	N	30 DEC 92	1	790
U S F & W	168290	1	4	4	4	1	N	20 JAN 93	5	218
U S F & W	168398	1	4	4	4	2	N	26 JAN 93	2	209
U S F & W	107071		2	1	1	1	N	2 FEB 93	7	394
LITTORAL SOCIETY	304253	1	4	4	4			16 FEB 93	7	357
LITTORAL SOCIETY	298449	1	3	4				19 FEB 93	7	325

TAG VARIABLE	COMMENT DESCRIPTION
Number	1 = Legend completely missing
Address	2 = Abraded and partly missing
Reward	3 = Abraded but completely legible
	4 = Completely legible
Number orientation	A = Tag number facing anterior(Head)
	P = Tag number facin posterior(Tail)
Anchor protrusion	Y = Yes
	N = No

TAG SITE

1 = Tag present, wound healed
2 = Tag present, wound poorly healed, evidence of infection or swelling.

time the tagged fish were recaptured (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. We selected scale radius measurements rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

Mean radius measurements for each annulus were obtained from the 1985 through 1990 cohorts of striped bass recaptured during the 1988-89 through 1992-93 programs (Table 3-22). A complementary set of scale samples was selected for each cohort of fish caught in the recapture samples to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X +1 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus. We calculated relative growth as the response variable by taking the difference between annulus measurements for the time of release and recapture and dividing by the annulus measurement for the time of release. This relative growth measurement accounts for variation in the size of scales taken for the release and recapture samples.

Tagged striped bass from the 1985 through 1990 cohorts that were at-large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way ANOVA comparisons of mean relative growth (Table 3-22). Since both the tagged and untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. Therefore, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit differential growth during one or two years at-large.

3.4.3 Condition of the Catch

Some of the striped bass caught in the 9 m trawl displayed one or more types of injury or abnormality, such as blindness, fin rot, fungal infection, skeletal deformity, or visible wounds. The incidence of such conditions among all fish that had not been previously caught

TABLE 3-22. ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT-LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE, 1988-89 THROUGH 1991-92 PROGRAMS.

						SCALE SAMPLE MEASUREMENT		
RECAPTURE PROGRAM	COHORT	RECAPTURE AGE	YEARS AT-LARGE	TAG STATUS	N	MEAN RADIUS	S.E.	Pr>f[a]
1988-89	1985	3+	1	Tagged	14	151.7	5.5	0.9015
			0	Untagged	48	147.6	3.0	
1988-89	1986	2+	1	Tagged	24	124.2	3.9	0.2580
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	51	101.3	2.5	0.6096
			0	Untagged	1,138	101.2	0.5	
1990-91	1987	3+	1	Tagged	21	152.3	5.0	0.1987
			2	Tagged	14	152.9	6.3	0.1023
			0	Untagged	53	143.4	3.2	
1990-91	1988	2+	1	Tagged	161	103.6	1.3	0.1435
			0	Untagged	1,844	97.0	0.4	
1991-92	1988	3+	1	Tagged	34	148.3	2.1	0.7432
			2	Tagged	18	144.1	5.4	0.3900
			0	Untagged	110	143.6	2.2	
1991-92	1989	2+	1	Tagged	45	114.4	2.7	0.2203
			0	Untagged	829	103.8	0.6	
1992-93	1989	3+	2	Tagged	18	145.7	6.1	0.0986
			1	Tagged	8	165.0	10.6	0.3650
			0	Untagged	90	156.5	2.6	
1992-93	1990	2+	1	Tagged	72	117.5	2.2	0.1817
			0	Untagged	1,263	114.5	0.5	

[a]Probability of finding that the mean relative growth is different by chance alone, under a least squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

(i.e., those without tags or tag wounds) was 4.38% (Table 3-23). Approximately three quarters of all unmarked fish were subsequently tagged and released (22,117 of 28,835, or 77%). Most of the remaining 23% were less than 150 mm and too small to tag, or were judged to be poor condition and not tagged. These groups of fish were either released without tags or were dead and taken to the laboratory for processing. The proportion of injured or anomalous striped bass among those tagged and released was 4.37%. The incidence of injuries or anomalies among recaptured fish (with tags or suspected tag wounds) was 18.47% (106 of 574).

The most frequently observed condition was finrot, which was noted in 1.5% of unmarked striped bass (Table 3-23). Stress from the sampling gear was observed in 1.4% of the unmarked fish, blindness (opaqueness in one or both eyes) was observed in 1.0%, and 0.3% of the unmarked fish displayed more than one type of injury or abnormality.

Each of the six general categories of poor condition were further classified (Table 3-24). Blindness in both eyes was roughly three and a half times more frequent than blindness in one eye. Fin rot most commonly occurred on the caudal fin, and occasionally on pectoral fins or on more than one fin on the same fish. Fungal infections were restricted to one side of the body 41% of the time. Skeletal anomalies usually involved fish hook damage to the mouth or gills, which was much more common than scoliosis (lateral spine curvature), head deformities (e.g., "pugnose"), or lordosis (dorso-ventral spine curvature). Many of the visible wounds on the body were healed over. Other commonly noted wounds were damaged gills and missing or damaged fins. Infrequently observed conditions included hemorrhaged (bloodshot) eyes, bulging eyes ("pop-eye"), wounds to the eye, and tumors.

Fin rot and fungus accounted for a much larger proportion of the injuries/anomalies in recaptured striped bass (79%) than in unmarked fish (35%) (Table 3-24). Stress from the sampling gear, however, was much less common among recaptured fish (7%) than among unmarked fish (30%), because very few "stressed" fish were tagged. The incidence of other types of conditions (blindness, skeletal deformities, wounds) was roughly twice as high in recaptured fish as it was in unmarked fish or tagged fish (Table 3-24).

TABLE 3-23. INCIDENCE OF FISH IN POOR CONDITION AMONG UNMARKED VS. RECAPTURED STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

TYPE(S) OF INJURY OR ABNORMALITY[a]	INCIDENCE AMONG 28,835 UNMARKED FISH		INCIDENCE AMONG 22,117 FISH TAGGED[b]		INCIDENCE AMONG RECAPTURED 574 FISH[c]	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Blind only	225	0.78	224	1.01	11	1.92
Stress only	386	1.34	121	0.55	5	0.87
Fin rot only	367	1.27	364	1.65	29	5.05
Fungus only	32	0.11	32	0.14	25	4.36
Skeleton only	72	0.25	67	0.30	1	0.17
Other only	98	0.34	90	0.41	2	0.35
Blind/stress	10	0.03	5	0.02		
Blind/fin rot	27	0.09	27	0.12		
Blind/fungus	2	0.01	2	0.01	1	0.17
Blind/other	7	0.02	6	0.03		
Stress/fin rot	6	0.02	4	0.02	2	0.35
Stress/fungus	5	0.02	1	<0.01	2	0.35
Stress/skeleton	1	<0.01	1	<0.01		
Fin rot/fungus	13	0.05	13	0.06	22	3.83
Fin rot/skeleton					2	0.35
Fin rot/other	3	0.01	3	0.01	1	0.17
Fungus/skeleton	2	0.01	2	<0.01		
Skeleton/other	1	<0.01	1	<0.01		
Blind/stress/fin rot	1	<0.01			1	0.17
Blind/fin rot/fungus					2	0.35
Blind/fin rot/other	1	<0.01	1	<0.01		
Blind/fungus/other	1	<0.01				
Stress/fin rot/fungus	1	<0.01	1	<0.01		
Stress/fin rot/other	1	≤0.01	1	≤0.01	—	—
Total	1262	4.38	966	4.37	106	18.47

[a]Categories are described in more detail in Table 3-24.
[b]Excludes 6718 not tagged.
[c]Including fish with suspected tag wounds, but excluding fish suspected of being recaptured hatchery releases.

TABLE 3-24. NATURE OF INJURIES AND ABNORMALITIES OBSERVED IN STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

GENERAL CATEGORY	SPECIFIC CONDITION	INCIDENCE AMONG 28,835 UNMARKED FISH CAPTURED	INCIDENCE AMONG 22,117 FISH TAGGED	INCIDENCE AMONG 574 RECAPTURED FISH
Blindness	Blind in one eye	58	56	4
	Blind in both eyes	216	209	11
Stress	Net rash	85	76	6
	Crushed	18	1	1
	Handling stress	308	57	3
Fin rot	On caudal fin	290	288	42
	On pectoral fin(s)	41	40	1
	On pelvic fin(s)	4	4	0
	On anal fin	2	1	0
	On dorsal fin(s)	5	5	1
	On multiple fins	78	76	15
Fungus	On one side of body	23	22	15
	On both sides of body	33	29	37
Skeleton	Side to side spine curvature	8	8	1
	Top to bottom spine curvature	6	6	0
	Head abnormalities	8	6	0
	Fish hook damage to mouth or gills	54	51	1
Other	Body wounds, damaged fins, etc.	112	102	3
Total[a]		1349	1037	141

[a]Totals exceed those in Table 3-23 because some fish exhibited more than one condition.

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1992-93 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently. This estimator was used during the 1985-86 through 1991-92 programs to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) mortality is not different for tagged and untagged bass,
2) tagging does not affect bass catchability,
3) tagged bass do not lose their marks,
4) all tags are recognized and reported,
5) natural marking does not occur or is recognizable,
6) immigration, emigration, and recruitment are negligible in the study area i.e., the population is closed,
7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is pro-portional to the abundance of fish in various river regions, and
8) marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hours and (2) in holding pools for up to 180 days. However, during the 1990-91 program, predation by birds (gulls) was observed to remove about 2.4% of the tagged fish as they were released from the tagging vessel (NAI 1992). Most of the bird predation was observed to occur as the released fish drifted away from the tagging vessel before sounding. In the 1991-92 and 1992-93 programs, all striped bass were released into a recovery pen that was suspended in the water alongside the tagging vessel. The pen provided cover until the fish sounded, and virtually eliminated bird predation. Therefore, the number of tagged striped bass at-large was not adjusted for mortality during the 1992-93 program.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1993) which would provide evidence of tag loss. QA/QC procedures (NAI 1993) and audits provide documentation that incorrect identification or non-reporting of tags by field crews did not occur. Dunning et al. (1987) found 97.7% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 345 fish out of 20,847 tagged fish approximately 8 fish would be expected to have lost tags in the 1992-93 program. However, the tag loss rate from Dunning et al. (1987) was based on Floy style tags which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1992-93 program, 22,996 striped bass were examined for tags and tag wounds, and 82 fish were observed with tag wounds (Table 3-19). Fifteen of these fish had anchors present without streamers indicating the streamer was cut and removed by fishermen. Only 45 of these fish exhibited a longitudinal scar, suggesting the scar originated from shed Hallprint tags. Since these longitudinal scars have been shown to originate from shed Hallprint tags with exposed filaments at the base of the external streamer (Section 3.4.2.2), these fish probably originated from previous programs. The exposed filament tag was not used during the 1992-93 program. The remaining fish exhibited atypical wounds at the insertion site suggesting they may have a natural origin and may not be from a shed tag. Therefore, loss of internal anchor tags for fish tagged and released during 1992-93 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and we adjusted for it, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1993, Geoghegan et al. 1990). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tags used in this study.

Immigration and emigration (Assumption 6) was apparently negligible during most of the study period (November 1992 through April 1993) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4, NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994). A linear regression of weekly recapture proportions (R/C) on cumulative number of marked fish (Figure 3-7) was significant and positive for the weeks of 23 November 1992 through the week of 15 March 1993 (Appendix Tables D-6 and D-7). Recapture rates (R/M) varied less during the weeks of 23 November 1992 through 15 March 1993 than any other 17 week period during the program. This 17 week period for the population estimator was nearly identical to the recapture period used in 1990-91 and 1991-92 (NAI 1992, 1994) and was similar to the period used in 1985-86 through 1988-89 for the population estimator (NAI 1986, 1987, 1988, 1990). During 1991-92, the period used for the Schumacher-Eschmeyer population estimate was 2 December 1991 through 15 March 1992. In 1985-86, 30 December 1985 through 21 February 1986 was used, in 1986-87 21 December 1986 through 13 March 1987 was used in 1987-88 21 December 1987 through 9 April 1989 was used, in 1988-89 12 December 1988 through 2 April 1989 was used, and in 1990-91 3 December 1990 through 15 March 1991 was used to estimate the size of the midwinter striped bass population in the combined Battery and Upper Harbor regions of the Hudson River. During 1989-90, the period used for the striped bass population estimate was 22 January through 9 April 1990, which was one month later than in the other years. The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass during the 1992-93 program (Assumption 7). Further-more, stepwise polynomial regressions did not significantly improve goodness of fit, which indicated a linear model was appropriate.

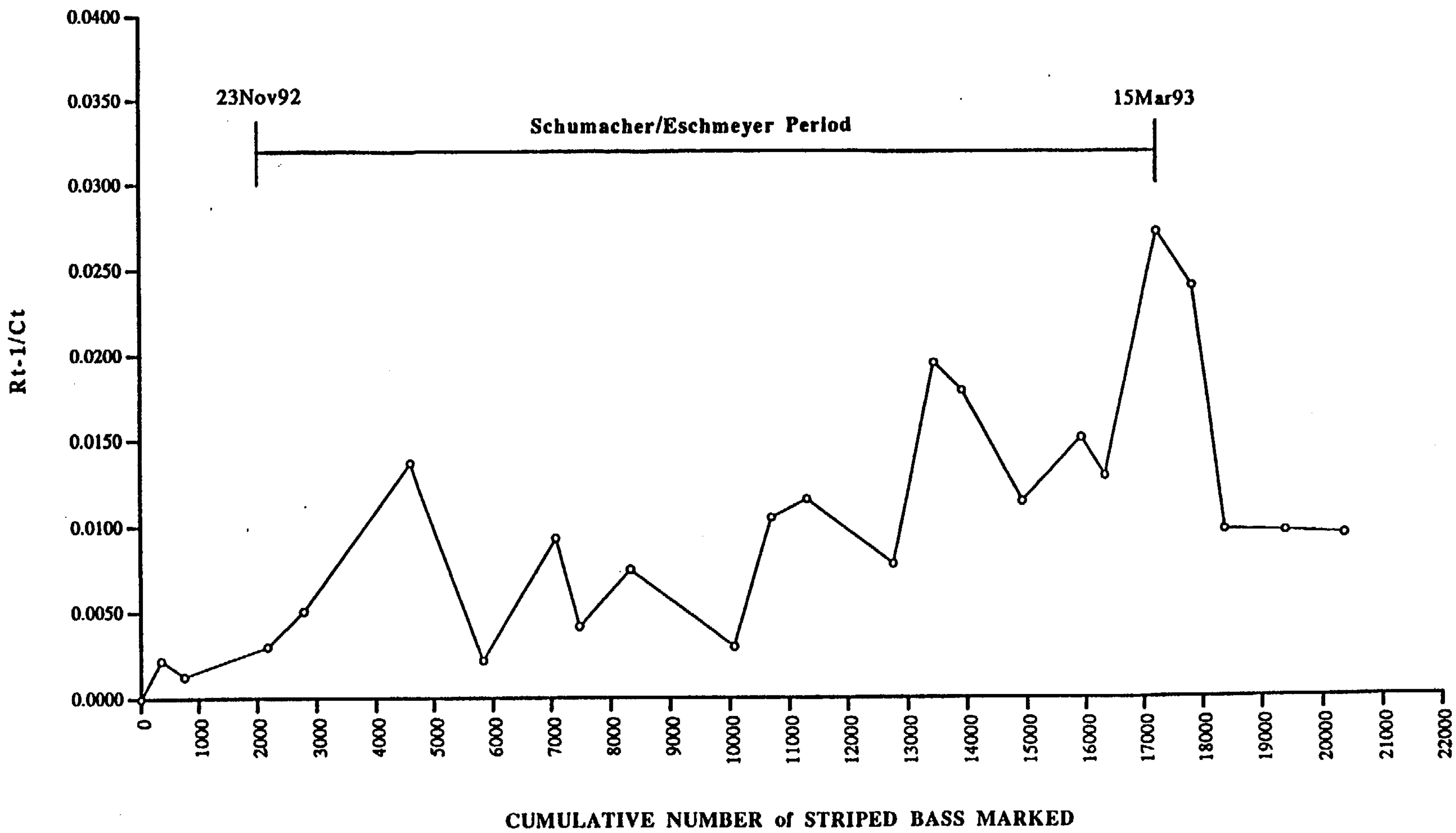


Figure 3-7. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged in the combined Upper Harbor and Battery regions of the Hudson River, 2 November 1992 through 16 April 1993.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied for the 23 November 1992 through 15 March 1993 period in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1992-93 was 920,000 fish ≥150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 677,000 to 1,435,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25). Based on the estimated hatchery proportion of 0.3% for Age 2+ and Age 3+ fish, (Section 3.3), about 1,000 Age 2+ and less than 1,000 Age 3+ hatchery fish were present among the striped bass overwintering in the Battery and upper New York harbor regions during winter 1992-93.

For comparison with previous programs, the total population of Age 1+ and older striped bass ≥200 mm was estimated as 717,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This estimate was the fourth highest calculated annually since 1985-86 (Table 3-27). The 1991 cohort of Age 1+ fish was the primary contributor to this estimate of Hudson River striped bass in the mid-winter population during 1992-93.

TABLE 3-25. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1992-93.

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥150 mm	PROPORTION ≥150 mm	ESTIMATED POPULATION[a]
1+	15,983	15,789	0.7290	671,000
2+	4,229	4,229	0.1953	180,000
3+	914	914	0.0422	39,000
>3+	558	558	0.0258	24,000
TOTAL	21,684	21,490	0.9923	913,000[b]

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 23 November 1992 through the week of 15 March 1993. Age 0+ striped bass were 0.8% (7,000) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 920,000 fish.

[b]Rounding of individual values presents the appearance that this column does not sum to the total.

TABLE 3-26. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1992-93.

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	15,983	11,179	0.5162	475,000
2+	4,229	4,229	0.1953	180,000
3+	914	914	0.0422	39,000
>3+	558	558	0.0258	24,000
TOTAL	21,684	16,880	0.7794	717,000[b]

[a]The total population estimate based on fish ≥150 mm (920,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (16,880/21,658 = 0.7794).

[b]Rounding of individual values presents the appearance that this column does not sum to the total

TABLE 3-27. ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86 THROUGH 1992-93.

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1992-93	717,000	920,000
1991-92	967,000	1,163,000
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged and we did not extrapolate the population estimate to fish ≥150 mm for the 1987-88, 1986-87 and 1985-86 programs.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9-m TRAWL.

	9-m TRAWL
Head rope length	6.9 m
Foot rope length (sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6-cm (stretch) mesh polypropylene; poly-propylene; 3-mm diameter twine
- cod end	3.8-cm (stretch) mesh, knotless polypropy-lene; 3-mm diameter twine
Roller gear	25.4-cm rollers spaced with 5-cm coookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY
UPPER HARBOR	23NOV92	10.00	28984	10.50	38788
	30NOV92	9.33	15264	10.67	41587
	07DEC92	7.00	32268	8.00	37842
	14DEC92	5.56	23763	6.14	34971
	04JAN93	5.71	26248	6.61	35305
	11JAN93	4.00	27607	5.00	41023
	18JAN93	4.67	31450	5.00	37604
	25JAN93	4.43	26095	5.29	36954
	01FEB93	3.00	33802	4.00	40598
	08FEB93	3.17	32955	3.83	38447
BATTERY	02NOV92	11.78	16612	12.40	38329
	09NOV92	11.12	28346	11.43	34492
	16NOV92	9.86	21427	10.55	33077
	23NOV92	10.52	29131	10.62	37655
	30NOV92	8.35	9561	10.48	37726
	07DEC92	7.21	29152	8.44	37787
	14DEC92	5.37	22643	6.00	33060
	21DEC92	5.50	20869	6.46	33580
	28DEC92	4.50	15070	5.97	36250
	04JAN93	5.64	21890	6.50	35418
	11JAN93	3.57	16934	4.98	32338
	18JAN93	4.02	27223	4.91	34692
	25JAN93	3.57	15162	4.85	32820
	01FEB93	2.62	19833	3.76	32779
	08FEB93	2.64	27507	3.05	32980
	15FEB93	2.02	21807	3.00	32492
	22FEB93	1.81	24508	2.64	33063
	01MAR93	1.35	20904	2.23	35147
	08MAR93	2.99	25033	3.01	29015
	15MAR93	2.38	22061	3.00	31720
	22MAR93	3.21	20884	3.20	31192
	29MAR93	4.12	2746	4.05	13352
	05APR93	5.03	5547	5.82	19410
	12APR93	6.99	2802	8.50	11635

Water temperature in °C.
Conductivity in µ/cm at 25 °C.

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER, 2 NOVEMBER THROUGH 16 APRIL 1993.

REGION	WEEK	CPUE			
		TOWS	N	MEAN	S.E.
UPPER HARBOR	23NOV92	6	192	32.0	8.6
	30NOV92	1	178	178.0	
	14DEC92	15	967	64.5	10.2
	04JAN93	12	1474	122.8	61.5
	18JAN93	3	167	55.7	24.5
	25JAN93	6	160	26.7	6.6
	01FEB93	1	0	0.0	
	08FEB93	3	26	8.7	7.2
	TOTAL	47	3164	67.3	16.8
BATTERY	02NOV92	44	367	8.3	1.1
	09NOV92	50	468	9.4	1.2
	16NOV92	39	1565	40.1	6.4
	23NOV92	20	406	20.3	5.0
	30NOV92	26	1759	67.7	6.7
	07DEC92	31	1481	47.8	7.3
	14DEC92	16	245	15.3	2.0
	21DEC92	23	539	23.4	2.2
	28DEC92	31	1170	37.7	3.8
	04JAN93	13	456	35.1	4.1
	11JAN93	26	1256	48.3	8.7
	18JAN93	18	867	48.2	7.7
	25JAN93	25	1397	55.9	7.2
	01FEB93	34	910	26.8	3.8
	08FEB93	33	733	22.2	2.9
	15FEB93	39	1459	37.4	4.7
	22FEB93	29	1433	49.4	8.6
	01MAR93	39	568	14.6	2.4
	08MAR93	45	1319	29.3	3.3
	15MAR93	42	872	20.8	3.3
	22MAR93	56	1153	20.6	3.1
	29MAR93	35	1728	49.4	4.1
	05APR93	29	1686	58.1	6.3
	12APR93	28	777	27.8	4.9
	TOTAL	771	24614	31.9	1.1

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE LOWER HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

REGION	RIVER MILE	CPUE			
		TOWS	N	MEAN	S.E.
UPPER HARBOR	2	16	939	58.7	11.1
	3	24	1900	79.2	31.6
	4	6	312	52.0	25.7
	5	1	13	13.0	
	TOTAL	47	3164	67.3	16.8
BATTERY	1	160	5601	35.0	2.5
	3	1	22	22.0	
	5	154	3847	25.0	2.1
	6	8	188	23.5	7.0
	7	80	2357	29.5	2.6
	8	114	3972	34.8	3.0
	9	170	5871	34.5	2.7
	10	79	2691	34.1	3.6
	11	5	65	13.0	8.8
	TOTAL	771	24614	31.9	1.1

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS CAPTURED AND STRIPED BASS TAGGED IN THE HUDSON RIVER CROSS-CLASSIFIED BY REGION, GEAR AND USE CODE FOR THE 9 m TRAWL, 2 NOVEMBER 1992 THROUGH 16 April 1993.

REGION	GEAR	USE CODE	SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
Battery	9 m trawl	1	771	24,614	16,769
		2	53	1,133	753
		5	5	0	0
Total			829	25,747	17,522
Upper Harbor	9 m trawl	1	47	3,164	2,898
		2	12	496	427
		5	0	0	0
Total			59	3,660	3,325

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN A 9 M TRAWL IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

			N TOWS		NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (mm TL)											NUMBER OF FISH				MORTALITY	
DATE	WATER TEMP.	COND.	TOTAL	VOID	<150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	801+	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	N	%
NOV 2 92	12.4	38329	46	0	20	79	175	87	16	2	0	0	0	379	8	355	5	0	19	0	0.0
NOV 9 92	11.4	34492	52	0	28	54	116	180	78	19	2	1	0	478	9	430	13	2	30	3	0.6
NOV 16 92	10.6	33077	40	0	43	107	803	525	98	18	2	0	0	1596	40	1486	53	1	52	4	0.3
NOV 23 92	10.6	37968	29	0	11	64	224	190	135	40	9	1	1	675	23	637	17	0	17	4	0.6
NOV 30 92	10.5	38126	29	0	65	328	985	417	175	47	11	1	0	2029	70	1882	30	7	92	18	0.9
DEC 7 92	8.4	37789	32	0	170	221	766	243	78	5	1	0	0	1484	46	1257	39	9	171	8	0.5
DEC 14 92	6.1	34071	34	0	88	30	371	637	279	40	2	0	0	1447	43	1321	22	3	99	2	0.1
DEC 21 92	6.5	33580	23	0	111	89	229	95	11	3	1	0	0	539	23	403	10	5	115	6	1.1
DEC 28 92	6.0	36250	31	0	214	235	488	203	26	3	0	1	0	1170	38	893	26	14	220	17	1.5
JAN 4 93	6.6	35362	28	1	93	232	1186	384	49	9	2	0	0	1955	70	1800	35	0	116	4	0.2
JAN 11 93	5.0	32649	28	0	683	216	372	63	13	2	2	0	0	1351	48	647	8	0	684	12	0.9
JAN 18 93	4.9	35028	26	0	512	278	310	54	22	1	0	0	0	1177	45	619	10	14	498	36	3.1
JAN 25 93	4.9	33526	41	0	237	250	923	420	41	2	0	0	0	1873	46	1548	40	2	253	30	1.6
FEB 1 93	3.8	33003	35	1	144	116	396	223	26	3	2	0	0	910	26	707	17	4	172	10	1.1
FEB 8 93	3.1	33390	40	1	256	179	261	58	10	1	1	2	0	768	19	487	12	3	258	8	1.0
FEB 15 93	3.0	32492	40	0	358	277	608	202	27	5	0	0	0	1477	37	1067	33	7	363	7	0.5
FEB 22 93	2.6	33063	32	0	335	431	581	94	23	4	1	0	0	1469	46	1053	27	2	350	37	2.5
MAR 1 93	2.2	35147	43	0	142	144	228	66	22	3	0	0	0	605	14	437	10	0	150	8	1.3
MAR 8 93	3.0	29015	48	0	456	447	405	53	18	1	0	0	0	1380	29	892	16	8	451	13	0.9
MAR 15 93	3.0	31720	43	0	213	270	337	42	6	4	0	0	0	872	20	616	23	1	217	15	1.7
MAR 22 93	3.2	31192	57	2	538	331	254	32	1	1	0	1	0	1158	20	593	20	2	533	10	0.9
MAR 29 93	4.1	13352	38	0	616	259	680	272	10	5	0	0	0	1842	48	1083	16	11	632	100	5.4
APR 5 93	5.8	19410	34	0	864	395	636	101	3	0	0	0	0	1999	59	1029	13	63	824	70	3.5
APR 12 93	8.5	11635	34	0	447	140	294	81	12	0	0	0	0	974	29	504	6	37	413	14	1.4
TOTAL	6.1	31819	883	5	6644	5172	11628	4722	1179	218	36	7	1	29607	34	21746	501	195	6729	436	1.5

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (mm) OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

	9 m TRAWL			
	NO. OF FISH	MEAN LENGTH	S.D	S.E.
WEEK				
02NOV92	367	253	77.31	4.04
09NOV92	468	318	108.62	5.02
16NOV92	1565	293	75.36	1.91
23NOV92	406	276	84.63	4.20
30NOV92	1759	257	72.29	1.72
07DEC92	1481	250	82.35	2.14
14DEC92	245	230	108.95	6.96
21DEC92	539	232	88.03	3.79
28DEC92	1170	232	84.54	2.47
04JAN93	456	240	91.20	4.27
11JAN93	1256	176	80.29	2.27
18JAN93	867	171	78.96	2.68
25JAN93	1397	253	79.72	2.13
01FEB93	910	248	88.10	2.92
08FEB93	733	192	85.28	3.15
15FEB93	1459	218	84.88	2.22
22FEB93	1433	204	74.01	1.95
01MAR93	568	219	87.96	3.69
08MAR93	1319	181	69.19	1.91
15MAR93	872	195	70.02	2.37
22MAR93	1153	161	66.27	1.95
29MAR93	1728	213	82.98	2.00
05APR93	1686	178	68.93	1.68
12APR93	777	181	81.27	2.92
ALL WEEKS	24614	220	88.59	0.56

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW IN A 9 m TRAWL FOR 50 MM LENGTH GROUPS IN THE BATTERY REGION OF THE HUDSON RIVER, 02 NOVEMBER 1992 THROUGH 16 APRIL 1993.

SAMPLING WEEK	NUMBER OF TOWS	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800
02NOV92	44	0.1	0.4	1.8	2.4	1.4	1.3	0.6	0.3	< 0.1	< 0.1	< 0.1				
09NOV92	50	0.2	0.4	1.0	1.1	1.1	1.9	1.7	1.0	0.5	0.3	< 0.1	< 0.1			< 0.1
16NOV92	39	0.3	0.8	2.7	6.5	13.7	8.2	5.1	1.9	0.5	0.2	0.2	0.1			
23NOV92	20	0.1	0.5	3.0	5.2	5.4	2.9	1.9	0.8	0.4	0.2	0.2		0.1		
30NOV92	26	0.2	2.3	12.6	19.0	17.8	9.3	3.5	2.0	0.6	0.2	0.1	< 0.1			
07DEC92	31	0.9	4.6	7.1	12.1	12.6	5.2	2.5	1.8	0.7	0.1	0.1	< 0.1			
14DEC92	16	1.9	3.3	1.3	1.9	2.3	2.1	1.4	0.8	0.3	0.1					
21DEC92	23	1.0	3.9	3.9	5.3	4.7	2.7	1.5	0.3	0.1	0.1	< 0.1	< 0.1			
28DEC92	31	1.3	5.6	7.6	7.3	8.5	4.8	1.7	0.5	0.4		0.1				< 0.1
04JAN93	13	1.2	4.5	7.2	7.5	6.0	4.5	2.5	1.2	0.2	0.2	0.1	0.1			
11JAN93	26	7.5	16.3	7.7	8.5	5.3	1.7	0.7	0.2	0.3	0.1		0.1			
18JAN93	18	7.6	16.2	9.8	7.4	3.7	1.8	0.7	0.6	0.3	0.1					
25JAN93	25	2.2	5.1	6.0	11.5	15.6	10.6	3.6	0.7	0.4	0.1					
01FEB93	34	1.1	3.1	3.4	5.7	6.0	4.7	1.8	0.5	0.3	0.1	< 0.1		0.1		
08FEB93	33	2.9	4.8	5.1	4.6	2.8	1.3	0.3	0.2	< 0.1	< 0.1		< 0.1			0.1
15FEB93	39	3.2	5.9	7.1	8.2	7.1	3.6	1.4	0.5	0.1	0.1	< 0.1				
22FEB93	29	3.8	6.8	14.7	13.1	6.9	2.6	0.7	0.6	0.2	0.1	0.1	< 0.1			
01MAR93	39	1.1	2.1	3.5	3.2	2.4	1.1	0.5	0.5	0.1	0.1	< 0.1				
08MAR93	45	3.5	6.3	9.4	6.5	2.1	0.8	0.3	0.3	0.1	< 0.1					
15MAR93	42	1.9	3.2	6.4	5.8	2.3	0.8	0.2	0.1	< 0.1	0.1	< 0.1				
22MAR93	56	3.8	5.8	5.9	3.3	1.2	0.4	0.2		< 0.1	< 0.1				< 0.1	
29MAR93	35	2.9	12.4	6.9	10.0	9.0	6.1	1.7	0.3		0.1	< 0.1				
05APR93	29	5.1	20.7	11.4	11.1	6.8	2.4	0.6	0.1							
12APR93	28	2.2	12.2	3.8	3.3	3.6	1.8	0.5	0.1	0.2						
ALL WEEKS	771	2.2	5.7	6.0	6.7	5.7	3.2	1.4	0.6	0.2	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

APPENDIX TABLE C-7. **MEAN LENGTH AT AGE AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER DURING THE 1986-87 THROUGH 1992-93 STRIPED BASS PROGRAMS.**

AGE	COHORT	PROGRAM	n[a]	STRATIFIED MEAN LENGTH (mm)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1992	1992-93	473	116	114	118
	1991[b]	1991-92	818	131	127	135
	1990[b]	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1,007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1991[b]	1992-93	3,899	231	229	233
	1990[b]	1991-92	3,675	245	244	246
	1989	1990-91	2,174	239	237	241
	1988	1989-90	3,514	214	213	215
	1987	1988-89	3,623	227	226	229
	1986	1987-88	1,503	253	251	255
	1985	1986-87	285	221	215	227
2+	1990[b]	1992-93	1,378	329	325	333
	1989	1991-92	961	324	319	328
	1988	1990-91	2,109	321	317	324
	1987	1989-90	1,216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1989	1992-93	125	414	400	428
	1988	1991-92	153	386	378	394
	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

[a] number of fish aged

[b] Stratified mean length for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HATCHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	11/10/92	BATTERY	9	128	92
0	9 M TRAWL	12/01/92	BATTERY	5	147	92
0	9 M TRAWL	12/01/92	BATTERY	5	127	92
0	9 M TRAWL	12/01/92	BATTERY	5	141	92
0	9 M TRAWL	12/02/92	BATTERY	1	130	92
0	9 M TRAWL	12/02/92	BATTERY	1	126	92
0	9 M TRAWL	12/04/92	BATTERY	5	120	92
0	9 M TRAWL	12/04/92	BATTERY	5	153	92
0	9 M TRAWL	12/07/92	BATTERY	1	146	92
0	9 M TRAWL	12/09/92	BATTERY	5	125	92
0	9 M TRAWL	12/10/92	BATTERY	8	129	92
0	9 M TRAWL	12/10/92	BATTERY	9	123	92
0	9 M TRAWL	12/10/92	BATTERY	9	132	92
0	9 M TRAWL	12/10/92	BATTERY	9	140	92
0	9 M TRAWL	12/10/92	BATTERY	9	114	92
0	9 M TRAWL	12/10/92	BATTERY	9	115	92
0	9 M TRAWL	12/14/92	BATTERY	1	118	92
0	9 M TRAWL	12/14/92	BATTERY	5	145	92
0	9 M TRAWL	12/14/92	BATTERY	5	150	92
0	9 M TRAWL	12/21/92	BATTERY	5	132	92
0	9 M TRAWL	12/21/92	BATTERY	1	132	92
0	9 M TRAWL	12/21/92	BATTERY	1	126	92
0	9 M TRAWL	12/22/92	BATTERY	5	127	92
0	9 M TRAWL	12/22/92	BATTERY	5	128	92
0	9 M TRAWL	12/23/92	BATTERY	5	126	92
0	9 M TRAWL	12/23/92	BATTERY	5	121	92
0	9 M TRAWL	01/14/93	BATTERY	9	137	92
0	9 M TRAWL	01/14/93	BATTERY	9	127	92
0	9 M TRAWL	01/14/93	BATTERY	9	121	92
0	9 M TRAWL	01/14/93	BATTERY	9	124	92
0	9 M TRAWL	01/14/93	BATTERY	9	128	92
0	9 M TRAWL	01/14/93	BATTERY	9	103	92
0	9 M TRAWL	01/14/93	BATTERY	9	122	92
0	9 M TRAWL	01/15/93	BATTERY	9	125	92
0	9 M TRAWL	01/15/93	BATTERY	9	136	92
0	9 M TRAWL	01/15/93	BATTERY	9	130	92
0	9 M TRAWL	01/15/93	BATTERY	9	130	92
0	9 M TRAWL	01/15/93	BATTERY	9	131	92
0	9 M TRAWL	01/15/93	BATTERY	9	145	92
0	9 M TRAWL	01/15/93	BATTERY	9	133	92
0	9 M TRAWL	01/20/93	BATTERY	9	135	92
0	9 M TRAWL	01/20/93	BATTERY	9	110	92
0	9 M TRAWL	01/20/93	BATTERY	9	144	92
0	9 M TRAWL	01/20/93	BATTERY	9	127	92
0	9 M TRAWL	01/20/93	BATTERY	5	133	92
0	9 M TRAWL	01/20/93	BATTERY	5	136	92
0	9 M TRAWL	01/21/93	BATTERY	9	142	92
0	9 M TRAWL	01/21/93	BATTERY	9	126	92
0	9 M TRAWL	01/21/93	BATTERY	9	121	92
0	9 M TRAWL	01/21/93	BATTERY	9	113	92

(continued)

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	01/21/93	BATTERY	9	131	92
0	9 M TRAWL	01/21/93	BATTERY	9	128	92
0	9 M TRAWL	01/21/93	BATTERY	9	140	92
0	9 M TRAWL	01/21/93	BATTERY	9	122	92
0	9 M TRAWL	01/25/93	BATTERY	1	116	92
0	9 M TRAWL	01/29/93	BATTERY	7	135	92
0	9 M TRAWL	02/04/93	BATTERY	9	125	92
0	9 M TRAWL	02/04/93	BATTERY	8	127	92
0	9 M TRAWL	02/11/93	BATTERY	9	142	92
0	9 M TRAWL	02/11/93	BATTERY	9	140	92
0	9 M TRAWL	02/16/93	BATTERY	7	114	92
0	9 M TRAWL	02/16/93	BATTERY	7	138	92
0	9 M TRAWL	02/16/93	BATTERY	7	108	92
0	9 M TRAWL	02/17/93	BATTERY	8	111	92
0	9 M TRAWL	02/18/93	BATTERY	8	117	92
0	9 M TRAWL	02/19/93	BATTERY	5	137	92
0	9 M TRAWL	02/19/93	BATTERY	5	137	92
0	9 M TRAWL	02/23/93	BATTERY	11	118	92
0	9 M TRAWL	02/25/93	BATTERY	9	137	92
0	9 M TRAWL	03/10/93	BATTERY	10	147	92
0	9 M TRAWL	03/10/93	BATTERY	10	146	92
0	9 M TRAWL	03/10/93	BATTERY	10	127	92
0	9 M TRAWL	03/10/93	BATTERY	10	121	92
0	9 M TRAWL	03/11/93	BATTERY	10	120	92
0	9 M TRAWL	03/11/93	BATTERY	10	135	92
0	9 M TRAWL	03/12/93	BATTERY	10	119	92
0	9 M TRAWL	03/16/93	BATTERY	9	145	92
0	9 M TRAWL	03/19/93	BATTERY	9	92	92
0	9 M TRAWL	03/22/93	BATTERY	9	133	92
0	9 M TRAWL	03/26/93	BATTERY	10	140	92
0	9 M TRAWL	04/01/93	BATTERY	8	144	92
0	9 M TRAWL	04/01/93	BATTERY	8	121	92
0	9 M TRAWL	04/01/93	BATTERY	9	101	92
0	9 M TRAWL	04/01/93	BATTERY	9	117	92
0	9 M TRAWL	04/02/93	BATTERY	9	120	92
0	9 M TRAWL	04/02/93	BATTERY	9	134	92
0	9 M TRAWL	04/02/93	BATTERY	9	125	92
0	9 M TRAWL	04/02/93	BATTERY	9	129	92
0	9 M TRAWL	04/02/93	BATTERY	9	128	92
0	9 M TRAWL	04/02/93	BATTERY	9	136	92
0	9 M TRAWL	04/02/93	BATTERY	9	109	92
0	9 M TRAWL	04/05/93	BATTERY	10	120	92
0	9 M TRAWL	04/05/93	BATTERY	10	138	92
0	9 M TRAWL	04/05/93	BATTERY	7	151	92
0	9 M TRAWL	04/05/93	BATTERY	9	120	92
0	9 M TRAWL	04/05/93	BATTERY	9	126	92
0	9 M TRAWL	04/05/93	BATTERY	5	139	92
0	9 M TRAWL	04/06/93	BATTERY	9	124	92
0	9 M TRAWL	04/06/93	BATTERY	9	133	92
0	9 M TRAWL	04/06/93	BATTERY	9	124	92
0	9 M TRAWL	04/06/93	BATTERY	9	114	92
0	9 M TRAWL	04/07/93	BATTERY	9	129	92

(continued)

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	04/07/93	BATTERY	9	116	92
0	9 M TRAWL	04/07/93	BATTERY	9	137	92
0	9 M TRAWL	04/07/93	BATTERY	9	145	92
0	9 M TRAWL	04/07/93	BATTERY	9	123	92
0	9 M TRAWL	04/07/93	BATTERY	9	130	92
0	9 M TRAWL	04/07/93	BATTERY	9	130	92
0	9 M TRAWL	04/07/93	BATTERY	9	139	92
0	9 M TRAWL	04/07/93	BATTERY	9	92	92
0	9 M TRAWL	04/07/93	BATTERY	9	102	92
0	9 M TRAWL	04/07/93	BATTERY	9	107	92
0	9 M TRAWL	04/08/93	BATTERY	9	159	92
0	9 M TRAWL	04/08/93	BATTERY	9	140	92
0	9 M TRAWL	04/08/93	BATTERY	9	149	92
0	9 M TRAWL	04/08/93	BATTERY	9	125	92
0	9 M TRAWL	04/08/93	BATTERY	9	106	92
0	9 M TRAWL	04/08/93	BATTERY	9	102	92
0	9 M TRAWL	04/08/93	BATTERY	9	128	92
0	9 M TRAWL	04/08/93	BATTERY	9	116	92
0	9 M TRAWL	04/08/93	BATTERY	9	125	92
0	9 M TRAWL	04/08/93	BATTERY	9	122	92
0	9 M TRAWL	04/08/93	BATTERY	9	117	92
0	9 M TRAWL	04/08/93	BATTERY	9	107	92
0	9 M TRAWL	04/08/93	BATTERY	9	134	92
0	9 M TRAWL	04/08/93	BATTERY	9	131	92
0	9 M TRAWL	04/08/93	BATTERY	9	140	92
0	9 M TRAWL	04/08/93	BATTERY	9	135	92
0	9 M TRAWL	04/09/93	BATTERY	9	140	92
0	9 M TRAWL	04/09/93	BATTERY	9	123	92
0	9 M TRAWL	04/09/93	BATTERY	9	121	92
0	9 M TRAWL	04/09/93	BATTERY	9	145	92
0	9 M TRAWL	04/09/93	BATTERY	9	106	92
0	9 M TRAWL	04/09/93	BATTERY	9	118	92
0	9 M TRAWL	04/09/93	BATTERY	9	101	92
0	9 M TRAWL	04/09/93	BATTERY	9	130	92
0	9 M TRAWL	04/09/93	BATTERY	9	136	92
0	9 M TRAWL	04/09/93	BATTERY	9	116	92
0	9 M TRAWL	04/09/93	BATTERY	9	119	92
0	9 M TRAWL	04/09/93	BATTERY	9	127	92
0	9 M TRAWL	04/09/93	BATTERY	9	133	92
0	9 M TRAWL	04/09/93	BATTERY	9	136	92
0	9 M TRAWL	04/09/93	BATTERY	9	137	92
0	9 M TRAWL	04/09/93	BATTERY	9	151	92
0	9 M TRAWL	04/09/93	BATTERY	9	130	92
0	9 M TRAWL	04/09/93	BATTERY	9	136	92
0	9 M TRAWL	04/09/93	BATTERY	9	140	92
0	9 M TRAWL	04/09/93	BATTERY	9	118	92
0	9 M TRAWL	04/09/93	BATTERY	9	126	92
0	9 M TRAWL	04/09/93	BATTERY	9	116	92
0	9 M TRAWL	04/09/93	BATTERY	9	127	92
0	9 M TRAWL	04/09/93	BATTERY	9	125	92
0	9 M TRAWL	04/09/93	BATTERY	9	111	92
0	9 M TRAWL	04/12/93	BATTERY	9	142	92
0	9 M TRAWL	04/12/93	BATTERY	9	125	92
0	9 M TRAWL	04/12/93	BATTERY	9	125	92

(continued)

APPENDIX TABLE D-1. (CONTINUED)

AGE	GEAR	DATE	STATION	RIVER MILE	LENGTH	RELEASE YEAR
0	9 M TRAWL	04/12/93	BATTERY	9	128	92
0	9 M TRAWL	04/12/93	BATTERY	9	113	92
0	9 M TRAWL	04/12/93	BATTERY	9	127	92
0	9 M TRAWL	04/12/93	BATTERY	9	115	92
0	9 M TRAWL	04/12/93	BATTERY	9	118	92
0	9 M TRAWL	04/12/93	BATTERY	9	152	92
0	9 M TRAWL	04/12/93	BATTERY	9	134	92
0	9 M TRAWL	04/12/93	BATTERY	9	123	92
0	9 M TRAWL	04/12/93	BATTERY	9	145	92
0	9 M TRAWL	04/12/93	BATTERY	9	150	92
0	9 M TRAWL	04/12/93	BATTERY	9	134	92
0	9 M TRAWL	04/12/93	BATTERY	9	124	92
0	9 M TRAWL	04/12/93	BATTERY	9	118	92
0	9 M TRAWL	04/12/93	BATTERY	10	128	92
0	9 M TRAWL	04/12/93	BATTERY	9	136	92
0	9 M TRAWL	04/13/93	BATTERY	9	133	92
0	9 M TRAWL	04/13/93	BATTERY	9	128	92
0	9 M TRAWL	04/13/93	BATTERY	9	110	92
0	9 M TRAWL	04/13/93	BATTERY	9	97	92
0	9 M TRAWL	04/13/93	BATTERY	8	127	92
0	9 M TRAWL	04/13/93	BATTERY	8	130	92
0	9 M TRAWL	04/13/93	BATTERY	8	128	92
0	9 M TRAWL	04/13/93	BATTERY	8	121	92
0	9 M TRAWL	04/13/93	BATTERY	8	113	92
0	9 M TRAWL	04/13/93	BATTERY	9	109	92
0	9 M TRAWL	04/14/93	BATTERY	7	118	92
0	9 M TRAWL	04/14/93	BATTERY	7	114	92
0	9 M TRAWL	04/15/93	BATTERY	9	112	92
0	9 M TRAWL	04/15/93	BATTERY	9	136	92
0	9 M TRAWL	04/15/93	BATTERY	9	97	92
0	9 M TRAWL	04/16/93	BATTERY	9	149	92
0	9 M TRAWL	04/16/93	BATTERY	9	118	92
3	9 M TRAWL	02/02/93	BATTERY	8	377	89
3	9 M TRAWL	02/09/93	BATTERY	3	469	89

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED, RELEASED AND RECAPTURED IN THE HUDSON RIVER, 02 NOVEMBER 1992 THROUGH 16 APRIL 1993.

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
05NOV92	410	BT	4	6	05NOV92	411	BT	4	6	0	0	0	1	357320
05NOV92	275	BT	5	8	05NOV92	275	BT	5	8	0	0	0	1	375139
13NOV92	317	BT	10	16	03NOV92	319	BT	5	8	10	5	8	1	357295
16NOV92	316	BT	8	13	10NOV92	316	BT	5	8	6	3	5	1	357454
17NOV92	300	BT	1	2	17NOV92	301	BT	1	2	0	0	0	1	358476
17NOV92	358	BT	1	2	17NOV92	360	BT	1	2	0	0	0	1	358483
17NOV92	310	BT	1	2	17NOV92	315	BT	1	2	0	0	0	1	358500
18NOV92	403	BT	1	2	09NOV92	404	BT	10	16	9	9	14	1	357351
18NOV92	312	BT	1	2	18NOV92	313	BT	1	2	0	0	0	1	358639
18NOV92	278	BT	1	2	17NOV92	280	BT	1	2	1	0	0	1	375528
18NOV92	289	BT	1	2	17NOV92	290	BT	1	2	1	0	0	1	375547
18NOV92	252	BT	1	2	17NOV92	251	BT	1	2	1	0	0	1	375601
18NOV92	266	BT	1	2	18NOV92	263	BT	1	2	0	0	0	1	375640
18NOV92	229	BT	1	2	18NOV92	227	BT	1	2	0	0	0	1	375644
18NOV92	247	BT	1	2	18NOV92	243	BT	1	2	0	0	0	1	375646
18NOV92	287	BT	1	2	18NOV92	287	BT	1	2	0	0	0	1	375652
18NOV92	262	BT	1	2	18NOV92	264	BT	1	2	0	0	0	1	375690
19NOV92	315	BT	1	2	18NOV92	313	BT	1	2	1	0	0	1	358678
19NOV92	318	BT	1	2	18NOV92	317	BT	1	2	1	0	0	1	358685
19NOV92	362	BT	1	2	19NOV92	360	BT	1	2	0	0	0	1	358723
19NOV92	303	BT	1	2	19NOV92	304	BT	1	2	0	0	0	1	358749
19NOV92	334	BT	1	2	19NOV92	335	BT	1	2	0	0	0	1	358763
19NOV92	355	BT	1	2	19NOV92	358	BT	1	2	0	0	0	1	358839
19NOV92	310	BT	1	2	19NOV92	310	BT	1	2	0	0	0	1	358854
19NOV92	261	BT	1	2	17NOV92	261	BT	1	2	2	0	0	1	375480
19NOV92	242	BT	1	2	17NOV92	240	BT	1	2	2	0	0	1	375538
19NOV92	265	BT	1	2	17NOV92	266	BT	1	2	2	0	0	1	375593
19NOV92	263	BT	1	2	18NOV92	263	BT	1	2	1	0	0	1	375659
19NOV92	270	BT	1	2	18NOV92	267	BT	1	2	1	0	0	1	375723
19NOV92	289	BT	1	2	19NOV92	289	BT	1	2	0	0	0	1	375836
19NOV92	251	BT	1	2	19NOV92	250	BT	1	2	0	0	0	1	375837
19NOV92	250	BT	1	2	19NOV92	250	BT	1	2	0	0	0	1	375837
20NOV92	205	BT	1	2	18NOV92	202	BT	1	2	2	0	0	1	375695
20NOV92	259	BT	1	2	18NOV92	259	BT	1	2	2	0	0	1	375733
20NOV92	249	BT	1	2	18NOV92	247	BT	1	2	2	0	0	1	375786
20NOV92	252	BT	1	2	19NOV92	250	BT	1	2	1	0	0	1	375837
20NOV92	282	BT	1	2	19NOV92	282	BT	1	2	1	0	0	1	375925
20NOV92	282	BT	1	2	20NOV92	282	BT	1	2	0	0	0	1	375925
20NOV92	267	BT	1	2	19NOV92	265	BT	1	2	1	0	0	1	375927
20NOV92	268	BT	1	2	19NOV92	268	BT	1	2	1	0	0	1	376057
20NOV92	255	BT	1	2	20NOV92	257	BT	1	2	0	0	0	1	376082
20NOV92	258	BT	1	2	20NOV92	258	BT	1	2	0	0	0	1	376117
23NOV92	366	BT	1	2	23NOV92	367	BT	1	2	0	0	0	1	359008
23NOV92	333	BT	1	2	23NOV92	334	BT	1	2	0	0	0	1	359011
23NOV92	313	BT	1	2	23NOV92	314	BT	1	2	0	0	0	1	359014

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE						DISTANCE TRAVELLED		TAG	
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	MILES	KM	COND	NUMBER
23NOV92	386	BT	1	2	23NOV92	388	BT	1	2	0	0	0	1	359035
23NOV92	200	BT	1	2	20NOV92	200	BT	1	2	3	0	0	1	376090
23NOV92	251	BT	1	2	23NOV92	250	BT	1	2	0	0	0	1	376291
23NOV92	277	BT	1	2	23NOV92	277	BT	1	2	0	0	0	1	376330
23NOV92	214	BT	1	2	23NOV92	214	BT	1	2	0	0	0	1	376341
23NOV92	205	BT	1	2	23NOV92	205	BT	1	2	0	0	0	1	376430
24NOV92	291	BT	1	2	24NOV92	291	BT	1	2	0	0	0	1	376540
25NOV92	376	UH	3	5	20NOV92	379	BT	1	2	5	4	6	1	358914
30NOV92	230	BT	1	2	20NOV92	229	BT	1	2	10	0	0	1	376103
01DEC92	200	BT	5	8	09NOV92	198	BT	5	8	22	0	0	1	375279
01DEC92	212	BT	1	2	20NOV92	215	BT	1	2	11	0	0	1	376168
01DEC92	297	BT	1	2	23NOV92	297	BT	1	2	8	0	0	1	376328
02DEC92	326	BT	1	2	02DEC92	328	BT	1	2	0	0	0	1	359677
02DEC92	313	BT	1	2	02DEC92	314	BT	1	2	0	0	0	1	359681
02DEC92	300	BT	1	2	02DEC92	301	BT	1	2	0	0	0	1	359705
02DEC92	294	BT	1	2	25NOV92	295	UH	3	5	7	4	6	1	376554
02DEC92	296	BT	1	2	02DEC92	295	UH	1	2	0	2	3	1	376554
02DEC92	271	BT	1	2	01DEC92	272	BT	1	2	1	0	0	1	376910
02DEC92	182	BT	1	2	02DEC92	182	BT	1	2	0	0	0	1	377042
02DEC92	232	BT	1	2	02DEC92	232	BT	1	2	0	0	0	1	377097
03DEC92	340	BT	1	2	24NOV92	339	UH	2	3	9	3	5	1	359165
03DEC92	203	BT	5	8	09NOV92	207	BT	5	8	24	0	0	1	375280
03DEC92	220	BT	5	8	10NOV92	221	BT	5	8	23	0	0	1	375320
03DEC92	279	BT	1	2	20NOV92	281	BT	1	2	13	0	0	1	376209
03DEC92	251	BT	1	2	02DEC92	240	BT	1	2	1	0	0	1	376989
03DEC92	242	BT	1	2	02DEC92	242	BT	1	2	1	0	0	1	377014
03DEC92	186	BT	1	2	02DEC92	186	BT	1	2	1	0	0	1	377172
07DEC92	265	BT	5	8	06NOV92	264	BT	5	8	31	0	0	2	375257
07DEC92	265	BT	5	8	13NOV92	265	BT	5	8	24	0	0	1	375422
07DEC92	276	BT	5	8	20NOV92	237	BT	1	2	17	4	6	1	376161
07DEC92	243	BT	1	2	23NOV92	243	BT	1	2	14	0	0	1	376464
07DEC92	254	BT	5	8	23NOV92	252	BT	1	2	14	4	6	1	376474
07DEC92	192	BT	5	8	03DEC92	191	BT	5	8	4	0	0	1	377428
07DEC92	153	BT	1	2	03DEC92	152	BT	5	8	4	4	6	1	377435
07DEC92	292	BT	5	8	04DEC92	291	BT	5	8	3	0	0	1	377665
07DEC92	209	BT	5	8	04DEC92	208	BT	5	8	3	0	0	1	377824
08DEC92	308	BT	5	8	08DEC92	309	BT	5	8	0	0	0	1	360073
08DEC92	345	BT	5	8	08DEC92	345	BT	5	8	0	0	0	1	360074
08DEC92	193	BT	1	2	02DEC92	193	BT	1	2	6	0	0	1	377225
08DEC92	277	BT	5	8	03DEC92	279	BT	5	8	5	0	0	1	377265
08DEC92	301	BT	5	8	04DEC92	297	BT	5	8	4	0	0	1	377675
08DEC92	237	BT	5	8	07DEC92	246	BT	5	8	1	0	0	1	377970
08DEC92	282	BT	5	8	08DEC92	283	BT	5	8	0	0	0	1	378249
08DEC92	294	BT	5	8	08DEC92	294	BT	5	8	0	0	0	1	378271
09DEC92	260	BT	1	2	30NOV92	263	BT	1	2	9	0	0	1	376624

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APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
09DEC92	273	BT	5	8	03DEC92	273	BT	5	8	6	0	0	1	377290
09DEC92	279	BT	5	8	03DEC92	272	BT	5	8	6	0	0	1	377320
09DEC92	262	BT	5	8	03DEC92	262	BT	5	8	6	0	0	1	377377
09DEC92	226	BT	5	8	04DEC92	228	BT	5	8	5	0	0	1	377619
09DEC92	290	BT	5	8	08DEC92	292	BT	5	8	1	0	0	1	378177
09DEC92	180	BT	1	2	09DEC92	180	BT	1	2	0	0	0	1	378621
09DEC92	172	BT	1	2	09DEC92	204	BT	1	2	0	0	0	1	378622
10DEC92	407	BT	1	2	10DEC92	407	BT	1	2	0	0	0	1	360235
10DEC92	377	BT	1	2	10DEC92	378	BT	1	2	0	0	0	1	360247
10DEC92	303	BT	1	2	10DEC92	303	BT	1	2	0	0	0	1	360302
10DEC92	316	BT	1	2	10DEC92	316	BT	1	2	0	0	0	1	360305
10DEC92	178	BT	1	2	24NOV92	176	BT	1	2	16	0	0	1	376489
14DEC92	203	BT	1	2	14DEC92	203	BT	1	2	0	0	0	1	378772
16DEC92	405	UH	3	5	16DEC92	413	UH	3	5	0	0	0	1	360507
17DEC92	314	BT	1	2	16DEC92	312	UH	2	3	1	3	5	1	360728
17DEC92	368	BT	1	2	17DEC92	367	BT	1	2	0	0	0	1	360755
17DEC92	181	BT	1	2	09DEC92	181	BT	1	2	8	0	0	1	378675
18DEC92	342	UH	2	3	20NOV92	340	BT	1	2	28	3	5	1	358903
18DEC92	234	UH	4	6	04DEC92	237	BT	5	8	14	9	14	1	377754
18DEC92	287	UH	4	6	14DEC92	286	BT	1	2	4	5	8	1	378771
18DEC92	277	UH	4	6	18DEC92	275	UH	4	6	0	0	0	1	378973
21DEC92	397	BT	1	2	21DEC92	396	BT	1	2	0	0	0	1	361264
21DEC92	358	BT	1	2	21DEC92	358	BT	1	2	0	0	0	1	361281
21DEC92	269	BT	1	2	02DEC92	268	BT	1	2	19	0	0	1	377023
21DEC92	160	BT	1	2	07DEC92	163	BT	1	2	14	0	0	1	378119
21DEC92	183	BT	1	2	09DEC92	182	BT	1	2	12	0	0	1	378672
21DEC92	255	BT	1	2	21DEC92	256	BT	1	2	0	0	0	1	379222
22DEC92	242	BT	5	8	22DEC92	242	BT	5	8	0	0	0	1	379276
23DEC92	242	BT	5	8	03DEC92	240	BT	5	8	20	0	0	1	377367
23DEC92	255	BT	5	8	23DEC92	257	BT	5	8	0	0	0	1	379403
28DEC92	583	BT	5	8	28DEC92	581	BT	5	8	0	0	0	1	361366
28DEC92	315	BT	5	8	28DEC92	316	BT	5	8	0	0	0	1	361373
28DEC92	234	BT	5	8	19NOV92	234	BT	1	2	39	4	6	1	375960
28DEC92	232	BT	5	8	28DEC92	233	BT	5	8	0	0	0	1	379508
29DEC92	251	BT	5	8	29DEC92	252	BT	5	8	0	0	0	1	379666
30DEC92	313	BT	1	2	30DEC92	314	BT	1	2	0	0	0	1	361475
30DEC92	288	BT	1	2	30DEC92	288	BT	1	2	0	0	0	1	379847
30DEC92	280	BT	1	2	30DEC92	281	BT	1	2	0	0	0	1	379849
30DEC92	255	BT	1	2	30DEC92	255	BT	1	2	0	0	0	1	379890
30DEC92	252	BT	5	8	30DEC92	250	BT	5	8	0	0	0	1	379954
31DEC92	321	BT	1	2	31DEC92	324	BT	1	2	0	0	0	1	361557
31DEC92	323	BT	1	2	31DEC92	324	BT	1	2	0	0	0	1	361557
31DEC92	168	BT	1	2	02DEC92	168	BT	1	2	29	0	0	1	377041
31DEC92	206	BT	1	2	21DEC92	204	BT	1	2	10	0	0	1	379225
31DEC92	193	BT	1	2	21DEC92	196	BT	1	2	10	0	0	1	379259

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APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
31DEC92	187	BT	1	2	31DEC92	188	BT	1	2	0	0	0	1	380014
31DEC92	260	BT	1	2	31DEC92	259	BT	1	2	0	0	0	1	380054
31DEC92	175	BT	1	2	31DEC92	175	BT	1	2	0	0	0	1	380078
04JAN93	349	UH	3	5	29DEC92	350	BT	5	8	6	8	13	1	361416
04JAN93	249	UH	3	5	06NOV92	248	BT	5	8	59	8	13	1	375198
04JAN93	185	UH	3	5	16NOV92	184	BT	9	14	49	12	19	1	375442
04JAN93	218	UH	3	5	02DEC92	220	BT	1	2	33	4	6	1	377016
04JAN93	249	UH	3	5	02DEC92	253	BT	1	2	33	4	6	1	377109
04JAN93	203	UH	3	5	09DEC92	202	BT	1	2	26	4	6	1	378679
05JAN93	377	UH	3	5	28DEC92	380	BT	5	8	8	8	13	1	361368
05JAN93	260	UH	3	5	20NOV92	261	BT	1	2	46	4	6	1	376182
05JAN93	258	UH	3	5	30DEC92	257	BT	1	2	6	4	6	1	379803
05JAN93	242	BT	1	2	04JAN93	244	UH	3	5	1	4	6	1	380392
06JAN93	263	UH	3	5	21DEC92	265	BT	1	2	16	4	6	1	379252
06JAN93	207	UH	3	5	29DEC92	209	BT	5	8	8	8	13	1	379674
06JAN93	223	UH	3	5	06JAN93	226	UH	3	5	0	0	0	1	381043
07JAN93	194	BT	8	13	30DEC92	193	BT	1	2	8	7	11	1	379869
07JAN93	222	BT	8	13	04JAN93	221	UH	3	5	3	11	18	1	380359
07JAN93	212	UH	3	5	06JAN93	210	UH	3	5	1	0	0	1	381027
08JAN93	314	UH	3	5	05JAN93	312	UH	3	5	3	0	0	1	361777
08JAN93	213	BT	1	2	01DEC92	212	BT	1	2	38	0	0	1	376945
08JAN93	198	BT	1	2	10DEC92	198	BT	1	2	29	0	0	1	378733
08JAN93	204	BT	1	2	05JAN93	203	BT	1	2	3	0	0	1	380917
08JAN93	234	BT	1	2	07JAN93	234	UH	3	5	1	4	6	1	381323
08JAN93	209	BT	1	2	07JAN93	208	UH	3	5	1	4	6	1	381342
11JAN93	234	BT	1	2	21DEC92	234	BT	1	2	21	0	0	1	379231
11JAN93	219	BT	1	2	07JAN93	218	UH	3	5	4	4	6	1	381334
11JAN93	261	BT	1	2	11JAN93	262	BT	1	2	0	0	0	1	381511
11JAN93	238	BT	1	2	11JAN93	240	BT	1	2	0	0	0	1	381530
11JAN93	220	BT	1	2	11JAN93	220	BT	1	2	0	0	0	1	381586
13JAN93	216	BT	1	2	13JAN93	216	BT	1	2	0	0	0	1	381662
21JAN93	306	BT	9	14	20NOV92	310	BT	1	2	62	8	13	1	358960
21JAN93	202	BT	9	14	08JAN93	203	BT	1	2	13	8	13	1	381478
21JAN93	191	BT	5	8	20JAN93	190	BT	3	5	1	2	3	1	382218
22JAN93	218	BT	1	2	30NOV92	219	BT	1	2	53	0	0	1	376702
22JAN93	218	UH	3	5	30NOV92	218	BT	5	8	53	8	13	1	376722
22JAN93	213	UH	3	5	01DEC92	212	BT	1	2	52	4	6	1	376938
22JAN93	289	UH	3	5	30DEC92	291	BT	1	2	23	4	6	1	379786
22JAN93	293	BT	1	2	06JAN93	295	UH	3	5	16	4	6	1	381009
25JAN93	249	UH	3	5	13NOV92	250	BT	9	14	73	12	19	1	375389
25JAN93	269	UH	3	5	03DEC92	268	BT	5	8	53	8	13	1	377347
25JAN93	231	UH	3	5	06JAN93	232	UH	3	5	19	0	0	1	381125
25JAN93	224	UH	3	5	19JAN93	225	BT	8	13	6	11	18	1	382091
25JAN93	153	BT	1	2	22JAN93	153	UH	3	5	3	4	6	1	382663
26JAN93	286	UH	2	3	14DEC92	285	BT	5	8	43	7	11	1	378810

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
26JAN93	176	BT	1	2	25JAN93	176	BT	1	2	1	0	0	1	382689
27JAN93	223	BT	8	13	29DEC92	226	BT	5	8	29	3	5	1	379753
27JAN93	283	BT	3	5	06JAN93	284	UH	4	6	21	7	11	1	381092
27JAN93	185	BT	8	13	08JAN93	187	BT	1	2	19	7	11	1	381393
27JAN93	206	UH	3	5	26JAN93	206	BT	1	2	1	4	6	1	382999
28JAN93	298	BT	4	6	03DEC92	300	BT	1	2	56	3	5	1	359946
28JAN93	312	BT	7	11	13JAN93	314	BT	1	2	15	6	10	1	362065
28JAN93	277	BT	9	14	18DEC92	276	UH	4	6	41	13	21	1	379007
28JAN93	289	BT	8	13	30DEC92	292	BT	1	2	29	7	11	1	379846
28JAN93	276	BT	9	14	31DEC92	276	BT	1	2	28	8	13	1	379994
28JAN93	177	BT	9	14	31DEC92	178	BT	1	2	28	8	13	1	380132
28JAN93	188	BT	8	13	27JAN93	188	BT	7	11	1	1	2	1	383299
29JAN93	330	BT	7	11	18DEC92	333	UH	2	3	42	9	14	1	361087
29JAN93	310	BT	9	14	29JAN93	307	BT	10	16	0	1	2	1	362549
29JAN93	255	BT	9	14	30NOV92	255	BT	5	8	60	4	6	1	376590
29JAN93	250	BT	9	14	04DEC92	255	BT	5	8	56	4	6	1	377531
29JAN93	293	BT	10	16	04DEC92	295	BT	5	8	56	5	8	1	377643
29JAN93	257	BT	9	14	09DEC92	255	BT	5	8	51	4	6	1	378519
29JAN93	268	BT	10	16	28JAN93	265	BT	9	14	1	1	2	1	383426
01FEB93	268	BT	5	8	25JAN93	267	UH	2	3	7	7	11	1	382698
02FEB93	195	BT	1	2	10NOV92	194	BT	5	8	84	4	6	1	375309
02FEB93	214	BT	5	8	30NOV92	218	BT	5	8	64	0	0	1	376722
02FEB93	192	BT	5	8	26JAN93	194	BT	3	5	7	2	3	1	383064
03FEB93	357	BT	9	14	18DEC92	357	UH	2	3	47	11	18	2	361189
04FEB93	345	BT	9	14	09DEC92	346	BT	5	8	57	4	6	1	360150
04FEB93	322	BT	8	13	30DEC92	320	BT	1	2	36	7	11	1	361474
04FEB93	265	BT	8	13	18NOV92	267	BT	1	2	78	7	11	1	375750
08FEB93	199	BT	10	16	07DEC92	199	BT	1	2	63	9	14	1	378163
08FEB93	198	BT	10	16	06JAN93	198	UH	3	5	33	13	21	1	380981
08FEB93	216	BT	9	14	25JAN93	213	BT	1	2	14	8	13	1	382843
08FEB93	207	BT	10	16	29JAN93	212	BT	9	14	10	1	2	1	383594
09FEB93	194	UH	2	3	20JAN93	195	UH	3	5	20	1	2	1	382185
09FEB93	244	BT	1	2	02FEB93	244	BT	5	8	7	4	6	1	383862
09FEB93	226	BT	1	2	04FEB93	226	BT	8	13	5	7	11	1	384172
10FEB93	238	BT	7	11	28DEC92	238	BT	5	8	44	2	3	1	379465
10FEB93	219	BT	7	11	28JAN93	220	BT	9	14	13	2	3	1	383406
11FEB93	196	BT	1	2	21JAN93	194	BT	9	14	21	8	13	1	382331
16FEB93	340	BT	7	11	10DEC92	341	BT	1	2	68	6	10	1	360246
16FEB93	227	BT	7	11	06JAN93	228	UH	3	5	41	10	16	1	381158
16FEB93	266	BT	7	11	27JAN93	266	BT	7	11	20	0	0	1	383286
16FEB93	263	BT	7	11	16FEB93	267	BT	7	11	0	0	0	1	384808
17FEB93	317	BT	8	13	18DEC92	319	UH	4	6	61	12	19	1	360903
17FEB93	344	BT	7	11	03NOV92	242	BT	5	8	106	2	3	1	375019
17FEB93	211	BT	8	13	01DEC92	215	BT	1	2	78	7	11	1	376863
17FEB93	293	BT	7	11	22DEC92	294	BT	5	8	57	2	3	1	379317

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
17FEB93	228	BT	8	13	04JAN93	230	UH	3	5	44	11	18	1	380166
17FEB93	195	BT	7	11	06JAN93	195	UH	3	5	42	10	16	1	381146
17FEB93	237	BT	7	11	07JAN93	238	UH	3	5	41	10	16	1	381312
17FEB93	252	BT	8	13	21JAN93	252	BT	9	14	27	1	2	1	382295
17FEB93	228	BT	7	11	17FEB93	228	BT	8	13	0	1	2	1	384927
18FEB93	267	BT	10	16	07DEC92	267	BT	5	8	73	5	8	1	377989
18FEB93	187	BT	8	13	23DEC92	188	BT	1	2	57	7	11	1	379448
18FEB93	198	BT	8	13	06JAN93	199	UH	3	5	43	11	18	1	380950
18FEB93	199	BT	7	11	18FEB93	199	BT	8	13	0	1	2	1	380950
18FEB93	255	BT	10	16	04FEB93	154	BT	9	14	14	1	2	1	384142
18FEB93	245	BT	8	13	11FEB93	243	BT	7	11	7	1	2	1	384630
18FEB93	255	BT	8	13	18FEB93	256	BT	10	16	0	2	3	1	385153
18FEB93	182	BT	8	13	18FEB93	181	BT	9	14	0	1	2	1	385202
19FEB93	352	BT	10	16	28JAN93	353	BT	8	13	22	2	3	1	362371
19FEB93	180	BT	5	8	20JAN93	182	BT	5	8	30	0	0	1	382256
19FEB93	294	BT	10	16	03FEB93	295	BT	9	14	16	1	2	1	384003
19FEB93	254	BT	7	11	19FEB93	255	BT	10	16	0	3	5	1	385371
22FEB93	186	BT	8	13	30NOV92	191	BT	5	8	84	3	5	1	376600
23FEB93	360	BT	10	16	19FEB93	361	BT	8	13	4	2	3	1	363099
23FEB93	170	BT	10	16	04FEB93	172	BT	8	13	19	2	3	1	384095
23FEB93	258	BT	8	13	17FEB93	258	BT	7	11	6	1	2	1	384906
24FEB93	298	BT	8	13	02DEC92	299	BT	1	2	84	7	11		376979
24FEB93	182	BT	8	13	07DEC92	182	BT	1	2	79	7	11	1	378064
24FEB93	245	BT	8	13	11JAN93	244	BT	1	2	44	7	11	1	381542
24FEB93	235	BT	8	13	22JAN93	235	UH	3	5	33	11	18	1	382636
25FEB93	214	BT	8	13	23NOV92	212	BT	1	2	94	7	11	1	376455
25FEB93	241	BT	8	13	29DEC92	242	BT	5	8	58	3	5	1	379724
25FEB93	218	BT	8	13	27JAN93	219	UH	3	5	29	11	18	1	383157
25FEB93	190	BT	8	13	18FEB93	190	BT	7	11	7	1	2	1	385257
25FEB93	231	BT	9	14	23FEB93	229	BT	10	16	2	1	2	1	385677
26FEB93	268	BT	8	13	28DEC92	169	BT	5	8	60	3	5	1	379479
26FEB93	274	BT	8	13	04JAN93	275	UH	3	5	53	11	18	1	380327
26FEB93	154	BT	8	13	26FEB93	152	BT	8	13	0	0	0	1	386396
26FEB93	183	BT	8	13	26FEB93	183	BT	8	13	0	0	0	1	386407
26FEB93	198	BT	8	13	26FEB93	199	BT	8	13	0	0	0	1	386460
01MAR93	280	BT	8	13	11FEB93	279	BT	7	11	18	1	2	1	384640
02MAR93	536	BT	7	11	18FEB93	536	BT	10	16	12	3	5	1	363050
02MAR93	170	BT	7	11	06JAN93	169	UH	3	5	55	10	16	1	381163
02MAR93	242	BT	8	13	07JAN93	243	BT	8	13	54	0	0	1	381246
02MAR93	179	BT	7	11	14JAN93	182	BT	9	14	47	2	3	1	381841
03MAR93	242	BT	7	11	09FEB93	240	BT	1	2	22	6	10	1	384372
03MAR93	224	BT	6	10	26FEB93	244	BT	8	13	5	2	3	1	386429
03MAR93	288	BT	6	10	01MAR93	287	BT	8	13	2	2	3	1	386554
03MAR93	284	BT	6	10	03MAR93	284	BT	7	11	0	1	2	1	386739
08MAR93	208	BT	8	13	07DEC92	210	BT	1	2	91	7	11	2	378068

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE										
DATE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	KM	TAG COND	NUMBER
08MAR93	169	BT	8	13	18FEB93	170	BT	7	11	18	1	2	1	385258
09MAR93	254	BT	10	16	05NOV92	255	BT	5	8	124	5	8	1	375107
09MAR93	193	BT	10	16	11NOV92	186	BT	9	14	118	1	2	1	375359
09MAR93	202	BT	10	16	09MAR93	203	BT	9	14	0	1	2	1	387028
09MAR93	243	BT	7	11	09MAR93	243	BT	10	16	0	3	5	1	387075
09MAR93	209	BT	7	11	09MAR93	210	BT	9	14	0	2	3	1	387148
10MAR93	235	BT	9	14	24NOV92	234	BT	1	2	106	8	13	1	376513
10MAR93	190	BT	10	16	25JAN93	190	BT	3	5	44	7	11	1	382866
10MAR93	177	BT	9	14	26JAN93	176	BT	1	2	43	8	13	1	383006
10MAR93	224	BT	10	16	04FEB93	225	BT	8	13	34	2	3	1	384091
12MAR93	200	BT	10	16	04NOV92	200	BT	5	8	128	5	8	1	375078
12MAR93	199	BT	10	16	02DEC92	199	BT	1	2	100	9	14	1	377254
12MAR93	194	BT	10	16	13JAN93	195	BT	1	2	58	9	14	1	381701
12MAR93	227	BT	10	16	17FEB93	228	BT	7	11	23	3	5	1	385132
16MAR93	240	BT	9	14	12NOV92	242	BT	8	13	124	1	2	1	375373
16MAR93	251	BT	10	16	08DEC92	255	BT	5	8	98	5	8	1	378320
16MAR93	198	BT	9	14	21DEC92	200	BT	1	2	85	8	13	2	379244
16MAR93	202	BT	10	16	31DEC92	205	BT	1	2	75	9	14	1	380012
16MAR93	221	BT	10	16	25JAN93	221	UH	3	5	50	13	21	1	382775
16MAR93	201	BT	9	14	17FEB93	203	BT	8	13	27	1	2	1	384946
16MAR93	168	BT	9	14	18FEB93	166	BT	5	8	26	4	6	1	385314
17MAR93	204	BT	10	16	03DEC92	207	BT	5	8	104	5	8	1	375280
17MAR93	262	BT	10	16	06JAN93	262	UH	3	5	70	13	21	1	380958
17MAR93	213	BT	10	16	13JAN93	212	BT	9	14	63	1	2	1	381773
17MAR93	193	BT	10	16	20JAN93	191	BT	11	18	56	1	2	1	382133
18MAR93	300	BT	10	16	05JAN93	307	UH	3	5	72	13	21	1	361769
18MAR93	277	BT	10	16	01MAR93	277	BT	7	11	17	3	5	1	386513
18MAR93	226	BT	10	16	03MAR93	223	BT	7	11	15	3	5	1	386691
19MAR93	288	BT	10	16	11FEB93	288	BT	1	2	36	9	14	1	384508
19MAR93	186	BT	10	16	19MAR93	187	BT	10	16	0	0	0	1	388192
20MAR93	196	BT	1	2	10NOV92	198	BT	5	8	130	4	6	1	375298
20MAR93	190	BT	5	8	04DEC92	192	BT	5	8	106	0	0	1	377778
20MAR93	200	BT	9	14	03MAR93	199	BT	6	10	17	3	5	1	386765
22MAR93	221	BT	8	13	22DEC92	219	BT	5	8	90	3	5	2	379337
22MAR93	215	BT	8	13	22FEB93	215	BT	8	13	28	0	0	1	385564
22MAR93	268	BT	8	13	25FEB93	268	BT	8	13	25	0	0	1	386104
22MAR93	265	BT	9	14	17MAR93	264	BT	10	16	5	1	2	1	387876
22MAR93	203	BT	8	13	22MAR93	203	BT	8	13	0	0	0	1	388307
23MAR93	220	BT	9	14	25JAN93	220	UH	2	3	57	11	18	1	382730
23MAR93	165	BT	10	16	08FEB93	163	BT	10	16	43	0	0	1	384295
24MAR93	212	BT	10	16	03MAR93	213	BT	6	10	21	4	6	1	386838
24MAR93	209	BT	10	16	17MAR93	209	BT	10	16	7	0	0	1	387953
25MAR93	240	BT	10	16	02FEB93	239	BT	7	11	51	3	5	1	383880
25MAR93	174	BT	9	14	12MAR93	175	BT	10	16	13	1	2	1	387698
25MAR93	158	BT	8	13	23MAR93	156	BT	9	14	2	1	2	1	388415

(continued)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE					RELEASE										
		RIVER								DAYS AT LARGE	DISTANCE TRAVELLED		TAG	
DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM		MILES	KM	COND	NUMBER
25MAR93	204	BT	8	13	23MAR93	204	BT	8	13	2	0	0	1	388436
26MAR93	325	BT	10	16	06JAN93	326	UH	3	5	79	13	21	1	361824
26MAR93	229	BT	10	16	20JAN93	228	BT	3	5	65	7	11	1	382166
26MAR93	254	BT	10	16	27JAN93	254	BT	7	11	58	3	5	1	383293
26MAR93	254	BT	10	16	19FEB93	252	BT	7	11	35	3	5	1	385502
26MAR93	192	BT	10	16	03MAR93	191	BT	7	11	23	3	5	1	386706
26MAR93	296	BT	10	16	26MAR93	283	BT	10	16	0	0	0	1	388649
29MAR93	262	BT	9	14	18NOV92	263	BT	1	2	131	8	13	1	375717
29MAR93	210	BT	8	13	02DEC92	210	BT	1	2	117	7	11	1	377171
29MAR93	190	BT	10	16	09DEC92	190	BT	1	2	110	9	14	1	378685
29MAR93	266	BT	8	13	28JAN93	267	BT	8	13	60	0	0	1	383452
29MAR93	172	BT	10	16	18FEB93	172	BT	10	16	39	0	0	1	385173
29MAR93	268	BT	10	16	24FEB93	267	BT	7	11	33	3	5	1	386009
30MAR93	331	BT	8	13	04JAN93	230	UH	3	5	85	11	18	1	380230
30MAR93	254	BT	8	13	25FEB93	236	BT	8	13	33	0	0	1	386044
30MAR93	214	BT	8	13	10MAR93	215	BT	10	16	20	2	3	1	387211
01APR93	183	BT	9	14	10MAR93	183	BT	10	16	22	1	2	1	387266
02APR93	225	BT	9	14	22DEC92	225	BT	5	8	101	4	6	1	379288
02APR93	250	BT	9	14	08JAN93	252	UH	3	5	84	12	19	1	381438
02APR93	280	BT	9	14	01APR93	281	BT	8	13	1	1	2	1	389530
05APR93	228	BT	7	11	01DEC92	229	BT	5	8	125	2	3	2	376742
05APR93	162	BT	9	14	25MAR93	163	BT	9	14	11	0	0	2	388570
06APR93	272	BT	9	14	04JAN93	272	UH	3	5	92	12	19	1	380348
06APR93	258	BT	9	14	17FEB93	259	BT	8	13	48	1	2	1	384958
07APR93	193	BT	9	14	20NOV92	193	BT	1	2	138	8	13	1	376101
07APR93	294	BT	9	14	03DEC92	293	BT	5	8	125	4	6	2	377266
07APR93	187	BT	9	14	21JAN93	185	BT	9	14	76	0	0	1	382311
08APR93	270	BT	9	14	23NOV92	277	BT	1	2	136	8	13	1	376330
08APR93	267	BT	9	14	03DEC92	265	BT	5	8	126	4	6	1	377339
09APR93	318	BT	9	14	04DEC92	320	BT	5	8	126	4	6	1	359980
09APR93	261	BT	9	14	31MAR93	260	BT	8	13	9	1	2	1	389373
13APR93	358	BT	8	13	24NOV92	356	BT	1	2	140	7	11	1	359099
14APR93	191	BT	9	14	18MAR93	194	BT	10	16	27	1	2	1	388174
15APR93	321	BT	9	14	16DEC92	324	UH	2	3	120	11	18	1	360633
15APR93	276	BT	1	2	19NOV92	275	BT	1	2	147	0	0	1	376013
15APR93	178	BT	1	2	09MAR93	178	BT	9	14	37	8	13	1	387037
16APR93	291	BT	9	14	25FEB93	291	BT	9	14	50	0	0	1	386223

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1992-1993 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION.

RECAPTURE							RELEASE										
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT		TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	GROWTH IN MM	COND	NUMBER
04NOV92	9 M TRAWL	2	336	BT	5	8	09MAR92	9 M TRAWL	1	268	BT	9	14	240	68	1	369192
05NOV92	9 M TRAWL	4	322	BT	4	6	12NOV91	9 M TRAWL	3	283	BT	5	8	359	39	1	342648
06NOV92	9 M TRAWL	4	404	BT	5	8	19DEC88	9 M TRAWL	1	175	BT	5	8	1418	229	1	264069
09NOV92	9 M TRAWL	2	206	BT	5	8	07APR92	9 M TRAWL	1	156	BT	8	13	216	50	1	372728
10NOV92	9 M TRAWL	6	432	BT	7	11	18JAN90	9 M TRAWL	3	397	BT	1	2	1027	35	1	274562
10NOV92	9 M TRAWL	2	305	BT	5	8	20NOV91	9 M TRAWL	1	315	BT	9	14	356	.	1	346203
11NOV92	9 M TRAWL	2	343	BT	11	18	23MAR92	9 M TRAWL	1	235	BT	9	14	233	108	1	371721
12NOV92	9 M TRAWL	4	485	BT	8	13	25JAN91	9 M TRAWL	2	357	BT	1	2	657	128	1	333115
12NOV92	9 M TRAWL	4	374	BT	8	13	21FEB91	9 M TRAWL	2	270	BT	1	2	630	104	1	337358
12NOV92	9 M TRAWL	3	314	BT	8	13	08APR91	9 M TRAWL	1	204	BT	5	8	584	110	1	342231
12NOV92	9 M TRAWL	3	386	BT	8	13	11DEC91	9 M TRAWL	2	363	BT	5	8	337	23	2	346611
12NOV92	9 M TRAWL	2	304	BT	8	13	30JAN92	9 M TRAWL	1	210	BT	8	13	287	94	1	354042
13NOV92	9 M TRAWL	2	373	BT	9	14	17DEC91	9 M TRAWL	1	270	BT	1	2	332	103	1	344713
13NOV92	9 M TRAWL	2	370	BT	10	16	12MAR92	9 M TRAWL	1	270	BT	10	16	246	100	1	370375
13NOV92	9 M TRAWL	2	326	BT	10	16	21APR92	9 M TRAWL	1	245	BT	1	2	206	81	2	374638
16NOV92	9 M TRAWL	2	386	BT	9	14	27DEC91	9 M TRAWL	1	295	BT	1	2	325	91	1	350312
16NOV92	9 M TRAWL	2	328	BT	7	11	16JAN92	9 M TRAWL	1	290	BT	1	2	305	38	1	352967
16NOV92	9 M TRAWL	2	341	BT	10	16	15APR92	9 M TRAWL	1	258	BT	5	8	215	83	1	373992
17NOV92	9 M TRAWL	2	347	BT	1	2	08JAN92	9 M TRAWL	1	266	BT	1	2	314	81	1	351084
18NOV92	9 M TRAWL	1	335	BT	1	2	08NOV91	9 M TRAWL	0	180	BT	1	2	376	155	1	342565
18NOV92	9 M TRAWL	1	245	BT	1	2	02DEC91	9 M TRAWL	0	163	BT	1	2	352	82	1	343438
18NOV92	9 M TRAWL	3	297	BT	1	2	17DEC91	9 M TRAWL	2	219	BT	1	2	337	78	1	344592
18NOV92	9 M TRAWL	2	295	BT	1	2	19DEC91	9 M TRAWL	1	223	BT	1	2	335	72	1	344942
18NOV92	9 M TRAWL	2	340	BT	1	2	29JAN92	9 M TRAWL	1	257	BT	1	2	294	83	1	353990
19NOV92	9 M TRAWL	1	242	BT	1	2	30DEC91	9 M TRAWL	0	154	BT	1	2	325	88	1	350395
19NOV92	9 M TRAWL	1	230	BT	1	2	16JAN92	9 M TRAWL	0	175	BT	1	2	308	55	1	352916
19NOV92	9 M TRAWL	1	282	BT	1	2	20FEB92	9 M TRAWL	0	188	BT	1	2	273	94	1	366776
20NOV92	9 M TRAWL	4	400	BT	1	2	11DEC90	9 M TRAWL	2	380	BT	1	2	710	20	1	322322
23NOV92	9 M TRAWL	3	369	BT	1	2	21NOV91	9 M TRAWL	2	352	BT	5	8	368	17	1	346251
23NOV92	9 M TRAWL	1	281	BT	1	2	04MAR92	9 M TRAWL	0	160	BT	9	14	264	121	1	368251
23NOV92	9 M TRAWL	1	225	BT	1	2	26MAR92	9 M TRAWL	0	160	BT	7	11	242	65	1	372329
25NOV92	9 M TRAWL	6	587	UH	2	3	17MAR89	9 M TRAWL	2	338	BT	8	13	1349	249	1	271535
25NOV92	9 M TRAWL	4	399	UH	3	5	11MAR91	9 M TRAWL	2	257	BT	8	13	625	142	1	340218
25NOV92	9 M TRAWL	2	377	UH	2	3	10JAN92	9 M TRAWL	1	206	BT	9	14	320	171	1	352044
30NOV92	9 M TRAWL	2	320	BT	5	8	15NOV91	9 M TRAWL	1	242	BT	5	8	381	78	1	342789
30NOV92	9 M TRAWL	2	254	BT	5	8	14JAN92	9 M TRAWL	1	177	BT	5	8	321	77	1	352458
01DEC92	9 M TRAWL	5	392	UH	2	3	25JAN89	9 M TRAWL	1	164	BT	1	2	1406	228	1	278176
01DEC92	9 M TRAWL	3	389	UH	2	3	07JAN91	9 M TRAWL	1	255	BT	9	14	694	134	1	324548
01DEC92	9 M TRAWL	4	512	UH	2	3	25MAR92	9 M TRAWL	3	415	BT	8	13	251	97	1	358214
02DEC92	9 M TRAWL	6	529	UH	2	3	30DEC88	9 M TRAWL	2	247	BT	5	8	1433	282	1	265907
02DEC92	9 M TRAWL	2	307	UH	2	3	18DEC91	9 M TRAWL	1	256	BT	1	2	350	51	1	344805
02DEC92	9 M TRAWL	2	330	BT	5	8	08JAN92	9 M TRAWL	1	253	BT	1	2	329	77	2	351075
02DEC92	9 M TRAWL	2	284	BT	1	2	12MAR92	9 M TRAWL	1	218	BT	10	16	265	66	1	370365
04DEC92	9 M TRAWL	3	349	BT	5	8	23APR92	9 M TRAWL	2	258	BT	5	8	225	91	2	356647

(continued)

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE							RELEASE										
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT	GROWTH	TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	IN MM	COND	NUMBER
07DEC92	9 M TRAWL	4	429	BT	1	2	18DEC90	9 M TRAWL	2	338	BT	1	2	720	91	2	330794
07DEC92	9 M TRAWL	3	327	BT	1	2	04FEB92	9 M TRAWL	2	320	BT	9	14	307	7	1	348441
07DEC92	9 M TRAWL	3	367	BT	1	2	11MAR92	9 M TRAWL	2	234	BT	9	14	271	133	1	369804
07DEC92	9 M TRAWL	2	291	BT	1	2	18MAR92	9 M TRAWL	1	240	BT	8	13	264	51	1	371319
08DEC92	9 M TRAWL	3	352	BT	1	2	23JAN91	9 M TRAWL	1	245	BT	1	2	685	107	1	326987
08DEC92	9 M TRAWL	3	303	BT	5	8	10APR92	9 M TRAWL	2	262	BT	5	8	242	41	1	373352
09DEC92	9 M TRAWL	2	281	BT	1	2	10JAN92	9 M TRAWL	1	234	BT	9	14	334	47	1	351987
09DEC92	9 M TRAWL	2	315	BT	5	8	18MAR92	9 M TRAWL	1	266	BT	8	13	266	49	1	371299
09DEC92	9 M TRAWL	1	314	BT	5	8	23MAR92	9 M TRAWL	0	155	BT	7	11	261	159	1	371618
09DEC92	9 M TRAWL	2	260	BT	5	8	15APR92	9 M TRAWL	1	199	BT	5	8	238	61	2	374090
10DEC92	9 M TRAWL	5	556	BT	1	2	09FEB90	9 M TRAWL	2	341	BT	1	2	1035	215	2	274756
15DEC92	9 M TRAWL	2	450	UH	2	3	01APR92	9 M TRAWL	1	307	BT	10	16	258	143	1	355520
16DEC92	9 M TRAWL	4	425	UH	2	3	20NOV90	9 M TRAWL	2	247	BT	1	2	757	178	1	321607
16DEC92	9 M TRAWL	3	400	UH	2	3	11MAR91	9 M TRAWL	1	277	BT	8	13	646	123	1	340124
16DEC92	9 M TRAWL	3	346	UH	2	3	02DEC91	9 M TRAWL	2	258	BT	1	2	380	88	1	343426
16DEC92	9 M TRAWL	3	438	UH	3	5	14MAR91	9 M TRAWL	2	349	BT	10	16	643	89	1	345164
16DEC92	9 M TRAWL	3	345	UH	2	3	27DEC91	9 M TRAWL	2	333	BT	1	2	355	12	1	347210
16DEC92	9 M TRAWL	2	347	UH	3	5	02JAN92	9 M TRAWL	1	227	BT	1	2	349	120	1	350522
17DEC92	9 M TRAWL	2	310	UH	4	6	23MAR92	9 M TRAWL	1	226	BT	7	11	269	84	1	371615
18DEC92	9 M TRAWL	2	393	UH	2	3	03MAR92	9 M TRAWL	1	307	BT	8	13	290	86	1	349697
18DEC92	9 M TRAWL	2	306	UH	2	3	04MAR92	9 M TRAWL	1	224	BT	9	14	289	82	1	368404
18DEC92	9 M TRAWL	2	331	UH	2	3	07APR92	9 M TRAWL	1	210	BT	8	13	255	121	2	372723
18DEC92	9 M TRAWL	2	373	UH	4	6	13APR92	9 M TRAWL	1	261	BT	5	8	249	112	2	373751
23DEC92	9 M TRAWL	2	327	BT	1	2	12MAR92	9 M TRAWL	1	249	BT	7	11	286	78	1	370045
28DEC92	9 M TRAWL	9	560	BT	5	8	16MAR88	12 M/9 M COD	4	342	BT	8	13	1748	218	2	255822
29DEC92	9 M TRAWL	3	455	BT	5	8	26NOV90	9 M TRAWL	1	247	BT	1	2	764	208	1	321827
30DEC92	9 M TRAWL	4	461	BT	5	8	08MAR90	9 M TRAWL	1	232	BT	8	13	1028	229	1	314953
30DEC92	9 M TRAWL	3	355	BT	1	2	01APR92	9 M TRAWL	2	285	BT	10	16	273	70	2	355365
30DEC92	9 M TRAWL	2	336	BT	1	2	05MAR92	9 M TRAWL	1	252	BT	11	18	300	84	1	368578
30DEC92	9 M TRAWL	1	291	BT	1	2	10MAR92	9 M TRAWL	0	165	BT	9	14	295	126	1	369314
31DEC92	9 M TRAWL	2	292	BT	1	2	05MAR92	9 M TRAWL	1	207	BT	9	14	301	85	1	368635
04JAN93	9 M TRAWL	3	315	UH	3	5	30NOV90	9 M TRAWL	1	179	BT	1	2	766	136	2	322551
04JAN93	9 M TRAWL	4	398	UH	3	5	18JAN91	9 M TRAWL	2	332	BT	1	2	717	66	1	332638
04JAN93	9 M TRAWL	2	385	UH	3	5	05DEC91	9 M TRAWL	1	264	BT	11	18	396	121	1	343572
04JAN93	9 M TRAWL	3	400	UH	3	5	03MAR92	9 M TRAWL	2	306	BT	8	13	307	94	1	349618
04JAN93	9 M TRAWL	1	273	UH	3	5	31JAN92	9 M TRAWL	0	186	BT	8	13	339	87	2	354203
04JAN93	9 M TRAWL	2	210	UH	3	5	13MAR92	9 M TRAWL	1	265	BT	7	11	297	.	1	370399
04JAN93	9 M TRAWL	.	.	UH	3	5	23MAR92	9 M TRAWL	1	192	BT	9	14	287	.	1	371685
05JAN93	9 M TRAWL	2	377	BT	1	2	16DEC91	9 M TRAWL	1	251	BT	1	2	386	126	1	344403
06JAN93	9 M TRAWL	4	325	UH	3	5	28FEB91	9 M TRAWL	2	256	BT	10	16	678	69	1	338635
06JAN93	9 M TRAWL	2	333	UH	4	6	10MAR92	9 M TRAWL	1	208	BT	9	14	302	125	2	369358
07JAN93	9 M TRAWL	4	386	BT	8	13	20NOV90	9 M TRAWL	1	250	BT	1	2	779	136	1	321600
07JAN93	9 M TRAWL	4	371	BT	8	13	18DEC90	9 M TRAWL	2	321	BT	1	2	751	50	1	330790
07JAN93	9 M TRAWL	1	315	BT	8	13	18MAR92	9 M TRAWL	0	203	BT	8	13	295	112	1	371076

(continued)

RECAPTURE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	RELEASE DATE	GEAR	AGE	TOTAL LENGTH IN MM	RIVER REGION	MILE	KM	DAYS AT LARGE	GROWTH IN MM	TAG COND	TAG NUMBER
11JAN93	9 M TRAWL	2	292	BT	1	2	25MAR92	9 M TRAWL	1	221	BT	7	11	292	71	1	372120
14JAN93	9 M TRAWL	1	297	BT	9	14	24MAR92	9 M TRAWL	0	170	BT	9	14	296	127	1	372011
20JAN93	9 M TRAWL	.	.	BT	3	5	14JAN91	9 M TRAWL	2	226	UH	3	5	737	.	1	325512
25JAN93	9 M TRAWL	2	325	BT	1	2	07FEB92	9 M TRAWL	1	252	BT	8	13	353	73	1	365361
25JAN93	9 M TRAWL	3	306	UH	3	5	11MAR92	9 M TRAWL	2	253	BT	10	16	320	53	1	369868
25JAN93	9 M TRAWL	2	301	UH	3	5	11MAR92	9 M TRAWL	1	208	BT	10	16	320	93	1	369877
25JAN93	9 M TRAWL	2	304	UH	2	3	12MAR92	9 M TRAWL	1	234	BT	7	11	319	70	1	370056
27JAN93	9 M TRAWL	3	295	BT	3	5	21JAN92	9 M TRAWL	2	263	BT	8	13	372	32	1	353154
27JAN93	9 M TRAWL	2	335	BT	7	11	09MAR92	9 M TRAWL	1	204	BT	7	11	324	131	1	369009
27JAN93	9 M TRAWL	1	274	BT	7	11	23MAR92	9 M TRAWL	0	171	BT	7	11	310	103	1	371578
28JAN93	9 M TRAWL	4	397	BT	8	13	08NOV91	9 M TRAWL	3	313	BT	1	2	447	84	1	345981
28JAN93	9 M TRAWL	2	267	BT	8	13	10FEB92	9 M TRAWL	1	225	BT	8	13	353	42	1	365778
28JAN93	9 M TRAWL	2	291	BT	8	13	11FEB92	9 M TRAWL	1	234	BT	7	11	352	57	1	365895
28JAN93	9 M TRAWL	.	.	BT	7	11	24FEB92	9 M TRAWL	2	242	BT	7	11	339	.	1	367129
28JAN93	9 M TRAWL	2	314	BT	8	13	20APR92	9 M TRAWL	1	245	BT	5	8	283	69	1	374513
29JAN93	9 M TRAWL	5	364	BT	7	11	05FEB92	9 M TRAWL	4	334	BT	8	13	359	30	1	348535
29JAN93	9 M TRAWL	2	327	BT	9	14	26MAR92	9 M TRAWL	1	265	BT	7	11	309	62	1	349806
29JAN93	9 M TRAWL	2	270	BT	9	14	31DEC91	9 M TRAWL	1	203	BT	7	11	395	67	1	350468
29JAN93	9 M TRAWL	3	409	BT	9	14	23MAR92	9 M TRAWL	2	259	BT	8	13	312	150	1	371626
01FEB93	9 M TRAWL	2	278	BT	7	11	28FEB92	9 M TRAWL	1	190	BT	7	11	339	88	1	367750
02FEB93	9 M TRAWL	3	340	BT	7	11	20FEB92	9 M TRAWL	2	329	BT	9	14	348	11	1	349205
02FEB93	9 M TRAWL	2	360	BT	8	13	01APR92	9 M TRAWL	1	251	BT	10	16	307	109	1	355501
02FEB93	9 M TRAWL	2	319	BT	7	11	12MAR92	9 M TRAWL	1	249	BT	7	11	327	70	1	370182
04FEB93	9 M TRAWL	2	354	BT	8	13	02MAR92	9 M TRAWL	1	210	BT	7	11	339	144	1	367895
04FEB93	9 M TRAWL	2	345	BT	9	14	23MAR92	9 M TRAWL	1	221	BT	7	11	318	124	1	371547
04FEB93	9 M TRAWL	2	250	BT	9	14	07APR92	9 M TRAWL	1	201	BT	8	13	303	49	1	372759
05FEB93	9 M TRAWL	4	345	BT	10	16	15JAN91	9 M TRAWL	1	241	UH	3	5	752	104	1	325935
11FEB93	9 M TRAWL	3	363	UH	3	5	26MAR92	9 M TRAWL	2	295	BT	7	11	322	68	1	349846
11FEB93	9 M TRAWL	2	286	BT	7	11	17MAR92	9 M TRAWL	1	249	BT	8	13	331	37	1	370910
16FEB93	9 M TRAWL	4	373	BT	7	11	01MAR91	9 M TRAWL	2	272	BT	10	16	718	101	1	338936
16FEB93	9 M TRAWL	2	330	BT	7	11	01APR92	9 M TRAWL	1	264	BT	10	16	321	66	1	355333
16FEB93	9 M TRAWL	2	227	BT	7	11	16APR92	9 M TRAWL	1	213	BT	5	8	306	14	1	374206
18FEB93	9 M TRAWL	2	271	BT	7	11	05MAR92	9 M TRAWL	1	229	BT	9	14	350	42	1	368501
19FEB93	9 M TRAWL	3	415	BT	10	16	21FEB92	9 M TRAWL	2	319	BT	8	13	364	96	1	349240
19FEB93	9 M TRAWL	2	241	BT	7	11	18MAR92	9 M TRAWL	1	219	BT	8	13	338	22	1	371237
23FEB93	9 M TRAWL	4	410	BT	10	16	21DEC90	9 M TRAWL	2	312	BT	1	2	795	98	1	331049
23FEB93	9 M TRAWL	2	281	BT	10	16	09JAN92	9 M TRAWL	1	203	BT	10	16	411	78	1	351578
24FEB93	9 M TRAWL	2	339	BT	8	13	26MAR92	9 M TRAWL	1	231	BT	7	11	335	108	1	349825
25FEB93	9 M TRAWL	4	347	BT	7	11	14FEB91	9 M TRAWL	2	294	BT	8	13	742	53	1	335688
25FEB93	9 M TRAWL	4	432	BT	8	13	26FEB92	9 M TRAWL	3	417	BT	8	13	365	15	.	349315
26FEB93	9 M TRAWL	7	570	BT	8	13	24FEB87	12 M W/L	1	313	BT	1	2	2194	257	1	27107
26FEB93	9 M TRAWL	4	406	BT	8	13	03MAR92	9 M TRAWL	3	327	BT	8	13	360	79	1	349698
26FEB93	9 M TRAWL	2	268	BT	8	13	15JAN92	9 M TRAWL	1	183	BT	1	2	408	85	1	352801
26FEB93	9 M TRAWL	2	325	BT	8	13	06APR92	9 M TRAWL	1	292	BT	9	14	326	33	1	372647

(continued)

APPENDIX TABLE D-3. (CONTINUED)

RECAPTURE							RELEASE											
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT	GROWTH	TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	IN MM	COND	NUMBER
01MAR93	9 M TRAWL	5	383	BT	7	11	03MAR89	9 M TRAWL	1	180	BT	9	14	1459	203	1	283900
10MAR93	9 M TRAWL	3	362	BT	10	16	04DEC91	9 M TRAWL	2	344	BT	1	2	462	18	1	346405
10MAR93	9 M TRAWL	2	245	BT	10	16	16MAR92	9 M TRAWL	1	222	BT	10	16	359	23	1	370749
16MAR93	9 M TRAWL	2	303	BT	10	16	09JAN92	9 M TRAWL	1	241	BT	6	10	432	62	1	351447
16MAR93	9 M TRAWL	2	287	BT	10	16	09JAN92	9 M TRAWL	1	225	BT	10	16	432	62	2	351659
16MAR93	9 M TRAWL	2	315	BT	9	14	07APR92	9 M TRAWL	1	228	BT	8	13	343	87	1	372716
19MAR93	9 M TRAWL	2	336	BT	7	11	08NOV91	9 M TRAWL	1	254	BT	1	2	497	82	1	342571
22MAR93	9 M TRAWL	1	271	BT	9	14	02JAN92	9 M TRAWL	0	188	BT	1	2	445	83	1	350544
30MAR93	9 M TRAWL	2	317	BT	8	13	11FEB92	9 M TRAWL	1	237	BT	7	11	413	80	1	365921
30MAR93	9 M TRAWL	2	308	BT	8	13	22APR92	9 M TRAWL	1	223	BT	6	10	342	85	1	374782
01APR93	9 M TRAWL	2	335	BT	8	13	12MAR92	9 M TRAWL	1	211	BT	10	16	385	124	1	370347
07APR93	9 M TRAWL	2	389	BT	9	14	27APR92	9 M TRAWL	1	275	BT	5	8	345	114	2	356728
08APR93	9 M TRAWL	2	335	BT	9	14	26MAR92	9 M TRAWL	1	260	BT	7	11	378	75	1	349857

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEWYORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																								
			2 NOV M=353	9 NOV M=404	16 NOV M=1424	23 NOV M=606	30 NOV M=1820	7 DEC M=1230	14 DEC M=1253	21 DEC M=394	28 DEC M=862	4 JAN M=1729	11 JAN M=629	18 JAN M=603	25 JAN M=1463	1 FEB M=678	8 FEB M=465	15 FEB M=1011	22 FEB M=1003	1 MAR M=401	8 MAR M=863	15 MAR M=597	22 MAR M=566	29 MAR M=1012	5 APR M=990	12 APR M=491	TOTAL M=20,847
2 NOV	360	R	2																								2
		R/M	0.00567																								0.00567
		R/C	0.00556																								0.00556
9 NOV	450	R	1	0																							1
		R/M	0.00283	0.00000																							0.00132
		R/C	0.00222	0.00000																							0.00222
16 NOV	1,554	R	0	2	37																						39
		R/M	0.00000	0.00495	0.02598																						0.01788
		R/C	0.00000	0.00129	0.02381																						0.02510
23 NOV	664	R	0	0	2	9																					11
		R/M	0.00000	0.00000	0.00140	0.01485																					0.00395
		R/C	0.00000	0.00000	0.00301	0.01355																					0.01657
30 NOV	1,966	R	0	3	3	4	8																				18
		R/M	0.00000	0.00743	0.00211	0.00660	0.00440																				0.00391
		R/C	0.00000	0.00153	0.00153	0.00203	0.00407																				0.00916
7 DEC	1,314	R	1	1	1	3	12	12																			30
		R/M	0.00283	0.00248	0.00070	0.00495	0.00659	0.00976																			0.00514
		R/C	0.00076	0.00076	0.00076	0.00228	0.00913	0.00913																			0.02283
14 DEC	1,360	R	0	0	1	0	1	1	6																		9
		R/M	0.00000	0.00000	0.00070	0.00000	0.00055	0.00081	0.00479																		0.00127
		R/C	0.00000	0.00000	0.00074	0.00000	0.00074	0.00074	0.00441																		0.00662
21 DEC	428	R	0	0	0	0	2	2	0	5																	9
		R/M	0.00000	0.00000	0.00000	0.00000	0.00110	0.00163	0.00000	0.01269																	0.00120
		R/C	0.00000	0.00000	0.00000	0.00000	0.00467	0.00467	0.00000	0.01168																	0.02103
28 DEC	958	R	0	0	1	0	1	0	0	2	14																18
		R/M	0.00000	0.00000	0.00070	0.00000	0.00055	0.00000	0.00000	0.00508	0.01624																0.00216
		R/C	0.00000	0.00000	0.00104	0.00000	0.00104	0.00000	0.00000	0.00209	0.01461																0.01879
4 JAN	1,864	R	1	0	2	0	3	2	0	1	5	8															22
		R/M	0.00283	0.00000	0.00140	0.00000	0.00165	0.00163	0.00000	0.00254	0.00580	0.00463															0.00218
		R/C	0.00054	0.00000	0.00107	0.00000	0.00161	0.00107	0.00000	0.00054	0.00268	0.00429															0.01180
11 JAN	669	R	0	0	0	0	0	0	0	1	0	1	4														6
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00254	0.00000	0.00058	0.00636														0.00056
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00149	0.00000	0.00149	0.00598														0.00897
18 JAN	665	R	0	0	1	0	3	0	0	0	1	2	0	1													8
		R/M	0.00000	0.00000	0.00070	0.00000	0.00165	0.00000	0.00000	0.00000	0.00116	0.00116	0.00000	0.00166													0.00071
		R/C	0.00000	0.00000	0.00150	0.00000	0.00451	0.00000	0.00000	0.00000	0.00150	0.00301	0.00000	0.00150													0.01203

(continued)

APPENDIX TABLE D-4. (CONTINUED)

	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																								
			2 NOV M=353	9 NOV M=404	16 NOV M=1424	23 NOV M=606	30 NOV M=1820	7 DEC M=1230	14 DEC M=1253	21 DEC M=394	28 DEC M=862	4 JAN M=1729	11 JAN M=629	18 JAN M=603	25 JAN M=1463	1 FEB M=678	8 FEB M=465	15 FEB M=1011	22 FEB M=1003	1 MAR M=401	8 MAR M=863	15 MAR M=597	22 MAR M=566	29 MAR M=1012	5 APR M=990	12 APR M=491	TOTAL M=20,847
25 JAN	1,637	R	0	1	0	0	5	1	3	0	4	3	0	2	5												24
		R/M	0.00000	0.00248	0.00000	0.00000	0.00275	0.00081	0.00239	0.00000	0.00464	0.00174	0.00000	0.00332	0.00342												0.00188
		R/C	0.00000	0.00061	0.00000	0.00000	0.00305	0.00061	0.00183	0.00000	0.00244	0.00183	0.00000	0.00122	0.00305												0.01466
1 FEB	767	R	0	1	0	0	1	0	1	0	1	0	0	0	2	0											6
		R/M	0.00000	0.00248	0.00000	0.00000	0.00055	0.00000	0.00080	0.00000	0.00116	0.00000	0.00000	0.00000	0.00137	0.00000											0.00045
		R/C	0.00000	0.00130	0.00000	0.00000	0.00130	0.00000	0.00130	0.00000	0.00130	0.00000	0.00000	0.00000	0.00261	0.00000											0.00782
8 FEB	512	R	0	0	0	0	0	1	0	0	1	1	0	2	3	2	0										10
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00081	0.00000	0.00000	0.00116	0.00058	0.00000	0.00332	0.00205	0.00295	0.00000										0.00072
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00195	0.00000	0.00000	0.00195	0.00195	0.00000	0.00391	0.00586	0.00391	0.00000										0.01953
15 FEB	1,119	R	1	0	0	0	1	2	1	2	0	6	0	2	2	2	1	4									24
		R/M	0.00283	0.00000	0.00000	0.00000	0.00055	0.00163	0.00080	0.00508	0.00000	0.00347	0.00000	0.00332	0.00137	0.00295	0.00215	0.00396									0 00161
		R/C	0.00089	0.00000	0.00000	0.00000	0.00089	0.00179	0.00089	0.00179	0.00000	0.00536	0.00000	0.00179	0.00179	0.00179	0.00089	0.00357									0.02145
22 FEB	1,135	R	0	0	0	1	1	1	0	0	2	1	1	1	1	1	0	3	4								17
		R/M	0.00000	0.00000	0.00000	0.00165	0.00055	0.00081	0.00000	0.00000	0.00232	0.00058	0.00159	0.00166	0.00068	0.00147	0.00000	0.00297	0.00399								0.00107
		R/C	0.00000	0.00000	0.00000	0.00088	0.00088	0.00088	0.00000	0.00000	0.00176	0.00088	0.00088	0.00088	0.00088	0.00088	0.00000	0.00264	0.00352								0 01498
1 MAR	463	R	0	0	0	0	0	0	0	0	0	2	1	0	0	0	2	1	1	2							9
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00116	0.00159	0.00000	0.00000	0.00000	0.00430	0.00099	0.00100	0.00499							0.00055
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00432	0.00216	0.00000	0.00000	0.00000	0.00432	0.00216	0.00216	0.00432							0.01944
8 MAR	929	R	2	1	0	1	1	1	0	0	0	0	1	0	2	1	0	2	0	0	3						15
		R/M	0.00567	0.00248	0.00000	0.00165	0.00055	0.00081	0.00000	0.00000	0.00000	0.00000	0.00159	0.00000	0.00137	0.00147	0.00000	0.00198	0.00000	0.00000	0.00348						0.00087
		R/C	0.00215	0.00108	0.00000	0.00108	0.00108	0.00108	0.00000	0.00000	0.00000	0.00000	0.00108	0.00000	0.00215	0.00108	0.00000	0.00215	0.00000	0.00000	0.00323						0.01615
15 MAR	662	R	0	3	0	0	1	1	0	1	1	2	1	1	1	0	1	2	0	3	0	1					19
		R/M	0.00000	0.00743	0.00000	0.00000	0.00055	0.00081	0.00000	0.00254	0.00116	0.00116	0.00159	0.00166	0.00068	0.00000	0.00215	0.00198	0.00000	0.00748	0.00000	0.00168					0.00107
		R/C	0.00000	0.00453	0.00000	0.00000	0.00151	0.00151	0.00000	0.00151	0.00151	0.00302	0.00151	0.00151	0.00151	0.00000	0.00151	0.00302	0.00000	0.00453	0.00000	0.00151					0.02870
22 MAR	625	R	0	0	0	0	0	0	0	1	0	1	0	1	2	1	1	1	2	2	1	2	4				19
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00254	0.00000	0.00058	0.00000	0.00166	0.00137	0.00147	0.00215	0.00099	0.00199	0.00499	0.00116	0.00335	0.00707				0.00104
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00160	0.00000	0.00160	0.00000	0.00160	0.00320	0.00160	0.00160	0.00160	0.00320	0.00320	0.00160	0.00320	0.00640				0.03040
29 MAR	1,228	R	0	0	1	0	1	1	0	1	0	2	0	0	1	0	0	1	2	0	2	0	0	1			13
		R/M	0.00000	0.00000	0.00070	0.00000	0.00055	0.00081	0.00000	0.00254	0.00000	0.00116	0.00000	0.00000	0.00068	0.00000	0.00000	0.00099	0.00199	0.00000	0.00232	0.00000	0.00000	0.00099			0.00067
		R/C	0.00000	0.00000	0.00081	0.00000	0.00081	0.00081	0.00000	0.00081	0.00000	0.00163	0.00000	0.00000	0.00081	0.00000	0.00000	0.00081	0.00163	0.00000	0.00163	0.00000	0.00000	0.00081			0.01059
5 APR	1,138	R	0	0	1	1	4	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	1	0		11
		R/M	0.00000	0.00000	0.00070	0.00165	0.00220	0.00000	0.00000	0.00000	0.00000	0.00058	0.00000	0.00166	0.00000	0.00000	0.00000	0.00099	0.00000	0.00000	0.00000	0.00000	0.00177	0.00099	0.00000		0.00054
		R/C	0.00000	0.00000	0.00088	0.00088	0.00351	0.00000	0.00000	0.00000	0.00000	0.00088	0.00000	0.00088	0.00000	0.00000	0.00000	0.00088	0.00000	0.00000	0.00000	0.00000	0.00088	0.00088	0.00000		0.00967
12 APR	529	R	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	5
		R/M	0.00000	0.00000	0.00070	0.00000	0.00000	0.00000	0.00080	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00100	0.00000	0.00116	0.00168	0.00000	0.00000	0.00000	0.00000	0.00024
		R/C	0.00000	0.00000	0.00189	0.00000	0.00000	0.00000	0.00189	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00189	0.00000	0.00189	0.00189	0.00000	0.00000	0.00000	0.00000	0.00945
TOTALS	22,996	R	8	12	51	19	45	25	12	14	29	30	8	11	19	7	5	15	10	7	7	4	5	2	0	0	345
		R/M	0.02266	0.02970	0.03581	0.03135	0.02473	0.02033	0.00958	0.03553	0.03364	0.01735	0.01272	0.01824	0.01299	0.01032	0.01075	0.01484	0.00997	0.01746	0.00811	0.00670	0.00883	0.00198	0.00000	0.00000	0.01655
		R/C	0.00035	0.00052	0.00222	0.00083	0.00196	0.00109	0.00052	0.00061	0.00126	0.00130	0.00035	0.00048	0.00083	0.00030	0.00022	0.00065	0.00043	0.00030	0.00030	0.00017	0.00022	0.00009	0.00000	0.00000	0.01500

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR THE HUDSON RIVER STRIPED BASS CAPTURED WITH ABRADED TAGS, 2 NOVEMBER 1992 THROUGH 16 APRIL 1993.

RECAPTURE					RELEASE					TAG INFORMATION		TAG CONDITION					
DATE (DD/MM/YY)	GEAR	STA-TION	RM	LENGTH (mm TL)	DATE (DD/MM/YY	GEAR	STA-TION	RM	LENGTH (mm TL)	M_C	TAG NUMBER	NUMBER	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	TAG CONDITION
FEB 26 93	9m	BT	8	570	FEB 24 87	12m	BT	1	313	96	27107	3	3	3	P	N	1

LEGEND: Gear 9m = 9m trawl

Station BT = Battery
NY = Upper Harbor

M_C 98 = Hallprint internatal anchor, external streamer tag

Tag Condition
1 = Tag present, wound healed
2 = Tag present, wound poorly healed, evidence of infection or swelling

TAG VARIABLE	COMMENT CODE	COMMENT DESCRIPTION
Number	1,2,3, or 4	1 = Legend completely missing
Address	1,2,3, or 4	2 = Abraded and partly missing
Reward	1,2,3, or 4	3 = Abraded but completely legible
		4 = Completely legible
Number orientation	A or P	A = Tag number facing anterior(Head)
		p = Tag number facing posterior(Tail)
Anchor protrusion	Y or N	Y = Yes
		N = No

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE ATLANTIC TOMCOD POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1992-93.

SAMPLING WEEK	(>150 mTL) C TOTAL	(>150 mTL) M TOTAL	CUM M TOTAL	R TOTAL	R/C	Ct*Cumm Mt	Cumm Mt*Rt	Ct*(Cumm Mt)2	Rt2/Ct
NOV 23 92	664	606	0	0	0.0000	0	0	0	0.0000
NOV 30 92	1,966	1,820	606	4	0.0020	1,191,396	2,424	721,985,976	0.0081
DEC 7 92	1,314	1,230	2,426	15	0.0114	3,187,764	36,390	7,733,515,464	0.1712
DEC 14 92	1,360	1,253	3,656	2	0.0015	4,972,160	7,312	18,178,216,960	0.0029
DEC 21 92	428	394	4,909	4	0.0093	2,101,052	19,636	10,314,064,268	0.0374
DEC 28 92	958	862	5,303	3	0.0031	5,080,274	15,909	26,940,693,022	0.0000
JAN 4 93	1,864	1,729	6,165	11	0.0059	11,491,560	67,815	70,845,467,400	0.0021
JAN 11 93	669	629	7,894	2	0.0030	5,281,086	15,788	41,688,892,884	0.0538
JAN 18 93	665	603	8,523	6	0.0090	5,667,795	51,138	48,306,616,785	0.4872
JAN 25 93	1,637	1,463	9,126	18	0.0110	14,939,262	164,268	136,335,705,012	0.1979
FEB 1 93	767	678	10,589	5	0.0065	8,121,763	52,945	86,001,348,407	0.0326
FEB 8 93	512	465	11,267	10	0.0195	5,768,704	112,670	64,995,987,968	0.1953
FEB 15 93	1,119	1,011	11,732	19	0.0170	13,128,108	222,908	154,018,963,056	0.3226
FEB 22 93	1,135	1,003	12,743	13	0.0115	14,463,305	165,659	184,305,895,615	0.1489
MAR 1 93	463	401	13,746	7	0.0151	6,364,398	96,222	87,485,014,908	0.1058
MAR 8 93	929	863	14,147	9	0.0097	13,142,563	127,323	185,927,838,761	0.0872
MAR 15 93	662	597	15,010	15	0.0227	9,936,620	225,150	149,148,666,200	0.3399
TOTAL	17,112	15,607	15,607	143	0.0084	124,837,810	1,383,557	1,272,948,872,686	2.1931

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 23 NOVEMBER 1992 THROUGH THE WEEK OF 15 MARCH 1993.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00185	0.00185	94.17	0.0001
Error	16	0.00031	0.00002		
Total	17	0.00216			

Regression Equation: R/C = (Cumulative M) X + error,

where,

X = 0.00000112 and

Standard Error of X = 0.00000012

R^2 = coefficient of determination = 0.855

df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F-ratio
p>F = probability of obtaining a larger F-ratio

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS PROGRAM, 1984 TO PRESENT.

PROGRAM YEAR	NUMBER TAGGED	TAG TYPE					
		ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)[a]	MODIFIED INTERNAL ANCHOR (HALL)[a]	SMALL DART (HALL)[a]
1984	737	737[b]	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819[b]
1989-1990	24,362	--	--	--	--	24,362	659[b]
1990-1991	22,406	--	--	--	--	22,406	--
1991-1992	24,307[c]	--	--	--	--	24,307[c]	--
1992-1993	21,746[d]	--	--	--	--	21,746[d]	--
TOTAL	158,305	737[b]	28,041	4,575	16,402	109,287	1,478[b]

[a]Hall - Hallprint.

[b]Not included in row total because fish were double tagged.

[c]Total includes 23,514 fish tagged and released in good condition (REL_REC = 1) and 793 fish tagged and released with one or more external anomalies (REL_REC = 6).

[d]Total includes 20,847 fish that were tagged and released in good condition (REL_REC = 1) and 899 fish tagged and released with one or more external anomalies (REL_REC = 6).

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RELEASED DURING THE 1992-93 HUDSON RIVER PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$5-$1000	9,771
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	6,034
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$15-$1000	3,952
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	$10-$1000	1,989
1992-93 TOTAL:				21,746

*Striped bass ≥ 150 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

Total includes 20,847 fish that were tagged and released in good condition (REL_REC = 1) and 899 fish tagged and released with one or more external anomalies (REL_REC = 6).

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 2 November 1992 and 16 April 1993 were taken to the Peekskill, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1985-86 through 1991-92 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS

Length, weight, sex, and sexual condition were determined for 405 striped bass that died during field sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-1.

E.2.2 Striped Bass Stomach Contents Analysis

A sample of 392 striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass were most abundant in the biocharacteristics samples from the 1992-93 striped bass program (Tables E-2 and E-3). The majority (97%) of the female striped bass examined were in the immature stage. The remaining 3% of the females were in the resting stage. Male striped bass followed a similar pattern with 69% in the immature stage and 26% in the resting stage. Nine male striped bass captured in January through April were in the developing stage. No striped bass of either sex in the ripe, or ripe and running stages were examined.

The lack of ripe, or ripe and running striped bass in the 1992-93 biocharacteristics samples agrees with the findings of the 1985-86 through 1991-92 programs (Tables E-3 and E-4). In previous programs the majority of female fish (94%) were immature and no female fish in the developing or ripe stages were examined. The majority of male fish examined from previous programs were in the immature (56%) and resting (24%) stages with the remainder in the developing stage (21%). The lack of ripe or ripe and running striped bass is not surprising because the majority of the fish captured in these programs were of pre-spawning size (< 400 mm) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the developing stage with time during the 1985-86 through 1992-93 programs indicated the approach of the spawning season, and that male striped bass may undergo a longer period of gonadal development prior to spawning than females. Due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature or resting.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 392 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Only 22 fish were captured in the larger (> 400 mm) length groups and a high percentage of stomachs were empty (55.1%) which made generalizations about changes in food habits with length difficult (Table E-5). Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and the majority of those were clupeids, or *Morone* sp. as incidentally noted by laboratory personnel.

Percentage of non-empty striped bass stomachs with invertebrate remains in their stomachs decreased with increasing length group (Table E-5). This is in general agreement with the findings from the 1985-86 Hudson River striped bass program where invertebrate remains were most common in striped bass ≤300 mm (NAI 1986), and with findings from the 1987-88, 1989-90, and 1991-92 programs where invertebrates were most common in striped bass ≤200 mm (NAI 1994). Invertebrate remains were most common in the 301-400 mm length group during the 1986-87 program (NAI 1987). Forty-eight fish were examined with fish remains in their stomachs during the 1992-93 program. The majority of these fish were greater than 200 mm and 34 of these fish also had invertebrates present in their stomachs.

The percentage of non-empty striped bass with fish remains in their stomachs increased with length in the 1992-93 program.

The sample sizes for food habit analyses from individual programs were generally too small to identify trends. However, when the foods habit data from the 1985-86 through 1992-93 programs were pooled several trends became evident (Table E-6). Invertebrates were the dominant prey item in striped bass stomachs examined as 39% contained invertebrate remains. A change in food habits was apparent when striped bass reached about 300 mm as the importance of invertebrates as a prey item decreased. About 45-47% of the striped bass less than 300 mm had invertebrates only in their stomachs while 8-25% of the stomachs of striped bass greater than 300 mm contained invertebrates only.

The percentage of striped bass with empty stomachs (45%) was greater than the percentage with invertebrate only remains in their stomachs. The percentage of striped bass with empty stomachs was relatively constant for length groups up to 400 mm. The majority of striped bass larger than 400 mm (56-67%) had empty stomachs.

Invertebrates and vertebrates were found in 11% of the stomachs examined. The importance of invertebrates and fish combined as food items increased in length groups greater than 300 mm as 8-18% of the stomachs in these length groups contained both invertebrates and fish. About 3-8% of the striped bass less than 300 had both invertebrates and vertebrates in their stomachs.

Only 6% of the stomachs examined contained fish. Fish were a more numerous prey item in larger striped bass as 11-17% of the striped bass in length groups larger than 300 mm contained fish. Only 2-5% of the fish less than 300 mm contained fish only in their stomachs. The trend of increasing importance of fish as food items as striped bass length increases has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). No Atlantic tomcod were observed in any of the 1,473 striped bass stomachs examined since 1985.

TABLE E-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS[a].

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, less firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and string-like, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in exture, but milt not running.

[a]From Con Edison Data Dictionary

APPENDIX TABLE E-2. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1992-93 PROGRAM.

PERCENTAGE (NUMBER) OF STRIPED BASS

	FEMALES					MALES					UNDETERMINED				
MONTH	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL	IMMATURE	RESTING	DEVELOPING	RIPE	TOTAL
NOV	100 (11)	(0)			100 (11)	62 (8)	38 (5)			100 (13)	100 (1)				100 (1)
DEC	92 (20)	9 (2)			100 (22)	60 (18)	40 (12)			100 (30)	100 (5)				100 (5)
JAN	100 (32)	(0)			100 (32)	38 (9)	58 (14)	4 (1)		100 (24)	100 (4)				100 (4)
FEB	96 (25)	4 (1)			100 (26)	41 (9)	55 (12)	4 (1)		100 (22)					
MAR	100 (46)	(0)			100 (46)	86 (36)	5 (2)	9 (4)		100 (42)	100 (5)				100 (5)
APR	97 (57)	3 (2)			100 (59)	87 (48)	7 (4)	5 (3)		100 (55)	100 (8)				100 (8)
TOTAL	97 (191)	3 (5)			100 (196)	69 (128)	26 (49)	5 (9)		100 (186)	100 (23)				100 (23)

APPENDIX TABLE E-3. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1992-93 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
98	8.2	24MAR93	BATTERY	10	UNDETERMINED	IMMATURE	EMPTY
100	7.7	16MAR93	BATTERY	10	UNDETERMINED	IMMATURE	INVERTS
103	8.4	15JAN93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
106	9.4	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
106	10.1	12APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	8.3	15JAN93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	11.2	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	11.6	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
120	13.6	06APR93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
121	15.6	05APR93	BATTERY	5	UNDETERMINED	IMMATURE	EMPTY
128	15.5	15JAN93	BATTERY	9	MALE	IMMATURE	INVERTS
146	25.9	25MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
150	29.6	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
152	28.8	31DEC92	BATTERY	1	UNDETERMINED	IMMATURE	INVERTS
152	27.8	29MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
153	27.6	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
153	31.3	05APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
153	32.4	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
154	29.2	26FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
154	32.3	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
155	22.0	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
155	32.4	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
156	31.1	08MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
157	30.5	13JAN93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
157	31.9	31MAR93	BATTERY	8	UNDETERMINED	IMMATURE	EMPTY
158	32.2	25FEB93	BATTERY	7	MALE	IMMATURE	EMPTY
158	33.4	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
158	32.6	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
158	31.4	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
158	31.9	12APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
159	31.3	21JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
160	30.9	01DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
160	36.2	28JAN93	BATTERY	7	UNDETERMINED	IMMATURE	INVERTS
160	35.3	05MAR93	BATTERY	6	MALE	IMMATURE	INVERTS
160	33.6	19MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
160	36.4	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
161	31.1	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
161	37.9	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
162	35.6	05MAR93	BATTERY	6	FEMALE	IMMATURE	EMPTY
162	37.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
162	34.2	02APR93	BATTERY	8	MALE	IMMATURE	EMPTY
163	36.6	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
163	39.8	17MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
164	33.2	31DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS
164	38.6	27JAN93	BATTERY	7	FEMALE	IMMATURE	INVERTS
164	37.9	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
165	40.6	18FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
165	36.6	03MAR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
165	39.4	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
165	36.6	06APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
165	36.8	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
166	30.8	30DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
166	38.6	23FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
167	36.5	29DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
167	36.5	14JAN93	BATTERY	9	MALE	IMMATURE	INVERTS
167	35.9	30MAR93	BATTERY	8	UNDETERMINED	IMMATURE	INVERTS
167	36.7	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
168	36.0	01APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
168	35.7	06APR93	BATTERY	9	MALE	IMMATURE	INVERTS
168	41.6	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
170	40.5	23NOV92	BATTERY	1	UNDETERMINED	IMMATURE	INVERTS
170	42.3	23FEB93	BATTERY	8	MALE	IMMATURE	INVERTS
170	36.6	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
170	40.7	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
170	44.9	09APR93	BATTERY	9	HERMAPHRODITE	IMMATURE	VERTS
171	37.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
172	38.2	22JAN93	BATTERY	1	FEMALE	IMMATURE	EMPTY
172	41.1	28JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
172	42.7	08MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
172	42.9	08MAR93	BATTERY	7	FEMALE	IMMATURE	EMPTY
172	43.4	17MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
172	41.4	26MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	42.0	30MAR93	BATTERY	7	MALE	IMMATURE	INVERTS
172	42.2	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
172	41.9	06APR93	BATTERY	8	MALE	IMMATURE	INVERTS AND VERTS
173	33.1	02DEC92	BATTERY	5	UNDETERMINED	IMMATURE	EMPTY
173	40.2	29DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
173	40.4	29MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
173	37.9	30MAR93	BATTERY	8	UNDETERMINED	IMMATURE	INVERTS
173	45.6	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
174	40.5	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
175	43.4	19MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
175	49.8	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
175	40.5	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
175	44.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
176	39.6	02DEC92	BATTERY	5	UNDETERMINED	IMMATURE	INVERTS
176	45.0	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
177	38.6	28JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
177	45.0	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
177	44.4	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
177	47.4	29MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
177	46.5	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
177	45.4	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
177	43.4	15APR93	BATTERY	9	MALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
178	50.8	27JAN93	UPPER HARBOR	3	MALE	RESTING	INVERTS
178	43.4	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
178	50.6	14APR93	BATTERY	9	MALE	IMMATURE	EMPTY
179	48.3	21JAN93	BATTERY	5	MALE	IMMATURE	INVERTS
179	72.6	08FEB93	BATTERY	5	MALE	IMMATURE	
179	48.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
179	51.0	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	49.2	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	50.0	06APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	45.9	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
180	53.3	09DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS
180	53.3	27JAN93	BATTERY	3	MALE	IMMATURE	INVERTS
180	40.9	01APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
180	43.5	02APR93	BATTERY	8	MALE	IMMATURE	INVERTS
180	54.5	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
181	50.7	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
181	49.9	02APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
181	50.4	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
182	47.9	02APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
182	150.7	05APR93	BATTERY	9	MALE	IMMATURE	EMPTY
183	55.3	18FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
183	57.2	25FEB93	BATTERY	8	MALE	IMMATURE	EMPTY
183	52.1	17MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
183	49.4	12APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
183	52.2	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS
184	51.3	30NOV92	BATTERY	5	MALE	IMMATURE	EMPTY
184	56.0	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
184	55.6	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
184	50.0	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
184	48.5	31MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
184	52.1	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
184	52.4	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
184	48.9	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
185	53.1	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
185	53.1	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
186	48.8	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
186	52.5	08MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
186	54.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
187	58.7	22JAN93	BATTERY	1	FEMALE	IMMATURE	EMPTY
187	52.7	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
187	55.3	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
188	52.0	01DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
188	50.1	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
189	55.8	18FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
190	66.2	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS
190	65.5	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
190	56.7	17MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
190	60.9	07APR93	BATTERY	9	MALE	IMMATURE	EMPTY
190	59.1	09APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
191	57.7	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
191	56.7	06APR93	BATTERY	9	MALE	IMMATURE	INVERTS
191	61.4	07APR93	BATTERY	9	MALE	IMMATURE	INVERTS
192	52.6	30DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
192	57.5	10MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
192	59.3	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
192	52.0	01APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
192	60.9	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
193	58.0	29DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
193	55.5	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
194	57.8	28DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
194	58.2	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
194	65.2	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
194	54.8	01APR93	BATTERY	8	MALE	IMMATURE	EMPTY
194	53.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
195	68.5	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
195	60.9	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
195	62.1	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
195	62.0	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
196	72.0	23DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
196	59.2	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
196	65.4	01APR93	BATTERY	9	MALE	IMMATURE	INVERTS
196	55.6	09APR93	BATTERY	9	MALE	IMMATURE	INVERTS
197	54.4	31DEC92	BATTERY	1	MALE	IMMATURE	INVERTS
197	63.0	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
197	65.5	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
198	61.2	29MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
198	70.6	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
198	67.4	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
198	62.7	12APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
199	65.7	21JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
199	69.3	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
199	72.5	24MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
199	64.3	05APR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
200	62.4	17MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
201	75.3	30MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
201	63.2	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
202	66.1	29JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
202	69.3	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
204	71.7	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
205	80.8	26JAN93	BATTERY	1	MALE	DEVELOPING	INVERTS
205	73.3	01APR93	BATTERY	9	MALE	IMMATURE	EMPTY
206	49.0	16MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
206	73.3	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
207	74.8	02FEB93	BATTERY	5	FEMALE	IMMATURE	INVERTS
207	83.3	30MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
207	75.1	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
208	89.2	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS AND VERTS
208	86.9	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
208	81.2	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
209	81.9	27JAN93	BATTERY	1	FEMALE	IMMATURE	INVERTS
210	70.1	07DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
210	65.5	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
211	84.8	10DEC92	BATTERY	1	UNDETERMINED	IMMATURE	EMPTY
211	75.1	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
212	74.2	30MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
212	79.2	31MAR93	BATTERY	7	MALE	IMMATURE	EMPTY
214	88.8	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
214	90.6	29JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
214	88.9	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
215	84.5	24FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
216	81.0	21JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
216	85.7	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
217	98.1	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
218	91.7	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
219	78.4	07DEC92	BATTERY	5	UNDETERMINED	IMMATURE	INVERTS AND VERTS
219	89.0	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
219	91.0	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
220	101.1	30MAR93	BATTERY	7	MALE	DEVELOPING	INVERTS
221	82.1	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
222	102.6	28JAN93	BATTERY	7	MALE	RESTING	EMPTY
222	99.8	17MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
222	86.6	25MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
223	89.6	07DEC92	BATTERY	5	MALE	IMMATURE	INVERTS
223	100.0	05APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
223	91.6	14APR93	BATTERY	9	MALE	IMMATURE	INVERTS
224	96.7	22JAN93	BATTERY	1	FEMALE	IMMATURE	INVERTS
225	92.2	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
226	90.7	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
227	103.0	15JAN93	BATTERY	9	MALE	IMMATURE	VERTS
227	105.1	30MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
228	114.0	22JAN93	BATTERY	1	MALE	RESTING	INVERTS
228	104.3	25JAN93	BATTERY	1	FEMALE	IMMATURE	
228	106.3	26JAN93	BATTERY	1	MALE	RESTING	EMPTY
229	101.8	30NOV92	BATTERY	5	MALE	IMMATURE	EMPTY
229	105.1	26JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
229	109.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
230	101.9	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
230	119.0	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
230	105.5	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
231	117.8	02FEB93	BATTERY	5	MALE	IMMATURE	EMPTY
231	105.1	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
231	104.2	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
232	123.3	25FEB93	BATTERY	8	MALE	RESTING	EMPTY
232	113.3	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
232	101.3	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
232	107.1	07APR93	BATTERY	9	MALE	IMMATURE	INVERTS
233	122.7	23NOV92	BATTERY	1	MALE	IMMATURE	EMPTY
236	112.2	02FEB93	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
236	107.6	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
237	114.4	07DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
237	118.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
237	128.3	05APR93	BATTERY	9	MALE	IMMATURE	EMPTY
238	129.0	16FEB93	BATTERY	8	MALE	DEVELOPING	INVERTS
238	104.7	31MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
241	145.4	19NOV92	BATTERY	1	MALE	IMMATURE	EMPTY
241	123.9	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
242	123.4	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
243	123.3	25FEB93	BATTERY	8	MALE	IMMATURE	INVERTS
244	128.0	16APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
246	130.0	28JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
247	153.5	28JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
247	132.2	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
247	141.4	30MAR93	BATTERY	9	MALE	DEVELOPING	INVERTS
250	143.7	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS
251	162.9	03MAR93	BATTERY	6	MALE	RESTING	EMPTY
251	143.3	02APR93	BATTERY	9	MALE	RESTING	EMPTY
251	174.8	05APR93	BATTERY	7	MALE	DEVELOPING	EMPTY
252	150.0	30DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
254	181.4	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
254	135.9	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
255	204.0	02FEB93	BATTERY	8	MALE	RESTING	EMPTY
255	150.1	08APR93	BATTERY	9	MALE	IMMATURE	INVERTS
256	146.8	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
257	180.0	30DEC92	BATTERY	1	MALE	IMMATURE	INVERTS
257	134.0	01APR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
258	154.7	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
260	144.7	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
260	151.4	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
261	164.3	31DEC92	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
261	164.0	27JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
262	199.9	18DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
262	200.9	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
263	226.1	28JAN93	BATTERY	9	MALE	RESTING	EMPTY
263	150.1	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
263	185.5	05APR93	BATTERY	5	FEMALE	IMMATURE	VERTS
264	170.5	11FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
265	205.6	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	EMPTY
266	168.6	05JAN93	UPPER HARBOR	3	MALE	IMMATURE	EMPTY
267	182.8	01FEB93	BATTERY	5	MALE	RESTING	EMPTY
267	186.4	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS AND VERTS
268	155.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
269	172.6	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
270	200.0	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
270	184.3	12APR93	BATTERY	9	MALE	IMMATURE	EMPTY
271	215.5	22JAN93	BATTERY	1	MALE	RESTING	EMPTY
272	208.3	24MAR93	BATTERY	0	FEMALE	IMMATURE	EMPTY
272	198.3	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
273	187.9	05APR93	BATTERY	9	MALE	IMMATURE	VERTS
275	172.6	08APR93	BATTERY	9	MALE	RESTING	INVERTS
276	209.1	19NOV92	BATTERY	1	MALE	IMMATURE	INVERTS
276	186.7	01DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS
276	184.2	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
279	208.7	29MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
280	202.4	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
281	291.8	10FEB93	BATTERY	7	FEMALE	IMMATURE	EMPTY
281	201.4	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS
283	181.6	19FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
283	228.3	24FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
285	179.1	30DEC92	BATTERY	1	FEMALE	IMMATURE	EMPTY
285	218.3	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
286	240.5	11FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
288	223.0	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
289	223.2	05APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
290	230.3	19NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
292	295.0	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
293	243.0	21DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
293	246.1	08APR93	BATTERY	9	MALE	RESTING	EMPTY
294	247.7	23FEB93	BATTERY	7	MALE	RESTING	INVERTS AND VERTS
296	316.1	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
296	266.4	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
297	230.3	17MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
299	258.5	12NOV92	BATTERY	8	FEMALE	IMMATURE	EMPTY
300	261.1	28JAN93	BATTERY	9	MALE	RESTING	EMPTY
300	219.5	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
301	242.3	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
305	260.3	13NOV92	BATTERY	5	MALE	RESTING	INVERTS
305	284.1	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
306	205.9	25JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
308	303.9	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
309	276.0	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
309	254.0	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
311	258.9	12NOV92	BATTERY	8	MALE	IMMATURE	INVERTS
311	311.1	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
312	290.3	07JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
315	297.6	08FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
316	357.7	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
316	254.1	26FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
317	297.0	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
318	301.5	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
320	329.5	03DEC92	BATTERY	5	MALE	RESTING	INVERTS AND VERTS

(continued)

\PPENDIX TABLE E-3. (CONTINUED)

.ENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
400	731.0	16DEC92	UPPER HARBOR	2	FEMALE	IMMATURE	EMPTY
401	494.7	01DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
403	603.0	12NOV92	BATTERY	8	MALE	RESTING	EMPTY
410	814.0	23FEB93	BATTERY	10	FEMALE	IMMATURE	EMPTY
413	762.0	10FEB93	BATTERY	7	MALE	RESTING	VERTS
415	699.0	05JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	EMPTY
420	750.1	06APR93	BATTERY	9	FEMALE	RESTING	INVERTS
421	779.0	09NOV92	BATTERY	9	FEMALE	IMMATURE	EMPTY
421	786.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
428	727.0	22JAN93	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
429	722.0	07DEC92	BATTERY	1	MALE	RESTING	EMPTY
430	860.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
435	817.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
435	846.0	18DEC92	UPPER HARBOR	2	MALE	RESTING	EMPTY
438	994.0	16DEC92	UPPER HARBOR	3	MALE	RESTING	INVERTS AND VERTS
444	671.0	17NOV92	BATTERY	1	FEMALE	IMMATURE	VERTS
457	1013.0	25NOV92	UPPER HARBOR	2	FEMALE	IMMATURE	EMPTY
474	1086.0	25NOV92	UPPER HARBOR	2	FEMALE	IMMATURE	INVERTS
478	1080.0	25JAN93	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
515	1426.0	24NOV92	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
529	1557.0	02DEC92	UPPER HARBOR	2	FEMALE	RESTING	EMPTY
649	3200.0	25NOV92	UPPER HARBOR	2	MALE	RESTING	VERTS
668	3302.0	25NOV92	UPPER HARBOR	2	MALE	RESTING	VERTS

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
269	172.6	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
270	200.0	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
270	184.3	12APR93	BATTERY	9	MALE	IMMATURE	EMPTY
271	215.5	22JAN93	BATTERY	1	MALE	RESTING	EMPTY
272	208.3	24MAR93	BATTERY	0	FEMALE	IMMATURE	EMPTY
272	198.3	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
273	187.9	05APR93	BATTERY	9	MALE	IMMATURE	VERTS
275	172.6	08APR93	BATTERY	9	MALE	RESTING	INVERTS
276	209.1	19NOV92	BATTERY	1	MALE	IMMATURE	INVERTS
276	186.7	01DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS
276	184.2	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
279	208.7	29MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
280	202.4	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
281	291.8	10FEB93	BATTERY	7	FEMALE	IMMATURE	EMPTY
281	201.4	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS
283	181.6	19FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
283	228.3	24FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
285	179.1	30DEC92	BATTERY	1	FEMALE	IMMATURE	EMPTY
285	218.3	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
286	240.5	11FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
288	223.0	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
289	223.2	05APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
290	230.3	19NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
292	295.0	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
293	243.0	21DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
293	246.1	08APR93	BATTERY	9	MALE	RESTING	EMPTY
294	247.7	23FEB93	BATTERY	7	MALE	RESTING	INVERTS AND VERTS
296	316.1	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
296	266.4	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
297	230.3	17MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
299	258.5	12NOV92	BATTERY	8	FEMALE	IMMATURE	EMPTY
300	261.1	28JAN93	BATTERY	9	MALE	RESTING	EMPTY
300	219.5	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
301	242.3	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
305	260.3	13NOV92	BATTERY	5	MALE	RESTING	INVERTS
305	284.1	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
306	205.9	25JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
308	303.9	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
309	276.0	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
309	254.0	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
311	258.9	12NOV92	BATTERY	8	MALE	IMMATURE	INVERTS
311	311.1	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
312	290.3	07JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
315	297.6	08FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
316	357.7	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
316	254.1	26FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
317	297.0	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
318	301.5	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
320	329.5	03DEC92	BATTERY	5	MALE	RESTING	INVERTS AND VERTS

(continued)

APPENDIX TABLE E-4. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1985-86 THROUGH 1992-93 PROGRAMS.

