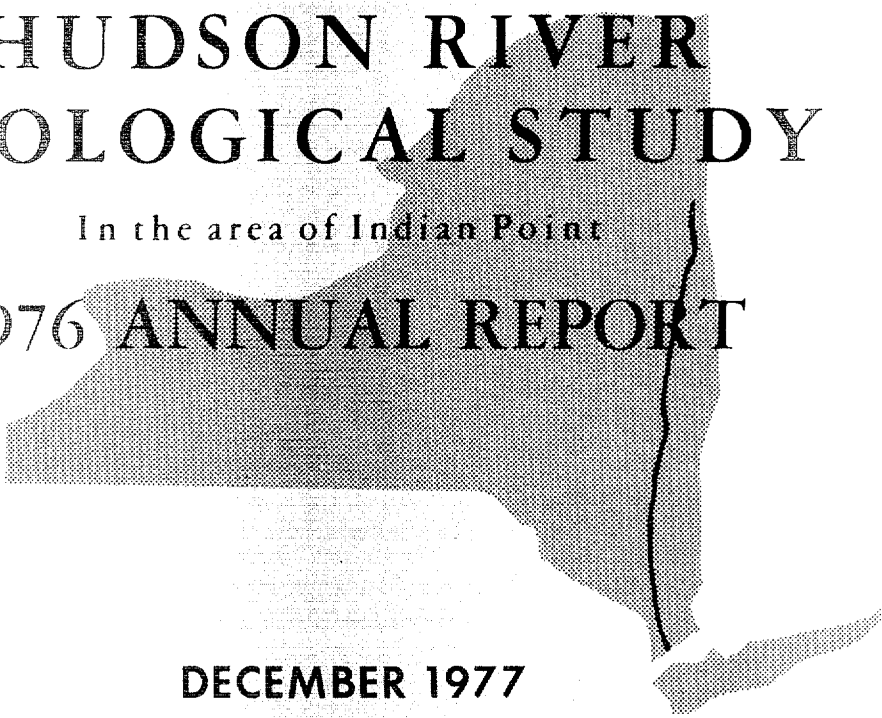
HUDSON RIVER ECOLOGICAL STUDY

In the area of Indian Point

1976 ANNUAL REPORT



DECEMBER 1977

Prepared for

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

4 Irving Place
New York, New York 10003

by

TEXAS INSTRUMENTS INCORPORATED
ECOLOGICAL SERVICES

P.O. Box 5621
Dallas, Texas 75222

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FOREWORD

Ecological investigations to determine effects of the Consolidated Edison Company of New York, Inc., Indian Point nuclear generating station on the aquatic biota in its vicinity have been almost continuous since June 1969 and, in 1972, were expanded to include the section of the Hudson River estuary from Haverstraw Bay to the Newburgh-Beacon Bridge. Texas Instruments Incorporated (TI), New York University (NYU), and Lawler, Matusky, and Skelly Engineers (LMS) are responsible for the various aspects of this program. Since 1972, TI has been monitoring impingement at Indian Point and fish populations at standard stations in the vicinity of Indian Point. Objectives were to:

- Monitor fish collected at Indian Point Units 2 and 3 and record plant operating and river conditions that may be related to impingement
- Determine the percentage of impinged fish that are not collected
- Provide data with which to evaluate the biological significance of fish impingement at Indian Point
- Determine seasonal fish species composition, relative abundance, and distribution at specific standard stations in the vicinity of Indian Point
- Collect water quality data with which to compare abundance, movements, and distribution of selected fish species in the vicinity of Indian Point
- Assess the biological characteristics of Hudson River striped bass, white perch, and Atlantic tomcod in the vicinity of Indian Point

Data resulting from these programs provide a base for determining the ecological significance of once-through cooling operations at Indian Point Units 2 and 3.

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SECTION I

INTRODUCTION

This report presents the results of TI's 1976 Indian Point study and impingement monitoring program. Also included are the results of data analysis of recaptured hatchery-reared striped bass — for example, their movements, survival, and food habits — not previously reported. Analyses of the impingement and standard station data represent assessment of the ecological effects of the Indian Point plant only in the immediate vicinity of Indian Point. This information must be viewed also in light of the overall distribution and abundance of each species. Since fish species are not restricted to the Indian Point region, impingement, as well as localized changes in abundance, must be considered against conditions existing within the entire Hudson River estuary.

SECTION II
SUMMARY AND CONCLUSIONS

A. SUMMARY

This report addresses the results of studies investigating the effects of the Indian Point nuclear generating station on the Hudson River biota in its vicinity. Specific program efforts were directed toward monitoring Indian Point impingement; determining abundance and distribution of fishes at standard sampling stations; studying the various biological characteristics of striped bass (*Morone saxatilis*), white perch (*Morone americana*), and Atlantic tomcod (*Microgadus tomcod*), including age structure, growth, reproduction, and food habits; and assessing the feasibility of striped bass culture and stocking.

1. Impingement

Of 57 species collected from the intake screens, four (white perch, blueback herring, Atlantic tomcod, and bay anchovy) accounted for more than 90% of the catch. These were predominantly young-of-the-year and yearling fish. Peak impingement periods were usually associated with saltfront movements through the region. Studies at Unit 3 indicated a collection efficiency of approximately 80%.

Striped bass marked and released downriver from river mile (RM) 24 (KM 38.6) or upriver from river mile 46 (KM 74) were not recovered from the screens at Indian Point. All marked striped bass recovered at Indian Point were released within this area. Marked white perch impinged had been released throughout the estuary, whereas Atlantic tomcod recaptures consisted primarily of fish marked upriver.

2. Abundance and Distribution

Standard station beach seine and trawl studies indicated that species composition, local distribution, and temporal abundance patterns in 1976 were similar to those determined for previous years.

Striped bass and white perch distribution and abundance were apparently regulated by temperature; as temperature declined in fall, striped bass left the region while white perch moved from shore to channel areas. Atlantic tomcod were most abundant in the Indian Point region during the summer when the catch was almost exclusively YOY. The peak catches during this period appeared to be associated with salt front intrusions into the Indian Point region. During the winter months tomcod catches were of the spawning adults.

3. Biological Characteristics

Striped bass and white perch age and length composition were similar to those of prior years. Adult Atlantic tomcod mean length in 1976 was between that reported for the 1974-75 and 1973-74 spawning seasons. The majority of these spawning fish were of the 1975 year class; only 3% were from the previous year class.

White perch and Atlantic tomcod growth rates were similar to those for prior years. Striped bass growth was similar to rates of 1973 and 1974 but lower than that of 1975. All male white perch were sexually mature by age IV; females by age V. Atlantic tomcod were sexually mature by 11-13 months. Sex ratios for adult white perch and Atlantic tomcod were approximately 1:1. The estimated white perch egg count was similar to that of previous years. Catch curve analyses provided total annual mortality estimates of 89% for age 0 and 70% for ages I-V.

4. Culturing and Stocking Striped Bass

Survival of hatchery-reared striped bass was not significantly different from that of wild fish for several months following stocking. These hatchery-reared fish were recaptured throughout most of the estuary but primarily below RM 60 (KM 96.6).

Stomach analyses of hatchery and wild striped bass indicated their food habits to be quite similar. Fish less than 126 mm in total length fed primarily on invertebrates, notably *Gammarus*. Larger fish (126-200 mm) were more piscivorous, although invertebrates still comprised a large part of the diets. Fish longer than 200 mm were primarily piscivorous.

B. CONCLUSIONS

This report summarizes results of the 1976 Indian Point ecological investigations. Based on this one year alone, there can be no conclusions as to the effects of the Indian Point generating station on the Hudson River aquatic biota; however, by comparing the 1976 results with those of previous years, trends through time can be observed. Analysis of standard stations sampling shows no change in species composition of fish in the vicinity of Indian Point and there appears to be no consistent trend in abundance of these fish within the period 1973-76 that could be related to the operation of the Indian Point station. There are also no major changes in the biocharacteristics of the key fish species evident that would indicate an overexploited population. Thus, to date, there is no indication that operation of the Indian Point nuclear generating station has had an adverse effect on the fish populations in the vicinity of the plant.

SECTION III

IMPINGEMENT OF FISHES AT INDIAN POINT

A. INTRODUCTION

Daily impingement monitoring at the Indian Point nuclear generating station continued during 1976, with emphasis directed toward describing the magnitude, composition, and seasonality of fish impingement at the plant. Data collected in 1976 expanded the previous data base used to evaluate the biological impact of the facility and to assess possible mitigative measures.

The specific objectives of the 1976 program, which was conducted between 1 January and 31 December 1976, were to:

- Monitor the species, numbers, and weight of fish impinged at Indian Point Units 1, 2, and 3
- Determine the percentage of impinged fish that were not collected during normal screen washes
- Monitor ambient river physicochemical conditions and plant operational variables thought to be related to fish impingement

B. DESCRIPTION OF PLANT SITE

The Indian Point facility withdraws cooling water from the Hudson River near Peekskill, New York [RM 42.5 (KM 68.4)]. The nuclear plant consists of three individual generating units (Figure III-1) having a combined water pumping capacity of 7700 m^3/min (2,058,000 gal/min). Unit 1 has two condenser circulating pumps, each having a capacity of 530 m^3/min (140,000 gal/min); Units 2 and 3 each have six 530 m^3/min circulator pumps. Service pumps with much lower capacities are also used to circulate water through each unit. The circulating pumps operate at 60% of capacity when ambient river temperature is below 4.4°C (40°F) and at 100% the remainder of the year. Details of the plant and associated intake structures have been presented previously (TI 1975a, McFadden 1977).

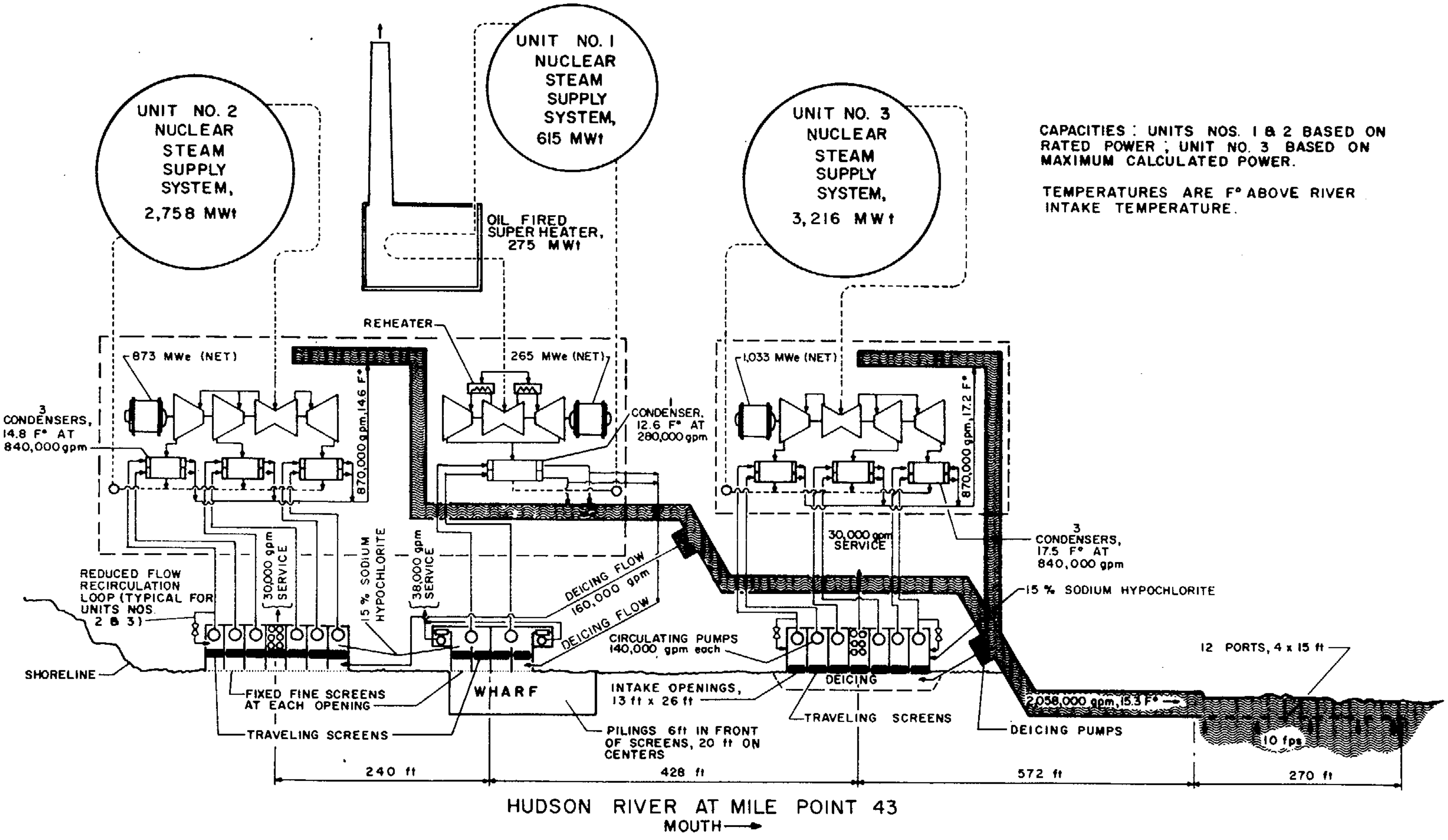


Figure III-1. Indian Point Plant Layout. (Courtesy of Consolidated Edison Company of New York)

During 1976, only Unit 3 operated regularly for most of the year; Unit 2 operation was limited and irregular; Unit 1 was not operated for electrical generation during 1976 but the circulator operated occasionally, primarily to reduce Δt in the discharge canal during the summer. Periods of operation for each unit appear below:

Unit 1	16 Jul - 10 Sep 18 Nov
Unit 2	1 Jan - 31 Mar 20-22 Apr 7-14 Jun 15 Sep - 9 Nov 10-31 Dec
Unit 3	13-16 Feb 21-22 Feb 19 Apr - 31 Dec

C. METHODS

1. Impingement Monitoring

Fish impingement at Indian Point was monitored on a daily basis by collecting specimens after intake screen washings at each unit. Collection procedures were the same as those employed in 1975 (TI 1976a).

Collection data were recorded separately for each unit. After being collected, all fish were taken to the laboratory for processing. Specimens were identified to species and the total collected per species determined. All striped bass, white perch, and Atlantic tomcod (young-of-the-year Atlantic tomcod only during the fall marking period) were counted; for all other species totals were estimated by the number/weight relationship of a subsample whenever the catch had more than 100 individuals (TI 1976a). Each species' total weight was also determined. The number of striped bass, white perch, Atlantic tomcod, alewives, blueback herring, and American shad in each of four length classes [0-X mm, (X+1)-150 mm, 151-250 mm, and 250+ mm, where X was the upper total length limit for yearling or young-of-the year for each species, depending on the season] was also recorded. The 0-X category represented yearling fish (through 31 March for Atlantic tomcod and 31 May for all other species); thereafter, the 0-X category contained young-of-the-year (YOY) fish. Additionally, all striped bass, white perch, and Atlantic tomcod were examined for the presence of tags or marks used to estimate the population size of each species.

Also, randomly selected specimens of these species were measured and weighed to determine length-weight relationships.

2. Monitoring of Physicochemical and Plant Operational Variables

Temperature (°C), dissolved oxygen concentration (ppm), and conductivity [μS/cm, where Siemens (S) is the International System of Units (SI) measurement of conductance] were measured daily at the surface in front of each intake unit and in the discharge canal. Measurements were made only when a unit was in operation.

Temperature and oxygen content were monitored with a YSI Model 54 meter; conductivity was determined with a YSI Model 33 S-C-T meter. Conductivity measurements were later converted to values at 25°C (TI 1976b). Tidal stage at the time of fish collection was determined using tide tables published annually by the National Ocean Survey, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Each unit's operational data (daily flow rate for each circulator and the duration of circulator operation) were obtained from the Indian Point Performance Group of Con Edison.

3. Length-Weight Relationships (Impinged Fish Versus River Fish)

Species' length-weight regression equations for impinged fish were calculated separately for each unit (1, 2, or 3) by season and compared with those for fish collected during standard station sampling. Statistical treatments and their applications were identical to those used to test 1975 data (TI 1976a). The regression equations were examined for homogeneity of variance, using Levene's test, to determine if they could be tested for differences by analysis of variance (Brown and Forsythe 1974).

4. Collection Efficiency Test

Experiments were conducted at Unit 3 to estimate the percentage of impinged fish that had not been collected during the impingement monitoring process. Procedures were similar to those used for experiments at Unit 2 during 1975 (TI 1976a). In seven tests (Table III-1), dead white perch marked with various dyes were released in front of and at the center of Unit 3 intake screens 33 or 36 to simulate impingement and were later collected to obtain estimate of the percent recovery. Data were compared using chi square (χ^2) analysis.

Table III-1

Collection Efficiency Tests at Unit 3 during 1976

Test No.	Date	Release Time	Release Screen	Release No. of Fish	Circulator Flow Rate (%)
1	11 Jun	0845	36	50	100
2	16 Jun	0845	36	50	100
3	22 Jun	0845	36	50	100
4	24 Jun	1400	36	50	100
	25 Jun	0900	36	50	100
5	7 Jul	1430	36	50	100
	8 Jul	0900	36	50	100
6	21 Jul	1400	36	50	100
	22 Jul	0900	36	50	100
7	11 Aug	1500	33	50	100
	12 Aug	0900	33	50	100

D. RESULTS

1. Impingement of Fishes

In 1976, 57 fish species representing 30 families were collected from the intake screens of Units 1, 2, and 3 (Table III-2). The large number of species observed was similar to the total of 60 collected during standard station sampling in the vicinity of Indian Point during 1972-75 (TI 1976b); however, the 1976 impingement collections were characterized by seasonal peaks (Table III-3), with relatively few species representing the major portion collected (Table III-4). Nine species of fish, sea lamprey, white bass, sea robin, brook trout, smallmouth bass, winter flounder, silver hake, white crappie and northern puffer, were collected in impingement sampling but not collected in the standard stations sampling during 1976 (Section IV).

White perch (54%), blueback herring (32%), Atlantic tomcod (4%), and bay anchovy (2%) accounted for more than 90% of the total number of fish collected; striped bass comprised only 0.8% of the total collection. White perch were most frequently impinged during the winter and fall (Figure III-2); summer collections consisted primarily of Atlantic tomcod and bay anchovies (Figure III-3). Blueback herring were prevalent during the fall, most being

Table III-2

Fish in Impingement Collections at Indian Point Plant during 1976

Species	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Petromyzontidae-lampreys				
Sea lamprey - *Petromyzon marinus*	+			+
Acipenseridae-sturgeons				
Shortnose sturgeon - *Acipenser brevirostrum*	+			
Atlantic sturgeon - *Acipenser oxyrhynchus*	+	+	+	+
Anguillidae-freshwater eels				
American eel - *Anguilla rostrata*	+	+	+	+
Clupeiformes-herrings				
Blueback herring - *Alosa aestivalis*	+	+	+	+
Alewife - *Alosa pseudoharengus*	+	+	+	+
American shad - *Alosa sapidissima*	+	+	+	+
Atlantic menhaden - *Brevoortia tyrannus*		+	+	+
Gizzard shad - *Dorosoma cepedianum*	+	+		+
Engraulidae-anchovies				
Bay anchovy - *Anchoa mitchilli*		+	+	+
Salmonidae-trouts				
Brown trout - *Salmo trutta*			+	
Brook trout - *Salvelinus fontinalis*		+		
Osmeridae-smelts				
Rainbow smelt - *Osmerus mordax*	+	+	+	+
Esocidae-pikes				
Grass pickeral - *Esox americanus vermiculatus*				+
Chain pickeral - *Esox niger*		+		
Cyprinidae-minnows and carps				
Goldfish - *Carassius auratus*	+	+		+
Carp - *Cyprinus carpio*		+		+
Golden shiner - *Notemigonus crysoleucas*	+	+	+	+
Emerald shiner- *Notropis atherinoides*	+			
Common shiner - *Notropis cornutus*				+
Spottail shiner - *Notropis hudsonius*	+	+	+	+
Catostomidae-suckers				
White sucker - *Catostomus commersoni*	+	+		+
Ictaluridae-freshwater catfishes				
White catfish - *Ictalurus catus*	+	+	+	+
Brown bullhead - *Ictalurus nebulosus*	+	+	+	+
Gadidae-codfishes				
Silver hake - *Merluccius bilinearis*				+
Atlantic tomcod - *Microgadus tomcod*	+	+	+	+

Table III-2 (Contd)

Species	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Belonidae-needlefishes				
Atlantic needlefish - *Strongylura marina*				+
Cyprinodontidae-killifishes				
Banded killifish - *Fundulus diaphanus*	+	+	+	+
Mummichog - *Fundulus heteroclitus*	+	+	+	+
Atherinidae-silversides				
Atlantic silverside - *Menidia menidia*			+	+
Gasterosteidae-sticklebacks				
Fourspine stickleback - *Apeltes quadracus*	+	+		+
Threespine stickleback - *Gasterosteus aculeatus*	+			+
Syngnathidae-pipefishes and seahorses				
Northern pipefish - *Syngnathus fuscus*			+	
Percichthyidae-temperate basses				
White perch - *Morone americana*	+	+	+	+
White bass - *Morone chrysops*	+			+
Striped bass - *Morone saxatilis*	+	+	+	+
Centrarchidae-sunfishes				
Redbreast sunfish - *Lepomis auritus*	+	+	+	+
Pumpkinseed - *Lepomis gibbosus*	+	+	+	+
Bluegill - *Lepomis macrochirus*	+	+	+	+
Smallmouth bass - *Micropterus dolomieui*				+
Largemouth bass - *Micropterus salmoides*	+		+	+
White crappie - *Pomoxis annularis*		+		+
Black crappie - *Pomoxis nigromaculatus*	+	+		+
Percidae-perches				
Tessellated darter - *Etheostoma olmstedi*	+	+	+	+
Yellow perch - *Perca flavescens*	+	+	+	+
Pomatomidae-bluefishes				
Bluefish - *Pomatomus saltatrix*		+	+	+
Carangidae-jacks and pompanos				
Crevalle jack - *Caranx hippos*			+	+
Sciaenidae-drums				
Weakfish - *Cynoscion regalis*			+	+
Spot - *Leiostomus xanthurus*			+	+
Atlantic croaker - *Micropogon undulatus*				+
Mugilidae-mullets				
Striped mullet - *Mugil cephalus*				+
Stromateidae-butterfishes				
Butterfish - *Peprilus triacanthus*			+	
Triglidae-searobins				
Sea robin - *Prionotus* sp.				+
Bothidae-lefteye flounders				
Summer flounder - *Paralichthys dentatus*				+
Pleuronectidae-righteye flounders				
Winter flounder - *Pseudopleuronectes americanus*	+		+	+
Soleidae-soles				
Hogchocker - *Trinectes maculatus*	+	+	+	+
Tetraodontidae-puffers				
Northern puffer - *Sphoeroides maculatus*	+			

+ = Species present

Table III-3

Number of Fish (All Species) Collected Monthly from Intake Screens of Units 1, 2, and 3, Indian Point Nuclear Plant during 1976

Month	Unit 1	Unit 2	Unit 3	All Units
Jan	0	98,512	0	98,512
Feb	0	28,669	2,856	31,525
Mar	0	19,842	0	19,842
Apr	0	52	4,477	4,529
May	0	0	9,488	9,488
Jun	0	499	5,280	5,779
Jul	0	0	7,993	7,993
Aug	71	0	15,521	15,592
Sep	357	5,445	22,298	28,100
Oct	0	187,759	143,379	331,138
Nov	306	5,198	102,098	107,602
Dec	0	114,044	41,822	155,866
TOTAL	734	460,020	355,212	815,966

Table III-4

Number of Fish Collected (Including Totals for Frequently Impinged Species) from Intake Screens at Units 1, 2, and 3, Indian Point Nuclear Plant during 1976

Species	Unit 1	Unit 2	Unit 3	All Units
Alewife	2	706	2,843	3,551
Striped bass	1	3,781	2,348	6,130
Bay anchovy	105	3,402	8,636	12,143
Atlantic tomcod	78	12,159	21,970	34,207
Blueback herring	25	132,290	125,949	258,264
White perch	442	283,524	156,672	440,638
All species	734	460,020	355,212	815,966

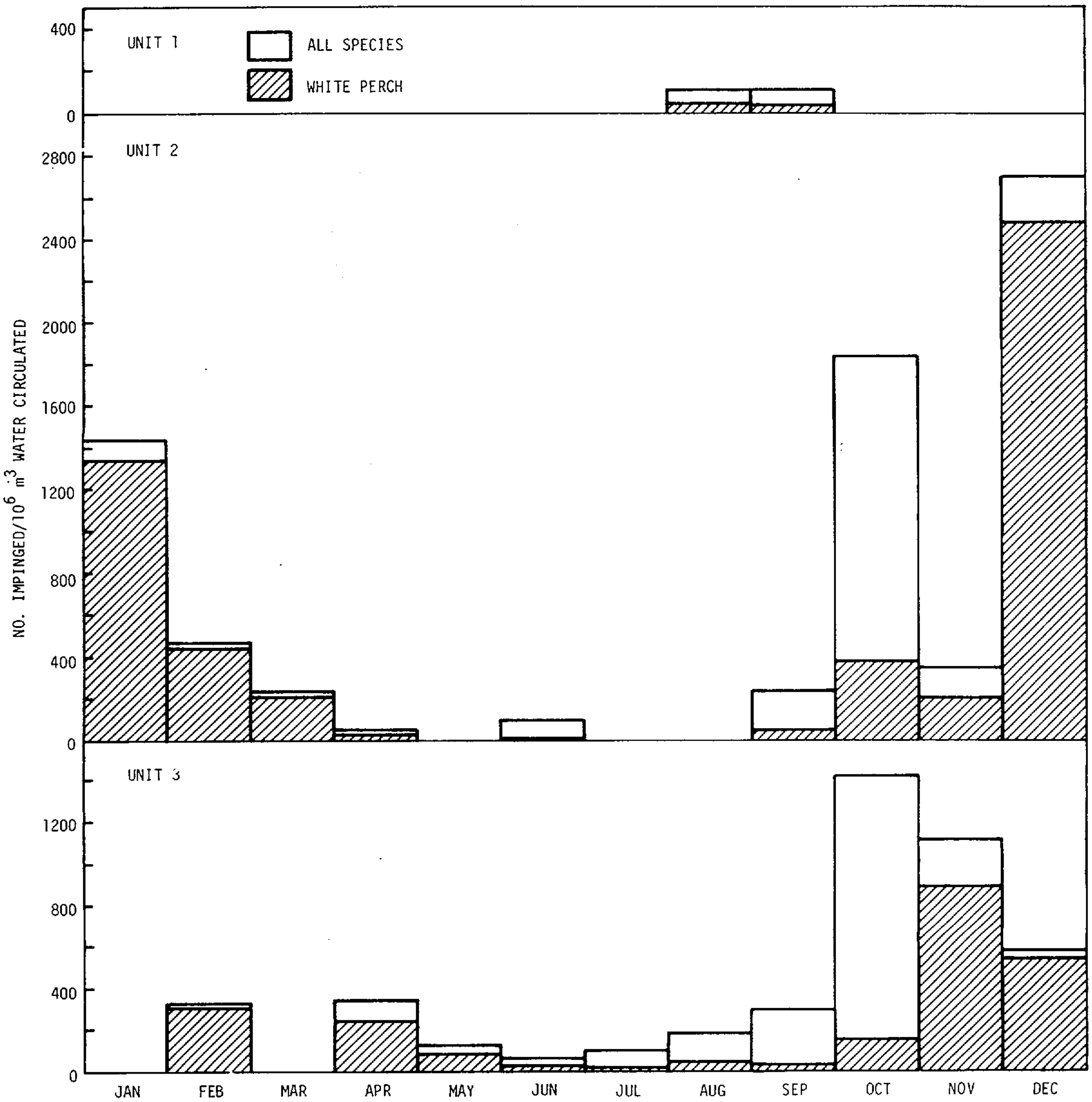


Figure III-2. White Perch Monthly Impingement Rates (Number Collected/$10^6 m^3$ Water Circulated) at Indian Point Units 1, 2, and 3 Compared with Rates of All Species for 1976

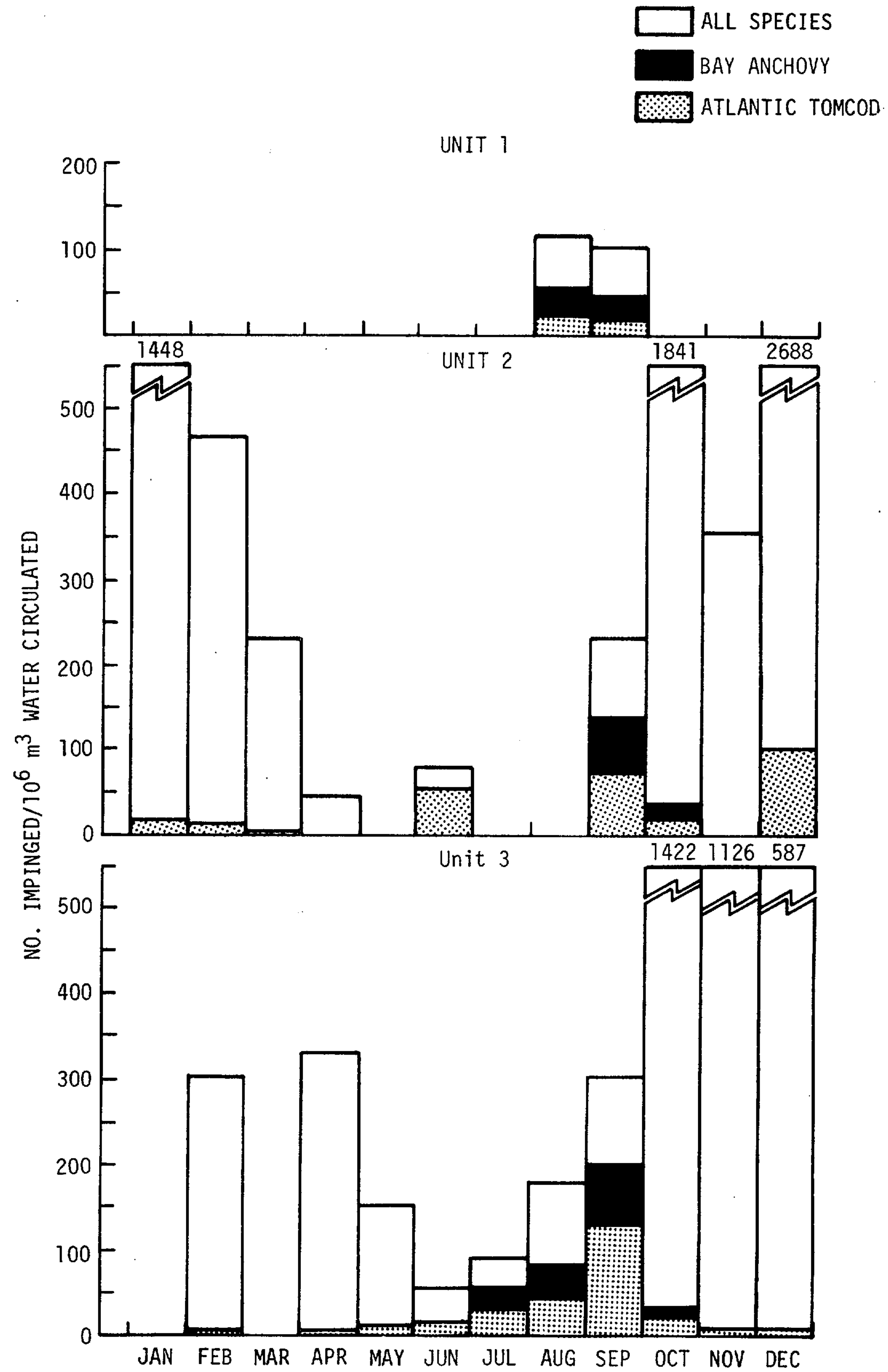


Figure III-3. Atlantic Tomcod and Bay Anchovy Monthly Impingement Rates (Number Collected/$10^6 m^3$ Water Circulated) at Indian Point Units 1, 2, and 3 Compared with Rates for All Species for 1976 impinged in October. Most striped bass were impinged during fall and early winter (Figure III-4). Weekly impingement summaries for selected species are presented by unit in Appendix Tables A-1 to A-3.

