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183

FEASIBILITY OF CULTURING AND STOCKING HUDSON RIVER STRIPED BASS

1974 ANNUAL REPORT

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Prepared for

CONSOLIDATED EDISON COMPANY
OF NEW YORK, INC.

4 Irving Place

New York, New York 10003

NOVEMBER 1975

by

TEXAS INSTRUMENTS INCORPORATED
ECOLOGICAL SERVICES

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FOREWORD

In 1970, the Federal Power Commission (FPC) issued a license to Consolidated Edison Company of New York, Inc. (Con Edison) for construction and operation of a pumped-storage hydroelectric power plant on the Hudson River at Cornwall, New York, river mile (RM) 56. Article 36 of the *Terms and Conditions* of the FPC license for the Cornwall plant required a study of the artificial propagation of striped bass, including implementation of a pilot hatchery. Con Edison contracted Texas Instruments Incorporated (TI) in April 1973 to conduct this study.

This report describes the results of the 1974 hatchery program, which encompasses the second year of this study. The report also includes results of work performed by Auburn University with artificially spawned Hudson River larvae (supplied by TI) and work contracted by Con Edison to UMA Engineering, Portland, Oregon and subcontracted to Southern Illinois University.

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SECTION I

INTRODUCTION

A. CHRONOLOGY

The striped bass *Morone saxatilis* (Walbaum) which spends most of its life at sea, but migrates into freshwater portions of rivers and estuaries to spawn, supports economically important commercial and sports fisheries along the East Coast of the United States. Since the Hudson River estuary is a spawning area for striped bass, the effects of power-plant operation along the Hudson River upon this species is a major interest in power-plant licensing and regulation.

In recent years, artificial propagation has been proposed as a mitigative measure to offset losses in the Hudson River striped bass population due to power-plant operation. The feasibility of this measure depends on (1) the development of culturing techniques which will insure efficient production of stockable striped bass fingerlings and (2) assessment of the survival of the stocked fish and their potential contribution to the striped bass spawning stock.

In 1970, the Federal Power Commission (FPC) issued a license to Consolidated Edison Company of New York, Inc. (Con Edison) for construction and operation of a pumped-storage hydroelectric plant on the Hudson River at Cornwall, New York. Under Article 36 of the *Terms and Conditions* of this license, the FPC stipulated a study of the artificial propagation of striped bass, including implementation of a pilot hatchery. A study plan which included a program to assess the feasibility of culturing Hudson River striped bass was prepared by Con Edison and contracted to Texas Instruments Incorporated (TI) in April 1973. Primary emphasis of this program involved establishing the need for and feasibility of mitigation and evaluating the state-of-the-art of artificial propagation of striped bass.

In 1973, the first year of TI's striped bass hatchery program, an estimated 26,700,000 eggs were artificially spawned from 16 female Hudson River striped bass brood fish at the Verplanck, New York, hatchery; 40% of these eggs hatched, producing approximately 10,600,000 larvae. In fall 1973, a total of 28,674 striped bass fingerlings reared by Marine Protein, Inc. in Florida and the Durant State Fish Hatchery in Oklahoma were marked with magnetic nose tags and fin clips and stocked in the Hudson River between river miles (RM) 26 and 62. As of 1 January 1974, 46 hatchery fingerlings had been recaptured. Preliminary analysis of mark/recapture data indicated that survival of hatchery-reared fingerlings was approximately the same or greater than that of wild fingerlings.

Specific results of the 1973 striped bass propagation and stocking program, in addition to a literature summary and review of striped bass culture state-of-the-art, are presented in the 1973 hatchery report prepared for Con Edison (Texas Instruments Incorporated, 1974).

B. STUDY PLAN

The primary objective of the 1974 hatchery program was to artificially propagate and stock Hudson River striped bass fingerlings and monitor their survival in the river. This objective was accomplished in four coordinated phases which are defined and addressed in specific sections of this report as follows:

- Production of Larvae (Section III)

  Collection and induced spawning of Hudson River brood fish and subsequent hatching and shipping of larvae to selected rearing and experimental facilities

- Production of Fingerlings (Section IV)

  Rearing of larvae to fingerling size (2 to 5 inches) at designated hatchery facilities

- Stocking and Distribution of Fingerlings (Section V)

  Marking, packing, and shipping of approximately 90,000 fingerlings from the selected rearing facilities to the Verplanck, New York, hatchery and the stocking of these fingerlings in the Hudson River

- Survivorship Studies and Analysis (Section VI)

  Estimation of initial survival of marked hatchery-reared fingerlings and evaluation of longer-term survival through comparison of hatchery-reared and wild striped bass fingerling mark/recapture data

A subsidiary objective of the 1974 hatchery program was to review and evaluate striped bass intensive culture and artificial propagation techniques used at various rearing or experimental agencies or discussed in the literature. This objective is addressed in specific report sections as follows:

- Intensive Culture (Section VII)

  Review of striped bass intensive culture techniques and results as conducted during 1974 by Auburn University and Southern Illinois University, and by Texas Instruments Incorporated in relation to production of larvae and fingerlings for distribution to specified research agencies for experimental purposes

- Literature Survey of Culture and Tagging Techniques (Section VIII)

  An updated review of literature pertaining to striped bass culture, fish tagging and marking techniques prepared as a supplement to the literature summary, and striped bass culture state-of-the-art presented in the 1973 hatchery report (Texas Instruments Incorporated, 1974)

C. PROGRAM SCHEDULE AND STATUS

Objectives for the 1974 hatchery program were completed between April 1974 and April 1975. During that period, phases of the program were completed as follows:

- Brood-stock collection and larvae production, June 1974
- Fingerling production, October 1974
- Stocking, November 1974
- Survival assessment of hatchery-reared striped bass fingerlings stocked in 1974 (based on recapture data through December 1974), April 1975

D. PROGRAM SUPPORT AND DIRECTION

Advisory support for the 1974 program was provided by the Hudson River Fish Co-operative and the Striped Bass Steering Committee.

Members of the Hudson River Fish Co-operative were as follows:

Mr. Russell Cookingham, Director
Division of Fish, Game & Shellfishes
Labor & Industry Building
P.O. Box 1809
Trenton, NJ 08625
(609) 272-2965

Mr. Herbert Doig, Director (chairman)
Division of Fish and Wildlife
New York State Department of Environmental Conservation
50 Wolf Road
Albany, NY 12201
(518) 457-5690

Mr. Richard E. Griffith, Regional Director
Bureau of Sport Fisheries and Wildlife
U.S. Post Office and Courthouse Building
Boston, MA 02109
(617) 223-2961

Mr. Albert C. Jensen, Regional Supervisor
Division of Marine and Coastal Resources
New York State Department of Environmental Conservation
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SUNY at Stony Brook
Stony Brook, NY 11790
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Mr. Russell T. Norris, Regional Director
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The Striped Bass Steering Committee membership included:

Mr. Jack Bayless
South Carolina Wildlife and Marine Resources Department
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(803) 825-3387

Mr. Jack L. Harper
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Caddo, OK 74729

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Mr. Charles Maloy, Regional Supervisor
U.S. Fish and Wildlife Service
Department of the Interior
17 Executive Park Drive
Atlanta, GA 30329

Dr. Robert Stevens
Chief of Coastal Fisheries
Texas Parks and Wildlife Department
John H. Reagan Building
Austin, Texas 78701

SECTION II

SUMMARY AND CONCLUSIONS

This section summarizes the accomplishments of the second year (1974) of the study to evaluate the feasibility of artificially propagating and stocking striped bass in the Hudson River as a possible mitigative measure to offset losses due to power-plant operation. Results are summarized according to the specific study phases to which they apply.

A. PRODUCTION OF LARVAE

During the 1974 hatchery program, 36 female and 35 male Hudson River striped bass were captured by gill net for use as brood stock for artificial propagation. Twenty-four females were successfully ovulated, producing 31,328,000 eggs (400,000 to 2,430,000 eggs/female). The eggs of 21 females hatched to produce 16,027,000 larvae, resulting in a 51% hatch compared with 40% in 1973.

B. PRODUCTION OF FINGERLINGS

Based on an agreement between Consolidated Edison, the U.S. Fish and Wildlife Service, and the New York Department of Environmental Conservation, 1,400,000 Hudson River striped bass larvae produced at the Verplanck, New York, hatchery by Texas Instruments Incorporated were shipped to the Edenton National Fish Hatchery in North Carolina to rear 90,000 fingerlings (2 to 5 inches) for stocking in the Hudson River. As part of this agreement, 3,100,000 Hudson River larvae were also shipped to the Welaka National Fish Hatchery in Florida; 518,500 fingerlings produced at Welaka were subsequently stocked in the Chocatawhatchee River. Also, 3,940,000 striped bass larvae were sent to the Durant State Fish Hatchery in Oklahoma to be reared to 4-inch fingerlings for the Hudson River stocking

program in case the Edenton hatchery was unable to produce the required 90,000 fingerlings. Additional Hudson River striped bass larvae were distributed to the following agencies for experimental uses: 3,240,000 to Southern Illinois University; 576,000 to New York University; 500,000 to Auburn University in Alabama; 200,000 to Lawler, Matusky, and Skelly Engineers, Inc.; and 100,000 to the University of Rhode Island. Texas Instruments Incorporated retained 330,000.

The 1,400,000 larvae supplied to the Edenton National Fish Hatchery (the primary facility designated to produce fingerlings for the Hudson River stocking program) were received at Edenton in two shipments — one on 28 May and the other on 6 June. Mortality rates for the two shipments (after acclimation to holding water) were 20-25% and 50% respectively. Surviving larvae were placed in earthern rearing ponds 9-15 days after they were received.

After remaining in the rearing ponds for an average of 49 days, 298,692 fingerlings (30.2%) with a mean length of 1.78 inches (45 mm) were harvested; of these, 5641 died in the holding facilities prior to distribution, 32,000 were shipped to New York for stocking in the Hudson River, 110,799 were stocked in the Tar River in North Carolina, 50 were given to Georgetown University in Washington, D.C., for experimental studies, and 150,202 were restocked in ponds at the Edenton hatchery for further growth.

The restocked fingerlings were held in the rearing ponds for an average of 66 additional days, after which 119,936 fingerlings (80%) were harvested and distributed as follows: 74,288 were shipped to New York for the Hudson River stocking program; 43,500 were stocked in the Tar River in North Carolina; 250 were given to Oak Ridge National Laboratory in Tennessee; and 123 were provided to Georgetown University. Prior to distribution, 1775 died in the holding facilities.

The Durant State Fish Hatchery in Oklahoma, which was to supply fingerlings for the Hudson River stocking program if the Edenton hatchery was unable to produce the necessary quota (90,000), received approximately 3,840,000 striped bass larvae in four shipments. Shipping mortality ranged from 0 to 40%. After being reared for approximately 50 days in earthen ponds, 468,737 fingerlings [2 to 3 inches (51 to 76 mm)] were harvested; of these, 339,228 were stocked in Lake Texoma and the remaining 129,509 were restocked in ponds for further growth. After an average of 119 additional days in these ponds, 4700 fingerlings [3 to 5 inches (76 to 127 mm)] were harvested.

C. STOCKING AND DISTRIBUTION OF FINGERLINGS

All striped bass used in the Hudson River stocking program were reared from larvae to fingerling size at the Edenton hatchery in North Carolina. Of the 106,288 fingerlings shipped from Edenton to the Verplanck hatchery in New York, 103,379 (97%) survived transport and approximately 101,524 (96%) were stocked in the Hudson River from RM 25 to RM 60. All fingerlings were stocked at night in bay or shoal areas where water depth was ≤10 ft. Shipping and stocking were conducted during three periods:

- In August, 32,000 fingerlings were marked with second-dorsal fin clips, and then flown to New York in two shipments. A total of 28,611 (89%) were stocked in the Hudson River

- In September and October, 58,511 fingerlings were marked with first-dorsal fin clips and micromagnetic nose tags, then flown to New York. A total of 57,474 (98%) were stocked

- On 23 October, the U.S. Fish and Wildlife Service transported an additional 15,777 fingerlings from the Edenton hatchery to the Verplanck hatchery in a recirculating fish-hauling truck. In New York, these fish were

marked with both left- and right-pelvic fin clips and different color-coded micro-magnetic nose tags; 15,439 (98%) were stocked on 30 October.

D. SURVIVORSHIP STUDIES AND ANALYSIS

In 14-day survivorship tests conducted on samples of marked and unmarked hatchery-reared striped bass fingerlings held in 2500-gal. circular pools supplied with Hudson River water, both test groups had consistently low mortalities (0 to 7%), suggesting that handling and marking had little effect on the initial survival of the stocked fingerlings. Because mortalities were similar between fin-clipped and control fish within each replicate test, variations in mortality rates observed between tests were apparently due to differences in handling rather than in marking.

Based on analysis of recapture data through December 1974, hatchery-reared striped bass fingerlings stocked in the Hudson River in 1974 apparently survived at least as well as marked, wild, young-of-the-year striped bass. Unlike results of the 1973 stocking in which wild striped bass fingerlings appeared to be more vulnerable to recapture than did hatchery fingerlings, hatchery-reared fingerlings stocked in 1974 were equal to wild fish in vulnerability to recapture. In 1974, as in 1973, hatchery-reared striped bass stocked after August were larger than their wild counterparts.

Three hatchery-reared striped bass stocked in fall 1973 were recaptured in 1974; their probability of capture was lower than that of wild fish, as observed also in fall 1973.

E. INTENSIVE CULTURE

Intensive culture techniques and experiments conducted by Auburn University and Southern Illinois University using Hudson River striped bass larvae were reviewed as a subsidiary objective of the 1974 hatchery

program. Observations were also made pertaining to striped bass intensive culture performed by Texas Instruments Incorporated (TI) in conjunction with the rearing of larvae and fingerlings for TI's striped bass relative contribution study and for distribution to specified research agencies.

Experimental programs conducted by Auburn University and Southern Illinois University, although hampered by shipping mortality and equipment failure, confirmed the existence of known problems such as cannibalism and the necessity of feeding a live food (i.e., brine shrimp nauplii) to striped bass larvae during their first few weeks to insure good survival and growth.

Striped bass intensive culture conducted by TI yielded a 6% production return after 118 days. The following results with respect to growth requirements and critical factors for survival were identified:

- Circular Current

  Natural schooling behavior is exhibited by post yolk-sac larvae through fingerling-size striped bass when provided with a steady current to swim against. More even distribution of food is possible to a moving school of fish than to dispersed individuals. The promotion of schooling behavior also may reduce the potential for cannibalism

- Feeding Regime

  Excessive and frequent feeding of live brine shrimp nauplii ($\approx$ 500 nauplii/larva/day) apparently satisfies the requirements of yolk-sac larvae and post yolk-sac larvae up to 20 mm. Transition from reliance on live brine shrimp nauplii to dry food or prepared mixtures is successfully accomplished by concurrently feeding both types of food to post yolk-sac larvae for not less than 2 weeks. Floating dry-flake food is more acceptable by larvae than is commercial trout feed (size No. 1)

- Water Quality

  High levels of un-ionized ammonia resulting from high pH (> 8.5), high density, and/or intensive feeding are possible causes of mortality.

- Cannibalism

  Low survival has frequently been associated with early harvests of fingerlings varying greatly in length (indicative of cannibalism). Significant reduction in cannibalism is accomplished by excessively and frequently feeding live brine shrimp nauplii to post yolk-sac larvae up to 20 mm in mean length and by grading into size classes fingerlings > 40 mm in length

SECTION III

PRODUCTION OF LARVAE

The first phase of the 1974 striped bass hatchery program involved Hudson River brood-fish collection, induced spawning, hatching, and shipping of larvae to selected rearing and experimental agencies. Propagation data are presented in Appendix A.

A. BROOD-FISH COLLECTION AND TRANSPORT

Between 16 and 31 May, 36 female and 35 male striped bass were captured from the Hudson River and transported to the Verplanck hatchery for induced spawning. Of the 36 females, four were purchased from commercial fishermen and 32 were caught by TI field crews licensed with a New York State Scientific Collector's Permit; of the 35 males, approximately one-half were purchased from a commercial fisherman operating in Haverstraw Bay (RM 37-39). Capture of all brood stock was by gill nets (3- to 4-inch bar mesh) staked or anchored in water 10 to 15 ft deep (Figure III-1).

Approximately 25 additional adults were caught but were subsequently rejected because they were spent, in poor condition, or had ovaries in a developmental stage of more than 50 hr to ovulation. The fish were sacrificed and utilized with other striped bass for the relative contribution study.*

Many of the striped bass rejected for spawning purposes were those obtained from commercial fishermen. Fish caught by TI field crews were generally in better condition because: (1) the nets were checked more

*Being conducted by TI for Consolidated Edison to determine the relative contribution of Hudson River striped bass to the Atlantic fishery.

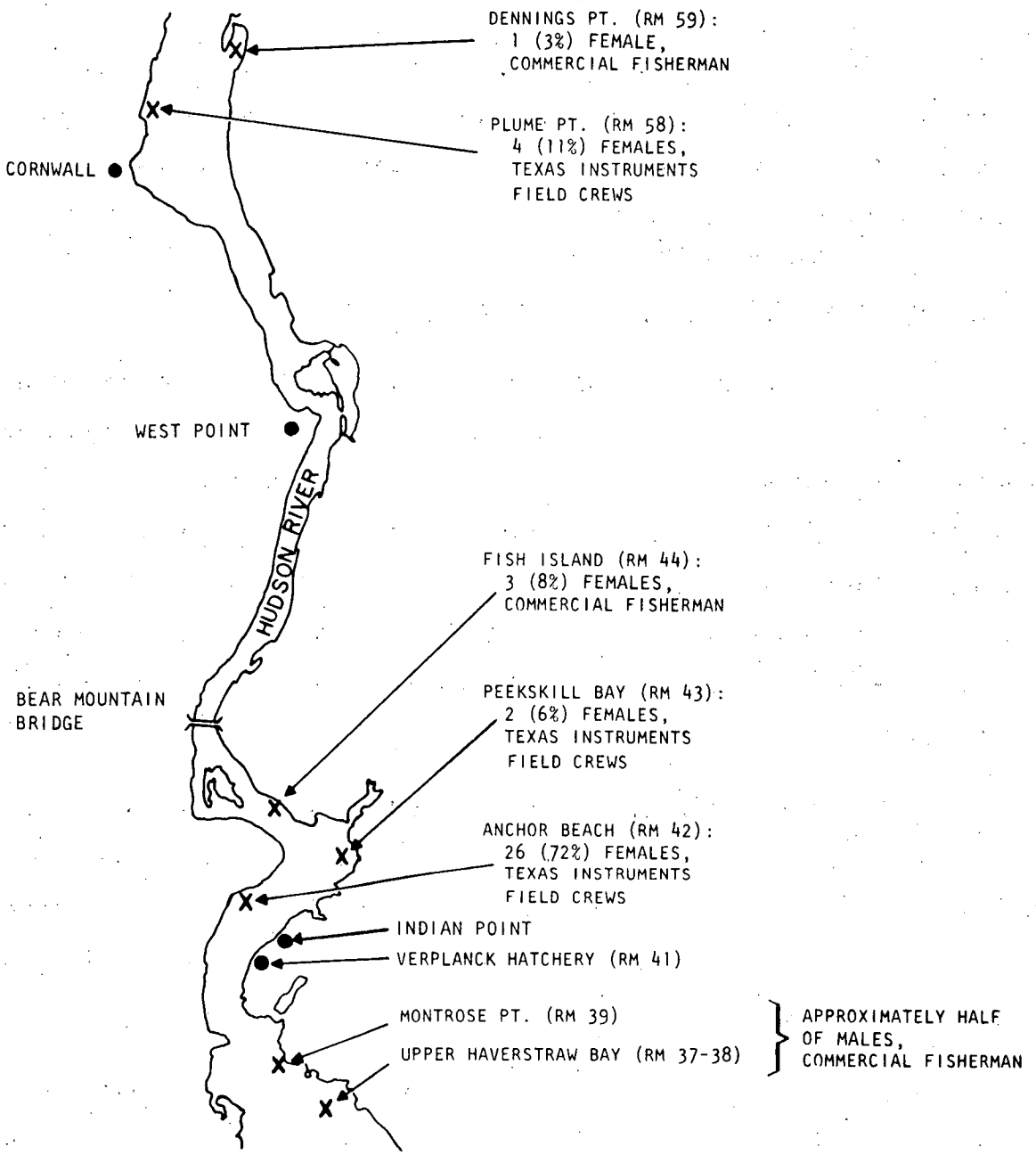

Figure III-1. Locations and Corresponding Yield of 1974 Gill-Netting for Hudson River Striped Bass Brood-Stock Collection

frequently (at least every 0.5 hr); (2) removal from nets and subsequent handling of gilled or tangled fish were done in a manner which minimized injuries and stress; and (3) the most productive nets fished by TI field crews were closer to the Verplanck hatchery (RM 41), thus shortening transport time.

The most productive period for capturing brood stock appeared to be during slack tide when reduced currents allowed the nets to hang vertically and close to the bottom. Day and night captures were nearly equal.

Once removed from the nets, brood fish captured from Haverstraw Bay and the Indian Point area (RM 37-38 and RM 42-44) were transported directly to the Verplanck hatchery in boats equipped with holding tanks. Brood fish captured near Cornwall, New York (RM 58-59), were temporarily held on shore in a 15-ft-diameter, 5000-gal. swimming pool supplied with pumped river water (10 gpm). Potential brood fish were later removed from the pool and transported to the Verplanck hatchery by a truck equipped with a 140-gal. rectangular canvas container (a maximum of five fish per trip) to which a 1% salt solution had been added as a prophylaxis for fungus infections. All females transported from Cornwall appeared to be in fair-to-good condition when received at Verplanck, but several of the males were in poor condition.