MONTH	IMMATURE MALES PROGRAM 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	TOTAL	MONTHLY %
NOV	0	0	1	1	4	6	6	8	26	62
DEC	16	2	2	7	2	12	13	18	72	60
JAN	13	7	5	10	5	16	57	9	122	68
FEB	8	9	17	6	1	11	24	9	85	62
MAR	11	10	8	5	2	7	3	36	82	65
APR	12	14	0	2	2	3	27	48	108	48
MAY	0	0	0	0	0	0	0	0	0	0
TOTAL	60	42	33	31	16	55	130	128	495	59

MONTH	RESTING MALES PROGRAM 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	TOTAL	MONTHLY %
NOV	1	0	1	1	1	1	4	5	14	33
DEC	0	0	4	5	1	6	7	12	35	29
JAN	0	1	9	1	0	2	14	14	41	23
FEB	0	1	0	0	0	9	9	12	31	23
MAR	0	8	0	0	0	3	6	2	19	15
APR	0	45	0	0	0	2	10	4	61	27
MAY	5	0	0	0	0	0	0	5	5	100
TOTAL	6	55	14	7	2	23	50	49	206	25

MONTH	DEVELOPING MALES PROGRAM 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	TOTAL	MONTHLY %
NOV	1	0	1	0	0	0	0	0	2	5
DEC	11	1	1	0	0	0	0	0	13	11
JAN	9	6	1	0	0	0	1	0	17	9
FEB	10	1	7	3	0	0	0	0	21	15
MAR	7	12	2	3	0	2	0	0	26	20
APR	50	2	3	0	0	1	1	0	57	25
MAY	0	0	0	0	0	0	0	0	0	0
TOTAL	88	22	15	6	0	3	2	0	136	16

MONTH	IMMATURE FEMALES PROGRAM 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	TOTAL	MONTHLY %
NOV	1	0	4	1	4	1	4	11	26	96
DEC	28	1	4	9	3	10	13	20	88	94
JAN	17	3	11	9	6	8	55	32	141	93
FEB	9	10	18	7	3	14	29	25	115	98
MAR	16	16	8	9	3	13	6	46	117	98
APR	24	9	0	3	1	8	8	57	110	92
MAY	1	0	0	0	0	0	0	0	1	50
TOTAL	96	39	45	38	20	54	115	191	598	95

MONTH	RESTING FEMALES PROGRAM 85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	TOTAL	MONTHLY %
NOV	0	0	0	0	0	0	1	0	1	4
DEC	0	0	0	2	0	0	2	2	6	6
JAN	0	1	0	1	0	0	8	0	10	7
FEB	0	0	1	0	0	0	0	1	2	2
MAR	0	0	0	0	0	0	2	0	2	2
APR	0	0	0	0	0	0	8	2	10	10
MAY	1	0	0	0	0	0	0	0	1	50
TOTAL	1	1	1	3	0	0	21	5	32	5

APPENDIX TABLE E-5. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1992-93 PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS					
LENGTH GROUP (mm TL)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤200	42.8(74)	1.7(3)	0.0(0)	4.6(8)	50.9(88)	100.0(173)
201-300	30.3(40)	3.0(4)	0.0(0)	8.3(11)	58.3(77)	100.0(132)
301-400	18.5(12)	4.6(3)	0.0(0)	16.9(11)	60.0(39)	100.0(65)
401-500	11.1(2)	11.1(2)	0.0(0)	16.7(3)	61.1(11)	100.0(18)
>500	0.0(0)	50.0(2)	0.0(0)	25.0(1)	25.0(1)	100.0(4)
TOTAL	32.7(128)	3.6(14)	0.0(0)	8.7(34)	55.1(216)	100.0(392)

APPENDIX TABLE E-6. FOOD HABITS OF HUDSON RIVER STRIPED BASS CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 THROUGH 1992-93 PROGRAMS.

INVERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	TOTAL	LENGTH GROUP %
≤200	5	8	3	2	16	3	52	74	163	45
201-300	88	25	39	9	3	29	85	40	318	47
301-400	18	16	12	2	1	7	18	12	86	25
401-500	3	2	2	0	0	0	1	2	10	14
>500	1	0	1	0	0	0	0	0	2	8
TOTAL	115	51	57	13	20	39	156	128	579	39

VERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	TOTAL	LENGTH GROUP %
≤200	1	0	0	1	0	0	2	3	7	2
201-300	4	0	0	6	0	8	13	4	35	5
301-400	5	1	3	8	0	8	9	3	37	11
401-500	3	0	1	0	0	0	2	2	8	11
>500	1	0	0	0	0	0	1	2	4	17
TOTAL	14	1	4	15	0	16	27	14	91	6

INVERTEBRATES AND VERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	TOTAL	LENGTH GROUP %
≤200	1	0	0	1	0	0	2	8	12	3
201-300	4	3	4	2	0	8	25	11	57	8
301-400	8	6	3	7	2	4	21	11	62	18
401-500	1	3	1	2	1	1	1	3	13	18
>500	0	1	0	0	0	0	0	1	2	8
TOTAL	14	13	8	12	3	13	49	34	146	10

EMPTY

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	TOTAL	LENGTH GROUP %
≤200	2	20	1	13	11	7	38	88	180	50
201-300	43	18	15	26	9	35	43	77	266	39
301-400	41	8	12	13	1	23	18	39	155	46
401-500	12	3	7	2	0	3	2	11	40	56
>500	11	0	3	0	0	0	1	1	16	67
TOTAL	109	49	38	54	21	68	102	216	657	45

HUDSON RIVER STRIPED BASS STOCK

ASSESSMENT PROGRAM

NOVEMBER 1993 - APRIL 1994

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

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EXECUTIVE SUMMARY

- The winter of 1993-94 was the 20th coldest on record for New York City, and the coldest experienced in the history of the striped bass program. Bank-to-bank ice floes in the Battery region of the Hudson River limited access by the trawling crew during the weeks of 17 January through 21 February 1994, and influenced both within-program and among-program comparisons throughout this report.

- The estimated proportion of hatchery striped bass was 0.2% for Age 0+, 1.05% for Age 1+, and 0.05% for Age 4+ fish among the same age cohorts of striped bass caught in the Hudson River between 1 November 1993 and 20 April 1994.

- We caught only one Age 4+ hatchery striped bass, and did not statistically compare the mean length of hatchery and wild fish from the 1989 cohort due to this small sample. Hatchery striped bass of the 1990 and 1991 cohorts were not tagged prior to their release, and therefore could not be distinguished from wild fish. The mean length of Age 0+ hatchery and wild striped bass from the 1993 cohort were not significantly different based on overlapping 95% confidence limits, while the mean length of Age 1+ hatchery fish was significantly smaller than the mean length for wild fish of the 1992 cohort.

- The 1992 cohort of Age 1+ striped bass and the 1991 cohort of Age 2+ fish dominated the catch and population statistics for Hudson River striped bass during the 1993-94 program. Age 1+ and Age 2+ fish represented 57% and 29% respectively of the population ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in upper New York Harbor and the Battery region was 443,000 fish with lower and upper 95% confidence limits of 339,000 and 641,000. Age 0+ striped bass accounted for 28,000 fish in the mid-winter population, Age 1+ contributed 253,000 fish, Age 2+ contributed 129,000 fish, Age 3+ contributed 24,000 fish, and Age >3+ contributed 9,000 fish.

- During the 1993-94 striped bass program, 19,941 fish ≥150 mm were caught and 17,500 fish in good condition were tagged and released bringing the total number of striped bass tagged and released in these programs since 1984 to 174,113. An additional 810 fish with one or more gross external injuries were tagged and released in 1993-94, bring the total number of these fish tagged and released to 2,502. Of the 481 fish that were recaptured, 333 were tagged and released in the present program, 124 were from 1992-93, 19 were from 1991-92, 4 were from 1990-91, and one fish was from the 1989-90 program.

- Overall mean catch per unit of effort (CPUE) in the Battery region was 38.0 striped bass per ten minute tow. Mean CPUE during mid-December through mid-March increased annually from 1985-86 to a peak of 45.3 in the 1989-90 program. Mean CPUE decreased following 1989-90 to 40.7 in the 1990-91 program, 35.5 in the 1991-92 program, 32.7 in the 1992-93 program, and was 33.7 in 1993-94.

- Handling mortality was less than 2% and was comparable to previous programs even though smaller fish (between 150 and 200 mm) were tagged compared to programs prior to 1988-89. No relationship between water temperature and handling mortality was observed.

1.0 INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 three-inch striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York to address this requirement. Annual hatchery production and stocking resumed in 1991 under an agreement between the Hudson River utilities and the regulatory agencies. The total number of hatchery striped bass that were stocked into the Hudson River in each year is (EA 1994):

Year	Number Stocked
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,800
1988	48,611
1989	202,068
1990	234,387
1991	256,631
1992	210,746
1993	568,410
Total	2,868,304

Section 2.J and Attachment V of the Settlement Agreement stipulate that an annual biological monitoring program to evaluate mitigation measures be conducted through May 1991. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow the differentiation of hatchery-released striped bass from naturally-spawned striped bass. Striped bass produced and stocked during 1990 and 1991 were not tagged, however tagging of

hatchery-reared striped bass resumed in 1992. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that non-hatchery fish be released alive after capture, after they are examined for hatchery-administered CWTs. If these striped bass are tagged with an external tag and released, then their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could also be used to estimate annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986). Consequently, the hatchery evaluation program focused on estimating annual survival rate for Age 1+ and Age 2+.

The Hudson River striped bass program began in 1984 as an evaluation of fishing gear and techniques that were most efficient and effective to catch and handle striped bass. The best locations, times, and fishing gear were evaluated in the 1984 through 1987-88 programs to maximize total catch and catch per unit of effort of Age 1+ and Age 2+ striped bass. The Battery region of the Hudson River adjacent to Manhattan, and upper New York Harbor in the vicinity of Liberty Island provided the most consistent catches of Age 1+ and Age 2+ striped bass during the November through March period. The 9-m trawl was the most effective gear for capturing Age 1+ and Age 2+ striped bass, and has been the only gear used from 1988-89 through the present program (Table 1-1). Concurrent with these gear evaluations, handling techniques were improved to increase the survival of striped bass that were caught, tagged, scanned for hatchery-administered magnetic tags, and released (Dunning et. al. 1987, 1989). As the Verplanck hatchery increased the annual production of fish, and more striped bass were recaptured with hatchery-administered tags, we also quantified magnetic tag detection efficiency (Mattson et al. 1989) and improved the internal anchor-external streamer tag design (Mattson et al. 1989; Waldman et al. 1990).

The Hudson River striped bass program from 1988-89 to the present has become primarily a stock assessment program. We have emphasized consistency of sampling gear and procedures, and the refinement of laboratory techniques for scale examination to accurately determine age (eg. Humphreys et al. 1989). Mark-recapture estimates are calculated for the total population and for the Age 1+ and Age 2+ sub-populations of striped bass found in the

TABLE 1-1. COMPARISON OF SAMPLING DESIGNS AND SELECTED RESULTS OF THE 1984 THROUGH 1992-93 HUDSON RIVER STRIPED BASS PROGRAMS.

				CATCH STATISTICS							POPULATION ESTIMATES		
PROGRAM	GEAR	DATES	SAMPLING REGIONS	N-TOWS	CPUE	N-TOTAL	N-TAGGED	N-RECAPTURED	N-HATCHERY	HANDLING MORTALITY (%)	TOTAL (≥200 mm)	AGE 1+	HATCHERY PROPORTION AGE 1+ (%)
1984	12 m trawl	9Apr-7Jun	TZ,CH,IP, WP,CW,PK	200	2.8		345[a]		0	18	--	--	
	Scottish seine	9Apr-7Jun	TZ,CH,CW	139	2.2		392[a]		0	16	--	--	
	Total			339	2.6	1,620	737	0	0	17	--	--	0
1985-86	9 m trawl	11Nov-18May	BT	900	8.2		6,366		0	1			
	12 m trawl	11Nov-18May	BT,HR,ER,LH	346	20.7		7,265		0	2			
	Scottish seine	31Mar-18May	TZ,CH	226	19.4		4,856		0	1			
	Total			1,472	12.9	20,820	18,487	171	0	1	540,000	239,000	0
1986-87	9 m trawl	21Dec-9May	BT	845	9.8		5,349		74	1			
	12 m trawl	21Dec-9May	BT	219	24.1		4,039		20	1			
	Total		BT	1,064	12.7	14,136	9,388	261	94	1	394,000	108,000	1.7
1987-88	9 m trawl	9Nov-22Apr	BT	896	20.0	18,075	7,582		176	<1			
	12 m trawl	9Nov-22Apr	BT	296	33.9	10,117	4,854		62	<1			
	Total		BT	1,192	23.5	28,192	12,436	465	238	<1	295,000	181,000	1.6
1988-89	9 m trawl	31Oct-15Apr	BT	1,151	28.5	32,975	24,393	453	213	<1	890,000	794,000	0.2
1989-90	9 m trawl	31Oct-15Apr	BT	891	37.3	33,386	24,362	655	141	<1	528,000	397,000	0.4
1990-91	9 m trawl	12Nov-20Apr	BT	971	29.7	29,346	22,406	865	52	<1	786,000	352,000	0.2
1991-92	9 m trawl	4Nov-7May	BT	1,169	29.3	34,202	25,710	631	17	<1	967,000	709,000	[a]
1992-93	9 m trawl	2Nov-16Apr	BT	818	34.0	27,778	20,847	345	190	1.6	717,000	475,000	[a]

SAMPLING REGIONS: BT = Battery and Upper New York Harbor, Hudson River Miles 0-11 (km 0-18) and Upper New York Harbor. TZ + Tappan Zee, Hudson River Miles 24-33 (km 38-53).53). CH = Croton-Haverstraw, Hudron River Miles 34-38 (km 54-61). IP = Indian Point, Hudson River Miles 39-46 (km 62-74). CW = Cornwall, Hudson River Miles 56-61 (km 90-98). PK = Poughkeepsie, Hudson river miles 62-76 (km 99-122). HR = Harlem River. ER = East River. LH = Lower New York Harbor.

[a]Hatchery striped bass were not tagged before release in 1990 or 1991. Therefore an Age 1+ hatchery proportion was not computed.

combined Battery and upper New York Harbor regions during the winter. Program consistency is documented through the use of Standard Operating Procedures and a quality control/quality assurance system that has helped improve data quality (Geoghegan et al. 1989).

The April-June 1984 adult striped bass program (NAI 1985) demonstrated that it was effective to use a 12 m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass ≥300 mm (total length) could be externally tagged and released without significantly increasing 24-hour mortality (Dunning et al. 1987). No hatchery-tagged striped bass were recaptured during the 1984 program, and population estimates were not calculated from the relatively small sample of 737 external-tagged fish that were released (Table 1-1).

The 1985-86 Hudson River striped bass program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East Rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East Rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean catch per unit of effort for a 12 m trawl was greater than for a 9 m trawl, but total catch and mean catch per day were similar for the two trawls because more tows could be taken with the 9 m trawl in a day. The 12 m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9 m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm. Striped bass handling mortality was reduced from 17% in 1984 to 1% of less in programs from 1985-86 to present by using an in-water live car to hold the fish prior to tagging (Dunning et. al. 1989). No hatchery-tagged fish were recaptured during the 1985-86 program among the 20,820 striped bass examined for magnetic tags. The mid-winter population of striped bass ≥200 mm was estimated to be 540,000 fish in the Battery and Upper New York Harbor, and 239,000 of these fish were estimated to be Age 1+ (Table 1-1).

Data from the 1984 and 1985-86 programs (NAI 1985, 1986) were used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimator could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River striped bass program was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per ten minute tow for both the 9 and 12 m trawls. Use of a cod end liner (2.5 cm stretch mesh) in the 9 m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of a cod end liner in the 12 m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+ and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm, and 108,000 of these fish were Age 1+ (Table 1-1).

The 1987-88 Hudson River striped bass hatchery evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per ten minute tow for both the 9 m trawl and 12 m trawl with a cod end similar to the 9 m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one half of the catch. The 9 m trawl was more efficient than the 12 m trawl with a 9 m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (< 1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6%. The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm, and 181,000 of these fish were estimated to be Age 1+ (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990). The minimum size of striped bass that were tagged was lowered from 200 mm to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm, and an estimated 794,000 of the fish ≥200 mm were from the strong 1987 Age 1+ cohort (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort of Age 1+ fish (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm, and an estimated 397,000 of the fish ≥200 mm were from the strong 1988 Age 1+ cohort (Table 1-1).

The striped bass population over-wintering in the Battery and Upper Harbor during 1990-91 was estimated as 858,000 fish ≥150 mm or 786,000 fish ≥200 mm (Table 1-1). About 352,000 striped bass ≥200 mm were Age 1+ (NAI 1992). The 1989 cohort of Age 1+ hatchery fish was 0.2% of the Age 1+ catch.

The 1990 cohort of Age 1+ striped bass and the 1991 cohort of Age 0+ fish dominated the population statistics for fish caught in the Battery and Upper Harbor during the winter of 1991-92 (NAI 1994). The estimated size of the mid-winter striped bass population was 1,163,000 fish ≥150 mm or 967,000 fish ≥200 mm (Table 1-1). Age 1+ striped bass represented 791,000 fish among the population ≥150 mm and 709,000 fish ≥200 mm. Age 2+ and Age 3+ hatchery striped bass were each about 0.3% of the respective cohort's catch. Age

0+ and Age 1+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohorts.

The striped bass population found in the Battery and Upper Harbor during the winter of 1992-93 was estimated as 920,000 fish ≥150 mm or 717,000 fish ≥200 mm (Table 1-1). About 475,000 striped bass ≥200 mm were Age 1+ during 1992-93 (Table 1-1). The 1991 cohort of Age 1+ fish and the 1992 cohort of Age 0+ fish dominated the total catch, while Age 1+ and Age 2+ fish contributed most to the population estimate. Age 3+ hatchery fish from the 1989 cohort were 0.02% of the total catch of Age 3+ fish. Age 1+ and Age 2+ hatchery striped bass were not tagged with CWTs prior to tagging and could not be differentiated from wild fish of the same cohorts.

Objectives of the 1993-94 Hudson River striped bass stock assessment program were to:

1. tag all wild striped bass greater than or equal to 150 mm, that are in good condition, with internal anchor tags,
2. determine the catch rate and handling mortality of striped bass,
3. estimate the abundance of striped bass overwintering in the lower Hudson River,
4. describe the age composition of the overwintering population of striped bass,
5. determine if marked hatchery striped bass, stocked during any year since 1983, can be caught in the Hudson River population and
6. estimate the proportion of marked hatchery fish among the Age 0+ through Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

The winter of 1993-94 was extremely cold, and the resulting bank-to-bank ice floes we experienced during the mid-January through mid-February period limited our access to the Hudson River. The mean of 28.1°F for New York City air temperatures during January through February 1994 was tied for the 20th coldest for the 1876-1995 period of record, and was the coldest winter in the 1985-1994 period representing the Hudson River striped bass program winter trawling effort (Northeast Regional Climate Center, Cornell University, Ithaca, NY, pers. comm.). Hudson River bottom water temperatures during January and February 1994 were below the 95% confidence limits for the weekly mean bottom water temperature for all previous years, and during two weeks approached and dropped below 0°C (Figure 1-1, Appendix Table B-1). The ice floes reduced the trawling effort in the January-February period and influenced both within-program and among-program comparisons throughout this report.

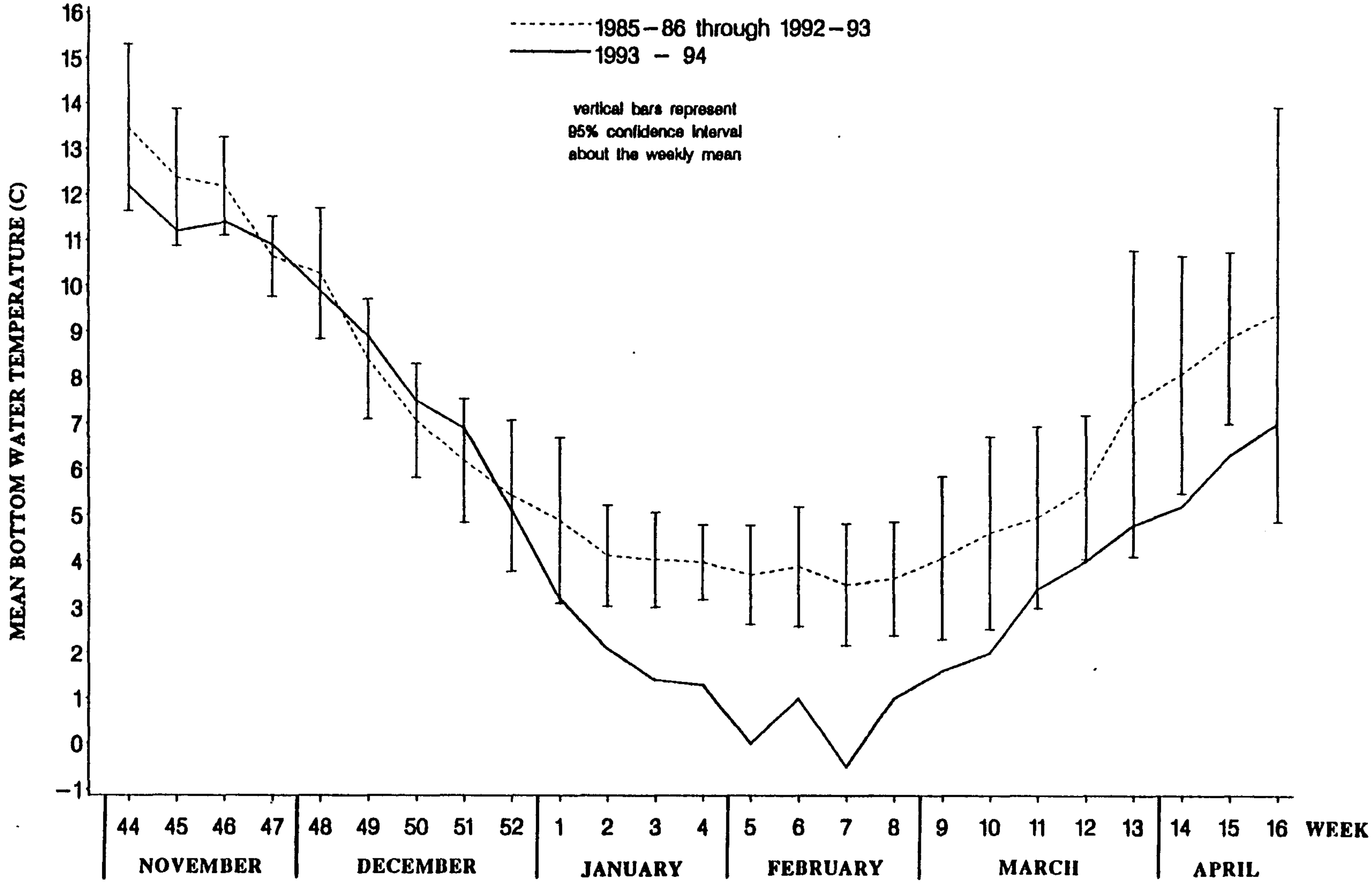


Figure 1-1. Weekly mean bottom temperature in the Battery region of the Hudson River during 1993-94 compared to the weekly mean and 95% confidence intervals for the 1995-86 through 1992-93 Hudson River Striped Bass programs.

2.0 METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1993-94 Hudson River Striped Bass and Atlantic Tomcod Programs Standard Operating Procedures (NAI 1993). These procedures have remained essentially unchanged since the start of the 1988-89 program. The 1993-94 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1) with a 9 m trawl (Appendix Table A-1). Sampling locations were selected to maximize the catch per unit of effort of striped bass in the lower Hudson River, based on the results of the 1985-86 through 1992-93 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1996). A 9 m trawl was used in the 1993-94 program to catch striped bass because the results of the 1987-88 program showed that the 9 m trawl was more efficient than other gear in catching striped bass of the target ages of Age 1+ and Age 2+ (NAI 1988). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2) and released.

For 25 weeks, from the week of 1 November 1993 through Wednesday of the week of 18 April 1994, the 9 m trawl was deployed in the Upper Harbor or Battery regions. The 9 m trawl was fished in each of the 25 weeks in the Battery region and on selected days during 17 weeks in the Upper Harbor region (Appendix Table C-1). Tow duration was 10 minutes unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawl were handled in a manner that minimized stress before tagging. The cod end of the net was transferred while remaining in the water to the holding facility alongside the boat. Fish were then released from the cod end into the holding facility. Striped bass were then removed from the holding facility for processing using the following procedures:

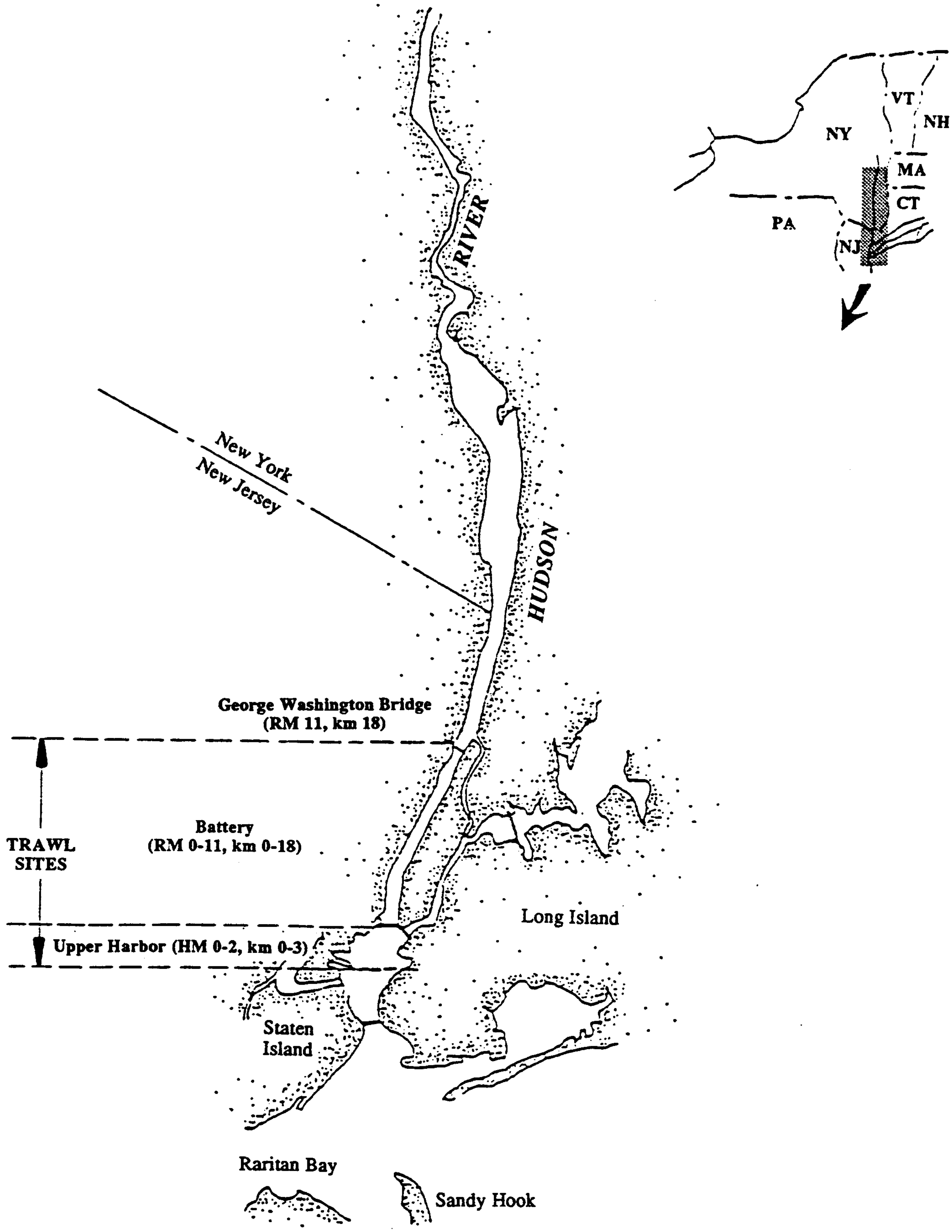
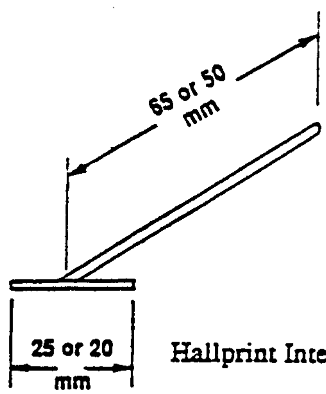
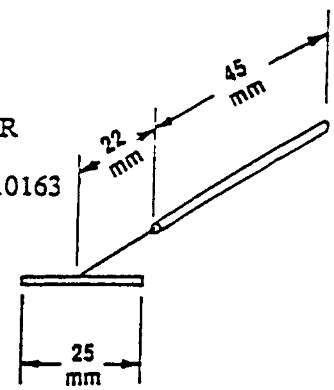


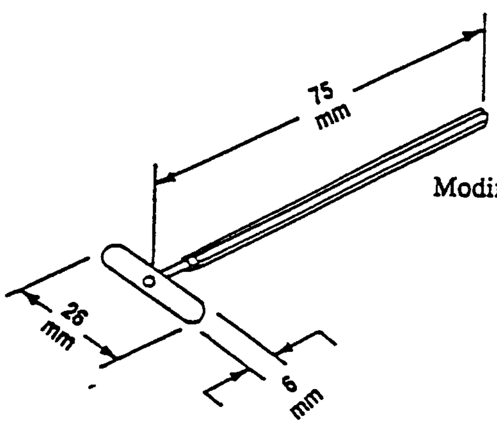
Figure 2-1. Sampling regions in the lower Hudson River and New York Harbor during the winter 1993-94 Hudson River Striped Bass Program.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

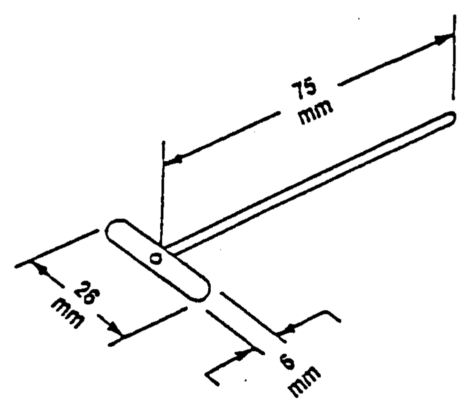
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

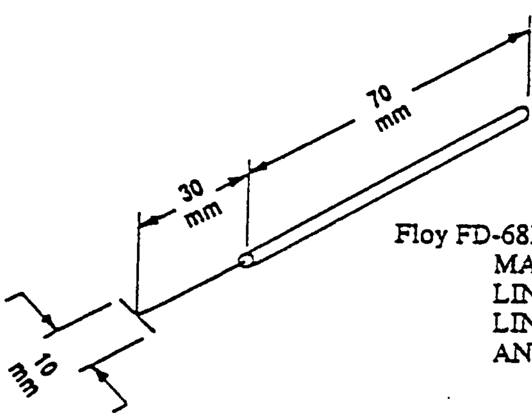




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-present Hudson River Striped Bass Programs.

(1) fish were removed from the live car using a dip net,

(2) all surfaces that came in contact with the live fish were wet,

(3) striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps, and

(4) struggling fish were quieted by covering the head and eyes with a wet hand, cloth or glove.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for coded wire tags (CWTs) using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

(1) no bleeding from gills or body wounds,
(2) no significant loss of scales,
(3) strong opercular movement, and
(4) no obvious external abnormalities such as blindness, fin rot or skeletal abnormalities.

The 1991-92 program was the first program in which we also tagged striped bass that were not in good condition, and we continued tagging these fish in the 1992-93 and 1993-94 programs to determine if the presence of certain gross anatomical abnormalities (such as blindness or bacterial infection) affected their survival. The nature of the particular abnormality of each striped bass was recorded prior to release. In previous programs, only striped bass in good condition were tagged.

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral mid-line. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a hooking movement of a curved scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue and all incisions were treated with a merbromin-based topical antiseptic.

Scale samples were taken from the left side from an area approximately 3-4 scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Fish less than 100 mm were considered Age 0+. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass were also evaluated.

After processing, striped bass were released into a recovery pen deployed alongside the tagging vessel. The pen was enclosed with netting on four sides, open on the top and bottom, and provided a refuge where striped bass could recover from processing without being preyed on by gulls. Bird predation was estimated to remove about 2.4% of the tagged fish released during the 1990-91 program (NAI 1992), so we began using this recovery pen to reduce this predation. Any fish remaining in the recovery pen at the end of sample processing were considered dead. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity-temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C for presentation in this report. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random sample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10 mm length group. Expected numbers of Age 1+ striped bass in each 10 mm length group were calculated from age at length data obtained during the current and 1992-93 programs (NAI 1996).

This program was conducted during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1991 and collected anywhere between November 1992 and May 1993 would be designated "Age 1+". This same fish, captured anywhere between November 1993 and April 1994, would be designated "Age 2+".

Striped bass scales were pressed on 0.050-inch thick, grade GC, acetate sheets with a Carver Press Model-C 12 ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment which would affect computation of catch per unit of effort, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-minute duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving catch per unit of effort. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were compared among locations and sampling weeks by analysis of the catch per unit of effort, length-frequency, and handling mortality.

2.3.1.1 Catch Per Unit Of Effort

Catch Per Unit of Effort (CPUE) for the 9 m trawl was defined as catch per ten-minute tow (Use Code = 1) and was calculated as

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{C_i}{E_i} x\ 10 \right] \qquad \text{Equation 1}$$

where, $\overline{X}$ = The mean trawl catch per ten minute tow,
C_i = total number of fish captured in trawl i,
E_i = the tow duration of trawl i in minutes, and
n = the number of trawls.

2.3.1.2 Length-Frequency

Length-frequency histograms, with the number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9 m trawl (Use Code = 1 tows). Length-frequency distributions for striped bass caught by the 9 m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 Handling Mortality

Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1°C temperature interval:

The sample variance for the stratified mean proportion of Age i fish in the total catch (s^2p_{sti}) was calculated by the method of Cochran (1977, Equation 5.53):

$$s^2_{p_{sti}} = 1/N^2 \left[\Sigma[N_h^2 \ (N_h - n_h)/(N_h - 1)][p_{hi}q_{hi})/(n_h - 1)]\right] \qquad \text{Equation 6}$$

where

N, N_h, p_{hi}, and q_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977) Equations 5.14 and 5.15:

$$95\% \text{ CI for } p_{sti} = p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 7}$$

$$95\% \text{ CI for } A_i = N\, p_{sti} \pm t\, s_{p_{sti}} \qquad \text{Equation 8}$$

where

$$s_{p_{sti}} = \sqrt{s^2_{p_{sti}}}$$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16), and

p_{sti}, A_i, N, $s^2_{p_{sti}}$ are as defined in Equations 4-7.

2.3.2.2 Stratified Mean Length in Each Age Category

The mean length of striped bass of a given age that were caught in the 1993-94 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi}\, \bar{y}_{hi}\right] / N_i \qquad \text{Equation 9}$$

where $\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught,

$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample,

n_{hi} = number of Age i fish caught in length group h,

N_i = number of Age i fish caught in the program, and

L = number of length groups in which at least two Age i fish were measured. If only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean.

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24 with the assumption that N_i is large and substantially larger than n_i, therefore $N_i^{-1} \approx 0$ and $g'_i \approx 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L} \left[w_{hi} (S^2_{hi} / n_i \; V_{hi}) \right] + (1/n'_i) \sum_{h=1}^{L} w_{hi} \, (\bar{y}_{hi} - \bar{y}_{sti})^2$$

Equation 10

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for α = 0.05 based on n_i' - 1 degrees of freedom (not the effective degrees of freedom), and

$\bar{y}_{sti}$ is as defined in Equation 9.

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1993-94 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / (H_{ai} + W_{ai}) \quad \text{Equation 13}$$

where

P_{ai} = the proportion of Age i hatchery striped bass in the population adjusted for tag loss and non-detection of tags,

H_{ai} = the number of Age i verified hatchery recaptures caught adjusted for tag loss and non-detection of tags, and

W_{ai} = the number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai}).

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and non-detection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1\text{-}TAG_i)(1\text{-}NDET)\right] \qquad \text{Equation 14}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught,

H_i = the number of Age i verified hatchery recaptures caught,

TAG_i = decimal percent 24-hour magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1), and

NDET = decimal percent non-detection rate for magnetic tags during the recapture program,

= $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected.

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Section 1.0) was not adjusted for handling mortality (Dunning et al. 1989) because handling mortality was minimal (<1%) and could not be associated with each lot of tagged fish stocked into the Hudson River (EA 1994).

2.3.4 Recaptured Striped Bass

Three groups of recaptured, internal anchor-tagged striped bass were considered: (1) fish recaptured from our previous programs (cross-year recaptures), (2) fish caught, tagged, released and recaptured within the current (1993-94) program (within-year recaptures), and (3) fish recaptured with external streamer tags from other programs (other recaptures). All cross-year recaptures were examined to determine the condition of the tag legend and insertion site, recapture rate, mean length, and days at-large. We also determined the age and growth for cross-year recaptures by examining the scale samples taken at the time of release and time of recapture. Within-year recaptures consisted of two groups of striped bass: fish that were in good condition at the time they were tagged and released (REL_REC = 1), and fish that were tagged and released but exhibited one or more gross anatomical abnormalities (REL_REC = 6). Both groups of within-year recaptures were examined to determine the tag condition, recapture rate, mean length and days at-large. Within-year recaptures that were in good condition at the time of release were also used for a mark-recapture estimate of population size (Section 2.3.6). We obtained release and recapture information and observed the condition of the tag streamer and insertion site for other agency recaptures.

2.3.5 Population Movement

The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and relatively few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$\text{Recapture rate} = R_{ij}/M_{ij} \qquad \text{Equation 15}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

M_{ij} = number of tagged striped bass released during time period (week) i in region j.

$$\text{Recapture Proportion} = R_{ij}/C_{ij} \qquad \text{Equation 16}$$

where R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j, and

C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j.

2.3.6 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i) with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$ where β is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals $(R_i/C_i - \beta M_i)$ are weighted by the catch (C_i), then N^{-1} equals the slope, β.

The Schumacher-Eschmeyer estimator (Ricker 1975) is

$$N = \Sigma(C_i M_i^2)/\Sigma(R_i M_i) \qquad \text{Equation 17}$$

where

N = estimated population size,

C_i = total catch during time interval i,

M_i = total number of marked fish tagged and released in good condition and available for recapture at the midpoint of time interval i, and

R_i = number of recaptured fish in C_i.

The variance of the reciprocal of the population size (1/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\Sigma(R_i^2/C_i) - (\Sigma R_i M_i)^2/\Sigma(C_i M_i)}{m-1} \qquad \text{Equation 18}$$

where

S^2 = mean of squared deviations from the regression model described above,

m = the number of data points in the regression, and C_i, M_i and R_i are as defined above in Equation 17.

The 95% confidence interval (CI) for the reciprocal of the population size (1/N) is computed as

$$CI = S^2/\Sigma C_i M_i \times t_{m-1} \qquad \text{Equation 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and $\alpha=0.05$.

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.7 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish at-large one or two years was compared within cohort to growth from scale samples taken at the time of tagging (untagged fish) in the 1988-89 through 1993-94 programs. We measured growth as the distance from the focus to each annulus along a radial line originating at the focus and running perpendicular to the anterior edge of the scale (radius measurement).

3.0 RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9 M TRAWL

3.1.1 Catch Per Unit Of Effort

The winter of 1993-94 was the only time in the history of the program that river access was so limited that less than five tows could be taken in each of three consecutive weeks (the weeks of 17 January, 24 January, and 31 January 1994), and fishing effort in the Battery was restricted to less than 24 tows per week for the weeks of 17 January through 21 February 1994 (Figure 3-1, Appendix Table C-1). A total of 651 ten minute tows (use code = 1) were taken with the 9 m trawl in the Battery region, and 143 tows were taken in the Upper Harbor region of the lower Hudson River between 1 November 1993 and 20 April 1994. The mean CPUE for striped bass in the Upper Harbor region was less than the CPUE in the Battery region over all sampling weeks combined (Table 3-1). The mean CPUE was higher in the Upper Harbor region compared to the Battery region during the week of 15 November and 29 November through 20 December 1993; in the remaining weeks mean CPUE was highest in the Battery (Appendix Table C-1). Among weeks when a significant number of samples were collected, mean CPUE exceeded 50 striped bass per ten minute tow during the week of 6 December in the Upper Harbor region and during the weeks of 22 November, 3 January, 14 March and 28 March through 18 April in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 182.4 striped bass per ten minute tow from 13 tows taken during the week of 11 April in the Battery region. The next highest weekly mean CPUE occurred during the week of 18 April in the Battery region when an average of 161.0 striped bass were collected in 12 tows. The highest CPUE was at river mile 1 of the Upper Harbor region (Appendix Table C-2). However, this CPUE was based on only one tow at this location. Consistent high catches occurred at river mile 5 of the Battery region where 17% of the sampling took place.

Mean CPUE for the 9 m trawl in the Battery region increased in each program from 8.1 in 1985-86 to a peak of 45.3 striped bass per ten minute tow in 1989-90 (Table 3-2). After the peak CPUE in the 1989-90 program, CPUE decreased to 32.7 striped bass per ten minute tow for the 1992-93 program, and was 33.7 striped bass per ten minute tow in 1993-

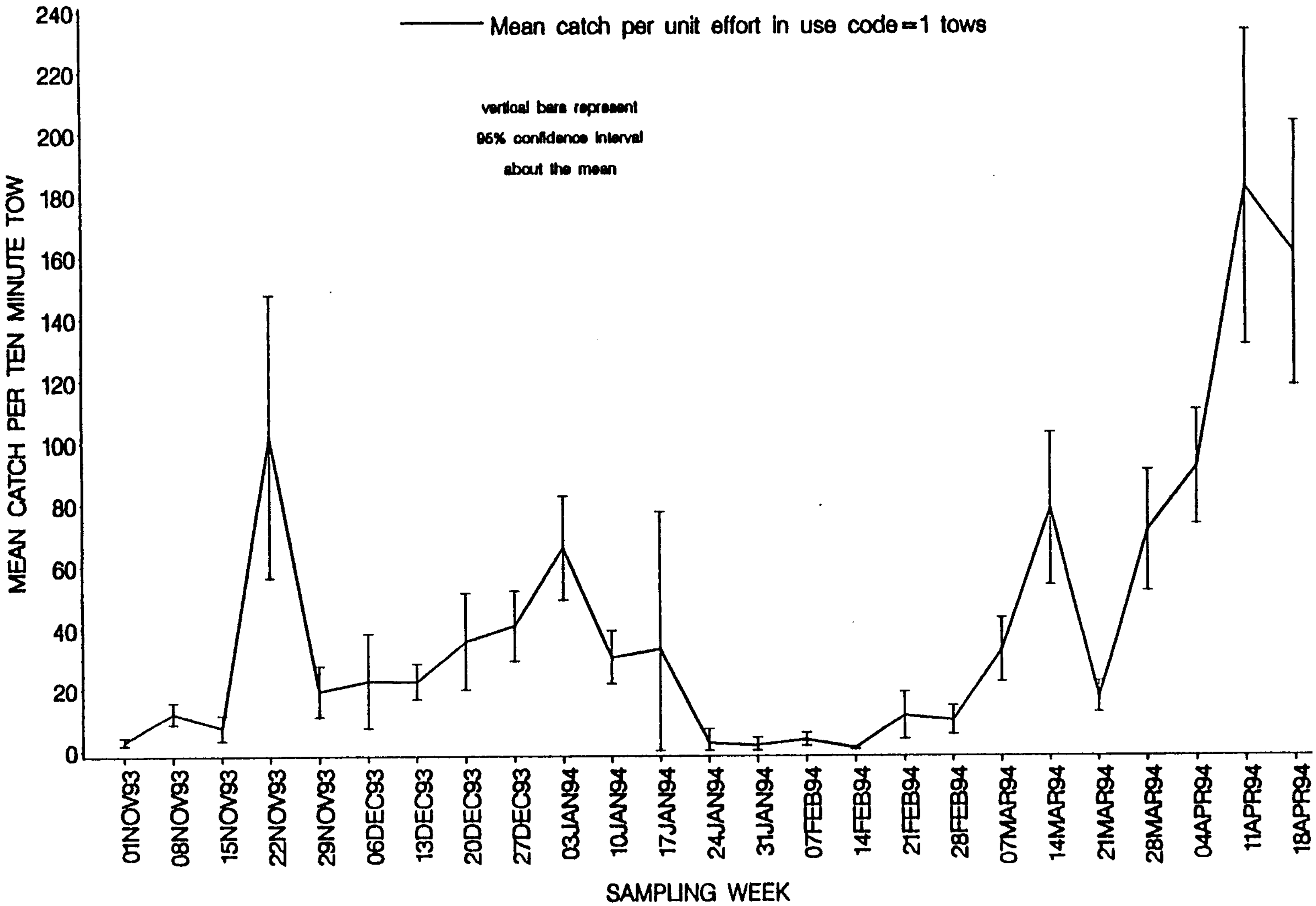


Figure 3-1. Weekly mean catch per ten minute tow by a 9m trawl in the battery region of the Hudson River, 1 November 1993 through 20 April 1994.

TABLE 3-1. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

REGION	NUMBER OF TOWS[1]	NUMBER OF FISH CAUGHT	MEAN CATCH PER TEN MINUTE TOW	STANDARD ERROR
Battery	651	24,713	38.0	2.1
Upper Harbor	143	4,026	28.2	3.0

[1]Use Code = 1 tows only.

TABLE 3-2. MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1993-94.

YEAR	PERIOD	TOWS	MEAN CPUE	95% CI
1985-86	23 DEC 85 - 21 MAR 86	638	8.1	±1.0
1986-87	21 DEC 86 - 21 MAR 87	385	12.2	±1.2
1987-88	20 DEC 87 - 19 MAR 88	437	28.5	±2.5
1988-89	19 DEC 88 - 18 MAR 89	527	38.9	±3.3
1989-90	18 DEC 89 - 16 MAR 90	458	45.3	±4.3
1990-91	17 DEC 90 - 15 MAR 91	477	40.7	±3.5
1991-92	23 DEC 91 - 21 MAR 92	578	35.5	±2.2
1992-93	21 DEC 92 - 20 MAR 93	397	32.7	±2.9
1993-94	20 DEC 93 - 20 MAR 94	341	33.7	±5.2

94. The increased CPUE observed during the 1988-89 and 1989-90 programs may be due to the complete recruitment of the numerically dominant 1987 and 1988 year classes to the 9 m trawl (CES 1989). The decrease in CPUE observed after the 1989-90 program may be due to migration or mortality of the 1987 and 1988 year classes and lower abundance of the 1989 through 1992 year classes. Effort (the number of tows) for part of the mid-winter period was low in 1993-94 because extremely cold temperatures and bank to bank ice floes in the Battery restricted access to the river, particularly during the weeks of 17 January through 31 January 1994.

3.1.2 Length-Frequency Distributions

The overall mean length of striped bass caught by the 9 m trawl in the Battery region was 197 mm during the 1993-94 program (Table 3-3). The length-frequency distribution for the 9 m trawl was: (1) skewed right i.e., more fish were smaller than the mean length than would be expected if the distribution was bell-shaped, (2) leptokurtotic, i.e., more fish were found in length groups close to the mean length than would be expected if the distribution was bell-shaped, and (3) the length-frequency was bimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 101-150 mm and 201-250 mm length groups.

Weekly mean length of striped bass caught by the 9 m trawl was largest early in the program and then generally declined to the smallest mean length during February and early March, and then increased again in late March and April (Appendix Table C-5). Mean length was highest (331 mm) during the week of 1 November 1993 and generally declined to a low between 17 January and 20 February when weekly mean lengths were between 124 mm and 130 mm (except for weeks with very low catch). Weekly mean length then increased to between 183 mm 221 mm during the period of 28 March through 20 April 1994. This pattern was similar to the pattern observed in the 1991-92 and 1992-93 programs when weekly mean lengths were largest during the first nine or ten weeks.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50 mm length classes, indicated that fish in the 201-350 mm length classes predominated during the week of 22 November (Figure 3-3). Beginning during

TABLE 3-3. DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTIONS OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

N	MEAN (MM)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
24,713	197	85.2	0.80 ±0.03	1.44 ±0.06	56	796	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. =Standard Deviation
±95% C.I. = 95% confidence interval

Right skewness =
Significant positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.
Leptokurtosis = Significant positive kurtosis indicating more striped bass were close to the mean length than would be expected from a normal distribution.

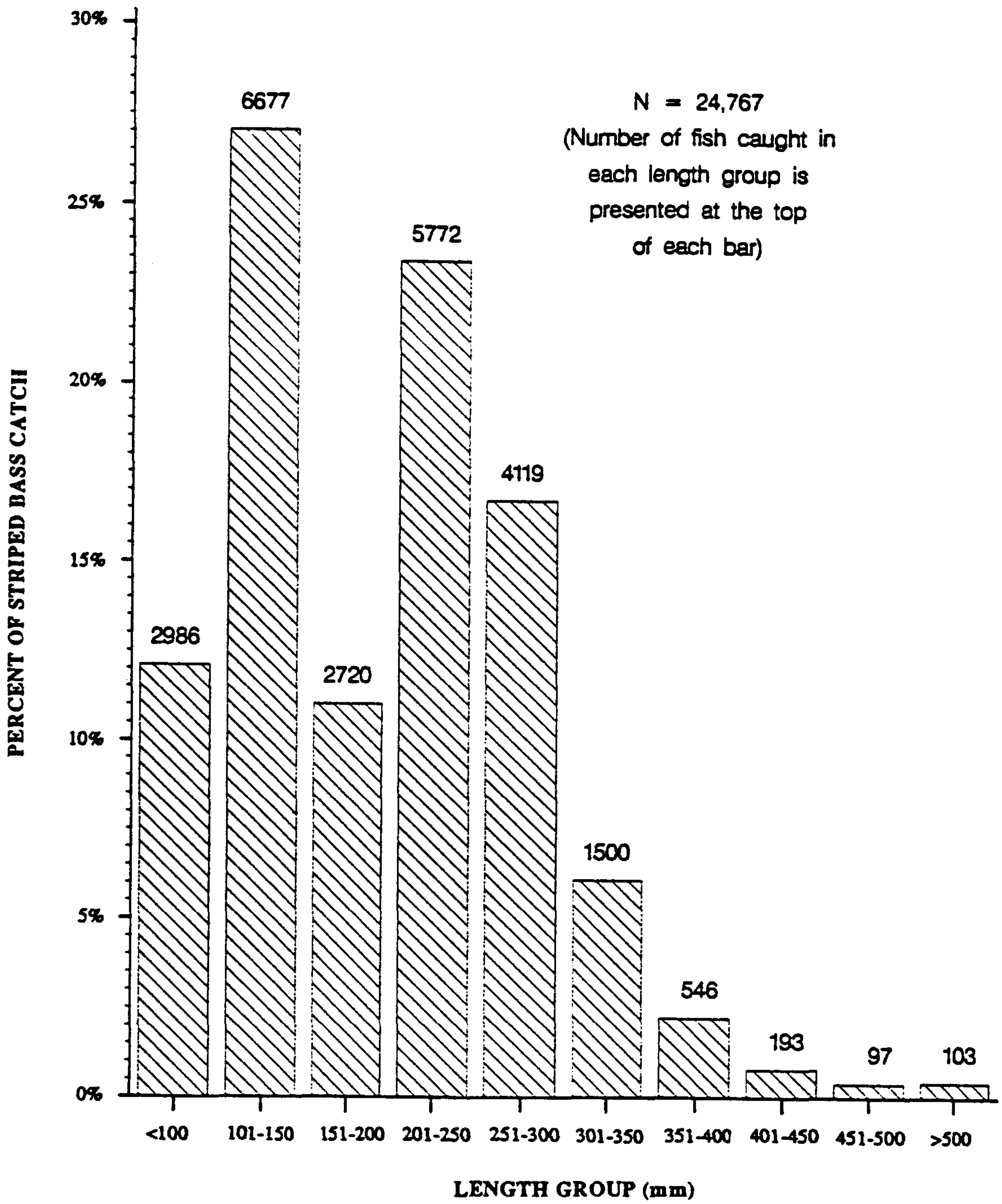


Figure 3-2. Length-frequency distribution for striped bass captured by a 9m trawl in the Battery region of the Hudson River, 1 November 1993 through 20 April 1994.

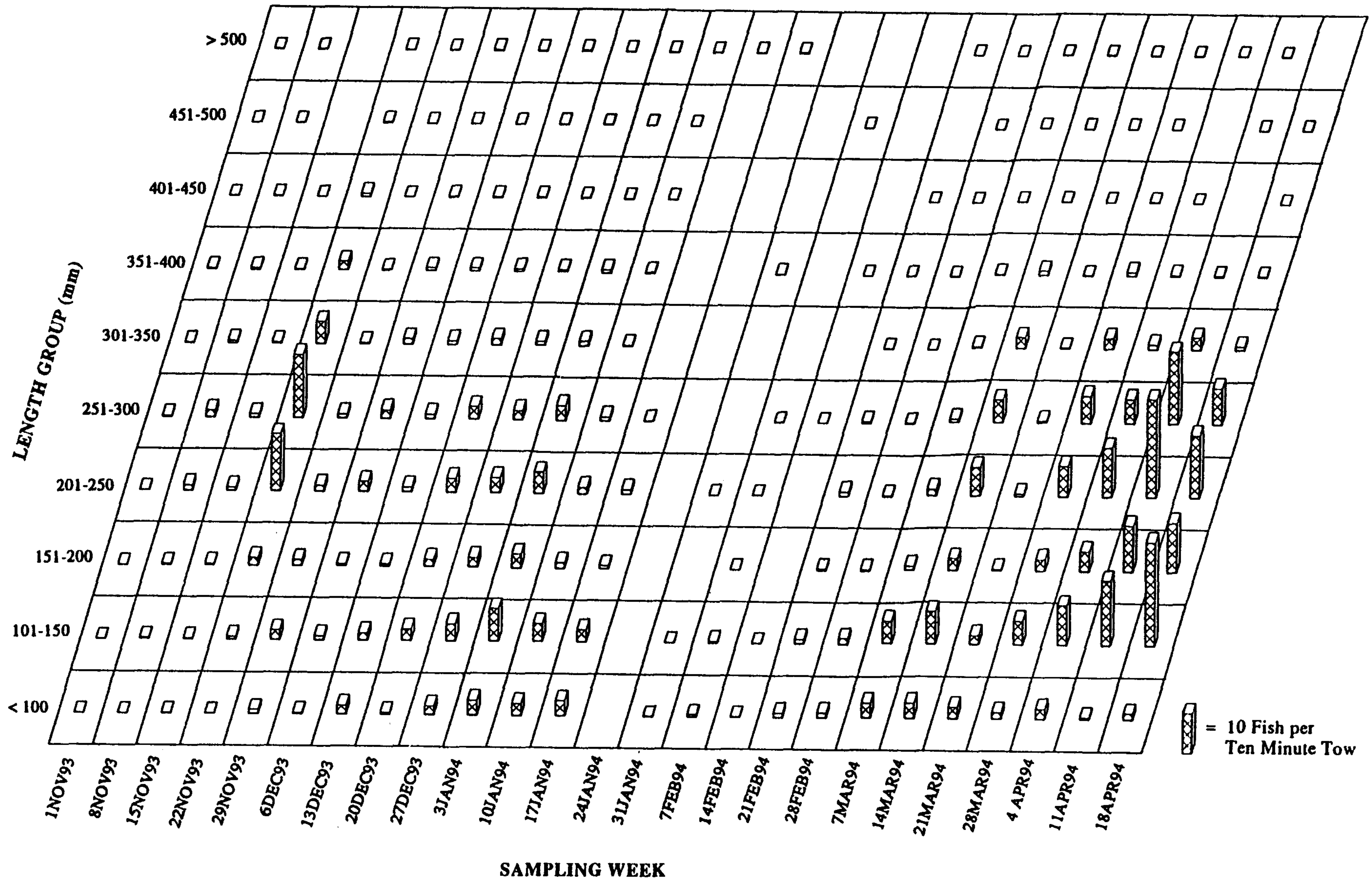


Figure 3-3. Weekly length-frequency distributions for striped bass caught per ten minute tow in a 9m trawl in the Battery region of the Hudson River, 1 November 1993 through 20 April 1994.

the week of 27 December catches of smaller length classes (<100 through 201-250 mm length classes) increased, until the sampling effort was interrupted by ice floes during the week of 17 January 1994. When the ice melted and fishing resumed, catches in the length classes between 101 and 300 mm predominated. The highest catch per tow over all weeks was 63.4 striped bass in the 101-150 mm length class during the week of 18 April 1994.

The standardized length-frequency of striped bass captured during the winter of 1993-94 was bimodal with a peak in the 101-150 mm and 201-250 mm length groups (Figure 3-4). Bimodal length-frequencies previously occurred during the winters of 1986-87, 1987-88, 1990-91, and 1991-92. The peak between 201 and 250 mm probably represents the 1992 year classes at age 1+, while the peat in the 101-150 mm length group represents the 1993 cohort of age 0+ striped bass.

3.1.3 Handling Mortality

Overall striped bass handling mortality in the 9 m trawl was less than 2% during 1993-94 at bottom water temperatures from -1 to 13°C (Table 3-4). A total of 451 striped bass died out of 24,407 fish caught in Use Code = 1 tows that had river bottom water temperature data associated with each tow. The highest handling mortality of 3.7% (1/27) was observed at a bottom water temperature of 0°C, and the second highest handling mortality was at 4°C (3.3%). The 1993-94 program was the first time we observed winter bottom water temperatures in the Battery at or below 0°C. Although the highest handling mortality was also observed at the 0°C temperature increment, relatively few fish were caught at these low temperatures and they contributed relatively little to the overall mortality. The relatively consistent, low handling mortality indicated there was no relationship between handling mortality and water temperature for the 9 m trawl over bottom water temperatures of -1 to 13°C experienced in this study. The 1993-94 data were not examined for an interaction between water temperature, fish length and immediate handling mortality because this interaction was not significant in previous programs (Dunning et al. 1989).

Striped bass handling mortality in the 1993-94 program was less than 2%, but was approximately six times higher than the pooled mortality for the 1985-86 through 1990-91

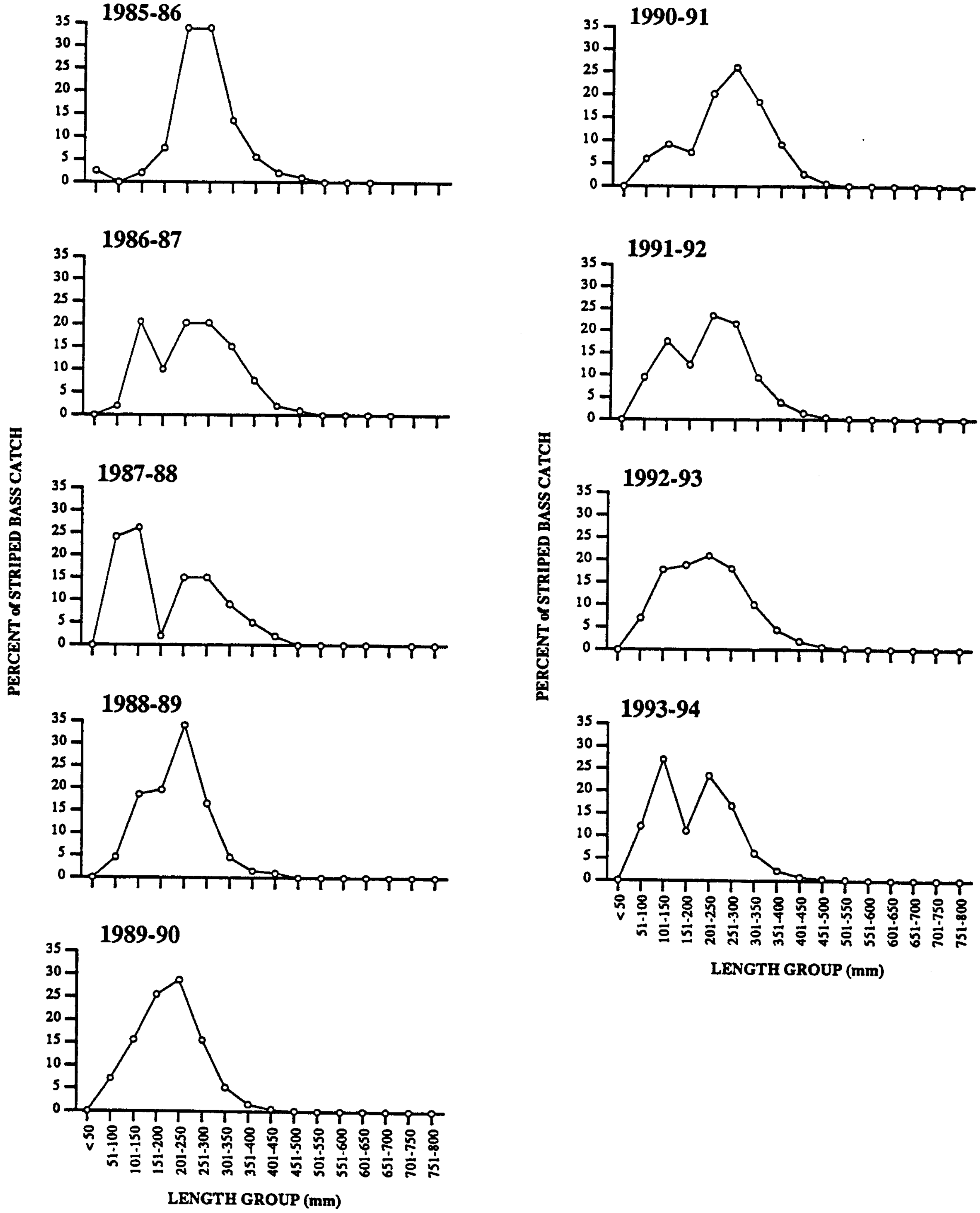


Figure 3-4. Standardized length-frequency of striped bass captured by a 9m trawl in the Battery region of the Hudson River, 1985-86 through 1993-94.

TABLE 3-4. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS IN A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL IN RELATION TO HUDSON RIVER BOTTOM WATER TEMPERATURE, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD[1]	NUMBER DEAD[1]	TOTAL CATCH[1]
-1	0.0	0	7
0	3.7	1	27
1	0.7	3	439
2	1.0	32	3,246
3	3.0	69	2,260
4	3.3	156	4,713
5	1.2	53	4,438
6	2.0	65	3,206
7	1.4	36	2,564
8	2.1	29	1,354
9	0.5	1	196
10	0.0	0	91
11	0.3	4	1,424
12	0.5	2	423
13	0.0	0	19
-1→13	1.8	451	24,407

[1]Mortality and catch data for striped bass caught in use code = 1 tows for which river bottom water temperature was available.

programs (Table 3-5). The apparent increase in handling mortality observed in the 1993-94 program was probably due to an underestimate of handling mortality during the 1985-86 through 1990-91 programs. During the 1985-86 through 1990-91 programs, bird predation on released striped bass was not considered to be a significant problem and little effort was made to quantify the bird predation rate. All striped bass that were not immediately identified as dead upon release were assumed to have survived. However, at the end of the 1990-91 program it became apparent that bird predation on released striped bass was significant. Approximately 2.4% of the 2,969 tagged striped bass released between 12 March and 12 April 1991 were removed from the water by gulls (NAI 1992). Therefore, handling mortality in the 1985-86 through 1990-91 programs may have been underestimated.

Field procedures were modified in 1991-92 and these modifications continued through the 1993-94 program to both quantify and minimize gull predation. After tagging, fish were released into a recovery pen that was deployed in the water alongside the boat. The pen was a 1 m x 2 m x 1 m deep enclosure with 0.9 cm mesh netting on four sides, open on the top and bottom, with the top of the frame suspended at the water surface. Striped bass released into the pen were provided a refuge alongside the boat where they could recover from handling stress without drifting away from the boat during recovery and possibly being preyed on by gulls. Fish in good condition typically escaped from the pen through the bottom. Stunned fish typically remained at the surface for several minutes until they recovered and escaped through the bottom of the pen. Any fish remaining in the recovery pen at the end of sample processing were considered dead and were removed and taken to the lab. A field technician also observed fish as they escaped from the recovery pen and recorded instances of gull predation. These procedures both minimized gull predation and accurately recorded handling mortality.

Quantitative comparison of the difference in handling mortality between the 1985-86 through 1990-91 programs and the 1991-92 through 1993-94 programs are probably not meaningful due to our change in field procedures. Striped bass handling mortality statistics from the recent programs are probably more accurate than previous programs because use of the observer and the recovery pen allowed more assessment of accurate bird predation data. Handling mortality during the 1991-92 through 1993-94 programs was probably lower than

TABLE 3-5. HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9 m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1993-94 HUDSON RIVER STRIPED BASS PROGRAMS.

BOTTOM WATER TEMPERATURE (°C)	1985-86 THROUGH 1990-91		1991-92		1992-93		1993-94	
	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N	% OF CATCH DEAD	n/N
3	0.3	58/ 16,781	1.3	20/ 1,557	1.4	80/ 5,940	3.0	69/2,260
4	0.3	51/ 16,155	0.5	45/ 9,685	3.5	107/ 3,090	3.3	156/4,713
5	0.3	58/ 21,071	0.2	13/ 5,419	2.2	86/ 3,858	1.2	53/4,438
6	0.2	43/ 18,783	1.5	98/ 6,438	1.8	44/ 2,380	2.0	65/3,206
7	0.4	43/ 11,785	1.0	26/ 2,728	1.2	16/ 1,347	1.4	36/2,564
8	0.2	20/ 8,731	1.4	29/ 2,135	2.2	17/ 756	2.1	29/1,354
9	0.5	29/ 5,709	0.9	10/ 1,133	0.2	3/ 1,361	0.5	1/ 196
10	0.2	8/ 4,843	1.1	21/ 1,897	0.7	6/ 806	0.0	0/ 91
11	0.3	11/ 3,185	0.6	5/ 879	0.5	17/ 3,406	0.3	4/ 1,424
12	0.3	6/ 1,995	0.5	1/ 187	0.2	1/ 434	0.5	2/ 243
3-12°C	0.3	327/109,038	0.8	268/32,058	1.6	377/234,307	2.0	415/20,669

n = Number dead at a temperature for use code = 1 tows.
N = Total number caught at a temperature for use code = 1 tows.

handling mortality recorded for previous programs because the recovery pen provided a refuge against gull predation.

Handling mortality in all programs conducted after the 1985-86 program was approximately ten times less than that observed in the 1984 program (NAI 1992). The primary reason for the decrease in handling mortality observed after 1984 was the use of a submerged holding facility and the increased tagging efficiency of field crews (Dunning et al. 1989).

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

Age-length frequency histograms, presented by 10 mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5) demonstrate minimal overlap in size of Age 0+ and Age 1+ striped bass caught during the 1993-94 program. Most of the fish in each length group <160 mm were Age 0+, while most of the fish in length groups between 160 and 299 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size primarily between 240 and 319 mm. Age 3+ striped bass overlapped with Age 2+ fish primarily between 320 and 449 mm.

The 9 m trawl with 7.6 cm (stretch) mesh in the body and 3.8 cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1993-94 programs. Therefore, the striped bass catch by this 9 m trawl was used for comparisons of mean length at age among programs. Overlap of the 95% confidence intervals about the estimated mean length of each age cohort was used for the comparison of mean length at age.

The 1993 wild cohort of Hudson River striped bass at Age 0+ was smaller than the 1991 cohort and similar in mean length to the 1986, 1988 and 1990 cohorts (Figure 3-6, Appendix Table C-7). All other cohorts were significantly smaller at Age 0+. At Age 1+, the 1992 cohort was larger than the 1991, 1988, 1987 and 1985 cohorts and equal in mean length to the 1989 cohort. The 1992 Age 1+ cohort was significantly smaller than the 1986 and 1990 cohorts, and the 1986 cohort was significantly larger than the Age 1+ wild striped

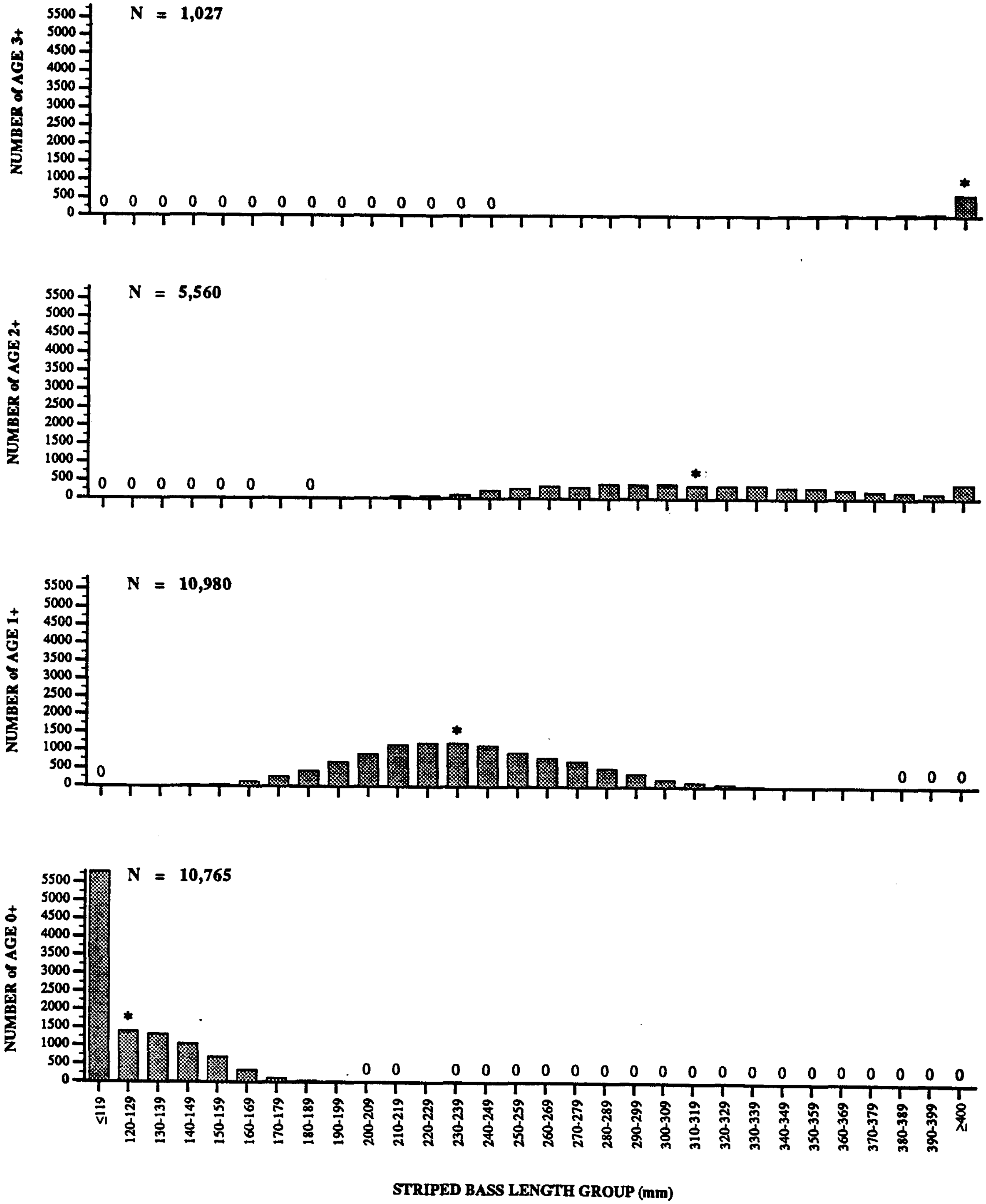


Figure 3-5. Length-frequency distributions for age 0+, 1+, 2+ and 3+ striped bass captured by a 9m trawl in the Hudson River, 1 November 1993 through 20 April 1994.

(Note: Length group which contains the stratified mean length at age is marked with an *.)

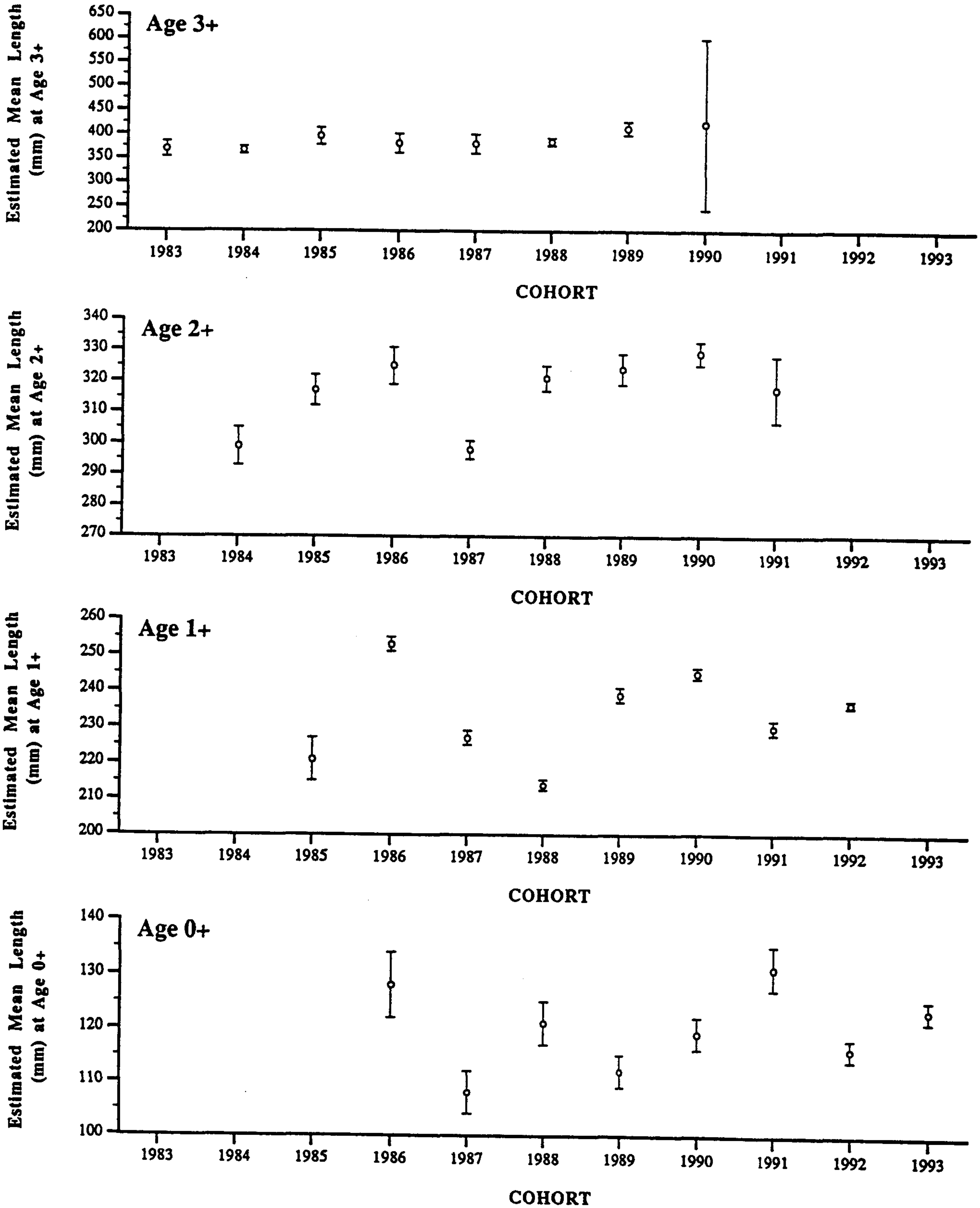


Figure 3-6. Mean length at age (and 95% confidence interval) for Age 0+ through Age 3+ wild striped bass of the 1983 through 1993 cohorts caught in a 9m trawl in the Hudson River.

bass from the 1985-1992 cohorts. The 1988 cohort was the smallest. At Age 2+, the 95% confidence intervals for the 1991, 1990, 1989, 1988, 1986 and 1985 cohorts overlapped indicating similarity among the estimated mean lengths. Estimated mean lengths of the 1984 and 1987 cohorts were the smallest of the Age 2+ cohorts examined. Confidence intervals about the estimated mean length at Age 3+ for striped bass caught in 1993-94 were wide and overlapped among the 1983 through 1990 cohorts.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling of about 15% of the scale samples resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in the 1993-94 program (Table 3-6). For the allocation of 5,445 scale samples actually selected, the precision based on 95% confidence limits was 1.3% corresponding to an error term of ± 148 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than about 10% of the total sample (28,739 fish in 1993-94). For example, doubling the number of striped bass scale samples examined for age determination from 3,000 to 6,000 would result in an improvement in the precision from 1.9% to 1.2% (Table 3-6). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (10,980) out of the 28,739 fish caught in use code = 1 samples during 1993-94 could be estimated with 95% confidence limits of ±553 fish (precision = 5.0%, Table 3-6).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10 mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 2+

TABLE 3-6. RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

	ESTIMATED NUMBER OF AGE 1+ FISH CAUGHT				
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL[b]	LOWER 95% CI	UPPER 95% CI	PRECISION (%)[a]
500	0.382	10,980	10,427	11,532	5.0
1,000	0.382	10,980	10,600	11,359	3.4
2,000	0.382	10,980	10,722	11,238	2.3
3,000	0.382	10,980	10,777	11,183	1.9
4,000	0.382	10,980	10,810	11,149	1.6
5,000	0.382	10,980	10,834	11,125	1.3
5,445[c]	0.382	10,980	10,832	11,128	1.3
6,000	0.382	10,980	10,852	11,107	1.2
7,000	0.382	10,980	10,867	11,092	1.0

[a]Precision = 95% confidence interval (CI) half width/stratified total x 100.

[b]Based on 28,739 striped bass caught in use code = 1 samples.

[c]Results for sample size = 5,445 are based on actual allocations from use code = 1 samples which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

striped bass (Table 3-7), which collectively comprised 95% of the fish caught in this program. Only 1,027 of the 28,739 striped bass caught in use code = 1 samples were estimated to be Age 3+, and 407 of the fish caught were older than Age 3+ in the 1993-94 program. The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1992 cohort of Age 1+ striped bass was approximately 38% of the total catch during 1993-94. The number of Age 2+ striped bass (1991 cohort) was estimated with somewhat lower precision than the number of Age 1+ fish because the Age 2+ were relatively evenly distributed over a wide range of size groups, and the sample size was smaller for these fish. The number of Age 3+ striped bass was estimated with relatively low precision because more than one-half of the catch of these fish were ≥400 mm and few scale samples were selected from this size group.

3.3 STRIPED BASS HATCHERY PROPORTION

Age 1+ striped bass stocked in the Hudson River from the Verplanck hatchery in 1992 were about 1% of the Age 1+ cohort of fish caught during the winter of 1993-94 (Table 3-8). Age 4+ striped bass from the 1989 cohort were about 0.5% of the catch during the 1993-94 program. Hatchery fish were not tagged in 1990 or 1991 and were therefore not detected among the Age 2+ or Age 3+ fish. Age 0+ hatchery fish from the 1993 cohort represented about 0.2% of the catch during 1993-94, but the reliability of this proportion is unknown because fish of the size range observed for the Age 0+ cohort are probably not fully recruited to the 9 m trawl. Comparison of the estimated hatchery proportions for the 1985 and 1986 hatchery cohorts caught in 1986-87 through 1988-89 suggested that the hatchery proportion for each cohort doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; this report Table 3-9). However, this trend did not continue or could not be evaluated for the more recent hatchery cohorts. Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 1+ 1988 cohort to 0.2% for Age 3+ fish from the 1987 cohort (Table 3-10).

TABLE 3-7. ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

			ESTIMATED NUMBER OF FISH CAUGHT			
AGE	YEAR CLASS	PROPORTION	STRATI-FIED TOTAL[a]	LOWER 95% CI	UPPER 95% CI	PRECISION (%)
0+	1993	0.375	10,765	10,648	10,881	1.1
1+	1992	0.382	10,980	10,832	11,128	1.3
2+	1991	0.193	5,560	5,343	5,778	3.9
3+	1990	0.036	1,027	840	1,214	18.2

[a]Based on a laboratory sample of scales from 5,445 striped bass selected by stratified random sampling from 28,739 fish caught in use code = 1 samples.

TABLE 3-9. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1993-94.

COHORT	1993	1992	1989	1988	1987	1986	1985	1984
NUMBER STOCKED	568,410	210,746	202,068	48,611	324,579	529,563	284,578	147,153
1986-87								
N						38	51	5
Lower 95% C.I.						0.0110	0.0126	0.0005
Proportion						0.0152	0.0170	0.0014
Upper 95% C.I.						0.0204	0.0225	0.0029
1987-88								
N					25	127	82	4
Lower 95% C.I.					0.0015	0.0137	0.0240	0.0011
Proportion					0.0023	0.0165	0.0311	0.0034
Upper 95% C.I.					0.0033	0.0196	0.0399	0.0081
1988-89								
N				120	39	48	6	0
Lower 95% C.I.				0.0127	0.0014	0.0245	0.0075	0.0000
Proportion				0.0155	0.0020	0.0353	0.0236	0.0056
Upper 95% C.I.				0.0187	0.0027	0.0500	0.0645	0.0514
1989-90								
N			46	92	3			
Lower 95% C.I.			0.0049	0.0034	0.0002			
Proportion			0.0068	0.0043	0.0010			
Upper 95% C.I.			0.0091	0.0054	0.0027			
1990-91								
N			27	24	1			
Lower 95% C.I.			0.0015	0.0012	0.0000			
Proportion			0.0024	0.0020	0.0013			
Upper 95% C.I.			0.0035	0.0031	0.0098			
1991-92								
N			13	4				
Lower 95% C.I.			0.0015	0.0012				
Proportion			0.0032	0.0035				
Upper 95% C.I.			0.0045	0.0048				
1992-93								
N		197	2					
Lower 95% C.I.		0.0258	0.0001					
Proportion		0.0300	0.0020					
Upper 95% C.I.		0.0347	0.0091					
1993-94								
N	23	121	1					
Lower 95% C.I.	0.0012	0.0085	0.0000					
Proportion	0.0020	0.0105	0.0046					
Upper 95% C.I.	0.0031	0.0128	0.0631					

TABLE 3-10. ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1993-94, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH.

COHORT	1993	1992	1989	1988	1987	1986	1985	1984
NUMBER STOCKED	568,410	210,746	202,068	48,611	324,579	529,563	284,578	147,153
1986-87								
N						38	51	5
Lower 95% CI						0.0126	0.0286	0.0038
Estimate						0.0171	0.0353	0.0058
Upper 95% CI						0.0226	0.0432	0.0084
1987-88								
N					25	127	82	4
Lower 95% CI					0.0031	0.0158	0.0526	0.0080
Estimate					0.0042	0.0187	0.0634	0.0135
Upper 95% CI					0.0055	0.0220	0.0761	0.0218
1988-89								
N				120	39	48	4	0
Lower 95% CI				0.1541	0.0030	0.0282	0.0221	0.0043
Estimate				0.1630	0.0038	0.0398	0.0493	0.0222
Upper 95% CI				0.1723	0.0048	0.0554	0.1062	0.0913
1989-90								
N			46	92	3			
Lower 95% CI			0.0165	0.0477	0.0006			
Estimate			0.0198	0.0509	0.0017			
Upper 95% CI			0.0235	0.0543	0.0037			
1990-91								
N			27	24	1			
Lower 95% CI			0.0055	0.0211	0.0002			
Estimate			0.0070	0.0243	0.0026			
Upper 95% CI			0.0088	0.0279	0.0127			
1991-92								
N			13	4				
Lower 95% CI			0.0091	0.0397				
Estimate			0.0095	0.0411				
Upper 95% CI			0.0099	0.0430				
1992-93								
N		197	2					
Lower 95% CI		0.0739	0.0017					
Estimate		0.0808	0.0059					
Upper 95% CI		0.0882	0.0163					
1993-94								
N	23	121	1					
Lower 95% CI	0.0013	0.0260	0.0017					
Estimate	0.0021	0.0294	0.0136					
Upper 95% CI	0.0032	0.0331	0.0964					

[a]Estimated hatchery proportion scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula:

$$\left[H_{ai} \times 600000/N_i\right] / \left[(H_a i \times 600000/N_i) + Wi\right]$$

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

During the 1993-94 program, recaptures were made of 134 verified hatchery striped bass which were tagged with a CWT, and 481 wild striped bass that were individually tagged with our internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin, except for 4,353 fish during three-week periods early and late in the program when one detector became inoperable. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1993-94 winter sampling program, 112 Age 0+ (1993 cohort), 21 Age 1+ (1992 cohort), and 1 Age 4+ (1989 cohort) verified hatchery striped bass were caught. The 1990 and 1991 cohorts of hatchery striped bass were not tagged.

3.4.1.1 Length

A total of 568,410 hatchery striped bass were tagged with magnetic tags and stocked to the Hudson River between 6 August and 5 October 1993 (EA 1994). The mean length of the 1993 cohort of wild fish was not significantly different from the hatchery cohort at Age 0+, based on overlapping 95% confidence intervals (Table 3-11). The 1992 cohort of Age 1+ wild fish were significantly smaller than the Age 1+ hatchery fish caught during the 1993-94 program (Table 3-11). Age 1+ hatchery fish were also significantly smaller than wild fish of the 1985, 1986, and 1987 cohorts (Table 3-12). It was not possible to compare mean length at age between the hatchery and wild 1990 and 1991 cohorts because these cohorts

TABLE 3-11. COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+, 1+, 2+, 3+ AND 4+ WILD AND HATCHERY STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER[a] 95% CI	UPPER[a] 95% CI	N	MEAN (mm)	LOWER 95% CI	UPPER 95% CI
0+	1993	828	123	121	125	21	128	121	135
1+	1992	2695	237	236	238	112	220	215	225
2+	1991[b]	1631	317	307	328	-	-	-	-
3+	1990[b]	152	424	246	602	-	-	-	-
4+	1989	11	505	-	-	1	507	-	-

[a]At statistic of 2.00 was used to calculate the confidence intervals about the stratified mean for of wild fish.

[b]The stratified mean lengths for the 1990 and 1991 wild cohorts of striped bass represent hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

were not tagged prior to release from the hatchery. Therefore, the stratified mean lengths presented for the 1990 and 1991 cohorts of wild fish in Table 3-11 represent hatchery and wild fish combined.

The 1989 hatchery cohort was tagged prior to stocking. Two separate groups of fish were stocked in 1989: 179,219 fish were stocked in August 1989 (summer-stocked); and 21,196 were stocked in October (fall-stocked). The fall-stocked fish were significantly larger than the summer stocked fish at the time of stocking. When recaptured at Ages 0+ and 1+, the 1989 hatchery cohort (summer and fall-stocked fish combined) was significantly larger than wild fish, fall-stocked fish were significantly larger than summer-stocked fish, and fall-stocked fish were preferentially recaptured compared to summer-stocked fish (NAI 1992). The larger size and preferential recapture of fall-stocked hatchery fish at Age 0+ and 1+ was attributed to either differential survival or differential behavior of the stocking groups. The 1989 hatchery cohort at Age 2+ was significantly smaller than the wild cohort (Table 3-13). However, similar to Ages 0+ and 1+, fall-stocked fish were preferentially recaptured as they comprised 79% (11/14) of the hatchery recaptures of these cohorts but only 11% of the fish stocked. Only two fish from the 1989 hatchery cohort were caught in the 1992-93 program, and only one fish from the 1989 hatchery cohort was recaptured at Age 4+ during the 1993-94 program. However, all three fish were from the 1989 fall-stocked group, and no members of the more numerous summer-stocked group, were recaptured in either 1992-93 or 1993-94 (Table 3-13).

No members of the 1988 or earlier hatchery cohorts were recaptured. Comparisons between estimated mean lengths between the hatchery and wild cohorts for the 1988 and previous year classes are found in NAI (1992) and Table 3-12.

3.4.1.2 Magnetic Tag Detection Efficiency

During the 1993-94 program, 30,093 striped bass were examined using the field magnetic tag detectors. Of these fish, 142 were classified as suspected Hudson River hatchery striped bass and 134 were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Eight fish suspected of having CWTs from the Verplanck hatchery did not have

TABLE 3-12. MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1993 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER.

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1984	Hatchery							3	275[c]	37.5	2[c]	349	31.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				26	205*	3.8	58	286	41.4	6	364	15.9
	Wild				285	221*	3.0	574	317	2.6	57	396	9.2
1986	Hatchery	22	107*	3.8	96	220*	2.7	48	315	5.2	--		
	Wild	83	128*	2.9	1,503	253*	1.2	361	324	3.5	55	382	10.1
1987	Hatchery	20	108	6.2	39	209*	5.2	3	290[c]	16.0	1[c]	350	--
	Wild	190	108	2.1	3,623	227*	0.8	1,216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	1.7	92	219	3.7	24	311	9.9	4[c]	380	18.8
	Wild	1,007	121*	2.0	3,514	214	0.7	2,109	321	1.8	156	386	6.2
1989	Hatchery	46	138*	2.0	27	245	7.8	13	305	12.3	2[c]	423	46.0
	Wild	368	112*	1.6	2,174	239	0.9	961	324	2.3	125	414	7.2
1990[d]	Hatchery	--			--			--			--		
	Wild	206	119	1.5	3,675	245	0.6	1,378	329	1.9	152	424	89.9
1991[d]	Hatchery	--			--			--					
	Wild	818	131	1.9	3,899	231	0.8	1,631	317	5.5			
1992	Hatchery	188	127	0.9	112	220*	2.8						
	Wild	473	116	1.0	2,695	237*	0.5						
1993	Hatchery	21	128	3.6									
	Wild	828	123	1.0									

*Indicates a significant ($p < 0.05$) difference in mean length between the hatchery and wild cohorts within an age class. Non-overlapping confidence intervals of mean lengths of hatchery and wild fish were used to indicate significance.

[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

[b]At statistic of 2.00 was used to calculate the confidence intervals about the stratified means of wild fish.

[c]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for hatchery striped bass.

[d]The mean length reported for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

TABLE 3-13. MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM, WINTERS OF 1988-89 THROUGH 1993-94.

		RECAPTURE STATISTICS FOR HATCHERY STRIPED BASS AT AGE														
		AGE 0+			AGE 1+			AGE 2+			AGE 3+			AGE 4+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVER PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVER PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGT H (mm)	RECOVER PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040	0	--	0.00000	0	--	0.00000
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052	4	380	0.00010	0	--	0.00000
1989	Verplanck Summer[3]	13	124	0.00007	5	215	0.00003	2	330	0.00001	0	--	0.00000	0	--	0.00000
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104	11	300	0.00052	2	423	0.00009	1	507	0.00005

[1]1988 Attleboro fall number stocked (H_2) = 10,057 at 80-84 mm modal length class.

[2]1988 Verplanck fall number stocked (H_2) = 38,554 at 139 mm mean length.

[3]1989 Verplanck summer number stocked (H_2) = 179,219 at 105 mm mean length.

[4]1989 Verplanck fall number stocked (H_2) = 21,196 at 152 mm mean length.

CWTs. Fish hooks were the primary reason for false positive detection of CWTs in suspected hatchery recaptures from previous programs (Mattson et al. 1990), and five of the eight fish without tags in this program had fish hooks present. One fish had rust present in the buccal cavity, and the remaining two false positive fish had no tag present.

Striped bass caught during the 1993-94 program were double-checked for CWTs with two "V-shaped" detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Two magnetic tag detectors were used on all sampling days during the first two weeks of the 1993-94 program. During the middle of the third week one detector became inoperable and only one detector was used to check fish between 17 November and 5 December 1993. The second detector was repaired and two detectors were again used between 6 December 1993 and 5 April 1994. One detector was used again off and on during the last three weeks of sampling. Two fish escaped detection by the primary detector during the week of 6 December 1993, and five fish escaped detection by the primary detector during the week of 11 April 1994, resulting in a total of 7 fish missed by one detector when two detectors were used. A non-detection rate of 0.00462 was applied to all verified hatchery recaptures caught during the entire 1993-94 program.

The hatchery striped bass nondetection rate of 0.0046 for 1993-94 was similar to the non-detection rate in 1986-87 and represented the fourth lowest magnetic tag detection efficiency (fourth highest non-detection rate) observed in the program since hatchery fish were first detected in 1986-87 (Table 3-14). The nondetection rate of 0.0459 for 1991-92, 0.0237 in 1986-87, and 0.0138 in 1992-93, were higher than the 1993-94 rate. Between 1987-88 and 1990-91, the nondetection rate varied between 0.0000 and 0.0005, about two orders of magnitude better in detection efficiency than in 1986-87 or 1991-92. The nondetection statistic does not take into account the large number of fish monitored, and as a ratio, is most sensitive to small numbers of verified hatchery fish examined. It appears that when all of the fish are checked with two detectors, as in 1989-90 through 1993-94, between one and three fish escape detection by the first detector unless specific operational problems occur as in 1992-93 or 1993-94 (Table 3-14). The consequences of this relatively high non-detection rate were small in 1991-92, resulting in one fish being added to adjust the 1989 cohort of 13 Age 2+ hatchery striped bass, and no fish were added to the 1988 cohort of four Age 3+ hatchery fish (NAI 1994). In 1992-93, the non-detection rate did not affect the 1989 cohort of Age 3+

TABLE 3-14. MAGNETIC TAG DETECTION EFFICIENCY OBSERVED FOR HUDSON RIVER HATCHERY STRIPED BASS DURING THE 1986-87 THROUGH 1993-94 WINTER PROGRAMS.

	DETECTOR TYPE		TOTAL NUMBER OF FISH			HATCHERY-TAGGED FISH DETECTED BY			
PROGRAM	PRIMARY	SECONDARY	MONITORED BY PRIMARY DETECTOR	MONITORED BY BOTH DETECTORS	VERIFIED RECAPTURES	PRIMARY	PRIMARY AND SECONDARY	MISSED BY PRIMARY	NON-DETECTION RATE[a]
1986-87	V-shaped	Tube	14,136	2,138	94	13	15	2	0.0237
1987-88	V-shaped	Tube	28,192	1,611	238	11	11	0	0.0000
1988-87	V-shaped	Tube/ V-shaped[b]	32,975	8,164[b]	213	51	52	1	0.0004
1989-90	V-shaped	V-shaped	33,386	33,386	141	138	141	3	0.0005
1990-91	V-shaped	V-shaped	29,346	29,346	52	51	52	1	0.0004
1991-92	V-shaped	V-shaped	35,072	35,072	17	14	17	3	0.0459
1992-93	V-shaped	V-shaped	29,607	28,813	190	139	149	10	0.0138[c]
1993-94	V-shaped	V-shaped	30,093	25,740	134	103	110	7	0.0046

[a]Non-Detection Rate = $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected when both detectors were used.

[b]3,368 fish on randomly selected days between 31 October 1988 and 13 March 1989 were first monitored with a V-shaped field detector and then with a Tube-shaped detector. The Tube-shaped detector became inoperable on 20 March 1989 and 4,796 fish representing the entire catch were monitored with both a primary and secondary V-shaped field detector until the end of field sampling on 15 April 1989.

[c]One tag detector became inoperable during the week of 29 March 1993; 10 hatchery fish were missed by this detector when two detectors were used. An additional 794 fish were checked with only one tag detector and 41 age 0+ hatchery fish were detected on that week. We applied a non-detection rate of 0.00000 to 82 hatchery recaptures prior to 29 March 1993 and a non-detection rate of 0.03078 for 67 hatchery recaptures on and after 29 March 1993. This value represents the weighted non-detection rate.

fish, and added only nine fish to the Age 0+ hatchery cohort (NAI 1996). In 1993-94, the non-detection rate adjusted the number of Age 0+ hatchery catch upwards from 21 to 23 fish, and the catch of the Age 1+ cohort of hatchery fish was adjusted from 112 to 121 fish. The 1989 cohort of one Age 4+ hatchery fish was not changed by the non-detection adjustment in 1993-94.

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1993-94 winter sampling program, 333 striped bass were recaptured out of 17,500 fish that were caught, tagged with internal anchor tags, and released in good condition. An additional 810 striped bass with external abnormalities were caught, tagged and released during the 1993-94 program, and we recaptured 11 of these fish. We also recaptured 148 striped bass with internal anchor tags implanted during previous programs, 52 fish were recaptured with suspected tag wounds, no fish were recaptured with illegible tag numbers, and 9 fish were recaptured with tags from other tagging studies. These groups of wild striped bass are described below in separate sections. A complete description of the number of fish caught, tagged with different types of internal anchor-external streamer tags since 1984, and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchor tags were used during the 1993-94 program.

3.4.2.1 Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1993-94 Winter Program

The majority (15,813 or 79%) of the taggable-size (≥150 mm) striped bass (19,941) were caught in the Battery region as were 244 or 73% of the 333 fish tagged, released and recaptured during this study (Table 3-15, Appendix Table D-2). This is not surprising since most (94%) of the trawl sampling effort was allocated to the Battery during 1993-94 based on the high CPUE in this region during the current and previous programs (NAI 1986, 1987, 1988, 1990, 1992, 1994, 1996).

TABLE 3-15. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

			NUMBER OF RECAPTURES* FROM RELEASE REGION		
RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	UPPER HARBOR M = 3,742	BATTERY M = 13,758	TOTAL M = 17,500
UPPER HARBOR	4,128	R	31	12	43
		R/M	0.00828	0.00087	0.00246
		R/C	0.00751	0.00291	0.01042
BATTERY	15,813	R	46	244	290
		R/M	0.01229	0.01774	0.01657
		R/C	0.00291	0.01543	0.01834
TOTAL	19,941	R	77	256	333
		R/M	0.02058	0.01861	0.01903
		R/C	0.00386	0.01284	0.01670

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

Recapture rates (R/M) and recapture proportions (R/C) can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-15, the recapture rate for striped bass tagged, released and recaptured in the Battery (cell total) was 244/13,758 or 0.01774. The recapture rate for striped bass tagged and released in the Battery and recaptured throughout the study area (column total) was 256/13,758 or 0.01861.

In contrast, recapture proportions (R/C) from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-15, the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 244/15,813 or 0.01543. It is generally most informative to examine recapture rates from the column totals and recapture proportions from the row totals since these statistics best describe specific movement among regions (or time periods).

Examination of monthly recapture rates (R/M) and recapture proportions (R/C) can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (R/M column totals; Table 3-16) were generally stable for the November 1993 through January 1994 period, low during February 1994 when fishing effort was extremely low, and remained low in March and April 1994. Monthly recapture proportions (R/C row totals) increased from November 1993 through January 1994, were zero during February 1994, and increased again in March and April 1994. This pattern of stable monthly recapture rates and increasing recapture proportions suggests that November 1993 through January 1994 was a period of little movement of the striped bass population in the lower

TABLE 3-16. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

			NUMBER OF RECAPTURES* FROM RELEASE MONTH						
RECAPTURE MONTH	STATISTIC	NUMBER CAUGHT (C)	NOV M = 2,439	DEC M = 4,626	JAN M = 1,251	FEB M = 113	MAR M = 4,562	APR M = 4,509	TOTAL M = 17,500
NOVEMBER	R	2,660	29						29
	R/M		0.01189						0.01189
	R/C		0.01090						0.01090
DECEMBER	R	5,091	19	48					67
	R/M		0.00779	0.01038					0.00948
	R/C		0.00373	0.00943					0.01316
JANUARY	R	1,452	3	14	11				28
	R/M		0.00123	0.00303	0.00879				0.00337
	R/C		0.00207	0.00964	0.00758				0.01928
FEBRUARY	R	153	0	0	0	0			0
	R/M		0.00000	0.00000	0.00000	0.00000			0.00000
	R/C		0.00000	0.00000	0.00000	0.00000			0.00000
MARCH	R	5,346	13	34	20	0	27		94
	R/M		0.00533	0.00735	0.01599	0.00000	0.00592		0.00724
	R/C		0.00243	0.00636	0.00374	0.00000	0.00505		0.01758
APRIL	R	5,239	7	14	9	1	37	47	115
	R/M		0.00287	0.00303	0.00719	0.00885	0.00811	0.01042	0.00657
	R/C		0.00134	0.00267	0.00172	0.00019	0.00706	0.00897	0.02195
TOTAL	R	19,941	71	110	40	1	64	47	333
	R/M		0.02911	0.02378	0.03197	0.00885	0.01403	0.01042	0.01903
	R/C		0.00356	0.00552	0.00201	0.00005	0.00321	0.00236	0.01670

*Excluding recapture from previous sampling seasons.

LEGEND: R = number of striped bass recaptured.
M = number of striped bass >150 mm marked and released.
C = number of striped bass >150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

Hudson River. This pattern would likely have continued through February 1994 if ice floes did not interfere with the trawling effort during this month.

Striped bass tagged and released in the combined Battery and upper New York harbor regions, and subsequently recaptured in those regions were at-large an average of 36 days and ranged in size between 150 mm and 443 mm (Table 3-17). Approximately 13% (43/333) of the striped bass were recaptured on the same day as they were tagged and released, and 65% (217/333) of the fish were recaptured within 30 days of release (Table 3-17), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 71% (238/333) of the striped bass were recaptured, and the maximum days at-large was 157 days. Days at-large and recapture length data for the 1993-94 program were similar to previous years (NAI 1987, 1988, 1990, 1991, 1992, 1994, 1996).

3.4.2.2 Striped Bass Internal Anchor-Tagged and Released Prior to, and Recaptured During the 1993-94 Winter Program

A total of 148 striped bass were recaptured during 1993-94 with internal anchor tags identified from previous programs (Appendix Table D-3). Most (130 or 88%) of these 148 recaptured striped bass had the external portion of the tag (streamer) present. Among the 130 striped bass with streamers intact, all fish had tags with completely legible numbers and only one fish exhibited any abrasion on the external streamer (Table 3-18, Appendix Table D-5). An additional 49 fish were observed with suspected tag wounds but no tag streamer present (Table 3-18). Eighteen of these fish with suspected tag wounds had Hallprint (MARK_CD=98) anchors in the abdominal cavity containing the tag number. The remaining 31 fish either had the tag and anchor removed by sportsmen, had wounds unrelated to tagging, or had shed the tag.

Tag numbers were defined as completely illegible if one or more digits of the 5-digit tag number could not be read in the field. Tag abrasion was first observed during 1986-87, is time dependent, and the tagged fish must be at-large for at least six months for abrasion

TABLE 3-17. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED AND RECAPTURED IN THE HUDSON RIVER BY A 9 M TRAWL, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

NUMBER TAGGED (≥150 mm)	M	17,500
NUMBER EXAMINED FOR TAGS (≥150 mm)	C	19,941
NUMBER RECAPTURED	R	333
SIZE RANGE OF RECAPTURED FISH (mm)	Min	150
	Max	443
	Mean	255
	S.D.	49
DAYS AT-LARGE	Min	0
	Max	157
	Mean	36
	S.D.	43
FREQUENCY OF DAYS AT-LARGE	0 Days	43
	1- 5 Days	62
	6- 10 Days	35
	11- 20 Days	57
	21- 30 Days	20
	31- 40 Days	15
	41- 50 Days	2
	51- 60 Days	4
	61- 70 Days	11
	71- 80 Days	11
	81- 90 Days	16
	91-100 Days	17
	101-110 Days	12
	111-120 Days	10
	121-130 Days	11
	131-140 Days	3
	141-150 Days	2
	151-160 Days	2

TABLE 3-18. INCIDENCE OF TAG NUMBER ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR HUDSON RIVER STRIPED BASS THAT WERE AT LARGE AT LEAST ONE YEAR PRIOR TO THEIR RECAPTURE DURING THE 1988-89 THROUGH 1993-94 PROGRAMS.

		NUMBER OF FISH RECAPTURED DURING PROGRAM*					
DESCRIPTION	CONDITION OF TAG INSERTION	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Tag number completely legible	Healed	34	63	206	102	118	116
	Infected	13	6	22	15	14	14
		47	69	228	117	132	130
	(Anchor Protruding)	(5)	(0)	(6)	(1)	(0)	(14)
Tag number abraded but legible	Healed	3	2	2	0	1	0
	Infected	3	1	0	1	0	0
		6	3	2	1	1	0
	(Anchor Protruding)	(1)	(0)	(0)	(0)	(0)	(0)
Tag number partly or completely missing and not legible	Healed	0	0	1	2	0	0
	Infected	0	0	0	0	0	0
		0	0	1	2	0	0
	(Anchor Protruding)	(0)	(0)	(0)	(0)	(0)	(0)
Suspected tag wound, tag and anchor missing	Healed	4	6	69	43	57	28
	Infected	0	0	3	4	7	3
		4	6	72	47	64	31
Suspected tag wound, anchor present	Healed	2	0	9	10	12	18
	Infected	0	0	0	0	3	0
		2	0	9	10	15	18

*Striped bass that were tagged and released prior to the program which could be cross-classified by degree of tag number abrasion and condition of the tag insertion site.

to affect the legibility of the legend on the external streamer (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged at-large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990). Changes in tag design since 1986-87 have virtually eliminated tag abrasion.

Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used: abrasion was observed in 28% of the recaptured fish at-large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but short length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990). Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was displaced out of the fish and shed.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a long-term shedding rate for the original Hallprint tag with an exposed filament of 22/94 or

23%. Among the 33 fish with suspected tag wounds (and no anchor found) caught during the 1993-94 program, 22 fish had a longitudinal scar suggesting they may have shed a tag and 11 fish had wounds that were judged to be not related to tagging. None of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has virtually eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has reduced tag loss due to shedding.

Among the 148 striped bass recaptured from previous programs during 1993-94 were 124 fish that had been tagged and released during 1992-93, 19 fish that had been tagged and released during 1991-92, 4 recaptured fish were tagged and released during 1990-91, and the remaining one fish was tagged and released during 1989-90 (Table 3-19, Appendix Table D-3). All recaptured fish from the 1989-90 through 1992-93 programs were caught, tagged and released from the 9 m trawl, which was the only gear used. Recaptured fish were at-large between 234 and 1,420 days, and ranged in length between 213 mm and 544 mm (Table 3-20). No striped bass were recaptured with both an internal anchor tag and a dart tag during 1993-94, and no striped bass were observed to have shed a dart tag.

Nine striped bass were recaptured in 1993-94 with tags originating from other tagging programs (Table 3-21). Five fish were recaptured with U.S. Fish and Wildlife Service internal anchor tags and four fish were recaptured with Littoral Society spaghetti tags. All nine striped bass with other agency tags were returned to the river without removing the tag. Two of the Floy internal anchor tags from the U.S. Fish and Wildlife Service fish had illegible tag numbers.

3.4.2.3 Effects of the Internal Anchor Tag on Striped Bass Growth

Growth based on focus to annulus (radius) measurements for scale samples from tagged striped bass that had been at-large one or two years was compared within cohort to growth from a corresponding set of scales taken from untagged fish of the same cohort at the

TABLE 3-19. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED (R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH			
					MIN	MAX	MEAN	S.D.
1992-93	9 m trawl	20,847	124	0.00595	213	489	326	67
1991-92	9 m trawl	23,514	19	0.00081	307	544	403	59
1990-91	9 m trawl	22,406	4	0.00018	382	502	451	51
1989-90	9 m trawl	24,362	1	0.00004	329	329	329	

TABLE 3-20. RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED PRIOR TO NOVEMBER 1993, AND RECAPTURED IN THE HUDSON RIVER BY A 9 m TRAWL, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

TOTAL NUMBER TAGGED	M	133,194
NUMBER AGE 2+ OR OLDER EXAMINED FOR TAGS	C	7,297
NUMBER RECAPTURED	R	148
RECAPTURE RATE	R/M	0.00111
RECAPTURE PROPORTION	R/C	0.02028
LENGTH OF RECAPTURED FISH (mm)	Min	213
	Max	544
	Mean	340
	S.D.	73
DAYS AT-LARGE	Min	234
	Max	1,420
	Mean	431
	S.D.	184
FREQUENCY OF DAYS AT LARGE	201-250 Days	6
	251-300 Days	13
	301-350 Days	29
	351-400 Days	45
	401-450 Days	20
	451-500 Days	10
	501-550 Days	1
	551-600 Days	1
	601-650 Days	6
	651-700 Days	1
	701-750 Days	6
	751-800 Days	4
	801-850 Days	1
	851-900 Days	0
	901-950 Days	0
	951-1000 Days	2
	1001-1050 Days	1
	1051-1100 Days	0
	1101-1150 Days	1
	1151-1200 Days	0
	1201-1250 Days	0
	>1401 Days	1

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, 1989-90, 1990-91, 1991-92, 1991-92, and 1992-93 programs.

TABLE 3-21. STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHERS AGENCY TAGS, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

		TAG CONDITION						RECAPTURE		
AGENCY	TAG NUMBER	SITE	TAG NO.	ADDRESSS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
U S F & W	249283							19 NOV 93	3	525
LITTORAL SOCIETY	334021	1	4	4	4		N	4 DEC 93	2	365
LITTORAL SOCIETY	7732	1	4	4	4		N	6 DEC 93	3	531
U S F & W	168407	1						6 DEC 93	2	277
LITTORAL SOCIETY	326617	1	4	4	4		N	27 DEC 93	2	636
U S F & W	249368	1	4	4	4	2	N	27 DEC 93	1	583
U S F & W	-	1	4	4	4	2	N	15 MAR 94	8	369
LITTORAL SOCIETY	321830	1						31 MAR 94	7	331
U S F & W	-	2	1	1	2	2	N	8 APR 94	5	253

TAG VARIABLE	COMMENT DESCRIPTION
Number Address Reward	1 = Legend completely missing 2 = Abraded and partly missing 3 = Abraded but completely legible 4 = Completely legible
Number orientation	A = Tag number facing anterior(Head) P = Tag number facin posterior(Tail)
Anchor protrusion	Y = Yes N = No

TAG SITE

1 = Tag present, wound healed
2 = Tag present, wound poorly healed, evidence of infection or swelling.

time the tagged fish were recaptured (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. We selected scale radius measurements rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

Mean radius measurements for each annulus were obtained from the 1985 through 1991 cohorts of striped bass recaptured during the 1988-89 through 1993-94 programs (Table 3-22). A complementary set of scale samples was selected for each cohort of fish caught in the recapture samples to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X +1 or X +2 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus. We calculated relative growth as the response variable by taking the difference between annulus measurements for the time of release and recapture and dividing by the annulus measurement for the time of release. This relative growth measurement accounts for variation in the size of scales taken for the release and recapture samples.

Tagged striped bass from the 1985 through 1990 cohorts that were at-large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way ANOVA comparisons of mean relative growth (Table 3-22). A significant difference was observed between the mean scale radius for tagged and untagged striped bass of the 1991 cohort. Fish that were tagged and released in 1992-93 at Age 1+ were significantly larger than untagged fish of the same cohort caught in 1993-94 after being at-large for one year. Since both the tagged and untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. Although we cannot explain why these tagged fish were larger than untagged fish, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit inhibited growth during one or two years at-large.

TABLE 3-22. ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT-LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE, 1988-89 THROUGH 1993-94 PROGRAMS.

						SCALE SAMPLE MEASUREMENT		
RECAPTURE PROGRAM	COHORT	RECAPTURE AGE	YEARS AT-LARGE	TAG STATUS	N	MEAN RADIUS	S.E.	Prf[a]
1988-89	1985	3+	1	Tagged	14	151.7	5.5	0.9015
			0	Untagged	48	147.6	3.0	
1988-89	1986	2+	1	Tagged	24	124.2	3.9	0.2580
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	51	101.3	2.5	0.6096
			0	Untagged	1,138	101.2	0.5	
1990-91	1987	3+	1	Tagged	21	152.3	5.0	0.1987
			2	Tagged	14	152.9	6.3	0.1023
			0	Untagged	53	143.4	3.2	
1990-91	1988	2+	1	Tagged	161	103.6	1.3	0.1435
			0	Untagged	1,844	97.0	0.4	
1991-92	1988	3+	1	Tagged	34	148.3	2.1	0.7432
			2	Tagged	18	144.1	5.4	0.3900
			0	Untagged	110	143.6	2.2	
1991-92	1989	2+	1	Tagged	45	114.4	2.7	0.2203
			0	Untagged	829	103.8	0.6	
1992-93	1989	3+	2	Tagged	18	145.7	6.1	0.0986
			1	Tagged	8	165.0	10.6	0.3650
			0	Untagged	90	156.5	2.6	
1992-93	1990	2+	1	Tagged	72	117.5	2.2	0.1817
			0	Untagged	1,263	114.5	0.5	
1993-94	1990	3+	2	Tagged	16	160.1	5.2	0.9511
			1	Tagged	20	164.3	6.7	0.5252
			0	Untagged	110	159.6	2.9	
1993-94	1991	2+	1	Tagged	87	118.7	2.3	0.0001
			0	Untagged	1,487	103.9	0.5	

[a]Probability of finding that the mean relative growth is different by chance alone, under a least squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

3.4.3 Condition of the Catch

Some of the striped bass caught in the 9 m trawl displayed one or more types of injury or abnormality, such as blindness, fin rot, fungal infection, skeletal deformity, or visible wounds. The incidence of such conditions among all fish that had not been previously caught (i.e., those without tags or tag wounds) was 6.01% (Table 3-23). Approximately two-thirds of all unmarked fish were subsequently tagged and released (18,690 of 29,186, or 64%). Most of the remaining 36% were less than 150 mm and too small to tag, or were judged to be poor condition and not tagged. These groups of fish were either released without tags or were dead and taken to the laboratory for processing. The proportion of injured or anomalous striped bass among those tagged and released was 6.13%. The incidence of injuries or anomalies among recaptured fish (with tags or suspected tag wounds) was 19.29% (103 of 534).

The most frequently observed condition was stress from the sampling gear which was noted in 3.5% of unmarked striped bass (Table 3-23). Fin rot was observed in 1.3% of the unmarked fish, blindness (opaqueness in one or both eyes) was observed in 0.6%, and 0.3% of the unmarked fish displayed more than one type of injury or abnormality.

Each of the six general categories of poor condition were further classified (Table 3-24). Blindness in both eyes was roughly two and a half times more frequent than blindness in one eye. Fin rot most commonly occurred on the caudal fin, and occasionally on pectoral fins or on more than one fin on the same fish. Fungal infections were restricted to one side of the body 22% of the time. Skeletal anomalies usually involved fish hook damage to the mouth or gills, which was much more common than scoliosis (lateral spine curvature), head deformities (e.g., "pugnose"), or lordosis (dorso-ventral spine curvature). Many of the visible wounds on the body were healed over. Other commonly noted wounds were damaged gills and missing or damaged fins. Infrequently observed conditions included hemorrhaged (bloodshot) eyes, bulging eyes ("pop-eye"), wounds to the eye, and tumors.

Fin rot and fungus accounted for a much larger proportion of the injuries/anomalies in recaptured striped bass (88%) than in unmarked fish (24%) (Table 3-24). Stress from the sampling gear, however, accounted for a smaller proportion of the injuries among recaptured fish (7%) than among unmarked fish (56%), because very few "stressed"

TABLE 3-23. INCIDENCE OF FISH IN POOR CONDITION AMONG UNMARKED VS. RECAPTURED STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

TYPE(S) OF INJURY OR ABNORMALITY[a]	INCIDENCE AMONG 29,186 UNMARKED FISH		INCIDENCE AMONG 18,690 FISH TAGGED[b]		INCIDENCE AMONG RECAPTURED 534 FISH[c]	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Blind only	133	0.46	133	0.71	4	0.75
Stress only	1004	3.44	420	2.25	7	1.31
Fin rot only	298	1.02	296	1.58	22	4.12
Fungus only	36	0.12	36	0.19	18	3.37
Skeleton only	59	0.20	59	0.32	1	0.19
Other only	124	0.42	119	0.64	2	0.37
Blind/stress	8	0.03	2	0.01		
Blind/fin rot	19	0.07	19	0.10		
Blind/fungus	1	<0.01	1	0.01	1	0.19
Blind/skeleton	1	<0.01	1	0.01		
Blind/other	7	0.02	7	0.04		
Stress/fin rot	15	0.05	8	0.04	1	0.19
Stress/fungus	2	0.01	1	0.01	1	0.19
Stress/skeleton	1	<0.01				
Stress/other	1	<0.01				
Fin rot/fungus	32	0.11	32	0.17	45	8.43
Fin rot/skeleton	1	<0.01	1	0.01		
Fungus/skeleton	1	<0.01				
Fungus/other	2	0.01	2	0.01		
Skeleton/other	2	0.01	2	0.01		
Blind/stress/fin rot	1	<0.01				
Blind/fin rot/fungus	1	<0.01	1	0.01		
Blind/fin rot/skeleton	1	<0.01	1	0.01		
Stress/fin rot/fungus	1	<0.01	1	0.01	1	0.19
Stress/fin rot/other	1	<0.01	1	0.01		
Fin rot/fungus/skeleton	1	<0.01	1	0.01		
Fin rot/fungus/other	1	<0.01	1	0.01	—	—
Total	1754	6.01	1145	6.13	103	19.29

[a]Categories are described in more detail in Table 3-24.
[b]Excludes 10,496 not tagged.
[c]Including fish with suspected tag wounds, but excluding fish suspected of being recaptured hatchery releases.

TABLE 3-24. NATURE OF INJURIES AND ABNORMALITIES OBSERVED IN STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

GENERAL CATEGORY	SPECIFIC CONDITION	INCIDENCE AMONG 29,186 UNMARKED FISH CAPTURED	INCIDENCE AMONG 18,690 FISH TAGGED	INCIDENCE AMONG 534 RECAPTURED FISH
Blindness	Blind in one eye	49	47	2
	Blind in both eyes	123	118	3
Stress	Net rash	162	153	4
	Crushed	14	3	0
	Handling stress	858	277	6
Fin rot	On caudal fin	205	198	35
	On pectoral fin(s)	60	60	5
	On pelvic fin(s)	2	2	0
	On anal fin	2	1	0
	On dorsal fin(s)	1	1	0
	On multiple fins	102	100	29
Fungus	On one side of body	17	17	4
	On both sides of body	61	59	62
Skeleton	Side to side spine curvature	5	4	0
	Top to bottom spine curvature	5	5	0
	Head abnormalities	4	3	0
	Fish hook damage to mouth or gills	53	53	1
Other	Body wounds, damaged fins, etc.	138	132	2
Total[a]		1861	1233	153

[a]Totals exceed those in Table 3-23 because some fish exhibited more than one condition.

fish were tagged. The incidence of other types of conditions (blindness, skeletal deformities, wounds) was higher in recaptured fish as it was in unmarked fish or tagged fish (Table 3-24).

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1993-94 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator which permits tagging and recapture efforts to occur concurrently. This estimator was used during the 1985-86 through 1992-93 programs to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1996).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1) mortality is not different for tagged and untagged bass,
2) tagging does not affect bass catchability,
3) tagged bass do not lose their marks,
4) all tags are recognized and reported,
5) natural marking does not occur or is recognizable,
6) immigration, emigration, and recruitment are negligible in the study area i.e., the population is closed,
7) tagged bass are randomly distributed among untagged fish or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions, and
8) marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hours and (2) in holding pools for up to 180 days. However, during the 1990-91 program, predation by birds (gulls) was observed to remove about 2.4% of the tagged fish as they were released from the tagging vessel (NAI 1992). Most of the bird predation was observed to occur as the released fish drifted away from the tagging vessel before sounding. In the 1991-92 through present programs, all striped bass were released into a recovery pen that was suspended in the water alongside the tagging vessel. The pen provided cover until the fish sounded, and virtually eliminated bird predation. Therefore, the number of tagged striped bass at-large was not adjusted for mortality during the 1993-94 program.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods which rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (NAI 1993) which would provide evidence of tag loss. QA/QC procedures (NAI 1993) and audits provide documentation that incorrect identification or non-reporting of tags by field crews did not occur. Dunning et al. (1987) found 97.7% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 333 fish out of 17,500 tagged fish approximately 8 fish would be expected to have lost tags in the 1993-94 program. However, the tag loss rate from Dunning et al. (1987) was based on Floy style tags which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1993-94 program, 19,941 striped bass were examined for tags and tag wounds, and 52 fish were observed with tag wounds (Table 3-19). Eighteen of these fish had anchors present without streamers indicating the streamer was cut and removed by fishermen. Only 22 of these fish exhibited a longitudinal scar, suggesting the scar originated from shed Hallprint tags. Since these longitudinal scars have been shown to originate from shed Hallprint tags with exposed filaments at the base of the external streamer (Section 3.4.2.2), these fish may have originated from previous programs. The exposed filament tag was not used during the 1993-94 program. The remaining fish exhibited atypical wounds at the insertion site suggesting they may have a natural origin and may not be from a shed tag. Therefore, loss of internal anchor tags for fish tagged and released during 1993-94 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and we adjusted for it, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by the NYSDEC (NAI 1993, Geoghegan et al. 1990). Since this program provided both marking and recapture efforts, non-reporting of tags did not occur. Assumption 5 was satisfied because marking techniques which could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tags used in this study.

Immigration and emigration (Assumption 6) were apparently negligible during most of the study period (November 1993 through April 1994) as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4, NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1996). A linear regression of weekly recapture proportions (R/C) on cumulative number of marked fish (Figure 3-7) was significant and positive for the weeks of 22 November 1993 through the week of 10 January 1994 (Appendix Tables D-6 and D-7). Recapture rates (R/M) varied less during the weeks of 22 November 1993 through 10 January 1994 than any other eight-week period during the program. This eight-week period for the population estimator was truncated by the severe weather conditions that prevented most trawling effort from the week of 17 January through 21 February 1994. In the previous programs, a late-November through mid-March period of about 15-17 weeks was found to be representative for the population estimator (NAI 1994). If the field crews had unrestricted sampling access to the Battery region during the mid-January through February 1994 period, it is likely that a significant, positive regression of recapture proportions on cumulative number of marked fish would have been found for the November through March period comparable with previous programs. The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass during the 1993-94 program (Assumption 7). Further-more, step-wise polynomial

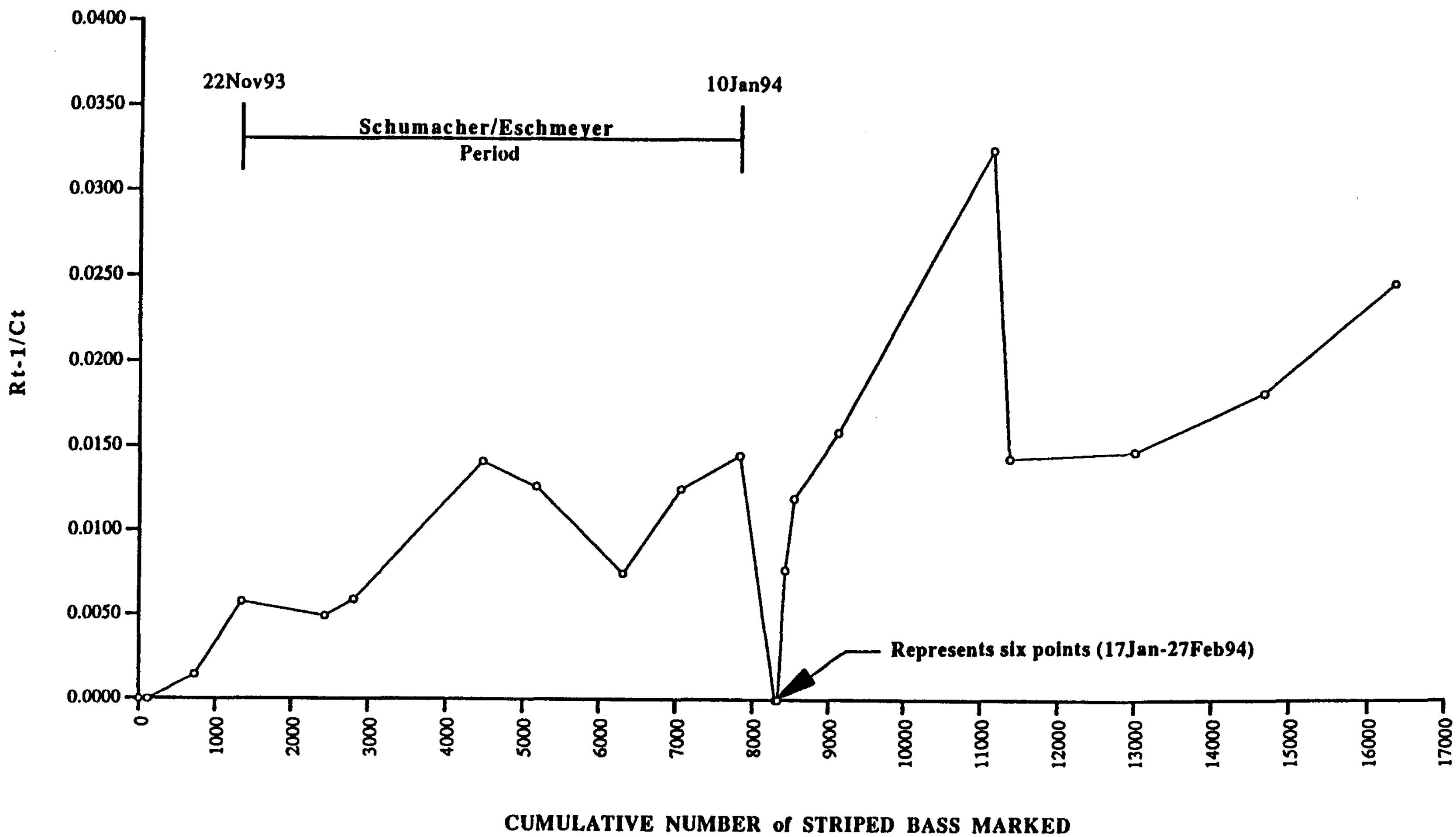


Figure 3-7. Striped bass recapture proportion (R/C) versus cumulative number of striped bass tagged in the combined Upper Harbor and Battery regions of the Hudson River, 1 November 1993 through 20 April 1994.

regressions did not significantly improve goodness of fit, which indicated a linear model was appropriate.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied for the weeks of 22 November 1993 through 10 January 1994 period in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1993-94 was 443,000 fish ≥150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 339,000 to 641,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25). Based on the estimated hatchery proportion of 1.05% for Age 1+ fish, (Section 3.3), about 3,000 Age 1+ hatchery fish ≥150 mm were present among the striped bass overwintering in the Battery and upper New York harbor regions during winter 1993-94.

For comparison with previous programs, the total population of Age 1+ and older striped bass ≥200 mm was estimated as 217,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This estimate was the second lowest calculated annually since 1985-86, with only the 1987-88 estimate being lower (Table 3-27). The 1991 cohort of Age 2+ fish and the 1992 cohort of Age 1+ fish were the primary contributor to this estimate of Hudson River striped bass in the mid-winter population during 1993-94.

TABLE 3-25. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1993-94.

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥150 mm	PROPORTION ≥150 mm	ESTIMATED POPULATION[a]
1+	10,980	10,914	0.5711	253,000
2+	5,560	5,560	0.2909	129,000
3+	1,027	1,027	0.0537	24,000
>3+	407	407	0.0213	9,000
TOTAL	17,974	17,908	0.9370	415,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 22 November 1993 through the week of 10 January 1994. Age 0+ striped bass were 6.3% (28,000) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 443,000 fish.

TABLE 3-26. ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER, WINTER 1993-94.

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	10,980	9,374	0.4905	217,000
2+	5,560	5,545	0.2901	129,000
3+	1,027	1,027	0.0537	24,000
≥3+	407	407	0.0213	9,000
TOTAL	17,974	16,353	0.8556	379,000

[a]The total population estimate based on fish ≥150 mm (443,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (16,353/19,112 = 0.8556).

TABLE 3-27. ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86 THROUGH 1993-94.

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1993-94	379,000	443,000
1992-93	717,000	920,000
1991-92	967,000	1,163,000
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged and we did not extrapolate the population estimate to fish ≥150 mm for the 1987-88, 1986-87 and 1985-86 programs.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9-m TRAWL.