The majority of striped bass, white perch, and Atlantic tomcod collected from the intake screens were YOY and yearling fish. Almost all of the striped bass (98%) and white perch (96%) impinged from January through May were yearlings (Table III-5), but YOY fish dominated late summer and fall collections. Young-of-the-year striped bass and white perch were first collected during the week of 13-19 July, whereas YOY Atlantic tomcod appeared initially in early May. Most Atlantic tomcod impinged during the winter were mature fish associated with the species' annual spawning migration.

Table III-5

Percent of Length Class 1 Fish by Species in Monthly Collections of Striped Bass, White Perch, and Atlantic Tomcod at Indian Point Units 1, 2, and 3 during 1976

	Percent of Catch											
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Striped Bass	98.3	96.6	100.0	100.0	90.2	0.0	74.3	82.0	91.9	95.0	92.4	97.1
White Perch	99.2	97.0	91.6	97.5	94.4	0.0	13.1	65.4	75.6	94.1	96.6	96.1
Atlantic Tomcod	98.7	98.6	100.0	11.1	99.0	99.8	97.8	93.2	93.8	99.3	98.0	99.0

2. Impingement Relative to Physicochemical Factors

Of the physicochemical factors monitored at Indian Point during 1976 (Figure III-5), only changes in conductivity levels appeared to be associated with changes in fish impingement rates at the plant. A similar association between conductivity and fish impingement has been reported for previous years (TI 1975a, 1976a). On a seasonal basis, a relationship between impingement and temperature also existed, since temperature affects the presence of species in the vicinity of the generating station within a year (Section IV). There was no apparent relationship between oxygen levels and impingement.

Periods of peak white perch impingement in winter, early spring, and late fall usually coincided with increases in conductivity (indication of salt-front intrusion) in the region (Figure III-6); during this period, white perch occur mainly in the channel areas of the estuary (Section IV), areas first to

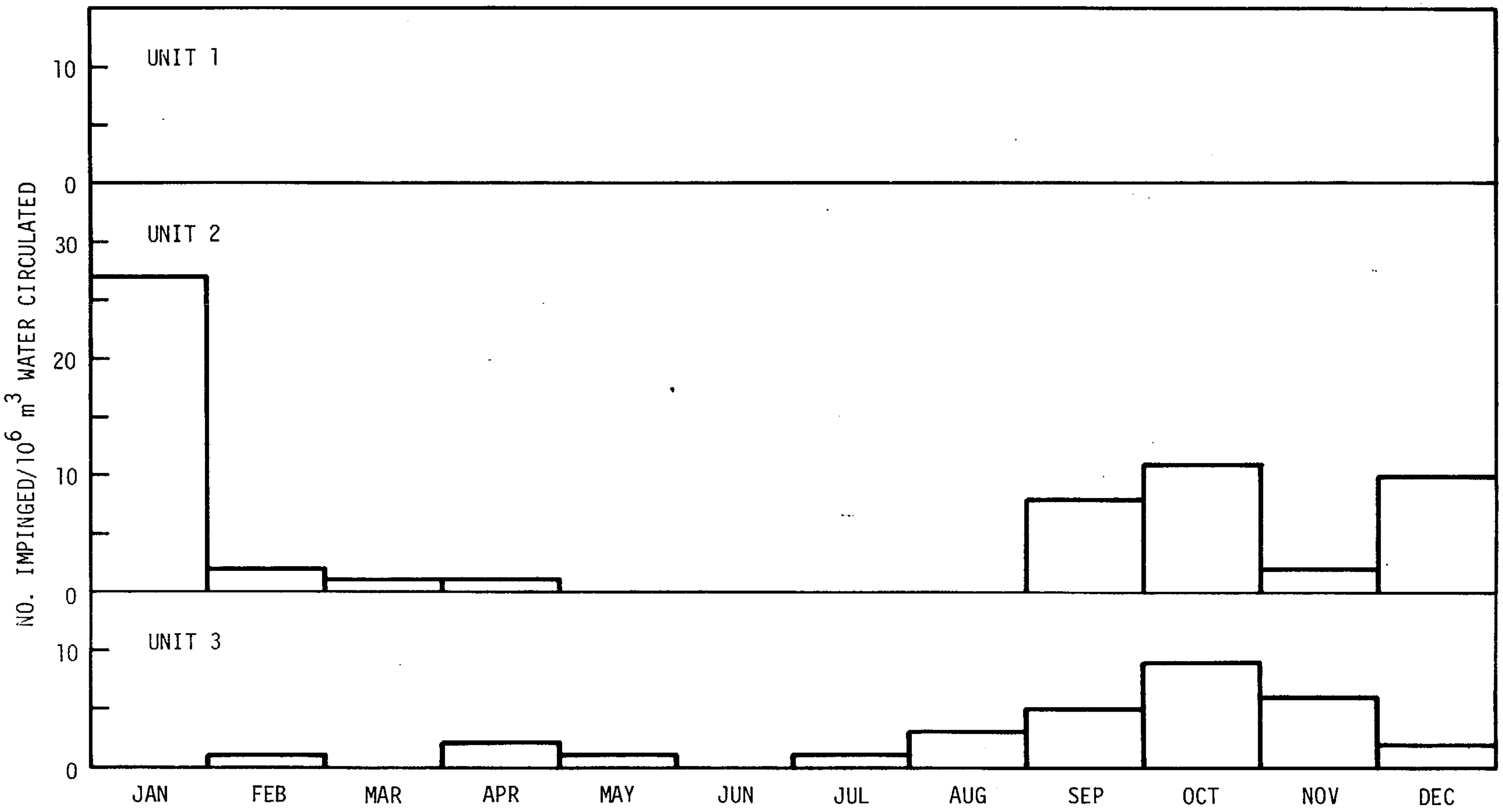


Figure III-4. Striped Bass Monthly Impingement Rates (Number Collected/$10^6 m^3$ Water Circulated) at Indian Point Units 1,2,and 3 for 1976

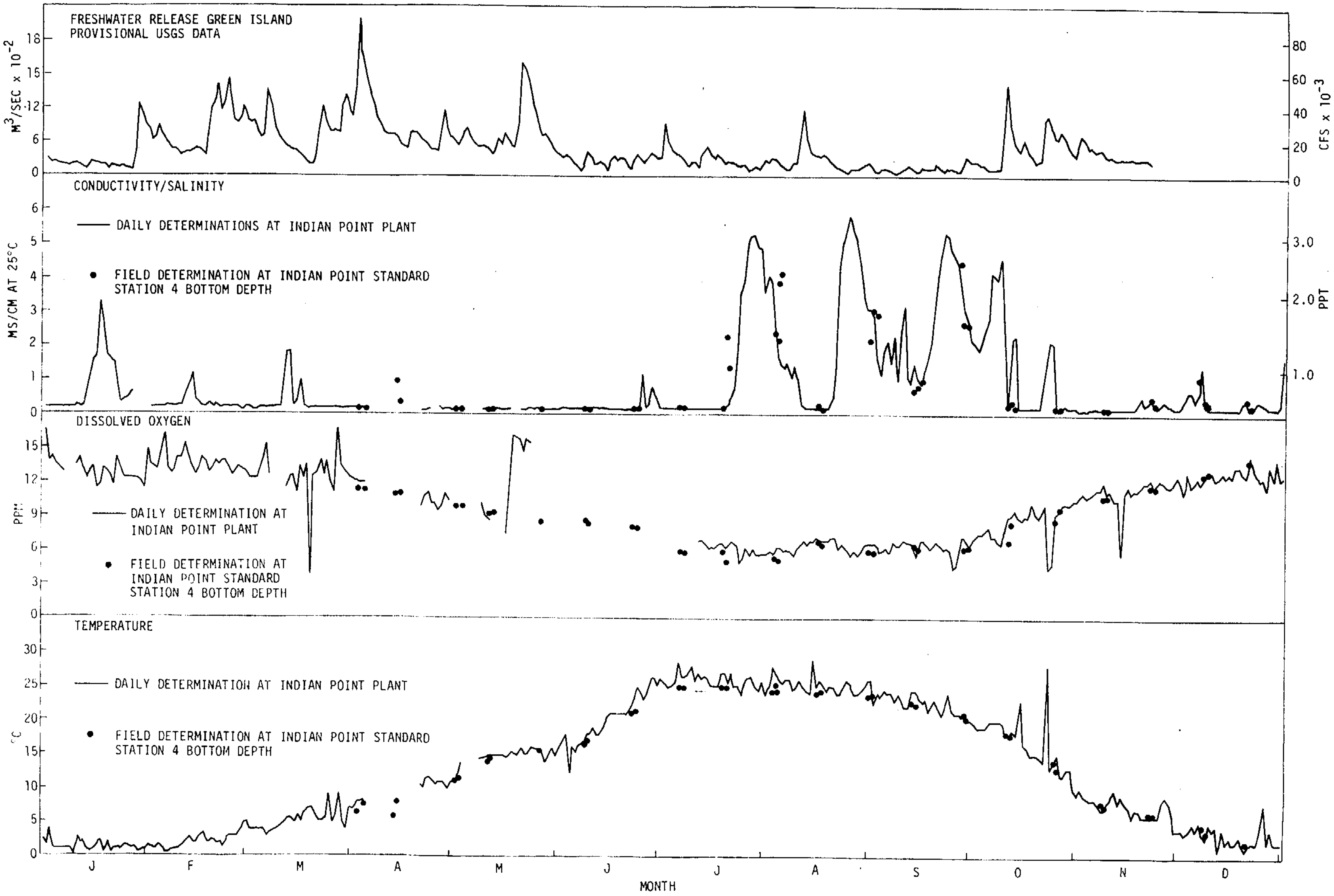


Figure III-5. Seasonal Variation of Temperature, Dissolved Oxygen, and Conductivity/ Salinity at Indian Point with Freshwater Release at Green Island, Hudson River Estuary, 1976

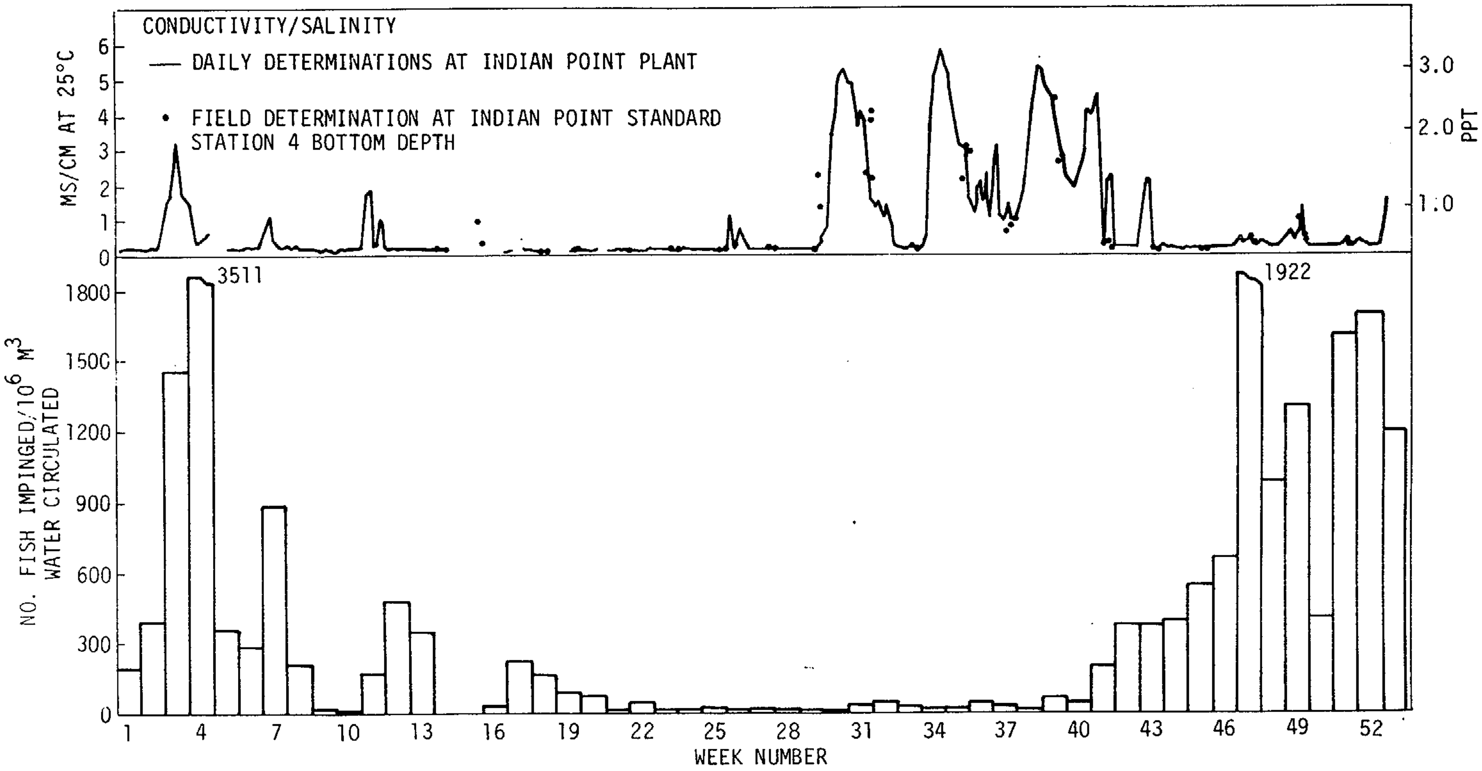


Figure III-6. White Perch Weekly Impingement Rates at Indian Point Units 2 and 3 in 1976 with Daily Conductivity Measurements receive surges of salt water in the region. An increase in the abundance of white perch in the vicinity of the plant as they moved with the salt front may have contributed to the increases in impingement during these periods. During the summer, white perch primarily utilize shorezone areas in the Indian Point region and generally are not vulnerable to the Indian Point plant.

Increased impingement of white perch was observed also during spring and fall when rapidly changing temperature caused a change in habitat preference for shallow or deep water. Periods of large impingement collections of Atlantic tomcod frequently coincided with summer salt intrusions into the region (Figure III-7). Impingement peaks during this period probably reflected an increase in abundance of the species in the area of the plant as a result of the species movements associated with saltfront movement.

Association between peak impingement at Indian Point and river environmental conditions near the plant suggest causes of fish impingement, but local distribution patterns, interactions among environmental factors, physiological state, and plant operations can contribute to fish impingement, so each aspect must be considered before final conclusions regarding the causes of increased impingement rates are formulated.

3. Length-Weight Relationships (Impinged Fish vs River Fish)

Analyses of the seasonal length-weight relationship for striped bass, white perch, and Atlantic tomcod indicated few significant differences between fish impinged at the Indian Point plant and fish collected by beach seine and bottom trawl in the vicinity of the plant. Significant differences ($\alpha = 0.05$) between regression equations occurred for white perch collected from Units 2 and 3 and from the river in the spring and fall, white perch from Unit 1 and from the river during the summer, Atlantic tomcod from Unit 2 and from the river during the summer, and Atlantic tomcod from Unit 2 and from the river during fall (Table III-6).

Interpreting the length-weight analyses is limited by confounding factors. The effect of impingement duration on weight is unknown, and differences in regression equations between units confound any conclusions. Based on analysis of 1976 length/weight data, fish impinged at Indian Point could not be inferred to be less robust or weaker members of the Hudson River populations examined. Similar results were observed in 1975 (1976a).

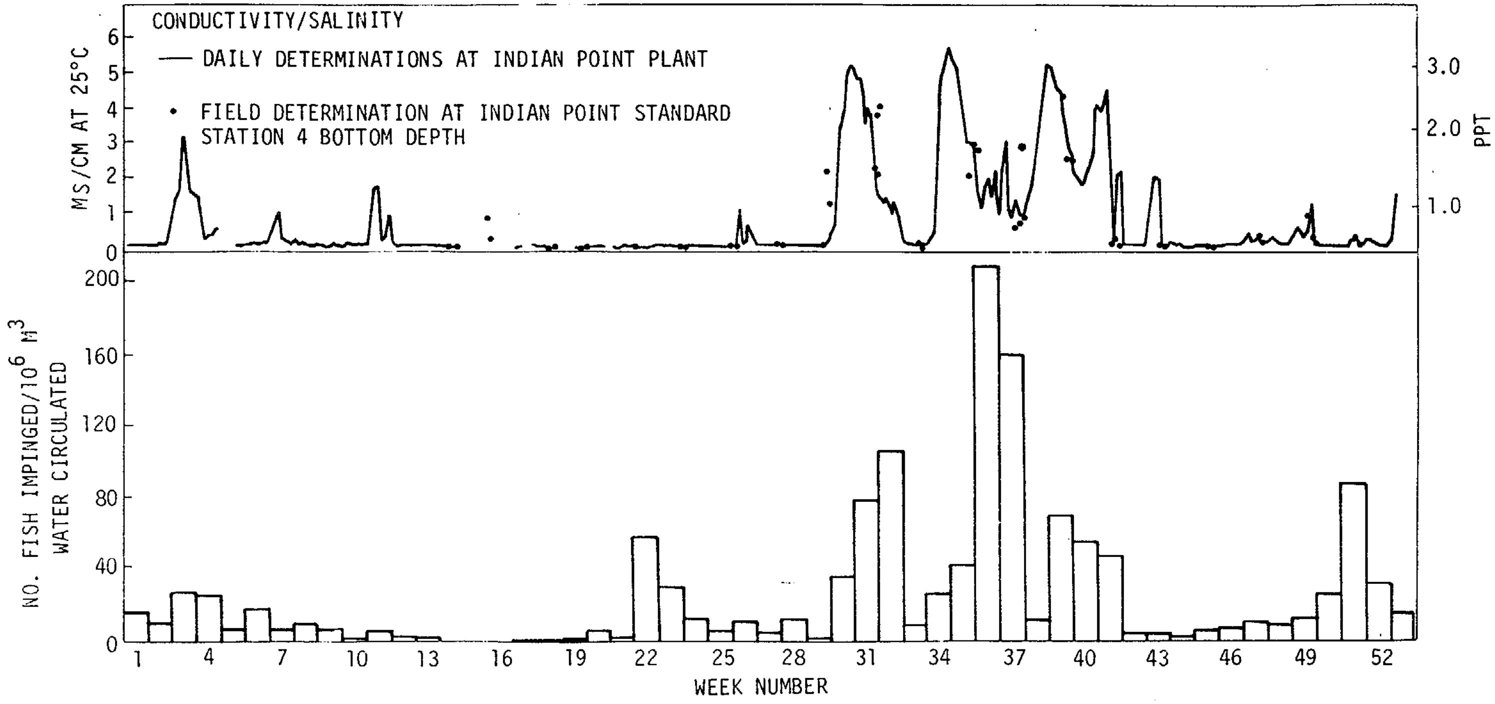


Figure III-7. Atlantic Tomcod Weekly Impingement Rates at Indian Point Units 2 and 3 in 1976 with Daily Conductivity Measurements

Table III-6

Length-Weight Regression Analysis* for Fish Collected by Impingement at Indian Point Units 1, 2, and 3, and Beach Seine and Bottom Trawl at Indian Point Standard Stations during 1976†

Species	Sample Site	Season	Sample Size	Y Intercept (a)	Slope (b)	Correlation Coefficient (r)
White perch	Unit 2	Spring	71	-4.891	2.989	0.9958
	Unit 3		268	-5.236	3.167	0.9952
	SS**		889	-5.396	3.253	0.9956
	Unit 1	Summer	56	-4.577	2.823	0.9971
	SS		1557	-5.099	3.098	0.9967
	Unit 2	Fall	357	-5.257	3.156	0.9898
	Unit 3		482	-5.199	3.131	0.9926
	SS		1615	-5.332	3.207	0.9969
Atlantic tomcod	Unit 2	Summer	36	-4.476	2.699	0.9940
	SS		366	-5.138	3.020	0.9871
	Unit 2	Fall	103	-5.614	3.255	0.9922
	SS		349	-5.318	3.124	0.9815

*Log_{10} transformed data; length-weight relationship expressed by:

$$\text{Log } W = \log a + b \log L$$

W = weight (g); L = length (mm)

†Only data sets in which there was a significant difference ($\alpha = 0.05$) in the length-weight regression between impingement and standard stations sampling are included.

**SS = Standard stations.

4. Collection Efficiency Tests

The percentage of marked fish recovered from the intake screens of Unit 3 following screen washings was similar in all tests (Table III-7). A mean recovery rate of 82.6% occurred for fish released just before a collection, and the mean was 77.8% for fish released in equal numbers approximately 18 hr and 1 hr before a collection. Chi-square analyses indicated no significant differences between recovery rates for tests 1 through 3 when fish were released just before collection or for tests 4 through 7 when fish were released 1 and 18 hr before collection.

Table III-7

Results of Collection Efficiency Tests Indian Point Unit 3 during 1976

Test Number	Number of Fish Released	Number of Fish Recovered	Percent Recovered
1	50	41	82
2	50	40	80
3	50	43	86
4	100	81	81
5	100	75	75
6	100	76	76
7	100	79	79

Experiments at Unit 3 in 1976 showed a consistent recovery rate of approximately 80% and suggest that there is no difference between screens. However, the tests were not designed to evaluate the effects of several factors that influence recovery rates, i.e., tidal flow at the time of screen washing, circulator flow rate (100% vs 60%), screen location, and time impinged prior to collection. Recovery rates at Unit 3 were high compared with those at Unit 2, which were 2-45% in 1975 (TI 1976a). The two units' large difference in recovery rates was primarily caused by the difference in screen-washing procedures: Unit 2, the fixed screens on which fish are initially impinged are backwashed, causing some individuals to be lost before they can be collected from the traveling screens, particularly when the air curtain is in operation; Unit 3, there are no fixed screens or air curtains in front of the traveling screens, thereby simplifing collection and causing a higher expected rate of return.

5. Zone of Influence

Mark/recapture studies were designed to provide information on Hudson River striped bass, white perch, and Atlantic tomcod population sizes and movements.

The fish, depending on size, were marked with finclips, fingerling tags, Carlin tags, or internal anchor tags. Release and recapture locations indicate minimum distances and direction traveled, information that can be used to assess these populations' potential vulnerability to power plant impact. From marked fish recaptured by impingement at Indian Point, a hypothetical "zone of influence," the spatial distribution of the vulnerable population, can be described for each species; however, a lack of recaptures from a region of the river does not necessarily indicate that fish in that region are not vulnerable.

In the following paragraphs, the spatial distribution of the populations vulnerable to impingement at Indian Point is developed using marked fish impinged during 1976.

a. Striped Bass

During 1976, impingement recaptures of finclipped 1975 and 1976 year class striped bass indicated little movement (Table III-8). There were only six recaptures at the Indian Point plant; all had been released between RM 24 (KM 38.6) and RM 46 (KM 74). The lack of recaptures of fish released outside the area may have been due to the small number of releases, restricted movement, or low vulnerability to impingement when movement does occur. No tagged striped bass were recaptured at Indian Point in 1976.

Table III-8

Release Locations of Finclipped Juvenile Striped Bass, White Perch, and Adult Atlantic Tomcod Impinged at Indian Point Nuclear Power Generating Station [RM 42 (KM 67.6)] during 1976.

Release Region River Mile (Kilometer)	Number of Fish Released/Impinged – Species/Year Class											
	Striped Bass				White Perch				Atlantic Tomcod			
	1975		1976		1975		1976		1974 - 1975		1975 - 1976	
12-23 (19-37)	2,195	0	2,032	0	206	1	141	0	0	0	0	0
24-38 (38-61)	10,968	2	6,913	2	39,823	17	21,653	19	628	0	748	0
39-46 (62-74)	4,074	2			7,695	14			77	0	0	0
47-76 (74-122)	820	0	522	0	3,992	4	2,736	4	25,605	43	17,606	13
77-153 (123-146)	133	0	36	0	2,365	3	699	2	0	0	0	0

b. **White Perch**

White perch of all ages showed substantial movement into the region of the Indian Point power plant. Young-of-the-year and yearling fish marked in all five mark/recapture regions, RM 12-153 (KM 19.3-246.2) were impinged (Table III-8). Young white perch from the entire estuary appear to be vulnerable to impingement at Indian Point. Recaptures of older white perch marked with fingerling (fish < 150 mm) and internal anchor (fish ≥ 150 mm) tags indicate that the vulnerable population of these fish ranges at least from Irvington [RM 26 (KM 41.8)] to New Baltimore [RM 129 (KM 207.6)], as shown in Figures III-8 and III-9. These recaptures indicate that white perch move extensively both up and down the Hudson River and that there is essentially a single Hudson River population rather than several local populations.

c. Atlantic Tomcod

Recaptures of Atlantic tomcod marked upriver from Indian Point exhibited a downriver movement (Figure III-10 and Table III-8). The apparent absence of upriver movement is due to the difficulty in capturing and marking the tomcod before their spawning migration; tomcod are marked in the shorezone where they apparently spawn and movement to the shorezone usually occurs upriver from Indian Point. Few tomcod were marked downriver from Indian Point [RM 42 (KM 67.7)]. Thus, the small number of impinged fish showing upstream movement may not be indicative of true population movements (Figure III-10 and Table III-8).

E. CONCLUSIONS

Impingement sampling at the Indian Point nuclear power generating station in 1976 indicated little change in the magnitude, composition, and seasonality of fish impingement observed during previous years.

- A total of 57 species were collected from the intake screens at Indian Point.
- Four species dominated collections, accounting for more than 90% of all fish impinged. White perch was the most abundant (54% of the collections).
- Young-of-the-year and yearling fish dominated collections, reflecting their abundance in the region and their possibly reduced avoidance capabilities.
- High rates of impingement were usually associated with the movement of the salt front through the region.

Comparisons of length/weight regressions for striped bass, white perch and Atlantic tomcod taken from impingement collections with those taken from nearly standard stations provided no evidence that fish impinged were less robust or healthy than those in the river population.

Collection efficiency experiments at Unit 3 indicated a recovery rate of approximately 80%.

Recaptures of marked striped bass, white perch, and Atlantic tomcod from the intake screens of the Indian Point plant in 1976 indicated the range of vulnerability to impingement for these species.

- Only striped bass marked and released between RM 24 and 46 (KM 38.6 and 74) were impinged at Indian Point. The small apparent range of susceptibility to impingement may be due to a combination of restricted movements of the fish, a low vulnerability to impingement, and the small number of fish released in the more distant regions (only 21% of the total released).

- Marked white perch impinged at the Indian Point plant had been released at areas throughout the estuary, indicating an extensive range of vulnerability.

- Atlantic tomcod recaptures at Indian Point consisted primarily of fish marked upriver, suggesting vulnerability to impingement during downriver movements. Vulnerability during upriver migration could not be adequately assessed since few fish were marked below the Indian Point generating station.

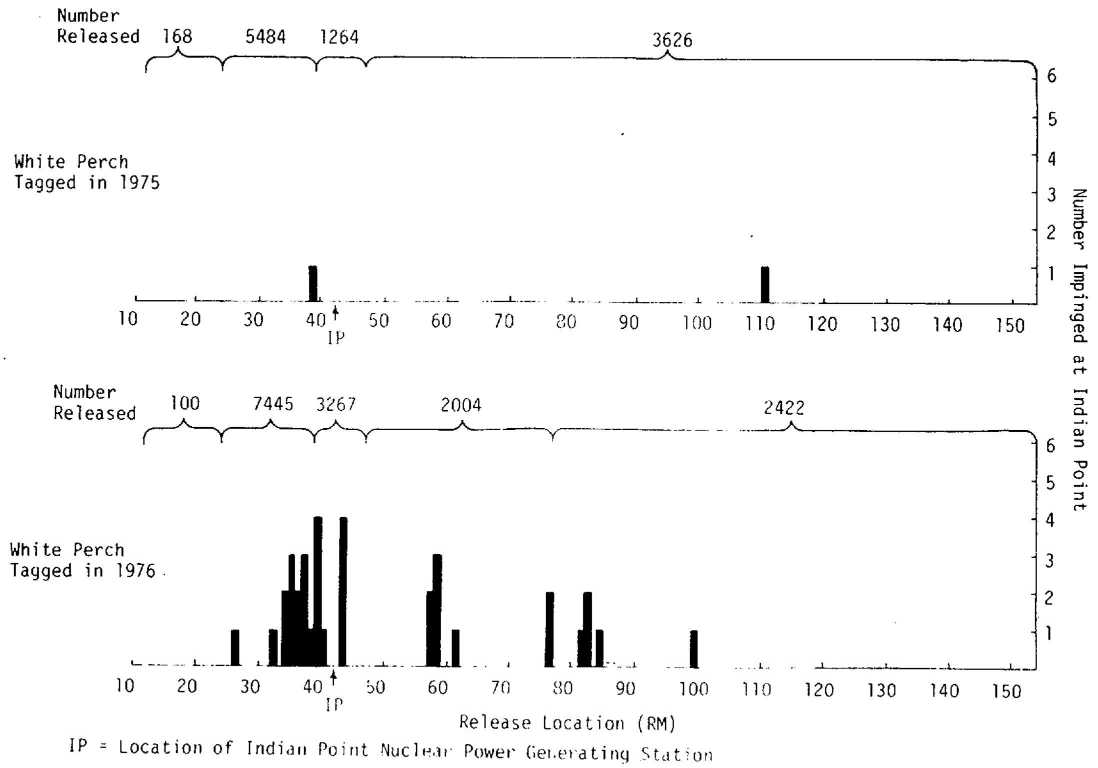


Figure III-8. Release Locations of Tagged White Perch < 150 mm in Total Length Impinged at Indian Point Nuclear Generating Station (IP) during 1976.