B. SPAWNING

After their arrival at the Verplanck hatchery, the brood fish were segregated by sex and placed in 12- and 15-ft-dia pools supplied with water (59° to 64°F) pumped from an adjacent rock quarry. Males were distinguished by the explusion of milt from the vent after palpation of the abdomen. To determine each female's ovarian maturation, a 3-mm-OD polished glass catheter was inserted through the oviduct and a sample of eggs withdrawn from an ovary and examined under 20X magnification.

Using techniques described by Bayless (1972), the number of 66°F-hr (hours at 66°F water temperature) required for ovulation was estimated for each female. Death before ovulation, as well as poor fertilization and hatch of eggs, were associated with females held over 50 hr (15+ 66°F-hr) during the 1973 hatchery program (Texas Instruments Incorporated, 1974); therefore, during the 1974 hatchery program, females requiring 15+ 66°F-hr to ovulate were rejected for induced spawning unless the number of females being held at a particular time was low (three fish or less).

Roe fish eligible for induced ovulation were injected intramuscularly with human-grade chorionic gonadotropin at a rate of 125 to 150 International Units (IUs) per pound of body weight (weights were approximated to reduce stress from handling). Individual females were identifiable by color-coded plastic streamers attached to the first ray of the first dorsal fin.

Ovarian maturation was monitored from subsequent egg examinations (usually limited to two, since capture of the roe fish by dip net and catherization caused additional stress). Revision of the predicted ovulation time was made by noting the relative polarization of the oil globule and translucence of the ova. As the predicted ovulation time neared, manual palpation of the abdomen was performed at intervals until free flowing eggs indicated complete ovulation. Figure III-2 compares actual ovulation times at 59°-64°F with predicted times for fish held at 66°F.

Of the 36 females brought to the Verplanck hatchery, 24 (67%) were induced to ovulate either partially or completely (20% to 100%). The number of eggs stripped from individual females ranged from 400,000 to 2,430,000 and totaled 31,328,000; of these, 30,476,000 were estimated to be viable (Table III-1).

Two factors contributed to partial ovulation (eggs left attached to the ovarian tissue) which occurred in 10 cases: Males were in

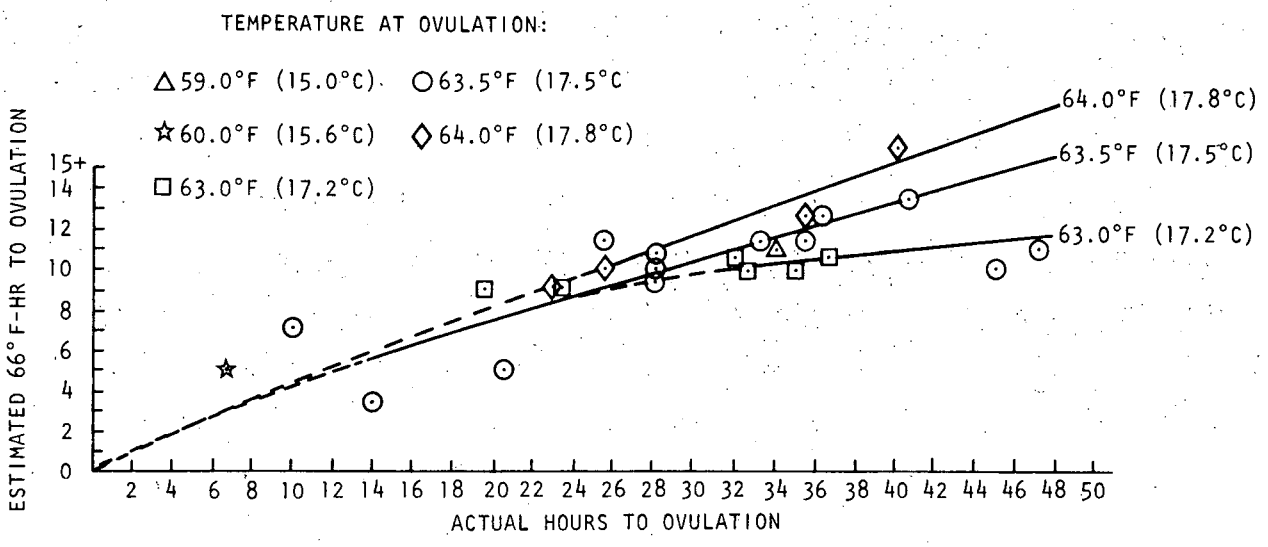

Figure III-2. Estimated 66°F-hr to Ovulation vs Actual Hours to Ovulation at 59-64°F

Table III-1

Results of Induced Ovulation of 24 Female Hudson River Striped Bass at Verplanck, New York, Hatchery, 1974

Component	Total No.	% of Total	Eggs per Female Avg. No.	Range (%)	Range (No.)
Striped eggs					
Overripe (est.)	852,000	3	33,500	0-20	–
Viable (est.)	30,476,000	90	1,269,833	0-80	–
Subtotal (measured 200,000/300 mℓ)	31,328,000	92	1,303,333	20-100	400,000-2,430,000
Unripe eggs attached to ovarian tissue (est.)	2,621,000	8	109,208	0-80	–
Total eggs (est.)	33,949,000	100	1,412,541	–	–

short supply and in poor condition early in the spawning period; consequently, a few roe fish were stripped prematurely to take advantage of available males. In addition, several roe fish succumbed to stress after experiencing excessive transport and/or holding time; in such cases, ovarian development practically ceased, causing death before ovulation or necessitating the stripping of a dying roe fish which had center-ovulated only (i.e., eggs detached only from the central ovarian tissue). After ovulating, each roe fish was carefully removed from the pool and killed by a blow on the head. Simultaneously, one to three males were netted and brought to the spawning table. As many eggs as possible were first stripped into one or more dry pans, after which the ovaries were dissected from the roe fish and further stripped to maximize egg procurement.

Fertilization was effected by one of two techniques: (1) the dry method in which milt is stripped onto eggs and the mixture agitated with a stream of water, and (2) the simultaneous method in which the stripping of milt and agitation with water are concurrent. In the few cases in which the simultaneous method was used, increased fertilization percentages as noted by Bayless (1972) did not result. When possible, at least two males per female were used to insure a higher probability of fertilization. After being stripped, the males were returned to the holding pool for possible further use; 35 males were stripped a total of 46 times.

Fertilization using stored sperm was attempted on the first roe of the season because no viable males were available. Milt was collected with syringes from the incised testes of a dying male and stored at 4°C for 3 hr. Fertilization was estimated to be 60%, but the resulting hatch was only 4% (60,000 larvae).

Percent fertilization was estimated by sampling eggs from the hatching jars 12 hr after ovulation. Fertilization, as indicated by normal cleavage observed under 20X magnification, ranged from 0 to 98% (63% average). Of the 24 females that ovulated, 21 produced larvae (Table III-2).

Table III-2

Summary of Induced Ovulation Attempts on 36 Females at Verplanck, New York, 1974

<table>
<tr><td colspan="7">36 females brought to Verplanck</td></tr>
<tr><td colspan="5">34 (94%) injected</td><td>1 (3%) not injected, died</td><td>1 (3%) returned to river</td></tr>
<tr><td colspan="3">24 (67%) successfully ovulated</td><td>2 (6%) spawned in pool</td><td>3 (8%) stolen or missing</td><td>5 (14%) died before ovulation</td><td></td></tr>
<tr><td>21 (58%) produced larvae</td><td>2 (6%) no fertilization</td><td>1 (3%) no hatch</td><td colspan="4"></td></tr>
</table>

C. HATCHING

Once fertilized, eggs remained in the pan with the milt/water mixture for 1 to 2 min. The milt-water mixture was then decanted and the eggs volumetrically measured and poured through a large long-stemmed funnel into modified MacDonald hatching jars (approximately 200,000/jar). Using a 300-mℓ beaker holding approximately 200,000 eggs, the number of eggs was estimated based on 100,000/149 mℓ (Bayless, 1972).

Initial water flow through the hatching jars was sufficient to agitate all eggs but had to be reduced periodically due to the gradual increase in buoyancy of the eggs while they were water-hardening. On several occasions, part or all of the eggs in a jar were flushed out as a result of problems with flow adjustment or fluctuating pressure in the water line, significantly reducing

the percent hatched. Water from the adjacent rock quarry (pH of 8.75 and temperatures ranging from 59° to 64°F) was used for hatching. Hatching time varied from 46 to 55 hr, with longest times occurring at lowest temperatures.

Hatching percent was computed volumetrically. Shortly after the eggs had water-hardened, the water flow to each hatching jar was temporarily shut off, the eggs allowed to settle, and the volume of the resulting level of eggs measured. This procedure was repeated 36 hr later after infertile and dead eggs had flowed out of the jars because of their high buoyancy. Since practically all remaining eggs were viable and would soon hatch, hatching percent was computed by comparing the two measured volumes. Percent hatch per female varied from 0 to 98%, averaging 55%. Of all eggs stripped, 51% hatched, producing 16,027,000 larvae. Production per female ranged from 60,000 to 1,600,000 larvae.

Hatching jars continually overflowed into 20-gal. aquaria, the drains of which were plugged shortly before hatching and after most of the dead eggs had flowed out. Larvae, upon hatching, swam upward and were carried with the flow into the aquaria. Four or five hatching jars supplied each aquarium, resulting in initial densities of up to 50,000 larvae/gal. of water. Each holding aquarium was supplied with a water flow of 1 to 2 gpm and was equipped with a standpipe drain surrounded by a perforated brass cylinder (1100 holes/inch^2). An air-bubble collar placed around the base of each cylinder prevented impingement.

Larvae were closely observed until their removal from the aquaria for shipping. Dead larvae were removed frequently and their estimated number recorded. If larvae were held for more than 4 days, feeding

of live brine shrimp nauplii* (*Artemia* sp.) was commenced; some larvae were observed feeding on shrimp when they were 5 days old, and nearly all of 7-day-old larvae were observed to be actively feeding.

D. SHIPPING OF LARVAE

Larvae were shipped to the various rearing and experimental agencies at ages ranging from 27 to 138 hr. They were packed in double 4-mil plastic bags filled with 2 gal. of quarry water (63°-64°F) and placed in styrofoam boxes; each box contained approximately 100,000 larvae. The bags were then inflated with industrial-grade oxygen and sealed with castrating bands. The styrofoam boxes were inserted in cardboard cartons (two boxes per carton) and transported to a New York City airport for shipment on scheduled flights.

Shipping mortality, which was estimated by the receiving agency upon arrival, averaged 26% (range <2-60%). In most cases, mortality was directly proportional to the water-temperature increase observed upon completion of transit (up to 12°F) and was apparently unrelated to the age of the larvae at packing. Techniques to acclimate the larvae to the water of the receiving agencies varied considerably; after 24 hr of holding, the total mortality (shipping plus holding) ranged from 2% to 90% and averaged 39%.

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*Nauplii are newly hatched crustacean larvae.

SECTION IV

PRODUCTION OF FINGERLINGS

In the second phase of the 1974 hatchery program, Hudson River striped bass larvae were reared to fingerling size at selected facilities. To accomplish this, an agreement was reached by Consolidated Edison, the U.S. Fish and Wildlife Service, and the New York Department of Environmental Conservation to produce 90,000 fingerlings from Hudson River striped bass larvae. These fingerlings were to be reared at the Edenton National Fish Hatchery in North Carolina from 1,400,000 larvae of Hudson River stock.*

The rearing was accomplished in two phases: Phase-I production, which consisted of rearing larvae to 2-inch (51-mm) fingerlings for the summer stocking program; Phase-II production, which consisted of restocking some of the 2-inch fingerlings in the rearing ponds to be grown to advanced size (3 to 5 inches or 76 to 107 mm) for the fall stocking program. Only fingerlings reared at the Edenton hatchery were stocked in the Hudson River.

Under a similar agreement, the Durant (Oklahoma) hatchery reared 4-inch fingerlings from Hudson River stock for use in the Hudson River stocking program if the Edenton hatchery was unable to produce the 90,000 fingerlings needed. To accomplish this, 3,940,000 larvae were sent to the Durant hatchery.

In addition, 4,946,000 larvae were utilized for experimental work by the following agencies:

Southern Illinois University	3,240,000
University of Rhode Island	100,000
Auburn University	500,000

*Two shipments containing a total of 3,100,000 Hudson River larvae were also shipped to the Welaka National Fish Hatchery as part of the agreement. A total of 518,500 fingerlings (1000/lb) produced at Welaka were stocked in the Chocatawhatchee River during July (Barkaloo, 1975).

New York University	576,000
Lawler, Matusky, and Skelly Engineers, Inc.	200,000
Texas Instruments Incorporated	330,000

A. EDENTON NATIONAL FISH HATCHERY, NORTH CAROLINA

Two shipments containing a total of 1,400,000 Hudson River striped bass larvae were received at the Edenton hatchery on 28 May and 6 June (Table IV-1). After arrival, the larvae were gradually adjusted to the holding-house well water and then released into 20-gal. rectangular tubs (interior painted black) supplied with circulating well water. Mortalities after tempering were estimated at 20 to 25% for the May shipment and 50% for the June shipment. The larvae were fed brine shrimp nauplii at 2- to 3-hr intervals during daylight hours until being stocked in the rearing ponds (Gruenthal and Baker, 1974). The rearing ponds were not filled until the fry were received to insure the presence of proper-sized zooplankton. Water strained through monofilament Saran filter bags (44 strand/inch mesh) was added to the ponds to achieve a depth sufficient to cover the bottom. To produce zooplankton blooms, dried peanut hay was initially applied to the ponds at a rate of 400 to 500 lb/acre.

Table IV-1

Shipping Data for Hudson River Striped Bass Larvae Utilized for Fingerling Production in 1974*

Recipient	Total Larvae Shipped	Roe No.	Hatching Date	Shipping Date	Age (hr)	Larvae Shipped (No.)	Shipping Mortality (%)	Shipping Water Temp (°C) (departure)	(arrival)
Edenton, NC	1,400,000	5	5-23	5-28	107	500,000	5	17.8	19.4
		6	5-24	5-28	103	600,000	5	17.8	19.4
		33	6-2	6-6	103	300,000	*	17.8	*
Welaka, FL	3,100,000	2	5-20	5-25	111	60,000	15-20	17.5	22.8
		3	5-24	5-25	27	1,600,000	15-20	17.5	22.8
		5	5-23	5-27	83	900,000	30-35	17.5	22.8
		7	5-24	5-27	80	540,000	30-35	17.5	22.8
Durant, OK	3,940,000	10	5-25	5-28	67	500,000	40	17.8	*
		15	5-25	5-30	107	700,000	*	17.8	*
		22	5-27	5-30	60	300,000	<2	17.8	*
		24	5-28	5-31	69	640,000	40	17.5	*
		26	5-30	5-31	27	300,000	<2	17.5	*
		26	5-30	6-4	100	400,000	*	17.8	*
		27	5-29	6-4	112	600,000	*	17.8	*
		30	6-1	6-4	44	400,000	*	17.8	*
		34	6-2	6-4	35	100,000	*	17.8	*

* No Data

Nine to fifteen days after the larvae were received, they were acclimated to the water of the 13 rearing ponds and stocked at rates of 80,000 - 129,000 per acre (Table IV-2). The ponds were then completely filled over a 2-week period to prevent early oxygen depletion, prolong the duration of the zooplankton bloom, and provide a current to disperse the larvae when stocked. Approximately 100 lb of peanut hay was added weekly to maintain the zooplankton bloom. Supplemental food was added when the quantity of the zooplankton population was insufficient to fulfill food requirements.

All rearing ponds were harvested between 15 July and 16 August after the fingerlings had been held in the ponds for an average of 49 days; 298,692 fingerlings (686 lb) with a mean length of 1.78 inches (45 mm) were harvested, yielding an average survival rate of 30.2% (Table IV-3). While the fingerlings were in holding facilities prior to distribution, 5641 died. Disposition of the Phase-I fingerlings was as follows: 32,000 were shipped to New York for stocking in the Hudson River; 110,799 were stocked in the Tar River in North Carolina; 50 were given to Georgetown University in Washington, D.C., for experimental studies; and the remaining 150,202 were restocked in 17 ponds for continued rearing to advance-sized fingerlings [3 to 5 inches (70 to 127 mm)] for Phase-II production.

Phase-II fingerlings were restocked at an average rate of 10,948 fish/acre (Table IV-4). A regular feeding schedule promoted maximum growth. Water-quality parameters (including temperature, dissolved oxygen, pH, chloride, and total hardness) were monitored regularly, and fish were periodically checked for disease, abnormalities, and growth.

Phase-II harvesting from 17 September through 30 November yielded 119,936 fingerlings (3681 lb) with a mean length of 4.23 inches (107 mm); growth and survival were extremely good. These fingerlings had been reared an average of 66 additional days after restocking and had an average survival

Table IV-2

Stocking and Pond-Management Data for Hudson River Striped Bass, Edenton Fish Hatchery, North Carolina Phase I, 1974 (Gruenthal, 1975)

Ranked by % Return	Pond No.	Surface (acres)	Start Fill (Date)	First Hay (date)	First Hay (lb)	First Hay (lb/acre)	Total Hay (lb)	Roe No.	Fry Hatched (date)	Fry Received (date)	Fry Stocked (date)	Age of Stocking (days)	No. Stocked (M)	Stocking Rate (1000/acre)	Pond Treatment ($CuSO_4$)	Pond Treatment (KMnO)
1	18	0.84	5/28	5/29	420	500	690	6	5/24	5/28	6/07	14	52	62	7/14	7/15
2	22	0.83	5/29	5/29	420	510	720	5	5/23	5/28	6/03	10	81	96	-	-
3	27	0.75	5/28	5/29	420	560	720	6	5/24	5/28	6/07	14	73	97	7/15	-
4	26	0.83	5/29	5/29	420	510	720	5	5/23	5/28	6/05	12	107	129	-	-
5	2	0.74	5/28	5/29	300	410	750	5	5/23	5/28	6/03	10	74	100	7/15	-
6	29	0.74	5/29	5/29	360	490	600	5	5/23	5/28	6/03	10	72	97	-	-
7	4	0.87	5/28	5/29	360	410	750	6	5/24	5/28	6/02	9	70	80	-	7/14
8	30	0.66	6/15	6/13	360	550	660	33	6/02	6/06	6/17	15	65	98	-	-
9	17	0.83	5/30	5/29	420	510	720	6	5/24	5/28	6/07	14	82	99	7/16	7/12
10	10	0.83	5/28	5/29	360	430	750	6	5/24	5/28	6/02	9	80	96	7/16	-
11	11	0.83	5/28	5/29	360	430	690	5	5/23	5/28	6/02	9	66	80	--	-
12	5	0.94	5/28	5/29	420	450	870	6	5/24	5/28	6/02	9	93	99	7/16	7/09
13	15	0.83	6/09	6/10	420	510	720	33	6/02	6/06	6/17	15	75	90	-	-
Totals		10.52			5040	480	9360						990			

services group

Table IV-3

Production Data for Hudson River Striped Bass, Edenton Fish Hatchery, North Carolina Phase I, 1974 (Gruenthal, 1975)

	Return (%)	Pond No.	Harvested (date)	Harvested (No.)	Harvested (lb)	(1000/acre)	(lb/acre)	Size (No./lb)	Length (inches)	Days in Pond	Production (lb/acre/day)
	56.2	18	7/17	29,251	61.02	35	73	479	1.73	40	1.8
	48.3	22	7/15	38,905	67.03	47	81	580	1.62	42	1.9
	46.4	27	7/24	33,908	107.40	45	143	316	1.98	47	3.0
	40.8	26	7/15	43,613	97.51	53	117	447	1.77	40	2.9
	38.8	2	7/24	28,711	39.74	39	54	722	1.51	51	1.1
	31.4	29	7/18	22,621	32.56	31	44	694	1.53	45	1.0
	28.2	4	8/08	19,678	49.03	23	56	401	1.83	67	0.8
	24.4	30	8/16	15,869	28.76	24	44	551	1.65	60	0.7
	23.3	17	7/25	19,122	38.22	23	46	500	1.70	48	1.0
	16.8	10	8/09	13,494	65.48	16	79	207	2.28	68	1.2
	16.2	11	8/08	10,736	30.36	13	37	353	1.01	67	0.6
	15.0	5	7/25	13,961	41.14	15	44	339	1.94	53	0.8
	11.8	15	8/16	8,823	28.04	11	34	314	1.99	60	0.6
Avg* and Totals	30.2			298,692	686.29	28	65	435	1.78	49	1.3

*Averages weighted against number of fish harvested, where applicable.