	9-m TRAWL
Head rope length	6.9 m
Foot rope length (sweep)	9.0 m
Legs (between doors and net)	6.0 m
Approximate vertical lift	3.6 m
Doors (steel V-doors)	1.0 m
Net body length	5.2 m
Cod end section	2.3 m
Mesh - body of net	7.6-cm (stretch) mesh polypropylene; polypropylene; 3-mm diameter twine
- cod end	3.8-cm (stretch) mesh, knotless polypropylene; 3-mm diameter twine
Roller gear	25.4-cm rollers spaced with 5-cm coookie disks

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

REGION	WEEK	SURFACE WATER TEMPERATURE	SURFACE WATER CONDUCTIVITY	BOTTOM WATER TEMPERATURE	BOTTOM WATER CONDUCTIVITY
UPPER HARBOR	01NOV93	12.00	31736	12.00	36949
	08NOV93	11.00	27543	11.46	35733
	15NOV93	11.59	30292	11.55	37248
	22NOV93	10.20	21453	10.85	36559
	29NOV93	9.00	26411	9.13	35728
	06DEC93	8.36	20190	8.88	29872
	13DEC93	6.86	27308	7.64	35972
	20DEC93	5.29	13929	6.79	32614
	27DEC93	4.14	26858	5.71	33252
	10JAN94	1.79	37841	2.64	40215
	17JAN94	0.67	32745	1.67	38549
	07FEB94	1.00	35857	1.00	39246
	14FEB94	-0.33	30098	-0.42	42615
	21FEB94	1.50	32462	1.75	41590
	28FEB94	2.00	33840	2.00	37812
	07MAR94	2.00	28143	2.00	36862
	21MAR94	4.25	18304	4.00	36666
	28MAR94	5.00	18776	5.00	33134
BATTERY	01NOV93	12.01	26664	12.16	34616
	08NOV93	11.14	28221	11.18	33631
	15NOV93	11.63	27260	11.44	34398
	22NOV93	10.50	20215	10.85	37417
	29NOV93	9.21	19785	9.94	30166
	06DEC93	8.06	18042	8.88	31322
	13DEC93	6.75	20757	7.48	31022
	20DEC93	5.36	12203	6.86	30480
	27DEC93	4.07	27176	5.17	35425
	03JAN94	1.56	22348	3.17	33151
	10JAN94	1.55	30938	2.08	35444
	17JAN94	0.10	27800	1.40	36532
	24JAN94	0.00	31646	1.25	42361
	31JAN94	-0.42	23063	0.00	33583
	07FEB94	0.18	25714	0.96	34965
	14FEB94	-0.32	19623	-0.46	36428
	21FEB94	0.98	19079	0.98	33249
	28FEB94	1.55	23654	1.57	31286
	07MAR94	2.21	18653	2.00	30815
	14MAR94	3.34	10163	3.36	32006
	21MAR94	4.46	13359	3.99	32449
	28MAR94	4.99	5527	4.84	24982
	04APR94	5.56	5213	5.19	28720
	11APR94	6.95	3547	6.32	23145
	18APR94	8.38	2238	7.00	32529

Water temperature in °C.
Conductivity in μ/cm at 25 °C.

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. REGIONAL AND WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

REGION	WEEK	CPUE			
		TOWS	N	MEAN	S.E.
UPPER HARBOR	01NOV93	2	5	2.5	0.5
	08NOV93	10	108	10.8	3.6
	15NOV93	25	441	17.6	2.8
	22NOV93	9	394	43.8	8.5
	29NOV93	7	164	23.4	5.3
	06DEC93	31	1687	54.4	6.1
	13DEC93	20	466	23.3	4.9
	20DEC93	7	535	76.4	35.2
	27DEC93	7	127	18.1	8.1
	03JAN94				
	10JAN94	7	62	8.9	6.9
	17JAN94	3	2	0.7	0.3
	24JAN94				
	31JAN94				
	07FEB94	1	0	0.0	
	14FEB94	6	0	0.0	0.0
	21FEB94	2	0	0.0	0.0
	28FEB94	1	6	6.0	
	07MAR94	2	1	0.5	0.5
	14MAR94				
	21MAR94	2	2	1.0	1.0
	28MAR94	1	26	26.0	
	04APR94				
	11APR94				
	18APR94				
	TOTAL	143	4026	28.2	3.0
BATTERY	01NOV93	39	118	3.0	0.6
	08NOV93	46	561	12.2	1.8
	15NOV93	25	186	7.4	2.0
	22NOV93	8	816	102.0	19.3
	29NOV93	15	290	19.3	3.9
	06DEC93	8	182	22.8	6.5
	13DEC93	23	520	22.6	2.8
	20DEC93	25	891	35.6	7.6
	27DEC93	27	1100	40.7	5.6
	03JAN94	24	1580	65.8	8.1
	10JAN94	36	1098	30.5	4.3
	17JAN94	4	88	22.0	17.4
	24JAN94	2	1	0.5	0.5
	31JAN94	4	4	1.0	1.0
	07FEB94	14	49	3.5	1.0
	14FEB94	22	17	0.8	0.2
	21FEB94	24	271	11.3	3.7
	28FEB94	44	435	9.9	2.4
	07MAR94	67	2196	32.8	5.2
	14MAR94	48	3768	78.5	12.2

(continued)

APPENDIX TABLE C-1. (CONTINUED)

REGION	WEEK	CPUE			
		TOWS	N	MEAN	S.E.
BATTERY	21MAR94	56	979	17.5	2.6
	28MAR94	35	2500	71.4	9.6
	04APR94	30	2760	92.0	9.1
	11APR94	13	2371	182.4	23.4
	18APR94	12	1932	161.0	19.3
	TOTAL	651	24713	38.0	2.1

APPENDIX TABLE C-2. REGIONAL AND RIVER MILE MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) FOR THE 9 M TRAWL IN THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

REGION	RIVER MILE	CPUE			
		TOWS	N	MEAN	S.E.
UPPER HARBOR	1	1	91	91.0	
	2	72	1846	25.6	4.9
	3	66	2038	30.9	3.3
	4	4	51	12.8	9.4
	TOTAL	143	4026	28.2	3.0
BATTERY	1	192	4347	22.6	2.2
	2	1	25	25.0	
	3	2	2	1.0	1.0
	4	7	1	0.1	0.1
	5	135	9853	73.0	6.5
	6	25	533	21.3	4.3
	7	79	2387	30.2	3.9
	8	85	4237	49.8	7.9
	9	89	2095	23.5	3.5
	10	11	266	24.2	9.5
	11	25	967	38.7	11.2
	TOTAL	651	24713	38.0	2.1

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS CAPTURED AND STRIPED BASS TAGGED IN THE HUDSON RIVER CROSS-CLASSIFIED BY REGION, GEAR AND USE CODE FOR THE 9 m TRAWL, 1 NOVEMBER 1993 THROUGH 20 April 1994.

REGION	GEAR	USE CODE	SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
Battery	9 m trawl	1	651	24,713	13,203
		2	54	1,199	555
		5	6	0	0
Total			711	25,912	13,758
Upper Harbor	9 m trawl	1	143	4,026	3,596
		2	9	155	146
		5	3	0	0
Total			155	4,181	3,742

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN A 9 M TRAWL IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

	WATER		N TOWS		NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (mm TL)											NUMBER OF FISH				MORTALITY	
DATE	TEMP.	COND.	TOTAL	VOID	<150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	801+	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	N	%
NOV 1 93	12.2	34720	45	0	7	2	40	51	23	7	0	0	0	130	3	120	4	0	5	1	0.8
NOV 8 93	11.2	34052	60	1	54	28	395	178	51	6	0	1	0	713	12	644	8	2	56	5	0.7
NOV 15 93	11.5	35876	54	1	35	26	239	242	133	23	2	1	1	702	13	649	12	0	40	1	0.1
NOV 22 93	10.9	36988	20	1	16	38	726	342	93	6	0	0	0	1,221	61	1,165	37	1	19	0	0.0
NOV 29 93	9.7	37946	25	0	133	53	157	144	39	8	2	0	0	536	21	394	6	4	135	1	0.2
DEC 6 93	8.9	30162	40	0	38	22	644	686	398	84	16	2	1	1,891	47	1,766	49	5	69	7	0.4
DEC 13 93	7.5	32846	47	0	273	34	296	315	89	30	10	2	0	1,049	22	741	24	1	282	2	0.2
DEC 20 93	6.8	30907	35	0	224	120	585	399	136	9	9	2	0	1,484	42	1,181	38	3	251	14	0.9
DEC 27 93	5.3	34978	34	1	437	156	463	128	28	10	2	3	0	1,227	36	770	13	5	444	0	0.0
JAN 3 94	3.2	33151	24	0	705	202	536	116	15	4	2	0	0	1,580	66	787	23	10	735	35	2.2
JAN 10 94	2.2	36112	50	0	935	158	299	57	23	9	1	0	0	1,482	30	505	11	14	940	26	1.8
JAN 17 94	1.5	37288	8	0	68	7	12	0	0	1	2	0	0	90	11	16	0	1	72	2	2.2
JAN 24 94	1.3	42361	2	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0.0
JAN 31 94	0.0	33583	6	0	9	0	3	2	0	0	0	0	0	14	2	5	0	0	9	0	0.0
FEB 7 94	1.0	35250	15	0	40	1	7	0	1	0	0	0	0	49	3	8	1	0	40	0	0.0
FEB 14 94	- 0.5	37626	44	2	28	1	4	1	0	0	0	0	0	34	1	3	0	0	30	1	2.9
FEB 21 94	1.0	33891	26	2	138	25	91	14	2	0	1	0	0	271	10	111	3	2	153	4	1.5
FEB 28 94	1.6	37422	48	1	331	43	67	12	3	1	1	0	0	458	10	119	3	3	332	4	0.9
MAR 7 94	2.0	30990	69	0	1533	162	407	80	7	5	3	0	0	2,197	32	628	15	5	1,541	13	0.6
MAR 14 94	3.4	32006	49	0	1483	354	1530	458	34	6	4	1	0	3,870	79	2,108	54	13	1,540	168	4.3
MAR 21 94	4.0	32592	59	0	716	51	164	46	8	4	1	1	0	991	17	246	19	3	719	7	0.7
MAR 28 94	4.9	25209	36	0	659	245	1261	323	30	7	0	1	0	2,526	70	1700	41	13	737	48	1.9
APR 4 94	5.2	28720	34	0	979	381	1442	130	1	2	1	0	0	2,936	86	1,732	46	21	1,091	67	2.3
APR 11 94	6.3	32145	15	0	597	401	1589	120	1	1	0	0	0	2,709	181	1,894	53	21	713	49	1.8
APR 18 94	7.0	32529	12	0	807	360	728	34	3	0	0	0	0	1,932	161	1,017	32	15	842	41	2.1
TOTAL	5.1	33974	857	9	10,245	2,870	11,685	3,878	1,118	223	57	15	2	30,093	35	18,310	492	142	10,795	496	1.6

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (mm) OF STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

	9 m TRAWL			
WEEK	NO. OF FISH	MEAN LENGTH	S.D	S.E.
01NOV93	118	331	97.00	8.93
08NOV93	561	268	78.32	3.31
15NOV93	186	234	75.17	5.51
22NOV93	816	269	56.92	1.99
29NOV93	290	185	82.48	4.84
06DEC93	182	266	104.63	7.76
13DEC93	520	208	117.91	5.17
20DEC93	891	238	98.76	3.31
27DEC93	1100	198	94.10	2.84
03JAN94	1580	187	84.30	2.12
10JAN94	1098	161	87.01	2.63
17JAN94	88	130	75.57	8.06
24JAN94	1	722		
31JAN94	4	202	137.48	68.74
07FEB94	49	126	73.16	10.45
14FEB94	17	124	84.54	20.50
21FEB94	271	172	83.20	5.05
28FEB94	435	142	74.67	3.58
07MAR94	2196	148	73.73	1.57
14MAR94	3768	202	86.08	1.40
21MAR94	979	144	83.97	2.68
28MAR94	2500	221	80.57	1.61
04APR94	2760	196	66.62	1.27
11APR94	2371	213	59.01	1.21
18APR94	1932	183	58.88	1.34
ALL WEEKS	24713	197	85.16	0.54

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW IN A 9 m TRAWL FOR 50 MM LENGTH GROUPS IN THE BATTERY REGION OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

SAMPLING WEEK	NUMBER OF TOWS	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800
01NOV93	39	< 0.1	0.1	0.1	0.3	0.7	0.6	0.6	0.2	0.3	0.1	< 0.1				
08NOV93	46	0.2	0.8	0.6	3.3	4.1	1.7	0.8	0.5	0.2	< 0.1	< 0.1				
15NOV93	25	0.6	0.6	0.8	2.2	2.1	0.8	0.3	0.1							
22NOV93	8	0.1	1.8	4.5	35.1	38.6	13.6	5.1	2.1	0.8	0.3					
29NOV93	15	2.6	5.9	3.3	3.6	2.2	0.9	0.4	0.2	0.1		0.1				
06DEC93	8	0.8	2.6	1.3	6.3	5.0	3.4	1.6	0.9	0.3	0.5			0.1		0.1
13DEC93	23	5.5	4.6	1.4	2.9	2.8	2.5	1.7	0.7	0.1	0.3	< 0.1		< 0.1	< 0.1	
20DEC93	25	1.2	7.0	4.4	8.3	7.5	3.8	1.5	0.8	0.6	0.2	< 0.1	0.3	< 0.1	< 0.1	< 0.1
27DEC93	27	5.6	10.4	5.4	9.2	5.3	2.4	1.1	0.6	0.4	0.2	0.1			< 0.1	< 0.1
03JAN94	24	9.0	20.4	8.4	13.3	9.0	3.1	1.8	0.5	0.2	0.1	0.1		0.1		
10JAN94	36	7.6	11.2	3.3	4.1	2.3	0.8	0.5	0.4	0.2	0.1	0.1		< 0.1		
17JAN94	4	9.3	7.8	1.8	2.8	0.3								0.3		
24JAN94	2														0.5	
31JAN94	4	0.3	0.3		0.3			0.3								
07FEB94	14	1.5	1.4	0.1	0.4	0.1				0.1						
14FEB94	22	0.5	0.2			< 0.1		< 0.1								
21FEB94	24	2.8	3.0	1.0	2.8	1.0	0.5	0.1	0.1					< 0.1		
28FEB94	44	3.2	4.0	0.9	0.9	0.6	0.2	0.1	< 0.1	< 0.1	< 0.1			< 0.1		
07MAR94	67	9.0	13.9	2.4	4.1	2.0	0.9	0.3	0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1		
14MAR94	48	9.4	20.2	7.2	17.8	13.8	7.0	2.4	0.5	0.2	0.1		0.1	< 0.1	< 0.1	
21MAR94	56	7.0	5.7	0.9	1.8	1.1	0.7	0.1	0.1	0.1	< 0.1	< 0.1		< 0.1		< 0.1
28MAR94	35	4.1	14.7	7.0	18.9	16.8	6.7	2.1	0.6	0.2	0.1	0.1				< 0.1
04APR94	30	6.4	24.3	12.1	30.4	14.8	3.3	0.6	< 0.1			0.1				
11APR94	13	1.3	39.9	28.2	60.5	44.2	7.7	0.4		0.1	0.1					
18APR94	12	3.8	63.4	30.0	38.4	22.3	2.4	0.4	0.1	0.2						
ALL WEEKS	651	4.6	10.3	4.2	8.9	6.3	2.3	0.8	0.3	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

APPENDIX TABLE C-7. MEAN LENGTH AT AGE AND 95% CONFIDENCE INTERVALS FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS CAPTURED BY A 9 m TRAWL IN THE HUDSON RIVER DURING THE 1986-87 THROUGH 1993-94 STRIPED BASS PROGRAMS.

AGE	COHORT	PROGRAM	n[a]	STRATIFIED MEAN LENGTH (mm)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1993	1993-94	828	123	121	125
	1992	1992-93	473	116	114	118
	1991[b]	1991-92	818	131	127	135
	1990[b]	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1,007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1992	1993-94	2,695	237	236	238
	1991[b]	1992-93	3,899	231	229	233
	1990[b]	1991-92	3,675	245	244	246
	1989	1990-91	2,174	239	237	241
	1988	1989-90	3,514	214	213	215
	1987	1988-89	3,623	227	226	229
	1986	1987-88	1,503	253	251	255
	1985	1986-87	285	221	215	227
2+	1991[b]	1993-94	1,631	317	307	328
	1990[b]	1992-93	1,378	329	325	333
	1989	1991-92	961	324	319	328
	1988	1990-91	2,109	321	317	324
	1987	1989-90	1,216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1990[b]	1993-94	152	424	246	602
	1989	1992-93	125	414	400	428
	1988	1991-92	153	386	378	394
	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

[a] number of fish aged from use cd = 1 Tows

[b] Stratified mean length for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined, because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HATCHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

AGE	GEAR	DATE	STATION	RIVER MILE	TOTAL LENGTH (mm)	RELEASE YEAR
0	9 M TRAWL	11/29/93	BATTERY	8	154	93
0	9 M TRAWL	11/29/93	BATTERY	5	129	93
0	9 M TRAWL	12/04/93	BATTERY	1	114	93
0	9 M TRAWL	12/06/93	BATTERY	1	117	93
0	9 M TRAWL	12/06/93	BATTERY	1	124	93
0	9 M TRAWL	12/15/93	BATTERY	1	132	93
0	9 M TRAWL	12/20/93	BATTERY	5	141	93
0	9 M TRAWL	12/21/93	BATTERY	1	153	93
0	9 M TRAWL	01/06/94	BATTERY	5	124	93
0	9 M TRAWL	01/07/94	BATTERY	1	136	93
0	9 M TRAWL	01/10/94	BATTERY	1	108	93
0	9 M TRAWL	01/11/94	BATTERY	9	115	93
0	9 M TRAWL	01/11/94	BATTERY	9	112	93
0	9 M TRAWL	01/12/94	BATTERY	8	136	93
0	9 M TRAWL	01/12/94	BATTERY	9	148	93
0	9 M TRAWL	01/12/94	BATTERY	5	117	93
0	9 M TRAWL	03/14/94	BATTERY	8	158	93
0	9 M TRAWL	03/25/94	BATTERY	6	116	93
0	9 M TRAWL	03/29/94	BATTERY	8	123	93
0	9 M TRAWL	04/02/94	BATTERY	5	96	93
0	9 M TRAWL	04/19/94	BATTERY	5	133	93
1	9 M TRAWL	11/09/93	BATTERY	1	224	92
1	9 M TRAWL	11/12/93	BATTERY	9	237	92
1	9 M TRAWL	11/23/93	BATTERY	1	233	92
1	9 M TRAWL	11/29/93	BATTERY	9	215	92
1	9 M TRAWL	12/10/93	UPPER HARBOR	3	242	92
1	9 M TRAWL	12/21/93	BATTERY	1	193	92
1	9 M TRAWL	12/27/93	BATTERY	1	188	92
1	9 M TRAWL	12/29/93	BATTERY	1	263	92
1	9 M TRAWL	12/29/93	BATTERY	5	218	92
1	9 M TRAWL	12/29/93	BATTERY	5	185	92
1	9 M TRAWL	12/29/93	BATTERY	5	204	92
1	9 M TRAWL	01/06/94	BATTERY	5	205	92
1	9 M TRAWL	01/06/94	BATTERY	5	222	92
1	9 M TRAWL	01/06/94	BATTERY	5	165	92
1	9 M TRAWL	01/06/94	BATTERY	5	240	92
1	9 M TRAWL	01/06/94	BATTERY	5	209	92
1	9 M TRAWL	01/06/94	BATTERY	5	191	92
1	9 M TRAWL	01/06/94	BATTERY	1	315	92
1	9 M TRAWL	01/07/94	BATTERY	1	229	92
1	9 M TRAWL	01/11/94	BATTERY	1	219	92
1	9 M TRAWL	01/12/94	BATTERY	9	203	92
1	9 M TRAWL	01/13/94	BATTERY	1	265	92
1	9 M TRAWL	01/13/94	BATTERY	1	248	92
1	9 M TRAWL	01/14/94	BATTERY	9	233	92
1	9 M TRAWL	01/14/94	BATTERY	9	276	92
1	9 M TRAWL	01/14/94	BATTERY	9	184	92
1	9 M TRAWL	01/17/94	BATTERY	1	198	92
1	9 M TRAWL	02/25/94	BATTERY	9	215	92
1	9 M TRAWL	02/28/94	BATTERY	7	183	92
1	9 M TRAWL	02/28/94	BATTERY	8	221	92
1	9 M TRAWL	03/01/94	BATTERY	10	180	92

(Continued)

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	TOTAL LENGTH (mm)	RELEASE YEAR
1	9 M TRAWL	03/09/94	BATTERY	11	212	92
1	9 M TRAWL	03/09/94	BATTERY	11	205	92
1	9 M TRAWL	03/12/94	BATTERY	8	211	92
1	9 M TRAWL	03/12/94	BATTERY	8	243	92
1	9 M TRAWL	03/14/94	BATTERY	8	213	92
1	9 M TRAWL	03/14/94	BATTERY	8	225	92
1	9 M TRAWL	03/14/94	BATTERY	8	188	92
1	9 M TRAWL	03/14/94	BATTERY	8	210	92
1	9 M TRAWL	03/14/94	BATTERY	8	190	92
1	9 M TRAWL	03/14/94	BATTERY	8	194	92
1	9 M TRAWL	03/17/94	BATTERY	6	278	92
1	9 M TRAWL	03/18/94	BATTERY	6	232	92
1	9 M TRAWL	03/18/94	BATTERY	7	183	92
1	9 M TRAWL	03/19/94	BATTERY	6	248	92
1	9 M TRAWL	03/24/94	BATTERY	9	225	92
1	9 M TRAWL	03/25/94	BATTERY	9	160	92
1	9 M TRAWL	03/29/94	BATTERY	8	212	92
1	9 M TRAWL	03/30/94	BATTERY	5	225	92
1	9 M TRAWL	03/30/94	BATTERY	5	208	92
1	9 M TRAWL	03/31/94	BATTERY	5	242	92
1	9 M TRAWL	03/31/94	BATTERY	7	258	92
1	9 M TRAWL	04/01/94	BATTERY	5	222	92
1	9 M TRAWL	04/01/94	BATTERY	8	230	92
1	9 M TRAWL	04/01/94	BATTERY	8	228	92
1	9 M TRAWL	04/02/94	BATTERY	5	250	92
1	9 M TRAWL	04/02/94	BATTERY	5	199	92
1	9 M TRAWL	04/04/94	BATTERY	5	222	92
1	9 M TRAWL	04/04/94	BATTERY	5	189	92
1	9 M TRAWL	04/04/94	BATTERY	5	211	92
1	9 M TRAWL	04/04/94	BATTERY	5	174	92
1	9 M TRAWL	04/04/94	BATTERY	5	193	92
1	9 M TRAWL	04/05/94	BATTERY	5	293	92
1	9 M TRAWL	04/05/94	BATTERY	5	259	92
1	9 M TRAWL	04/05/94	BATTERY	5	258	92
1	9 M TRAWL	04/05/94	BATTERY	5	218	92
1	9 M TRAWL	04/05/94	BATTERY	5	237	92
1	9 M TRAWL	04/05/94	BATTERY	5	236	92
1	9 M TRAWL	04/06/94	BATTERY	5	232	92
1	9 M TRAWL	04/06/94	BATTERY	5	180	92
1	9 M TRAWL	04/06/94	BATTERY	5	241	92
1	9 M TRAWL	04/06/94	BATTERY	5	226	92
1	9 M TRAWL	04/07/94	BATTERY	9	201	92
1	9 M TRAWL	04/07/94	BATTERY	5	192	92
1	9 M TRAWL	04/07/94	BATTERY	5	217	92
1	9 M TRAWL	04/07/94	BATTERY	5	187	92
1	9 M TRAWL	04/08/94	BATTERY	5	303	92
1	9 M TRAWL	04/11/94	BATTERY	5	229	92
1	9 M TRAWL	04/11/94	BATTERY	5	204	92
1	9 M TRAWL	04/11/94	BATTERY	9	204	92
1	9 M TRAWL	04/11/94	BATTERY	9	219	92
1	9 M TRAWL	04/12/94	BATTERY	5	278	92
1	9 M TRAWL	04/13/94	BATTERY	5	166	92

(Continued)

APPENDIX TABLE D-1. (Continued)

AGE	GEAR	DATE	STATION	RIVER MILE	TOTAL LENGTH (mm)	RELEASE YEAR
1	9 M TRAWL	04/13/94	BATTERY	5	237	92
1	9 M TRAWL	04/13/94	BATTERY	5	269	92
1	9 M TRAWL	04/13/94	BATTERY	5	211	92
1	9 M TRAWL	04/13/94	BATTERY	5	208	92
1	9 M TRAWL	04/13/94	BATTERY	5	200	92
1	9 M TRAWL	04/14/94	BATTERY	5	194	92
1	9 M TRAWL	04/14/94	BATTERY	5	188	92
1	9 M TRAWL	04/14/94	BATTERY	5	205	92
1	9 M TRAWL	04/14/94	BATTERY	5	241	92
1	9 M TRAWL	04/15/94	BATTERY	5	189	92
1	9 M TRAWL	04/15/94	BATTERY	5	181	92
1	9 M TRAWL	04/15/94	BATTERY	5	204	92
1	9 M TRAWL	04/15/94	BATTERY	5	227	92
1	9 M TRAWL	04/15/94	BATTERY	5	204	92
1	9 M TRAWL	04/15/94	BATTERY	5	219	92
1	9 M TRAWL	04/19/94	BATTERY	5	218	92
1	9 M TRAWL	04/19/94	BATTERY	5	222	92
1	9 M TRAWL	04/19/94	BATTERY	5	241	92
1	9 M TRAWL	04/19/94	BATTERY	5	231	92
1	9 M TRAWL	04/19/94	BATTERY	5	207	92
1	9 M TRAWL	04/20/94	BATTERY	5	217	92
1	9 M TRAWL	04/20/94	BATTERY	5	255	92
1	9 M TRAWL	04/20/94	BATTERY	5	250	92
1	9 M TRAWL	04/20/94	BATTERY	5	210	92
1	9 M TRAWL	04/20/94	BATTERY	5	245	92
1	9 M TRAWL	04/20/94	BATTERY	5	243	92
1	9 M TRAWL	04/20/94	BATTERY	5	188	92
1	9 M TRAWL	04/20/94	BATTERY	5	260	92
1	9 M TRAWL	04/20/94	BATTERY	5	188	92
4	9 M TRAWL	03/30/94	BATTERY	7	507	89

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED, RELEASED AND RECAPTURED IN THE HUDSON RIVER, 01 NOVEMBER 1993 THROUGH 20 APRIL 1994.

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
09DEC93	321	UH	3	5	08NOV93	323	UH	4	6	31	1	2	1	364073
22NOV93	320	UH	3	5	08NOV93	323	UH	4	6	14	1	2	1	364087
23NOV93	305	BT	1	2	09NOV93	303	BT	1	2	14	0	0	1	364136
15APR94	313	BT	5	8	09NOV93	317	BT	1	2	157	4	6	1	364139
23NOV93	340	UH	3	5	09NOV93	344	BT	1	2	14	4	6	1	364148
16NOV93	404	UH	3	5	10NOV93	403	BT	1	2	6	4	6	1	364214
22DEC93	360	UH	2	3	17NOV93	359	UH	3	5	35	1	2	1	364406
30NOV93	322	BT	7	11	19NOV93	321	UH	2	3	11	9	14	1	364601
17MAR94	307	BT	8	13	19NOV93	308	UH	2	3	118	10	16	1	364643
24NOV93	334	UH	3	5	22NOV93	334	UH	3	5	2	0	0	1	364765
22NOV93	307	BT	1	2	22NOV93	306	BT	1	2	0	0	0	1	364780
24NOV93	315	UH	3	5	22NOV93	315	BT	1	2	2	4	6	1	364829
29MAR94	303	BT	5	8	22NOV93	300	BT	1	2	127	4	6	1	364854
29MAR94	303	BT	8	13	22NOV93	305	BT	1	2	127	7	11	1	364856
23NOV93	366	UH	3	5	23NOV93	366	UH	3	5	0	0	0	1	364903
09MAR94	354	BT	9	14	23NOV93	355	UH	3	5	106	12	19	2	364912
14APR94	334	BT	5	8	23NOV93	336	UH	3	5	142	8	13	1	364948
06JAN94	326	BT	1	2	23NOV93	325	UH	3	5	44	4	6	1	364959
23NOV93	326	BT	1	2	23NOV93	324	BT	1	2	0	0	0	1	364991
17DEC93	326	BT	1	2	23NOV93	331	BT	1	2	24	0	0	1	364997
03NOV93	150	BT	1	2	03NOV93	150	BT	1	2	0	0	0	1	391155
07JAN94	253	BT	1	2	04NOV93	253	BT	9	14	64	8	13	1	391175
09NOV93	271	BT	1	2	09NOV93	269	BT	1	2	0	0	0	1	391283
09NOV93	292	BT	1	2	09NOV93	291	BT	1	2	0	0	0	1	391332
09NOV93	260	BT	1	2	09NOV93	260	BT	1	2	0	0	0	1	391349
17MAR94	265	BT	8	13	10NOV93	266	BT	1	2	127	7	11	1	391433
06JAN94	291	BT	1	2	10NOV93	289	BT	1	2	57	0	0	1	391448
23DEC93	231	UH	2	3	11NOV93	231	BT	9	14	42	11	18	1	391472
10DEC93	241	UH	3	5	11NOV93	241	BT	1	2	29	4	6	1	391526
14MAR94	258	BT	8	13	12NOV93	256	BT	9	14	122	1	2	1	391583
13APR94	239	BT	5	8	12NOV93	240	BT	1	2	152	4	6	1	391605
20DEC93	235	BT	5	8	15NOV93	236	BT	5	8	35	0	0	1	391638
09DEC93	290	UH	3	5	16NOV93	289	UH	3	5	23	0	0	1	391713
22NOV93	271	BT	1	2	17NOV93	270	UH	3	5	5	4	6	1	391736
22NOV93	299	BT	1	2	18NOV93	296	UH	2	3	4	3	5	1	391780
22NOV93	231	BT	1	2	19NOV93	230	UH	3	5	3	4	6	1	391809
22NOV93	249	BT	1	2	19NOV93	251	UH	2	3	3	3	5	1	391834
23NOV93	359	BT	1	2	22NOV93	260	BT	1	2	1	0	0	1	391876
15DEC93	293	BT	7	11	22NOV93	297	UH	3	5	23	10	16	1	391897
22NOV93	280	BT	1	2	22NOV93	281	BT	1	2	0	0	0	1	391940
29NOV93	217	BT	8	13	22NOV93	221	BT	1	2	7	7	11	1	392091
10DEC93	286	UH	2	3	23NOV93	286	UH	3	5	17	1	2	1	392135
09DEC93	256	UH	3	5	23NOV93	257	UH	3	5	16	0	0	1	392166
23NOV93	268	BT	1	2	23NOV93	269	BT	1	2	0	0	0	1	392180
16DEC93	231	BT	8	13	23NOV93	233	BT	1	2	23	7	11	1	392215
23NOV93	227	BT	1	2	23NOV93	228	BT	1	2	0	0	0	1	392219
23NOV93	280	BT	1	2	23NOV93	280	BT	1	2	0	0	0	1	392228
21MAR94	266	BT	9	14	23NOV93	268	BT	1	2	118	8	13	1	392230
13DEC93	260	UH	3	5	23NOV93	263	BT	1	2	20	4	6	1	392232
23NOV93	240	BT	1	2	23NOV93	242	BT	1	2	0	0	0	1	392247
23NOV93	252	BT	1	2	23NOV93	253	BT	1	2	0	0	0	1	392264
24NOV93	244	BT	1	2	23NOV93	244	BT	1	2	1	0	0	1	392265
23NOV93	251	BT	1	2	23NOV93	251	BT	1	2	0	0	0	1	392271
05APR94	279	BT	5	8	23NOV93	280	BT	1	2	133	4	6	1	392298
23NOV93	202	BT	1	2	23NOV93	202	BT	1	2	0	0	0	1	392311

(Continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH IN MM	RECAPTURE RIVER REGION	RECAPTURE RIVER MILE	RECAPTURE RIVER KM	RELEASE DATE	RELEASE TOTAL LENGTH IN MM	RELEASE REGION	RELEASE MILE	RELEASE KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
09MAR94	256	BT	9	14	23NOV93	256	BT	1	2	106	8	13	1	392314
06APR94	258	BT	5	8	23NOV93	258	BT	1	2	134	4	6	1	392401
08APR94	268	BT	5	8	23NOV93	267	BT	1	2	136	4	6	1	392410
02MAR94	215	BT	1	2	23NOV93	217	BT	1	2	99	0	0	1	392453
09DEC93	205	UH	3	5	23NOV93	206	BT	1	2	16	4	6	1	392460
20APR94	207	BT	5	8	24NOV93	209	BT	1	2	147	4	6	1	392518
24NOV93	226	BT	1	2	24NOV93	227	BT	1	2	0	0	0	1	392523
23MAR94	220	BT	7	11	24NOV93	227	BT	1	2	119	6	10	1	392523
09MAR94	203	BT	11	18	24NOV93	204	BT	1	2	105	10	16	1	392553
22DEC93	153	BT	1	2	24NOV93	154	BT	1	2	28	0	0	1	392556
30MAR94	247	BT	5	8	24NOV93	245	BT	1	2	126	4	6	1	392568
23DEC93	286	UH	2	3	24NOV93	289	UH	3	5	29	1	2	1	392587
14MAR94	156	BT	8	13	29NOV93	157	BT	8	13	105	0	0	1	392628
07APR94	211	BT	9	14	29NOV93	211	BT	9	14	129	0	0	1	392637
04APR94	227	BT	5	8	29NOV93	226	BT	9	14	126	4	6	1	392657
08DEC93	210	BT	1	2	04DEC93	213	BT	1	2	4	0	0	1	392751
06DEC93	278	UH	2	3	04DEC93	277	UH	3	5	2	1	2	1	392765
06APR94	259	BT	5	8	04DEC93	280	UH	2	3	123	7	11	1	392801
08DEC93	298	UH	3	5	06DEC93	298	BT	1	2	2	4	6	1	392813
13DEC93	227	UH	3	5	07DEC93	227	UH	3	5	6	0	0	1	392879
14MAR94	252	BT	7	11	08DEC93	253	UH	3	5	96	10	16	1	392900
15DEC93	287	UH	2	3	08DEC93	287	UH	3	5	7	1	2	1	392949
10DEC93	280	UH	2	3	08DEC93	280	UH	3	5	2	1	2	1	392950
14JAN94	247	BT	1	2	09DEC93	250	UH	3	5	36	4	6	1	392972
15APR94	281	BT	5	8	09DEC93	282	UH	3	5	127	8	13	1	392994
12JAN94	267	BT	1	2	09DEC93	268	UH	3	5	34	4	6	1	392995
10DEC93	290	UH	3	5	09DEC93	289	UH	3	5	1	0	0	1	393041
23DEC93	253	UH	2	3	09DEC93	254	UH	3	5	14	1	2	1	393054
10DEC93	233	UH	2	3	09DEC93	231	UH	3	5	1	1	2	1	393087
05APR94	265	BT	5	8	09DEC93	264	UH	3	5	117	8	13	1	393104
29MAR94	259	BT	8	13	09DEC93	259	UH	3	5	110	11	18	1	393111
13DEC93	284	UH	3	5	09DEC93	283	UH	2	3	4	1	2	1	393173
13DEC93	283	UH	3	5	09DEC93	283	UH	2	3	4	1	2	1	393173
14MAR94	225	BT	8	13	10DEC93	227	BT	1	2	94	7	11	1	393198
18MAR94	230	BT	7	11	10DEC93	229	BT	1	2	98	6	10	1	393201
17MAR94	216	BT	8	13	10DEC93	217	BT	1	2	97	7	11	1	393213
16MAR94	267	BT	7	11	10DEC93	270	BT	1	2	96	6	10	1	393214
10DEC93	274	UH	2	3	10DEC93	273	UH	2	3	0	0	0	1	393257
05APR94	240	BT	5	8	10DEC93	239	UH	2	3	116	7	11	1	393289
10DEC93	298	UH	2	3	10DEC93	299	UH	2	3	0	0	0	1	393310
13DEC93	286	UH	2	3	10DEC93	286	UH	2	3	3	0	0	1	393316
29DEC93	235	BT	1	2	10DEC93	238	UH	2	3	19	3	5	1	393333
15DEC93	244	BT	8	13	10DEC93	245	UH	3	5	5	11	18	1	393381
20DEC93	257	BT	1	2	13DEC93	258	BT	1	2	7	0	0	1	393437
15MAR94	263	BT	8	13	13DEC93	263	UH	3	5	92	11	18	1	393452
10JAN94	290	BT	1	2	13DEC93	296	UH	3	5	28	4	6	1	393460
16MAR94	216	BT	8	13	13DEC93	217	UH	3	5	93	11	18	1	393513
31MAR94	264	BT	1	2	14DEC93	265	BT	1	2	107	0	0	1	393560
28DEC93	196	BT	1	2	14DEC93	197	BT	1	2	14	0	0	1	393564
15DEC93	203	BT	1	2	14DEC93	202	BT	1	2	1	0	0	1	393570
20DEC93	195	BT	5	8	14DEC93	195	BT	9	14	6	4	6	1	393590
21DEC93	201	BT	1	2	15DEC93	199	BT	8	13	6	7	11	1	393619
21DEC93	204	BT	1	2	15DEC93	203	BT	1	2	6	0	0	1	393636
15APR94	232	BT	5	8	15DEC93	234	BT	1	2	121	4	6	1	393637
11APR94	263	BT	9	14	15DEC93	263	UH	2	3	117	11	18	1	393652

(Continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
07MAR94	253	BT	1	2	17DEC93	257	BT	1	2	80	0	0	1	393674
15APR94	246	BT	5	8	17DEC93	246	BT	1	2	119	4	6	1	393676
17MAR94	253	BT	8	13	17DEC93	247	BT	1	2	90	7	11	1	393688
31MAR94	255	BT	7	11	17DEC93	256	UH	3	5	104	10	16	1	393741
21DEC93	222	BT	5	8	20DEC93	223	BT	5	8	1	0	0	1	393823
23DEC93	254	UH	2	3	20DEC93	253	BT	5	8	3	7	11	1	393859
30MAR94	216	BT	7	11	20DEC93	219	BT	5	8	100	2	3	1	393913
12JAN94	219	BT	8	13	20DEC93	224	BT	5	8	23	3	5	1	393917
05JAN94	253	BT	1	2	20DEC93	255	BT	5	8	16	4	6	1	393924
06JAN94	220	BT	1	2	20DEC93	223	BT	1	2	17	0	0	1	394023
07JAN94	205	BT	1	2	20DEC93	206	BT	1	2	18	0	0	1	394027
17MAR94	270	BT	8	13	23DEC93	272	UH	2	3	84	10	16	1	394042
15APR94	226	BT	5	8	21DEC93	228	BT	5	8	115	0	0	1	394120
29DEC93	240	BT	5	8	21DEC93	243	BT	5	8	8	0	0	1	394156
22DEC93	253	BT	1	2	22DEC93	253	BT	1	2	0	0	0	1	394230
14MAR94	189	BT	8	13	22DEC93	188	BT	1	2	82	7	11	1	394232
23DEC93	204	BT	1	2	22DEC93	205	BT	1	2	1	0	0	1	394242
16MAR94	277	BT	8	13	22DEC93	153	BT	1	2	84	7	11	1	394243
23DEC93	298	UH	2	3	22DEC93	297	UH	2	3	1	0	0	1	394289
31MAR94	230	BT	1	2	23DEC93	230	BT	1	2	98	0	0	1	394307
17MAR94	264	BT	8	13	23DEC93	265	BT	1	2	84	7	11	1	394314
28DEC93	277	BT	1	2	23DEC93	278	BT	1	2	5	0	0	1	394330
06JAN94	251	BT	1	2	23DEC93	250	BT	1	2	14	0	0	1	394331
29DEC93	272	BT	1	2	23DEC93	272	UH	2	3	6	3	5	1	394344
12JAN94	276	BT	8	13	23DEC93	276	UH	2	3	20	10	16	1	394371
01APR94	274	BT	5	8	23DEC93	272	UH	2	3	99	7	11	2	394388
07MAR94	194	BT	7	11	23DEC93	195	UH	3	5	74	10	16	1	394396
06APR94	197	BT	5	8	27DEC93	197	BT	5	8	100	0	0	1	394417
16MAR94	214	BT	8	13	27DEC93	213	UH	2	3	79	10	16	1	394484
18MAR94	214	BT	6	10	27DEC93	212	BT	1	2	81	5	8	2	394552
28DEC93	233	BT	5	8	28DEC93	272	BT	5	8	0	0	0	1	394627
14JAN94	223	BT	1	2	28DEC93	222	BT	5	8	17	4	6	1	394631
29DEC93	227	BT	1	2	29DEC93	228	BT	1	2	0	0	0	1	394698
30DEC93	266	BT	1	2	29DEC93	267	BT	5	8	1	4	6	2	394753
06JAN94	206	BT	1	2	29DEC93	206	BT	5	8	8	4	6	1	394794
30DEC93	227	BT	1	2	30DEC93	228	BT	1	2	0	0	0	1	394861
20APR94	167	BT	5	8	30DEC93	167	BT	5	8	111	0	0	1	394929
15MAR94	243	BT	8	13	30DEC93	241	BT	5	8	75	3	5	1	394940
18MAR94	172	BT	8	13	30DEC93	176	BT	5	8	78	3	5	1	394962
23MAR94	216	BT	5	8	30DEC93	217	BT	5	8	83	0	0	1	394991
18APR94	239	BT	5	8	30DEC93	241	BT	5	8	109	0	0	1	394992
11APR94	237	BT	5	8	05JAN94	228	BT	5	8	96	0	0	1	395063
13APR94	223	BT	5	8	05JAN94	224	BT	5	8	98	0	0	1	395065
06JAN94	151	BT	5	8	05JAN94	150	BT	5	8	1	0	0	1	395097
02APR94	265	BT	5	8	05JAN94	265	BT	5	8	87	0	0	1	395107
19APR94	160	BT	5	8	05JAN94	158	BT	5	8	104	0	0	1	395144
05JAN94	255	BT	1	2	05JAN94	255	BT	1	2	0	0	0	1	395165
05APR94	279	BT	5	8	05JAN94	277	BT	1	2	90	4	6	1	395171
04APR94	234	BT	5	8	06JAN94	234	BT	5	8	88	0	0	1	395275
17MAR94	279	BT	8	13	06JAN94	278	BT	5	8	70	3	5	1	395318
05APR94	237	BT	5	8	06JAN94	233	BT	5	8	89	0	0		395416
06JAN94	284	BT	1	2	06JAN94	283	BT	1	2	0	0	0	1	395460
07JAN94	223	BT	1	2	07JAN94	223	BT	1	2	0	0	0	1	395534
12JAN94	253	BT	8	13	07JAN94	252	BT	1	2	5	7	11	1	395555
16MAR94	217	BT	8	13	07JAN94	218	BT	1	2	68	7	11	1	395559
07JAN94	198	BT	1	2	07JAN94	198	BT	1	2	0	0	0	1	395566

(Continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE									
DATE	TOTAL LENGTH IN MM	RIVER REGION	RIVER MILE	RIVER KM	DATE	TOTAL LENGTH IN MM	REGION	MILE	KM	DAYS AT LARGE	DISTANCE TRAVELLED MILES	DISTANCE TRAVELLED KM	TAG COND	TAG NUMBER
18MAR94	260	BT	7	11	07JAN94	261	BT	1	2	70	6	10	1	395639
23MAR94	261	BT	8	13	07JAN94	261	BT	1	2	75	7	11	1	395639
11JAN94	195	BT	8	13	07JAN94	196	BT	1	2	4	7	11	1	395697
09MAR94	159	BT	11	18	10JAN94	160	BT	7	11	58	4	6	1	395733
18MAR94	216	BT	7	11	10JAN94	219	BT	1	2	67	6	10	1	395765
19MAR94	208	BT	10	16	11JAN94	207	BT	1	2	67	9	14	1	395778
29MAR94	252	BT	1	2	11JAN94	252	BT	1	2	77	0	0	1	395783
31MAR94	230	BT	7	11	11JAN94	230	BT	1	2	79	6	10	1	395793
05APR94	257	BT	5	8	11JAN94	257	BT	7	11	84	2	3	1	395802
16MAR94	227	BT	8	13	12JAN94	227	BT	9	14	63	1	2	1	395875
29MAR94	150	BT	8	13	12JAN94	150	BT	7	11	76	1	2	1	395908
17MAR94	193	BT	8	13	13JAN94	193	UH	2	3	63	10	16	1	395930
13APR94	260	BT	5	8	13JAN94	261	BT	1	2	90	4	6	1	395938
17MAR94	265	BT	8	13	13JAN94	263	BT	1	2	63	7	11	1	395944
15MAR94	213	BT	8	13	13JAN94	210	BT	1	2	61	7	11	1	395947
13APR94	244	BT	5	8	13JAN94	245	BT	9	14	90	4	6	1	395955
14MAR94	185	BT	8	13	13JAN94	185	BT	9	14	60	1	2	1	395997
17MAR94	210	BT	8	13	14JAN94	211	BT	1	2	62	7	11	1	396024
09MAR94	233	BT	9	14	14JAN94	233	BT	1	2	54	8	13	1	396027
05APR94	188	BT	5	8	25FEB94	187	BT	8	13	39	3	5	1	396232
04APR94	227	BT	5	8	28FEB94	227	BT	7	11	35	2	3	1	396268
14MAR94	242	BT	8	13	28FEB94	240	BT	9	14	14	1	2	1	396308
21MAR94	269	BT	5	8	04MAR94	270	BT	7	11	17	2	3	1	396366
11MAR94	213	BT	8	13	07MAR94	212	BT	9	14	4	1	2	1	396378
17MAR94	292	BT	8	13	08MAR94	290	BT	8	13	9	0	0	1	396437
11APR94	257	BT	5	8	08MAR94	256	BT	8	13	34	3	5	1	396438
15MAR94	230	BT	11	18	09MAR94	230	BT	9	14	6	2	3	2	396461
13APR94	260	BT	5	8	09MAR94	258	BT	10	16	35	5	8	1	396502
29MAR94	223	BT	8	13	11MAR94	222	BT	7	11	18	1	2	1	396646
05APR94	275	BT	5	8	11MAR94	274	BT	7	11	25	2	3	1	396717
15APR94	210	BT	5	8	11MAR94	210	BT	7	11	35	2	3	1	396721
11APR94	236	BT	5	8	11MAR94	235	BT	11	18	31	6	10	1	396781
14MAR94	226	BT	9	14	12MAR94	225	BT	11	18	2	2	3	1	396789
31MAR94	198	BT	7	11	12MAR94	199	BT	8	13	19	1	2	1	396872
02APR94	250	BT	5	8	14MAR94	249	BT	8	13	19	3	5	1	397062
31MAR94	245	BT	1	2	14MAR94	212	BT	8	13	17	7	11	1	397125
14MAR94	272	BT	8	13	14MAR94	292	BT	8	13	0	0	0	1	397144
17MAR94	271	BT	8	13	15MAR94	271	BT	8	13	2	0	0	1	397298
08APR94	226	BT	5	8	15MAR94	224	BT	8	13	24	3	5	1	397342
17MAR94	232	BT	8	13	15MAR94	232	BT	8	13	2	0	0	1	397372
02APR94	204	BT	5	8	15MAR94	214	BT	8	13	18	3	5	1	397417
14APR94	243	BT	5	8	15MAR94	245	BT	8	13	30	3	5	1	397522
13APR94	211	BT	5	8	15MAR94	211	BT	8	13	29	3	5	1	397523
24MAR94	241	BT	1	2	15MAR94	242	BT	8	13	9	7	11	1	397773
18APR94	207	BT	5	8	15MAR94	207	BT	8	13	34	3	5	1	397845
24MAR94	239	BT	8	13	16MAR94	239	BT	8	13	8	0	0	1	397975
08APR94	215	BT	5	8	17MAR94	216	BT	8	13	22	3	5	1	398231
11APR94	266	BT	5	8	17MAR94	267	BT	8	13	25	3	5	1	398284
15APR94	288	BT	5	8	17MAR94	291	BT	8	13	29	3	5	1	398290
07APR94	266	BT	5	8	17MAR94	263	BT	8	13	21	3	5	1	398329
18APR94	266	BT	5	8	18MAR94	265	BT	7	11	31	2	3	1	398511
14APR94	214	BT	5	8	18MAR94	220	BT	7	11	27	2	3	1	398538
06APR94	237	BT	5	8	18MAR94	237	BT	6	10	19	1	2	1	398582
21MAR94	215	BT	7	11	19MAR94	216	BT	6	10	2	1	2	1	398619
04APR94	296	BT	5	8	19MAR94	296	BT	6	10	16	1	2	1	398642

(Continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
24MAR94	214	BT	9	14	23MAR94	214	BT	9	14	1	0	0	1	398697
31MAR94	233	BT	7	11	24MAR94	233	BT	9	14	7	2	3	1	398741
14APR94	270	BT	5	8	24MAR94	270	BT	1	2	21	4	6	1	398776
24MAR94	264	BT	1	2	24MAR94	264	BT	1	2	0	0	0	1	398785
25MAR94	179	BT	6	10	25MAR94	179	BT	6	10	0	0	0	1	398830
31MAR94	280	BT	1	2	25MAR94	280	BT	6	10	6	5	8	1	398857
28MAR94	277	BT	1	2	28MAR94	278	BT	1	2	0	0	0	1	398888
02APR94	248	BT	1	2	28MAR94	247	BT	1	2	5	0	0	1	398908
30MAR94	264	BT	7	11	29MAR94	264	BT	8	13	1	1	2	1	399010
15APR94	201	BT	5	8	29MAR94	204	BT	5	8	17	0	0	1	399139
19APR94	262	BT	5	8	29MAR94	263	BT	5	8	21	0	0	1	399151
31MAR94	265	BT	1	2	29MAR94	267	BT	5	8	2	4	6	1	399160
07APR94	242	BT	9	14	29MAR94	243	BT	5	8	9	4	6	1	399161
07APR94	242	BT	5	8	29MAR94	243	BT	5	8	9	0	0	1	399161
12APR94	201	BT	5	8	31MAR94	202	BT	5	8	12	0	0	1	399615
05APR94	155	BT	5	8	31MAR94	155	BT	5	8	5	0	0	1	399619
18APR94	246	BT	5	8	31MAR94	247	BT	5	8	18	0	0	1	399627
14APR94	272	BT	5	8	31MAR94	274	BT	7	11	14	2	3	1	399675
05APR94	260	BT	5	8	31MAR94	261	BT	7	11	5	2	3	1	399703
18APR94	221	BT	5	8	31MAR94	230	BT	7	11	18	2	3	1	399724
05APR94	277	BT	5	8	01APR94	279	BT	5	8	4	0	0	1	399852
08APR94	240	BT	5	8	01APR94	241	BT	5	8	7	0	0	1	399928
14APR94	262	BT	5	8	01APR94	264	BT	5	8	13	0	0	1	399936
24NOV93	349	BT	1	2	24NOV93	349	BT	1	2	0	0	0	1	400045
09DEC93	301	UH	3	5	24NOV93	303	UH	3	5	15	0	0	1	400073
27DEC93	325	UH	2	3	24NOV93	326	UH	3	5	33	1	2	1	400093
31MAR94	305	BT	1	2	24NOV93	304	UH	3	5	127	4	6	1	400094
06DEC93	343	UH	3	5	04DEC93	343	UH	3	5	2	0	0	1	400162
06JAN94	325	BT	1	2	04DEC93	323	UH	3	5	33	4	6	1	400176
10DEC93	315	UH	2	3	04DEC93	315	UH	3	5	6	1	2	1	400196
09DEC93	335	UH	3	5	06DEC93	332	BT	1	2	3	4	6	1	400311
09DEC93	317	UH	3	5	08DEC93	316	UH	3	5	1	0	0	1	400765
20DEC93	311	BT	5	8	08DEC93	312	UH	3	5	12	8	13	1	400891
12MAR94	330	BT	10	16	09DEC93	332	UH	3	5	93	13	21	1	400968
31MAR94	331	BT	1	2	09DEC93	330	UH	3	5	112	4	6	1	401028
14MAR94	375	BT	8	13	09DEC93	372	UH	3	5	95	11	18	1	401077
20DEC93	298	BT	1	2	09DEC93	300	UH	3	5	11	4	6	1	401099
17DEC93	388	UH	2	3	10DEC93	387	BT	1	2	7	3	5	1	401222
23DEC93	303	UH	2	3	10DEC93	304	UH	3	5	13	1	2	1	401368
23DEC93	331	UH	2	3	13DEC93	331	UH	3	5	10	1	2	1	401471
22DEC93	331	BT	1	2	14DEC93	331	UH	2	3	8	3	5	1	401567
15MAR94	302	BT	8	13	15DEC93	301	BT	8	13	90	0	0	1	401605
17DEC93	345	UH	2	3	15DEC93	344	BT	8	13	2	10	16	1	401624
31MAR94	332	BT	1	2	17DEC93	330	UH	2	3	104	3	5	1	401809
06APR94	358	BT	5	8	17DEC93	357	UH	3	5	110	8	13	1	401858
23DEC93	312	UH	2	3	17DEC93	312	UH	3	5	6	1	2	1	401873
21DEC93	359	BT	5	8	20DEC93	358	BT	5	8	1	0	0	1	401885
31MAR94	330	BT	1	2	20DEC93	331	BT	5	8	101	4	6	1	401937
14MAR94	324	BT	8	13	22DEC93	331	UH	2	3	82	10	16	1	402153
05JAN94	312	BT	1	2	22DEC93	313	UH	2	3	14	3	5	1	402240
23DEC93	375	UH	2	3	23DEC93	376	UH	2	3	0	0	0	1	402317
05JAN94	369	BT	5	8	23DEC93	376	UH	2	3	13	7	11	1	402317
28MAR94	353	BT	1	2	23DEC93	352	UH	2	3	95	3	5	1	402360

(Continued)

APPENDIX TABLE D-2. (Continued)

RECAPTURE					RELEASE									
	TOTAL LENGTH	RIVER				TOTAL LENGTH				DAYS AT	DISTANCE TRAVELLED		TAG	
DATE	IN MM	REGION	MILE	KM	DATE	IN MM	REGION	MILE	KM	LARGE	MILES	KM	COND	NUMBER
07JAN94	373	BT	1	2	05JAN94	373	BT	1	2	2	0	0	1	402613
07JAN94	443	BT	1	2	07JAN94	443	BT	1	2	0	0	0	1	402683
07JAN94	304	BT	1	2	07JAN94	304	BT	1	2	0	0	0	1	402685
07JAN94	352	BT	1	2	07JAN94	351	BT	1	2	0	0	0	1	402686
23MAR94	259	BT	7	11	10JAN94	357	BT	7	11	72	0	0	1	402724
31MAR94	339	BT	1	2	13JAN94	336	BT	8	13	77	7	11	1	402788
31MAR94	305	BT	1	2	17MAR94	305	BT	8	13	14	7	11	1	403273
15APR94	336	BT	5	8	15APR94	337	BT	5	8	0	0	0	1	404014
13APR94	219	BT	5	8	02APR94	218	BT	5	8	11	0	0	1	405035
07APR94	240	BT	5	8	02APR94	240	BT	5	8	5	0	0	1	405092
14APR94	265	BT	5	8	02APR94	267	BT	5	8	12	0	0	1	405226
15APR94	283	BT	5	8	02APR94	285	BT	5	8	13	0	0	1	405227
12APR94	276	BT	5	8	02APR94	279	BT	5	8	10	0	0	1	405234
18APR94	238	BT	5	8	04APR94	238	BT	5	8	14	0	0	1	405287
07APR94	196	BT	5	8	04APR94	196	BT	5	8	3	0	0	1	405378
19APR94	187	BT	5	8	04APR94	193	BT	5	8	15	0	0	1	405439
05APR94	228	BT	5	8	05APR94	229	BT	5	8	0	0	0	1	405564
07APR94	228	BT	9	14	05APR94	228	BT	5	8	2	4	6	1	405690
19APR94	196	BT	5	8	05APR94	197	BT	5	8	14	0	0	1	405724
18APR94	243	BT	5	8	05APR94	246	BT	5	8	13	0	0	1	405736
06APR94	235	BT	5	8	05APR94	235	BT	5	8	1	0	0	1	405807
08APR94	292	BT	5	8	06APR94	292	BT	6	10	2	1	2	1	405921
07APR94	269	BT	5	8	06APR94	270	BT	5	8	1	0	0	1	405928
13APR94	289	BT	5	8	06APR94	290	BT	5	8	7	0	0	1	406022
19APR94	240	BT	5	8	06APR94	243	BT	5	8	13	0	0	1	406026
06APR94	226	BT	5	8	06APR94	226	BT	5	8	0	0	0	1	406050
14APR94	229	BT	5	8	06APR94	232	BT	5	8	8	0	0	1	406089
18APR94	200	BT	5	8	06APR94	200	BT	5	8	12	0	0	1	406127
18APR94	228	BT	5	8	06APR94	228	BT	5	8	12	0	0	1	406146
06APR94	210	BT	5	8	06APR94	209	BT	5	8	0	0	0	1	406166
20APR94	250	BT	5	8	06APR94	251	BT	5	8	14	0	0	1	406174
18APR94	154	BT	5	8	06APR94	154	BT	5	8	12	0	0	1	406220
15APR94	258	BT	5	8	07APR94	260	BT	9	14	8	4	6	1	406230
15APR94	252	BT	5	8	07APR94	253	BT	9	14	8	4	6	1	406233
19APR94	198	BT	5	8	07APR94	201	BT	9	14	12	4	6	1	406297
12APR94	254	BT	5	8	07APR94	254	BT	9	14	5	4	6	1	406329
20APR94	247	BT	5	8	07APR94	248	BT	9	14	13	4	6	1	406342
15APR94	251	BT	5	8	07APR94	252	BT	9	14	8	4	6	1	406360
07APR94	168	BT	9	14	07APR94	168	BT	9	14	0	0	0	1	406397
20APR94	287	BT	5	8	07APR94	288	BT	5	8	13	0	0	1	406490
20APR94	287	BT	5	8	07APR94	286	BT	5	8	13	0	0	1	406523
15APR94	185	BT	5	8	07APR94	188	BT	5	8	8	0	0	1	406543
20APR94	273	BT	5	8	08APR94	275	BT	5	8	12	0	0	1	406639
19APR94	199	BT	5	8	08APR94	202	BT	5	8	11	0	0	1	406647
08APR94	235	BT	5	8	08APR94	237	BT	5	8	0	0	0	1	406693
14APR94	169	BT	5	8	08APR94	170	BT	5	8	6	0	0	1	406726
08APR94	186	BT	5	8	08APR94	187	BT	5	8	0	0	0	1	406799
13APR94	209	BT	5	8	08APR94	210	BT	5	8	5	0	0	1	406925
14APR94	215	BT	5	8	11APR94	215	BT	9	14	3	4	6	1	407110
18APR94	238	BT	5	8	12APR94	240	BT	5	8	6	0	0	1	407299
14APR94	212	BT	5	8	12APR94	212	BT	5	8	2	0	0	1	407483
13APR94	223	BT	5	8	13APR94	158	BT	5	8	0	0	0	1	407665
20APR94	233	BT	5	8	13APR94	233	BT	5	8	7	0	0	1	407698
14APR94	248	BT	5	8	13APR94	249	BT	5	8	1	0	0	1	407824
15APR94	213	BT	5	8	14APR94	214	BT	5	8	1	0	0	1	408057
20APR94	229	BT	5	8	18APR94	229	BT	5	8	2	0	0	1	408800
19APR94	233	BT	5	8	18APR94	234	BT	5	8	1	0	0	1	408803
19APR94	214	BT	5	8	18APR94	215	BT	5	8	1	0	0	1	408881
19APR94	215	BT	5	8	18APR94	215	BT	5	8	1	0	0	1	408961

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED DURING, THE 1993-1994 HUDSON RIVER STRIPED BASS HATCHERY PROGRAM.

RECAPTURE							RELEASE										
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT	GROWTH	TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	IN MM	COND	NUMBER
02NOV93	9 M TRAWL	6	486	BT	1	2	13DEC89	9 M TRAWL	2	329	BT	8	13	1420	157	1	272633
03NOV93	9 M TRAWL	2	290	BT	1	2	17DEC92	9 M TRAWL	1	220	UH	4	6	321	70	1	378963
03NOV93	9 M TRAWL	2	296	BT	1	2	06JAN93	9 M TRAWL	1	222	UH	3	5	301	74	1	381150
08NOV93	9 M TRAWL	2	273	UH	3	5	06JAN93	9 M TRAWL	1	235	UH	3	5	306	38	1	381055
08NOV93	9 M TRAWL	2	280	UH	2	3	22JAN93	9 M TRAWL	1	200	UH	3	5	290	80	1	382562
09NOV93	9 M TRAWL	3	489	BT	1	2	03NOV92	9 M TRAWL	2	376	BT	5	8	371	113	1	357266
09NOV93	9 M TRAWL	3	411	BT	1	2	06MAR92	9 M TRAWL	1	218	BT	11	18	613	193	1	368662
09NOV93	9 M TRAWL	2	352	BT	1	2	04JAN93	9 M TRAWL	1	267	UH	3	5	309	85	1	380305
15NOV93	9 M TRAWL	4	402	BT	5	8	09DEC92	9 M TRAWL	3	362	BT	5	8	341	40	1	360185
16NOV93	9 M TRAWL	2	254	UH	3	5	09FEB93	9 M TRAWL	1	187	BT	1	2	280	67	1	384316
17NOV93	9 M TRAWL	3	307	UH	3	5	25NOV91	9 M TRAWL	1	227	BT	9	14	723	80	1	343184
17NOV93	9 M TRAWL	2	284	UH	3	5	06JAN93	9 M TRAWL	1	221	UH	3	5	315	63	1	381209
17NOV93	9 M TRAWL	2	379	UH	3	5	25JAN93	9 M TRAWL	1	268	UH	3	5	296	111	1	382759
18NOV93	9 M TRAWL	4	399	UH	2	3	25NOV92	9 M TRAWL	3	356	UH	3	5	358	43	1	359304
19NOV93	9 M TRAWL	4	469	UH	3	5	20MAR91	9 M TRAWL	1	236	BT	8	13	975	233	1	341170
19NOV93	9 M TRAWL	4	455	UH	2	3	24NOV92	9 M TRAWL	3	418	UH	2	3	360	37	2	359140
19NOV93	9 M TRAWL	2	281	UH	2	3	02DEC92	9 M TRAWL	1	184	BT	1	2	352	97	1	377233
19NOV93	9 M TRAWL	3	351	UH	3	5	26MAR93	9 M TRAWL	2	232	BT	10	16	238	119	1	388830
22NOV93	9 M TRAWL	4	382	UH	3	5	09JAN91	9 M TRAWL	.	221	BT	1	2	1048	161	1	324770
22NOV93	9 M TRAWL	3	443	UH	3	5	03APR92	9 M TRAWL	1	265	BT	10	16	598	178	1	355801
22NOV93	9 M TRAWL	3	360	UH	3	5	20JAN93	9 M TRAWL	2	307	BT	9	14	306	53	1	362102
22NOV93	9 M TRAWL	2	342	UH	3	5	17NOV92	9 M TRAWL	1	235	BT	1	2	370	107	1	375483
22NOV93	9 M TRAWL	2	242	BT	1	2	17MAR93	9 M TRAWL	1	197	BT	9	14	250	45	1	388061
23NOV93	9 M TRAWL	3	348	UH	3	5	24MAR92	9 M TRAWL	1	210	BT	8	13	609	138	1	371838
23NOV93	9 M TRAWL	2	300	BT	1	2	04JAN93	9 M TRAWL	1	265	UH	3	5	323	35	1	380334
23NOV93	9 M TRAWL	2	280	BT	1	2	18MAR93	9 M TRAWL	1	217	BT	10	16	250	63	1	388098
24NOV93	9 M TRAWL	3	467	UH	3	5	20NOV91	9 M TRAWL	1	270	BT	9	14	735	197	1	343077
24NOV93	9 M TRAWL	3	388	UH	3	5	25NOV92	9 M TRAWL	.	376	UH	3	5	364	12	1	358914
24NOV93	9 M TRAWL	3	381	UH	3	5	04JAN93	9 M TRAWL	2	330	UH	3	5	324	51	1	361725
24NOV93	9 M TRAWL	3	250	UH	3	5	22JAN93	9 M TRAWL	2	244	UH	3	5	306	6	1	382551
04DEC93	9 M TRAWL	3	386	UH	3	5	08JAN92	9 M TRAWL	1	233	BT	9	14	696	153	1	351233
04DEC93	9 M TRAWL	4	451	UH	3	5	09NOV92	9 M TRAWL	3	430	BT	9	14	390	21	1	357409
04DEC93	9 M TRAWL	3	426	UH	3	5	13MAR92	9 M TRAWL	1	215	BT	7	11	631	211	1	370582
06DEC93	9 M TRAWL	3	403	UH	2	3	26NOV91	9 M TRAWL	1	270	BT	8	13	741	133	1	343282
06DEC93	9 M TRAWL	3	432	UH	2	3	20DEC91	9 M TRAWL	1	237	BT	8	13	717	195	1	344983
06DEC93	9 M TRAWL	3	395	UH	2	3	03NOV92	9 M TRAWL	2	342	BT	5	8	398	53	1	357272
06DEC93	9 M TRAWL	3	359	UH	2	3	02DEC92	9 M TRAWL	2	339	BT	1	2	369	20	1	359804
06DEC93	9 M TRAWL	2	334	UH	2	3	18DEC92	9 M TRAWL	1	239	UH	4	6	353	95	1	379003
06DEC93	9 M TRAWL	3	375	UH	2	3	04JAN93	9 M TRAWL	2	285	UH	3	5	336	90	1	380734
06DEC93	9 M TRAWL	2	311	UH	2	3	26JAN93	9 M TRAWL	1	182	BT	9	14	314	129	1	382893
06DEC93	9 M TRAWL	3	464	UH	2	3	16APR93	9 M TRAWL	2	298	BT	9	14	234	166	1	391088
07DEC93	9 M TRAWL	4	502	UH	3	5	20MAR91	9 M TRAWL	2	203	BT	8	13	993	299	1	341168
07DEC93	9 M TRAWL	4	407	UH	3	5	12NOV92	9 M TRAWL	3	390	BT	8	13	390	17	1	358307
07DEC93	9 M TRAWL	2	405	UH	3	5	04DEC92	9 M TRAWL	1	267	BT	5	8	368	138	1	377571
07DEC93	9 M TRAWL	2	334	UH	3	5	30MAR93	9 M TRAWL	1	207	BT	8	13	252	127	1	389333
08DEC93	9 M TRAWL	5	450	UH	3	5	19NOV90	9 M TRAWL	2	284	BT	9	14	1115	166	1	321526
08DEC93	9 M TRAWL	3	440	UH	3	5	18DEC92	9 M TRAWL	2	354	UH	4	6	355	86	1	361046
08DEC93	9 M TRAWL	3	482	UH	3	5	21DEC92	9 M TRAWL	2	370	BT	5	8	352	112	1	361257
08DEC93	9 M TRAWL	3	392	UH	3	5	04JAN93	9 M TRAWL	2	351	UH	3	5	338	41	1	361691
08DEC93	9 M TRAWL	2	414	UH	3	5	09MAR92	9 M TRAWL	0	173	BT	7	11	639	241	1	369019
08DEC93	9 M TRAWL	2	333	UH	3	5	18DEC92	9 M TRAWL	1	267	UH	4	6	355	66	1	379077
08DEC93	9 M TRAWL	2	332	UH	3	5	25JAN93	9 M TRAWL	1	251	BT	1	2	317	81	1	382812
08DEC93	9 M TRAWL	2	358	UH	2	3	22MAR93	9 M TRAWL	1	241	BT	9	14	261	117	1	388332

(Continued)

APPENDIX TABLE D-3. (Continued)

RECAPTURE							RELEASE											
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT	GROWTH	TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	IN MM	COND	NUMBER
09DEC93	9 M TRAWL	3	431	UH	3	5	11DEC91	9 M TRAWL	1	294	BT	6	10	729	137	1	344036
09DEC93	9 M TRAWL	2	437	UH	3	5	20NOV92	9 M TRAWL	1	319	BT	1	2	384	118	2	358924
09DEC93	9 M TRAWL	2	272	UH	3	5	30NOV92	9 M TRAWL	1	186	BT	5	8	374	86	1	376614
09DEC93	9 M TRAWL	2	303	UH	3	5	21DEC92	9 M TRAWL	1	233	BT	1	2	353	70	1	379227
09DEC93	9 M TRAWL	2	370	UH	3	5	06JAN93	9 M TRAWL	1	286	UH	3	5	337	84	1	381218
09DEC93	9 M TRAWL	2	383	UH	3	5	16APR93	9 M TRAWL	1	283	BT	9	14	237	100	1	391118
10DEC93	9 M TRAWL	2	329	UH	2	3	09DEC92	9 M TRAWL	1	205	BT	5	8	366	124	1	378506
10DEC93	9 M TRAWL	2	388	UH	2	3	06JAN93	9 M TRAWL	1	292	UH	3	5	338	96	1	381117
13DEC93	9 M TRAWL	2	354	UH	3	5	04JAN93	9 M TRAWL	1	289	UH	3	5	343	65	1	380352
13DEC93	9 M TRAWL	2	340	UH	3	5	30MAR93	9 M TRAWL	1	260	BT	9	14	258	80	2	389282
15DEC93	9 M TRAWL	3	444	UH	2	3	03NOV92	9 M TRAWL	2	345	BT	5	8	407	99	1	357268
15DEC93	9 M TRAWL	3	382	BT	8	13	09NOV92	9 M TRAWL	2	321	BT	8	13	401	61	1	357396
17DEC93	9 M TRAWL	3	336	BT	1	2	22APR92	9 M TRAWL	1	191	BT	1	2	604	145	1	374750
17DEC93	9 M TRAWL	2	338	UH	2	3	19NOV92	9 M TRAWL	1	282	BT	1	2	393	56	1	375817
17DEC93	9 M TRAWL	2	422	UH	2	3	28DEC92	9 M TRAWL	1	297	BT	5	8	354	125	1	379484
17DEC93	9 M TRAWL	2	342	UH	2	3	05JAN93	9 M TRAWL	1	234	UH	3	5	346	108	1	380867
17DEC93	9 M TRAWL	2	290	BT	1	2	25MAR93	9 M TRAWL	1	214	BT	10	16	267	76	2	388622
20DEC93	9 M TRAWL	3	310	BT	1	2	29JAN93	9 M TRAWL	2	270	BT	9	14	325	40	1	350468
21DEC93	9 M TRAWL	2	242	BT	5	8	24MAR93	9 M TRAWL	1	217	BT	10	16	272	25	1	388498
21DEC93	9 M TRAWL	2	343	BT	5	8	05APR93	9 M TRAWL	1	240	BT	9	14	260	103	1	389907
22DEC93	9 M TRAWL	3	343	BT	1	2	26MAR92	9 M TRAWL	1	224	BT	7	11	636	119	1	349926
22DEC93	9 M TRAWL	2	429	UH	2	3	22DEC92	9 M TRAWL	1	359	BT	5	8	365	70	1	361322
22DEC93	9 M TRAWL	2	391	UH	2	3	06JAN93	9 M TRAWL	1	292	UH	3	5	350	99	1	381117
22DEC93	9 M TRAWL	2	345	UH	2	3	06JAN93	9 M TRAWL	1	196	UH	3	5	350	149	1	381144
22DEC93	9 M TRAWL	2	235	BT	1	2	11FEB93	9 M TRAWL	1	192	BT	1	2	314	43	1	384523
22DEC93	9 M TRAWL	2	352	UH	2	3	02MAR93	9 M TRAWL	1	220	BT	7	11	295	132	2	386592
22DEC93	9 M TRAWL	.	278	UH	2	3	18MAR93	9 M TRAWL	1	176	BT	10	16	279	102	1	388081
22DEC93	9 M TRAWL	2	395	UH	2	3	16APR93	9 M TRAWL	1	277	BT	9	14	250	118	1	391149
23DEC93	9 M TRAWL	2	364	UH	2	3	17NOV92	9 M TRAWL	1	272	BT	1	2	401	92	2	375521
23DEC93	9 M TRAWL	2	337	UH	2	3	29MAR93	9 M TRAWL	.	262	BT	9	14	269	75	1	375717
23DEC93	9 M TRAWL	2	273	UH	2	3	20NOV92	9 M TRAWL	1	218	BT	1	2	398	55	1	376139
23DEC93	9 M TRAWL	2	265	UH	2	3	05JAN93	9 M TRAWL	1	214	UH	3	5	352	51	1	380819
06JAN94	9 M TRAWL	2	259	BT	5	8	10MAR93	9 M TRAWL	1	198	BT	10	16	302	61	1	387237
07JAN94	9 M TRAWL	2	275	BT	1	2	08MAR93	9 M TRAWL	1	218	BT	8	13	305	57	2	386977
07JAN94	9 M TRAWL	2	247	BT	1	2	18MAR93	9 M TRAWL	1	200	BT	9	14	295	47	1	388127
10JAN94	9 M TRAWL	2	269	BT	1	2	06JAN93	9 M TRAWL	1	247	UH	3	5	369	22	1	381099
13JAN94	9 M TRAWL	2	307	UH	2	3	03MAR93	9 M TRAWL	1	255	BT	6	10	316	52	1	386809
14JAN94	9 M TRAWL	4	370	BT	7	11	28JAN93	9 M TRAWL	3	346	BT	8	13	351	24	2	362467
10FEB94	9 M TRAWL	2	280	BT	9	14	03DEC92	9 M TRAWL	1	246	BT	5	8	434	34	1	377359
22FEB94	9 M TRAWL	3	323	BT	9	14	28JAN93	9 M TRAWL	2	344	BT	8	13	390	.	1	362443
24FEB94	9 M TRAWL	2	288	BT	7	11	30MAR93	9 M TRAWL	1	237	BT	8	13	331	51	1	389191
25FEB94	9 M TRAWL	2	357	BT	7	11	30MAR93	9 M TRAWL	1	269	BT	8	13	332	88	1	389250
01MAR94	9 M TRAWL	4	452	BT	1	2	31DEC92	9 M TRAWL	3	403	BT	1	2	425	49	1	361572
09MAR94	9 M TRAWL	2	324	BT	11	18	02MAR93	9 M TRAWL	1	239	BT	7	11	372	85	1	386586
09MAR94	9 M TRAWL	2	241	BT	11	18	16MAR93	9 M TRAWL	1	182	BT	10	16	358	59	1	387812
11MAR94	9 M TRAWL	2	331	BT	8	13	18DEC91	9 M TRAWL	0	184	BT	1	2	814	147	1	344817
11MAR94	9 M TRAWL	3	390	BT	7	11	08DEC92	9 M TRAWL	2	358	BT	1	2	458	32	1	360122
11MAR94	9 M TRAWL	2	265	BT	9	14	26MAR93	9 M TRAWL	1	179	BT	10	16	350	86	1	388777
12MAR94	9 M TRAWL	2	266	BT	9	14	05JAN93	9 M TRAWL	1	214	UH	3	5	431	52	1	380819
14MAR94	9 M TRAWL	2	273	BT	8	13	06JAN93	9 M TRAWL	1	251	UH	3	5	432	22	1	380961
15MAR94	9 M TRAWL	2	336	BT	8	13	19NOV92	9 M TRAWL	1	282	BT	1	2	481	54	1	375817
15MAR94	9 M TRAWL	2	287	BT	8	13	30DEC92	9 M TRAWL	1	216	BT	5	8	440	71	1	379947
15MAR94	9 M TRAWL	2	340	BT	8	13	04JAN93	9 M TRAWL	1	285	UH	3	5	435	55	1	380404
15MAR94	9 M TRAWL	2	291	BT	8	13	04JAN93	9 M TRAWL	1	243	UH	3	5	435	48	1	380626
15MAR94	9 M TRAWL	2	317	BT	11	18	19MAR93	9 M TRAWL	1	207	BT	10	16	361	110	1	388188
15MAR94	9 M TRAWL	2	245	BT	8	13	26MAR93	9 M TRAWL	1	177	BT	10	16	354	68	1	388767
15MAR94	9 M TRAWL	2	285	BT	11	18	06APR93	9 M TRAWL	1	195	BT	9	14	343	90	1	390183

(Continued)

APPENDIX TABLE D-3. (Continued)

RECAPTURE							RELEASE										
			TOTAL LENGTH	RIVER						TOTAL LENGTH	RIVER			DAYS AT		TAG	
DATE	GEAR	AGE	IN MM	REGION	MILE	KM	DATE	GEAR	AGE	IN MM	REGION	MILE	KM	LARGE	GROWTH IN MM	COND	NUMBER
16MAR94	9 M TRAWL	2	242	BT	7	11	26FEB93	9 M TRAWL	1	167	BT	8	13	383	75	1	386330
17MAR94	9 M TRAWL	3	393	BT	8	13	07JAN93	9 M TRAWL	2	344	BT	8	13	434	49	2	361908
17MAR94	9 M TRAWL	3	384	BT	8	13	13MAR92	9 M TRAWL	1	187	BT	7	11	734	197	1	370504
17MAR94	9 M TRAWL	2	235	BT	8	13	27JAN93	9 M TRAWL	1	175	BT	8	13	414	60	2	383218
18MAR94	9 M TRAWL	3	425	BT	7	11	15DEC92	9 M TRAWL	2	414	UH	2	3	458	11	1	360444
19MAR94	9 M TRAWL	7	544	BT	6	10	07FEB92	9 M TRAWL	5	465	BT	8	13	771	79	1	348755
21MAR94	9 M TRAWL	3	340	BT	7	11	14JAN92	9 M TRAWL	1	258	BT	5	8	797	82	2	352433
24MAR94	9 M TRAWL	3	457	BT	9	14	07FEB92	9 M TRAWL	1	249	BT	8	13	776	208	1	365399
24MAR94	9 M TRAWL	2	315	BT	9	14	19NOV92	9 M TRAWL	1	240	BT	1	2	490	75	1	375993
24MAR94	9 M TRAWL	2	286	BT	1	2	04JAN93	9 M TRAWL	1	217	UH	3	5	444	69	1	380504
24MAR94	9 M TRAWL	2	227	BT	1	2	11MAR93	9 M TRAWL	1	204	BT	10	16	378	23	1	387460
24MAR94	9 M TRAWL	3	258	BT	9	14	31MAR93	9 M TRAWL	2	235	BT	7	11	358	23	1	389362
28MAR94	9 M TRAWL	2	404	BT	1	2	05FEB93	9 M TRAWL	1	305	BT	10	16	416	99	1	362840
28MAR94	9 M TRAWL	2	322	BT	1	2	17DEC92	9 M TRAWL	1	296	UH	4	6	466	26	1	378905
29MAR94	9 M TRAWL	2	446	BT	8	13	17DEC92	9 M TRAWL	1	327	UH	4	6	467	119	1	360809
30MAR94	9 M TRAWL	3	348	BT	8	13	19NOV92	9 M TRAWL	1	290	BT	1	2	496	58	1	376028
30MAR94	9 M TRAWL	2	325	BT	8	13	18DEC92	9 M TRAWL	1	262	UH	4	6	467	63	1	378970
31MAR94	9 M TRAWL	2	326	BT	1	2	09DEC92	9 M TRAWL	1	255	BT	1	2	477	71	1	378634
31MAR94	9 M TRAWL	2	295	BT	7	11	02FEB93	9 M TRAWL	1	237	BT	8	13	422	58	1	383924
31MAR94	9 M TRAWL	2	215	BT	7	11	09APR93	9 M TRAWL	1	185	BT	9	14	356	30	1	390697
01APR94	9 M TRAWL	3	447	BT	5	8	11MAR92	9 M TRAWL	1	240	BT	10	16	751	207	2	369923
01APR94	9 M TRAWL	2	301	BT	9	14	11JAN93	9 M TRAWL	1	223	BT	1	2	445	78	2	381568
02APR94	9 M TRAWL	2	436	BT	1	2	29JAN93	9 M TRAWL	1	326	BT	9	14	428	110	1	362566
05APR94	9 M TRAWL	2	230	BT	5	8	07APR93	9 M TRAWL	1	197	BT	9	14	363	33	1	390315
06APR94	9 M TRAWL	2	360	BT	5	8	18FEB93	9 M TRAWL	1	270	BT	7	11	412	90	1	385241
06APR94	9 M TRAWL	2	276	BT	5	8	25MAR93	9 M TRAWL	1	202	BT	10	16	377	74	1	388515
07APR94	9 M TRAWL	2	298	BT	5	8	26MAR93	9 M TRAWL	1	212	BT	10	16	377	86	1	388662
08APR94	9 M TRAWL	.	232	BT	5	8	06APR93	9 M TRAWL	1	187	BT	9	14	367	45	1	390077
08APR94	9 M TRAWL	1	214	BT	5	8	06APR93	9 M TRAWL	0	153	BT	9	14	367	61	2	390098
12APR94	9 M TRAWL	1	263	BT	5	8	09APR93	9 M TRAWL	0	150	BT	9	14	368	113	1	390704
13APR94	9 M TRAWL	2	213	BT	5	8	25JAN93	9 M TRAWL	1	178	BT	3	5	443	35	1	382871
13APR94	9 M TRAWL	2	225	BT	5	8	23MAR93	9 M TRAWL	1	193	BT	8	13	386	32	1	388434
13APR94	9 M TRAWL	1	255	BT	5	8	16APR93	9 M TRAWL	0	153	BT	9	14	362	102	1	391129
14APR94	9 M TRAWL	2	246	BT	5	8	05NOV92	9 M TRAWL	1	169	BT	5	8	525	77	1	375175
15APR94	9 M TRAWL	2	312	BT	5	8	04DEC92	9 M TRAWL	1	255	BT	5	8	497	57	1	377605
15APR94	9 M TRAWL	.	262	BT	5	8	17MAR93	9 M TRAWL	1	208	BT	10	16	394	54	1	388016
15APR94	9 M TRAWL	2	242	BT	5	8	25MAR93	9 M TRAWL	1	156	BT	9	14	386	86	1	388567
19APR94	9 M TRAWL	2	285	BT	5	8	11MAR93	9 M TRAWL	1	187	BT	10	16	404	98	1	387425

APPENDIX TABLE B-6. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER FROM 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

			NUMBER OF RECAPTURES IN WEEK																									
RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	1 NOV N = 112	8 NOV N = 618	15 NOV N = 620	22 NOV N = 1089	29 NOV N = 375	6 DEC N = 1656	13 DEC N = 703	20 DEC N = 1139	27 DEC N = 749	3 JAN N = 766	10 JAN N = 470	17 JAN N = 13	24 JAN N = 0	31 JAN N = 5	7 FEB N = 7	14 FEB N = 3	21 FEB N = 98	28 FEB N = 113	7 MAR N = 509	14 MAR N = 2,020	21 MAR N = 223	28 MAR N = 1,617	4 APR N = 1,676	11 APR N = 1,840	18 APR N = 993	TOTAL N = 17,500
1 NOV	125	R	1																									1
		R/M	0.00893																									0.00893
		R/C	0.00800																									0.00800
8 NOV	662	R	0	3																								3
		R/M	0.00000	0.00485																								0.00411
		R/C	0.00000	0.00453																								0.00453
15 NOV	667	R	0	1	0																							1
		R/M	0.00000	0.00162	0.00000																							0.00074
		R/C	0.00000	0.00150	0.00000																							0.00150
22 NOV	1,206	R	0	3	4	17																						24
		R/M	0.00000	0.00485	0.00645	0.01561																						0.00984
		R/C	0.00000	0.00249	0.00332	0.01410																						0.01990
29 NOV	403	R	0	0	1	1	0																					2
		R/M	0.00000	0.00000	0.00161	0.00092	0.00000																					0.00071
		R/C	0.00000	0.00000	0.00248	0.00248	0.00000																					0.00496
6 DEC	1,853	R	0	2	1	4	4	8																				19
		R/M	0.00000	0.00324	0.00161	0.00367	0.01067	0.00483																				0.00425
		R/C	0.00000	0.00108	0.00054	0.00216	0.00216	0.00432																				0.01025

(continued)

APPENDIX TABLE B-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK: 1 NOV N = 112	8 NOV N = 618	15 NOV N = 620	22 NOV N = 1089	29 NOV N = 375	6 DEC N = 1658	13 DEC N = 705	20 DEC N = 1139	27 DEC N = 749	3 JAN N = 766	10 JAN N = 470	17 JAN N = 13	24 JAN N = 0	31 JAN N = 5	7 FEB N = 7	14 FEB N = 3	21 FEB N = 98	28 FEB N = 113	7 MAR N = 309	14 MAR N = 2,020	21 MAR N = 222	28 MAR N = 1,617	4 APR N = 1,676	11 APR N = 1,840	18 APR N = 993	TOTAL N = 17,500
13 DEC	777	R	0	0	0	4	0	7	2																			13
		R/M	0.00000	0.00000	0.00000	0.00367	0.00000	0.00422	0.00284																			0.00231
		R/C	0.00000	0.00000	0.00000	0.00515	0.00000	0.00901	0.00257																			0.01673
20 DEC	1,262	R	0	1	2	2	0	4	7	7																		23
		R/M	0.00000	0.00162	0.00323	0.00184	0.00000	0.00241	0.00993	0.00615																		0.00364
		R/C	0.00000	0.00079	0.00158	0.00158	0.00000	0.00317	0.00555	0.00555																		0.01823
27 DEC	796	R	0	0	0	1	0	1	1	3	4																	10
		R/M	0.00000	0.00000	0.00000	0.00092	0.00000	0.00060	0.00142	0.00263	0.00534																	0.00142
		R/C	0.00000	0.00000	0.00000	0.00126	0.00000	0.00126	0.00126	0.00377	0.00503																	0.01256
3 JAN	878	R	1	1	0	1	1	0	0	6	1	9																20
		R/M	0.00893	0.00162	0.00000	0.00092	0.00267	0.00000	0.00000	0.00527	0.00134	0.01175																0.00235
		R/C	0.00114	0.00114	0.00000	0.00114	0.00114	0.00000	0.00000	0.00683	0.00114	0.01025																0.02278
10 JAN	551	R	0	0	0	0	0	2	1	2	1	2	0															8
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00121	0.00142	0.00176	0.00134	0.00261	0.00000															0.00096
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00363	0.00181	0.00363	0.00181	0.00363	0.00000															0.01452
17 JAN	22	R	0	0	0	0	0	0	0	0	0	0	0	0														0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000														0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000														0.00000

(continued)

APPENDIX TABLE B-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS (C)	STA-TISTIC	NUMBER OF RECAPTURES IN WEEK																									
			1 NOV N = 112	8 NOV N = 618	15 NOV N = 630	22 NOV N = 1089	29 NOV N = 373	6 DEC N = 1630	13 DEC N = 785	20 DEC N = 1139	27 DEC N = 749	3 JAN N = 766	10 JAN N = 470	17 JAN N = 13	24 JAN N = 0	31 JAN N = 5	7 FEB N = 7	14 FEB N = 3	21 FEB N = 98	28 FEB N = 113	7 MAR N = 349	14 MAR N = 2,020	21 MAR N = 223	28 MAR N = 1,617	4 APR N = 1,676	11 APR N = 1,040	18 APR N = 993	TOTAL N = 17,500
24 JAN	1	R	0	0	0	0	0	0	0	0	0	0	0	0	0													0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000													0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000													0.00000
31 JAN	5	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0												0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000												0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000												0.00000
7 FEB	9	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000											0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000											0.00000
14 FEB	6	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000										0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000										0.00000
21 FEB	133	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000									0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000									0.00000
28 FEB	129	R	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0								1
		R/M	0.00000	0.00000	0.00000	0.00092	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000								0.00012
		R/C	0.00000	0.00000	0.00000	0.00775	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000								0.00775

(continued)

APPENDIX TABLE B-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS TRAWLS (C)	STA-TISTIC	1 NOV N = 112	8 NOV N = 618	15 NOV N = 620	22 NOV N = 1089	29 NOV N = 373	6 DEC N = 1650	13 DEC N = 705	20 DEC N = 1139	27 DEC N = 749	3 JAN N = 766	10 JAN N = 470	17 JAN N = 15	24 JAN N = 0	31 JAN N = 5	7 FEB N = 7	14 FEB N = 3	21 FEB N = 98	28 FEB N = 113	7 MAR N = 589	14 MAR N = 2,020	21 MAR N = 223	28 MAR N = 1,617	4 APR N = 1,676	11 APR N = 1,040	18 APR N = 993	TOTAL N = 17,300
			NUMBER OF RECAPTURES IN WEEK																									
7 MAR	667	R	0	0	0	3	0	1	1	1	0	0	2	0	0	0	0	0	0	0	1							9
		R/M	0.00000	0.00000	0.00000	0.00275	0.00000	0.00061	0.00142	0.00088	0.00000	0.00000	0.00426	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00170							0.00099
		R/C	0.00000	0.00000	0.00000	0.00450	0.00000	0.00150	0.00150	0.00150	0.00000	0.00000	0.00300	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00150							0.01349
14 MAR	2,393	R	0	2	1	0	1	6	4	5	4	3	8	0	0	0	0	0	0	1	3	3						41
		R/M	0.00000	0.00324	0.00161	0.00000	0.00267	0.00364	0.00567	0.00439	0.00534	0.00392	0.01702	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00885	0.00509	0.00149						0.00368
		R/C	0.00000	0.00084	0.00042	0.00000	0.00042	0.00251	0.00167	0.00209	0.00167	0.00125	0.00334	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00042	0.00125	0.00125						0.01713
21 MAR	277	R	0	0	0	2	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	3	3					12
		R/M	0.00000	0.00000	0.00000	0.00184	0.00000	0.00000	0.00000	0.00000	0.00134	0.00131	0.00213	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00885	0.00000	0.00149	0.01345					0.00186
		R/C	0.00000	0.00000	0.00000	0.00722	0.00000	0.00000	0.00000	0.00000	0.00361	0.00361	0.00361	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00361	0.00000	0.01083	0.01083					0.04332
28 MAR	1,880	R	0	0	0	4	0	2	3	5	0	1	4	0	0	0	0	0	0	0	2	4	2	4				31
		R/M	0.00000	0.00000	0.00000	0.00367	0.00000	0.00121	0.00426	0.00439	0.00000	0.00131	0.00851	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00340	0.00198	0.00897	0.00247				0.00239
		R/C	0.00000	0.00000	0.00000	0.00213	0.00000	0.00106	0.00160	0.00266	0.00000	0.00053	0.00213	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00106	0.00213	0.00106	0.00213				0.01649
4 APR	1,962	R	0	0	0	3	3	2	1	0	1	3	1	0	0	0	0	0	1	1	1	5	0	7	11			40
		R/M	0.00000	0.00000	0.00000	0.00275	0.00000	0.00121	0.00142	0.00000	0.00134	0.00392	0.00213	0.00000	0.00000	0.00000	0.00000	0.00000	0.01020	0.00885	0.00170	0.00248	0.00000	0.00433	0.00656			0.00273
		R/C	0.00000	0.00000	0.00000	0.00153	0.00153	0.00102	0.00051	0.00000	0.00051	0.00153	0.00051	0.00000	0.00000	0.00000	0.00000	0.00000	0.00051	0.00051	0.00051	0.00255	0.00000	0.00357	0.00561			0.02039

(continued)

APPENDIX TABLE B-4. (CONTINUED)

NUMBER OF RECAPTURES IN WEEK

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS IN TRAWLS TRAWLS (C)	STA- TISTIC	1 NOV N = 112	8 NOV N = 618	15 NOV N = 620	22 NOV N = 1089	29 NOV N = 375	6 DEC N = 1658	13 DEC N = 705	20 DEC N = 1139	27 DEC N = 749	3 JAN N = 766	10 JAN N = 470	17 JAN N = 13	24 JAN N = 0
11 APR	2,140	R	0	2	0	1	0	1	3	1	0	2	2	0	0
		R/M	0.00000	0.00324	0.00000	0.00092	0.00000	0.00060	0.00426	0.00088	0.00000	0.00261	0.00426	0.00000	0.00000
		R/C	0.00000	0.00093	0.00000	0.00047	0.00000	0.00047	0.00140	0.00047	0.00000	0.00093	0.00093	0.00000	0.00000
18 APR	1,137	R	0	0	0	1	0	0	0	0	2	1	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00092	0.00000	0.00000	0.00000	0.00000	0.00267	0.00131	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00088	0.00000	0.00000	0.00000	0.00000	0.00176	0.00088	0.00000	0.00000	0.00000
TOTALS	19,941	R	2	15	9	45	9	34	23	30	14	22	18	0	0
		R/M	0.01786	0.02427	0.01452	0.04132	0.02400	0.02051	0.03262	0.02634	0.01869	0.02872	0.03830	0.00000	0.00000
		R/C	0.00010	0.00075	0.00045	0.00226	0.00045	0.00171	0.00115	0.00150	0.00070	0.00110	0.00090	0.00000	0.00000

RECAPTURE PERIOD	STA- TISTIC	31 JAN N = 5	7 FEB N = 7	14 FEB N = 3	21 FEB N = 98	28 FEB N = 113	7 MAR N = 589	14 MAR N = 2,020	21 MAR N = 223	28 MAR N = 1,617	4 APR N = 1,676	11 APR N = 1,840	18 APR N = 993	TOTAL N = 17,300
11 APR	R	0	0	0	0	0	4	5	1	8	9	6		45
	R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00679	0.00248	0.00448	0.00493	0.00537	0.00326		0.00273
	R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00187	0.00234	0.00047	0.00374	0.00421	0.00280		0.02103
18 APR	R	0	0	0	0	0	0	2	0	3	15	2	4	30
	R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00099	0.00000	0.00186	0.00895	0.00109	0.00403	0.00182
	R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00176	0.00000	0.00264	0.01319	0.00176	0.00352	0.02639
TOTALS	R	0	0	0	1	3	11	22	6	22	35	8	4	333
	R/M	0.00000	0.00000	0.00000	0.01020	0.02655	0.01868	0.01089	0.02691	0.01361	0.02088	0.00435	0.00403	0.01903
	R/C	0.00000	0.00000	0.00000	0.00005	0.00015	0.00055	0.00110	0.00030	0.00110	0.00176	0.00040	0.00020	0.01670

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR THE HUDSON RIVER STRIPED BASS CAPTURED WITH ABRADED TAGS, 1 NOVEMBER 1993 THROUGH 20 APRIL 1994.

RECAPTURE					RELEASE					TAG INFORMATION		TAG CONDITION					
DATE (DD/MM/YY)	GEAR	STATION	RM	LENGTH (mm TL)	DATE (DD/MM/YY)	GEAR	STATION	RM	LENGTH (mm TL)	M_C	TAG NUMBER	NUMBER	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	TAG CONDITION
NOV 3 93	9m	BT	1	296	JAN 6 93	9m	NY	3	222	98	381150	4	4	2	P	N	1

LEGEND:

Gear 9m = 9m trawl

Station BT = Battery
NY = Upper Harbor

M_C 98 = Hallprint internatal anchor, external streamer tag

Tag Condition
1 = Tag present, wound healed
2 = Tag present, wound poorly healed, evidence of infection or swelling

TAG VARIABLE	COMMENT CODE	COMMENT DESCRIPTION
Number	1,2,3, or 4	1 = Legend completely missing
Address	1,2,3, or 4	2 = Abraded and partly missing
Reward	1,2,3, or 4	3 = Abraded but completely legible
		4 = Completely legible
Number orientation	A or P	A = Tag number facing anterior(Head)
		p = Tag number facing posterior(Tail)
Anchor protrusion	Y or N	Y = Yes
		N = No

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE ATLANTIC TOMCOD POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1993-94.

SAMPLING WEEK	(>150 mTL) C TOTAL	(>150 mTL) M TOTAL	CUM M TOTAL	R TOTAL	R/C
NOV 23 93	1,206	1,089	0	0	0.0000
NOV 29 93	403	375	1,089	1	0.0025
DEC 6 93	1,853	1,658	1,464	8	0.0043
DEC 13 93	777	705	3,122	11	0.0142
DEC 20 93	1,262	1,139	3,827	13	0.0103
DEC 27 93	796	749	4,966	6	0.0075
JAN 3 94	878	766	5,715	9	0.0103
JAN 10 94	551	470	6,481	8	0.0145
TOTAL	7,726	6,951	6,951	56	0.0072

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE BATTERY AND UPPER HARBOR REGIONS OF THE LOWER HUDSON RIVER FROM THE WEEK OF 22 NOVEMBER 1993 THROUGH THE WEEK OF 10 JANUARY 1994.

SOURCE	df	SS	MS	F	p>F
Model	1	0.00063	0.00063	58.51	0.0001
Error	7	0.00008	0.00001		
Total	8	0.00071			

Regression Equation: R/C = (Cumulative M) X + error,

where,

X = 0.00000223 and

Standard Error of X = 0.00000029

R^2 = coefficient of determination = 0.893

df = degrees of freedom
SS = sum of squares
MS = mean square
F = calculated F-ratio
p>F = probability of obtaining a larger F-ratio

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)[a]	MODIFIED INTERNAL ANCHOR (HALL)[a]	SMALL DART (HALL)[a]
1984	737	737[b]	737	–	–	–	–
1985-1986	18,448	–	18,448	–	–	–	–
1986-1987	9,473	–	7,258	2,215	–	–	–
1987-1988	12,433	–	1,598	2,360	8,475	–	–
1988-1989	24,393	–	–	–	7,927	16,466	819[b]
1989-1990	24,362	–	–	–	–	24,362	659[b]
1990-1991	22,406	–	–	–	–	22,406	–
1991-1992	24,307[c]	–	–	–	–	24,307[c]	–
1992-1993	21,746[d]	–	–	–	–	21,746[d]	–
1993-1994	18,310[e]	–	–	–	–	18,310[e]	–
TOTAL	176,615	737[b]	28,041	4,575	16,402	127,597	1,478[b]

[a]Hall - Hallprint.

[b]Not included in row total because fish were double tagged.

[c]Total includes 23,514 fish tagged and released in good condition (REL_REC = 1) and 793 fish tagged and released with one or more external anomalies (REL_REC = 6).

[d]Total includes 20,847 fish tagged and released in good condition (REL_REC = 1) and 899 fish tagged and released with one or more external anomalies (REL_REC = 6).

[e]Total includes 17,500 fish tagged and released in good condition (REL_REC = 1) and 810 fish tagged and released with one or more external anomalies (REL_REC = 6).

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS CAUGHT, TAGGED AND RE-LEASED DURING THE 1993-94 HUDSON RIVER HATCHERY EVALUATION PROGRAM.

TAG	ANCHOR*	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	\$5-\$1000	9,414
Hallprint Internal Anchor	Small, yellow, legend	Yellow polypropylene with covered filament	\$10-\$1000	3,830
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	\$5-\$1000	1,021
Hallprint Internal Anchor	Large, yellow, legend	Yellow polypropylene with covered filament	\$10-\$1000	4,045
1993-94 TOTAL:				18,310

*Striped bass ≥ 150 mmTL and < 300 mmTL in good condition were tagged with small anchor (20 mm) tags and released.

Striped bass ≥ 300 mmTL in good condition were tagged with large anchor (25 mm) tags and released.

Total includes 17,500 fish that were tagged and released in good condition (REL_REC = 1) and 810 fish tagged and released with one or more external anomalies (REL_REC = 6).

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted between 1 November 1993 and 20 April 1994 were taken to the Peekskill, NY laboratory and examined in fresh condition to determine length, weight, sex, and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for these observations. Similar biocharacteristics data were obtained during the 1985-86 through 1992-93 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200 mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 LENGTH, WEIGHT, SEX, AND SEXUAL CONDITION OF STRIPED BASS

Length, weight, sex, and sexual condition were determined for 497 striped bass that died during field sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 50.0 g for fish less than or equal to 10 kg, and to the nearest 100.0 g for fish greater than 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-1.

E.2.2 Striped Bass Stomach Contents Analysis

A sample of 496 striped bass that were processed as described above in Section E2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in striped bass stomach contents. Atlantic tomcod were differentiated from other fish species by comparing vertebral counts and, if necessary, vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 STRIPED BASS SEXUAL CONDITION

Immature striped bass were most abundant in the biocharacteristics samples from the 1993-94 striped bass program (Tables E-2 and E-3). The majority (95%) of the female striped bass examined were in the immature stage. The remaining females were either resting (4%), developing (<1%) or spent (<1%). Male striped bass followed a similar pattern with 77% in the immature stage and 16% in the resting stage. The remaining 7% of the male striped bass were in the developing stage and most of those (16 of 19 fish) were captured in March and April. No striped bass of either sex in the ripe, or ripe and running stages were examined.

The lack of ripe, or ripe and running striped bass in the 1993-94 biocharacteristics samples agrees with the findings of the 1985-86 through 1992-93 programs (Tables E-3 and E-4). In previous programs the majority of female fish (95%) were immature and no female fish in the developing or ripe stages were examined. The majority of male fish examined from previous programs were also in the immature (63%) and resting (22%) stages with the remainder in the developing stage (14%). The lack of ripe or ripe and running striped bass is not surprising because the majority of the fish captured in these programs were of pre-spawning size (< 400 mm) and the programs terminated before the onset of peak spawning (NAI 1986; TI 1981). The general increase in the percentage of males in the developing stage with time during the 1985-86 through 1993-94 programs indicated the approach of the spawning season, and that male striped bass may undergo a longer period of gonadal development prior to spawning than females. Due to both the small size of striped bass sampled, and the time period during which the program was conducted, the majority of the fish sampled were immature or resting.

E.3.2 STRIPED BASS FOOD HABITS

Food habits from a subsample of 497 striped bass that died during collection were determined by identifying stomach contents as invertebrates, vertebrates, or Atlantic tomcod. Only 11 fish were captured in the larger (> 400 mm) length group and a high percentage of stomachs were empty (91%) which made generalizations about changes in food habits with length difficult (Table E-5). Presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River estuary during the winter, and as a result, Atlantic tomcod may be a winter food item of striped bass. No Atlantic tomcod were observed in any of the striped bass stomachs examined. All vertebrate remains were identifiable as fish, and the majority of those were clupeids, or *Morone* sp. as incidentally noted by laboratory personnel.

Percentage of non-empty striped bass with invertebrate remains in their stomachs decreased with increasing length group (Table E-5). This is in general agreement with the findings from the previous Hudson River programs where invertebrate remains were most common in striped bass 201-300 mm (Table E-6). Twenty striped bass were examined with fish remains in their stomachs during the 1993-94 program. The majority of these striped bass were greater than 300 mm, and 11 of these striped bass also had invertebrates present in their stomachs (Table E-5). The percentage of non-empty striped bass with fish remains in their stomachs generally increased with length in the 1993-94 program.

The sample sizes for food habit analyses from individual programs were generally too small to identify trends. However, when the foods habit data from the 1985-86 through 1993-94 programs were pooled several trends became evident (Table E-6). Invertebrates were the dominant prey item in non-empty striped bass stomachs examined as 36% contained invertebrate remains. A change in food habits was apparent when striped bass reached about 300 mm as the importance of invertebrates as a prey item decreased. About

62% of the striped bass less than 300 mm with food items present in their stomachs had invertebrates only, while 11% of the stomachs of striped bass greater than 300 mm contained invertebrates only.

A majority of the striped bass examined for food habits had empty stomachs (51%). The percentage of striped bass with empty stomachs varied by length group between 2% and 47%. The majority of striped bass larger than 400 mm (62%) had empty stomachs.

Invertebrates and vertebrates were found in 8% of the stomachs examined. Only 5% of the stomachs examined contained exclusively fish. Fish were a more numerous prey item in larger striped bass as 56% of the striped bass in length groups ≥300 mm contained fish. Only 7% of the fish less than 200 mm contained fish only in their stomachs. The trend of increasing importance of fish as food items as striped bass length increases has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). No Atlantic tomcod were observed in any of the 1,970 striped bass stomachs examined since 1985.

TABLE E-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS[a].

STATE OF MATURITY	CODE	FEMALES	MALES
Gravid or milting (ripe)	1	Ovaries full of yellowish granular eggs that are partially translucent. Eggs can be released when ovary is compressed.	Testes white, less firm in texture, and if compressed will readily milt.
Ripe and running	2	Adult prepared to spawn immediately; expulsion of eggs with little provocation.	Adult prepared to spawn immediately; expulsion of milt with little provocation.
Partially spent	3	Ovaries somewhat flaccid and convoluted, with a variable number of eggs left. Ovarian membrane somewhat vascular.	Testes whitish, somewhat flaccid and convoluted, with free flow of milt.
Spent	4	Ovaries flaccid, few translucent eggs left. Ovarian membrane very vascular or sac-like.	Testes brownish white, flaccid, convoluted, with no flow of milt upon compression.
Immature	5	Ovaries very small and string-like, thicker than testes, somewhat opaque and gelatinous in appearance.	Testes very small and stringlike, thinner than ovaries, somewhat translucent, and extremely tender.
Not gravid or not milting (Resting)	6	Underdeveloped ovaries in an adult female. Ovaries larger, more firm, opaque, and relatively thick. No eggs discernible to naked eye.	Underdeveloped testes in an adult male. Testes larger, more firm, opaque, but still tender.
Semi-gravid semi-milting (developing)	7	Subripe females heading into spawning season. Ovaries considerably larger, yellow, granular in consistency. Eggs discernible to naked eye, but not readily released when ovary is compressed.	Subripe males heading into spawning season. Testes considerably larger, white, firm in exture, but milt not running.

[a]From Con Edison Data Dictionary

APPENDIX TABLE E-2. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1993-94 PROGRAM.

	PERCENTAGE (NUMBER) OF STRIPED BASS										
	FEMALES					MALES				UNDETERMINED	
MONTH	IMMATURE	RESTING	DEVELOPING	SPENT	TOTAL	IMMATURE	RESTING	DEVELOPING	TOTAL	IMMATURE	TOTAL
NOV	100 (5)	(0)	(0)	(0)	100 (5)	20 (1)	80 (4)	(0)	100 (5)	100 (2)	100 (2)
DEC	100 (17)	(0)	(0)	(0)	100 (17)	47 (9)	53 (10)	(0)	100 (19)	100 (0)	100 (0)
JAN	86 (19)	5 (1)	5 (1)	5 (1)	100 (22)	76 (34)	18 (8)	7 (3)	100 (45)	100 (1)	100 (1)
FEB	100 (3)	(0)	(0)	(0)	100 (3)	67 (2)	33 (1)	(0)	100 (3)	100 (18)	100 (18)
MAR	93 (82)	7 (6)	(0)	(0)	100 (88)	81 (83)	13 (13)	6 (6)	100 (102)	100 (14)	100 (14)
APR	99 (69)	1 (1)	(0)	(0)	100 (70)	83 (69)	5 (4)	12 (10)	100 (83)	100 (2)	100 (2)
TOTAL	95 (195)	4 (8)	<1 (1)	<1 (1)	100 (205)	77 (198)	16 (40)	7 (19)	100 (257)	100 (35)	100 (35)

APPENDIX TABLE E-3. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1993-94 PROGRAM.

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
98	8.2	24MAR93	BATTERY	10	UNDETERMINED	IMMATURE	EMPTY
100	7.7	16MAR93	BATTERY	10	UNDETERMINED	IMMATURE	INVERTS
103	8.4	15JAN93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
106	9.4	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
106	10.1	12APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	8.3	15JAN93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	11.2	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
110	11.6	05APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
120	13.6	06APR93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
121	15.6	05APR93	BATTERY	5	UNDETERMINED	IMMATURE	EMPTY
128	15.5	15JAN93	BATTERY	9	MALE	IMMATURE	INVERTS
146	25.9	25MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
150	29.6	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
152	28.8	31DEC92	BATTERY	1	UNDETERMINED	IMMATURE	INVERTS
152	27.8	29MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
153	27.6	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
153	31.3	05APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
153	32.4	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
154	29.2	26FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
154	32.3	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
155	22.0	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
155	32.4	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
156	31.1	08MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
157	30.5	13JAN93	BATTERY	9	UNDETERMINED	IMMATURE	INVERTS
157	31.9	31MAR93	BATTERY	8	UNDETERMINED	IMMATURE	EMPTY
158	32.2	25FEB93	BATTERY	7	MALE	IMMATURE	EMPTY
158	33.4	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
158	32.6	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
158	31.4	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
158	31.9	12APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
159	31.3	21JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
160	30.9	01DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
160	36.2	28JAN93	BATTERY	7	UNDETERMINED	IMMATURE	INVERTS
160	35.3	05MAR93	BATTERY	6	MALE	IMMATURE	INVERTS
160	33.6	19MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
160	36.4	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
161	31.1	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
161	37.9	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
162	35.6	05MAR93	BATTERY	6	FEMALE	IMMATURE	EMPTY
162	37.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
162	34.2	02APR93	BATTERY	8	MALE	IMMATURE	EMPTY
163	36.6	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
163	39.8	17MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
164	33.2	31DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS
164	38.6	27JAN93	BATTERY	7	FEMALE	IMMATURE	INVERTS
164	37.9	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
165	40.6	18FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
165	36.6	03MAR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
165	39.4	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
165	36.6	06APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
165	36.8	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
166	30.8	30DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
166	38.6	23FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
167	36.5	29DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
167	36.5	14JAN93	BATTERY	9	MALE	IMMATURE	INVERTS
167	35.9	30MAR93	BATTERY	8	UNDETERMINED	IMMATURE	INVERTS
167	36.7	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
168	36.0	01APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
168	35.7	06APR93	BATTERY	9	MALE	IMMATURE	INVERTS
168	41.6	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
170	40.5	23NOV92	BATTERY	1	UNDETERMINED	IMMATURE	INVERTS
170	42.3	23FEB93	BATTERY	8	MALE	IMMATURE	INVERTS
170	36.6	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
170	40.7	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
170	44.9	09APR93	BATTERY	9	HERMAPHRODITE	IMMATURE	VERTS
171	37.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
172	38.2	22JAN93	BATTERY	1	FEMALE	IMMATURE	EMPTY
172	41.1	28JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
172	42.7	08MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
172	42.9	08MAR93	BATTERY	7	FEMALE	IMMATURE	EMPTY
172	43.4	17MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
172	41.4	26MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	42.0	30MAR93	BATTERY	7	MALE	IMMATURE	INVERTS
172	42.2	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
172	41.9	06APR93	BATTERY	8	MALE	IMMATURE	INVERTS AND VERTS
173	33.1	02DEC92	BATTERY	5	UNDETERMINED	IMMATURE	EMPTY
173	40.2	29DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
173	40.4	29MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
173	37.9	30MAR93	BATTERY	8	UNDETERMINED	IMMATURE	INVERTS
173	45.6	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
174	40.5	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
175	43.4	19MAR93	BATTERY	10	FEMALE	IMMATURE	INVERTS
175	49.8	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
175	40.5	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
175	44.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
176	39.6	02DEC92	BATTERY	5	UNDETERMINED	IMMATURE	INVERTS
176	45.0	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
177	38.6	28JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
177	45.0	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
177	44.4	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
177	47.4	29MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
177	46.5	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
177	45.4	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
177	43.4	15APR93	BATTERY	9	MALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
178	50.8	27JAN93	UPPER HARBOR	3	MALE	RESTING	INVERTS
178	43.4	02APR93	BATTERY	9	MALE	IMMATURE	EMPTY
178	50.6	14APR93	BATTERY	9	MALE	IMMATURE	EMPTY
179	48.3	21JAN93	BATTERY	5	MALE	IMMATURE	INVERTS
179	72.6	08FEB93	BATTERY	5	MALE	IMMATURE	
179	48.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
179	51.0	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	49.2	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	50.0	06APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
179	45.9	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
180	53.3	09DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS
180	53.3	27JAN93	BATTERY	3	MALE	IMMATURE	INVERTS
180	40.9	01APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
180	43.5	02APR93	BATTERY	8	MALE	IMMATURE	INVERTS
180	54.5	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
181	50.7	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
181	49.9	02APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
181	50.4	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
182	47.9	02APR93	BATTERY	9	UNDETERMINED	IMMATURE	EMPTY
182	150.7	05APR93	BATTERY	9	MALE	IMMATURE	EMPTY
183	55.3	18FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
183	57.2	25FEB93	BATTERY	8	MALE	IMMATURE	EMPTY
183	52.1	17MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
183	49.4	12APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
183	52.2	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS
184	51.3	30NOV92	BATTERY	5	MALE	IMMATURE	EMPTY
184	56.0	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
184	55.6	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
184	50.0	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
184	48.5	31MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
184	52.1	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
184	52.4	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
184	48.9	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
185	53.1	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
185	53.1	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
186	48.8	25FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
186	52.5	08MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
186	54.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
187	58.7	22JAN93	BATTERY	1	FEMALE	IMMATURE	EMPTY
187	52.7	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
187	55.3	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
188	52.0	01DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
188	50.1	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
189	55.8	18FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
190	66.2	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS
190	65.5	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
190	56.7	17MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
190	60.9	07APR93	BATTERY	9	MALE	IMMATURE	EMPTY
190	59.1	09APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
191	57.7	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
191	56.7	06APR93	BATTERY	9	MALE	IMMATURE	INVERTS
191	61.4	07APR93	BATTERY	9	MALE	IMMATURE	INVERTS
192	52.6	30DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
192	57.5	10MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
192	59.3	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
192	52.0	01APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
192	60.9	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
193	58.0	29DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
193	55.5	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
194	57.8	28DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
194	58.2	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
194	65.2	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
194	54.8	01APR93	BATTERY	8	MALE	IMMATURE	EMPTY
194	53.6	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
195	68.5	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
195	60.9	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
195	62.1	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
195	62.0	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
196	72.0	23DEC92	BATTERY	5	MALE	IMMATURE	EMPTY
196	59.2	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
196	65.4	01APR93	BATTERY	9	MALE	IMMATURE	INVERTS
196	55.6	09APR93	BATTERY	9	MALE	IMMATURE	INVERTS
197	54.4	31DEC92	BATTERY	1	MALE	IMMATURE	INVERTS
197	63.0	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS AND VERTS
197	65.5	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
198	61.2	29MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
198	70.6	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
198	67.4	05APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
198	62.7	12APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
199	65.7	21JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
199	69.3	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
199	72.5	24MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
199	64.3	05APR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
200	62.4	17MAR93	BATTERY	10	MALE	IMMATURE	INVERTS
201	75.3	30MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
201	63.2	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS
202	66.1	29JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
202	69.3	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
204	71.7	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS
205	80.8	26JAN93	BATTERY	1	MALE	DEVELOPING	INVERTS
205	73.3	01APR93	BATTERY	9	MALE	IMMATURE	EMPTY
206	49.0	16MAR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
206	73.3	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
207	74.8	02FEB93	BATTERY	5	FEMALE	IMMATURE	INVERTS
207	83.3	30MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
207	75.1	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
208	89.2	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS AND VERTS
208	86.9	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
208	81.2	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
209	81.9	27JAN93	BATTERY	1	FEMALE	IMMATURE	INVERTS
210	70.1	07DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
210	65.5	29MAR93	BATTERY	10	MALE	IMMATURE	EMPTY
211	84.8	10DEC92	BATTERY	1	UNDETERMINED	IMMATURE	EMPTY
211	75.1	09APR93	BATTERY	9	MALE	IMMATURE	EMPTY
212	74.2	30MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
212	79.2	31MAR93	BATTERY	7	MALE	IMMATURE	EMPTY
214	88.8	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
214	90.6	29JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS
214	88.9	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
215	84.5	24FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
216	81.0	21JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
216	85.7	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
217	98.1	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
218	91.7	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
219	78.4	07DEC92	BATTERY	5	UNDETERMINED	IMMATURE	INVERTS AND VERTS
219	89.0	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
219	91.0	08APR93	BATTERY	9	MALE	IMMATURE	EMPTY
220	101.1	30MAR93	BATTERY	7	MALE	DEVELOPING	INVERTS
221	82.1	02APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
222	102.6	28JAN93	BATTERY	7	MALE	RESTING	EMPTY
222	99.8	17MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
222	86.6	25MAR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
223	89.6	07DEC92	BATTERY	5	MALE	IMMATURE	INVERTS
223	100.0	05APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
223	91.6	14APR93	BATTERY	9	MALE	IMMATURE	INVERTS
224	96.7	22JAN93	BATTERY	1	FEMALE	IMMATURE	INVERTS
225	92.2	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
226	90.7	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
227	103.0	15JAN93	BATTERY	9	MALE	IMMATURE	VERTS
227	105.1	30MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
228	114.0	22JAN93	BATTERY	1	MALE	RESTING	INVERTS
228	104.3	25JAN93	BATTERY	1	FEMALE	IMMATURE	
228	106.3	26JAN93	BATTERY	1	MALE	RESTING	EMPTY
229	101.8	30NOV92	BATTERY	5	MALE	IMMATURE	EMPTY
229	105.1	26JAN93	BATTERY	9	FEMALE	IMMATURE	INVERTS AND VERTS
229	109.1	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
230	101.9	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
230	119.0	09APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
230	105.5	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
231	117.8	02FEB93	BATTERY	5	MALE	IMMATURE	EMPTY
231	105.1	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
231	104.2	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
232	123.3	25FEB93	BATTERY	8	MALE	RESTING	EMPTY
232	113.3	25FEB93	BATTERY	8	FEMALE	IMMATURE	INVERTS
232	101.3	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
232	107.1	07APR93	BATTERY	9	MALE	IMMATURE	INVERTS
233	122.7	23NOV92	BATTERY	1	MALE	IMMATURE	EMPTY
236	112.2	02FEB93	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
236	107.6	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
237	114.4	07DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS AND VERTS
237	118.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
237	128.3	05APR93	BATTERY	9	MALE	IMMATURE	EMPTY
238	129.0	16FEB93	BATTERY	8	MALE	DEVELOPING	INVERTS
238	104.7	31MAR93	BATTERY	9	MALE	IMMATURE	EMPTY
241	145.4	19NOV92	BATTERY	1	MALE	IMMATURE	EMPTY
241	123.9	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
242	123.4	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
243	123.3	25FEB93	BATTERY	8	MALE	IMMATURE	INVERTS
244	128.0	16APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
246	130.0	28JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
247	153.5	28JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
247	132.2	30MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
247	141.4	30MAR93	BATTERY	9	MALE	DEVELOPING	INVERTS
250	143.7	22JAN93	BATTERY	1	MALE	IMMATURE	INVERTS
251	162.9	03MAR93	BATTERY	6	MALE	RESTING	EMPTY
251	143.3	02APR93	BATTERY	9	MALE	RESTING	EMPTY
251	174.8	05APR93	BATTERY	7	MALE	DEVELOPING	EMPTY
252	150.0	30DEC92	BATTERY	5	FEMALE	IMMATURE	EMPTY
254	181.4	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
254	135.9	31MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
255	204.0	02FEB93	BATTERY	8	MALE	RESTING	EMPTY
255	150.1	08APR93	BATTERY	9	MALE	IMMATURE	INVERTS
256	146.8	02APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
257	180.0	30DEC92	BATTERY	1	MALE	IMMATURE	INVERTS
257	134.0	01APR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
258	154.7	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
260	144.7	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
260	151.4	09APR93	BATTERY	9	FEMALE	IMMATURE	INVERTS
261	164.3	31DEC92	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
261	164.0	27JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
262	199.9	18DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
262	200.9	27JAN93	BATTERY	8	FEMALE	IMMATURE	INVERTS
263	226.1	28JAN93	BATTERY	9	MALE	RESTING	EMPTY
263	150.1	31MAR93	BATTERY	8	MALE	IMMATURE	EMPTY
263	185.5	05APR93	BATTERY	5	FEMALE	IMMATURE	VERTS
264	170.5	11FEB93	BATTERY	7	MALE	IMMATURE	INVERTS
265	205.6	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	EMPTY
266	168.6	05JAN93	UPPER HARBOR	3	MALE	IMMATURE	EMPTY
267	182.8	01FEB93	BATTERY	5	MALE	RESTING	EMPTY
267	186.4	05APR93	BATTERY	7	FEMALE	IMMATURE	INVERTS AND VERTS
268	155.3	05APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
269	172.6	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
270	200.0	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
270	184.3	12APR93	BATTERY	9	MALE	IMMATURE	EMPTY
271	215.5	22JAN93	BATTERY	1	MALE	RESTING	EMPTY
272	208.3	24MAR93	BATTERY	0	FEMALE	IMMATURE	EMPTY
272	198.3	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
273	187.9	05APR93	BATTERY	9	MALE	IMMATURE	VERTS
275	172.6	08APR93	BATTERY	9	MALE	RESTING	INVERTS
276	209.1	19NOV92	BATTERY	1	MALE	IMMATURE	INVERTS
276	186.7	01DEC92	BATTERY	5	FEMALE	IMMATURE	INVERTS
276	184.2	30MAR93	BATTERY	8	MALE	IMMATURE	INVERTS
279	208.7	29MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
280	202.4	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
281	291.8	10FEB93	BATTERY	7	FEMALE	IMMATURE	EMPTY
281	201.4	12APR93	BATTERY	9	MALE	IMMATURE	INVERTS
283	181.6	19FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
283	228.3	24FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
285	179.1	30DEC92	BATTERY	1	FEMALE	IMMATURE	EMPTY
285	218.3	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
286	240.5	11FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
288	223.0	02APR93	BATTERY	9	MALE	IMMATURE	INVERTS AND VERTS
289	223.2	05APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
290	230.3	19NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
292	295.0	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
293	243.0	21DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
293	246.1	08APR93	BATTERY	9	MALE	RESTING	EMPTY
294	247.7	23FEB93	BATTERY	7	MALE	RESTING	INVERTS AND VERTS
296	316.1	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
296	266.4	05APR93	BATTERY	7	MALE	IMMATURE	EMPTY
297	230.3	17MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
299	258.5	12NOV92	BATTERY	8	FEMALE	IMMATURE	EMPTY
300	261.1	28JAN93	BATTERY	9	MALE	RESTING	EMPTY
300	219.5	08APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
301	242.3	31MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
305	260.3	13NOV92	BATTERY	5	MALE	RESTING	INVERTS
305	284.1	27JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
306	205.9	25JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
308	303.9	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
309	276.0	30DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
309	254.0	07APR93	BATTERY	9	FEMALE	IMMATURE	EMPTY
311	258.9	12NOV92	BATTERY	8	MALE	IMMATURE	INVERTS
311	311.1	04JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	INVERTS
312	290.3	07JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
315	297.6	08FEB93	BATTERY	9	FEMALE	IMMATURE	INVERTS
316	357.7	16FEB93	BATTERY	7	FEMALE	IMMATURE	INVERTS
316	254.1	26FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
317	297.0	31MAR93	BATTERY	8	MALE	DEVELOPING	EMPTY
318	301.5	29MAR93	BATTERY	10	FEMALE	IMMATURE	EMPTY
320	329.5	03DEC92	BATTERY	5	MALE	RESTING	INVERTS AND VERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
322	326.4	19FEB93	BATTERY	11	FEMALE	IMMATURE	INVERTS AND VERTS
323	285.6	30MAR93	BATTERY	8	FEMALE	IMMATURE	EMPTY
324	304.9	23NOV92	BATTERY	1	MALE	IMMATURE	EMPTY
325	391.0	17DEC92	UPPER HARBOR	4	FEMALE	IMMATURE	INVERTS
325	387.1	06JAN93	UPPER HARBOR	3	MALE	RESTING	INVERTS
325	299.3	06APR93	BATTERY	8	FEMALE	RESTING	EMPTY
326	413.3	27JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
330	378.5	16FEB93	BATTERY	7	MALE	RESTING	EMPTY
331	329.0	02DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
335	369.8	30DEC92	BATTERY	1	FEMALE	IMMATURE	EMPTY
335	314.3	30DEC92	BATTERY	1	FEMALE	IMMATURE	INVERTS
335	351.8	27JAN93	BATTERY	7	FEMALE	IMMATURE	INVERTS
335	371.1	08FEB93	BATTERY	8	FEMALE	RESTING	EMPTY
337	363.4	17DEC92	UPPER HARBOR	4	FEMALE	RESTING	VERTS
337	355.7	30MAR93	BATTERY	8	FEMALE	IMMATURE	INVERTS
340	412.0	18NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
340	397.4	20NOV92	BATTERY	1	FEMALE	IMMATURE	EMPTY
340	448.4	16FEB93	BATTERY	8	MALE	RESTING	INVERTS
343	442.2	27JAN93	BATTERY	8	FEMALE	IMMATURE	EMPTY
343	413.8	28JAN93	BATTERY	7	FEMALE	IMMATURE	EMPTY
344	473.1	19FEB93	BATTERY	7	MALE	RESTING	EMPTY
345	433.2	04JAN93	UPPER HARBOR	3	MALE	RESTING	EMPTY
348	403.2	02APR93	BATTERY	9	MALE	DEVELOPING	EMPTY
350	372.4	10NOV92	BATTERY	5	MALE	IMMATURE	EMPTY
352	486.3	28JAN93	BATTERY	8	MALE	RESTING	EMPTY
354	409.7	08APR93	BATTERY	9	MALE	DEVELOPING	INVERTS AND VERTS
355	473.4	02DEC92	UPPER HARBOR	2	MALE	RESTING	INVERTS
357	421.8	18DEC92	UPPER HARBOR	4	FEMALE	IMMATURE	INVERTS AND VERTS
357	423.5	03FEB93	BATTERY	9	MALE	RESTING	INVERTS AND VERTS
360	528.0	03FEB93	BATTERY	9	MALE	RESTING	EMPTY
362	538.0	04JAN93	UPPER HARBOR	3	MALE	RESTING	EMPTY
363	564.0	11FEB93	UPPER HARBOR	3	MALE	RESTING	INVERTS AND VERTS
367	494.7	18DEC92	UPPER HARBOR	2	MALE	RESTING	VERTS
368	552.0	16DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
368	431.6	24FEB93	BATTERY	8	FEMALE	IMMATURE	EMPTY
370	467.5	18DEC92	UPPER HARBOR	4	FEMALE	IMMATURE	INVERTS AND VERTS
370	529.0	30DEC92	BATTERY	1	MALE	RESTING	EMPTY
378	493.1	21DEC92	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
380	470.5	02APR93	BATTERY	9	FEMALE	IMMATURE	VERTS
381	562.0	16DEC92	UPPER HARBOR	2	MALE	IMMATURE	INVERTS AND VERTS
382	574.7	31MAR93	BATTERY	8	MALE	RESTING	EMPTY
385	523.0	19NOV92	BATTERY	1	MALE	RESTING	EMPTY
385	613.0	17DEC92	BATTERY	1	MALE	RESTING	EMPTY
385	675.0	05APR93	BATTERY	7	MALE	RESTING	EMPTY
386	477.2	07JAN93	BATTERY	8	MALE	RESTING	INVERTS AND VERTS
387	655.0	09DEC92	BATTERY	5	MALE	RESTING	EMPTY
389	715.0	01DEC92	UPPER HARBOR	2	MALE	RESTING	EMPTY
389	567.0	02DEC92	UPPER HARBOR	2	FEMALE	IMMATURE	EMPTY
390	785.0	08FEB93	BATTERY	10	MALE	RESTING	INVERTS AND VERTS

(continued)

APPENDIX TABLE E-3. (CONTINUED)

LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIV_MILE	SEX	SEX_COND	FOOD
400	731.0	16DEC92	UPPER HARBOR	2	FEMALE	IMMATURE	EMPTY
401	494.7	01DEC92	BATTERY	1	MALE	IMMATURE	EMPTY
403	603.0	12NOV92	BATTERY	8	MALE	RESTING	EMPTY
410	814.0	23FEB93	BATTERY	10	FEMALE	IMMATURE	EMPTY
413	762.0	10FEB93	BATTERY	7	MALE	RESTING	VERTS
415	699.0	05JAN93	UPPER HARBOR	3	FEMALE	IMMATURE	EMPTY
420	750.1	06APR93	BATTERY	9	FEMALE	RESTING	INVERTS
421	779.0	09NOV92	BATTERY	9	FEMALE	IMMATURE	EMPTY
421	786.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
428	727.0	22JAN93	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
429	722.0	07DEC92	BATTERY	1	MALE	RESTING	EMPTY
430	860.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
435	817.0	01DEC92	UPPER HARBOR	2	MALE	IMMATURE	EMPTY
435	846.0	18DEC92	UPPER HARBOR	2	MALE	RESTING	EMPTY
438	994.0	16DEC92	UPPER HARBOR	3	MALE	RESTING	INVERTS AND VERTS
444	671.0	17NOV92	BATTERY	1	FEMALE	IMMATURE	VERTS
457	1013.0	25NOV92	UPPER HARBOR	2	FEMALE	IMMATURE	EMPTY
474	1086.0	25NOV92	UPPER HARBOR	2	FEMALE	IMMATURE	INVERTS
478	1080.0	25JAN93	BATTERY	1	MALE	RESTING	INVERTS AND VERTS
515	1426.0	24NOV92	BATTERY	1	FEMALE	IMMATURE	INVERTS AND VERTS
529	1557.0	02DEC92	UPPER HARBOR	2	FEMALE	RESTING	EMPTY
649	3200.0	25NOV92	UPPER HARBOR	2	MALE	RESTING	VERTS
668	3302.0	25NOV92	UPPER HARBOR	2	MALE	RESTING	VERTS

APPENDIX TABLE E-4. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1985-86 THROUGH 1993-94 PROGRAMS.

MONTH	IMMATURE MALES PROGRAM											RESTING MALES PROGRAM										
	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	TOTAL	MON-THLY %	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	TOTAL	MON-THLY %
NOV	0	0	1	1	4	6	6	8	1	27	57	1	0	1	1	1	1	4	5	4	18	38
DEC	16	2	2	7	2	12	13	18	9	81	58	0	0	4	5	1	6	7	12	10	45	32
JAN	13	7	5	10	5	16	57	9	34	156	69	0	1	9	1	0	2	14	14	8	49	22
FEB	8	9	17	6	1	11	24	9	2	87	62	0	1	0	0	0	9	9	12	1	32	23
MAR	11	10	8	5	2	7	3	36	83	165	72	0	8	0	0	0	3	6	2	13	32	14
APR	12	14	0	2	2	3	27	48	69	177	57	0	45	0	0	0	2	10	4	4	65	21
MAY	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	0	5	100
TOTAL	60	42	33	31	16	55	130	128	198	693	63	6	55	14	7	2	23	50	49	40	246	22

MONTH	DEVELOPING MALES PROGRAM										
	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	TOTAL	MON-THLY %
NOV	1	0	1	0	0	0	0	0	0	2	4
DEC	11	1	1	0	0	0	0	0	0	13	9
JAN	9	6	1	0	0	0	1	0	3	20	9
FEB	10	1	7	3	0	0	0	0	0	21	15
MAR	7	12	2	3	0	2	0	0	6	32	14
APR	50	2	3	0	0	1	1	0	10	67	22
MAY	0	0	0	0	0	0	0	0	0	0	0
TOTAL	88	22	15	6	0	3	2	0	19	155	14

MONTH	IMMATURE FEMALES PROGRAM											RESTING FEMALES PROGRAM										
	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	TOTAL	MON-THLY %	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	TOTAL	MON-THLY %
NOV	1	0	4	1	4	1	4	11	5	31	97	0	0	0	0	0	0	1	0	0	1	3
DEC	28	1	4	9	3	10	13	20	17	105	95	0	0	0	2	0	0	2	2	0	6	5
JAN	17	3	11	9	6	8	55	32	19	160	94	0	1	0	1	0	0	8	0	1	11	6
FEB	9	10	18	7	3	14	29	25	3	118	98	0	0	1	0	0	0	0	1	0	2	2
MAR	16	16	8	9	3	13	6	46	82	199	96	0	0	0	0	0	0	2	0	6	8	4
APR	24	9	0	3	1	8	8	57	59	179	94	0	0	0	0	0	0	8	2	1	11	6
MAY	1	0	0	0	0	0	0	0	0	1	50	1	0	0	0	0	0	0	0	0	1	50
TOTAL	96	39	45	38	20	54	115	191	195	793	95	1	1	1	3	0	0	21	5	8	40	5

APPENDIX TABLE E-5. PERCENTAGE OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS, OR EMPTY STOMACHS, CROSS-CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1993-94 PROGRAM.

PERCENTAGE (NUMBER) OF STRIPED BASS WITH STOMACH CONTENTS						
LENGTH GROUP (mm TL)	INVERTEBRATE REMAINS	VERTEBRATE REMAINS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤200	26.9(35)	0.0(0)	0.0(0)	0.0(0)	73.1(95)	100.0(130)
201-300	27.2(81)	0.7(2)	0.0(0)	2.0(6)	70.1(209)	100.0(298)
301-400	17.5(10)	10.5(6)	0.0(0)	8.8(5)	63.2(36)	100.0(57)
401-500	0.0(0)	9.1(1)	0.0(0)	0.0(0)	90.9(10)	100.0(11)
TOTAL	25.4(126)	1.8(9)	0.0(0)	2.2(11)	70.6(350)	100.0(496)

APPENDIX TABLE E-6. FOOD HABITS OF HUDSON RIVER STRIPED BASS CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 THROUGH 1993-94 PROGRAMS.

INVERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	TOTAL	LENGTH GROUP %
≤200	5	8	3	2	16	3	52	74	35	198	28
201-300	88	25	39	9	3	29	85	40	81	399	57
301-400	18	16	12	2	1	7	18	12	10	96	14
401-500	3	2	2	0	0	0	1	2	0	10	1
>500	1	0	1	0	0	0	0	0	0	2	<1
TOTAL	115	51	57	13	20	39	156	128	126	705	36

VERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	TOTAL	LENGTH GROUP %
≤200	1	0	0	1	0	0	2	3	0	7	7
201-300	4	0	0	6	0	8	13	4	2	37	37
301-400	5	1	3	8	0	8	9	3	6	43	43
401-500	3	0	1	0	0	0	2	2	1	9	9
>500	1	0	0	0	0	0	1	2	0	4	4
TOTAL	14	1	4	15	0	16	27	14	9	100	5

INVERTEBRATES AND VERTEBRATES

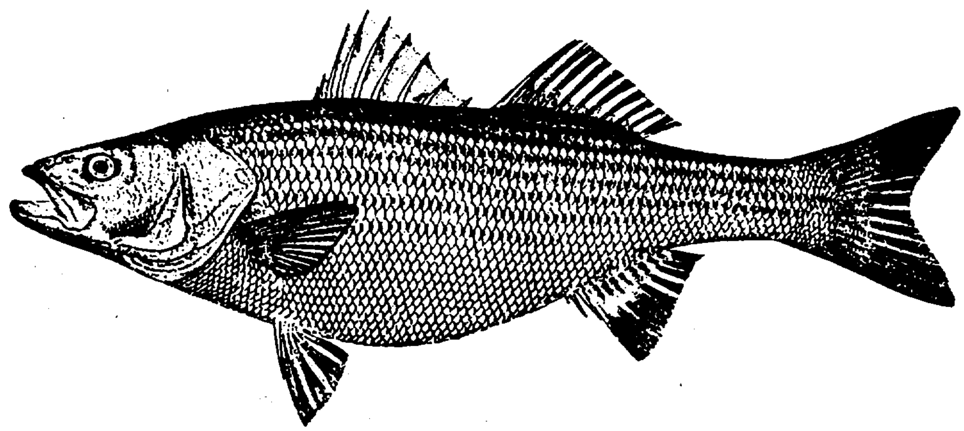
LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	TOTAL	LENGTH GROUP %
≤200	1	0	0	1	0	0	2	8	0	12	8
201-300	4	3	4	2	0	8	25	11	6	63	40
301-400	8	6	3	7	2	4	21	11	5	67	43
401-500	1	3	1	2	1	1	1	3	0	13	8
>500	0	1	0	0	0	0	0	1	0	2	1
TOTAL	14	13	8	12	3	13	49	34	11	157	8

EMPTY

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	TOTAL	LENGTH GROUP %
≤200	2	20	1	13	11	7	38	88	95	275	27
201-300	43	18	15	26	9	35	43	77	209	475	47
301-400	41	8	12	13	1	23	18	39	36	191	19
401-500	12	3	7	2	0	3	2	11	10	50	5
>500	11	0	3	0	0	0	1	1	0	16	2
TOTAL	109	49	38	54	21	68	102	216	350	1,007	51

Hudson River Striped Bass Stock Assessment Program

November 1994 - April 1995



Prepared under contract with:

NEW YORK POWER AUTHORITY
White Plains, New York

Jointly Financed by:

Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

March 1999

Final Report

Prepared by

LMS

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Environmental Science & Engineering Consultants
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#260-015

HUDSON RIVER STRIPED BASS STOCK ASSESSMENT PROGRAM

NOVEMBER 1994 - APRIL 1995

FINAL REPORT

Prepared under contract with:

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123 Main Street White Plains, New York 10601

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LMSE-99/0371&260/014

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Cover art: *Fishes of the Gulf of Maine* by Henry B. Bigelow and William C. Schroeder. 1953. First Revision Fishery Bulletin 74. Fishery Bulletin of the Fish and Wildlife Service. Vol. 53.