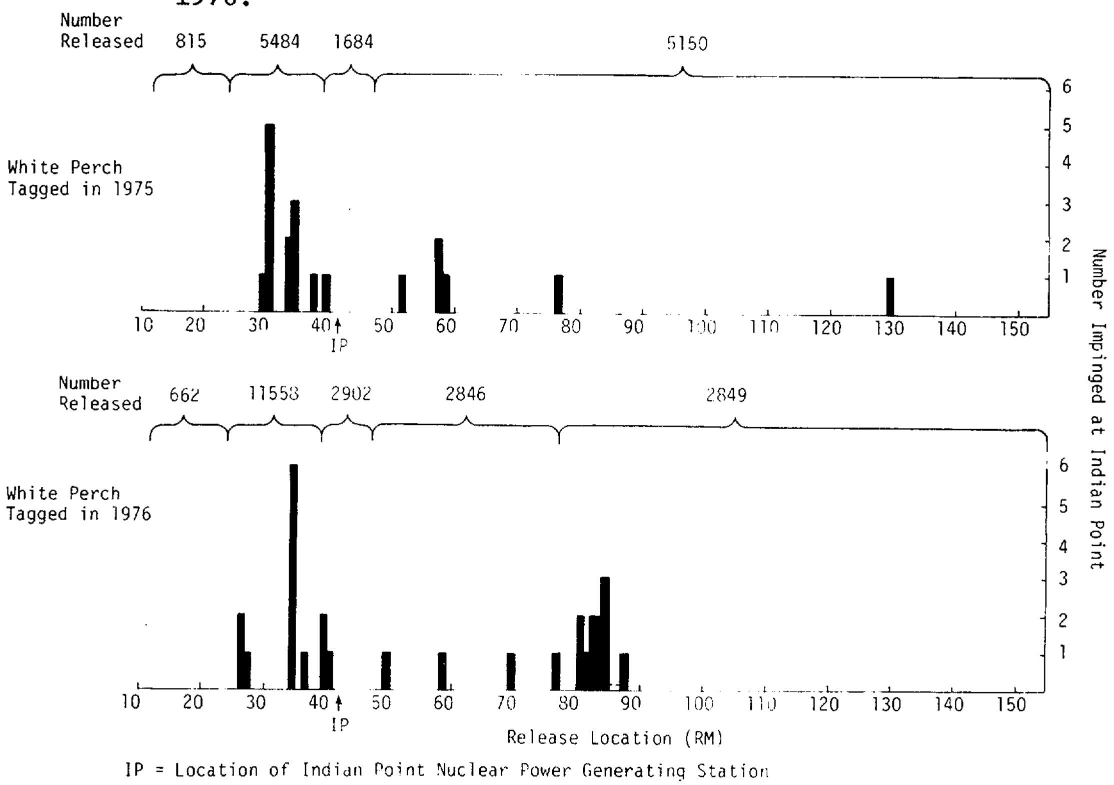
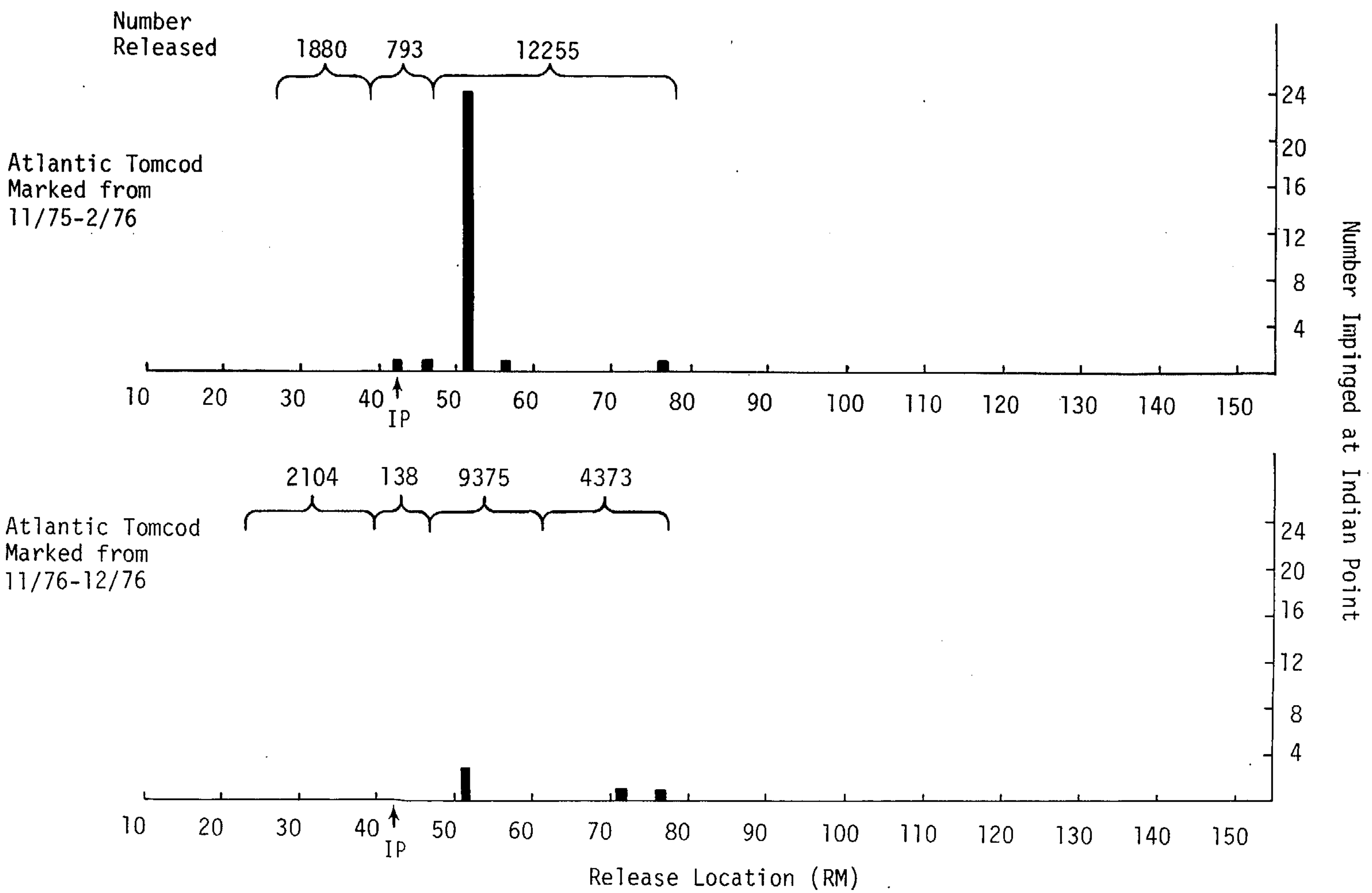


Figure III-9. Release Locations of Tagged White Perch ≥ 150 mm in Total Length Impinged at Indian Point Nuclear Generating Station (IP) during 1976.



IP = Location of Indian Point Nuclear Power Generating Station

Figure III-10. Release Locations of Tagged Atlantic Tomcod Impinged at Indian Point Nuclear Generating Station (IP) during 1976.

SECTION IV

INDIAN POINT STANDARD STATION BEACH SEINE AND TRAWL STUDIES

A. INTRODUCTION

The standard station fisheries sampling program contributes to a data base describing the fish community in the Indian Point region. The study design permits development of a "trend-through-time" data series to determine changes in the fish community.

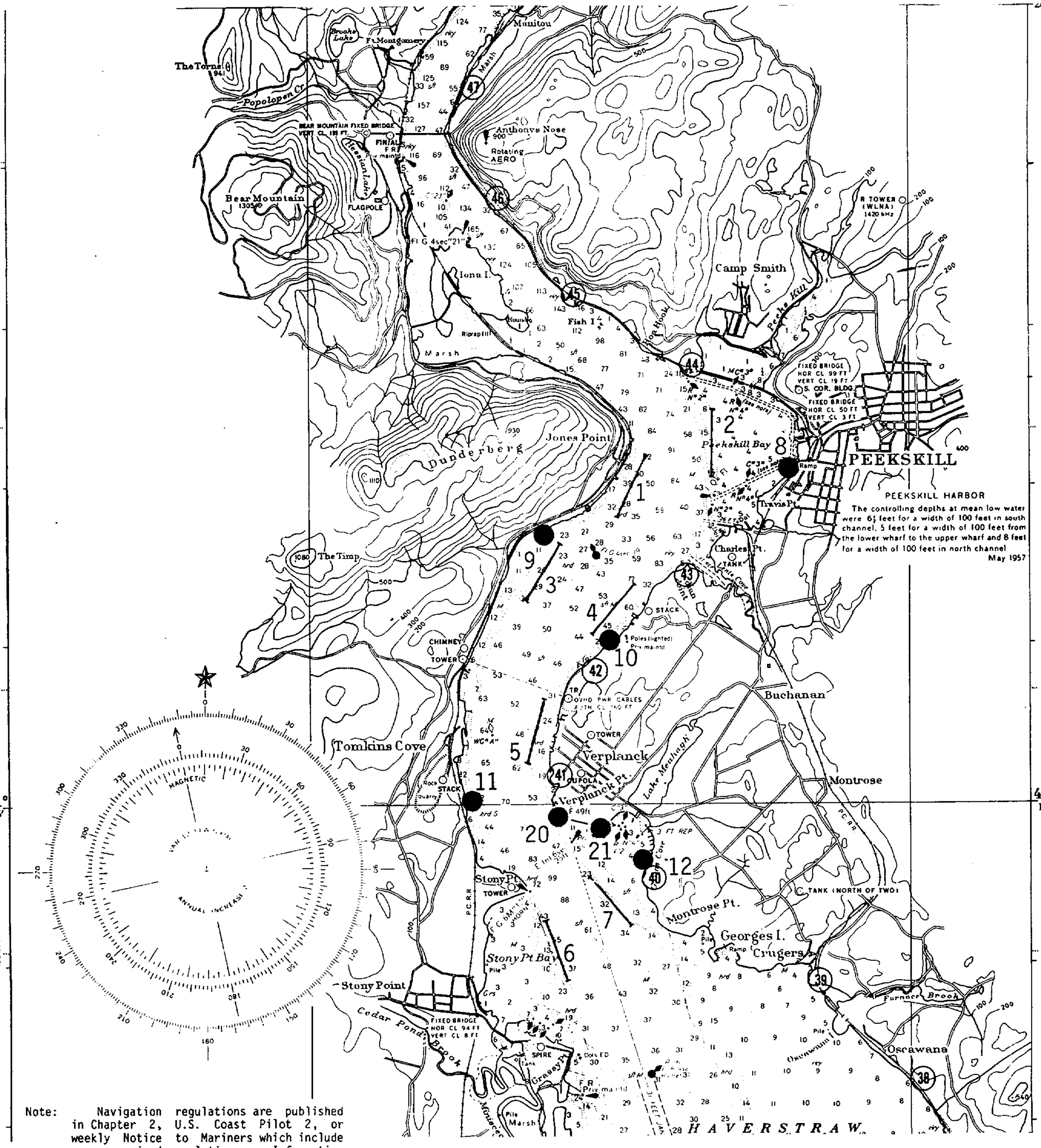
Objectives of the 1976 study were to determine the seasonal composition, relative abundance, and distribution of fish species at 14 sampling stations in the vicinity of Indian Point and to monitor river physicochemical factors for comparison with the fisheries data. This section discusses the results and offers some comparison with data from prior years.

B. METHODS

From late March through December, 14 stations in the Indian Point region (Figure IV-1) were sampled during the day. Seven shorezone collections were made weekly with a 100-ft (30.5-m) beach seine, and channel and shoal stations were sampled biweekly with an otter-type bottom trawl used with and without a fine mesh liner inside the cod end. Beginning in July, the bottom trawl stations were sampled also at the surface with a modified midwater trawl. Sampling gear specifications and deployment were identical to those used in 1975 (TI 1976b).

Temperature, dissolved oxygen, pH, and conductivity were measured *in situ* concurrently with all fish sampling, and turbidity was determined in the laboratory from a surface sample taken at each station. Instrumentation and procedures used during 1976 were the same as those in 1975.

All fish were brought to the laboratory for processing. There, they were identified to species and sorted into the following length classes: 0-X mm, (X + 1) - 150 mm, 151-250 mm, and 251 + mm, where X denotes the upper total



Note: Navigation regulations are published in Chapter 2, U.S. Coast Pilot 2, or weekly Notice to Mariners which include new or revised regulations. Information concerning the regulations may be obtained at the Office of the District Engineer, Corps of Engineers in New York, N.Y.
Anchorage regulations may be obtained at the Office of the Commander, 3rd Coast Guard District in New York, N.Y.
Refer to section numbers shown with area designation.

● Beach seine sites

I Bottom trawl and surface trawl sites

○ Indicates river mile

Figure IV-1. Indian Point Standard Station Beach Seine, Bottom Trawl, and Surface Trawl Sites, Hudson River Estuary, RM 39-43 (KM 62-69), 1976 length limit for yearling or young-of-the-year of each species, depending on season. The 0-X category represented yearling fish (from 1 January through 31 March for Atlantic tomcod and through 31 May for all other species); thereafter, the 0-X category contained young-of-the-year fish. The number of fish in each length class was recorded for each species. All individuals within a length class were counted unless a large sample (>1000) was encountered. In the latter case, the number of fish was estimated as follows:

$$\hat{N} = \frac{W \times n}{w}$$

where

$\hat{N}$ = estimated total number in sample

W = total weight of sample

w = weight of subsample

n = number in subsample

The average weight of three subsamples of 100 randomly selected fish represented the subsample weight (w). Up to 20 randomly selected fish in each length category also were measured and weighed. Laboratory processing included the collection of scales to determine age, ovaries to determine fecundity, and stomachs to determine food habits.

Catch-per-unit-effort (C/f) values were calculated biweekly for each gear type to assess the distribution and relative abundance of fishes commonly collected in the Indian Point area. Relative abundance and distribution were evaluated by graphical interpretation.

C. RESULTS

1. Species Composition

The 14 standard stations yielded 43 species representing 21 families (Table IV-1). The greatest variety (richness) of species (20 families, 30 species) occurred in beach seine collections. Bottom trawl catches contained 26 species, while surface trawls yielded only 14. The most species occurred during

Table IV-1

Fishes by Season and Gear, Standard Stations, Indian Point Region, Hudson River, 1976

Species	Life Stage	Beach Seine Sp	Beach Seine Su	Beach Seine Fall	Bottom Trawl Sp	Bottom Trawl Su	Bottom Trawl Fall	Surface Trawl Sp	Surface Trawl Su	Surface Trawl Fall	Combined Gear Sp	Combined Gear Su	Combined Gear Fall
Sturgeons-Acipenseridae								NS					
Shortnose sturgeon													
Acipenser brevirostrum	yr+				+						+		
Atlantic sturgeon													
Acipenser oxyrhynchus	yr+				+	+					+	+	
Freshwater Eels-Anguillidae													
American eel													
Anguilla rostrata	yr+	+	+	+	+	+	+			+	+	+	+
Herrings-Clupeidae													
Blueback herring	YOY		+	+		+	+		+	+		+	+
Alosa aestivalis	yr+	+	+		+	+			+	+	+	+	+
Alewife	YOY	+	+	+		+	+		+	+	+	+	+
Alosa pseudoharengus	yr+	+	+		+	+	+				+	+	+
American shad	YOY	+	+	+		+	+		+	+	+	+	+
Alosa sapidissima	yr+	+	+		+	+					+	+	
Atlantic menhaden	YOY	+	+		+	+			+		+	+	
Brevoortia tyrannus	yr+	+	+		+	+	+		+	+	+	+	+
Gizzard shad	YOY			+			+			+			+
Dorosoma cepedianum	yr+	+	+	+			+			+	+	+	+
Anchovies-Engraulidae													
Bay anchovy	YOY		+	+		+	+		+	+		+	+
Anchoa mitchilli	yr+	+	+		+	+	+		+		+	+	+
Smelts-Osmeridae													
Rainbow smelt	YOY			+	+	+	+		+	+	+	+	+
Osmerus mordax	yr+	+			+	+	+				+	+	+
Minnows and Carps-Cyprinidae													
Goldfish	YOY		+	+								+	+
Carassius auratus	yr+	+	+	+							+	+	+
Carp													
Cyprinus carpio	yr+	+	+	+	+						+	+	+
Golden shiner	YOY		+	+								+	+
Notemigonus crysoleucus	yr+	+	+	+							+	+	+
Emerald shiner	YOY			+									+
Notropis atherinoides	yr+	+	+								+	+	
Spottail shiner	YOY		+	+								+	+
Notropis hudsonius	yr+	+	+	+	+	+	+				+	+	+
Suckers-Catostomidae													
White sucker													
Catostomus commersoni	yr+	+	+								+	+	
Freshwater Catfishes-Ictaluridae													
White catfish	YOY		+		+	+	+				+	+	+
Ictalurus catus	yr+	+	+		+	+	+				+	+	+
Black bullhead													
Ictalurus melas	yr+				+						+		
Brown bullhead	YOY		+	+								+	+
Ictalurus nebulosus	yr+	+	+	+	+						+	+	+
Cods-Gadidae													
Atlantic tomcod	YOY	+	+	+	+	+	+			+	+	+	+
Microgadus tomcod	yr+				+	+	+				+	+	+
Needlefishes-Belonidae													
Atlantic needlefish	YOY		+									+	
Strongylura marina	yr+		+									+	
Killifishes-Cyprinodontidae													
Banded killifish	YOY	+	+	+						+	+	+	+
Fundulus diaphanus	yr+	+	+	+							+	+	+
Mummichog													
Fundulus heteroclitus	yr+	+	+					NS			+	+	

Table IV-1 (Contd)

Species	Life Stage	Beach Seine Sp	Beach Seine Su	Beach Seine Fall	Bottom Trawl Sp	Bottom Trawl Su	Bottom Trawl Fall	Surface Trawl Sp	Surface Trawl Su	Surface Trawl Fall	Combined Gear Sp	Combined Gear Su	Combined Gear Fall
Silversides-Atherinidae								NS					
Tidewater silverside *Menidia beryllina*	YOY		+	+								+	+
Atlantic silverside *Menidia menidia*	YOY			+									+
Rough silverside *Membras martinica*	yr+		+									+	
Sticklebacks-Gasterosteidae													
Fourspine stickleback	YOY		+	+								+	+
Apeltes quadracus	yr+	+	+	+							+	+	+
Pipefishes and Seahorses Syngnathidae													
Northern pipefish	YOY		+	+								+	+
Syngnathus fuscus	yr+		+									+	
Temperate Basses Percichthyidae													
White perch	YOY		+	+		+	+			+		+	+
Morone americana	yr+	+	+	+	+	+	+		+	+	+	+	+
Striped bass	YOY		+	+		+	+					+	+
Morone saxatilis	yr+	+	+	+	+	+	+			+	+	+	+
Sunfishes Centrarchidae													
Redbreast sunfish *Lepomis auritus*	yr+	+	+								+	+	
Pumpkinseed	YOY	+	+	+			+				+	+	+
Lepomis gibbosus	yr+	+	+	+	+						+	+	+
Bluegill	YOY		+	+								+	+
Lepomis macrochirus	yr+	+	+	+							+	+	+
Largemouth bass	YOY		+									+	
Micropterus salmoides	yr+	+	+	+							+	+	+
Black crappie *Pomoxis nigromaculatus*	yr+	+	+								+	+	
Perches-Percidae													
Tessellated darter	YOY	+	+	+			+				+	+	+
Etheostoma olmstedi	yr+	+	+	+	+						+	+	+
Yellow perch	YOY		+									+	
Perca flavescens	yr+	+	+	+	+						+	+	+
Bluefish-Pomatomidae													
Bluefish *Pomatomus saltatrix*	YOY	+	+	+	+	+			+		+	+	+
Jacks and Pompanos-Carangidae													
Crevalle jack *Caranx hippos*	YOY			+									+
Drums-Sciaendae													
Weakfish *Cynoscion regalis*	YOY					+						+	
Spot	YOY		+	+		+	+					+	+
Leiostomus xanthurus	yr+		+	+		+	+		+			+	+
Atlantic croaker *Micropogon undulatus*	yr+						+						+
Soles-Soleidae													
Hogchoker	YOY	+		+							+		+
Trinectes maculatus	yr+	+	+	+	+	+	+	NS			+	+	+
Species Totals		31	35	30	22	17	18	NS	9	12	34	38	33

Sp = Spring - late March-June
Su = Summer - July-September
Fall - October-December

YOY = young-of-the-year
yr+ = yearling and older
+ = presence of species
NS = no sampling

the summer when typically marine fishes enter the estuary. Species composition and richness observed during 1976 were similar to those found in previous years (TI 1976b), indicating that no major changes in the composition of the fish community had occurred. Stressed environments are often characterized by fewer species than undisturbed habitats (Cairns and Kaesler 1971, Odum 1971). Based on this criterion, there was no indication of a stressed fish community.

2. Relative Abundance and Distribution of Common Species

a. Striped Bass *(Morone saxatilis)*

Young-of-the-year (YOY) striped bass utilize the Indian Point region primarily as a nursery area. Adult striped bass pass through the area during their annual spawning migration but are not vulnerable to the gear used at the standard sampling sites.

Yearling and YOY striped bass were captured regularly and in relatively large numbers by beach seine (Figure IV-2) but occurred infrequently in bottom trawls (Figure IV-3). Surface trawls captured only one individual. YOY striped bass began to occur consistently in standard station catches during early July, primarily in beach seines. Beach seine C/f increased in July and reached its highest level in August. YOY in the Indian Point region began to decline in September and continued to decline through the remainder of the sampling period. YOY striped bass distribution and abundance patterns were similar to those of previous years (TI 1976b). The largest catches were at stations 10, 11, and 20, sites along open stretches of the river near deep water. The smallest catches were at stations 8, 9, and 12, densely vegetated shoal areas.

Age I and older striped bass were first collected by beach seine and bottom trawl in early April. Bottom trawl catches were limited thereafter, but beach seine catches increased through early July. Age I and older fish were found primarily at station 10, the station closest to the effluent of the power plant; a similar occurrence was noted in previous years (TI 1976b). The catch distribution among stations was similar to that observed for YOY striped bass: most were collected at stations 10 and 11.

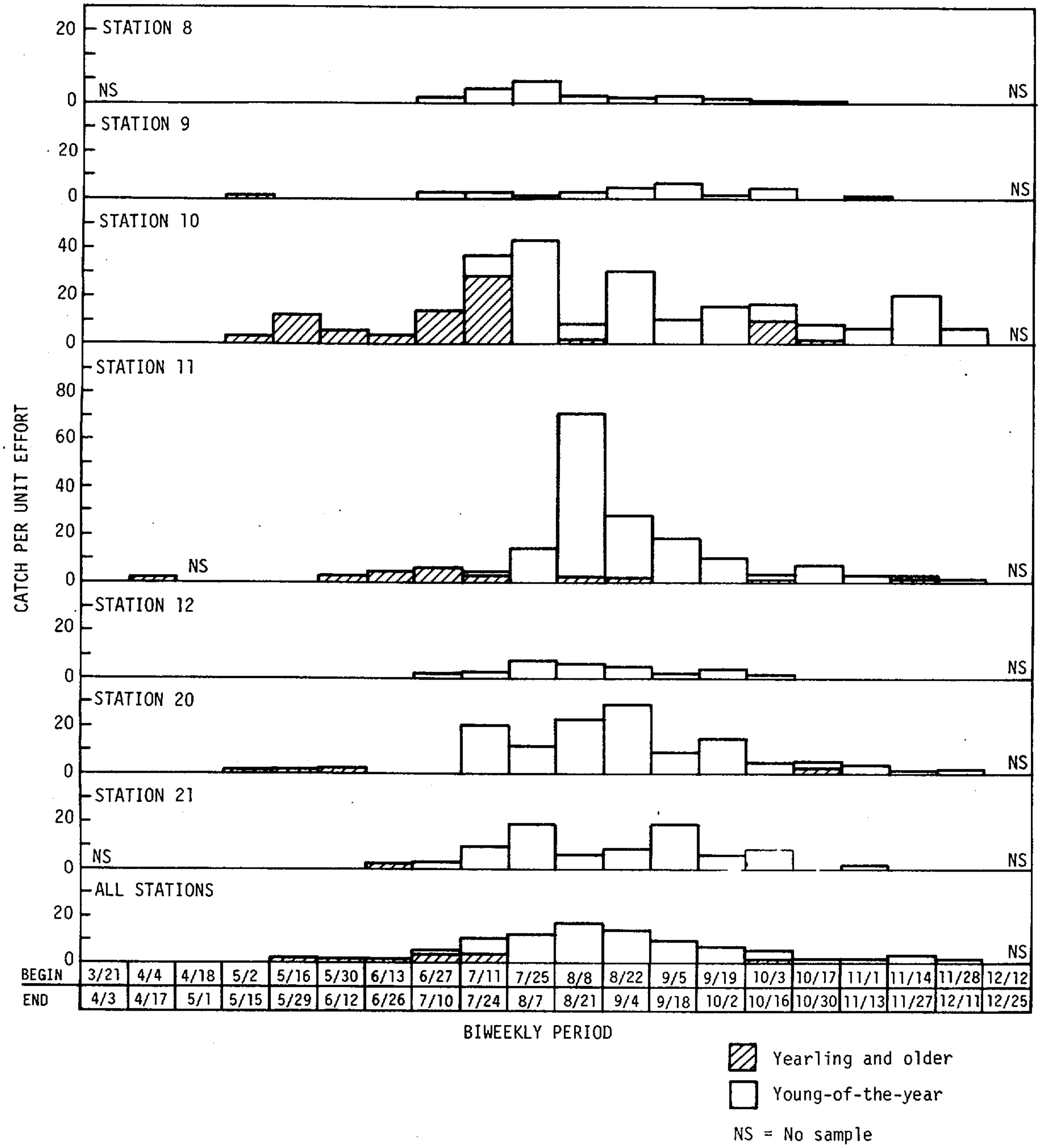


Figure IV-2. Striped Bass Biweekly Catch per Unit Effort by Beach Seine, Indian Point Standard Stations, 1976

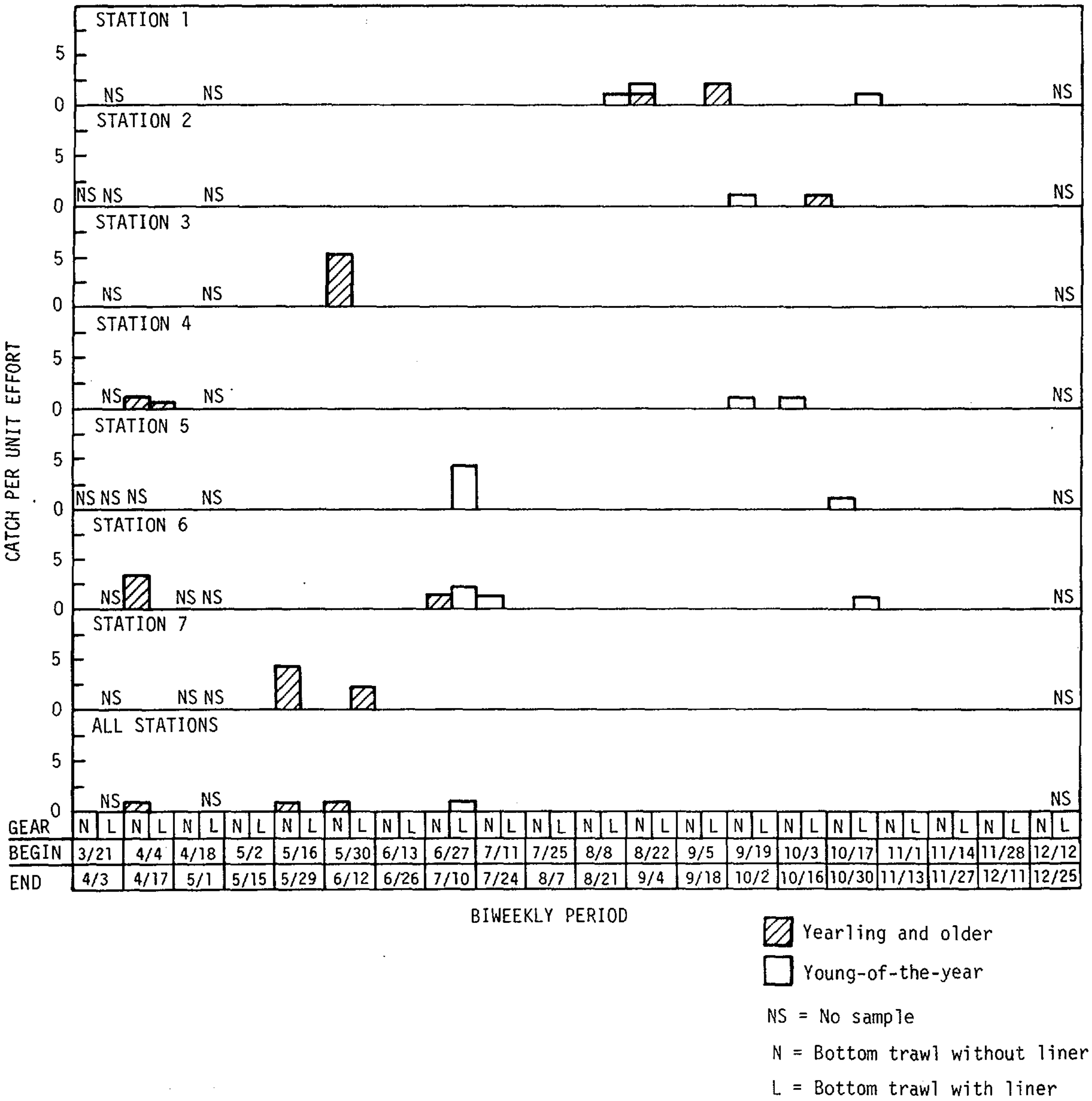


Figure IV-3. Striped Bass Biweekly Catch per Unit Effort by Bottom Trawl (with and without Attached Liner), Indian Point Standard Stations, 1976

b. White Perch (*Morone americana*)

YOY and older white perch were present in the Indian Point area throughout the year and were captured regularly by beach seine (Figure IV-4) and bottom trawl (Figure IV-5). Only 17 white perch were collected all year by surface trawls. YOY white perch were initially caught in July by both bottom trawl and beach seine. Bottom trawl catches were small and infrequent during summer but increased in October and remained at about the same level for the remainder of the sampling period. Beach seine catches were high throughout the summer, then declined sharply in the fall.

During the initial sampling period in April, bottom trawls collected age I and older white perch. Catches peaked in the region through early June, declined to low levels late in the summer, and increased again during fall. Beach seine collections of age I and older white perch were highest between early June and early August and declined to zero in fall. Seasonal differences in distribution indicated by the C/f values for each gear were the same as those observed in prior years (TI 1976b). White perch preferred the channel during spring and fall and the shorezone during summer. YOY fish exhibited the same seasonal distribution as older fish.

Bottom trawl catches differed among stations; at stations 2, 3, and 7, these were infrequent and low compared with the other stations, which was also the case in 1975 (TI 1976b). Catch distribution differences at the seven beach seine sites were less pronounced; the smallest catches were at stations 11 and 20, which are relatively unsheltered.

c. Atlantic Tomcod (*Microgadus tomcod*)

Predominantly YOY Atlantic tomcod were collected during standard station sampling (Figure IV-6); the majority of the age I and older fish were caught early in the sampling season (March-May). Atlantic tomcod were present in bottom trawls throughout the year. Bottom trawls accounted for most of the Atlantic tomcod collected because of the species' demersal nature. Surface trawls captured only eight YOY during the year. Only 36 tomcod were caught by beach seine during 1976.