Table IV-4

Stocking and Pond-Management Data for Hudson River Striped Bass, Edenton Fish Hatchery, North Carolina Phase II, 1974 (Gruenthal, 1975)

Rank (% return)	Pond No.	Surface (acres)	Roe No.	Fingerlings Stocked (Date)	Fingerlings Stocked (No.)	Fingerlings Stocked (Weight)	Size (No./lb)	Length (inches)	Stocking Rate (No./acre)	Food (lb)
1	11	0.83	33&6	8/20	9,481	48.46	196	2.33	11,423	275
2	10	0.83	6	8/20	9,463	73.08	129	2.67	11,401	265
3	4	0.87	5	8/21	9,375	25.00	375	1.87	10,776	140
4	24	0.82	6	7/29	8,917	24.10	370	1.88	10,874	164
5	15	0.83	6	8/21	12,092	30.30	399	1.84	14,569	287
6	27	0.75	5	8/06	6,684	18.99	352	1.91	8,912	139
7	29	0.74	6	7/26	10,289	27.17	379	1.87	13,904	230
8	26	0.83	6	8/21	9,135	60.94	150	2.54	11,006	150
9	17	0.83	6	7/29	9,435	25.50	370	1.88	11,367	326
10	1	0.57	6	7/22	6,051	18.44	328	1.96	10,616	110
11	16	0.83	5	7/22	9,092	19.10	476	1.73	10,954	338
12	18	0.84	5	7/23	8,513	17.05	499	1.70	10,135	161
13	2	0.74	5	7/30	6,228	18.32	340	1.94	8,416	165
14	22	0.83	5	7/23	8,828	16.50	535	1.66	10,636	129
15	8	0.83	5	7/23	8,461	16.74	505	1.70	10,194	220
16	13	0.81	5	7/22	8,527	16.90	505	1.70	10,527	82
17	5	0.94	5	8/06	9,631	27.36	352	1.91	10,246	239
Avg* and Totals		13.72			150,202	483.95	310	2.00	10,948	3,420

*Averages are weighted against the number of fish harvested, where applicable.

rate of 80% (Table IV-5). A mortality of 1775 fingerlings occurred while the fish were in the holding facilities prior to shipping. Distribution of the Phase-II fingerlings was as follows: 74,288 were shipped to New York for the Hudson River stocking program; 43,500 were stocked in the Tar River, North Carolina; 250 were given to Oak Ridge National Laboratory in Tennessee; and 123 were provided to Georgetown University.

B. DURANT STATE FISH HATCHERY, OKLAHOMA

Approximately 3,940,000 Hudson River striped bass larvae were sent to the Durant hatchery in four shipments. Shipping mortality ranged from 0 to 40% for all shipments (Table IV-1). After arrival at Durant, the larvae were acclimated for approximately 3 hr and then released into 40-gal. aquaria. When approximately 5 days old, the larvae were given live brine shrimp nauplii every 4 hr; frozen brine shrimp were substituted for nauplii as the larvae grew older. When the larvae were 8 to 12 days old, they were stocked in ponds which were fertilized on a weekly basis with mixtures of alfalfa pellets, cottonseed meal pellets, soybean meal, and inorganic nitrate and phosphate fertilizers in sufficient amounts to maintain abundant zooplankton blooms (Harper, 1975). Three weeks after stocking, supplemental feeding was initiated using the following prepared diets: Purina Trout Chow in four ponds, Silver Cup Trout Chow in four ponds, Clark's Chow in three, and no supplemental food for two. In Table IV-6 are the results of these feeding regimes.

Between 16 and 24 July, 468,737 fingerlings (2 to 3 inches or 51-76 mm) were harvested; of these, 339,228 were stocked in Lake Texoma, while the remaining 129,509 were restocked in five culture ponds to be held as a backup supply of fingerlings for the Hudson River stocking program (Table IV-7). Each of the five ponds which served as a backup supply received 2 lb of Purina Trout Chow three times daily until being harvested. Many disease and

vegetation problems were encountered in these ponds during the rearing period. Potassium permanganate (4 to 5 ppm) was used as a treatment for infestations of the protozoan *Trichodina*; however, reinfestations occurred from 7 to 10 days after treatment. On 7 November (Table IV-8), 4700 fingerlings weighing 76 lb (61.8 fish/lb) were harvested. The chronic disease was probably responsible for the poor returns from these ponds (Harper, 1975).

Table IV-5

Production Data for Hudson River Striped Bass, Edenton Fish Hatchery, North Carolina Phase II, 1974 (Gruenthal, 1975)

	Return (%)	Pond No.	(date)	Harvest (No.)	Harvest (lb)	(No./acre)	(lb/acre)	Size (no./lb)	Length (inches)	Days in Pond	Gain in Weight (lb)	Food/gain (lb/lb)	Gain in Length	Gain/Day Length	Gain/30 Days Length	TU/Inch†
	99	11	10/17	9,381	229.58	11,302	277	40.9	3.92	58	181	1.52	1.59	0.027	0.81	26.7
	99	10	10/15	9,335	270.50	11,247	326	34.5	4.15	56	197	1.35	1.48	0.026	0.78	27.7
	91	4	11/01	8,512	221.69	9,784	255	38.4	4.00	72	197	0.71	2.13	0.030	0.90	23.0
	89	24	10/03	7,966	199.04	9,715	243	40.0	3.95	66	175	0.94	2.07	0.031	0.93	25.8
	87	15	11/01	10,563	254.55	12,727	307	41.5	3.90	72	224	1.28	2.06	0.029	0.87	23.7
	86	27	10/10	5,778	174.90	7,704	233	33.0	4.21	65	156	0.89	2.30	0.035	1.1	21.7
	85	29	9/27	8,778	321.76	11,862	435	27.3	4.49	63	295	0.78	2.62	0.042	1.3	20.0
	85	26	10/15	7,782	217.60	9,376	262	35.8	4.10	55	157	0.96	1.56	0.028	0.84	25.8
	84	17	10/30	7,888	256.27	9,504	309	30.8	4.31	93	231	1.41	2.43	0.026	0.78	27.7
	83	1	9/17	5,007	162.78	8,784	286	30.8	4.31	57	144	0.76	2.35	0.041	1.2	20.6
	80	16	10/17	7,279	283.26	8,770	341	25.7	4.58	87	264	1.28	2.85	0.033	0.99	23.6
	75	18	9/25	6,376	209.70	7,590	250	30.4	4.33	64	193	0.83	2.63	0.041	1.2	20.4
	70	2	9/27	4,334	212.09	5,857	286	20.4	4.94	59	194	0.85	3.00	0.051	1.5	16.3
	67	22	9/18	5,874	179.52	7,077	216	32.7	4.22	57	163	0.79	2.56	0.045	1.4	18.9
	65	8	9/25	5,539	211.05	6,673	254	26.2	4.55	64	194	1.13	2.85	0.045	1.4	18.8
	60	13	9/17	5,122	109.86	6,323	136	46.6	3.75	57	93	0.88	2.05	0.036	1.1	23.7
	46	5	10/10	4,422	166.90	4,704	178	26.5	4.53	65	140	1.71	2.62	0.040	1.2	19.1
Avg* and Totals	80			119,936	3,681.05	8,742	268	32.6	4.23	66	3,197	1.07	2.23	0.034	1.0	22.7

*Averages are weighted against the number of fish harvested, where applicable.
†TU (temperature units) = avg. monthly water temperature in °C.

Table IV-6

Experimental Feeding Program with Hudson River Striped Bass, Durant Hatchery, Oklahoma, 1974 (Harper, 1975)

Food Supplement	No. Ponds Receiving Feed	No. Stocked	No. Harvested	Percent Return	Total Pounds	No. Pounds
Purina	4	500,000	95,817	19.16	218.0	440.5
Silver Cup	4	500,000	95,358	19.07	165.0	581.4
Clark's	3	400,000	122,181	30.55	170.5	717.6
None	2	200,000	155,381	77.69	122.5	1,268.4
Total	13	1,600,000	468,737	29.30	676.0	693.4

services group

Table IV-7

Fry Survival and Stocking Data for Hudson River Striped Bass, Durant Hatchery, Oklahoma, 1974 (Harper, 1975)

Shipment No.	Shipping Age (days)	Roe No.	Received (date)	Received (No.)	Hatched (date)	Stocked (date)	Stocked (No.)	Stocked (age in days)	Stocked (pond No.)	Aquaria Mortality (%)	Harvested (date)	Harvested (No.)	Pond % Return	% Return from Fry	Remarks
1	4	10	5/28	500,000	5/24	6/03	100,000	10	20	80.00	7/16	8,700	8.70	1.74	Mortality due to dissolved-oxygen depletion
2	3	22	5/30	300,000	5/27	6/04	200,000	8	108	33.00	7/19	13,620	6.80	4.54	All restocked for Con Ed
2	5	15	5/30	700,000	5/25	6/04	100,000	10	19	85.71	7/16	98,518	98.50	14.07	
3	2	26	6/01	300,000*	5/30	6/07	100,000	8	4		7/19	36,354	36.40		All restocked
						6/07	100,000	8	10	33.30	7/17	57,317	57.30	16.17	
4	5	26	6/04	400,000*	5/30	6/10	200,000	11	110	35.00	7/24	19,500	9.80		
3	4	24	6/01	700,000	5/28	6/07	100,000	10	3	57.14	7/19	53,975	53.98		
						6/07	100,000	10	8		7/18	98,064	98.06	30.13	57,204 restocked
						6/07	100,000	10	16		7/17	58,904	58.90		
4	6	27	6/04	600,000	5/29	6/10	100,000	12	9	40.00	7/17	100	0.10	0.017	
						6/10	200,000	12	109		7/24	0	0		Risor dropped during night; pond overflowed
4	3	30	6/04	500,000	6/01	6/10	100,000	9	5	35.00	7/18	19,522	19.50		All restocked
						6/10	100,000	9	6		7/18	4,163	4.16	4.70	All restocked

*TI records show that 640,000 larvae were shipped on May 30, 1974, instead of 700,000 reported by Oklahoma.

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Table IV-8

Fingerling Production with Hudson River Striped Bass, Durant Hatchery, Oklahoma, 1974 (Harper, 1975)

	Shipment No.	Pond No.	Hatched (date)	Roe No.	Stocked (date)	Stocked (no.)	Stocked (age in days)	Days in Pond (No.)	Harvest (date)	Harvest (no.)	Harvest (no./lb)	Harvest (total lb)	Harvest (age in days)	Return %	Food Supp.
	1	20	5/24	10	6/03	100,000	10	43	7/16	8,700	290	30.0	53	8.7	Purina
	2	103	5/27	22	6/04	200,000	8	45	7/19	13,620	227	60.0	53	6.8	Purina
	2	19	5/25	15	6/04	100,000	10	42	7/16	98,518	908	108.5	52	98.5	Clark's
	3	4	5/30	26	6/07	100,000	8	42	7/19	35,154	378	93.0	50	36.4	Silver Cup
									9/06*	1,200	240	5.0			
	3	10	5/30	26	6/07	100,000	8	40	7/17	57,317	1,135	50.0	48	57.3	None
	3	3	5/28	24	6/07	100,000	10	42	7/19	53,975	635	85.0	52	54.0	Purina
	3	8	5/28	24	6/07	100,000	10	41	7/18	98,064	1,362	72.0	51	98.1	None
	3	16	5/28	24	6/07	100,000	10	40	7/17	56,504	1,009	56.0	50	58.9	Silver Cup
									9/06*	2,400	240	10.0			
	4	110	5/30	26	6/10	200,000	11	44	7/24	19,500	500	39.0	55	9.8	Clark's
	4	9	5/29	27	6/10	100,000	12	37	7/17	100	100	1.0	49	0.1	Silver Cup
	4	109	5/29	27	6/10	100,000	12	44	7/24	0	0	0.0	56	0.0	Silver Cup
	4	5	6/01	30	6/10	100,000	9	38	7/18	19,522	454	43.0	47	19.5	Purina
	4	6	6/01	30	6/10	100,000	9	38	7/18	4,163	181	23.0	47	4.2	Clark's
Totals		13				1,600,000		41.2		468,737	693.4	676.0	51.5	29.30	

*Due to the large amounts of vegetation, complete harvesting was delayed until this time.

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SECTION V

STOCKING AND DISTRIBUTION OF FINGERLINGS

The third phase of the 1974 hatchery program involved marking, packing, shipping striped bass fingerlings, and stocking them into the Hudson River. The methods and results of this phase are described in detail in this section.

A. FINGERLINGS STOCKED IN HUDSON RIVER

Of the 106,288 fingerlings reared at the Edenton National Fish Hatchery, North Carolina, 101,524 (96%) were stocked in the Hudson River from river mile 25 to river mile 60 (Figures V-1 and V-2).* Shipping and stocking were conducted during three periods: (1) in August, 32,000 fingerlings [2-2.5 inches (50-64 mm)] were flown to New York in two shipments; (2) from late September through October, 58,511 fingerlings [3-5 inches (76-107 mm)] were flown to New York in eight shipments; and (3) on 23 October, an additional 15,777 fingerlings (3 to 5 inches) from the Edenton hatchery were transported to the Verplanck hatchery, New York, in a fish-hauling truck with recirculating water (Table V-1).

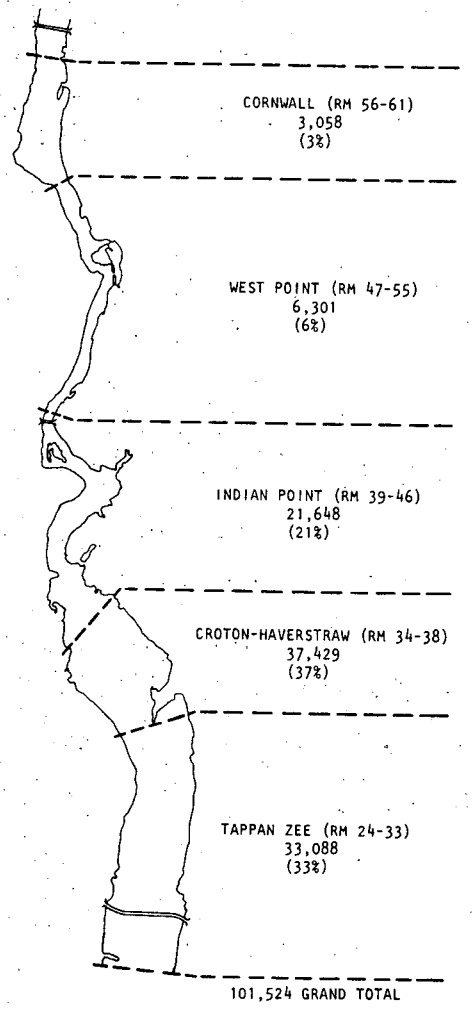

Figure V-1. Total Number by Geographical Region of Hatchery-Reared Striped Bass Fingerlings Stocked in Hudson River, 1974

*An additional 1.7% survived transport and were utilized for initial survival studies.

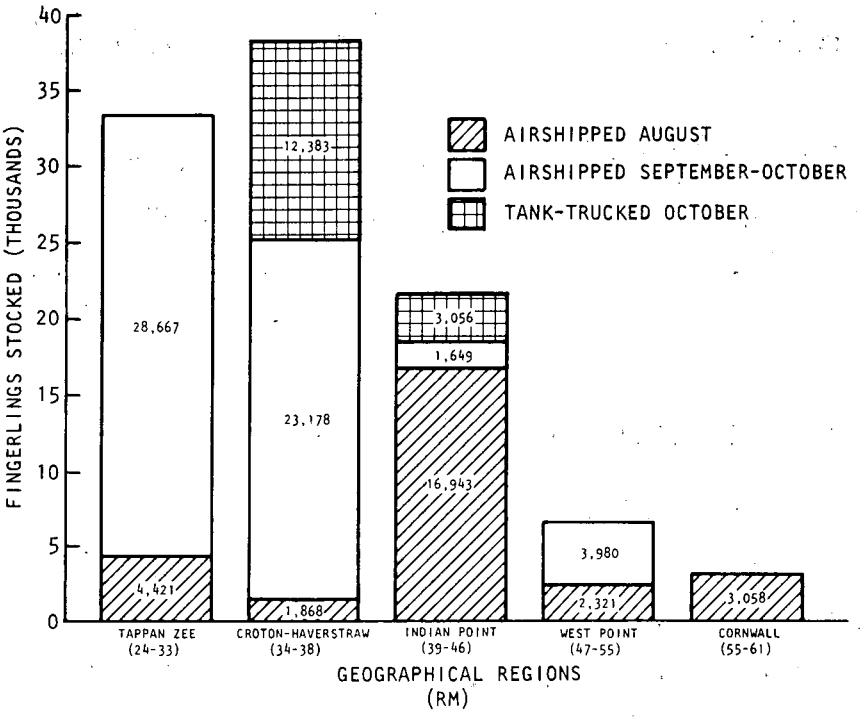

Figure V-2. Stocking Regime of Various Shipments of Striped Bass Fingerlings, 1974

1. Handling and Marking

Before they were marked in North Carolina, the airshipped fingerlings were held in 400-gal. retangular troughs containing 18°C (64.4°F) well water. Tank-trucked fingerlings which were marked in New York were held in 2500-gal. circular pools containing 12-14°C (53.6-57.2°F) river water. At the time of marking, the fish were netted from the holding facilities and anesthesized in a 50-ppm solution of quinaldine. All fingerlings were held in a 10°/oo salt and 10-ppm combiotic bath for at least 24 hr after they were marked.

Table V-1

Shipping and Stocking Data for Hatchery-Reared Striped Bass, 1974

Date	No. of Fish Shipped	No. Stocked	No. of Stocking Sites	Range of Stocking Sites (river miles)	Mortalities Shipping	Percent	Other*	Percent	Total	Percent	No. of Fish used for Survival Tests	Percent
8/7-8	15,061	14,654	12	40-60	7	0.05	0	0	7	0.05	400	2.66
8/9-10	16,939	13,957	18	25-41	2,544	15.02	0	0	2,544	15.02	438	2.58
9/25-26	3,296	3,096	4	49-54	0	0	0	0	0	0	200	6.06
9/28-29	8,246	7,989	9	37-54	54	0.65	3	0.03	57	0.69	200	2.42
10/2-3	9,322	9,293	4	35-37	4	0.04	25	0.27	29	0.31	0	0
10/5-6	5,953	5,754	5	33-36	0	0	0	0	0	0	199	3.34
10/9-10	6,585	6,573	4	32-35	0	0	12	0.18	12	0.18	0	0
10/12-13	8,725	8,711	5	29-33	3	0.03	11	0.12	14	0.16	0	0
10/16-17	9,470	9,162	4	26-30	93	0.98	15	0.16	108	1.10	200	2.11
10/19-20	6,914	6,896	4	25-28	0	0	18	0.26	18	0.26	0	0
10/30	Tank truck 15,777	15,439	5	35-39	Unknown		Unknown		125	0.08	213	1.35
Grand Total	106,288	101,524	59	25-60	~2,705	2.54	~84	0.08	2,914	2.74	1,850	1.74

*These mortalities were encountered during stocking and included fish concealed in creases of the plastic bags and inadvertently left to die or those dropped on the boat's deck from torn bags.

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Different marks were used during each of the three stocking periods: fingerlings shipped in August, because of their small size, were marked only with a second-dorsal fin-clip; fingerlings shipped by air during September and October were marked with a first-dorsal fin-clip and a micromagnetic nose tag (equipment and tags acquired from Technical Research Company in Seattle, Washington); tank-trucked fingerlings shipped in October were each marked with left- and right-pelvic fin-clips and a nose tag with a color code different from that used on airshipped fish.

Nose-tagged fingerlings were passed through a 2-inch diameter plastic pipe with a water flow of approximately 2 gpm. This pipe was coupled to a magnetizing apparatus and a nose-tag detecting device which verified the presence of a magnetized nose tag. Approximately 750 fish/hr could be nose-tagged.

2. Packing and Shipping

A solution of fresh well water [18 °C (64.4 °F)] containing 10-ppm Combiotic and 5 °/oo salt was prepared for use as packing water; 4 gal. of the packing water and a predetermined quantity of fish were placed in double 2-mil plastic bags placed inside 22-inch x 14-inch x 16-inch cardboard shipping cartons with 1-inch-thick styrofoam inserts. The bags were evacuated of air, inflated with industrial-grade compressed oxygen, and sealed. The cartons were trucked to the Edenton airport (6 mi) and flown to Westchester County (New York) airport. Then, the fingerlings were trucked 30 mi to the Verplanck hatchery and loaded onto boats for stocking in the Hudson River. Elapsed time between packaging of the fish and their arrival at Verplanck was from 8 to 10 hr.

The 32,000 fingerlings shipped from North Carolina in August were packed at a density of 0.25 lb/gal., a density that had proven effective during the 1973 hatchery program (Texas Instruments Incorporated, 1974).

The total transport mortality encountered in the two August shipments was 2551 fingerlings (8.0%); 2544 (7.95%) of these mortalities occurred during the second flight on 9 August when extremely adverse weather conditions prompted the pilot to climb from a crusing altitude of 3000 ft to 9000 ft. Due to the presence of compressed oxygen within the bags and decreasing air pressure within the storage compartment of the aircraft which was not pressurized, the lids of many cartons were observed lifting and several plastic bags exploded. The mortalities probably resulted because the fingerlings could not tolerate abrupt changes in pressure and dissolved-oxygen levels (the saturation level of oxygen in water decreases with decreased air pressure). Also during this flight, a window blew out, creating cabin temperatures of 2 °C (35.6 °F); although this was probably of secondary importance, water temperatures in the shipping containers (measured upon arrival in New York) were several degrees centigrade lower than those on the previous August flight.

Fingerlings airshipped during September and October were packed at different densities to determine the maximum weight that could be packed per gallon of water without imposing high mortalities. Weights evaluated in pounds/gallon were 0.25, 0.33, 0.40, 0.50, and 0.60 (Table V-2). No mortalities occurred in boxes packed carrying 0.25 lb/gal., and only low mortalities (≥0.2%) were recorded for boxes packed at higher densities. Based on these results, subsequent packaging was at higher densities per carton (0.50 lb/gal) to reduce the total number of air shipments.

On 23 October, approximately 15,777 fingerlings were netted from the holding facilities (18 °C or 64.4 °F well water) at the Edenton hatchery and placed in a tank truck filled with 1000 gal. of a solution of 18 °C (64.4 °F) well water and 10 °/oo salt. Fish were shipped at a density of approximately 0.50 lb/gal. of water. A pump recirculated the water, and a continuous flow of compressed oxygen maintained safe oxygen levels (5 ppm)

for the 15-hr journey. Upon arrival at the Verplanck hatchery, the hauling water was tempered with river water pumped into the tank truck for 1 hr before the fish were released into 2500-gal. circular pools. Exact mortalities could not be determined upon arrival; however, 125 dead fingerlings (0.8%) were observed prior to stocking.