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was 1.0% for Age 0+ fish among the same age cohort of striped bass collected in the Hudson River between 7 November 1994 and 14 April 1995.

- The mean length of Age 0+ hatchery and wild striped bass from the 1994 cohort were significantly different (wild was smaller) based on non-overlapping 95% confidence limits. Hatchery striped bass of the 1990 and 1991 cohorts were not tagged prior to their release, and therefore could not be distinguished from wild fish.

- The 1993 cohort of Age 1+ striped bass and the 1994 cohort of Age 0+ fish dominated the catch of Hudson River striped bass during the 1994-95 program, while the Age 1+ and Age 2+ cohorts dominated the population estimate. The 1993 and 1994 cohorts represented 39 and 46%, respectively, of the total catch, while Age 1+ and Age 2+ fish represented 71% and 23%, respectively, of the population ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in upper New York Harbor and the Battery region was 350,000 fish with lower and upper 95% confidence limits of 107,000 and 593,000. Age 0+ striped bass accounted for approximately 4000 fish in the mid- winter population, Age 1+ contributed 248,000 fish, Age 2+ contributed 80,000 fish, Age 3+ contributed 19,000 fish, and Age >3+ contributed 1,000 fish.

- During the 1994-95 striped bass program 6941 fish ≥150 mm were caught and 6838 fish in good condition were tagged and released, bringing the total number of striped bass tagged and released in these programs since 1984 to 180,951. Of the 105 fish that were recaptured, 75 were tagged and released in the present program and 30 were from the 1993-94 program.

- Overall mean catch per unit of effort (CPUE) in the Battery region was 16.26 striped bass per 10-min tow. Mean CPUE during mid-December through mid-March increased annually from 1985-86 to a peak of 45.3 in the 1989-90 program. Mean CPUE decreased following 1989-90 to 40.7 in the 1990-91 program, 35.5 in the 1991-92 program, 32.7 in the 1992-93 program, 33.7 in the 1993-94 program, and 21.9 in the 1994-95 program.

CHAPTER 1

INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulates that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 3-in. striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York, to address this requirement. Hatchery production and stocking continued from 1991 through 1994 in accordance with paragraph 9 of the stipulation of Settlement and Judicial Consent Order, entered into by parties to the Settlement Agreement. The total number of hatchery striped bass that were stocked into the Hudson River in each year is as follows (EA 1995):

YEAR	NUMBER STOCKED
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,800
1988	48,611
1989	202,068
1990	234,387
1991	256,631
1992	210,746
1993	568,410
1994	306,529
Total	3,174,833

Section 2.J and Attachment V of the Settlement Agreement stipulated that an annual biological monitoring program be conducted through May 1991 to evaluate mitigation measures. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow differentiation between hatchery-released striped bass and naturally spawned striped bass. Striped bass produced and stocked during 1990 and 1991 were not tagged; however, tagging of hatchery-reared striped bass resumed in 1992. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that nonhatchery fish be released alive after capture, after they are examined for hatchery administered CWTs. If these striped bass are tagged and released, their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could be used to estimate the annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too high (MMES 1986) and the assumptions required for fish younger than Age 1+ may be violated (Wells et al. 1991). Consequently, the biological monitoring program focused on estimating the proportional contribution of hatchery stocked striped bass to the Hudson River stocks; estimation of annual survival rate for Age 1+ and Age 2+ fish; and estimation of the Age 1+ and Age 2+ striped bass overwintering stock in the lower Hudson River and Upper New York Harbor area.

The Hudson River striped bass program began in 1984 as an evaluation of fishing gear and techniques that were most efficient and effective for catching and handling striped bass. The best locations, times, and fishing gear were evaluated in the 1984 through 1987-88 programs to maximize total catch and CPUE of Age 1+ and Age 2+ striped bass. The Battery region of the Hudson River adjacent to Manhattan and Upper New York Harbor in the vicinity of Liberty Island provided the most consistent catches of Age 1+ and Age 2+ striped bass during the November through March period. The 9-m trawl was the most effective gear for capturing Age 1+ and Age 2+ striped bass, and has been the only gear used from 1988-89 through the present program (Table 1-1). Concurrent with these gear evaluations, handling techniques were improved to increase the survival of striped bass that were caught, tagged, scanned for hatchery-administered magnetic tags, and released (Dunning et al. 1987, 1989). As the hatchery and biological monitoring program progressed, more striped bass were recaptured with hatchery-administered tags, the magnetic tag detection efficiency was quantified (Mattson et al. 1989) and the internal anchor-external streamer tag design was improved (Mattson et al. 1989; Waldman et al. 1990).

TABLE 1-1

COMPARISON OF SAMPLING DESIGNS AND SELECTED RESULTS OF THE 1984 THROUGH 1993-94 HUDSON RIVER STRIPED BASS PROGRAMS

				CATCH STATISTICS							POPULATION ESTIMATES		
PROGRAM	GEAR	DATES	SAMPLING REGIONS	N-TOWS	CPUE	N-TOTAL	N-TAGGED	N-RECAPTURED	N-HATCHERY	HANDLING MORTALITY (%)	TOTAL (≥200 mm)	AGE 1+	HATCHERY PROPORTION AGE 1+ (%)
1984	12-m trawl	09 Apr-07 Jun	TZ,CH,IP, WP,CW,PK	200	2.8		345[a]		0	18	-	-	
	Scottish seine	09 Apr-07 Jun	TZ,CH,CW	139	2.2		392[a]	-	0	16	-	-	
	Total			339	2.6	1,620	737	0	0	17	-	-	0
1985-86	9-m trawl	11 Nov-18 May	BT	900	8.2		6,366		0	1			
	12-m trawl	11 Nov-18 May	BT,HR,ER, LH	346	20.7	7,265			0	2			
	Total			1,472	12.9	20,820	18,487	171	0	1	540,000	239,000	0
1986-87	9-m trawl	21 Dec-09 May	BT	845	9.8		5,349		74	1			
	12-m trawl	21 Dec-09 May	BT	219	24.1		4,039		20	1			
	Total		BT	1,064	12.7	14,136	9,388	261	94	1	394,000	108,000	1.7
1987-88	9-m trawl	09 Nov-22 Apr	BT	896	20.0	18,075	7,582		175	<1			
	12-m trawl	09 Nov-22 Apr	BT	296	33.9	10,117	4,854		62	1			
	Total		BT	1,192	23.5	28,192	12,436	465	238	<1	295,000	181,000	1.6
1988-89	9-m trawl	31 Oct-15 Apr	BT	1,151	28.5	32,975	24,393	453	213	<1	890,000	794,000	0.2
1989-90	9-m trawl	31 Oct-15 Apr	BT	891	37.3	33,386	24,362	655	141	<1	528,000	397,000	0.4
1990-91	9-m trawl	12 Nov-20 Apr	BT	971	29.7	29,346	22,406	865	52	<1	786,000	352,000	0.2
1991-92	9-m trawl	04 Nov-07 May	BT	1,169	29.3	34,202	25,710	631	17	1	967,000	709,000	a
1992-93	9-m trawl	02 Nov-16 Apr	BT	771	34.0	27,778	20,847	345	190	1.6	717,000	475,000	a
1993-94	9-m trawl	01 Nov-20 Apr	BT	794	36.2	28,739	16,799	333	134	1.6	379,000	217,000	0.01

[a] Hatchery striped bass were not tagged before release in 1990 or 1991. Therefore, an Age 1+ hatchery proportion was not computed.

SAMPLING REGIONS: BT = Battery and Upper New York, Hudson River miles 0-11 9 (km 0-18) and Upper New York Harbor TZ = Tappan Zee, Hudson River Harbor Miles 24-33 (km 38-53)
CH = Croton-Haverstraw, Hudson River miles 34-38 (km 54-61) IP = Indian Point, Hudson River miles 39-46 (km 62-74)
CW = Cornwall, Hudson River miles 56-61 (km 90-98) PK = Poughkeepsie, Hudson River miles 62-76 (km 99-122)
HR = Harlem River ER = East River LH = Lower New York Harbor

The April-June 1984 adult striped bass program (NAI 1985) demonstrated that it was effective to use a 12-m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass ≥300 mm (total length) could be externally tagged and released without significantly increasing 24-hr mortality (Dunning et al. 1987). No hatchery-tagged striped bass were recaptured during the 1984 program, and population estimates were not calculated from the relatively small sample of 737 external-tagged fish that were released (Table 1-1).

The 1985-86 Hudson River striped bass program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean CPUE for a 12-m trawl was greater than for a 9-m trawl, but total catch and mean catch per day were similar for the two trawls because more tows could be taken in a day with the 9-m trawl. Because of a larger mesh size, the 12-m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9-m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm. Striped bass handling mortality was reduced from 17% in 1984 to 1% or less in programs from 1985-86 to present by using an in-water live car to hold the fish prior to tagging (Dunning et al. 1989). No hatchery-tagged fish were recaptured during the 1985-86 program among the 20,820 striped bass examined for magnetic tags. The midwinter population of striped bass ≥200 mm was estimated to be 540,000 fish in the Battery and Upper New York Harbor; 239,000 of these fish were estimated to be Age 1+ (Table 1-1).

Data from the 1984 and 1985-86 programs (NAI 1985, 1986) were used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of

the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimators could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River striped bass program was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per 10-min tow for both the 9- and 12-m trawls. Use of a cod end liner (2.5-cm stretch mesh) in the 9-m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of a cod end liner in the 12-m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+, and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm, and 108,000 of these fish were Age 1+ (Table 1-1).

The 1987-88 Hudson River striped bass hatchery evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per ten minute tow for both the 9-m trawl and 12-m trawl with a cod end similar to the 9-m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one-half the catch. The 9-m trawl was more efficient than the 12-m trawl with a 9-m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6% The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm, and 181,000 of these fish were estimated to be Age 1+ (Table 1-1).

The Hudson River striped bass program from 1988-89 to the present has become primarily a Hudson River striped bass stock assessment program. The program has emphasized consistency of sampling gear and procedures and the refinement of laboratory techniques for scale examination to accurately determine age (e.g., Humphreys et al. 1989). Mark-recapture estimates are calculated for the total population and for the Age 1+ and Age 2+ subpopulations of striped bass found in the combined Battery and upper New York Harbor regions during the winter. Program consistency is documented through the use of standard operating procedures (SOPs) and a quality assurance/control assurance (QA/QC) system that has helped improve data quality (Geoghegan et al. 1989).

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990). The minimum size of striped bass that were tagged was lowered from 200 to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm, and an estimated 794,000 of the fish ≥200 mm were from the strong 1987 Age 1+ cohort (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort of Age 1+ fish (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm, and an estimated 397,000 of the fish ≥200 mm were from the strong 1988 Age 1+ cohort (Table 1-1).

The striped bass population overwintering in the Battery and Upper Harbor during 1990-91 was estimated as 858,000 fish ≥150 mm or 786,000 fish ≥200 mm (Table 1-1). About 352,000 striped bass ≥200 mm were Age 1+ (NAI 1992). The 1989 cohort of Age 1+ hatchery fish was 0.2% of the Age 1+ catch.

The 1990 cohort of Age 1 + striped bass and the 1991 cohort of Age 0+ fish dominated the population statistics for fish caught in the Battery and Upper Harbor during the winter of 1991-92 (NAI 1994). The estimated size of the midwinter striped bass population was 1,163,000 fish ≥150 mm or 967,000 fish ≥200 mm (Table 1-1). Age 1+ striped bass represented 791,000 fish among the population ≥150 mm and 709,000 fish ≥200 mm. Age 2+ and Age 3+ hatchery striped bass were each about 0.3% of the respective cohort's catch. Age 0+ and Age 1+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The estimated size of the midwinter striped bass population ≥150 mm in upper New York Harbor and the Battery region during 1992-93 was 920,000 fish with lower and upper 95% confidence limits of 677,000 and 1,435,000 (NAI 1995a). The 1991 cohort of Age 1+ striped bass and the 1992 cohort of Age 0+ fish dominated the catch, representing 58% and 22% of the total number of striped bass collected, respectively. Age 1+ and Age 2+ striped bass dominated the midwinter population estimate. Age 1+ striped bass accounted for 671,000 fish, while Age 2+ contributed 180,000. The estimated hatchery proportion of striped bass was 3.0% for Age 0+ and 0.02% for Age 3+ fish. Age 1+ and Age 2+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The 1993-94 program experienced the 20th coldest winter on record for New York City and the coldest in the history of the striped bass program (NAI 1995b). Bank-to-bank ice floes limited access to the Battery and Upper Harbor regions from 17 January through 21 February 1994, and influenced within and among-program comparisons. The estimated size of the midwinter striped bass population ≥150 mm in upper New York Harbor and the Battery region during 1992-93 was 443,000 fish with lower and upper 95% confidence limits of 339,000 and 641,000 (NAI 1995a). The 1992 cohort of Age 1+ striped bass and the 1991 cohort of Age 2+ fish dominated both the catch and midwinter population estimate, comprising 57% (253,000) and 29% (129,000) of the population ≥150 mm, respectively. The estimated hatchery proportion of striped bass was 0.2% for Age 0+, 1.05% for Age 1+ and 0.05% for Age 4+ fish among the same age cohorts.

Objectives of the 1994-95 Hudson River striped bass stock assessment program were to:

- Tag all wild striped bass greater than or equal to 150 mm, that are in good condition, with internal anchor tags.
- Determine the catch rate and handling mortality of striped bass.
- Estimate the abundance of striped bass overwintering in the lower Hudson River.
- Describe the age composition of the overwintering population of striped bass.
- Determine if marked hatchery striped bass, stocked during any year since 1983, can be caught in the Hudson River population.

- Estimate the proportion of hatchery fish among the Age 0+ through Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

CHAPTER 2

METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1994-95 Hudson River Striped Bass and Atlantic Tomcod Programs Standard Operating Procedures (LMS 1994). These procedures have remained essentially unchanged since the start of the 1988-89 program. The 1994-95 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1, NAI 1995b) with a 9-m trawl (Appendix Table A-1). Sampling locations were selected to maximize the CPUE of striped bass in the lower Hudson River, based on the results of the 1985-86 through 1993-94 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b). A 9-m trawl was used in the 1994-95 program to catch striped bass because the results of the 1987-88 program showed that the 9-m trawl was more efficient than other gear in catching striped bass of the target ages of Age 1+ and Age 2+ (NAI 1988). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2, NAI 1995b) and released.

For 23 weeks, from the week of 7 November 1994 through the week of 10 April 1995, the 9-m trawl was deployed in the Upper Harbor or Battery regions. The 9-m trawl was fished in each of the 23 weeks in the Battery region and on selected days during eight weeks in the Upper Harbor region (Appendix Table C-1). Tow duration was 10 min, unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawl were handled in a manner that minimized stress before tagging. The cod end of the net was transferred while remaining in the water to the holding facility alongside the boat. Fish were then released from the cod end into the holding facility. Striped bass were then removed from the holding facility for processing using the following procedures:

1. Fish were removed from the live car using a dip net.
2. All surfaces that came in contact with the live fish were wet.

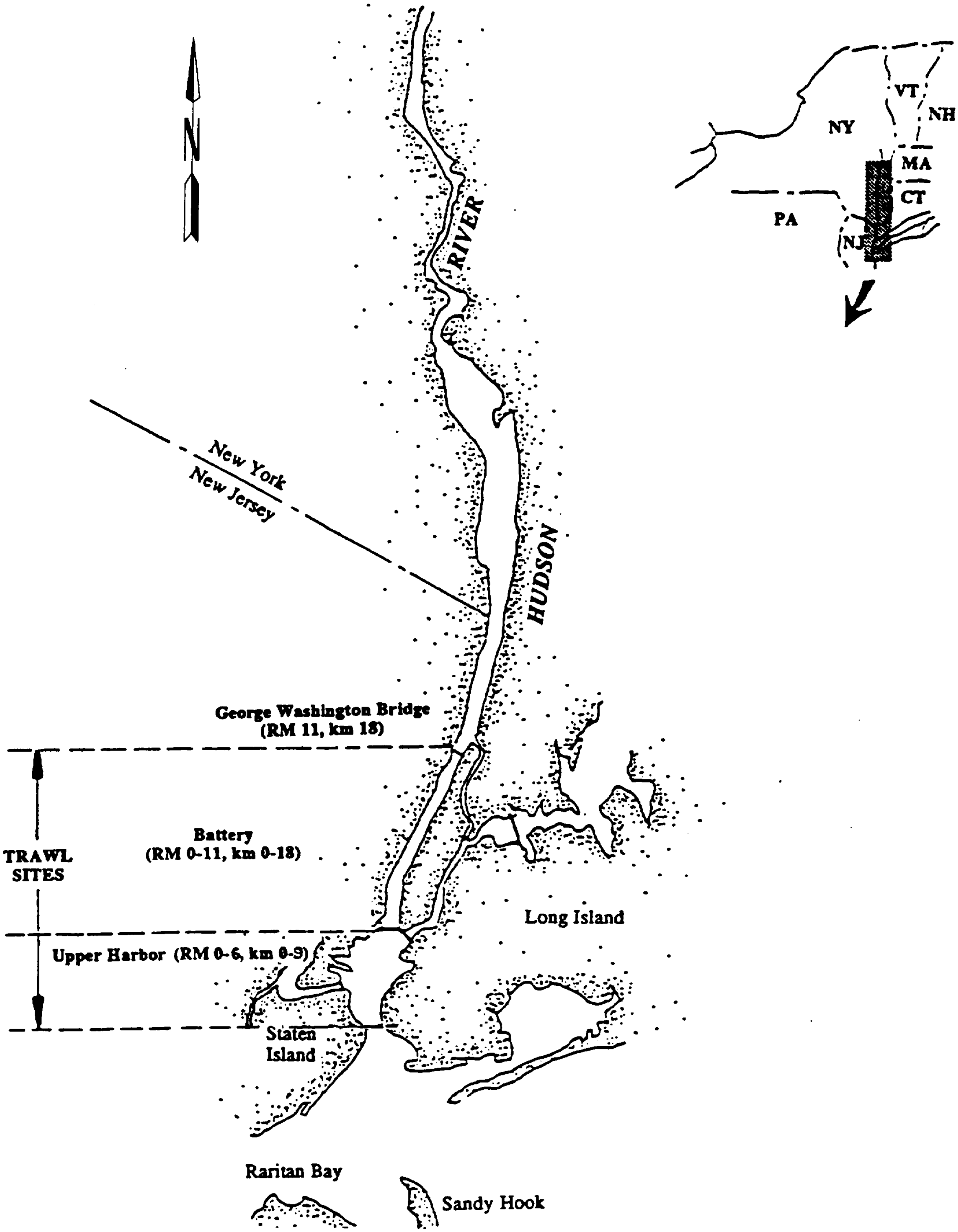
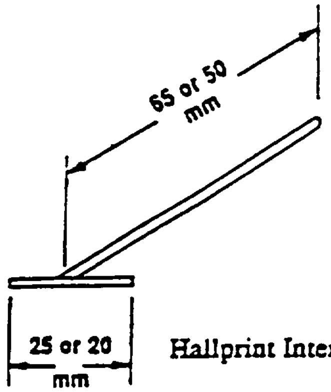
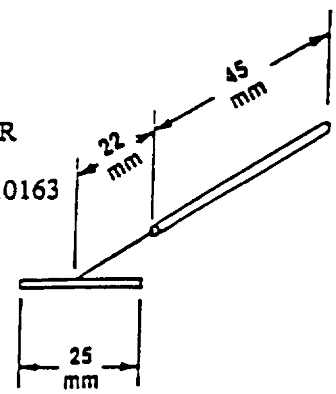


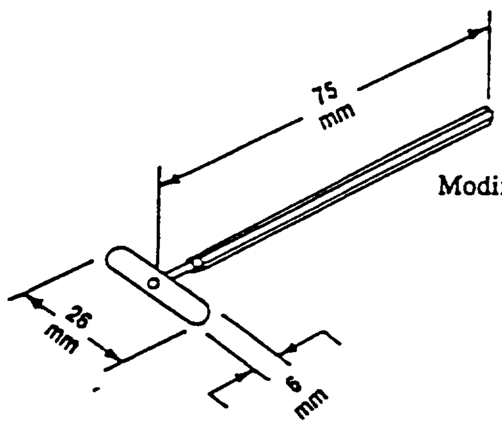
Figure 2-1. Sampling regions in the lower Hudson River and New York Harbor during the winter 1994-95 Hudson River Striped Bass Program.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

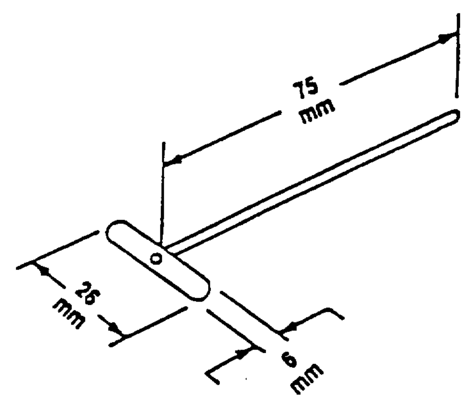
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

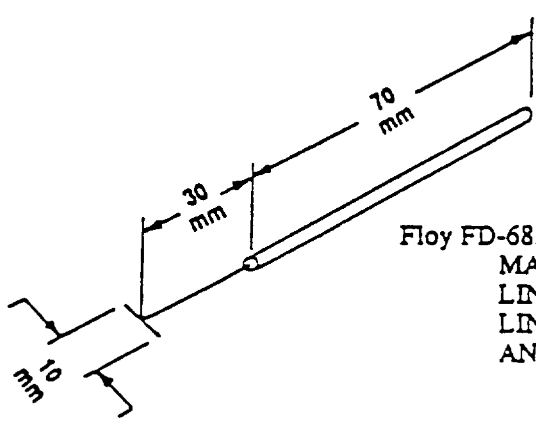




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-present Hudson River Striped Bass Programs.

3. Striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps.

4. Struggling fish were quieted by covering the head and eyes with a wet hand, cloth, or glove.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for CWTs using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition, and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

- No bleeding from gills or body wounds
- No significant loss of scales
- Strong opercular movement
- No obvious external abnormalities such as blindness, fin rot, or skeletal abnormalities

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral midline. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a pointed scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue, and all incisions were treated with a merbromin-based topical antiseptic.

Scale samples were taken from the left side from an area approximately three to four scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Fish less than 100 mm were considered Age 0+. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass were also evaluated.

After processing, striped bass were released into a recovery pen deployed alongside the tagging vessel. The pen was enclosed with netting on four sides, open on the top and bottom, and provided a refuge where striped bass could recover from processing without being preyed on by gulls. Any fish remaining in the recovery pen at the end of sample processing were considered dead. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25°C for presentation in this report. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random sample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10-mm length group. Expected numbers of Age 1+ striped bass in each 10-mm length group were calculated from age at length data obtained during the current and 1993-94 programs (NAI 1995b).

This program was conducted during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1992 and collected anywhere between November 1993 and May 1994 would be designated "Age 1+." This same fish, captured anywhere between November 1994 and May 1995, would be designated "Age 2+."

Striped bass scales were pressed on 0.050-in.-thick, grade GC, acetate sheets with a Carver Press Model-C 12-ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls, and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally, an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment, which would affect computation of CPUE, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-min duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving CPUE. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

2.3.1 **Analysis of Catch Characteristics**

Characteristics of the catch were compared among locations and sampling weeks by analysis of the CPUE, length-frequency, and handling mortality.

2.3.1.1 ***Catch Per Unit of Effort.*** CPUE for the 9-m trawl was defined as catch per 10-min tow (Use Code = l) and was calculated as:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{C_i}{E_i}\cdot 10\right] \qquad \text{Eq. 1}$$

where

$\overline{X}$ = mean trawl catch per 10-min tow
C_i = total number of fish captured in trawl i
E_i = tow duration of trawl i in minutes
n = number of trawls

2.3.1.2 ***Length-Frequency.*** Length-frequency histograms, with the number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9-m trawl (Use Code = 1 tows). Length-frequency distributions for striped bass caught by the 9-m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 ***Handling Mortality.*** Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1 °C temperature interval:

$$Prop\ D_x = D_x / T_x \qquad \text{Eq. 2}$$

where

Prop D_x = proportion of dead striped bass at bottom water temperature x
D_x = the number of dead striped bass at bottom water temperature x
T_x = total number of striped bass captured at bottom water temperature x

Comparisons of handling mortality among the 1985-86 through 1994-95 programs were also made using data subsetted to include the same sampling gear deployed during comparable water temperature ranges within the Battery region in each year. Differences in striped bass handling mortality among programs (1985-86 through 1994-95) were assessed by comparing the percentage of dead fish in the catch in 1 °C bottom water temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 ***Estimated Number of Striped Bass in Each Age Category.*** A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1994-95 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10-mm length increment and the variance of the proportion of Age 1+ fish in each 10-mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish; it is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n\left[\frac{N_h\sqrt{p_h q_h}}{\sum N_h\sqrt{p_h q_h}}\right] \qquad \text{Eq. 3}$$

where

n_h = number of scale samples selected for age determination from length group h
n = number of scale samples to be selected from the total of N fish caught
N_h = total number of fish caught in length group h
p_h = proportion of Age 1+ fish in length group h from the laboratory sample
q_h = 1 - p_h

The stratified sampling plan was designed to select approximately 15% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1993-94 (NAI 1995b) were applied to the first of three lots of 1994-95 length-frequency data to permit scale analysis to proceed during the study. Age and length-frequency data from analysis of the first lot of striped bass scales in 1994-95 were then applied to the remaining two lots of 1994-95 scale samples. In each lot (7 November - 31 December, 1 January - 28 February, and 1 March - 14 April), scale samples from approximately 15% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1994-95 program were estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \sum \left(N_h p_{hi} / N \right) \qquad \text{Eq. 4}$$

where

p_{sti} = stratified mean proportion of Age i fish
p_{hi} = proportion of Age i fish in length group h
N_h and N are as defined in Equation 3

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N\left(p_{sti}\right) \qquad \text{Eq. 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2 p_{sti}$) was calculated by the method of Cochran (1977, Equation 5.53):

$$S^2 p_{sti} = 1/N^2 \left[\Sigma [N_h^2 \left(N_h - n_h\right)\left(N_h - n_h\right)][\left(p_{hi} q_{hi}\right)/\left(n_h - 1\right)] \right] \qquad \text{Eq. 6}$$

where

N, N_h, and p_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977, Equations 5.14 and 5.15):

$$95\%\ CI\ for\ p_{sti} = p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 7}$$

$$95\%\ CI\ for\ A_i = N_{sti} p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 8}$$

where

$s_{p_{sti}} = \sqrt{S^2 p_{sti}}$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16)

p_{sti}, A_i, N_{sti}, $s^2_{p_{sti}}$ are defined in Equations 4-7

2.3.2.2 ***Stratified Mean Length in Each Age Category.*** The mean length of striped bass of a given age that were caught in the 1992-93 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi} \bar{y}_{hi} \right] \Big/ N_i \qquad \text{Eq. 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught
$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample
n_{hi} = number of Age i fish caught in length group h
N_i = number of Age i fish caught in the program
L = number of length groups in which at least two Age i fish were measured; if only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24, with the assumption that N_i is large and substantially larger than n_i; therefore, $N_i^{-1} \approx 0$ and $g'_i \approx 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L}\left[w_{hi}\left(S^2_{hi}/n_i V_{hi}\right)\right] + \left(1/n'_i\right)\sum_{h=1}^{L} w_{hi}\left(\bar{y}_{hi} - \bar{y}_{sti}\right)^2 \qquad \text{Eq. 10}$$

where

$S^2_{\bar{y}_{sti}}$ = two-phase variance of the stratified mean length of striped bass of Age i
w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes theorem presented in Equation 11
S^2_{hi} = variance of the mean length of Age fish in length group of the laboratory sample
n'_i = total number of Age i fish in the laboratory sample
V_{hi} = proportion of Age i fish in length group h
$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P\left(L_h | A_i\right) = \left[P\left(L_h\right)P\left(A | L_h\right)\right]/P\left(A_i\right) \qquad \text{Eq. 11}$$

where

W_{hi} is as defined in Equation 10
A_i = Age i striped bass
$P(L_h)$ = proportion of the total catch of striped bass in length group h
$P(A_i|L_h)$ = proportion of aged fish in length group h that are Age i
$P(A_i)$ = proportion of Age i fish in the total catch

Confidence intervals for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ CI\ for\ \bar{y}_{sti} = \bar{y}_{sti} \pm\ t\ S_{\bar{y}_{sti}} \qquad \text{Eq. 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for a = 0.05 based on n_i'-1 degrees of freedom (not the effective degrees of freedom)

$\bar{y}_{sti}$ = as defined in Equation 9

2.3.3 Estimated Hatchery Proportion

All striped bass caught during the winter 1994-95 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / \left(H_{ai} + W_{ai} \right) \qquad \text{Eq. 13}$$

where

P_{ai} = proportion of Age i hatchery striped bass in the population adjusted for tag loss and nondetection of tags

H_{ai} = number of Age i verified hatchery recaptures caught adjusted for tag loss and nondetection of tags

W_{ai} = number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai})

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and nondetection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[\left(i - TAG_i \right) \left(1 - NDET \right) \right] \quad \text{Eq. 14}$$

where

H_{ai} = adjusted number of Age i hatchery striped bass caught
H_i = number of Age i verified hatchery recaptures caught
TAG_i = weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1)
NDET = decimal percent nondetection rate for magnetic tags during the recapture program
= $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected when both detectors were used

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Chapter 1) was not adjusted for handling mortality (Dunning et al. 1989) because handling mortality was minimal (<1%) and could not be associated with each lot of tagged fish stocked into the Hudson River (EA 1994).

2.3.4 **Recaptured Striped Bass**

Three groups of recaptured, internal anchor-tagged striped bass were considered: (1) fish recaptured from previous programs (cross-year recaptures); (2) fish caught, tagged, released, and recaptured within the current (1994-95) program (within-year recaptures); and (3) fish recaptured with external streamer tags from other programs (other recaptures). All cross-year recaptures were examined to determine the condition of the tag legend and insertion site, recapture rate, mean length, and days at large. We also determined the age and growth for cross-year recaptures by examining the scale samples taken at the time of release and time of recapture. Within-year recaptures consisted of two groups of striped bass: fish that were tagged and released (REL_REC

TABLE 2-1

FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOG LOSS (TAG_i) AND NONDETECTION OF TAGS (NDET) DURING 1994-95

COHORT	AGE	TAG_i	NDET
1994	0+	0.032[a]	0.00000[b]
1993	1+	0.071	0.00000
1992	2+	0.029	0.00000
1991	3+	[c]	[c]
1990	4+	[c]	[c]
1989	5+	0.057	0.00000
1988	6+	0.017	0.00000
1987	7+	0.0147	0.00000
1986	8+	0.075	0.00000
1985	9+	0.065	0.00000
1984	10+	0.276	0.00000

[a]Weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (EA 1995).

[b]Weighted nondetection rate based on a nondetection rate of 0.00000 for hatchery recaptures checked with two detectors.

[c]Hatchery fish were not tagged prior to release in 1990 or 1991.

= 1), and fish that were tagged and released but exhibited one or more gross anatomical abnormalities (REL_REC= 6). Both groups of within-year recaptures were examined to determine the tag condition, recapture rate, mean length, and days at large. Within-year recaptures that were in good condition at the time of release were also used for a mark-capture estimate of population size (Section 2.3.6). LMS obtained release and recapture information and observed the condition of the tag streamer and insertion site for other agency recaptures.

2.3.5 **Population Movement**

The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$Recapture\ rate = R_{ij} / M_{ij} \qquad \text{Eq. 15}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
M_{ij} = number of tagged striped bass released during time period (week) i in region j

$$Recapture\ proportion = R_{ij} / C_{ij} \qquad \text{Eq. 16}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j

2.3.6 **Population Size**

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator, which permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i), with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$, where ß is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals ($R_i/C_i - ßM_i$) are weighted by the catch (C_i), then N^{-1} equals the slope, ß.

The Schumacher-Eschmeyer estimator (Ricker 1975) is:

$$N = \sum\left(C_i M_i^2\right) \Big/ \sum\left(R_i M_i\right) \quad \text{Eq. 17}$$

where

N = estimated population size
C_i = total catch during time interval i
M_i = total number of marked fish tagged and released in good condition and available for recapture at the midpoint of time interval i
R_i = number of recaptured fish in C_i

The variance of the reciprocal of the population size (l/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\sum\left(R_i^2/C_i\right) - \left(\sum R_i M_i\right)^2 \Big/ \sum\left(C_i M_i\right)}{m-1} \quad \text{Eq. 18}$$

where

S^2 = mean of squared deviations from the regression model described above
m = number of data points in the regression, and C_i, M_i, and R_i are as defined above in Equation 17

The 95% CI for the reciprocal of the population size (1/N) is computed as

$$CI = S^2 \Big/ \sum C_i M_i^2 \cdot t_{m-1} \quad \text{Eq. 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and $\alpha = 0.05$

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.7 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish recaptured after being at large one or two years was compared within cohort to growth from scale samples taken from untagged fish caught at the time the tagged fish were recaptured in the 1988-89 through 1994-95 programs. We measured growth as the distance from the focus to each annulus along a radial line originating at the focus and running perpendicular to the anterior edge of the scale (radius measurement).

CHAPTER 3

RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9-M TRAWL

3.1.1 Catch Per Unit of Effort

A total of 541 10-min tows (Use Code = 1) were taken with the 9-m trawl in the Battery region, and 278 tows were taken in the Upper Harbor region of the lower Hudson River between 7 November 1994 and 14 April 1995. The mean CPUE for striped bass in the Upper Harbor region was less than the CPUE in the Battery region over all sampling weeks combined (Table 3-1). Prior to 5 December 1994, the mean CPUE was consistently higher in the Upper Harbor region compared to the Battery region. After 5 December, mean CPUE was higher in the Battery region in all but one sampling week (23 January 1995). Most of the sampling effort was concentrated in the Battery region following the week of 30 January 1995 (Appendix Table C-1). Mean CPUE exceeded 30 striped bass per 10-min tow during the week of 28 November 1994 in the Upper Harbor region during the weeks of 12 December, 19 December 1994, and 13 March 1995 in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 37 striped bass per 10-min tow during the week of 12 December 1994 in the Battery region (based on nine tows). The next highest weekly mean CPUE occurred during the week of 13 March in the Battery region, when an average of 33.1 striped bass were collected in 32 tows. The highest CPUE was at river mile 8 of the Battery region (Appendix Table C-2). However, the CPUE was based on only two tows at this location. Consistently high catches (> 15 mean CPUE) occurred at river mile 9 of the Battery region, and harbor mile 2 of the Upper Harbor region, where 31% of the sampling took place.

Mean CPUE for the 9-m trawl in the Battery region increased in each program from 8.1 in 1985-86 to a peak of 45.3 striped bass per 10-min tow in 1989-90 (Table 3-2). After the peak CPUE in the 1989-90 program, CPUE decreased to the present level of 21.9 striped bass per 10-min tow for the 1994-95 program. The increased CPUE observed during the 1988-89 and 1989-90 programs may be due to the complete recruitment of the numerically dominant 1987 and 1988 year classes to the 9-m trawl (CES 1989). The decrease in CPUE observed after the 1989-90 program

TABLE 3-1

MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9-m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1994-95.

REGION	NUMBER OF TOWS	NUMBER OF FISH COLLECTED	MEAN CPUE	S.E.
Battery	541	8,796	16.26	0.80
Upper Harbor	278	3,839	13.81	1.15

NOTE: Includes only valid (use code = 1) samples.

CPUE = Catch per unit effort (catch per ten minute tow)
S.E. = Standard error

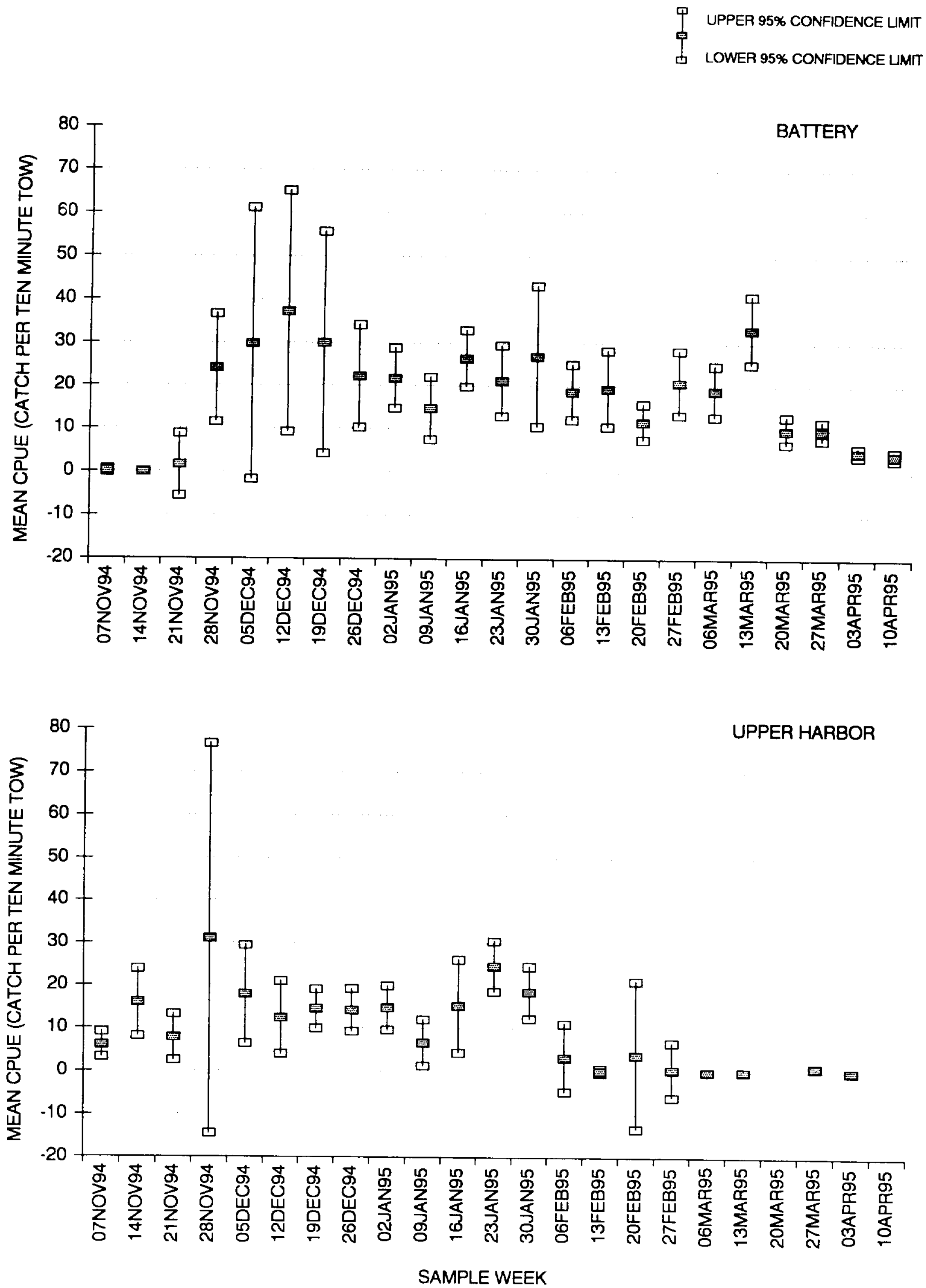


Figure 3-1. Weekly mean catch per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1994-95.

TABLE 3-2

MEAN CATCH PER UNIT (CPUE) OF STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1994-95

YEAR	PERIOD	NUMBER OF TOWS	MEAN CPUE	95% CI
1985-86	23 Dec 85 - 21 Mar 86	638	8.1	±1.0
1986-87	21 Dec 86 - 21 Mar 87	385	12.2	±1.2
1987-88	20 Dec 87 - 19 Mar 88	437	28.5	±2.5
1988-89	19 Dec 88 - 18 Mar 89	527	38.9	±3.3
1989-90	18 Dec 89 - 16 Mar 90	458	45.3	±4.3
1990-91	17 Dec 90 - 15 Mar 91	477	40.7	±3.5
1991-92	23 Dec 91 - 21 Mar 92	578	35.5	±2.2
1992-93	21 Dec 92 - 20 Mar 93	397	32.7	±2.9
1993-94	20 Dec 93 - 20 Mar 94	341	33.7	±5.2
1994-95	19 Dec 94 - 19 Mar 95	291	21.9	±2.2

NOTE: CPUE = Catch per unit effort (catch per ten minute tow).
Includes only valid (use code = 1) samples.

may be due increased gear avoidance, migration, or mortality of the 1987 and 1988 year classes and lower abundance of the 1989 through 1993 year classes.

3.1.2 Length-Frequency Distribution

The overall mean length of striped bass caught by the 9-m trawl in the Battery region was 196 mm during the 1994-95 program (Table 3-3). The length-frequency distribution for the 9-m trawl was (1) skewed right, i.e., more fish were smaller than the mean length than would be expected if the distribution was bell-shaped; (2) platykurtotic, i.e., more fish were found between the mean and the tails (minimum and maximum) than would be expected if the distribution was normal; and (3) the length-frequency was bimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 101 to 150-mm and 251 to 300-mm length groups.

Weekly mean length of striped bass caught by the 9-m trawl was low for the first three weeks of the program and then increased to above 225 mm in the Upper Harbor region for the next 11 weeks. Weekly mean length in the Battery region remained around 200 mm and below during most of the sampling program until the last three weeks, when mean length increased to 261, 280 and 274 respectively (Appendix Table C-5). Mean length was highest (342 mm) in the Upper Harbor region during the week of 27 March 1995 and lowest (89 mm) during the week of 27 February 1995. However, mean length for those weeks was based on only one fish. Weekly mean length for both the Upper Harbor and Battery regions generally increased from the early weeks of the program. This pattern differs from that observed in previous years (1991-92, 1992-93, and 1993-94) where mean length was greatest during the early weeks of the program and then steadily declined.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50-mm length classes, indicated that fish in the 51 to 150-mm length classes predominated prior to 28 November 1994 (Figure 3-3). Beginning during the week of 28 November 1994 catches of larger length classes (201 to 350-mm) increased and remained steady until the week of 6 February 1995 when catches diminshed. Weekly mean CPUE in the 101 to 150-mm length class remained steady during much of the program, increasing to a high of 8.2 fish per tow during the week of 13 March 1995 (Appendix Table C-6). CPUE also increased in the 51 to 100-mm length class during the weeks of 16 January 1995 through 13 March 1995. Larger length classes (201 to 350-mm) dominated in the remaining three weeks of the sampling program. The highest mean

TABLE 3-3

DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED BY A 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER WINTER 1994-95

N	MEAN (mm)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
12,645	196	94.6	0.50 ± 0.03	-0.06 ± 0.06	53	910	Right skewness platykurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I.= 95% confidence interval

Right skewness = Positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.

Platykurtosis = Negative kurtosis indicating more striped bass were between the mean and the tails (minimum and maximum) than would be expected from a normal distribution.

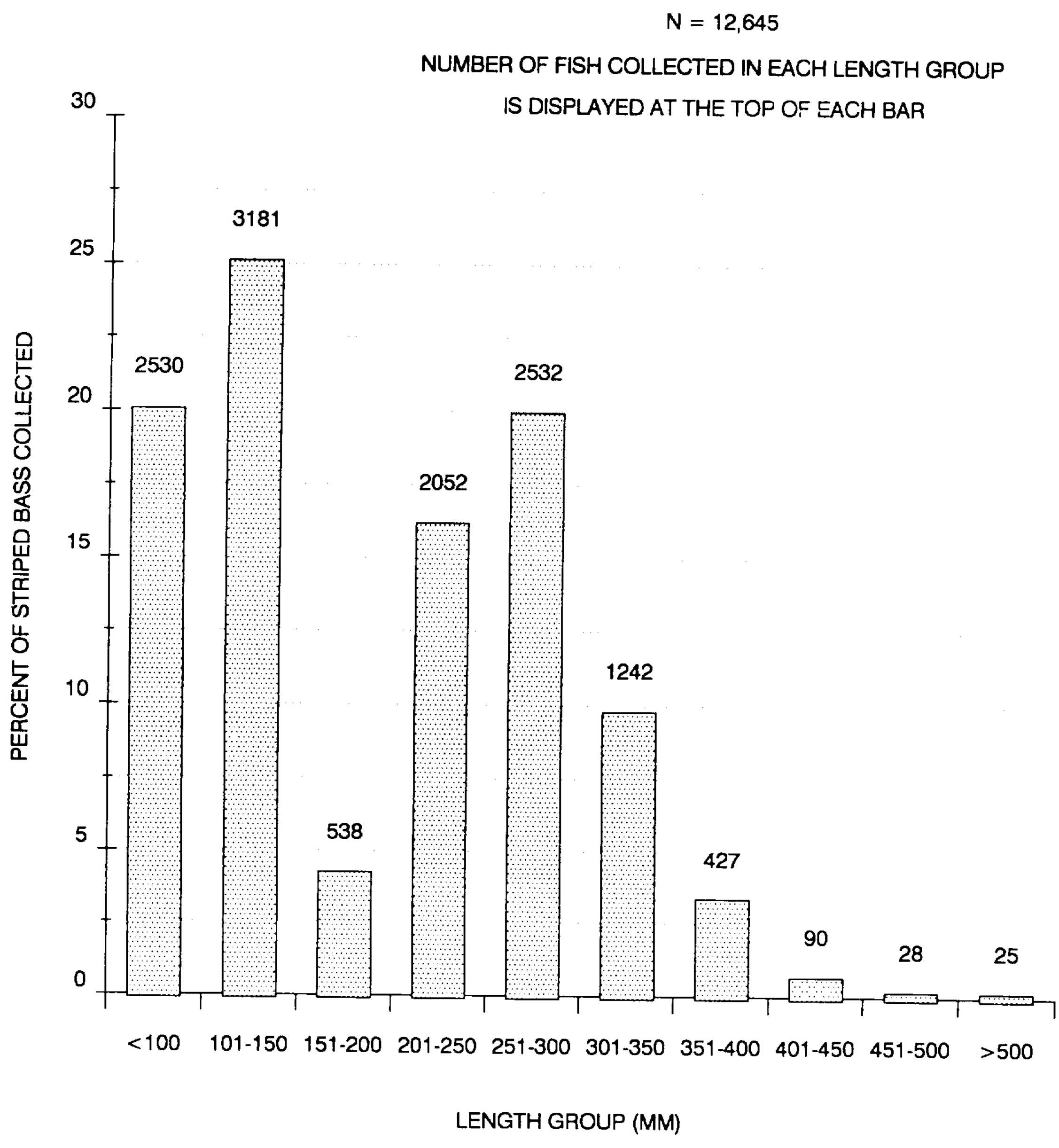


Figure 3-2. Length-frequency distribution for striped bass collected by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1994-95.

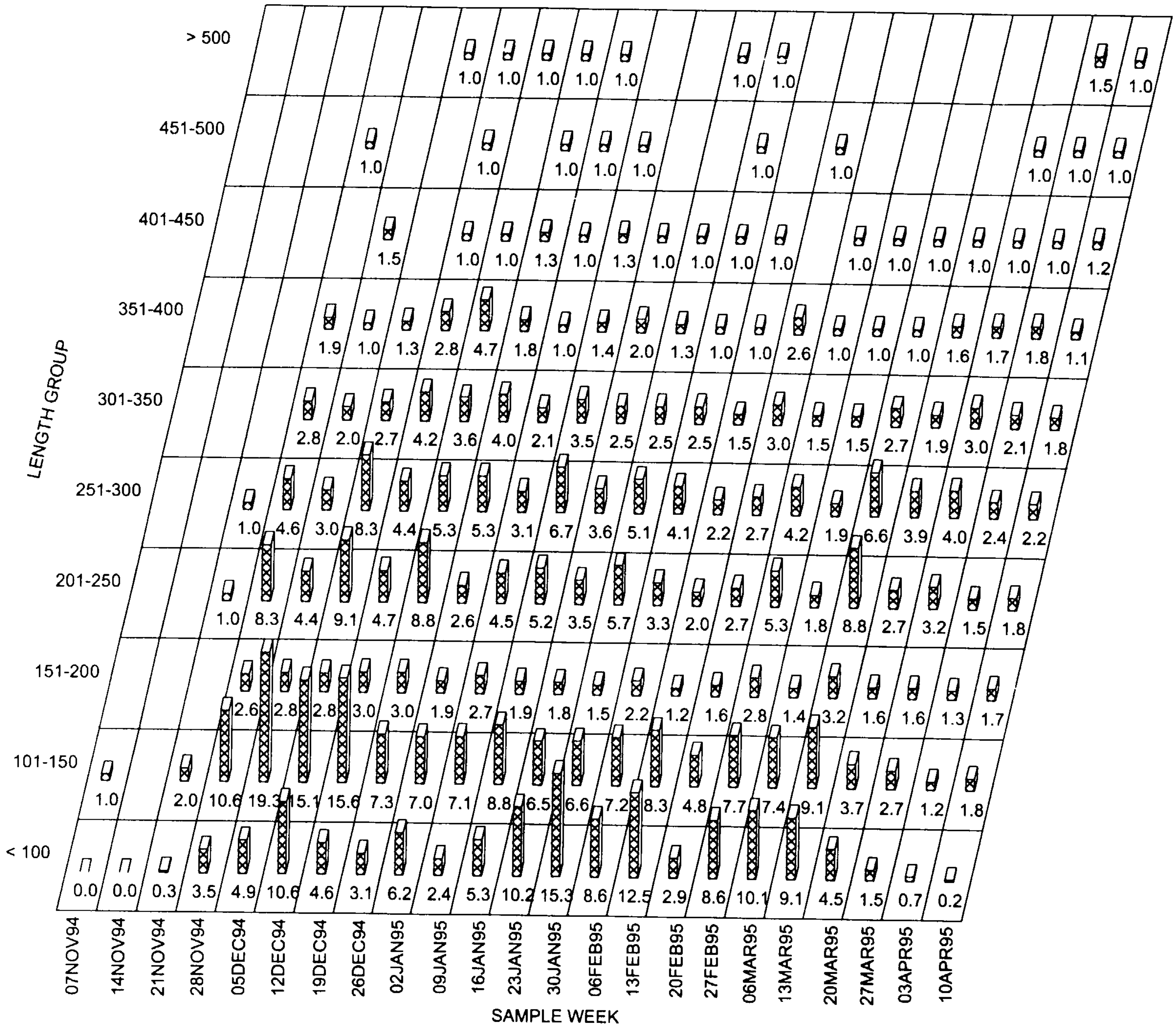


Figure 3-3. Weekly length-frequency distributions for striped bass collected per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1994-95.

catch per tow over all weeks was 8.3 striped bass in the 51 to 100-mm length class during the week of 13 March 1995.

The standardized length-frequency of striped bass captured during the winter of 1994-95 was bimodal with peaks in the 101-150 mm and 251-300 mm length groups (Figure 3-4). Bimodal length-frequencies previously occurred during the winters of 1986-87, 1987-88, 1990-91, 1991-92, and 1993-94. The peak between 251 and 300 mm probably represents the 1993 year class at age 1+, while the peak between 101 and 150 mm represents the 1994 cohort of age 0+ striped bass.

3.1.3 **Handling Mortality**

Striped bass handling mortality in the 9-m trawl was less than 0.5% during 1994-95 at bottom water temperatures from 0 to 17°C (Table 3-4). A total of 58 striped bass died out of 12,596 fish caught in Use Code = 1 tows that had river bottom water temperature data associated with each tow. The highest handling mortality of 1.3% (17/1310) occurred at a bottom water temperature of 3°C. An interaction between water temperature, fish length and immediate handling mortality was not significant in previous programs (Dunning et al. 1989). However, recent programs, 1992-93 through 1994-95, have displayed a pattern of higher handling mortality at lower bottom water temperatures ($\leq$ 8°C). Recent program data has not been examined for an interaction between water temperature, fish length and immediate handling mortality. Immediate handling mortality should not affect mark-recapture estimates because field crews remove fish which are dead or considered to be in poor condition after tagging prior to their release.

Striped bass handling mortality in the 1994-95 program was higher than the pooled mortality for the 1985-86 through 1990-91 programs (Table 3-5) but lower than the average mortality observed in recent programs (1991-92 through 1993-94). The apparent increase in handling mortality observed in recent programs was probably due to an underestimate of handling mortality during the 1985-86 through 1990-91 programs. During the 1985-86 through 1990-91 programs, bird predation was not factored into the program handling mortality. All striped bass that were not immediately identified as dead upon release were assumed to have survived. However, at the end of the 1990-91 program bird predation on released striped bass was quantified. Approximately 2.4% of the 2969 tagged striped bass released between 12 March and 12 April 1991 were removed from the water by gulls (NAI 1992). Therefore, handling mortality in the 1985-86 through 1990-91 programs may have been underestimated.

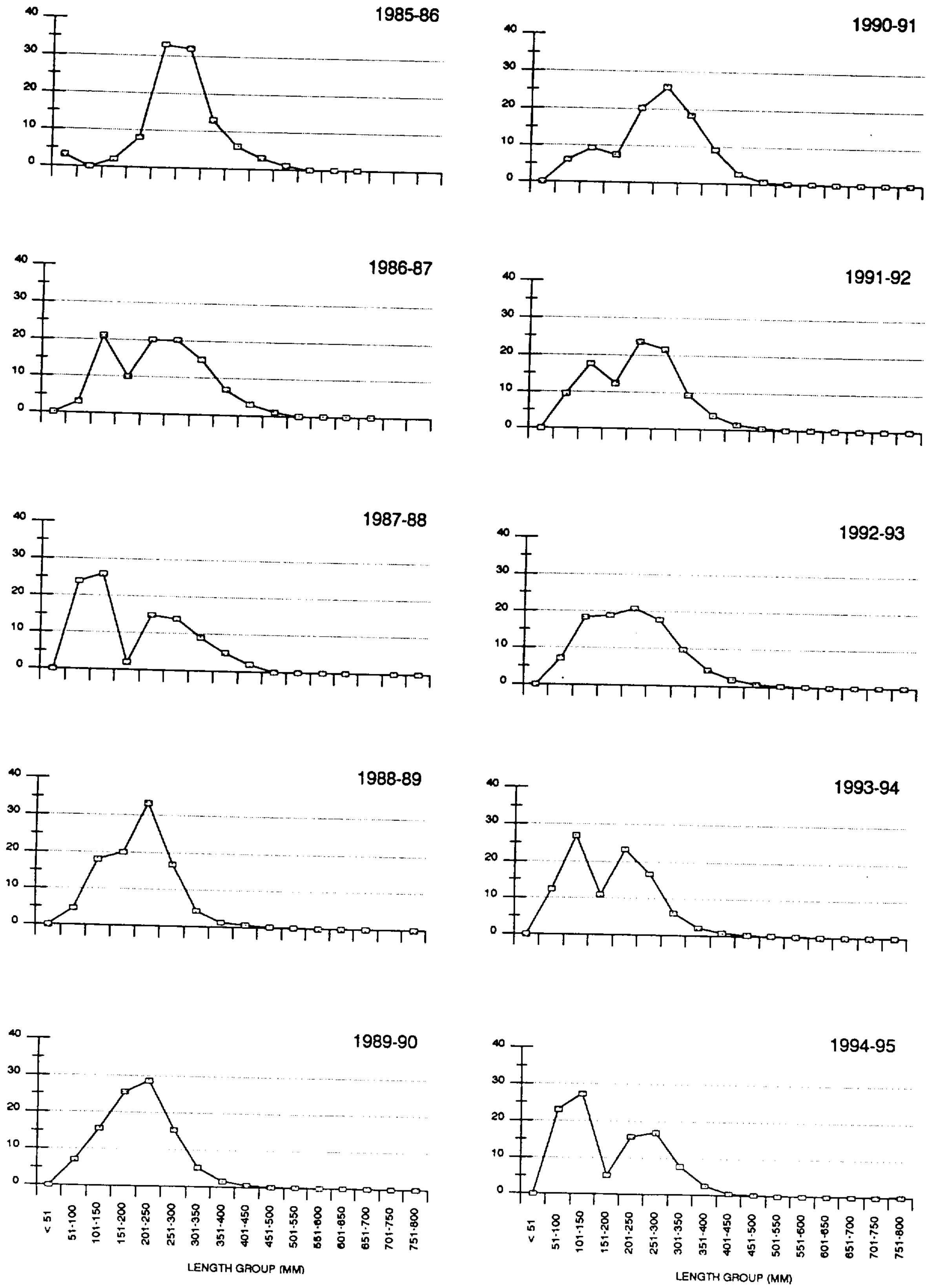


Figure 3-4. Standardized (50mm interval) length-frequency of striped bass collected in the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1994-95.

TABLE 3-4

HANDLING MORTALITY FOR STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER IN RELATION TO BOTTOM WATER TEMPERATURE, WINTER 1994-95

BOTTOM WATER TEMPERATURE (°C)	PERCENT OF CATCH DEAD (%)	NUMBER DEAD	TOTAL CATCH
0.0	0.0	0	19
2.0	0.8	2	246
3.0	1.3	17	1310
4.0	0.3	6	1756
5.0	0.6	15	2692
6.0	0.4	8	1987
7.0	0.3	4	1585
8.0	0.6	2	326
9.0	0.2	1	640
10.0	0.4	3	836
11.0	0.0	0	295
12.0	0.0	0	69
13.0	0.0	0	688
14.0	0.0	0	145
15.0	-	0	0
16.0	0.0	0	2
17.0	-	0	0
0.0-17.0	0.5	58	12596

NOTE: Mortality expressed as the percentage of dead Striped bass collected in a temperature increment. Mortality calculated from catch data for valid (use code = 1) tows for which bottom water temperature was available.

TABLE 3-5 (Page 1 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1994-95 HUDSON RIVER STRIPED BASS PROGRAMS

BOTTOM WATER TEMPERATURE (°C)	1985-86 THROUGH 1990-91		1991-92		1992-93	
	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	0.3	58/16,781	1.3	20/1,557	1.4	80/5,940
4	0.3	51/16,155	0.5	45/9,685	3.5	107/3,090
5	0.3	58/21,071	0.2	13/5,419	2.2	86/3,585
6	0.2	43/18,783	1.5	98/6,438	1.8	44/2,380
7	0.4	43/11,785	1.0	26/2,728	1.2	16/1,347
8	0.2	20/8,731	1.4	29/2,135	2.2	17/756
9	0.5	29/5,709	0.9	10/1,133	0.2	3/1,361
10	0.2	8/4,843	1.1	21/1,897	0.7	6/806
11	0.3	11/3,185	0.6	5/879	0.5	17/3,406
12	0.3	6/1,995	0.5	1/187	0.2	1/434
3-12°C	0.3	327/109,038	0.8	268/32,058	1.6	377/24,307

Dx = Number of dead Striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of Striped bass collected at a temperature (Use Code = 1 samples only).

TABLE 3-5 (Page 2 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1994-95 HUDSON RIVER STRIPED BASS PROGRAMS

BOTTOM WATER TEMPERATURE (°C)	1993-94		1994-95	
	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	3.0	69/2,260	1.3	17/1,310
4	3.3	156/4,713	0.3	6/1,759
5	1.2	53/4,438	0.6	15/2,692
6	2.0	65/3,206	0.4	8/1,987
7	1.4	36/2,564	0.3	4/1,585
8	2.1	29/1,354	0.6	2/326
9	0.5	1/196	0.2	1/640
10	0.0	0/91	0.4	3/836
11	0.3	4/1,424	0.0	0/295
12	0.5	2/243	0.0	0/69
3-12°	2.0	415/20,669	0.5	56/11,496

Dx = Number of dead Striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of Striped bass collected at a temperature (Use Code = 1 samples only).

Field procedures were modified during the 1991-92 and 1992-93 programs to both quantify and minimize gull predation. After tagging, fish were released into a recovery pen that was deployed in the water alongside the boat. The pen was a 1-m x 2-m x 1-m deep enclosure with 0.9-cm mesh netting on four sides, open on the top and bottom, with the top of the frame suspended at the water surface. Striped bass released into the pen were provided a refuge alongside the boat where they could recover from handling stress without drifting away from the boat during recovery and possibly being preyed upon by gulls. Fish in good condition typically escaped from the pen through the bottom. Stunned fish typically remained at the surface for several minutes until they recovered and escaped through the bottom of the pen. Any fish remaining in the recovery pen at the end of sample processing were considered dead and were removed and taken to the lab. A field technician also observed fish as they escaped from the recovery pen and recorded instances of gull predation. These procedures both minimized gull predation and accurately recorded handling mortality.

Quantitative comparison of the difference in handling mortality between the 1985-86 through 1990-91 programs and the 1991-92 through 1994-95 programs are probably not meaningful due to the changes in field procedures. Striped bass handling mortality statistics from the 1991-92 through 1994-95 programs are probably more accurate than previous programs because bird predation was quantified. Handling mortality during the 1991-92 through 1994-95 programs was probably lower than the actual handling mortality for previous programs because the recovery pen provided a refuge against gull predation.

The calculated handling mortality in all programs conducted after the 1985-86 program was approximately 10 times less than that observed in the 1984 program (NAI 1992). The primary reason for the decrease in handling mortality observed after 1984 was the use of a submerged holding facility and the increased tagging efficiency of field crews (Dunning et al. 1989).

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

Age-length frequency histograms, presented by 10-mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5) demonstrate little overlap in size of Age 0+ and Age 1+ striped bass

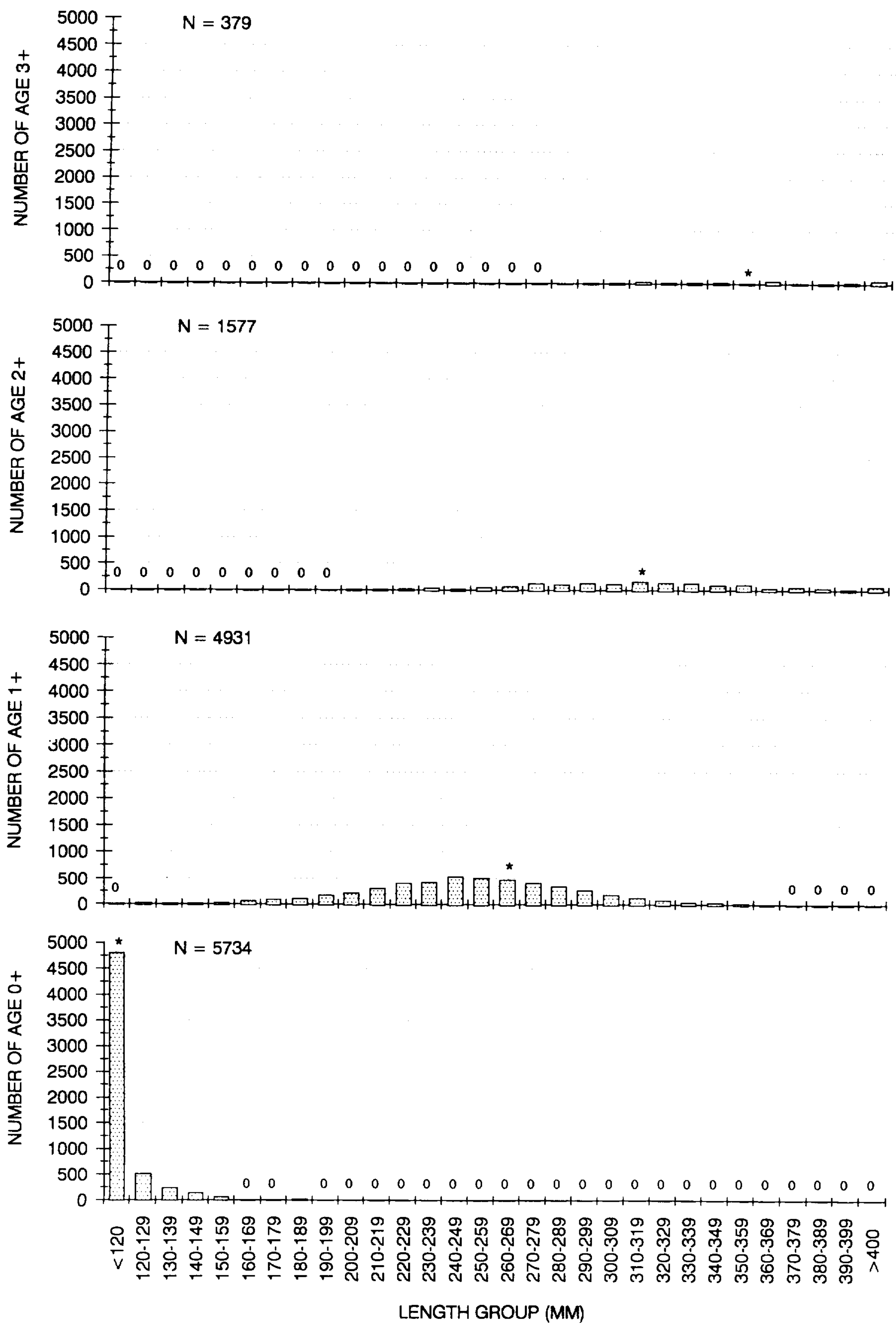


Figure 3-5. Length-frequency distributions for Age 0+, 1+, 2+ and 3+ striped bass collected by the 9m trawl in the lower regions of the Hudson River, winter 1994-95.

Note: * = length group containing the stratified mean length at age.

caught during the 1994-95 program. Most of the fish in each length group <160 mm were Age 0+, while most of the fish in length groups between 160 and 299 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size, primarily between 260 and 329 mm. Age 3+ striped bass overlapped with Age 2+ fish, primarily between 330 and 499 mm.

The 9-m trawl with 7.6-cm (stretch) mesh in the body and 3.8-cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1994-95 programs. Therefore, the striped bass catch by this 9-m trawl was used for comparisons of mean length at age among programs. Overlap of the 95% confidence intervals about the estimated mean length of each age cohort was used for the comparison of mean length at age.

The 1994 wild cohort of Hudson River striped bass at Age 0+ was the smallest in mean length among all recent Age 0+ cohorts (Figure 3-6; Appendix Table C-7). The 1987 Age 0+ cohort was the only cohort similar in mean length.

At Age 1+ the 1993 cohort was the largest Age 1+ cohort, with a mean length of 260 ±2 mm. The 95% confidence intervals did not overlap with any other cohort. Previous Age 1+ cohorts range from mean lengths of 214 mm to 253 mm. The 1992, 1991, 1990, 1989, 1987, and 1985 cohorts at Age 1+ were similar in mean length while the 1988 cohort was the smallest.

The 1992 cohort at Age 2+ was similar in length to the 1991 and 1985 cohorts. The 1990 cohort remained the largest at Age 2+, with a mean length of 329 ±4 mm. The 95% confidence intervals for the 1991, 1990, 1989, and 1986 cohorts overlapped indicating similarity among the estimated mean lengths. Estimated mean lengths of the 1984 and 1987 cohorts were the smallest of the Age 2+ cohorts examined.

Confidence intervals about the estimated mean length at Age 3+ for the 1991 cohort overlapped among the 1990, 1987, 1986, 1984 and 1983 cohorts. However, the estimated mean length at Age 3+ of the 1991 cohort ranked smallest, while the 1990 cohort ranked largest.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling of about 15% of the scale samples resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-6). For the

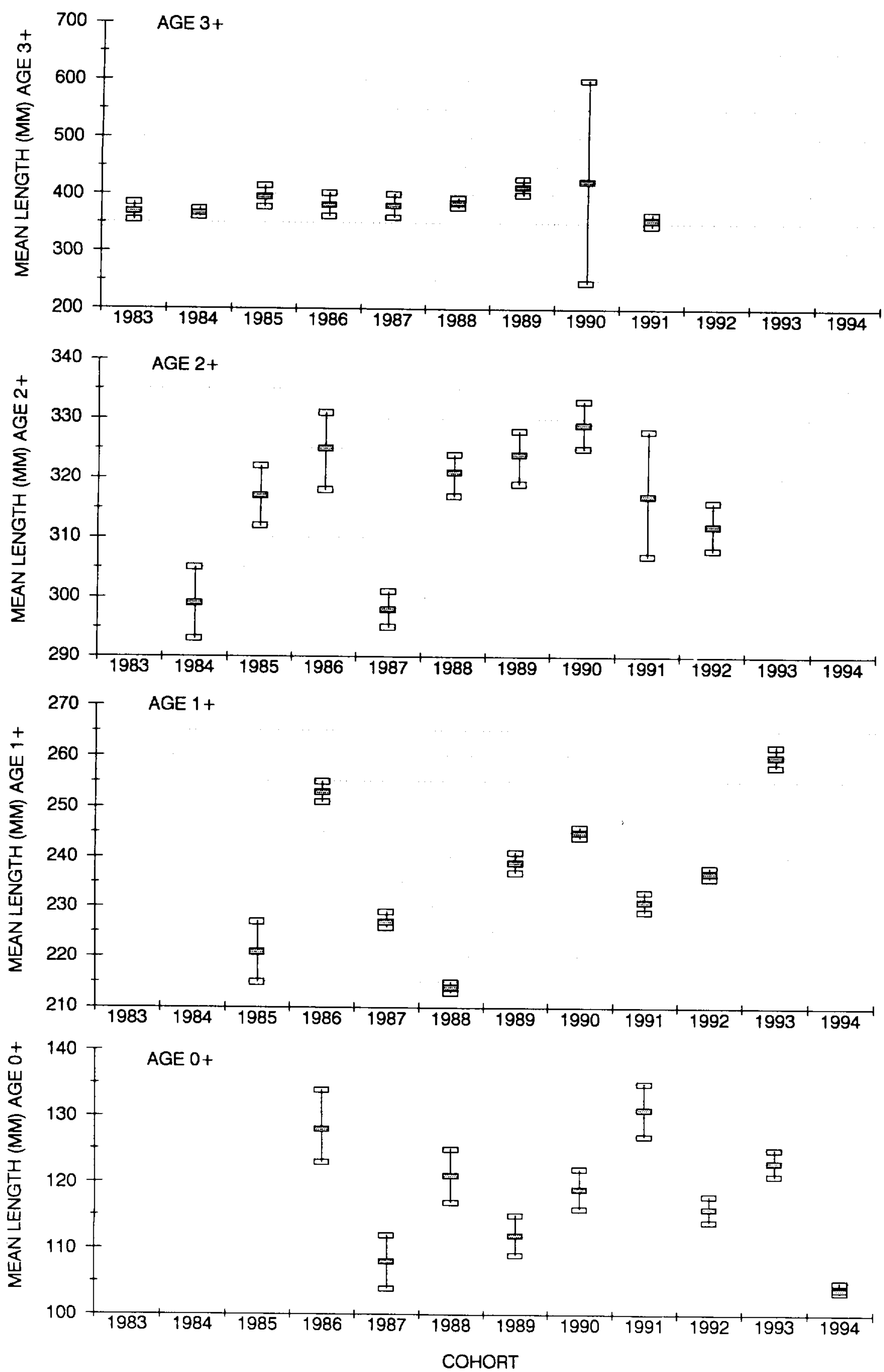


Figure 3-6. Mean length at age and 95% confidence interval for Age 0+ through Age 3+ wild striped bass of the 1983 through 1994 cohorts collected in the Hudson River.

TABLE 3-6

RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER
WINTER 1994-95

		ESTIMATED NUMBER OF AGE 1+ STRIPED BASS COLLECTED			
SAMPLE SIZE	PROPORTION AGE 1+	STRATIFIED TOTAL[b]	LOWER 95% C.I.	UPPER 95% C.I.	PRECISION (%)[a]
500	0.390	4,931	4,832	5,030	2.0
1,000	0.390	4,931	4,836	5,026	1.9
1,994[c]	0.390	4,931	4,836	5,026	1.9
2,000	0.390	4,931	4,838	5,025	1.9
3,000	0.390	4,931	4,837	5,025	1.9
4,000	0.390	4,931	4,837	5,025	1.9
5,000	0.390	4,931	4,837	5,025	1.9
6,000	0.390	4,931	4,838	5,024	1.8
7,000	0.390	4,931	4,838	5,024	1.8

[a]Precision = 95% confidence interval (C.I.) half width/stratified total x 100.

[b]Based on 12,635 striped bass caught in Use Code = 1 sample.

[c]Results for sample size = 1,994 are based on actual allocation from Use Code = 1 sample, which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

allocation of 1994 scale samples actually selected, the precision based on 95% confidence limits was 1.9%, corresponding to an error term of ±95 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than about 10% of the total sample (12,635 fish in 1994-95). For example, doubling the number of striped bass scale samples examined for age determination from 3000 to 6000 would result in an improvement in the precision from 1.9 to 1.8% (Table 3-6). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (4931) out of the 12,635 fish caught in Use Code = 1 samples during 1994-95 could be estimated with 95% confidence limits of ±99 fish (precision = 2.0%, Table 3-6).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10-mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design was also precise for estimating the proportion and number of Age 0+ through Age 2+ striped bass (Table 3-7), which collectively constituted 99.9% of the fish caught in this program. Only 379 of the 12,635 striped bass caught in Use Code = 1 samples were estimated to be Age 3+, and 24 of the fish caught were older than Age 3+ in the 1994-95 program.

The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1993 cohort of Age 1+ striped bass was approximately 39% of the total catch during 1994-95. The number of Age 2+ striped bass (1992 cohort) was estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ was wider, and the sample size was smaller for these fish.

3.3 STRIPED BASS HATCHERY PROPORTION

No Age 1+ striped bass stocked in the Hudson River from the Verplank hatchery in 1993 were collected during the 1994-95 program. Hatchery fish were not tagged in 1990 or 1991 and could not be detected among the Age 3+ or Age 4+ fish. Age 0+ hatchery fish represented 1% of the catch during 1994-95 (Table 3-8), but the reliability of this proportion is unknown because fish

TABLE 3-7

ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1994-95

			ESTIMATED NUMBER OF STRIPED BASS COLLECTED			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% C.I.	UPPER 95% C.I.	PRECISION (%)
0+	1994	0.454	5,734	5,699	5,770	0.6
1+	1993	0.390	4,930	4,836	5,026	1.9
2+	1992	0.125	1,577	1,480	1,675	6.2
3+	1981	0.030	379	322	435	14.8

[a]Based on a laboratory sample of scales from 1,994 striped bass selected by stratified random sampling from 12,635 fish collected (Use Code = 1 samples only).

TABLE 3-8

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER WINTER 1994-95

STATISTIC	COHORT 1994
Age	0+
Total hatchery stocking (N_i)	306,529
Hatchery recaptures (H_i)	54
Adjusted hatchery recaptures (H_{ai})	56[a]
Wild fish examined (W_{ai})	5,678
Estimated hatchery proportion ($H_{ai}/(H_{ai}+W_{ai})$)	0.0098
Lower 95% C.I.	0.0074
Upper 95% C.I.	0.0127

[a]Based on a nondetection rate of 0.00000 for age 0+ hatchery recaptures and a weighted decimal percent 24-hour magnetic tag loss of 0.032 (EA 1995).

of the size range observed for the Age 0+ cohort are probably not fully recruited to the 9-m trawl (Wells et al. 1991).

Comparison of the estimated hatchery proportions for the 1985 and 1986 hatchery cohorts caught in 1986-87 through 1988-89 suggested that the hatchery proportion for each cohort doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; Table 3-9 in this report). However, this trend did not continue for the more recent hatchery cohorts. Estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 1+ 1988 cohort to 0.2% for Age 3+ fish from the 1987 cohort (Table 3-10).

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

During the 1994-95 program, recaptures were made of 54 hatchery striped bass tagged with a CWT and 75 wild striped bass individually tagged with our internal anchor-external streamer tag (internal anchor tag) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York, to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1994-95 winter sampling program, 54 Age 0+ (1994 cohort) hatchery striped bass were caught. The 1990 and 1991 cohorts of hatchery striped bass were not tagged.

3.4.1.1 ***Length.*** A total of 306,529 hatchery striped bass were tagged with magnetic tags and stocked to the Hudson River between 3 and 28 October 1994. The mean length of the 1994 cohort of wild fish was significantly smaller than the hatchery cohort at Age 0+, based on non-overlapping 95% confidence intervals. It was not possible to compare mean length at age between the hatchery and wild 1990 and 1991 cohorts because these cohorts were not tagged prior to release from the hatchery. Therefore, the stratified mean lengths presented for the 1991 cohort of wild fish in Table 3-11 represent hatchery and wild fish combined.

TABLE 3-9 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1994-95

STOCK ASSESSMENT PROGRAM YEAR	COHORT (NUMBER STOCKED)								
	1994 (306,529)	**1993** (568,746)	**1992** (210,746)	**1989** (202,068)	**1988** (48,611)	**1987** (324,579)	**1986** (529,563)	**1985** (284,578)	**1984** (147,153)
1986-87									
N							38	51	5
Lower 95% C.I.							0.0110	0.0126	0.0005
Proportion							0.0152	0.0170	0.0014
Upper 95% C.I.							0.0204	0.0225	0.0029
1987-88									
N						25	127	82	4
Lower 95% C.I.						0.0015	0.0137	0.0240	0.0011
Proportion						0.0023	0.0165	0.0311	0.0034
Upper 95% C.I.						0.0033	0.0196	0.0399	0.0081
1988-89									
N					120	39	49	6	0
Lower 95% C.I.					0.0127	0.0014	0.0245	0.0075	0.0000
Proportion					0.0155	0.0020	0.0353	0.0236	0.0056
Upper 95% C.I.					0.0187	0.0027	0.0500	0.0645	0.0514
1989-90									
N				46	92	3			
Lower 95% C.I.				0.0049	0.0034	0.0002			
Proportion				0.0068	0.0043	0.0010			
Upper 95% C.I.				0.0091	0.0054	0.0027			
1990-91									
N				27	24	1			
Lower 95% C.I.				0.0015	0.0012	0.0000			
Proportion				0.0024	0.0020	0.0013			
Upper 95% C.I.				0.0035	0.0031	0.0098			

TABLE 3-9 (Page 2 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1994-95

STOCK ASSESSMENT PROGRAM YEAR	COHORT (NUMBER STOCKED)								
	1994 (306,529)	1993 (568,746)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1991-92									
N				13	4				
Lower 95% C.I.				0.0015	0.0012				
Proportion				0.0032	0.0035				
Upper 95% C.I.				0.0045	0.0048				
1992-93									
N			197	2					
Lower 95% C.I.			0.0020	0.0015					
Proportion			0.0030	0.0020					
Upper 95% C.I.			0.0441	0.0045					
1993-94									
N		23	121	1					
Lower 95% C.I.		0.0014	0.0991	0.0025					
Proportion		0.0020	0.0105	0.0046					
Upper 95% C.I.		0.0036	0.0121	0.0070					
1994-95									
N	54								
Lower 95% C.I.	0.0097								
Proportion	0.0098								
Upper 95% C.I.	0.0099								

TABLE 3-10 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1994-95, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH

	COHORT (NUMBER STOCKED)								
STOCK ASSEMENT PROGRAM YEAR	1994 (306,529)	1993 (568,410)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1986-87									
N							38	51	5
Lower 95% C.I.							0.0126	0.0286	0.0038
Estimate							0.0171	0.0353	0.0058
Upper 95% C.I.							0.0226	0.0432	0.0084
1987-88									
N						25	127	82	4
Lower 95% C.I.						0.0031	0.0158	0.0526	0.0080
Estimate						0.0042	0.0187	0.0634	0.0135
Upper 95% C.I.						0.0055	0.0220	0.0076	0.0218
1988-89									
N					120	39	49	4	0
Lower 95% C.I.					0.1541	0.0030	0.0282	0.0221	0.0043
Estimate					0.1630	0.0038	0.0398	0.0493	0.0222
Upper 95% C.I.					0.1723	0.0048	0.0554	0.1062	0.0913
1989-90									
N				46	92	3			
Lower 95% C.I.				0.0165	0.0477	0.0006			
Estimate				0.0198	0.0509	0.0017			
Upper 95% C.I.				0.1723	0.0543	0.0037			
1990-91									
N				27	24	1			
Lower 95% C.I.				0.0055	0.0211	0.0002			
Estimate				0.0070	0.0243	0.0026			
Upper 95% C.I.				0.0088	0.0279	0.0127			
1991-92									
N				13	4				
Lower 95% C.I.				0.0091	0.0397				
Estimate				0.0095	0.0411				
Upper 95% C.I.				0.0099	0.0430				

TABLE 3-10 (Page 2 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1994-95, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH

	COHORT (NUMBER STOCKED)								
STOCK ASSEMENT PROGRAM YEAR	1994 (306,529)	1993 (568,410)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1992-93									
N			197	2					
Lower 95% C.I.			0.0710	0.0041					
Estimate			0.0808	0.0059					
Upper 95% C.I.			0.0919	0.0072					
1993-94			121	1					
N		23	0.0309	0.0088					
Lower 95% C.I.		0.0009	0.0294	0.0136					
Estimate		0.0021	0.0289	0.0165					
Upper 95% C.I.		0.0037							
1994-95									
N	56								
Lower 95% C.I.	0.0188								
Estimate	0.0189								
Upper 95% C.I.	0.0191								

[a]Estimated hatchery proporation scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula: $[H_{ai} \times 600{,}000/N_i] / [(H_{ai} \times 600{,}000/N_i) + W_i]$.

TABLE 3-11

COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+ WILD AND HATCHERY STRIPED BASS COLLECTED 9-m TRAWL IN THE HUDSON RIVER WINTER 1994-95

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.	N	MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.
0+	1994	219	104	104	105	54	127	117	123
1+	1993	1,216	260	258	262	–	–	–	–
2+	1992	455	312	308	316	–	–	–	–
3+	1991[a]	99	356	346	366	–	–	–	–

[a]The stratified mean lengths for the 1991 wild cohort of striped bass represent hatchery and wild fish combined because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

The 1989 hatchery cohort was tagged prior to stocking. Two separate groups of fish were stocked in 1989: 179,219 fish were stocked in August 1989 (summer-stocked); and 21,196 were stocked in October (fall-stocked). The fall-stocked fish were significantly larger than the summer stocked fish at the time of stocking. When recaptured at Ages 0+ and 1+, the 1989 hatchery cohort (summer and fall-stocked fish combined) was significantly larger than wild fish, fall-stocked fish were significantly larger than summer-stocked fish, and fall-stocked fish were preferentially recaptured compared to summer-stocked fish (NAI 1992). The larger size and preferential recapture of fall-stocked hatchery fish at Age 0+ and 1+ were attributed to either differential survival or differential behavior of the stocking groups. The 1989 hatchery cohort at Age 2+ was significantly smaller than the wild cohort (Table 3-12). However, similar to Ages 0+ and 1+, fall-stocked fish were preferentially recaptured as they comprised 79% (11/14) of the hatchery recaptures of these cohorts but only 11% of the fish stocked. Too few members of the 1989 hatchery cohort (two) were recaptured at Age 3+ to make significant comparisons with the 1989 wild cohort. However, both of the 1989 hatchery fish were from the fall-stocked group, and no members of the more numerous summer-stocked group were recaptured in 1992-92 through 1994-95 (Table 3-12).

No members of the 1988 or earlier hatchery cohorts were recaptured. Comparisons between estimated mean lengths between the hatchery and wild cohorts for the 1988 and previous year classes are found in NAI (1992) and Table 3-13.

3.4.1.2 ***Magnetic Tag Detection Efficiency.*** During the 1994-95 program, 12,657 striped bass were examined using the field magnetic tag detectors. Of these fish, 56 were classified as suspected Hudson River hatchery striped bass and 54 were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Two fish suspected of having CWTs from the Verplanck hatchery did not have CWTs. Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990); however, none of the fish without tags in this program had fish hooks present.

Striped bass caught during the 1994-95 program were double-checked for CWTs with two "V-shaped" detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Two magnetic tag detectors were used on all sampling days. No fish escaped detection with the first or second magnetic tag detector out of 54 verified

TABLE 3-12

MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM WINTERS OF 1988-89 THROUGH 1994-95

		RECAPTURE FOR HATCHERY STRIPED BASS AT AGE											
		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040	0	-	0.00000
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052	4	380	0.00010
1989	Verplanck Summer[3]	13	124	0.00007	5	215	0.00003	2	330	0.00001	0	-	0.00000
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104	11	300	0.00052	2	423	0.00009

[1]1988 Attleboro fall number stocked (H_2) = 10,057 at 80- to 84-mm model length class.

[2]1988 Verplanck fall number stocked (H_2) = 38,554 at 139-mm mean length.

[3]1989 Verplanck summer number stocked (H_2) = 179,219 at 105-mm mean length.

[4]1989 Verplanck fall number stocked (H_2) = 21,196 at 152-mm mean length.

TABLE 3-13 (Page 1 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1994 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1984	Hatchery							3	275[c]	37.5	2[c]	349	31.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				26	205*	3.8	58	286	41.4	6	364	15.9
	Wild				285	221*	3.0	574	317	2.6	57	396	9.2
1986	Hatchery	22	107*	3.8	96	220*	2.7	48	315	5.2	–		
	Wild	83	128*	2.9	1503	253*	1.2	361	324	3.5	55	382	10.1
1987	Hatchery	20	108	6.2	39	209*	5.2	3	290[c]	16.0	–	350	
	Wild	190	108	2.1	3623	227*	0.8	1216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	1.7	92	219	3.7	24	311	9.9	4[c]	380	18.8
	Wild	1007	121*	2.0	3514	214	0.7	2109	321	1.8	156	386	6.2
1989	Hatchery	46	138*	2.0	27	245	7.8	13	305	12.3	2[c]	423	46.0
	Wild	368	112*	1.6	2174	239	0.9	961	324	2.3	125	414	7.2
1900[d]	Hatchery	–			–			–			–		
	Wild	206	119	1.5	3675	245	0.6	1378	329	1.9	152	424	89.9
1991[d]	Hatchery	–			–			–			–		
	Wild	818	131	1.9	3899	231	0.8	1631	317	5.5	99	356	5.5

TABLE 3-13 (Page 2 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1994 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1992	Hatchery	188	127	0.9	112	220*	2.8	—					
	Wild	473	116	1.0	2695	237*	0.5	455	312	1.9			
1993	Hatchery	21	128	3.6	—								
	Wild	828	123	1.0	1216	260	1.1						
1994	Hatchery	54	127*	1.7									
	Wild	219	104*	0.7									

*Indicates a significant difference in mean length between the hatchery and wild cohorts within an age class. Nonoverlapping confidence intervals of mean lengths of hatchery and wild fish were used to indicate significance.

[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

[b]A t statistic of 2.00 was used to calculate the confidence intervals about the stratified means of wild fish prior to 1994.

[c]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for hatchery striped bass.

[d]The mean length reported for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

hatchery fish found. A nondetection rate 0.0000 was applied to the Age 0+ verified hatchery recaptures.

The weighted hatchery striped bass nondetection rate of 0.0000 for 1994-95 represented the highest magnetic tag detection efficiency (lowest nondetection rate) observed in the program since 1987-88. The 1987-88 program was the only other program to acheive a nondetection rate of 0.0000 (Table 3-14). The nondetection rate for 1993-94 was comparatively high at 0.005, the fourth highest value observed since the program was started. The nondetection rates of 0.0459 for 1991-92 and 0.0237 in 1986-87 were comparable to the 1992-93 rate. Between 1987-88 and 1991-92, the nondetection rate varied between 0.0000 and 0.0005, about two orders of magnitude better in detection efficiency than in 1986-87 or 1991-92. The nondetection statistic does not take into account the large number of fish monitored, and as a ratio, is most sensitive to small numbers of verified hatchery fish examined. Historically, it appeared that when all the fish are checked with two detectors, as in 1989-90 through 1993-94, between one and three fish escape detection by the first detector unless specific operational problems occur as in 1992-93 or 1993-94. In 1994-95, however, no fish were missed by the primary detector (Table 3-14).

3.4.2 **Internal Anchor-Tagged Striped Bass**

During the 1994-95 winter sampling program, 75 striped bass were recaptured out of 6838 fish that were caught, tagged with internal anchor tags, and released in good condition. A total of 30 striped bass with internal anchor tags implanted during previous programs were recaptured during the 1994-95 winter sampling program. One striped bass was recaptured with an illegible tag number (tag portion missing), and three were recaptured with tags from other tagging studies. No striped bass were recaptured with suspected tag wounds. These groups of wild striped bass are described below in separate sections. A complete description of the number of fish caught tagged with different types of internal anchor-external streamer tags since 1984 and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchor tags were used during the 1994-95 program.

3.4.2.1 ***Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1994- 95 Winter Program.*** The majority (4357, or 63%) of the taggable-size (≥150 mm) striped bass (6941) were caught in the Battery region, as were 59, or 79%, of the 75 fish tagged, released, and recaptured during this study (Table 3-15; Appendix Table D-2). This is not surprising as most

TABLE 3-14

MAGNETIC TAG DETECTION EFFICIENCY OBSERVED FOR HUDSON RIVER HATCHERY STRIPED BASS DURING THE 1986-87 THROUGH 1994-95 WINTER PROGRAMS

	DETECTOR TYPE		TOTAL NUMBER OF FISH			HATCHERY-TAGGED FISH DETECTED BY			
PROGRAM	PRIMARY	SECONDARY	MONITORED BY PRIMARY DETECTOR	MONITORED BY BOTH DETECTORS	VERIFIED RECAPTURES	PRIMARY	PRIMARY AND SECONDARY	MISSED BY PRIMARY	NON-DETECTION RATE [a]
1986-87	V-shaped	Tube	13,136	2,138	94	13	15	2	0.0237
1987-88	V-shaped	Tube	28,192	1,611	238	11	11	0	0.0000
1988-89	V-shaped	Tube/V-shaped[b]	32,975	8,164[b]	213	51	52	1	0.0004
1989-90	V-shaped	V-shaped	33,386	33,386	141	138	141	3	0.0005
1990-91	V-shaped	V-shaped	29,346	29,346	52	51	52	1	0.0004
1991-92	V-shaped	V-shaped	35,072	35,072	17	14	17	3	0.0459
1992-93	V-shaped	V-shaped	29,607	28,813	190	139	149	10	0.0138[c]
1993-94	V-shaped	V-shaped	30,093	25,740	134	103	110	7	0.0046
1994-95	V-shaped	V-shaped	12,657	12,657	54	54	54	0	0.0000

[a]Nondetection rate = $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector and H is the total number of verified hatchery fish detected when both detectors were used.

[b]3,368 fish on randomly selected days between 31 October 1988 and 13 March 1989 were first monitored with a V-shaped field detector and then with a tube-shaped detector. The tube-shaped detector became inoperable on 20 March 1989, and 4,796 fish representing the entire catch were monitored with both a primary and secondary V-shaped field detector until the end of field sampling on 15 April 1989.

[c]One tag detector became inoperable during the week of 29 March 1993; 10 hatchery fish were missed by this detector when two detectors were used. An additional 794 fish were checked with only one tag detector and 41 Age 0+ hatchery fish were detected on that week. We applied a nondetector rate of 0.00000 to 82 hatchery recaptures prior to 29 March 1993 and a nondetection rate of 0.03078 for 67 hatchery recaptures on and after 29 March 1993. This value represents the weighted nondetection rate.

TABLE 3-15

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE HUDSON RIVER WINTER 1994-95

			NUMBER OF RECAPTURES FROM RELEASE REGION[a]		
RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	UPPER HARBOR M = 2,553	BATTERY M = 4,284	TOTAL M = 6,837
Upper harbor	2,584	R	15	1	16
		R/M	0.00588	0.00023	0.00234
		R/C	0.00580	0.00039	0.00619
Battery	4,357	R	17	42	59
		R/M	0.00666	0.00980	0.00863
		R/C	0.00390	0.00964	0.01354
Total	6,941	R	32	43	75
		R/M	0.01253	0.01004	0.01097
		R/C	0.00461	0.00620	0.01081

[a]Excluding recapture from previous sampling seasons.

LEGEND:
- R = number of striped bass recaptured.
- M = number of striped bass ≥150 mm marked and released.
- C = number of striped bass ≥150 mm caught and examined for tags.
- R/M = recapture rate.
- R/C = recapture proportion.

(66%) of the trawl sampling effort was allocated to the Battery during 1994-95 based on the high CPUE in this region during the current and previous programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b).

Recapture rates and recapture proportions can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-15 the recapture rate for striped bass tagged, released, and recaptured in the Battery (cell total) was 42/4284 or 0.0098. The recapture rate for striped bass tagged and released in the Battery and recaptured throughout the study area (column total) was 43/4284, or 0.01004.

In contrast, recapture proportions from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-15 the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 42/4357, or 0.000964. It is generally most informative to examine recapture rates from the column totals and recapture proportions from the row totals as these statistics best describe specific movement among regions (or time periods).

Examination of monthly recapture rates and recapture proportions can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (Table 3-16 column totals) were generally stable from November 1994 through February 1995 and decreased in March and April 1993. Monthly recapture proportions (R/C row totals) generally increased from November 1994 through April 1995. This pattern of stable monthly recapture rates and increasing recapture proportions suggests that November 1994 through February 1995 was a period of little movement of the striped bass population in the lower Hudson River.

TABLE 3-16

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1994-95

			NUMBER OF RECAPTURES FROM RELEASE MONTH*						
RECAPTURE MONTH	NUMBER CAUGHT (C)	STATISTIC	NOV M = 255	DEC M = 1,915	JAN M = 1,877	FEB M = 722	MAR M = 1,669	APR M = 429	TOTAL M = 6,837
NOVEMBER	230	R	1						1
		R/M	0.00444						0.00444
		R/C	0.00435						0.00435
DECEMBER	1,925	R	1	9					10
		R/M	0.00444	0.00470					0.00467
		R/C	0.00052	0.00468					0.00519
JANUARY	1,911	R	1	6	12				19
		R/M	0.00444	0.00313	0.00639				0.00473
		R/C	0.00052	0.00314	0.00628				0.00994
FEBRUARY	737	R	0	1	3	3			7
		R/M	0.00000	0.00052	0.00160	0.00416			0.00148
		R/C	0.00000	0.00136	0.00407	0.00407			0.00950
MARCH	1,702	R	1	7	9	5	11		33
		R/M	0.00444	0.00366	0.00479	0.00693	0.00659		0.00515
		R/C	0.00059	0.00411	0.00529	0.00294	0.00646		0.01939
APRIL	436	R	0	2	1	1	1	0	5
		R/M	0.00000	0.00104	0.00053	0.00139	0.00060	0.00000	0.00073
		R/C	0.00000	0.00459	0.00229	0.00229	0.00229	0.00000	0.01147
TOTAL	6,941	R	4	25	25	9	12	0	75
		R/M	0.01778	0.01305	0.01332	0.01247	0.00719	0.00000	0.01097
		R/C	0.00058	0.00360	0.00360	0.00130	0.00173	0.00000	0.01081

*Excluding recapture from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

Striped bass tagged and released in the combined Battery and Upper New York Harbor regions, and subsequently recaptured in those regions were at large an average of 33 days and ranged in size between 153 and 382 mm (Table 3-17). Approximately 13% (10/75) of the striped bass were recaptured on the same day as they were tagged and released, and 57% (43/75) of the fish were recaptured within 30 days of release (Table 3-17), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within two months (60 days), 77% (58/75) of the striped bass were recaptured, and the maximum number of days at large was 121. Days at large and recapture length data for the 1994-95 program were similar to previous years (NAI 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b).

3.4.2.2 ***Striped Bass Internal Anchor-Tagged and Released Prior to and Recaptured During the 1994-95 Winter Program.*** A total of 30 striped bass were recaptured during 1994-95 with internal anchor tags identified from previous programs (Appendix Table D-3). All recaptured striped bass had the external portion of the tag (streamer) present. Among the 30 striped bass with streamers intact, all but one fish had tags with completely legible numbers (Table 3-18).
Tag numbers were defined as completely illegible if one or more of the five-digit tag number could not be read in the field. Tag abrasion, first observed during 1986-87, is time dependent; the tagged fish must be at large for at least six months for abrasion to affect the legibility of the legend on the external streamer (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged to have been at large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990). Changes in tag design since 1986-87 have virtually eliminated tag abrasion.

Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used; abrasion was observed in 28% of the recaptured fish at large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core.

TABLE 3-17

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED, AND RECAPTURED IN THE HUDSON RIVER BY A 9-m TRAWL
WINTER 1994-95

	STATISTIC	NUMBER OF STRIPED BASS
Number tagged (≥150 mm)	M	6,837
Number examined for tags (≥150 mm)	C	6,941
Number recaptures	R	75
Size range of recaptured fish (mm)	Min	153
	Max	382
	Mean	251
	S.D.	44
Days at large	Min	0
	Max	121
	Mean	33
	S.D.	35
Frequency of days at large	0 days	10
	1-5 days	11
	6-10 days	10
	11-20 days	9
	21-30 days	3
	31-40 days	3
	41-50 days	7
	51-60 days	5
	61-70 days	3
	71-80 days	5
	81-90 days	2
	91-100 days	2
	101-110 days	3
	111-120 days	1
	121-130 days	1
	131-140 days	0
	141-150 days	0

TABLE 3-18

INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR HUDSON RIVER STRIPED BASS THAT WERE AT LARGE AT LEAST ONE YEAR PRIOR TO THEIR RECAPTURE DURING THE 1988-89 THROUGH 1994-95 PROGRAMS

		NUMBER OF FISH RECAPTURED DURING PROGRAM[a]						
DESCRIPTION	CONDITION OF TAG INSERTION	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95
Tab number completely legible	Healed	34	63	206	102	130	117	27
	Infected	13	6	22	15	17	12	2
	Total	47	69	228	117	147	129	29
	(Anchor protruding)	(5)	(0)	(6)	(1)		(0)	(0)
Tag number abraded but legible	Healed	3	2	2	0	1	0	0
	Infected	3	1	0	1	0	0	0
	Total	6	3	2	1	1	0	0
	(Anchor protruding)	(1)	(0)	(0)	(0)	(0)	(0)	(0)
Tag number partly or completely missing and not legible	Healed	0	0	1	2	0	0	1
	Infected	0	0	0	0	0	0	0
	Total	0	0	1	2	0	0	1
	(Anchor protruding)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Suspected tag wound, tag and anchor missing	Healed	4	6	69	43	57	28	0
	Infected	0	9	3	4	7	3	0
	Total	4	6	72	47	64	31	0
Suspected tag wound, anchor present	Healed	2	0	9	10	12	18	0
	Infected	0	0	0	0	3	0	0
	Total	2	0	9	10	15	18	0

[a]Striped bass that were tagged and released prior to the program that could by cross-classified by degree of tag number abrasion and condition of the tag insertion site.

The streamer was angled so that its distal end is posterior to the tag site. A similar but short length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990). Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish, forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was shed from the fish.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a long-term shedding rate of 22/94, or 23%, for the original Hallprint tag with an exposed filament. Among the 67 fish with suspected tag wounds (and no anchor found) caught during the 1992-93 program, 45 fish had a longitudinal scar, suggesting they may have shed a tag, and 22 fish had wounds that were judged to be not related to tagging. None of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has virtually eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has reduced tag loss due to shedding.

Among the 30 striped bass recaptured from previous programs during 1994-95 were 25 fish that had been tagged and released during 1993-94, and five fish that had been tagged and released during 1992-93 (Table 3-19; Appendix Table D-3). All recaptured fish from the 1988-89 through 1993-94 programs were caught, tagged, and released from the 9-m trawl, which was the only gear used. Recaptured fish were at large between 229 and 762 days and ranged in length between 242 and 516 mm (Table 3-20). No striped bass were recaptured with both an internal anchor tag and a dart tag during 1994-95, and no striped bass were observed to have shed a dart tag.

TABLE 3-19

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1994-95

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED (R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH (mm)			
					MIN	MAX	MEAN	S.D.
1993-94	9-m trawl	17,500	25	0.00143	242	516	320	60
1991-92	9-m trawl	20,847	5	0.00240	294	377	348	47

TABLE 3-20

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED BY GEAR PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1994-95

	STATISTIC	9-m TRAWL
Total number tagged	M	150,694[a]
Number Age 2+ or older examined for tags	C	1,980
Number recaptured	R	30
Recapture rate	R/M	0.00020
Recapture proportion	R/C	0.01515
Length of recaptured fish (mm)	Min	242
	Max	516
	Mean	326
	S.D.	58
Days at large	Min	229
	Max	762
	Mean	406
	S.D.	154
Frequency of days at large	201-250 days	1
	251-300 days	5
	301-350 days	7
	350-400 days	6
	401-450 days	5
	451-500 days	1
	500-550 days	0
	551-600 days	0
	601-650 days	1
	651-700 days	1
	700-751 days	1
	751-800 days	2

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, 1989-90, 1990-91, 1991-92,1992-93, and 1993-94 programs.

Three striped bass were recaptured in 1994-95 with tags originating from other tagging programs (Table 3-21). Two fish were recaptured with U.S. Fish and Wildlife Service internal anchor tags and one fish was recaptured with a Littoral Society spaghetti tag.

3.4.2.3 ***Effects of the Internal Anchor Tag on Striped Bass Growth.*** During previous programs, growth based on focus, to annulus (radius) measurements for scale samples from tagged striped bass that had been at large one or two years was compared within cohort to growth from a corresponding set of scales taken from untagged fish of the same cohort at the time the tagged fish were recaptured (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. Scale radius measurements were selected rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

Mean radius measurements for each annulus were obtained from the 1985 through 1991 cohorts of striped bass recaptured during the 1988-89 through 1993-94 programs (Table 3-22). No radius measurements were obtanied from striped bass recaptures during the 1994-95 program. A complementary set of scale samples was selected from the time of release for each cohort of fish caught in the samples providing the recaptured fish to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X + 1 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus. Relative growth was calculated as the response variable by taking the difference between annulus measurements for the time of release and recapture and dividing by the annulus measurement for the time of release. This relative growth measurement accounts for variation in the size of scales taken for the release and recapture samples.

Tagged striped bass from the 1985 through 1990 cohorts that were at large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way ANOVA comparisons of mean relative growth (Table 3-22). A significant difference was observed between the mean scale radius for tagged and untagged striped bass of the 1991 cohort. Fish that were tagged and released in 1992-93 at Age 1+ were significantly larger than untagged fish of the same cohort in 1993-94 after being at-large for one year. As both the tagged and

TABLE 3-21

STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHER AGENCY TAGS
WINTER 1994-95

		TAG CONDITION						RECAPTURE		
AGENCY	TAG NUMBER	SITE	TAG NO	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
Littoral Society	35020	1	4	4	4			07 Dec 92	2	283
USF&W	168891	1	4	4	4	2	2	17 Dec 93	4	304
USF&W	169229	1	4	4	4	2	2	03 Jan 93	4	342

TAG VARIABLE	COMMENT DESCRIPTION
Number Address Reward	1 = legend completely missing 2 = abraded and partly missing 3 = abraded but completely legible 4 = completely legible
Number orientation	1 = tag number facing anterior (head) 1 = tag number facing posterior (tail)
Anchor protrusion	1 = yes 2 = no

TAG SITE

1 = tag present, wound healed
2 = tag present, wound poorly healed, evidence of infection or swelling

TABLE 3-22

ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE 1988-89 THROUGH 1993-94 PROGRAMS

RECAPTURE PROGRAM	COHORT	RECAPTURE AGE	YEARS AT LARGE	TAG STATUS	N	SCALE SAMPLE MEASUREMENT: MEAN RADIUS	S.E.	Pr>f[a]
1988-89	1985	3+	1	Tagged	14	151.7	5.5	0.9015
			0	Untagged	48	147.6	3.0	
1988-89	1986	2+	1	Tagged	24	124.2	3.9	0.2580
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	51	101.3	2.5	0.6096
			0	Untagged	1138	101.2	0.5	
1990-91	1987	3+	1	Tagged	21	152.3	5.0	0.1987
			2	Tagged	14	152.9	6.3	0.1023
			0	Untagged	53	143.4	3.2	
1991-92	1988	2+	1	Tagged	161	103.6	1.3	0.1435
			0	Untagged	1844	97.0	0.4	
1991-92	1988	3+	1	Tagged	34	148.3	2.1	0.7432
			2	Tagged	18	144.1	5.4	
			0	Untagged	110	143.6	2.2	
1991-92	1989	2+	1	Tagged	45	114.4	2.7	0.2203
			0	Untagged	829	103.8	0.6	
1992-93	1989	3+	2	Tagged	18	145.7	6.1	0.0986
			1	Tagged	8	165.0	10.6	0.3650
			0	Untagged	90	156.5	2.6	
1992-93	1990	2+	1	Tagged	72	117.5	2.2	0.11817
			0	Untagged	1263	114.5	0.5	
1993-94	1990	3+	2	Tagged	16	160.1	5.2	0.9511
			1	Tagged	20	164.3	6.7	0.5252
			0	Untagged	110	159.6	2.9	
1993-94	1991	2+	1	Tagged	87	118.7	2.3	0.0001
			0	Untagged	1487	103.9	0.5	

[a]Probability of finding that the mean relative growth is different by chance alone, under a least-squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. Therefore, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit differential growth during one or two years at large.

3.4.3 Condition of the Catch

Historically, striped bass caught in the 9-m trawl displayed one or more types of injury or abnormality such as blindness, fin rot, fungal infection, skeletal deformity, or visible wounds. During the 1994-95 program, only fin rot and/or fungus were observed among collected fish (Table 3-23). The incidence of injuries or anomalies among recaptured fish (with tags or suspected tag wounds) was 8.4% (nine of 107). No fish that had not been previously caught (i.e., those without tags or tag wounds) displayed any such conditions (Table 3-23).

The most frequently observed condition was fin rot and fungus, which was noted in 5.6% of recaptured striped bass (Table 3-23). Fin rot only was observed in approximately 1.9% of striped bass recaptured.

Each of the six general categories of poor condition were further classified to the specific area of the fish (Table 3-24). Fin rot most commonly occurred on the caudal fin, and occasionally on more than one fin on the same fish. Fungal infections were observed on both sides of the body 67% of the time.

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1994-95 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator that permits tagging and recapture efforts to occur concurrently. This estimator was used during the 1985-86 through 1993-94 programs to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b).

TABLE 3-23

INCIDENCE OF FISH IN POOR CONDITION AMONG UNMARKED vs RECAPTURED STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER WINTER 1994-95

TYPE(S) OF INJURY OR ABNORMALITY	INCIDENCE AMONG 5,805 UNMARKED FISH (≤ 150mm)		INCIDENCE AMONG 6,947 FISH TAGGED (≥ 150mm)		INCIDENCE AMONG RECAPTURED 107 FISH[b]	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Fin rot only	0	0.00	2	0.03	2	1.87
Fungus only	0	0.00	1	0.01	1	0.93
Fin rot/fungus	0	0.00	7	0.10	6	5.6
Total	0	0.00	10	0.14	9	8.4

[a]Categories are described in more detail in Table 3-24.
[b]Including fish with suspected tag wounds, but excluding fish suspected of being recaptured hatchery releases.

TABLE 3-24

NATURE OF INJURIES AND ABNORMALITIES OBSERVED IN STRIPED BASS COLLECTED BY THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1994-95

GENERAL CATEGORY	SPECIFIC CONDITION	INCIDENCE AMONG 5,805 UNMARKED FISH CAPTURED	INCIDENCE AMONG 6,947 FISH TAGGED	INCIDENCE AMONG 107 RECAPTURED FISH
Fin rot	On caudal fin	0	6	5
	On multiple fins	0	3	3
Fungus	On one side of body	0	3	2
	On both sides of body	0	5	5
Total[a]		0	17	15

[a]Totals exceed those in Table-3-23 because some fish exhibited more than one condition.

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1. Mortality is no different for tagged and untagged striped bass.
2. Tagging does not affect striped bass catchability.
3. Tagged bass do not lose their marks.
4. All tags are recognized and reported.
5. Natural marking does not occur or is recognizable.
6. Immigration, emigration, and recruitment are negligible in the study area, i.e., the population is closed.
7. Tagged striped bass are randomly distributed among untagged fish, or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions.
8. Marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hrs and (2) in holding pools for up to 180 days. However, during the 1990-91 program, predation by birds (gulls) was observed to remove about 2.4% of the tagged fish as they were released from the tagging vessel (NAI 1992). Most of the bird predation was observed to occur as the released fish drifted away from the tagging vessel before sounding. In the 1991-92 program, all striped bass were released into a recovery pen that was suspended in the water alongside the tagging vessel. The pen provided cover until the fish sounded and virtually eliminated bird predation. Therefore, the number of tagged striped bass at large was not adjusted for mortality during the 1994-95 program.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods that rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (LMS 1995), which would provide evidence of tag loss. QA/QC procedures (LMS 1995) and audits provide, documentation that incorrect identification or nonreporting of tags by field crews did not occur. Dunning et al. (1987) found 91.1% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 345 fish out of 20,847 tagged fish, approximately eight fish would be expected to have lost tags in the 1992-93 program. However, the tag loss rate from Dunning et al. (1987) was based on Floy-style tags, which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1994-95 program, 6941 striped bass were examined for tags and tag wounds, and none were observed with tag wounds. Therefore, loss of internal anchor tags for fish tagged and released during 1994-95 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and we adjusted for it, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by NYSDEC (Geoghegan et al. 1990). As this program provided both marking and recapture efforts, nonreporting of tags did not occur. Assumption 5 was satisfied because marking techniques that could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., New York University or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration, Assumption 6, was apparently negligible during most of the study period (November 1994 through April 1995), as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4; NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b). A linear regression of weekly recapture proportions on cumulative number of marked fish (Figure 3-7) was significant and positive for the weeks of 28 November 1994 through the week of 27 March 1995 (Appendix Tables D-6 and D-7). This 18-week period for the population estimator was nearly identical to the recapture period used in 1990-91, 1991-92, and 1992-93 (NAI 1992, 1994, 1995a) and was similar to the period used in 1985-86 through 1988-89 for the population estimator (NAI 1986, 1987, 1988, 1990). During 1989-90, the period used for the striped bass population estimate was 22 January through 9 April 1990, which was one month later than in the other years. During 1993-94 the period used for the Schumacher-Eschmeyer population estimate was truncated (22 November 1994 through 10 January 1995) by severe weather conditions that prevented most

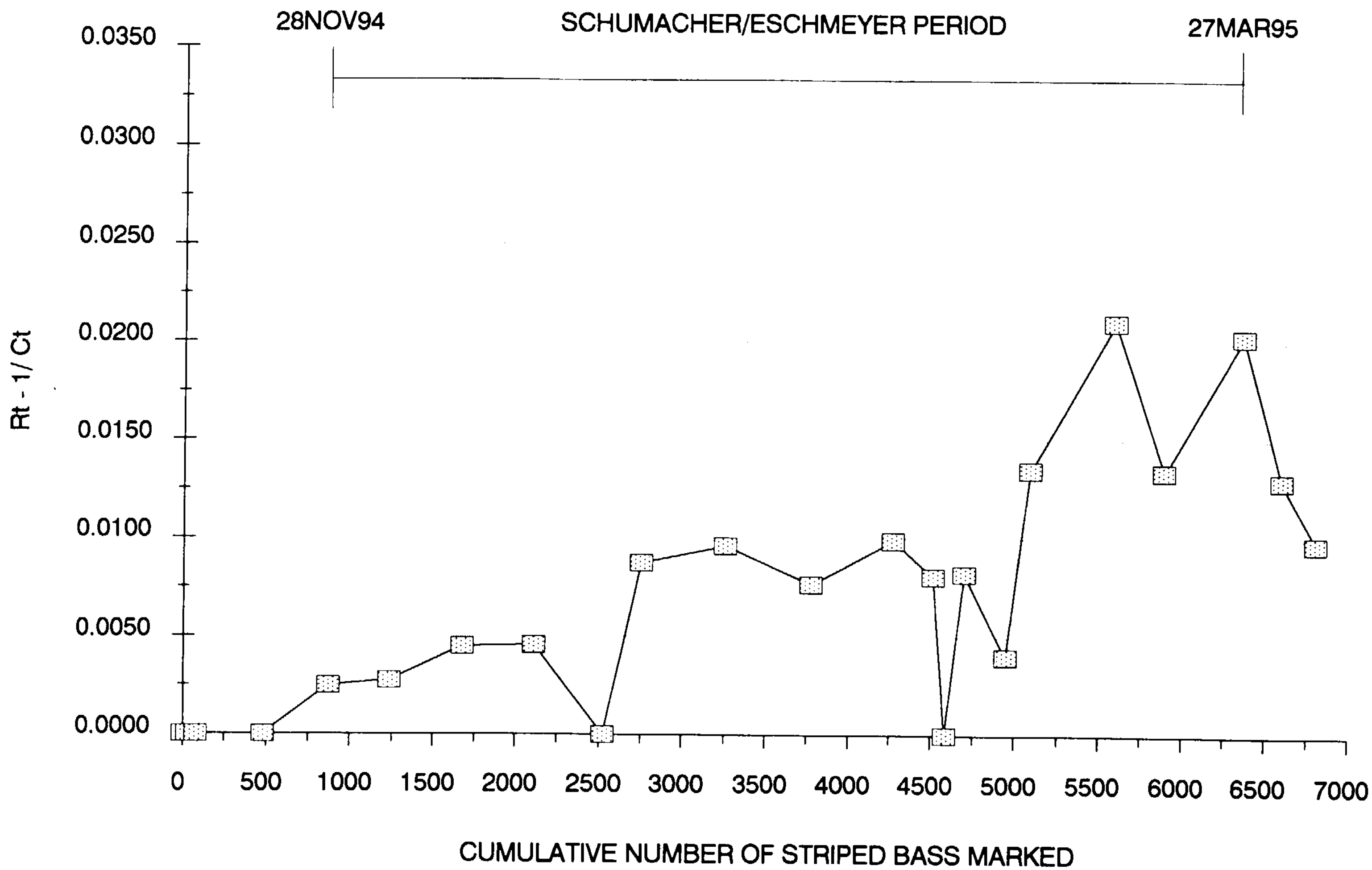


Figure 3-7. Striped bass recapture proportion (R/C) compared to the cumulative number of striped bass tagged in the Battery and Upper Harbor regions of the Hudson River, winter 1994-95.

trawling efforts from the week of 17 January through 21 February 1994 (NAI 1995b). The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass during the 1994-95 program (Assumption 7). Furthermore, stepwise polynomial regressions did not significantly improve goodness of fit, which indicated a linear model was appropriate.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition, which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture, population estimator appeared to be satisfied for the 28 November 1994 through 27 March 1995 period in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated. The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1994-95 was 350,000 fish ≥150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 107,000 to 593,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25).

For comparison with previous programs, the total population of Age 1+ and older striped bass ≥200 mm was estimated as 325,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This estimate was the lowest calculated annually since 1985-86 (Table 3-27). The 1993 cohort of Age 1+ fish was the primary contributor to this estimate of Hudson River striped bass in the mid-winter population during 1994-95.

TABLE 3-25

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1994-95

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥150 mm	PROPORTION ≥150 MM	ESTIMATED POPULATION[a]
1+	4,931	4,888	0.7073	248,000
2+	1,577	1,577	0.2282	80,000
3+	379	379	0.0548	19,000
>3+	24	24	0.0035	1,000
Total	6,911	6,868	0.9938	348,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released, and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 28 November 1994 through the week of 27 March 1995. Age 0+ striped bass were 1.1% (4,000) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 350,000 fish.

TABLE 3-26

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1994-95

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	4,931	4,439	0.6423	225,000
2+	1,577	1,577	0.2282	80,000
3+	379	379	0.0548	19,000
>3+	24	24	0.0035	1,000
Total	6,911	6,419	0.9288	325,000

[a]The total population estimate based on fish ≥150 mm (350,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (6,419/6,911 = 0.9288).

TABLE 3-27

ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86 THROUGH 1994-95

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1994-95	325,000	350,000
1993-94	379,000	443,000
1992-93	717,000	920,000
1991-92	967,000	1,163,000
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged. The population estimate during the 1987-88, 1986-87, and 1985-86 programs was not extrapolated for fish ≥150 mm.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9M TRAWL

GEAR DESCRIPTION (9M TRAWL)	SPECIFICATIONS
HEAD ROPE LENGTH	6.9 M
FOOT ROPE LENGTH (SWEEP)	9.0 M
LEGS (BETWEEN DOORS AND NET)	6.0 M
APPROXIMATE VERTICAL LIFT	3.6 M
DOORS (STEEL V-DOORS)	1.0 M
NET BODY LENGTH	5.2 M
COD END SECTION LENGTH	2.3 M
MESH - BODY	7.6 CM (STRETCH) MESH POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
- COD END	3.8 CM (STRETCH) MESH KNOTLESS POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
ROLLER GEAR	25.4 CM ROLLERS SPACED WITH 5 CM COOKIE DISKS

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AVERAGE WATER TEMPERATURE AND CONDUCTIVITY IN THE UPPER HARBOR HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1994-95.

REGION	SAMPLE WEEK	SURFACE WATER TEMPERATURE (°C)	SURFACE WATER CONDUCTIVITY (μmhos)	BOTTOM WATER TEMPERATURE (°C)	BOTTOM WATER CONDUCTIVITY (μmhos)
UPPER HARBOR	07NOV94	13.7	23541	13.8	27497
	14NOV94	12.7	26129	12.7	27834
	21NOV94	12.1	24500	12.2	27529
	28NOV94	9.3	23600	9.5	25844
	05DEC94	9.7	20848	10.1	25548
	12DEC94	7.6	19667	8.5	25310
	19DEC94	6.6	21030	7.0	26374
	26DEC94	6.5	21879	6.9	25695
	02JAN95	4.7	20313	5.3	24469
	09JAN95	3.7	17786	4.7	23964
	16JAN95	5.5	20000	6.1	25000
	23JAN95	4.5	15474	5.3	21342
	30JAN95	4.5	22238	4.7	25071
	06FEB95	1.2	17333	3.1	23333
	13FEB95	2.2	23500	2.9	27983
	20FEB95	3.6	23167	3.8	24833
	27FEB95	3.1	22000	3.7	25000
	06MAR95	4.3	22000	3.9	25000
	13MAR95	5.1	16000	4.5	25000
	27MAR95	6.1	22000	5.8	25500
	03APR95	6.7	22000	6.2	24500
BATTERY	07NOV94	13.8	19400	14.2	24625
	14NOV94	13.0	23000	13.3	25750
	21NOV94	13.0	22667	13.2	25200
	28NOV94	9.4	21108	9.7	25338
	05DEC94	9.2	13111	9.8	22667
	12DEC94	7.1	11722	9.0	24056
	19DEC94	6.9	19963	7.4	26538
	26DEC94	5.9	16409	6.5	21727
	02JAN95	3.6	13500	4.7	20583
	09JAN95	2.8	11222	4.9	25583
	16JAN95	5.4	15142	5.9	22642
	23JAN95	3.9	7614	5.1	17143
	30JAN95	3.5	13654	4.6	21385
	06FEB95	0.7	8822	3.1	22047
	13FEB95	2.1	17536	2.8	21791
	20FEB95	3.5	17000	4.0	21500
	27FEB95	3.2	17500	3.6	21471
	06MAR95	3.4	8695	3.8	17463
	13MAR95	5.2	11984	4.7	20641
	20MAR95	6.1	9198	6.0	17083
	27MAR95	6.8	16536	6.4	21655
	03APR95	7.2	11716	7.1	21392
	10APR95	7.6	16421	7.3	22830

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1994-95.

REGION	SAMPLE WEEK	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	07NOV94	30	187	6.23	1.43
	14NOV94	38	611	16.08	3.88
	21NOV94	17	136	8.00	2.54
	28NOV94	9	280	31.11	19.77
	05DEC94	23	414	18.00	5.57
	12DEC94	21	264	12.57	4.06
	19DEC94	24	352	14.67	2.20
	26DEC94	21	302	14.38	2.39
	02JAN95	16	238	14.88	2.42
	09JAN95	14	95	6.79	2.51
	16JAN95	5	77	15.40	3.91
	23JAN95	19	468	24.63	2.84
	30JAN95	21	389	18.52	2.91
	06FEB95	3	10	3.33	1.86
	13FEB95	6	2	0.33	0.21
	20FEB95	3	12	4.00	4.00
	27FEB95	2	1	0.50	0.50
	06MAR95	2	0	0.00	0.00
	13MAR95	1	0	0.00	.
	27MAR95	1	1	1.00	.
	03APR95	2	0	0.00	0.00
	TOTAL	278	3839	13.81	1.15
BATTERY	07NOV94	8	2	0.25	0.16
	14NOV94	1	0	0.00	.
	21NOV94	3	5	1.67	1.67
	28NOV94	14	339	24.21	5.82
	05DEC94	9	269	29.89	13.65
	12DEC94	9	336	37.33	12.13
	19DEC94	8	241	30.12	10.87
	26DEC94	11	246	22.36	5.36
	02JAN95	18	395	21.94	3.32
	09JAN95	18	269	14.94	3.43
	16JAN95	26	692	26.62	3.20
	23JAN95	14	300	21.43	3.82
	30JAN95	13	352	27.08	7.51
	06FEB95	32	603	18.84	3.16
	13FEB95	22	431	19.59	4.27
	20FEB95	21	250	11.90	1.97
	27FEB95	35	734	20.97	3.68
	06MAR95	41	782	19.07	2.94
	13MAR95	32	1066	33.31	3.86
	20MAR95	47	469	9.98	1.55
	27MAR95	55	545	9.91	1.04
	03APR95	50	247	4.94	0.53
	10APR95	54	223	4.13	0.45
	TOTAL	541	8796	16.26	0.80

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-2. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1994-95.

REGION	RIVER MILE	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	-6	2	2	1.00	1.00
	-5	25	325	13.00	4.56
	-4	138	1836	13.30	1.07
	-3	29	190	6.55	1.43
	-2	79	1477	18.70	3.16
	-1	2	9	4.50	1.50
	0	3	0	0.00	0.00
	TOTAL	278	3839	13.81	1.15
BATTERY	1	8	97	12.13	6.45
	2	250	3726	14.90	1.12
	3	1	0	0.00	.
	4	1	12	12.00	.
	6	86	1084	12.60	1.49
	7	2	32	16.00	6.00
	8	2	69	34.50	25.50
	9	177	3547	20.04	1.56
	11	6	102	17.00	7.92
	12	5	98	19.60	15.44
	13	2	29	14.50	13.50
	28	1	0	0.00	.
	TOTAL	541	8796	16.26	0.80

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS COLLECTED AND STRIPED BASS TAGGED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER FOR THE 9M TRAWL, WINTER 1994-95.

REGION	GEAR	USE CODE	NUMBER OF SAMPLES	STRIPED BASS COLLECTED	STRIPED BASS TAGGED
UPPER HARBOR	9 m TRAWL	1	278	3839	2552
		2	1	4	1
		5	4	0	0
	TOTAL		283	3843	2553
BATTERY	9 m TRAWL	1	541	8796	4273
		2	4	18	12
		5	4	0	0
	TOTAL		549	8814	4285
COMBINED TOTAL			832	12657	6838

USE CODE: 1 = NO SAMPLING PROBLEMS
2 = SAMPLING PROBLEMS OCCURRED; MARKABLE FISH WERE CAUGHT, BUT SAMPLE WAS NOT USED FOR CATCH/EFFORT ANALYSIS
5 = VOID; SAMPLING PROBLEMS OCCURRED AND NO MARKABLE FISH WERE CAUGHT

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1994-95.

SAMPLE WEEK	WATER TEMP	WATER COND	N TOWS TOTAL	N TOWS VOID	≤ 150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	≥ 801	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	MORTALITY N	MORTALITY %
07NOV94	13.4	24109	41	3	168	3	20	2	0	0	0	0	0	193	5.0	24	1	0	0	0	0.0
14NOV94	12.7	26851	40	1	581	6	23	5	0	0	0	0	0	615	15.7	34	0	0	0	0	0.0
21NOV94	12.3	25703	21	1	93	4	25	19	0	0	0	0	0	141	7.1	47	1	0	0	0	0.0
28NOV94	9.1	23778	24	1	217	23	287	86	6	0	0	0	0	619	26.9	399	2	0	0	0	0.0
05DEC94	9.8	21705	32	0	282	25	269	98	7	0	1	0	1	683	21.3	395	6	2	0	0	0.0
12DEC94	8.1	21108	30	0	236	16	248	90	6	3	1	0	0	600	20.0	366	3	0	0	2	0.3
19DEC94	6.9	23585	32	0	150	20	255	154	12	1	0	1	0	593	18.5	440	3	0	0	0	0.0
26DEC94	6.5	22165	32	0	110	20	285	123	9	1	0	0	0	548	17.1	436	2	0	0	1	0.2
02JAN95	4.6	19559	34	0	211	17	248	137	17	3	0	0	0	633	18.6	415	6	1	0	4	0.6
09JAN95	3.8	18338	34	2	135	23	157	39	8	0	1	1	0	364	11.4	225	4	0	0	3	0.8
16JAN95	5.7	19474	31	0	251	38	360	113	7	0	0	0	0	769	24.8	508	12	6	0	6	0.8
23JAN95	4.5	14944	35	2	246	30	371	118	3	0	0	0	0	768	23.3	518	4	1	0	1	0.1
30JAN95	4.4	21309	34	0	236	18	337	141	7	2	0	0	0	741	21.8	494	11	1	0	1	0.1
06FEB95	2.0	15854	35	0	365	30	156	55	4	1	1	0	1	613	17.5	241	6	0	0	12	1.9
13FEB95	2.4	20347	29	1	364	7	51	10	1	0	0	0	0	433	15.5	70	0	2	0	0	0.0
20FEB95	3.8	19870	24	0	140	20	70	31	1	0	0	0	0	262	10.9	118	4	1	0	1	0.4
27FEB95	3.4	19703	37	0	487	54	171	19	4	0	0	0	0	735	19.9	247	4	7	0	7	0.1
06MAR95	3.6	13564	43	0	634	20	98	29	1	0	0	0	0	782	18.2	147	2	13	0	5	0.6
13MAR95	4.9	16439	33	0	545	77	379	63	2	0	0	0	0	1066	32.3	509	14	17	0	5	0.5
20MAR95	6.0	13141	48	1	181	27	216	52	3	0	0	0	0	479	10.0	294	4	2	0	1	0.2
27MAR95	6.6	19179	56	0	53	30	311	144	8	0	0	0	0	546	9.8	482	11	0	0	1	0.2
03APR95	7.1	16807	53	1	20	10	130	84	4	2	1	0	0	251	4.8	226	4	1	0	1	0.4
10APR95	7.4	19424	54	0	18	20	117	57	8	0	2	0	1	223	4.1	203	2	0	0	0	0.0
TOTAL	6.5	19467	832	13	5723	538	4584	1669	118	13	7	2	3	12657	15.4	6838	106	54	0	51	0.4

Size groups are NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (MM TL); TAGGED, RECAPTURED, HATCHERY, NOT TAGGED are NUMBER OF STRIPED BASS.

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (MM) OF STRIPED BASS COLLECTED IN THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1994-95.

	UPPER HARBOR				BATTERY			
SAMPLE WEEK	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.
07NOV94	191	124	55.88	4.04	2	113	6.36	4.50
14NOV94	609	110	37.32	1.51	4	126	24.28	12.14
21NOV94	136	166	89.77	7.70	5	159	79.74	35.66
28NOV94	280	225	85.78	5.13	339	199	85.50	4.64
05DEC94	413	247	87.12	4.29	269	151	70.69	4.31
12DEC94	264	239	99.82	6.14	329	187	81.64	4.50
19DEC94	352	285	66.58	3.55	241	187	99.83	6.43
26DEC94	302	283	47.31	2.72	246	200	92.94	5.93
02JAN95	238	273	78.00	5.06	395	201	103.24	5.19
09JAN95	95	253	73.81	7.57	269	192	94.86	5.78
16JAN95	77	271	50.43	5.75	692	211	88.20	3.35
23JAN95	468	248	68.70	3.18	300	167	88.13	5.09
30JAN95	389	264	75.30	3.82	352	173	90.35	4.82
06FEB95	10	269	75.23	23.79	603	166	95.23	3.88
13FEB95	2	205	124.45	88.00	431	123	62.46	3.01
20FEB95	12	159	64.30	18.56	250	181	92.46	5.85
27FEB95	1	89	.	.	733	149	73.55	2.72
06MAR95	.	.	.	.	781	130	68.02	2.43
13MAR95	.	.	.	.	1066	172	79.23	2.43
20MAR95	.	.	.	.	479	202	87.87	4.02
27MAR95	1	342	.	.	545	261	69.27	2.97
03APR95	.	.	.	.	251	280	78.54	4.96
10APR95	.	.	.	.	223	274	92.79	6.21
TOTAL	3840	224	93.99	1.52	8805	184	92.20	0.98

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
S.E. = STANDARD ERROR

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) IN THE 9M TRAWL FOR 50MM LENGTH GROUPS IN THE BATTERY REGION AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1994-95

SAMPLING WEEK	NUMBER OF TOWS	≤ 50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800	≥ 801
07NOV94	38	--	1.9	2.4	0.1	0.2	0.3	< 0.1	< 0.1	--	--	--	--	--	--	--	--	--
14NOV94	39	0.1	7.3	7.5	0.1	0.3	0.3	0.1	0.1	--	--	--	--	--	--	--	--	--
21NOV94	20	--	1.4	3.2	0.2	0.4	0.9	0.7	0.3	--	--	--	--	--	--	--	--	--
28NOV94	23	--	2.8	6.7	1.0	7.3	5.2	2.8	0.9	0.2	< 0.1	--	--	--	--	--	--	--
05DEC94	32	< 0.1	1.5	7.2	0.8	3.5	4.9	2.2	0.8	0.2	< 0.1	--	--	--	< 0.1	--	--	< 0.1
12DEC94	30	0.2	2.4	5.2	0.5	3.9	4.3	2.3	0.7	0.2	--	0.1	< 0.1	< 0.1	--	--	--	--
19DEC94	32	--	0.9	3.8	0.6	2.9	5.1	3.2	1.7	0.2	0.2	< 0.1	--	--	--	--	< 0.1	--
26DEC94	32	--	0.9	2.5	0.6	3.2	5.7	2.8	1.0	0.2	< 0.1	< 0.1	--	--	--	--	--	--
02JAN95	34	--	2.7	3.5	0.5	2.7	4.6	2.7	1.3	0.4	0.1	0.1	--	--	--	--	--	--
09JAN95	32	--	0.8	3.4	0.7	3.0	1.9	0.9	0.3	0.1	0.1	--	--	< 0.1	--	< 0.1	--	--
16JAN95	31	--	2.6	5.5	1.2	4.8	6.8	2.9	0.7	0.2	0.1	--	--	--	--	--	--	--
23JAN95	33	--	3.7	3.8	0.9	4.6	6.6	2.9	0.7	0.1	--	--	--	--	--	--	--	--
30JAN95	34	--	4.0	2.9	0.5	4.5	5.4	3.0	1.2	0.2	< 0.1	0.1	--	--	--	--	--	--
06FEB95	35	--	6.1	4.3	0.9	2.1	2.3	1.3	0.3	0.1	0.1	< 0.1	--	< 0.1	--	--	--	< 0.1
13FEB95	28	--	7.6	5.4	0.2	0.9	0.9	0.3	< 0.1	< 0.1	--	--	--	--	--	--	--	--
20FEB95	24	--	2.2	3.6	0.8	1.2	1.8	0.8	0.5	--	< 0.1	--	--	--	--	--	--	--
27FEB95	37	< 0.1	6.5	6.6	1.5	2.6	2.1	0.5	0.1	0.1	--	--	--	--	--	--	--	--
06MAR95	43	< 0.1	8.2	6.6	0.5	1.1	1.2	0.6	0.1	< 0.1	--	--	--	--	--	--	--	--
13MAR95	33	--	8.3	8.2	2.3	6.9	4.6	1.6	0.3	0.1	--	--	--	--	--	--	--	--
20MAR95	47	--	1.8	2.0	0.5	1.7	2.8	0.9	0.2	0.1	--	--	--	--	--	--	--	--
27MAR95	56	--	0.2	0.8	0.5	2.3	3.2	2.0	0.6	0.1	0.1	--	--	--	--	--	--	--
03APR95	52	--	0.1	0.3	0.2	0.7	1.8	1.1	0.5	< 0.1	0.1	< 0.1	< 0.1	--	< 0.1	--	--	--
10APR95	54	--	< 0.1	0.3	0.4	0.8	1.4	0.8	0.3	0.1	< 0.1	--	--	< 0.1	< 0.1	--	--	< 0.1
TOTAL	819	< 0.1	3.1	3.9	0.7	2.5	3.1	1.5	0.5	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX TABLE C-7. MEAN LENGTH AT AGE FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS COLLECTED BY THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER DURING THE 1986-87 THROUGH 1994-94 STRIPED BASS PROGRAMS.

AGE	COHORT	PROGRAM	N	STRATIFIED MEAN LENGTH (MM)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1994	1994-95	216	104	104	105
	1993	1993-94	828	123	121	125
	1992	1992-93	473	116	114	118
	1991	1991-92	818	131	127	135
	1990	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1993	1994-95	1216	260	258	262
	1992	1993-94	2695	237	236	238
	1991	1992-93	3899	231	229	233
	1990	1991-92	3675	245	244	246
	1989	1990-91	2174	239	237	241
	1988	1989-90	3514	214	213	215
	1987	1988-89	3623	227	226	229
	1986	1987-88	1503	253	251	255
	1985	1986-87	285	221	215	227
2+	1992	1994-95	455	312	308	316
	1991	1993-94	1631	317	307	328
	1990	1992-93	1378	329	325	333
	1989	1991-92	961	324	319	328
	1988	1990-91	2109	321	317	324
	1987	1989-90	1216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1991	1994-95	99	356	346	366
	1990	1993-94	152	424	246	602
	1989	1992-93	125	414	400	428
	1988	1991-92	153	386	378	394
	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

NOTE: STRATIFIED MEAN LENGTH FOR THE 1990 AND 1991 WILD COHORTS OF STRIPED BASS INCLUDE HACTHERY AND WILD FISH COMBINED. HATCHERY FISH WERE NOT TAGGED PRIOR TO STOCKING DURING THESE YEARS.

N = NUMBER OF FISH AGED FROM VALID (USE CODE = 1) SAMPLES.

APPENDIX D

STRIPED BASS MARK/RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HACTHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1994-95.