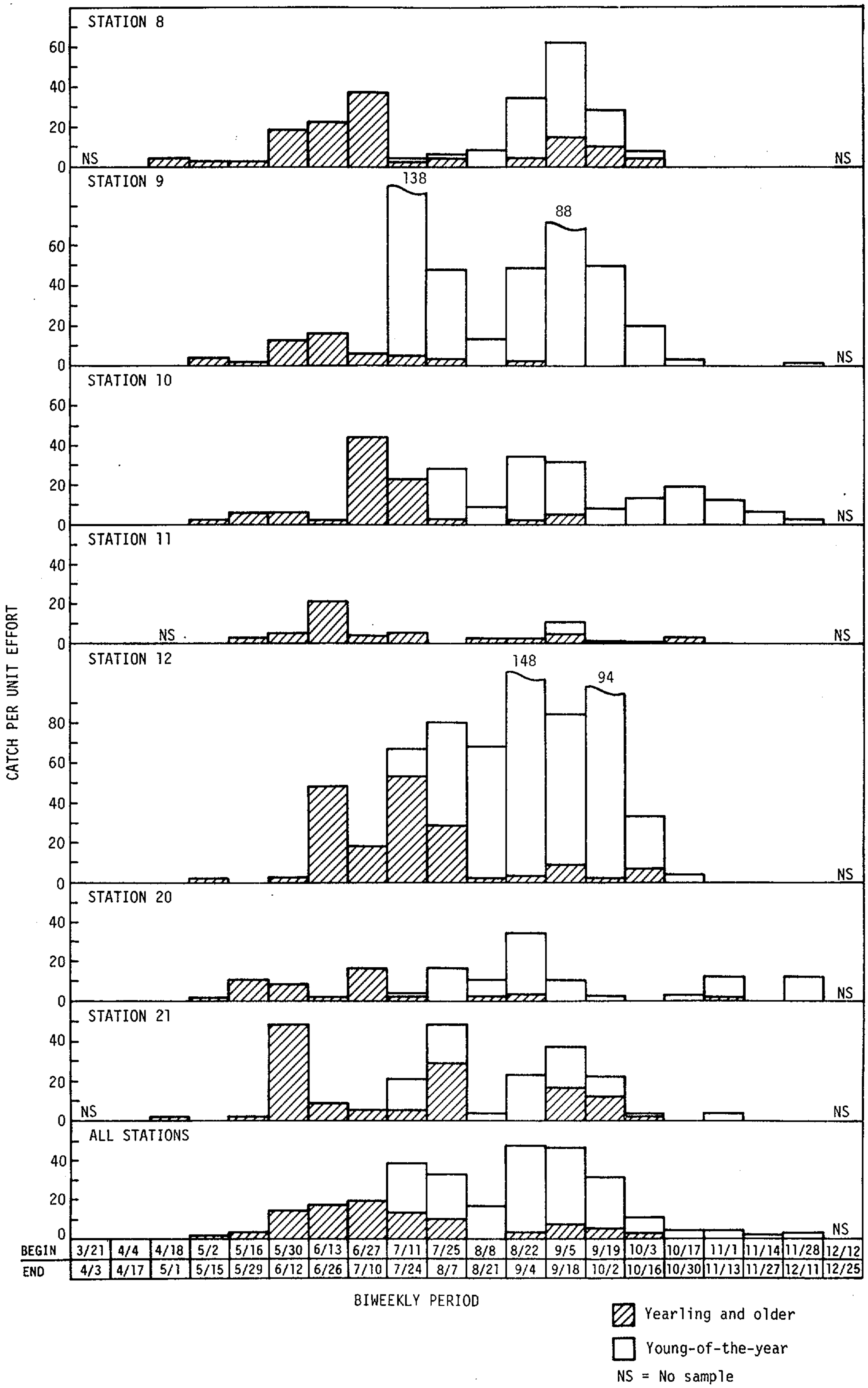


Figure IV-4. White Perch Biweekly Catch per Unit Effort by Beach Seine, Indian Point Standard Stations, 1976

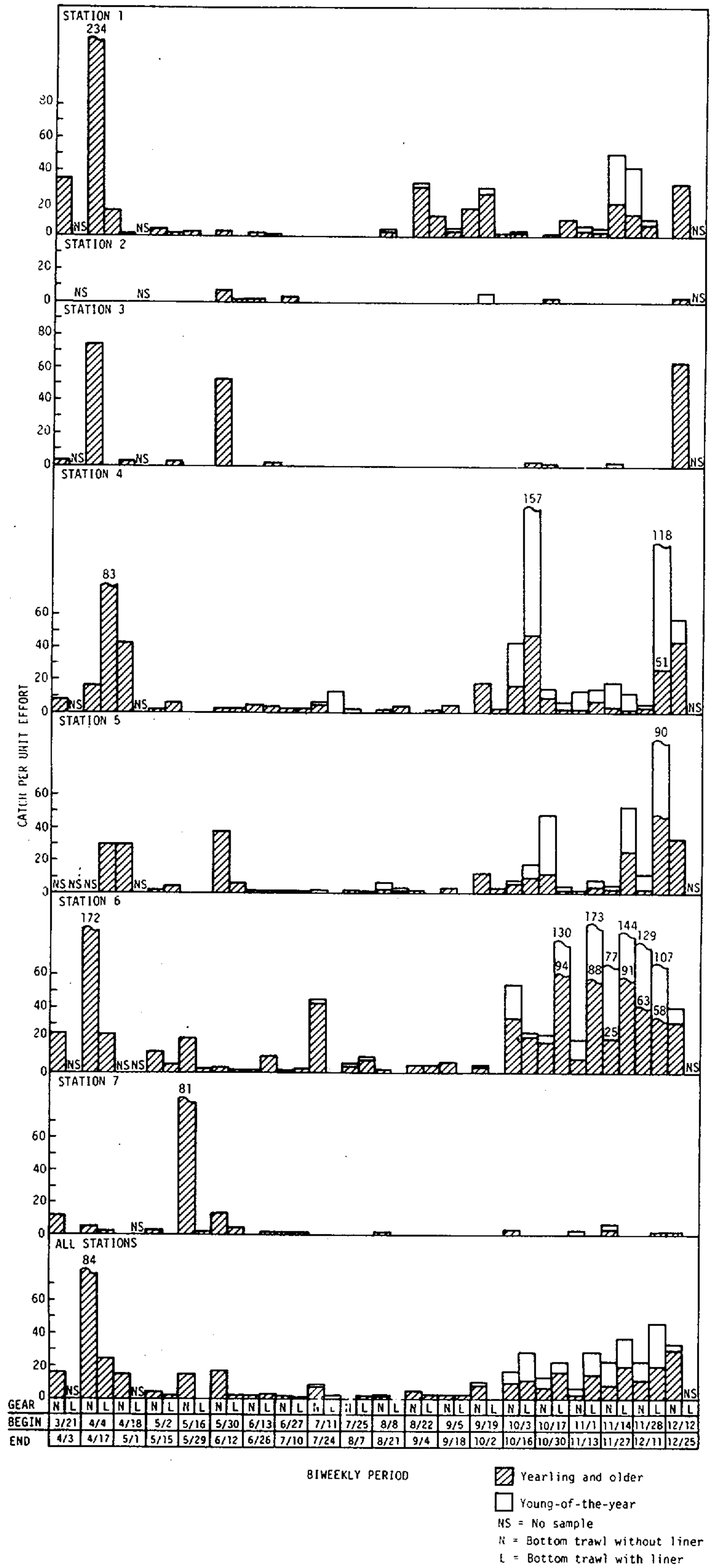


Figure IV-5. White Perch Biweekly Catch per Unit Effort by Bottom Trawl, Indian Point Standard Stations, 1976

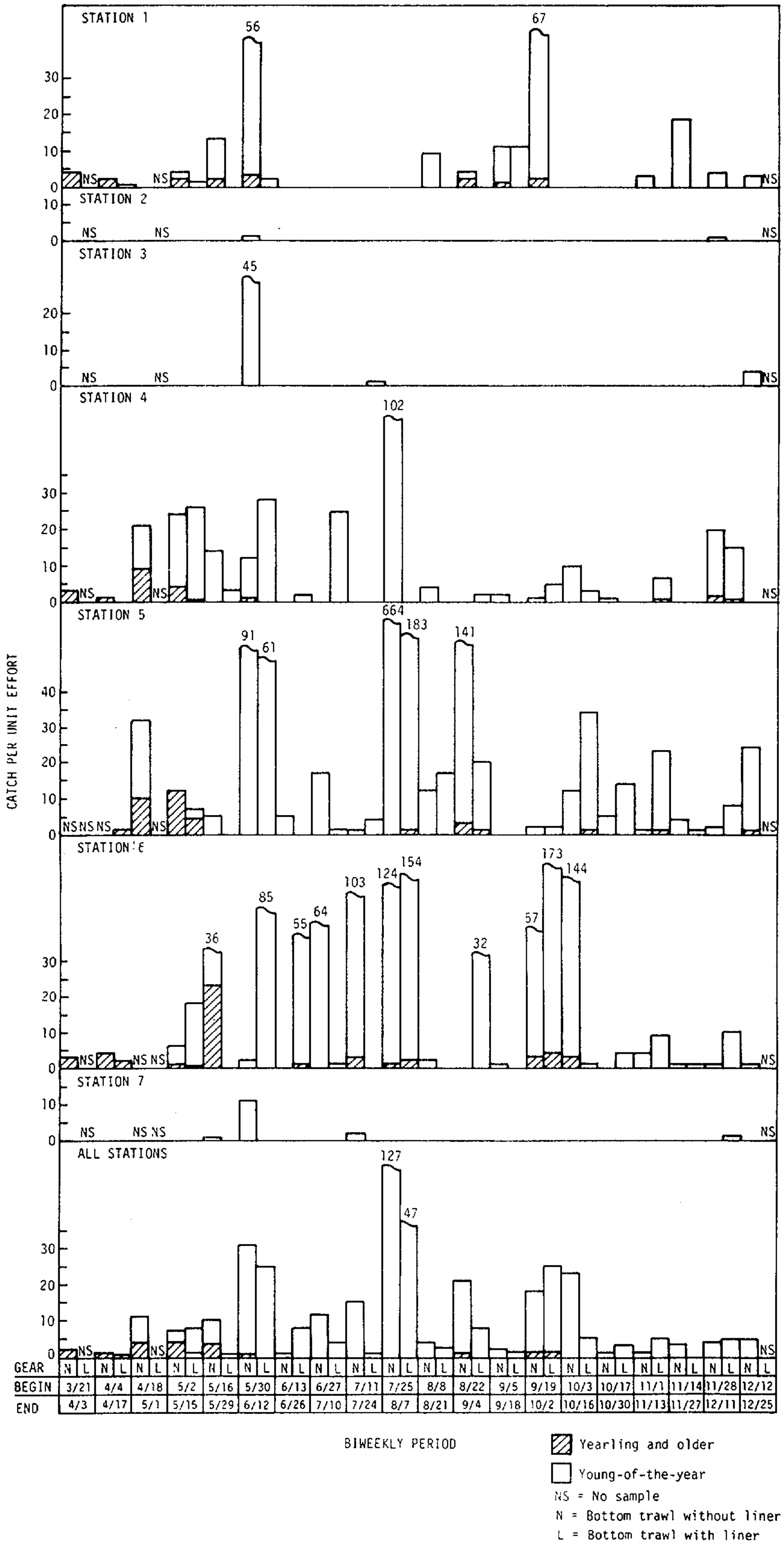


Figure IV-6. Atlantic Tomcod Biweekly Catch per Unit Effort by Bottom Trawl (With and Without Attached Liner), Indian Point Standard Stations, 1976

YOY Atlantic tomcod were initially caught in mid-April; large catches occurred during 30 May-12 June, 25 July-7 August, and 17 September-16 October. Station differences were apparent: very few fish were collected at stations 2, 3, and 7, the shallowest of the stations sampled and similar in depths. Catches were more frequent and much larger at stations 1, 4, 5, and 6.

No deviation from prior years (TI 1976b) was indicated by the 1976 data. YOY continued to dominate the catches; their initial appearance, distribution, and abundance among stations were similar to those of previous years.

d. American Shad *(Alosa sapidissima)*

Adult American shad support a substantial gill net fishery in the Hudson River estuary during April and May. Most shad pass through the Indian Point area on their way to the spawning areas in the Hyde Park to Albany regions (TI 1976d). Shad are active swimmers, able to avoid the standard station collecting gear. Adults leave the estuary soon after spawning (Walburg and Nichols 1967).

YOY shad were collected in all standard station gear from late June through October. Beach seines and surface trawls had highest C/f values (Figure IV-7). Spatial distribution was similar to that of alewife and blueback herring. No shad were collected after October when the majority of the juveniles emigrate from the estuary (TI 1976c); the emigration is apparently temperature-related, increasing as temperatures drop below 15-16°C (59-60.8°F) (Leggett and Whitney 1972).

Few yearling and older shad were collected at any time of the year. Spatial and temporal patterns of distribution and abundance were similar to those previously reported for 1973-75 standard stations in the Indian Point area (TI 1976b).

e. Alewife *(Alosa pseudoharengus)*

Adult alewives spawn primarily upriver from Indian Point; hence, many adults pass Indian Point during the spring (TI 1976c). As with shad,

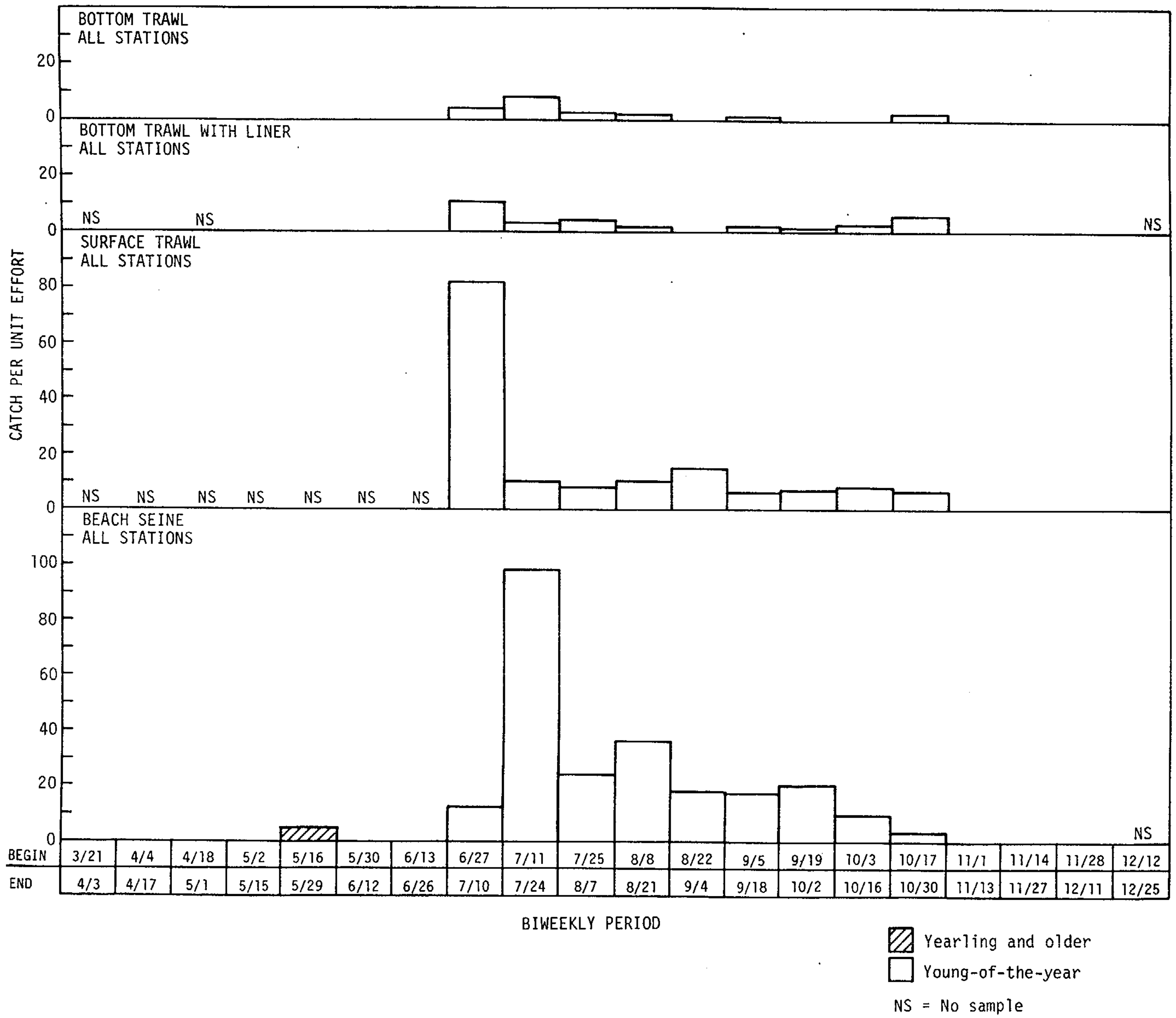


Figure IV-7. American Shad Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976 few adult alewives were collected with standard station gear. YOY alewives were collected in all standard station gear but appeared most frequently in beach seines (Figure IV-8). YOY abundance exhibited no temporal peaks from June through October 1976. The seasonal pattern of abundance was similar to that previously reported for the 1972-75 sampling periods (TI 1976b); however, the 1976 abundance was generally lower. At least part of the juvenile alewife population remains in the estuary as yearling and older fish; they are abundant in the Indian Point region during spring.

f. Blueback Herring *(Alosa aestivalis)*

Most blueback herring spawn in the same upriver regions used by alewives and shad, with adults passing through the Indian Point region in the spring (TI 1976c). As with shad and alewives, few adult bluebacks were collected in standard station sampling. All gear caught YOY bluebacks, however, surface trawls exhibiting the highest C/f from August through October (Figure IV-9). Juvenile abundance and distribution patterns in 1976 were similar to those previously reported for 1972-75 (TI 1976d). Yearling and older blueback herring were abundant in the shorezone areas of the Indian Point region during spring and early summer.

g. Bay Anchovy *(Anchoa mitchilli)*

Adult bay anchovies first appeared in bottom trawl and beach seine catches during late May (Figure IV-10) and were collected in all gear throughout the summer and until late September. Bottom trawls exhibited the highest C/f. Bay anchovy may spawn at 2.5 to 3 months of age, so those hatched in July may be adults by September (TI 1976c), perhaps accounting part for the continued high adult catches late in the season.

Catches of YOY bay anchovies occurred from late July through early October, peaking in surface trawls in August. The surface trawl C/f for these YOY remained high throughout this time period, generally higher than that from the bottom trawl. Adult bay anchovies were initially more abundant in the surface trawl catches; however, with time, the surface trawl C/f declined whereas the bottom trawl C/f remained fairly constant.

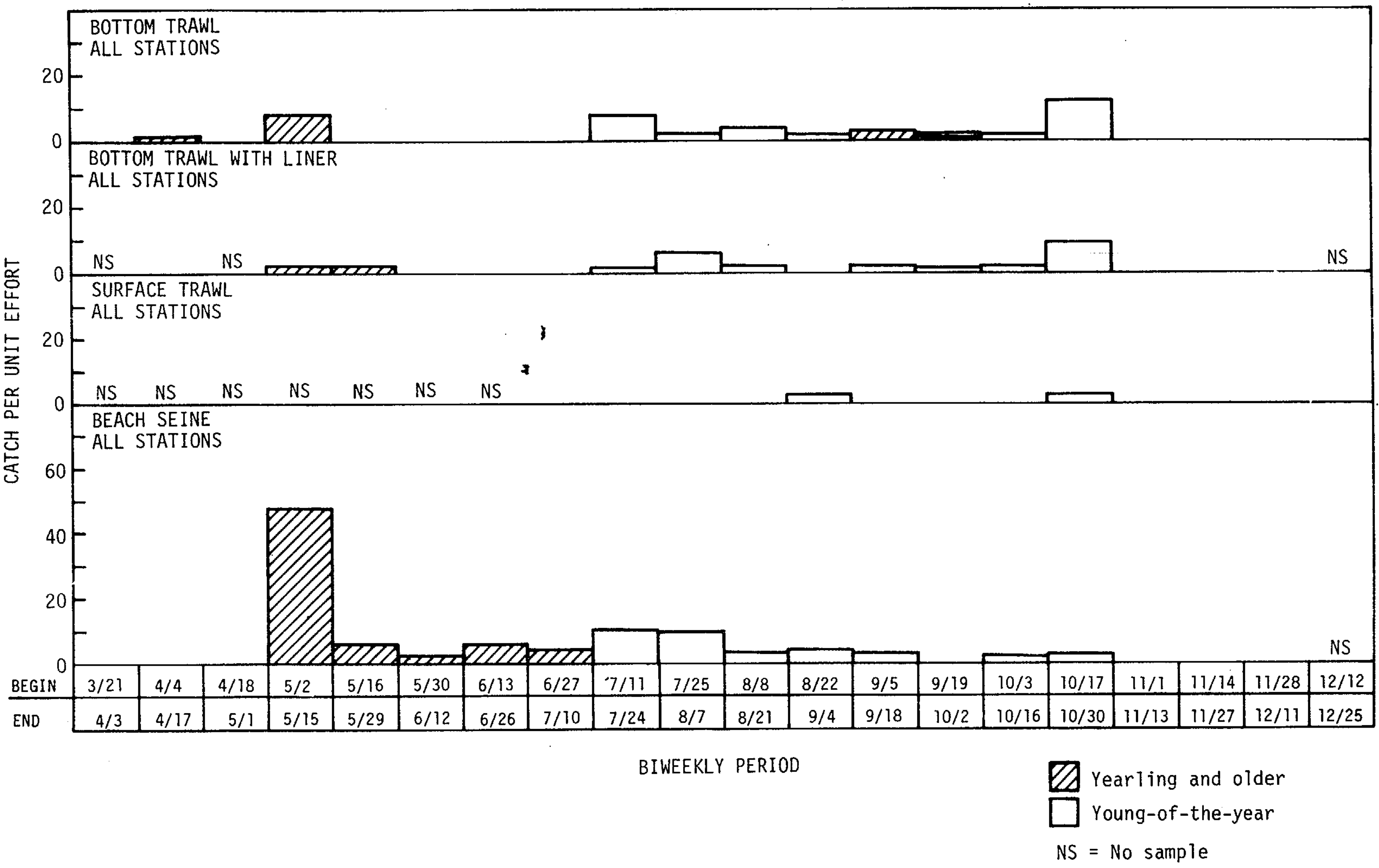


Figure IV-8. Alewife Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

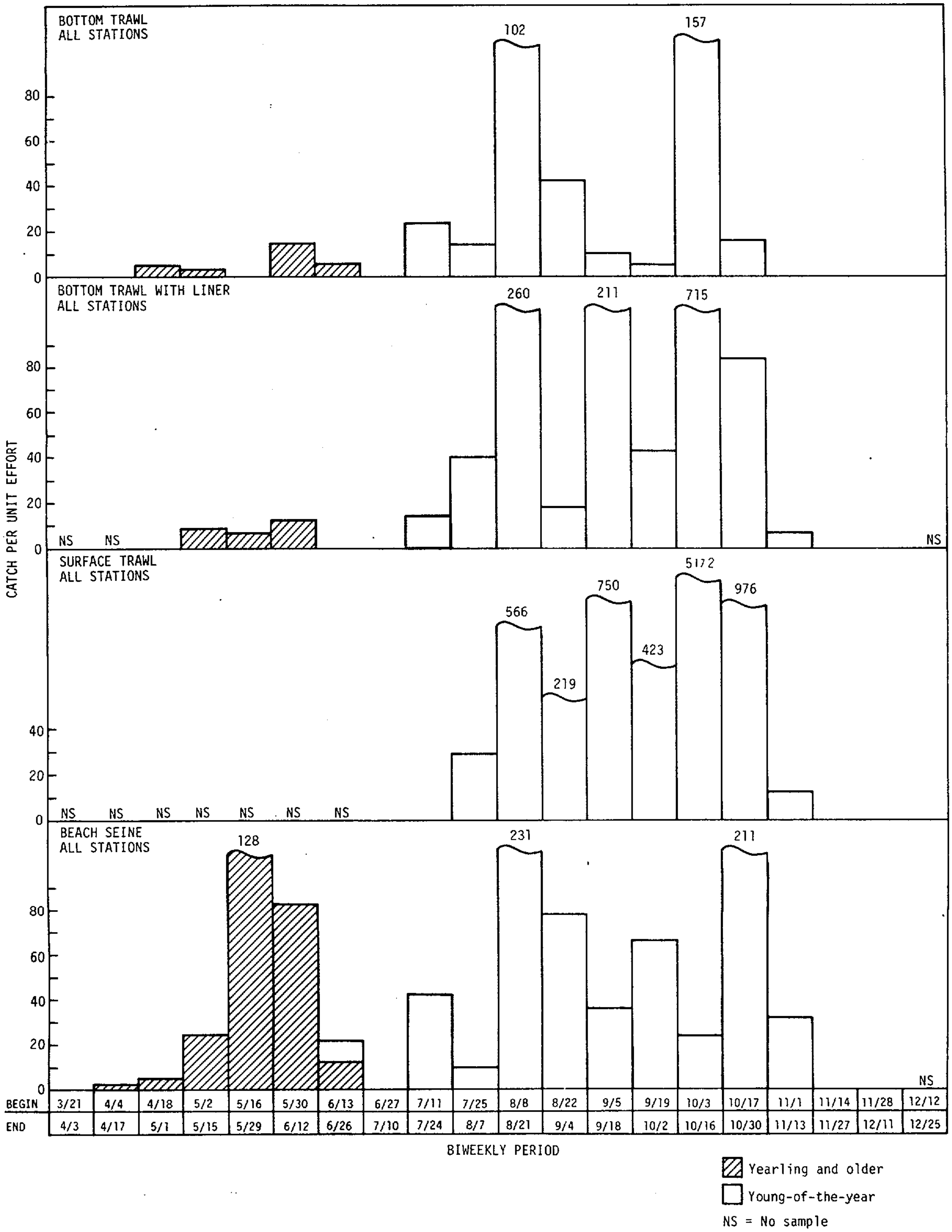


Figure IV-9. Blueback Herring Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

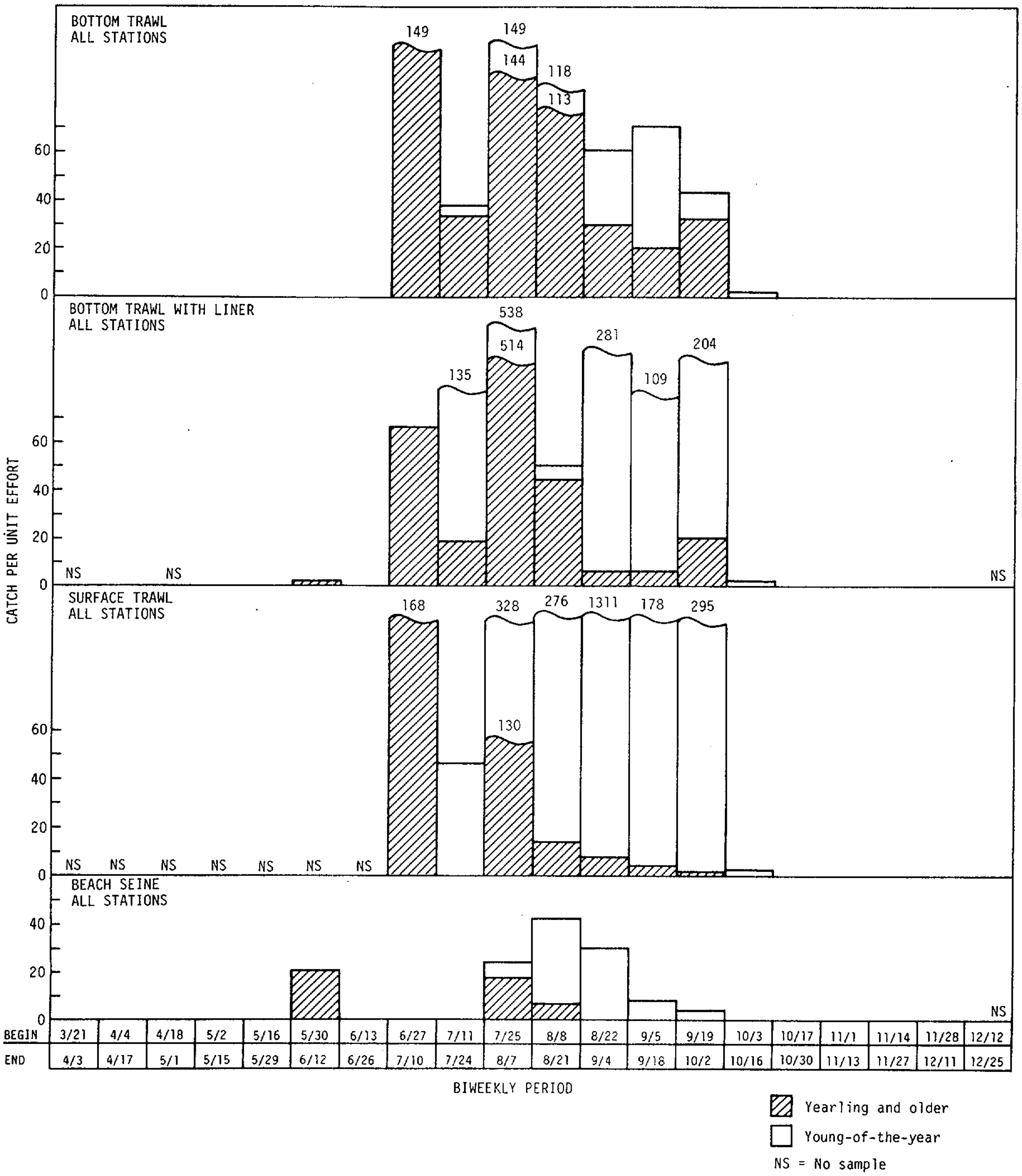


Figure IV-10. Bay Anchovy Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

Thus, it appears that the YOY bay anchovies remain higher in the water column than do the adults. The 1976 abundance and distribution pattern resembled those previously reported from 1974 and 1975 (TI 1976b).

h. Bluefish *(Pomatomus saltatrix)*

YOY bluefish enter the estuarine nursery areas in summer and fall (Bigelow and Schroeder 1953). They were found in the Indian Point area in 1976 from late June through early September (Figure IV-11). YOY were collected in small numbers with all standard station gear. The 1976 C/f values were lower than during 1973-75 and similar to those in 1972 (TI 1976b).

i. Tessellated Darter *(Etheostoma olmstedi)*

This common resident is generally found inshore (TI 1976c). Yearling and older tessellated darters were collected in beach seines throughout the sampling season and in bottom trawls during March (Figure IV-12). YOY tessellated darters appeared in beach seines from June through November. Distribution and C/f values remained unchanged from earlier years (TI 1976b).

j. Spottail Shiner *(Notropis hudsonius)*

The spottail shiner, like the tessellated darter, is a resident freshwater fish taken primarily by beach seines (TI 1976c). Yearling and older spottail shiners were collected during all biweekly beach seine sampling periods and during May and June in trawls (Figure IV-13). YOY were taken in beach seines during June-November. Relative abundance and distribution remained unchanged from previously reported years (TI 1976b).

k. Banded Killifish *(Fundulus diaphanus)*

Banded killifish occurred exclusively in beach seine samples (Figure IV-14), reflecting the shorezone habitat preference reported for all previous years (TI 1976b). Adult abundance remained nearly constant throughout the sampling season. YOY, first collected in July, were abundant from August through September. Catches decreased in the fall. Similar trends in seasonal abundance were reported for 1972-75 (TI 1976b).