Table V-2

Results of Striped Bass Fingerling Shipping Density Tests Based on September and October 1974 Airshipped Fish

Density (lb/gal.)	No. Shipped	No. Dead	Percent Dead	Percent of Total Shipped	Percent Dead of Total Shipped
0.25	3296	0	0	5.6	0
0.33	2000	19	1.0	3.4	0.03
0.40	1368	12	0.9	2.3	0.02
0.50	50937	121	0.2	87.1	0.2
0.60	910	2	0.2	1.6	0.003

Total survival for the entire program was high: 103,374 (97%) of the 106,288 fingerlings shipped from the Edenton hatchery survived. A total of 101,524 (96%) of those shipped were stocked into the Hudson River. Because survival of fingerlings shipped by tank truck was high and the cost lower than air transport, it proved to be the most practical and economical transport method.

3. Stocking

Airshipped cartons of fish were transported by boats from the Verplanck hatchery to release points in the Hudson River (RM 24 to 60) that had been determined from the 1973 beach-seine survey catch-per-unit effort data for wild Hudson River young-of-the-year striped bass (Texas Instruments Incorporated, 1975). The maximum time in which fingerlings were held in the packing cartons was 14 hr.

In August, the temperature difference between the shipping water and the river water was >± 3°C (± 5.4°F) (Table V-3). Acclimation was accomplished by mixing the packing water with approximately 50% river water and allowing it to stand for 5 min before the fish were released. Of the 32,000 fingerlings shipped in August, 28,611 (89%) were stocked in the Hudson River (Table V-1).[1]

Of the 58,511 fingerlings airshipped to New York in September and October, 57,474 (98%) were stocked in the Hudson River.[2]

Of an additional 15,777 fingerlings shipped by tank truck to New York in October, 15,439 were stocked in the river.[3] These fish were transported to predetermined stocking areas in a 275-gal. holding tank aboard a boat and quick-released into the river. Since there was little temperature difference between the shipping water and the river water in September and October (Table V-3), fingerlings stocked during this period were not acclimated before release.

All stocking was conducted at night to prevent the possibility of shock upon opening the cartons in bright daylight and to limit predation by

[1] An additional 838 fingerlings survived shipping and were used in survival tests.
[2] An additional 799 fish survived shipping and were used for survival tests.
[3] An additional 213 survived shipping and were used in survival tests.

Table V-3

Water-Quality Data for Hatchery-Reared Striped Bass Stocking Program, 1974

Date	Air Temp. (x °C)	Stocking Sites: Conductivity (μmhos/cm²) Range	Stocking Sites: Conductivity (μmhos/cm²) Mean	Stocking Sites: Water Temp. (°C) Range	Stocking Sites: Water Temp. (°C) Mean	Stocking Sites: pH Range	Stocking Sites: Dissolved Oxygen (mg/ℓ) Range	Stocking Sites: Dissolved Oxygen (mg/ℓ) Mean	Shipping Boxes: Conductivity (μmhos/cm²) Range	Shipping Boxes: Conductivity (μmhos/cm²) Mean	Shipping Boxes: Water Temp. (°C) Range	Shipping Boxes: Water Temp. (°C) Mean	Shipping Boxes: pH Range	Shipping Boxes: Dissolved Oxygen (mg/ℓ) Range	Shipping Boxes: Dissolved Oxygen (mg/ℓ) Mean
8/ 7-8	18.5	251-4550	1322	24.0-25.5	24.4	7.20-8.30	6.7-10.6	8.1	8000-9000	8500	20.8-25.5	24.4	6.70-6.90	10.1-15+	approx. 13.1
8/ 9-10	21.2	3100-10060	6448	24.5-26.5	25.4	7.20-7.73	3.2-7.2	5.6	5500-9950	8386	20.0-24.0	21.4	6.75-7.10	5.8-15+	approx. 10.3
9/25-26	Unknown	180-255	212	19.5-19.8	19.6	7.19-7.60	7.6-9.6	8.1	7000-9100	8367	17.0-17.8	17.4	7.20-7.30	15+	15+
9/28-29	21.8	268-4750	2280	20.0-21.2	20.6	7.30-8.20	7.2-8.9	7.7	1 sample	14100	1 sample	20.4	1 sample 6.80	1 sample	2.6
10/2-3	7.5	3300-3850	3690	17.0-19.0	17.9	6.71-7.40	6.4-8.5	7.3	5199-7100	6279	15.1-16.5	15.8	6.70-7.10	11.6-20+	15+
10/5-6	16.3	1950-3100	2462	17.8-18.4	18.1	6.91-7.33	7.9-8.4	8.1	1900-6230	4543	17.6-18.9	18.2	6.80-7.25	14.4-19.8	17.1
10/9-10	12.5	2090-3500	2810	16.0-18.4	17.3	7.40-7.50	7.2-9.1	8.4	6030-6940	6485	17.0-17.3	17.2	6.90-7.05	11.2-11.8	11.5
10/12-13	18.1	3590-6050	4932	16.5-18.0	17.4	7.28-7.60	7.3-8.8	8.2	7500-8000	7750	19.0-19.3	19.2	6.90-6.93	8.8-9.2	9.0
10/16-17	10.6	4950-6230	5545	14.5-16.0	15.4	7.21-7.51	8.5-9.3	8.8	5090-7030	5480	14.5-18.0	16.0	6.61-6.92	3.4-15.0	9.2
10/19-20	5.7	3900-5230	4534	10.0-14.9	12.5	6.99-7.40	9.8-11.6	10.7	5998-6350	6127	10.0-16.0	13.5	6.79-7.05	15+	15+
Tank truck									Fiberglass minnow tank						
10/30	18.0	3440-4500	4180	13.8-14.7	14.2	7.22-7.59	8.6-9.5	9.0	3310-3900	3544	14.5-15.5	15.1	6.99-7.50	11.5-14.3	12.9
Total through Stocking Period	15.0	180-10060	3492	10.0-26.5	18.4	6.71-8.30	3.2-11.6	8.2	5090-14100	7233	10.0-25.5	18.1	6.61-7.30	3.4-20+	approx. 11.9

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fish and birds. Hatchery-reared striped bass fingerlings have been observed to sound in deep water upon release and sometimes surface with ruptured gas bladders. For this reason, the fingerlings were stocked in bay and shoal areas at depths of ≤ 10 ft.

B. FINGERLINGS UTILIZED FOR EXPERIMENTAL PURPOSES

An additional 12,325 hatchery-reared striped bass fingerlings were supplied to various projects and agencies for experimental uses (Table V-4). TI's intensive-culture experiment at the Verplanck hatchery produced approximately 6000 fingerlings which were utilized by New York Ocean Science Lab (NYOSL) for a cage-culture experiment, New York University for Indian Point thermal-plume studies, Stone and Webster for an experimental flume study, and TI for striped bass subpopulation studies.

NYOSL requested additional hatchery-reared fingerlings for use in a second cage-culture experiment so, in October 1974, NYOSL personnel transported 1595 striped bass fingerlings by pick-up truck from the Edenton hatchery to Montauk, Long Island; 11 boxes contained 0.25 lb/gal. (148 fish per box) as previously described for air shipment. The fish arrived at NYOSL approximately 15 hr after the first box had been packed at Edenton; they appeared to be in good condition, and only one mortality was observed. At Montauk, the fingerlings were acclimated from the shipping water (17°C or 62.6°F) to the holding water (20°C or 68°F, 7 °/oo salinity).

Since various agencies requested more fingerlings for use in experiments, 4700 fingerlings were shipped from the Durant, Oklahoma hatchery on 7 November (Table V-4). These fish were not marked and were handled and packed, as previously described, at a shipping density of 0.25 lb/gal. All boxes of fish were shipped by air from Durant to New York City, then trucked to the Verplanck hatchery; total time in transit was approximately 13 hr. No mortalities were observed upon arrival at Verplanck; however,

many fish were observed swimming vertically, indicating possible air-bladder abnormalities. These fish were held at Verplanck until transportation to the receiving agencies could be arranged.

Table V-4

Striped Bass Fingerlings Supplied and Shipped for Experimental Studies

Source	Number	Size (inches)	Recipient	Use
TI Verplanck Hatchery	3,000	1-1.5	NYOSL	Cage culture experiments
	925	1.5-2.5	NYU	Indian Point thermal plume studies
	1,900	2-2.5	S&W	Holding experiments
	200	3	TI	Relative contribution study
Edenton National Fish Hatchery	1,595	3-4	NYOSL	Cage culture experiments
Durant State Fish Hatchery, Oklahoma	2,115	3-5	TI	Active respiration and impingement experiments
	2,090	3-5	S&W	Holding experiments
	500	3-5	NYU	Pressure studies
Total	12,325			

SECTION VI

SURVIVORSHIP STUDIES AND ANALYSIS

The fourth phase of the 1974 hatchery program compared hatchery-reared and wild striped bass fingerlings with respect to initial survival and vulnerability to fishing gear. A sample of fingerlings released during each stocking period was held in river water for 14 days to determine the effects of tagging and to estimate initial survival. Long-term survival was evaluated as part of the overall mark/recapture program of the Hudson River ecological study.

A. EVALUATION OF HATCHERY-REARED STRIPED BASS MARKING/ HANDLING MORTALITY

1. Methods

To evaluate initial survival of hatchery-reared striped bass fingerlings stocked in the summer, portions of the two August shipments were subjected to 14-day marking/handling tests. The two tests employed a total of 838 fingerlings (2.6% of the total shipped). Of the 400 fish tested from the 7 August shipment, 200 were marked with second-dorsal fin-clips and 200 were control fish (handled in a similar manner but not clipped). The test group for the 9 August shipment contained 438 (316 marked and 122 control) fingerlings; during this shipment, 100 control fingerlings were lost in flight when the plastic bag in which they were shipped burst due to decrease in air pressure in the aircraft's storage compartment, but these unmarked fish were replaced by an equal number of marked fish to maintain the prescribed density.

Upon arrival at the Verplanck hatchery, each test group was placed in a separate 2500-gal. circular pool (supplied with approximately 5 gpm of Hudson River water) and left there for 14 days without food. Water-quality measurements and fingerling mortalities were recorded daily (Table VI-1).

Table VI-1

Water-Quality Data for 1974 Hatchery-Reared Striped Bass 14-Day Marking/Handling Mortality Test

Test No.	Dates	Air Temp. (x°C)	Test Pool								River							
			Conductivity (μmhos/cm²)		Water Temp. (°C)		ph		Dissolved Oxygen (mg/ℓ)		Conductivity (μmhos/cm²)		Water Temp. (°C)		ph		Dissolved Oxygen (mg/ℓ)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	8/8-22	26.5	3350-7800	5735	25.0-26.1	25.7	6.95-7.30	7.20	5.3-7.2	6.0	3350-7800	5500	25.0-27.0	25.9	7.00-7.50	7.26	5.8-8.2	6.7
2	8/11-24	26.8	4050-7800	6015	24.5-27.2	26.0	6.90-7.38	7.20	5.0-7.2	6.0	3400-7800	5785	25.0-27.8	26.0	7.00-7.50	7.25	5.8-8.2	6.6
3	9/25-10/9	15.8	1100-3950	2408	13.4-21.1	17.8	6.74-7.50	7.21	6.3-8.8	7.5	0998-3350	2025	17.0-22.2	19.1	6.65-7.55	7.27	8.0-9.6	8.3
4	9/28-10/13	16.5	1130-3930	2121	16.0-21.0	17.8	6.65-7.50	7.19	7.6-8.6	8.1	0998-3350	2017	17.1-21.0	18.4	6.65-7.50	7.26	5.6-8.4	8.0
5	10/5-19	16.6	0780-2240	1416	15.0-18.1	16.8	6.92-7.38	7.21	7.7-10.1	8.5	0930-1999	1357	15.8-18.0	17.5	7.10-7.40	7.32	5.6-9.4	8.3
6	10/16-31	16.3	0259-3900	1878	13.0-16.3	14.3	6.61-7.45	7.21	8.4-12.0	9.7	0390-4500	1881	13.6-17.0	15.2	7.30-7.50	7.36	8.6-12.0	9.6
7	10/31-11/15	11.9	1700-4650	2720	12.0-14.0	12.4	6.95-7.50	7.22	8.8-10.4	9.7	1555-4500	2460	12.0-14.0	12.8	7.30-7.50	7.42	9.0-11.0	9.7
Total through Testing Period 8/8-11/15		18.6	0259-7800	3185	12.0-27.2	18.7	6.61-7.50	7.21	5.0-12.0	7.9	0390-7800	3004	12.0-27.8	19.3	6.65-7.65	7.31	5.6-12.0	8.2

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Similar tests were conducted to estimate initial survival during the fall (September-October) stocking period. Four of the eight flights used to ship the fall stocked fingerlings to New York were randomly selected for the initial survival tests. The fingerlings used in each test were treated as follows: 50 received both nose tags with first-dorsal fin-clips; 50 received nose tags only; 50 received first-dorsal fin-clips only; and 50 were unmarked control fish. The tests were conducted in the same manner as described for the August shipments.

From the 30 October shipment of tank-trucked fish a single sample of 213 fish was selected, with lots of 50 each receiving nose tags, double-pelvic fin-clips, or nose tags plus double-pelvic fin-clips. A fourth lot of 63 fish was handled similarly but remained unmarked as a control group.

2. Results

Samples of marked and unmarked control fish held for 14 days had few mortalities (Tables VI-2, VI-3, and VI-4), suggesting that handling and marking had little effect on initial survival of stocked fingerlings. During the two replicate tests of sample fish from the 7 August and 9 August stockings, fin-clipped and control fish suffered similar mortality rates within each replicate test (Table VI-2), with mortality rate (%) defined as the number of dead specimens divided by the total number of fish in the sample multiplied by 100. The mortalities observed in these samples were apparently associated with handling rather than with the fin-clipping.

There were no significant differences in mortalities ($p = 0.51$) among unmarked fish and fish marked with fin-clip, nose tag, and both fin-clip and nose tag (Tables VI-3 and VI-5) during the four replicate tests of airshipped hatchery-reared fish stocked in September and October. The mortality rates used for an analysis of variance (Steele and Torrie, 1960)

Table VI-2

Results of 14-Day Marking/Handling Mortality Tests of Hatchery-Reared Striped Bass Airshipped in August 1974

Replicate	Fin-Clipped			Control		
	Sample Size	No. Died	%	Sample Size	No. Died	%
1	200	11	5.5	200	14	7.0
2	316	0	0	122	3	2.5
Total	516	11	2.1	322	17	5.3

were based on the observed mortalities only, so they represented minimum rates (Table VI-5). A malfunction in the nose-tag detecting apparatus at the time of these tests precluded verification of the presence of nose tags in fish surviving the 14-day observation period, as was necessary to determine the mark type of unobserved losses, but it is unlikely that all the unobserved losses (ranging from 0 to 6 fish per replicate sample of 200) were of the same mark type. Therefore, it is not expected that the inclusion of the unobserved mortalities would greatly affect the results of this analysis of variance.

Fish shipped by tank truck for stocking (30 October) experienced low mortality rates (0 to 6%) similar to earlier airshipped samples. Mark types appeared to have had little effect on mortality (Table VI-4).

Most mortalities, particularly during the four September-October tests (Figure VI-1), occurred within the first week of testing, indicating that a 14-day period was sufficient to detect mortality associated with handling and marking.

Table VI-3

Results of 14-Day Marking/Handling Mortality Tests of Hatchery-Reared Striped Bass Airshipped in September and October 1974*

Replicate	Fin-Clipped Sample Size	Fin-Clipped No. Died	Fin-Clipped %	Nose Tagged Sample Size	Nose Tagged No. Died	Nose Tagged %	Fin-Clipped and Nose Tagged Sample Size	Fin-Clipped and Nose Tagged No. Died	Fin-Clipped and Nose Tagged %	Control Sample Size	Control No. Died	Control %	Total† Sample Size	Total† No. Died	Total† %
1	50	0	0	50	0	0	50	0	0	50	1	2.0	200	6	3.0
2	50	1	2.0	50	0	0	50	1	2.0	50	0	0	200	8	4.0
3	50	0	0	50	0	0	50	7	14.0	49	0	0	199	12	6.0
4	50	1	2.0	50	3	6.0	50	1	2.0	50	0	0	200	5	2.5
Total	200	2	1.0	200	3	1.5	200	9	4.5	199	1	0.5	799	31	3.8

*Entries for each mark type do not include unobserved losses and thus represent minimum mortality

†Totals include unobserved losses; mark types unknown

services group

Table VI-4

Results of 14-Day Marking/Handling Mortality Test of Hatchery-Reared Striped Bass Shipped by Tank Truck, October 1974

Mark Type	Sample Size	No. Died*	%
Fin-clipped	50	1	2.0
Nose-tagged	50	0	0
Fin-clipped and nose-tagged	50	3	6.0
Control	63	0	0
Total	213	9†	4.2†

*Entries for each mark type do not include unobserved losses and thus represent minimum mortality

†Includes five unobserved losses; mark types unknown

Table VI-5

2-Way Analysis of Variance of 14-Day Observed Marking/Handling Mortality of Hatchery-Reared Striped Bass Airshipped, September and October 1974*

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	P
Replicates	37.99	3	12.66	0.45	0.72
Mark types†	69.75	3	23.25	0.83	0.51
Error	252.32	9	28.04		
Total	360.07	15			

*Data were transformed by inverse sine transformation (arcsine$\sqrt{x}$); 1/4n was substituted for proportions equaling 0.

†Fin-clipped; nose-tagged; fin-clipped and nose-tagged; unmarked.

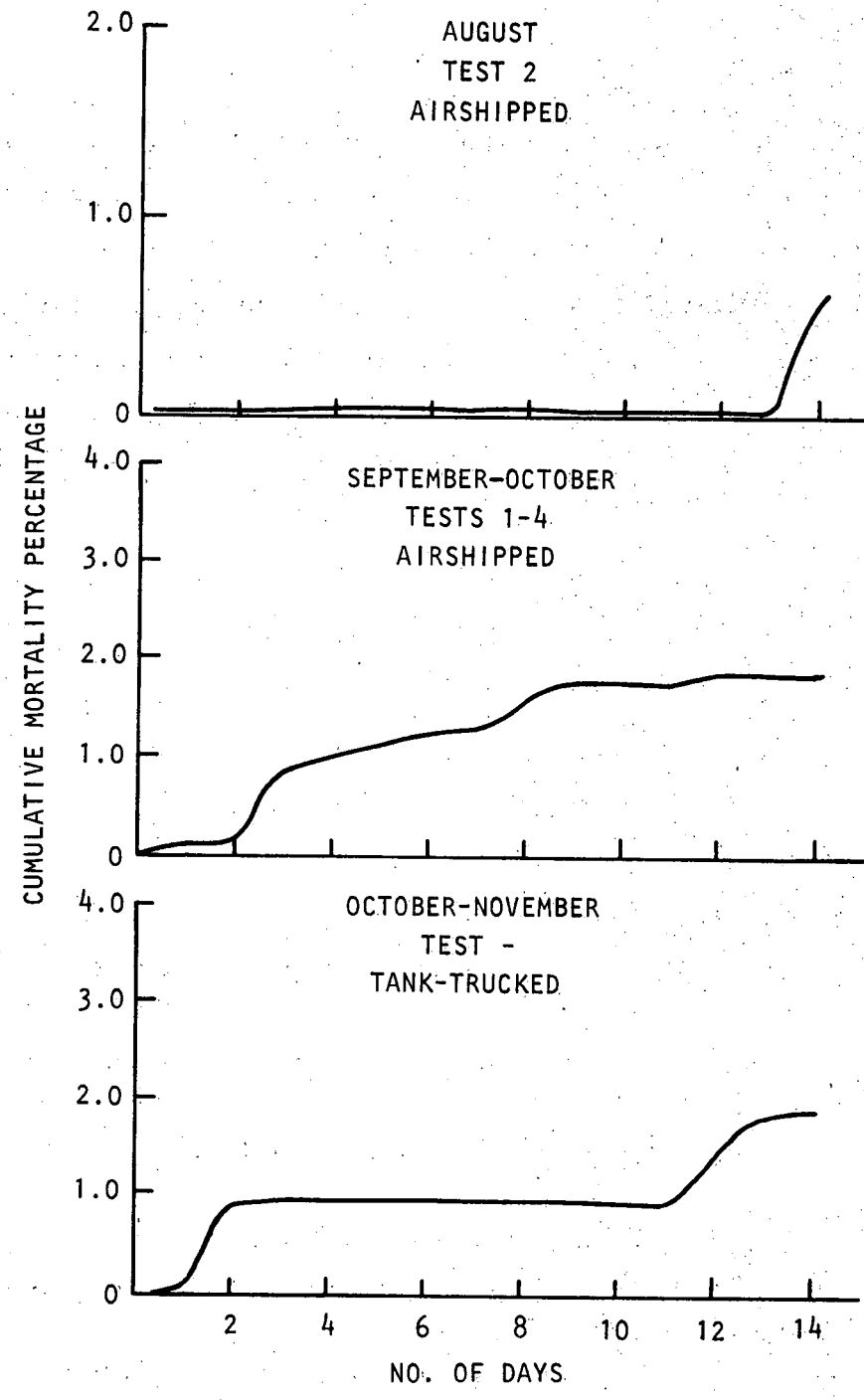

Figure VI-1. Cumulative Mortality Observed during 14-Day Tests of Effects of Handling and Marking (All Types Combined)

B. RELATIVE SURVIVAL OF HATCHERY-REARED FINGERLINGS IN HUDSON RIVER ESTUARY

1. Methods

The intensive 1974 mark/recapture program on wild young-of-the-year striped bass in the Hudson River provided an opportunity to assess the survival of stocked fish during an extended period of time. An estimate of the survival of stocked fish relative to that of wild fish was made using the change-in-ratio technique described by Paulik and Robson (1969). The ratio of hatchery fish survival to wild fish survival was determined by the equation:

$$\frac{S_h}{S_w} = \frac{R_{h_2}}{R_{h_1}} \Big/ \frac{R_{w_2}}{R_{w_1}}$$

where

S_h = survival of hatchery fish

S_w = survival of wild fish

R_{h_1} = number of hatchery fish recaptured during time interval 1

R_{h_2} = number of hatchery fish recaptured during time interval 2

R_{w_1} = number of wild fish recaptured during time interval 1

R_{w_2} = number of wild fish recaptured during time interval 2

To obtain an unbiased estimate of relative survival, an equal amount of recapture effort must be applied to both groups, hatchery and wild, during the evaluation period. Weekly evaluation periods beginning at least 1 week after the last date of release of marked fish were chosen for analysis to allow time for more complete mixing of marked and unmarked fish in the

river. As a further step to reduce bias in the estimate, stocking locations were selected on the basis of the distribution of wild striped bass juveniles in the river at the time of stocking as determined by beach-seine survey catch-per-unit-effort data. Fish were stocked in the region of heaviest concentration of wild juveniles (between RM 24 and RM 62). Stocked fish were marked with a fin-clip (second dorsal, first dorsal, and right plus left pelvic fins, corresponding to the August airshipped, September-October airshipped, and October tank-trucked stockings, respectively). All fingerlings stocked in September and October additionally received a color-coded magnetic nose tag. Wild striped bass juveniles received various single or double fin-clips (other than those used to mark hatchery fingerlings) to depict times and locations of marking (Texas Instruments Incorporated, 1975). Relative survival of hatchery-reared fingerlings which were airshipped and stocked in August and those which were tank-trucked and stocked on 31 October, could not be estimated using the change-in-ratio technique since no comparable group of marked wild fish were released during these periods.