AGE	GEAR	RECAPTURE DATE	STATION	RECAPTURE RIVER MILE	TOTAL LENGTH (MM)	RELEASE YEAR
0+	9 m TRAWL	07DEC94	BATTERY	1	111	1994
0+	9 m TRAWL	07DEC94	BATTERY	1	95	1994
0+	9 m TRAWL	05JAN95	BATTERY	5	97	1994
0+	9 m TRAWL	16JAN95	BATTERY	1	139	1994
0+	9 m TRAWL	17JAN95	BATTERY	1	133	1994
0+	9 m TRAWL	17JAN95	BATTERY	7	106	1994
0+	9 m TRAWL	17JAN95	BATTERY	7	118	1994
0+	9 m TRAWL	18JAN95	BATTERY	1	104	1994
0+	9 m TRAWL	18JAN95	BATTERY	8	118	1994
0+	9 m TRAWL	25JAN95	BATTERY	8	110	1994
0+	9 m TRAWL	03FEB95	BATTERY	5	122	1994
0+	9 m TRAWL	14FEB95	BATTERY	11	118	1994
0+	9 m TRAWL	16FEB95	BATTERY	10	97	1994
0+	9 m TRAWL	24FEB95	BATTERY	1	124	1994
0+	9 m TRAWL	28FEB95	BATTERY	1	117	1994
0+	9 m TRAWL	02MAR95	BATTERY	8	117	1994
0+	9 m TRAWL	02MAR95	BATTERY	8	122	1994
0+	9 m TRAWL	02MAR95	BATTERY	8	98	1994
0+	9 m TRAWL	02MAR95	BATTERY	8	127	1994
0+	9 m TRAWL	03MAR95	BATTERY	8	109	1994
0+	9 m TRAWL	03MAR95	BATTERY	8	146	1994
0+	9 m TRAWL	08MAR95	BATTERY	1	131	1994
0+	9 m TRAWL	08MAR95	BATTERY	5	121	1994
0+	9 m TRAWL	08MAR95	BATTERY	5	129	1994
0+	9 m TRAWL	08MAR95	BATTERY	5	120	1994
0+	9 m TRAWL	08MAR95	BATTERY	8	135	1994
0+	9 m TRAWL	08MAR95	BATTERY	8	112	1994
0+	9 m TRAWL	08MAR95	BATTERY	8	129	1994
0+	9 m TRAWL	08MAR95	BATTERY	8	140	1994
0+	9 m TRAWL	09MAR95	BATTERY	8	114	1994
0+	9 m TRAWL	10MAR95	BATTERY	8	128	1994
0+	9 m TRAWL	10MAR95	BATTERY	8	103	1994
0+	9 m TRAWL	10MAR95	BATTERY	8	117	1994
0+	9 m TRAWL	10MAR95	BATTERY	8	136	1994
0+	9 m TRAWL	13MAR95	BATTERY	8	128	1994
0+	9 m TRAWL	13MAR95	BATTERY	8	122	1994
0+	9 m TRAWL	13MAR95	BATTERY	5	112	1994
0+	9 m TRAWL	14MAR95	BATTERY	8	131	1994
0+	9 m TRAWL	14MAR95	BATTERY	8	112	1994
0+	9 m TRAWL	15MAR95	BATTERY	8	125	1994
0+	9 m TRAWL	15MAR95	BATTERY	8	103	1994
0+	9 m TRAWL	15MAR95	BATTERY	8	127	1994
0+	9 m TRAWL	16MAR95	BATTERY	8	110	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	133	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	119	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	127	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	105	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	117	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	146	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	137	1994
0+	9 m TRAWL	17MAR95	BATTERY	8	130	1994
0+	9 m TRAWL	20MAR95	BATTERY	8	130	1994
0+	9 m TRAWL	20MAR95	BATTERY	5	124	1994
0+	9 m TRAWL	03APR95	BATTERY	8	107	1994

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED, RELEASED AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1994-95.

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
09DEC94	337	UPPER HARBOR	-3	06DEC94	338	UPPER HARBOR	-5	3	2	1	404231
07DEC94	330	UPPER HARBOR	-5	05DEC94	328	UPPER HARBOR	-2	2	3	1	404268
16MAR95	310	BATTERY	9	19DEC94	313	BATTERY	2	87	7	1	404435
17MAR95	304	BATTERY	9	03JAN95	300	UPPER HARBOR	-4	73	13	1	404731
15MAR95	341	BATTERY	9	03JAN95	342	UPPER HARBOR	-4	71	13	1	404753
16MAR95	311	BATTERY	9	16JAN95	312	BATTERY	2	59	7	1	404935
15MAR95	320	BATTERY	9	16JAN95	323	BATTERY	9	58	0	1	404953
09NOV94	257	UPPER HARBOR	-2	09NOV94	257	UPPER HARBOR	-2	0	0	1	410006
14MAR95	252	BATTERY	9	23NOV94	252	UPPER HARBOR	-2	111	11	1	410066
16JAN95	247	BATTERY	9	28NOV94	247	BATTERY	1	49	8	1	410098
06DEC94	257	BATTERY	2	30NOV94	260	BATTERY	2	6	0	1	410165
12DEC94	206	BATTERY	2	02DEC94	206	BATTERY	2	10	0	1	410366
18JAN95	192	BATTERY	2	06DEC94	194	BATTERY	2	43	0	1	410427
19DEC94	178	BATTERY	2	06DEC94	177	BATTERY	2	13	0	1	410433
09MAR95		BATTERY	9	07DEC94	267	UPPER HARBOR	-5	92	14	1	410569
19JAN95	232	UPPER HARBOR	-4	09DEC94	232	UPPER HARBOR	-5	41	1	1	410664
12APR95	197	BATTERY	2	12DEC94		BATTERY	2	121	0	1	410721
25FEB95	265	BATTERY	2	12DEC94	264	UPPER HARBOR	-2	75	4	1	410755
13DEC94	285	BATTERY	2	12DEC94	285	BATTERY	2	1	0	1	410789
15DEC94	239	BATTERY	2	12DEC94	238	BATTERY	2	3	0	1	410814
29MAR95	241	BATTERY	6	12DEC94	241	BATTERY	2	107	4	1	410816
21MAR95	251	BATTERY	9	13DEC94	253	BATTERY	2	98	7	1	410871
13MAR95	291	BATTERY	9	15DEC94	292	UPPER HARBOR	-4	88	13	1	410909
27JAN95	240	UPPER HARBOR	-4	15DEC94	239	UPPER HARBOR	-5	43	1	1	410912
20DEC94	205	BATTERY	2	15DEC94	206	BATTERY	2	5	0	1	410913
28MAR95	270	BATTERY	9	15DEC94	270	BATTERY	2	103	7	1	410929
28DEC94	204	UPPER HARBOR	-5	19DEC94	206	UPPER HARBOR	-4	9	1	1	410959
27DEC94	267	UPPER HARBOR	-3	21DEC94	272	UPPER HARBOR	-4	6	1	1	411101
11JAN95	214	BATTERY	2	21DEC94	215	BATTERY	2	21	0	1	411142
05APR95	287	BATTERY	2	22DEC94	291	UPPER HARBOR	-4	104	6	1	411153
30JAN95	248	UPPER HARBOR	-4	22DEC94	247	UPPER HARBOR	-4	39	0	1	411203
31JAN95	229	BATTERY	2	27DEC94	227	UPPER HARBOR	-3	35	5	1	411253
02MAR95	189	BATTERY	9	29DEC94	189	BATTERY	2	63	7	1	411423
09JAN95	297	UPPER HARBOR	-4	03JAN95	225	UPPER HARBOR	-4	6	0	1	411539
18JAN95	274	BATTERY	2	04JAN95	272	UPPER HARBOR	-4	14	6	1	411587
21MAR95	211	BATTERY	9	05JAN95	211	BATTERY	2	75	7	1	411698
30JAN95	253	UPPER HARBOR	-4	06JAN95	252	BATTERY	2	24	6	1	411757
25JAN95	243	BATTERY	2	09JAN95	241	UPPER HARBOR	-4	16	6	1	411812
16JAN95	232	BATTERY	2	09JAN95	232	UPPER HARBOR	-4	7	6	1	411817
31MAR95	277	BATTERY	2	11JAN95	277	BATTERY	6	79	4	1	411878
17JAN95	287	BATTERY	2	16JAN95	287	BATTERY	2	1	0	1	411993
16JAN95	254	BATTERY	2	16JAN95	254	BATTERY	2	0	0	1	412001
25JAN95	207	BATTERY	2	17JAN95	204	BATTERY	2	8	0	1	412145
09MAR95	247	BATTERY	9	18JAN95	244	BATTERY	2	50	7	1	412230
19JAN95	266	UPPER HARBOR	-4	19JAN95	264	UPPER HARBOR	-4	0	0	1	412310
23JAN95	252	UPPER HARBOR	-4	19JAN95	253	UPPER HARBOR	-4	4	0	1	412352
31JAN95	233	UPPER HARBOR	-4	24JAN95	233	UPPER HARBOR	-4	7	0	1	412518
08FEB95	246	BATTERY	9	24JAN95	248	UPPER HARBOR	-4	15	13	1	412573
30JAN95	218	UPPER HARBOR	-4	25JAN95	218	UPPER HARBOR	-4	5	0	1	412618
29MAR95	236	BATTERY	9	27JAN95	236	UPPER HARBOR	-4	61	13	1	412723

(CONTINUED)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
02FEB95	214	UPPER HARBOR	-4	30JAN95	216	UPPER HARBOR	-4	3	0	1	412822
06FEB95	230	BATTERY	2	31JAN95	230	UPPER HARBOR	-4	6	6	1	412918
02FEB95	230	UPPER HARBOR	-4	01FEB95	236	UPPER HARBOR	-4	1	0	1	412980
27MAR95	235	BATTERY	9	02FEB95	238	BATTERY	9	53	0	1	413082
03APR95	214	BATTERY	6	03FEB95	221	BATTERY	9	59	3	1	413119
21MAR95	178	BATTERY	9	07FEB95	170	BATTERY	9	42	0	1	413236
09FEB95	250	BATTERY	9	09FEB95	250	BATTERY	9	0	0	1	413281
09FEB95	250	BATTERY	9	09FEB95	251	BATTERY	9	0	0	1	413286
27MAR95	205	BATTERY	2	21FEB95	210	BATTERY	2	34	0	1	413392
17MAR95	203	BATTERY	9	25FEB95	200	BATTERY	2	20	7	1	413444
17MAR95	251	BATTERY	9	01MAR95	251	BATTERY	9	16	0	1	413514
01MAR95	255	BATTERY	9	01MAR95	255	BATTERY	9	0	0	1	413518
02MAR95	235	BATTERY	9	02MAR95	238	BATTERY	9	0	0	1	413580
16MAR95	247	BATTERY	9	10MAR95	250	BATTERY	9	6	0	1	413802
16MAR95	243	BATTERY	9	16MAR95	245	BATTERY	9	0	0	1	413983
16MAR95	275	BATTERY	9	16MAR95	279	BATTERY	9	0	0	1	413986
20MAR95	186	BATTERY	9	16MAR95	182	BATTERY	9	4	0	1	414037
29MAR95	195	BATTERY	9	16MAR95	196	BATTERY	9	13	0	1	414069
27MAR95	336	BATTERY	2	16MAR95	152	BATTERY	9	11	7	1	414102
16MAR95	213	BATTERY	9	16MAR95	214	BATTERY	9	0	0	1	414117
14APR95	295	BATTERY	2	27MAR95	297	BATTERY	9	18	7	1	414513
04APR95	318	BATTERY	2	27JAN95	317	UPPER HARBOR	-4	67	6	1	415170
16MAR95	251	BATTERY	9	31JAN95	357	UPPER HARBOR	-4	44	13	1	415219
28MAR95	385	BATTERY	9	02FEB95	382	UPPER HARBOR	-4	54	13	1	415300
28MAR95	300	BATTERY	9	01MAR95	300	BATTERY	9	27	0	1	415429

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION
2 = INFECTED TAG INSERTION

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1994-95.

RECAPTURE				RELEASE								
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	GEAR	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	GROWTH (MM)	TAG CONDITION	TAG NUMBER
03JAN95	402	UPPER HARBOR	-4	18DEC92	9 m TRAWL	316	UPPER HARBOR	4	746	86	1	360963
03JAN95	365	UPPER HARBOR	-4	02DEC92	9 m TRAWL	244	BATTERY	1	762	121	1	376982
28NOV94	294	BATTERY	1	30DEC92	9 m TRAWL	232	BATTERY	1	698	62	1	379837
30JAN95	377	UPPER HARBOR	-4	05JAN93	9 m TRAWL	233	UPPER HARBOR	3	755	144	1	380845
07DEC94	303	UPPER HARBOR	-5	07APR93	9 m TRAWL	212	BATTERY	9	609	91	1	390350
04JAN95	247	BATTERY	2	17NOV93	9 m TRAWL	210	UPPER HARBOR	3	413	37	1	391766
20JAN95	340	BATTERY	2	23NOV93	9 m TRAWL	231	BATTERY	1	423	109	1	392377
28MAR95	372	BATTERY	9	09DEC93	9 m TRAWL	280	UPPER HARBOR	3	474	92	1	393004
24FEB95	253	BATTERY	2	20DEC93	9 m TRAWL	229	BATTERY	5	431	24	1	393872
10JAN95	314	BATTERY	2	23DEC93	9 m TRAWL	278	UPPER HARBOR	2	383	36	1	394099
22DEC94	311	UPPER HARBOR	-4	27DEC93	9 m TRAWL	236	UPPER HARBOR	2	360	75	1	394497
09JAN95	301	UPPER HARBOR	-4	15MAR94	9 m TRAWL	243	BATTERY	8	300	58	1	397572
19JAN95	316	BATTERY	2	15MAR94	9 m TRAWL	200	BATTERY	8	310	116	1	397578
20JAN95	305	BATTERY	2	17MAR94	9 m TRAWL	287	BATTERY	8	309	18	1	398303
28NOV94	329	BATTERY	1	18MAR94	9 m TRAWL	262	BATTERY	7	255	67	1	398534
02FEB95	323	UPPER HARBOR	-4	18MAR94	9 m TRAWL	248	BATTERY	8	321	75	1	398567
01FEB95	302	UPPER HARBOR	-4	18MAR94	9 m TRAWL	214	BATTERY	8	320	88	1	398569
06DEC94	.	UPPER HARBOR	-5	19MAR94	9 m TRAWL	200	BATTERY	6	262	.	1	398626
06APR95	318	BATTERY	2	31MAR94	9 m TRAWL	200	BATTERY	1	371	118	1	399554
31JAN95	390	BATTERY	2	09DEC93	9 m TRAWL	357	UPPER HARBOR	3	418	33	1	401002
02MAR95	.	BATTERY	9	10DEC93	9 m TRAWL	310	UPPER HARBOR	2	447	.	1	401398
05JAN95	516	BATTERY	2	21DEC93	9 m TRAWL	494	BATTERY	8	380	22	1	402015
17JAN95	340	BATTERY	2	27DEC93	9 m TRAWL	306	BATTERY	1	386	34	1	402449
06JAN95	369	BATTERY	2	11JAN94	9 m TRAWL	337	BATTERY	7	360	32	1	402762
23NOV94	310	UPPER HARBOR	-2	13JAN94	9 m TRAWL	315	BATTERY	1	314	.	1	402782
05DEC94	375	UPPER HARBOR	-5	18MAR94	9 m TRAWL	310	BATTERY	6	262	65	1	403367
03JAN95	256	UPPER HARBOR	-4	07APR94	9 m TRAWL	165	BATTERY	5	271	91	1	406484
08FEB95	295	BATTERY	9	08APR94	9 m TRAWL	210	BATTERY	5	306	85	1	406724
21FEB95	242	BATTERY	2	13APR94	9 m TRAWL	207	BATTERY	5	314	35	1	407784
28NOV94	252	BATTERY	1	13APR94	9 m TRAWL	200	BATTERY	5	229	52	1	408004

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION
2 = INFECTED TAG INSERTION

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED BY THE 9M TRAWL IN THE HUDSON RIVER, WINTER 1994-95.

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS (C)	STATISTIC	NUMBER OF STRIPED BASS RECAPTURED DURING WEEK																							
			07NOV94 M = 24	14NOV94 M = 34	21NOV94 M = 47	28NOV94 M = 399	05DEC94 M = 395	12DEC94 M = 366	19DEC94 M = 439	26DEC94 M = 436	02JAN95 M = 415	09JAN95 M = 225	16JAN95 M = 508	23JAN95 M = 518	30JAN95 M = 494	06FEB95 M = 241	13FEB95 M = 70	20FEB95 M = 118	27FEB95 M = 247	06MAR95 M = 147	13MAR95 M = 509	20MAR95 M = 294	27MAR95 M = 482	03APR95 M = 228	10APR95 M = 203	TOTAL M = 6837
07NOV94	25	R	1																							1
		R/M	0.04167																							0.04167
		R/C	0.04000																							0.04000
14NOV94	34	R	0	0																						0
		R/M	0.00000	0.00000																						0.00000
		R/C	0.00000	0.00000																						0.00000
21NOV94	48	R	0	0	0																					0
		R/M	0.00000	0.00000	0.00000																					0.00000
		R/C	0.00000	0.00000	0.00000																					0.00000
28NOV94	402	R	0	0	0	0																				0
		R/M	0.00000	0.00000	0.00000	0.00000																				0.00000
		R/C	0.00000	0.00000	0.00000	0.00000																				0.00000
05DEC94	401	R	0	0	0	1	2																			3
		R/M	0.00000	0.00000	0.00000	0.00251	0.00506																			0.00334
		R/C	0.00000	0.00000	0.00000	0.00249	0.00499																			0.00748
12DEC94	364	R	0	0	0	1	0	2																		3
		R/M	0.00000	0.00000	0.00000	0.00251	0.00000	0.00546																		0.00237
		R/C	0.00000	0.00000	0.00000	0.00275	0.00000	0.00549																		0.00824
19DEC94	443	R	0	0	0	0	1	1	0																	2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00253	0.00273	0.00000																	0.00117
		R/C	0.00000	0.00000	0.00000	0.00000	0.00226	0.00226	0.00000																	0.00451
26DEC94	438	R	0	0	0	0	0	0	2	0																2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00456	0.00000																0.00093
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00457	0.00000																0.00457
02JAN95	422	R	0	0	0	0	0	0	0	0	0															0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000															0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000															0.00000
09JAN95	229	R	0	0	0	0	0	0	1	0	1	0														2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00228	0.00000	0.00241	0.00000														0.00072
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00437	0.00000	0.00437	0.00000														0.00873
16JAN95	520	R	0	0	0	1	2	0	0	0	1	1	3													8
		R/M	0.00000	0.00000	0.00000	0.00251	0.00506	0.00000	0.00000	0.00000	0.00241	0.00444	0.00591													0.00243
		R/C	0.00000	0.00000	0.00000	0.00192	0.00385	0.00000	0.00000	0.00000	0.00192	0.00192	0.00577													0.01538
23JAN95	522	R	0	0	0	0	0	1	0	0	0	1	2	0												4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00273	0.00000	0.00000	0.00000	0.00444	0.00394	0.00000												0.00105
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00192	0.00000	0.00000	0.00000	0.00192	0.00383	0.00000												0.00766
30JAN95	505	R	0	0	0	0	0	0	1	1	1	0	0	2	2											7
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00228	0.00229	0.00241	0.00000	0.00000	0.00386	0.00405											0.00163
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00198	0.00198	0.00198	0.00000	0.00000	0.00396	0.00396											0.01386

(CONTINUED)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS (C)	STATISTIC	NUMBER OF STRIPED BASS RECAPTURED DURING WEEK																						
			07NOV94 M = 24	14NOV94 M = 34	21NOV94 M = 47	28NOV94 M = 399	05DEC94 M = 395	12DEC94 M = 366	19DEC94 M = 439	26DEC94 M = 436	02JAN95 M = 415	09JAN95 M = 225	16JAN95 M = 508	23JAN95 M = 518	30JAN95 M = 494	06FEB95 M = 241	13FEB95 M = 70	20FEB95 M = 118	27FEB95 M = 247	06MAR95 M = 147	13MAR95 M = 509	20MAR95 M = 294	27MAR95 M = 482	03APR95 M = 226	10APR95 M = 203	TOTAL M = 6837
06FEB95	248	R	0	0	0	0	0	0	0	0	0	0	0	1	1	2										4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00193	0.00202	0.00830										0.00088
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00403	0.00403	0.00806										0.01613
13FEB95	70	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000									0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000									0.00000
20FEB95	122	R	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0								1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00273	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000								0.00021
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00820	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000								0.00820
27FEB95	250	R	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2							3
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00229	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00810							0.00060
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00400	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00800							0.01200
06MAR95	148	R	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0						2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00253	0.00000	0.00000	0.00000	0.00000	0.00000	0.00197	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000						0.00039
		R/C	0.00000	0.00000	0.00000	0.00000	0.00676	0.00000	0.00000	0.00000	0.00000	0.00000	0.00676	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000						0.01351
13MAR95	523	R	0	0	1	0	0	1	1	0	2	0	2	0	1	0	0	1	1	1	3					14
		R/M	0.00000	0.00000	0.02128	0.00000	0.00000	0.00273	0.00228	0.00000	0.00482	0.00000	0.00394	0.00000	0.00202	0.00000	0.00000	0.00847	0.00405	0.00680	0.00589					0.00249
		R/C	0.00000	0.00000	0.00191	0.00000	0.00000	0.00191	0.00191	0.00000	0.00382	0.00000	0.00382	0.00000	0.00191	0.00000	0.00000	0.00191	0.00191	0.00191	0.00574					0.02677
20MAR95	298	R	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0				4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00273	0.00000	0.00000	0.00241	0.00000	0.00000	0.00000	0.00000	0.00415	0.00000	0.00000	0.00000	0.00000	0.00196	0.00000				0.00067
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00336	0.00000	0.00000	0.00336	0.00000	0.00000	0.00000	0.00000	0.00336	0.00000	0.00000	0.00000	0.00000	0.00336	0.00000				0.01342
27MAR95	493	R	0	0	0	0	0	2	0	0	0	1	0	1	2	0	0	1	1	0	2	0	0			10
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00546	0.00000	0.00000	0.00000	0.00444	0.00000	0.00193	0.00405	0.00000	0.00000	0.00847	0.00405	0.00000	0.00393	0.00000	0.00000			0.00156
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00406	0.00000	0.00000	0.00000	0.00203	0.00000	0.00203	0.00406	0.00000	0.00000	0.00203	0.00203	0.00000	0.00406	0.00000	0.00000			0.02028
03APR95	231	R	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0		3
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00228	0.00000	0.00000	0.00000	0.00000	0.00193	0.00202	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00045
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00433	0.00000	0.00000	0.00000	0.00000	0.00433	0.00433	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.01299
10APR95	205	R	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00273	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00207	0.00000	0.00000	0.00029
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00488	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00488	0.00000	0.00000	0.00976
TOTAL	6941	R	1	0	1	3	6	10	6	2	6	3	8	5	7	3	0	2	4	1	6	0	1	0	0	75
		R/M	0.04167	0.00000	0.02128	0.00752	0.01519	0.02732	0.01367	0.00459	0.01446	0.01333	0.01575	0.00965	0.01417	0.01245	0.00000	0.01695	0.01619	0.00680	0.01179	0.00000	0.00207	0.00000	0.00000	0.01097
		R/C	0.00014	0.00000	0.00014	0.00043	0.00086	0.00144	0.00086	0.00029	0.00086	0.00043	0.00115	0.00072	0.00101	0.00043	0.00000	0.00029	0.00058	0.00014	0.00086	0.00000	0.00014	0.00000	0.00000	0.01081

R = NUMBER OF STRIPED BASS RECAPTURED
M = NUMBER OF STRIPED BASS >= 150 MM MARKED AND RELEASED
C = NUMBER OF STRIPED BASS >= 150 MM COLLECTED AND EXAMINED FOR TAGS
R/M = RECAPTURE RATE.
R/C = RECAPTURE PROPORTION.

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1994-95.

SAMPLING WEEK	(≥ 150 MM TL) C TOTAL	(≥ 150 MM TL) M TOTAL	CUM M TOTAL	R TOTAL	R/C	Ct*Cumm Mt	Cumm Mt*Rt	Ct*(Cumm Mt)2	Rt2/Ct
28NOV94	402	399	0	0	0.00000	0	0	0	0.0000
05DEC94	401	395	395	1	0.00249	158,395	395	62,566,025	0.0025
12DEC94	364	366	761	1	0.00275	277,004	761	210,800,044	0.0027
19DEC94	443	439	1200	2	0.00451	531,600	2400	637,920,000	0.0090
26DEC94	438	436	1636	2	0.00457	716,568	3272	1,172,305,248	0.0091
02JAN95	422	415	2051	0	0.00000	865,522	0	1,775,185,622	0.0000
09JAN95	229	225	2276	2	0.00437	521,204	4552	1,186,260,304	0.0175
16JAN95	520	508	2784	5	0.00962	1,447,680	13,920	4,030,341,120	0.0481
23JAN95	522	518	3302	4	0.00958	1,723,644	13,208	5,691,472,488	0.0307
30JAN95	505	494	3796	5	0.00792	1,916,980	18,980	7,276,856,080	0.0495
06FEB95	248	241	4037	2	0.01210	1,001,176	8074	4,041,747,512	0.0161
13FEB95	70	70	4107	0	0.00000	287,490	0	1,180,721,430	0.0000
20FEB95	122	118	4225	1	0.00820	515,450	4225	2,177,776,250	0.0082
27FEB95	250	247	4472	1	0.00400	1,118,000	4472	4,999,696,000	0.0040
06MAR95	148	147	4619	2	0.01351	683,612	9238	3,157,603,828	0.0270
13MAR95	523	509	5128	11	0.01530	2,681,944	56,408	13,753,008,832	0.2314
20MAR95	298	294	5422	4	0.01678	1,615,756	21,688	8,760,629,032	0.0537
27MAR95	493	482	5904	10	0.02231	2,910,672	59,040	17,184,607,488	0.2028
TOTAL	6398		56115	53	0.13799	18,972,697	220,633	77,299,497,303	0.7123

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE HUDSON RIVER, WINTER 1994-95.

SOURCE	DF	SS	MS	F-RATIO	p > F
MODEL	1	0.00146	0.00146	85.84	< 0.0001
ERROR	17	0.00029	0.00002		
TOTAL	18	0.00175			

REGRESSION EQUATION: R/C = (CUMULATIVE M) X + ERROR

WHERE,

X = 0.0000025 (STANDARD ERROR OF X = 0.00000027)

p > F = PROBABILITY OF OBTAINING A LARGER F-RATIO
df = DEGREES OF FREEDOM
SS = SUM OF SQUARES
MS = MEAN SQUARE

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)	MODIFIED INTERNAL ANCHOR (HALL)	SMALL DART (HALL)
1984	737	737	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819
1989-1990	24,362	--	--	--	--	24,362	659
1990-1991	22,406	--	--	--	--	22,406	--
1991-1992	24,307	--	--	--	--	24,307	--
1992-1993	21,746	--	--	--	--	21,746	--
1993-1994	18,310	--	--	--	--	18,310	--
1994-1995	6,838	--	--	--	--	6,838	--
TOTAL	183,453	737	28,041	4,575	16,402	134,435	1,478

NOTE: HALL = HALLPRINT.

PROGRAM YEAR(S):

1988-1989 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1989-1990 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1991-1992 TOTAL INCLUDES 23,514 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 793 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1992-1993 TOTAL INCLUDES 20,847 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 899 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1993-1994 TOTAL INCLUDES 17,500 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 810 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS COLLECTED, TAGGED AND RELEAED DURING THE 1994-95 STRIPED BASS EVALUATION PROGRAM.

TAG	ANCHOR	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
HALLPRINT INTERNAL ANCHOR	SMALL, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	5938
HALLPRINT INTERNAL ANCHOR	LARGE, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	900
TOTAL				6838

NOTE: STRIPED BASS ≥ 150 MM TL < 300 MM TL IN GOOD CONDITION WERE TAGGED WITH SMALL ANCHOR (20 MM) TAGS AND RELEASED.

STRIPED BASS ≥ 300 MM TL IN GOOD CONDITION WERE TAGGED WITH LARGE ANCHOR (25 MM) TAGS AND RELEASED.

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted during the 1994-95 program were returned to the laboratory and examined in fresh condition to determine length, weight, sex and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for those observations. Similar biocharacteristic data were obtained during the 1985-86 through 1993-94 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 Length, Weight, Sex and Sexual Condition of Striped Bass

Length, weight, sex and sexual condition were determined for 5 striped bass that died during field sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 100.0 g for fish greater that 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-1.

E.2.2 Striped Bass Stomach Contents Analysis

Striped bass that were processed as described above in Section E.2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in the striped bass stomach contents. Atlantic tomcod were

APPENDIX TABLE E-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS

SEXUAL CONDITION	FEMALES	MALES
GRAVID OR MILTING (RIPE)	OVARIES FULL OF YELLOWISH GRANULAR EGGS THAT ARE PARTIALLY TRANSLUCENT. EGGS CAN BE RELEASED WHEN OVARY IS COMPRESSED.	TESTES WHIRE, LESS FIRM IN TEXTURE, AND IF COMPRESSED WILL READILY MILT.
RIPE AND RUNNING	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF EGGS WITH LITTLE PROVOCATION.	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF MILT WITH LITTLE PROVOCATION.
PARTIALLY SPENT	OVARIES SOMEWHAT FLACCID AND CONVOLUTED, WITH A VARIABLE NUMBER OF EGGS LEFT. OVARIAN MEMBRANE SOMEWHAT WASCULAR.	TESTES WHITISH, SOMEWHAT FLACCID AND CONVOLUTED, WITH FREE FLOW OF MILT.
SPENT	OVARIES FLACCID, FEW TRANSLUCENT EGGS LEFT. OVARIAN MEMBRANE VERY VASCULAR OR SAC LIKE.	TESTES BROWNISH WHITE, FLACCID, CONVOLUTED WITH NO FLOW OF MILT UPON COMPRESSION.
IMMATURE	OVARIES VERY SMALL AND STRING-LIKE, THICKER THAN TESTES, SOMEWHAT OPAQUE AND GELATINOUS IN APPEARANCE.	TESTES VERY SMALL AND STRINGLIKE, THINNER THAN OVARIES, SOMEWHAT TRANSLUCENT, AND EXTREMELY TENDER.
NOT GRAVID OR NOT MILTING (RESTING)	UNDERDEVLOPED OVARIES IN AN ADULT FEMALE. OVARIES LARGER, MORE FIRM, OPAQUE, AND RELATIVELY THICK. NO EGGS DISCERNIBLE TO NAKED EYE.	UNDERDEVELOPED TESTES IN AN ADULT MALE. TESTES LARGER MORE FIRM, OPAQUE, BUT STILL TENDER.
SEMI-GRAVID OR SEMI-MILTING (DEVELOPING)	SUBRIPE FEAMLES HEADING INTO SPAWNING SEASON. OVARIES CONSIDERABLY LARGER, YELLOW, GRANULAR IN CONSISTENCY. EGGS DISCERNIBLE TO NAKED EYE, BUT NOT READILY RELEASED WHEN OVARY IS COMPRESSED.	SUBRIPE MALES HEADING INTO SPAWNING SEASON. TESTES CONSIDERABLY LARGER, WHITE, FIRM IN TEXTURE, BUT MILT NOT RUNNING.

differentiated from other fish species by comparing vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 Striped bass Sexual Condition

Two male and one female striped bass were returned to the laboratory for biocharacteristic analysis. Two additional striped bass were of undetermined sex. Both the male and female striped bass were in the resting stage (Table 3-2).

The lack of ripe, or ripe and running striped bass in the 1994-95 biocharacteristic sample agrees with the findings of the 1985-86 through 1993-94 programs (Table E-3 and E-4). Detailed comparisons between the 1994-95 program and previous years are difficult due to the limited number of dead fish returned for biocharacteristic analysis. Historically, the majority of male fish from previous programs were considered immature or resting, with the remainder in the developing stage. Immature fish made up the majority of female striped bass included in biocharacteristic samples. No female fish in the developing or ripe stages have been examined (NAI 1995b). The lack of ripe or ripe and running striped bass is not surprising because the majority of the fish collected are of pre-spawning size (< 400 mm) and the program terminates before the onset of peak spawning (NAI 1986; TI 1981).

E.3.1 Striped Bass Food Habits

Food habits of striped bass that died during field sample collection were determined for all fish returned to the laboratory for biocharacteristic analysis. Stomach contents were identified as invertebrates, vertebrates, or Atlantic tomcod. The presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River Estuary during the winter months.

No Atlantic tomcod were observed in any of the striped bass stomachs examined. Invertebrates were the only food item identified in each sample (Table E-5). The majority of these were amphipods, with some shrimp (Paleomentes sp.) also present. This is in general agreement with the findings from previous programs where invertebrate remains were most common in striped

APPENDIX TABLE E-2. SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1994-95 PROGRAM.

	FEMALES					MALES					UNDETERMINED	
MONTH	IMMATURE	RESTING	DEVELOPING	SPENT	TOTAL	IMMATURE	RESTING	DEVELOPING	SPENT	TOTAL	IMMATURE	TOTAL
NOV	--	--	--	--	0	--	1	--	--	1	--	0
DEC	--	--	--	--	0	--	1	--	--	1	2	2
JAN	--	1	--	--	1	--	--	--	--	0	--	0
FEB	--	--	--	--	0	--	--	--	--	0	--	0
MAR	--	--	--	--	0	--	--	--	--	0	--	0
APR	--	--	--	--	0	--	--	--	--	0	--	0
TOTAL	0	1	0	0	1	0	2	0	0	2	2	2

APPENDIX TABLE E-3. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1994-95 PROGRAM.

LENGTH (MM)	WEIGHT (G)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	FOOD
90	6.3	14DEC94	BATTERY	2	UNDETERMINED	IMMATURE	INVERTS
96	7.4	14DEC94	BATTERY	2	UNDETERMINED	IMMATURE	INVERTS
277	248.5	17DEC94	UPPER HARBOR	-4	MALE	RESTING	INVERTS
293	293.1	28NOV94	BATTERY	1	MALE	RESTING	INVERTS
342	420.7	03JAN95	UPPER HARBOR	-4	FEMALE	RESTING	INVERTS

APPENDIX TABLE E-4. **SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1985-86 THROUGH 1994-95 PROGRAMS.**

IMMATURE MALES

MONTH	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	MONTHLY %
	PROGRAM											
NOV	0	0	1	1	4	6	6	8	1	0	27	56
DEC	16	2	2	7	2	12	13	18	9	0	81	58
JAN	13	7	5	10	5	16	57	9	34	0	156	69
FEB	8	9	17	6	1	11	24	9	2	0	87	62
MAR	11	10	8	5	2	7	3	36	83	0	165	72
APR	12	14	0	2	2	3	27	48	69	0	177	57
MAY	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	60	42	33	31	16	55	130	128	198	0	693	63

RESTING MALES

MONTH	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	MONTHLY %
	PROGRAM											
NOV	1	0	1	1	1	1	4	5	4	1	19	40
DEC	0	0	4	5	1	6	7	12	10	1	46	33
JAN	0	1	9	1	0	2	14	14	8	0	49	22
FEB	0	1	0	0	0	9	9	12	1	0	32	23
MAR	0	8	0	0	0	3	6	2	13	0	32	14
APR	0	45	0	0	0	2	10	4	4	0	65	21
MAY	5	0	0	0	0	0	0	5	0	0	10	100
TOTAL	6	55	14	7	2	23	50	54	40	2	253	23

DEVELOPING MALES

MONTH	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	MONTHLY %
	PROGRAM											
NOV	1	0	1	0	0	0	0	0	0	0	2	4
DEC	11	1	1	0	0	0	0	0	0	0	13	9
JAN	9	6	1	0	0	0	1	0	3	0	20	9
FEB	10	1	7	3	0	0	0	0	0	0	21	15
MAR	7	12	2	3	0	2	0	0	6	0	32	14
APR	50	2	3	0	0	1	1	0	10	0	67	22
MAY	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	88	22	15	6	0	3	2	0	19	0	155	14

IMMATURE FEMALES

LENGTH GROUP	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	MONTHLY %
	PROGRAM											
NOV	1	0	4	1	4	1	4	11	5	0	31	97
DEC	28	1	4	9	3	10	13	20	17	0	105	95
JAN	17	3	11	9	6	8	55	32	19	0	160	93
FEB	9	10	18	7	3	14	29	25	3	0	118	98
MAR	16	16	8	9	3	13	6	46	82	0	199	96
APR	24	9	0	3	1	8	8	57	59	0	169	94
MAY	1	0	0	0	0	0	0	0	0	0	1	50
TOTAL	96	39	45	38	20	54	115	191	185	0	783	95

RESTING FEMALES

LENGTH GROUP	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	MONTHLY %
	PROGRAM											
NOV	0	0	0	0	0	0	1	0	0	0	1	3
DEC	0	0	0	2	0	0	2	2	0	0	6	5
JAN	0	1	0	1	0	0	8	0	1	1	12	7
FEB	0	0	1	0	0	0	0	1	0	0	2	2
MAR	0	0	0	0	0	0	2	0	6	0	8	4
APR	0	0	0	0	0	0	8	2	1	0	11	6
MAY	1	0	0	0	0	0	0	0	0	0	1	50
TOTAL	1	1	1	3	0	0	21	5	8	1	41	5

APPENDIX TABLE E-5. NUMBER OF HUDSON RIVER STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS OR EMPTY STOMACHS, CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1994-95 PROGRAM.

LENGTH GROUP (MM TL)	INVERTEBRATE REMAINS	VERTEBRATE REMIANS	ATLANTIC TOMCOD	VERTEBRATE AND INVERTEBRATE	EMPTY	TOTAL
≤ 200	2	0	0	0	0	2
201-300	2	0	0	0	0	2
301-400	1	0	0	0	0	1
TOTAL	5	0	0	0	0	5

bass 201-300 mm (Table E-6). Detailed comparisons between the 1994-95 and previous years are difficult due to the limited number of dead fish returned for biocharacteristic analysis.

Food habit data from the 1985-86 through 1993-94 programs has displayed several trends (Table E-6). Invertebrates were the dominant food item among non-empty striped bass stomachs. The dominance of invertebrates in stomach contents however decreases when striped bass reach approximately 300 mm (TL). The occurrence of empty stomach also varied with length group. The trend of increasing importance of fish as food items as striped bass length increases has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). No Atlantic tomcod have been observed in any of the striped bass stomachs examined since 1985.

APPENDIX TABLE E-6. **FOOD HABITS OF HUDSON RIVER STRIPED BASS CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 THROUGH 1994-95 PROGRAMS.**

INVERTEBRATES

LENGTH GROUP	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	LENGTH GROUP %
<=200	5	8	3	2	16	3	52	74	35	2	200	28
201-300	88	25	39	9	3	29	85	40	81	2	401	56
301-400	18	16	12	2	1	7	18	12	10	1	97	14
401-500	3	2	2	0	0	0	1	2	0	0	10	1
>500	1	0	1	0	0	0	0	0	0	0	2	<1
TOTAL	115	51	57	13	20	39	156	128	126	5	710	36

VERTEBRATES

LENGTH GROUP	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	LENGTH GROUP %
<=200	1	0	0	1	0	0	2	3	0	0	7	7
201-300	4	0	0	6	0	8	13	4	2	0	37	37
301-400	5	1	3	8	0	8	9	3	6	0	43	43
401-500	3	0	1	0	0	0	2	2	1	0	9	9
>500	1	0	0	0	0	0	1	2	0	0	4	4
TOTAL	14	1	4	15	0	16	27	14	9	0	100	5

INVERTEBRATES AND VERTEBRATES

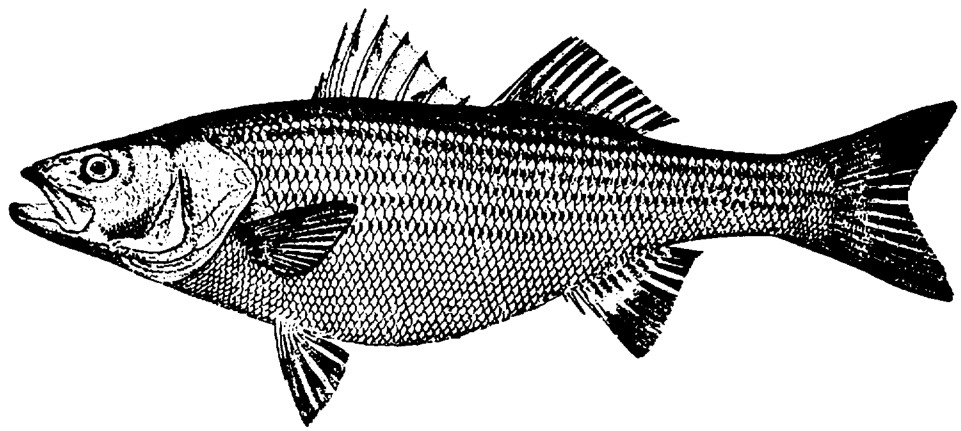
LENGTH GROUP	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	LENGTH GROUP %
<=200	1	0	0	1	0	0	2	8	0	0	12	8
201-300	4	3	4	2	0	8	25	11	6	0	63	40
301-400	8	6	3	7	2	4	21	11	5	0	67	43
401-500	1	3	1	2	1	1	1	3	0	0	13	8
>500	0	1	0	0	0	0	0	1	0	0	2	1
TOTAL	14	13	8	12	3	13	49	34	11	0	157	8

EMPTY

LENGTH GROUP	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	TOTAL	LENGTH GROUP %
<=200	2	20	1	13	11	7	38	88	95	0	275	27
201-300	43	18	15	26	9	35	43	77	209	0	475	47
301-400	41	8	12	13	1	23	18	39	36	0	191	49
401-500	12	3	7	2	0	3	2	11	10	0	50	5
>500	11	0	3	0	0	0	1	1	0	0	16	2
TOTAL	109	49	38	54	21	68	102	216	350	0	1007	51

Hudson River Striped Bass Stock Assessment Program

November 1995 - April 1996



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March 1999

Final Report

Prepared by

LMS

LAWLER, MATUSKY & SKELLY ENGINEERS LLP

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HUDSON RIVER STRIPED BASS
STOCK ASSESSMENT PROGRAM

NOVEMBER 1995 - APRIL 1996

FINAL REPORT

March 1999

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street White Plains, New York 10601

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was less than 1.0% for Age 0+ and Age 1+ fish among the same age cohort of striped bass collected in the Hudson River between 6 November 1995 and 19 April 1996.

- The mean lengths of Age 0+ hatchery (n=2) and wild striped bass (n=207) from the 1995 cohort were not compared due to the small sample size of hatchery fish. The mean lengths of Age 1+ hatchery (n=7) and wild striped bass (n=1501) from the 1994 cohort were significantly different (hatchery was smaller) based on non-overlapping 95% confidence limits (see page 3-8). Hatchery striped bass of the 1990 and 1991 cohorts were not tagged prior to their release, and therefore could not be distinguished from wild fish.

- The 1994 (Age 1+) and 1995 (Age 0+) cohort dominated the catch of Hudson River striped bass during the 1995-96 program. The 1994 and 1995 cohorts represented 64 and 22%, respectively, of the total catch. Age 1+ represented 77% of the population estimate ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in Upper New York Harbor and the Battery region was 949,000 fish, with lower and upper 95% confidence limits of 745,000 and 1,308,000. Age 0+ striped bass accounted for approximately 50,000 fish in the mid-winter population, Age 1+ contributed 734,000 fish, Age 2+ contributed 137,000 fish, Age 3+ contributed 25,000 fish, and Age >3+ contributed 3,000 fish.

- During the 1995-96 striped bass program 11,224 fish ≥150 mm were caught and 10,889 fish in good condition were tagged and released, bringing the total number of striped bass tagged and released in these programs since 1984 to 191,840. Of the 113 fish that were recaptured during the 1995-96 striped bass program, 105 were tagged and released in the present program, six were from the 1994-95 program, and two were from other agency tagging programs.

- Overall mean catch per unit of effort (CPUE) in the Battery and Upper Harbor region was 16.9 striped bass per 10-min tow. Mean CPUE from mid-December through mid-March increased annually from 1985-86 to a peak of 45.3 in the 1989-90 program. Mean CPUE decreased following 1989-90 to 40.7 in the 1990-91 program, 35.5 in the 1991-92 program, 32.7 in the 1992-93 program, 33.7 in the 1993-94 program, 21.9 in the 1994-95 program, and 14.3 in the 1995-96 program.

CHAPTER 1

INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulated that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 3-in. striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York, to address this requirement. Hatchery production and stocking continued from 1991 through 1994 in accordance with paragraph 9 of the Stipulation of Settlement and Judicial Consent Order, entered into by parties to the Settlement Agreement. The total number of hatchery striped bass that were stocked into the Hudson River in each year is (EA 1996):

YEAR	NUMBER STOCKED
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,800
1988	48,611
1989	202,068
1990	234,387
1991	256,631
1992	210,746
1993	568,410
1994	306,529
1995	613,758
Total	3,788,591

Section 2.J and Attachment V of the Settlement Agreement stipulated that an annual biological monitoring program be conducted through May 1991 to evaluate mitigation measures. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow differentiation between hatchery-released striped bass and naturally spawned striped bass. Striped bass produced and stocked during 1990 and 1991 were not tagged; however, tagging of hatchery-reared striped bass resumed in 1992. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that nonhatchery fish be released alive after capture, after they are examined for hatchery administered CWTs. If these striped bass are tagged and released, their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could be used to estimate the annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too costly (MMES 1986) and the assumptions required for fish younger than Age 1+ may be violated (Wells et al. 1991). Consequently, the biological monitoring program focused on estimating the proportional contribution of hatchery stocked striped bass to the Hudson River stocks; estimation of annual survival rate for Age 1+ and Age 2+ fish; and estimation of the Age 1+ and Age 2+ striped bass overwintering stock in the lower Hudson River and Upper New York Harbor area.

The Hudson River striped bass program began in 1984 as an evaluation of fishing gear and techniques that were most efficient and effective for catching and handling striped bass. The best locations, times, and fishing gear were evaluated in the 1984 through 1987-88 programs to maximize total catch and CPUE of Age 1+ and Age 2+ striped bass. The Battery region of the Hudson River adjacent to Manhattan and Upper New York Harbor in the vicinity of Liberty Island provided the most consistent catches of Age 1+ and Age 2+ striped bass during the November through March period. The 9-m trawl was the most effective gear for capturing Age 1+ and Age 2+ striped bass, and has been the only gear used from 1988-89 through the present program (Table 1-1). Concurrent with these gear evaluations, handling techniques were improved to increase the survival of striped bass that were caught, tagged, scanned for hatchery-administered magnetic tags, and released (Dunning et al. 1987, 1989). As the hatchery and biological monitoring program progressed, more striped bass were recaptured with hatchery-administered tags, the magnetic tag detection efficiency was quantified (Mattson et al. 1989), and the internal anchor-external streamer tag design was improved (Mattson et al. 1989; Waldman et al. 1990).

TABLE 1-1

COMPARISON OF SAMPLING DESIGNS AND SELECTED RESULTS OF THE 1984 THROUGH 1994-95 HUDSON RIVER STRIPED BASS PROGRAMS

				CATCH STATISTICS							POPULATION ESTIMATES		
PROGRAM	GEAR	DATES	SAMPLING REGIONS	N-TOWS	CPUE	N-TOTAL	N-TAGGED	N-RECAPTURED	N-HATCHERY	HANDLING MORTALITY (%)	TOTAL (≥200 mm)	AGE 1+	HATCHERY PROPORTION AGE 1+ (%)
1984	12-m trawl	09 Apr-07 Jun	TZ,CH,IP, WP,CW,PK	200	2.8		345[a]		0	18	-	-	
	Scottish seine	09 Apr-07 Jun	TZ,CH,CW	139	2.2		392[a]	-	0	16	-	-	
	Total			339	2.6	1,620	737	0	0	17	-	-	0
1985-86	9-m trawl	11 Nov-18 May	BT	900	8.2		6,366		0	1			
	12-m trawl	11 Nov-18 May	BT,HR,ER, LH	346	20.7	7,265			0	2			
	Total			1,472	12.9	20,820	18,487	171	0	1	540,000	239,000	0
1986-87	9-m trawl	21 Dec-09 May	BT	845	9.8		5,349		74	1			
	12-m trawl	21 Dec-09 May	BT	219	24.1		4,039		20	1			
	Total		BT	1,064	12.7	14,136	9,388	261	94	1	394,000	108,000	1.7
1987-88	9-m trawl	09 Nov-22 Apr	BT	896	20.0	18,075	7,582		175	<1			
	12-m trawl	09 Nov-22 Apr	BT	296	33.9	10,117	4,854		62	1			
	Total		BT	1,192	23.5	28,192	12,436	465	238	<1	295,000	181,000	1.6
1988-89	9-m trawl	31 Oct-15 Apr	BT	1,151	28.5	32,975	24,393	453	213	<1	890,000	794,000	0.2
1989-90	9-m trawl	31 Oct-15 Apr	BT	891	37.3	33,386	24,362	655	141	<1	528,000	397,000	0.4
1990-91	9-m trawl	12 Nov-20 Apr	BT	971	29.7	29,346	22,406	865	52	<1	786,000	352,000	0.2
1991-92	9-m trawl	04 Nov-07 May	BT	1,169	29.3	34,202	25,710	631	17	1	967,000	709,000	[a]
1992-93	9-m trawl	02 Nov-16 Apr	BT	771	34.0	27,778	20,847	345	190	1.6	717,000	475,000	[a]
1993-94	9-m trawl	01 Nov-20 Apr	BT	794	36.2	28,739	16,799	333	134	1.6	379,000	217,000	0.01
1994-95	9-m trawl	07 Nov-14 Apr	BT	819	15.4	12,635	6837	75	54	<1	325,000	225,000	1.0

[a]Hatchery striped bass were not tagged before release in 1990 or 1991. Therefore, an Age 1+ hatchery proportion was not computed.
SAMPLING REGIONS: BT = Battery and Upper New York, Hudson River miles 0-11 9 (km 0-18) and Upper New York Harbor TZ = Tappan Zee, Hudson River Harbor Miles 24-33 (km 38-53)
CH = Croton-Haverstraw, Hudson River miles 34-38 (km 54-61) IP = Indian Point, Hudson River miles 39-46 (km 62-74)
CW = Cornwall, Hudson River miles 56-61 (km 90-98) PK = Poughkeepsie, Hudson River miles 62-76 (km 99-122)
HR = Harlem River ER = East River LH = Lower New York Harbor

The April-June 1984 adult striped bass program (NAI 1985) demonstrated that it was effective to use a 12-m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass ≥300 mm (total length) could be externally tagged and released without significantly increasing 24-hr mortality (Dunning et al. 1987). No hatchery-tagged striped bass were recaptured during the 1984 program, and population estimates were not calculated from the relatively small sample of 737 externally tagged fish that were released (Table 1-1).

The 1985-86 Hudson River striped bass program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean CPUE for a 12-m trawl was greater than for a 9-m trawl, but total catch and mean catch per day were similar for the two trawls because more tows could be taken in a day with the 9-m trawl. Because of a larger mesh size, the 12-m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9-m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm. Striped bass handling mortality was reduced from 17% in 1984 to 1% or less in programs from 1985-86 to the present by using an in-water live car to hold the fish prior to tagging (Dunning et al. 1989). No hatchery-tagged fish were recaptured during the 1985-86 program among the 20,820 striped bass examined for magnetic tags. The midwinter population of striped bass ≥200 mm was estimated to be 540,000 fish in the Battery and Upper New York Harbor; 239,000 of these fish were estimated to be Age 1+ (Table 1-1).

Data from the 1984 and 1985-86 programs (NAI 1985, 1986) were used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of

the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimators could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River striped bass program was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per 10-min tow for both the 9- and 12-m trawls. Use of a cod end liner (2.5-cm stretch mesh) in the 9-m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of a cod end liner in the 12-m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+, and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm, and 108,000 of these fish were Age 1+ (Table 1-1).

The 1987-88 Hudson River striped bass hatchery evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per 10-min. tow for both the 9-m trawl and 12-m trawl with a cod end similar to the 9-m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one-half the catch. The 9-m trawl was more efficient than the 12-m trawl with a 9-m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6% The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm, and 181,000 of these fish were estimated to be Age 1+ (Table 1-1).

The Hudson River striped bass program from 1988-89 to the present has become primarily a Hudson River striped bass stock monitoring program. The program has emphasized consistency of sampling gear and procedures and the refinement of laboratory techniques for scale examination to accurately determine age (e.g., Humphreys et al. 1989). Mark-recapture estimates are calculated for the total population and for the Age 1+ and Age 2+ subpopulations of striped bass found in the combined Battery and Upper New York Harbor regions during the winter. Program consistency is documented through the use of standard operating procedures (SOPs) and a quality assurance/quality control (QA/QC) system that has helped improve data quality (Geoghegan et al. 1989).

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990). The minimum size of striped bass that were tagged was lowered from 200 to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm, and an estimated 794,000 of the fish ≥200 mm were from the strong 1987 Age 1+ cohort (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort (Age 1+ fish) (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm, and an estimated 397,000 of the fish ≥200 mm were from the strong 1988 Age 1+ cohort (Table 1-1).

The striped bass population overwintering in the Battery and Upper Harbor during 1990-91 was estimated as 858,000 fish ≥150 mm or 786,000 fish ≥200 mm (Table 1-1). About 352,000 striped bass ≥200 mm were Age 1+ (NAI 1992). The 1989 cohort of Age 1+ hatchery fish was 0.2% of the Age 1+ catch.

Age 1+ (1990 cohort) and Age 0+ (1991 cohort) fish dominated the population statistics for striped bass caught in the Battery and Upper Harbor during the winter of 1991-92 (NAI 1994). The estimated size of the midwinter striped bass population was 1,163,000 fish ≥150 mm or 967,000 fish ≥200 mm (Table 1-1). Age 1+ striped bass represented 791,000 fish among the population ≥150 mm and 709,000 fish ≥200 mm. Age 2+ and Age 3+ hatchery striped bass were each about 0.3% of the respective cohort's catch. Age 0+ and Age 1+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The estimated size of the midwinter striped bass population ≥150 mm in Upper New York Harbor and the Battery region during 1992-93 was 920,000, fish with lower and upper 95% confidence limits of 677,000 and 1,435,000 (NAI 1995a). The 1991 cohort of Age 1+ striped bass and the 1992 cohort of Age 0+ fish dominated the catch, representing 58% and 22% of the total number of striped bass collected, respectively. Age 1+ and Age 2+ striped bass dominated the midwinter population estimate. Age 1+ striped bass accounted for 671,000 fish, while Age 2+ contributed 180,000. The estimated hatchery proportion of striped bass was 3.0% for Age 0+ and 0.02% for Age 3+ fish. Age 1+ and Age 2+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The 1993-94 program experienced the 20th coldest winter on record for New York City and the coldest in the history of the striped bass program (NAI 1995b). Bank-to-bank ice floes limited access to the Battery and Upper Harbor regions from 17 January through 21 February 1994, and influenced within- and among-program comparisons. The estimated size of the midwinter striped bass population ≥150 mm in Upper New York Harbor and the Battery region during 1992-93 was 443,000 fish, with lower and upper 95% confidence limits of 339,000 and 641,000 (NAI 1995a). The 1992 cohort of Age 1+ striped bass and the 1991 cohort of Age 2+ fish dominated both the catch and midwinter population estimate, accounting 57% (253,000) and 29% (129,000) of the population ≥150 mm, respectively. The estimated hatchery proportion of striped bass was 0.2% for Age 0+, 1.05% for Age 1+ and 0.05% for Age 4+ fish among the same age cohorts.

The striped bass population overwintering in the Battery and Upper Harbor during 1994-95 was estimated at 350,000 fish ≥200 mm. About 225,000 striped bass ≥200 mm were Age 1+ (LMS 1995). No Age 1+ (1993 cohort) hatchery fish among the total Age 1+ fish were captured.

Objectives of the 1995-96 Hudson River striped bass stock assessment program were to:

- Tag wild striped bass greater than or equal to 150 mm collected in the Battery and Upper New York Harbor regions, that are in good condition, with internal anchor tags.
- Determine the catch rate and handling mortality of striped bass collected using the 9m trawl.

- Estimate the abundance of striped bass overwintering in the lower Hudson River.
- Describe the age composition of the overwintering population of striped bass.
- Estimate the proportion of hatchery fish among the Age 0+ through Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

CHAPTER 2

METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1995-96 Hudson River Striped Bass and Atlantic Tomcod Programs Standard Operating Procedures (LMS 1994). These procedures have remained essentially unchanged since the start of the 1988-89 program. The 1995-96 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1, NAI 1995b) with a 9-m trawl (Appendix Table A-1). Sampling locations were selected to maximize the CPUE of striped bass in the lower Hudson River, based on the results of the 1985-86 through 1994-95 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2, NAI 1995b) and released.

From the week of 6 November 1995 through the week of 15 April 1996, the 9-m trawl was deployed in the Upper Harbor or Battery regions. The 9-m trawl was fished in the Battery region for 23 weeks and during 15 weeks in the Upper Harbor region (Appendix Table C-1). No tows were conducted during the week of 8 January 1996 due to ice and severe weather conditions in both the Battery and Upper Harbor regions. Tow duration was 10 min, unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawl were handled in a manner that minimized stress before tagging. The cod end of the net was transferred (while remaining in the water) to the holding facility alongside the boat. Fish were then released from the cod end into the holding facility. Striped bass were then removed from the holding facility for processing using the following procedures:

1. Fish were removed from the live car using a dip net.

2. All surfaces that came in contact with the live fish were wet.

3. Striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps.

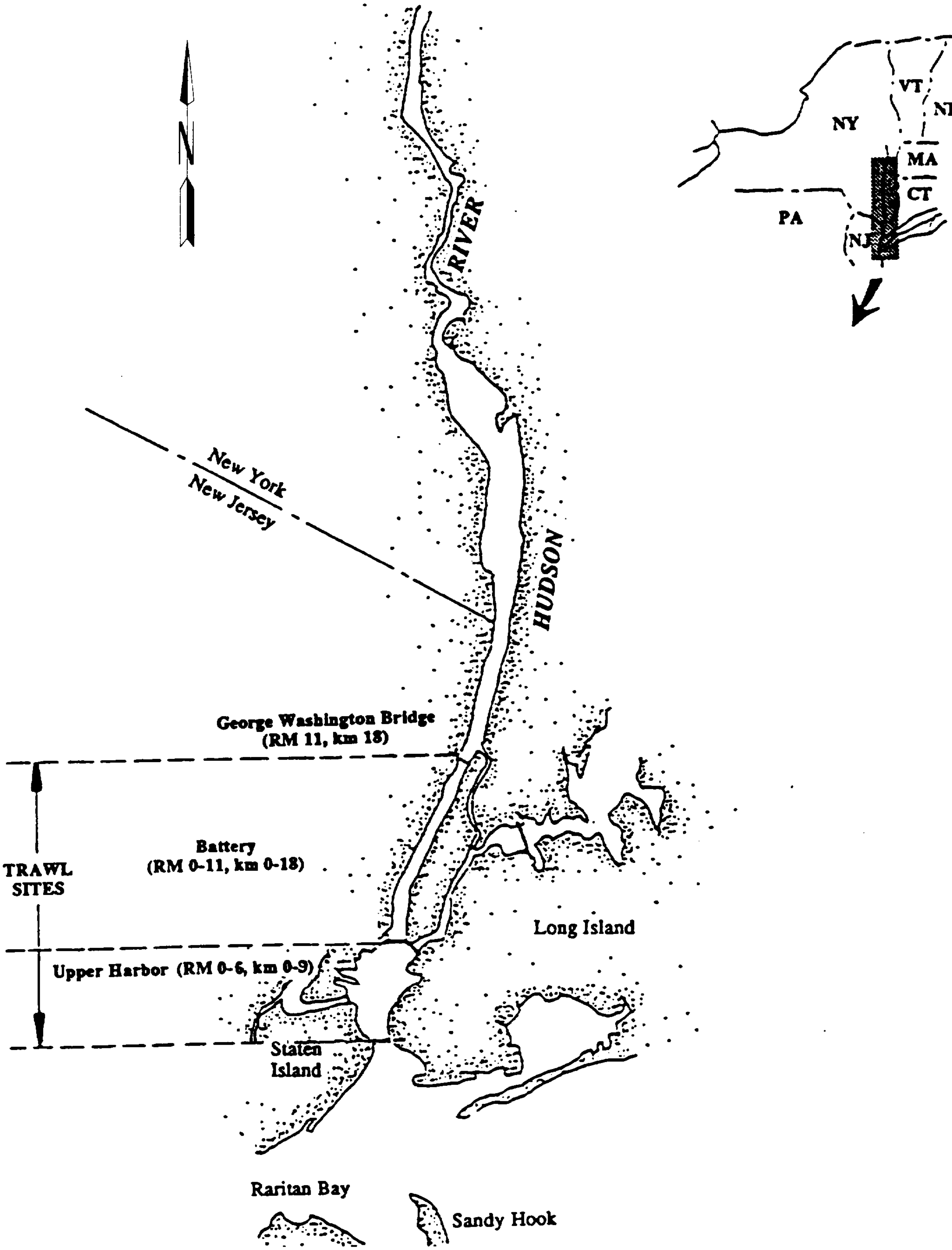
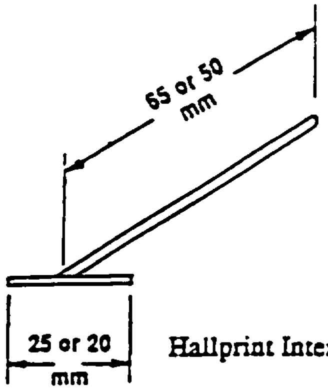
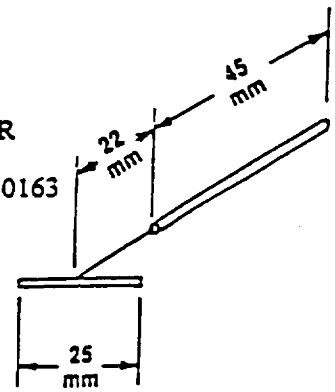


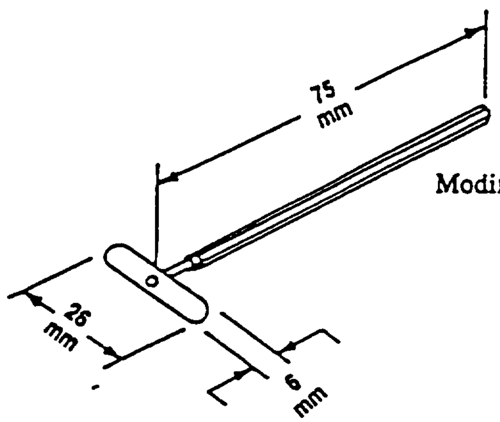
Figure 2-1. Sampling regions in the lower Hudson River and New York Harbor during the winter 1995-96 Hudson River Striped Bass Program.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

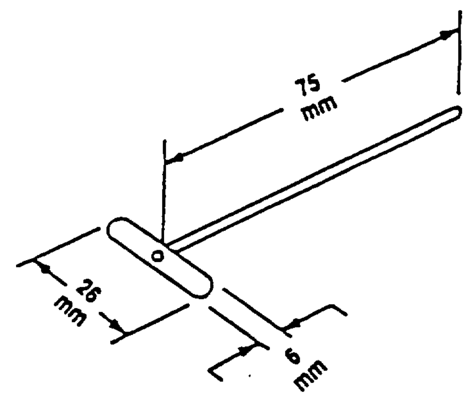
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

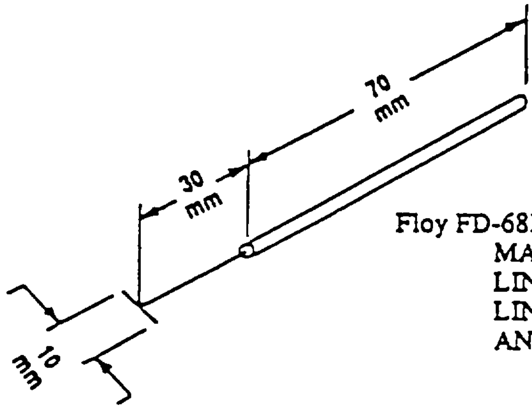




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-present Hudson River Striped Bass Programs.

4. Struggling fish were quieted by covering the head and eyes with a wet hand, cloth, or glove.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for CWTs using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

- No bleeding from gills or body wounds
- No significant loss of scales
- Strong opercular movement
- No obvious external abnormalities such as blindness, fin rot, or skeletal abnormalities

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral midline. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a pointed scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue, and all incisions were treated with a merbromin-based topical antiseptic.

Scale samples were taken from the left side from an area approximately three to four scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Fish less than 100 mm were considered Age 0+. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass were also evaluated.

After processing, striped bass were released into a recovery pen deployed alongside the tagging vessel. The pen was enclosed with netting on four sides, open on the top and bottom, and provided a refuge where striped bass could recover from processing without being preyed on by gulls. Any fish remaining in the recovery pen at the end of sample processing were considered dead. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25 °C for presentation in this report. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random sample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+ striped bass in each 10-mm length group. Expected numbers of Age 1+ striped bass in each 10-mm length group were calculated from age at length data obtained during the current and 1994-95 programs (LMS 1995).

This program was conducted during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1993 and collected anywhere between November 1994 and 15 May 1995 would be designated "Age 1+." This same fish, captured anywhere between November 1995 and 15 May 1996, would be designated "Age 2+."

Striped bass scales were pressed on 0.050-in.-thick, grade GC, acetate sheets with a Carver Press Model-C 12-ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls, and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally, an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment, which would affect computation of CPUE, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-min duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving CPUE. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

2.3.1 Analysis of Catch Characteristics

Characteristics of the catch were described among locations and sampling weeks by analysis of the CPUE, length-frequency, and handling mortality.

2.3.1.1 ***Catch Per Unit of Effort.*** CPUE for the 9-m trawl was defined as catch per 10-min tow (Use Code = 1) and was calculated as:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{C_i}{E_i}\cdot 10\right] \qquad \text{Eq. 1}$$

where

$\overline{X}$ = mean trawl catch per 10-min tow
C_i = total number of fish captured in trawl i
E_i = tow duration of trawl i in minutes
n = number of trawls

2.3.1.2 ***Length-Frequency.*** Length-frequency histograms, with the number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9-m trawl (Use Code = 1 tows). Length-frequency distributions for striped bass caught by the 9-m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 ***Handling Mortality.*** Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1°C temperature interval:

$$Prop\ D_x = D_x / T_x \qquad \text{Eq. 2}$$

where

- $Prop\ D_x$ = proportion of dead striped bass at bottom water temperature x
- D_x = the number of dead striped bass at bottom water temperature x
- T_x = total number of striped bass captured at bottom water temperature x

Comparisons of handling mortality among the 1985-86 through 1995-96 programs were also made using data subsetted to include the same sampling gear deployed during comparable water temperature ranges within the Battery region in each year. Differences in striped bass handling mortality among programs (1985-86 through 1995-96) were assessed by comparing the percentage of dead fish in the catch in 1°C bottom water temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 ***Estimated Number of Striped Bass in Each Age Category.*** A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1995-96 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10-mm length increment and the variance of the proportion of Age 1+ fish in each 10-mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish; it is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n\left[\frac{N_h\sqrt{p_h q_h}}{\sum N_h\sqrt{p_h q_h}}\right] \qquad \text{Eq. 3}$$

where

- n_h = number of scale samples selected for age determination from length group h
- n = number of scale samples to be selected from the total of N fish caught
- N_h = total number of fish caught in length group h
- p_h = proportion of Age 1+ fish in length group h from the laboratory sample
- q_h = 1 - p_h

The stratified sampling plan was designed to select approximately 15% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1994-95 (LMS 1995) were applied to the first of three lots of 1995-96 length-frequency data to permit scale analysis to proceed during the study. Age and length-frequency data from analysis of the first lot of striped bass scales in 1995-96 were then applied to the remaining two lots of 1995-96 scale samples. In each lot (6 November - 31 December, 1 January - 3 March, and 4 March - 19 April), scale samples from approximately 15% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1995-96 program were estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \sum \left(N_h p_{hi} / N \right) \qquad \text{Eq. 4}$$

where

p_{sti} = stratified mean proportion of Age i fish
p_{hi} = proportion of Age i fish in length group h
N_h and N are as defined in Equation 3

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N\left(p_{sti}\right) \qquad \text{Eq. 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2 p_{sti}$) was calculated by the method of Cochran (1977, Equation 5.53):

$$S^2 p_{sti} = 1/N^2 \left[\Sigma [N_h^2 \left(N_h - n_h\right)\left(N_h - n_h\right)][\left(p_{hi} q_{hi}\right)/\left(n_h - 1\right)] \right] \qquad \text{Eq. 6}$$

where

N, N_h, n_h, q_{hi} and p_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977, Equations 5.14 and 5.15):

$$95\%\ CI\ for\ p_{sti} = p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 7}$$

$$95\%\ CI\ for\ A_i = N_{sti} p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 8}$$

where

$s_{p_{sti}} = \sqrt{S^2 p_{sti}}$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16)

p_{sti}, A_i, N_{sti}, $s^2_{p_{sti}}$ are defined in Equations 4-7

2.3.2.2 ***Stratified Mean Length in Each Age Category.*** The mean length of striped bass of a given age that were caught in the 1995-96 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi} \bar{y}_{hi} \right] \Big/ N_i \qquad \text{Eq. 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught
$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample
n_{hi} = number of Age i fish caught in length group h
N_i = number of Age i fish caught in the program
L = number of length groups in which at least two Age i fish were measured; if only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24, with the assumption that N_i is large and substantially larger than n_i; therefore, $N_i^{-1} \approx 0$ and $g'_i \approx 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L}\left[w_{hi}\left(S^2_{hi}/n_i V_{hi}\right)\right] + \left(1/n'_i\right)\sum_{h=1}^{L} w_{hi}\left(\bar{y}_{hi} - \bar{y}_{sti}\right)^2 \qquad \text{Eq. 10}$$

where

$S^2_{\bar{y}_{sti}}$ = two-phase variance of the stratified mean length of striped bass of Age i

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes theorem presented in Equation 11

S^2_{hi} = variance of the mean length of Age fish in length group of the laboratory sample

n'_i = total number of Age i fish in the laboratory sample

V_{hi} = proportion of Age i fish in length group h

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P\left(L_h|A_i\right) = \left[P\left(L_h\right)\, P\left(A_i|L_h\right)\right]/P\left(A_i\right) \qquad \text{Eq. 11}$$

where

W_{hi} is as defined in Equation 10

A_i = Age i striped bass

$P(L_h)$ = proportion of the total catch of striped bass in length group h

$P(A_i|L_h)$ = proportion of aged fish in length group h that are Age i

$P(A_i)$ = proportion of Age i fish in the total catch

CIs for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\%\ CI\ for\ \bar{y}_{sti} = \bar{y}_{sti} \pm\ t\ S_{\bar{y}_{sti}} \qquad \text{Eq. 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for a = 0.05 based on n_i'-1 degrees of freedom (not the effective degrees of freedom)

$\bar{y}_{sti}$ = as defined in Equation 9

2.3.3 **Estimated Hatchery Proportion**

All striped bass caught during the winter 1995-96 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and taken to the Verplanck hatchery for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / \left(H_{ai} + W_{ai} \right) \qquad \text{Eq. 13}$$

where

P_{ai} = proportion of Age i hatchery striped bass in the population adjusted for tag loss and nondetection of tags

H_{ai} = number of Age i verified hatchery recaptures caught adjusted for tag loss and nondetection of tags

W_{ai} = number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai})

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and nondetection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1 - TAG_i)(1 - NDET) \right] \qquad \text{Eq. 14}$$

where

H_{ai}	=	adjusted number of Age i hatchery striped bass caught
H_i	=	number of Age i verified hatchery recaptures caught
TAG_i	=	weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-1)
NDET	=	decimal percent nondetection rate for magnetic tags during the recapture program
	=	$[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected when both detectors were used

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Chapter 1) was not adjusted for handling mortality (Dunning et al. 1989) because handling mortality was minimal (<1%) and could not be associated with each lot of tagged fish stocked into the Hudson River (EA 1996).

2.3.4 Recaptured Striped Bass

Three groups of recaptured, internal anchor-tagged striped bass were considered: (1) fish recaptured from previous programs (cross-year recaptures); (2) fish caught, tagged, released, and recaptured within the current (1995-96) program (within-year recaptures); and (3) fish recaptured with external streamer tags from other programs (other recaptures). All cross-year recaptures were examined to determine the condition of the tag legend and insertion site, recapture rate, mean length, and days at large. We also determined the age and growth for cross-year recaptures by examining the scale samples taken at the time of release and time of recapture. Within-year recaptures consisted of two groups of striped bass: fish that were tagged and released (REL_REC = 1), and fish that were tagged and released but exhibited one or more gross anatomical

TABLE 2-1

FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOG LOSS (TAG_i) AND NONDETECTION OF TAGS (NDET) DURING 1995-96

COHORT	AGE	TAG_i	NDET
1995	0+	0.040[a]	0.00000[b]
1994	1+	0.032	0.00000
1993	2+	0.071	0.00000
1992	3+	0.029	0.00000
1991	4+	c	c
1990	5+	c	c
1989	6+	0.057	0.00000
1988	7+	0.017	0.00000
1987	8+	0.0147	0.00000
1986	9+	0.075	0.00000
1985	10+	0.065	0.00000
1984	11+	0.276	0.00000

[a]Weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (EA 1996).

[b]Weighted nondetection rate based on a nondetection rate of 0.00000 for hatchery recaptures checked with two detectors.

[c]Hatchery fish were not tagged prior to release in 1990 or 1991.

abnormalities (REL_REC= 6). Both groups of within-year recaptures were examined to determine the tag condition, recapture rate, mean length, and days at large. Within-year recaptures that were in good condition at the time of release were also used for a mark-capture estimate of population size (Section 2.3.6). LMS obtained release and recapture information and observed the condition of the tag streamer and insertion site for other agency recaptures.

2.3.5 **Population Movement**

The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$Recapture\ rate = R_{ij} / M_{ij} \qquad \text{Eq. 15}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
M_{ij} = number of tagged striped bass released during time period (week) i in region j

$$Recapture\ proportion = R_{ij} / C_{ij} \qquad \text{Eq. 16}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j

2.3.6 **Population Size**

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator that permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i), with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$, where ß is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals (R_i/C_i- βM_i) are weighted by the catch (C_i), then N^{-1} equals the slope, ß.

The Schumacher-Eschmeyer estimator (Ricker 1975) is:

$$N = \sum\left(C_i M_i^2\right) / \sum\left(R_i M_i\right) \qquad \text{Eq. 17}$$

where

- N = estimated population size
- C_i = total catch during time interval i
- M_i = total number of marked fish tagged and released in good condition and available for recapture at the midpoint of time interval i
- R_i = number of recaptured fish in Ci

The variance of the reciprocal of the population size (l/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\sum\left(R_i^2/C_i\right) - \left(\sum R_i M_i\right)^2 / \sum\left(C_i M_i\right)}{m-1} \qquad \text{Eq. 18}$$

where

- S^2 = mean of squared deviations from the regression model described above
- m = number of data points in the regression, and C_i, M_i, and R_i are as defined above in Equation 17

The 95% CI for the reciprocal of the population size (1/N) is computed as

$$CI = S^2 / \sum C_i M_i^2 \cdot t_{m-1} \qquad \text{Eq. 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and $\alpha = 0.05$

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.7 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish recaptured after being at large one or two years was compared within cohort to growth from scale samples taken from untagged fish caught at the time the tagged fish were recaptured in the 1988-89 through 1993-94 programs. Growth was measured as the distance from the focus to each annulus along a radial line originating at the focus and running perpendicular to the anterior edge of the scale (radius measurement).

CHAPTER 3

RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9-M TRAWL

3.1.1 Catch Per Unit of Effort

A total of 166 10-min tows (Use Code = 1) were completed with the 9-m trawl in the Battery region, and 640 tows were completed in the Upper Harbor region of the lower Hudson River between 6 November 1995 and 19 April 1996. Sampling effort (i.e., number of tows) varied between regions in order to maximize the CPUE of striped bass in the lower Hudson River. The mean CPUE for striped bass in the Upper Harbor region was 15.47 fish per 10-min tow. (Table 3-1). The mean CPUE for striped bass in the Battery region was 22.49 fish per 10-min tow for all sampling weeks combined (Table 3-1). Most of the sampling effort was concentrated in the Battery region following the week of 4 December 1995 (Appendix Table C-1). Mean CPUE exceeded 30 striped bass per 10-min tow during the weeks of 13 November, 27 November, and 4 December 1995 and 15 April 1996 in the Upper Harbor region and during the weeks of 11 December, 18 December, 25 December 1995 and 1 January 1996 in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 45 striped bass per 10-min tow during the last week of sampling (15 April 1996) in the Battery region (based on four tows). The next highest weekly mean CPUE occurred during the week of 27 November in the Battery region, when an average of 43.3 striped bass were collected in 19 tows.

The highest CPUE was at harbor/river mile (RM) 1 of the Upper Harbor region (Appendix Table C-2). The CPUE was based on 95 tows at this location, approximately 12% of the overall sampling effort. Consistently high catches (> 15 mean CPUE) occurred at RM 6 and 9 of the Battery region, where 53% of the sampling took place.

A comparison of mean CPUE for the 9-m trawl in the Battery region during common time periods, indicates mean CPUE increased in each program from 8.1 in 1985-86 to a peak of 45.3 striped bass per 10-min tow in 1989-90 (Table 3-2). After the peak CPUE in the 1989-90 program, CPUE decreased to the present level of 14.3 striped bass per 10-min tow for the 1995-96 program. The increased CPUE observed during the 1988-89 and 1989-90 programs may be due to the complete

TABLE 3-1

MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9-m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1995-96.

REGION	NUMBER OF TOWS	NUMBER OF FISH COLLECTED	MEAN CPUE	S.E.
Battery	166	3,734	22.49	2.22
Upper Harbor	640	9,902	15.47	0.66

NOTE: Includes only valid (use code = 1) samples.

CPUE = Catch per unit effort (catch per ten minute tow)
S.E. = Standard error

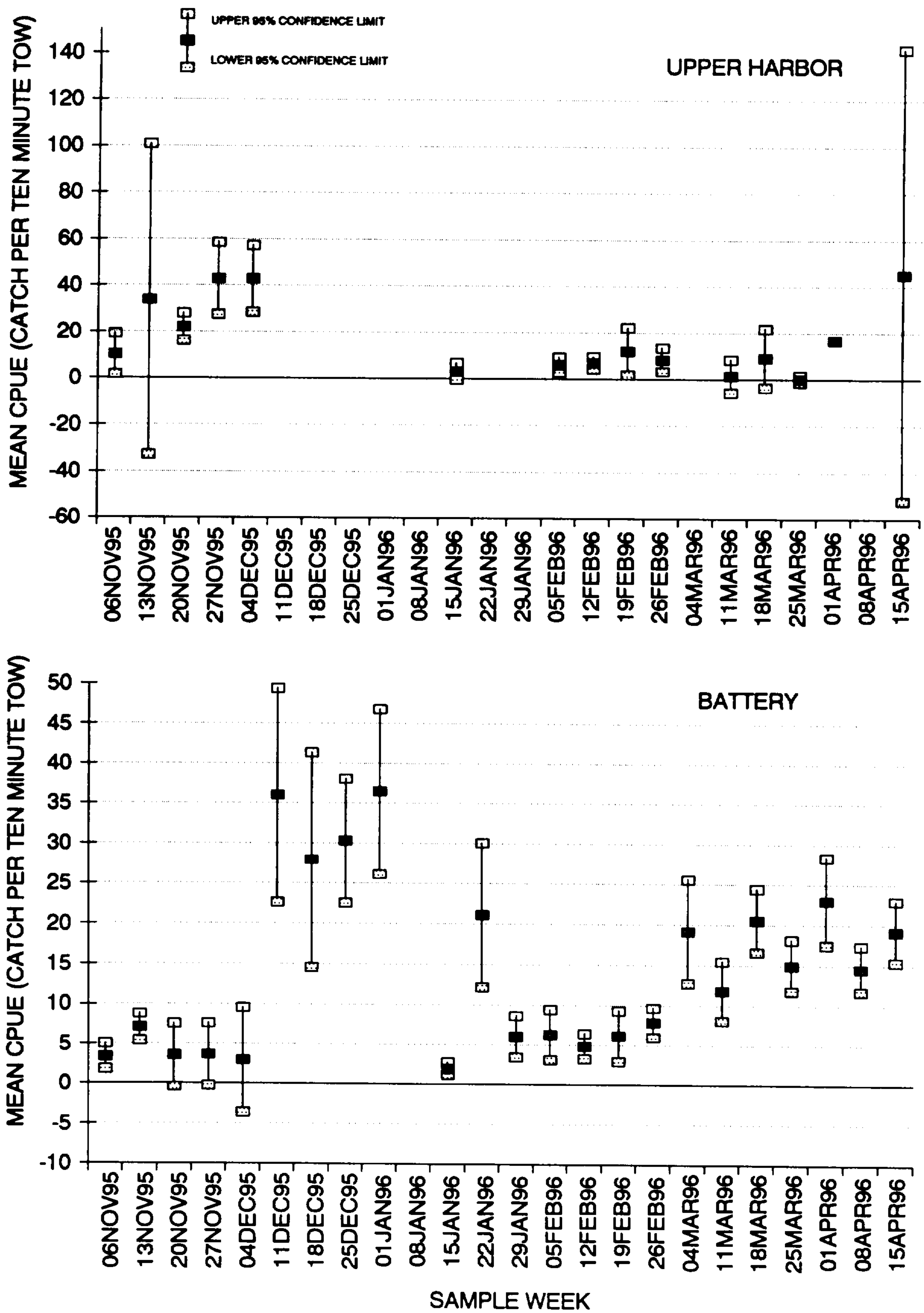


Figure 3-1. Weekly mean catch per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1995-96.

TABLE 3-2

MEAN CATCH PER UNIT (CPUE) OF STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1995-96

YEAR	PERIOD	NUMBER OF TOWS	MEAN CPUE	95% CI
1985-86	23 Dec 85 - 21 Mar 86	638	8.1	±1.0
1986-87	21 Dec 86 - 21 Mar 87	385	12.2	±1.2
1987-88	20 Dec 87 - 19 Mar 88	437	28.5	±2.5
1988-89	19 Dec 88 - 18 Mar 89	527	38.9	±3.3
1989-90	18 Dec 89 - 16 Mar 90	458	45.3	±4.3
1990-91	17 Dec 90 - 15 Mar 91	477	40.7	±3.5
1991-92	23 Dec 91 - 21 Mar 92	578	35.5	±2.2
1992-93	21 Dec 92 - 20 Mar 93	397	32.7	±2.9
1993-94	20 Dec 93 - 20 Mar 94	341	33.7	±5.2
1994-95	19 Dec 94 - 19 Mar 95	291	21.9	±2.2
1995-96	18 Dec 95 - 17 Mar 96	299	14.32	±2.0

NOTE: CPUE = Catch per unit effort (catch per ten minute tow).
Includes only valid (use code = 1) samples.

recruitment of the numerically dominant 1987 and 1988 year classes to the 9-m trawl (CES 1989). The decrease in CPUE observed after the 1989-90 program may be due to increased gear avoidance, migration, or mortality of the 1987 and 1988 year classes and lower abundance of the 1989 through 1993 year classes.

3.1.2 Length-Frequency Distribution

The overall mean length of striped bass caught by the 9-m trawl in the Battery region was 228 mm during the 1994-95 program (Table 3-3). The length-frequency distribution for the 9-m trawl was (1) skewed right, i.e., more fish were smaller than the mean length than would be expected if the distribution were bell-shaped; (2) leptokurtotic, i.e., more fish were found closer to the mean length than would be expected if the distribution were normal; and (3) bimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 201- to 250-mm and 251- to 300-mm length groups.

Weekly mean length of striped bass collected by the 9-m trawl in the Battery region ranged between 224 and 263 mm for the first eight weeks of the program and then decreased to 151 mm during the week of 29 January 1996 (Appendix Table C-5). Weekly mean length of striped bass caught in the Battery region generally increased for the remaining 11 weeks of the sampling program. Weekly mean length in the Upper Harbor region was also high during the first five weeks of the sampling period, ranging between 234 and 269 mm. Mean length then decreased during February, to approximately 200 mm. Mean length was highest (284 mm) in the Upper Harbor region during the week of 15 April 1996, the last week of the sampling program, and lowest (103 mm) during the week of 11 March 1996. However, mean length for this week was based on only five fish. Weekly mean length for both the Upper Harbor and Battery regions generally decreased from early weeks before increasing at the end of the program. This pattern is similar to that observed in previous years (1991-92, 1992-93, and 1993-94) where mean length was greatest during the early weeks of the program and then steadily declined.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50-mm length classes, indicated that larger fish in the 201 to 300-mm length classes predominated trawl collections prior to 1 January 1996 (Figure 3-3). Beginning the week of 1 January 1996, catches of smaller length classes (101 to 200 mm) increased and remained steady until the week of 25 March 1996, when catches diminished. Weekly mean CPUE in the 101- to

TABLE 3-3

DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED BY A 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER WINTER 1995-96

N	MEAN (mm)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
13,641	228	72.6	0.44 ± 0.03	2.76 ± 0.06	64	1060	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I.= 95% confidence interval

Right skewness = Positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.

Leptokurtosis = Positive kurtosis indicating more striped bass were closer to the mean length than would be expected from a normal distribution.

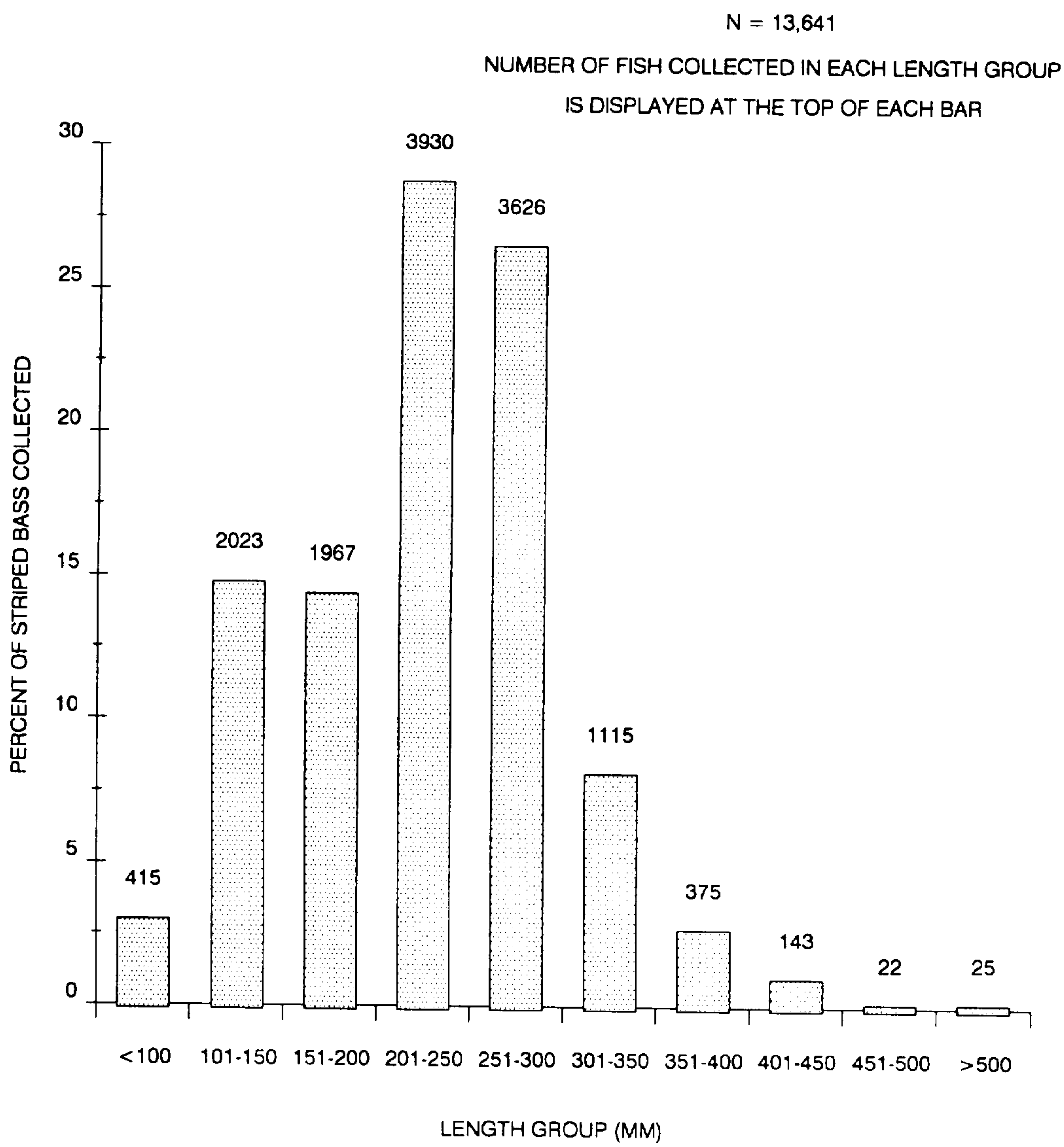


Figure 3-2. Length-frequency distribution for striped bass collected by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1995-96.

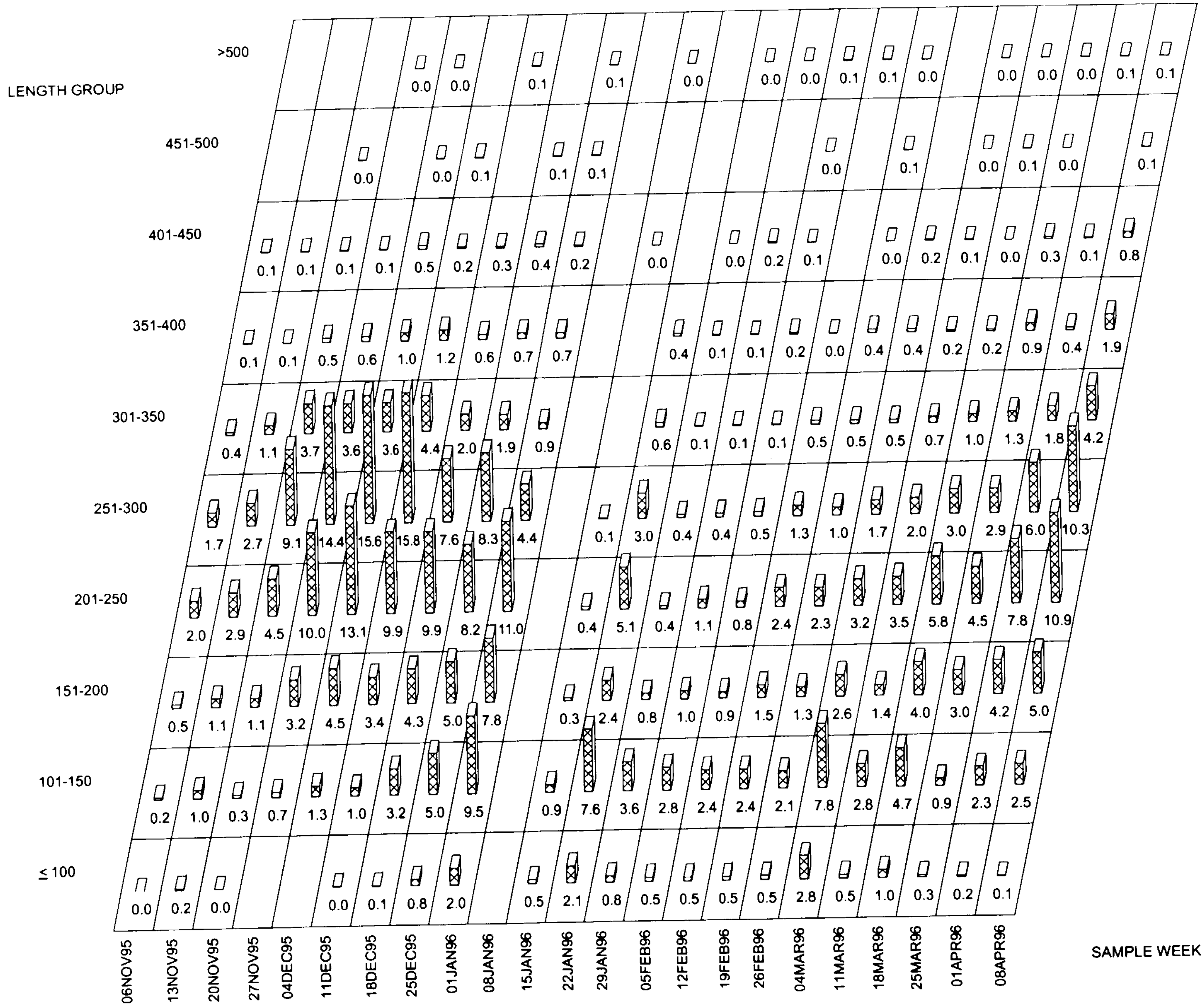


Figure 3-3. Weekly length-frequency distributions for striped bass collected per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1995-96.

150-mm length class reached a high of 9.5 fish per tow during the week of 1 January 1996 (Appendix Table C-6). Larger length classes (201 to 350 mm) dominated in the remaining three weeks of the sampling program. The highest mean catch per tow over all weeks was 15.8 striped bass in the 251- to 300-mm length class during the week of 11 December 1995.

The standardized length-frequency of striped bass captured during the winter of 1995-96 was bimodal with peaks in the 101-150 mm and 201-250 mm length groups (Figure 3-4). Bimodal length-frequencies previously occurred during the winters of 1986-87, 1987-88, 1990-91, 1991-92, 1993-94, and 1994-95. The peak between 201 and 250 mm probably represents the 1994 year class at age 1+, while the peak between 101 and 150 mm represents the 1995 cohort of age 0+ striped bass.

3.1.3 **Handling Mortality**

Striped bass handling mortality in the 9-m trawl was less than 0.1% during 1995-96 at bottom water temperatures from 0 to 19°C (Table 3-4). A total of 209 striped bass died out of 13,615 fish caught in Use Code = 1 tows that had river bottom water temperature data associated with each tow. The highest handling mortality of 4.9% (70/1424) occurred at a bottom water temperature of 3°C. An interaction between water temperature, fish length and immediate handling mortality was not significant in previous programs (Dunning et al. 1989). However, recent programs, 1992-93 through 1994-95, have displayed a pattern of higher handling mortality at lower bottom water temperatures (≤ 8°C) when compared to mortality at higher bottom water temperatures (> 8°C). Recent program data have not been examined for an interaction between water temperature, fish length, and immediate handling mortality. Immediate handling mortality should not affect mark-recapture estimates because field crews remove fish that are dead or considered to be in poor condition after tagging prior to their release.

Striped bass handling mortality in the 1995-96 program was the lowest observed in recent programs (Table 3-5). The apparent increase in handling mortality observed in the 1991-92 through 1993-94 programs was probably due to an underestimate of handling mortality during the 1985-86 through 1990-91 programs. During the 1985-86 through 1990-91 programs, bird predation was not factored into the program handling mortality. All striped bass that were not immediately identified as dead upon release were assumed to have survived. However, at the end of the 1990-91 program bird predation on released striped bass was quantified. Approximately

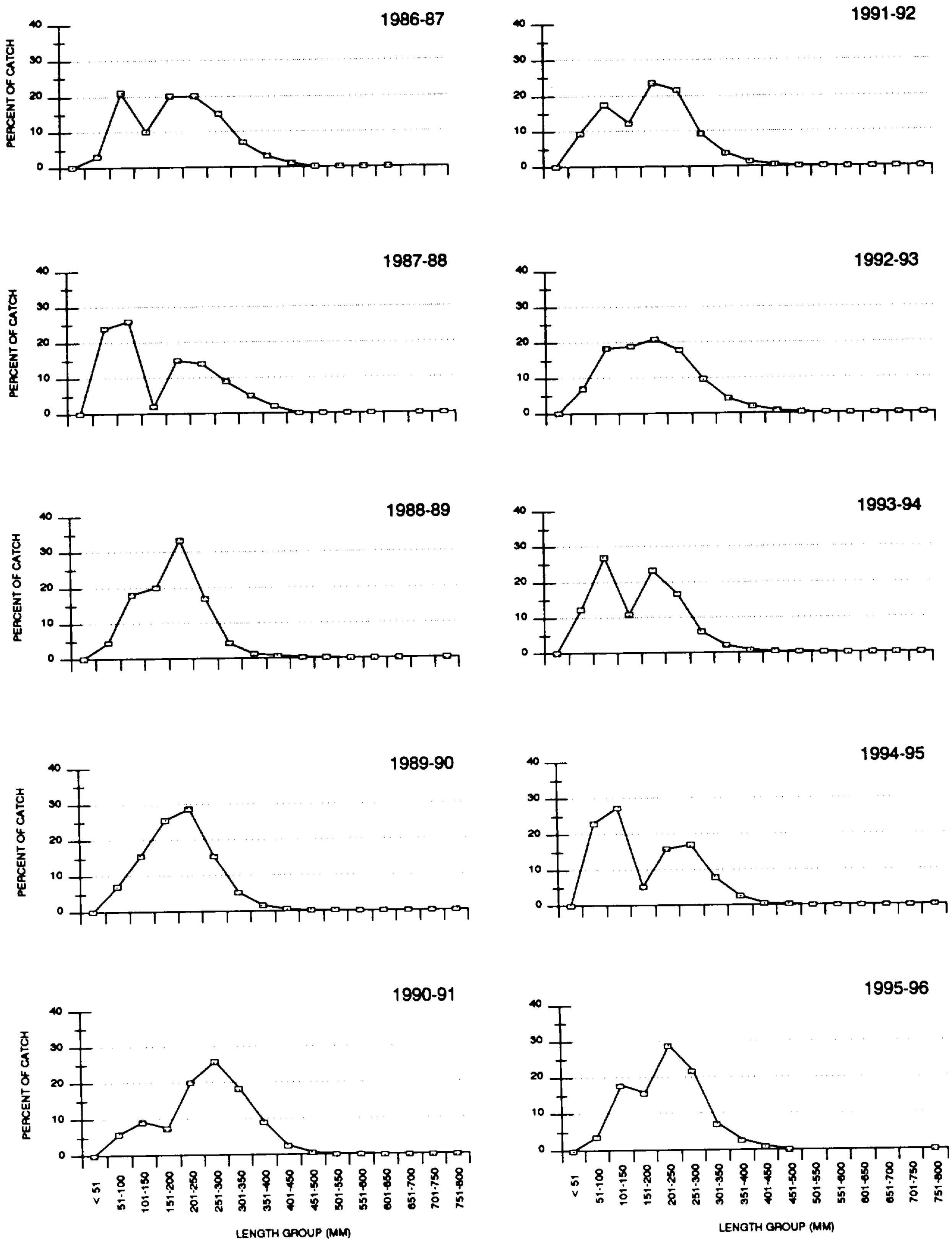


Figure 3-4. Standardized (50mm interval) length-frequency of striped bass collected in the 9m trawl in the Battery region of the Hudson River, winter 1995-96.

TABLE 3-4

HANDLING MORTALITY FOR STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER IN RELATION TO BOTTOM WATER TEMPERATURE, WINTER 1995-96

BOTTOM WATER TEMPERATURE (°C)	PERCENT OF CATCH DEAD (%)	NUMBER DEAD	TOTAL CATCH
0.0	2.3	2	86
1.0	0.6	2	348
2.0	3.3	29	884
3.0	4.9	70	1424
4.0	0.7	3	448
5.0	1.2	8	664
6.0	1.5	18	1180
7.0	1.7	34	1989
8.0	0.2	4	1935
9.0	0.9	17	1790
10.0	0.2	1	578
11.0	1.0	16	1617
12.0	1.1	5	447
13.0	0.0	0	125
14.0	0.0	0	89
15.0	0.0	0	1
19.0	0.0	0	10
0.0-19.0	<0.1	209	13615

NOTE: Mortality expressed as the percentage of dead striped bass collected in a temperature increment.
Mortality calculated from catch data for valid (Use Code = 1) tows for which bottom water temperature was available.

TABLE 3-5 (Page 1 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1995-96 HUDSON RIVER STRIPED BASS PROGRAMS

BOTTOM WATER TEMPERATURE (°C)	1985-86 THROUGH 1990-91		1991-92		1992-93	
	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	0.3	58/16,781	1.3	20/1,557	1.4	80/5,940
4	0.3	51/16,155	0.5	45/9,685	3.5	107/3,090
5	0.3	58/21,071	0.2	13/5,419	2.2	86/3,585
6	0.2	43/18,783	1.5	98/6,438	1.8	44/2,380
7	0.4	43/11,785	1.0	26/2,728	1.2	16/1,347
8	0.2	20/8,731	1.4	29/2,135	2.2	17/756
9	0.5	29/5,709	0.9	10/1,133	0.2	3/1,361
10	0.2	8/4,843	1.1	21/1,897	0.7	6/806
11	0.3	11/3,185	0.6	5/879	0.5	17/3,406
12	0.3	6/1,995	0.5	1/187	0.2	1/434
3-12°C	0.3	327/109,038	0.8	268/32,058	1.6	377/24,307

Dx = Number of dead striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of striped bass collected at a temperature (Use Code = 1 samples only).

TABLE 3-5 (Page 2 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1995-96 HUDSON RIVER STRIPED BASS PROGRAMS

BOTTOM WATER TEMPERATURE (°C)	1993-94		1994-95		1995-96	
	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	3.0	69/2,260	1.3	17/1,310	4.9	70/1,424
4	3.3	156/4,713	0.3	6/1,759	0.7	3/448
5	1.2	53/4,438	0.6	15/2,692	1.2	8/664
6	2.0	65/3,206	0.4	8/1,987	1.5	18/1,180
7	1.4	36/2,564	0.3	4/1,585	1.7	34/1,989
8	2.1	29/1,354	0.6	2/326	0.2	4/1,935
9	0.5	1/196	0.2	1/640	0.9	17/1,790
10	0.0	0/91	0.4	3/836	0.2	1/578
11	0.3	4/1,424	0.0	0/295	1.0	16/1,617
12	0.5	2/243	0.0	0/69	1.1	5/447
3-12°	2.0	415/20,669	0.5	56/11,496	<0.1	176/12,072

Dx = Number of dead striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of striped bass collected at a temperature (Use Code = 1 samples only).

2.4% of the 2969 tagged striped bass released between 12 March and 12 April 1991 were removed from the water by gulls (NAI 1992).

Field procedures were modified during subsequent programs to both quantify and minimize gull predation. After tagging, fish were released into a recovery pen that was deployed in the water alongside the boat. The pen was a 1-m x 2-m x 1-m deep enclosure with 0.9-cm mesh netting on four sides, open on the top and bottom, with the top of the frame suspended at the water surface. Striped bass released into the pen were provided a refuge alongside the boat where they could recover from handling stress without drifting away from the boat during recovery and possibly being preyed upon by gulls. Fish in good condition typically escaped from the pen through the bottom. Stunned fish typically remained at the surface for several minutes until they recovered and escaped through the bottom of the pen. Any fish remaining in the recovery pen at the end of sample processing were considered dead and were removed and taken to the laboratory. A field technician also observed fish as they escaped from the recovery pen and recorded instances of gull predation. These procedures both minimized gull predation and accurately recorded handling mortality.

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

Age-length frequency histograms, presented by 10-mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5), demonstrate little overlap in size of Age 0+ and Age 1+ striped bass caught during the 1995-96 program. Age-length frequency distributions are based on scale samples from a stratified random sampling of about 15% of the total catch (See Section 3.2.2). Most of the fish in each length group <170 mm were Age 0+, while most of the fish in length groups between 160 and 319 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size, primarily between 220 and 349 mm. Age 3+ striped bass overlapped with Age 2+ fish, primarily between 270 and 499 mm.

The 9-m trawl with 7.6-cm (stretch) mesh in the body and 3.8-cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1995-96 programs. Therefore, the striped bass catch by this 9-m trawl was used for comparisons of mean length at age

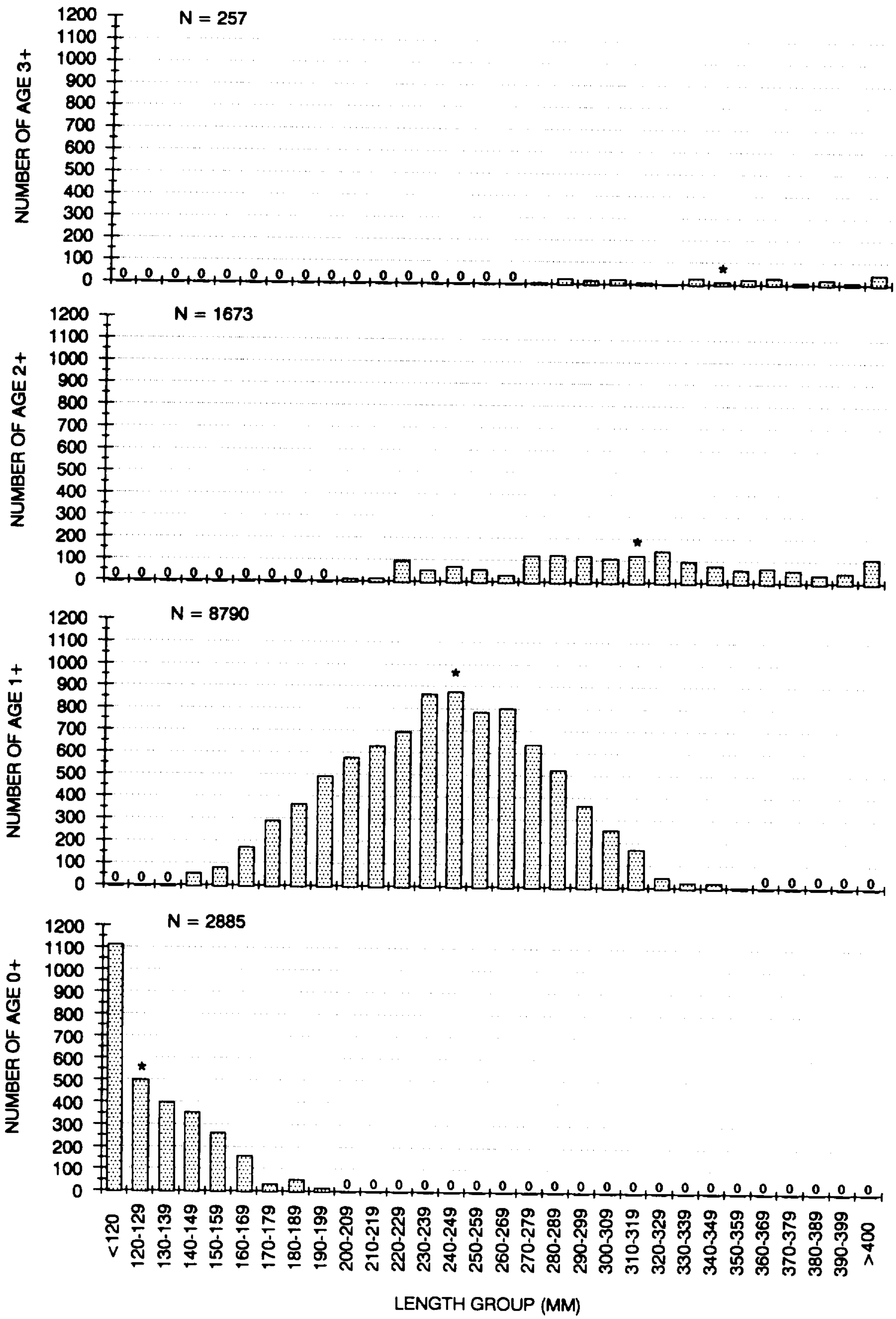


Figure 3-5. Length-frequency distributions for Age 0+, 1+, 2+ and 3+ striped bass collected by the 9m trawl in the lower regions of the Hudson River, winter 1995-96.

Note: * = length group containing the stratified mean length at age.

among programs. Overlap of the 95% confidence intervals about the estimated mean length of each age cohort was used for the comparison of mean length at age.

The 1995 wild cohort of Hudson River striped bass at Age 0+ was the largest in mean length among recent (1992 through 1994) Age 0+ cohorts (Figure 3-6; Appendix Table C-7). The 1986 and 1991 Age 0+ cohorts were similar in mean length.

At Age 1+ the 1994 cohort was the third largest Age 1+ cohort since 1985, with a mean length of 251 ±2 mm. The 95% CIs overlapped with the 1986 cohort. Previous Age 1+ cohorts range from mean lengths of 214 to 260 mm. The 1992, 1991, 1990, 1989, 1987, and 1985 cohorts at Age 1+ were similar in mean length, while the 1988 cohort was the smallest.

The 1993 cohort at Age 2+ was the smallest in length compared to the five previous Age 2+ cohorts (1988 through 1992). The 1990 cohort remained the largest at Age 2+, with a mean length of 329 ±4 mm. The 95% CIs for the 1993, 1992, and 1991 cohorts overlapped, indicating similarity among the estimated mean lengths. Estimated mean lengths of the 1984 and 1987 cohorts were the smallest of the Age 2+ cohorts examined.

CIs about the estimated mean length at Age 3+ for the 1992 cohort overlapped among the 1991, 1990, 1987, 1986, 1984, and 1983 cohorts. However, the estimated mean length at Age 3+ of the 1992 cohort ranked smallest, while the 1990 cohort ranked largest.

3.2.2 Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass

Stratified random sampling of about 15% of the scale samples resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-6). For the allocation of 2121 scale samples actually selected, the precision based on 95% confidence limits was 1.6%, corresponding to an error term of ±141 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than about 10% of the total sample (1,364 fish in 1995-96). For example, doubling the number of striped bass scale samples examined for age determination from 3000 to 6000 would not improve the precision of the estimate by more than 0.6% (Table 3-6). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (8790) out

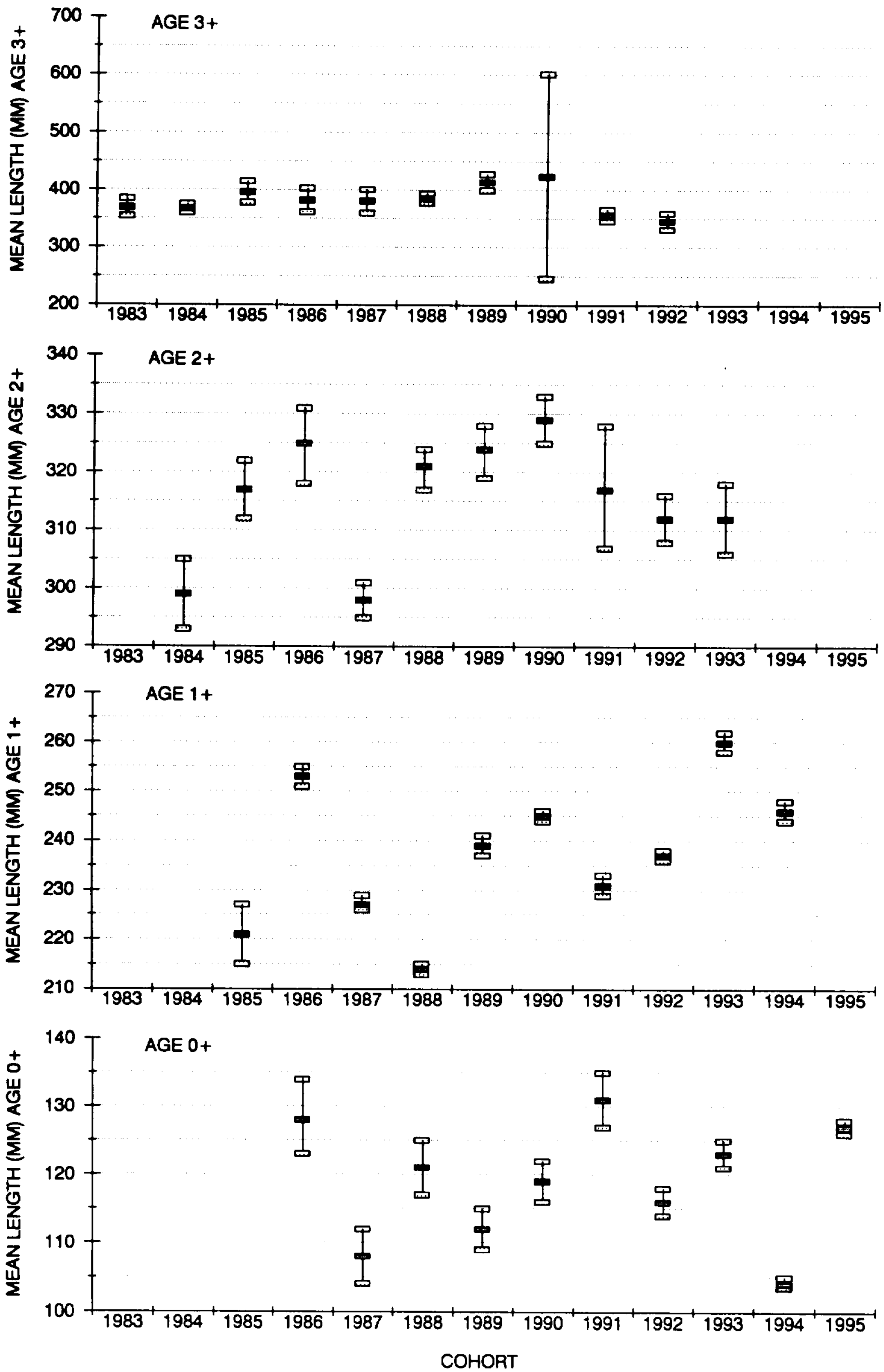


Figure 3-6. Mean length at age and 95% confidence interval for Age 0+ through Age 3+ wild striped bass of the 1983 through 1995 cohorts collected in the Hudson River.

TABLE 3-6

RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

		ESTIMATED NUMBER OF AGE 1+ STRIPED BASS COLLECTED			
SAMPLE SIZE	**PROPORTION AGE 1+**	**STRATIFIED TOTAL[b]**	**LOWER 95% C.I.**	**UPPER 95% C.I.**	**PRECISION (%)[a]**
500	0.645	8,790	8,467	9,112	3.7
1,000	0.645	8,790	8,571	9,009	2.5
2,000	0.645	8,790	8,644	8,936	1.7
2,121[c]	0.645	8,790	8,649	8,930	1.6
3,000	0.645	8,790	8,678	8,902	1.3
4,000	0.645	8,790	8,699	8,881	1.0
5,000	0.645	8,790	8,714	8,865	0.9
6,000	0.645	8,790	8,726	8,853	0.7
7,000	0.645	8,790	8,737	8,843	0.6

[a]Precision = 95% confidence interval (C.I.) half width/stratified total x 100.

[b]Based on 13,636 striped bass caught in Use Code = 1 sample.

[c]Results for sample size = 2121 are based on actual allocation from Use Code = 1 sample, which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

of the 13,636 fish caught in Use Code = 1 samples during 1995-96 could be estimated with 95% confidence limits of ±322 fish (precision = 3.7%, Table 3-6).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10-mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design also yields a precise estimate of the proportion and number of Age 0+ through Age 2+ striped bass (Table 3-7), which collectively constituted 33.4% of the fish caught in this program. Only 257 of the 13,636 striped bass caught in Use Code = 1 samples were estimated to be Age 3+, and 32 of the fish caught were older than Age 3+ in the 1995-96 program.

The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1994 cohort of Age 1+ striped bass was approximately 64% of the total catch during 1995-96. The number of Age 2+ striped bass (1993 cohort) was estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ was wider, and the sample size was smaller for these fish.

3.3 STRIPED BASS HATCHERY PROPORTION

A total of seven Age 1+ striped bass stocked in the Hudson River from the Verplank hatchery in 1994 were collected during the 1995-96 program. Hatchery fish were not tagged in 1990 or 1991 and could not be detected among the Age 4+ or older fish. A total of two Age 0+ striped bass stocked in the Hudson River from the Verplank hatchery in 1995 were collected during the 1995-96 program. Age 0+ hatchery fish represented < 1% of the catch during 1995-96 (Table 3-8), but the reliability of this proportion is unknown because fish of the size range observed for the Age 0+ cohort are probably not fully recruited to the 9-m trawl (Wells et al. 1991).

Comparison of the estimated hatchery proportions for the 1985 and 1986 hatchery cohorts caught in 1986-87 through 1988-89 suggested that the hatchery proportion for each cohort doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; Table 3-9 in this report). However, this trend did not continue for the more recent hatchery cohorts. Prior to 1995, estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the

TABLE 3-7

ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

			ESTIMATED NUMBER OF STRIPED BASS COLLECTED			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% C.I.	UPPER 95% C.I.	PRECISION (%)
0+	1995	0.212	2,885	2,807	2,963	2.7
1+	1994	0.645	8,790	8,649	8,930	1.6
2+	1993	0.123	1,673	1,547	1,799	7.5
3+	1992	0.019	257	198	316	22.9

[a]Based on a laboratory sample of scales from 2,121 striped bass selected by stratified random sampling from 13,636 fish collected (Use Code = 1 samples only).

TABLE 3-8

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER WINTER 1995-96

STATISTIC	COHORT 1995	COHORT 1994
Age	0+	1+
Total hatchery stocking (N_i)	613,758	306,529
Hatchery recaptures (H_i)	2	7
Adjusted hatchery recaptures (H_{ai})	2[a]	7[b]
Wild fish examined (W_{ai})	2,883	8,783
Estimated hatchery proportion ($H_{ai}/(H_{ai}+W_{ai})$)	0.00069	0.00080
Lower 95% C.I.	0.00008	0.00032
Upper 95% C.I.	0.00250	0.00164

[a]Based on a nondetection rate of 0.00000 for age 0+ hatchery recaptures and a weighted decimal percent 24-hr magnetic tag loss of 0.040 (EA 1996).

[b]Based on a nondetection rate of 0.00000 for age 0+ hatchery recaptures and a weighted decimal percent 24-hr magnetic tag loss of 0.032 (EA 1995).

TABLE 3-9 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1995-96

	COHORT (NUMBER STOCKED)									
STOCK ASSESSMENT PROGRAM YEAR	1995 (613,758)	1994 (306,529)	1993 (568,746)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1986-87										
N								38	51	5
Lower 95% C.I.								0.0110	0.0126	0.0005
Proportion								0.0152	0.0170	0.0014
Upper 95% C.I.								0.0204	0.0225	0.0029
1987-88										
N							25	127	82	4
Lower 95% C.I.							0.0015	0.0137	0.0240	0.0011
Proportion							0.0023	0.0165	0.0311	0.0034
Upper 95% C.I.							0.0033	0.0196	0.0399	0.0081
1988-89										
N						120	39	49	6	0
Lower 95% C.I.						0.0127	0.0014	0.0245	0.0075	0.0000
Proportion						0.0155	0.0020	0.0353	0.0236	0.0056
Upper 95% C.I.						0.0187	0.0027	0.0500	0.0645	0.0514
1989-90										
N					46	92	3			
Lower 95% C.I.					0.0049	0.0034	0.0002			
Proportion					0.0068	0.0043	0.0010			
Upper 95% C.I.					0.0091	0.0054	0.0027			
1990-91										
N					27	24	1			
Lower 95% C.I.					0.0015	0.0012	0.0000			
Proportion					0.0024	0.0020	0.0013			
Upper 95% C.I.					0.0035	0.0031	0.0098			

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ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1995-96

STOCK ASSESSMENT PROGRAM YEAR	COHORT (NUMBER STOCKED)									
	1995 (613,758)	1994 (306,529)	1993 (568,746)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1991-92										
N					13	4				
Lower 95% C.I.					0.0015	0.0012				
Proportion					0.0032	0.0035				
Upper 95% C.I.					0.0045	0.0048				
1992-93										
N				197	2					
Lower 95% C.I.				0.0020	0.0015					
Proportion				0.0030	0.0020					
Upper 95% C.I.				0.0441	0.0045					
1993-94										
N			23	121	1					
Lower 95% C.I.			0.0014	0.0991	0.0025					
Proportion			0.0020	0.0105	0.0046					
Upper 95% C.I.			0.0036	0.0121	0.0070					
1994-95										
N		54								
Lower 95% C.I.		0.0097								
Proportion		0.0098								
Upper 95% C.I.		0.0099								
1995-96										
N	2	7								
Lower 95% C.I.	0.00008	0.00320								
Proportion	0.00069	0.00080								
Upper 95% C.I.	0.00250	0.00164								

Age 1+ 1988 cohort to 0.2% for Age 0+ fish from the 1993 cohort (Table 3-10). The hatchery proportions of Age 0+ and Age 1+ fish from the 1995 and 1994 cohorts, respectivley, are the smallest hatchery proportions among all program estimates.

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

During the 1995-96 program, recaptures were made of nine hatchery striped bass tagged with a CWT and 111 wild striped bass individually tagged with internal anchor-external streamer tags (internal anchor tags) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were taken to the striped bass hatchery at Verplanck, New York, to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1995-96 winter sampling program, two Age 0+ (1995 cohort) and seven Age 1+ (1994 cohort) hatchery striped bass were caught. The 1990 and 1991 cohorts of hatchery striped bass were not tagged.

3.4.1.1 ***Length.*** A total of 613,758 hatchery striped bass were tagged with magnetic tags and stocked to the Hudson River between 31 July and 21 September 1995. The mean length of the two recaptured 1995 cohort of hatchery fish was 123 mm (Table 3-11). The mean length of the 1995 cohort of wild fish was 127 mm. No comparison between lengths of hatchery and wild striped bass from the 1995 cohort was made due to the small sample size of hatchery fish. The mean length of Age 1+ wild fish (246±2 mm) was significantly larger than the mean length of recaptured hatchery fish (216±10 mm) at Age 1+, based on non-overlapping 95% CIs.

The 1989 hatchery cohort was tagged prior to stocking. Two separate groups of fish were stocked in 1989: 179,219 fish were stocked in August 1989 (summer-stocked); and 21,196 were stocked in October (fall-stocked). The fall-stocked fish were significantly larger than the summer stocked fish at the time of stocking. When recaptured at Ages 0+ and 1+, the 1989 hatchery cohort

TABLE 3-10 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1995-96, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH[a]

	COHORT (NUMBER STOCKED)									
STOCK ASSEMENT PROGRAM YEAR	1995 (613,758)	1994 (306,529)	1993 (568,410)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1986-87										
N								38	51	5
Lower 95% C.I.								0.0126	0.0286	0.0038
Estimate								0.0171	0.0353	0.0058
Upper 95% C.I.								0.0226	0.0432	0.0084
1987-88										
N							25	127	82	4
Lower 95% C.I.							0.0031	0.0158	0.0526	0.0080
Estimate							0.0042	0.0187	0.0634	0.0135
Upper 95% C.I.							0.0055	0.0220	0.0076	0.0218
1988-89										
N						120	39	49	4	0
Lower 95% C.I.						0.1541	0.0030	0.0282	0.0221	0.0043
Estimate						0.1630	0.0038	0.0398	0.0493	0.0222
Upper 95% C.I.						0.1723	0.0048	0.0554	0.1062	0.0913
1989-90										
N					46	92	3			
Lower 95% C.I.					0.0165	0.0477	0.0006			
Estimate					0.0198	0.0509	0.0017			
Upper 95% C.I.					0.1723	0.0543	0.0037			
1990-91										
N					27	24	1			
Lower 95% C.I.					0.0055	0.0211	0.0002			
Estimate					0.0070	0.0243	0.0026			
Upper 95% C.I.					0.0088	0.0279	0.0127			
1991-92										
N					13	4				
Lower 95% C.I.					0.0091	0.0397				
Estimate					0.0095	0.0411				
Upper 95% C.I.					0.0099	0.0430				

TABLE 3-10 (Page 2 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1995-96, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH[a]

	COHORT (NUMBER STOCKED)									
STOCK ASSEMENT PROGRAM YEAR	**1995** (613,758)	**1994** (306,529)	**1993** (568,410)	**1992** (210,746)	**1989** (202,068)	**1988** (48,611)	**1987** (324,579)	**1986** (529,563)	**1985** (284,578)	**1984** (147,153)
1992-93										
N				197	2					
Lower 95% C.I.				0.0710	0.0041					
Estimate				0.0808	0.0059					
Upper 95% C.I.				0.0919	0.0072					
1993-94										
N			23	121	1					
Lower 95% C.I.			0.0009	0.0309	0.0088					
Estimate			0.0021	0.0294	0.0136					
Upper 95% C.I.			0.0037	0.0289	0.0165					
1994-95										
N		56								
Lower 95% C.I.		0.0188								
Estimate		0.0189								
Upper 95% C.I.		0.0191								
1995-96										
N	2	7								
Lower 95% C.I.	0.00008	0.00063								
Estimate	0.00069[b]	0.00156								
Upper 95% C.I.	0.00250	0.00322								

[a]Estimated hatchery proporation scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula: $[H_{ai} \times 600{,}000/N_i] / [(H_{ai} \times 600{,}000/N_i) + W_i]$.
[b]Estimated hatchery proportion not adjusted. Number of hatchery striped bass stocked surpassed target release of 600,000 fish.

TABLE 3-11

COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+ WILD AND HATCHERY STRIPED BASS COLLECTED 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.	N	MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.
0+	1995	207	127	126	128	2	123	–	–
1+	1994	1501	246	244	248	7	216	206	225
2+	1993	355	312	306	318	–	–	–	–
3+	1992	53	346	332	360	–	–	–	–

(summer and fall-stocked fish combined) was significantly larger than wild fish, fall-stocked fish were significantly larger than summer-stocked fish, and fall-stocked fish were preferentially recaptured compared to summer-stocked fish (NAI 1992). The larger size and preferential recapture of fall-stocked hatchery fish at Age 0+ and 1+ were attributed to either differential survival or differential behavior of the stocking groups. The 1989 hatchery cohort at Age 2+ was significantly smaller than the wild cohort (Table 3-12). However, similar to Ages 0+ and 1+, fall-stocked fish were preferentially recaptured as they accounted for 79% (11/14) of the hatchery recaptures of these cohorts but only 11% of the fish stocked. Too few members of the 1989 hatchery cohort (two) were recaptured at Age 3+ to make significant comparisons with the 1989 wild cohort. However, both of the 1989 hatchery fish were from the fall-stocked group, and no members of the more numerous summer-stocked group were recaptured (Table 3-12).

No members of the 1988 or earlier hatchery cohorts were recaptured. Comparisons between estimated mean lengths between the hatchery and wild cohorts for the 1988 and previous year classes are found in NAI (1992) and Table 3-13.

3.4.1.2 ***Magnetic Tag Detection Efficiency.*** During the 1995-96 program, 13,636 striped bass were examined using the field magnetic tag detectors. Of these fish, nine were classified as suspected Hudson River hatchery striped bass. All nine striped bass were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990); however, no false-positives were detected in this program.

Striped bass caught during the 1995-96 program were double-checked for CWTs with two V-shaped detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Two magnetic tag detectors were used on all sampling days. Of nine verified hatchery fish found no fish escaped detection with the first or second magnetic tag detector. A nondetection rate 0.0000 was applied to the Age 0+ and Age 1+ verified hatchery recaptures.

The weighted hatchery striped bass nondetection rate of 0.0000 for 1995-96 was the third time that the magnetic tag detection efficiency (nondetection rate) reached this level. The 1987-88 and 1994-95 programs were the only other programs to achieve a nondetection rate of 0.0000 (Table 3-14). The nondetection rate for 1993-94 was comparatively high at 0.005, the fourth highest

TABLE 3-12

MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM WINTERS OF 1988-89 THROUGH 1995-96

		RECAPTURE FOR HATCHERY STRIPED BASS AT AGE											
		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040	0	-	0.00000
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052	4	380	0.00010
1989	Verplanck Summer[3]	13	124	0.00007	5	215	0.00003	2	330	0.00001	0	-	0.00000
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104	11	300	0.00052	2	423	0.00009

[1]1988 Attleboro fall number stocked (H_2) = 10,057 at 80- to 84-mm model length class.

[2]1988 Verplanck fall number stocked (H_2) = 38,554 at 139-mm mean length.

[3]1989 Verplanck summer number stocked (H_2) = 179,219 at 105-mm mean length.

[4]1989 Verplanck fall number stocked (H_2) = 21,196 at 152-mm mean length.

TABLE 3-13 (Page 1 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1995 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1984	Hatchery							3[c]	275	37.5	2[c]	349	31.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				26	205*	3.8	58	286	41.4	6	364	15.9
	Wild				285	221*	3.0	574	317	2.6	57	396	9.2
1986	Hatchery	22	107*	3.8	96	220*	2.7	48	315	5.2	–		
	Wild	83	128*	2.9	1503	253*	1.2	361	324	3.5	55	382	10.1
1987	Hatchery	20	108	6.2	39	209*	5.2	3[c]	290	16.0	–	350	
	Wild	190	108	2.1	3623	227*	0.8	1216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	1.7	92	219	3.7	24	311	9.9	4[c]	380	18.8
	Wild	1007	121*	2.0	3514	214	0.7	2109	321	1.8	156	386	6.2
1989	Hatchery	46	138*	2.0	27	245	7.8	13	305	12.3	2[c]	423	46.0
	Wild	368	112*	1.6	2174	239	0.9	961	324	2.3	125	414	7.2
1990[d]	Hatchery	–			–			–			–		
	Wild	206	119	1.5	3675	245	0.6	1378	329	1.9	152	424	89.9
1991[d]	Hatchery	–			–			–			–		
	Wild	818	131	1.9	3899	231	0.8	1631	317	5.5	99	356	5.5

TABLE 3-13 (Page 2 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1995 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1992	Hatchery	188	127	0.9	112	220*	2.8	—					
	Wild	473	116	1.0	2695	237*	0.5	455	312	1.9			
1993	Hatchery	21	128	3.6	—								
	Wild	828	123	1.0	1216	260	1.1						
1994	Hatchery	54	127*	1.7									
	Wild	219	104*	0.7									
1995	Hatchery	2[c]	123	19.5	7	216*	3.8						
	Wild	143	128	1.4	839	251*	1.4						

*Indicates a significant difference in mean length between the hatchery and wild cohorts within an age class. Nonoverlapping confidence intervals of mean lengths of hatchery and wild fish were used to indicate significance.

[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

[b]A t statistic of 2.00 was used to calculate the confidence intervals about the stratified means of wild fish prior to 1994.

[c]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for hatchery striped bass.

[d]The mean length reported for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

TABLE 3-14

MAGNETIC TAG DETECTION EFFICIENCY OBSERVED FOR HUDSON RIVER HATCHERY STRIPED BASS DURING THE 1986-87 THROUGH 1995-96 WINTER PROGRAMS

	DETECTOR TYPE		TOTAL NUMBER OF FISH			HATCHERY-TAGGED FISH DETECTED BY			
PROGRAM	PRIMARY	SECONDARY	MONITORED BY PRIMARY DETECTOR	MONITORED BY BOTH DETECTORS	VERIFIED RECAPTURES	PRIMARY	PRIMARY AND SECONDARY	MISSED BY PRIMARY	NON-DETECTION RATE [a]
1986-87	V-shaped	Tube	13,136	2,138	94	13	15	2	0.0237
1987-88	V-shaped	Tube	28,192	1,611	238	11	11	0	0.0000
1988-89	V-shaped	Tube/V-shaped[b]	32,975	8,164[b]	213	51	52	1	0.0004
1989-90	V-shaped	V-shaped	33,386	33,386	141	138	141	3	0.0005
1990-91	V-shaped	V-shaped	29,346	29,346	52	51	52	1	0.0004
1991-92	V-shaped	V-shaped	35,072	35,072	17	14	17	3	0.0459
1992-93	V-shaped	V-shaped	29,607	28,813	190	139	149	10	0.0138[c]
1993-94	V-shaped	V-shaped	30,093	25,740	134	103	110	7	0.0046
1994-95	V-shaped	V-shaped	12,657	12,657	54	54	54	0	0.0000
1995-96	V-shaped	V-shaped	13,636	13,636	9	9	9	0	0.0000

[a]Nondetection rate = $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector and H is the total number of verified hatchery fish detected when both detectors were used.

[b]3,368 fish on randomly selected days between 31 October 1988 and 13 March 1989 were first monitored with a V-shaped field detector and then with a tube-shaped detector. The tube-shaped detector became inoperable on 20 March 1989, and 4,796 fish representing the entire catch were monitored with both a primary and secondary V-shaped field detector until the end of field sampling on 15 April 1989.

[c]One tag detector became inoperable during the week of 29 March 1993; 10 hatchery fish were missed by this detector when two detectors were used. An additional 794 fish were checked with only one tag detector and 41 Age 0+ hatchery fish were detected on that week. We applied a nondetector rate of 0.00000 to 82 hatchery recaptures prior to 29 March 1993 and a nondetection rate of 0.03078 for 67 hatchery recaptures on and after 29 March 1993. This value represents the weighted nondetection rate.

value observed since the program began. The nondetection rates of 0.0459 for 1991-92 and 0.0237 in 1986-87 were comparable to the 1992-93 rate. Between 1987-88 and 1991-92, the nondetection rate varied between 0.0000 and 0.0005, about two orders of magnitude better in detection efficiency than in 1986-87 or 1991-92. The nondetection statistic does not take into account the large number of fish monitored and, as a ratio, is most sensitive to small numbers of verified hatchery fish examined. Historically, it appeared that when all the fish are checked with two detectors, as in 1989-90 through 1993-94, between one and three fish escape detection by the first detector unless specific operational problems occur (as in 1992-93 or 1993-94). In 1994-95 and 1995-96, however, no fish were missed by the primary detector (Table 3-14).

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1995-96 winter sampling program, 105 striped bass were recaptured out of 10,889 fish that were caught, tagged with internal anchor tags, and released in good condition. A total of six striped bass with internal anchor tags implanted during previous programs were recaptured during the 1995-96 winter sampling program. Two striped bass were recaptured with tags from other tagging studies. No striped bass were recaptured with suspected tag wounds. These groups of wild striped bass are described below in separate sections. A complete description of the number of fish caught tagged with different types of internal anchor-external streamer tags since 1984 and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchor tags were used during the 1995-96 program.

3.4.2.1 ***Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1994- 95 Winter Program.*** The majority (7755, or 69%) of the taggable-size (≥150 mm) striped bass (11,224) were caught in the Battery region, as were 62, or 59%, of the 105 fish tagged, released, and recaptured during this study (Table 3-15; Appendix Table D-2). This is not surprising as most (79%) of the trawl sampling effort was allocated to the Battery during 1995-96, based on the high CPUE in this region during the current and previous programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1996).

Recapture rates and recapture proportions can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals in Table 3-15 compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the

TABLE 3-15

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE HUDSON RIVER WINTER 1995-96

			NUMBER OF RECAPTURES FROM RELEASE REGION[a]		
RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	UPPER HARBOR M = 3,365	BATTERY M = 7,524	TOTAL M = 10,889
Upper Harbor	3,469	R	42	1	43
		R/M	0.01248	0.00013	0.00395
		R/C	0.01211	0.00029	0.01240
Battery	7,755	R	23	39	62
		R/M	0.00684	0.00518	0.00569
		R/C	0.00297	0.00503	0.00799
Total	11,224	R	65	40	105
		R/M	0.01932	0.00532	0.00964
		R/C	0.00579	0.00356	0.00935

[a]Excluding recaptures from previous sampling seasons.

LEGEND:
- R = number of striped bass recaptured.
- M = number of striped bass ≥150 mm marked and released.
- C = number of striped bass ≥150 mm caught and examined for tags.
- R/M = recapture rate.
- R/C = recapture proportion.

row totals in Table 3-15 compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-15 the recapture rate for striped bass tagged, released, and recaptured in the Battery (cell total) was 39/7524 or 0.0052. The recapture rate for striped bass tagged and released in the Battery and recaptured throughout the study area (column total) was 40/7524, or 0.0053.

In contrast, recapture proportions from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-15 the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 39/7755, or 0.00503.