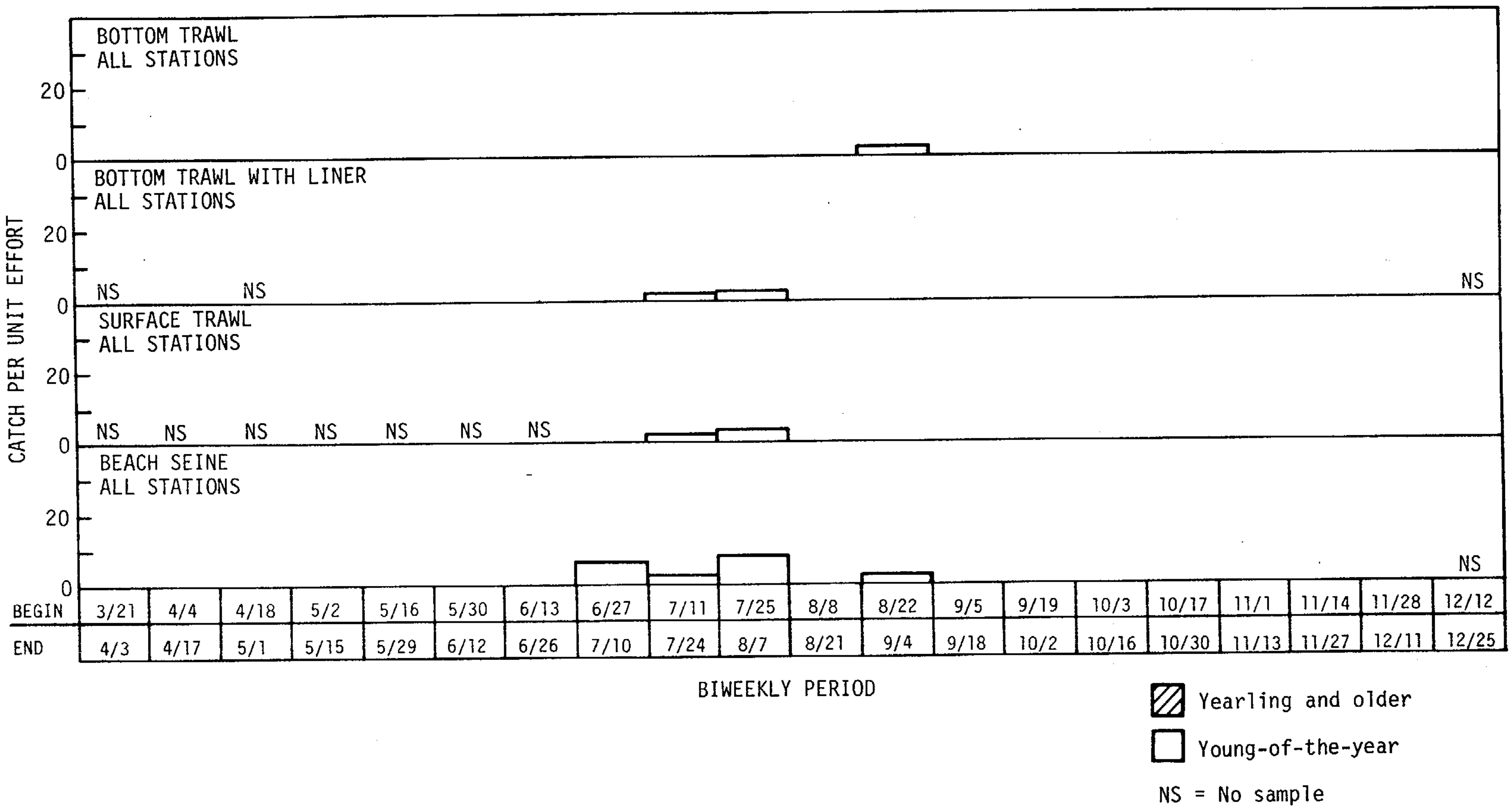


Figure IV-11. Bluefish Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

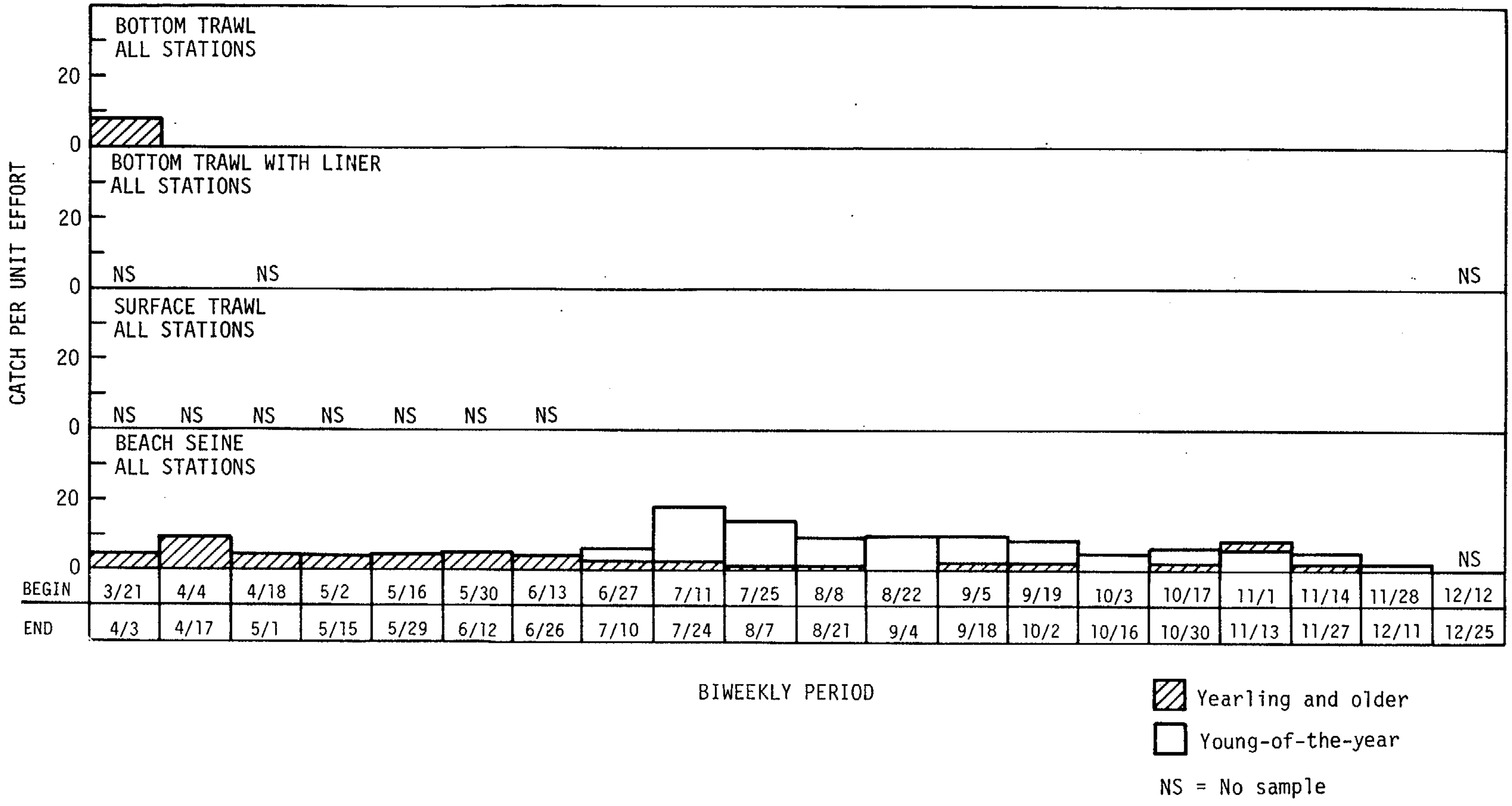


Figure IV-12. Tessellated Darter Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

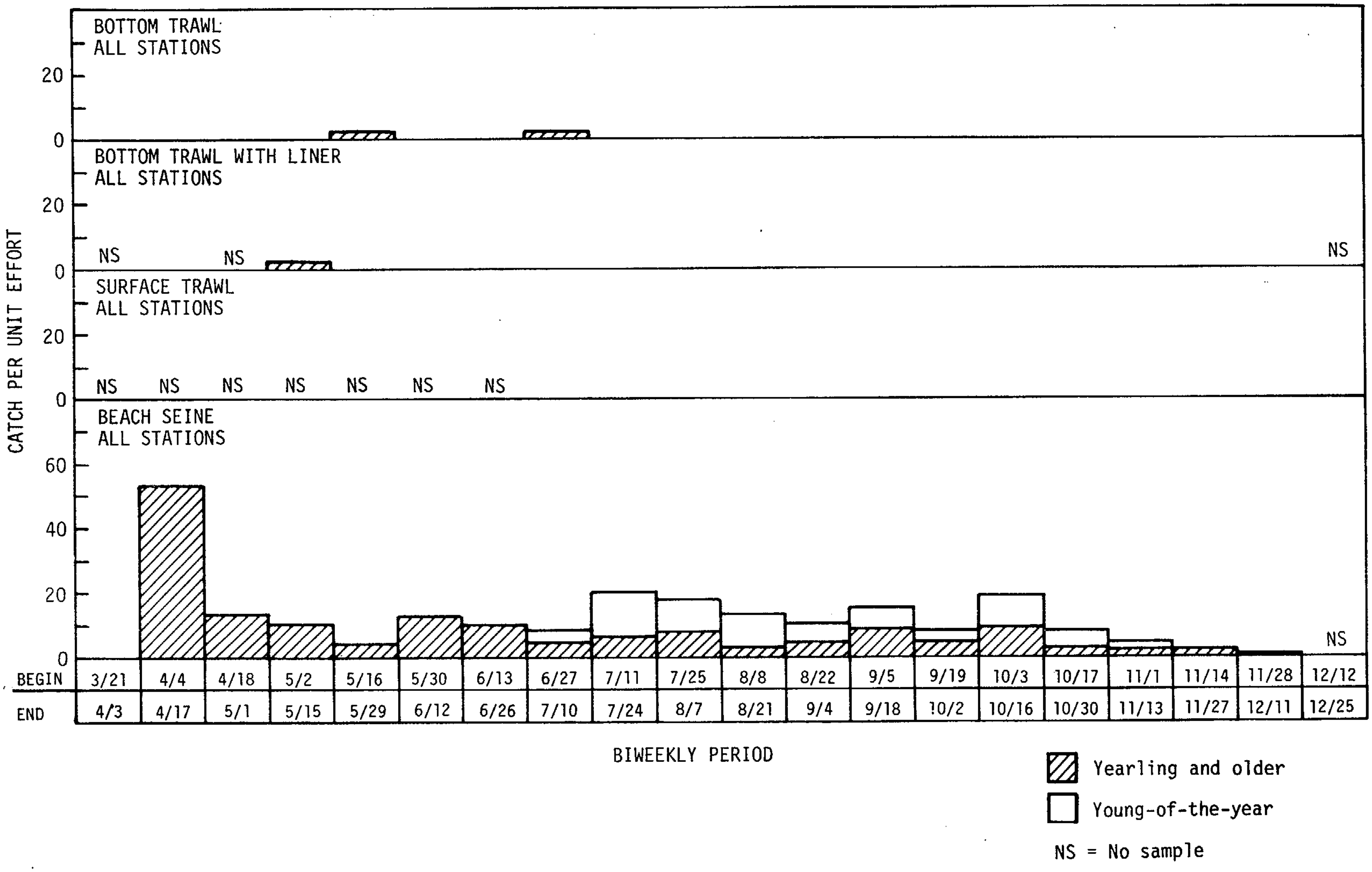


Figure IV-13. Spottail Shiner Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

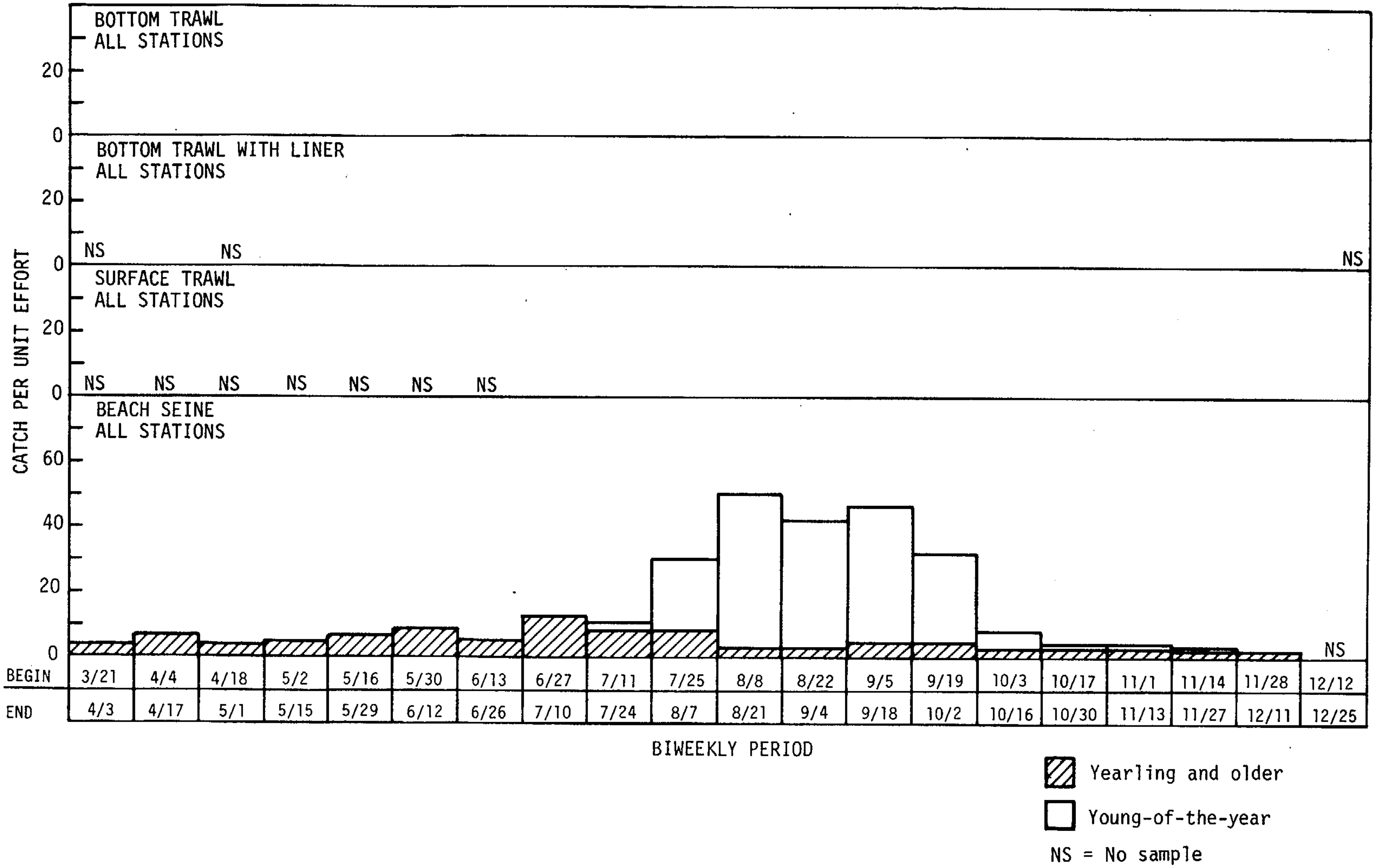


Figure IV-14. Banded Killifish Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

l. Hogchoker *(Trinectes maculatus)*

Hogchokers are the only flatfish found in large numbers in the Indian Point area. Only beach seines and bottom trawls collected them, reflecting their bottom-dwelling habits (Figure IV-15). Abundance during 1976 was lower than during 1972-75 (TI 1976b). No YOY hogchokers were collected during 1976.

m. Other Species

The 1976 sampling season yielded 31 other species, but their occurrences in collections were usually limited and infrequent. C/f data for all species are presented in Appendix Tables B-1 through B-4.

3. Abundance and Distribution of Striped Bass, White Perch, and Atlantic Tomcod Relative to Physicochemical Factors

Data collected in previous years indicated that temperature and conductivity have some relationship to the distribution and abundance of striped bass, white perch, and Atlantic tomcod within the estuary (TI 1975b, 1976b, 1976c). Temperature and conductivity appear to influence the time and location of striped bass and Atlantic tomcod spawning, and the movements of white perch between shore and channel regions correspond to spring and fall changes in temperature. Atlantic tomcod and white perch abundances appear to be associated with the salt front; this is most apparent during the summer for YOY Atlantic tomcod and during the fall and winter months for white perch.

The seasonal variation of temperature, conductivity, and dissolved oxygen at Indian Point during 1976 (Figure III-5) was similar to that observed in previous years (TI 1976b). Ambient river temperatures ranged from approximately 2 to 25°C (35.6 to 77°F) during the sampling season; beach seine stations were slightly warmer than trawl areas during the summer months (Figure IV-16). Oxygen levels ranged from summer minimum values of 4-5 ppm to winter peaks of >12 ppm. Salt intruded into the region several times, and there was an extended period of increased salinity from mid-August through mid-October. Standard stations were sampled throughout the range of temperature and oxygen

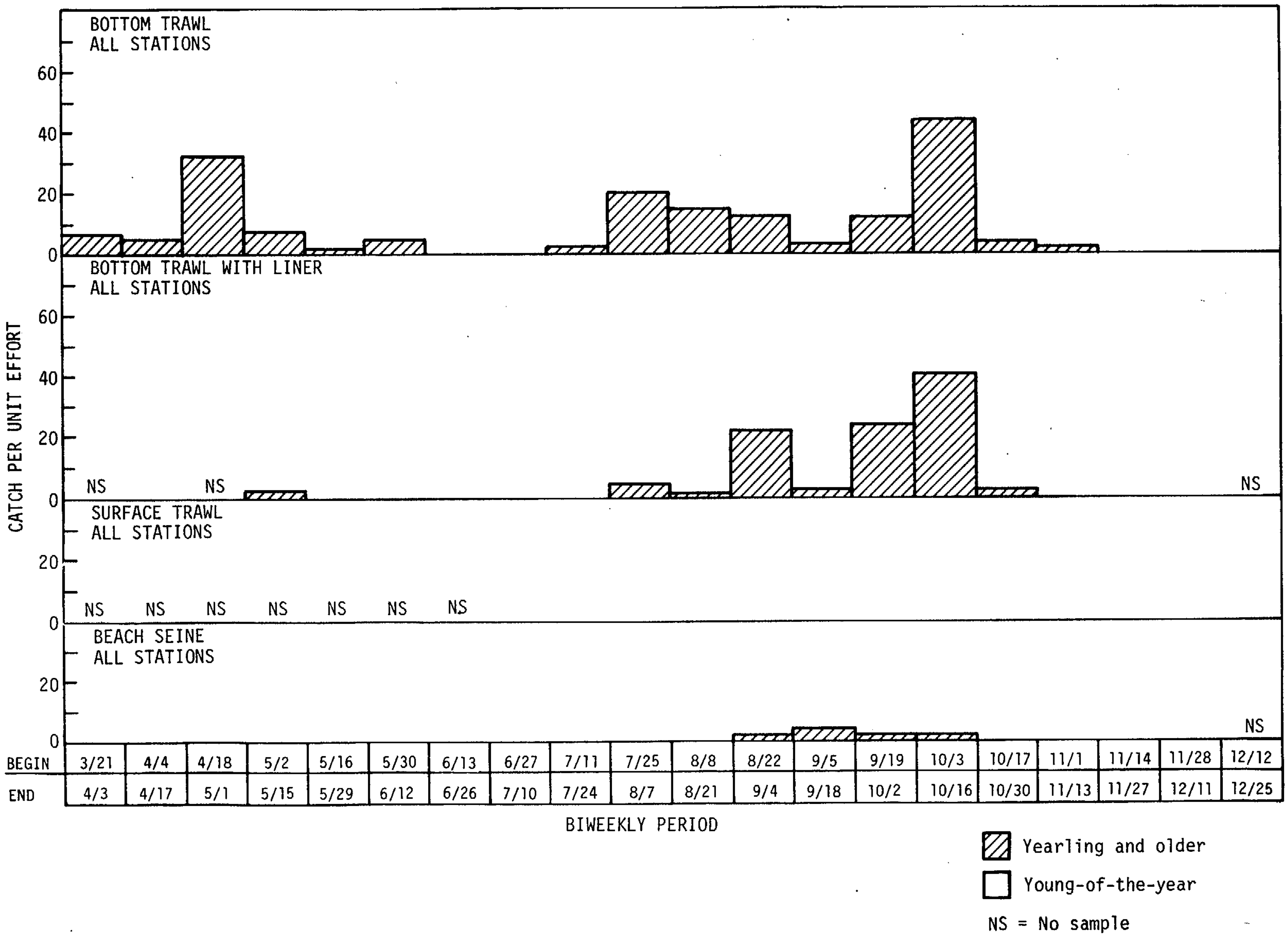


Figure IV-15. Hogchoker Biweekly Catch per Unit Effort during Standard Station Sampling in Indian Point Vicinity, 1976

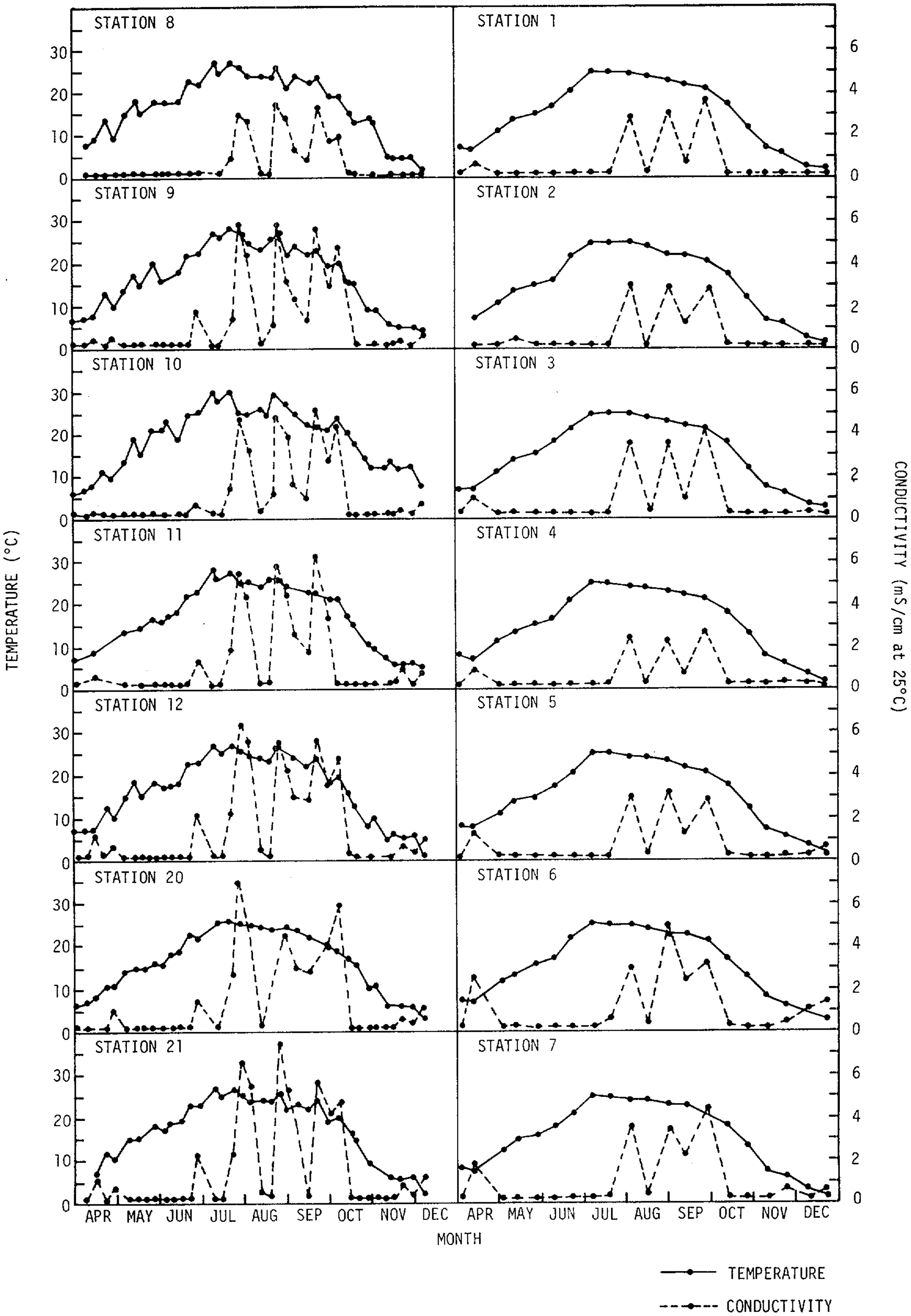


Figure IV-16. Seasonal Variation in Water Temperature and Conductivity Determined during Fish Collections at Indian Point Standard Stations in 1976 levels observed for the area. Collections were made also over a wide range of conductivity levels.

YOY striped bass were most abundant in the Indian Point region from July through September, a period during which temperatures were at maximum levels and remained stable. Catches declined in early October as water temperatures decreased below 20°C (68°F), suggesting that movement of the species from the region was related to the onset of rapidly cooling temperatures in the shorezone; this pattern was not observed at station 10 where water temperatures were approximately 6°C (42.8°F) higher than at the other sampling stations during November and December because of the proximity of the thermal effluent of the Indian Point generating facility. The number of striped bass seined at station 10 remained high throughout the fall, even as ambient river temperatures approached 0°C (32°F). There was no apparent relationship between striped bass distribution and abundance with either conductivity or oxygen.

Temperature appeared to be an important factor influencing the distribution of white perch at Indian Point. After they had overwintered in deep water, they exhibited a shoreward movement in mid-May as water temperatures began to increase. They were primarily captured at beach stations throughout the summer, but beach seine catches declined sharply in early October as temperatures declined below 20°C (68°F). Trawl catches increased during the same period, indicating that white perch prefer deeper channel areas as temperatures drop. No relationship between conductivity or oxygen content and distribution was apparent.

Atlantic tomcod abundance in the Indian Point area was probably related to conductivity; most peak catches occurred during periods of salt intrusion into the region. Temperature may have influenced the general movement of yearling and older fish from the region in the spring and YOY fish from the area during the fall. Oxygen content did not appear to be related to the abundance of Atlantic tomcod.

D. CONCLUSIONS

Standard station sampling during 1976 indicated no major changes in the fish community inhabiting the Indian Point area:

- Species composition and the number of species and families collected were similar to those observed during the 1972-75 study period.
- The local distribution of species remained unchanged from prior years. Differences in catches among the various sampling stations was probably a function of habitat preference.
- Most species exhibited seasonal peaks in abundance, with numbers being similar to those of earlier years.

Abundances and distributions of striped bass, white perch, and Atlantic tomcod in the Indian Point region in 1976 showed some relationship to river temperature and salt intrusion:

- Most striped bass left the region during the fall with the onset of declining river temperatures.
- Striped bass abundance may have remained higher at station 10 near the thermal plume in the late fall because of somewhat elevated temperatures.
- White perch movements between shore and channel areas were associated with spring increases and fall decreases in water temperature.
- Peak catches of Atlantic tomcod in the Indian Point area appeared to be associated with salt intrusion into the area.

SECTION V
BIOLOGICAL CHARACTERISTICS

A. INTRODUCTION

Biological characteristics such as growth, length frequency, age composition, age at maturity, sex ratio, and mortality are indicators of the dynamics of fish populations. These characteristics are labile and may change in response to changes in density. Documentations of the present biological characteristics of the striped bass, white perch, and Atlantic tomcod and detection of changes in these characteristics may aid in defining the operations impact of the Indian Point electrical generating plants.

This section addresses the following biological characteristics of Hudson River fish collected by TI in the Indian Point vicinity:

- Length-frequency distribution of striped bass *(Morone saxatilis)* and white perch *(Morone americana)* for 1976 and Atlantic tomcod *(Microgadus tomcod)* for December 1975 and January-February 1976
- Age composition of the striped bass and white perch populations during 1976 and the Atlantic tomcod population during December 1975 and January-February 1976
- Growth rates of young-of-the-year (YOY) striped bass, white perch, and Atlantic tomcod during 1976
- Estimates of the number of eggs for white perch for 1975 and 1976 and for Atlantic tomcod for the 1975-76 spawning season
- Sex ratio and age at maturity of white perch for 1975 and 1976 and of Atlantic tomcod for 1976
- White perch mortality rates based on catch curve analysis for 1976

- Additional information concerning striped bass captured during 1975 and 1976 is treated elsewhere as follows: 1975 age at maturity and 1975 fecundity results are reported in McFadden (1977), 1975 standard station age and length compositions are reported in TI (1976b) and 1976 information on age at maturity, length composition for older striped bass, sex ratio, fecundity and mortality estimates are reported in McFadden and Lawler (1977)

B. METHODS

1. Sample Collection

Striped bass and white perch were collected during 1975 and 1976 by beach seines and bottom trawls from standard station sites in the Indian Point region of the Hudson River (see Section IV). Unless otherwise noted, bottom trawl data combines information from efforts using the regular mesh (32-mm stretch) cod-end and the fine mesh (16-mm stretch) cod-end described by TI (1976b). Atlantic tomcod were collected by bottom trawl, epibenthic sled, and box traps. Standard stations were sampled from April into December. The entire catch of fish from each station was returned to the laboratory for processing. From December 1975 through February 1976, on a weekly basis, entire trap catches of Atlantic tomcod were returned to the laboratory from selected trapsites. From March through November 1976 tomcod samples were obtained on approximately a semiweekly basis from bottom trawls and/or epibenthic sleds.

2. Laboratory Procedures

During the preliminary lab workup, scale samples were removed from all white perch and striped bass subsampled from the three largest length groups from each gear (Section IV). In 1976 scales were taken from five YOY striped bass and five YOY white perch to monitor the length division cut off between YOY and older fish (Section IV). These five fish were the three largest, one medium-length, and one of the smaller YOY striped bass and white perch from each effort. No scales were taken from fish <50 mm in total length. In 1975 only three of the larger YOY striped bass and white perch were subsampled for scales.

During the spawning season (December-February) Atlantic tomcod were subsampled and processed as described for the 1975-76 spawning season (TI 1976b). Otoliths were removed from all sampled tomcod $\geq$175 mm.

a. Age Determination

Age determinations for striped bass and white perch were made from scale annuli using a Trisimplex projector. Atlantic tomcod ages were determined for otoliths examined with reflected light.

b. Growth Determination

Monthly age and length frequencies for striped bass and white perch were obtained from standard station beach seine and bottom trawl data. Mean weights by month for YOY striped bass and white perch were obtained from the same standard stations samples.

Instantaneous growth rates for striped bass and white perch were calculated using monthly mean weights as the initial and final weights and 30 days as the elapsed time.

$$G = \frac{\log_e W_f - \log_e W_i}{t}$$

where:

G = instantaneous growth rate

W_f = final mean weight

W_i = initial mean weight

t = elapsed time (days)

Atlantic tomcod length frequency data for the 1975-76 spawning season were obtained from mark (tag and finclip) release data collected between RM 26 (KM 57) and 73 (KM 161).

Mean weights of samples of YOY tomcod, collected at approximately two week intervals, were used to calculate instantaneous growth rates for

1976. All samples were from bottom trawls and were fresh when processed in the laboratory.

c. Age at Maturity and Egg Count Data

During May and June of 1975 and 1976, gonads were removed from white perch collected in standard station samples and stored in 10% formalin for estimation of age at maturity and egg count. This procedure was used also for tomcod collected during July-November 1976.

Age at maturity for white perch was determined by air drying the preserved gonads for 15 minutes on paper towels and weighing them to the nearest 0.01 gram. Both the ratio of the gonad weight to body weight and visual examination of the gonad were used to determine state of maturity. The rate of YOY tomcod sexual maturation was determined as in 1975 (TI 1976b).

The number of eggs ≥0.2 mm diameter in mature white perch was estimated from aliquots (TI 1976b). Diameter measurements were made with an ocular micrometer. The mean number of eggs by age was determined from the egg count within each age group. Estimates of tomcod fecundity were determined as in 1975 (TI 1976b).

d. Sex Ratio

Sex determinations were made from subsampled white perch captured in standard station beach seines and bottom trawls from April through December of 1975 and 1976. Determinations during 1975 were made during processing of standard station samples (Section IV); gonads were discarded if not required for other uses. During 1976 the determinations were made during the workup, and gonads were preserved in 10% formalin. Sex was determined from samples of YOY tomcod on approximately a weekly basis from June through September 1976. Sample sizes ranged from 20 to 80 fish. The data were grouped by month.

e. Mortality

Total annual mortality rates (Ricker 1975) for white perch were estimated from October through December 1976 standard station age composition data. The YOY white perch mortality rate was estimated from beach seine data by

$$A = 1 - \frac{N_{t+1}}{N_t}$$

where

A = total annual mortality estimate for age t

N_t = number of individuals collected of age t

N_{t+1} = number of individuals collected of age t + 1

The mortality rate for yearling and older white perch was estimated from bottom trawl (16-mm stretch mesh cod-end liner) data by using a least squares regression to describe the linear relationship

$$\log_e N_t = \alpha + \beta(t)$$

where

α = constant

β = slope = instantaneous mortality rate (Ricker's Z)

t = age

From this relationship the total annual mortality rate (A) for age I through age V is

$$A = 1 - e^{\beta}$$

The linear relationship did not include age 0 white perch as they are considered to be under-represented in the bottom trawl catches. Beach seine data were not used since older age white perch are considered to be under-represented in beach seine catches.

C. RESULTS

1. Striped Bass

a. Age and Length Composition

Yearling striped bass predominated in beach seine (Figures V-1 and V-2) and bottom trawl (Figures V-3 and V-4) catches until July when YOY were first captured. Young-of-the-year, once encountered, remained the dominant age group throughout the remainder of the year.