2. Results

Hatchery-reared fish stocked in fall 1974 apparently survived at least as well as the marked wild young-of-the-year striped bass (Table VI-6), with relative survival ratios of 1.5, 1.9, and 2.8; this observation corroborates similar estimates of 1.29 to 2.0 for the 1973 stocking (Texas Instruments Incorporated, 1974). Unlike the 1973 stocking in which wild striped bass fingerlings appeared to be more vulnerable to recapture than hatchery fingerlings, hatchery-reared fingerlings stocked in 1974 were about equal to wild fish in vulnerability to recapture (Table VI-6). It was suspected that marked and unmarked wild fish in 1973 were not as randomly distributed as were the hatchery fish; to insure a more random distribution of marked wild fish in 1974, they were given more time to disperse throughout the population. In 1974, as in 1973, hatchery-reared striped bass stocked after August were larger than were their wild counterparts (Table VI-7).

Table VI-6

Relative Survival of Wild and Stocked Airshipped Hatchery-Reared Striped Bass Fingerlings in Hudson River Estuary, 1974

Date	Hatchery-Reared		Wild	
	Cumulative Marks*	Recaptures**	Cumulative Marks†	Recaptures**
8/11-17			70	
8/18-24			472	3
8/25-31			1,422	5
9/1-7			2,690	10
9/8-14			3,558	9
9/15-21			4,405	33
9/22-28	2,957		4,925	16
9/29-10/5	19,461	3	5,001	4
10/6-12	39,552	6		6
10/13-19	48,302	16		4
10/20-26	54,888	25		3
10/27-11/2		10		2
11/3-9		19		2
11/10-16		17		0
11/17-23		14		1
11/24-30		7		0
12/1-7		4		0
12/8-14		1		0

S_h/S_w = 1.5 for period 1 (11/3-9) through period 2 (11/17-23)

S_h/S_w = 2.8 for period 1 (10/27-11/2) through period 2 (11/17-23)

S_h/S_w = 1.9 for period 1 (10/27-11/2) through period 2 (11/3-9)

Probability of recapture 10/24-12/14: Hatchery fish = 0.0011307
Wild Fish = 0.0010187

*Adjusted for postrelease mortality rate of 4.5% as determined by 14-day survival tests conducted on members of this stocking, 1974

**Includes only recaptures from conventional sampling gear (e.g., beach seines, bottom trawl, box traps, and epibenthic sled). All recaptures of hatchery fish from every source, including those taken at power-intake screens, are summarized in Appendix B.

†Adjusted for postrelease mortality rates as follows: August, 7%; September, 0%; based on 1973 tests of wild striped bass young-of-the-year.

Table VI-7

Comparison of Mean Total Lengths of Stocked Hatchery-Reared Vs Wild Striped Bass Fingerlings, 1974

Date	Mean Total Length (mm)	
	Wild*	Hatchery
8/4-10	58.6	57.9
9/15-21	72.9	104.1
9/22-28	80.3	115.3
9/29-10/5	81.6	100.3
10/13-19	83.2	105.9
10/27-11/2	82.6	102.9

*Computed from standard-station beach-seine samples, RM 42.

Assuming that the probability of recapture of hatchery fish is equal to that of wild fish, as indicated by the 1974 data, an additional method can be used for estimating relative survival (Paulik and Robson, 1969):

$$\frac{S_h}{S_w} = \frac{R_h}{M_h} \Big/ \frac{R_w}{M_w}$$

where

M_h = number of marked hatchery fish released

M_w = number of marked wild fish released

This equation is essentially a comparison of the capture rates (0.0011307/0.0010187) and yields a ratio of 1.109, which indicates approximately equal survival rates for hatchery-reared and wild fish.

During 1974, three hatchery-reared striped bass stocked in fall 1973, were recaptured compared with 21 fin-clipped wild striped bass. The lower probability of capture (number of marks caught divided by number of marks in the population) observed for hatchery fish (Table VI-8) may have been due to many factors including better avoidance of collection gear by hatchery fish, a higher emigration rate of hatchery fish from the area of the estuary sampled, or a lower survival rate of hatchery fish compared with wild fish. Hatchery-reared fish also showed a lower probability of capture (Table VI-8) in fall 1973 (Texas Instruments Incorporated, 1974), which was attributed to gear avoidance. There were too few recaptures during comparable time intervals in 1974 to estimate reliably the relative overwinter survival of hatchery-reared and wild fish.*

Table VI-8

Probability of Capture in 1973 and 1974 for Hatchery-Reared and Wild Striped Bass Fin-Clipped and Released during September-November 1973

	Wild	Hatchery-Reared
No. marked (M), 1973*	14,339	27,778
No. recaptured (R), 1974	21	3
Probability of capture (R/M), 1974	0.0014645	0.0001079
Probability of capture, 1973†	0.0073780	0.0003595

*Adjusted for postrelease mortality as determined by 14-day survival tests and for recaptures of marked fish removed from population.

†From 1973 Hatchery Annual Report.

*For a complete listing of recaptured wild and hatchery-reared striped bass, including collection dates during 1974, refer to Appendixes B, C, and D.

SECTION VII
INTENSIVE CULTURE

A subsidiary objective of the 1974 hatchery program was to review intensive culture of striped bass conducted by various agencies. Intensive culture experiments using Hudson River striped bass were conducted by Auburn University and Southern Illinois University (subcontracted by UMA Engineering Pacific, Incorporated for Consolidated Edison); their results are summarized from letter reports submitted to Consolidated Edison. Texas Instruments Incorporated (TI) also reared striped bass using intensive-culture techniques to produce fingerlings for its striped bass relative contribution study and for distribution to specified agencies for experimental purposes. Results and observations of TI's intensive-culture program are presented and discussed.

A. AUBURN UNIVERSITY

Hudson River striped bass larvae were utilized by Auburn University in tests to determine the effects of different feeding regimes on the growth and survival of striped bass reared in intensive-culture systems. The following results were summarized from letter reports submitted to Consolidated Edison by Braid, 1975.

On 5 June 1974, 500,000 larvae 3 to 6 days old were sent to Auburn University from the Texas Instruments hatchery at Verplanck, New York. Shipping mortality during the 8-hr trip was high (60%), which may have resulted from an increase in water temperature during transport; water temperature in the shipping containers increased from 64°F when the larvae were packaged to 76°F upon arrival at Auburn. At Auburn, the larvae were acclimated to the 77°F holding water for 1.75 hr, after which different-aged larvae were mixed together and distributed randomly into 12 aquaria. The

water supply to the aquaria was recirculated from a concrete reservoir after passing through a charcoal-floss filter. High mortality continued for 6 to 8 hr after arrival at Auburn.

On 7 June, enough synthetic sea-salt mix to produce a salinity of 10 $^{o}/oo$ was added to the water reservoir over a 2-hr period and the following food then adminstered to the larvae: live brine shrimp nauplii, freeze-dried brine shrimp, ground Purina Trout Chow, and Chinook Swim-Up Fry Starter. Larvae were fed live brine shrimp seven times a day at 3-hr intervals; dry food was dispensed approximately nine times per day. Cannibalism due to mixing of larvae of different ages and sizes was first observed on 8 June and was a serious problem throughout the experiment.

A total of 895 post yolk-sac larvae survived until 24 June when the experiment was terminated. Estimates of stocking density and survival were not possible since the numbers of larvae originally stocked were calculated from numbers of dead and surviving larvae, thus not taking into account those removed by cannibalism. Live brine shrimp nauplii were the most readily accepted food, resulting in a ratio of live to dead larvae of 0.45 and a mean total length of 11.2 mm after 18 days of culture. Survival on dry food was much lower, and the post yolk-sac larvae produced were small. The Chinook Starter was the most successful dry food, producing a live/dead ratio of 0.12 and a mean length of 6.1 mm. The freeze-dried brine shrimp provided a 0.02 live/dead ratio and an average length of 7.1 mm, while Purina Trout Chow yielded only a 0.005 ratio and an average length of 5.8 mm. Surviving fingerlings were used in an attempt to establish a striped bass tissue culture for virus research (Braid, 1975).

B. SOUTHERN ILLINOIS UNIVERSITY

Southern Illinois University utilized Hudson River striped bass larvae from TI's Verplanck hatchery for high-density tank culture experiments.

The primary objective was to evaluate four different types of holding facilities, two water sources, and different feeding regimes. The results of these experiments are summarized from letter reports submitted to Consolidated Edison by Lewis and Heidinger, 1975.

A total of 3,240,000* larvae were sent to Southern Illinois University in two shipments: 2,240,000 on 31 May and an additional 1,000,000 on 5 June. Shipping mortalities averaged 10%. Approximately 90,000 larvae (1300 larvae/ft^3 of water) from the first shipment were stocked into each of five 10-ft diameter redwood tanks, each filled with water to a depth of 12 inches. These tanks were supplied with 1 to 2 gpm of pond water initially rich in zooplankton. At 23 days of age, accumulated mortality was 30%; when the larvae were 24 days old, a weather change produced high water temperatures which, in combination with the high pH (8.5-9.1), produced high levels of un-ionized ammonia (0.13-0.78 ppm), causing complete mortality. At this time, the larvae ranged in length from 10 to 15 mm (UMA Engineers, 1974; Lewis and Heidinger, 1975).

An additional 180,000 larvae from the first shipment were used for feeding studies to determine the age at which larvae accept dry feed. These larvae were stocked into 10 aluminum raceways (10 ft x 20 inches) supplied with 1 gpm of filtered sterilized pond water. Two replicates of the following feeding regimes were used for 2 weeks:

(1) Brine shrimp nauplii only
(2) Abernathy Starter only
(3) Brine shrimp 3 days, then Abernathy Starter
(4) Brine shrimp 6 days, then Abernathy Starter
(5) Brine shrimp 9 days, then Abernathy Starter

Total mortality had occurred in groups 2, 3, and 4 (a total of 108,000 larvae) after the larvae were 21 days old. Total mortality in one of the group-5 raceways occurred when the larvae were 13 days old; this raceway was subsequently restocked with 2000 larvae. Larvae in the other raceway

*Lewis and Heidinger (1975) reported receiving a total of 3,000,000 larvae in the two shipments.

in group 5 and both raceways in group 1 appeared healthy and had exhibited only 1 to 2% mortality per day at 22 days of age when they ranged from 5 to 9 mm in length; however, when these larvae were 24 days old, total mortality occurred as a result of a weather change which altered water quality.

Additional feeding experiments were conducted with 90,000 larvae from the first shipment. These fish were held in aquaria and fed four times daily. At the end of the study, 450 fish 3 to 4 inches in length were stocked in a small pond for future observations.

Each of 12 fiberglass tanks 6 ft in diameter was stocked with 90,000 larvae from the first shipment; total mortality, which was attributed to a toxic level of resin from the new tanks, occurred in all but one of these tanks within 4 days. Each of 10 tanks was restocked with 90,000 larvae from the second shipment; within 7 days, complete mortality occurred in five tanks and 50% mortality in the remaining tanks. On 2 August 1974, a total of 1454 fingerlings (approximately 1 inch in length) were redistributed into five of the fiberglass tanks; on 20 September, 1233 fingerlings (approximately 4 inches in length) were recovered and stocked in Crab Orchard Lake, a 7000-acre reservoir located in Williamson County, Illinois (Lewis and Heidinger, 1975).

Lewis and Heidinger (1974) concluded that striped bass are highly adaptable to intensive-culture techniques. The fingerlings, after reaching 20 to 30 mm, exhibit good utilization of artificial food and high survival and good growth in tanks or raceways. The importance of feeding live food (brine shrimp nauplii) to post yolk-sac larvae was acknowledged, but it was theorized that poor survival and growth at this stage were due primarily to difficulty experienced while feeding in a current produced by only 1 to 2 gpm.

C. TEXAS INSTRUMENTS INCORPORATED

Texas Instruments Incorporated (TI) reared striped bass at the Verplanck hatchery in both aquaria and pool intensive-culture facilities.

Larvae from different roe batches (i.e., different females) were reared in aquaria through the post yolk-sac stage to observe growth and determine the percent occurrence of uninflated gas bladders at this stage of development.* Larval offspring from a cross between one female and one male also were raised to fingerling size (≥1 inch) in two small pools for the TI striped bass relative contribution study. Data taken pertained to growth, survival, gas-bladder inflation, and stomach contents of both aquarium- and pool-cultured fish (Appendixes E and F, respectively).

1. Aquarium Culture

a. Methods

From 23 May to 30 June, larvae from portions of six roe batches were reared in 18 (20-gal.) aquaria supplied with quarry water (63-75 F), pH 8.75) at a flow rate of 1 to 2 gpm. Number of larvae per aquarium ranged from 1000 to 100,000. When the larvae were 5 days old, they were fed brine shrimp nauplii at a rate of ≥20 nauplii per larva every 3 hr. Feeding behavior, stomach contents, and gas-bladder inflation were observed by examining ≥10 larvae per aquarium every 3 days. Throughout the rearing period, yolk-sac and post yolk-sac larvae (a total of 2100) were periodically removed from the aquaria and provided to New York University for hydrostatic pressure tests.

b. Results and Observations

Large numbers of larvae in the aquaria (up to approximately 90%) were observed to be actively feeding when 1 week old. At 2 to 4 weeks of age, stomachs of 57% of all larvae examined were visually estimated to be more than 20% full. Cannibalism was not observed among the fish examined for feeding; however, after deliberate searching through all aquaria, at least one cannibal was found.

*Stevens (1973) observed Hudson River striped bass fingerlings with high incidences (up to 20%) of uninflated gas bladders accompanied by abnormal spinal curvature and vertical orientation. McIlwain (1974) also reported this abnormality.

In the majority of the aquaria, larvae showed a growth rate of approximately 0.5 mm/day, which was apparently independent of initial rearing density. Samples of 28-day-old larvae had mean total lengths of 12 to 16 mm, and the range of total lengths of larvae 31 to 32 days old was 13.5 to 24.0 mm. Lengths of 28-day-old wild Hudson River striped bass larvae captured on 27 June 1974 ranged from 7 to 15 mm.

Of all fish sampled, 16% had inflated gas bladders; 21% of the 4-week-old post yolk-sac larvae had inflated gas bladders. However, larvae without inflated gas bladders were observed to be less active and tended to remain near the surface where they were more likely to be captured during periodic dip-net sampling than were the more active larvae which did have inflated gas bladders. This factor may have biased the estimates of percent occurrence of larvae with uninflated vs inflated gas bladders.

Between roe batches, survival of yolk-sac larvae varied, with initial accumulated mortality ranging from 5 to 75% after 5 to 8 days; after that time, however, mortality leveled off to < 5%/day. Massive die-offs began when the larvae were 3 to 4 weeks old; at that time, total mortality occurred within 3 days in each aquarium except one. The single aquarium which produced survivors was supplied with a water flow of 5 to 6 gpm (three times the flow supplied to the other aquaria), indicating that mortality in the other aquaria may have been caused by chronic levels of un-ionized ammonia due to the high pH and low turnover at the bottom of aquaria where dead nauplii, larvae, and excrement accumulated. Aquarium culturing of surviving larvae continued for 90 days, at which time 91 fingerlings were harvested and given to the TI relative-contribution study.

2. Pool Culture

a. Methods

A total of 100,000 12-day-old striped bass larvae from a specific male-female cross were transferred from holding aquaria to a metal vinyl-lined

pool at the Verplanck hatchery to be reared to fingerling size for the TI relative-contribution study. The pool-culture facilities consisted of a 12-ft-diameter culture pool and a 15-ft-diameter reservoir pool. Quarry water treated with Nektonic Marine Mix to produce a salinity of 2.0 $^{o}/oo$ was circulated between the culture and reservoir pools and through an activated carbon filter at 2 to 3 gpm. Water entering the culture pool was directed to maintain a circular current at the periphery of the pool. The water was changed in the culture system once per week. Throughout the culturing period (12 June-25 September), the water source and flow rate were modified to maintain acceptable water quality. Because of suspected high levels of unionized ammonia resulting from the high pH (8.75) of the quarry water, river water was substituted for quarry water when the larvae were 28 to 30 days old. When the larvae were 62 days old, the system was converted from recirculating to flow-through river water (5 gpm), utilizing the reservoir as a settling tank; however, the water remained turbid during the remainder of the culturing period as the flow was gradually increased to 10 gpm. Salinity ranged from 0.5 to 4.0 $^{o}/oo$, and temperature varied from 63 °F to 84 °F (75 °F mean) throughout the culture period.

The larvae were fed newly hatched brine shrimp nauplii (*Artemia* sp.) every 3 hr at a rate of ≥60 nauplii per larva until the fish were 59 days old; from 59 to 83 days of age, the rate was ≥250 nauplii per fish at 3-hr intervals during daylight. In addition, post yolk-sac larvae were started on Tetra-Min (floating high-protein dry-flake food) when they were 25 days old. Initially, an automatic feeder delivered at 0.5-hr intervals a ration of food that could be completely consummed in 1 to 2 min. After the fish were 59 days old, the feeder delivered this same ration every 10 min. Fish were also hand-fed twice daily in an attempt to satiate the appetites of both aggressive and nonaggressive fish. From 83 to 118 days of age, the larvae were fed frozen adult brine shrimp twice daily as a supplement to the Tetra-Min. Feeding behavior was observed throughout the rearing period, and larvae were periodically sampled to record growth data.

When the fish were 44 to 47 days old (20 to 25 mm long), the density in the pools was reduced by transferring approximately 25,000 fingerlings (half the estimated total) to a duplicate culture system.

When the larvae were 90 to 91 days old, they were graded with a floating minnow grader into three size classes in an attempt to limit cannibalism. The largest 151 fingerlings (≥70 mm in total length) were removed for the relative-contribution study, and 31 of these were eventually culled due to abnormalities such as uninflated gas bladders and spinal curvature. Fingerlings in the remaining size categories (≥70 mm, 70-54 mm, and <54 mm) were placed in separate culture pools for continued rearing.

b. Results and Observations

Approximately 6000 fingerlings, 1.5 to 2.5 inches in length, were harvested from the culture pools and shipped to various research agencies (Table VII-1). The production return from larvae to fingerlings was 6%.

Table VII-1

Age, Number, Size, and Utilization of Striped Bass Fingerlings Harvested from Intensive Culture Facilities at Verplanck, New York, 1974

Age (days)	No.	Size (xTL)	Receiving Agency	Utilization
83	3000	40 mm	NYOSL	Cage culture experiments
90	151*	92 mm	TI	Relative contribution study
106	900	64 mm	S&W	Flume studies
106-110	925	≈50 mm	NYU	Thermal plume studies at Indian Point
118	1000	≈75 mm	S&W	Flume studies
Total	5976			

*Suspected cannibals that were graded out and killed; 38 were examined for abnormalities and stomach contents. The balance of the 200 fingerlings due to the relative contribution study was made up of the 91 fingerlings (roe batch 26) that survived in the aquaria culturing

Striped bass larvae reared in the pool-culture facilities showed uniform growth, as indicated by plotting mean total length with age (Figure VII-1). Larvae adapted readily to ingesting Tetra-Min but rejected Purina Trout Chow (size No. 1). Unlike other dry food, Tetra-Min had the added value of floating or very slowly sinking until being consumed, thus reducing contamination of the water. The circular current in the culture tank appeared to be beneficial due to its effect on schooling and feeding behavior; from the post yolk-sac through the fingerling stages, a high proportion of the fish constantly swam against the current and fed as a school. Cannibalism proved eventually to have a significant impact on survival (Figure VII-2). Although the total number of obvious cannibals was low (151 fish ≥70 mm), removal by grading at 90 days of age apparently was not early enough to prevent high losses.