Examination of monthly recapture rates and recapture proportions can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (Table 3-16 column totals) were generally stable from November 1995 through February 1996 and decreased in March and April 1996. Monthly recapture proportions (R/C row totals) were generally stable through much of the sampling program, but decreased during January and March 1996. Decreases in recapture proportions may have been influenced by drops in sampling efforts and numbers of striped bass examined for tags. Ice and weather conditions during January precluded sampling efforts in the Battery and Upper Harbor regions. Overall, recapture rates and proportions suggest little movement of the striped bass population in the lower Hudson River.

Striped bass tagged and released in the combined Battery and Upper New York Harbor regions and subsequently recaptured in those regions were at large an average of 33 days and ranged in size between 152 and 356 mm (Table 3-17). Approximately 36% (38/105) of the striped bass were recaptured on the same day as they were tagged and released, and 74% (78/105) of the fish were recaptured within 30 days of release (Table 3-17), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within three months (90 days), 80% (84/105) of the striped bass were recaptured, and the maximum number of days

TABLE 3-16

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1995-96

			NUMBER OF RECAPTURES FROM RELEASE MONTH*						
RECAPTURE MONTH	NUMBER CAUGHT (C)	STATISTIC	NOV M = 1,761	DEC M = 3,350	JAN M = 695	FEB M = 483	MAR M = 2,118	APR M = 2,482	TOTAL M = 10,889
NOVEMBER	1,797	R	18						18
		R/M	0.01022						0.01022
		R/C	0.01002						0.01002
DECEMBER	3,428	R	6	25					31
		R/M	0.00341	0.00746					0.00607
		R/C	0.00175	0.00729					0.00904
JANUARY	734	R	0	3	2				5
		R/M	0.00000	0.00090	0.00288				0.00086
		R/C	0.00000	0.00409	0.00272				0.00681
FEBRUARY	515	R	1	1	1	4			7
		R/M	0.00057	0.00030	0.00144	0.00828			0.00111
		R/C	0.00194	0.00194	0.00194	0.00777			0.01359
MARCH	2,198	R	3	4	1	1	6		15
		R/M	0.00170	0.00119	0.00144	0.00207	0.00283		0.00178
		R/C	0.00136	0.00182	0.00045	0.00045	0.00273		0.00682
APRIL	2552	R	5	8	2	0	6	8	29
		R/M	0.00284	0.00239	0.00288	0.00000	0.00283	0.00322	0.00266
		R/C	0.00196	0.00313	0.00078	0.00000	0.00235	0.00313	0.01136
TOTAL	11,224	R	33	41	6	5	12	8	105
		R/M	0.01874	0.01224	0.00863	0.01035	0.00567	0.00322	0.00964
		R/C	0.00294	0.00365	0.00053	0.00045	0.00107	0.00071	0.00935

*Excluding recaptures from previous sampling seasons.

LEGEND: R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

TABLE 3-17

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED, AND RECAPTURED IN THE HUDSON RIVER BY A 9-m TRAWL WINTER 1995-96

	STATISTIC	NUMBER OF STRIPED BASS
Number tagged (≥150 mm)	M	10,889
Number examined for tags (≥150 mm)	C	11,224
Number recaptures	R	105
Size range of recaptured fish (mm)	Min	152
	Max	356
	Mean	240
	S.D.	44
Days at large	Min	0
	Max	158
	Mean	33
	S.D.	48
Frequency of days at large	0 days	38
	1-5 days	17
	6-10 days	4
	11-20 days	10
	21-30 days	9
	31-40 days	1
	41-50 days	0
	51-60 days	1
	61-70 days	0
	71-80 days	1
	81-90 days	3
	91-100 days	1
	101-110 days	4
	111-120 days	8
	121-130 days	3
	131-140 days	3
	141-150 days	1
	151-160 days	1

at large was 158. Days at large and recapture length data for the 1995-96 program were similar to previous years (NAI 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1996).

3.4.2.2 ***Striped Bass Internal Anchor-Tagged and Released Prior to and Recaptured During the 1994-95 Winter Program.*** A total of six striped bass were recaptured during 1995-96 with internal anchor tags identified from previous programs (Appendix Table D-3). All recaptured striped bass had the external portion of the tag (streamer) present. Among the six striped bass collected, only one fish was recaptured with a tag number abraded but legible (Table 3-18).

Tag numbers were defined as completely illegible if one or more of the five-digit tag numbers could not be read in the field. Tag abrasion, first observed during 1986-87, is time dependent; the tagged fish must be at large for at least six months for abrasion to affect the legibility of the legend on the external streamer (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged to have been at large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990). Changes in tag design since 1986-87 have virtually eliminated tag abrasion.

Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used; abrasion was observed in 28% of the recaptured fish at large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but shorter length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990).

TABLE 3-18

INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR HUDSON RIVER STRIPED BASS THAT WERE AT LARGE AT LEAST ONE YEAR PRIOR TO THEIR RECAPTURE DURING THE 1988-89 THROUGH 1995-96 PROGRAMS

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH RECAPTURED DURING PROGRAM[a]							
		1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
Tag number completely legible	Healed	34	63	206	102	130	117	27	4
	Infected	13	6	22	15	17	12	2	1
	Total	47	69	228	117	147	129	29	5
	(Anchor protruding)	(5)	(0)	(6)	(1)		(0)	(0)	(0)
Tag number abraded but legible	Healed	3	2	2	0	1	0	0	1
	Infected	3	1	0	1	0	0	0	0
	Total	6	3	2	1	1	0	0	1
	(Anchor protruding)	(1)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Tag number partly or completely missing and not legible	Healed	0	0	1	2	0	0	1	0
	Infected	0	0	0	0	0	0	0	0
	Total	0	0	1	2	0	0	1	0
	(Anchor protruding)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Suspected tag wound, tag and anchor missing	Healed	4	6	69	43	57	28	0	0
	Infected	0	9	3	4	7	3	0	0
	Total	4	6	72	47	64	31	0	0
Suspected tag wound, anchor present	Healed	2	0	9	10	12	18	0	0
	Infected	0	0	0	0	3	0	0	0
	Total	2	0	9	10	15	18	0	0

[a]Striped bass that were tagged and released prior to the program that could by cross-classified by degree of tag number abrasion and condition of the tag insertion site.

Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish, forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was shed from the fish.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a long-term shedding rate of 22/94, or 23%, for the original Hallprint tag with an exposed filament. Among the 67 fish with suspected tag wounds (and no anchor found) caught during the 1992-93 program, 45 fish had a longitudinal scar, suggesting they may have shed a tag, and 22 fish had wounds that were judged to be not related to tagging. None of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has virtually eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has reduced tag loss due to shedding.

All six striped bass recaptured from previous programs during 1995-96 had been tagged and released during 1994-95 (Table 3-19; Appendix Table D-3). All recaptured fish from the 1988-89 through 1994-95 programs were caught, tagged, and released from the 9-m trawl, which was the only gear used. Recaptured fish were at large between 237 and 486 days and ranged in length between 283 and 412 mm (Table 3-20). No striped bass were recaptured with both an internal anchor tag and a dart tag during 1995-96, and no striped bass were observed to have shed a dart tag.

Two striped bass were recaptured in 1995-96 with tags originating from other tagging programs (Table 3-21). One fish was recaptured with a U.S. Fish and Wildlife Service internal anchor tag and one fish was recaptured with a Littoral Society spaghetti tag.

3.4.2.3 ***Effects of the Internal Anchor Tag on Striped Bass Growth.*** During previous programs, growth based on focus, to annulus (radius) measurements for scale samples from tagged striped bass that had been at large one or two years was compared within cohort to growth from a

TABLE 3-19

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1995-96

					LENGTH OF RECAPTURED FISH (mm)			
RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED (R)	RECAPTURE RATE (R/M)	MIN	MAX	MEAN	S.D.
1994-95	9-m trawl	6838	6	0.00088	283	412	329	46

TABLE 3-20

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED BY GEAR PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1995-96

	STATISTIC	9-m TRAWL
Total number tagged	M	157,532[a]
Number Age 2+ or older examined for tags	C	1,949
Number recaptured	R	6
Recapture rate	R/M	0.00004
Recapture proportion	R/C	0.00308
Length of recaptured fish (mm)	Min	283
	Max	412
	Mean	329
	S.D.	46
Days at large	Min	237
	Max	486
	Mean	398
	S.D.	109
Frequency of days at large	201-250 days	1
	251-300 days	1
	301-350 days	0
	350-400 days	0
	401-450 days	0
	451-500 days	4
	500-550 days	0
	551-600 days	0
	601-650 days	0
	651-700 days	0
	700-751 days	0
	751-800 days	0

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, 1989-90, 1990-91, 1991-92, 1992-93, 1993-94, and 1994-95 programs.

TABLE 3-21

STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHER AGENCY TAGS WINTER 1995-96

		TAG CONDITION						RECAPTURE		
AGENCY	TAG NUMBER	SITE	NUMBER	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
Littoral Society	388349	1	4	4	4	2	2	27 Mar 96	9	360
USF&W	169937	1	4	4	4	2	2	16 Apr 96	9	257

TAG VARIABLE	COMMENT DESCRIPTION
Number Address Reward	1 = legend completely missing 2 = abraded and partly missing 3 = abraded but completely legible 4 = completely legible
Number orientation	1 = tag number facing anterior (head) 1 = tag number facing posterior (tail)
Anchor protrusion	1 = yes 2 = no

TAG SITE

1 = tag present, wound healed
2 = tag present, wound poorly healed, evidence of infection or swelling

corresponding set of scales taken from untagged fish of the same cohort at the time the tagged fish were recaptured (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. Scale radius measurements were selected rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

Mean radius measurements for each annulus were obtained from the 1985 through 1991 cohorts of striped bass recaptured during the 1988-89 through 1993-94 programs (Table 3-22). No radius measurements were obtained from striped bass recaptures during the 1994-95 or 1995-96 programs. A complementary set of scale samples was selected from the time of release for each cohort of fish caught in the samples providing the recaptured fish to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X + 1 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus. Relative growth was calculated as the response variable by taking the difference between annulus measurements for the time of release and recapture and dividing by the annulus measurement for the time of release. This relative growth measurement accounts for variation in the size of scales taken for the release and recapture samples.

Tagged striped bass from the 1985 through 1990 cohorts that were at large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way analysis of variance (ANOVA) comparisons of mean relative growth (Table 3-22). A significant difference was observed between the mean scale radius for tagged and untagged striped bass of the 1991 cohort. Fish that were tagged and released in 1992-93 at Age 1+ were significantly larger than untagged fish of the same cohort in 1993-94 after being at-large for one year. As both the tagged and untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. Therefore, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit differential growth during one or two years at large.

TABLE 3-22

ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE 1988-89 THROUGH 1992-93 PROGRAMS

RECAPTURE PROGRAM	COHORT	RECAPTURE AGE	YEARS AT LARGE	TAG STATUS	N	SCALE SAMPLE MEASUREMENT		
						MEAN RADIUS	S.E.	Prf^a
1988-89	1985	3+	1	Tagged	14	151.7	5.5	0.9015
			0	Untagged	48	147.6	3.0	
1988-89	1986	2+	1	Tagged	24	124.2	3.9	0.2580
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	51	101.3	2.5	0.6096
			0	Untagged	1138	101.2	0.5	
1990-91	1987	3+	1	Tagged	21	152.3	5.0	0.1987
			2	Tagged	14	152.9	6.3	0.1023
			0	Untagged	53	143.4	3.2	
1991-92	1988	2+	1	Tagged	161	103.6	1.3	0.1435
			0	Untagged	1844	97.0	0.4	
1991-92	1988	3+	1	Tagged	34	148.3	2.1	0.7432
			2	Tagged	18	144.1	5.4	
			0	Untagged	110	143.6	2.2	
1991-92	1989	2+	1	Tagged	45	114.4	2.7	0.2203
			0	Untagged	829	103.8	0.6	
1992-93	1989	3+	2	Tagged	18	145.7	6.1	0.0986
			1	Tagged	8	165.0	10.6	0.3650
			0	Untagged	90	156.5	2.6	
1992-93	1990	2+	1	Tagged	72	117.5	2.2	0.11817
			0	Untagged	1263	114.5	0.5	
1993-94	1990	3+	2	Tagged	16	160.1	5.2	0.9511
			1	Tagged	20	164.3	6.7	0.5252
			0	Untagged	110	159.6	2.9	
1993-94	1991	2+	1	Tagged	87	118.7	2.3	0.0001
			0	Untagged	1487	103.9	0.5	

[a]Probability of finding that the mean relative growth is different by chance alone, under a least-squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

3.4.3 Condition of the Catch

Occasionally, striped bass caught in the 9-m trawl displayed one or more types of injury or abnormality such as blindness, fin rot, fungal infection, skeletal deformity, or visible wounds. During the 1995-96 program, blindness, fin rot, stress, and fungus were observed among collected fish (Table 3-23). The incidence of injuries or anomalies was most prevelant among recaptured fish (with tags or suspected tag wounds), with 4.4% of fish examined in poor condition (5 of 113). Fungal infection was observed on two of the recaptured fish; blindness, fin rot, and other injuries (e.g., body damage) were observed on one fish each.

Injuries or anomalies were also observed among unmarked and marked fish (3.9 and 1.1%, respectively). The most frequently observed condition among tagged fish was blindness, accounting for 0.63% of fish in poor condition. Other conditions (e.g., body wounds, fin damage) also made up for a large portion of the striped bass identified as in poor condition, accounting for 3.5 and 0.4% of unmarked and marked fish, respectively (Table 3-23). Fungal infection was observed among both unmarked and marked fish; fin rot was only observed among tagged fish.

Each of the general categories of poor condition were further classified to the specific area of the fish (Table 3-24). Among those fish identified as blind, blindness was observed in both eyes more than twice as often (64%) as blindness observed in one eye only. Fin rot most commonly occurred on the caudal and pectoral fins, while fungal infections were observed on both sides of the body 55% of the time.

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1995-96 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator that permits tagging and recapture efforts to occur concurrently. This estimator was used during the 1985-86 through 1994-95 programs to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995b).

TABLE 3-23

INCIDENCE OF FISH IN POOR CONDITION AMONG UNMARKED vs RECAPTURED STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

TYPE(S) OF INJURY OR ABNORMALITY[a]	INCIDENCE AMONG 2,506 UNMARKED FISH[b]		INCIDENCE AMONG 11,015 FISH TAGGED		INCIDENCE AMONG RECAPTURED 113 FISH[c]	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Blind Only	2	0.08	69	0.63	1	0.88
Stress Only	7	0.28				
Fin Rot Only			7	0.06	1	0.88
Fungus Only	2	0.08	4	0.04	2	1.77
Other Only	89	3.55	45	0.41	1	0.88
Fungus/Other			1	0.01		
Total	100	3.99	126	1.14	5	4.42

[a]Categories are described in more detail in Table 3-24.
[b]Including fish < 150 mm and fish ≥ 150 mm considered in poor condition and released without tagging or were taken to the laboratory for processing.
[c]Including fish with suspected tag wounds, prior year, and other agency recaptures, but excluding fish suspected of being recaptured hatchery releases.

TABLE 3-24

NATURE OF INJURIES AND ABNORMALITIES OBSERVED IN STRIPED BASS COLLECTED BY THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

GENERAL CATEGORY	SPECIFIC CONDITION	INCIDENCE AMONG 2,506 UNMARKED FISH	INCIDENCE AMONG 11,015 FISH TAGGED	INCIDENCE AMONG 113 RECAPTURED FISH
Blindness	Blind in one eye	1	24	1
	Blind in both eyes	1	45	
Stress	Crushed	7		
Fin rot	On caudal fin		5	1
	On pectoral fins		2	
Fungus	On one side of body		2	2
	On both sides of body	2	3	
Other	Body wounds, damaged fins, etc.	89	46	1
Total[a]		100	127	5

[a]Totals exceed those in Table 3-23 because some fish exhibited more than one condition.

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1. Mortality is no different for tagged and untagged striped bass.
2. Tagging does not affect striped bass catchability.
3. Tagged bass do not lose their marks.
4. All tags are recognized and reported.
5. Natural marking does not occur or is recognizable.
6. Immigration, emigration, and recruitment are negligible in the study area, i.e., the population is closed.
7. Tagged striped bass are randomly distributed among untagged fish, or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions.
8. Marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hrs and (2) in holding pools for up to 180 days. However, during the 1990-91 program, predation by birds (gulls) was observed to remove about 2.4% of the tagged fish as they were released from the tagging vessel (NAI 1992). Most of the bird predation was observed to occur as the released fish drifted away from the tagging vessel before sounding. In the 1995-96 program, all striped bass were released into a recovery pen that was suspended in the water alongside the tagging vessel. The pen provided cover until the fish sounded and virtually eliminated bird predation. Therefore, the number of tagged striped bass at large was not adjusted for mortality during the 1995-96 program.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods that rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (LMS 1995a), which would provide evidence of tag loss. QA/QC procedures (LMS 1995a) and audits provide documentation that incorrect identification or nonreporting of tags by field crews did not occur. Dunning et al. (1987) found 91.1% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 345 fish out of 20,847 tagged fish, approximately eight fish would be expected to have lost tags in the 1992-93 program. However, the tag loss rate from Dunning et al. (1987) was based on Floy-style tags, which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1995-96 program, 11,224 striped bass were examined for tags and tag wounds, and none were observed with tag wounds. Therefore, loss of internal anchor tags for fish tagged and released during 1995-96 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and was adjusted for, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by NYSDEC (Geoghegan et al. 1990). As this program provided both marking and recapture efforts, nonreporting of tags did not occur. Assumption 5 was satisfied because marking techniques that could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., U.S. Fish & Wildlife Service or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration, Assumption 6, was apparently negligible during most of the study period (November 1995 through April 1996), as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4; NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995b). A linear regression of weekly recapture proportions on cumulative number of marked fish (Figure 3-7) was significant and positive for the weeks of 13 November 1995 through the week of 8 April 1996 (Appendix Tables D-6 and D-7). This 22-week period for the population estimator was nearly identical to the recapture period used in 1990-91, 1991-92, 1992-93, and 1994-95 (NAI 1992, 1994, 1995a; LMS 1995b) and was similar to the period used in 1985-86 through 1988-89 for the population estimator (NAI 1986, 1987, 1988, 1990). During 1989-90, the period used for the striped bass population estimate was 22 January through 9 April 1990, which was one month later than in the other years. During 1993-94 the period used for the Schumacher-Eschmeyer population estimate was truncated (22 November 1994 through 10 January 1995) by severe

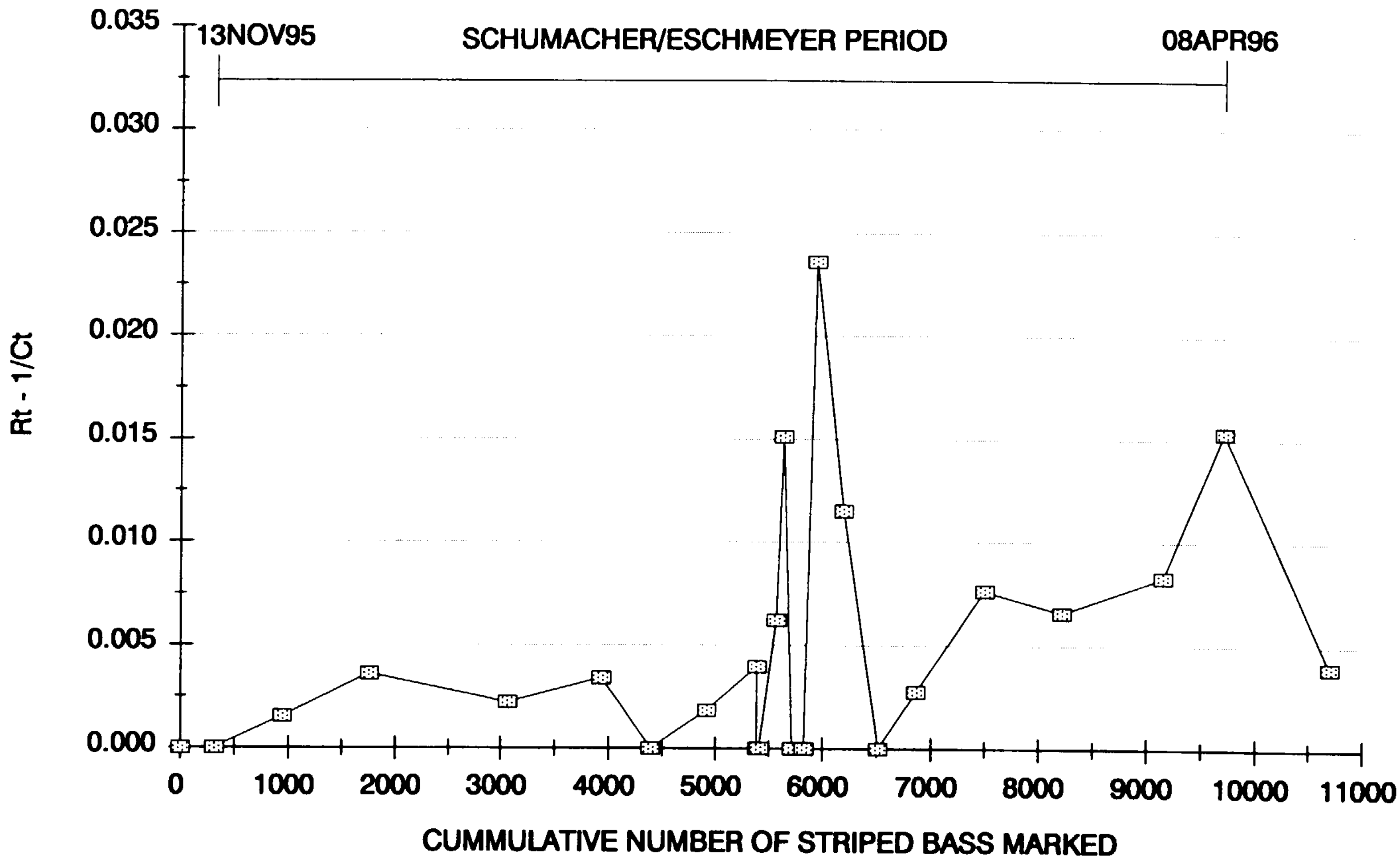

Figure 3-7. Striped bass recapture proportion (R/C) compared to the cumulative number of striped bass tagged in the Battery and Upper Harbor regions of the Hudson River, winter 1995-96.

weather conditions that prevented most trawling efforts from the week of 17 January through 21 February 1994 (NAI 1995b). The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass during the 1995-96 program (Assumption 7). Furthermore, stepwise polynomial regressions offered no statistically significant improvement in model fit over the linear model.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition, which probably are equally exposed to the trawl recapture effort.

The assumptions of a closed population, mark-recapture population estimator appeared to be satisfied for the 13 November 1995 through 8 April 1996 period in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated based on 9156 fish marked, 10,029 examined, and 46 recaptured (Appendix D-6). The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1995-96 was 949,000 fish ≥150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 745,000 to 1,308,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25).

For comparison with previous programs, the total population of Age 1+ and older striped bass ≥200 mm was estimated as 786,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This estimate was the same as the 1990-91 population estimate and the third highest calculated annually since 1985-86 (Table 3-27). The 1994 cohort of Age 1+ fish was the primary contributor to this estimate of Hudson River striped bass in the mid-winter population during 1995-96.

TABLE 3-25

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1995-96

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥150 mm	PROPORTION ≥150 MM	ESTIMATED POPULATION[a]
1+	8,710	8,680	0.7733	734,000
2+	1,619	1,619	0.1442	137,000
3+	298	298	0.0265	25,000
>3+	32	32	0.0028	3,000
Total	10,659	10,629	0.9469	899,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released, and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 13 November 1995 through the week of 8 April 1996. Age 0+ striped bass were 5.3% (50,000) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 949,000 fish.

TABLE 3-26

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1995-96

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	8,710	7,344	0.6543	621,000
2+	1,619	1,619	0.1442	137,000
3+	298	298	0.0265	25,000
>3+	32	32	0.0028	3,000
Total	10,659	9,293	0.8279	786,000

[a]The total population estimate based on fish ≥150 mm (949,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (9,293/11,224 = 0.8279).

TABLE 3-27

ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86 THROUGH 1995-96

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1995-96	786,000	949,000
1994-95	325,000	350,000
1993-94	379,000	443,000
1992-93	717,000	920,000
1991-92	967,000	1,163,000
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged. The population estimate during the 1987-88, 1986-87, and 1985-86 programs was not extrapolated for fish ≥150 mm.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9M TRAWL

GEAR DESCRIPTION (9M TRAWL)	SPECIFICATIONS
HEAD ROPE LENGTH	6.9 M
FOOT ROPE LENGTH (SWEEP)	9.0 M
LEGS (BETWEEN DOORS AND NET)	6.0 M
APPROXIMATE VERTICAL LIFT	3.6 M
DOORS (STEEL V-DOORS)	1.0 M
NET BODY LENGTH	5.2 M
COD END SECTION LENGTH	2.3 M
MESH - BODY	7.6 CM (STRETCH) MESH POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
- COD END	3.8 CM (STRETCH) MESH KNOTLESS POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
ROLLER GEAR	25.4 CM ROLLERS SPACED WITH 5 CM COOKIE DISKS

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AND REGIONAL AVERAGE WATER TEMPERATURE AND CONDUCTIVITY DURING TRAWL SAMPLING IN THE HUDSON RIVER, WINTER 1995-96.

REGION	SAMPLE WEEK	SURFACE WATER TEMPERATURE (°C)	SURFACE WATER CONDUCTIVITY (µmhos)	BOTTOM WATER TEMPERATURE (°C)	BOTTOM WATER CONDUCTIVITY (µmhos)
UPPER HARBOR	06NOV95	13.1	22611	13.4	25556
	13NOV95	10.6	10333	11.7	19333
	20NOV95	10.2	19159	10.6	22117
	27NOV95	8.1	13374	8.6	17974
	04DEC95	7.9	19366	8.3	21547
	15JAN96	1.8	20483	1.8	21017
	05FEB96	2.4	16219	2.1	20313
	12FEB96	2.0	18086	2.2	22093
	19FEB96	2.6	15500	2.7	20444
	26FEB96	3.7	15067	3.3	22267
	11MAR96	6.0	17333	5.8	19667
	18MAR96	7.0	15667	6.5	20667
	25MAR96	8.5	13000	8.0	19000
	01APR96	11.0	20000	11.0	20500
	15APR96	10.8	11900	11.6	14250
BATTERY	06NOV95	13.2	15847	14.1	24473
	13NOV95	10.1	4443	11.6	15178
	20NOV95	9.9	15860	10.6	19940
	27NOV95	8.6	10586	8.7	14814
	04DEC95	7.8	16000	8.9	22667
	11DEC95	3.6	9180	6.4	21060
	18DEC95	3.9	17342	5.4	22495
	25DEC95	2.2	14864	2.7	19273
	01JAN96	1.4	15775	2.6	21350
	15JAN96	1.0	15400	1.4	19200
	22JAN96	1.0	2064	1.4	9750
	29JAN96	0.6	4464	2.1	16441
	05FEB96	1.6	13231	1.5	18500
	12FEB96	0.4	10186	0.9	16179
	19FEB96	2.3	14200	2.1	21054
	26FEB96	2.6	7138	2.5	20500
	04MAR96	4.3	13066	5.3	18408
	11MAR96	4.5	10405	5.0	15398
	18MAR96	6.0	10065	6.6	14891
	25MAR96	6.1	4175	7.1	15527
	01APR96	8.3	13359	8.9	19102
	08APR96	9.2	12091	9.4	16068
	15APR96	10.0	9298	10.6	16367

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1995-96.

REGION	SAMPLE WEEK	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	06NOV95	9	95	10.56	3.82
	13NOV95	3	102	34.00	15.52
	20NOV95	29	645	22.24	2.82
	27NOV95	19	822	43.26	7.42
	04DEC95	32	1378	43.06	7.10
	15JAN96	6	20	3.33	1.45
	05FEB96	16	100	6.25	1.56
	12FEB96	14	100	7.14	1.23
	19FEB96	9	110	12.22	4.46
	26FEB96	15	130	8.67	2.39
	11MAR96	3	5	1.67	1.67
	18MAR96	3	28	9.33	2.96
	25MAR96	3	1	0.33	0.33
	01APR96	1	17	17.00	.
	15APR96	4	181	45.25	30.50
	TOTAL	166	3734	22.49	2.22
BATTERY	06NOV95	30	103	3.43	0.79
	13NOV95	37	264	7.14	0.82
	20NOV95	5	18	3.60	1.44
	27NOV95	7	26	3.71	1.60
	04DEC95	3	9	3.00	1.53
	11DEC95	25	901	36.04	6.47
	18DEC95	19	532	28.00	6.36
	25DEC95	22	668	30.36	3.71
	01JAN96	20	730	36.50	4.94
	15JAN96	20	40	2.00	0.38
	22JAN96	14	296	21.14	4.14
	29JAN96	37	225	6.08	1.28
	05FEB96	13	82	6.31	1.45
	12FEB96	28	137	4.89	0.77
	19FEB96	13	80	6.15	1.47
	26FEB96	32	252	7.87	0.89
	04MAR96	38	731	19.24	3.18
	11MAR96	43	510	11.86	1.83
	18MAR96	43	886	20.60	1.94
	25MAR96	55	827	15.04	1.58
	01APR96	46	1058	23.00	2.69
	08APR96	44	643	14.61	1.40
	15APR96	46	884	19.22	1.88
	TOTAL	640	9902	15.47	0.66

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-2. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1995-96.

REGION	RIVER MILE	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	-4	1	13	13.00	.
	-3	2	0	0.00	0.00
	-2	68	734	10.79	2.13
	-1	95	2987	31.44	3.28
	TOTAL	166	3734	22.49	2.22
BATTERY	2	213	2325	10.92	0.81
	6	157	2937	18.71	1.68
	9	270	4640	17.19	1.01
	TOTAL	640	9902	15.47	0.66

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS COLLECTED AND STRIPED BASS TAGGED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER FOR THE 9M TRAWL, WINTER 1995-96.

REGION	GEAR	USE CODE	NUMBER OF SAMPLES	STRIPED BASS COLLECTED	STRIPED BASS TAGGED
UPPER HARBOR	9 m TRAWL	1	166	3734	3365
		5	2	0	0
			---------	------------	------------
	TOTAL		168	3734	3365
BATTERY	9 m TRAWL	1	640	9902	7517
		2	1	7	7
			---------	------------	------------
	TOTAL		641	9909	7524
			=========	============	============
COMBINED TOTAL			809	13643	10889

USE CODE: 1 = NO SAMPLING PROBLEMS
2 = SAMPLING PROBLEMS OCCURRED; MARKABLE FISH WERE CAUGHT, BUT SAMPLE WAS NOT USED FOR CATCH/EFFORT ANALYSIS
5 = VOID; SAMPLING PROBLEMS OCCURRED AND NO MARKABLE FISH WERE CAUGHT

APPENDIX TABLE C-4. WEEKLY REPORT OF STRIPED BASS CAUGHT IN THE COMBINED BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1995-96.

SAMPLE WEEK	WATER TEMP	WATER COND	N TOWS TOTAL	N TOWS VOID	≤ 150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	≥ 801	TOTAL	MEAN CPUE	TAGGED	RECAPTURED	HATCHERY	NOT TAGGED	MORTALITY N	MORTALITY %
06NOV95	13.6	21065	39	0	8	20	145	20	5	0	0	0	0	198	5.1	187	3	0	0	0	0.0
13NOV95	10.9	10188	40	0	49	45	225	44	3	0	0	0	0	366	9.2	316	1	0	0	1	0.3
20NOV95	10.4	20235	34	0	12	37	465	144	5	0	0	0	0	663	19.5	631	11	0	3	3	0.5
27NOV95	8.5	14873	26	0	17	84	634	109	3	1	0	0	0	848	32.6	815	9	0	1	1	0.1
04DEC95	8.1	20360	35	0	44	157	1007	160	18	0	1	0	0	1387	39.6	1308	17	0	2	1	0.1
11DEC95	4.8	14538	25	1	26	84	642	140	9	0	0	0	0	901	36.0	866	6	0	0	14	1.6
18DEC95	2.7	19918	19	0	62	81	333	49	5	1	1	0	0	532	28.0	462	0	0	8	12	2.3
25DEC95	2.5	17068	22	0	127	111	363	56	11	0	0	0	0	668	30.4	526	4	0	7	13	1.9
01JAN96	1.0	18563	20	0	230	156	307	30	6	1	0	0	0	730	36.5	470	3	0	27	67	9.2
08JAN96	--	--	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0	0	0	--
15JAN96	1.3	18096	26	1	37	9	12	0	1	0	0	0	1	60	2.3	22	0	0	1	0	0.0
22JAN96	1.2	5907	14	0	135	34	114	13	0	0	0	0	0	296	21.1	157	11	0	1	4	1.4
29JAN96	1.3	10452	37	0	160	30	27	6	1	1	0	0	0	225	6.9	63	1	0	1	1	0.4
05FEB96	1.9	17190	29	0	96	29	44	6	6	1	0	0	0	182	6.3	83	0	0	2	3	1.6
12FEB96	1.1	15485	42	0	121	36	56	16	5	3	0	0	0	237	5.6	107	1	0	5	7	3.0
19FEB96	2.4	17768	22	0	63	34	80	11	0	1	0	1	0	190	8.6	115	3	0	4	5	2.6
26FEB96	2.9	15366	47	0	124	60	152	40	5	2	0	0	0	383	8.1	250	3	0	5	4	1.0
04MAR96	4.8	15737	38	0	404	99	187	33	7	0	0	0	0	730	19.2	322	0	1	0	1	0.1
11MAR96	4.8	13306	46	0	152	63	250	43	6	0	1	0	0	515	11.2	351	1	2	3	11	2.1
18MAR96	6.3	16077	46	0	261	186	406	56	4	1	0	0	0	914	19.9	635	15	2	5	13	1.4
25MAR96	6.6	10343	58	0	70	175	431	130	20	1	0	0	1	828	14.3	721	9	4	4	13	1.6
01APR96	8.6	18187	47	0	116	196	651	103	6	1	1	1	0	1075	22.9	936	13	0	2	17	1.6
08APR96	9.3	14080	44	0	58	84	322	150	28	0	1	0	0	643	14.6	560	13	0	0	7	1.1
15APR96	10.4	12860	50	1	68	157	703	131	11	0	2	0	0	1072	21.3	986	7	0	9	11	1.0
TOTAL	6.1	15352	806	3	2440	1967	7556	1490	165	14	7	2	2	13643	16.9	10889	111	9	90	209	1.5

Column groups: N TOWS (TOTAL, VOID); NUMBER OF STRIPED BASS CAUGHT BY SIZE GROUP (MM TL) (≤ 150 through TOTAL); NUMBER OF STRIPED BASS (TAGGED, RECAPTURED, HATCHERY, NOT TAGGED); MORTALITY (N, %).

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (MM) OF STRIPED BASS COLLECTED IN THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1995-96.

	UPPER HARBOR				BATTERY			
SAMPLE WEEK	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.
06NOV95	95	234	47.23	4.85	103	263	58.18	5.73
13NOV95	102	254	47.37	4.69	264	226	68.18	4.20
20NOV95	645	269	45.61	1.80	18	225	70.61	16.64
27NOV95	822	256	47.64	1.66	26	247	57.81	11.34
04DEC95	1378	252	52.36	1.41	9	259	78.24	26.08
11DEC95	.	.	.	.	901	259	51.99	1.73
18DEC95	.	.	.	.	532	234	64.53	2.80
25DEC95	.	.	.	.	668	224	70.98	2.75
01JAN96	.	.	.	.	730	195	68.07	2.52
08JAN96	.	.	.	.	.	.	.	.
15JAN96	20	162	80.37	17.97	40	169	154.45	24.42
22JAN96	.	.	.	.	296	181	70.68	4.11
29JAN96	.	.	.	.	225	151	66.33	4.42
05FEB96	100	184	90.30	9.03	82	171	65.70	7.26
12FEB96	100	195	84.42	8.44	137	177	98.66	8.43
19FEB96	110	202	81.19	7.74	80	194	82.88	9.27
26FEB96	130	201	79.18	6.94	253	209	84.78	5.33
04MAR96	.	.	.	.	730	167	74.50	2.76
11MAR96	5	103	10.04	4.49	510	209	76.15	3.37
18MAR96	28	244	67.25	12.71	884	198	67.38	2.27
25MAR96	1	110	.	.	827	242	75.95	2.64
01APR96	17	205	67.45	16.36	1058	232	63.48	1.95
08APR96	.	.	.	.	643	257	76.73	3.03
15APR96	181	284	44.64	3.32	891	238	61.22	2.05
TOTAL	3734	249	59.59	0.98	9907	220	75.38	0.76

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
S.E. = STANDARD ERROR

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) IN THE 9M TRAWL FOR 50MM LENGTH GROUPS IN THE BATTERY REGION AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1995-96

SAMPLING WEEK	NUMBER OF TOWS	<=50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800	>=801
06NOV95	39	--	--	0.2	0.5	2.0	1.7	0.4	0.1	0.1	--	--	--	--	--	--	--	--
13NOV95	40	--	0.2	1.0	1.1	2.9	2.7	1.1	0.1	0.1	--	--	--	--	--	--	--	--
20NOV95	34	--	< 0.1	0.3	1.1	4.5	9.1	3.7	0.5	0.1	< 0.1	--	--	--	--	--	--	--
27NOV95	26	--	--	0.7	3.2	10.0	14.4	3.6	0.6	0.1	--	< 0.1	--	--	--	--	--	--
04DEC95	35	--	--	1.3	4.5	13.1	15.6	3.6	1.0	0.5	< 0.1	--	--	< 0.1	--	--	--	--
11DEC95	25	--	< 0.1	1.0	3.4	9.9	15.8	4.4	1.2	0.2	0.1	--	--	--	--	--	--	--
18DEC95	19	--	0.1	3.2	4.3	9.9	7.6	2.0	0.6	0.3	--	0.1	--	--	0.1	--	--	--
25DEC95	22	--	0.8	5.0	5.0	8.2	8.3	1.9	0.7	0.4	0.1	--	--	--	--	--	--	--
01JAN96	20	--	2.0	9.5	7.8	11.0	4.4	0.9	0.7	0.2	0.1	--	0.1	--	--	--	--	--
08JAN96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15JAN96	26	--	0.5	0.9	0.3	0.4	0.1	--	--	< 0.1	--	--	--	--	--	--	--	< 0.1
22JAN96	14	--	2.1	7.6	2.4	5.1	3.0	0.6	0.4	--	--	--	--	--	--	--	--	--
29JAN96	37	--	0.8	3.6	0.8	0.4	0.4	0.1	0.1	< 0.1	--	< 0.1	--	--	--	--	--	--
05FEB96	29	--	0.5	2.8	1.0	1.1	0.4	0.1	0.1	0.2	--	< 0.1	--	--	--	--	--	--
12FEB96	42	--	0.5	2.4	0.9	0.8	0.5	0.1	0.2	0.1	< 0.1	< 0.1	< 0.1	--	--	--	--	--
19FEB96	22	--	0.5	2.4	1.5	2.4	1.3	0.5	< 0.1	--	--	--	< 0.1	--	--	< 0.1	--	--
26FEB96	47	--	0.5	2.1	1.3	2.2	0.9	0.5	0.4	< 0.1	0.1	< 0.1	--	--	--	--	--	--
04MAR96	38	--	2.8	7.8	2.6	3.2	1.7	0.5	0.4	0.2	--	--	--	--	--	--	--	--
11MAR96	46	--	0.5	2.8	1.4	3.5	2.0	0.7	0.2	0.1	< 0.1	--	--	--	< 0.1	--	--	--
18MAR96	46	< 0.1	0.9	4.7	4.0	5.8	3.0	1.0	0.2	< 0.1	0.1	< 0.1	--	--	--	--	--	--
25MAR96	58	--	0.3	0.9	3.0	4.5	2.9	1.3	0.9	0.3	< 0.1	< 0.1	--	--	--	--	--	< 0.1
01APR96	47	--	0.2	2.3	4.2	7.8	6.0	1.8	0.4	0.1	--	--	< 0.1	--	< 0.1	--	< 0.1	--
08APR96	44	--	0.1	1.2	1.9	3.9	3.4	2.3	1.1	0.6	< 0.1	--	--	--	< 0.1	--	--	--
15APR96	50	--	< 0.1	1.3	3.1	7.0	6.9	1.8	0.8	0.2	0.1	--	--	< 0.1	--	--	--	--
TOTAL	806	< 0.1	0.5	2.5	2.4	4.9	4.5	1.4	0.5	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX TABLE C-7. MEAN LENGTH AT AGE FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS COLLECTED BY THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER DURING THE 1986-87 THROUGH 1995-96 STRIPED BASS PROGRAMS.

AGE	COHORT	PROGRAM	N	STRATIFIED MEAN LENGTH (MM)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1995	1995-96	207	127	126	128
	1994	1994-95	216	104	104	105
	1993	1993-94	828	123	121	125
	1992	1992-93	473	116	114	118
	1991	1991-92	818	131	127	135
	1990	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1994	1995-96	1501	246	244	248
	1993	1994-95	1216	260	258	262
	1992	1993-94	2695	237	236	238
	1991	1992-93	3899	231	229	233
	1990	1991-92	3675	245	244	246
	1989	1990-91	2174	239	237	241
	1988	1989-90	3514	214	213	215
	1987	1988-89	3623	227	226	229
	1986	1987-88	1503	253	251	255
	1985	1986-87	285	221	215	227
2+	1993	1995-96	355	312	306	318
	1992	1994-95	455	312	308	316
	1991	1993-94	1631	317	307	328
	1990	1992-93	1378	329	325	333
	1989	1991-92	961	324	319	328
	1988	1990-91	2109	321	317	324
	1987	1989-90	1216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1992	1995-96	53	346	332	360
	1991	1994-95	99	356	346	366
	1990	1993-94	152	424	246	602
	1989	1992-93	125	414	400	428
	1988	1991-92	153	386	378	394
	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

NOTE: STRATIFIED MEAN LENGTH FOR THE 1990 AND 1991 WILD COHORTS OF STRIPED BASS INCLUDE HACTHERY AND WILD FISH COMBINED. HATCHERY FISH WERE NOT TAGGED PRIOR TO STOCKING DURING THESE YEARS.

N = NUMBER OF FISH AGED FROM VALID (USE CODE = 1) SAMPLES.

APPENDIX D

STRIPED BASS MARK-RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HACTHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1995-96.

AGE	GEAR	RECAPTURE DATE	STATION	RECAPTURE RIVER MILE	TOTAL LENGTH (MM)	RELEASE YEAR
0+	9 m TRAWL	04MAR96	BATTERY	8	142	1995
0+	9 m TRAWL	11MAR96	BATTERY	5	103	1995
1+	9 m TRAWL	15MAR96	BATTERY	1	218	1994
1+	9 m TRAWL	20MAR96	BATTERY	1	201	1994
1+	9 m TRAWL	22MAR96	BATTERY	8	217	1994
1+	9 m TRAWL	25MAR96	BATTERY	8	213	1994
1+	9 m TRAWL	27MAR96	BATTERY	8	208	1994
1+	9 m TRAWL	27MAR96	BATTERY	8	233	1994
1+	9 m TRAWL	29MAR96	BATTERY	8	221	1994

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED, RELEASED AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1995-96.

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
07DEC95	313	UPPER HARBOR	-1	10NOV95	311	UPPER HARBOR	-1	27	0	1	415924
03APR96	310	BATTERY	2	16NOV95	306	BATTERY	2	139	0	1	415955
21NOV95	314	UPPER HARBOR	-1	21NOV95	314	UPPER HARBOR	-1	0	0	1	416018
24NOV95	322	UPPER HARBOR	-1	24NOV95	322	UPPER HARBOR	-1	0	0	1	416091
24NOV95	322	UPPER HARBOR	-1	24NOV95	322	UPPER HARBOR	-1	0	0	1	416093
24NOV95	323	UPPER HARBOR	-1	24NOV95	323	UPPER HARBOR	-1	0	0	1	416094
10APR96	341	BATTERY	2	24NOV95	340	UPPER HARBOR	-1	138	3	1	416117
13DEC95	302	BATTERY	6	05DEC95	306	UPPER HARBOR	-2	8	8	1	416268
09APR96	301	BATTERY	2	26DEC95	301	BATTERY	2	105	0	1	416647
12APR96	303	BATTERY	2	28MAR96	356	BATTERY	2	15	0	1	417130
24NOV95	257	UPPER HARBOR	-1	06NOV95	257	UPPER HARBOR	-1	18	0	1	420124
07NOV95	272	UPPER HARBOR	-1	07NOV95	272	UPPER HARBOR	-1	0	0	1	420148
09NOV95	262	BATTERY	2	07NOV95	267	BATTERY	2	2	0	1	420161
15APR96	221	BATTERY	9	09NOV95	217	BATTERY	2	158	7	1	420209
10NOV95	181	UPPER HARBOR	-1	10NOV95	180	UPPER HARBOR	-1	0	0	1	420242
30NOV95	192	UPPER HARBOR	-1	10NOV95	187	UPPER HARBOR	-1	20	0	1	420243
16NOV95	236	BATTERY	2	16NOV95	236	BATTERY	2	0	0	1	420360
29MAR96	263	BATTERY	2	17NOV95	263	UPPER HARBOR	-1	133	3	1	420483
20NOV95	264	UPPER HARBOR	-1	20NOV95	264	UPPER HARBOR	-1	0	0	1	420547
01DEC95	235	UPPER HARBOR	-1	20NOV95	236	UPPER HARBOR	-1	11	0	1	420567
20NOV95	282	UPPER HARBOR	-1	20NOV95	282	UPPER HARBOR	-1	0	0	1	420658
20NOV95	254	UPPER HARBOR	-1	20NOV95	254	UPPER HARBOR	-1	0	0	1	420676
17APR96	228	BATTERY	6	20NOV95	230	UPPER HARBOR	-1	149	7	1	420704
14DEC95	280	BATTERY	6	20NOV95	279	UPPER HARBOR	-1	24	7	1	420705
21NOV95	258	UPPER HARBOR	-1	20NOV95	258	UPPER HARBOR	-1	1	0	1	420707
13DEC95	235	BATTERY	6	20NOV95	233	UPPER HARBOR	-1	23	7	1	420726
28FEB96	183	UPPER HARBOR	-2	20NOV95	181	UPPER HARBOR	-1	100	1	1	420727
21NOV95	280	UPPER HARBOR	-1	21NOV95	280	UPPER HARBOR	-1	0	0	1	420789
01DEC95	270	UPPER HARBOR	-1	22NOV95	270	UPPER HARBOR	-1	9	0	1	420908
24NOV95	244	UPPER HARBOR	-1	24NOV95	244	UPPER HARBOR	-1	0	0	1	420946
18MAR96	284	BATTERY	9	27NOV95	283	UPPER HARBOR	-1	112	10	1	421064
29NOV95	258	UPPER HARBOR	-1	27NOV95	258	UPPER HARBOR	-1	2	0	1	421082
06DEC95	235	UPPER HARBOR	-1	29NOV95	236	UPPER HARBOR	-1	7	0	1	421363
30NOV95	248	UPPER HARBOR	-1	29NOV95	248	UPPER HARBOR	-1	1	0	1	421366
22MAR96	255	BATTERY	9	29NOV95	257	UPPER HARBOR	-1	114	10	1	421413
01APR96	228	BATTERY	2	30NOV95	227	UPPER HARBOR	-1	123	3	1	421458
01DEC95	263	UPPER HARBOR	-1	01DEC95	264	UPPER HARBOR	-1	0	0	1	421604
01DEC95	271	UPPER HARBOR	-1	01DEC95	271	UPPER HARBOR	-1	0	0	1	421611
06DEC95	155	UPPER HARBOR	-4	01DEC95	154	UPPER HARBOR	-1	5	3	1	421643
01DEC95	200	UPPER HARBOR	-1	01DEC95	201	UPPER HARBOR	-1	0	0	1	421649
18MAR96	222	BATTERY	9	01DEC95	220	UPPER HARBOR	-1	108	10	1	421674
08DEC95	230	UPPER HARBOR	-1	04DEC95	228	UPPER HARBOR	-1	4	0	1	421745
06DEC95	235	UPPER HARBOR	-1	04DEC95	233	UPPER HARBOR	-1	2	0	1	421756
02APR96	211	BATTERY	2	04DEC95	211	UPPER HARBOR	-1	120	3	1	421798
03APR96	259	BATTERY	9	04DEC95	258	UPPER HARBOR	-1	121	10	1	421801
04DEC95	256	UPPER HARBOR	-1	04DEC95	264	UPPER HARBOR	-1	0	0	1	421860
04DEC95	258	UPPER HARBOR	-1	04DEC95	261	UPPER HARBOR	-1	0	0	1	421864
04DEC95	190	UPPER HARBOR	-1	04DEC95	188	UPPER HARBOR	-1	0	0	1	421871
06DEC95	218	UPPER HARBOR	-1	04DEC95	220	UPPER HARBOR	-1	2	0	1	421912
07DEC95	209	UPPER HARBOR	-1	04DEC95	209	UPPER HARBOR	-1	3	0	1	421933

(CONTINUED)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE DATE	RECAPTURE TOTAL LENGTH (MM)	RECAPTURE REGION	RECAPTURE RM	RELEASE DATE	RELEASE TOTAL LENGTH (MM)	RELEASE REGION	RELEASE RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
06DEC95	185	UPPER HARBOR	-1	04DEC95	185	UPPER HARBOR	-1	2	0	1	421942
27MAR96	284	BATTERY	9	05DEC95	226	UPPER HARBOR	-1	113	10	1	421980
06DEC95	186	UPPER HARBOR	-1	05DEC95	186	UPPER HARBOR	-1	1	0	1	422037
29JAN96	282	BATTERY	2	05DEC95	281	UPPER HARBOR	-2	55	4	1	422048
05DEC95	251	UPPER HARBOR	-2	05DEC95	252	UPPER HARBOR	-2	0	0	1	422065
15MAR96	220	BATTERY	9	05DEC95	222	UPPER HARBOR	-1	101	10	1	422183
06DEC95	190	UPPER HARBOR	-1	05DEC95	191	UPPER HARBOR	-1	1	0	1	422192
23FEB96	278	UPPER HARBOR	-2	06DEC95	279	UPPER HARBOR	-1	79	1	1	422296
06DEC95	243	UPPER HARBOR	-1	06DEC95	243	UPPER HARBOR	-1	0	0	1	422336
09APR96	271	BATTERY	2	06DEC95	274	UPPER HARBOR	-1	125	3	1	422339
02APR96	298	BATTERY	9	06DEC95	299	UPPER HARBOR	-1	118	10	1	422404
02JAN96	272	BATTERY	9	07DEC95	275	UPPER HARBOR	-1	26	10	1	422452
03APR96	241	BATTERY	9	07DEC95	241	UPPER HARBOR	-1	118	10	1	422487
08DEC95	216	UPPER HARBOR	-1	07DEC95	218	UPPER HARBOR	-1	1	0	1	422493
02APR96	235	BATTERY	2	07DEC95	237	UPPER HARBOR	-1	117	3	1	422495
28DEC95	230	BATTERY	2	07DEC95	228	UPPER HARBOR	-1	21	3	1	422577
11DEC95	240	BATTERY	2	11DEC95	240	BATTERY	2	0	0	1	422884
13DEC95	200	BATTERY	6	13DEC95	197	BATTERY	6	0	0	1	423102
15DEC95	269	BATTERY	6	15DEC95	271	BATTERY	6	0	0	1	423435
03JAN96	181	BATTERY	6	18DEC95	181	BATTERY	6	16	0	1	423780
16APR96	237	BATTERY	9	18DEC95	239	BATTERY	6	120	3	1	423783
19MAR96	171	BATTERY	9	28DEC95	169	BATTERY	2	82	7	1	424300
28DEC95	256	BATTERY	2	28DEC95	256	BATTERY	2	0	0	1	424304
28DEC95	276	BATTERY	2	28DEC95	276	BATTERY	2	0	0	1	424307
29DEC95	279	BATTERY	6	29DEC95	279	BATTERY	6	0	0	1	424407
01APR96	183	BATTERY	2	02JAN96	184	BATTERY	9	90	7	1	424583
29MAR96	164	BATTERY	9	02JAN96	162	BATTERY	9	87	0	1	424584
04JAN96	295	BATTERY	6	04JAN96	295	BATTERY	6	0	0	1	424663
25JAN96	219	BATTERY	2	05JAN96	221	BATTERY	9	20	7	1	424898
15APR96	244	BATTERY	6	05JAN96	245	BATTERY	6	101	0	1	424930
23FEB96	151	UPPER HARBOR	-2	31JAN96	152	BATTERY	6	23	8	1	430140
23FEB96	282	UPPER HARBOR	-2	15FEB96	282	UPPER HARBOR	-2	8	0	1	430292
15FEB96	228	UPPER HARBOR	-2	15FEB96	228	UPPER HARBOR	-2	0	0	1	430304
27FEB96	220	BATTERY	2	23FEB96	219	UPPER HARBOR	-2	4	4	1	430371
28FEB96	184	UPPER HARBOR	-2	23FEB96	186	UPPER HARBOR	-2	5	0	1	430420
29MAR96	184	BATTERY	9	28FEB96	183	UPPER HARBOR	-2	30	11	1	430535
27MAR96	176	BATTERY	9	01MAR96	175	BATTERY	2	26	7	1	430586
10APR96	167	BATTERY	9	05MAR96	177	BATTERY	9	36	0	1	430701
18MAR96	234	BATTERY	9	07MAR96	237	BATTERY	9	11	0	1	430893
10APR96	230	BATTERY	9	15MAR96	231	BATTERY	9	26	0	1	431170
10APR96	250	BATTERY	2	25MAR96	245	BATTERY	2	16	0	1	431891
11APR96	240	BATTERY	2	27MAR96	242	BATTERY	9	15	7	1	432116
28MAR96	248	BATTERY	9	28MAR96	218	BATTERY	9	0	0	1	432241
28MAR96	217	BATTERY	9	28MAR96	247	BATTERY	9	0	0	1	432242
12APR96	162	BATTERY	9	28MAR96	162	BATTERY	9	15	0	1	432290
29MAR96	245	BATTERY	9	29MAR96	245	BATTERY	9	0	0	1	432372
29MAR96	241	BATTERY	9	29MAR96	241	BATTERY	9	0	0	1	432383
02APR96	271	BATTERY	9	02APR96	241	BATTERY	9	0	0	1	432581
04APR96	181	BATTERY	9	03APR96	187	BATTERY	9	1	0	1	432830
03APR96	176	BATTERY	2	03APR96	176	BATTERY	2	0	0	1	432901

(CONTINUED)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
05APR96	202	BATTERY	9	05APR96	204	BATTERY	9	0	0	1	433105
12APR96	198	BATTERY	9	12APR96	198	BATTERY	9	0	0	1	433559
16APR96	250	BATTERY	9	16APR96	250	BATTERY	9	0	0	1	433875
19APR96	208	BATTERY	6	17APR96	208	BATTERY	6	2	0	1	434051
18APR96	222	BATTERY	6	18APR96	182	BATTERY	6	0	0	1	434237

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION
2 = INFECTED TAG INSERTION

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1995-96.

RECAPTURE				RELEASE								
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	GEAR	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	GROWTH (MM)	CONDITION	TAG NUMBER
11APR96	412	BATTERY	2	21DEC94	9 m TRAWL	329	UPPER HARBOR	-4	477	83	1	404522
12APR96	337	BATTERY	9	13DEC94	9 m TRAWL	241	BATTERY	2	486	96	1	410829
02APR96	283	BATTERY	2	04JAN95	9 m TRAWL	241	UPPER HARBOR	-4	454	42	1	411606
12APR96	332	BATTERY	2	16JAN95	9 m TRAWL	265	BATTERY	9	452	67	1	412046
30NOV95	320	UPPER HARBOR	-1	21FEB95	9 m TRAWL	185	BATTERY	2	282	135	1	413397
06DEC95	290	BATTERY	2	13APR95	9 m TRAWL	246	BATTERY	2	237	44	2	420077

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION
2 = INFECTED TAG INSERTION

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED IN THE 9M TRAWL IN THE HUDSON RIVER, WINTER 1995-96

			NUMBER OF STRIPED BASS RECAPTURED DURING WEEK																								
RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS (C)	STATISTIC	08NOV95 M= 187	13NOV95 M= 316	20NOV95 M= 631	27NOV95 M= 815	04DEC95 M= 1308	11DEC95 M= 866	18DEC95 M= 462	25DEC95 M= 526	01JAN96 M= 470	08JAN96 M= .	15JAN96 M= 22	22JAN96 M= 157	29JAN96 M= 63	05FEB96 M= 63	12FEB96 M= 107	19FEB96 M= 115	26FEB96 M= 249	04MAR96 M= 323	11MAR96 M= 351	18MAR96 M= 635	25MAR96 M= 721	01APR96 M= 836	08APR96 M= 360	15APR96 M= 966	TOTAL M= 10889
08NOV95	190	R	3																								3
		R/M	0.01604																								0.00028
		R/C	0.01579																								0.01579
13NOV95	317	R	0	1																							1
		R/M	0.00000	0.00316																							0.00009
		R/C	0.00000	0.00315																							0.00315
20NOV95	651	R	1	0	10																						11
		R/M	0.00535	0.00000	0.01585																						0.00101
		R/C	0.00154	0.00000	0.01536																						0.01690
27NOV95	832	R	1	0	2	5																					8
		R/M	0.00535	0.00000	0.00317	0.00813																					0.00073
		R/C	0.0012	0.00000	0.0024	0.00601																					0.00962
04DEC95	1346	R	1	0	0	2	13																				16
		R/M	0.00535	0.00000	0.00000	0.00246	0.00994																				0.00147
		R/C	0.00074	0.00000	0.00000	0.00149	0.00966																				0.01189
11DEC95	876	R	0	0	2	0	1	3																			6
		R/M	0.00000	0.00000	0.00317	0	0.00076	0.00346																			0.00055
		R/C	0.00000	0.00000	0.00228	0	0.00114	0.00342																			0.00685
18DEC95	472	R	0	0	0	0	0	0	0																		0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000																		0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000																		0.00000
25DEC95	541	R	0	0	0	0	1	0	0	3																	4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00076	0.00000	0.00000	0.00570																	0.00037
		R/C	0.00000	0.00000	0.00000	0.00000	0.00185	0.00000	0.00000	0.00555																	0.00739
01JAN96	502	R	0	0	0	0	1	0	1	0	1																3
		R/M	0.00000	0.00000	0.00000	0.00000	0.00076	0.00000	0.00216	0.00000	0.00213																0.00028
		R/C	0.00000	0.00000	0.00000	0.00000	0.00199	0.00000	0.00199	0.00000	0.00199																0.00598
08JAN96	.	R	0	0	0	0	0	0	0	0	0	0															0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000																0.00000
		R/C																									
15JAN96	23	R	0	0	0	0	0	0	0	0	0	0	0														0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000														0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000														0.00000
22JAN96	161	R	0	0	0	0	0	0	0	0	1	0	0	0													1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00213		0.00000	0.00000													0.00009
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00621	0.00000	0.00000	0.00000													0.00621
29JAN96	66	R	0	0	0	0	1	0	0	0	0	0	0	0	0												1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00076	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000												0.00009
		R/C	0.00000	0.00000	0.00000	0.00000	0.01515	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000												0.01515
05FEB96	66	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0											0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000											0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000											0.00000

(CONTINUED)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTURE PERIOD	NUMBER EXAMINED FOR MARKS (C)	STATISTIC	NUMBER OF STRIPED BASS RECAPTURED DURING WEEK 06NOV85 M= 187	13NOV85 M= 316	20NOV85 M= 631	27NOV85 M= 815	04DEC85 M= 1309	11DEC85 M= 867	18DEC85 M= 462	25DEC85 M= 526	01JAN86 M= 470	08JAN86 M= .	15JAN86 M= 22	22JAN86 M= 157	29JAN86 M= 63	05FEB86 M= 93	12FEB86 M= 107	19FEB86 M= 115	26FEB86 M= 249	04MAR86 M= 323	11MAR86 M= 351	18MAR86 M= 635	25MAR86 M= 721	01APR86 M= 936	08APR86 M= 560	15APR86 M= 986	TOTAL M= 10869
12FEB86	116	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1										1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00935										0.00009
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00862										0.00862
19FEB86	127	R	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0									3
		R/M	0.00000	0.00000	0.00000	0.00000	0.00076	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.01587	0.00000	0.00935	0.00000									0.00028
		R/C	0.00000	0.00000	0.00000	0.00000	0.00787	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00787	0.00000	0.00787	0.00000									0.02362
26FEB86	260	R	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0								3
		R/M	0.00000	0.00000	0.00158	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.01739	0.00000								0.00028
		R/C	0.00000	0.00000	0.00385	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00769	0.00000								0.01154
04MAR86	329	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000							0.00000
11MAR86	363	R	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00076	0.00000	0.00000	0.00000	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000						0.00009
		R/C	0.00000	0.00000	0.00000	0.00000	0.00275	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000						0.00275
18MAR86	654	R	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0					5
		R/M	0.00000	0.00000	0.00000	0.00368	0.00000	0.00000	0.00000	0.00190	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00310	0.00000	0.00000					0.00046
		R/C	0.00000	0.00000	0.00000	0.00459	0.00000	0.00000	0.00000	0.00153	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00153	0.00000	0.00000					0.00765
25MAR86	760	R	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	4				9
		R/M	0.00000	0.00316	0.00000	0.00000	0.00076	0.00000	0.00000	0.00000	0.00213		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00803	0.00000	0.00000	0.00000	0.00555				0.00083
		R/C	0.00000	0.00132	0.00000	0.00000	0.00132	0.00000	0.00000	0.00000	0.00132	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00263	0.00000	0.00000	0.00000	0.00526				0.01184
01APR86	961	R	0	1	0	1	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4			12
		R/M	0.00000	0.00316	0.00000	0.00123	0.00382	0.00000	0.00000	0.00000	0.00213		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00427			0.00110
		R/C	0.00000	0.00104	0.00000	0.00104	0.00520	0.00000	0.00000	0.00000	0.00104	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00416			0.01249
08APR86	586	R	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	4	0	1		10
		R/M	0.00000	0.00000	0.00158	0.00000	0.00076	0.00000	0.00000	0.00190	0.00000		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00310	0.00285	0.00000	0.00555	0.00000	0.00179		0.00092
		R/C	0.00000	0.00000	0.00171	0.00000	0.00171	0.00000	0.00000	0.00171	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00171	0.00171	0.00000	0.00683	0.00000	0.00171		0.01706
15APR86	1005	R	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7
		R/M	0.00535	0.00000	0.00158	0.00000	0.00000	0.00000	0.00216	0.00000	0.00213		0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00304	0.00064
		R/C	0.00100	0.00000	0.00100	0.00000	0.00000	0.00000	0.00100	0.00000	0.00100	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00299	0.00697
TOTAL	11224	R	7	3	17	11	26	3	2	5	5	0	0	0	1	0	2	2	2	2	1	0	8	4	1	3	108
		R/M	0.03743	0.00949	0.02694	0.01350	0.01986	0.00346	0.00433	0.00951	0.01064		0.00000	0.00000	0.01587	0.00000	0.01869	0.01739	0.00803	0.00619	0.00285	0.00000	0.01110	0.00427	0.00179	0.00304	0.00994
		R/C	0.00062	0.00027	0.00151	0.00098	0.00232	0.00027	0.00018	0.00045	0.00045	0.00000	0.00000	0.00000	0.00009	0.00000	0.00018	0.00018	0.00018	0.00018	0.00009	0.00000	0.00071	0.00036	0.00009	0.00027	0.00962

R = NUMBER OF STRIPED BASS RECAPTURED
M = NUMBER OF STRIPED BASS 150 MM MARKED AND RELEASED
C = NUMBER OF STRIPED BASS 150 MM COLLECTED AND EXAMINED FOR TAGS
R/M = RECAPTURE RATE.
R/C = RECAPTURE PROPORTION.

APPENDIX TABLE D-5. TAG CONDITION AND RELEASE/RECAPTURE INFORMATION FOR STRIPED BASS CAPTURED WITH ABRADED TAGS DURING THE DURING THE 1995-96 PROGRAM.

RECAPTURE				RELEASE				TAG INFORMATION		TAG CONDITION					
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	MARK CODE	TAG NUMBER	NUMBER	ADDRESS	REWARD	ORIEN-TATION	ANCHOR PROTRUSION	CONDITION
11APR96	412	BATTERY	2	21DEC94	329	UPPER HARBOR	-4	98	404522	3	3	3	1	2	1

NOTE: NUMBER, ADDRESS, REWARD: 1 = LEGEND COMPLETELY MISSING
2 = ABRADED AND PARTLY MISSING
3 = ABRADED BUT COMPLETELY LEGIBLE
4 = COMPLETELY LEGIBLE

TAG ORIENTATION : 1 = TAG NUMBER FACING ANTERIOR (HEAD)
2 = TAG NUMBER FACING POSTERIOR (TAIL)

TAG PROTRUSION : 1 = YES (TAG PROTRUSION EVIDENT)
2 = NO (TAG PROTRUSION NOT EVIDENT)

TAG CONDITION: 1 = HEALED TAG INSERTION
2 = INFECTED TAG INSERTION

MARK CODE : 98 = HALLPRINT INTERNAL ANCHOR, EXTERNAL STREAMER

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1995-96.

SAMPLING WEEK	(· 150 MM TL) C TOTAL	(· 150 MM TL) M TOTAL	CUM M TOTAL	R TOTAL	R/C	Ct*Cumm Mt	Cumm Mt*Rt	Ct*(Cumm Mt)2	Rt2/Ct
13NOV95	317	316	0	0	0.00000	0	0	0	0.0000
20NOV95	651	631	316	0	0.00000	205,716	0	65,006,256	0.0000
27NOV95	832	815	947	2	0.00240	787,904	1894	746,145,088	0.0048
04DEC95	1346	1308	1762	2	0.00149	2,371,652	3524	4,178,850,824	0.0030
11DEC95	876	866	3070	3	0.00342	2,689,320	9210	8,256,212,400	0.0103
18DEC95	472	462	3936	0	0.00000	1,857,792	0	7,312,269,312	0.0000
25DEC95	541	526	4398	1	0.00185	2,379,318	4398	10,464,240,564	0.0018
01JAN96	502	470	4924	2	0.00398	2,471,848	9848	12,171,379,552	0.0080
08JAN96	0	0	5394	0	0.00000	0	0	0	0.0000
15JAN96	23	22	5394	0	0.00000	124,062	0	669,190,428	0.0000
22JAN96	161	157	5416	1	0.00621	871,976	5416	4,722,622,016	0.0062
29JAN96	66	63	5573	1	0.01515	367,818	5573	2,049,849,714	0.0152
05FEB96	86	107	5636	0	0.00000	484,696	0	2,731,746,656	0.0000
12FEB96	116	115	5719	0	0.00000	663,404	0	3,794,007,476	0.0000
19FEB96	127	249	5826	3	0.02362	739,902	17,478	4,310,669,052	0.0709
26FEB96	260	323	5941	3	0.01154	1,544,660	17,823	9,176,825,060	0.0346
04MAR96	329	351	6190	0	0.00000	2,036,510	0	12,605,996,900	0.0000
11MAR96	363	635	6513	1	0.00275	2,364,219	6513	15,398,158,347	0.0028
18MAR96	654	721	6864	5	0.00765	4,489,056	34,320	30,812,880,384	0.0382
25MAR96	760	936	7499	5	0.00658	5,699,240	37,495	42,738,600,760	0.0329
01APR96	961	560	8220	8	0.00832	7,899,420	65,760	64,933,232,400	0.0666
08APR96	586	986	9156	9	0.01536	5,365,416	82,404	49,125,748,896	0.1382
TOTAL	10,029		108,695	46	0.11029	45,414,008	301,656	286,264,672,434	0.43328

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE HUDSON RIVER, WINTER 1995-96.

SOURCE	DF	SS	MS	F-RATIO	p > F
MODEL	1	0.00018	0.00018	5.41	0.0307
ERROR	20	0.00068	0.00003		
TOTAL	21	0.00086			

REGRESSION EQUATION: R/C = (CUMULATIVE M) X + ERROR

WHERE,

X = 0.0000012 (STANDARD ERROR OF X = 0.00000054)

p > F = PROBABILITY OF OBTAINING A LARGER F-RATIO
df = DEGREES OF FREEDOM
SS = SUM OF SQUARES
MS = MEAN SQUARE

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS PROGRAM, 1984 TO PRESENT.

		TAG TYPE					
PROGRAM YEAR	NUMBER TAGGED	ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)	MODIFIED INTERNAL ANCHOR (HALL)	SMALL DART (HALL)
1984	737	737	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819
1989-1990	24,362	--	--	--	--	24,362	659
1990-1991	22,406	--	--	--	--	22,406	--
1991-1992	24,307	--	--	--	--	24,307	--
1992-1993	21,746	--	--	--	--	21,746	--
1993-1994	18,310	--	--	--	--	18,310	--
1994-1995	6,838	--	--	--	--	6,838	--
1995-1996	11,015	--	--	--	--	11,015	--
TOTAL	194,468	737	28,041	4,575	16,402	145,450	1,478

NOTE: HALL = HALLPRINT.

PROGRAM YEAR(S):

1988-1989 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1989-1990 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1991-1992 TOTAL INCLUDES 23,514 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 793 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1992-1993 TOTAL INCLUDES 20,847 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 899 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1993-1994 TOTAL INCLUDES 17,500 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 810 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1995-1996 TOTAL INCLUDES 10,889 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 126 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS COLLECTED, TAGGED AND RELEAED DURING THE 1995-96 STRIPED BASS EVALUATION PROGRAM.

TAG	ANCHOR	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
HALLPRINT INTERNAL ANCHOR	SMALL, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	1710
HALLPRINT INTERNAL ANCHOR	LARGE, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	9305
TOTAL				11,015

NOTE: STRIPED BASS ≥ 150 MM TL < 300 MM TL IN GOOD CONDITION WERE TAGGED WITH SMALL ANCHOR (20 MM) TAGS AND RELEASED.

STRIPED BASS ≥ 300 MM TL IN GOOD CONDITION WERE TAGGED WITH LARGE ANCHOR (25 MM) TAGS AND RELEASED.

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted during the 1995-96 program were returned to the laboratory and examined in fresh condition to determine length, weight, sex and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for those observations. Similar biocharacteristic data were obtained during the 1985-86 through 1993-94 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 Length, Weight, Sex and Sexual Condition of Striped Bass

Length, weight, sex and sexual condition were determined for 93 striped bass that died during field sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 100.0 g for fish greater that 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-1.

E.2.2 Striped Bass Stomach Contents Analysis

Striped bass that were processed as described above in Section E.2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in the striped bass stomach contents. Atlantic tomcod were

APPENDIX TABLE E-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS

SEXUAL CONDITION	FEMALES	MALES
GRAVID OR MILTING (RIPE)	OVARIES FULL OF YELLOWISH GRANULAR EGGS THAT ARE PARTIALLY TRANSLUCENT. EGGS CAN BE RELEASED WHEN OVARY IS COMPRESSED.	TESTES WHIRE, LESS FIRM IN TEXTURE, AND IF COMPRESSED WILL READILY MILT.
RIPE AND RUNNING	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF EGGS WITH LITTLE PROVOCATION.	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF MILT WITH LITTLE PROVOCATION.
PARTIALLY SPENT	OVARIES SOMEWHAT FLACCID AND CONVOLUTED, WITH A VARIABLE NUMBER OF EGGS LEFT. OVARIAN MEMBRANE SOMEWHAT WASCULAR.	TESTES WHITISH, SOMEWHAT FLACCID AND CONVOLUTED, WITH FREE FLOW OF MILT.
SPENT	OVARIES FLACCID, FEW TRANSLUCENT EGGS LEFT. OVARIAN MEMBRANE VERY VASCULAR OR SAC LIKE.	TESTES BROWNISH WHITE, FLACCID, CONVOLUTED WITH NO FLOW OF MILT UPON COMPRESSION.
IMMATURE	OVARIES VERY SMALL AND STRING-LIKE, THICKER THAN TESTES, SOMEWHAT OPAQUE AND GELATINOUS IN APPEARANCE.	TESTES VERY SMALL AND STRINGLIKE, THINNER THAN OVARIES, SOMEWHAT TRANSLUCENT, AND EXTREMELY TENDER.
NOT GRAVID OR NOT MILTING (RESTING)	UNDERDEVLOPED OVARIES IN AN ADULT FEMALE. OVARIES LARGER, MORE FIRM, OPAQUE, AND RELATIVELY THICK. NO EGGS DISCERNIBLE TO NAKED EYE.	UNDERDEVELOPED TESTES IN AN ADULT MALE. TESTES LARGER MORE FIRM, OPAQUE, BUT STILL TENDER.
SEMI-GRAVID OR SEMI-MILTING (DEVELOPING)	SUBRIPE FEAMLES HEADING INTO SPAWNING SEASON. OVARIES CONSIDERABLY LARGER, YELLOW, GRANULAR IN CONSISTENCY. EGGS DISCERNIBLE TO NAKED EYE, BUT NOT READILY RELEASED WHEN OVARY IS COMPRESSED.	SUBRIPE MALES HEADING INTO SPAWNING SEASON. TESTES CONSIDERABLY LARGER, WHITE, FIRM IN TEXTURE, BUT MILT NOT RUNNING.

differentiated from other fish species by comparing vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 Striped bass Sexual Condition

A total of 43 male and 50 female striped bass were returned to the laboratory for biocharacteristic analysis. The majority of striped of both male and female striped bass were immature. Approximately 91% of the male striped bass analyzed were immature, with the remainder either resting or developing. Female striped bass examined were either immature (96%) or developing (4%) (Table E-2).

The lack of ripe, or ripe and running striped bass in the 1995-96 biocharacteristic sample agrees with the findings of the 1985-86 through 1994-95 programs (Table E-3 and E-4). Detailed comparisons between the 1995-96 program and previous years are difficult due to the limited number of dead fish returned for biocharacteristic analysis. Historically, the majority of male fish from previous programs were considered immature or resting, with the remainder in the developing stage. Immature fish made up the majority of female striped bass included in biocharacteristic samples. No female fish in the developing or ripe stages have been examined (NAI 1995b). The lack of ripe or ripe and running striped bass is not surprising because the majority of the fish collected are of pre-spawning size (< 400 mm) and the program terminates before the onset of peak spawning (NAI 1986; TI 1981).

E.3.1 Striped Bass Food Habits

Food habits of striped bass that died during field sample collection were determined for all fish returned to the laboratory for biocharacteristic analysis. Stomach contents were identified as invertebrates, vertebrates, or Atlantic tomcod. The presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River Estuary during the winter months.

No Atlantic tomcod were observed in any of the striped bass stomachs examined. The majority of stomachs examined contained invertebrates (48%) or were empty (45%) (Table E-5). The

APPENDIX TABLE E-2. SEXUAL CONDITION OF STRIPED BASS EXAMINED FROM FISH THAT DIED DURING COLLECTION IN THE 1995-96 HUDSON RIVER STRIPED BASS STOCK ASSESSMENT PROGRAM.

MONTH	PERCENTAGE AND NUMBER OF STRIPED BASS											
	MALE							FEMALE				
	IMMATURE		RESTING		DEVELOPING		TOTAL	IMMATURE		DEVELOPING		TOTAL
	%	N	%	N	%	N	N	%	N	%	N	N
NOVEMBER	100.0	3	--	--	--	--	3	100.0	1	--	--	1
DECEMBER	87.5	7	12.5	1	--	--	8	100.0	9	--	--	9
JANUARY	80.0	8	10.0	1	10.0	1	10	100.0	18	--	--	18
FEBRUARY	100.0	7	--	--	--	--	7	75.0	6	25.0	2	8
MARCH	100.0	10	--	--	--	--	10	100.0	8	--	--	8
APRIL	80.0	4	--	--	20.0	1	5	100.0	6	--	--	6
TOTAL	90.7	39	4.7	2	4.7	2	43	96.0	48	4.0	2	50

APPENDIX TABLE E-3. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1995-96 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
112	11	14MAR96	BATTERY	9	MALE	IMMATURE	EMPTY
115	14	18MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
118	14	18MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
120	12	18MAR96	BATTERY	9	MALE	IMMATURE	EMPTY
142	22	18MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
151	29	14FEB96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
152	30	15FEB96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
152	30	29MAR96	BATTERY	9	MALE	IMMATURE	EMPTY
152	35	02FEB96	BATTERY	2	FEMALE	IMMATURE	EMPTY
153	32	12APR96	BATTERY	2	FEMALE	IMMATURE	EMPTY
154	35	14FEB96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
156	30	04JAN96	BATTERY	6	MALE	IMMATURE	EMPTY
157	37	05JAN96	BATTERY	6	MALE	IMMATURE	INVERTBRATES
160	38	04JAN96	BATTERY	6	MALE	IMMATURE	INVERTBRATES
163	38	30NOV95	UPPER HARBOR	-1	MALE	IMMATURE	EMPTY
164	41	05JAN96	BATTERY	9	FEMALE	IMMATURE	INVERTBRATES
166	40	19APR96	BATTERY	6	MALE	IMMATURE	EMPTY
167	39	05JAN96	BATTERY	9	MALE	IMMATURE	EMPTY
167	42	19APR96	UPPER HARBOR	-2	FEMALE	IMMATURE	EMPTY
168	43	27MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
169	42	18MAR96	BATTERY	9	FEMALE	IMMATURE	INVERTBRATES
170	40	05APR96	BATTERY	9	MALE	IMMATURE	EMPTY
170	43	18MAR96	BATTERY	9	MALE	IMMATURE	INVERTBRATES
173	49	27DEC95	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
173	49	26DEC95	BATTERY	2	FEMALE	IMMATURE	EMPTY
174	43	05JAN96	BATTERY	9	FEMALE	IMMATURE	EMPTY
174	52	07FEB96	UPPER HARBOR	-2	MALE	IMMATURE	EMPTY
176	52	29DEC95	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
178	47	18MAR96	BATTERY	9	MALE	IMMATURE	INVERTBRATES
179	48	04JAN96	BATTERY	6	FEMALE	IMMATURE	EMPTY
179	48	21FEB96	BATTERY	2	MALE	IMMATURE	EMPTY
184	54	04JAN96	BATTERY	6	FEMALE	IMMATURE	EMPTY
185	63	18MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
187	64	19DEC95	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
189	65	19DEC95	BATTERY	6	MALE	IMMATURE	EMPTY
190	58	05APR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
191	60	04JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
191	61	27MAR96	BATTERY	9	MALE	IMMATURE	EMPTY
192	72	05JAN96	BATTERY	9	FEMALE	IMMATURE	EMPTY
193	69	05JAN96	BATTERY	9	FEMALE	IMMATURE	EMPTY
195	72	04JAN96	BATTERY	6	MALE	IMMATURE	VERTEBRATES
200	76	12APR96	BATTERY	2	MALE	IMMATURE	INVERTBRATES
200	78	05JAN96	BATTERY	9	MALE	IMMATURE	EMPTY
202	69	21DEC95	BATTERY	2	MALE	IMMATURE	INVERTBRATES
203	80	05JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
204	73	23FEB96	UPPER HARBOR	-2	MALE	IMMATURE	EMPTY
204	77	23FEB96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
204	84	12APR96	BATTERY	2	FEMALE	IMMATURE	BOTH
205	80	04JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
208	83	19APR96	BATTERY	6	MALE	IMMATURE	EMPTY
219	103	14FEB96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES

(CONTINUED)

APPENDIX TABLE E-3. (CONTINUED)

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
219	114	27FEB96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
220	98	04JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
221	112	02MAR96	BATTERY	6	MALE	IMMATURE	EMPTY
222	94	14MAR96	BATTERY	2	MALE	IMMATURE	INVERTBRATES
222	108	27MAR96	BATTERY	9	MALE	IMMATURE	EMPTY
225	104	04JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
225	111	04JAN96	BATTERY	6	MALE	IMMATURE	INVERTBRATES
227	117	02JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
228	108	02MAR96	BATTERY	6	MALE	IMMATURE	EMPTY
228	112	29DEC95	BATTERY	6	MALE	IMMATURE	EMPTY
228	116	19DEC95	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
234	125	29DEC95	BATTERY	6	FEMALE	IMMATURE	VERTEBRATES
235	20	14MAR96	BATTERY	2	FEMALE	IMMATURE	EMPTY
241	137	05JAN96	BATTERY	9	FEMALE	IMMATURE	VERTEBRATES
242	129	05JAN96	BATTERY	6	MALE	IMMATURE	INVERTBRATES
243	139	05JAN96	BATTERY	9	FEMALE	IMMATURE	EMPTY
245	147	21NOV95	UPPER HARBOR	-1	MALE	IMMATURE	INVERTBRATES
251	169	04JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
253	159	05JAN96	BATTERY	9	FEMALE	IMMATURE	INVERTBRATES
257	178	19APR96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
260	175	23FEB96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
261	176	27FEB96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
264	184	23FEB96	UPPER HARBOR	-2	MALE	IMMATURE	EMPTY
265	176	03JAN96	BATTERY	6	FEMALE	IMMATURE	EMPTY
266	211	21DEC95	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
274	200	19DEC95	BATTERY	6	MALE	IMMATURE	INVERTBRATES
277	213	05JAN96	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
277	244	20NOV95	UPPER HARBOR	-1	MALE	IMMATURE	INVERTBRATES
280	233	06DEC95	UPPER HARBOR	-1	FEMALE	IMMATURE	EMPTY
280	245	14DEC95	BATTERY	6	MALE	IMMATURE	INVERTBRATES
281	204	19APR96	UPPER HARBOR	-2	MALE	DEVELOPING	EMPTY
282	236	27DEC95	BATTERY	2	MALE	IMMATURE	BOTH
297	287	24NOV95	UPPER HARBOR	-1	FEMALE	IMMATURE	INVERTBRATES
300	264	19DEC95	BATTERY	6	MALE	IMMATURE	INVERTBRATES
323	325	19DEC95	BATTERY	6	FEMALE	IMMATURE	BOTH
352	436	27DEC95	BATTERY	6	MALE	RESTING	INVERTBRATES
360	432	27MAR96	BATTERY	9	FEMALE	IMMATURE	EMPTY
365	462	19APR96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
411	675	10FEB96	UPPER HARBOR	-2	FEMALE	DEVELOPING	INVERTBRATES
424	741	14FEB96	UPPER HARBOR	-2	FEMALE	DEVELOPING	INVERTBRATES
433	818	31JAN96	BATTERY	2	MALE	DEVELOPING	EMPTY
565	1491	05JAN96	BATTERY	9	MALE	RESTING	INVERTBRATES

APPENDIX TABLE E-4. **SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1985-86 THROUGH 1995-96 PROGRAMS.**

IMMATURE MALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	0	0	1	1	4	6	6	8	1	0	3	30	58.8
DEC	16	2	2	7	2	12	13	18	9	0	7	88	59.5
JAN	13	7	5	10	5	16	57	9	34	0	8	164	69.8
FEB	8	9	17	6	1	11	24	9	2	0	7	94	63.9
MAR	11	10	8	5	2	7	3	36	83	0	10	175	73.2
APR	12	14	0	2	2	3	27	48	69	0	4	181	57.6
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	60	42	33	31	16	55	130	128	198	0	39	732	64.0

RESTING MALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	1	0	1	1	1	1	4	5	4	1	0	19	37.3
DEC	0	0	4	5	1	6	7	12	10	1	1	47	31.8
JAN	0	1	9	1	0	2	14	14	8	0	1	50	21.3
FEB	0	1	0	0	0	9	9	12	1	0	0	32	21.8
MAR	0	8	0	0	0	3	6	2	13	0	0	32	13.4
APR	0	45	0	0	0	2	10	4	4	0	0	65	20.7
MAY	5	0	0	0	0	0	0	5	0	0	0	10	100.0
TOTAL	6	55	14	7	2	23	50	54	40	2	2	255	22.3

DEVELOPING MALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	1	0	1	0	0	0	0	0	0	0	0	2	3.9
DEC	11	1	1	0	0	0	0	0	0	0	0	13	8.8
JAN	9	6	1	0	0	0	1	0	3	0	1	21	8.9
FEB	10	1	7	3	0	0	0	0	0	0	0	21	14.3
MAR	7	12	2	3	0	2	0	0	6	0	0	32	13.4
APR	50	2	3	0	0	1	1	0	10	0	1	68	21.7
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	88	22	15	6	0	3	2	0	19	0	2	157	13.7

DEVELOPING FEMALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	0	0	0	0	0	0	0	0	0	0	0	0	0.0
DEC	0	0	0	0	0	0	0	0	0	0	0	0	0.0
JAN	0	0	0	0	0	0	0	0	0	0	0	0	0.0
FEB	0	0	0	0	0	0	0	0	1	0	0	1	0.5
MAR	0	0	0	0	0	0	0	0	0	0	2	2	1.6
APR	0	0	0	0	0	0	0	0	0	0	0	0	0.0
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	0	0	0	0	0	0	0	0	1	0	2	3	0.3

IMMATURE FEMALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	1	0	4	1	4	1	4	11	5	0	1	32	97.0
DEC	28	1	4	9	3	10	13	20	17	0	9	114	95.0
JAN	17	3	11	9	6	8	55	32	19	0	18	178	93.2
FEB	9	10	18	7	3	14	29	25	3	0	6	124	96.9
MAR	16	16	8	9	3	13	6	46	82	0	8	207	96.3
APR	24	9	0	3	1	8	8	57	59	0	6	175	94.1
MAY	1	0	0	0	0	0	0	0	0	0	0	1	50.0
TOTAL	96	39	45	38	20	54	115	191	185	0	48	831	95.0

RESTING FEMALES

MONTH	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	MONTHLY %
	PROGRAM												
NOV	0	0	0	0	0	0	1	0	0	0	0	1	3.0
DEC	0	0	0	2	0	0	2	2	0	0	0	6	5.0
JAN	0	1	0	1	0	0	8	0	1	1	0	12	6.3
FEB	0	0	1	0	0	0	0	1	0	0	0	2	1.6
MAR	0	0	0	0	0	0	2	0	6	0	0	8	3.7
APR	0	0	0	0	0	0	8	2	1	0	0	11	5.9
MAY	1	0	0	0	0	0	0	0	0	0	0	1	50.0
TOTAL	1	1	1	3	0	0	21	5	8	1	0	41	4.7

APPENDIX TABLE E-5. PERCENT OF STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS, OR EMPTY STOMACHS, CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1995-96 MONITORING PROGRAM

LENGTH GROUP (mm TL)	PERCENTAGE AND NUMBER OF STRIPED BASS WITH STOMACH CONTENTS										
	EMPTY		INVERTEBRATES		VERTEBRATES		INVERTEBRATES & VERTEBRATES		ATLANTIC TOMCOD		
	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	TOTAL
≤ 200	65.1	28	32.6	14	2.3	1	--	--	--	--	43
201-300	28.6	12	61.9	26	4.8	2	4.8	2	--	--	42
301-400	25.0	1	50.0	2	--	--	25.0	1	--	--	4
401-500	33.3	1	66.7	2	--	--	--	--	--	--	3
> 501	--	--	100.0	1	--	--	--	--	--	--	1
TOTAL	45.2	42	48.4	45	3.2	3	3.2	3	--	--	93

majority of invertebrates found were amphipods, with some shrimp (*Paleomentes* sp.) also present. This is in general agreement with the findings from previous programs where invertebrate remains were most common in striped bass 201-300 mm (Table E-6). Detailed comparisons between the 1995-96 program and previous years are difficult due to the limited number of dead fish returned for biocharacteristic analysis.

Food habit data from the 1985-86 through 1993-94 programs has displayed several trends (Table E-6). Invertebrates were the dominant food item among non-empty striped bass stomachs. The dominance of invertebrates in stomach contents however decreases when striped bass reach approximately 300 mm (TL). The occurrence of empty stomach also varied with length group. The trend of increasing importance of fish as food items as striped bass length increases has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). No Atlantic tomcod have been observed in any of the striped bass stomachs examined since 1985.

APPENDIX TABLE E-6. **FOOD HABITS OF HUDSON RIVER STRIPED BASS CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 THROUGH 1995-96 PROGRAMS.**

INVERTEBRATES

LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	LENGTH GROUP %
<=200	5	8	3	2	16	3	52	74	35	2	14	214	39.9
201-300	88	25	39	9	3	29	85	40	81	2	26	427	41.9
301-400	18	16	12	2	1	7	18	12	10	1	2	99	24.6
401-500	3	2	2	0	0	0	1	2	0	0	2	12	14.1
>500	1	0	1	0	0	0	0	0	0	0	1	3	12.0
TOTAL	115	51	57	13	20	39	156	128	126	5	45	755	36.5

VERTEBRATES

	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	LENGTH GROUP %
	1	0	0	1	0	0	2	3	0	0	1	8	1.5
	4	0	0	6	0	8	13	4	2	0	2	39	3.8
	5	1	3	8	0	8	9	3	6	0	0	43	10.7
	3	0	1	0	0	0	2	2	1	0	0	9	10.6
	1	0	0	0	0	0	1	2	0	0	0	4	16.0
	14	1	4	15	0	16	27	14	9	0	3	103	5.0

INVERTEBRATES AND VERTEBRATES

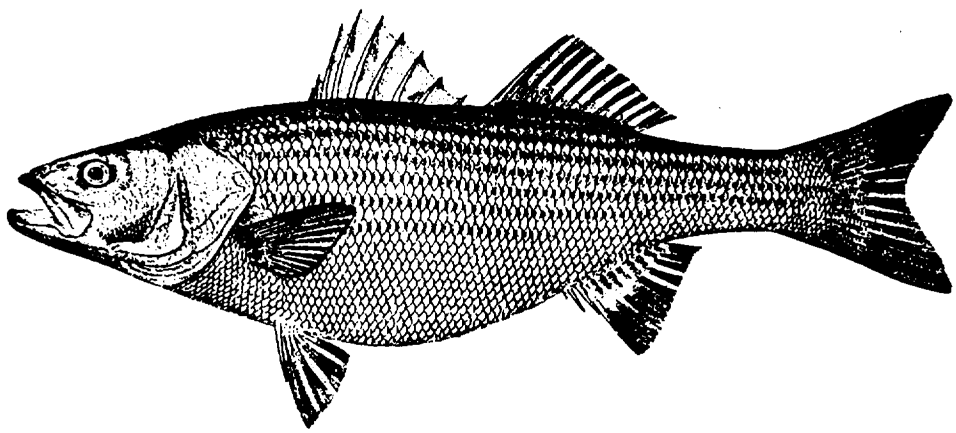
LENGTH GROUP	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	LENGTH GROUP %
<=200	1	0	0	1	0	0	2	8	0	0	0	12	2.2
201-300	4	3	4	2	0	8	25	11	6	0	2	65	6.4
301-400	8	6	3	7	2	4	21	11	5	0	1	68	16.9
401-500	1	3	1	2	1	1	1	3	0	0	0	13	15.3
>500	0	1	0	0	0	0	0	1	0	0	0	2	8.0
TOTAL	14	13	8	12	3	13	49	34	11	0	3	160	7.7

EMPTY

	PROGRAM 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	TOTAL	LENGTH GROUP %
	2	20	1	13	11	7	38	88	95	0	28	303	56.4
	43	18	15	26	9	35	43	77	209	0	12	487	47.8
	41	8	12	13	1	23	18	39	36	0	1	192	47.8
	12	3	7	2	0	3	2	11	10	0	1	51	60.0
	11	0	3	0	0	0	1	1	0	0	0	16	64.0
	109	49	38	54	21	68	102	216	350	0	42	1049	50.7

Hudson River Striped Bass Stock Assessment Program

November 1996 - April 1997



Prepared under contract with:

NEW YORK POWER AUTHORITY
White Plains, New York

Jointly Financed by:

Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

April 1999

Final Report

Prepared by

LMS **LAWLER, MATUSKY & SKELLY ENGINEERS LLP**

Environmental Science & Engineering Consultants
One Blue Hill Plaza • Pearl River, New York 10965

#260-015

HUDSON RIVER STRIPED BASS
STOCK ASSESSMENT PROGRAM

NOVEMBER 1996 - APRIL 1997

FINAL REPORT

April 1999

Prepared under contract with

NEW YORK POWER AUTHORITY
123 Main Street White Plains, New York 10601

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EXECUTIVE SUMMARY

- The estimated proportion of hatchery striped bass was less than 1.0% for Age 1+ and Age 2+ fish among the same age cohort of striped bass collected in the Hudson River between 4 November 1996 and 11 April 1997.

- The 1995 (Age 1+) and 1994 (Age 2+) cohort dominated the catch of Hudson River striped bass during the 1996-97 program. The 1995 and 1994 cohorts represented 61 and 27%, respectively, of the total catch. Age 1+ represented 64% of the population estimate ≥150 mm (total length).

- The estimated size of the mid-winter striped bass population ≥150 mm in Upper New York Harbor and the Battery region was 768,000 fish, with lower and upper 95% confidence limits of 682,000 and 880,000. Age 0+ striped bass accounted for approximately 6,000 fish in the mid-winter population, Age 1+ contributed 493,000 fish, Age 2+ contributed 219,000 fish, Age 3+ contributed 43,000 fish, and Age >3+ contributed 7,000 fish.

- During the 1996-97 striped bass program 13,498 fish ≥150 mm were caught and 12,794 fish in good condition were tagged and released, bringing the total number of striped bass tagged and released in these programs since 1984 to 207,479. Of the 162 fish that were recaptured during the 1996-97 striped bass program, 125 were tagged and released in the present program, 30 were from the 1995-96 program, five were from the 1994-95 program, and two were from the 1993-94 program. A total of seven striped bass were colleted with tags from other agency tagging programs.

- Overall mean catch per unit of effort (CPUE) in the Battery and Upper Harbor region was 15.1 striped bass per 10-min tow. Mean CPUE from mid-December through mid-March increased annually from 1985-86 to a peak of 45.3 in the 1989-90 program. Mean CPUE decreased following 1989-90 to 40.7 in the 1990-91 program, 35.5 in the 1991-92 program, 32.7 in the 1992-93 program, 33.7 in the 1993-94 program, 21.9 in the 1994-95 program, and 14.3 in the 1995-96 program. Mean CPUE increased to 19.6 during in the 1996-97 program.

CHAPTER 1

INTRODUCTION

Section 2.G of the Hudson River Cooling Tower Settlement Agreement stipulated that the Hudson River Utilities (Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, and Orange and Rockland Utilities, Inc.) shall construct, lease, or contract for the operation of a hatchery on or adjacent to the Hudson River, capable of stocking the river with 600,000 3-in. striped bass fingerlings per year from 1983 to 1990. The Hudson River Utilities contracted for the construction and operation of a striped bass hatchery at Verplanck, New York, to address this requirement. Hatchery production and stocking continued from 1991 through 1994 in accordance with paragraph 9 of the stipulation of Settlement and Judicial Consent Order, entered into by parties to the Settlement Agreement. The total number of hatchery striped bass that were stocked into the Hudson River in each year is as follows (EA 1996):

YEAR	NUMBER STOCKED
1983	61,357
1984	147,153
1985	284,578
1986	529,563
1987	324,800
1988	48,611
1989	202,068
1990	234,387
1991	256,631
1992	210,746
1993	568,410
1994	306,529
1995	613,758
Total	3,788,591

Section 2.J and Attachment V of the Settlement Agreement stipulated that an annual biological monitoring program be conducted through May 1991 to evaluate mitigation measures. One such measure is striped bass stocking. To facilitate a stocking evaluation, striped bass produced at the hatchery between 1983 and 1989 were tagged prior to release with an internal, coded, magnetic, wire tag (CWT). These CWTs can be detected in the field and allow differentiation between hatchery-released striped bass and naturally spawned striped bass. Striped bass produced and stocked during 1990 and 1991 were not tagged; however, tagging of hatchery-reared striped bass resumed in 1992. The identification of hatchery-released striped bass is essential for determining the presence of hatchery fish in any cohort, and if present, their proportional abundance. It is also desirable that nonhatchery fish be released alive after capture, after they are examined for hatchery administered CWTs. If these striped bass are tagged and released, their recovery may provide valuable information on the Hudson River stock. Mark-recapture methodologies could be used to estimate the annual survival rate of the post-juvenile stock. However, the sampling effort to produce precise estimates of survival for fish older than Age 2+ was judged to be too costly (MMES 1986) and the assumptions required for fish younger than Age 1+ may be violated (Wells et al. 1991). Consequently, the biological monitoring program focused on estimating the proportional contribution of hatchery stocked striped bass to the Hudson River stocks; estimation of annual survival rate for Age 1+ and Age 2+ fish; and estimation of the Age 1+ and Age 2+ striped bass overwintering stock in the lower Hudson River and Upper New York Harbor area.

The Hudson River striped bass program began in 1984 as an evaluation of fishing gear and techniques that were most efficient and effective for catching and handling striped bass. The best locations, times, and fishing gear were evaluated in the 1984 through 1987-88 programs to maximize total catch and CPUE of Age 1+ and Age 2+ striped bass. The Battery region of the Hudson River adjacent to Manhattan and Upper New York Harbor in the vicinity of Liberty Island provided the most consistent catches of Age 1+ and Age 2+ striped bass during the November through March period. The 9-m trawl was the most effective gear for capturing Age 1+ and Age 2+ striped bass, and has been the only gear used from 1988-89 through the present program (Table 1-1). Concurrent with these gear evaluations, handling techniques were improved to increase the survival of striped bass that were caught, tagged, scanned for hatchery-administered magnetic tags, and released (Dunning et al. 1987, 1989). As the hatchery and biological monitoring program progressed, more striped bass were recaptured with hatchery-administered tags, the magnetic tag detection efficiency was quantified (Mattson et al. 1989), and the internal anchor-external streamer tag design was improved (Mattson et al. 1989; Waldman et al. 1990).

TABLE 1-1

COMPARISON OF SAMPLING DESIGNS AND SELECTED RESULTS OF THE 1984 THROUGH 1995-96 HUDSON RIVER STRIPED BASS PROGRAMS

				CATCH STATISTICS							POPULATION ESTIMATES		
PROGRAM	GEAR	DATES	SAMPLING REGIONS	N-TOWS	CPUE	N-TOTAL	N-TAGGED	N-RECAPTURED	N-HATCHERY	HANDLING MORTALITY (%)	TOTAL (≥200 mm)	AGE 1+	HATCHERY PROPORTION AGE 1+ (%)
1984	12-m trawl	09 Apr-07 Jun	TZ,CH,IP, WP,CW,PK	200	2.8		345[a]		0	18	-	-	
	Scottish seine	09 Apr-07 Jun	TZ,CH,CW	139	2.2		392[a]		0	16	-	-	
	Total			339	2.6	1,620	737	0	0	17	-	-	0
1985-86	9-m trawl	11 Nov-18 May	BT	900	8.2		6,366		0	1			
	12-m trawl	11 Nov-18 May	BT,HR,ER, LH	346	20.7	7,265			0	2			
	Total			1,472	12.9	20,820	18,487	171	0	1	540,000	239,000	0
1986-87	9-m trawl	21 Dec-09 May	BT	845	9.8		5,349		74	1			
	12-m trawl	21 Dec-09 May	BT	219	24.1		4,039		20	1			
	Total		BT	1,064	12.7	14,136	9,388	261	94	1	394,000	108,000	1.7
1987-88	9-m trawl	09 Nov-22 Apr	BT	896	20.0	18,075	7,582		175	<1			
	12-m trawl	09 Nov-22 Apr	BT	296	33.9	10,117	4,854		62	1			
	Total		BT	1,192	23.5	28,192	12,436	465	238	<1	295,000	181,000	1.6
1988-89	9-m trawl	31 Oct-15 Apr	BT	1,151	28.5	32,975	24,393	453	213	<1	890,000	794,000	0.2
1989-90	9-m trawl	31 Oct-15 Apr	BT	891	37.3	33,386	24,362	655	141	<1	528,000	397,000	0.4
1990-91	9-m trawl	12 Nov-20 Apr	BT	971	29.7	29,346	22,406	865	52	<1	786,000	352,000	0.2
1991-92	9-m trawl	04 Nov-07 May	BT	1,169	29.3	34,202	25,710	631	17	1	967,000	709,000	a
1992-93	9-m trawl	02 Nov-16 Apr	BT	771	34.0	27,778	20,847	345	190	1.6	717,000	475,000	a
1993-94	9-m trawl	01 Nov-20 Apr	BT	794	36.2	28,739	16,799	333	134	1.6	379,000	217,000	0.01
1994-95	9-m trawl	07 Nov-14 Apr	BT	819	15.4	12,635	6837	75	54	<1	325,000	225,000	1.0
1995-96	9-m trawl	06 Nov-15 Apr	BT	806	16.9	13,643	10,889	111	9	1.5	786,000	621,000	0.08

[a]Hatchery striped bass were not tagged before release in 1990 or 1991. Therefore, an Age 1+ hatchery proportion was not computed.

SAMPLING REGIONS BT = Battery and Upper New York, Hudson River miles 0-11 9 (km 0-18) and Upper New York Harbor TZ = Tappan Zee, Hudson River Harbor Miles 24-33 (km 38-53)
CH = Croton-Haverstraw, Hudson River miles 34-38 (km 54-61) IP = Indian Point, Hudson River miles 39-46 (km 62-74)
CW = Cornwall, Hudson River miles 56-61 (km 90-98) PK = Poughkeepsie, Hudson River miles 62-76 (km 99-122)
HR = Harlem River ER = East River LH = Lower New York Harbor

The April-June 1984 adult striped bass program (NAI 1985) demonstrated that it was effective to use a 12-m trawl and a Scottish seine to capture striped bass with an average mortality of less than 18% at water temperatures ranging from 8 to 16°C. The 1984 program also demonstrated that striped bass ≥300 mm (total length) could be externally tagged and released without significantly increasing 24-hr mortality (Dunning et al. 1987). No hatchery-tagged striped bass were recaptured during the 1984 program, and population estimates were not calculated from the relatively small sample of 737 externally tagged fish that were released (Table 1-1).

The 1985-86 Hudson River striped bass program (NAI 1986) was conducted primarily in the lower Hudson, Harlem, and East rivers from November 1985 through May 1986. Sampling with trawls in the Battery and Upper Harbor regions of the Hudson River estuary between mid-December 1985 and mid-April 1986 produced higher catches of striped bass per tow than in the Harlem and East rivers. When fished in the Battery region of the lower Hudson River in the same weeks, mean CPUE for a 12-m trawl was greater than for a 9-m trawl, but total catch and mean catch per day were similar for the two trawls because more tows could be taken in a day with the 9-m trawl. Because of a larger mesh size, the 12-m trawl was more efficient for capturing striped bass from 251 to 450 mm (total length), while the 9-m trawl was more efficient for capturing striped bass <250 mm. The Scottish seine, fished in the Tappan Zee and Croton-Haverstraw regions during April and May 1986, was efficient for capturing striped bass >400 mm. Striped bass handling mortality was reduced from 17% in 1984 to 1% or less in programs from 1985-86 to the present by using an in-water live car to hold the fish prior to tagging (Dunning et al. 1989). No hatchery-tagged fish were recaptured during the 1985-86 program among the 20,820 striped bass examined for magnetic tags. The midwinter population of striped bass ≥200 mm was estimated to be 540,000 fish in the Battery and Upper New York Harbor; 239,000 of these fish were estimated to be Age 1+ (Table 1-1).

Data from the 1984 and 1985-86 programs (NAI 1985, 1986) were used to recommend sampling options and determine the number of fish needed to calculate statistically reliable estimates of the proportion of hatchery-reared striped bass in the Hudson River striped bass population (MMES 1986; Heimbuch et al. 1990). Of the seven sampling options reviewed for the hatchery evaluation, three were recommended for further consideration: (1) sampling yearling striped bass in the mouth of the river in winter, (2) sampling Age 2+ (nonharvestable adult) striped bass in the mouth of the river in winter, and (3) sampling harvestable and nonharvestable adult striped bass downriver of

the spawning grounds in spring. These options were selected because the underlying statistical assumptions of the estimators could be satisfied and the required sampling effort was feasible.

The 1986-87 Hudson River striped bass program was conducted in the Croton-Haverstraw, Tappan Zee, Battery, and Upper Harbor regions of the Hudson River. The Battery and Upper Harbor exhibited the highest catches per 10-min tow for both the 9- and 12-m trawls. Use of a cod end liner (2.5-cm stretch mesh) in the 9-m trawl did not affect the length-frequency or handling mortality of Age 1+ or older striped bass caught in the trawl. However, use of a cod end liner in the 12-m trawl significantly increased the catch of Age 1+ and older striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Stratified sampling to select scales for age analysis resulted in highly precise estimates of the proportion of Age 0+, 1+, and 2+ striped bass caught in this study (NAI 1987). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1986-87, the estimated hatchery proportion was 1.7%. The estimated overwintering population in the Battery and Upper Harbor was 394,000 striped bass ≥200 mm, and 108,000 of these fish were Age 1+ (Table 1-1).

The 1987-88 Hudson River striped bass hatchery evaluation was conducted in the Upper Harbor and Battery regions of the Hudson River (NAI 1988). The Battery region received 98% of the fishing effort and exhibited a higher catch per 10-min. tow for both the 9-m trawl and 12-m trawl with a cod end similar to the 9-m trawl. The catch was dominated by the strong 1987 year class of Age 0+ fish, which contributed more than one-half the catch. The 9-m trawl was more efficient than the 12-m trawl with a 9-m trawl cod end in capturing Age 0+ and Age 1+ striped bass. Handling mortality was extremely low (<1%) and was not related to gear type or the use of the cod end liners (Dunning et al. 1989). Based on the estimated number of Age 1+ fish and the number of verified striped bass of hatchery origin that were recaptured in 1987-88, the estimated hatchery proportion was 1.6% The estimated overwintering population in the Battery and Upper Harbor was 295,000 striped bass ≥200 mm, and 181,000 of these fish were estimated to be Age 1+ (Table 1-1).

The Hudson River striped bass program from 1988-89 to the present has become primarily a Hudson River striped bass stock monitoring program. The program has emphasized consistency of sampling gear and procedures and the refinement of laboratory techniques for scale examination to accurately determine age (e.g., Humphreys et al. 1989). Mark-recapture estimates are calculated for the total population and for the Age 1+ and Age 2+ subpopulations of striped bass found in the combined Battery and Upper New York Harbor regions during the winter. Program consistency is documented through the use of standard operating procedures (SOPs) and a quality assurance/quality control (QA/QC) system that has helped improve data quality (Geoghegan et al. 1989).

The striped bass catch in the Battery and Upper Harbor during the 1988-89 program was dominated by a strong 1987 cohort of Age 1+ fish (70%), and the hatchery proportion for this cohort was estimated as 0.2% (NAI 1990). The minimum size of striped bass that were tagged was lowered from 200 to 150 mm during 1988-89 to align the tagging effort with the expected size range of this large cohort of Age 1+ fish. Handling mortality remained low (<1%) even though smaller fish were tagged for the first time. The estimated overwintering population of striped bass in the Battery and Upper Harbor was 1,190,000 fish ≥150 mm or 890,000 fish ≥200 mm, and an estimated 794,000 of the fish ≥200 mm were from the strong 1987 Age 1+ cohort (Table 1-1).

The striped bass catch in the Battery and Upper Harbor during the 1989-90 program was dominated by a strong 1988 cohort (Age 1+ fish) (65%), and the hatchery proportion for this cohort was estimated as 0.4% (NAI 1991). The estimated overwintering population of striped bass was 776,000 fish ≥150 mm or 528,000 fish ≥200 mm, and an estimated 397,000 of the fish ≥200 mm were from the strong 1988 Age 1+ cohort (Table 1-1).

The striped bass population overwintering in the Battery and Upper Harbor during 1990-91 was estimated as 858,000 fish ≥150 mm or 786,000 fish ≥200 mm (Table 1-1). About 352,000 striped bass ≥200 mm were Age 1+ (NAI 1992). The 1989 cohort of Age 1+ hatchery fish was 0.2% of the Age 1+ catch.

Age 1+ (1990 cohort) and Age 0+ (1991 cohort) fish dominated the population statistics for striped bass caught in the Battery and Upper Harbor during the winter of 1991-92 (NAI 1994). The estimated size of the midwinter striped bass population was 1,163,000 fish ≥150 mm or 967,000 fish ≥200 mm (Table 1-1). Age 1+ striped bass represented 791,000 fish among the population ≥150 mm and 709,000 fish ≥200 mm. Age 2+ and Age 3+ hatchery striped bass were each about 0.3% of the respective cohort's catch. Age 0+ and Age 1+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The estimated size of the midwinter striped bass population ≥150 mm in Upper New York Harbor and the Battery region during 1992-93 was 920,000, fish with lower and upper 95% confidence limits of 677,000 and 1,435,000 (NAI 1995a). The 1991 cohort of Age 1+ striped bass and the 1992 cohort of Age 0+ fish dominated the catch, representing 58% and 22% of the total number of striped bass collected, respectively. Age 1+ and Age 2+ striped bass dominated the midwinter population estimate. Age 1+ striped bass accounted for 671,000 fish, while Age 2+ contributed 180,000. The estimated hatchery proportion of striped bass was 3.0% for Age 0+ and 0.02% for Age 3+ fish. Age 1+ and Age 2+ hatchery striped bass were not tagged with CWTs and could not be differentiated from wild fish of the same cohort.

The 1993-94 program experienced the 20th coldest winter on record for New York City and the coldest in the history of the striped bass program (NAI 1995b). Bank-to-bank ice floes limited access to the Battery and Upper Harbor regions from 17 January through 21 February 1994, and influenced within- and among-program comparisons. The estimated size of the midwinter striped bass population ≥150 mm in Upper New York Harbor and the Battery region during 1992-93 was 443,000 fish, with lower and upper 95% confidence limits of 339,000 and 641,000 (NAI 1995a). The 1992 cohort of Age 1+ striped bass and the 1991 cohort of Age 2+ fish dominated both the catch and midwinter population estimate, accounting 57% (253,000) and 29% (129,000) of the population ≥150 mm, respectively. The estimated hatchery proportion of striped bass was 0.2% for Age 0+, 1.05% for Age 1+ and 0.05% for Age 4+ fish among the same age cohorts.

The striped bass population overwintering in the Battery and Upper Harbor during 1994-95 was estimated at 350,000 fish ≥200 mm. About 225,000 striped bass ≥200 mm were Age 1+ (LMS 1995). No Age 1+ (1993 cohort) hatchery fish among the total Age 1+ fish were captured.

The 1995-96 program estimated the midwinter striped bass population ≥150 mm in Upper New York Harbor and the Battery region to be approximately 949,000, fish with lower and upper 95% confidence limits of 745,000 and 1,308,000 (LMS 1996). The 1994 (Age 1+) cohort dominated the catch of Hudson River striped bass during the 1995-96 program and represented 77% of the population estimate ≥150 mm. The total population of Age 1+ and older striped bass ≥ 200 mm was estimated as 786,000 fish, the same as estimated during the 1990-91 program and the third highest calculated annually since 1985-86. The estimated hatchery proportion of striped bass was < 0.1% for both Age 0+ and Age 1+ fish among the same age cohorts.

Following the 1995-96 program, the operation of the striped bass hatchery at Verplank, New York was discontinued. Hatchery production of striped bass fingerlings and stocking efforts ceased, however, the biological monitoring program was continued through 1996-97. The Hudson River striped bass program continued to focus on estimating the proportional contribution of previously stocked hatchery striped bass (Age 1+ and older) to the Hudson River stocks; estimation of annual survival rate for Age 1+ and Age 2+ fish; and estimation of the Age 1+ and Age 2+ striped bass overwintering stock in the lower Hudson River and Upper New York area.

Objectives of the 1996-97 Hudson River striped bass stock assessment program were to:

- Tag wild striped bass greater than or equal to 150 mm collected in the Battery and Upper New York Harbor regions, that are in good condition, with internal anchor tags.
- Determine the catch rate and handling mortality of striped bass collected using the 9m trawl.
- Estimate the abundance of striped bass overwintering in the lower Hudson River.
- Describe the age composition of the overwintering population of striped bass.
- Estimate the proportion of hatchery fish among the Age 1+ through Age 3+ Hudson River striped bass if hatchery fish of these cohorts are caught.

CHAPTER 2

METHODS

2.1 FIELD PROCEDURES

2.1.1 Field Sampling

A complete description of field and laboratory procedures is found in the 1996-97 Hudson River Striped Bass and Atlantic Tomcod Programs Standard Operating Procedures (LMS 1996). These procedures have remained essentially unchanged since the start of the 1988-89 program. The 1996-97 Hudson River Striped Bass Hatchery Evaluation/Monitoring Program consisted of sampling in the Battery and Upper Harbor regions of the lower Hudson River (Figure 2-1, NAI 1995b) with a 9-m trawl (Appendix Table A-1). Sampling locations were selected to maximize the CPUE of striped bass in the lower Hudson River, based on the results of the 1985-86 through 1995-96 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995, 1996). Striped bass captured in each trawl sample were enumerated and fish ≥150 mm in good condition were marked with internal anchor tags (Figure 2-2, NAI 1995b) and released.

From the week of 4 November 1996 through the week of 7 April 1997, the 9-m trawl was deployed in the Upper Harbor or Battery regions. The 9-m trawl was fished in the Battery region for 23 weeks and during 12 weeks in the Upper Harbor region (Appendix Table C-1). Tow duration was 10 min, unless sampling difficulties such as bottom obstructions required shortening the tow. All striped bass captured by the trawl were handled in a manner that minimized stress before tagging. The cod end of the net was transferred (while remaining in the water) to the holding facility alongside the boat. Fish were then released from the cod end into the holding facility. Striped bass were then removed from the holding facility for processing using the following procedures:

1. Fish were removed from the live car using a dip net.
2. All surfaces that came in contact with the live fish were wet.
3. Striped bass were handled gently by the body and not handled by the eye sockets, gill arches, isthmus, or opercular flaps.

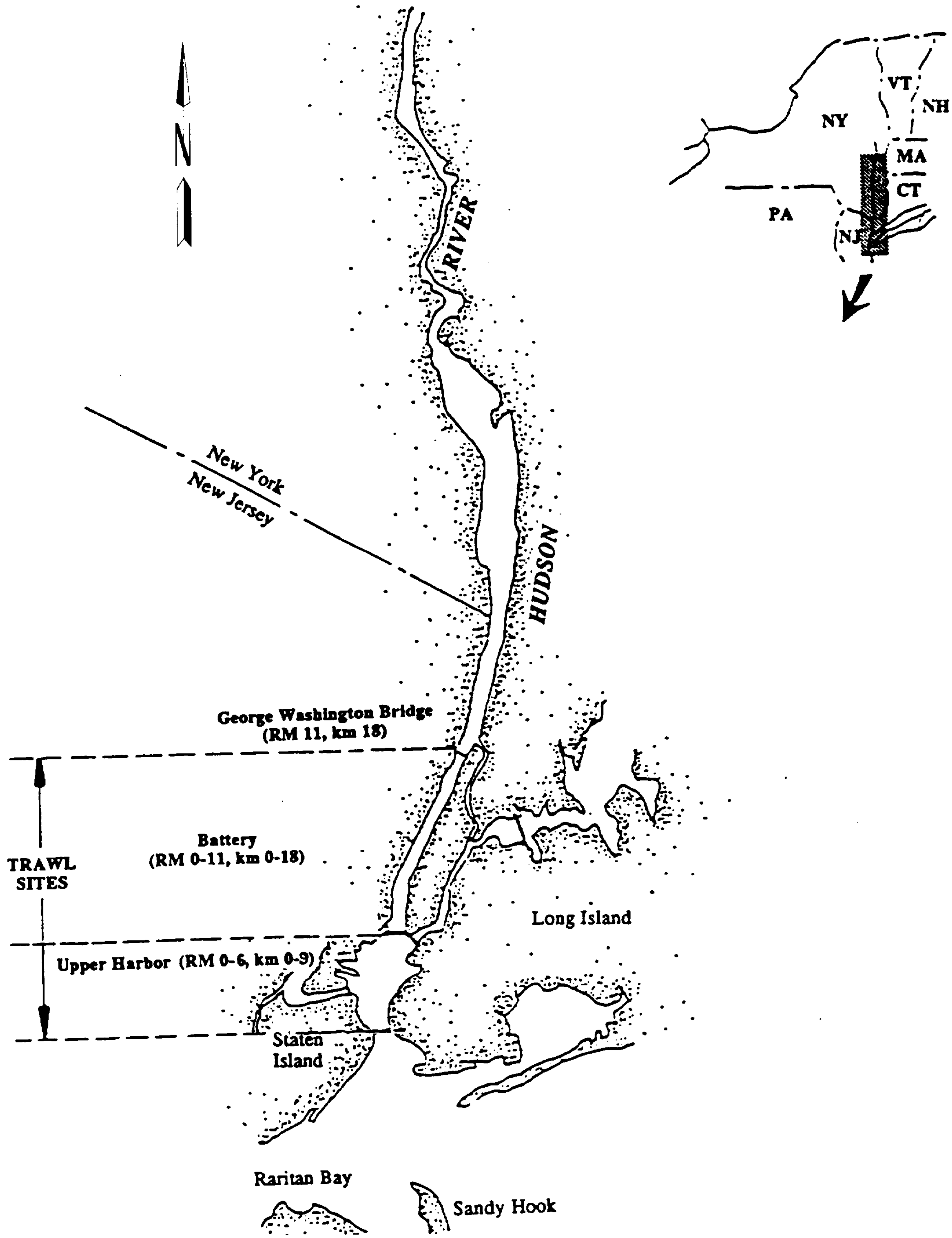
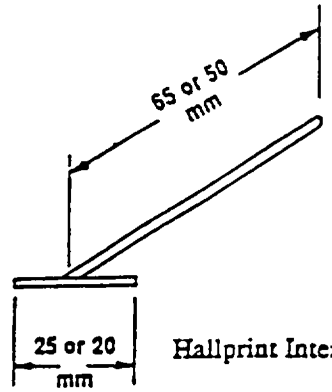
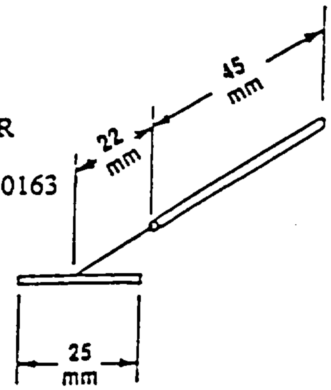


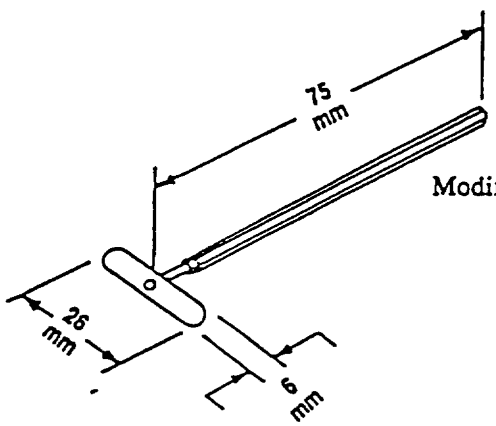
Figure 2-1. Sampling regions in the lower Hudson River and New York Harbor during the winter 1996-97 Hudson River Striped Bass Program.



Hallprint Internal Anchor-External Streamer Tag (1988-present)
(with covered filament)
65 mm x 25 mm tags for fish ≥ 300mmTL
50 mm x 20 mm tags for fish 150-299mmTL
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

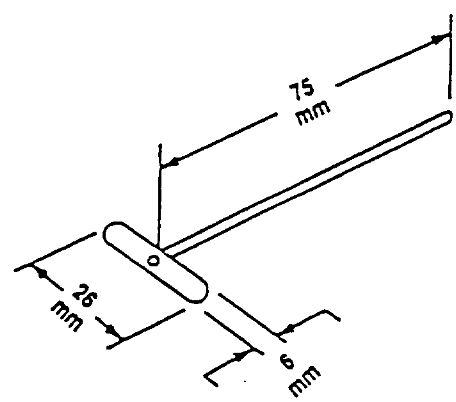
Hallprint Internal Anchor-External Streamer Tag (1987-1988)
(with exposed filament)
MARK_CD = 98 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 No ######
LINE 2: MAIL TO HRF BOX 1731 G.C.S. NY NY 10163
ANCHOR: YELLOW No ######

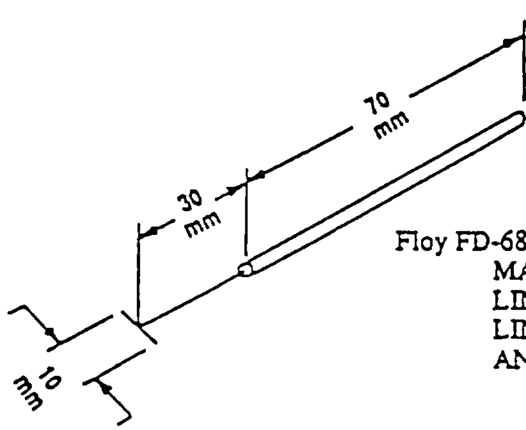




Modified Floy Internal Anchor-External Streamer Tag (1987)
(with clear vinyl tubing over external streamer)
MARK_CD = 97 PINK EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
same legend as lines 1 and 2 of the external streamer

Floy Internal Anchor-External Streamer Tag (1984-1987)
MARK_CD = 96 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 #####
LINE 2: MAIL TO HRF BOX 1731 GCS NY NY 10163
ANCHOR: (BLUE 26 mm x 6 mm for fish ≥300 mmTL,
RED 20 mm x 5 mm for fish 200-299 mmTL)
no legend





Floy FD-68B Anchor Tag (1984)
MARK_CD = 82 YELLOW EXTERNAL STREAMER
LINE 1: REWARD $10-$1000 A#####
LINE 2: RET TO HRF BOX 1731 GRAND CENTRAL STN NY 10163
ANCHOR: monofilament, no legend

Figure 2-2. Tags used to mark striped bass during the 1984-present Hudson River Striped Bass Programs.

4. Struggling fish were quieted by covering the head and eyes with a wet hand, cloth, or glove.

All striped bass were measured (mm total length), visually examined for external tags and tag wounds, and examined for CWTs using magnetic tag detectors. Two V-shaped field detectors were used in series throughout the study. All striped bass were passed through the first magnetic tag detector. If a tag was detected, the fish was preserved for later verification. If a tag was not detected, the fish was passed through a second detector. If a tag was detected on the second pass, the fish was preserved for later verification. If a tag was not detected on the second pass, the fish was processed and released.

All striped bass ≥150 mm, in good condition and not already tagged, were tagged with an internal anchor tag. Good condition was defined as:

- No bleeding from gills or body wounds
- No significant loss of scales
- Strong opercular movement
- No obvious external abnormalities such as blindness, fin rot, or skeletal abnormalities

The internal anchor tag was inserted by removing a scale midway between the vent and distal tip of the depressed pelvic fins, and five to six scale rows dorsolaterally from the ventral midline. This tag insertion site was selected to minimize the damage to internal organs during tag placement, based on gross anatomical examination of striped bass (NAI 1988). A horizontal incision about 5 mm long was made with a pointed scalpel blade. The incision was made through the musculature but not deep enough to damage the intestines. The anchor of the tag was inserted through the incision and set with a gentle pull on the streamer. Scalpel blades were changed frequently to avoid tearing of the tissue, and all incisions were treated with a topical antiseptic.

Scale samples were taken from the left side from an area approximately three to four scale rows below the notch between the spinous and soft dorsal fins of all striped bass caught, except for fish less than 100 mm. Fish less than 100 mm were considered Age 0+. Scale samples from recaptured, tagged fish were taken on the right side of the fish to avoid regenerated scales from the release sample. Scale samples were taken from recaptured fish only if the tag number indicated the fish had been released in previous year's programs. Condition of the tag and tag insertion site of recaptured striped bass were also evaluated.

After processing, striped bass were released into a recovery pen deployed alongside the tagging vessel. The pen was enclosed with netting on four sides, open on the top and bottom, and provided a refuge where striped bass could recover from processing without being preyed on by gulls. Any fish remaining in the recovery pen at the end of sample processing were considered dead. Fish were released at least 400 m from active fishing gear, but within 1.5 km (1 mile) of capture location.

2.1.2 Water Quality Sampling

During each trawl sample, direction of tow, time of tow, date, and sample number were recorded. A Yellow Springs Instruments (YSI) model 33 salinity-conductivity temperature meter was used to take surface (0.3 m) and bottom measurements of water temperature and conductivity at the end of each tow. All conductivity measurements were adjusted to 25 °C for presentation in this report. Water quality data are summarized by region and week in Appendix Table B-1.

2.2 LABORATORY METHODS

2.2.1 Biocharacteristics and Food Habits

Striped bass that died during sampling procedures were placed on ice and transported to the laboratory at the end of each day for determination of biocharacteristics (Appendix E). This included determination of length, weight, sex, and sexual condition. In addition, striped bass stomachs were analyzed for the presence of invertebrates, vertebrates, and Atlantic tomcod (Appendix E).

2.2.2 Age of Striped Bass Using Scales

Age was determined for a stratified random sample of striped bass using scales collected from the fish in the field. All striped bass less than 100 mm were considered Age 0+ and scale samples were not taken. The stratified random subsample was based on the expected number of Age 1+

striped bass in each 10-mm length group. Expected numbers of Age 1+ striped bass in each 10-mm length group were calculated from age at length data obtained during the current and 1995-96 programs (LMS 1996).

This program was conducted during the winter from one calendar year to the next. To eliminate confusion that may be caused by a fish becoming a year older on 1 January, the hatching date of striped bass was assumed to be 15 May. To note this, the convention of adding a "+" after the age of a fish was used. Therefore, a fish hatched 15 May 1993 and collected anywhere between November 1994 and 15 May 1995 would be designated "Age 1+." This same fish, captured anywhere between November 1995 and 15 May 1996, would be designated "Age 2+."

Striped bass scales were pressed on 0.050-in.-thick, grade GC, acetate sheets with a Carver Press Model-C 12-ton hydraulic press equipped with a pressure gauge, electric hot plates, temperature controls, and thermometers. Scale impressions were then examined with a microfiche reader at approximately 46x magnification and the location of each annulus was determined. Criteria used to determine the presence of annuli on striped bass scales were (1) changes in the relative spacing of circuli in the anterior field of the scale, (2) crossing of circuli across previously deposited circuli in the lateral field of the scale, and (3) variations in the thickness and shape of the circuli. Generally, an annulus exhibited all three of the above characteristics. The distance from the scale focus to each annulus was measured along a line drawn through the focus and perpendicular to the anterior edge of each scale.

2.3 ANALYTICAL METHODS

All field samples were assigned a Use Code (1, 2, or 5) that defined their use in analytical tasks (Appendix Table C-3). Use Code 1 samples were samples from which valid data were collected and no sampling problems were encountered. These data were used for all analytic tasks. Use Code 2 samples were samples in which striped bass were captured, but sampling problems were encountered. Sampling problems were generally related to gear deployment, which would affect computation of CPUE, such as noticing a tear in the net after a tow, or stopping a tow before the required 10-min duration. Use Code 1 and 2 samples were used for mark-recapture analysis. Use Code 2 samples were excluded from calculations involving CPUE. Use Code 5 samples were Use Code 2 samples where no striped bass were caught. Use Code 5 samples were excluded from all analyses. Most data analyses were conducted using the Statistical Analysis System (SAS) software (SAS 1985).

No rounding of data was done prior to the final step in each analysis. This prevented introduction of rounding error in the final result, and may present the appearance in a table that a column of data does not sum exactly to the total shown in the last row.

2.3.1 **Analysis of Catch Characteristics**

Characteristics of the catch were described among locations and sampling weeks by analysis of the CPUE, length-frequency, and handling mortality.

2.3.1.1 ***Catch Per Unit of Effort.*** CPUE for the 9-m trawl was defined as catch per 10-min tow (Use Code = l) and was calculated as:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{C_i}{E_i}\cdot 10\right] \qquad \text{Eq. 1}$$

where

$\overline{X}$ = mean trawl catch per 10-min tow
C_i = total number of fish captured in trawl i
E_i = tow duration of trawl i in minutes
n = number of trawls

2.3.1.2 ***Length-Frequency.*** Length-frequency histograms, with the number of fish on the ordinate and total length on the abscissa were constructed to describe the characteristics of the catch from the 9-m trawl (Use Code = 1 tows). Length-frequency distributions for striped bass caught by the 9-m trawl were characterized using moment statistics and frequency histograms. Moment statistics compare the observed length-frequency distributions with hypothetical, normal (bell-shaped) distributions.

2.3.1.3 ***Handling Mortality.*** Handling mortality was expressed as the proportion of dead striped bass in a "successful" trawl sample (Use Code = 1) by the following formula for each 1 °C temperature interval:

$$Prop\ D_x = D_x / T_x \qquad \text{Eq. 2}$$

where

$Prop\ D_x$ = proportion of dead striped bass at bottom water temperature x
D_x = the number of dead striped bass at bottom water temperature x
T_x = total number of striped bass captured at bottom water temperature x

Comparisons of handling mortality among the 1985-86 through 1996-97 programs were also made using data subsetted to include the same sampling gear deployed during comparable water temperature ranges within the Battery region in each year. Differences in striped bass handling mortality among programs (1985-86 through 1996-97) were assessed by comparing the percentage of dead fish in the catch in 1 °C bottom water temperature increments.

2.3.2 Stratified Sampling for Age Determination and Mean Length at Age

2.3.2.1 ***Estimated Number of Striped Bass in Each Age Category.*** A stratified random sampling plan was used to determine the number of striped bass scale samples to be selected for age determination from the total scale samples collected during the 1996-97 program. The stratified plan selected striped bass scale samples for age analysis in direct proportion to both the number of fish in each 10-mm length increment and the variance of the proportion of Age 1+ fish in each 10-mm length group. This Neyman allocation scheme is considered optimal with respect to its ability to maximize precision of the estimated proportion of Age 1+ fish; it is based on the following formula (Cochran 1977, Equation 5.60):

$$n_h = n\left[\frac{N_h\sqrt{p_h q_h}}{\sum N_h\sqrt{p_h q_h}}\right] \qquad \text{Eq. 3}$$

where

n_h = number of scale samples selected for age determination from length group h
n = number of scale samples to be selected from the total of N fish caught
N_h = total number of fish caught in length group h
p_h = proportion of Age 1+ fish in length group h from the laboratory sample
q_h = 1 - p_h

The stratified sampling plan was designed to select approximately 15% of the scale samples from fish caught for age analysis. Age and length-frequency data from 1995-96 (LMS 1996) were applied to the first of three lots of 1996-97 length-frequency data to permit scale analysis to proceed during the study. Age and length-frequency data from analysis of the first lot of striped bass scales in 1996-97 were then applied to the remaining two lots of 1996-97 scale samples. In each lot (4 November - 5 January, 6 January - 2 March, and 3 March - 11 April), scale samples from approximately 15% of the fish caught were randomly selected for age determination using the Neyman allocation formula. It should also be noted that the Neyman allocation for stratified random sampling was based on variance estimates derived from the proportion of Age 1+ fish and was, therefore, most precise for estimating the proportion and number of Age 1+ fish. However, age was determined for all fish examined in the laboratory so that the number and proportion could be determined for all age groups sampled.

The proportion and number of striped bass of a given age that were caught in the 1996-97 program were estimated by stratified random sampling, as described in the preceding paragraph, using the following formula (Cochran 1977, Equation 5.5.2):

$$p_{sti} = \sum \left(N_h p_{hi} / N \right) \qquad \text{Eq. 4}$$

where

p_{sti} = stratified mean proportion of Age i fish
p_{hi} = proportion of Age i fish in length group h
N_h and N are as defined in Equation 3

The number of striped bass of Age i in the total catch (A_i) is:

$$A_i = N\left(p_{sti} \right) \qquad \text{Eq. 5}$$

The sample variance for the stratified mean proportion of Age i fish in the total catch ($s^2 p_{sti}$) was calculated by the method of Cochran (1977, Equation 5.53):

$$S^2 p_{sti} = 1/N^2 \left[\Sigma [N_h^2 \left(N_h - n_h \right)\left(N_h - n_h \right)][\left(p_{hi} q_{hi} \right)/\left(n_h - 1 \right)] \right] \qquad \text{Eq. 6}$$

where

N, N_h, n_h, q_{hi} and p_{hi} are as defined in Equation 3 for Age i fish.

Confidence intervals (CI) for the stratified mean proportion of Age i striped bass and for the total number of Age i fish were calculated based on Cochran (1977, Equations 5.14 and 5.15):

$$95\%\ CI\ for\ p_{sti} = p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 7}$$

$$95\%\ CI\ for\ A_i = N_{sti} p_{sti} \pm t\ s_{p_{sti}} \qquad \text{Eq. 8}$$

where

$s_{p_{sti}} = \sqrt{S^2 p_{sti}}$

t = Student's two-tailed t statistic for $\alpha = 0.05$, based on the effective degrees of freedom (Cochran 1977, Equation 5.16)

p_{sti}, A_i, N_{sti}, $s^2_{p_{sti}}$ are defined in Equations 4-7

2.3.2.2 ***Stratified Mean Length in Each Age Category.*** The mean length of striped bass of a given age that were caught in the 1996-97 program was estimated based on the same stratified random sampling plan described above in Section 2.3.2.1, using the following formula (Cochran 1977, Equation 12.1):

$$\bar{y}_{sti} = \left[\sum_{h=1}^{L} n_{hi} \bar{y}_{hi} \right] \Big/ N_i \qquad \text{Eq. 9}$$

where

$\bar{y}_{sti}$ = stratified mean length of striped bass of Age i among the total fish of Age i caught
$\bar{y}_{hi}$ = mean length of Age i fish in length group h of the laboratory sample
n_{hi} = number of Age i fish caught in length group h
N_i = number of Age i fish caught in the program
L = number of length groups in which at least two Age i fish were measured; if only one Age i fish was present in a length group, its length was pooled with those of length group closest to the group containing the mean

Variance estimates and confidence intervals for the stratified mean length of Age i fish were based on extrapolating mean length from the sample of striped bass for which age was determined (n_{hi}) to the entire population of striped bass in the Hudson River (N_i). However, extrapolating the variance of mean length to the entire river population is a two-phase sampling procedure in which the total catch is the primary sample and the aged fish are the secondary sample.