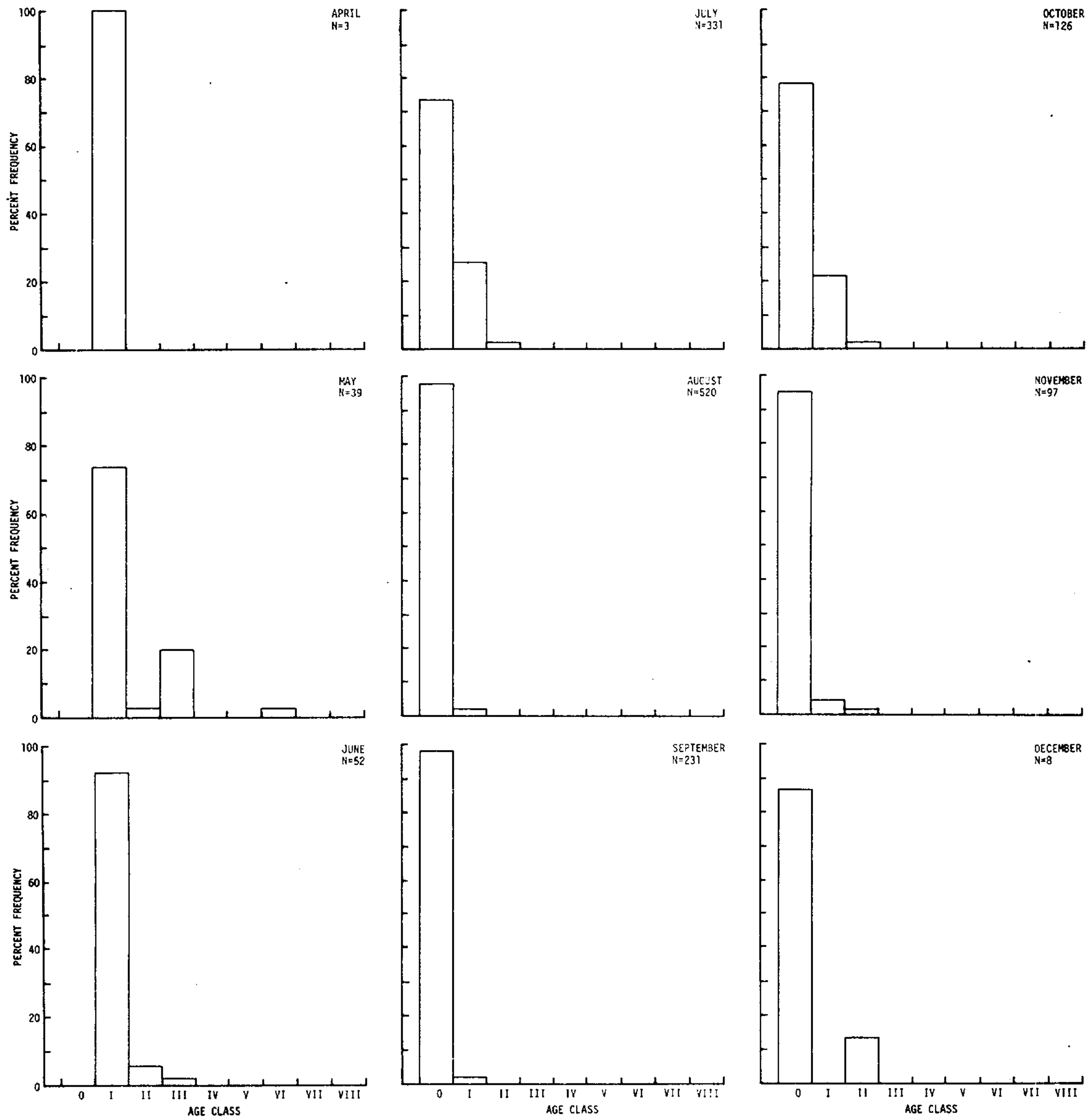


Figure V-1. Age Composition of Striped Bass in Standard Station Beach Seines, April-December 1976

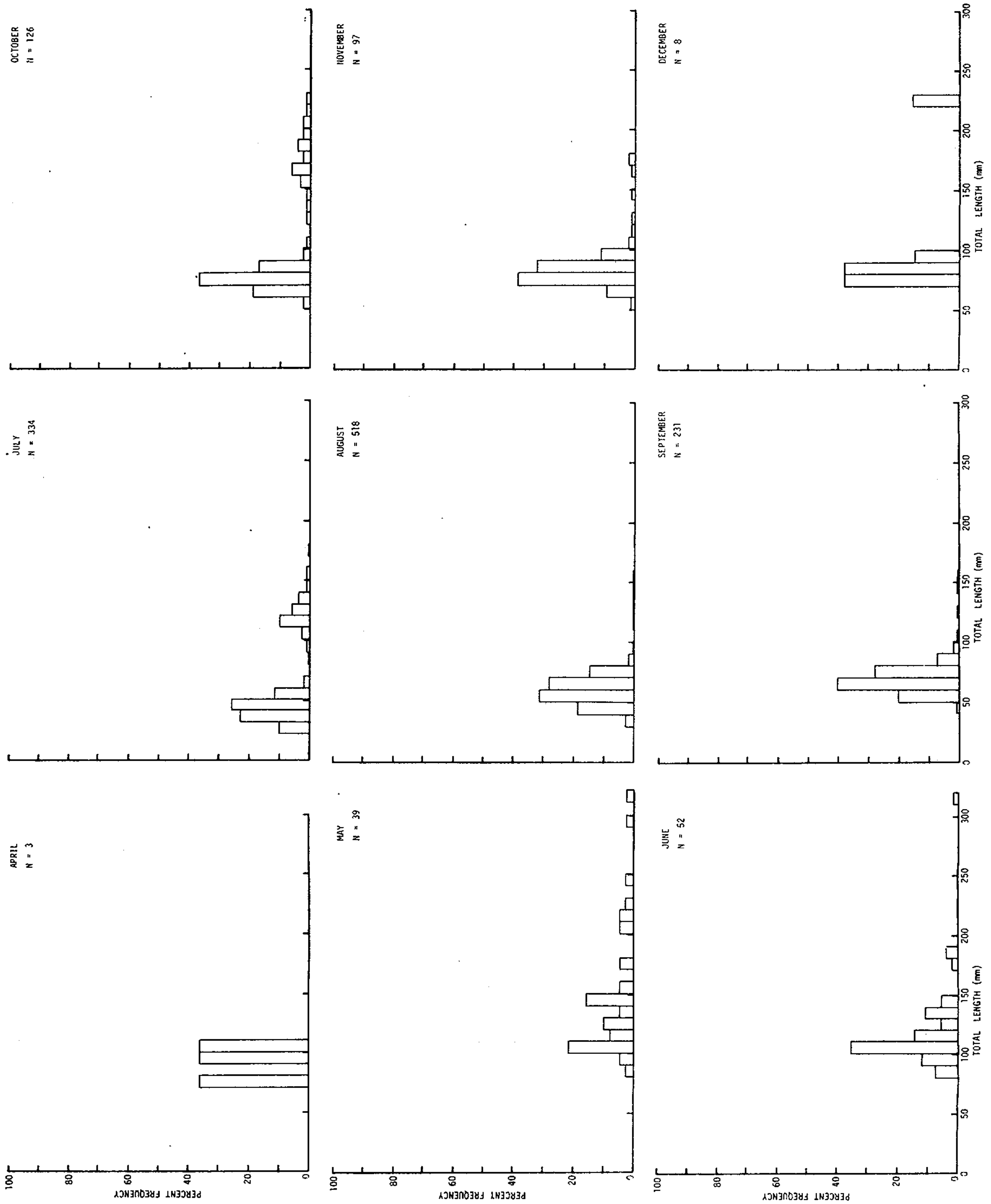


Figure V-2. Length-Frequency Distribution of Striped Bass Collected by Standard Station Beach Seine, April-December 1976

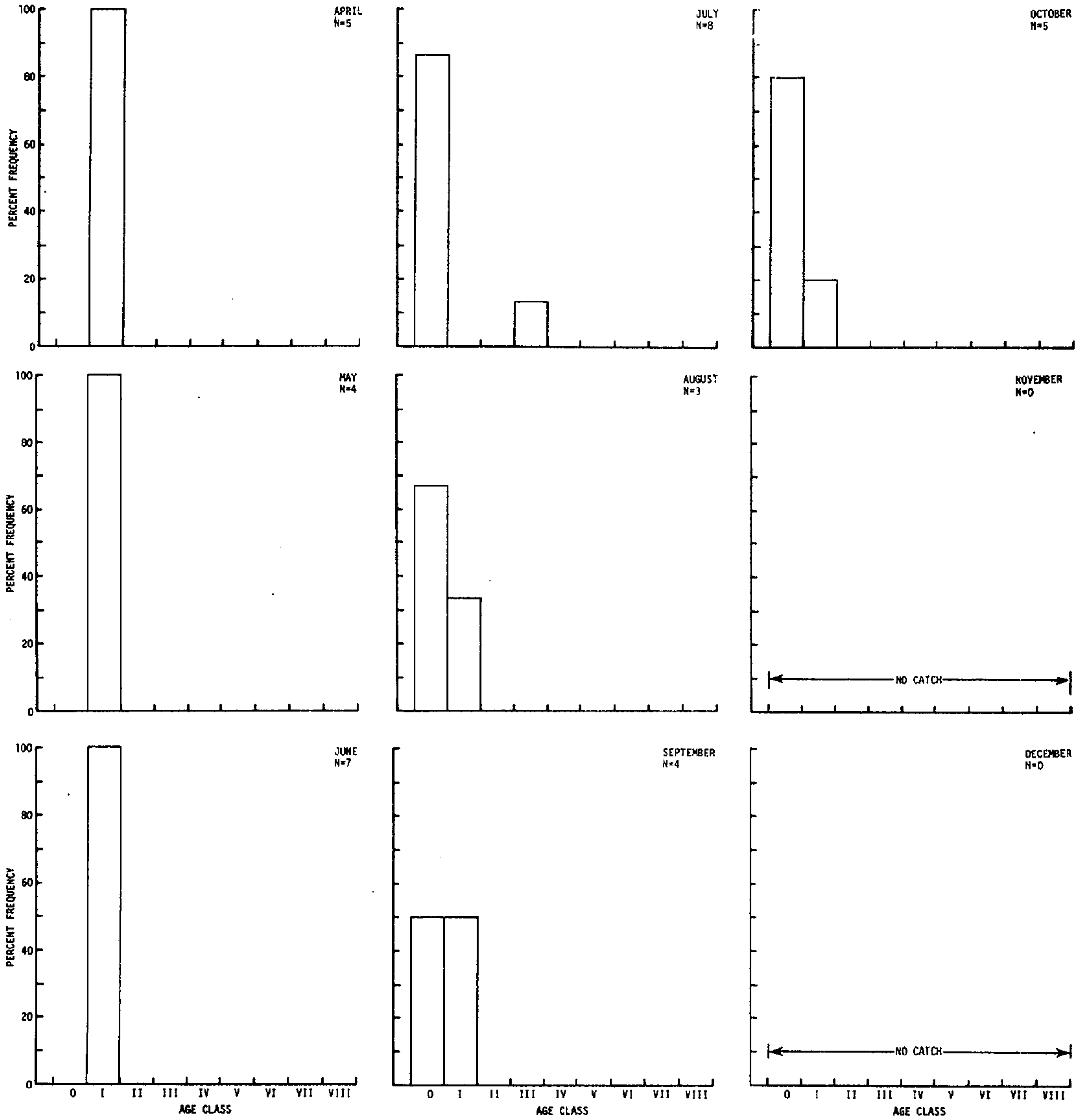


Figure V-3. Age Composition of Striped Bass in Standard Station Bottom Trawls, April-December 1976

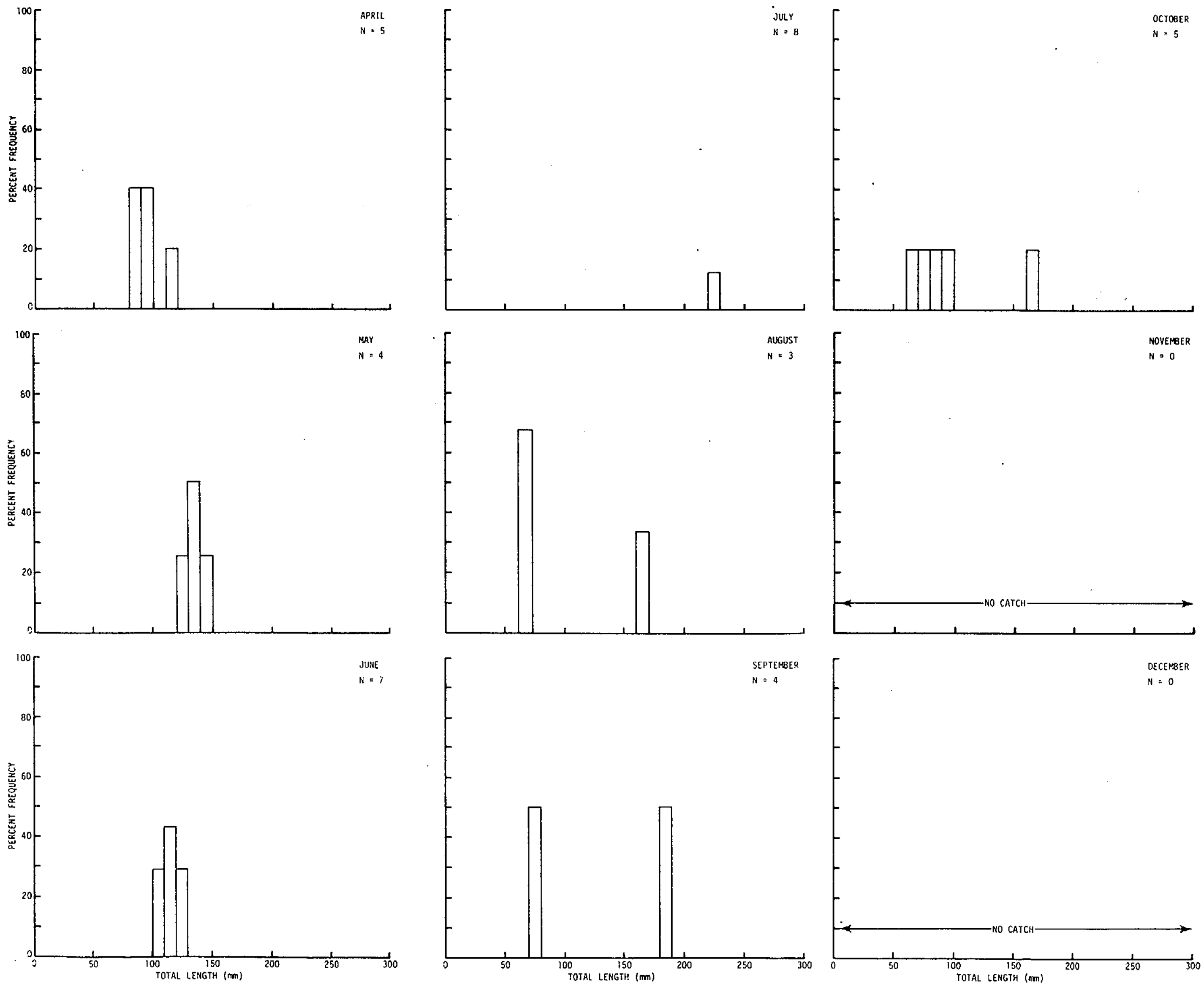


Figure V-4. Length-Frequency Distribution of Striped Bass Collected by Standard Station Bottom Trawl, April-December 1976

Young-of-the-year were first caught by bottom trawl in July instead of August as in previous years. It should be noted, however, that the total catch from bottom trawls during July was only 8 striped bass and 7 were young-of-the-year. Otherwise the age and length composition was similar to past years (TI 1976b).

b. Growth

Instantaneous growth rates for YOY striped bass (Table V-1) were highest between July and August and decreased through the remainder of the season. Growth rates determined from beach seine catches were similar to those observed in 1973 and 1974 and lower than the rates determined in 1975 (TI 1976b). Growth rates determined from bottom trawl catches (although the sample sizes are small) also resemble those of past years.

Table V-1

Instantaneous Growth Rates of Young-of-the-Year Striped Bass Collected in Standard Station Beach Seines and Bottom Trawls, July-December 1976

	Month	Sample Size	Mean Wt (g)	Instantaneous Growth Rate (G)
Beach Seine	Jul	174	0.88	
				0.0392
	Aug	140	2.85	
				0.0081
	Sep	97	3.63	
				0.0045
	Oct	67	4.16	
				0.0103
	Nov	43	5.67	
				0.0019
	Dec	6	6.00	
Bottom Trawl	Jul	7	0.13	
				0.0979
	Aug	2	2.45	
				0.0155
	Sep	2	3.90	
				0.0128
	Oct	3	5.73	

2. White Perch

a. Age and Length Composition

Young-of-the-year white perch were first captured in standard station beach seines (Figures V-5 and V-6) and bottom trawls (Figures V-7 and V-8) in July. They remained the predominant group in the beach seine catches, but older fish were the most abundant in bottom trawl catches. These results are generally consistent with earlier years (TI 1976b). During April 1976 an 11-year-old female white perch, the oldest sampled to date in this study, was captured with a beach seine in the Indian Point area.

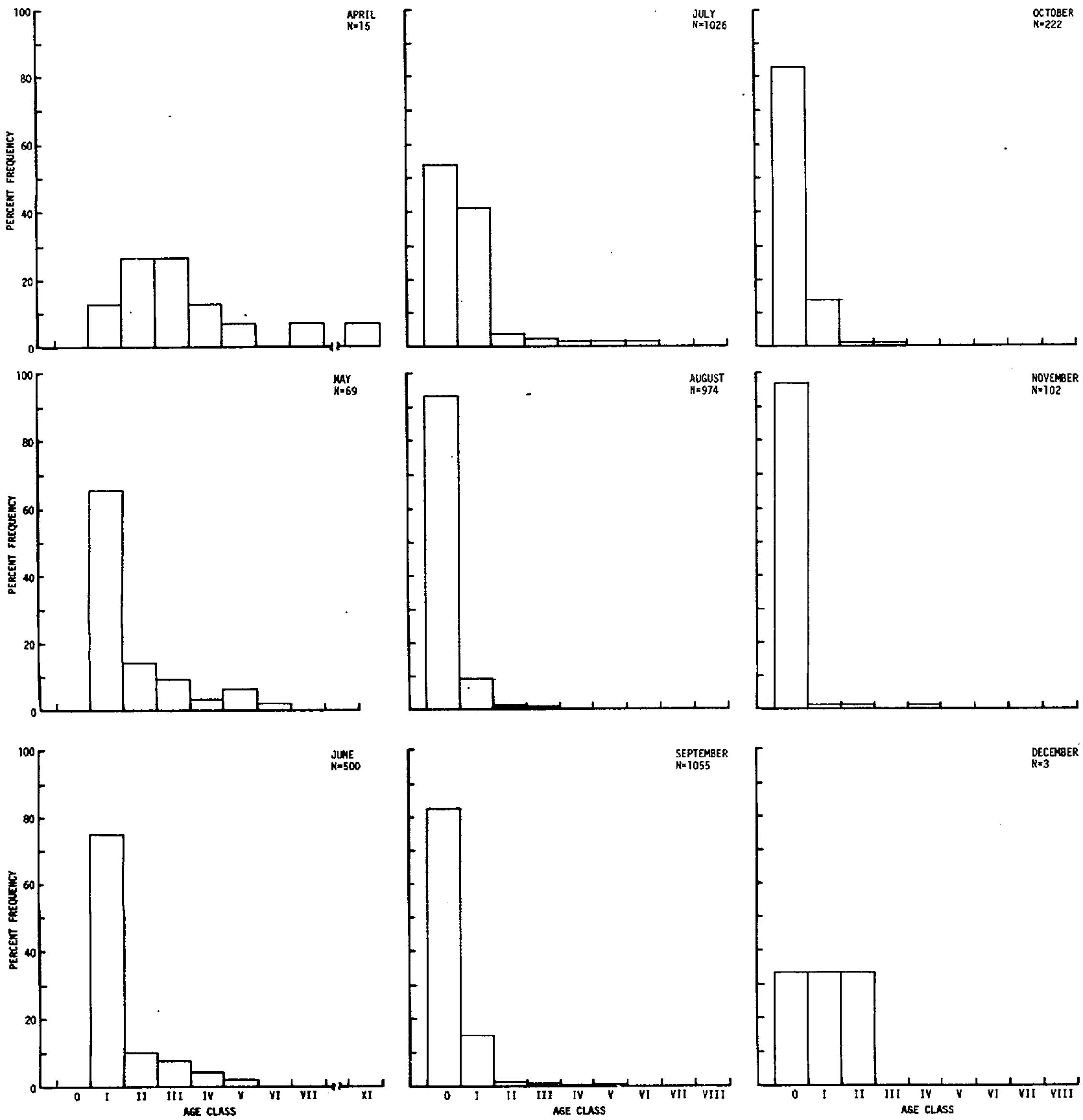


Figure V-5. Age Composition of White Perch in Standard Station Beach Seines, April-December 1976

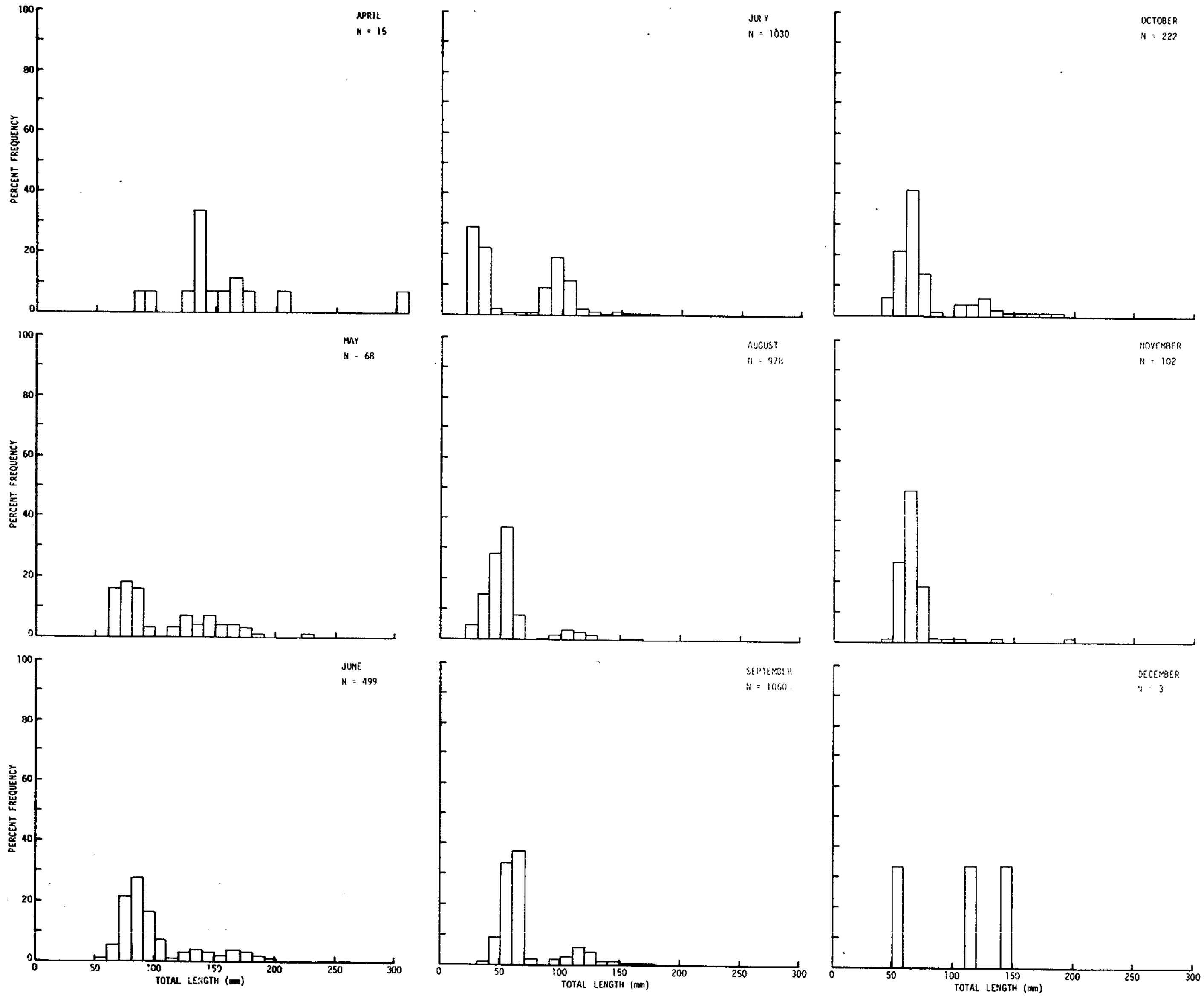


Figure V-6. Length-Frequency Distribution of White Perch Collected by Standard Station Beach Seine, April-December 1976

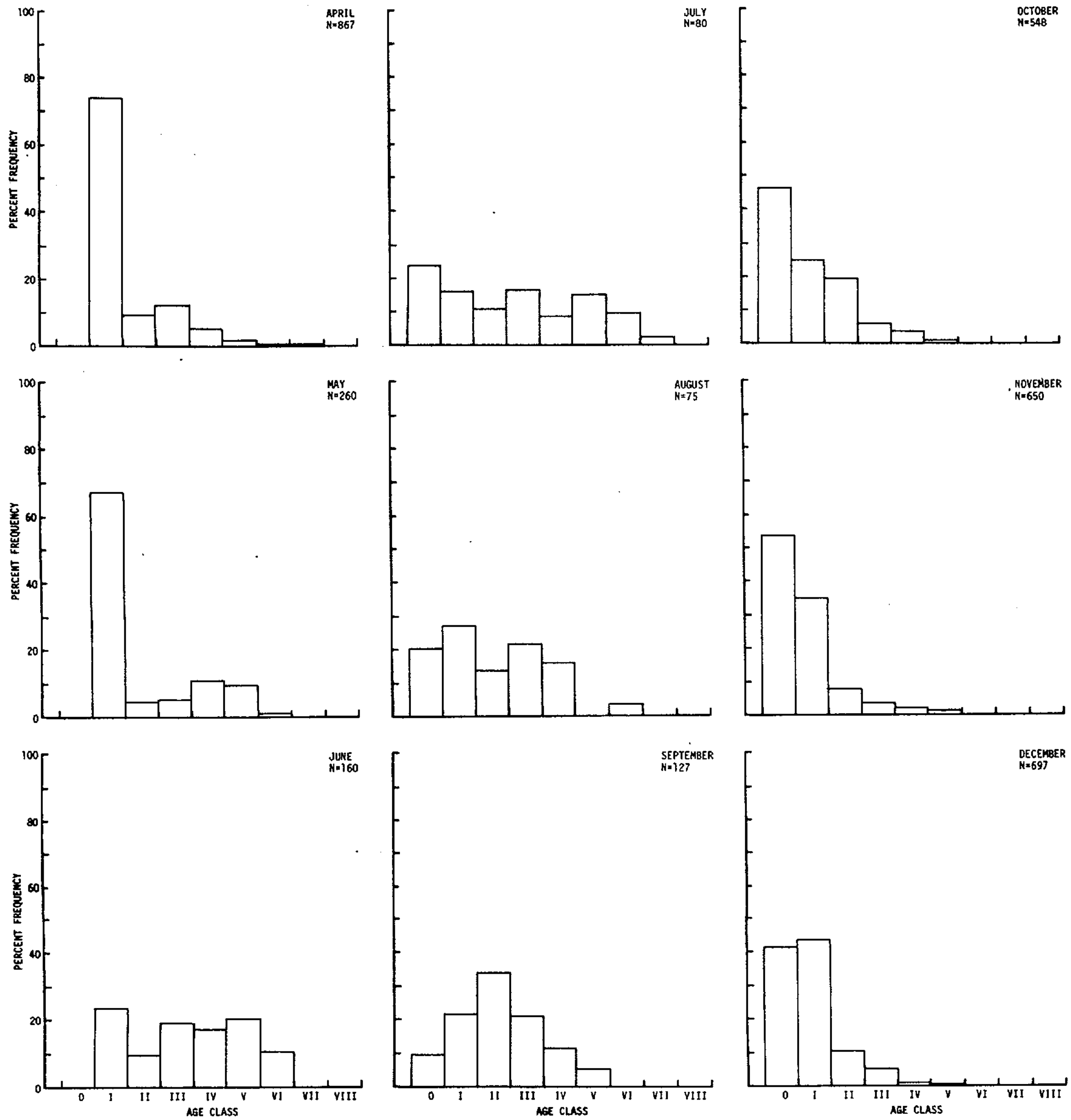


Figure V-7. Age Composition of White Perch in Standard Station Bottom Trawls, April-December 1976

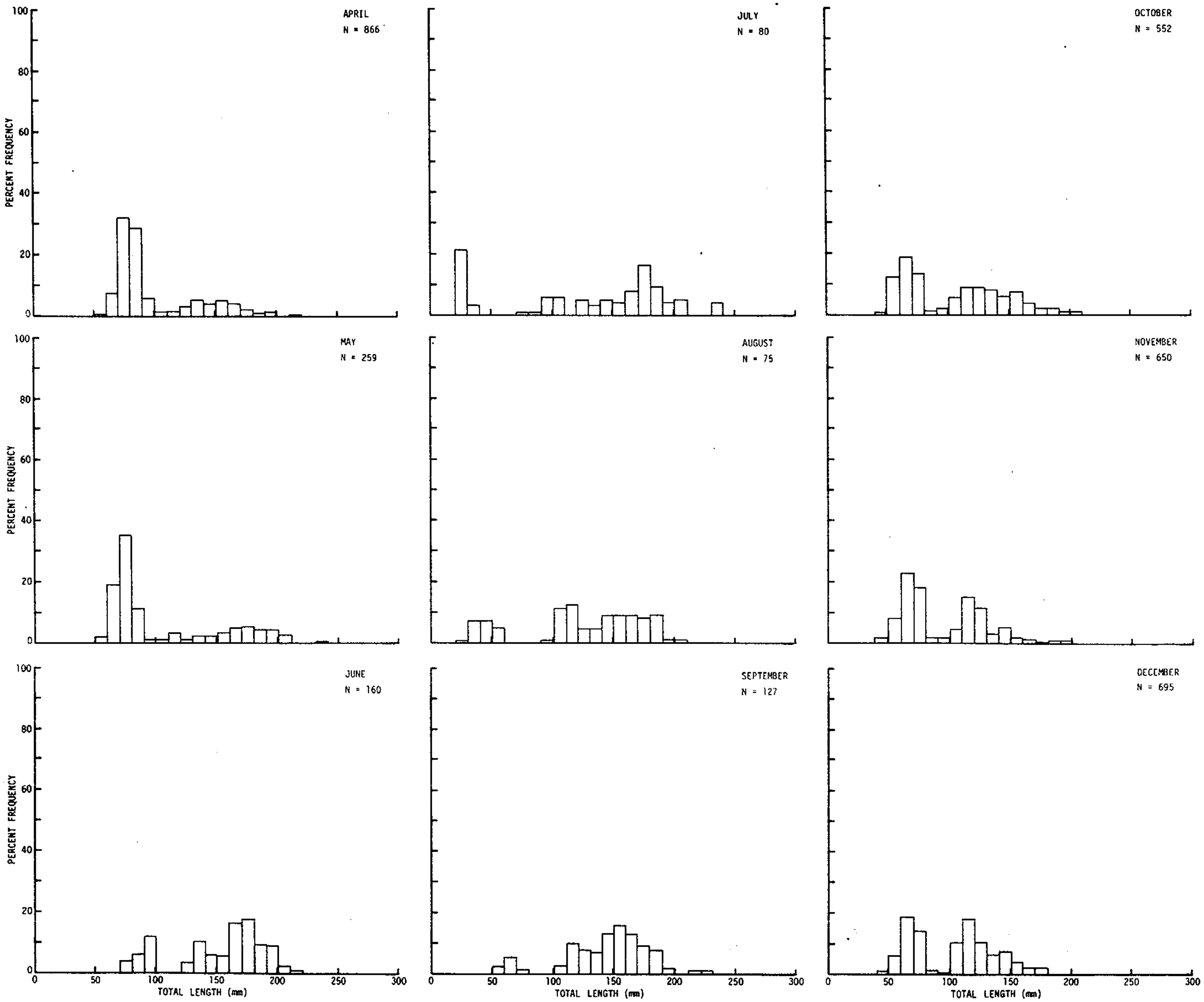


Figure V-8. Length-Frequency Distribution of White Perch Collected by Standard Station Bottom Trawl, April-December 1976

b. Growth

Instantaneous growth rates for YOY white perch (Table V-2) were greatest between July and August and decreased through the remainder of the season. The negative growth rate obtained from October-November beach seine data indicates cessation of growth. Growth rates during 1976 were similar to previous years (TI 1976b).