D. DISCUSSION

Extensive (pond) culture conducted recently by some hatchery facilities has produced highly successful results: Edenton National Fish Hatchery, for example, achieved production returns of 30% during the rearing of Phase-I (2-inch) fingerlings and 80% during the rearing of Phase-II (>2-inch) fingerlings using extensive-culture techniques (Gruenthal, 1974). Generally, production returns achieved by intensive (tank or pool) culture are lower; however, the Gulf Coast Research Laboratory (GCRL), which has intensively cultured striped bass for 4 years, has achieved extremely successful production returns of 3.6 to 13.7% for Phase-I rearing and 25.8 to 70.8% for Phase-II rearing using various striped bass stocks (McIlwain, 1974).

Intensive-culture programs conducted by Auburn University and the University of Southern Illinois, although hampered by shipping mortality and equipment problems, confirmed existence of known problems such as cannibalism and requirements such as feeding of live food to larvae.

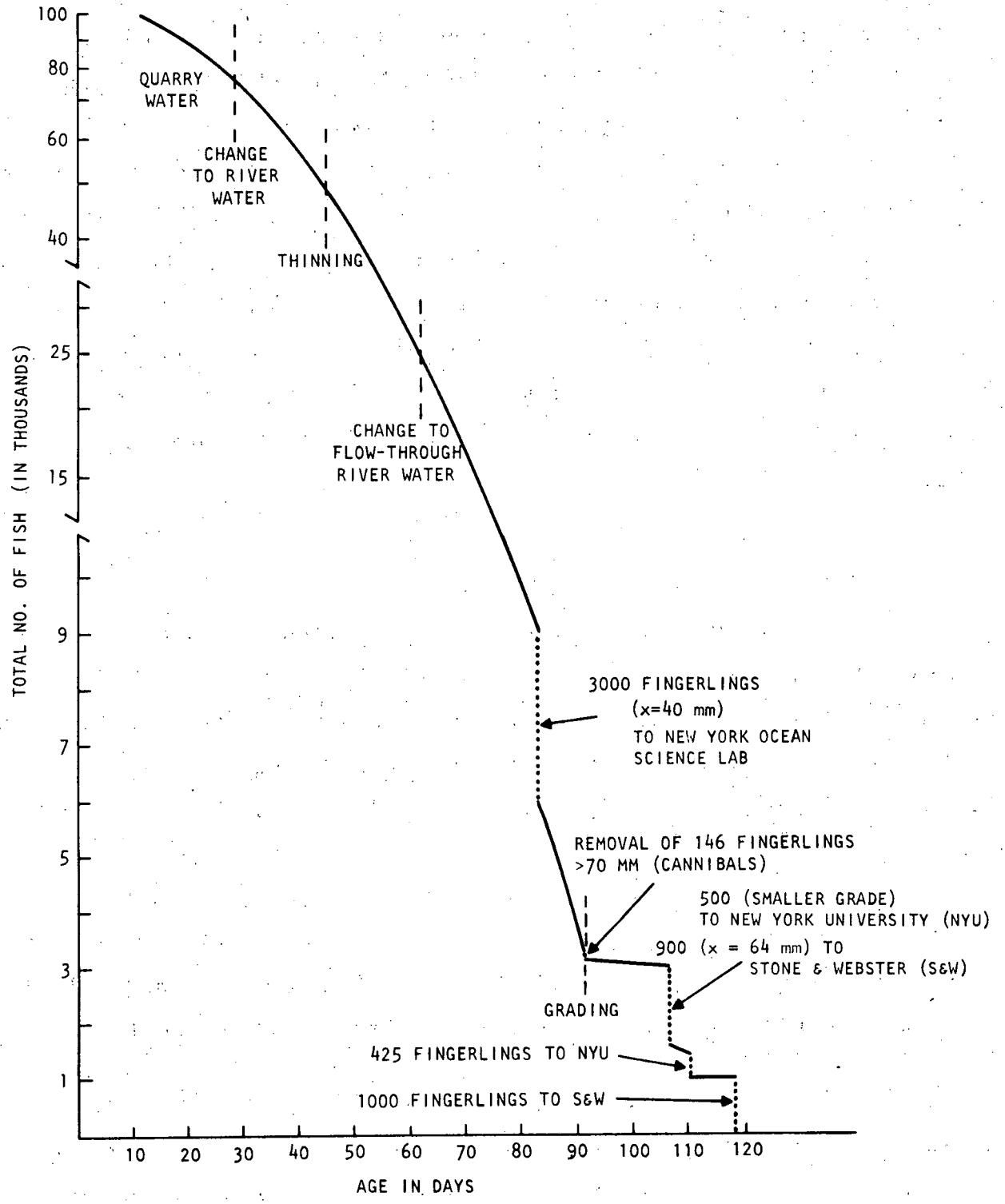

Figure VII-1. Survival and Harvest of Striped Bass Reared in Pool-Culture Systems at Verplanck, New York

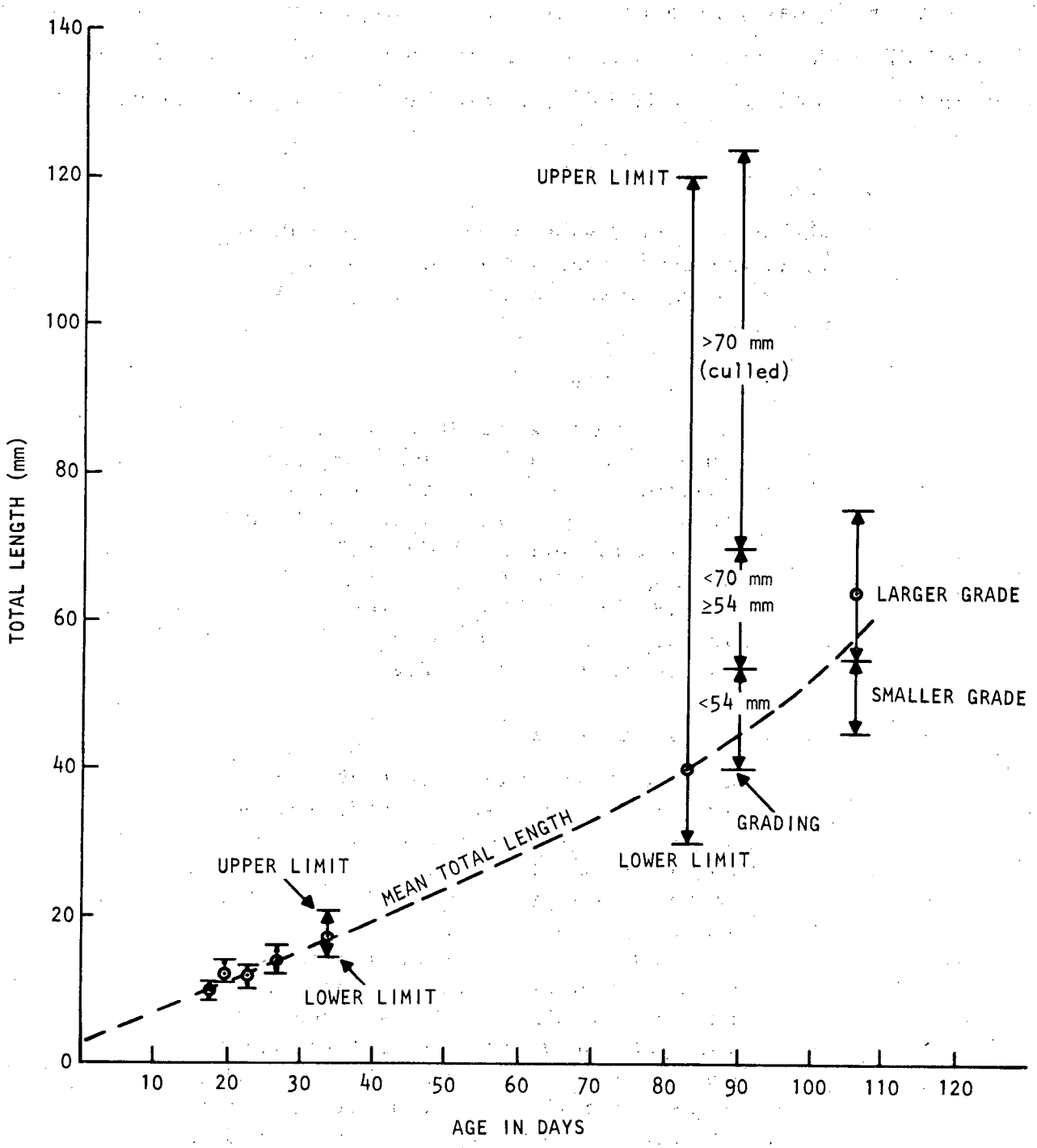

Figure VII-2. Growth (Mean Total Length/Time) of Pool-Cultured Striped Bass at Verplanck, New York

Intensive culture conducted by TI, which yielded a 6% production return after 118 days, produced results and findings similar to those reported by the GCRL. The following are conclusions regarding growth requirements and critical factors for survival determined from TI and GCRL work.

- Growth

  The production of even-sized fingerlings through uniform growth resulted from improvements in culture techniques. Recent success has been associated with:

  (1) Circular Current

  Post yolk-sac larvae through fingerling-size striped bass exhibit natural schooling behavior when there is a steady current to swim against. Food can be more evenly distributed to a moving school of fish than to dispersed individuals, and the promotion of schooling behavior also may reduce the potential for cannibalism.

  (2) Feeding Regime

  Excessive and frequent feeding (every 3 hr) of live brine shrimp nauplii (≈500 naupliii/larva/day) apparently satisfies the requirements of yolk-sac larvae and post yolk-sac larvae up to 20 mm. Transition from reliance on live brine shrimp nauplii to dry food or prepared mixtures is successfully accomplished by concurrently feeding both types of food to post-yolk-sac larvae for not less than 2 weeks. Floating dry-flake food crumbled to the appropriate size is more acceptable to larvae than commercial trout feed (size No. 1). Mixtures of trout feed and canned fish have also been accepted by larvae (McIlwain, 1974).

- Survival

  Two critical factors limiting survival have been identified:

  (1) Water Quality

  High levels of un-ionized ammonia resulting from high pH (>8.5), high density, and/or intensive feeding have been blamed for mortality. Research is needed to identify acute and chronic lethal levels of metabolites for the larval and juvenile stages of striped bass and to define acceptable water-quality criteria. Disease and parasitism have not been problems when a salinity of approximately 2 $^{o}/oo$ has been maintained (McIlwain, 1974).

  (2) Cannibalism

  Low survival has frequently been associated with early harvests of fingerlings ranging widely in length (indicative of cannibalism). Significant reduction in cannibalism has been accomplished by excessive and frequent feeding of live brine shrimp nauplii to post yolk-sac larvae up to 20 mm in mean length and by grading fingerlings >40 mm in length into size classes. Grading of fish 20 to 40 mm long has often failed due to the extreme and often fatal shock phenomenon exhibited by striped bass of this size (McIlwain, 1974). The development of effective and safe methods for grading this size fish is necessary to increase survival.

SECTION VIII

LITERATURE SURVEY OF STRIPED BASS CULTURE AND FISH-TAGGING TECHNIQUES

In conjunction with the 1974 hatchery program, an updated literature review of striped bass culture and fish-tagging techniques was prepared to supplement the summary and review of literature pertaining to striped bass artificial propagation presented in the 1973 hatchery report (Texas Instruments Incorporated, 1974).

A. HATCHERY SPAWNING TECHNIQUES

Development of the tank spawning technique (Bishop, 1974) is perhaps the most significant advance in striped bass culture since introduction of hormones to induce ovulation as currently used in the hand-stripping spawning method (Stevens, 1966; Bayless, 1972) described in Section III. The Tennessee Game and Fish Commission (Bishop 1974) evolved the tank spawning method from the hand-stripping method. In 1972, a male and an injected female striped bass brood fish were placed in a circular tank; the female spawned but fertilization did not occur. In 1973, injected males were placed in circular tanks with four injected females; three of the females spawned, and fertilization percentages were estimated at 60%, 65%, and 85%. Based on these results, Tennessee continued to refine their tank spawning techniques during 1974; the percent hatch for eight females that were allowed to spawn undisturbed ranged from 61.6% to 84.6%.

The basic tank spawning procedures used by the Tennessee Game and Fish Commission (Bishop, 1974) were as follows:

- Brood fish were collected with electrofishing gear to reduce stress, and female brood fish were injected with gonadotropin in the field to minimize handling

- One or two injected males were placed in a circular raceway with the female approximately 24 hr prior to the anticipated spawning time of the female. Greatest success was obtained from brood fish that were undisturbed, particularly at night, during spawning.
- After the eggs became water-hardened, the brood fish were removed and the eggs were allowed to hatch in the tank.

Advantages of tank spawning are that (1) many brood fish survive due to reduced handling and thus can be released; and (2) man-power requirements are also less than required for the hand-stripping method. Disadvantages are that (1) brood fish must be in excellent condition; and (2) to produce a large quantity of larvae, many tanks are needed so separate holding facilities can be provided for each female from the time of capture until larvae can be removed for shipping.

B. MARKING TECHNIQUES

A safe and efficient method of marking large numbers of small striped bass fingerlings is required since long-term identification of stocked hatchery-reared fish is necessary if their contribution to the wild Hudson River spawning population is to be determined.

The mass marking technique of administering a drug has proved effective but is impractical as a long-term mark since retention is short. Several investigators (Weber and Ridgeway, 1962; Choate, 1964; and Trojnar, 1973) have used various techniques to mark fish with tetracyclin drugs; adequate doses result in deposition of the drug in bones, teeth, and scales where it can be detected by fluorescence in photomicrographs. This marking technique has produced satisfactory short-term results when administered to fry and fingerling salmonids. Trojnar (1973) reported no loss of the initial tetracycline mark after 1 year when injected into rainbow trout held in the

laboratory; however, it is known that sunlight can deactivate tetracycline and a gradual loss of the mark could result in the field.

In studies reported by Fry et al (1960), a permanent mark was administered by injecting lead versenate (50 mg/kg body weight) into whitefish and lake trout, resulting in detectable lead deposits (rings) in the scale and bones. Mortality of injected fish was low and growth was not affected, but only relatively large fish (> 12 in. or 305 mm) were marked.

Experiments to develop an efficient mark for fry and small fingerlings have involved immersion in various types of stains. Watson (1970) marked juvenile American shad with Bismarch brown and reported high survival and good retention after 3 days. Renne and Deacon (1973) produced visible colors on the bases of the fins of the killifish, *Cyprinoden macularius*, which lasted for 3 to 4 days. This method appears effective for producing short-term mass marks on small fish.

Andrews (1972) had reasonable success in applying fluorescent pigments with a low pressure sandblast gun to fathead minnows: survival was good and the mark still detectable after 600 days in the laboratory. When Renne and Deacon (1973) used this technique with adult killifish in field studies, the mark was detectable after approximately 240 days.

Another method for marking fish with dyes utilizes a jet inoculator, an inexpensive dental tool which injects dye subdermally, producing a visible tatoo. Hart and Pitcher (1969) used the jet inoculator to mark a variety of species with Alcian blue and Indian ink; the marks were retained for up to 14 months in the laboratory and up to 12 months in the field. McIlwain and Christmas (1975) marked 80- to 150-mm striped bass fingerlings with Aniline blue with relatively few mortalities; marks were returned for up to 3.5 years after release in the field. This method may have potential as a long-term marking technique where returns depend on visible detection.

There are also several types of internal metallic tags which can be detected by magnets and magnetic-detecting devices. Using a specially designed gun, Kroger and Dryfoos (1972) injected ferromagnetic tags into the body cavity of adult and juvenile Atlantic menhaden. Mortalities and tag loss were relatively high for the juveniles (77 mm), but it was concluded that, once the tag is properly inserted, the surviving specimen has a permanent mark which can be detected.

In the hatchery program as described previously (Section V), Texas Instruments Incorporated (TI) employed the micromagnetic nose tag which has been used extensively at salmon hatcheries. Poor tag insertion and retention results (18%) during the 1973 hatchery program (Texas Instruments Incorporated, 1974) also initiated a search for a more effective method of long-term marking. After various tagging refinements administered during the 1974 hatching program,* however, the combined rates of nose-tag insertion and retention were increased to 82%.

*The major nose-tag refinement resulted because the nose-tag detection unit was found to be unreliable due to interference from plumbing and electrical agitators in the Edenton hatchery holding house; the nose tag wire had to be constantly observed as it advanced through the machine to determine if the nose tags were being inserted. Also, the machine had to be frequently cleaned which prevented jamming and improved the tagging technique.

SECTION IX

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APPENDIX A

PROPAGATION OF HUDSON RIVER STRIPED BASS AT VERPLANCK, NEW YORK, 1974

PROPAGATION OF HUDSON RIVER STRIPED BASS AT VERPLANCK, N.Y., 1974, TEXAS INSTRUMENTS ECOLOGICAL SERVICES, CON. EDISON CORNWALL PROJECT

CAPTURE / OVULATION

Female No.	Catch Location	Date/Time of Catch	Source	Transport/holding[1] Duration (hr.)	Resulting Condition	Approx.[2] Weight	Estimated[3] hours to Ovulation	Units Chorionic Gonadotropin Injected	Actual Ovulation Time After Injection	Temp. (°F.) at Ovulation	Date	Quantity of[8] Eggs Stripped	% of Total[4] Eggs Unviable	Method of Fertil-[5] ization Used	No. Males Used	%[6] Fert.	Tag #[7] Synoptic Subpop. Study
1	RM-44-3	5-16/0630	Commercial fisherman	1/2 / 0	fair	25 lb.	11	2500	34.0	59°	5-17	1,260,000	0	Simultaneous sperm water introduction	1	0	326
2	RM-42-1	5-18/0300	Scientific Collector's permit (T1)	1/12 / 0	good	20	5	2500	6.5	60°	5-18	1,600,000	23 unripe (on ovarian wall)	simultaneous, stored sperm	1	60	330
3	RM-42-1	5-20/1320	Collector's permit	1/6 / 0	good	18	10-11	2500	36.6	63°	5-18	2,430,000	0	dry	2	83	1664
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
4	RM-42-1	5-17/1200	Collection permit	1/6 / 0	fair	20	11-12	3000	missing on 5-19, 1200 hrs.		—	—	—	—	—	—	—
5	RM-42-1	5-20/1200	Collector's permit	1/6 / 0	good	18	10	3000	32.5	63°	5-21	2,300,000	1 unripe	dry	2	74	1661
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
6	RM-42-1	5-20/1300	Collector's permit	1/6 / 0	good	15	10-11	2500	32.0	63°	5-21	1,678,000	3 unripe	dry, wet, simultaneous	3	71	1662
7	RM-42-1	5-20/1310	Collector's permit	1/6 / 0	good	22	10	2500	35.0	63°	5-21	1,580,000	1 unripe	dry	2	72	1663
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
8	RM-42-1	5-22/night	Collector's permit	1/4 / 0	good	15	9	3000	23.0	63°	5-24	1,600,000	2% over-ripe	semi-dry	2 (poor)	0	—
9	RM-42-1	5-22/0930	Collector's permit	1/16 / 0	good	25	9	4000	19.5	63°	5-23	(spawned in pool)	—	—	—	—	—
10	RM-42-1	5-22/0945	Collector's permit	1/4 / 0	fair	15	10	2500	28.0	63.5°	5-23	1,800,000	0	dry	3	88	—
11	RM-42-1	5-22/1430	Collector's permit	1/4 / 0	fair	15	13-14	2500	40.5	63.5°	5-24	1,000,000	20% over-ripe	dry	2	40	—
12	RM-42-1	5-22/1430	Collector's permit	1/4 / 0	fair to poor	20	10	3000	25.5	63.5°	5-23	1,200,000	0	dry + simultaneous	2	72	—
13	RM-42-1	5-22/1430	Collector's permit	1/4 / 0	good	18	8-9	2500	spawned in pool		—	—	—	—	—	—	—
14	RM-43-3	5-22/1930	Collector's permit	1 / 0	fair	30	4-6	3500	20.5	63.5°	5-23	600,000 (fish became sick)	70% unripe	dry	1	1	—
15	RM-42-1	5-23/0400	Collector's permit	1/4 / 0	fair	20	7	2500	10	63.5°	5-23	800,000	0	dry	2	98	—
16	RM-42-1	5-23/0300	Collector's permit	1/4 / 0	fair	20	12	2500	missing on 5-24		—	—	—	—	—	—	—
17	RM-42-1	5-23/0300	Collector's permit	1/4 / 0	good	30	13	3000	47	63.5°	5-25	1,600,000	5% unripe	dry	3	60	—
18	RM-43-3	5-23/0945	Collector's permit	1/5 / 0	fair	20	10	2500	died after 26 hrs. and center ovulating		—	—	—	—	—	—	381
19	RM-59-3	5-24/0400		1 / 3.5	good	20	10	2500	died after 10 hrs.		—	—	—	—	—	—	382
20	RM-58-1	5-24/0400	Collection permit	1 / 3.5	good	20	10	2500	died after 16 hrs.		—	—	—	—	—	—	—
21	RM-42-1	5-24/0400	Collector's permit	1/4 / 5.5	fair to poor	20	10	2500	died 18.5 hrs. after injection		—	—	—	—	—	—	—
22	RM-42-1	5-24/0400	Collector's permit	1/4 / 6	fair	20	10-11	2500	28	63.5°	5-25	1,800,000	10% white	dry	3	93	383
															(200 eggs given to A. Beck, N.Y.U. Pressure Studies)		
23	RM-42-1	5-24/1000	Collector's permit	1/4 / 1/2	fair	20	11-12	2500	35.5	63.5°	5-25	780,000	10 unripe	dry	2 (poor)	79	
24	RM-42-1	5-25/2300	Collector's permit	1/4 / 0	good	15	10-13	2500	25.5	64.0°	5-27	800,000	0	dry	1	88	384
															(200 eggs given to A. Beck, N.Y.U. Pressure Studies)		
25	RM-42-1	5-26/0400	Collector's permit	1/4 / 5	fair	10	15+	2000	fish died 38 hrs. after injection		—	—	—	—	—	—	—
26	RM-44-3	5-26/2300	Commercial fisherman	1/5 / 0	fair	15	12-13	2500	35.5	64.0°	5-28	1,000,000	5 unripe	dry	1 (#389)	92	387
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
27	RM-42-1	5-26/2330	Collector's permit	1/4 / 0	good	15-20	9	2500	23.0	64.0°	5-27	800,000	0	dry	2	96	
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
28	RM-42-1	5-26/2400	Collector's permit	1/4 / 0	good	12-15	15+	2500	40.0	64.0°	5-28	800,000	5% over-ripe	dry	2 (1 poor)	61	1476
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
29	RM-42-1	5-26/2400	Collector's permit	1/4 / 0	good	12-15	15+	2500	STOLEN 48 hrs. after injection		—	—	—	—	—	—	—
30	RM-58-1	*	Collector's permit	2 / *	fair	25-30	9-10	3000	28.0	63.5°	5-30	1,400,000	0	dry	1	75	1488
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
											—	500,000	—	dry, river water	1	75	—
31	RM-42-1	5-27/0930	Collector's permit	1/6 / 0	fair	23	11-12	2500	33.0	63.5°	5-28	800,000	10 unripe	dry	2 (1 poor)	46	1478
32	RM-44-3	5-29/0400	Commercial fisherman	1/4 / 9.5	good	25	10	2500	45.0 (center only)	63.5°	5-31	400,000	80 unripe	dry	1	30	—
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
33	RM-58-1	5-29/0300	Collector's permit	2 / 8.5	fair	15	12-13	2000	33.5	63.5°	5-30	800,000	0	dry	2	65	—
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
34	RM-42-1	5-30/1230	Collector's permit	1/6 / 0	good	35	3-4	4000	14.0	63.5°	5-31	2,000,000	20% over-ripe	dry	2	60	—
															(100 eggs given to A. Beck, N.Y.U. Pressure Studies)		
35	RM-42-1	5-31/0330	Collector's permit	1/4 / 19	good	15	12	—	died 6-3 after progressing to 8 hr. stage		—	—	—	—	—	—	ED 1403
36	RM-58-1	5-31/0400	Collector's permit	1 / 6	fair	15-20	15	—	ineligible, returned to river		—	—	—	—	—	—	—