The two-phase variance of the stratified mean length of striped bass of a given age was estimated using the following formula (simplified from Cochran 1977, Equation 12.24, with the assumption that N_i is large and substantially larger than n_i; therefore, $N_i^{-1} \approx 0$ and $g'_i \approx 1$):

$$S^2_{\bar{y}_{sti}} = \sum_{h=1}^{L}\left[w_{hi}\left(S^2_{hi}/n_i V_{hi}\right)\right] + \left(1/n'_i\right)\sum_{h=1}^{L} w_{hi}\left(\bar{y}_{hi} - \bar{y}_{sti}\right)^2 \qquad \text{Eq. 10}$$

where

$S^2_{\bar{y}_{sti}}$ = two-phase variance of the stratified mean length of striped bass of Age i

w_{hi} = proportion of Age i fish in length group h, as estimated by the Bayes theorem presented in Equation 11

S^2_{hi} = variance of the mean length of Age fish in length group of the laboratory sample

n'_i = total number of Age i fish in the laboratory sample

V_{hi} = proportion of Age i fish in length group h

$\bar{y}_{hi}$, $\bar{y}_{sti}$, and L are as defined in Equation 9

The Neyman allocation for selecting scales to be aged (Section 2.3.2.1) requires the use of the Bayes theorem as an indirect method of estimating w_{hi} as follows:

$$w_{hi} = P\left(L_h | A_i\right) = \left[P\left(L_h\right) P\left(A_i | L_h\right)\right] / P\left(A_i\right) \qquad \text{Eq. 11}$$

where

W_{hi} is as defined in Equation 10

A_i = Age i striped bass

$P(L_h)$ = proportion of the total catch of striped bass in length group h

$P(A_i|L_h)$ = proportion of aged fish in length group h that are Age i

$P(A_i)$ = proportion of Age i fish in the total catch

CIs for the stratified mean length of Age i fish were calculated using the following formula (Cochran 1977, Equation 5.14):

$$95\% \ CI \ for \ \bar{y}_{sti} = \bar{y}_{sti} \pm \ t \ S_{\bar{y}_{sti}} \qquad \text{Eq. 12}$$

where

$$S_{\bar{y}_{sti}} = \sqrt{S^2_{\bar{y}_{sti}}}$$

t = Student's t statistic for a = 0.05 based on n_i'-1 degrees of freedom (not the effective degrees of freedom)

$\bar{y}_{sti}$ = as defined in Equation 9

2.3.3 **Estimated Hatchery Proportion**

All striped bass caught during the winter 1996-97 sampling program were examined for CWTs and second dorsal finclips. All striped bass suspected to be of hatchery origin based on field detection techniques were sacrificed and for verification of origin and release year. The number of verified hatchery recaptures was then compared to the total number of fish of the same cohort examined to estimate the proportion of hatchery fish in the striped bass population caught in the Hudson River using the following adjusted formula (MMES 1986):

$$P_{ai} = H_{ai} / \left(H_{ai} + W_{ai} \right) \qquad \text{Eq. 13}$$

where

P_{ai} = proportion of Age i hatchery striped bass in the population adjusted for tag loss and nondetection of tags

H_{ai} = number of Age i verified hatchery recaptures caught adjusted for tag loss and nondetection of tags

W_{ai} = number of Age i wild striped bass caught (A_i from Equation 5 - H_{ai})

By substituting the upper or lower 95% CI values from Equation 8 for the number of Age i striped bass (W_{ai}) in Equation 13, the exact binomial variance of P_{ai} can be calculated for determination of confidence limits for the estimated proportion of Age i fish in the population.

The number of Age i hatchery striped bass caught was adjusted for magnetic tag loss (Dunning et al. 1989) and nondetection of tags on an age-specific basis as follows:

$$H_{ai} = H_i / \left[(1 - TAG_i)(1 - NDET) \right] \qquad \text{Eq. 14}$$

where

H_{ai}	=	adjusted number of Age i hatchery striped bass caught
H_i	=	number of Age i verified hatchery recaptures caught
TAG_i	=	weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (Table 2-l)
NDET	=	decimal percent nondetection rate for magnetic tags during the recapture program
	=	$[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector, and H is the total number of verified hatchery fish detected when both detectors were used

The adjusted number of Age i hatchery striped bass caught (H_{ai}) was then used in Equation 13. The total number of hatchery striped bass that were stocked in each year (Chapter 1) was not adjusted for handling mortality (Dunning et al. 1989) because handling mortality was minimal (<1%) and could not be associated with each lot of tagged fish stocked into the Hudson River (EA 1996).

2.3.4 **Recaptured Striped Bass**

Three groups of recaptured, internal anchor-tagged striped bass were considered: (1) fish recaptured from previous programs (cross-year recaptures); (2) fish caught, tagged, released, and recaptured within the current (1996-97) program (within-year recaptures); and (3) fish recaptured with external streamer tags from other programs (other recaptures). All cross-year recaptures were examined to determine the condition of the tag legend and insertion site, recapture rate, mean length, and days at large. We also determined the age and growth for cross-year recaptures by examining the scale samples taken at the time of release and time of recapture. Within-year recaptures consisted of two groups of striped bass: fish that were tagged and released (REL_REC = 1), and fish that were tagged and released but exhibited one or more gross anatomical abnormalities (REL_REC=6). Both groups of within-year recaptures were examined to determine the tag condition, recapture rate, mean length, and days at large. Within-year recaptures that were in good condition at the time of release were also used for a mark-capture estimate of population

TABLE 2-1

FACTORS USED TO ADJUST THE NUMBER OF VERIFIED STRIPED BASS HATCHERY RECAPTURES IN EACH AGE COHORT FOR MAGNETIC TAG LOG LOSS (TAG_i) AND NONDETECTION OF TAGS (NDET) DURING 1996-97

COHORT	AGE	TAG_i	NDET
1995	1+	0.040[a]	0.00000[b]
1994	2+	0.032	0.00000
1993	3+	0.071	0.00000
1992	4+	0.029	0.00000
1991	5+	[c]	[c]
1990	6+	[c]	[c]
1989	7+	0.057	0.00000
1988	8+	0.017	0.00000
1987	9+	0.0147	0.00000
1986	10+	0.075	0.00000
1985	11+	0.065	0.00000
1984	12+	0.276	0.00000

[a]Weighted, decimal percent 24-hr magnetic tag loss for Age i hatchery striped bass determined at the time of tagging (EA 1996).

[b]Weighted nondetection rate based on a nondetection rate of 0.00000 for hatchery recaptures checked with two detectors.

[c]Hatchery fish were not tagged prior to release in 1990 or 1991.

size (Section 2.3.6). LMS obtained release and recapture information and observed the condition of the tag streamer and insertion site for other agency recaptures.

2.3.5 Population Movement

The two regions of the study area (Battery and Upper Harbor, Figure 2-1) were combined and treated as one region for analyses of population movement and abundance because they are contiguous and few fish were caught in the Upper Harbor. Movement within this combined Battery region was determined directly by plotting and by comparison of recapture rates and recapture proportions in each week:

$$Recapture\ rate = R_{ij} / M_{ij} \qquad \text{Eq. 15}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
M_{ij} = number of tagged striped bass released during time period (week) i in region j

$$Recapture\ proportion = R_{ij} / C_{ij} \qquad \text{Eq. 16}$$

where

R_{ij} = number of tagged striped bass recaptured in time period (week) i in region j
C_{ij} = number of striped bass caught and examined for tags in time period (week) i in region j

2.3.6 Population Size

The Schumacher-Eschmeyer estimator was used to estimate striped bass population size because it is a multiple census population estimator that permits tagging and recapture efforts to occur concurrently. This estimator is a weighted linear regression of R_i/C_i as a function of M_i (where M_i is the cumulative number marked prior to time i), with the restriction that the regression line must pass through the origin. The model is $R_i/C_i = \beta M_i + e_i$, where ß is the slope of the regression line and e_i is a random error term with a mean of 0 (Seber 1982). When the squared residuals (R_i/C_i- βM_i) are weighted by the catch (C_i), then N^{-1} equals the slope, ß.

The Schumacher-Eschmeyer estimator (Ricker 1975) is:

$$N = \sum\left(C_i M_i^2\right) / \sum\left(R_i M_i\right) \qquad \text{Eq. 17}$$

where

- N = estimated population size
- C_i = total catch during time interval i
- M_i = total number of marked fish tagged and released in good condition and available for recapture at the midpoint of time interval i
- R_i = number of recaptured fish in Ci

The variance of the reciprocal of the population size (l/N) is estimated by first calculating the mean of squared deviations from the regression as

$$S^2 = \frac{\sum\left(R_i^2/C_i\right) - \left(\sum R_i M_i\right)^2 / \sum\left(C_i M_i\right)}{m-1} \qquad \text{Eq. 18}$$

where

- S^2 = mean of squared deviations from the regression model described above
- m = number of data points in the regression, and C_i, M_i, and R_i are as defined above in Equation 17

The 95% CI for the reciprocal of the population size (1/N) is computed as

$$CI = S^2 / \sum C_i M_i^2 \cdot t_{m-1} \qquad \text{Eq. 19}$$

where

t_{m-1} = Student's t-statistic for m-1 degrees of freedom and $\alpha = 0.05$

Confidence limits for the population size N are obtained by first computing the 95% CI about 1/N and then inverting.

2.3.7 Length at Age Analysis

Analysis of variance was used to evaluate the effect of the tag on growth of tagged fish. Growth based on focus to annulus measurements for scale samples from tagged fish recaptured after being at large one or two years was compared within cohort to growth from scale samples taken from untagged fish caught at the time the tagged fish were recaptured in the 1988-89 through 1993-94 programs. Growth was measured as the distance from the focus to each annulus along a radial line originating at the focus and running perpendicular to the anterior edge of the scale (radius measurement).

CHAPTER 3

RESULTS AND DISCUSSION

3.1 CATCH CHARACTERISTICS OF THE 9-M TRAWL

3.1.1 Catch Per Unit of Effort

A total of 831 10-min tows (Use Code = 1) were completed with the 9-m trawl in the Battery region, and 123 tows were completed in the Upper Harbor region of the lower Hudson River between 4 November 1996 and 11 April 1997. Sampling effort (i.e., number of tows) varied between regions in order to maximize the CPUE of striped bass in the lower Hudson River. The mean CPUE for striped bass in the Upper Harbor region was 13.56 fish per 10-min tow. (Table 3-1). The mean CPUE for striped bass in the Battery region was 15.29 fish per 10-min tow for all sampling weeks combined (Table 3-1). Most of the sampling effort was concentrated in the Battery region following the week of 23 December 1996 (Appendix Table C-1). Mean CPUE exceeded 30 striped bass per 10-min tow during the weeks of 2 December and 30 December 1996 in the Upper Harbor region and during the weeks of 17 February and 17 March 1997 in the Battery region (Figure 3-1; Appendix Table C-1). The highest weekly mean CPUE during the entire program was 37 striped bass per 10-min tow during the week of 2 December 1996 in the Upper Harbor region (based on 13 tows). The next highest weekly mean CPUE occurred during the week of 17 February 1997 in the Battery region, when an average of 33.7 striped bass were collected in 37 tows.

The highest CPUE was at river mile (RM) 4 of the Battery region (Appendix Table C-2). The CPUE was based on 11 tows at this location, approximately 1% of the overall sampling effort. Consistently high catches (> 18 mean CPUE) occurred at RM 10 of the Battery region, where 57% of the sampling took place.

A comparison of mean CPUE for the 9-m trawl in the Battery region during common time periods, indicates mean CPUE increased in each program from 8.1 in 1985-86 to a peak of 45.3 striped bass per 10-min tow in 1989-90 (Table 3-2). After the peak CPUE in the 1989-90 program, CPUE decreased to 14.3 striped bass per 10-min tow for the 1995-96 program before increasing to 19.6 for the 1996-97 program. The increased CPUE observed during the 1988-89 and 1989-90

TABLE 3-1

MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9-m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1996-97.

REGION	NUMBER OF TOWS	NUMBER OF FISH COLLECTED	MEAN CPUE	S.E.
Upper Harbor	123	1668	13.56	1.75
Battery	831	12,709	15.29	0.69

NOTE: Includes only valid (use code = 1) samples.

CPUE = Catch per unit effort (catch per ten minute tow)
S.E. = Standard error

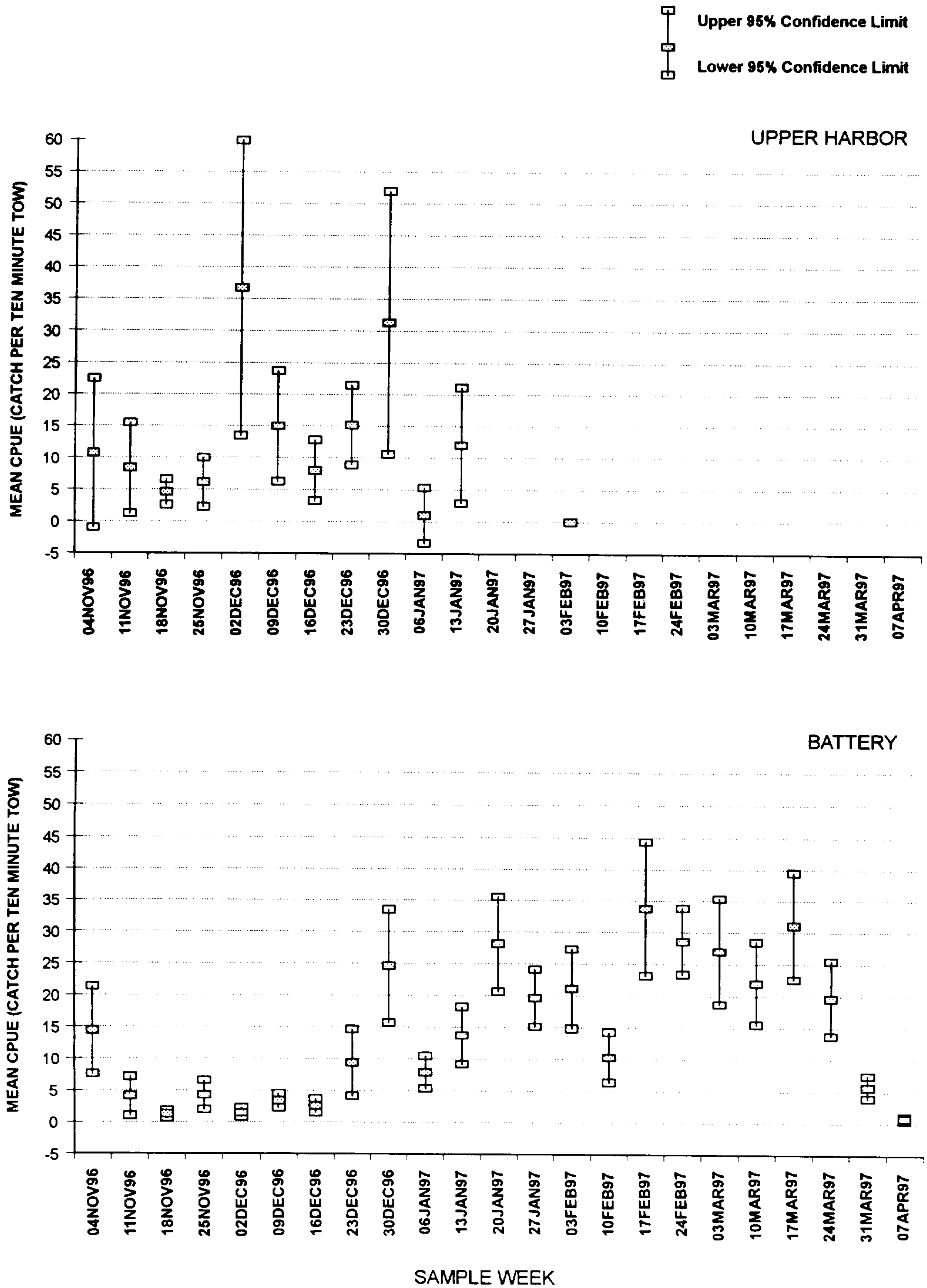


Figure 3-1. Weekly mean catch per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1996-97.

TABLE 3-2

MEAN CATCH PER UNIT (CPUE) OF STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER DURING COMMON TIME PERIODS IN THE WINTERS OF 1985-86 THROUGH 1996-97

YEAR	PERIOD	NUMBER OF TOWS	MEAN CPUE	95% CI
1985-86	23 Dec 85 - 21 Mar 86	638	8.1	±1.0
1986-87	21 Dec 86 - 21 Mar 87	385	12.2	±1.2
1987-88	20 Dec 87 - 19 Mar 88	437	28.5	±2.5
1988-89	19 Dec 88 - 18 Mar 89	527	38.9	±3.3
1989-90	18 Dec 89 - 16 Mar 90	458	45.3	±4.3
1990-91	17 Dec 90 - 15 Mar 91	477	40.7	±3.5
1991-92	23 Dec 91 - 21 Mar 92	578	35.5	±2.2
1992-93	21 Dec 92 - 20 Mar 93	397	32.7	±2.9
1993-94	20 Dec 93 - 20 Mar 94	341	33.7	±5.2
1994-95	19 Dec 94 - 19 Mar 95	291	21.9	±2.2
1995-96	18 Dec 95 - 17 Mar 96	299	14.3	±2.0
1996-97	16 Dec 96 - 16 Mar 97	476	19.6	±1.8

NOTE: CPUE = Catch per unit effort (catch per ten minute tow).
Includes only valid (use code = 1) samples.

programs may be due to the complete recruitment of the numerically dominant 1987 and 1988 year classes to the 9-m trawl (CES 1989). The decrease in CPUE observed after the 1989-90 program may be due to increased gear avoidance, migration, or mortality of the 1987 and 1988 year classes and lower abundance of the 1989 through 1993 year classes.

3.1.2 Length-Frequency Distribution

The overall mean length of striped bass caught by the 9-m trawl in the Battery region was 268 mm during the 1996-97 program (Table 3-3). The length-frequency distribution for the 9-m trawl was (1) skewed right, i.e., more fish were smaller than the mean length than would be expected if the distribution were bell-shaped; (2) leptokurtotic, i.e., more fish were found closer to the mean length than would be expected if the distribution were normal; and (3) unimodal (Table 3-3; Figure 3-2). The greatest percentage of the striped bass caught were in the 251- to 300-mm length group.

Weekly mean length of striped bass collected by the 9-m trawl in the Battery region varied for most of the sampling program, ranging between 224 and 291 mm for the first 21 weeks of the program. Weekly mean length increased to 327 and 337 mm in the Battery region during the final two weeks of the sampling program (Appendix Table C-5). Mean length was highest (321 mm) in the Upper Harbor region during the week of 6 January 1997 (based on three striped bass) and lowest (269 mm) during the week of 16 December 1996. Weekly mean length for both the Upper Harbor and Battery regions generally varied during the entire sampling program. This pattern differs to that observed in previous years (1991-92, 1992-93, 1993-94, and 1995-96) where mean length was greatest during the early weeks of the program and then steadily declined.

Weekly changes in length-frequency of striped bass, characterized by the catch of striped bass per tow in 50-mm length classes, indicated that larger fish in the 201 to 301-mm length classes predominated trawl collections for the majority of the sampling program (Figure 3-3). Weekly mean CPUE in these length classes was inconsistent during the first 11 weeks of the sampling program, ranging between 0.5 and 9.3 fish per tow. Weekly mean CPUE remained above 3.0 fish per tow from 17 February through the week of 24 March 1997. Weekly mean CPUE in the 251- to 300-mm length class reached a high of 10.5 fish per tow during the week of 17 February 1997 (Appendix Table C-6). Catch of smaller length classes (101-150 and 151-200 mm) also increased during the second half of the sampling program, with peaks of 4.0 and 2.5 fish per tow, respectively.

TABLE 3-3

DESCRIPTIVE STATISTICS FOR LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS COLLECTED BY A 9-m TRAWL IN THE BATTERY REGION OF THE HUDSON RIVER WINTER 1996-97

N	MEAN (mm)	S.D.	SKEWNESS (95% C.I.)	KURTOSIS (95% C.I.)	MINIMUM	MAXIMUM	DESCRIPTION
14,374	268	73.5	0.42 ± 0.03	2.55 ± 0.06	51	1030	Right skewness leptokurtotic

N = Number caught
TL = Total length
S.D. = Standard Deviation
±95% C.I.= 95% confidence interval

Right skewness = Positive skewness indicating more striped bass were smaller than the mean length than would be expected from a normal distribution.

Leptokurtosis = Positive kurtosis indicating more striped bass were closer to the mean length than would be expected from a normal distribution.

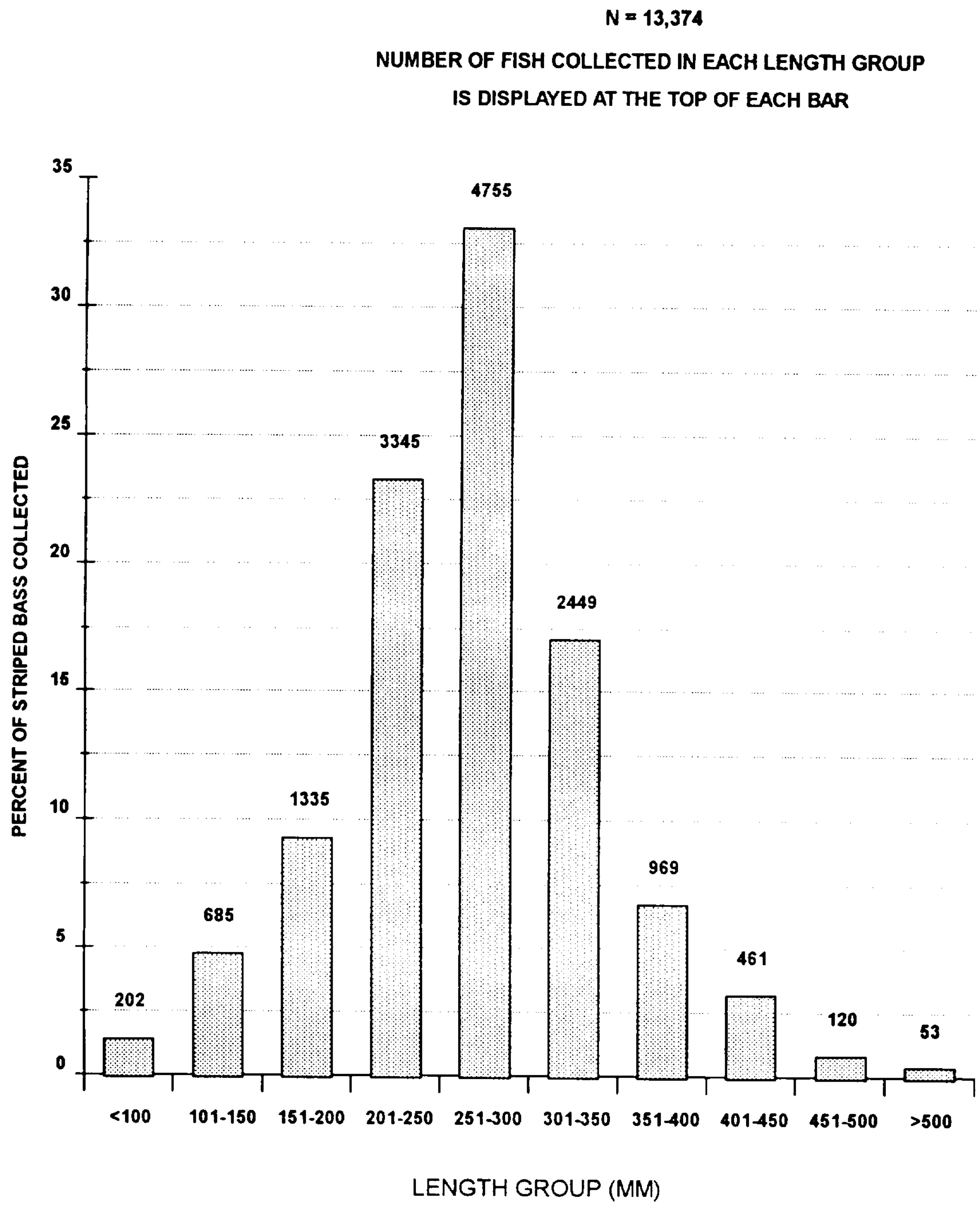


Figure 3-2. Length-frequency distribution for striped bass collected by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1996-97.

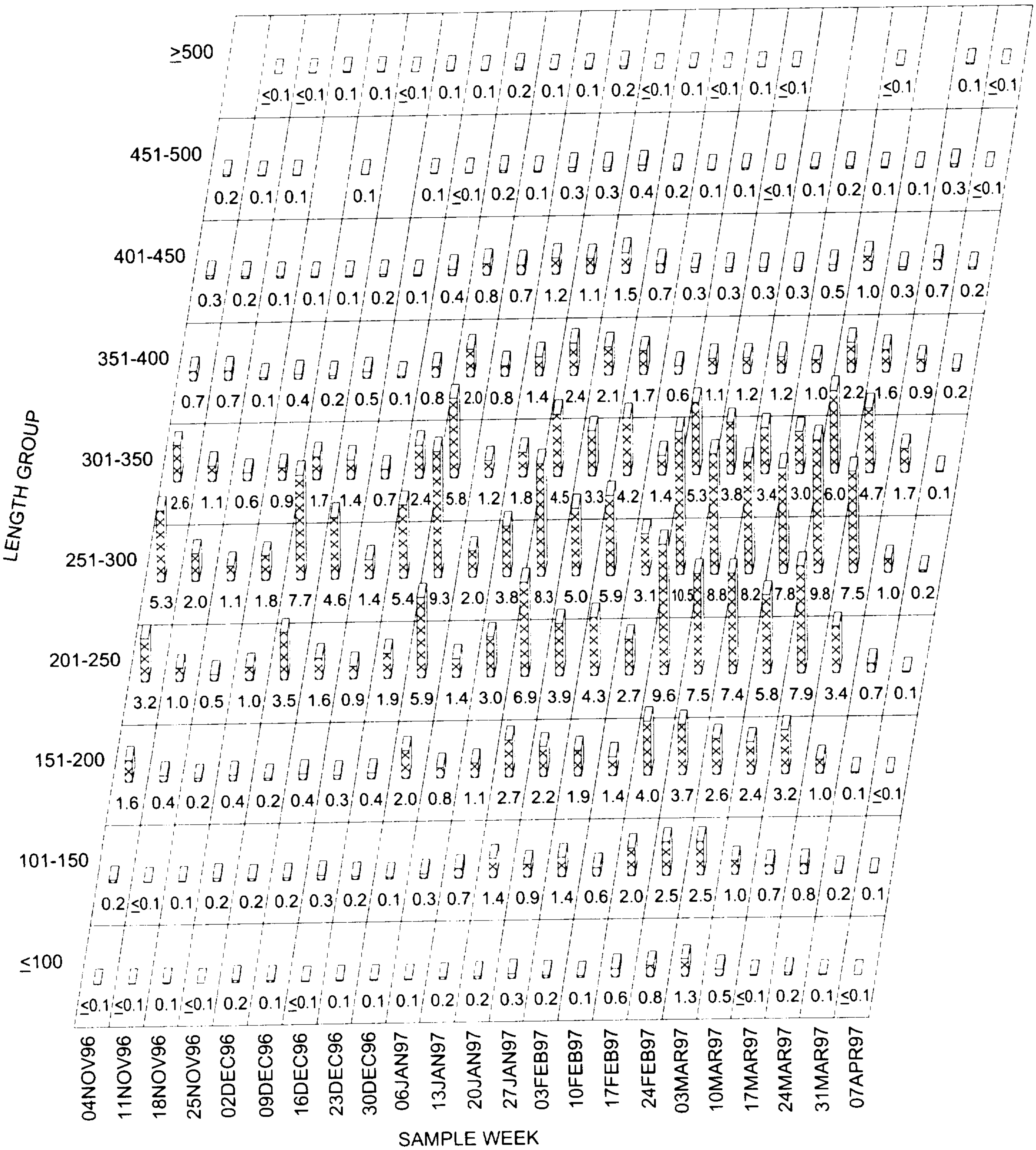


Figure 3-3. Weekly length-frequency distributions for striped bass collected per ten minute tow by the 9m trawl in the Battery and Upper Harbor regions of the Hudson River, winter 1996-97.

The standardized length-frequency of striped bass captured during the winter of 1995-96 was unimodal with a peak in the 251-300 mm length groups (Figure 3-4). Unimodal length-frequencies previously occurred during the winters of 1988-89, and 1989-90. The peak between 251 and 300 mm probably represents the 1995 cohort of age 1+ striped bass.

3.1.3 **Handling Mortality**

Striped bass handling mortality in the 9-m trawl was 1.2% during 1996-97 at bottom water temperatures from 0 to 14°C (Table 3-4). A total of 182 striped bass died out of 14,374 fish caught in Use Code = 1 tows that had river bottom water temperature data associated with each tow. The highest handling mortality of 10.0% (10/100) occurred at a bottom water temperature of 1 °C. An interaction between water temperature, fish length and immediate handling mortality was not significant in previous programs (Dunning et al. 1989). However, recent programs, 1992-93 through 1994-95, have displayed a pattern of higher handling mortality at lower bottom water temperatures (≤ 8°C) when compared to mortality at higher bottom water temperatures (> 8°C). Recent program data have not been examined for an interaction between water temperature, fish length, and immediate handling mortality. Immediate handling mortality should not affect mark-recapture estimates because field crews remove fish that are dead or considered to be in poor condition after tagging prior to their release.

Striped bass handling mortality in the 1996-97 program was slightly higher than that observed during the previous programs (Table 3-5). The apparent increase in handling mortality observed in the 1991-92 through 1993-94 programs was probably due to an underestimate of handling mortality during the 1985-86 through 1990-91 programs. During the 1985-86 through 1990-91 programs, the bird predation rate was not factored into the handling mortality rate of the program. All striped bass that were not immediately identified as dead upon release were assumed to have survived. However, at the end of the 1990-91 program bird predation on released striped bass was quantified. Approximately 2.4% of the 2969 tagged striped bass released between 12 March and 12 April 1991 were removed from the water by gulls (NAI 1992).

Field procedures were modified during the 1991-92 and 1992-93 programs to both quantify and minimize gull predation. After tagging, fish were released into a recovery pen that was deployed in the water alongside the boat. The pen was a 1-m x 2-m x 1-m deep enclosure with 0.9-cm mesh netting on four sides, open on the top and bottom, with the top of the frame suspended at the water

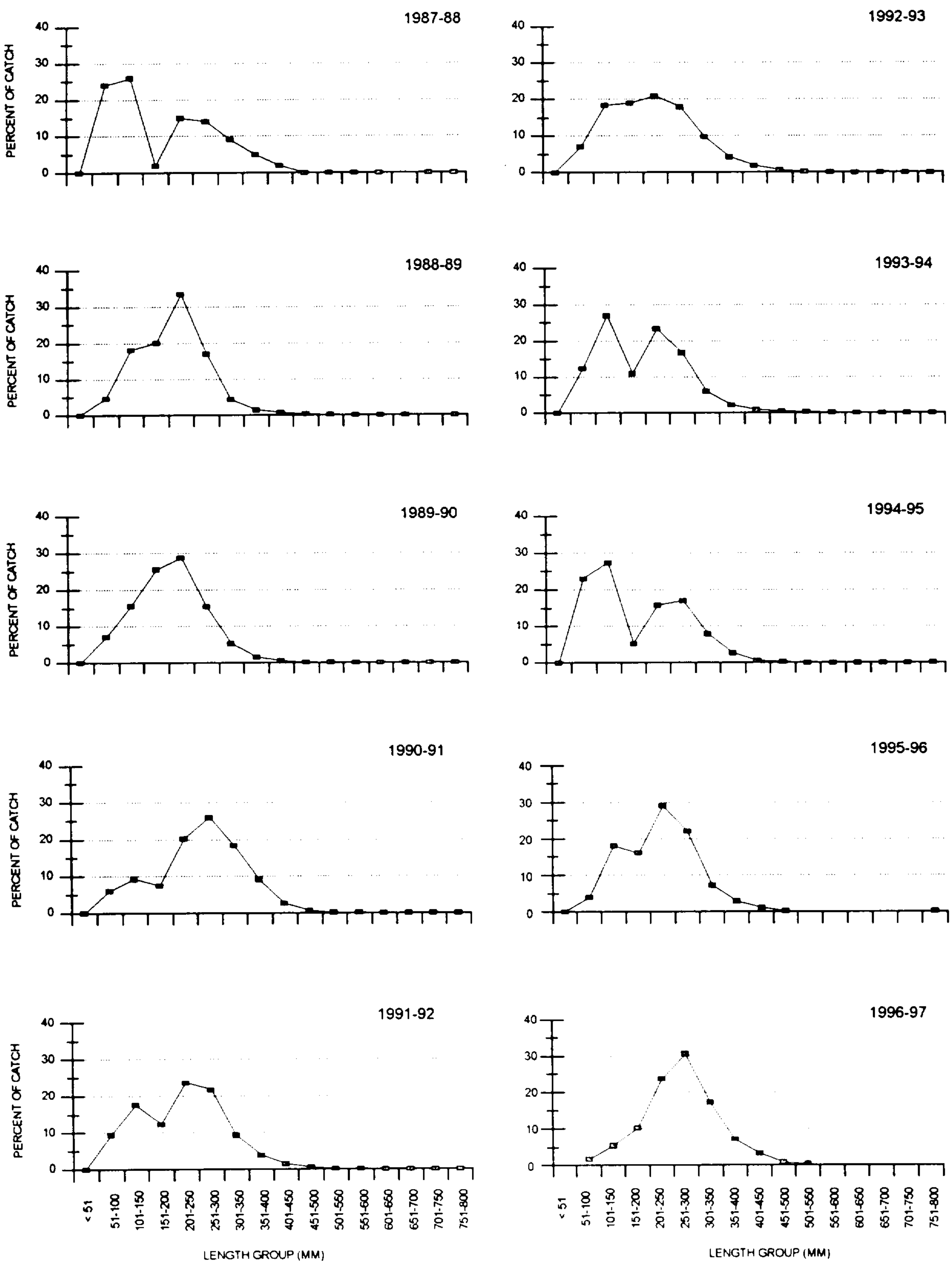


Figure 3-4. Standardized (50mm interval) length-frequency of striped bass collected in the 9m trawl in the Battery region of the Hudson River, winter 1996-97.

TABLE 3-4

HANDLING MORTALITY FOR STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER IN RELATION TO BOTTOM WATER TEMPERATURE, WINTER 1996-97

BOTTOM WATER TEMPERATURE (°C)	PERCENT OF CATCH DEAD (%)	NUMBER DEAD	TOTAL CATCH
0.0	0.0	0	13
1.0	10.0	10	100
2.0	0.0	0	59
3.0	1.4	15	1071
4.0	2.0	60	3030
5.0	1.0	34	3500
6.0	0.9	32	3571
7.0	1.6	18	1111
8.0	2.3	11	471
9.0	0.0	0	489
10.0	0.0	0	180
11.0	0.5	1	212
12.0	0.9	1	110
13.0	0.0	0	299
14.0	0.0	0	158
0.0-14.0	1.2	182	14,374

NOTE: Mortality expressed as the percentage of dead striped bass collected in a temperature increment.
Mortality calculated from catch data for valid (Use Code = 1) tows for which bottom water temperature was available.

TABLE 3-5 (Page 1 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1996-97 HUDSON RIVER STRIPED BASS PROGRAMS

	1985-86 THROUGH 1990-91		1991-92		1992-93	
BOTTOM WATER TEMPERATURE (°C)	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	0.3	58/16,781	1.3	20/1,557	1.4	80/5,940
4	0.3	51/16,155	0.5	45/9,685	3.5	107/3,090
5	0.3	58/21,071	0.2	13/5,419	2.2	86/3,585
6	0.2	43/18,783	1.5	98/6,438	1.8	44/2,380
7	0.4	43/11,785	1.0	26/2,728	1.2	16/1,347
8	0.2	20/8,731	1.4	29/2,135	2.2	17/756
9	0.5	29/5,709	0.9	10/1,133	0.2	3/1,361
10	0.2	8/4,843	1.1	21/1,897	0.7	6/806
11	0.3	11/3,185	0.6	5/879	0.5	17/3,406
12	0.3	6/1,995	0.5	1/187	0.2	1/434
3-12°C	0.3	327/109,038	0.8	268/32,058	1.6	377/24,307

Dx = Number of dead striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of striped bass collected at a temperature (Use Code = 1 samples only).

TABLE 3-5 (Page 2 of 2)

HANDLING MORTALITY FOR STRIPED BASS (PERCENTAGE OF DEAD STRIPED BASS AT A TEMPERATURE INCREMENT) CAPTURED BY A 9-m TRAWL AMONG COMMON BOTTOM WATER TEMPERATURE INCREMENTS DURING THE 1985-86 THROUGH THE 1996-97 HUDSON RIVER STRIPED BASS PROGRAMS

BOTTOM WATER TEMPERATURE (°C)	1993-94		1994-95		1995-96		1996-97	
	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx	% OF CATCH DEAD	Dx/Tx
3	3.0	69/2,260	1.3	17/1,310	4.9	70/1,424	1.4	15/1071
4	3.3	156/4,713	0.3	6/1,759	0.7	3/448	2.0	60/3030
5	1.2	53/4,438	0.6	15/2,692	1.2	8/664	1.0	34/3500
6	2.0	65/3,206	0.4	8/1,987	1.5	18/1,180	0.9	32/3571
7	1.4	36/2,564	0.3	4/1,585	1.7	34/1,989	1.6	18/1111
8	2.1	29/1,354	0.6	2/326	0.2	4/1,935	2.3	11/471
9	0.5	1/196	0.2	1/640	0.9	17/1,790	0.0	0/489
10	0.0	0/91	0.4	3/836	0.2	1/578	0.0	0/180
11	0.3	4/1,424	0.0	0/295	1.0	16/1,617	0.5	1/212
12	0.5	2/243	0.0	0/69	1.1	5/447	0.9	1/110
3-12°	2.0	415/20,669	0.5	56/11,496	<0.1	176/12,072	1.2	172/13,745

Dx = Number of dead striped bass collected at a temperature (Use Code = 1 samples only).
Tx = Total number of striped bass collected at a temperature (Use Code = 1 samples only).

surface. Striped bass released into the pen were provided a refuge alongside the boat where they could recover from handling stress without drifting away from the boat during recovery and possibly being preyed upon by gulls. Fish in good condition typically escaped from the pen through the bottom. Stunned fish typically remained at the surface for several minutes until they recovered and escaped through the bottom of the pen. Any fish remaining in the recovery pen at the end of sample processing were considered dead and were removed and taken to the laboratory. A field technician also observed fish as they escaped from the recovery pen and recorded instances of gull predation. These procedures both minimized gull predation and accurately recorded handling mortality.

3.2 STRIPED BASS LENGTH AND AGE DISTRIBUTION

3.2.1 Length Distribution and Associated Statistics for Each Age Cohort

Age-length frequency histograms, presented by 10-mm length groups for Age 0+ through Age 3+ striped bass (Figure 3-5), demonstrate little overlap in size of Age 0+ and Age 1+ striped bass caught during the 1996-97 program. Age-length frequency distributions are based on scale samples from a stratified random sampling of about 15% of the total catch (See Section 3.2.2). Most of the fish in each length group <170 mm were Age 0+, while most of the fish in length groups between 160 and 319 mm were Age 1+. Age 1+ and Age 2+ striped bass overlapped in size between 220 and 349 mm. Age 3+ striped bass overlapped with Age 2+ fish, primarily between 270 and 499 mm.

The 9-m trawl with 7.6-cm (stretch) mesh in the body and 3.8-cm (stretch) mesh in the cod end was the only gear that was consistently used among the 1986-87 through 1996-97 programs. Therefore, the striped bass catch by this 9-m trawl was used for comparisons of mean length at age among programs. Overlap of the 95% confidence intervals about the estimated mean length of each age cohort was used for the comparison of mean length at age.

The 1996 wild cohort of Hudson River striped bass at Age 0+ was smaller in mean length (120 mm) than the previous Age 0+ cohort (127 mm). Previous Age 0+ cohorts ranged between 104 and 131 mm in length (Figure 3-6; Appendix Table C-7). The 1988, 1990, and 1993 Age 0+ cohorts were similar in mean length to the 1996 cohort.

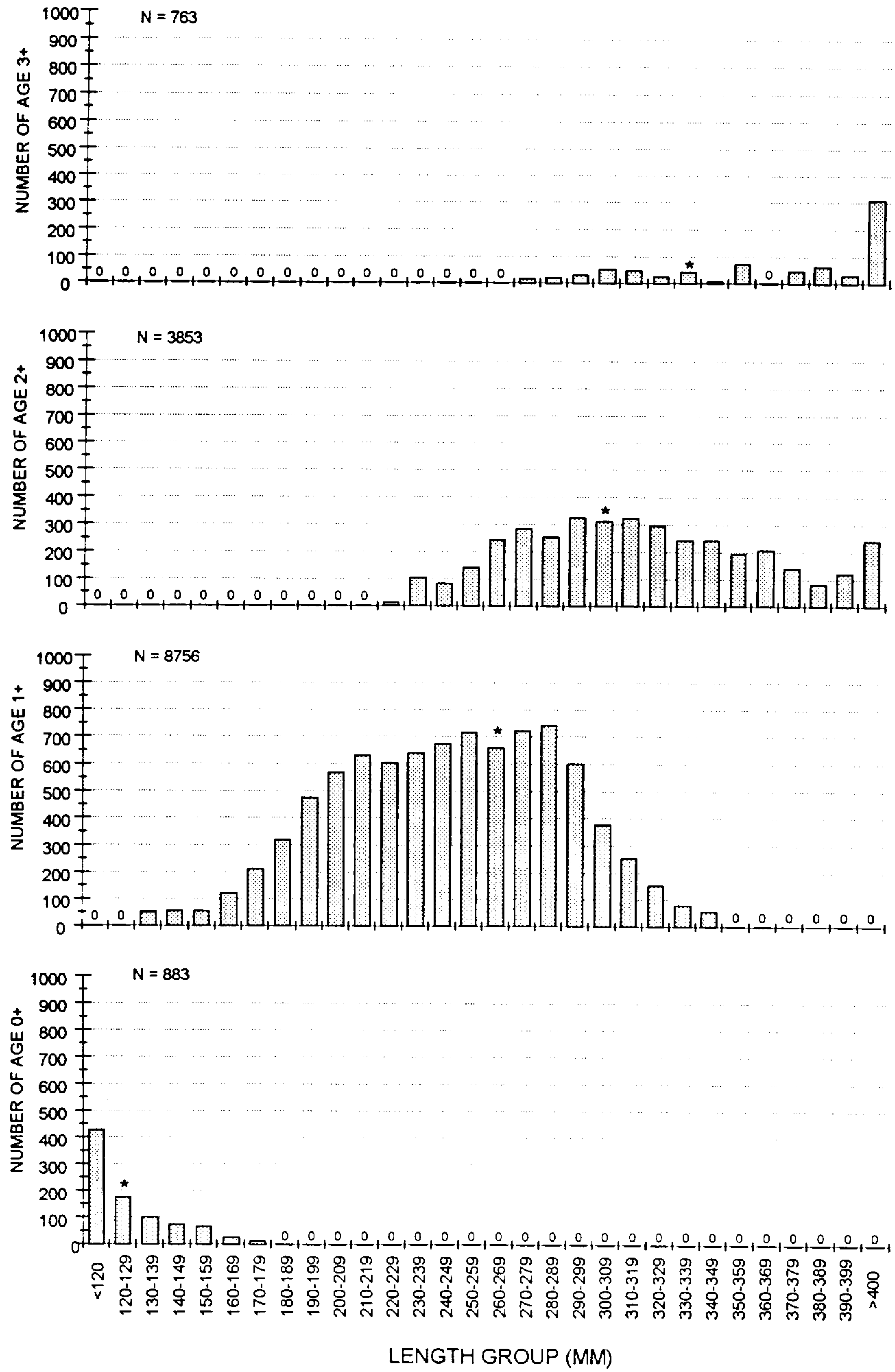


Figure 3-5. Length-frequency distributions for Age 0+, 1+, 2+ and 3+ striped bass collected by the 9m trawl in the lower regions of the Hudson River, winter 1996-97.

Note: * = length group containing the stratified mean length at age.

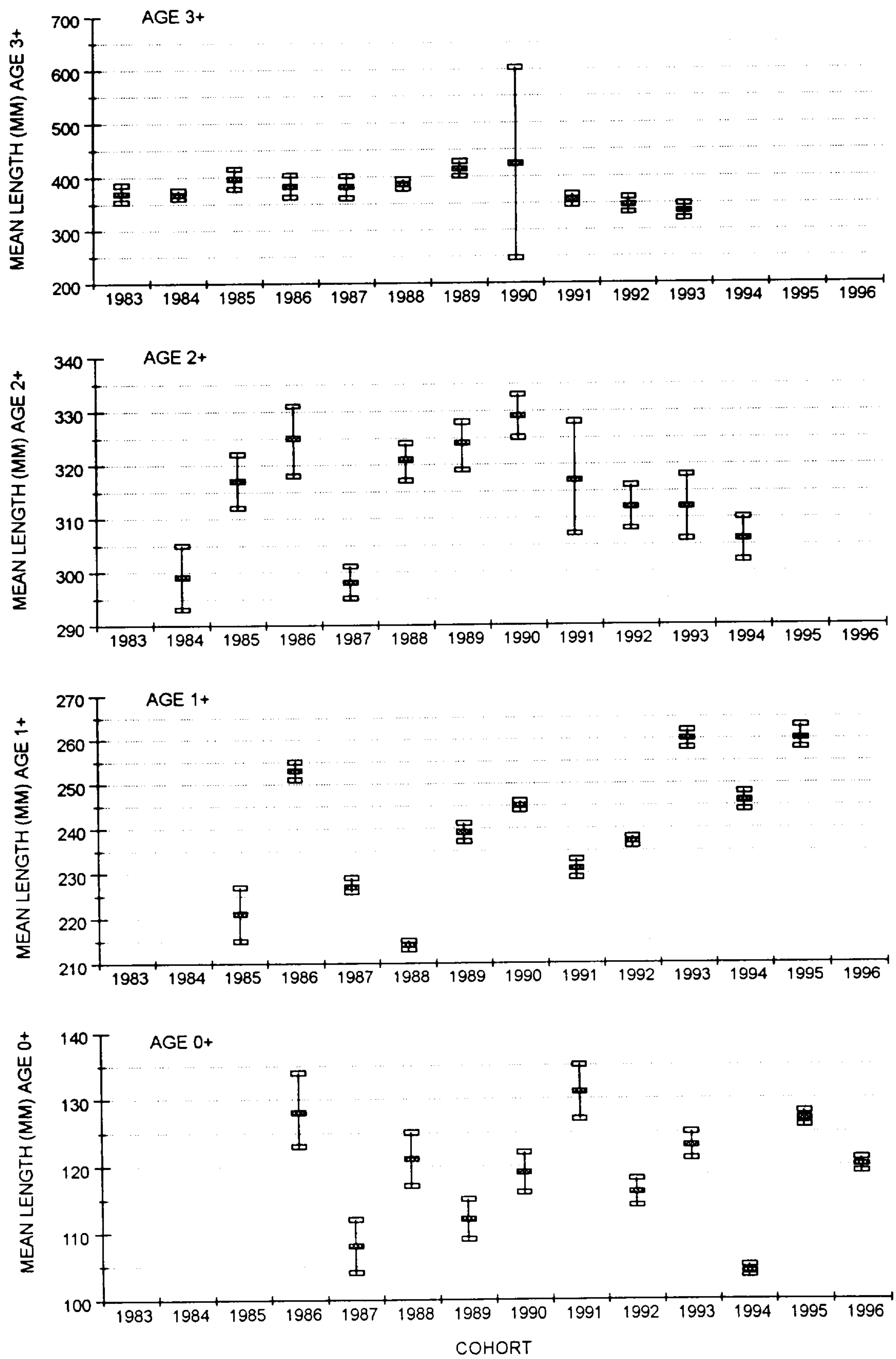


Figure 3-6. Mean length at age and 95% confidence interval for Age 0+ through Age 3+ wild striped bass of the 1983 through 1996 cohorts collected in the Hudson River.

At Age 1+ the 1995 cohort was among the larger Age 1+ cohorts since 1985, with a mean length of 260 ±2 mm. This was similar to the 1993 and 1986 cohorts. Previous Age 1+ cohorts range from mean lengths of 214 to 260 mm. The 1992, 1991, 1990, 1989, 1987, and 1985 cohorts at Age 1+ were similar in mean length, while the 1988 cohort was the smallest.

The 1994 cohort at Age 2+ was the smallest in length compared to the six previous Age 2+ cohorts (1988 through 1993). The 1990 cohort remained the largest at Age 2+, with a mean length of 329 ±4 mm. The 95% CIs for the 1994, 1993, 1992, and 1991 cohorts overlapped, indicating similarity among the estimated mean lengths. Estimated mean lengths of the 1984 and 1987 cohorts were the smallest of the Age 2+ cohorts examined.

The 1993 cohort at Age 3+ was the smallest in length compared to previous years. CIs about the estimated mean length at Age 3+ for the 1993 cohort overlapped among the 1992, 1991, and 1990 cohorts. However, the estimated mean length at Age 3+ of the 1993 cohort ranked smallest, while the 1990 cohort ranked largest.

3.2.2 **Estimated Proportion and Number of Age 0+ Through Age 3+ Striped Bass**

Stratified random sampling of about 15% of the scale samples resulted in extremely precise estimates of the proportion and number of Age 1+ striped bass in this study (Table 3-6). For the allocation of 2233 scale samples actually selected, the precision based on 95% confidence limits was 1.9%, corresponding to an error term of ±170 fish.

Relatively little gain in precision would be realized compared to the cost if age were determined for more than about 10% of the total sample (1,437 fish in 1996-97). For example, doubling the number of striped bass scale samples examined for age determination from 3000 to 6000 would not improve the precision of the estimate by more than 0.3% (Table 3-6). By determining the age from scale samples from as few as 500 fish, the total number of Age 1+ striped bass (8756) out of the 14,377 fish caught in Use Code = 1 samples during 1996-97 could be estimated with 95% confidence limits of ±411 fish (precision = 4.7%, Table 3-6).

Using the stratified sampling plan, scales were selected for age analysis in direct proportion to both the number of fish in each 10-mm length group and the variance of the proportion of Age 1+ fish in each group. Therefore, it was expected a priori that a sufficient number of both hatchery

TABLE 3-6

RELATIONSHIP BETWEEN THE NUMBER OF SCALE SAMPLES SELECTED FOR AGE DETERMINATION BY NEYMAN SAMPLE ALLOCATION AND PRECISION OF THE STRATIFIED ESTIMATE OF PROPORTION AND TOTAL NUMBER OF AGE 1+ STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER
WINTER 1996-97

		ESTIMATED NUMBER OF AGE 1+ STRIPED BASS COLLECTED			
SAMPLE SIZE	**PROPORTION AGE 1+**	**STRATIFIED TOTAL[b]**	**LOWER 95% C.I.**	**UPPER 95% C.I.**	**PRECISION (%)[a]**
500	0.609	8756	8345	9167	4.7
1,000	0.609	8756	8482	9030	3.1
2,000	0.609	8756	8574	8938	2.1
2,233[c]	0.609	8756	8586	8926	1.9
3,000	0.609	8756	8616	8896	1.6
4,000	0.609	8756	8642	8870	1.3
5,000	0.609	8756	8661	8851	1.1
6,000	0.609	8756	8677	8835	0.9
7,000	0.609	8756	8690	8823	0.8

[a]Precision = 95% confidence interval (C.I.) half width/stratified total x 100.

[b]Based on 14,377 striped bass caught in Use Code = 1 sample.

[c]Results for sample size = 2233 are based on actual allocation from Use Code = 1 sample, which deviate slightly from the Neyman sample allocations because some scale samples consisted of regenerated scales and could not be used for age determination.

and wild Age 1+ fish would be caught to obtain a precise and accurate estimate of hatchery contribution at this age (MMES 1986). However, the stratified design also yields a precise estimate of the proportion and number of Age 0+ and Age 2+ striped bass (Table 3-7), which collectively constituted 32.9% of the fish caught in this program. Only 763 of the 14,377 striped bass caught in Use Code = 1 samples were estimated to be Age 3+, and 32 of the fish caught were older than Age 3+ in the 1996-97 program.

The number of Age 0+ fish was estimated more precisely than would be expected based on Age 1+ fish because there was little overlap in size between these ages. The 1995 cohort of Age 1+ striped bass was approximately 61% of the total catch during 1996-97. The number of Age 2+ striped bass (1994 cohort) was estimated with lower precision than the number of Age 1+ fish because the size range of Age 2+ was wider, and the sample size was smaller for these fish.

3.3 STRIPED BASS HATCHERY PROPORTION

Only one Age 2+ striped bass stocked in the Hudson River from the Verplank hatchery in 1994 was collected during the 1996-97 program. Hatchery fish were not tagged in 1990 or 1991 and could not be detected among the Age 5+ or older fish. One Age 1+ striped bass stocked in the Hudson River from the Verplank hatchery in 1995 was collected during the 1996-97 program. Stocking of striped bass from the Verplank hatchery ceased following 1995, therefore no Age 0+ hatchery fish were present in trawl samples. Age 0+ hatchery fish represented < 1% of the catch during 1995-96 (Table 3-8), the last year hatchery stocking occurred, but the reliability of this proportion is unknown because fish of the size range observed for the Age 0+ cohort are probably not fully recruited to the 9-m trawl (Wells et al. 1991).

Comparison of the estimated hatchery proportions for the 1985 and 1986 hatchery cohorts caught in 1986-87 through 1988-89 suggested that the hatchery proportion for each cohort doubled as the cohort increased in age from Age 1+ to Age 2+ (NAI 1990; Table 3-9 in this report). However, this trend did not continue for the more recent hatchery cohorts. Prior to 1995, estimated hatchery proportions if 600,000 hatchery striped bass were stocked in each year ranged from 16.3% for the Age 1+ 1988 cohort to 0.2% for Age 0+ fish from the 1993 cohort (Table 3-10). The hatchery proportions of Age 0+ and Age 1+ fish from the 1995 and 1994 cohorts, respectivley, are the smallest hatchery proportions among all program estimates.

TABLE 3-7

ESTIMATED PROPORTION AND NUMBER OF AGE 0+ THROUGH AGE 3+ STRIPED BASS COLLECTED IN THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1996-97

			ESTIMATED NUMBER OF STRIPED BASS COLLECTED			
AGE	YEAR CLASS	PROPORTION	STRATIFIED TOTAL[a]	LOWER 95% C.I.	UPPER 95% C.I.	PRECISION (%)
0+	1996	0.061	883	818	948	7.4
1+	1995	0.609	8756	8586	8926	1.9
2+	1994	0.268	3853	3621	4086	6.0
3+	1993	0.053	763	580	946	24.0

[a]Based on a laboratory sample of scales from 2233 striped bass selected by stratified random sampling from 14,377 fish collected (Use Code = 1 samples only).

TABLE 3-8

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER WINTER 1996-97

STATISTIC	COHORT 1995	COHORT 1994
Age	1+	2+
Total hatchery stocking (N_i)	613,758	306,529
Hatchery recaptures (H_i)	1	1
Adjusted hatchery recaptures (H_{ai})	1[a]	1[b]
Wild fish examined (W_{ai})	8,755	3,852
Estimated hatchery proportion ($H_{ai}/(H_{ai}+W_{ai})$)	0.000114	0.000260
Lower 95% C.I.	0.000003	0.000007
Upper 95% C.I.	0.000636	0.001445

[a]Based on a nondetection rate of 0.00000 for age 1+ hatchery recaptures and a weighted decimal percent 24-hr magnetic tag loss of 0.040 (EA 1996).

[b]Based on a nondetection rate of 0.00000 for age 2+ hatchery recaptures and a weighted decimal percent 24-hr magnetic tag loss of 0.032 (EA 1995).

TABLE 3-9 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1996-97

	COHORT (NUMBER STOCKED)									
STOCK ASSESSMENT PROGRAM YEAR	1995 (613,758)	1994 (306,529)	1993 (568,746)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1986-87										
N								38	51	5
Lower 95% C.I.								0.0110	0.0126	0.0005
Proportion								0.0152	0.0170	0.0014
Upper 95% C.I.								0.0204	0.0225	0.0029
1987-88										
N							25	127	82	4
Lower 95% C.I.							0.0015	0.0137	0.0240	0.0011
Proportion							0.0023	0.0165	0.0311	0.0034
Upper 95% C.I.							0.0033	0.0196	0.0399	0.0081
1988-89										
N						120	39	49	6	0
Lower 95% C.I.						0.0127	0.0014	0.0245	0.0075	0.0000
Proportion						0.0155	0.0020	0.0353	0.0236	0.0056
Upper 95% C.I.						0.0187	0.0027	0.0500	0.0645	0.0514
1989-90										
N					46	92	3			
Lower 95% C.I.					0.0049	0.0034	0.0002			
Proportion					0.0068	0.0043	0.0010			
Upper 95% C.I.					0.0091	0.0054	0.0027			
1990-91										
N					27	24	1			
Lower 95% C.I.					0.0015	0.0012	0.0000			
Proportion					0.0024	0.0020	0.0013			
Upper 95% C.I.					0.0035	0.0031	0.0098			
1991-92										
N					13	4				
Lower 95% C.I.					0.0015	0.0012				
Proportion					0.0032	0.0035				
Upper 95% C.I.					0.0045	0.0048				

TABLE 3-9 (Page 2 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) IN THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1996-97

	COHORT (NUMBER STOCKED)									
STOCK ASSESSMENT PROGRAM YEAR	**1995** (613,758)	**1994** (306,529)	**1993** (568,746)	**1992** (210,746)	**1989** (202,068)	**1988** (48,611)	**1987** (324,579)	**1986** (529,563)	**1985** (284,578)	**1984** (147,153)
1992-93										
N				197	2					
Lower 95% C.I.				0.0020	0.0015					
Proportion				0.0030	0.0020					
Upper 95% C.I.				0.0441	0.0045					
1993-94										
N			23	121	1					
Lower 95% C.I.			0.0014	0.0991	0.0025					
Proportion			0.0020	0.0105	0.0046					
Upper 95% C.I.			0.0036	0.0121	0.0070					
1994-95										
N		54								
Lower 95% C.I.		0.0097								
Proportion		0.0098								
Upper 95% C.I.		0.0099								
1995-96										
N	2	7								
Lower 95% C.I.	0.00008	0.00320								
Proportion	0.00069	0.00080								
Upper 95% C.I.	0.00250	0.00164								
1996-97										
N	1	1								
Lower 95% C.I.	0.000003	0.00007								
Proportion	0.000114	0.00026								
Upper 95% C.I.	0.000636	0.001445								

TABLE 3-10 (Page 1 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1996-97, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH[a]

	COHORT (NUMBER STOCKED)									
STOCK ASSEMENT PROGRAM YEAR	**1995** (613,758)	**1994** (306,529)	**1993** (568,410)	**1992** (210,746)	**1989** (202,068)	**1988** (48,611)	**1987** (324,579)	**1986** (529,563)	**1985** (284,578)	**1984** (147,153)
1986-87										
N								38	51	5
Lower 95% C.I.								0.0126	0.0286	0.0038
Estimate								0.0171	0.0353	0.0058
Upper 95% C.I.								0.0226	0.0432	0.0084
1987-88										
N							25	127	82	4
Lower 95% C.I.							0.0031	0.0158	0.0526	0.0080
Estimate							0.0042	0.0187	0.0634	0.0135
Upper 95% C.I.							0.0055	0.0220	0.0076	0.0218
1988-89										
N						120	39	49	4	0
Lower 95% C.I.						0.1541	0.0030	0.0282	0.0221	0.0043
Estimate						0.1630	0.0038	0.0398	0.0493	0.0222
Upper 95% C.I.						0.1723	0.0048	0.0554	0.1062	0.0913
1989-90										
N					46	92	3			
Lower 95% C.I.					0.0165	0.0477	0.0006			
Estimate					0.0198	0.0509	0.0017			
Upper 95% C.I.					0.1723	0.0543	0.0037			
1990-91										
N					27	24	1			
Lower 95% C.I.					0.0055	0.0211	0.0002			
Estimate					0.0070	0.0243	0.0026			
Upper 95% C.I.					0.0088	0.0279	0.0127			
1991-92										
N					13	4				
Lower 95% C.I.					0.0091	0.0397				
Estimate					0.0095	0.0411				
Upper 95% C.I.					0.0099	0.0430				

TABLE 3-10 (Page 2 of 2)

ESTIMATED PROPORTION OF HATCHERY STRIPED BASS BY COHORT (AND NUMBER OF RECAPTURED HATCHERY FISH) AMONG THE POPULATION OF STRIPED BASS CAPTURED BY TRAWLS IN THE HUDSON RIVER DURING THE WINTERS OF 1986-87 THROUGH 1996-97, SCALED UP TO A TARGET RELEASE OF 600,000 HATCHERY FISH[a]

	COHORT (NUMBER STOCKED)									
STOCK ASSEMENT PROGRAM YEAR	1995 (613,758)	1994 (306,529)	1993 (568,410)	1992 (210,746)	1989 (202,068)	1988 (48,611)	1987 (324,579)	1986 (529,563)	1985 (284,578)	1984 (147,153)
1992-93										
N				197	2					
Lower 95% C.I.				0.0710	0.0041					
Estimate				0.0808	0.0059					
Upper 95% C.I.				0.0919	0.0072					
1993-94										
N			23	121	1					
Lower 95% C.I.			0.0009	0.0309	0.0088					
Estimate			0.0021	0.0294	0.0136					
Upper 95% C.I.			0.0037	0.0289	0.0165					
1994-95										
N		56								
Lower 95% C.I.		0.0188								
Estimate		0.0189								
Upper 95% C.I.		0.0191								
1995-96										
N	2	7								
Lower 95% C.I.	0.00008	0.00063								
Estimate	0.00069[b]	0.00156								
Upper 95% C.I.	0.00250	0.00322								
1996-97										
N	1	1								
Lower 95% C.I.	0.000003	0.00026								
Estimate	0.00011[b]	0.00050								
Upper 95% C.I.	0.000636	0.00146								

[a]Estimated hatchery proporation scaled up to the proportion expected if 600,000 hatchery striped bass were stocked in each year, using Equation 13, the factors in Table 2-1, and the following formula: $[H_{ai} \times 600{,}000/N_i] / [(H_{ai} \times 600{,}000/N_i) + W_i]$.
[b]Estimated hatchery proportion not adjusted. Number of hatchery striped bass stocked surpassed target release of 600,000 fish.

3.4 CHARACTERIZATION OF RECAPTURED STRIPED BASS

During the 1996-97 program, recaptures were made of six hatchery striped bass tagged with a CWT and 162 wild striped bass individually tagged with internal anchor-external streamer tags (internal anchor tags) inserted into the body cavity through the abdominal musculature. All striped bass caught in the trawls were examined in the field with a magnetic tag detector to identify fish suspected to be of hatchery origin. Suspected hatchery fish were returned to verify the presence of a CWT and to determine the hatchery cohort (stocking year) by reading the tag code. All striped bass were examined in the field for the presence of internal anchor tags or tag wounds at the insertion site. Internal anchor tag numbers for recaptured fish were recorded in the field and used to link recapture data with release data.

3.4.1 Hatchery-Tagged Striped Bass

During the 1996-97 winter sampling program, one Age 1+ (1995 cohort) and one Age 2+ (1994 cohort) hatchery striped bass were caught. The 1990 and 1991 cohorts of hatchery striped bass were not tagged. The 1995 cohort was the last year striped bass were stocked from the Verplank hatchery.

3.4.1.1 ***Length.*** A total of 613,758 hatchery striped bass were tagged with magnetic tags and stocked to the Hudson River between 31 July and 21 September 1995. The length of the one recapture from the 1995 cohort of hatchery fish was 247 mm (Table 3-11). The mean length of the 1995 cohort of wild fish was 260 mm. No comparison between lengths of hatchery and wild striped bass from the 1995 or 1994 cohorts was made due to the small sample size of hatchery fish.

The 1989 hatchery cohort was tagged prior to stocking. Two separate groups of fish were stocked in 1989: 179,219 fish were stocked in August 1989 (summer-stocked); and 21,196 were stocked in October (fall-stocked). The fall-stocked fish were significantly larger than the summer stocked fish at the time of stocking. When recaptured at Ages 0+ and 1+, the 1989 hatchery cohort (summer and fall-stocked fish combined) was significantly larger than wild fish, fall-stocked fish were significantly larger than summer-stocked fish, and fall-stocked fish were preferentially recaptured compared to summer-stocked fish (NAI 1992). The larger size and preferential recapture of fall-stocked hatchery fish at Age 0+ and 1+ were attributed to either differential survival or differential behavior of the stocking groups. The 1989 hatchery cohort at Age 2+ was

TABLE 3-11

COMPARISON OF MEAN LENGTH AT AGE FOR AGE 0+ WILD AND HATCHERY STRIPED BASS COLLECTED 9-m TRAWL IN THE HUDSON RIVER WINTER 1996-97

		WILD				HATCHERY			
AGE	COHORT	N	STRATIFIED MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.	N	MEAN (mm)	LOWER 95% C.I.	UPPER 95% C.I.
1+	1995	1410	260	258	263	1	247		
2+	1994	686	306	302	310	1	262		
3+	1993	82	334	320	348				

significantly smaller than the wild cohort (Table 3-12). However, similar to Ages 0+ and 1+, fall-stocked fish were preferentially recaptured as they accounted for 79% (11/14) of the hatchery recaptures of these cohorts but only 11% of the fish stocked. Too few members of the 1989 hatchery cohort (two) were recaptured at Age 3+ to make significant comparisons with the 1989 wild cohort. However, both of the 1989 hatchery fish were from the fall-stocked group, and no members of the more numerous summer-stocked group were recaptured (Table 3-12).

No members of the 1988 or earlier hatchery cohorts were recaptured. Comparisons between estimated mean lengths between the hatchery and wild cohorts for the 1988 and previous year classes are found in NAI (1992) and Table 3-13.

3.4.1.2 ***Magnetic Tag Detection Efficiency.*** During the 1996-97 program, 13,636 striped bass were examined using the field magnetic tag detectors. Of these fish, six were classified as suspected Hudson River hatchery striped bass. Two striped bass were verified as having CWTs from the Verplanck hatchery (Appendix Table D-1). Fish hooks were the primary reason for false positive detection of CWT in suspected hatchery recaptures from previous programs (Mattson et al. 1990). Fish hooks were found in three of the four false-positives detected in this program.

Striped bass caught during the 1996-97 program were double-checked for CWTs with two V-shaped detectors. Striped bass that did not elicit a response from the first tag detector were checked again with a second detector. Two magnetic tag detectors were used on all sampling days. Of two verified hatchery fish found no fish escaped detection with the first or second magnetic tag detector. A nondetection rate 0.0000 was applied to the Age 1+, Age 2+ and Age 3+ verified hatchery recaptures.

The weighted hatchery striped bass nondetection rate of 0.0000 for 1996-97 was the fourth time that the magnetic tag detection efficiency (nondetection rate) reached this level. The 1987-88, 1994-95, and 1995-96 programs were the only other programs to acheive a nondetection rate of 0.0000 (Table 3-14). The nondetection rate for 1993-94 was comparatively high at 0.005, the fifth highest value observed since the program began. The nondetection rates of 0.0459 for 1991-92 and 0.0237 in 1986-87 were comparable to the 1992-93 rate. Between 1987-88 and 1991-92, the nondetection rate varied between 0.0000 and 0.0005, about two orders of magnitude better in detection efficiency than in 1986-87 or 1991-92. The nondetection statistic does not take into account the large number of fish monitored and, as a ratio, is most sensitive to small numbers of

TABLE 3-12

MEAN LENGTH AND RECOVERY PROPORTIONS FOR 1988 AND 1989 HATCHERY STRIPED BASS STOCKED INTO THE HUDSON RIVER AND RECOVERED DURING THE STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM WINTERS OF 1988-89 THROUGH 1996-97

		RECAPTURE FOR HATCHERY STRIPED BASS AT AGE											
		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
HATCHERY COHORT	STOCKING GROUP	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)	NUMBER (H_1)	MEAN LENGTH (mm)	RECOVERY PROPORTION (H_1/H_2)
1988	Attleboro Fall[1]	9	97	0.00089	6	187	0.00060	4	221	0.00040	0	-	0.00000
	Verplanck Fall[2]	111	137	0.00288	86	221	0.00223	20	327	0.00052	4	380	0.00010
1989	Verplanck Summer[3]	13	124	0.00007	5	215	0.00003	2	330	0.00001	0	-	0.00000
	Verplanck Fall[4]	33	143	0.00156	22	252	0.00104	11	300	0.00052	2	423	0.00009

[1]1988 Attleboro fall number stocked (H_2) = 10,057 at 80- to 84-mm model length class.

[2]1988 Verplanck fall number stocked (H_2) = 38,554 at 139-mm mean length.

[3]1989 Verplanck summer number stocked (H_2) = 179,219 at 105-mm mean length.

[4]1989 Verplanck fall number stocked (H_2) = 21,196 at 152-mm mean length.

TABLE 3-13 (Page 1 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1996 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1984	Hatchery							3[c]	275	37.5	2[c]	349	31.5
	Wild							359	299	3.1	273	368	3.9
1985	Hatchery				26	205*	3.8	58	286	41.4	6	364	15.9
	Wild				285	221*	3.0	574	317	2.6	57	396	9.2
1986	Hatchery	22	107*	3.8	96	220*	2.7	48	315	5.2	–		
	Wild	83	128*	2.9	1503	253*	1.2	361	324	3.5	55	382	10.1
1987	Hatchery	20	108	6.2	39	209*	5.2	3[c]	290	16.0	–	350	
	Wild	190	108	2.1	3623	227*	0.8	1216	298	1.5	69	381	10.4
1988	Hatchery	120	133*	1.7	92	219	3.7	24	311	9.9	4[c]	380	18.8
	Wild	1007	121*	2.0	3514	214	0.7	2109	321	1.8	156	386	6.2
1989	Hatchery	46	138*	2.0	27	245	7.8	13	305	12.3	2[c]	423	46.0
	Wild	368	112*	1.6	2174	239	0.9	961	324	2.3	125	414	7.2
1990[d]	Hatchery	–			–			–			–		
	Wild	206	119	1.5	3675	245	0.6	1378	329	1.9	152	424	89.9
1991[d]	Hatchery	–			–			–			–		
	Wild	818	131	1.9	3899	231	0.8	1631	317	5.5	99	356	5.5

TABLE 3-13 (Page 2 of 2)

MEAN LENGTH AT AGE[a] FOR THE 1984 THROUGH 1996 HATCHERY AND WILD[b] STRIPED BASS COHORTS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER

		AGE 0+			AGE 1+			AGE 2+			AGE 3+		
COHORT	ORIGIN	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR	n	MEAN LENGTH (mm)	STANDARD ERROR
1992	Hatchery	188	127	0.9	112	220*	2.8	—					
	Wild	473	116	1.0	2695	237*	0.5	455	312	1.9			
1993	Hatchery	21	128	3.6	—								
	Wild	828	123	1.0	1216	260	1.1						
1994	Hatchery	54	127*	1.7									
	Wild	219	104*	0.7									
1995	Hatchery	2[c]	123	19.5	7	216*	3.8						
	Wild	143	128	1.4	839	251*	1.4						
1996	Hatchery				1[c]	247		1[c]	262				
	Wild				1410	260		686	306		82	334	

*Indicates a significant difference in mean length between the hatchery and wild cohorts within an age class. Nonoverlapping confidence intervals of mean lengths of hatchery and wild fish were used to indicat significance.

[a]Simple mean length at age for hatchery striped bass and stratified mean length at age for wild striped bass.

[b]A t statistic of 2.00 was used to calculate the confidence intervals about the stratified means of wild fish prior to 1994.

[c]Comparison of mean length at age between hatchery and wild striped bass was not conducted due to small sample size for hatchery striped bass.

[d]The mean length reported for the 1990 and 1991 wild cohorts of striped bass represents hatchery and wild fish combined because hatchery fish were not tagged prior to stocking and therefore could not be distinguished from wild fish.

TABLE 3-14

MAGNETIC TAG DETECTION EFFICIENCY OBSERVED FOR HUDSON RIVER HATCHERY STRIPED BASS DURING THE 1986-87 THROUGH 1996-97 WINTER PROGRAMS

PROGRAM	DETECTOR TYPE		TOTAL NUMBER OF FISH			HATCHERY-TAGGED FISH DETECTED BY			NON-DETECTION RATE [a]
	PRIMARY	SECONDARY	MONITORED BY PRIMARY DETECTOR	MONITORED BY BOTH DETECTORS	VERIFIED RECAPTURES	PRIMARY	PRIMARY AND SECONDARY	MISSED BY PRIMARY	
1986-87	V-shaped	Tube	13,136	2,138	94	13	15	2	0.0237
1987-88	V-shaped	Tube	28,192	1,611	238	11	11	0	0.0000
1988-89	V-shaped	Tube/V-shaped[b]	32,975	8,164[b]	213	51	52	1	0.0004
1989-90	V-shaped	V-shaped	33,386	33,386	141	138	141	3	0.0005
1990-91	V-shaped	V-shaped	29,346	29,346	52	51	52	1	0.0004
1991-92	V-shaped	V-shaped	35,072	35,072	17	14	17	3	0.0459
1992-93	V-shaped	V-shaped	29,607	28,813	190	139	149	10	0.0138[c]
1993-94	V-shaped	V-shaped	30,093	25,740	134	103	110	7	0.0046
1994-95	V-shaped	V-shaped	12,657	12,657	54	54	54	0	0.0000
1995-96	V-shaped	V-shaped	13,636	13,636	9	9	9	0	0.0000
1996-97	V-shaped	V-shaped	14,380	14,380	2	2	2	0	0.0000

[a]Nondetection rate = $[D_2/(H-D_2)]^2$, where D_2 is the number of fish not detected by the first detector and detected by the second detector and H is the total number of verified hatchery fish detected when both detectors were used.

[b]3,368 fish on randomly selected days between 31 October 1988 and 13 March 1989 were first monitored with a V-shaped field detector and then with a tube-shaped detector. The tube-shaped detector became inoperable on 20 March 1989, and 4,796 fish representing the entire catch were monitored with both a primary and secondary V-shaped field detector until the end of field sampling on 15 April 1989.

[c]One tag detector became inoperable during the week of 29 March 1993; 10 hatchery fish were missed by this detector when two detectors were used. An additional 794 fish were checked with only one tag detector and 41 Age 0+ hatchery fish were detected on that week. We applied a nondetector rate of 0.00000 to 82 hatchery recaptures prior to 29 March 1993 and a nondetection rate of 0.03078 for 67 hatchery recaptures on and after 29 March 1993. This value represents the weighted nondetection rate.

verified hatchery fish examined. Historically, it appeared that when all the fish are checked with two detectors, as in 1989-90 through 1993-94, between one and three fish escape detection by the first detector unless specific operational problems occur (as in 1992-93 or 1993-94). In 1994-95, 1995-96 and 1996-97, however, no fish were missed by the primary detector (Table 3-14).

3.4.2 Internal Anchor-Tagged Striped Bass

During the 1996-97 winter sampling program, 125 striped bass were recaptured out of 12,794 fish that were caught, tagged with internal anchor tags, and released in good condition. A total of 37 striped bass with internal anchor tags implanted during previous programs were recaptured during the 1996-97 winter sampling program. Seven striped bass were recaptured with tags from other tagging studies. No striped bass were recaptured with suspected tag wounds. These groups of wild striped bass are described below in separate sections. A complete description of the number of fish caught tagged with different types of internal anchor-external streamer tags since 1984 and the associated reward values printed on the external streamers is presented in Appendix Tables D-8 and D-9. Only internal anchor tags were used during the 1996-97 program.

3.4.2.1 ***Striped Bass Internal Anchor-Tagged, Released, and Recaptured During the 1996- 97 Winter Program.*** The majority (11,203, or 88%) of the taggable-size (≥150 mm) striped bass (12,794) were caught in the Battery region, as were 113, or 90%, of the 125 fish tagged, released, and recaptured during this study (Table 3-15; Appendix Table D-2). This is not surprising as most (87%) of the trawl sampling effort was allocated to the Battery during 1996-97, based on the high CPUE in this region during the current and previous programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1996b, 1995).

Recapture rates and recapture proportions can be used to examine the recapture of fish among different space or time frames. Recapture rates from the column totals in Table 3-15 compare the number of fish recaptured throughout the program (recaptured any time on or after the release date) to the number of fish released in a particular region or time period. Recapture rates from the row totals in Table 3-15 compare the number of fish recaptured in a region or time period to the number marked throughout the program. For example, in Table 3-15 the recapture rate for striped bass tagged, released, and recaptured in the Upper Harbor (cell total) was 12/1591 or 0.00754. The recapture rate for striped bass tagged and released in the Upper Harbor and recaptured throughout the study area (column total) was 23/1591, or 0.01446.

TABLE 3-15

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE REGION IN THE HUDSON RIVER WINTER 1996-97

			NUMBER OF RECAPTURES FROM RELEASE REGION[a]		
RECAPTURE REGION	NUMBER CAUGHT (C)	STATISTIC	UPPER HARBOR M = 1591	BATTERY M = 11,203	TOTAL M = 12,794
Upper Harbor	1657	R	12	0	12
		R/M	0.00754	0.00000	0.00094
		R/C	0.00724	0.00000	0.00724
Battery	11,841	R	11	102	113
		R/M	0.00691	0.00910	0.00883
		R/C	0.00093	0.00861	0.00954
Total	13,498	R	23	102	125
		R/M	0.01446	0.00910	0.00977
		R/C	0.00170	0.00756	0.00926

[a]Excluding recaptures from previous sampling seasons.

LEGEND:
R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

In contrast, recapture proportions from column totals compare the number of fish released in a particular region or month to the number examined for tags throughout the program, while recapture proportions from the row totals compare the number of fish recaptured in a particular region or month (regardless of origin) to the number of fish caught and examined for tags in that region or month. For example, in Table 3-15 the recapture proportion for striped bass tagged, released, and recaptured in the Battery among all fish examined for tags in the Battery (cell total) was 102/11,841, or 0.00861.

Examination of monthly recapture rates and recapture proportions can provide insight into the movements of marked striped bass during the study period. Recapture rates that are stable with time (Schaefer 1951) and recapture proportions that increase with time suggest little movement of the marked population (Cormack 1968). Striped bass monthly recapture rates (Table 3-16 column totals) increased from December 1996 through January 1997 and decreased in March and April 1997. Monthly recapture proportions (R/C row totals) increased from November 1996 through March 1997, but decreased in April 1997. A decrease in recapture proportion and recapture rate in April is likely due to the fewer number of samples taken (only one week of sampling was conducted in April 1997). Overall, recapture rates and proportions suggest little movement of the striped bass population in the lower Hudson River.

Striped bass tagged and released in the combined Battery and Upper New York Harbor regions and subsequently recaptured in those regions were at large an average of 26 days and ranged in size between 168 and 418 mm (Table 3-17). Approximately 20% (25/125) of the striped bass were recaptured on the same day as they were tagged and released, and 66% (82/125) of the fish were recaptured within 30 days of release (Table 3-17), suggesting most fish had remained in the contiguous region for at least a month after they were tagged and released. Within three months (90 days), 94% (118/125) of the striped bass were recaptured, and the maximum number of days at large was 120. Days at large and recapture length data for the 1996-97 program were similar to previous years (NAI 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995, 1996b).

3.4.2.2 ***Striped Bass Internal Anchor-Tagged and Released Prior to and Recaptured During the 1996-97 Winter Program.*** A total of 37 striped bass were recaptured during 1996-97 with internal anchor tags identified from previous programs (Appendix Table D-3). All recaptured striped bass had the external portion of the tag (streamer) present. All tag numbers among recaptures from previous programs were completely legible (Table 3-18).

TABLE 3-16

RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE MONTH FOR FISH RELEASED AND RECAPTURED BY TRAWLS IN THE COMBINED UPPER NEW YORK HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1996-97

			NUMBER OF RECAPTURES FROM RELEASE MONTH*						
RECAPTURE MONTH	NUMBER CAUGHT (C)	STATISTIC	NOV M = 925	DEC M = 1562	JAN M = 2796	FEB M = 3411	MAR M = 3878	APR M = 222	TOTAL M = 12,794
NOVEMBER	951	R	10						10
		R/M	0.01081						0.00078
		R/C	0.01052						0.01052
DECEMBER	1624	R	4	6					10
		R/M	0.00432	0.00384					0.00078
		R/C	0.00246	0.00369					0.00616
JANUARY	2996	R	2	5	11				18
		R/M	0.00216	0.00320	0.00393				0.00141
		R/C	0.00067	0.00167	0.00367				0.00601
FEBRUARY	3593	R	4	1	8	13			26
		R/M	0.00432	0.00064	0.00286	0.00381			0.00203
		R/C	0.00111	0.00028	0.00223	0.00362			0.00724
MARCH	4090	R	0	4	17	14	22		57
		R/M	0.00000	0.00256	0.00608	0.00410	0.00567		0.00446
		R/C	0.00000	0.00098	0.00416	0.00342	0.00538		0.01394
APRIL	244	R	0	1	0	1	1	1	4
		R/M	0.00000	0.00064	0.00000	0.00029	0.00026	0.00450	0.00031
		R/C	0.00000	0.00410	0.00000	0.00410	0.00410	0.00410	0.01639
TOTAL	13,498	R	20	17	36	28	23	1	125
		R/M	0.02162	0.01088	0.01288	0.00850	0.00593	0.00450	0.00977
		R/C	0.00148	0.00126	0.00267	0.00207	0.00170	0.00007	0.00926

*Excluding recaptures from previous sampling seasons.

LEGEND: R = number of striped bass recaptured.
M = number of striped bass ≥150 mm marked and released.
C = number of striped bass ≥150 mm caught and examined for tags.
R/M = recapture rate.
R/C = recapture proportion.

TABLE 3-17

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED, RELEASED, AND RECAPTURED IN THE HUDSON RIVER BY A 9-m TRAWL
WINTER 1996-97

	STATISTIC	NUMBER OF STRIPED BASS
Number tagged (≥150 mm)	M	12,794
Number examined for tags (≥150 mm)	C	13,498
Number recaptures	R	125
Size range of recaptured fish (mm)	Min	168
	Max	418
	Mean	264
	S.D.	53
Days at large	Min	0
	Max	120
	Mean	26
	S.D.	29
Frequency of days at large	0 days	25
	1-5 days	14
	6-10 days	12
	11-20 days	19
	21-30 days	12
	31-40 days	12
	41-50 days	9
	51-60 days	6
	61-70 days	6
	71-80 days	1
	81-90 days	2
	91-100 days	2
	101-110 days	3
	111-120 days	2

TABLE 3-18

INCIDENCE OF TAG ABRASION AND CONDITION OF THE TAG INSERTION SITE FOR HUDSON RIVER STRIPED BASS THAT WERE AT LARGE AT LEAST ONE YEAR PRIOR TO THEIR RECAPTURE DURING THE 1988-89 THROUGH 1996-97 PROGRAMS

DESCRIPTION	CONDITION OF TAG INSERTION	NUMBER OF FISH RECAPTURED DURING PROGRAM[a]								
		1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97
Tag number completely legible	Healed	34	63	206	102	130	117	27	4	37
	Infected	13	6	22	15	17	12	2	1	0
	Total	47	69	228	117	147	129	29	5	37
	(Anchor protruding)	(5)	(0)	(6)	(1)		(0)	(0)	(0)	(0)
Tag number abraded but legible	Healed	3	2	2	0	1	0	0	1	0
	Infected	3	1	0	1	0	0	0	0	0
	Total	6	3	2	1	1	0	0	1	0
	(Anchor protruding)	(1)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Tag number partly or completely missing and not legible	Healed	0	0	1	2	0	0	1	0	0
	Infected	0	0	0	0	0	0	0	0	0
	Total	0	0	1	2	0	0	1	0	0
	(Anchor protruding)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Suspected tag wound, tag and anchor missing	Healed	4	6	69	43	57	28	0	0	0
	Infected	0	9	3	4	7	3	0	0	0
	Total	4	6	72	47	64	31	0	0	0
Suspected tag wound, anchor present	Healed	2	0	9	10	12	18	0	0	0
	Infected	0	0	0	0	3	0	0	0	0
	Total	2	0	9	10	15	18	0	0	0

[a]Striped bass that were tagged and released prior to the program that could by cross-classified by degree of tag number abrasion and condition of the tag insertion site.

Tag numbers were defined as completely illegible if one or more of the five-digit tag numbers could not be read in the field. Tag abrasion, first observed during 1986-87, is time dependent; the tagged fish must be at large for at least six months for abrasion to affect the legibility of the legend on the external streamer (Mattson et al. 1990). In previous programs illegible tags were observed on 12-20% of the recaptured striped bass judged to have been at large at least one year, and 20-30% exhibited some degree of tag number abrasion (NAI 1987, 1988, and 1990). Changes in tag design since 1986-87 have virtually eliminated tag abrasion.

Prior to the 1986-87 program, Floy internal anchor-external streamer tags were used; abrasion was observed in 28% of the recaptured fish at large for at least six months (Mattson et al. 1990). During the 1986-87 program, Floy internal anchor tags were first used with a clear, PVC tube over the external streamer to protect the legend from abrasion. Unfortunately, this tubing could not be sealed watertight and algal or bacterial growth proliferated between the clear tube and legend, making most of the external streamer legends unreadable. These tubing-type tags also had the number printed on the anchor, so the release information could be determined by sacrificing the fish and extracting the internal anchor.

Hallprint internal anchor tags were first used in 1987-88. These tags have the legend sealed between layers of polyethylene on the external streamer, which is bonded to a monofilament core. The streamer was angled so that its distal end is posterior to the tag site. A similar but shorter length of streamer containing the tag number is used for the anchor (Figure 2-2). The external streamer on the Hallprint tag has exhibited no abrasion or information loss due to abrasion. However, the streamer had an exposed section of monofilament core at the site of tag anchor insertion. A longitudinal scar at the tag wound site was observed frequently during early 1988-89 from fish tagged and released during 1987-88 with the exposed filament Hallprint tag (NAI 1990). Apparently, as continuous force was applied to the tag during swimming, the monofilament strand cut through the ventral body wall of the fish, forming a longitudinal scar from the tag insertion site to the end of the abdominal cavity at the vent. When the tag reached the end of the abdominal cavity, it was shed from the fish.

The Hallprint tag was modified in 1989 so that there was no exposed monofilament core. This modified extended-streamer Hallprint tag appears to have significantly reduced or eliminated the tag shedding problem. In 1988-89, 13/26 fish recaptured with a wound at the insertion site exhibited a longitudinal scar and an additional 9/68 of the fish recaptured with a tag exhibited posterior displacement and a longitudinal scar. The 1988-89 data suggested a long-term shedding rate of 22/94, or 23%, for the original Hallprint tag with an exposed filament. Among the 67 fish with suspected tag wounds (and no anchor found) caught during the 1992-93 program, 45 fish had a longitudinal scar, suggesting they may have shed a tag, and 22 fish had wounds that were judged to be not related to tagging. None of the fish recaptured with the modified Hallprint tag exhibited any posterior displacement of the tag or longitudinal scarring, either within the program or from previous years. Changing to the Hallprint tag in 1987-88 has virtually eliminated the problem of lost streamer information due to tag abrasion, and the change to the modified Hallprint tag with extended streamer in 1988-89 has reduced tag loss due to shedding.

Of the 37 striped bass recaptured from previous programs during 1996-97, two had been tagged and released during 1993-94, five had been tagged and released during 1994-95, and 30 had been tagged and released during 1995-96 (Table 3-19; Appendix Table D-3). All recaptured fish from the 1993-94 through 1995-96 programs were caught, tagged, and released from the 9-m trawl, which was the only gear used. Recaptured fish were at large between 201 and 1143 days and ranged in length between 231 and 458 mm (Table 3-20). No striped bass were recaptured with both an internal anchor tag and a dart tag during 1996-97, and no striped bass were observed to have shed a dart tag.

Seven striped bass were recaptured in 1996-97 with tags originating from other tagging programs (Table 3-21). Three fish were recaptured with a U.S. Fish and Wildlife Service internal anchor tag and four fish were recaptured with a Littoral Society spaghetti tag.

3.4.2.3 ***Effects of the Internal Anchor Tag on Striped Bass Growth.*** During previous programs, growth based on focus, to annulus (radius) measurements for scale samples from tagged striped bass that had been at large one or two years was compared within cohort to growth from a corresponding set of scales taken from untagged fish of the same cohort at the time the tagged fish were recaptured (untagged fish). The null hypothesis was that the measured radius for the same cohort and annulus was not significantly different between tagged and untagged fish. Scale radius measurements were selected rather than actual fish measurement because the annulus represents a common period in time for fish of the same age. The use of fish length may introduce field measurement error and added variation due to growth during the period between tagging and formation of the next annulus.

TABLE 3-19

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED IN YEARS PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1996-97

RELEASE YEAR	RELEASE GEAR	NUMBER RELEASED (M)	NUMBER RECAPTURED (R)	RECAPTURE RATE (R/M)	LENGTH OF RECAPTURED FISH (mm)			
					MIN	MAX	MEAN	S.D.
1995-96	9-m trawl	10,889	30	0.00276	231	458	311	57
1994-95	9-m trawl	6838	5	0.00073	269	447	377	66
1993-94	9-m trawl	17,500	2	0.00011	354	428	391	52

TABLE 3-20

RECAPTURE STATISTICS FOR STRIPED BASS TAGGED AND RELEASED BY GEAR PRIOR TO AND RECAPTURED IN THE HUDSON RIVER WINTER 1996-97

	STATISTIC	9-m TRAWL
Total number tagged	M	168,421[a]
Number Age 2+ or older examined for tags	C	4735
Number recaptured	R	37
Recapture rate	R/M	0.00022
Recapture proportion	R/C	0.00781
Length of recaptured fish (mm)	Min	231
	Max	458
	Mean	325
	S.D.	63
Days at large	Min	201
	Max	1143
	Mean	438
	S.D.	216
Frequency of days at large	201-250 days	3
	251-300 days	5
	301-350 days	8
	351-400 days	6
	401-450 days	5
	451-500 days	3
	501-550 days	0
	551-600 days	0
	601-650 days	1
	651-700 days	1
	701-750 days	2
	751-800 days	0
	801-850 days	1
	1001-1050 days	1
	1051-1100 days	0
	1101-1150 days	1

[a]Contains fish tagged and released in the 1985-1986, 1986-87, 1987-88, 1988-89, 1989-90, 1990-91, 1991-92, 1992-93, 1993-94, 1994-95, and 1995-96 programs.

TABLE 3-21

STRIPED BASS RECAPTURED IN THE HUDSON RIVER WITH OTHER AGENCY TAGS
WINTER 1996-97

		TAG CONDITION						RECAPTURE		
AGENCY	TAG NUMBER	SITE	NUMBER	ADDRESS	REWARD	ORIENTATION	ANCHOR PROTRUSION	DATE	RIVER MILE	LENGTH
Littoral Society	3061	1	4	4	4	2	2	09 Jan 97	2	406
Littoral Society	377278	1	4	4	4	2	2	28 Jan 97	10	464
Littoral Society	314220	1	4	4	4	2	2	28 Jan 97	10	457
Littoral Society	412797	1	4	4	4	2	2	26 Feb 97	10	331
USF&W	310389	1	4	4	4	2	2	28 Feb 97	10	275
Littoral Society	396445	1	4	4	4	2	2	17 Mar 97	10	429
USF&W	170311	1	4	4	4	2	2	04 Dec 96	-2	270

TAG VARIABLE	COMMENT DESCRIPTION
Number Address Reward	1 = legend completely missing 2 = abraded and partly missing 3 = abraded but completely legible 4 = completely legible
Number orientation	1 = tag number facing anterior (head) 2 = tag number facing posterior (tail)
Anchor protrusion	1 = yes 2 = no

TAG SITE

1 = tag present, wound healed
2 = tag present, wound poorly healed, evidence of infection or swelling

Mean radius measurements for each annulus were obtained from the 1985 through 1991 cohorts of striped bass recaptured during the 1988-89 through 1993-94 programs (Table 3-22). No radius measurements were obtained from striped bass recaptures during the 1994-95, 1995-96, or 1996-97 programs. A complementary set of scale samples was selected from the time of release for each cohort of fish caught in the samples providing the recaptured fish to represent untagged fish (fish of the same cohort that had grown between annulus X and annulus X + 1 without a tag present). This approach avoids the influence of Lee's phenomenon (Ricker 1975; Gutreuter 1987; Smale and Tayler 1987) by blocking the data within the same cohort and annulus. Relative growth was calculated as the response variable by taking the difference between annulus measurements for the time of release and recapture and dividing by the annulus measurement for the time of release. This relative growth measurement accounts for variation in the size of scales taken for the release and recapture samples.

Tagged striped bass from the 1985 through 1990 cohorts that were at large for one or two years exhibited similar growth compared to untagged fish of the same cohort, based on one-way analysis of variance (ANOVA) comparisons of mean relative growth (Table 3-22). A significant difference was observed between the mean scale radius for tagged and untagged striped bass of the 1991 cohort. Fish that were tagged and released in 1992-93 at Age 1+ were significantly larger than untagged fish of the same cohort in 1993-94 after being at-large for one year. As both the tagged and untagged fish came from the same gear at both the time of original release and at the time of recapture, a sampling bias is unlikely. Therefore, we have no evidence that striped bass tagged with Hallprint internal anchor tags exhibit differential growth during one or two years at large.

3.4.3 Condition of the Catch

Occasionally, striped bass caught in the 9-m trawl displayed one or more types of injury or abnormality such as blindness, fin rot, fungal infection, skeletal deformity, or visible wounds. During the 1996-97 program, blindness, fin rot, stress, and fungus were observed among collected fish (Table 3-23). The incidence of injuries or anomalies was most prevalent among striped bass not tagged, with 26.0% of fish examined in poor condition (312 of 1200). The most frequently observed condition among untagged fish was stress, accounting for 8.4% of fish in poor condition. Other conditions (e.g., body wounds, fin damage) and the combination of fungus and finrot also made up for a large portion of the striped bass identified as in poor condition, accounting for 8.2 and 5.6%, respectively.

TABLE 3-22

ONE-WAY ANOVA OF MEAN SCALE RADIUS MEASUREMENTS FOR TAGGED HUDSON RIVER STRIPED BASS AT LARGE ONE OR TWO YEARS COMPARED TO UNTAGGED FISH OF THE SAME COHORT AND AGE 1988-89 THROUGH 1992-93 PROGRAMS

RECAPTURE PROGRAM	COHORT	RECAPTURE AGE	YEARS AT LARGE	TAG STATUS	N	SCALE SAMPLE MEASUREMENT MEAN RADIUS	S.E.	Prf[a]
1988-89	1985	3+	1	Tagged	14	151.7	5.5	0.9015
			0	Untagged	48	147.6	3.0	
1988-89	1986	2+	1	Tagged	24	124.2	3.9	0.2580
			0	Untagged	326	108.6	1.1	
1989-90	1987	2+	1	Tagged	51	101.3	2.5	0.6096
			0	Untagged	1138	101.2	0.5	
1990-91	1987	3+	1	Tagged	21	152.3	5.0	0.1987
			2	Tagged	14	152.9	6.3	0.1023
			0	Untagged	53	143.4	3.2	
1991-92	1988	2+	1	Tagged	161	103.6	1.3	0.1435
			0	Untagged	1844	97.0	0.4	
1991-92	1988	3+	1	Tagged	34	148.3	2.1	0.7432
			2	Tagged	18	144.1	5.4	
			0	Untagged	110	143.6	2.2	
1991-92	1989	2+	1	Tagged	45	114.4	2.7	0.2203
			0	Untagged	829	103.8	0.6	
1992-93	1989	3+	2	Tagged	18	145.7	6.1	0.0986
			1	Tagged	8	165.0	10.6	0.3650
			0	Untagged	90	156.5	2.6	
1992-93	1990	2+	1	Tagged	72	117.5	2.2	0.11817
			0	Untagged	1263	114.5	0.5	
1993-94	1990	3+	2	Tagged	16	160.1	5.2	0.9511
			1	Tagged	20	164.3	6.7	0.5252
			0	Untagged	110	159.6	2.9	
1993-94	1991	2+	1	Tagged	87	118.7	2.3	0.0001
			0	Untagged	1487	103.9	0.5	

[a]Probability of finding that the mean relative growth is different by chance alone, under a least-squares means test of the null hypothesis that the mean scale radius for tagged and untagged fish are equal. A Pr>f of 0.05 or less is considered significant.

TABLE 3-23

INCIDENCE OF FISH IN POOR CONDITION AMONG UNMARKED vs RECAPTURED STRIPED BASS CAPTURED BY A 9-m TRAWL IN THE HUDSON RIVER WINTER 1996-97

TYPE(S) OF INJURY OR ABNORMALITY[a]	INCIDENCE AMONG 1,200 UNMARKED FISH[b]		INCIDENCE AMONG 13,011 FISH TAGGED		INCIDENCE AMONG RECAPTURED 163 FISH[c]	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Blind Only	2	0.16	109	0.84		
Stress Only	101	8.42				
Fin Rot Only			5	0.04		
Skeleton Only	3	0.25				
Fungus Only	39	3.25	51	0.39	1	0.61
Other Only	98	8.16	31	0.24	4	2.45
Blind/Stress	2	0.16				
Fungus/Finrot	67	5.58	19	0.15		
Fungus/Finrot/Other			1	0.01		
Fungus/Other			1	0.01		
Total	312	26.00	217	1.67	5	3.07

[a]Categories are described in more detail in Table 3-24.
[b]Including fish < 150 mm and fish ≥ 150 mm considered in poor condition and released without tagging or were taken to the laboratory for processing.
[c]Including fish with suspected tag wounds, prior year, and other agency recaptures, but excluding fish suspected of being recaptured hatchery releases.

Injuries or anomalies were also observed among tagged and recaptured fish (1.7 and 3.1%, respectively). The most frequently observed condition among tagged fish was blindness, accounting for 0.84% of fish in poor condition. Fungal infection was observed on 51 of the recaptured fish. Other conditions, fin rot, or a combination of these injuries accounted for the remaining fish observed in poor condition. Fungal infection was observed among both tagged and recaptured fish; fin rot was only observed among tagged fish.

Each of the general categories of poor condition were further classified to the specific area of the fish (Table 3-24). Among those fish identified as blind, blindness was observed in both eyes more than twice as often (63%) as blindness observed in one eye only. Fin rot most commonly occurred on multiple fins, while fungal infections were observed on both sides of the body 96% of the time.

3.5 STRIPED BASS POPULATION SIZE

An important objective of the 1996-97 program was to estimate the size of the striped bass population that overwintered in the Battery and Upper Harbor regions of the Hudson River. The Schumacher-Eschmeyer regression technique was selected because it is a multiple census estimator that permits tagging and recapture efforts to occur concurrently. This estimator was used during the 1985-86 through 1995-96 programs to estimate the size of the mid-winter striped bass population in the Upper Harbor and Battery regions of the lower Hudson River (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995, 1996b).

Eight assumptions must be satisfied to estimate the winter striped bass population size in the lower Hudson River estuary using the Schumacher-Eschmeyer method or related methods (Cormack 1968; Ricker 1975; Seber 1982; MMES 1986):

1. Mortality is no different for tagged and untagged striped bass.
2. Tagging does not affect striped bass catchability.
3. Tagged bass do not lose their marks.
4. All tags are recognized and reported.
5. Natural marking does not occur or is recognizable.

TABLE 3-24

NATURE OF INJURIES AND ABNORMALITIES OBSERVED IN STRIPED BASS COLLECTED BY THE 9-m TRAWL IN THE HUDSON RIVER WINTER 1995-96

GENERAL CATEGORY	SPECIFIC CONDITION	INCIDENCE AMONG 1,200 UNMARKED FISH	INCIDENCE AMONG 13,011 FISH TAGGED	INCIDENCE AMONG 163 RECAPTURED FISH
Blindness	Blind in one eye	2	40	
	Blind in both eyes	2	69	
Stress	Net rash	76		
	Crushed or cut	3		
	Handling	24		
Fin rot	On caudal fin	3	6	
	On dorsal fins	1		
	On multiple fins	62	18	
Skeleton	Scoliosis	3		
Fungus	On one side of body	1	7	1
	On both sides of body	105	65	
Other	Body wounds, damaged fins, etc.	98	31	4
Total[a]		377	236	5

[a]Totals exceed those in Table 3-23 because some fish exhibited more than one condition.

6. Immigration, emigration, and recruitment are negligible in the study area, i.e., the population is closed.

7. Tagged striped bass are randomly distributed among untagged fish, or the distribution of recapture fishing effort is proportional to the abundance of fish in various river regions.

8. Marked fish have the same probability of being caught as unmarked fish.

With regard to Assumption 1, Dunning et al. (1987) observed no difference in mortality between tagged and untagged striped bass retained (1) in the Hudson River for 24 hrs and (2) in holding pools for up to 180 days. However, during the 1990-91 program, predation by birds (gulls) was observed to remove about 2.4% of the tagged fish as they were released from the tagging vessel (NAI 1992). Most of the bird predation was observed to occur as the released fish drifted away from the tagging vessel before sounding. In the 1996-97 program, all striped bass were released into a recovery pen that was suspended in the water alongside the tagging vessel. The pen provided cover until the fish sounded and virtually eliminated bird predation. Therefore, the number of tagged striped bass at large was not adjusted for mortality during the 1996-97 program.

Differential catchability of tagged and untagged striped bass during the winter (Assumption 2) was probably not significant. With respect to trawling as recapture gear, tagged fish would not be differentially caught due to the presence of tags. This assumption is more a problem with gill nets or other recapture methods that rely on entanglement to catch fish.

With regard to Assumption 3, field crews were specifically instructed to examine fish for tag wounds (LMS 1996a), which would provide evidence of tag loss. QA/QC procedures (LMS 1996a) and audits provide documentation that incorrect identification or nonreporting of tags by field crews did not occur. Dunning et al. (1987) found 91.1% of tagged fish held for 180 days in pools retained their tags. Based on a 2.3% loss rate (Dunning et al. 1987) and the recapture of 345 fish out of 20,847 tagged fish, approximately eight fish would be expected to have lost tags in the 1992-93 program. However, the tag loss rate from Dunning et al. (1987) was based on Floy-style tags, which may exhibit a higher shedding rate than the Hallprint tags now used. Throughout the 1996-97 program, 13,498 striped bass were examined for tags and tag wounds, and none were observed with tag wounds. Therefore, loss of internal anchor tags for fish tagged and released during 1996-97 was considered to be zero. This assumption provides a conservative estimate of abundance. If tag loss did occur and was adjusted for, abundance estimates would be higher.

The recognition and reporting of tags, Assumption 4, was addressed by field and laboratory standard operating procedures and QA/QC procedures reviewed by NYSDEC (Geoghegan et al. 1990). As this program provided both marking and recapture efforts, nonreporting of tags did not occur. Assumption 5 was satisfied because marking techniques that could be imitated by natural conditions (e.g., fin-clips) were not used in this study. Furthermore, tags from other programs (e.g., U.S. Fish & Wildlife Service or Littoral Society) were observed by field crews and easily distinguished from the internal anchor tag used in this study.

Immigration and emigration, Assumption 6, was apparently negligible during most of the study period (November 1995 through April 1996), as indicted by recapture rates, recapture proportions, and previous studies of the movement of striped bass in the lower Hudson River (Appendix Table D-4; NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995 1996b). A linear regression of weekly recapture proportions on cumulative number of marked fish (Figure 3-7) was significant and positive for the weeks of 6 January 1997 through the week of 31 March 1997 (Appendix Tables D-6 and D-7). This 13-week period for the population estimator was similar to the recapture period used in previous years (NAI 1986, 1987, 1988, 1990, 1992, 1994, 1995a; LMS 1995). During 1989-90, the period used for the striped bass population estimate was 22 January through 9 April 1990, which was one month later than in the other years. During 1993-94 the period used for the Schumacher-Eschmeyer population estimate was truncated (22 November 1994 through 10 January 1995) by severe weather conditions that prevented most trawling efforts from the week of 17 January through 21 February 1994 (NAI 1995b). The significant linear regression (Appendix Table D-7), which formed the basis for the Schumacher-Eschmeyer closed population estimator, supported the assumption of random mixing of tagged and untagged striped bass during the 1996-97 program (Assumption 7). Furthermore, stepwise polynomial regressions offered no statistically significant improvement in model fit over the linear model.

With regard to Assumption 8, marked fish in the winter striped bass population of the Battery and Upper Harbor regions do not appear to be differentially exposed to recapture. This assumption is generally applied to fish populations where one or more age groups of tagged fish may migrate out of the study area while other age groups remain in the area. The winter population in the Battery and Upper Harbor regions was composed primarily of immature fish (Section 3.2; Appendix E) of similar size and age composition, which probably are equally exposed to the trawl recapture effort.

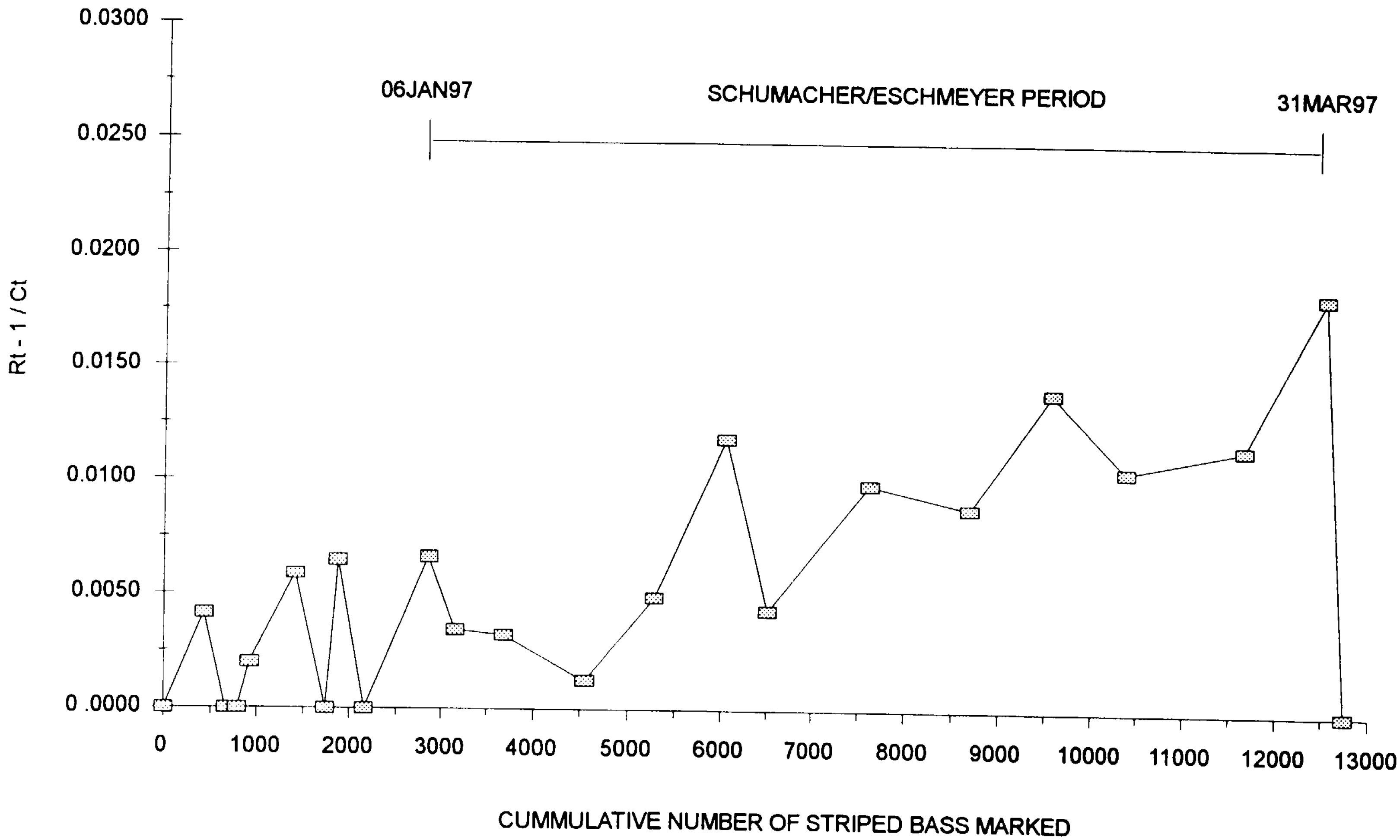


Figure 3-7. Striped bass recapture proportion (R/C) compared to the cumulative number of striped bass tagged in the Battery and Upper Harbor regions of the Hudson River, winter 1996-97.

The assumptions of a closed population, mark-recapture population estimator appeared to be satisfied for the 6 January 1997 through 31 March 1997 period in this study. Therefore, a Schumacher-Eschmeyer population estimate was calculated based on 9684 fish marked, 10,469 examined, and 61 recaptured (Appendix D-6). The estimated size of the mid-winter striped bass population in Upper New York Harbor and the Battery during 1996-97 was 768,000 fish ≥150 mm, with upper and lower 95% confidence limits (based on the t-distribution) ranging from 682,000 to 880,000 fish. The age composition of the winter population was approximated using the population estimate and the data from Section 3.2 (Table 3-25).

For comparison with previous programs, the total population of Age 1+ and older striped bass ≥200 mm was estimated as 694,000 fish by adjusting the estimate derived for the entire population of fish ≥150 mm, based on the proportion of Age 1+ fish between 150 and 200 mm (Table 3-26). This was the fifth largest estimate among the 12 programs conducted since 1985-86 (Table 3-27). The 1995 cohort of Age 1+ fish was the primary contributor to this estimate of Hudson River striped bass in the mid-winter population during 1996-97.

TABLE 3-25

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥150 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1996-97

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥150 mm	PROPORTION ≥150 MM	ESTIMATED POPULATION[a]
1+	8,756	8,652	0.6413	493,000
2+	3,853	3,853	0.2856	219,000
3+	763	763	0.0566	43,000
>3+	119	119	0.0088	7,000
Total	13,491	13,387	0.9923	762,000

[a]Estimated population is based on a Schumacher-Eschmeyer estimate of the number of Age 1+ and older striped bass ≥150 mm marked, released, and recaptured in the Upper Harbor and Battery regions of the Hudson River from the week of 6 January 1997 through the week of 31 March 1997. Age 0+ striped bass were 0.8% (6,000) of the population ≥150 mm. Estimated total population of striped bass ≥150 mm was 768,000 fish.

TABLE 3-26

ESTIMATED POPULATION OF AGE 1+ AND OLDER STRIPED BASS ≥200 mm BY AGE COHORT IN THE LOWER HUDSON RIVER WINTER 1996-97

AGE	TOTAL NUMBER CAUGHT	TOTAL CATCH ≥200 mm	PROPORTION ≥200 mm	ESTIMATED POPULATION[a]
1+	8,756	7,473	0.5539	425,000
2+	3,853	3,853	0.2856	219,000
3+	763	763	0.0566	43,000
>3+	119	119	0.0088	7,000
Total	13,491	12,208	0.9048	694,000

[a]The total population estimate based on fish ≥150 mm (768,000) was adjusted for the estimated proportion of Age 1+ and older striped bass ≥200 mm (12,208/13,492 = 0.9048).

TABLE 3-27

ESTIMATED NUMBER OF STRIPED BASS ≥200 mm AND ≥150 mm PRESENT IN THE LOWER HUDSON RIVER DURING THE WINTERS OF 1985-86 THROUGH 1996-97

PROGRAM	ESTIMATED NUMBER ≥200 mm	ESTIMATED NUMBER ≥150 mm
1996-97	694,000	768,000
1995-96	786,000	949,000
1994-95	325,000	350,000
1993-94	379,000	443,000
1992-93	717,000	920,000
1991-92	967,000	1,163,000
1990-91	786,000	858,000
1989-90	528,000	776,000
1988-89	890,000	1,190,000
1987-88	295,000	[a]
1986-87	394,000	[a]
1985-86	540,000	[a]

[a]Fish <200 mm were not tagged. The population estimate during the 1987-88, 1986-87, and 1985-86 programs was not extrapolated for fish ≥150 mm.

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APPENDIX A

GEAR CHARACTERISTICS

APPENDIX TABLE A-1. SPECIFICATIONS OF THE 9M TRAWL

GEAR DESCRIPTION (9M TRAWL)	SPECIFICATIONS
HEAD ROPE LENGTH	6.9 M
FOOT ROPE LENGTH (SWEEP)	9.0 M
LEGS (BETWEEN DOORS AND NET)	6.0 M
APPROXIMATE VERTICAL LIFT	3.6 M
DOORS (STEEL V-DOORS)	1.0 M
NET BODY LENGTH	5.2 M
COD END SECTION LENGTH	2.3 M
MESH - BODY	7.6 CM (STRETCH) MESH POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
- COD END	3.8 CM (STRETCH) MESH KNOTLESS POLYPROPYLENE; 3 MM DIAMETER POLYPROPYLENE TWINE
ROLLER GEAR	25.4 CM ROLLERS SPACED WITH 5 CM COOKIE DISKS

APPENDIX B

WATER QUALITY

APPENDIX TABLE B-1. WEEKLY AND REGIONAL AVERAGE WATER TEMPERATURE AND CONDUCTIVITY DURING TRAWL SAMPLING IN THE HUDSON RIVER, WINTER 1996-97.

REGION	SAMPLE WEEK	SURFACE WATER TEMPERATURE (°C)	SURFACE WATER CONDUCTIVITY (µmhos)	BOTTOM WATER TEMPERATURE (°C)	BOTTOM WATER CONDUCTIVITY (µmhos)
UPPER HARBOR	04NOV96	13.6	35892	13.7	37296
	11NOV96	11.6	22687	11.5	26647
	18NOV96	10.1	21100	10.5	23087
	25NOV96	10.0	22660	10.0	24700
	02DEC96	8.0	11700	8.6	19362
	09DEC96	7.6	18567	8.2	22334
	16DEC96	6.5	19802	7.0	29343
	23DEC96	5.3	23692	5.9	29833
	30DEC96	5.5	22225	6.2	32154
	06JAN97	5.4	32383	5.5	36674
	13JAN97	3.7	18000	4.2	23000
	03FEB97	4.8	21200	5.0	22200
BATTERY	04NOV96	12.9	17879	13.2	28840
	11NOV96	12.0	14994	12.2	26609
	18NOV96	9.3	13008	10.0	21104
	25NOV96	8.5	12800	9.4	22600
	02DEC96	7.6	6219	8.0	11729
	09DEC96	6.8	11307	7.7	19620
	16DEC96	5.1	5882	5.6	13297
	23DEC96	5.4	18124	5.8	25405
	30DEC96	4.3	12780	5.7	29620
	06JAN97	4.9	22328	5.6	29894
	13JAN97	3.0	11541	3.5	19463
	20JAN97	2.4	14319	3.5	19936
	27JAN97	1.8	11286	3.3	20141
	03FEB97	3.7	13712	4.1	18795
	10FEB97	2.9	10840	3.4	16008
	17FEB97	4.1	13534	4.3	18450
	24FEB97	4.2	5984	4.9	17375
	03MAR97	4.2	6821	5.1	17818
	10MAR97	4.8	9150	5.1	17464
	17MAR97	4.7	6859	5.6	20716
	24MAR97	6.3	12402	6.2	19049
	31MAR97	6.8	6623	6.8	15585
	07APR97	8.1	3595	7.9	14507

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
. = MISSING VALUE

APPENDIX C

STRIPED BASS CATCH CHARACTERISTICS

APPENDIX TABLE C-1. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1996-97.

REGION	SAMPLE WEEK	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	04NOV96	4	43	10.75	3.68
	11NOV96	15	125	8.33	3.33
	18NOV96	23	105	4.57	0.95
	25NOV96	10	61	6.10	1.71
	02DEC96	13	477	36.69	10.67
	09DEC96	19	285	15.00	4.16
	16DEC96	10	80	8.00	2.12
	23DEC96	11	167	15.18	2.82
	30DEC96	8	250	31.25	8.76
	06JAN97	3	3	1.00	1.00
	13JAN97	6	72	12.00	3.55
	03FEB97	1	0	0.00	.
	TOTAL	123	1668	13.56	1.75
BATTERY	04NOV96	28	404	14.43	3.34
	11NOV96	29	119	4.10	1.50
	18NOV96	24	30	1.25	0.28
	25NOV96	20	85	4.25	1.10
	02DEC96	24	36	1.50	0.36
	09DEC96	20	67	3.35	0.53
	16DEC96	25	64	2.56	0.53
	23DEC96	16	150	9.38	2.47
	30DEC96	20	491	24.55	4.26
	06JAN97	40	317	7.93	1.27
	13JAN97	40	547	13.68	2.23
	20JAN97	35	983	28.09	3.69
	27JAN97	43	844	19.63	2.22
	03FEB97	42	884	21.05	3.07
	10FEB97	53	546	10.30	1.96
	17FEB97	37	1248	33.73	5.21
	24FEB97	44	1258	28.59	2.58
	03MAR97	39	1053	27.00	4.11
	10MAR97	42	925	22.02	3.22
	17MAR97	44	1367	31.07	4.20
	24MAR97	51	1000	19.61	2.93
	31MAR97	40	229	5.73	0.89
	07APR97	75	62	0.83	0.13
	TOTAL	831	12709	15.29	0.69

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-2. WEEKLY MEAN CATCH PER UNIT EFFORT (CPUE) OF STRIPED BASS CAUGHT IN THE 9m TRAWL IN THE HUDSON RIVER SOUTH OF THE GEORGE WASHINGTON BRIDGE, WINTER 1996-97.

REGION	RIVER MILE	TOWS	N	MEAN CPUE	S.E.
UPPER HARBOR	-2	122	1666	13.66	1.77
	-1	1	2	2.00	.
	TOTAL	123	1668	13.56	1.75
BATTERY	2	247	2810	11.38	1.14
	3	7	121	17.29	3.94
	4	11	330	30.00	5.66
	6	80	591	7.39	1.02
	9	11	62	5.64	2.15
	10	475	8795	18.52	0.98
	TOTAL	831	12709	15.29	0.69

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
N = NUMBER OF STRIPED BASS COLLECTED
CPUE = CATCH PER UNIT EFFORT (CATCH PER TEN MINUTE TOW)
S.E. = STANDARD ERROR

APPENDIX TABLE C-3. NUMBER OF SAMPLES, STRIPED BASS COLLECTED AND STRIPED BASS TAGGED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER FOR THE 9M TRAWL, WINTER 1996-97.

REGION	GEAR	USE CODE	NUMBER OF SAMPLES	STRIPED BASS	TAGGED STRIPED BASS
UPPER HARBOR	9 m TRAWL	1	123	1668	1591
	TOTAL		123	1668	1591
BATTERY	9 m TRAWL	1	831	12709	11202
		2	1	3	2
		5	2	0	0
	TOTAL		834	12712	11204
COMBINED TOTAL			957	14380	12795

USE CODE:
1 = NO SAMPLING PROBLEMS
2 = SAMPLING PROBLEMS OCCURRED; MARKABLE FISH WERE CAUGHT, BUT SAMPLE WAS NOT USED FOR CATCH/EFFORT ANALYSIS
5 = VOID; SAMPLING PROBLEMS OCCURRED AND NO MARKABLE FISH WERE CAUGHT

APPENDIX TABLE C-5. WEEKLY MEAN LENGTH (MM) OF STRIPED BASS COLLECTED IN THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1996-97.

	UPPER HARBOR				BATTERY			
SAMPLE WEEK	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.	NUMBER OF STRIPED BASS	MEAN LENGTH	S.D.	S.E.
04NOV96	43	299	66.41	10.13	403	266	58.92	2.93
11NOV96	125	315	54.10	4.84	119	258	60.86	5.58
18NOV96	104	302	70.46	6.91	30	224	81.42	14.86
25NOV96	61	292	56.23	7.20	85	261	83.83	9.09
02DEC96	477	272	36.79	1.68	36	239	126.96	21.16
09DEC96	285	278	43.14	2.56	67	249	95.17	11.63
16DEC96	80	269	62.74	7.02	64	264	110.13	13.77
23DEC96	166	281	58.23	4.52	150	291	66.44	5.42
30DEC96	250	275	53.59	3.39	491	285	68.39	3.09
06JAN97	3	321	51.59	29.78	317	288	93.02	5.22
13JAN97	72	286	63.95	7.54	547	284	89.70	3.84
20JAN97	.	.	.	.	986	271	76.95	2.45
27JAN97	.	.	.	.	844	278	84.67	2.91
03FEB97	.	.	.	.	884	270	76.82	2.58
10FEB97	.	.	.	.	546	258	74.58	3.19
17FEB97	.	.	.	.	1245	251	66.17	1.88
24FEB97	.	.	.	.	1258	245	69.94	1.97
03MAR97	.	.	.	.	1053	242	73.25	2.26
10MAR97	.	.	.	.	925	258	67.14	2.21
17MAR97	.	.	.	.	1367	271	64.25	1.74
24MAR97	.	.	.	.	1000	277	63.46	2.01
31MAR97	.	.	.	.	229	327	102.31	6.76
07APR97	.	.	.	.	62	337	107.64	13.67
TOTAL	1666	281	52.50	1.29	12708	266	75.62	0.67

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK
S.E. = STANDARD ERROR

APPENDIX TABLE C-6. WEEKLY MEAN CATCH OF STRIPED BASS PER TEN MINUTE TOW (CPUE) IN THE 9M TRAWL FOR 50MM LENGTH GROUPS IN THE BATTERY REGION AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1996-97

SAMPLING WEEK	NUMBER OF TOWS	µ 50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800	· 801
04NOV96	32	< 0.1	--	0.2	1.6	3.2	5.3	2.6	0.7	0.3	0.2	--	--	--	--	--	--	--
11NOV96	44	--	< 0.1	< 0.0	0.4	1.0	2.0	1.1	0.7	0.2	0.1	< 0.1	--	--	--	--	--	--
18NOV96	47	< 0.1	< 0.1	0.1	0.2	0.5	1.1	0.6	0.1	0.1	0.1	--	< 0.1	< 0.1	--	--	--	--
25NOV96	30	--	--	0.2	0.4	1.0	1.8	0.9	0.4	0.1	--	< 0.1	0.1	--	--	--	--	--
02DEC96	37	--	0.2	0.2	0.2	3.5	7.7	1.7	0.2	0.1	0.1	0.1	--	< 0.1	--	--	--	--
09DEC96	39	--	0.1	0.2	0.4	1.6	4.6	1.4	0.5	0.2	--	--	< 0.1	--	--	--	--	--
16DEC96	35	--	< 0.1	0.3	0.3	0.9	1.4	0.7	0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	--	--	--	--
23DEC96	27	< 0.1	< 0.1	0.2	0.4	1.9	5.4	2.4	0.8	0.4	< 0.1	< 0.1	--	--	< 0.1	--	--	--
30DEC96	28	--	0.1	0.1	2.0	5.9	9.3	5.8	2.0	0.8	0.2	0.1	0.1	--	--	--	--	--
06JAN97	43	--	0.1	0.3	0.8	1.4	2.0	1.2	0.8	0.7	0.1	--	< 0.1	< 0.1	--	--	--	< 0.1
13JAN97	46	--	0.2	0.7	1.1	3.0	3.8	1.8	1.4	1.2	0.3	0.1	--	--	< 0.1	< 0.1	--	--
20JAN97	35	--	0.2	1.4	2.7	6.9	8.3	4.5	2.4	1.1	0.3	0.2	< 0.1	--	< 0.1	--	--	--
27JAN97	43	--	0.3	0.9	2.2	3.9	5.0	3.3	2.1	1.5	0.4	< 0.1	--	--	--	--	--	--
03FEB97	43	--	0.2	1.4	1.9	4.3	5.9	4.2	1.7	0.7	0.2	< 0.1	< 0.1	--	--	< 0.1	--	--
10FEB97	53	--	0.1	0.6	1.4	2.7	3.1	1.4	0.6	0.3	0.1	--	--	--	--	< 0.1	--	--
17FEB97	37	0.1	0.5	2.0	4.0	9.6	10.5	5.3	1.1	0.3	0.1	< 0.1	--	< 0.1	--	--	--	--
24FEB97	44	--	0.8	2.5	3.7	7.5	8.8	3.8	1.2	0.3	< 0.1	< 0.1	< 0.1	--	--	--	--	--
03MAR97	39	--	1.3	2.5	2.6	7.4	8.2	3.4	1.2	0.3	0.1	--	--	--	--	--	--	--
10MAR97	42	--	0.5	1.0	2.4	5.8	7.8	3.0	1.0	0.5	0.2	--	--	--	--	--	--	--
17MAR97	44	--	< 0.1	0.7	3.2	7.9	9.8	6.0	2.2	1.0	0.1	< 0.1	< 0.1	--	--	--	--	--
24MAR97	51	--	0.2	0.8	1.0	3.4	7.5	4.7	1.6	0.3	0.1	--	--	--	--	--	--	--
31MAR97	40	--	0.1	0.2	0.1	0.7	1.0	1.7	0.9	0.7	0.3	< 0.1	--	--	< 0.1	--	< 0.1	< 0.1
07APR97	75	--	--	0.1	< 0.1	0.1	0.2	0.1	0.2	0.2	< 0.1	--	< 0.1	--	--	< 0.1	--	--
TOTAL	954	< 0.1	0.2	0.7	1.4	3.5	5.0	2.6	1.0	0.5	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

NOTE: SAMPLE WEEK = BEGINNING MONDAY OF EACH WEEK

APPENDIX TABLE C-7. MEAN LENGTH AT AGE FOR AGE 0+ THROUGH AGE 3+ WILD STRIPED BASS COLLECTED BY THE 9M TRAWL IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER DURING THE 1986-87 THROUGH 1996-97 STRIPED BASS PROGRAMS.

AGE	COHORT	PROGRAM	N	STRATIFIED MEAN LENGTH (MM)	LOWER 95% CONFIDENCE LIMIT	UPPER 95% CONFIDENCE LIMIT
0+	1996	1996-97	51	120	119	121
	1995	1995-96	207	127	126	128
	1994	1994-95	216	104	104	105
	1993	1993-94	828	123	121	125
	1992	1992-93	473	116	114	118
	1991	1991-92	818	131	127	135
	1990	1990-91	206	119	116	122
	1989	1989-90	368	112	109	115
	1988	1988-89	1007	121	117	125
	1987	1987-88	190	108	104	112
	1986	1986-87	83	128	123	134
1+	1995	1996-97	1410	260	258	263
	1994	1995-96	1501	246	244	248
	1993	1994-95	1216	260	258	262
	1992	1993-94	2695	237	236	238
	1991	1992-93	3899	231	229	233
	1990	1991-92	3675	245	244	246
	1989	1990-91	2174	239	237	241
	1988	1989-90	3514	214	213	215
	1987	1988-89	3623	227	226	229
	1986	1987-88	1503	253	251	255
	1985	1986-87	285	221	215	227
2+	1994	1996-97	686	306	302	310
	1993	1995-96	355	312	306	318
	1992	1994-95	455	312	308	316
	1991	1993-94	1631	317	307	328
	1990	1992-93	1378	329	325	333
	1989	1991-92	961	324	319	328
	1988	1990-91	2109	321	317	324
	1987	1989-90	1216	298	295	301
	1986	1988-89	361	325	318	331
	1985	1987-88	574	317	312	322
	1984	1986-87	359	299	293	305
3+	1993	1996-97	82	334	320	348
	1992	1995-96	53	346	332	360
	1991	1994-95	99	356	346	366
	1990	1993-94	152	424	246	602
	1989	1992-93	125	414	400	428
	1988	1991-92	153	386	378	394
	1987	1990-91	69	381	360	401
	1986	1989-90	55	382	362	403
	1985	1988-89	57	396	378	415
	1984	1987-88	273	367	360	375
	1983	1986-87	54	369	354	385

NOTE: STRATIFIED MEAN LENGTH FOR THE 1990 AND 1991 WILD COHORTS OF STRIPED BASS INCLUDE HACTHERY AND WILD FISH COMBINED. HATCHERY FISH WERE NOT TAGGED PRIOR TO STOCKING DURING THESE YEARS.

N = NUMBER OF FISH AGED FROM VALID (USE CODE = 1) SAMPLES.

APPENDIX D

STRIPED BASS MARK-RECAPTURE STUDIES

APPENDIX TABLE D-1. VERIFIED HACTHERY STRIPED BASS RECAPTURED IN THE BATTERY AND UPPER HARBOR REGIONS OF THE HUDSON RIVER, WINTER 1996-97.

AGE	GEAR	RECAPTURE DATE	STATION	RECAPTURE RIVER MILE	TOTAL LENGTH (MM)	RELEASE YEAR
1+	9 m TRAWL	03DEC96	UPPER HARBOR	-2	247	1995
2+	9 m TRAWL	22NOV96	UPPER HARBOR	-2	262	1994

APPENDIX TABLE D-2. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED, RELEASED AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1996-97.

RECAPTURE DATE	RECAPTURE TOTAL LENGTH (MM)	RECAPTURE REGION	RECAPTURE RM	RELEASE DATE	RELEASE TOTAL LENGTH (MM)	RELEASE REGION	RELEASE RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
24FEB97	303	BATTERY	10	04NOV96	300	BATTERY	4	112	6	1	417629
10JAN97	331	BATTERY	2	05NOV96	330	BATTERY	4	66	2	1	417652
07NOV96	323	BATTERY	4	07NOV96	324	BATTERY	4	0	0	1	417719
07NOV96	298	BATTERY	4	07NOV96	302	BATTERY	4	0	0	1	417720
15NOV96	354	UPPER HARBOR	-2	14NOV96	354	UPPER HARBOR	-2	1	0	1	417774
11DEC96	389	UPPER HARBOR	-2	14NOV96	386	UPPER HARBOR	-2	27	0	1	417788
15NOV96	376	UPPER HARBOR	-2	15NOV96	377	UPPER HARBOR	-2	0	0	1	417797
04DEC96	314	UPPER HARBOR	-2	22NOV96	316	UPPER HARBOR	-2	12	0	1	417873
28NOV96	317	BATTERY	2	28NOV96	317	BATTERY	2	0	0	1	417908
28MAR97	304	BATTERY	10	10DEC96	306	UPPER HARBOR	-2	108	12	1	418028
20JAN97	311	BATTERY	10	31DEC96	309	UPPER HARBOR	-2	20	12	1	418279
19MAR97	417	BATTERY	10	17JAN97	418	BATTERY	10	61	0	1	418786
13MAR97	361	BATTERY	10	23JAN97	361	BATTERY	10	49	0	1	419058
27FEB97	343	BATTERY	10	28JAN97	343	BATTERY	10	30	0	1	419213
28JAN97	342	BATTERY	10	28JAN97	341	BATTERY	10	0	0	1	419246
28FEB97	302	BATTERY	10	30JAN97	302	BATTERY	2	29	8	1	419357
18MAR97	413	BATTERY	2	03FEB97	413	BATTERY	2	43	0	1	419486
20FEB97	375	BATTERY	10	12FEB97	373	BATTERY	10	8	0	1	419755
19FEB97	327	BATTERY	10	12FEB97	330	BATTERY	10	7	0	1	419767
27MAR97	336	BATTERY	10	25FEB97	343	BATTERY	10	30	0	1	425179
25MAR97	309	BATTERY	10	05MAR97	312	BATTERY	2	20	8	1	425431
02APR97	356	BATTERY	2	11MAR97	356	BATTERY	10	22	8	1	425589
20MAR97	387	BATTERY	2	17MAR97	389	BATTERY	10	3	8	1	425759
21MAR97	309	BATTERY	10	18MAR97	310	BATTERY	2	3	8	1	425823
03APR97	329	BATTERY	2	02APR97	328	BATTERY	2	1	0	1	426445
05NOV96	251	BATTERY	4	04NOV96	252	BATTERY	4	1	0	1	434520
13NOV96	180	BATTERY	2	05NOV96	179	BATTERY	4	8	2	1	434581
06NOV96	169	BATTERY	4	06NOV96	169	BATTERY	4	0	0	1	434625
10DEC96	257	UPPER HARBOR	-2	07NOV96	227	UPPER HARBOR	-2	33	0	1	434686
07NOV96	267	BATTERY	4	07NOV96	267	BATTERY	4	0	0	1	434717
20FEB97	255	BATTERY	10	11NOV96	253	BATTERY	2	101	8	1	434818
11FEB97	168	BATTERY	2	15NOV96	168	BATTERY	2	88	0	1	434946
11FEB97	209	BATTERY	10	15NOV96	209	BATTERY	2	88	8	1	434947
26DEC96	196	UPPER HARBOR	-2	20NOV96	192	UPPER HARBOR	-2	36	0	1	434990
10JAN97	225	BATTERY	2	21NOV96	223	UPPER HARBOR	-2	50	4	1	435015
26NOV96	273	UPPER HARBOR	-2	25NOV96	272	UPPER HARBOR	-2	1	0	1	435074
27DEC96	261	BATTERY	3	03DEC96	263	UPPER HARBOR	-2	24	5	1	435309
04DEC96	236	UPPER HARBOR	-2	03DEC96	236	UPPER HARBOR	-2	1	0	1	435359
12MAR97	282	BATTERY	10	04DEC96	284	UPPER HARBOR	-2	98	12	1	435439
10MAR97	281	BATTERY	10	04DEC96	282	UPPER HARBOR	-2	96	12	1	435446
27JAN97	286	BATTERY	10	04DEC96	286	UPPER HARBOR	-2	54	12	1	435500
04APR97	280	BATTERY	10	05DEC96	283	UPPER HARBOR	-2	120	12	1	435533
15JAN97	280	UPPER HARBOR	-2	11DEC96	278	UPPER HARBOR	-2	35	0	1	435682
25MAR97	265	BATTERY	10	11DEC96	266	UPPER HARBOR	-2	104	12	1	435710
23JAN97	277	BATTERY	10	13DEC96	276	UPPER HARBOR	-2	41	12	1	435799
16DEC96	295	UPPER HARBOR	-2	16DEC96	296	UPPER HARBOR	-2	0	0	1	435817
23DEC96	281	UPPER HARBOR	-2	23DEC96	283	UPPER HARBOR	-2	0	0	1	435922
22JAN97	297	BATTERY	10	26DEC96	298	UPPER HARBOR	-2	27	12	1	435996
26DEC96	287	UPPER HARBOR	-2	26DEC96	286	UPPER HARBOR	-2	0	0	1	435998
31DEC96	276	BATTERY	2	30DEC96	275	BATTERY	2	1	0	1	436109

(CONTINUED)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
13FEB97	237	BATTERY	10	30DEC96	237	BATTERY	6	45	4	1	436174
02JAN97	283	BATTERY	6	02JAN97	284	BATTERY	6	0	0	1	436358
03JAN97	202	BATTERY	2	03JAN97	203	BATTERY	2	0	0	1	436386
03JAN97	261	BATTERY	2	03JAN97	261	BATTERY	2	0	0	1	436387
28FEB97	195	BATTERY	2	03JAN97	195	BATTERY	2	56	0	1	436425
05MAR97	197	BATTERY	10	03JAN97	197	BATTERY	2	61	8	1	436427
14MAR97	190	BATTERY	10	03JAN97	192	BATTERY	2	70	8	1	436438
20MAR97	207	BATTERY	2	03JAN97	207	BATTERY	2	76	0	1	436469
17JAN97	299	BATTERY	2	06JAN97	233	BATTERY	2	11	0	1	436596
19MAR97	258	BATTERY	10	10JAN97	258	BATTERY	2	68	8	1	436747
12MAR97	238	BATTERY	10	15JAN97	237	BATTERY	2	56	8	1	436877
12FEB97	268	BATTERY	10	16JAN97	269	BATTERY	2	27	8	1	436972
28JAN97	298	BATTERY	10	17JAN97	299	BATTERY	2	11	8	1	437041
11MAR97	254	BATTERY	10	20JAN97	255	BATTERY	10	50	0	1	437115
13MAR97	273	BATTERY	10	20JAN97	273	BATTERY	10	52	0	1	437117
24FEB97	275	BATTERY	10	21JAN97	274	BATTERY	10	34	0	1	437285
19MAR97	261	BATTERY	2	22JAN97	260	BATTERY	10	56	8	1	437406
18MAR97	273	BATTERY	10	22JAN97	272	BATTERY	10	55	0	1	437464
23JAN97	288	BATTERY	10	23JAN97	288	BATTERY	10	0	0	1	437521
28MAR97	249	BATTERY	10	23JAN97	251	BATTERY	10	64	0	1	437560
04FEB97	287	BATTERY	10	23JAN97	288	BATTERY	10	12	0	1	437602
28JAN97	236	BATTERY	10	23JAN97	236	BATTERY	10	5	0	1	437653
29JAN97	226	BATTERY	2	24JAN97	227	BATTERY	10	5	8	1	437698
27JAN97	207	BATTERY	10	27JAN97	206	BATTERY	10	0	0	1	437769
13MAR97	290	BATTERY	10	27JAN97	290	BATTERY	10	45	0	1	437771
27JAN97	241	BATTERY	10	27JAN97	243	BATTERY	10	0	0	1	437789
19MAR97	219	BATTERY	2	28JAN97	218	BATTERY	10	50	8	1	437858
03MAR97	268	BATTERY	10	28JAN97	268	BATTERY	10	34	0	1	437882
05MAR97	268	BATTERY	10	28JAN97	268	BATTERY	10	36	0	1	437917
20FEB97	274	BATTERY	10	31JAN97	272	BATTERY	10	20	0	1	438129
10MAR97	282	BATTERY	10	31JAN97	283	BATTERY	10	38	0	1	438134
27FEB97	221	BATTERY	10	31JAN97	224	BATTERY	2	27	8	1	438151
21FEB97	271	BATTERY	10	03FEB97	270	BATTERY	6	18	4	1	438260
12FEB97	223	BATTERY	10	04FEB97	228	BATTERY	10	8	0	1	438345
24FEB97	204	BATTERY	10	04FEB97	203	BATTERY	10	20	0	1	438370
12FEB97	189	BATTERY	10	04FEB97	187	BATTERY	10	8	0	1	438422
27FEB97	219	BATTERY	10	05FEB97	220	BATTERY	10	22	0	1	438494
13MAR97	246	BATTERY	10	06FEB97	247	BATTERY	10	35	0	1	438606
25FEB97	283	BATTERY	10	10FEB97	282	BATTERY	2	15	8	1	438709
04MAR97	229	BATTERY	10	11FEB97	230	BATTERY	10	21	0	1	438796
27FEB97	178	BATTERY	10	11FEB97	178	BATTERY	10	16	0	1	438854
26MAR97	196	BATTERY	10	12FEB97	201	BATTERY	10	42	0	1	438979
18MAR97	222	BATTERY	10	13FEB97	221	BATTERY	10	33	0	1	439003
25FEB97	266	BATTERY	10	19FEB97	267	BATTERY	10	6	0	1	439198
06MAR97	207	BATTERY	10	20FEB97	208	BATTERY	10	14	0	1	439535
24MAR97	211	BATTERY	10	20FEB97	208	BATTERY	10	32	0	1	439535
05MAR97	253	BATTERY	2	21FEB97	254	BATTERY	10	12	8	1	439667
31MAR97	240	BATTERY	2	25FEB97	241	BATTERY	10	34	8	1	440239
20MAR97	186	BATTERY	2	25FEB97	185	BATTERY	10	23	8	1	440278
05MAR97	292	BATTERY	10	25FEB97	292	BATTERY	10	8	0	1	440284

(CONTINUED)

APPENDIX TABLE D-2. (CONTINUED)

RECAPTURE				RELEASE							
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	DISTANCE TRAVELED (MILES)	TAG CONDITION	TAG NUMBER
06MAR97	242	BATTERY	10	26FEB97	243	BATTERY	10	8	0	1	440406
13MAR97	285	BATTERY	10	26FEB97	293	BATTERY	10	15	0	1	440437
27FEB97	265	BATTERY	10	27FEB97	267	BATTERY	10	0	0	1	440693
27FEB97	209	BATTERY	10	27FEB97	209	BATTERY	10	0	0	1	440694
27FEB97	217	BATTERY	10	27FEB97	218	BATTERY	10	0	0	1	440695
02APR97	227	BATTERY	2	28FEB97	229	BATTERY	2	33	0	1	440762
04MAR97	258	BATTERY	10	04MAR97	257	BATTERY	10	0	0	1	440935
04MAR97	183	BATTERY	10	04MAR97	183	BATTERY	10	0	0	1	440942
19MAR97	239	BATTERY	2	04MAR97	239	BATTERY	10	15	8	1	440970
11MAR97	223	BATTERY	10	04MAR97	231	BATTERY	10	7	0	1	441045
24MAR97	243	BATTERY	10	05MAR97	243	BATTERY	2	19	8	1	441170
20MAR97	295	BATTERY	10	06MAR97	295	BATTERY	10	14	0	1	441367
19MAR97	201	BATTERY	2	07MAR97	201	BATTERY	10	12	8	1	441465
11MAR97	237	BATTERY	2	10MAR97	286	BATTERY	10	1	8	1	441617
11MAR97	264	BATTERY	10	11MAR97	264	BATTERY	10	0	0	1	441721
19MAR97	212	BATTERY	2	11MAR97	213	BATTERY	10	8	8	1	441789
18MAR97	255	BATTERY	2	12MAR97	253	BATTERY	10	6	8	1	441898
28MAR97	201	BATTERY	10	13MAR97	197	BATTERY	2	15	8	1	441991
19MAR97	201	BATTERY	2	18MAR97	202	BATTERY	2	1	0	1	442413
19MAR97	274	BATTERY	10	19MAR97	274	BATTERY	10	0	0	1	442422
19MAR97	206	BATTERY	10	19MAR97	206	BATTERY	10	0	0	1	442430
19MAR97	277	BATTERY	10	19MAR97	279	BATTERY	10	0	0	1	442434
28MAR97	283	BATTERY	2	20MAR97	283	BATTERY	10	8	8	1	442723
21MAR97	226	BATTERY	10	20MAR97	225	BATTERY	2	1	8	1	442802
21MAR97	230	BATTERY	10	20MAR97	229	BATTERY	2	1	8	1	442934

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION SITE
2 = INFECTED TAG INSERTION SITE

APPENDIX TABLE D-3. RELEASE AND RECAPTURE DATA FOR STRIPED BASS MARKED PRIOR TO, AND RECAPTURED IN THE HUDSON RIVER USING THE 9M TRAWL, WINTER 1996-97.