Table V-2

Instantaneous Growth Rates of Young-of-the-Year White Perch Collected in Standard Station Beach Seines and Bottom Trawls, July-December 1976

	Month	Sample Size	Mean Wt (g)	Instantaneous Growth Rate (G)
Beach Seine	Jul	180	0.40	
				0.0496
	Aug	121	1.77	
				0.0149
	Sep	99	2.77	
				0.0099
	Oct	63	3.73	
				-0.0037
	Nov.	41	3.34	
Bottom Trawl	Jul	19	0.16	
				0.0778
	Aug	8	1.65	
				0.0152
	Sep	12	2.60	
				0.0119
	Oct	48	3.71	
				0.0002
	Nov	72	3.73	
				0.0005
	Dec	36	3.79	

c. Age at Maturity and Egg Count Estimates

During 1975 and 1976, 18% of the age II female white perch were considered sexually mature (Table V-3). The percentage of age II mature males was 32% for 1975 and 46% for 1976 (Table V-4). All age V females and age IV males were mature. These results were similar to prior years (TI 1976b).

Estimates of the mean number of eggs ≥0.2 mm in diameter increase with age for both 1975 and 1976 (Table V-3). Estimates for individual age groups typically have a large variance.

d. Sex Composition

Sex information from fish collected in standard station beach seines and bottom trawls in 1976 (Table V-5) indicates the overall sex ratio is

Table V-3

Female White Perch Mean Number of Eggs ≥0.2 mm in Diameter and Age at Maturity, Indian Point Region, 1975 and 1976

Age	Year	No. Examined	No. Mature	% Mature	No. Examined	Mean No. Eggs
II	1975	60	11	18	2	51363
	1976	33	6	18	8	22063
III	1975	23	18	78	11	49700
	1976	25	22	88	24	38876
IV	1975	43	41	95	21	69437
	1976	21	20	95	21	56576
V	1975	34	34	100	16	74582
	1976	12	12	100	23	76501
VI	1975	8	8	100	8	82779
	1976	3	3	100	4	107685
VII	1975	2	2	100	2	61441
	1976	0			0	

Table V-4

Percentages of Sexually Mature Male White Perch Collected in Indian Point Region, 1975 and 1976

Age	Year	No. Examined	No. Mature	% Mature
II	1975	50	16	32
	1976	28	13	46
III	1975	20	16	80
	1976	38	28	74
IV	1975	38	38	100
	1976	27	27	100
V	1975	27	27	100
	1976	35	35	100
VI	1975	3	3	100
	1976	14	14	100

Table V-5

White Perch Sex Composition by Age and Gear, Standard Station Bottom Trawls and Beach Seines, 1975 and 1976

1975

Gear	Age	Sex	Apr N	Apr %	May N	May %	Jun N	Jun %	Jul N	Jul %	Aug N	Aug %	Sep N	Sep %	Oct N	Oct %	Nov N	Nov %	Dec N	Dec %
Beach Seine	I	M	-	-	-	-	2	67	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	1	33	-	-	-	-	-	-	-	-	-	-	-	-
	II	M	-	-	14	54	23	48	-	-	-	-	1	9	1	100	-	-	-	-
		F	-	-	12	46	25	52	-	-	2	100	10	91	-	-	1	100	-	-
	III	M	-	-	5	71	3	43	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	2	29	4	57	-	-	-	-	4	100	1	100	1	100	-	-
	IV	M	-	-	8	80	4	33	-	-	-	-	2	50	-	-	-	-	-	-
		F	2	100	2	20	8	67	-	-	-	-	2	50	-	-	-	-	-	-
	V	M	-	-	-	-	3	43	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	3	100	4	57	1	100	-	-	1	100	1	100	-	-	-	-
	VI	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	1	100	-	-	5	100	1	100	-	-	-	-	-	-	-	-	-	-
	VII	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VIII	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-
	IX	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	X	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	XI	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottom Trawl	I	M	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-
	II	M	-	-	15	37	15	37	1	9	-	-	1	14	3	38	7	47	5	29
		F	1	100	26	63	26	63	10	91	5	100	6	86	5	62	8	53	12	71
	III	M	13	43	2	17	9	11	8	62	-	-	4	29	5	45	1	20	2	67
		F	17	57	10	83	13	59	5	38	10	100	10	71	6	55	4	80	1	33
	IV	M	22	31	12	23	15	35	3	37	2	17	1	12	9	75	1	33	-	-
		F	48	69	40	77	28	65	5	63	10	83	7	88	3	25	2	67	1	100
	V	M	16	52	11	39	13	38	2	40	-	-	-	-	1	20	2	67	-	-
		F	15	48	17	61	21	62	3	60	3	100	2	100	4	80	1	33	-	-
	VI	M	-	-	2	50	2	40	3	75	-	-	-	-	-	-	-	-	-	-
		F	7	100	2	50	3	60	1	25	2	100	-	-	1	100	-	-	-	-
	VII	M	-	-	-	-	1	33	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	2	67	-	-	-	-	-	-	-	-	-	-	-	-

1976

Gear	Age	Sex	Apr N	Apr %	May N	May %	Jun N	Jun %	Jul N	Jul %	Aug N	Aug %	Sep N	Sep %	Oct N	Oct %	Nov N	Nov %	Dec N	Dec %
Beach Seine	I	M	-	-	-	-	7	58	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	5	42	-	-	-	-	-	-	-	-	-	-	-	-
	II	M	-	-	3	50	19	59	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	3	50	13	41	1	100	-	-	-	-	1	100	-	-	-	-
	III	M	1	100	3	50	17	55	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	3	50	14	45	5	100	-	-	-	-	1	100	-	-	-	-
	IV	M	1	50	1	50	7	47	-	-	-	-	-	-	-	-	-	-	-	-
		F	1	50	1	50	8	53	2	100	-	-	-	-	-	-	1	100	-	-
	V	M	-	-	3	75	2	25	2	67	-	-	-	-	-	-	-	-	-	-
		F	1	100	1	25	6	75	1	33	-	-	-	-	-	-	-	-	-	-
	VI	M	-	-	-	-	-	-	1	50	-	-	-	-	-	-	-	-	-	-
		F	-	-	1	100	-	-	1	50	-	-	-	-	-	-	-	-	-	-
	VII	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VIII	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IX	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	X	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	XI	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottom Trawl	I	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	M	-	-	-	-	2	20	1	33	-	-	-	-	11	33	5	33	11	48
		F	-	-	3	100	8	80	2	67	-	-	-	-	22	67	10	67	12	52
	III	M	22	55	4	36	12	55	2	29	-	-	-	-	7	30	3	30	14	64
		F	18	45	7	64	10	45	5	71	-	-	-	-	16	70	7	70	8	36
	IV	M	23	72	8	30	12	55	2	67	-	-	-	-	5	36	3	33	2	50
		F	9	28	19	70	10	45	1	33	-	-	-	-	9	64	6	67	2	50
	V	M	5	56	13	50	20	74	2	29	-	-	-	-	-	-	-	-	1	100
		F	4	44	13	50	7	26	5	71	-	-	-	-	2	100	2	100	-	-
	VI	M	1	100	3	75	11	79	3	60	-	-	-	-	-	-	-	-	-	-
		F	-	-	1	25	3	21	2	40	-	-	-	-	-	-	-	-	-	-
	VII	M	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-

approximately equal. There was no significant difference in sex composition between fish of different ages from beach seine catches ($\chi^2 = 28.7$, $p > 0.001$). The reason for this time difference is unknown at the present time, but it may be due to gear selection.

White perch collected in standard station beach seines and bottom trawls during 1976 were classified by sex (Table V-5). These data, however, are potentially biased since there was not an equal opportunity to determine the sex of each fish (i.e., sex information was recorded only when a positive identification could be made at the time of initial laboratory processing).

e. Mortality

A total annual mortality for age I through V white perch, based on a linear relationship of bottom trawl data, was estimated to be 69.8% (Table V-6). This value is comparable with the 65% found earlier by TI (1974). Annual mortality for YOY white perch was estimated to be 88.8% based on beach seine data and 22.2% based on bottom trawl data. The beach seine mortality estimate is considered to be better than the trawl estimate since YOY white perch are primarily in the shore zone at this time and are thus underrepresented in the trawls.

Table V-6

Estimates of Annual Mortality Rates (A) for White Perch Captured in Standard Station Beach Seines and 16-mm Cod-End Bottom Trawls, October-December 1976

	Age	Between Ages N	Between Ages A	Linear Regression Estimate* A
Beach Seine Data	0	286	0.8881	
	1	32		
16-mm Cod-End	0	535	0.2224	0.6976
	I	416	0.7067	
	II	122	0.7787	
	III	27	0.4444	
	IV	15	0.8000	
	V	3		

*$\text{Log}_e Y = \text{Log}_e \alpha + \beta(X)$ where $\alpha = 7.1755$, $\beta = -1.1960$, $r = 0.99316$; regression excludes age 0 white perch

3. Atlantic Tomcod

a. Age and Length Composition

Mean lengths of the 1975-76 spawning population (Table V-7) were approximately 10 mm larger than those observed from the 1974-75 spawning population (TI 1976b) and 14 mm smaller than the mean length observed during January-February of the 1973-74 spawning season.

Table V-7

Length Frequency and Age Composition of Atlantic Tomcod Collected in Traps during 1975-76 Spawning Season

Length Class (mm)	Length Frequency (%)			Age Composition (%)*	
	December 1975	January 1976	February 1976	Age I*	Age II*
81-90		0.01		100	
91-100		0	0.08	100	
101-110		0.08	1.3	100	
111-120	0.3	0.9	3.7	100	
121-130	3.0	4.9	10.3	100	
131-140	12.3	14.1	18.6	100	
141-150	21.8	20.0	24.3	100	
151-160	23.8	19.7	19.8	100	
161-170	18.4	15.6	11.9	100	
171-180	10.5	11.1	4.6	98.2	1.8
181-190	4.5	6.7	1.8	98.3	1.7
191-200	1.9	3.6	1.2	96.6	3.4
201-210	1.2	1.5	1.0	81.5	18.5
211-220	0.8	0.6	0.4	57.4	42.6
221-230	0.4	0.2	0.3	25.0	75.0
231-240	0.3	0.2	0.08		100
241-250	0.2	0.2	0.2		100
251-260	0.2	0.1	0.2		100
261-270	0.1	0.06	0		100
271-280		0.03	0.08		100
281-290		0.03			100
291-300		0.01			100
Sample Size	13711	26013	1291	471	130
Mean Total Length (mm)	158.4	157.6	148.0		

*3 months combined; Age I = 11-13 months and Age II = 22-26 months assuming January 1 spawning.

In the 1975-76 Atlantic tomcod spawning population (Table V-7), all tomcod less than 170 mm were of the 1975 year class and only 3.3% were from the 1974 year class.

b. Growth

Instantaneous growth rates for YOY tomcod (Table V-8) were highest in May, declined through the summer, and increased in the fall. This pattern, reflecting rapid growth in the spring and fall and a growth slowdown during the summer, is consistent with previous years (TI 1976b).

Table V-8

Instantaneous Growth Rates of Young-of-the-Year Atlantic Tomcod Collected in Bottom Trawls during 1976

Date	Initial Mean Wt (g)	Time (days)	Instantaneous Growth Rate (G)
5/12	0.36		
		14	0.1043
5/26	1.55		
		15	0.0294
6/10	2.41		
		13	0.0166
6/23	2.99		
		8	0.0329
7/1	3.89		
		14	0.0138
7/15	4.72		
		11	0.0040
7/26	4.93		
		17	0.0123
8/12	6.08		
		19	0.0029
8/31	6.43		
		10	0.0141
9/10	7.40		
		19	0.0084
9/29	8.68		
		12	0.0029
10/11	8.99		
		14	0.0277
10/25	13.24		
		14	0.0294
11/8	19.97		
		15	0.0099
11/23	23.16		

c. Age at Maturity and Fecundity

In 1976 YOY tomcod were sexually mature by the age of 11-12 months (Figure V-9) as determined by gonad weight/body weight ratio. Commencement of rapid maturation, as in previous years (TI 1976b), occurred in October for males and November for females. The maximum testes weights in 1976 were about 20% of body weight, about 4% greater than in previous years.

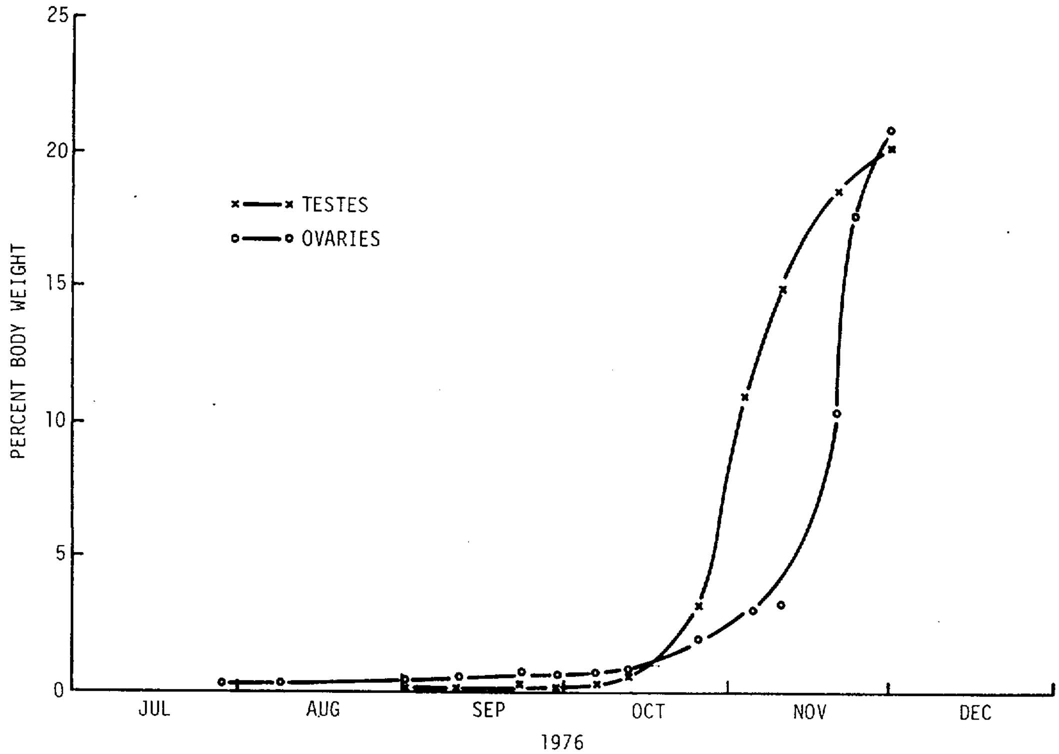


Figure V-9. Mean Gonad Weight Expressed as Percentage of Total Body Weight for Young-of-the-Year Atlantic Tomcod, Hudson River, 1976

Fecundity estimates from the 1975-76 Atlantic tomcod spawning season were found to increase with length and weight (Table V-9).

Table V-9

Regression Results from Log_{10} Transformed Length, Weight, and Fecundity Data from the 1975-76 Spawning Season

Fecundity vs	Sample Size	y Intercept a	Slope b	Correlation Coefficient r
Length	80	-3.77224	3.48399	0.9188
Weight	80	2.28524	1.01741	0.9376

d. Sex Ratio

The sex ratio of YOY Atlantic tomcod was approximately 50:50 from June through September 1976 (Table V-10), as in previous years (TI 1976b).

Table V-10

Young-of-the-Year Male and Female Atlantic Tomcod Percentage by Month, Hudson River, 1976

Sex	Jun		Jul		Aug		Sep		Combined	
	%	N	%	N	%	N	%	N	%	N
Male	44.5	105	57.3	258	48.0	193	52.1	149	51.3	705
Female	55.5	131	42.7	192	52.0	209	47.9	137	48.7	669
Total		236		450		402		286		1374

SECTION VI
HATCHERY PROGRAM

A. INTRODUCTION

The striped bass culture and stocking feasibility study conducted from 1973-75 has shown it is possible to raise large numbers of fingerling striped bass. During those years over 318,000 striped bass fingerlings were stocked into the Hudson River between RM 24 and 62 (KM 38.6-99.8) (TI 1977). These fish were marked with finclips and magnetic nose tags to permit positive identification if recaptured at a later date. In 1976, 266 hatchery-reared striped bass were recovered, 260 from the 1975 stocking and 6 from 1974 (see Appendix C and TI 1977). These hatchery-reared fish were compared with recaptured wild striped bass to evaluate survival and movement patterns.

The diets of young-of-the-year and yearling hatchery-reared and wild striped bass were compared to determine similarities or trends. Food habits may reflect the ability of hatchery-reared striped bass to survive in the wild, as well as the effect of captivity.

B. SURVIVAL AND MOVEMENTS

1. Survival

Survival of hatchery-reared striped bass in the weeks following stocking compared favorably with that of marked wild fish (TI 1977). For most time intervals, the relative survival estimate (survival of hatchery fish/survival of marked wild fish) was greater than one, although the difference was not statistically significant.

Relative survival estimates based on fish recaptured in the year following release were more variable (range 0.24 to 3.14), but not statistically different (TI 1977). Even though some hatchery-reared fish were recaptured through November (Table VI-1), the number of marked wild fish recaptured after June was too small to make relative survival estimates for the latter part of the year. The best indication of long-term survival is that 12 hatchery fish have been caught after being at large one year or more.

Table VI-1

Hatchery-Reared Striped Bass Recaptured in 1976*

Recapture Period	Release Period 1974	Sep 1975	Oct 1975
Jan	0	10	25
Feb	2	1	7
Mar	0	8	13
Apr	1	31	69
May	0	24	10
Jun	2	22	16
Jul	0	9	1
Aug	0	4	0
Sep	0	1	1
Oct	1	5	2
Nov	0	1	0
Dec	0	0	0
Total	6	116	144

Dashed box in table: Recaptured after at least one year at large

*Recaptures from all sources are included.

2. Movement

Hatchery-reared striped bass disperse throughout the entire length of the Hudson River below Albany. When the number of recaptures of hatchery-reared and marked wild fish permitted comparison, the hatchery fish appeared to move more extensively; i.e., a greater proportion of recaptures occurred outside the region in which the fish were released (TI 1977). Hatchery-reared fish recovered in 1976 were also widely distributed (Table VI-2); however, not enough wild fish were recaptured to allow comparison of the two groups. The number of recaptures per region cannot be interpreted as population density because the amount and type of recapture effort varied tremendously among regions and recapture periods. The apparent downriver distribution (below RM 46) (KM 70) in the January-April recapture period may reflect the small amount of sampling in the upper regions during this time. From May-August, the fish appeared to be dispersed throughout the entire sampling area. After August, no hatchery fish were recaptured below RM 34 (KM 54.7) or above RM 60 (KM 96.6).

Table VI-2

Distribution of Hatchery-Reared Striped Bass Recaptured in 1976

Release Region	Recapture Period	Recapture Region (RM) <12	12-23	24-33	34-38	39-46	47-55	56-61	62-76	77-153	Total
Tappan Zee 24-33	Jan-Apr	1	9		17	9					36
	May-Aug		1	1	2	4			1		9
	Sep-Dec					1					1
Croton-Haverstraw 34-38	Jan-Apr		3	1	26	13					43
	May-Aug				8	5				1	14
	Sep-Dec				1	1		2			4
Indian Point 39-46	Jan-Apr		2	1	10	5					18
	May-Aug					20	1			2	23
	Sep-Dec					1		1			2
West Point 47-55	Jan-Apr		1								1
	May-Aug										0
	Sep-Dec					1					1
Cornwall 56-61	Jan-Apr		1			2					3
	May-Aug			1		1					2
	Sep-Dec										0
Undetermined (nose tag missing)	Jan-Apr	2	13	2	29	19			1		66
	May-Aug	1	3	3	6	23		1	1	2	43
	Sep-Dec				2						3*
Total	Jan-Apr	3	29	4	82	48			1		167
	May-Aug	1	4	5	16	53	1	1	2	5	88
	Sep-Dec				3	4		3			11
	Jan-Dec	4	33	9	101	105	1	4	3	5	266

*Exact location of recapture could not be determined for one fish.

The decline in recaptures from 167 in January-April to 88 in May-August to 11 in September-December suggests that many of the hatchery fish emigrated from the river or died during the year. A similar decline has also been noted for wild striped bass yearlings (McFadden 1977). Since no sampling was done outside the river in 1976, no recaptured fish are available to verify that emigration was occurring, although hatchery fish were recaptured outside the river during May, June, and July 1975 (TI 1977). Variations in sampling effort would not be responsible for the decline as effort was quite low in January-April when compared to the remainder of the year.

C. COMPARATIVE DIETS OF WILD AND HATCHERY-REARED STRIPED BASS

1. Methods

The striped bass analyzed in this study were captured in beach seines during October-November 1974 and 1975. All fish were collected between river miles 34 and 43 (KM 54.7 - 69.2; Croton Bay to Peekskill Bay), with the exception of 1974 wild striped bass which were collected between river miles 38 and 46 (KM 61.2 - 74; Oscawana to Bear Mountain). The location and time periods for collections of wild striped bass were chosen to correspond roughly to the location and times of hatchery striped bass recaptures. All striped bass samples were preserved in 10% formalin in the field, and stomachs were later removed in the laboratory.

The stomach contents were placed in a petri dish, sorted under a dissecting microscope, identified and counted. The number of identifiable dismembered organisms was estimated by counting the number of heads or portions of animals judged to constitute 50% or more of the original animal. If there were large numbers (>250) of small organisms, total count estimates were made by subsampling in a petri dish with a grid superimposed on the bottom. Items such as filamentous algae, animal remains, plant remains, detritus and occasionally fish remains were not counted but were noted as being present or absent.

The percent frequency of each countable food item was calculated for each hatchery-reared and wild striped bass in 1974 and 1975 as follows:

$$f_{ij} = \frac{m_{ij}}{m_j} \times 100\% \qquad (1)$$

where

f_{ij} = percent frequency of food item i in stomach j

m_{ij} = number of organisms of food item i in stomach j

m_j = total number of organisms counted in stomach j

The mean percent frequency of each countable food item on a monthly basis for hatchery-reared and wild striped bass for four length groups (1-75 mm, 76-125 mm, 126-200 mm, and 201+ mm) and for all length groups combined was then obtained using the formula:

$$\bar{f}_i = \frac{1}{n} \sum_{j=1}^{n} f_{ij} \qquad (2)$$

where

$\bar{f}_i$ = mean percent frequency of food item i for all stomachs

f_{ij} = percent frequency of food item i in stomach j

n = total number of stomachs with at least one countable food item

Trends in food habits of hatchery-reared and wild striped bass were obtained by ranking all food items consumed according to mean percent frequency. The top ranked food items were then compared among different length groups for hatchery-reared and wild striped bass.

2. Results and Discussion

Both wild and hatchery-reared striped bass consumed a wide variety of prey organisms (Tables C-2, C-3, C-4, and C-5). Wild striped bass fed primarily on small invertebrates when young, gradually changing their preference toward larger invertebrates and fish as they increased in size (Tables VI-3 and

VI-4). Small striped bass (1-75 mm) consumed *Gammarus* and other amphipods, copepods, invertebrate eggs, isopods, cladocerans, polychaetes, and dipterans. As the wild striped bass increased in length (76-125 mm) they continued to eat *Gammarus* and other amphipods, isopods, copepods, dipterans, as well as oligochaetes, decapods, and fish. Larger striped bass (≥ 126 mm) became more piscivorous with mummichogs (*Fundulus heteroclitus*), clupeids (*Alosa* spp.), striped bass (*Morone saxatilis*), and *Morone* spp. (unidentified) contributing a substantial portion of their diet in 1974. Despite the increase in piscivorous feeding habits, *Gammarus*, *Neomysis*, decapods, and isopods still constituted a substantial portion of the wild striped bass diet.

The hatchery-reared striped bass fed on similar food items as wild striped bass (Table VI-3 and VI-4). Because hatchery-reared striped bass are generally larger than their wild counterparts (TI 1977), none smaller than 76 mm were available for analysis. Hatchery-reared striped bass of 76-125 mm total length fed primarily on *Gammarus* and other amphipods, isopods, decapods, insects, and fish such as centrarchids, clupeids, bay anchovies *(Anchoa mitchilli)*, and blueback herring *(Alosa aestivalis)*. As the striped bass increased in size (≥126 mm), they became more piscivorous, consuming bluegills *(Lepomis macrochirus)*, blueback herring *(Alosa aestivalis)*, and other clupeids. *Gammarus* and other amphipods, isopods, decapods, and dipterans still constituted a substantial portion of the hatchery-reared striped bass diet.

More hatchery-reared striped bass had empty stomachs than wild striped bass. Thirty-seven (37) percent and 36% of the hatchery-reared striped bass had empty stomachs in 1974 and 1975 respectively, while only 0% and 11% of the wild fish had no food in their stomachs. This difference is difficult to interpret; however, factors such as poor correlation between times of capture or conditioning of hatchery-reared striped bass to feed at specific times may account for some of this variation.

Overall, *Gammarus* and other amphipods, *Neomysis*, calanoid copepods, decapods, isopods, and fish were the major food items consumed by both hatchery-reared and wild striped bass in 1974 and 1975. Uncountable food items such as

Table VI-3

Comparison of Major Countable Food Items of Wild and Hatchery-Reared Bass by Mean Percent Frequency, October-November 1974

Wild Striped Bass				Hatchery-Reared Striped Bass			
Length Group (mm)	Sample Size	Food Item	Mean Percent Frequency	Length Group (mm)	Sample Size	Food Item	Mean Percent Frequency
1-75	33	*Gammarus*	47.69	1-75	0		
		Calanoida	14.36				
		Corophium	8.54				
		Cyathura	6.35				
		Monoculodes	4.95				
		Leptocheirus	4.26				
		Polychaeta	3.86				
		Cyclopoida	3.07				
76-125	52	*Gammarus*	59.81	76-125	39	*Gammarus*	55.88
		Calanoida	10.61			*Neomysis*	12.31
		Fish remains	6.66			*Corophium*	10.05
		Chironomid (P)	4.30			*Crangon*	3.88
		Cyathura	3.25			*Cyathura*	3.46
		Rithropanopeus	2.40			Centrarchid (Unid.)	2.56
		Leptocheirus	2.08			Fish remains	2.56
		Oligochaeta	1.92			Odonata (A)	2.56
						Callinectes sapidus	2.56
126-200	12	Mummichog	16.67	126-200	11	*Gammarus*	60.95
		Gammarus	15.28			*Neomysis*	15.45
		Neomysis	14.82			*Crangon*	9.15
		Clupeid (Unid.)	13.89			Bluegill	9.09
		Striped bass	8.33			Amphipoda (Unid.)	3.22
		Chirodotea	8.33			*Cyathura*	1.52
		Rithropanopeus	6.67			Chaoborus (L)	0.16
		Crangon	4.34			*Corophium*	0.13
						Isopod (Unid.)	0.13
201+	10	Clupeid (Unid.)	53.75	201+	0		
		Fish remains	30.00				
		Morone (Unid.)	10.00				
		Crangon	6.25				
All	107	*Gammarus*	45.49	All	50	*Gammarus*	57.00
		Calanoida	9.59			*Neomysis*	13.00
		Clupeid (Unid.)	6.58			*Corophium*	7.87
		Fish remains	6.25			*Crangon*	5.04
		Cyathura	3.54			*Cyathura*	3.03
		Corophium	3.08			Bluegill	2.00
		Leptocheirus	2.33			Centrarchid (Unid.)	2.00
		Monoculodes	2.25			Fish remains	2.00
						Odonata (A)	2.00
						Callinetes sapidus	2.00

(Unid.) = Unidentified
(P) = Pupae
(A) = Adult
(L) = Larvae

Table VI-4

Comparison of Major Countable Food Items of Wild and Hatchery-Reared Bass by Mean Percent Frequency, October-November 1975

Wild Striped Bass				Hatchery-Reared Striped Bass			
Length Group (mm)	Sample Size	Food Item	Mean Percent Frequency	Length Group (mm)	Sample Size	Food Item	Mean Percent Frequency
1-75	2	Invertebrate eggs	35.00	1-75	0		
		Amphipoda (Unid.)	24.26				
		Cladocera (Unid.)	20.37				
		Corophium	5.56				
		Cricotopus (L)	5.56				
		Chironomid (L)	4.63				
		Copepod (Unid.)	1.85				
		Calanoida	1.85				
76-125	88	Amphipoda (Unid.)	24.75	76-125	55	Amphipoda (Unid.)	21.88
		Gammarus	23.30			*Gammarus*	16.21
		Corophium	14.05			*Corophium*	15.54
		Cyathura	7.94			*Cyathura*	12.68
		Fish remains	6.28			Bay anchovy	7.27
		Chironomid (L)	3.58			Blueback herring	3.64
		Oligochaeta	2.53			Clupeid (Unid.)	3.64
		Cumacea	2.30			Cumacea	3.22
126-200	1	*Corophium*	100.00	126-200	39	Amphipoda (Unid.)	21.90
						Fish remains	19.23
						Gammarus	12.40
						Blueback herring	11.54
						Clupeid (Unid.)	10.26
						Corophium	9.44
						Cyathura	4.13
						Procladius	2.66
201+	2	Fish remains	100.00	201+	1	Clupeid (Unid.)	100.00
All	93	Amphipoda (Unid.)	23.94	All	95	Amphipoda (Unid.)	21.66
		Gammarus	22.05			*Gammarus*	14.47
		Corophium	14.49			*Corophium*	12.87
		Fish remains	8.09			*Cyathura*	9.04
		Cyathura	7.52			Fish remains	8.95
		Chironomid (L)	3.49			Clupeid (Unid.)	7.37
		Oligochaeta	2.39			Blueback herring	6.84
		Cumacea	2.18			Bay anchovy	4.21

(Unid.) = Unidentified
(L) = Larvae
(P) = Pupae

filamentous algae, detritus, plant remains, animal remains, and fish remains were present in many stomachs of both hatchery-reared and wild striped bass. It appears that hatchery-reared and wild striped bass have similar diets. Hatchery-reared striped bass are able to survive in the wild after being released from captivity and, despite any feeding habit pattens established in captivity, they consume most of the same food items that wild fish consume.

SECTION VII

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APPENDIX A

IMPINGEMENT DATA

Table A-1

Numbers and Weights of Major Impinged Species and All Species Combined Collected at Indian Point, Unit 1, 1976

	Total Number*							Total Weight (g)*						
Period	All Species Combined	WP†	SB	TC	BH	AL	BA	All Species Combined	WP	SB	TC	BH	AL	BA
Week														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	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
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	2	1	0	0	0	0	0	45	43	0	0	0	0	0
35	69	29	0	22	1	0	10	1235	873	0	244	1	0	22
36	228	87	1	46	12	2	42	4868	1862	3	974	18	52	122
37	129	33	0	10	8	0	53	1504	760	0	80	12	0	163
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	306	292	0	0	4	0	0	1234	1179	0	0	8	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MONTH														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	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
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	71	30	0	22	1	0	10	1280	916	0	244	1	0	22
9	357	120	1	56	20	2	95	6372	2622	3	1054	30	52	285
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	306	292	0	0	4	0	0	1234	1179	0	0	8	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Recorded to nearest whole number.