HATCHING / DISPOSITION / STOCKING/UTILIZATION

Female No.	Temp. (°F) at Hatching	Hatching Time (hrs. after Ovulation)	Date of Hatch	Quantity[9] of Larvae	% Hatch[10] of Stripped Eggs	Quantity Shipped	Date	Age of Larvae (hrs.)	Temp. (°F) Shipping Water	Temp. (°F) Shipping Water at Arrival	Acclimation Temp. (°F)	Shipping Mortality	Total Mortality After 24 hours	Recipient	Utilization or Site of Stocking	Date	Number Stocked	Size
1	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—
2	63.0°	55.0	5-20	60,000	4	60,000	5-25	111	63.5°	73.0°	73°	10%	15-20%	Welaka, Fla.	Choctauhatchee R., Fla.	July '74		
						(100 given to A. Beck, N.Y.U. Pressure studies)												
3	63.0°	51.0	5-24	1,600,000	64	1,600,000	5-25	27	63.5°	73.0°	73°	10%	15-20%	Welaka, Fla.	Choctawhatchee R., Fla.	July '74		
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	63.5°	50.0	5-23	1,590,000	69	900,000	5-27	83	63.5°	73.0°	73°	20%	30-35%	Welaka, Fla.	Choctawhatchee R.	July/Sept. '74		
						500,000	5-28	107	64.0°	67.0°	64°	5%	20%	Edenton, N. Car.	Hudson River, RM25 to RM61	Aug./Oct. '74	8,300/ 72,913	2"/ 4-6"
6	63.0°	51.5	5-24	704,000	42	600,000	5-28	103	64.0°	67.0°	64°	5%	25%	Edenton, N. Car.	Hudson River, RM25 to RM61	Aug./Oct. '74	20,311/	2"/
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)									Tar R., N. Carolina	Nov. '74		
7	63.0°	51.0	5-24	1,410,000	89	540,000	5-27	80	63.5°	73.0°	73°	20%	30-35%	Welaka, Fla.	Choctawhatchee R.	July '74	534,000	1000/lb.
						(6,500 retained at Verplanck for study, 600 given to A. Beck, N.Y.U. Pressure Studies)											Total, Roes 2, 3, 5, 7	
8	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	63.5°	48.0	5-25	900,000	50	500,000	5-28	67	64.0°	67°	65°	40%	40%	Durant, Okla.	Lake Texoma	*	—	—
						300,000	5-31	138	64.0°	63°	*	*	5%	Univ. S. Illinois	for culture experiments	—	—	—
						(10,000 retained at Verplanck for study)												
11	63.5°	50.0	5-26	300,000	30	100,000	5-30	104	63.5°	—	—	—	—	Univ. Rhode Island	for lab experiments	—	—	—
12	63.5°	46.0	5-25	700,000	60	200,000	*	*	63.5°	*	*	*	*	Q.L.M.	for lab experiments	—	—	—
						80,000	*	*	63.5°	*	*	*	*	N.Y.U.	Indian Pt. Dye experiments	—	—	—
						(5,000 retained at Verplanck for study) (200 larvae given to A. Beck, N.Y.U. Pressure Studies)												
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	63.5°	—	—	—	0	—	—	—	—	—	—	—	—	—	—			
15	63.5°	46.0	5-25	784,000	98	700,000	5-30	107	64.0°	65°	68°	*	80%	Durant, Okla.	Lake Texoma	*		
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)												
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—				
17	63.5°	47.0	5-27	800,000	50	800,000	5-31	100	63.5°	63°	*	35%	80-90%	Univ. S. Illinois	for culture experiments			
						(300 larvae given to A. Beck, N.Y.U. Pressure Studies)												
18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
22	63.5°	48.0	5-27	900,000	50	300,000	5-30	60	64.0°	65°	68°	<2%	2-5%	Durant, Okla.	For Stone & Webster flume studies and TI studies			
						500,000	5-31	91	63.5°	*	*	5%	*	Univ. S. Illinois	for culture experiments			
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)												
23	63.5°	48.0	5-27	640,000	80	640,000	5-31	83	63.5°	*	*	5%	*	Univ. S. Illinois	for culture experiments			
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)												
24	64.0°	47.5	5-28	640,000	80	640,000	5-31	69	63.5°	64°	62°	40%	50%	Durant, Okla.	Lake Texoma, Stone & Webster flume and TI studies			
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)												
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
26	64.0°	49.0	5-30	877,000	90	300,000	5-31/6-1	27	63.5°	64°	62°	<2%	2-5%	Durant, Okla.	Lake Texoma, Stone & Webster flume and TI studies			
						400,000	6-3/6-4	100	64.0°	*	*	*	*	Durant, Okla.				
						(177,000 retained at Verplanck for study, 200 larvae to A. Beck, N.Y.U. Pressure Studies)												
27	64.0°	48.0	5-29	720,000	90	600,000	6-3/6-4	112	64.0°	*	*	*	*	Durant, Okla.	Lake Texoma			
						(15,000 retained at Verplanck for study, 400 larvae to A. Beck, N.Y.U. Pressure Studies)												
28	64.0°	48.0	5-30	400,000	50	80,000	6-6	—	64.0°	*	*	*	*	N.Y.U.	Indian Pt. dye experiments			
						(100,000 retained at Verplanck for study, 400 larvae to A. Beck, N.Y.U. Pressure Studies)												
29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
30	63.5°	49.0	6-1	1,050,000	75	500,000	6-5	86	64.0°	*	*	*	*	Univ. S. Illinois	for culture experiments			
						100,000	6-5	86	64.0°	76°	77°	*	*	Auburn Univ.	for culture experiments			
						400,000	6-3/6-4	44	64.0°	*	*	*	35%	Durant, Okla.	Stone & Webster flume and TI studies			
	—	—	6-1	375,000	75	375,000	5-30	(as eggs)	—	—	—	—	—	N.Y.U.	Indian Pt. dye experiments			
31	63.5°	50.0	5-30	320,000	40	100,000	6-5	130	64.0°	76°	77°	*	*	Auburn, Univ.	for culture experiments			
						100,000	6-5	130	64.0°	*	*	*	*	Univ. S. Illinois	for culture experiments			
32	63.5°	48.5	6-2	120,000	30	100,000	6-5	80	64.0°	*	*	*	*	Univ. S. Illinois	for culture experiments			
33	63.5°	50.0	6-2	480,000	60	100,000	6-5	80	64.0°	76°	77°	*	*	Auburn Univ.	for culture experiments			
						300,000	6-6	103	64.0°	*	64°	*	50%	Edenton, N. Car.	Tar R., N. Carolina	Jul/Nov '74	154,299	2-6"
						(100 larvae given to A. Beck, N.Y.U. Pressure Studies)											Total, Roes 5,33	
34	63.5°	49.0	6-2	657,000	40	300,000	6-5	79	64.0°	*	*	*	*	Univ. S. Illinois	for culture experiments			
						100,000	6-3/6-4	35	64.0°	*	*	*	35%	Durant, Okla.	Stone & Webster flume and TI studies			
						200,000	6-5	79	64.0°	76°	77°	*	*	Auburn Univ.	for culture experiments			
						40,000	6-6	*	64.0°	*	*	*	*	N.Y.U.	Indian Pt. dye experiments			
						(16,500 retained at Verplanck for study, 300 larvae to A. Beck, N.Y.U. Pressure Studies)												
35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			

Summary

36[11]	Total number females captured for propagation
3	Females missing or stolen
6	Females that died before ovulation
34	Total number of females that were injected
24	Total number of females that successfully ovulated
21	Total number of females that produced larvae

710	Approx. total weight of females caught for propagation
490	Approx. total weight of females successfully ovulated
420[12]	Approx. total weight of females producing larvae

31,328,000	Total, eggs stripped for hafthing
1,400	Total, eggs used in N.Y.U. Pressure Studies
46	Total male uses
35	Total number of males used
63	Average % fertilization
16,027,000	Total, larvae hatched out
51	% Hatch of total eggs stripped
55	Average % Hatch

8,440,000	S. Total, larvae shipped for fingerling production
4,615,000	S. Total, larvae shipped for culture & lab experiments
330,000	S. Total, larvae retained at Verplanck for study, of these, 2100 larvae & fry given to N.Y.U. Pressure Studies
1,000	S. Total, larvae retained at Verplanck, N.Y.U. Pressure Studies
13,386,000	TOTAL NUMBER LARVAE UTILIZED

Total fingerlings stocked in Choct. R.	534,000
Total fingerlings stocked in L. Texoma	339,000
Total fingerlings stocked in Tar R.	154,299
Total fingerlings stocked in Hudson R.	101,524
Grand Total	1,129,051

FOOTNOTES

[1]Holding duration: time between delivery of fish after transport and injection.
[2]Weights were approximated to lessen handling and subsequent mortality.
[3]Estimated hours to ovulation: stated in South Carolina hours, meaning normal egg development at 66°F (Bayless, J.D., Artificial Propagation and Hybridization of Striped Bass, 1972, South Carolina Dept. Wildlife and Marine Resources).
[4]% of total eggs unviable; the sources of unviable eggs are: 1) Center ovulation—the center of the ovary only becomes ripe and the fish is mistakenly stripped, or the fish becomes sick and ovarian development ceases, hence in both cases, eggs are left attached to the ovarian wall (unripe). 2) A portion of the eggs become over-ripe, meaning the fish wasn't stripped soon enough; such eggs can be detected by slight magnification or very soon after placed in jars they become white. 3) White eggs: a certain portion of a female's eggs may be damaged or bad and come out white. Estimation of the percentages was by eye.
[5]Method of fertilization: simultaneous = sperm and water sprayed on eggs at the same time; Dry = sperm sprayed on eggs and then water sprayed with mixing action.
[6]% fertilization: computed after 12 hours by sampling eggs in hatching jars. As seen under 20X scope, normal cleavage indicates fertilization.
[7]Tag #, [illegible]: immediately after stripping, many females and some males were given to this study for blood, tissue, and scale samples. In some cases, the number of tag was not recorded for hatchery records.
[8]Quantity of eggs stripped: measured volumetrically before water hardening, 200,000/300 ml. beaker.
[9]Quantity of larvae: estimated volumetrically by comparing fertile eggs left after 24 hours (dead eggs flow out of jar) with original level of all eggs in the hatching jar. At that stage, most egg mortality has already occurred and almost all the fertile eggs left will hatch and become larvae.
[10]% Hatch of stripped eggs: computed from the estimations of eggs and hatched-out larvae.
[11]36-Total number of females captured for propagation: actually, more females were captured but these were deemed unsuitable (spent or ineligible for induced ovulation, or injured too greatly) and given to the [illegible] study.
[12]Stored at 4°C for 3 hrs.

*Data unavailable

services group

APPENDIX B

HATCHERY RECAPTURE DATA
JANUARY-DECEMBER 1974

Table B-1

Hatchery Recapture Data, April-September 1974

No.	Date	Time	RM	Site	Gear	Clip	Stocking Season	Ref.† Tag No.	Length (mm)	Weight (g)	Nose Tag	Remarks
1	4/ 2	----	42	3	Screens*	2nd dorsal	Fall 1973	R992	146	33.1	No	
2	4/ 6	----	42	3	Screens	2nd dorsal	Fall 1973	R989	138	26.6	No	
3	4/ 8	----	42	3	Screens	2nd dorsal	Fall 1973	R696	148	----	Yes	Dissection
4	8/20	2351	38	3	Beach seine	2nd dorsal	Summer 1974	R643	68	4.1	--	
5	8/21	0241	36	2	Epibenthic sled	2nd dorsal	Summer 1974	R1293	71	3.0	--	
6	8/21	0930	42	3	Screens	2nd dorsal	Summer 1974	R642	48	1.2	--	
7	8/26	1240	41	3	Box trap	2nd dorsal	Summer 1974	----	60	----	--	Fish lost back into river*
8	8/27	2100	40	3	Beach seine	2nd dorsal	Summer 1974	R628	62	2.7	--	
9	8/27	2100	40	3	Beach seine	2nd dorsal	Summer 1974	R629	67	3.8	--	
10	8/27	2100	40	3	Beach seine	2nd dorsal	Summer 1974	R632	61	2.4	--	
11	8/28	1335	42	1	Box trap	2nd dorsal	Summer 1974	R625	80	5.9	--	
12	8/30	1010	42	3	Beach seine	2nd dorsal	Summer 1974	R646	64	3.0	--	
13	9/30	1220	39	1	Beach seine	1st dorsal	Fall 1974	R679	100	11.1	Yes	

*Indian Point Power Plant †Ref. = reference

services group

Table B-2

Hatchery Recapture Data, October 1974

No.	Date	Time	RM	Site	Gear	Clip	Stocking Season	Ref. Tag No.	Length (mm)	Weight (g)	Nose Tag	Remarks
14	10/ 2	1945	39	1	Beach seine	1st dorsal	Fall 1974	R761	100	11.2	Yes	
15	10/ 3	2230	37	3	Epibenthic sled	1st dorsal	Fall 1974	R1147	122	21.8	Yes	
16	10/ 6	1340	42	3	Beach seine	1st dorsal	Fall 1974	R926	125	22.6	Yes	
17	10/ 7	2130	35	1	Beach seine	1st dorsal	Fall 1974	R740	117	19.3	Yes	
18	10/ 9	1355	35	3	Beach seine	1st dorsal	Fall 1974	R919	85	6.7	Yes	
19	10/ 9	1025	40	3	Beach seine	1st dorsal	Fall 1974	R939	109	14.4	Yes	
20	10/ 9	1025	40	3	Beach seine	1st dorsal	Fall 1974	R940	108	14.4	No	
21	10/10	1330	38	1	Beach seine	1st dorsal	Fall 1974	R988	131	21.6	No	
22	10/10	1515	40	3	Beach seine	1st dorsal	Fall 1974	R902	121	20.2	Yes	
23	10/14	1255	38	1	Beach seine	1st dorsal	Fall 1974	R827	77	4.6	Yes	
24	10/14	1255	38	1	Beach seine	1st dorsal	Fall 1974	R828	100	10.5	Yes	
25	10/14	1255	38	1	Beach seine	1st dorsal	Fall 1974	R829	84	6.0	Yes	
26	10/14	1450	38	1	Beach seine	1st dorsal	Fall 1974	R809	115	17.2	Yes	
27	10/15	1525	40	3	Beach seine	2nd dorsal	Summer 1974	R953	83	5.8	--	Nose tag not used
28	10/15	0520	42	3	Epibenthic sled	1st dorsal	Fall 1974	R1269	125	23.5	Yes	
29	10/15	1400	42	3	Beach seine	1st dorsal	Fall 1974	R895	125	18.5	Yes	
30	10/15	1400	42	3	Beach seine	1st dorsal	Fall 1974	R896	112	14.1	Yes	
31	10/15	0406	43	2	Epibenthic sled	1st dorsal	Fall 1974	R1021	136	25.7	No	
32	10/16	0030	40	3	Beach seine	1st dorsal	Fall 1974	R957	114	16.5	Yes	
33	10/16	0318	39	2	Epibenthic sled	1st dorsal	Fall 1974	R1023	126	21.4	No	
34	10/16	1335	37	1	Beach seine	1st dorsal	Fall 1974	R866	134	27.5	Yes	
35	10/16	0258	38	1	Epibenthic sled	1st dorsal	Fall 1974	R1070	91	7.1	Yes	
36	10/17	1345	43	3	Beach seine	1st dorsal	Fall 1974	R974	134	23.1	Yes	
37	10/17	0408	29	2	Epibenthic sled	1st dorsal	Fall 1974	R1008	100	10.3	Yes	Dissection
38	10/17	0408	29	2	Epibenthic sled	1st dorsal	Fall 1974	R1009	107	15.7	Yes	
39	10/18	0132	31	1	Epibenthic sled	1st dorsal	Fall 1974	R1012	87	6.1	Yes	
40	10/21	2112	40	1	Beach seine	1st dorsal	Fall 1974	R837	123	19.8	Yes	
41	10/21	2112	40	1	Beach seine	1st dorsal	Fall 1974	R838	111	16.9	Yes	
42	10/21	2112	40	1	Beach seine	1st dorsal	Fall 1974	R839	118	18.0	Yes	
43	10/23	1020	39	1	Beach seine	1st dorsal	Fall 1974	R943	89	6.3	No	
44	10/23	1020	39	1	Beach seine	1st dorsal	Fall 1974	R944	85	6.0	Yes	Dissection
45	10/23	1020	39	1	Beach seine	1st dorsal	Fall 1974	R945	93	7.1	Yes	
46	10/23	1045	39	1	Beach seine	1st dorsal	Fall 1974	R952	92	7.1	No	
47	10/23	2034	41	1	Beach seine	1st dorsal	Fall 1974	R962	95	9.2	Yes	
48	10/23	2143	40	3	Beach seine	1st dorsal	Fall 1974	R846	109	----	No	
49	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R848	117	17.0	Yes	
50	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R849	115	17.5	Yes	
51	10/23	1000	39	1	Beach seine	1st dorsal	Fall 1974	R958	109	12.1	Yes	
52	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R850	113	15.0	Yes	
53	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R851	114	14.9	Yes	
54	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R852	131	22.7	No	
55	10/23	2233	41	3	Beach seine	1st dorsal	Fall 1974	R853	97	9.3	Yes	
56	10/24	1115	40	1	Beach seine	1st dorsal	Fall 1974	R884	108	16.5	No	
57	10/24	1130	40	3	Box trap	1st dorsal	Fall 1974	R948	121	20.1	Yes	
58	10/24	1300	36	1	Beach seine	1st dorsal	Fall 1974	R833	124	19.6	Yes	
59	10/24	1954	39	1	Beach seine	1st dorsal	Fall 1974	R830	105	12.6	No	
60	10/21	1750	38	1	Beach seine	1st dorsal	Fall 1974	2425	80	4.7	Yes	
61	10/24	2255	41	3	Beach seine	1st dorsal	Fall 1974	R813	120	20.0	Yes	
62	10/25	1436	34	3	Beach seine	1st dorsal	Fall 1974	R814	120	19.7	Yes	
63	10/25	1436	34	3	Beach seine	1st dorsal	Fall 1974	R813	103	11.2	Yes	
64	10/25	1354	34	3	Beach seine	1st dorsal	Fall 1974	R842	95	9.2	Yes	
65	10/29	2018	40	3	Beach seine	1st dorsal	Fall 1974	R831	79	5.4	Yes	
66	10/29	0457	43	3	Epibenthic sled	1st dorsal	Fall 1974	R1295	133	21.6	Yes	
67	10/29	1445	37	1	Beach seine	1st dorsal	Fall 1974	R915	82	5.6	No	
68	10/30	2030	42	3	Beach seine	1st dorsal	Fall 1974	R855	119	16.7	Yes	
69	10/31	0300	34	1	Epibenthic sled	1st dorsal	Fall 1974	R1276	108	13.8	Yes	
70	10/31	0455	35	1	Epibenthic sled	1st dorsal	Fall 1974	R1277	109	12.8	Yes	
71	10/31	1235	15	1	Beach seine	Double pelvic	Fall 1974 (trucked)	R868	85	6.2	Yes	
72	10/31	1459	44	2	Surface trawl	1st dorsal	Fall 1974	R1466	111	15.6	Yes	
73	10/31	1950	40	1	Beach seine	1st dorsal	Fall 1974	R969	124	18.0	Yes	
74	10/31	1950	40	1	Beach seine	1st dorsal	Fall 1974	R970	120	16.5	Yes	
75	10/31	1950	40	1	Beach seine	1st dorsal	Fall 1974	R971	99	8.7	Yes	
76	10/31	----	42	3	Screens	1st dorsal	Fall 1974	R1243	79	3.3	Yes	
77	10/	----	--	-	-----	1st dorsal	Fall 1974	R816	78	3.9	No	Wet lab
78	10/	----	--	-	-----	1st dorsal	Fall 1974	R984	82	4.8	Yes	Wet lab