RECAPTURE				RELEASE								
DATE	TOTAL LENGTH (MM)	REGION	RM	DATE	GEAR	TOTAL LENGTH (MM)	REGION	RM	DAYS AT LARGE	GROWTH (MM)	CONDITION	NUMBER
06FEB97	428	BATTERY	10	21DEC93	9 m TRAWL	189	BATTERY	1	1143	239	1	394193
27JAN97	354	BATTERY	10	16MAR94	9 m TRAWL	239	BATTERY	7	1048	115	1	397710
03DEC96	447	UPPER HARBOR	-2	09DEC94	9 m TRAWL	361	UPPER HARBOR	-3	725	86	1	404318
24FEB97	380	BATTERY	10	12DEC94	9 m TRAWL	346	UPPER HARBOR	-2	805	34	1	404335
03JAN97	269	BATTERY	2	30MAR95	9 m TRAWL	188	BATTERY	6	645	81	1	414720
23DEC96	400	BATTERY	2	31JAN95	9 m TRAWL	368	UPPER HARBOR	-4	692	32	1	415210
17MAR97	374	BATTERY	10	12APR96	9 m TRAWL	327	BATTERY	2	339	47	1	417467
14JAN97	458	BATTERY	2	19APR96	9 m TRAWL	411	UPPER HARBOR	-2	270	47	1	417566
04APR97	391	BATTERY	10	14APR95	9 m TRAWL	278	BATTERY	2	721	113	1	420104
02JAN97	269	BATTERY	2	10NOV95	9 m TRAWL	224	UPPER HARBOR	-1	419	45	1	420249
18MAR97	331	BATTERY	2	01DEC95	9 m TRAWL	214	UPPER HARBOR	-1	473	117	1	421627
15NOV96	249	UPPER HARBOR	-2	04DEC95	9 m TRAWL	163	UPPER HARBOR	-1	347	86	1	421755
28MAR97	335	BATTERY	2	06DEC95	9 m TRAWL	229	UPPER HARBOR	-1	478	106	1	422378
24FEB97	286	BATTERY	10	08DEC95	9 m TRAWL	224	UPPER HARBOR	-1	444	62	1	422724
21NOV96	300	UPPER HARBOR	-2	08DEC95	9 m TRAWL	267	UPPER HARBOR	-2	349	33	1	422800
10DEC96	306	UPPER HARBOR	-2	11DEC95	9 m TRAWL	291	BATTERY	6	365	15	1	422932
20MAR97	302	BATTERY	10	18DEC95	9 m TRAWL	276	BATTERY	6	458	26	1	423674
22FEB97	310	BATTERY	10	28DEC95	9 m TRAWL	236	BATTERY	2	422	74	1	424296
23DEC96	231	UPPER HARBOR	-2	28DEC95	9 m TRAWL	200	BATTERY	2	361	31	1	424323
21MAR97	310	BATTERY	10	02JAN96	9 m TRAWL	213	BATTERY	9	444	97	1	424481
18MAR97	231	BATTERY	10	03JAN96	9 m TRAWL	192	BATTERY	6	440	39	1	424632
23JAN97	291	BATTERY	10	15FEB96	9 m TRAWL	202	BATTERY	2	343	89	1	430318
20FEB97	231	BATTERY	10	28FEB96	9 m TRAWL	156	UPPER HARBOR	-2	358	75	1	430530
25FEB97	255	BATTERY	10	04MAR96	9 m TRAWL	211	BATTERY	6	358	44	1	430654
15NOV96	340	UPPER HARBOR	-2	05MAR96	9 m TRAWL	198	BATTERY	9	255	142	1	430723
03DEC96	370	UPPER HARBOR	-2	18MAR96	9 m TRAWL	287	BATTERY	9	260	83	1	431314
03FEB97	259	BATTERY	2	18MAR96	9 m TRAWL	161	BATTERY	9	322	98	1	431325
21NOV96	.	UPPER HARBOR	-2	26MAR96	9 m TRAWL	193	BATTERY	9	240	.	1	431959
16JAN97	408	BATTERY	10	27MAR96	9 m TRAWL	295	BATTERY	9	295	113	1	432069
28JAN97	253	BATTERY	10	27MAR96	9 m TRAWL	214	BATTERY	9	307	39	1	432119
19MAR97	295	BATTERY	10	01APR96	9 m TRAWL	183	BATTERY	2	352	112	1	432436
25NOV96	332	UPPER HARBOR	-2	03APR96	9 m TRAWL	281	BATTERY	9	236	51	1	432798
17JAN97	301	BATTERY	2	12APR96	9 m TRAWL	237	BATTERY	9	280	64	1	433577
05APR97	398	BATTERY	10	16APR96	9 m TRAWL	269	BATTERY	9	354	129	1	433885
07MAR97	382	BATTERY	10	18APR96	9 m TRAWL	256	BATTERY	6	323	126	1	434236
05MAR97	314	BATTERY	10	18APR96	9 m TRAWL	220	BATTERY	6	321	94	1	434269
05NOV96	.	BATTERY	4	19APR96	9 m TRAWL	192	BATTERY	2	200	.	1	434458

NOTE: TAG CONDITION: 1 = HEALED TAG INSERTION SITE
2 = INFECTED TAG INSERTION SITE

APPENDIX TABLE D-4. RECAPTURE OF TAGGED STRIPED BASS CROSS-CLASSIFIED BY RELEASE AND RECAPTURE WEEK FOR FISH RELEASED AND RECAPTURED IN THE 9M TRAWL IN THE HUDSON RIVER, WINTER 1995-96

NUMBER OF STRIPED BASS RECAPTURED DURING WEEK

RECAPTU PERIOD	NUMBER EXAMINED FOR MARKS (C)	STAT	04NOV96 M= 434	11NOV96 M= 232	18NOV96 M= 125	25NOV96 M= 134	02DEC96 M= 493	09DEC96 M= 323	16DEC96 M= 127	23DEC96 M= 288	30DEC96 M= 702	06JAN97 M= 290	13JAN97 M= 538	20JAN97 M= 869	27JAN97 M= 728	03FEB97 M= 767	10FEB97 M= 478	17FEB97 M= 1100	24FEB97 M= 1066	03MAR9 M= 880	10MAR9 M= 818	17MAR9 M= 1269	24MAR9 M= 881	31MAR9 M= 203	07APR97 M= 49	TOTAL M= 12794
04NOV96	440	R	5																							5
		R/M	0.01152																							0.00039
		R/C	0.01136																							0.01136
11NOV96	241	R	1	2																						3
		R/M	0.00230	0.00862																						0.00023
		R/C	0.00415	0.00830																						0.01245
18NOV96	129	R	0	0	0																					0
		R/M	0.00000	0.00000	0.00000																					0.00000
		R/C	0.00000	0.00000	0.00000																					0.00000
25NOV96	139	R	0	0	0	2																				2
		R/M	0.00000	0.00000	0.00000	0.01493																				0.00016
		R/C	0.00000	0.00000	0.00000	0.01439																				0.01439
02DEC96	501	R	0	0	1	0	1																			2
		R/M	0.00000	0.00000	0.00800	0.00000	0.00203																			0.00016
		R/C	0.00000	0.00000	0.00200	0.00000	0.00200																			0.00399
09DEC96	340	R	1	1	0	0	0	0																		2
		R/M	0.00230	0.00431	0.00000	0.00000	0.00000	0.00000																		0.00016
		R/C	0.00294	0.00294	0.00000	0.00000	0.00000	0.00000																		0.00588
16DEC96	131	R	0	0	0	0	0	0	1																	1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00787																	0.00008
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00763																	0.00763
23DEC96	309	R	0	0	1	0	1	0	0	2																4
		R/M	0.00000	0.00000	0.00800	0.00000	0.00203	0.00000	0.00000	0.00694																0.00031
		R/C	0.00000	0.00000	0.00324	0.00000	0.00324	0.00000	0.00000	0.00647																0.01294
30DEC96	735	R	0	0	0	0	0	0	0	0	4															4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00570															0.00031
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00544															0.00544
06JAN97	302	R	1	0	1	0	0	0	0	0	0	0														2
		R/M	0.00230	0.00000	0.00800	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000														0.00016
		R/C	0.00331	0.00000	0.00331	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000														0.00662
13JAN97	581	R	0	0	0	0	0	1	0	0	0	1	0													2
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00310	0.00000	0.00000	0.00000	0.00345	0.00000													0.00016
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00172	0.00000	0.00000	0.00000	0.00172	0.00000													0.00344
20JAN97	930	R	0	0	0	0	0	1	0	1	1	0	0	1												4
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00310	0.00000	0.00347	0.00142	0.00000	0.00000	0.00115												0.00031
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00108	0.00000	0.00108	0.00108	0.00000	0.00000	0.00108												0.00430
27JAN97	790	R	0	0	0	0	1	0	0	0	0	0	0	0	0											1
		R/M	0.00000	0.00000	0.00000	0.00000	0.00203	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000											0.00008
		R/C	0.00000	0.00000	0.00000	0.00000	0.00127	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000											0.00127
03FEB97	816	R	0	0	0	0	1	0	0	0	0	0	0	1	2	3										7
		R/M	0.00000	0.00000	0.00000	0.00000	0.00203	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00115	0.00275	0.00391										0.00055
		R/C	0.00000	0.00000	0.00000	0.00000	0.00123	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00123	0.00245	0.00368										0.00858

(CONTINUED)

APPENDIX TABLE D-4. (CONTINUED)

RECAPTU PERIOD	NUMBER EXAMINED FOR MARKS (C)	STATISTI	NUMBER OF STRIPED BASS RECAPTURED DURING WEEK																						
			04NOV96 M= 434	11NOV96 M= 232	18NOV96 M= 125	25NOV96 M= 134	02DEC96 M= 493	09DEC96 M= 323	16DEC96 M= 127	23DEC96 M= 288	30DEC96 M= 702	06JAN97 M= 290	13JAN97 M= 538	20JAN97 M= 869	27JAN97 M= 728	03FEB97 M= 767	10FEB97 M= 478	17FEB97 M= 1100	24FEB97 M= 1066	03MAR9 M= 880	10MAR9 M= 818	17MAR9 M= 1269	24MAR9 M= 881	31MAR9 M= 203	07APR97 M= 49	TOTAL M= 12794
10FEB97	507	R	0	2	0	0	0	0	0	0	1	0	1	0	0	2	0									6
		R/M	0.00000	0.00862	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00142	0.00000	0.00186	0.00000	0.00000	0.00261	0.00000									0.00047
		R/C	0.00000	0.00394	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00197	0.00000	0.00197	0.00000	0.00000	0.00394	0.00000									0.01183
17FEB97	1150	R	0	1	0	0	0	0	0	0	0	0	0	0	1	1	2	0								5
		R/M	0.00000	0.00431	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00137	0.00130	0.00418	0.00000								0.00039
		R/C	0.00000	0.00087	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00087	0.00087	0.00174	0.00000								0.00435
24FEB97	1117	R	1	0	0	0	0	0	0	0	1	0	0	1	3	2	2	1	3							14
		R/M	0.00230	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00142	0.00000	0.00000	0.00115	0.00412	0.00261	0.00418	0.00091	0.00281							0.00109
		R/C	0.00090	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00090	0.00000	0.00000	0.00090	0.00269	0.00179	0.00179	0.00090	0.00269							0.01253
03MAR97	907	R	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	2	2	2						10
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00142	0.00000	0.00000	0.00000	0.00275	0.00000	0.00209	0.00182	0.00188	0.00227						0.00078
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00110	0.00000	0.00000	0.00000	0.00221	0.00000	0.00110	0.00221	0.00221	0.00221						0.01103
10MAR97	863	R	0	0	0	0	2	0	0	0	1	0	1	3	2	1	0	0	1	1	2					14
		R/M	0.00000	0.00000	0.00000	0.00000	0.00406	0.00000	0.00000	0.00000	0.00142	0.00000	0.00186	0.00345	0.00275	0.00130	0.00000	0.00000	0.00094	0.00114	0.00244					0.00109
		R/C	0.00000	0.00000	0.00000	0.00000	0.00232	0.00000	0.00000	0.00000	0.00116	0.00000	0.00116	0.00348	0.00232	0.00116	0.00000	0.00000	0.00116	0.00116	0.00232					0.01622
17MAR97	1335	R	0	0	0	0	0	0	0	0	1	1	1	2	1	1	1	0	1	3	2	8				22
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00142	0.00345	0.00186	0.00230	0.00137	0.00130	0.00209	0.00000	0.00094	0.00341	0.00244	0.00630				0.00172
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00075	0.00075	0.00075	0.00150	0.00075	0.00075	0.00075	0.00000	0.00075	0.00225	0.00150	0.00599				0.01648
24MAR97	952	R	0	0	0	0	0	2	0	0	0	0	0	1	0	0	1	2	1	2	1	1	0			11
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00619	0.00000	0.00000	0.00000	0.00000	0.00000	0.00115	0.00000	0.00000	0.00209	0.00182	0.00094	0.00227	0.00122	0.00079	0.00000			0.00086
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00210	0.00000	0.00000	0.00000	0.00000	0.00000	0.00105	0.00000	0.00000	0.00105	0.00210	0.00105	0.00210	0.00105	0.00105	0.00000			0.01155
31MAR97	219	R	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	1		5
		R/M	0.00000	0.00000	0.00000	0.00000	0.00203	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00188	0.00000	0.00122	0.00000	0.00000	0.00493		0.00039
		R/C	0.00000	0.00000	0.00000	0.00000	0.00457	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00913	0.00000	0.00457	0.00000	0.00000	0.00457		0.02283
07APR97	58	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		R/M	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		R/C	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TOTAL	13492	R	9	6	3	2	7	4	1	3	10	2	3	9	11	10	7	5	10	8	6	9	0	1	0	126
		R/M	0.02074	0.02586	0.02400	0.01493	0.01420	0.01238	0.00787	0.01042	0.01425	0.00690	0.00558	0.01036	0.01511	0.01304	0.01464	0.00455	0.00938	0.00909	0.00733	0.00709	0.00000	0.00493	0.00000	0.00985
		R/C	0.00067	0.00044	0.00022	0.00015	0.00052	0.00030	0.00007	0.00022	0.00074	0.00015	0.00022	0.00067	0.00082	0.00074	0.00052	0.00037	0.00074	0.00059	0.00044	0.00067	0.00000	0.00007	0.00000	0.00934

R = NUMBER OF STRIPED BASS RECAPTURED
M = NUMBER OF STRIPED BASS _ 150 MM MARKED AND RELEASED
C = NUMBER OF STRIPED BASS _ 150 MM COLLECTED AND EXAMINED FOR TAGS
R/M = RECAPTURE RATE
R/C = RECAPTURE PROPORTION

APPENDIX TABLE D-6. INTERMEDIATE COMPUTATIONAL DATA USED IN THE CALCULATION OF A SCHUMACHER-ESCHMEYER POPULATION ESTIMATE OF THE STRIPED BASS POPULATION SIZE IN THE COMBINED UPPER HARBOR AND BATTERY REGIONS OF THE HUDSON RIVER, WINTER 1996-97.

SAMPLING WEEK	(· 150 MM TL) C TOTAL	(· 150 MM TL) M TOTAL	CUM M TOTAL	R TOTAL	R/C	Ct*Cumm Mt	Cumm Mt*Rt	Ct*(Cumm Mt)2	Rt2/Ct
06JAN97	302	290	0	0	0.00000	0	0	0	0.00000
13JAN97	581	538	290	1	0.00172	168,490	290	48,862,100	0.00172
20JAN97	930	869	828	0	0.00000	770,040	0	637,593,120	0.00000
27JAN97	790	728	1697	0	0.00000	1,340,630	0	2,275,049,110	0.00000
03FEB97	816	767	2425	3	0.00368	1,978,800	7275	4,798,590,000	0.01103
10FEB97	507	478	3192	3	0.00592	1,618,344	9576	5,165,754,048	0.01775
17FEB97	1150	1100	3670	4	0.00348	4,220,500	14680	15,489,235,000	0.01391
24FEB97	1117	1066	4770	9	0.00806	5,328,090	42930	25,414,989,300	0.07252
03MAR97	907	880	5836	7	0.00772	5,293 252	40852	30,891 418 672	0.05402
10MAR97	863	818	6716	9	0.01043	5,795,908	60444	38,925,318,128	0.09386
17MAR97	1335	1269	7534	13	0.00974	10,057,890	97942	75,776,143,260	0.12659
24MAR97	952	881	8803	9	0.00945	8,380,456	79227	73,773,154,168	0.08508
31MAR97	219	203	9684	3	0.01370	2,120,796	29052	20,537,788,464	0.04110
TOTAL	10,469		55,445	61	0.07389	47,073,196	382,268	293,733,895,370	0.51759

APPENDIX TABLE D-7. ANALYSIS OF VARIANCE FOR THE UNWEIGHTED REGRESSION OF WEEKLY RECAPTURE PROPORTION (R/C) AGAINST THE WEEKLY CUMULATIVE NUMBER OF STRIPED BASS TAGGED AND RELEASED (M) IN THE HUDSON RIVER, WINTER 1996-97.

SOURCE	DF	SS	MS	F-RATIO	p > F
MODEL	1	0.00022	0.000225	102.71	<0.0001
ERROR	11	0.00003	0.000002		
TOTAL	12	0.00025			

REGRESSION EQUATION: R/C = (CUMULATIVE M) X + ERROR

WHERE,

X = 0.0000013 (STANDARD ERROR OF X = 0.00000013)

p > F = PROBABILITY OF OBTAINING A LARGER F-RATIO
df = DEGREES OF FREEDOM
SS = SUM OF SQUARES
MS = MEAN SQUARE

APPENDIX TABLE D-8. TAG TYPE AND NUMBER OF STRIPED BASS TAGGED AND RELEASED DURING THE HUDSON RIVER STRIPED BASS PROGRAM, 1984 TO PRESENT.

PROGRAM YEAR	NUMBER TAGGED	TAG TYPE					
		ANCHOR	INTERNAL ANCHOR (FLOY)	INTERNAL ANCHOR W/TUBE (FLOY)	INTERNAL ANCHOR (HALL)	MODIFIED INTERNAL ANCHOR (HALL)	SMALL DART (HALL)
1984	737	737	737	--	--	--	--
1985-1986	18,448	--	18,448	--	--	--	--
1986-1987	9,473	--	7,258	2,215	--	--	--
1987-1988	12,433	--	1,598	2,360	8,475	--	--
1988-1989	24,393	--	--	--	7,927	16,466	819
1989-1990	24,362	--	--	--	--	24,362	659
1990-1991	22,406	--	--	--	--	22,406	--
1991-1992	24,307	--	--	--	--	24,307	--
1992-1993	21,746	--	--	--	--	21,746	--
1993-1994	18,310	--	--	--	--	18,310	--
1994-1995	6,838	--	--	--	--	6,838	--
1995-1996	11,015	--	--	--	--	11,015	--
1996-1997	13,011	--	--	--	--	13,011	--
TOTAL	207,479	737	28,041	4,575	16,402	158,461	1,478

NOTE: HALL = HALLPRINT.

PROGRAM YEAR(S):

1988-1989 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1989-1990 SMALL DART TAGS NOT INCLUDED IN ROW TOTAL BECAUSE STRIPED BASS WERE DOUBLE TAGGED.
1991-1992 TOTAL INCLUDES 23,514 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 793 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1992-1993 TOTAL INCLUDES 20,847 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 899 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1993-1994 TOTAL INCLUDES 17,500 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 810 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1995-1996 TOTAL INCLUDES 10,889 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 126 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).
1996-1997 TOTAL INCLUDES 12,794 FISH TAGGED AND RELEASED IN GOOD CONDITION (REL_REC=1) AND 217 TAGGED AND RELEASED WITH EXTERNAL ANOMALIES (REL_REC=6).

APPENDIX TABLE D-9. DESCRIPTION OF THE DIFFERENT TYPES OF INTERNAL ANCHOR EXTERNAL STREAMER TAGS AND REWARD VALUES FOR STRIPED BASS COLLECTED, TAGGED AND RELEAED DURING THE 1996-97 STRIPED BASS EVALUATION PROGRAM.

TAG	ANCHOR	STREAMER	REWARD VALUE	NUMBER OF FISH TAGGED AND RELEASED
HALLPRINT INTERNAL ANCHOR	SMALL, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	9060
HALLPRINT INTERNAL ANCHOR	LARGE, YELLOW LEGEND	YELLOW POLYPROPYLENE WITH COVERED FILAMENT	\$5-\$1000	3951
TOTAL				13,011

NOTE: STRIPED BASS ≥ 150 MM TL < 300 MM TL WERE TAGGED WITH SMALL ANCHOR (20 MM) TAGS AND RELEASED.

STRIPED BASS ≥ 300 MM TL WERE TAGGED WITH LARGE ANCHOR (25 MM) TAGS AND RELEASED.

APPENDIX E

STRIPED BASS BIOCHARACTERISTICS AND FOOD HABITS

E.1.0 INTRODUCTION

Striped bass that died during collection and tagging operations conducted during the 1996-97 program were returned to the laboratory and examined in fresh condition to determine length, weight, sex and food habits. This laboratory program gathered incidental data on striped bass biocharacteristics and food habits without sacrificing fish specifically for those observations. Similar biocharacteristic data were obtained during the 1985-86 through 1995-96 programs (NAI 1986, 1987, 1988, 1990, 1991, 1992, 1994, 1995a, 1995b; LMS 1995, 1996). Analysis of striped bass food habits was initiated in 1985-86 at the request of the New York State Department of Environmental Conservation (letter from Horn to Dunning dated 7 November 1985), specifically to determine the predominance of Atlantic tomcod as a winter food item for striped bass. Merriman (1941) observed Atlantic tomcod to be rare in the diet of Hudson River striped bass during the spring, but striped bass with tomcod present in their stomachs were found to consume tomcod approximately 50% of their body length (200mm tomcod).

E.2.0 LABORATORY METHODS

E.2.1 Length, Weight, Sex and Sexual Condition of Striped Bass

Length, weight, sex and sexual condition were determined for 93 striped bass that died during field sample processing. Total length was measured to the nearest mm. Total weight was measured to the nearest 100.0 g for fish greater that 10 kg. Sex and sexual condition were determined through examination of the gonads using the criteria in Table E-1.

E.2.2 Striped Bass Stomach Contents Analysis

Striped bass that were processed as described above in Section E.2.1 were also examined for stomach contents. Stomachs were excised from fresh striped bass and analyzed within 24 hours after they were received in the laboratory. The presence of invertebrates and vertebrates in the stomach was determined. If vertebrates were present, it was determined if they were fish, and if so, if they were Atlantic tomcod. The presence of bony structures (vertebrae) was used to separate fish and invertebrate remains in the striped bass stomach contents. Atlantic tomcod were

APPENDIX TABLE E-1. CRITERIA FOR DETERMINING SEX AND STATE OF MATURITY OF STRIPED BASS

SEXUAL CONDITION	FEMALES	MALES
GRAVID OR MILTING (RIPE)	OVARIES FULL OF YELLOWISH GRANULAR EGGS THAT ARE PARTIALLY TRANSLUCENT. EGGS CAN BE RELEASED WHEN OVARY IS COMPRESSED.	TESTES WHIRE, LESS FIRM IN TEXTURE, AND IF COMPRESSED WILL READILY MILT.
RIPE AND RUNNING	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF EGGS WITH LITTLE PROVOCATION.	ADULT PREPARED TO SPAWN IMMEDIATELY; EXPULSION OF MILT WITH LITTLE PROVOCATION.
PARTIALLY SPENT	OVARIES SOMEWHAT FLACCID AND CONVOLUTED, WITH A VARIABLE NUMBER OF EGGS LEFT. OVARIAN MEMBRANE SOMEWHAT WASCULAR.	TESTES WHITISH, SOMEWHAT FLACCID AND CONVOLUTED, WITH FREE FLOW OF MILT.
SPENT	OVARIES FLACCID, FEW TRANSLUCENT EGGS LEFT. OVARIAN MEMBRANE VERY VASCULAR OR SAC LIKE.	TESTES BROWNISH WHITE, FLACCID, CONVOLUTED WITH NO FLOW OF MILT UPON COMPRESSION.
IMMATURE	OVARIES VERY SMALL AND STRING-LIKE, THICKER THAN TESTES, SOMEWHAT OPAQUE AND GELATINOUS IN APPEARANCE.	TESTES VERY SMALL AND STRINGLIKE, THINNER THAN OVARIES, SOMEWHAT TRANSLUCENT, AND EXTREMELY TENDER.
NOT GRAVID OR NOT MILTING (RESTING)	UNDERDEVLOPED OVARIES IN AN ADULT FEMALE. OVARIES LARGER, MORE FIRM, OPAQUE, AND RELATIVELY THICK. NO EGGS DISCERNIBLE TO NAKED EYE.	UNDERDEVELOPED TESTES IN AN ADULT MALE. TESTES LARGER MORE FIRM, OPAQUE, BUT STILL TENDER.
SEMI-GRAVID OR SEMI-MILTING (DEVELOPING)	SUBRIPE FEAMLES HEADING INTO SPAWNING SEASON. OVARIES CONSIDERABLY LARGER, YELLOW, GRANULAR IN CONSISTENCY. EGGS DISCERNIBLE TO NAKED EYE, BUT NOT READILY RELEASED WHEN OVARY IS COMPRESSED.	SUBRIPE MALES HEADING INTO SPAWNING SEASON. TESTES CONSIDERABLY LARGER, WHITE, FIRM IN TEXTURE, BUT MILT NOT RUNNING.

differentiated from other fish species by comparing vertebral shape from fish specimens in the stomach contents to stained and cleared specimens of Atlantic tomcod.

E.3.0 RESULTS AND DISCUSSION

E.3.1 Striped bass Sexual Condition

A total of 52 male and 133 female striped bass were returned to the laboratory for biocharacteristic analysis. The majority of striped of both male and female striped bass were immature. Approximately 81% of the male striped bass analyzed were immature, with the remainder resting. Female striped bass examined were also either immature (98%) or resting (2%) (Table E-2).

The lack of ripe, or ripe and running striped bass in the 1996-97 biocharacteristic sample agrees with the findings of the 1985-86 through 1995-96 programs (Table E-3 and E-4). Historically, the majority of male fish from previous programs were considered immature or resting, with the remainder in the developing stage. Immature fish also made up the majority of female striped bass included in biocharacteristic samples. Only three female fish in the developing stage have been examined during the course of the program. No ripe, or ripe and running females have been examined. The lack of ripe or ripe and running striped bass is not surprising because the majority of the fish collected are of pre-spawning size (< 400 mm) and the program terminates before the onset of peak spawning (NAI 1986; TI 1981).

E.3.1 Striped Bass Food Habits

Food habits of striped bass that died during field sample collection were determined for all fish returned to the laboratory for biocharacteristic analysis. Stomach contents were identified as invertebrates, vertebrates, or Atlantic tomcod. The presence of Atlantic tomcod in striped bass stomachs was of specific interest, because both striped bass and Atlantic tomcod are present in the Hudson River Estuary during the winter months.

No Atlantic tomcod were observed in any of the striped bass stomachs examined. The majority of stomachs examined were empty (65%) or contained invertebrates (29%) (Table E-5). The majority of invertebrates found were amphipods, with some shrimp (*Paleomentes* sp.) also present. Most striped bass stomachs examined during the course of the program have been empty (52%)

APPENDIX TABLE E-2. SEXUAL CONDITION OF STRIPED BASS EXAMINED FROM FISH THAT DIED DURING COLLECTION IN THE 1996-97 HUDSON RIVER STRIPED BASS STOCK ASSESSMENT PROGRAM.

	PERCENTAGE AND NUMBER OF STRIPED BASS									
	MALE					FEMALE				
	IMMATURE		RESTING		TOTAL	IMMATURE		RESTING		TOTAL
MONTH	%	N	%	N	N	%	N	%	N	N
NOVEMBER	--	--	100.0	1	1	--	--	--	--	--
DECEMBER	83.3	10	16.7	2	12	93.3	14	6.7	1	15
JANUARY	68.4	13	31.6	6	19	95.0	38	5.0	2	40
FEBRUARY	93.3	14	6.7	1	15	100.0	54	--	--	54
MARCH	100.0	5	--	--	5	100.0	24	--	--	24
APRIL	--	--	--	--	--	--	--	--	--	--
TOTAL	80.8	42	19.2	10	52	97.7	130	2.3	3	133

APPENDIX TABLE E-3. LENGTH, WEIGHT, SEXUAL CONDITION AND FOOD HABITS OF HUDSON RIVER STRIPED BASS THAT DIED DURING THE 1996-97 HUDSON RIVER STRIPED BASS HATCHERY EVALUATION/MONITORING PROGRAM

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
150	30	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
152	30	04MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
154	28	28MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
156	36	31JAN97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
159	43	31JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
160	34	20FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
161	35	28FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
161	37	24JAN97	BATTERY	2	MALE	IMMATURE	EMPTY
162	35	21FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
162	35	21JAN97	BATTERY	10	MALE	IMMATURE	EMPTY
162	37	30JAN97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
163	40	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
163	41	26FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
164	35	05FEB97	BATTERY	2	FEMALE	IMMATURE	EMPTY
164	44	09DEC96	UPPER HARBOR	-2	MALE	IMMATURE	BOTH
168	40	23DEC96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
168	42	03JAN97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
168	43	31JAN97	BATTERY	2	MALE	IMMATURE	EMPTY
168	44	30JAN97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
170	44	28MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
170	46	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
170	47	22FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
171	41	03FEB97	BATTERY	6	MALE	IMMATURE	EMPTY
171	44	28JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	42	19FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	42	12MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	46	28JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	46	19FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
172	48	22JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
174	44	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
175	52	25FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
176	46	27MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
177	48	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
177	49	17JAN97	BATTERY	2	MALE	IMMATURE	EMPTY
177	49	09DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
178	53	24JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
178	54	22JAN97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
179	50	22FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
179	52	11MAR97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
180	51	03FEB97	BATTERY	6	FEMALE	IMMATURE	EMPTY
181	59	30DEC96	BATTERY	6	MALE	IMMATURE	EMPTY
182	58	05MAR97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
183	55	25FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
184	56	03FEB97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
185	53	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
185	61	21JAN97	BATTERY	10	MALE	IMMATURE	EMPTY
186	52	22FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
186	60	30JAN97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
186	62	11DEC96	UPPER HARBOR	-2	MALE	IMMATURE	BOTH
187	52	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY

(CONTINUED)

APPENDIX TABLE E-3. (CONTINUED)

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
187	60	12FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
187	61	17JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
188	48	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
188	60	12FEB97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
188	62	20JAN97	BATTERY	6	FEMALE	IMMATURE	EMPTY
189	67	17JAN97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
190	52	30DEC96	BATTERY	6	FEMALE	IMMATURE	EMPTY
190	69	27JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
191	61	20MAR97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
191	63	20JAN97	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
192	59	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
194	74	20JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
195	66	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
195	68	03FEB97	BATTERY	2	FEMALE	IMMATURE	EMPTY
196	63	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
196	66	04FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
196	68	03JAN97	BATTERY	2	MALE	IMMATURE	EMPTY
197	68	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
197	68	05MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
197	71	30DEC96	BATTERY	6	FEMALE	IMMATURE	EMPTY
197	71	03FEB97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
198	68	03JAN97	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
198	70	03JAN97	UPPER HARBOR	-2	FEMALE	IMMATURE	EMPTY
198	75	20FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
199	69	23DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
199	73	03JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
199	74	05FEB97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
199	79	03JAN97	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
200	63	14FEB97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
200	71	03JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
201	69	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
202	71	03JAN97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
203	75	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
205	76	06FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
206	79	28FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
206	89	02JAN97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
210	76	19FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
211	83	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
211	92	17JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
212	89	03FEB97	BATTERY	6	FEMALE	IMMATURE	INVERTBRATES
213	87	27DEC96	BATTERY	3	FEMALE	IMMATURE	INVERTBRATES
215	76	20FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
215	91	20FEB97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
215	96	03JAN97	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
216	87	20FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
217	89	17JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
218	83	19FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
218	85	05FEB97	BATTERY	2	FEMALE	IMMATURE	EMPTY
218	98	30JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
219	95	03JAN97	UPPER HARBOR	-2	FEMALE	IMMATURE	EMPTY

(CONTINUED)

APPENDIX TABLE E-3. (CONTINUED)

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
221	105	20FEB97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
225	108	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
226	108	05FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
227	104	05FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
227	106	06FEB97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
228	120	25FEB97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
228	145	16JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
230	112	26FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
231	112	23DEC96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
232	113	27DEC96	BATTERY	3	MALE	IMMATURE	EMPTY
234	116	23DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
235	128	26FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
240	112	28MAR97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
240	132	28MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
243	128	20MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
243	134	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
245	143	27DEC96	BATTERY	3	MALE	IMMATURE	INVERTBRATES
245	148	27MAR97	BATTERY	6	FEMALE	IMMATURE	EMPTY
246	135	21FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
249	141	11FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
249	148	26FEB97	BATTERY	10	MALE	IMMATURE	EMPTY
250	154	09DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	BOTH
250	161	21JAN97	BATTERY	10	MALE	IMMATURE	INVERTBRATES
255	157	20MAR97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
255	158	10DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	BOTH
261	171	27DEC96	BATTERY	3	FEMALE	IMMATURE	INVERTBRATES
262	158	24JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
262	175	27MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
264	169	10DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	BOTH
264	170	11MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
265	176	26FEB97	BATTERY	10	MALE	IMMATURE	BOTH
266	172	05FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
266	189	28MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
267	181	18MAR97	BATTERY	2	MALE	IMMATURE	EMPTY
268	180	10DEC96	UPPER HARBOR	-2	MALE	IMMATURE	BOTH
268	191	12FEB97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
269	188	06FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
270	193	23DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	BOTH
270	206	04FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
271	221	03FEB97	BATTERY	6	FEMALE	IMMATURE	EMPTY
273	182	03FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
273	182	20MAR97	BATTERY	2	MALE	IMMATURE	INVERTBRATES
273	201	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
274	198	17MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
276	192	20MAR97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
278	204	28MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
278	208	23DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	BOTH
280	205	26MAR97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
280	566	23JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
282	243	11DEC96	UPPER HARBOR	-2	MALE	IMMATURE	BOTH

(CONTINUED)

APPENDIX TABLE E-3. (CONTINUED)

TOTAL LENGTH (mm)	WEIGHT (g)	DATE	STATION	RIVER MILE	SEX	SEXUAL CONDITION	STOMACH CONTENT
282	254	06FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
283	2104	16DEC96	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
284	215	10MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
286	198	20MAR97	BATTERY	2	FEMALE	IMMATURE	EMPTY
287	230	10DEC96	UPPER HARBOR	-2	MALE	IMMATURE	INVERTBRATES
290	239	27MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
291	218	03JAN97	UPPER HARBOR	-2	FEMALE	IMMATURE	INVERTBRATES
292	231	11DEC96	UPPER HARBOR	-2	MALE	RESTING	INVERTBRATES
295	234	31JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
298	265	06FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
298	286	03FEB97	BATTERY	6	MALE	RESTING	INVERTBRATES
299	260	03FEB97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
300	254	17JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
300	258	25FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
302	253	10MAR97	BATTERY	10	FEMALE	IMMATURE	INVERTBRATES
302	286	27DEC96	BATTERY	3	MALE	RESTING	EMPTY
309	311	09DEC96	UPPER HARBOR	-2	FEMALE	RESTING	INVERTBRATES
310	271	15NOV96	UPPER HARBOR	-2	MALE	RESTING	INVERTBRATES
310	280	23JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
311	268	28MAR97	BATTERY	2	FEMALE	IMMATURE	INVERTBRATES
315	264	26MAR97	BATTERY	10	FEMALE	IMMATURE	EMPTY
317	323	02JAN97	BATTERY	2	FEMALE	IMMATURE	EMPTY
317	324	02JAN97	BATTERY	2	MALE	RESTING	INVERTBRATES
333	363	17JAN97	BATTERY	2	MALE	RESTING	INVERTBRATES
347	423	04FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
348	468	17JAN97	BATTERY	2	MALE	RESTING	EMPTY
382	604	16JAN97	BATTERY	10	MALE	RESTING	EMPTY
383	608	31DEC96	BATTERY	2	FEMALE	IMMATURE	EMPTY
386	547	21JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
394	619	06FEB97	BATTERY	10	FEMALE	IMMATURE	EMPTY
405	694	17JAN97	BATTERY	2	FEMALE	RESTING	EMPTY
425	834	16JAN97	BATTERY	10	FEMALE	RESTING	INVERTBRATES
467	920	28JAN97	BATTERY	10	FEMALE	IMMATURE	EMPTY
515	1458	17JAN97	BATTERY	2	MALE	RESTING	EMPTY
738	4431	17JAN97	BATTERY	10	MALE	RESTING	BOTH

APPENDIX TABLE E-4. **SEXUAL CONDITION OF HUDSON RIVER STRIPED BASS EXAMINED FROM A SAMPLE OF FISH THAT DIED DURING THE 1985-86 THROUGH 1996-97 PROGRAMS.**

IMMATURE MALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	MONTHLY %
NOV	0	0	1	1	4	6	6	8	1	0	3	0	30	57.7
DEC	16	2	2	7	2	12	13	18	9	0	7	10	98	61.3
JAN	13	7	5	10	5	16	57	9	34	0	8	13	177	69.7
FEB	8	9	17	6	1	11	24	9	2	0	7	14	108	66.7
MAR	11	10	8	5	2	7	3	36	83	0	10	5	180	73.8
APR	12	14	0	2	2	3	27	48	69	0	4	0	181	57.6
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	60	42	33	31	16	55	130	128	198	0	39	42	774	64.7

RESTING MALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	MONTHL %
NOV	1	0	1	1	1	1	4	5	4	1	0	1	20	38.5
DEC	0	0	4	5	1	6	7	12	10	1	1	2	49	30.6
JAN	0	1	9	1	0	2	14	14	8	0	1	6	56	22.0
FEB	0	1	0	0	0	9	9	12	1	0	0	1	33	20.4
MAR	0	8	0	0	0	3	6	2	13	0	0	0	32	13.1
APR	0	45	0	0	0	2	10	4	4	0	0	0	65	20.7
MAY	5	0	0	0	0	0	0	5	0	0	0	0	10	100.0
TOTAL	6	55	14	7	2	23	50	54	40	2	2	10	265	22.2

DEVELOPING MALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	MONTHLY %
NOV	1	0	1	0	0	0	0	0	0	0	0	0	2	3.8
DEC	11	1	1	0	0	0	0	0	0	0	0	0	13	8.1
JAN	9	6	1	0	0	0	1	0	3	0	1	0	21	8.3
FEB	10	1	7	3	0	0	0	0	0	0	0	0	21	13.0
MAR	7	12	2	3	0	2	0	0	6	0	0	0	32	13.1
APR	50	2	3	0	0	1	1	0	10	0	1	0	68	21.7
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	88	22	15	6	0	3	2	0	19	0	2	0	157	13.1

DEVELOPING FEMALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	MONTHL %
NOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
DEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
JAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
FEB	0	0	0	0	0	0	0	0	1	0	0	0	1	0.4
MAR	0	0	0	0	0	0	0	0	0	0	2	0	2	1.1
APR	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	0	0	0	0	0	0	0	0	1	0	2	0	3	0.3

IMMATURE FEMALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1997 -96	TOTAL	MONTHLY %
NOV	1	0	4	1	4	1	4	11	5	0	1	0	32	97.0
DEC	28	1	4	9	3	10	13	20	17	0	9	14	128	94.8
JAN	17	3	11	9	6	8	55	32	19	0	18	38	216	93.5
FEB	9	10	18	7	3	14	29	25	3	0	6	54	178	97.8
MAR	16	16	8	9	3	13	6	46	82	0	8	24	231	96.7
APR	24	9	0	3	1	8	8	57	59	0	6	0	175	94.1
MAY	1	0	0	0	0	0	0	0	0	0	0	0	1	50.0
TOTAL	96	39	45	38	20	54	115	191	185	0	48	130	961	95.3

RESTING FEMALES

MONTH	PROGRAM 1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	MONTHL %
NOV	0	0	0	0	0	0	1	0	0	0	0	0	1	3.0
DEC	0	0	0	2	0	0	2	2	0	0	0	1	7	5.2
JAN	0	1	0	1	0	0	8	0	1	1	0	2	14	6.1
FEB	0	0	1	0	0	0	0	1	0	0	0	0	2	1.1
MAR	0	0	0	0	0	0	2	0	6	0	0	0	8	3.3
APR	0	0	0	0	0	0	8	2	1	0	0	0	11	5.9
MAY	1	0	0	0	0	0	0	0	0	0	0	0	1	50.0
TOTAL	1	1	1	3	0	0	21	5	8	1	0	3	44	4.4

APPENDIX TABLE E-5. PERCENT OF STRIPED BASS WITH INVERTEBRATE, VERTEBRATE, ATLANTIC TOMCOD REMAINS, VERTEBRATE AND INVERTEBRATE REMAINS, OR EMPTY STOMACHS, CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1996-97 MONITORING PROGRAM

	PERCENTAGE AND NUMBER OF STRIPED BASS WITH STOMACH CONTENTS										
LENGTH GROUP (mm TL)	EMPTY		INVERTEBRATES		VERTEBRATES		INVERTEBRATES & VERTEBRATES		ATLANTIC TOMCOD		TOTAL
	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	
µ 200	71.3	57	26.3	21	--	--	2.5	2	--	--	80
201-300	59.5	50	31.0	26	--	--	9.5	8	--	--	84
301-400	62.5	10	37.5	6	--	--	--	--	--	--	16
401-500	66.7	2	33.3	1	--	--	--	--	--	--	3
> 501	50.0	1	--	--	--	--	50.0	1	--	--	2
TOTAL	64.9	120	29.2	54	--	--	5.9	11	--	--	185

or contained invertebrates (36%). Only a small percentage of all stomachs examined have contained both invertebrates or vertebrates alone (7.6 and 4.6%, respectively).

Food habit data from the 1985-86 through 1996-97 programs has displayed several trends (Table E-6). Invertebrates were the dominant food item among non-empty striped bass stomachs. The dominance of invertebrates in stomach contents however decreases when striped bass reach approximately 300 mm (TL). The occurrence of empty stomach also varied with length group. The trend of increasing importance of fish as food items as striped bass length increases has been observed elsewhere (Westin and Rogers 1978; Rulifson and McKenna 1987). No Atlantic tomcod have been observed in any of the striped bass stomachs examined since 1985.

APPENDIX TABLE E-6. **FOOD HABITS OF HUDSON RIVER STRIPED BASS CROSS CLASSIFIED BY LENGTH GROUP FOR FISH THAT DIED DURING THE 1985-86 THROUGH 1995-96 PROGRAMS.**

INVERTEBRATES

PROGRAM

LENGT GROUP	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	LENGTH GROUP %
<=200	5	8	3	2	16	3	52	74	35	2	14	21	235	38.1
201-300	88	25	39	9	3	29	85	40	81	2	26	26	453	41.1
301-400	18	16	12	2	1	7	18	12	10	1	2	6	105	25.1
401-500	3	2	2	0	0	0	1	2	0	0	2	1	13	14.8
>500	1	0	1	0	0	0	0	0	0	0	1	0	3	11.1
TOTAL	115	51	57	13	20	39	156	128	126	5	45	54	809	35.9

VERTEBRATES

PROGRAM

1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	LENGT GROUP
1	0	0	1	0	0	2	3	0	0	1	0	8	1.3
4	0	0	6	0	8	13	4	2	0	2	0	39	3.5
5	1	3	8	0	8	9	3	6	0	0	0	43	10.3
3	0	1	0	0	0	2	2	1	0	0	0	9	10.2
1	0	0	0	0	0	1	2	0	0	0	0	4	14.8
14	1	4	15	0	16	27	14	9	0	3	0	103	4.6

INVERTEBRATES AND VERTEBRATES

PROGRAM

LENGT GROUP	1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	LENGTH GROUP %
<=200	1	0	0	1	0	0	2	8	0	0	0	2	14	2.3
201-300	4	3	4	2	0	8	25	11	6	0	2	8	73	6.6
301-400	8	6	3	7	2	4	21	11	5	0	1	0	68	16.3
401-500	1	3	1	2	1	1	1	3	0	0	0	0	13	14.8
>500	0	1	0	0	0	0	0	1	0	0	0	1	3	11.1
TOTAL	14	13	8	12	3	13	49	34	11	0	3	11	171	7.6

EMPTY

PROGRAM

1985 -86	1986 -87	1987 -88	1988 -89	1989 -90	1990 -91	1991 -92	1992 -93	1993 -94	1994 -95	1995 -96	1996 -97	TOTAL	LENGT GROUP
2	20	1	13	11	7	38	88	95	0	28	57	360	58.3
43	18	15	26	9	35	43	77	209	0	12	50	537	48.7
41	8	12	13	1	23	18	39	36	0	1	10	202	48.3
12	3	7	2	0	3	2	11	10	0	1	2	53	60.2
11	0	3	0	0	0	1	1	0	0	0	1	17	63.0
109	49	38	54	21	68	102	216	350	0	42	120	1169	51.9

STANDARD OPERATING PROCEDURES

OPRS Aging of Hudson River Striped Bass

January 29, 1988

BioSonics, Inc.
4520 Union Bay Place N.E.
Seattle, Washington 98105

Prepared Under Contract With:

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Bedford, New Hampshire 03102

For:

NEW YORK POWER AUTHORITY
123 Main Street
White Plains, New York 10601

Jointly financed by:
Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

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1.0 Introduction

This Standard Operating Procedure manual describes how to use the BioSonics Optical Pattern Recognition System (OPRS) to process and age scales from striped bass. The procedures presented are those developed and used by BioSonics for Objective 1 of the 1986–1987 Hudson River Striped Bass Hatchery Evaluation.

This manual covers the essential operations of the OPRS as they pertain to aging striped bass scales. For a complete description of the OPRS, including such basic operations as using the mouse to select menu items, please refer to the OPRS Data Acquisition Program Manual v. 1.08.

To age or identify fish using scales, the OPRS parameters are first set using composite samples from known fish. Scales from unknown fish can then be identified by comparison to the known samples. Setting parameters of these known samples using Fourier analysis identifies characteristic spatial harmonics which are then used for aging unknown scales.

The OPRS consists of both hardware and software:

Hardware

Microscope fitted with a video camera
Video monitor
Compaq hard disk computer with monitor
Matrox frame grabber board installed in Compaq
Digi-Pad Digitizing Pad with mouse.

Software

OPRS Data Acquisition Program v.1.08
Statgraphics v. 2.1
APL*PLUS v. 6.0
OPRS Striped Bass Pattern Recognition Program

The OPRS Data Acquisition software is organized into eight "pages," each of which deals with a specific function. The pages contain a number of windows, and each window contains a number of items. The program is operated by the sequential selection of items. Items can be selected manually using either the keyboard or the mouse. A sequence of items can also be selected automatically by running a pre-programmed macro sequence. Macros stop at steps that require user input, then automatically advance to the next step.

Each of the eight pages deals with a specific data acquisition, editing or image operator function. The pages are identified by the following abbreviations:

CON- Configuration	TR - Truss Network
SL- Single Line Luminance	MOR - Morphology
RAD- Radial Distance	FRM - Frame Operators
AGE - Age/Annuli Detection	EDT - Editing

2.0 OPRS Set-up and Configuration

2.1 Setting Up

The standard OPRS configuration is used for aging striped bass scales. The hardware and software are installed as described in Chapter 2 of the OPRS Data Acquisition Program Manual v. 1.08.

Type "Start" in response to the C:\> prompt on the computer screen, and hit the <Enter> key. The following menu appears on screen:

1) Load OPRS Data Acquisition Software
2) Load STSC APL*PLUS/PC SYSTEM
3) Load STATGRAPHICS

Type "1" and <Enter> it. This elicits the program's title page with the BioSonics logo. Hit any key to continue.

2.2 Load Configuration File

The program opens to the Configuration (CON) page. Go to the Configuration window, select Load, and enter the configuration file WNYPA.CFG, assuming this file has already been created or provided.

Although it is not necessary to load a configuration file to the run the OPRS, there are several advantages of using a configuration file: 1) all non-default parameters for a standard procedure can be set at one time; and 2) up to five macro sequences, each containing up to 15 steps, can be saved and re-loaded at once.

For the Hudson River striped bass studies, BioSonics created the configuration file WNYPA.CFG that sets the initial system parameters for not only the aging study, but also the hatchery vs. wild and Hudson vs. non-Hudson studies. This file is provided on disk and documented below. Once the configuration file has been loaded, the individual items may be manually or automatically changed without affecting the contents of the configuration file.

IMPORTANT: If loading the WNYPA.CFG file created by BioSonics onto a system other than the same one on which it was created, it's important that the lens calibration rulers be re-established using a micrometer slide and the same microscope that will be used for the application at hand. To do this, load the WNYPA.CFG file from BioSonics, go directly to the Lens Calibration window, and re-establish the calibration rulers following the procedure described in Section 2.3 of this manual. Then go directly to the Configuration window, select Save, and re-enter the file name WNYPA.CFG.

OPRS Parameters set by WNYPA.CFG

All items (parameters) that are set by the WNYPA.CFG configuration file are listed here even though some of these are simply the system default values. Macros 2-5 and the items listed under the MOR, AGE and EDT pages are not utilized for aging striped bass scales as described in this manual. This is a complete list of all items or windows that are saved to a configuration file.

CON page:

Macro Sequence: Macros 1-5 (see Section 2.4 for macro 1 documentation)
Channel window: 2
Overlay window: Red
Video window: NTSC (USA), External Sync
Smoothing (RAD) window: 0,0,1,3,4,6,8,4,3,1,0,0; Hys: 15
Lens Calibration window:

1. 1.00000 E-03 2X
2. ....
3. ....
4. ....
5. ....

Directories and Pathnames
Data Directory: \VIDEO\DIGDAT
Image Directory: \VIDEO\IMAGE
Data File Extension: <filename>.agl

SL, RAD, AGE, MOR, TR pages:

Amplification window: Gain =31, Offset =31
(These values are arbitrary since the macros apply automatic amplification to adjust image quality.)

File window:
File: SLL01.agl
SampID: 1-01-401
SpecID: 1-b
Other: 275
(All of these values must be manually changed before saving a data record to file.)

MOR page:

Shape Measurement subwindow: Grad = 3.500E-001
FD1 and FD2 subwindows: FD Size = 128.

AGE page:

Smoothing (AGE) window: 0,0,0,0,1,3,5,3,1,0,0,0,0; Hys. = 15.

FRM page:

Input Lookup Table: Normal ramp
Output Lookup Table: Normal ramp

EDT page:

Input & Output file window: Output Data File = \DEV\CON

2.3 Lens Calibration Ruler

The lens calibration values contained in the WNYPA.CFG configuration file provided were entered using an OPRS system at BioSonics. If using a different system, the lens calibration values should be re-established using the following procedure.

For collecting single line luminance data on striped bass scales (macro 1) it's only necessary to recalibrate the 2X objective (line 3 in Lens Calibration window). It is important that the length of the ruler line is known exactly. BioSonics used a 1.0 mm Olympus B-0550 micrometer when calibrating the 2X objective.

Place an appropriate micrometer slide on the microscope stage, rotate the 2X objective into place, and focus the image. Select the numeric value on the third line directly under the Ruler (m) item. Upon selection, the current value becomes highlighted and a mouse-controlled arrow appears on appears on the image. You can now draw a calibration ruler line on the image.

First, position the arrow at one end of an object of known length and click the red mouse key once. This creates a cross (+) at that point and a variable line between the cross and the arrow. Now position the arrow at the other endpoint of the known length, and click the red key again to complete the ruler line. The prompt "Enter ruler length in meters" now appears at the top of the computer screen. The number entered defines the length of the line just drawn. Numbers may be entered in either decimal or exponential (E) format. If using the latter, do not insert blank spaces before or after the E.

2.4 Programming Macro Sequence 1

This section of the manual describes how to program macro 1 for collecting SL data on striped bass scales. Since this macro is already contained in the configuration file SBDA.CFG provided by BioSonics, you can skip this section if you load this file directly. To run macro 1 to collect SL data, see Section 4.0.

To program a macro sequence, the microscope and video camera should be on, but it isn't necessary that there be an image on the screen.

To program macro 1 to collect SL data on striped bass scales:

1. Go to Macro Sequence window on the SL page and select Learn Macro 1.

2. Go to Lens Calibration window and select number 3 on the left.

   A lens calibration ruler for a 2X lens objective should also be entered on this line *either before or after* programming the macro, then saved to the WNYPA.CFG configuration file. Do not select the ruler length item when programming the macro or else you will be asked to recalibrate the lens every time you run the macro.

3. Go to the Run window and select Acquire.

4. Go to the File window, select SampID and enter any letter/number combination of up to 8 characters.

5. Select SpecID and enter any letter/number combination.

6. Select Other and enter any letter/number combination.

7. Go to the Run window, select Reference, and draw any reference line following on-screen instructions. Note that a double arrow (>>) now indicates that the reference line is "toggled on."

8. Select Draw Line and draw any line following on-screen instructions.

9. Go to Amplification window, select Automatic and wait for the machine to finish adjusting Gain and Offset.

10. Select Reference to "toggle off" this item. Do not attempt to draw another reference line.

11. Go to Run window and select Acquire. This is the last step in the macro.

12. Go back to the Macro Sequence window and select End of Sequence. The macro is now programmed.

13. Note that Save to File has not been included in the macro sequence. Because of the potential for human error, saving data to file should always be a manually executed step. When collecting SL data using the above macro, Save to File is usually selected immediately after the macro is completed

14. To save the macro to a configuration file, go to the Configuration window on the CON page, select Save and enter a configuration file name. However, before saving to a configuration file, check all relevant items in other windows and pages, including the lens calibration ruler, because these items will be saved too. The items that can be saved to a configuration file are listed in Section 2.2.

2.5 Prepare Data Files

Establish a nomenclature system for the data files so that they can be easily and logically accessed by the post-processing programs. For collecting SL data on Hudson River striped bass scales BioSonics used the following system:

SLL0.HG0 - Age 0+, hatchery fish
SLL0.WG0 - Age 0+, wild fish
SLL01.AG1 - Age 1+ fish, hatchery and wild
SLL02.AG2 - Age 2+ fish, hatchery and wild
SLL03.AG3 - Age 3+ fish, hatchery and wild

For the unknown scale impressions used to test the system under task 4 of objective 1, there was only one data file:

SLL0X.IMX

Individual data records within these files were identified by the text identifiers listed in the File window. The following identifiers were used:

SampID: *aaa-bb-xccc*

aaa = river location
 hr = Hudson River
 hr1 = region 1
 hr2 = region 2
bb = month scale collected
 01 = January.....12 = December

x = hatchery (h) or wild (w)

ccc = slide ID number (provided by NAI)

SpecID: *d–e*

d = scale number counting from slide label
 1 = scale closest to label

e = scale quality
 a,b,c,d,e where a is highest quality and e is unuseable.
 See Section 3.1 for full explanation.

Other: *ff* = total fish length in mm.

3.0 Selecting a Scale

The procedure described below follows that used by BioSonics to select and grade striped bass scales provided to BioSonics by Normandeau Associates Inc. (NAI) in spring 1987. The procedure assumes that each slide contains several scales, or acetate impressions of scales, from the same fish.

Rotate the 2X microscope objective into place. Place a slide containing the scales (or impressions) on the microscope stage with the label facing up and towards the left. Adjust the microscope's light source (power and condenser iris) to optimize image quality. Although the exact settings of the light source are not critical for the subsequent analysis, they should be reasonably consistent.

Examine each of the scales on the slide and select the best one according to the criteria outlined below. Rotate the video camera so that the ctenni of the scale are pointing straight up on the video monitor and focus the image.

Do not change the magnification. For aging scales based on Fourier analysis of single line luminance data, it's important that all scales are read at the same magnification.

For aging striped bass scales, it was decided that SL data should be collected along a line where the widely-spaced circuli are well-defined. In general, this line ran from the focus to the edge of the scale along the scale's dorsal-ventral axis (Figure 1). To standardize data collection as much as possible, it was decided to draw the SL data line at 30° from a reference line drawn through the "transition zone" between the widely-spaced circuli (dorsal lateral field) and closely-spaced circuli (anterior field). This method was chosen because this transition zone is a convenient scale feature that can be consistently and reliably identified across all age groups.

This process requires two subjective decisions by the operator:

1. Choosing the highest quality scale on the slide (Section 3.1).
2. Determining where to draw the reference line through the transition zone (Section 3.2).

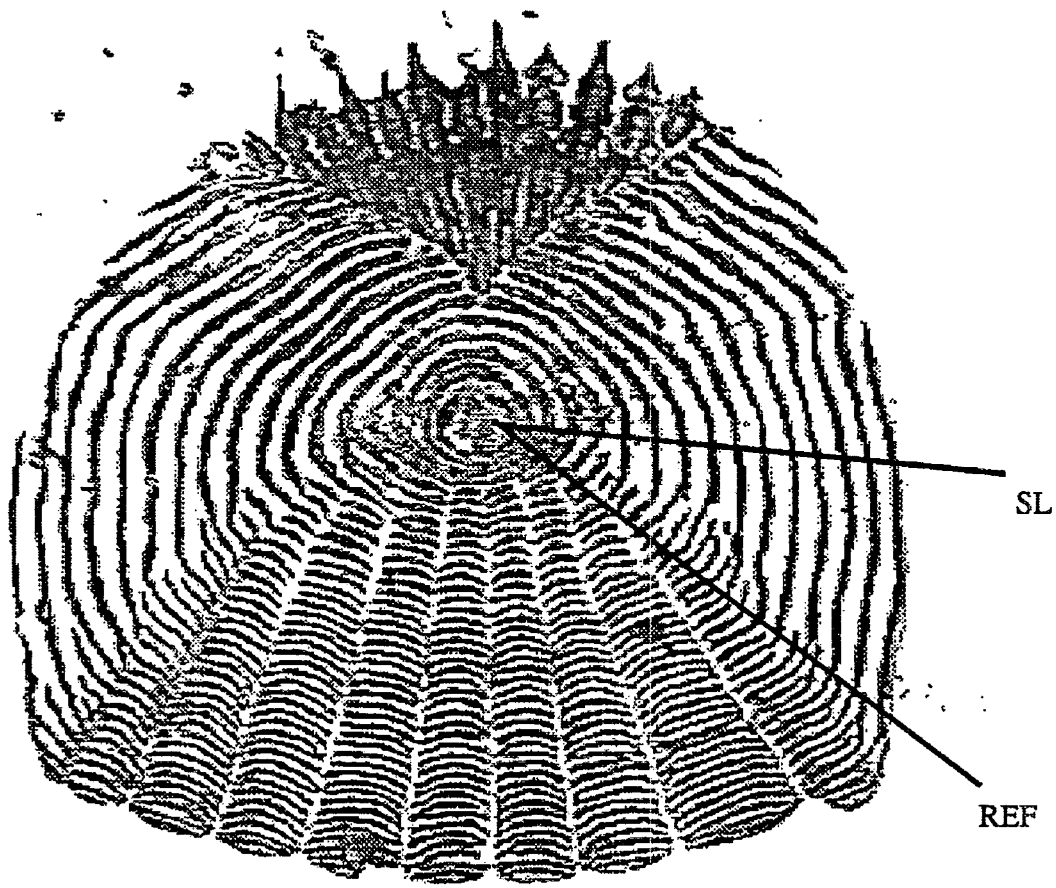


Figure 1. Hudson River Striped Bass scale (Age 0+, quality b) showing luminance extraction line (SL) and reference line (REF).

3.1 Scale Quality

For the striped bass study, the operator graded the quality of the scales and scale impressions as follows. The video camera is rotated so that the scales ctenni are pointed upward. Examples of quality b, c and d scales are shown in Figures 2 and 3.

a – Virtually perfect left/right (dorsal/ventral) symmetry of the widely spaced circuli. Whole scale appears bright, sharp and clean with no spots, smudges or excessive darkness in the ventral-lateral field.

b – Almost symmetrical (left/right). No spotting, smudges or excessive darkness in the widely-spaced circuli on the right. All widely spaced circuli can be clearly distinguished visually.

c - Clearly asymmetrical, but otherwise in good condition as described for (b) above. This description applied mostly to scales, and less so to impressions.

or

Almost symmetrical, but area of widely-spaced circuli on right contains spots, smudges or excessive darkness, resulting in poor definition of some circuli. This description applied mostly to impressions, and less so to scales.

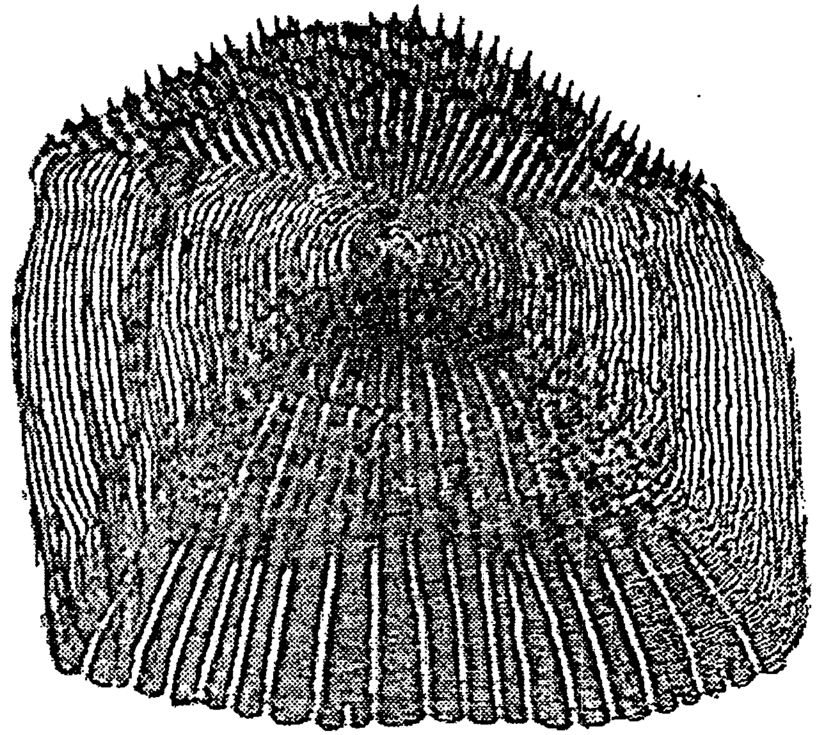
d – Very severely asymmetrical and/or widely spaced circuli on right poorly defined due to spots, smudges or excessive darkness.

e – Unusable. Squashed appearance, especially prevalent with impressions.

For the striped bass study, all scales (or impressions) were rated b, c or d. Few scales were rated a-quality. Although e–quality scales were found, it was always possible to find a better specimen on the same slide. In general, scale impressions were judged to be of lower quality than actual scales. The quality ratings were appended to the data records using the SpecID identifier as described in the previous section.

The operator always chose the highest quality scale (or impression) on the slide. In the event that two or more scales were judged to be of the same quality, the operator chose the one with the most clearly defined transition from the widely-spaced to closely-spaced circuli. As described in the next section, the reference line was drawn through this transition.

Quality b



Quality c

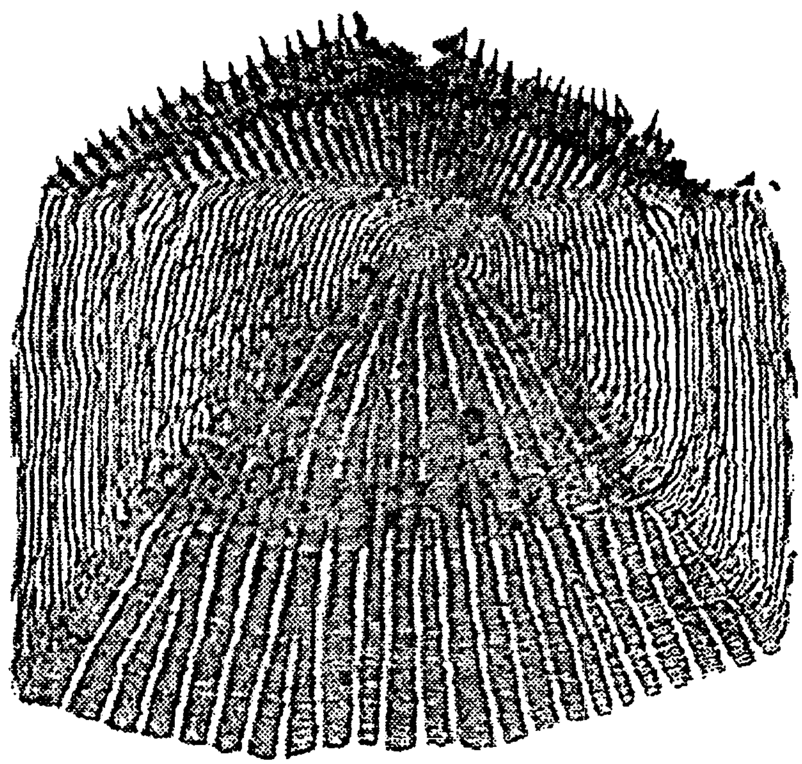


Figure 2. Quality b and c Striped Bass scales.

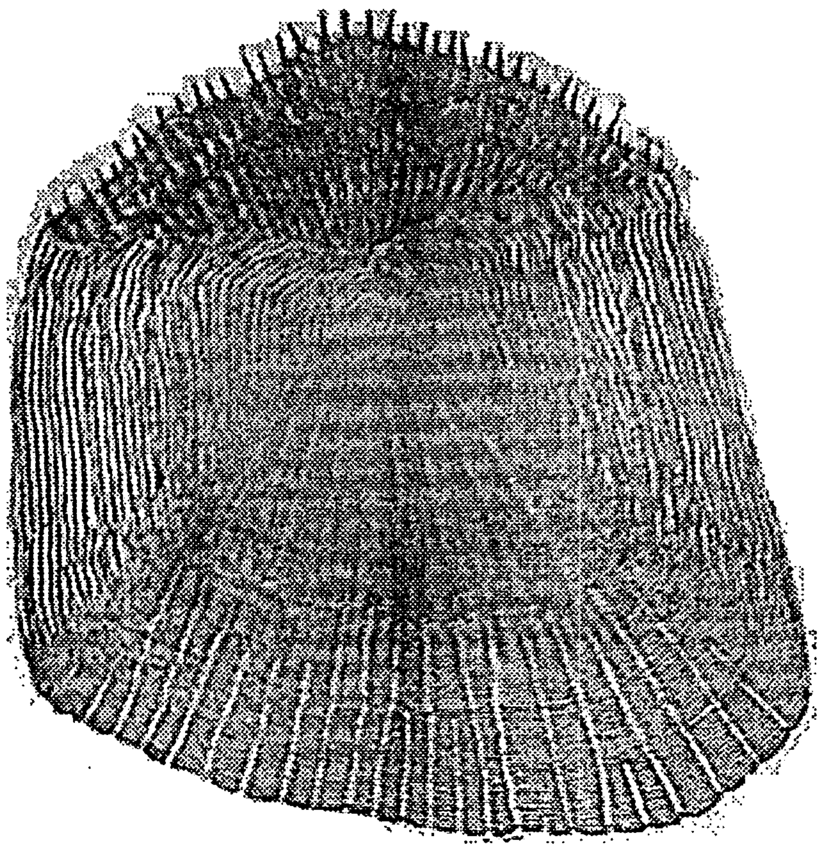


Figure 3. Quality d Striped Bass scale

3.2 Reference Line / Transition Zone

To standardize data collection as much as possible, a reference line is first drawn through the transition from the widely-spaced to the narrowly-spaced circuli (step 7 in Section 4). The reference line extended from the focus to the edge of the scale. For age 0+ scales, the transition between the two circuli types is usually sharp and unambiguous. However, on older scales, there is usually a transition zone between the regions of widely-spaced and narrowly-spaced scales. Within this transition zone, the operator looks near the edge of the scale for the line along which the circuli bent from a mostly y-axis orientation (widely-spaced) to a mostly x-axis orientation (narrowly-spaced).

4.0 Run Macro

This section describes how the OPRS macro sequence 1 is operated to collect single line luminance (SL) data on striped bass scales. Programming macro sequence 1 is described in Section 2.1. The same macro is used for both known scales and unknown scales (or impressions).

The macro steps are summarized in the following table:

Step	Item or Window	Fully Automatic	Manual Action Required	Press Mouse Key to Select (s), Enter (e), or Continue (c)
1.	Run Macro 2			s
MACRO				
2.	Lens Calibration	x		
3.	Acquire	x		
4.	Samp ID		x	e
5.	Spec ID		x	e
6.	Other		x	e
7.	Reference Line, On		x	
8.	Draw Line		x	c
9.	Amplification, Auto			c
10.	Reference Line, Off	x		
11.	Acquire	x		
12.	Save to File Answer "Y" to Invalid Data Flag prompt			s

Procedure and explanation of macro steps:

1. Select the best scale on the slide and adjust the image as described in Section 3. Rotate the video camera so that the scale's ctenni are pointing straight up on the video monitor.

2. Go to file window on SL page and enter the correct filename to which SL data will be saved. Filenames are listed in Section 2.5

3. Go to Macro Sequence window and select Run Macro 1.

4. The macro begins by automatically selecting Ruler 3 (2X) in the Lens Calibration window.

5. The macro automatically selects Acquire in the Run window.

6. The macro stops at Samp ID in the File window. Enter the appropriate SampID as described in Section 2.5.

7. The macro stops at SpecID. Enter the appropriate SpecID as described in Section 2.5.

8. The macro stops at Other. Enter the appropriate Other as described in Section 2.5.

9. The macro proceeds and stops at Reference in the Run window. A mouse-controlled arrow appears on the image. Position the arrow in the center of the scale's focus and press the red key once. This creates a cross (+) at that point. Move the mouse and note the appearance of a variable line between the cross and the arrow. Move the arrow to the edge of the scale so that the reference line marks the transition from the widely-spaced to closely-spaced circuli, as described in Section 3.2. Click the red key again to mark the end of the reference line.

10. The macro proceeds and stops at Draw Line in the Run window. This is the line for which luminance data will be collected.

Position the mouse-controlled arrow at the center of the scale's focus and press the red key once to mark the beginning of the SL data line. Use the mouse to set the endpoint of this line at the scale's edge at exactly 30° counterclockwise from the reference line. Note that the angle from the reference line is displayed in real time in the upper right of the video monitor. Press the red key again to mark the endpoint. A graph of luminance values vs. distance in sampling units now appears on screen. Press the white key to continue.

11. The macro proceeds to the Amplification window and automatically optimizes the image offset and gain along the line drawn in step 10. After the automatic amplification is completed, a new graph of luminance values vs. distance appears on screen. These are the values that will be saved-to-file in step 14 below. Inspect the graph to see if there are more than two luminance values of 0 or more than two of 255. If not, press white key to continue to steps 12 and 13.

Note: When the line "bottoms out" at 0, it may not be possible to visually determine whether there are more than two zero 0 values. Later, when you run the CHECKSLL program (Section 5.1), you will be able to determine exactly how many 0 (or 255) values are contained in each data record.

11a. If there are more than two 0 values (or more than two 255 values), then the data will not be suitable for the subsequent Fourier analysis. If this is the case, let the macro proceed through step 13, then manually select Automatic in the Amplification window. If resulting luminance value graph still bottoms out to 0 at more than two points (or 255 at more than two points), repeat Automatic Amplication until this is no longer the case. Then press white key to continue.

12. The macro now erases ("toggles off") the reference line.

13. The macro re-selects Acquire in preparation for collecting data on the next scale. This is the end of macro 1.

14. If satisfied that all steps above have been correctly performed, manually select Save-to-File. A beep sounds and the data are saved to file.

This saves the data collected in steps 10 and 11 to the file currently in the File window. Each data record contains the following: the luminance value (0-255) of each sampled point, the ruler measure indicated in the Lens Calibration Window, and the text identifiers (SampID, SpecID and Other). Records are positioned in the file by the order in which they are saved.

5.0 Checking and Editing SL Data

5.1 Run CHECKSLL

If a SL data record contains more than two 0 values, or more than two 255 values, the data record will not be suitable for the subsequent Fourier analysis. (Note: because of the nature of the automatic amplification, a data record will not contain both 0 and 255 values.)

Data records can be conveniently checked for 0 or 255 values using the CHECKSLL program in the APL*PLUS environment. This program will print any record in a file containing either a 0 or a 255 value. The operator must then inspect the printout to see if there are more than two 0's (or more than two 255's) in that record. If so, that record must be marked invalid. The scale or impression is then reprocessed, and the data saved to the same file.

User-typed responses in this procedure are denoted by underlining.

To run CHECKSLL:

1. Connect printer and turn printer on.
2. Starting from MSDOS, type START at the C:\> prompt:

   C:\>START <Enter>

   This elicits the following menu:

   1) Load OPRS Data Acquisition Software
   2) Load STSC APL*PLUS/PC SYSTEM
   3) Load STATGRAPHICS

3. Type "3" <Enter>.

This starts the APL*PLUS program.

4. Now type:

)LOAD BILL3 <Enter>

Note:) in APL is <shift> " on keyboard

The following appears on screen:

   2BILL3 SAVED 3/16/1987 13:54:54

5. The cursor is ready for a command. Type:

CMD 'CD C:\video\digdat' <Enter>

Note: , ', :, and \ in APL is <shift> L, <shift> K , <shift> > and <shift> ? on keyboard

6. Now type:

CHECKSLL

7. To activate print screen function, type:

<Ctrl> <PrtSc>

Hit <Enter> to print out the CHECKSLL header.

8. Enter name of file to be checked and press <Enter>.

The CHECKSLL programs begins checking each data record for 0's and 255's. If none are found in a record, CHECKING RECORD ## is printed. If one or more are found, then the entire record in printed out. At end of file, EOF is printed out. You can now go back and visually check on the printout whether a data record has more than two 0's (or more than two 255's).

When completed, de-activate the print screen function by typing <Ctrl> <PrtSc>.

9. To return to the VIDEO\DIGDAT directory, type

)OFF <Enter>

Note:) in APL is <shift> " on keyboard.

For those records with more than two 0's (or 255's), go to the Edit page in OPRS and mark those records invalid in the Edit Input File window.

Now reprocess the scale so that not more than two 0's (or 255's) occur. Save this new data record to the same file. See step 9a in Section 4 (Run Macro) for procedure on how to eliminate excess 0's and 255's in data record.

5.2 Checking Record Headers

After running the CHECKSLL program above, check the data record headers as follows:

1. Go to Input & Output Files window on EDT page, select Input Data File and enter filename to be checked.

2. Go to Convert to ASCII window, select PRN, then select Output Headers Only. This writes to the printer all data record headers in the file.

3. Check the printout of record headers against original master sheet cataloging slides or the information contained on slides or impressions. If an error is found in text identifier (SampID, SpecID or Other), go to Edit Input File window and correct it. If error occurs anywhere else, flag the record as Invalid and reprocess the scale (or impression). Save data to same file.

6.0 Converting SL files by FFT

The first step in the data analysis is to apply a Fast Fourier Transform (FFT) algorithm to covert the single line luminance data, L(x), to an equivalent representation as a sum of cosine functions of regularly increasing frequency, but with different amplitudes and phase shifts. In this equivalent representation, called a discrete Fourier transform, each line of luminance data is represented by two arrays of coefficients:

$$L(x) \overset{\text{FFT}}{=\!=\!=\!=\!=\!>} \begin{array}{cc} |A_0| & |B_0| \\ |A_1| & |B_1| \\ |A_2| & |B_2| \\ |A_3| & |B_3| \\ |\ldots| & |\ldots| \\ |A_n| & |B_n| \end{array}$$

where the A_i and B_i coefficients represent the amplitudes and phase shifts of the n cosine functions, or harmonics, and n = X - 1 where X is the length of the line in sampling units. All subsequent analysis of circuli patterns takes place in terms of the A and B coefficients, and specifically in terms of $[A_i^2 + B_i^2]^{1/2}$. See Appendix A for a more complete explanation of Fourier analysis.

Procedure for FFT Conversions

After all SL data has been saved to file and edited according to procedures in Section 5, the file is ready to be converted by an FFT as follows:

1. Go to the Input & Output Files window on the EDT page, select Input Data File, and enter the filename of the SL data to be converted.

2. Select Output Data File in same window and enter directory and filename to which the discrete Fourier transforms will be written. For aging striped bass scales, the directory was \VIDEO\DIGDAT and the "FFT" files were named as follows:

SL Data File	FFT Data File
SLL0.HG0	SLL0H.FFT
SLL0.WG0	SLL0W.FFT
SLL01.AG1	SLL01.FFT
SLL02.AG2	SLL02.FFT
SLL03.AG3	SLL03.FFT
SLL0X.IMX	SLL0X.FFT

3. Go to FFT window and enter the FFT size (8,16,32......1024). The FFT size should be greater than the longest line length, or data record, in the file.

4. Select Normalize Input and Truncate Long Records. See Appendix A for an explanation of these items.

5. When all is ready, select Start FFT Conversions. It will take about 10 or 15 minutes to convert a file containing 100 records of SL data. Initially the "FFT" files should be created on the hard disk.

6. When the conversion is complete, exit the program and check the directory to make sure that the file has indeed been saved on disk. To check the directory, type:

C:\>dir\video\digdat

7. Each "FFT" file should be backed-up on floppy disks. An "FFT" file derived from 100 lines of luminance data will fill 2 or 3 floppy disks. Use blank disks because the backup process writes over any existing files. Insert the first floppy in the B: drive and type:

C:\>backup \video\digdat (filename) B:

Upon hitting <Enter>, the following message appears on screen:

> WARNING! Files in the target drive root directory will be erased. Strike any key when ready.

8. An on-screen prompt informs you when the first floppy disk is filled. Remove the first floppy, insert another, and hit <Enter>. Repeat as many times as needed to complete the backup procedure.

7.0 System Parameterization for Age-Class Discrimination

Representation of single line luminance data (luminance values vs. sampling unit) as a discrete Fourier transform permits analysis of the data in terms of its component spatial frequencies, or harmonics (Section 6 and Appendix A). The contribution of the nth harmonic to the overall shape of the original data is given by its magnitude:

$$\sqrt{A_n^2 + B_n^2}$$

where A_n and B_n are the amplitudes of the real and imaginary sinusoidal components (or, equivalently, the amplitude and phase shift of a real cosine function).

The greater the magnitude, the greater the contribution of that harmonic to the overall shape of the original data. For aging fish scales, these magnitudes are subjected to statistical analyses in order to identify key harmonics, or groups of harmonics, that can uniquely identify a particular age group.

7.1 Periodigram

The harmonic magnitudes for individual data records can be displayed as periodigrams (magnitude vs. harmonic number) using the Edit Input File window on the EDT page:

1. Go to Input & Output Files window and at the Input Data file prompt, enter the name of the SL data file (or FFT converted file name). Hit <Enter> and OPRS reads the file. Note that Record number in Edit Input File advances to the last record in this file.

2. Use Next, Previous, First and Last items to choose the data that you would like displayed.

3. Select Graph FFT to display periodigram of that record.

Because of an intrinsic symmetry to the solution for the discrete Fourier transform, the periodigram is symmetric about the middle harmonic. For this reason, only half the periodigram is graphed by the OPRS. For instance, for an FFT size of 256, the x-axis of the periodigram corresponds to harmonic numbers 0 to 127 *and* 255 to 128. An example of a periodigram is shown Figure 4.

If an FFT is performed on unnormalized data, the A_0 coefficient is typically quite large, resulting in a large magnitude for the first harmonic in the periodigram. (The A_0 value corresponds to the DC level in electrical engineering applications.) If Normalize Input is chosen in the FFT window and the SL file converted by an FFT, then the resulting discrete Fourier transform has $A_0 = 0$. This will result in a low or zero magnitude for the first harmonic in the periodigram.

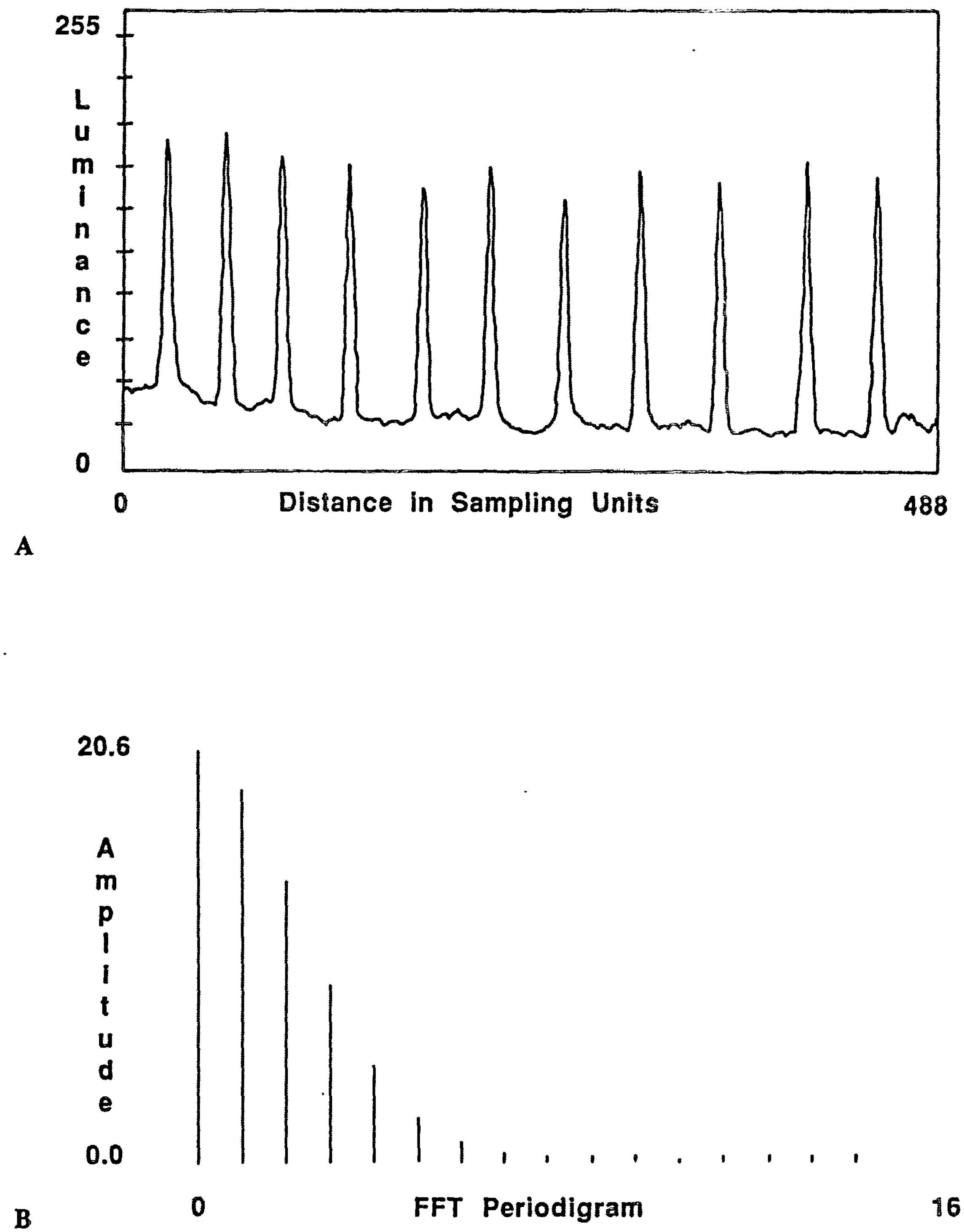


Figure 4. A) Single line luminance data. B) Periodigram after data in A is transformed by FFT (select Graph FFT in Edit Input File window).

7.2 Identifying Potential Discriminators by ANOVA

Before applying the OPRS Pattern Recognition Program, you need to identify those harmonics that show significant differences between age groups. These harmonics will then be used by the Pattern Recognition Program for discrimination between age groups.

To test harmonics (or other data parameters) for significant differences between age groups, you must first read the OPRS data files into the STATGRAPHICS program. Later you will read these same OPRS data files into the Pattern Recognition Program.

This section describes how to read in the OPRS data files into STATGRAPHICS. User-typed responses in this procedure are denoted by underlining.

1. Starting from MSDOS, type START at the C:\> prompt:

    C:\>START

This elicits the following menu:

    1) Load OPRS Data Acquisition Software
    2) Load STSC APL*PLUS/PC SYSTEM
    3) Load STATGRAPHICS

2. Type "3" and <Enter> key.

If this is the first time you have run the STATGRAPHICS program, the following message appears: "Do you want to initialize the system?" Consult the STATGRAPHICS manual (Section 3-1) on how to initialize the system. To speed up subsequent start-ups, answer yes to the prompt: "Do you want to save these settings for automatic logon? (N/Y)"

If the system has already been initialized and the settings saved, answer yes to the prompt:

    Do you want to use automatic logon? (Y/N)

3. This elicits a STATGRAPHICS logo page and the following message:

    System initializing. Please be patient. This will take a few moments.

A different STATGRAPHICS logo page now appears, with the prompt:

    Press Enter to begin.

4. The following message now appears:

> Please wait while a STATG data directory is created.

After a moment, the STATGRAPHICS Main Menu appears on screen.

```
STATGRAPHICS Statistical Graphics System

DATA MANAGEMENT AND SYSTEM UTILITIES       TIME SERIES PROCEDURES
   A. Data Management                         L. Forecasting
   B. System Environment                      M. Quality Control
   C. Report Writer and Graphics Replay       N. Smoothing
   D. Plotter Interface                       O. Time Series Analysis

PLOTTING AND DESCRIPTIVE STATISTICS        ADVANCED PROCEDURES
   E. Plotting Functions                      P. Categorical Data Analysis
   F. Descriptive Methods                     Q. Multivariate Methods
   G. Estimation and Testing                  R. Nonparametric Methods
   H. Distribution Functions                  S. Sampling
   I . Exploratory Data Analysis              T. Experimental Design

ANOVA AND REGRESSION ANALYSIS              MATHEMATICAL AND USER PROCEDURES
   J. Analysis of Variance                    U. Mathematical Functions
   K. Regression Analysis                     V. Supplementary Operations
```

5. Press <Escape> key to enter the APL environment. The following message appears:

> You have ended menu control and are now in APL.
> To restart menu control, enter: RESTART
> To return to DOS, enter:)OFF

6. At the flashing cursor, type:

)PCOPY INPVAR GOFER2 <Enter>

Note:
) is <Shift> " on keyboard.
)PCOPY = APL protected copy command.
INPVAR = APL file functions that are used to read OPRS data files. There is one function for each data type.
GOFER2 = a program that displays the Data Type Selection Menu and passes control to the data reading routine.

7. At the flashing cursor, type:

GOFER2 <Enter>

This elicits the Data Type Selection Menu:

** DATA TYPE SELECTION MENU **
This menu allows you to specify the type of data that has been digitized with the data acquisition package. Only files with the specified data type will be accessable, so be sure to specify the correct data type.
SINGLE LINE OF RAW LUMINANCE VALUES TRUSS NETWORK FOURIER TRANSFORMS OF LUMINANCE PROFILES ANNULAR DISTANCE MEASUREMENTS POINTS FROM MORPHOLOGY PAGE LINES OR CURVES FROM MORPHOLOGY PAGE BOUNDARY POINTS FROM MORPHOLOGY PAGE FOURIER SHAPE DESCRIPTOR ONE FOURIER SHAPE DESCRIPTOR TWO
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

8. Select and enter the appropriate OPRS data type (i.e. Fourier transforms of luminance profiles). This will elicit another smaller menu from which a choice must be made. For FFT converted SL data, select "Magnitudes and Phases"from this second menu and press <Enter>.

9. The following prompt appears:

PLEASE ENTER THE DIRECTORY CONTAINING THE DATA FILES (C:\VIDEO\DIGDAT):

Press <Return> if files are already in the C:\VIDEO\DIGDAT directory, as they normally would be. If in another directory, enter name and press <Return>.

Note: All files that will be grouped together for statistical analysis must reside in the same directory.

10. The following prompt appears on screen:

PLEASE ENTER THE NAME OF THE FILE THAT YOU WISH TO READ: BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE.DT1)

Type in the appropriate OPRS data file name and press <Enter>. The message 1 FILE COPIED appears. As the file is read in, SKIPPING INVALID RECORD messages will appear on screen (if you have already marked certain records as invalid). When completed, END OF FILE ENCOUNTERED and FINISHED messages appear.

11. The following prompt now appears:

DO YOU WISH TO INCLUDE ANOTHER FILE IN THIS GROUP?

If you type Y, the program goes back to step 10. If you type N, the program ends with the message:

DATA CONTAINED IN ARRAY XX

From here you can type RESTART to run STATGRAPHICS again if you want to run tests on the current data in the XX array. However, for testing for significant differences between age groups, continue with the procedure as outlined below.

The following procedure is written for comparing FFT data from three age groups (age 1+, age 2+ and age 3+). With the obvious modifications at the appropriate steps, the same procedure applies to comparing data from 2 or 4 age groups, or as many as can be accomodated in the computer's memory.

Once all the data files for a particular age group (e.g. age 1+) are read into the XX array, you must repeat the procedure (Steps 8-10 above) for the other groups (age 2+ and age 3+). However, before reading in the age 2+ data, you must transfer the age 1+ data from the XX array to a temporary AA array (step 12 below) or else the age 2+ data will overwrite the age 1+ data. Likewise the age 2+ data must be transfered to a BB array before reading in the age 3+ data.

You will then combine the current XX array (age 3+) with the AA (age 1+) and BB (age 2+) arrays into a new ZZ array, along with a level code variable that identifies the rows that belong to the three data sets. The analysis of variance is then performed on the ZZ array to identify those harmonics (columns) that differ significantly between the three age groups.

NOTE: the array which results from the data input procedure is always called XX. The names of the temporary arrays to which these data are transferred are arbitrary alphanumeric sequences. In this example these temporary arrays are called AA, BB and ZZ.

12. To transfer current data (age 1+) from XX array to a temporary AA array type:

AA[XX <Enter>

(Note: in APL, typing "[" produces a left pointing arrow)

13. To enter age 2+ data into the now vacated XX array, type:

GOFER2 <Enter>

This takes you back to step 8 above. Repeat steps 8-13 above for the age 2+ data. In step 12, type BB[XX. Now repeat steps 8-11 for the age 3+ data and continue to step 14.

14. To elicit STATGRAPHICS Main Menu, type:

RESTART <Enter>

15. To display the contents of the computer's memory (called the WORKAREA file in STATGRAPHICS), select A (Data Management) from the main menu and then select 1 (Display Data Directory) from the resulting sub-menu. The AA, BB and XX arrays should be listed with the appropriate number of rows followed by the number of columns.

DATA MANAGEMENT

1. Display Data Directory
2. File Operations
3. Import Data Files
4. Export Data Files

16. Hit <Escape> key once to return to the sub-menu and select 2 (File Operations).

17. At the prompt, type in the filename:

WORKAREA <Enter>

Select Desired Operation from the following menu and type J for Update.

FILE OPERATIONS

STATGRAPHICS File Name: WORKAREA

Operations:	A. Copy	D. Erase	G. Recode	J. Update
	B. Create	E. Join	H. Rename	
	C. Edit	F. Print	I. Split	

Desired Operation: J

Files on Data Drives

TEST.DAT

18. Hit the F6 key to execute.

19. The program is now ready to update the WORKAREA file.

20. Type N to create a new variable.

21. At the prompt, enter ZZ for the name of the new variable.

22. At the prompt, enter for assignment:

AA,[1]BB,[1]XX

Statgraphics creates the ZZ variable and updates the variable list displayed. ZZ should be on the list with AA + BB + XX number of rows.

23. Now you must make a new variable containing the level codes. At the prompt, enter LEVELCODE for the name of the new variable.

24. An "Enter Assignment" prompts appears. If there are 55 rows in AA (55 scales in age 1+), 50 rows in BB (age 2+) and 45 in XX (age 3+), type:

(55 RESHAPE 1), (50 RESHAPE 2), 45 RESHAPE 3

This will assign level code 1 (for age 1+) to the first 55 rows in ZZ (from AA), level code 2 (for age 2+) to the next 50 rows, and level code 3 (age 3+) to the next 45 rows.

25. To display the level codes, use cursor keys to highlight LEVELCODE, then type D.

26. To return to the STATGRAPHICS Main Menu, hit the <escape> key four times.

27. You are now ready to perform an analysis of variance (ANOVA) on the ZZ array. From the main menu, select and enter option J (analysis of variance).

28. On the resulting sub-menu, select and enter 1 for a one-way analysis of variance.

29. To test the sixth harmonic (column) for a significant difference between level codes 1, 2 and 3 (age 1+, age 2+ and age 3+) first type:

ZZ[;6]

(Note: The format here is ZZ[row; column]. When all rows are to be included in the analysis,type ZZ[;column], as above.)

30. At the Level Codes prompt, type:

LEVELCODE

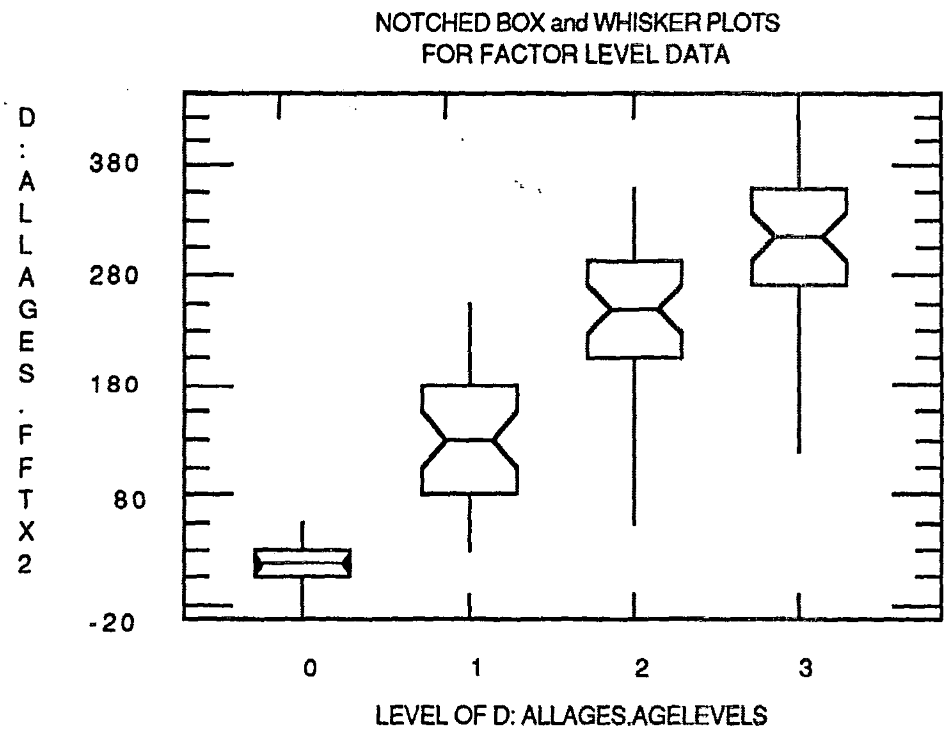
31. Hit the F6 key to run the ANOVA.

32. To graphically display the results of the ANOVA, hit the F5 key, then select the Notched Box Plot. This plot appears on screen. To print out the plot, hit the F4 key.

Interpretation of Notched Box and Whisker Plots:

Notched box and whisker plots are a graphic way to determine whether there are significant differences between the data sets. A full explanation of these plots are contained in Section 13-4 of the STATGRAPHICS manual. A brief explanation of these plots is provided here.

The x-axis represents the level codes of the data sets and the y-axis is the data variable. For each data set, 50 percent of the data points fall within the area inscribed by the box. The median is represented by a horizontal line within the box. The 95 percent confidence intervals are indicated by the notched portions of the boxes, as shown in the example below. At the notches, draw horizontal lines to extend across the whole graph. If these lines intersect any notched portion of a box for another data set, then the two data sets are not significantly different. If the lines do not interesect another notched portion of a box, then that data set is significantly different at the 95 percent confidence interval. In other words, the harmonic represented in that data set is a potential discriminator for that age class when inserted in the Pattern Recognition Program.



7.3 Pattern Recognition Program

This section describes the application of the Pattern Recognition Program for separating scales from four age classes of Striped Bass. However, before applying the Pattern Recognition Program, you must first apply an analysis of variance (ANOVA) to identify those Fourier harmonics (or other data parameters) that show significant differences between age groups, as described in Section 7.2. In this application, scales will be separated based on these harmonics, plus the fish lengths, which were entered in the "Other" field of the data records. User-typed responses in this procedure are denoted by underlining, such as: Y   Age1+

1. Go to the OPRS Main Menu and type 2 (APL*PLUS).

2a. At the prompt, type

) LOAD PR <Enter>

2b. Then type   *Note:) in APL is <shift> " on keyboard.*

GOFER 1 <Enter>

The following menu appears:

** PATTERN RECOGNITION ** MAIN MENU **
The main menu is used to set up and control the various applications that you may wish to examine. The first selection reads and interprets (if needed) the data produced by the front end data acquisition system. Various files may be organized to set up the controlling information and application files that are needed for further investigation. These applications may be archived on floppy disk or kept on the computer for frequent access. Once an application has been set up, the data are available for statistical analysis. Statistical procedures are available on subsequent menus.
SELECT AND INTERPRET STANDARD SAMPLES PROCESS STANDARD SAMPLES ERASE AN APPLICATION DOWNLOAD AN APPLICATION PROCESS UNKNOWN SAMPLES STATUS REPORT EXIT TO APL OR DOS
COPYRIGHT 1985, BIOSONICS INC. ALL RIGHTS RESERVED

Note: To select an item from this or subsequent menus, use the <up> and <down> cursor keys to move the highlight to the item of choice. Then press the <Enter> key.

7.3.1 Processing Known Standard Samples

3. Select the first item on the menu:

   SELECT AND INTERPRET STANDARD SAMPLES

The following message appears. Answer Yes (Y) to "Do you wish to proceed?"

> THIS PROGRAM WILL PROMPT YOU FOR SEVERAL ITEMS OF INFORMATION. IF YOU KNOW THE FILE NAMES FOR EACH OF YOUR STANDARD SAMPLES, AND THEY ARE STORED IN THE SAME DIRECTORY, THEN YOU SHOULD BE ABLE TO PROCEED.
>
> ?? DO YOU WISH TO PROCEED ??
>
> Y <Enter>

The following menu appears:

** DATA TYPE SELECTION MENU **
This menu allows you to specify the type of data that has been digitized with the data acquisition package. Only files with the specified data type will be accessable, so be sure to specify the correct data type.
SINGLE LINE OF RAW LUMINANCE VALUES TRUSS NETWORK FOURIER TRANSFORMS OF LUMINANCE PROFILES ANNULAR DISTANCE MEASUREMENTS POINTS FROM MORPHOLOGY PAGE LINES OR CURVES FROM MORPHOLOGY PAGE BOUNDARY POINTS FROM MORPHOLOGY PAGE FOURIER SHAPE DESCRIPTOR ONE FOURIER SHAPE DESCRIPTOR TWO
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

4. For separating scales of striped bass by age class, select FOURIER TRANSFORMS OF LUMINANCE PROFILES. The following sub-menu appears:

* INTERPRETATION MENU FOR FOURIER TRANSFORMS OF LUMINANCE PROFILES *
This menu offers the choices for reading and interpreting raw luminance profiles that have been subjected to the Fourier transform. The Fourier transform must have been invoked through the file handling and editing section of the data acquisition package.
MAGNITUDES PHASES MAGNITUDES AND PHASES
HIGHLIGHT THE APPROPRIATE CHOICE AND ENTER

5. Select MAGNITUDES

(Note: In keeping with the discussion of Fourier analysis presented earlier in Section 7.0 and Appendix A of this document, the three items in this menu (MAGNITUDES, PHASES, and MAGNITUDES AND PHASES) should read MAGNITUDES, AMPLITUDES, and PHASE SHIFTS, respectively).

Fish lengths, which were entered as the "Other" text identifier during data collection, will also be used for separating scales by age class. In the next step, a custom interpretation function is prepared to automatically read in the fish lengths and 512 harmonics of the FFT data into a focused subset of 22 elements, including those harmonics that would appear to give the optimum separation as determined by the ANOVA tests. This custom interpretation function is written specifically for the striped bass study at hand. Other custom interpretation functions can be written for reading in other subsets of data. (In the standard version of the program, the interpretation function reads in the first 50 harmonics of the FFT data.)

6. Answer Yes (Y) to the following message:

A CUSTOM DESIGNED INTERPRETATION FUNCTION IS BEING USED TO READ THE DATA FILES AND CREATES FEATURES FOR ANALYSIS.

?? DO YOU WISH TO PROCEED ??

Y <Enter>

7. The following prompt now appears:

PLEASE ENTER A DESCRIPTION OF THIS APPLICATION. THE DESCRIPTION MAY BE UP TO 50 CHARACTERS IN LENGTH AND SHOULD INCLUDE ENOUGH INFORMATION TO IDENTIFY THE APPLICATION AT A LATER DATE.

For this application we entered:

STRIPED BASS AGING, MAGNITUDES AND LENGTHS

8. The following prompt now appears:

YOU WILL NOW BE PROMPTED FOR THE CATEGORY NAMES. A SHORT DESCRIPTIVE NAME UP TO 12 CHARACTERS IN LENGTH SHOULD BE USED.

In this case the categories are Age 0+, Age 1+, Age 2+ and Age 3+ . The prompts are:

PLEASE ENTER THE NAME OF THE CATEGORY FOR TRAINING SAMPLE 1

AGE 0+ <Enter>

DO YOU WISH TO INCLUDE ANOTHER CATEGORY IN THIS APPLICATION?

Y <Enter>

PLEASE ENTER THE NAME OF THE CATEGORY FOR TRAINING SAMPLE 2

AGE 1+ <Enter>

DO YOU WISH TO INCLUDE ANOTHER CATEGORY IN THIS APPLICATION?

Y <Enter>

PLEASE ENTER THE NAME OF THE CATEGORY FOR TRAINING SAMPLE 3

AGE 2+ <Enter>

DO YOU WISH TO INCLUDE ANOTHER CATEGORY IN THIS APPLICATION?

Y <Enter>

PLEASE ENTER THE NAME OF THE CATEGORY FOR TRAINING SAMPLE 4

AGE 3+ <Enter>

DO YOU WISH TO INCLUDE ANOTHER CATEGORY IN THIS APPLICATION?

N <Enter>

9. Upon answering No (N) to this last prompt, the program proceeds with:

PLEASE ENTER THE DIRECTORY CONTAINING THE DATA FILES (C:\VIDEO\DIGDAT)

If the data files are already in the \VIDEO\DIGDAT directory, press <ENTER>. If the data files are elsewhere, enter the appropriate directory name and press <ENTER>.

10. You will now be prompted to enter data files for the categories (groups) that you defined in step 8 above. The prompts on screen appear as follows (user-entered responses are underlined).

THE FILE NAMES FOR THE AGE 0+ CATEGORY WILL NOW BE REQUESTED.

PLEASE ENTER THE NAME FOR THE FIRST FILE IN THE AGE 0+ GROUP:
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE.DT1).

FFT.WG0 <Enter>

END OF FILE ENCOUNTERED
FINISHED

IS THERE ANOTHER FILE FOR THE AGE 0+ GROUP?

Y <Enter>

PLEASE ENTER THE NAME FOR THE FIRST FILE IN THE AGE 0+ GROUP:
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE.DT1).

FFT.WG0 <Enter>

END OF FILE ENCOUNTERED
FINISHED

IS THERE ANOTHER FOR THE FILE AGE 0+ GROUP?

N <Enter>

THE FILE NAMES FOR THE AGE 1+ CATEGORY WILL NOW BE REQUESTED.

PLEASE ENTER THE NAME FOR THE FILE IN THE AGE 1+ GROUP:
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE DT1).

FFT01.AG1 <Enter>

END OF FILE ENCOUNTERED
FINISHED

IS THERE ANOTHER FILE FOR THE AGE 1+ GROUP?

N <Enter>

THE FILE NAMES FOR THE AGE 2+ CATEGORY WILL NOW BE REQUESTED.

PLEASE ENTER THE NAME FOR THE FILE IN THE AGE 2+ GROUP:
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE DT1).

FFT02.AG2 <Enter>

END OF FILE ENCOUNTERED
FINISHED

IS THERE ANOTHER FILE FOR THE AGE 2+ GROUP?

N <Enter>

THE FILE NAMES FOR THE AGE 3+ CATEGORY WILL NOW BE REQUESTED.

PLEASE ENTER THE NAME FOR THE FILE IN THE AGE 3+ GROUP:
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE DT1).

FFT03.AG3 <Enter>

END OF FILE ENCOUNTERED
FINISHED

IS THERE ANOTHER FILE FOR THE AGE 3+ GROUP?

N <Enter>

SCALING DATA.....

Upon answering no to "another file?" for the last specified category, an application file containing copies of all the specified data files is created. The prompt SCALING DATA appears on screen. The data are scaled to prevent subsequent overflow or underflow errors.

11. The program now returns to the main menu. Select

PROCESS STANDARD SAMPLES

12. Upon selection, you are prompted with the following choices:

1) FISHERS IRIS DATA
2) STRIPED BASS AGING, MAGNITUDES AND LENGTHS

PLEASE ENTER THE NUMER OF THE APPLICATION YOU WISH TO USE:

2 <Enter>

2) STRIPED BASS AGING, MAGNITUDES AND LENGTHS.

ARE YOU SURE THIS IS THE APPLICATION YOU WISH TO USE?

Y <Enter>

13. The following menu appears:

DISCRIMINANT ANALYSIS PROCEDURES
This menu allows the selection of several techniques for conducting discriminant analyses with a set of standard samples. (The classification of specimens from unknown catagories is subsequently conducted by making selections from another menu.) One technique will usually provide better performance than the others. This will depend on the underlying distribution of the data. Consult your documentation for a more thorough discussion of the strengths and weaknesses of the various mothods.
LINEAR DISCRIMINANT ANALYSIS QUADRATIC DISCRIMINANT ANALYSIS NON-PARAMETRIC DISCRIMINANT ANALYSIS
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

For aging striped bass, select

LINEAR DISCRIMINANT ANALYSIS

14. The following prompt appears:

THE TIED FILE CONTAINS DATA FOR THE ABOVE APPLICATION.
IS THIS THE APPLICATION YOU INTEND TO USE? (Y/N)?

Y <Enter>

15. The following menu appears:

** VARIABLE SELECTION PROCEDURES - LINEAR DISCRIMINANT ANALYSIS **
These options allow several different variable selection procedures to be chosen. Those offered here are specific to linear discriminant analysis. Consult your documentation for the recommended choice.
MANUAL SELECTION F STATISTIC KRUSKAL-WALLIS STATISTIC
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

Select MANUAL SELECTION

Manual Selection means that in the next step you will enter those elements (harmonics) that will be used for discrimination. These elements were previously determined in Section 7.2 by using ANOVAs in STATGRAPHICS to determine those harmonics that showed significant differences between age classes.

16. The next prompt reads:

WHICH ELEMENTS ARE TO BE USED FOR DISCRIMINATION?

For striped bass, enter

1 2 3 4 19 21 22 <Enter>

Based on the custom interpretation function (step 6), the first six numbers select the following Fourier harmonics:

2 3 4 5 43 45

The last number, variable 22, refers to fish length entered as the Other text identifier.

17. The following menu appears:

** ERROR RATE ESTIMATORS - LINEAR DISCRIMINANT ANALYSIS **
The following error rate estimation procedures are available. The leaving one out approach is recommended; however, the other procedures may be faster for large applications. The documentation discusses the implications of using the faster approaches.
LEAVING-ONE-OUT LEAVING-ONE-OUT FOR MEANS ONLY RESUBSTITUTION
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

Select:

LEAVING-ONE-OUT

Error rate refers to the percentage of scales from a given age class (e.g. age 0+) that are incorrectly assigned to other age groups. By testing known samples, an error rate matrix is developed. When processing unknown samples, re-assignment of scale classifications based on this error rate matrix allows an important correction to the final results.

The three menu items refer to different methods of estimating error rates. The preferred method is "leaving one out." EXAMPLE: Suppose you have data on 100 known scales from each of the four age classes (age 0+, age 1+, age 2+, age 3+). One of the age 0+ data records is removed, and a discriminant function is developed using the other 399 scales. The removed 0+ record is then tested using the discriminant function constructed from the other 399. Its classification is noted. This process is repeated for all 400 scales, and the results summarized as an error classification matrix.

18. After selecting the error rate estimator technique, the Main Menu reappears. To see how well the chosen variables separate the known sample, select STATUS REPORT. You then answer the following prompts:

PRINT OUTPUT TO SCREEN OR PRINTER (S/P)?

P <Enter>

and

1) FISHERS IRIS DATA
2) STRIPED BASS AGING, MAGNITUDES AND LENGTHS

2 <Enter>

ARE YOU SURE THIS IS THE APPLICATION YOU WANT FOR THE REPORT?

Y <Enter>

The following is then printed out as the first part of the Status Report:

Application: Hudson River Striped Bass Aging, Magnitudes and Lengths

This application has been set up for the following categories:

1.) Age0+
2.) Age1+
3.) Age2+
4.) Age3+

Linear Discriminant Analysis Has Been Configured And The Variables Were Selected Manually.

The following variables were selected:
1 2 3 4 19 21 22

The vector of means for the AGE0+ category is:
-1.276204 -1.135804 -0.779467 -0.440257 -0.555004 -0.496358
-1.424520
The sample size for the AGE0+ category is 100.

The vector of means for the AGE1+ category is:
-0.294713 0.897680 0.638681 0.052008 0.140468 -0.063967
-0.233509
The sample size for the AGE1+ category is 100.

The vector of means for the AGE2+ category is:
0.968746 -0.203061 0.047204 0.382684 0.349693 0.349245
1.107427
The sample size for the AGE2+ category is 100.

The vector of means for the AGE3+ category is:
0.968746 -0.203061 0.047204 0.382684 0.349693 0.349245
1.107427
The sample size for the AGE3+ category is 100.

The pooled variance covariance matrix is:

0.2458000	-0.037339	-0.101392	-0.040762	-0.057815	0.030689	0.076470
-0.037339	0.418748	0.074832	-0.039723	-0.101392	-0.110343	-0.060968
-0.101392	0.074832	0.748367	0.161840	-0.097856	-0.098627	-0.001716
-0.040762	-0.039723	0.161840	0.920957	-0.034288	0.004115	0.009149
-0.057815	-0.101392	-0.097856	-0.034288	0.892866	0.123137	0.033306
0.030689	-0.110343	-0.098627	0.004115	0.123137	0.902275	0.047441
0.076470	-0.060968	-0.001716	0.009149	0.033306	0.047441	0.095116

19. After the above printout, which is the first part of the status report, the following menu appears:

** A PRIORI PROBABILITY PROCEDURE SELECTION **

These procedures are used to adjust the decision surfaces. There may be many reasons to do this but the main reason is to balance classification errors. See the documentation for a more thorough discussion of these procedures.

BALANCED ERROR RATES
BALANCED ERRORS
SAMPLE SIZE WEIGHTS
EQUAL VALUES
USER-SUPPLIED

HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

Select EQUAL VALUES.

This results in a printout of the classification array (error rate matrix) for the known sample:

```
THE CLASSIFICATION ARRAY IS:
APPLICATION: HUDSON RIVER STRIPED BASS AGING, MAGNITUDES AND LENGTHS.
```

		FROM 1	2	3	4
T	1	100	1	0	0
O	2	0	92	16	0
	3	0	7	54	20
	4	0	0	30	80

This is the end of the Status Report. The above matrix shows that all 100 Age 0+ scales (group 1) were correctly classified using the selected variables. 92 of Age 1+ scales (group 2) were correctly classified, 1 was misclassified as Age 0+, and 7 as Age 2+. 54 of the Age 2+ (group 3) scales were correctly classified, 16 were incorrectly classified as Age 1+ and 30 as Age 3+. 80 of Age 3+ (group 4) were correctly classified and 20 were misclassified as Age 2+.

If satisfied with the resolving power of this set of variables, you can now proceed with processing unknown scales. If you would like to try to test the resolving power of another set of variables, go back to step 16 and enter a different set. Note that the variables that can be selected in step 16 are limited to those chosen by the custom interpretation function in step 6.

In general, discrimination power is maximized using about 5 or 6 variables. Adding more variables may decrease the discrimination power of the variable set.

7.3.2 Processing Unknown Samples

20. You are now ready to process unknown scales. On the Main Menu, select

PROCESS UNKNOWN SAMPLES

21. Respond to the following messages:

1) FISHERS IRIS DATA
2) HUDSON RIVER STRIPED BASS AGING. MAGNITUDES AND LENGTHS

2 <Enter>

2) HUDSON RIVER STRIPED BASS AGING. MAGNITUDES AND LENGTHS

ARE YOU SURE THIS IS THE APPLICATION YOU WISH TO USE?

Y <Enter>

22. The following menu appears:

** PROCESS SAMPLES OF UNKNOWN CATEGORY **
By selecting one of these choices a sample with specimens from a mixture of unknown categories will be processed. In order for these procedures to execute, the corresponding procedure must have been run on a set of standard samples.
LINEAR DISCRIMINANT ANALYSIS QUADRATIC DISCRIMINANT ANALYSIS NON-PARAMETRIC DISCRIMINANT ANALYSIS
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

23. Select

LINEAR DISCRIMINANT ANALYSIS

24. The following prompts essentially act as error check messages. The TIED file referred to includes the classification array and the set of variables to find, as defined in the Standard Samples procedure above. The interpretation function is discussed in steps 5 and 6.

STRIPED BASS, MAGNITUDES AND LENGTHS

THE TIED FILE CONTAINS DATA FOR THE ABOVE APPLICATION.
IS THIS THE APPLICATION THAT YOU INTENDED TO USE (Y/N)?

Y <Enter>

A CUSTOM DESIGNED INTERPRETATION FUNCTION IS BEING USED TO
READ THE DATA FILES AND CREATE FEATURES FOR ANALYSIS.

?? DO YOU WISH TO PROCEEED ??

Y <Enter>

25. You are now prompted to enter the "unknown" data files, beginning with the directory. In this example, the data file is called "UNKNOWN3.DAT."

PLEASE ENTER THE DIRECTORY CONTAINING THE DATA FILES (C:\VIDEO\DIGDAT):

<ENTER>

PLEASE ENTER THE NAME FOR THE FILE OF SPECIMENS TO BE CLASSIFIED.
BE SURE TO INCLUDE AN EXTENSION (E.G. MYFILE.DT1).

UNKNOWN3.DAT

END OF FILE ENCOUNTERED
FINISHED

DO YOU WISH TO INCLUDE ANOTHER FILE IN THIS GROUP?

N <Enter>

COMPUTING LINEAR KERNELS

26. The next message displays the age group categories from which the standard sample was created, and prompts you to re-enter them. If you know for certain that a particular age group is not present in the unknown sample, then it's recommended that you omit this age group when responding to this prompt. This will eliminate unnecessary classification errors to this group.

ENTER A VECTOR WITH THE NUMBERS OF THE STOCKS THAT YOU
WISH TO INCLUDE IN YOUR ESTIMATION

1) AGE 0+
2) AGE 1+
3) AGE 2+
4) AGE 3+

1 2 3 4 <Enter>

27. The following menu appears. Select EQUAL VALUES.

** A PRIORI PROBABILITY PROCEDURE SELECTION **
These procedures are used to adjust the decision surfaces. There may be many reasons to do this but the main reason is to balance classification errors. See the documentation for a more thorough discussion of these procedures.
BALANCED ERROR RATES BALANCED ERRORS SAMPLE SIZE WEIGHTS EQUAL VALUES USER-SUPPLIED
HIGHLIGHT THE APPROPRIATE CHOICE AND PRESS ENTER

The following information appears:

THE A PRIORI PROBABILITIES ARE:

0.250
0.250
0.250
0.250

THE SAMPLE SIZE FOR THE UNKNOWN POPULATION IS: 50

THE CLASSIFICATION ARRAY IS:

100	1	0	0
0	92	16	0
0	7	54	20
0	0	30	80

THE ESTIMATED CLASSIFICATION MATRIX IS:

1.000	0.010	0.000	0.000
0.000	0.920	0.160	0.000
0.000	0.070	0.540	0.200
0.000	0.000	0.300	0.800

THE NATURAL ESTIMATE IS:
0.160 Proportion AGE0+
0.290 Proportion AGE1+
0.300 Proportion AGE2+
0.250 Proportion AGE3+

The above natural estimate is that before the error classification array is applied. The nearly unbiased estimate below is that obtained after the classification array is applied.

THE NEARLY UNBIASED ESTIMATE IS:

0.158 Proportion AGE0+
0.232 Proportion AGE1+
0.476 Proportion AGE2+
0.134 Proportion AGE3+

THE CORRESPONDING SIMULTANEOUS CONFIDENCE INTERVALS ARE:

0.092	0.223	Lower and Upper Bounds for AGE 0+
0.100	0.357	Lower and Upper Bounds for AGE 1+
0.214	0.737	Lower and Upper Bounds for AGE 2+
0.000	0.329	Lower and Upper Bounds for AGE 3+

THE CORRESPONDING INDIVIDUAL CONFIDENCE INTERVALS ARE:

0.115	0.200	Lower and Upper Bounds for AGE 0+
0.151	0.314	Lower and Upper Bounds for AGE 1+
0.304	0.647	Lower and Upper Bounds for AGE 2+
0.006	0.262	Lower and Upper Bounds for AGE 3+

DO YOU WISH TO SEE THE RESULTS FOR INDIVIDUAL SPECIMENS? (Y/N)

Y <Enter>

(PRINTOUT OF RELATIVE PROBABILITIES)

DO YOU WISH TO TRY ANOTHER COMBINATION OF STOCKS? (Y/N)

N <Enter>

The End.

Appendix A: Fourier Analysis

In the early 19th century the French mathematician Fourier discovered that any continuous periodic function f(x) could be represented by an infinite series of sine and cosine functions of various amplitudes and frequencies. Later work showed that a bounded non-periodic function could also be approximated by a sum of trigonometric functions called a Fourier transform. Today Fourier analysis has become a powerful and versatile mathematical technique with a wide range of applications, from electrical engineering to sensory physiology.

A.1 Basic Mathematics of Fourier Analysis

In its simplest formulation, the Fourier series for a continuous periodic function f (x) is:

$$f(x) = \sum [a_n \cos(n\omega x + b_n)] \qquad (1)$$

where

$\omega = 2\pi/T$ and T is the function's period $[f(x) = f(x + T)]$
a_n = amplitude of the nth harmonic
b_n = phase shift of the nth harmonic

Note that for n=0, the first term reduces to the constant a_0 (often called the DC level in electrical engineering applications).

Obviously, for a practical application, it is not possible to sum an infinite series. However, the function f(x) can be approximated to any necessary degree of accuracy by choosing a high enough value of n. Note that the function can then be represented by two arrays:

$[a_0, a_1 \ldots a_n]$ representing the amplitudes of the n harmonics

and

$[b_0, b_1 \ldots b_n]$ representing the phase shifts of the n harmonics.

Although it may seem unnecessarily complicated to try to represent a known mathematical function as a sum of trigonometric functions, the real power of Fourier analysis lies in its ability to represent measured data in the real world as a function of some physical variable.

Essentially Fourier series enables a set of measured data (function) to be expressed in terms of a consistent set of trigonometric coefficients that can be easily manipulated for analysis. From another point of view, Fourier analysis breaks down a function into its component frequencies, or harmonics. For functions that are obviously periodic in nature – such as the regular spacing of circuli on a fish scale – this "freqency decomposition" aspect of

Fourier analysis has intuitive meaning. However, any function can be broken down into component frequencies, even if none are apparent to the eye.

There are many other variations of the Fourier theorem depending on the nature of the original function and its boundary conditions. However, they are all similar in form and principle to the equation above.

A.2 Fourier Analysis and the OPRS

For bounded non-periodic functions of discrete variables -- such as those created when the OPRS samples luminance values at a discrete number of points (sampling units) -- the Fourier representation is called a **discrete Fourier transform**. The computer algorthm that computes a discrete Fourier transform is called a **fast Fourier transform (FFT)**.

As shown below in equation 2 below, the discrete Fourier transform of a function has both real and imaginary components, even though the original real valued function has no imaginary component. (Recall that the imaginary number j has the property $j^2 = -1$.) This formulation, which is used extensively in engineering applications, works because the imaginary sine wave component behaves mathematically exactly as a phase shift relative to the cosine component. That is, the amplitudes (A_n, B_n) of the sinusoidal components in equation 2 are equivalent to the amplitude (a_n) and phase shift (b_n) in equation 1.

For luminance data extracted at a discrete number of points along a single line of total length X:

L(x) = luminance value as a function of distance (x) in sampling units along a single line of total length (X). A sampling unit in the OPRS is defined as the ration of virtual units to pixels along a 45° diagonal line (See OPRS Data Acquisition Manual)

$$L(x) \overset{FFT}{=\!=\!=\!=\!=\!=\!=\!=\!=\!>} H(x,y) = \text{discrete Fourier transform of } L(x)$$

$$H(x,y) = 1/X\,[\,\Sigma\, A_n\cos(2\pi xn/X) - j\,\Sigma\, B_n\sin(2\pi xn/X)\,] \qquad (2)$$

where

X = number of discrete points sampled (i.e. length of line in sampling units)

$j = \sqrt{-1}$

The amplitudes of the sinusoidal components (A_n , B_n) in equation 2 are analogous to the amplitude and phase shift (a_n, b_n) in equation 1. The contribution of the n^{th} harmonic to the overall shape of the original function is given by its magnitude:

$$\sqrt{A_n^2 + B_n^2}$$

The larger the magnitude , the greater the contribution of that harmonic. A plot of magnitude vs. harmonic number (n) is called a periodigram. Because of a characteristic symetry to the solution for the discrete Fourier transform, the periodigram is symetric about the middle harmonic. That is,

$$\sqrt{A_n^2 + B_n^2} = \sqrt{A_{X-n}^2 + B_{X-n}^2} \qquad \text{for } n > 0$$

Because of this symetry, the OPRS displays only the first half of the periodogram.

When single line luminance data are converted to FFT files on the EDT page, the input and output data files consists of the following arrays:

L_0	0		A_0	0
L_1	0		A_1	B_1
L_2	0		A_2	B_2
L_3	0	FFT	A_3	B_3
...	...	=====>		... ...
...	...		...	...
L_X	0		A_X	B_X

The first input array represents the X luminance values collected along a single line. The second input array represents the imaginary component of the luminance values, which of course are all zeroes because the luminance values are real numbers.

When converted by the FFT to a discrete Fourier transform, all the values in the first two arrays are converted to the A_n and B_n values as shown, and the original data (L_n) are erased.

All subsequent analyses of that data record are carried out in terms of the A_n and B_n values, amd specifically in terms of the magnitudes:

$$\sqrt{A_n^2 + B_n^2}$$

A.3 Normalization and Truncation

When converting single line luminance files to FFT files, select the normalization and truncation items.

Normalize Input

When this item is selected, the luminance values for each single line are normalized as follows:

For each line (data record), a mean luminance is calculated and then subtracted from each sampled luminance value. This may result in some negative values. These results are then divided by the standard deviation for that line. If the FFT size is greater than the length of the line in sampling units, the line is then extended with zero values to match the FFT size. The file is then transformed by the FFT to a discrete Fourier transform, which is expressed as arrays of A_n and B_n coefficients as described above.

Truncate Long Records

If the length of an SL line in sampling units exceeds that of the FFT size, then the line will be truncated at the FFT size if the the Truncate Long Records items has been selected. The truncated portion of the line is not transformed or reflected in the discrete Fourier transform. If this item has not been selected, then lines longer the FFT size will not be transformed at all by the FFT.

Figure B-1. Age0+ Striped Bass scale

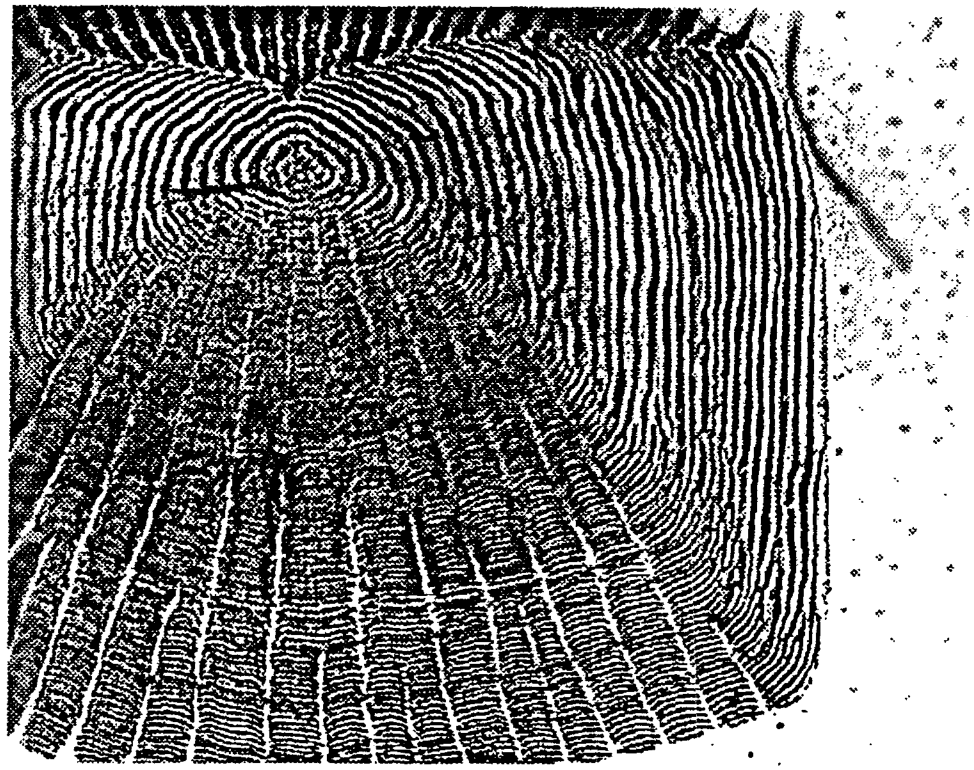


Figure B-2. Age 1+ Striped Bass scale

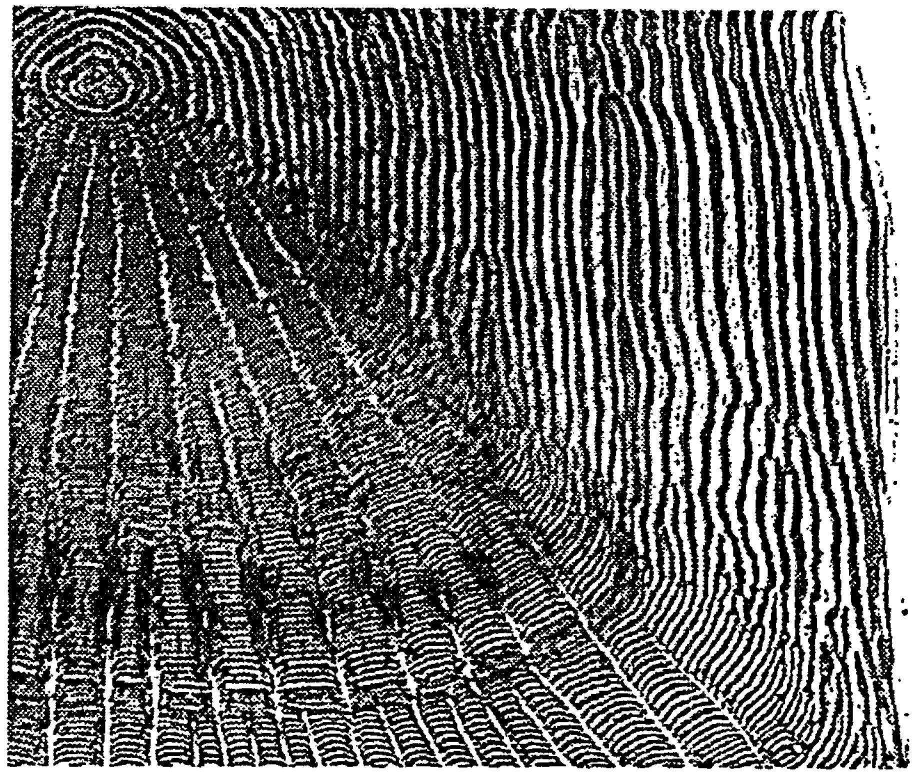


Figure B-3. Age 2+ Striped Bass scale

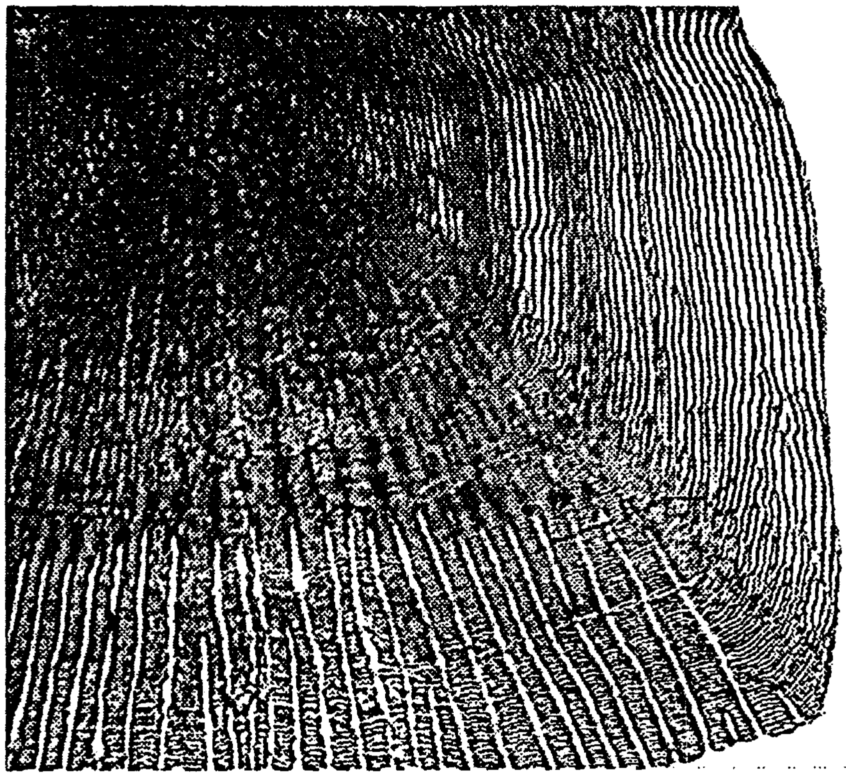


Figure B-4. Age 3+ Striped Bass scale