†WP = white perch
SB = striped bass
TC = Atlantic tomcod
BH = blueback herring
AL = alewife
BA = bay anchovy

Table A-2

Numbers and Weights of Major Impinged Species and All Species Combined Collected at Indian Point, Unit 2, 1976

Period	Total Number*: All Species Combined	WP†	SB	TC	BH	AL	BA	Total Weight (g)*: All Species Combined	WP	SB	TC	BH	AL	BA
Week														
1	3193	2525	12	213	2	0	0	24867	12297	103	7314	4	0	0
2	7629	6649	47	178	1	1	0	51396	35132	390	6209	2	18	0
3	28544	25879	578	481	12	10	0	265817	216377	8087	14676	33	191	0
4	56677	54211	1133	407	6	18	0	363076	330115	11188	9785	20	154	0
5	2662	2401	52	47	0	0	0	18400	13260	1578	1227	0	0	0
6	3250	2907	34	193	0	0	0	37359	26515	1215	6309	0	0	0
7	20373	19874	46	155	0	1	0	149711	139728	472	4134	0	3	0
8	4472	3900	14	217	0	0	0	36110	25518	123	5650	0	0	0
9	618	322	9	108	0	0	0	10399	4243	124	2919	0	0	0
10	284	141	1	27	0	0	0	5531	2493	4	597	0	0	0
11	3637	3285	45	95	1	0	0	31357	25902	445	2963	57	0	0
12	9532	9074	58	67	0	0	0	83034	75375	460	1841	0	0	0
13	6152	5835	6	26	0	0	0	55255	51321	35	714	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	33	25	1	0	0	0	0	326	100	8	0	0	0	0
17	19	18	0	0	0	0	0	42	40	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	128	14	1	94	2	2	0	1504	479	6	205	193	285	0
24	371	60	0	285	4	1	3	3751	2344	0	664	214	214	7
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	415	136	4	182	29	2	26	4299	1193	540	1595	40	23	58
39	4920	1061	165	1355	333	11	1598	26175	6774	781	9344	545	177	2600
40	4454	1211	59	1620	406	13	308	37037	8121	697	10535	662	79	796
41	27326	7372	356	1004	15487	39	1092	110157	37867	2677	7840	26328	267	2743
42	59567	14408	311	138	39139	85	287	164220	56520	3168	1277	69413	403	405
43	83626	10237	330	80	68839	362	65	192894	42314	2591	1097	117919	1737	96
44	15035	6430	86	13	7298	126	2	44254	24371	409	187	12374	553	6
45	3059	1971	25	1	727	33	21	12547	7125	144	1622	1329	133	21
46	0	0	0	0	0	0	0	1400	0	0	1400	0	0	0
47	0	0	0	0	0	0	0	1400	0	0	1400	0	0	0
48	0	0	0	0	0	0	0	1400	0	0	1400	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	9635	7943	49	656	0	0	0	62029	29691	986	13588	0	0	0
51	48503	43845	187	2442	1	1	0	270910	190977	1187	48059	1	11	0
52	45533	41879	135	1950	3	0	0	274126	213839	758	36303	7	0	0
53	10370	9911	37	125	0	1	0	57829	50862	203	2770	0	4	0
Month														
1	98512	91536	1818	1307	21	29	0	721768	606540	21309	38826	59	363	0
2	28669	27013	104	648	0	1	0	230471	194162	1906	18273	0	3	0
3	19842	18454	113	259	1	0	0	180073	157574	1009	7239	57	0	0
4	52	43	1	0	0	0	0	368	140	8	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	499	74	1	379	6	3	3	5255	2823	6	869	407	499	7
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	5445	1234	173	1569	378	15	1632	31518	8249	1472	11331	612	204	2676
10	187759	38457	1127	2819	130499	611	1745	541112	165385	9341	20495	225542	2990	4027
11	5198	3135	36	5	1381	45	22	23153	10651	194	5871	2456	178	22
12	114044	103578	408	5173	4	2	0	664894	485369	3134	100720	8	15	0

*Recorded to nearest whole number.

†WP = white perch
SB = striped bass
TC = Atlantic tomcod
BH = blueback herring
AL = alewife
BA = bay anchovy

Table A-3

Numbers and Weights of Major Impinged Species and All Species Combined Collected at Indian Point, Unit 3, 1976

	Total Number*							Total Weight (g)*						
Period	All Species Combined	WP[†]	SB	TC	BH	AL	BA	All Species Combined	WP	SB	TC	BH	AL	BA
Week														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	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
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1754	1710	10	4	0	0	0	11391	10411	67	151	0	0	0
8	1102	1072	2	2	0	0	0	6877	5729	13	89	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	2756	1940	16	6	24	47	51	27653	11440	165	150	137	8956	188
18	3540	2625	18	5	102	32	37	32584	14652	185	134	1262	6445	154
19	2823	1608	23	19	148	99	5	39172	9360	320	208	2758	9785	13
20	2368	1299	38	85	263	72	3	35020	9385	704	203	3909	10708	7
21	435	227	6	25	16	38	7	13556	3183	68	39	628	5345	18
22	2274	712	18	866	245	71	52	36382	9421	707	1646	8134	6912	161
23	1380	245	9	682	159	44	30	31911	6638	788	1446	12440	5529	88
24	983	333	20	225	195	30	10	45602	15628	553	654	16441	2278	35
25	908	450	7	123	122	26	7	38705	20308	613	340	9775	1679	19
26	1778	488	4	256	110	52	33	47585	24085	298	995	9277	4191	89
27	423	205	2	57	33	6	47	19179	11213	96	240	3294	946	153
28	1575	297	8	310	35	10	637	29042	15237	303	1234	2432	188	1914
29	811	129	12	23	6	41	446	12139	6532	109	84	76	301	1240
30	2176	168	9	744	5	88	784	21169	6892	163	4995	250	700	2452
31	4815	494	68	1389	54	110	1056	60514	14443	330	9811	1115	2400	2827
32	6180	1025	89	2204	125	185	998	72868	15855	785	15155	1446	2070	2895
33	2576	737	51	199	287	61	708	25438	10042	1221	1168	851	412	2047
34	1744	528	25	569	107	51	133	27719	10508	942	6845	462	960	372
35	3935	495	56	888	203	43	323	68606	10268	2258	13537	797	1254	964
36	12291	1119	174	5684	406	146	1099	163789	18915	4198	54968	1526	2938	3417
37	8310	794	157	4107	242	100	1143	92177	15798	1664	33773	660	1513	3798
38	153	64	4	17	24	3	12	4553	2554	601	307	156	56	40
39	800	152	14	134	212	8	127	9187	2419	379	1437	503	43	258
40	1348	279	50	284	211	25	85	18347	4600	256	2311	390	613	240
41	60563	3730	221	1733	51771	215	670	182657	26665	3463	13819	97703	1477	2291
42	37601	3458	140	85	31056	231	105	117676	18555	1353	898	72665	1410	172
43	31489	3742	380	89	24584	172	26	99340	16168	2736	911	55212	970	53
44	17242	6122	102	68	7790	320	0	73807	30670	2367	1101	13931	1557	0
45	29328	17639	237	205	7117	479	0	138029	77804	3232	3754	14150	2174	0
46	16502	14433	128	143	271	36	0	98031	68519	1354	3627	637	193	0
47	32414	30559	100	193	14	1	2	156436	120028	1137	6038	37	7	2
48	21153	20312	27	175	9	1	0	95626	73754	362	5347	38	5	0
49	25531	24678	46	221	2	0	0	104637	81792	236	5750	13	0	0
50	2943	2541	19	29	0	0	0	29233	10639	87	642	0	0	0
51	1822	1522	15	39	1	0	0	18578	7843	73	969	3	0	0
52	8056	7511	35	67	0	0	0	96383	53630	156	1578	0	0	0
53	1330	1230	8	16	0	0	0	10150	5386	43	299	0	0	0
Month														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2856	2782	12	6	0	0	0	18268	16140	80	240	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4477	3188	26	9	71	66	81	43597	18834	255	237	440	13053	315
5	9488	5161	92	911	708	278	69	133931	37716	1872	1962	14806	33197	212
6	5280	1578	41	1372	605	167	85	170642	67550	2274	3616	49515	15578	245
7	7993	1056	70	2117	89	212	2702	109910	46122	778	12424	6440	3321	7826
8	15521	2919	233	4106	724	376	2388	212029	52469	4755	37550	4139	5830	6906
9	22298	2239	366	10102	931	265	2426	284879	42403	7606	93580	2998	4633	7654
10	143379	15306	862	2225	114001	892	883	464724	84663	9590	18452	238326	5712	2747
11	102098	82945	518	688	8817	587	2	503822	345840	6644	17601	17428	2691	2
12	41822	39498	128	434	3	0	0	269946	165232	621	10991	16	0	0

*Recorded to nearest whole number.

[†]WP = white perch
SB = striped bass
TC = Atlantic tomcod
BH = blueback herring
AL = alewife
BA = bay anchovy

Table A-4

Tagged Tomcod Recaptured by Impingement at Indian Point Power Plant, 1976

Tag Number	Release Date	Release Location (RM)	Recovery Date	Total Length (m)	Days at Large	Net Movement* (Mi)
6-4812	12/15/75	51	1/1	162	17	9
6-7912	12/18/75	51	1/3	163	16	9
6-6120	12/16/75	51	1/6	151	21	9
6-7990	12/18/75	51	1/7	145	20	9
6-4515	12/17/75	51	1/8	153	22	9
6-6251	12/19/75	51	1/8	157	20	9
6-12267	12/24/75	51	1/8	169	15	9
6-7804	12/18/75	51	1/13	155	26	9
6-7970	12/18/75	51	1/13	154	26	9
6-8768	12/23/75	51	1/13	165	21	9
6-8267	12/18/75	51	1/16	172	29	9
6-5656	12/23/75	51	1/17	168	18	9
6-13124	12/22/75	51	1/17	171	26	9
6-14273	12/29/75	51	1/17	228	19	9
6-11221	12/23/75	51	1/21	146	29	9
6-12334	12/24/75	51	1/22	133	29	9
6-10934	12/29/75	51	1/24	134	26	9
6-12206	12/24/75	51	1/24	158	31	9
6-18390	1/21/76	51	1/27	123	6	9
6-5397	12/18/75	51	2/5	176	49	9
6-8721	12/19/75	51	2/5	174	48	9
6-10585	12/29/75	56	2/5	132	38	14
6-18999	1/30/76	76	2/11	137	12	34
6-17346	1/23/76	41	2/13	165	21	-1
6-10901	12/29/75	51	2/14	138	47	9
6-8600	12/19/75	51	2/17	158	60	9
6-16917	1/16/76	46	2/21	151	36	4
6-18092	2/3/76	51	2/29	138	138	9
6-11179	12/23/75	51	8/8	164	229	9
6-21077	12/15/76	76	12/23	134	8	34
6-29540	12/21/76	51	12/24	141	3	9
6-20606	12/9/76	71	12/26	144	17	29
6-23220	12/13/76	51	12/30	127	17	9
6-23351	12/14/76	51	12/30	130	16	9

*Positive = downriver
Negative = upriver

Table A-5

Tagged White Perch Recaptured by Impingement at Indian Point Power Plant, 1976

Tag Number	Release Date	Release Location (RM)	Recovery Date	Total Length (mm)	Days at Large	Net Movement* (mi)
9-37132	5/29/75	57	1/16	170	232	15
9-54301	12/1/75	37	1/16	155	46	-5
9-33669	5/19/75	58	1/17	165	243	16
9-41037	9/11/75	76	1/19	150	130	34
9-49858	11/4/75	30	1/19	177	76	-12
9-28330	4/11/75	33	1/26	190	290	-9
9-55450	12/4/75	30	3/13	165	100	-12
5-29030	11/14/75	38	3/21	125	128	-4
5-30168	4/30/76	61	5/4	125	4	19
9-60211	5/11/76	69	5/15	155	4	27
9-33229	5/20/75	129	5/18	165	364	87
5-32929	5/26/76	58	5/29	130	3	16
9-62194	5/26/76	58	5/29	164	3	16
5-31751	5/28/76	57	6/2	123	5	15
5-31905	5/29/76	82	6/4	119	6	40
9-61094	5/20/76	84	6/5	151	16	42
9-64177	5/29/76	83	6/5	152	7	41
5-33104	6/3/76	81	6/7	112	4	39
5-32509	5/29/76	84	6/8	125	10	42
5-29992	6/8/76	58	6/14	124	6	16
9-64811	6/9/76	82	6/15	157	6	40
5-33228	6/9/76	76	6/16	126	7	34
5-33242	6/9/76	76	6/16	133	7	34
5-34069	6/10/76	82	6/17	142	7	40
5-34254	6/17/76	43	6/22	121	5	1
9-51691	11/7/75	34	6/27	169	233	-8
9-64768	6/3/76	81	7/8	183	35	39
9-66743	6/15/76	40	7/16	178	31	-2
9-54576	12/2/75	30	7/30	162	241	-12
9-55414	12/4/75	30	7/30	184	239	-12
9-64613	6/3/76	76	7/30	180	57	34
9-63205	5/29/76	87	8/1	181	64	45
9-64426	6/16/76	27	8/2	191	47	-15
9-61650	5/27/76	80	8/5	156	70	38
9-62948	5/29/76	84	8/5	157	68	42
9-56570	5/20/76	49	8/6	151	78	7
9-51884	11/6/75	34	9/1	150	300	-8
9-55265	12/3/75	29	9/1	175	273	-13
9-61632	5/27/76	80	9/3	148	99	38
5-34817	8/31/76	39	9/6	101	6	-3
5-36648	9/2/76	37	9/7	103	5	-5
9-49186	10/8/75	33	9/7	165	335	-9

* Positive = dcwnriver
Negative = upriver

Table A-5 (Contd)

Tag Number	Release Date	Release Location (RM)	Recovery Date	Total Length (mm)	Days at Large	Net Movement (mi)
5-28194	10/7/75	110	9/8	136	337	68
5-36664	9/2/76	37	9/8	121	6	-5
9-63663	6/9/76	26	9/11	224	94	-16
5-39621	9/15/76	35	9/20	108	5	-7
9-55741	12/4/75	30	9/27	166	298	-12
5-39987	9/21/76	34	10/3	132	12	-8
5-40055	9/20/76	26	10/4	137	14	-16
9-61682	5/29/76	82	10/4	161	128	40
9-70596	9/20/76	26	10/4	161	14	-16
5-42755	9/28/76	43	10/5	117	7	1
5-42903	9/27/76	38	10/6	107	9	-4
9-44311	11/6/75	51	10/6	198	335	9
9-61254	5/24/76	83	10/6	160	135	41
5-39451	9/17/76	32	10/9	125	22	-10
5-42232	9/29/76	39	10/10	115	11	-3
5-37961	9/13/76	43	10/14	124	31	1
5-41912	10/11/76	58	10/14	115	3	16
5-45305	10/6/76	39	10/14	123	8	-3
9-44557	11/7/75	34	10/14	172	342	-8
5-45957	10/14/76	43	10/17	109	3	1
5-46116	10/7/76	36	10/21	106	14	-6
9-74757	10/4/76	34	10/21	182	17	-8
9-70326	9/16/76	34	10/24	170	38	-8
5-28890	10/29/76	34	11/4	124	372	-8
9-61845	5/26/76	84	11/9	154	167	42
5-47686	11/10/76	40	11/12	123	2	-2
9-59748	9/9/76	39	11/28	178	80	-3
5-39284	9/16/76	39	12/7	108	82	-3
5-45245	10/5/76	35	12/7	110	63	-7
9-38269	6/5/75	57	12/10	159	554	15
5-43428	10/14/76	38	12/20	112	67	-4
5-46192	10/7/76	36	12/21	162	75	-6
5-44376	10/5/76	35	12/23	114	79	-7
5-31614	5/25/76	57	12/25	135	214	15
9-40180	9/8/75	39	12/25	180	474	-3
9-71488	10/11/76	34	12/25	183	75	-8
9-72985	9/23/76	34	12/26	155	94	-8
9-74800	10/4/76	34	12/26	183	83	-8
9-67793	9/20/76	39	12/29	180	100	-3
5-37910	9/9/76	99	12/31	101	113	57
9-65434	9/13/76	36	12/31	157	109	-6
9-74978	10/8/76	34	12/31	182	84	-8

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Table B-2

Biweekly Catch per Tow for Species Collected by Surface Trawl, All Standard Station Combined, Indian Point Area, 1976

Species	Life Stage**	6/27 7/10	7/11 7/24	7/25 8/7	8/8 8/21	8/22 9/4	9/5 9/18	9/19 10/2	10/3 10/16	10/17 10/30	11/1 11/13	11/14 11/27	11/28 12/11	12/12 12/25
		Biweekly Periods*												
American eel	YOY	0	0	0	0	0	0	0	0	0	0	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0	0	0.29	0
Blueback herring	YOY	0	0.43	28.57	566.43	219.43	749.71	422.57	5297.57	976.43	11.57	0.43	0	0
	yr+	0.14	0.14	0	0.14	0	0	0	0.14	0	0	0	0	0
Alewife	YOY	0.43	0	0.86	0	2.00	0.14	0	0.57	2.86	0.14	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
American shad	YOY	82.57	10.57	8.14	9.43	14.71	6.29	7.29	7.71	7.14	0	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlantic menhaden	YOY	0	0	0	0	0	0.14	0	0	0	0	0	0	0
	yr+	0.14	0	0.29	0	0.29	0	0	0.43	0	0	0	0	0
Gizzard shad	YOY	0	0	0	0	0	0	0	0	0	0	0.14	0	0
	yr+	0	0	0	0	0	0	0	0	0	0.14	0.14	0	0
Unidentified Clupeid	YOY	79.00	0.71	0	0.14	0	0	0	0	0	0	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
Bay anchovy	YOY	0	45.57	197.43	262.57	1303.14	174.14	294.57	2.43	0	0	0	0	0
	yr+	168.43	0.14	130.14	14.00	8.00	4.00	0.86	0	0	0	0	0	0
Rainbow smelt	YOY	0	0	0.49	0	0	0	0	0	0.86	0	0.29	1.43	3.14
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlantic tomcod	YOY	0	0	0	0	0	0	0	0	0	0	0	0	1.14
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
Banded killifish	YOY	0	0	0	0	0	0	0	0	0	0	0	0	0.14
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
White perch	YOY	0	0	0	0	0	0	0	0	0	0.14	1.28	0.28	0.14
	yr+	0	0.14	0	0.14	0	0	0	0	0	0.14	0.14	0	0
Striped bass	YOY	0	0	0	0	0	0	0	0	0	0	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0.14	0	0	0
Bluefish	YOY	0.57	2.29	2.86	0	1.14	0	0.57	0	0	0	0	0	0
	yr+	0	0	0	0	0	0	0	0	0	0	0	0	0
Spot	YOY	0	0	0	0	0	0	0	0	0	0	0	0	0
	yr+	0	0	0	0	0.14	0	0	0	0	0.14	0	0	0

*Beginning date is at top; ending date is on lower line.

**YOY = young-of-the-year
YR+ = yearling and older

Table B-3

Biweekly Catch per Tow for Species Collected by Bottom Trawl with Liner, All Standard Stations Combined, Indian Point Area, 1976

Species	Life Stage**	3/21 4/3	4/4 4/17	4/18 5/1	5/2 5/15	5/16 5/29	5/30 6/12	6/13 6/26	6/27 7/10	7/11 7/24	7/25 8/7	8/8 8/21	8/22 9/4	9/5 9/18	9/19 10/2	10/3 10/16	10/17 10/30	11/1 11/13	11/14 11/27	11/28 12/11
		Biweekly Periods*																		
Shortnose sturgeon	YOY	NS	0	NS***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlantic sturgeon	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0.07	0	0.14	0	0	0	0	0	0.14	0	0	0	0	0	0	0
American eel	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0.33		2.57	0.43	0.29	0.14	3.00	0	1.14	0.14	0	0	0.57	0.14	0.14	0.14	0	0
Blueback herring	YOY		0		0	0	0	0	0	14.14	39.14	259.71	18.00	211.14	43.00	715.14	83.71	6.57	0	0
	YR+		0.17		9.14	6.86	12.14	0.29	0.29	0	0	0	0	0	0	0	0	0	0	0
Alewife	YOY		0		0	0	0	0	0.14	1.43	6.00	2.43	0.29	1.57	0.71	1.86	8.86	2.71	0	0
	YR+		0.17		2.29	2.29	0.14	0	0.43	0	0	0.14	0	0.57	0.29	0.71	0.14	0	0	0
American shad	YOY		0		0	0	0	0	10.86	3.14	3.57	1.29	0.43	1.71	1.43	2.57	5.57	0	0	0
	YR+		0		0.07	0	0.14	0	0.14	0	0	0	0	0.14	0	0	0	0	0	0
Atlantic menhaden	YOY		0		0	0	0	0.29	0.29	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0	0.43	0	0.14	1.14	0	0	0	0.43	0.29	0.29	0.14	0	0	0	0
Gizzard shad	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0.29	0	0
Unidentified Clupeid	YOY		0		0	0	0	0	0.71	32.86	0	0	0	0	0	0	0	0	0	0
	YR+		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bay anchovy	YOY		0		0	0.29	0.86	0	0.14	117.14	24.43	6.00	275.43	102.14	185.14	2.71	0	0	0	0
	YR+		0		0	0.71	0.14	0.43	65.71	18.14	513.71	44.29	5.57	6.57	19.29	0.43	0.14	0	0	0
Rainbow smelt	YOY		0		0	0	5.29	7.71	3.14	4.71	1.71	1.86	2.14	5.29	3.71	6.29	1.14	0	0	1.57
	YR+		0		0.29	0.14	1.29	1.00	0.43	0	0	0.29	0	0	0	1.29	0	0.43	0	0
Spottail shiner	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0.57	0	0.43	0	0	0	0	0	0	0	0	0	0	0	0	0
White catfish	YOY		0		0	0	0	0	0	0	0	0.14	0	0	0	2.14	6.86	0.29	0	0.14
	YR+		0.58		1.43	0	1.14	0.71	0.14	0	0	0.43	0	0	0	0.14	1.00	0.71	0.71	1.14
Atlantic tomcod	YOY		0.08		6.64	0.43	25.14	8.00	3.86	0.71	47.43	2.43	7.57	1.57	25.14	5.29	2.71	5.29	0.29	4.71
	YR+		0.42		0.79	0	0	0.14	0	0	0.43	0	0.14	0	0.57	0.14	0	0.29	0	0.14
White perch	YOY		0		0	0	0	0	0	1.86	0.29	0.29	0.14	0	0	17.43	6.29	14.29	17.14	25.86
	YR+		23.67		2.00	0.43	2.00	2.57	0.36	0	1.14	0.71	2.43	2.43	0.86	11.14	15.14	14.43	18.71	19.29
Striped bass	YOY		0		0	0	0	0	0.86	0	0.14	0	0	0	0	0	0.29	0	0	0
	YR+		0.08		0	0	0.29	0	0	0	0	0	0	0.29	0	0.14	0	0	0	0
Bluefish	YOY		0		0	0	0	0.29	0	0.86	1.71	0	0.43	0	0	0	0	0	0	0
	YR+		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weakfish	YOY		0		0	0	0	0	0	0	0	0	0.43	0	0.14	0	0	0	0	0
	YR+		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spot	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0		0	0	0	0	0	0	0	0	3.57	0.71	0.29	1.29	0	0	0	0
Atlantic croaker	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0.14	0	0	0.14	0
	YR+		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hogchocker	YOY		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	YR+		0.58		2.14	0	0.14	0	0.14	0.29	5.00	1.29	21.29	2.29	24.29	40.71	2.86	0.43	0	0.43

*Beginning date is at top; ending date is on lower line.

**YOY = young-of-the-year
YR+ = yearling and older

***NS = no sample

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APPENDIX C

HATCHERY-REARED STRIPED BASS
RECAPTURE AND FOOD HABITS DATA

Table C-1

Hatchery-Reared Striped Bass Recaptured from July through December 1976

Date	Time	RM	Site	Gear	Fin Clip	Stocking Season	Ref. Tag No.	Length (mm)	Weight (g)	Nose Tag (?)	Stocking Region*
7/2	0946	39	2	Bottom trawl	1st dorsal	9/75	R 7118	158	35.2	No	
7/8	0016	40	2	Epibenthic sled	1st dorsal	9/75	R 7096	156	37.8	No	
7/8	1430	94	1	100' beach seine	1st dorsal	9/12-26/75	R 7099	153	32.3	Yes	IP
7/9	1508	42	3	100' beach seine	1st dorsal	9/75	R 7110	126	18.0	No	
7/9	1508	42	3	100' beach seine	1st dorsal	9/75	R 7109	169	47.8	No	
7/12	1836	42	3	100' beach seine	1st dorsal	9/12-26/75	R 7100	173		Yes	IP
7/14	1115	38	1	200' beach seine	1st dorsal	9/75	R 7097	141	24.8	No	
7/13	1130	41	3	100' beach seine	1st dorsal	9/12-26/75	R 7093	152	25.7	Yes	IP
7/21	1215	55	3	200' beach seine	1st dorsal	9/12-26/75	R 7095	139	21.6	Yes	IP
7/27	1045	39	3	Box trap	2nd dorsal	10/12-11/3/75	R 7101	153	35.1	Yes	TZ
8/9	1340	40	3	200' beach seine	1st dorsal	9/75	R 7319	149	29.5	No	
8/16	1425	46	3	100' beach seine	1st dorsal	9/12-26/75	R 7301	147	33.3	Yes	IP
8/18	1330	41	3	100' beach seine	1st dorsal	9/12-26/75	R 7308	135	20.9	Yes	IP
8/30	1100	39	3	Box trap	1st dorsal	9/75	R 7343	155	39.4	No	
9/20	1730	57	1	200' beach seine	2nd dorsal	9/27-10/12/75	R 7826	197	77.3	Yes	CH
9/29				N.Y.S.D.E.C.	1st dorsal	9/75	R 7503	153	35.9	No	
10/4	1430	60	3	Box trap	2nd dorsal	9/27-10/12/75	R 8599	205	86.3	Yes	CH
10/4	1715	34	3	200' beach seine	1st dorsal	1974	R 8600	241	174	Yes	
10/6	1140	58	1	100' beach seine	1st dorsal	9/12-26-75	R 8822	174	51.5	Yes	IP
10/12	1315	34	3	500' haul seine	1st dorsal	9/75	R 8816	167	51.0		
10/14	0848	42	3	100' beach seine	1st dorsal	9/12-26/75	R 9036	182		Yes	IP
10/18	1945	42	3	200' beach seine	2nd dorsal	10/12-11/3/75	R 8474	190	76.2	Yes	TZ
10/25	1025	42	3	100' beach seine	1st dorsal	9/27-10/12/75	R 9037	233	142	Yes	CH
10/27	1428	37	1	L.M.S.	1st dorsal	9/27-10/12/75	R 9658	205	87.7	Yes	CH
11/9	2050	42	3	200' beach seine	1st dorsal	9/10-11/75	R 9337	198	89.7	Yes	WP

*IP - Indian Point
TZ - Tappan Zee
CH - Croton-Haverstraw
WP - West Point

Table C-4

Food Items of Wild Striped Bass Collected in Beach Seines from RM 34-43 during October and November, 1975

Total Number of Stomachs Examined = 112   Empty Stomachs = 12

Number of Stomaches in which at Least One Countable Food Item was Present = 93

Food Item	# Stomachs Containing Food Item	Count For Food Item	Mean Count	S.E. for Count	Mean Percent Frequency	S.E. for Percent Frequency
Banded killifish	1	1	0.01	0.01	0.54	0.54
Fish remains	9	11	0.12	0.04	8.09	2.79
Chironomid (L)	25	57	0.61	0.15	3.49	0.91
Chironomid (P)	7	13	0.14	0.07	1.14	0.75
Cricotopus (L)	11	19	0.20	0.08	0.71	0.23
Odonata (J)	2	8	0.09	0.08	0.21	0.18
Coenagrionidae (J)	1	1	0.01	0.01	0.05	0.05
Enallagma (J)	2	29	0.31	0.30	0.74	0.72
Trichoptera (J)	1	1	0.01	0.01	0.02	0.02
Coleoptera (L), Terrestrial	1	3	0.03	0.03	0.10	0.10
Polypedilum (L)	4	6	0.06	0.03	0.39	0.20
Dolichopodidae (L)	3	11	0.12	0.07	0.35	0.21
Diptera (L)	2	4	0.04	0.03	0.12	0.10
Diptera (P)	3	5	0.05	0.03	1.64	1.20
Decapoda	6	9	0.10	0.05	1.03	0.59
Gammarus	50	482	5.18	1.02	22.05	2.74
Corophium	45	271	2.91	0.85	14.49	2.47
Chirodotea	1	1	0.01	0.01	0.03	0.03
Edotea	2	2	0.02	0.02	0.39	0.36
Cyathura	34	114	1.23	0.35	7.52	1.56
Cumacea	9	41	0.44	0.18	2.01	0.81
Isopod (Unid.)	7	8	0.09	0.03	2.18	1.20
Amphipoda (Unid.)	63	446	4.80	0.69	23.94	2.41
Exosphaeroma	7	21	0.23	0.12	1.28	0.80
Copepod (Unid.)	2	7	0.08	0.06	0.11	0.08
Calanoida	8	70	0.75	0.59	1.46	0.84
Cladocera (Unid.)	2	24	0.26	0.24	0.47	0.44
Oligochaeta	4	58	0.62	0.37	2.39	1.34
Polychaeta	9	13	0.14	0.05	1.23	0.52
Invertebrate eggs	2	13	0.14	0.10	1.83	1.31

Number of Occurrences of Uncountable Food Items

Food Item	Number
Fish remains	18
Filamentous algae	8
Animal remains	42
Plant remains	32
Detritus	53

(Unid.) = Unidentified
(L) = Larvae
(P) = Pupae
(J) = Juvenile

Table C-5

Food Items of Hatchery-Reared Striped Bass Collected in Beach Seines from RM 34-43 during October and November, 1975

Total Number of Stomachs Examined = 184   Empty Stomachs = 65

Number of Stomachs in which at Least One Countable Food Item was present = 95

Food Item	# Stomachs Containing Food Item	Count for Food Item	Mean Count	S.E. for Count	Mean Percent Frequency	S.E. for Percent Frequency
Bay Anchovy	4	4	0.04	0.02	4.21	2.07
Banded killifish	1	1	0.01	0.01	1.05	1.05
Blueback herring	7	7	0.07	0.03	6.84	2.55
White perch	1	1	0.01	0.01	1.05	1.05
Clupeid (Unid.)	7	8	0.08	0.03	7.37	2.69
Fish remains	9	9	0.09	0.03	8.95	2.90
Chaoborus (L)	1	1	0.01	0.01	1.05	1.05
Chironomid (L)	4	4	0.04	0.02	0.24	0.13
Chironomid (P)	1	1	0.01	0.01	0.05	0.05
Cricotopus (L)	1	1	0.01	0.01	0.26	0.26
Enallagma (J)	1	2	0.02	0.02	0.04	0.04
Polypedilum (L)	2	2	0.02	0.02	1.10	1.05
Procladius (P)	3	10	0.11	0.09	1.16	1.05
Dolichopodidae (L)	1	2	0.02	0.02	0.18	0.18
Palaemonetes pugio	3	3	0.03	0.02	1.93	1.22
Decapoda	1	1	0.01	0.01	0.53	0.53
Gammarus	29	444	4.67	1.86	14.47	2.86
Corophium	24	154	1.62	0.76	12.87	2.79
Chirodotea	1	9	0.09	0.09	0.14	0.14
Edotea	1	18	0.19	0.19	0.86	0.86
Cyathura	18	52	0.55	0.22	9.04	2.60
Cumacea	4	17	0.18	0.11	1.87	1.18
Isopod (Unid.)	1	1	0.01	0.01	0.15	0.15
Amphipoda (Unid.)	40	429	4.52	1.18	21.66	3.12
Exosphaeroma	1	9	0.09	0.09	0.23	0.23
Eurytemora	1	4737	49.86	49.86	1.05	1.05
Copepod (Unid.)	1	129	1.36	1.36	0.10	0.10
Cyclopoida	2	75	0.79	0.78	0.06	0.06
Calanoida	3	1127	11.86	11.84	1.07	0.89
Leptodora	1	2	0.02	0.02	0.35	0.35
Cladocera (Unid.)	2	3	0.03	0.02	0.00	0.00
Nematoda	1	1	0.01	0.01	0.00	0.00
Oligochaeta	1	1	0.01	0.01	0.09	0.09

Number of Occurrences of Uncountable Food Items

Food Item	Number
Fish remains	14
Filamentous algae	6
Animal remains	26
Plant remains	29
Detritus	40

(Unid.) = Unidentified
(L) = Larvae
(P) = Pupae
(J) = Juvenile