Table B-3

Hatchery Recapture Data, November 1974

No.	Date	Time	RM	Site	Gear	Clip	Stocking Season	Ref. Tag No.	Length (mm)	Weight (g)	Nose Tag	Remarks
79	11/ 1	2212	36	1	Epibenthic sled	Double pelvic	Fall 1974	R1273	105	15.1	Yes	
80	11/ 4	1445	40	3	Box trap	1st dorsal	Fall 1974	R1129	126	21.2	Yes	
81	11/ 4	1445	40	3	Box trap	1st dorsal	Fall 1974	R1130	127	22.2	Yes	
82	11/ 5	1135	41	3	Beach seine	Both pelvic	Fall 1974	R1037	100	10.5	Yes	
83	11/ 5	1135	41	3	Beach seine	1st dorsal	Fall 1974	R1038	132	25.9	Yes	
84	11/ 6	1040	40	3	Beach seine	Both pelvic	Fall 1974	R1112	102	11.2	No	
85	11/ 6	1231	42	2	Bottom trawl	1st dorsal	Fall 1974	R1022	132	24.3	Yes	
86	11/ 6	1315	41	1	Beach seine	Both pelvic	Fall 1974	R1114	110	16.6	Yes	
87	11/ 6	1315	41	1	Beach seine	1st dorsal	Fall 1974	R1115	110	15.1	No	
88	11/ 6	2000	41	3	Beach seine	1st dorsal	Fall 1974	R1118	121	19.3	Yes	Dissection
89	11/ 6	2000	41	3	Beach seine	1st dorsal	Fall 1974	R1119	132	33.4	Yes	
90	11/ 6	2000	41	3	Beach seine	1st dorsal	Fall 1974	R1120	130	21.2	Yes	
91	11/ 7	1140	40	1	Beach seine	1st dorsal	Fall 1974	R1072	87	7.9	No	
92	11/ 7	1416	29	3	Epibenthic sled	1st dorsal	Fall 1974	R1280	89	6.6	Yes	
93	11/ 7	2201	42	3	Beach seine	1st dorsal	Fall 1974	R1140	110	13.5	Yes	
94	11/ 7	2201	42	3	Beach seine	1st dorsal	Fall 1974	R1141	116	17.6	Yes	
95	11/ 7	2203	32	1	Epibenthic sled	1st dorsal	Fall 1974	R1282	103	12.0	Yes	
96	11/ 8	0925	40	3	Beach seine	1st dorsal	Fall 1974	R1005	131	23.2	Yes	Dissection
97	11/ 8	1050	35	1	Beach seine	1st dorsal	Fall 1974	R1292	86	6.3	Yes	
98	11/ 8	1130	47	1	Beach seine	1st dorsal	Fall 1974	R1139	112	14.4	No	
99	11/ 8	2222	37	2	Epibenthic sled	1st dorsal	Fall 1974	R1369	130	23.0	Yes	
100	11/ 8	2003	40	3	Epibenthic sled	1st dorsal	Fall 1974	R1371	124	17.8	Yes	
101	11/ 8	2352	36	2	Epibenthic sled	1st dorsal	Fall 1974	R1370	112	13.9	Yes	
102	11/11	2200	39	3	Beach seine	1st dorsal	Fall 1974	R1155	110	14.0	Yes	
103	11/12	2220	42	3	Beach seine	1st dorsal	Fall 1974	R1076	128	25.6	Yes	
104	11/12	2220	42	3	Beach seine	1st dorsal	Fall 1974	R1077	122	18.7	Yes	
105	11/12	2220	42	3	Beach seine	1st dorsal	Fall 1974	R1078	135	28.5	Yes	
106	11/12	2220	42	3	Beach seine	1st dorsal	Fall 1974	R1079	138	32.1	Yes	
107	11/13	1000	40	3	Box trap	1st dorsal	Fall 1974	R1071	122	23.5	Yes	
108	11/13	1835	40	3	Beach seine	1st dorsal	Fall 1974	R1080	119	18.1	Yes	
109	11/13	1925	40	3	Beach seine	1st dorsal	Fall 1974	R1056	126	22.1	Yes	
110	11/13	1930	41	3	Beach seine	Both pelvic	Fall 1974	R1014	105	13.0	Yes	
111	11/13	2100	42	3	Beach seine	1st dorsal	Fall 1974	R1094	105	12.4	Yes	
112	11/13	2100	42	3	Beach seine	1st dorsal	Fall 1974	R1095	125	18.5	Yes	
113	11/13	2310	42	3	Beach seine	1st dorsal	Fall 1974	R1121	135	29.2	Yes	
114	11/13	----	--	-	Beach seine	1st dorsal	Fall 1974	R1131	82	5.8	No	
115	11/14	0040	22	1	Epibenthic sled	1st dorsal	Fall 1974	R1885	82	5.7	No	
116	11/14	1208	35	3	Beach seine	Both pelvic	Fall 1974	R1081	102	11.5	No	
117	11/14	1225	35	3	Beach seine	1st dorsal	Fall 1974	R1090	101	10.5	Yes	
118	11/14	1225	35	3	Beach seine	1st dorsal	Fall 1974	R1091	121	22.1	Yes	
119	11/14	1920	41	3	Beach seine	1st dorsal	Fall 1974	R1025	85	6.7	Yes	
120	11/15	1450	40	3	Beach seine	1st dorsal	Fall 1974	R1096	128	23.2	Yes	
121	11/17	0830	42	3	Screens*	1st dorsal	Fall 1974	R1266	85	5.6	Yes	
122	11/18	2015	42	3	Beach seine	1st dorsal	Fall 1974	R1082	90	6.6	Yes	
123	11/18	2015	42	3	Beach seine	1st dorsal	Fall 1974	R1083	135	28.0	Yes	
124	11/19	1837	42	3	Beach seine	1st dorsal	Fall 1974	R1067	125	23.4	Yes	
125	11/19	1900	40	3	Beach seine	Both pelvic	Fall 1974	R1164	105	13.7	Yes	
126	11/20	0200	28	2	Epibenthic sled	1st dorsal	Fall 1974	R1886	111	14.0	Yes	
127	11/20	0422	30	1	Epibenthic sled	1st dorsal	Fall 1974	R1887	133	25.5	No	
128	11/20	0525	31	1	Epibenthic sled	1st dorsal	Fall 1974	R1888	113	15.4	Yes	
129	11/20	1810	42	3	Beach seine	Both pelvic	Fall 1974	R1001	110	13.4	Yes	Dissection
130	11/20	1810	42	3	Beach seine	1st dorsal	Fall 1974	R1002	114	14.7	Yes	
131	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1065	81	5.7	Yes	
132	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1103	95	8.7	No	
133	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1104	88	6.6	Yes	
134	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1105	105	12.0	Yes	
135	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1106	110	16.5	Yes	
136	11/20	1833	41	3	Beach seine	1st dorsal	Fall 1974	R1107	89	7.9	No	
137	11/21		35	3	Epibenthic sled	1st dorsal	Fall 1974	R2006	121	20.9	Yes	
138	11/22	1215	36	3	Beach Seine	Both pelvic	Fall 1974	R1019	109	15.1	Yes	
139	11/22	----	42	3	Screens*	1st dorsal	Fall 1974	R1195	80	4.3	Yes	Dissection
140	11/24	----	26	1	Epibenthic sled	1st dorsal	Fall 1974	R2002	108	13.5	Yes	
141	11/25	1410	40	1	Beach seine	1st dorsal	Fall 1974	R1007	119	18.1	Yes	Dissection
142	11/25	1425	42	3	Beach seine	1st dorsal	Fall 1974	R1153	135	25.8	Yes	
143	11/25	1425	42	3	Beach seine	1st dorsal	Fall 1974	R1154	150	40.5	Yes	
144	11/25	1855	41	3	Beach seine	1st dorsal	Fall 1974	R1168	107	14.4	Yes	
145	11/25	1855	41	3	Beach seine	1st dorsal	Fall 1974	R1169	134	24.4	Yes	
146	11/25	2259	37	2	Beach seine	1st dorsal	Fall 1974	R2003	116	16.0	No	
147	11/27	----	42	3	Screens*	1st dorsal	Fall 1974	R1255	87	6.7	Yes	

*Indian Point Power Plant

Table B-4

Hatchery Recapture Data, December 1974

No.	Date	Time	RM	Site	Gear	Clip	Stocking Season	Ref. Tag No.	Length (mm)	Weight (g)	Nose Tag	Remarks
148	12/ 2	1930	42	3	Beach seine	Both pelvic	Fall 1974	R1058	122	20.1	Yes	
149	12/ 2	1930	42	3	Beach seine	1st dorsal	Fall 1974	R1059	133	24.8	Yes	
150	12/ 3	1856	14	1	Epibenthic sled	1st dorsal	Fall 1974	R2005	114	16.2	Yes	
151	12/ 3	2258	24	2	Epibenthic sled	1st dorsal	Fall 1974	R2007	98	9.3	Yes	
152	12/ 6	1246	39	1	Bottom trawl	1st dorsal	Fall 1974	R1274	87	7.0	Yes	
153	12/10	0446	31	3	Epibenthic sled	Both pelvic	Fall 1974	R2082	122	21.1	No	
154	12/11	1350	44	1	Bottom trawl	Both pelvic	Fall 1974	R1283	110	17.2	Yes	
155	12/12	0134	14	1	Epibenthic sled	1st dorsal	Fall 1974	R2297	104	12.5	Yes	
156	12/14	----	42	3	Screens*	1st dorsal	Fall 1974	R1410	114	15.5	Yes	
157	12/19	----	42	3	Screens	1st dorsal	Fall 1974	R1668	75	----	Yes	
158	12/27	----	42	3	Screens	1st dorsal	Fall 1974	R1391	96	9.8	No	
159	12/27	----	42	3	Screens	1st dorsal	Fall 1974	R1392	115	17.3	Yes	
160	12/27	----	42	3	Screens	1st dorsal	Fall 1974	R1393	80	5.9	Yes	
161	12/28	----	42	3	Screens	1st dorsal	Fall 1974	R1572	104	11.6	No	
162	12/29	----	42	3	Screens	1st dorsal	Fall 1974	R1720	86	5.9	Yes	Dissection
163	12/29	0900	42	3	Screens	1st dorsal	Fall 1974	R1642	108	12.5	No	
164	12/29	0900	42	3	Screens	1st dorsal	Fall 1974	R1641	111	14.5	Yes	
165	12/30	----	42	3	Screens	Both pelvic	Fall 1974	R1318	90	8.8	Yes	Dissection
166	12/31	0900	42	3	Screens	Both pelvic	Fall 1974	R1414	104	11.6	Yes	
167	12/31	0900	42	3	Screens	1st dorsal	Fall 1974	R1415	110	13.6	Yes	

*Indian Point Power Plant

APPENDIX C

1974 RECAPTURES OF WILD STRIPED BASS FIN-CLIPPED AND RELEASED IN 1973

Table C-1

1974 Recaptures of Wild Striped Bass Fin-Clipped and Released in 1973

Fish No.	Date	Recapture RM	Site	Gear	Release Region*	Release Date	Total Length (mm)	Weight (g)
1	3/25	37	----	Sled	A	9/73	113	13
2	4/ 4	39	West	3-ft x 6-ft box trap	A	9/73	99	--
3	4/18	29	West	3-ft x 6-ft box trap	B	9/73	110	--
4	4/18	29	East	3-ft x 6-ft box trap	B	9/73	112	--
5	5/11	24	West	Sled	B	10/73	114	15
6	5/24	--	----	----	A	9/73	107	13
7	5/24	--	----	----	A	9/73	97	9.5
8	5/29	35	West	100-ft beach seine	B	9/73	---	--
9	6/ 4	--	----	----	C	10/73	112	12
10	6/ 6	41	West	100-ft beach seine	A	9/73	90	8.1
11	6/ 6	40	East	100-ft beach seine	B	9/73	101	13
12	6/ 6	40	East	200-ft beach seine	B	9/73	76	5.1
13	6/ 6	41	West	100-ft beach seine	B	9/73	72	4.5
14	6/ 6	41	West	100-ft beach seine	B	9/73	89	8.9
15	6/12	40	East	100-ft beach seine	B	9/73	84	7.9
16	6/12	40	East	100-ft beach seine	A	9/73	105	9.9
17	6/12	40	East	100-ft beach seine	A	9/73	84	6.5
18	6/17	42	West	100-ft beach seine	A	9/73	104	10.4
19	6/21	40	East	200-ft beach seine	B	9/73	79	6.2
20	6/28	54	East	100-ft beach seine	A	9/73	114	16
21	7/11	Little Neck Bay	6	200-ft beach seine	A	9/73	86	5.7

*A = RM 0-38 --- No data
B = RM 39-46
C = RM 47-61

services group

APPENDIX D

1974 RECAPTURES OF WILD STRIPED BASS FIN-CLIPPED AND RELEASED DURING AUGUST AND SEPTEMBER 1974

Table D-1

1974 Recaptures of Wild Striped Bass Fin-Clipped and Released during August and September 1974

Fish No.	Date	RM	Site	Gear	Release Region*	Release Month	Total Length (mm)	Weight (g)
1	8/23	40	East	100-ft beach seine	C	Aug	---	---
2	8/23	40			C		75	4.6
3	8/23	42			C		63	2.7
4	8/25	42			C		68	3.4
5	8/26	40			C		79	5.7
6	8/27	33	East		B		73	4.8
7	8/29	41	West		C		68	3.2
8	8/29	41	East		C		69	4.3
9	9/ 3	35	West		B		76	5.4
10	9/ 3	40	West		C		66	3.4
11	9/ 3	40	East		C		83	6.5
12	9/ 3	42			C	Aug	66	3.5
13	9/ 4	40			C	Aug-Sep	113	18.4
14	9/ 5	43			C		56	2.0
15	9/ 5	33			B		92	8.9
16	9/ 5	33	East		B		89	7.9
17	9/ 6	57	West		D		84	6.3
18	9/ 6	59	East	100-ft beach seine	D		111	15
19	9/ 9	42	West	3-ft x 6-ft box trap	C		85	6.5
20	9/10	40	West	100-ft beach seine	C		74	3.9
21	9/10	42	East		C		62	2.1
22	9/11	40	West		C		70	3.5
23	9/11	40	West		C		63	2.6
24	9/11	42	West		C		57	2.2
25	9/12	43	East		C		116	17.3
26	9/12	36	East		B		85	6.2
27	9/13	42	East		C		74	3.4
28	9/16	40	West		C		86	6.7
29	9/16	40	East		C		81	5.8
30	9/16	34	East		B		114	15.2
31	9/16	38	West		B		82	5.5
32	9/16	38			B		77	3.9
33	9/16	38			B		114	16.0
34	9/16	38			B		85	6.1
35	9/17	40			C		89	6.8
36	9/17	42			C		73	3.9
37	9/18	27			B		71	3.8
38	9/18	34			B		90	7.2
39	9/19	40	West		C		77	5.3
40	9/19	38	East		B		91	7.3
41	9/19	38					82	6.0
42	9/19	38					76	3.4
43	9/19	39					93	8.0
44	9/21	33					88	7.1
45	9/21	33					86	6.6
46	9/21	33					94	7.6
47	9/21	33					111	13.6
48	9/21	33					94	8.4
49	9/21	33					98	8.7
50	9/21	33	East	100-ft beach seine	B	Aug-Sep	88	7.0

*A = RM 12-23
B = RM 24-38
C = RM 39-46
D = RM 47-61

---No data

services group

Table D-1 (Contd)

Fish No.	Date	RM	Site	Gear	Release Region*	Release Month	Total Length (mm)	Weight (g)
51	9/21	33	East	100-ft beach seine	B	Aug-Sep	91	7.0
52	9/21	33					105	11.1
53	9/21	33					81	5.3
54	9/21	33					100	10.1
55	9/21	33					97	9.0
56	9/21	34					95	10.1
57	9/21	38					74	3.6
58	9/21	38					94	7.1
59	9/21	38					87	6.9
60	9/21	38	East				87	5.8
61	9/23	30	West				81	5.7
62	9/23	30	West				94	9.0
63	9/23	36	East				79	4.4
64	9/23	39	East				76	4.5
65	9/23	39	East				83	6.3
66	9/23	39	East				75	4.6
67	9/23	39	East		B		78	4.5
68	9/24	40	West		C		64	2.5
69	9/25	40	East		C		73	3.5
70	9/25	33	West		B		88	6.5
71	9/25	34	West	100-ft beach seine	B		83	6.3
72	9/26	40	East	3-ft x 6-ft box trap	C		86	6.1
73	9/27	40	East	3-ft x 6-ft box trap	C		89	9.3
74	9/27	29	West	100-ft beach seine	B		102	11.2
75	9/27	32	West		B		89	7.6
76	9/27	32	West		B		75	4.6
77	9/30	39	West		B		83	6.4
78	10/ 2	40	East		C		82	6.0
79	10/ 2	40	East		C		76	4.3
80	10/ 2	43	East	100-ft beach seine	C		89	7.3
81	10/ 7	40	West	3-ft x 6-ft box trap	C		121	17.1
82	10/ 8	30	West	100-ft beach seine	B		88	6.0
83	10/ 8	33	East		B		82	5.9
84	10/ 8	33	East		B		105	11.6
85	10/ 8	33	East		B		99	9.6
86	10/ 9	39	East		C		72	4.6
87	10/14	34	East		B		98	10.3
88	10/16	40	West		B		87	7.2
89	10/18	28	West	100-ft beach seine	B		97	9.6
90	10/18	42	West	3-ft x 6-ft box trap	C		91	7.6
91	10/21	39	East	100-ft beach seine	B		92	7.9
92	10/21	40	East		C		137	26.1
93	10/25	34	East		B		93	8.7
94	10/30	42	East		A		70	2.9
95	11/ 1	40	West		C		95	8.4
96	11/ 4	40	East	100-ft beach seine	C		117	16.5
97	11/ 6	40	East	200-ft beach seine	A		79	5.0
98	11/18	35	East	100-ft beach seine	B	Aug-Sep	92	9.2

*A = RM 12-23
B = RM 24-38
C = RM 39-46
D = RM 47-61

APPENDIX E

DATA PERTAINING TO GROWTH, PERCENT OCCURRENCE OF GAS BLADDER INFLATION, AND STOMACH CONTENTS OF STRIPED BASS CULTURED IN AQUARIA AT VERPLANCK, NEW YORK

Table E-1

Growth, Percent Occurrence of Gas Bladder Inflation, and Stomach Contents of Striped Bass Larvae Cultured in Aquaria at Verplanck, New York

Roe No.	Tank No.	Date (days)	Age	Approx. No.	Sample Size	Total Length (mm)			Inflated Gas Bladder		Stomach Contents				
						Shortest	Longest	Mean	No.	%	No. >20% Full, Nauplii	No. >20% Full, Nauplii Plus Egg Shells	No. Empty or <20% Full	No. with Egg Shells Only	No. Cannibals
7	4	6/16	23	3000	18	10.0	14.5	11.8	5	28	9	9	0	0	0
7	4	6/19	26	3000	10	11.0	14.5	12.9	1	10	0	0	8	2	0
7	4	6/22	29	3000	14	10.0	14.0	12.0	1	7	0	3	6	5	0
7	4	6/25	32	Insuff. to test											
			Subtotals		42				7		9	12	14	7	0
			% of Subtotals						17		21	29	33	17	0
7	8	6/16	23	2000	16	9.0	13.0	11.1	0	0	12	1	0	3	0
7	8	6/19	26	2000	12	9.5	12.5	11.1	1	8	0	0	4	8	0
7	8	6/22	29	5											
			Subtotals		28				1		12	1	4	11	0
			% of Subtotals						4		43	4	14	39	0
7	9	6/16	23	1000	10	11.0	13.5	12.4	0	0	10	0	0	0	0
7	9	6/19	26	1000	10	11.0	15.0	13.2	0	0	0	0	5	5	0
7	9	6/22	29	1000	15	11.0	17.0	14.0	1	7	0	5	6	4	0
		6/24		0											
			Subtotals		35				1		10	5	11	9	0
			% of Subtotals						3		29	14	31	26	0
7	13	6/16	23	500	12	9.5	13.0	11.8	0	0	11	0	1	0	0
7	13	6/19	26	500	13	11.0	17.0	13.7	0	0	7	6	0	0	0
7	13	6/22	29	500	15	12.0	17.0	14.5	0	0	0	7	2	4	0
7	13	6/25	32	100	10	15.5	24.0	17.2	0	0	4	0	6	0	0
			Subtotals		50				0		22	13	9	4	0
			% of Subtotals						0		44	26	18	8	0
10	12	6/16	22	2500	13	8.0	13.0	11.3	0	0	6	5	2	0	0
10	12	6/19	25	2500	10	10.0	12.5	11.0	0	0	4	5	1	0	0
10	12	6/22	28	2500	14	12.0	15.0	13.5	3	21	0	3	3	8	0
10	12	6/25	31	1000	10	14.0	20.5	15.7	5	50	5	0	5	0	0
			Subtotals		47										
			% of Subtotals						18		15	13	11	18	0
10	14	6/16	22	5000	16	9.5	12.0	11.1	0	0	16	0	0	0	0
10	14	6/19	25	5000	10	11.5	14.5	12.9	0	0	10	0	0	0	0
10	14	6/22	28	5000	13	15.0	18.0	16.5	10	77	0	7	2	4	0
10	14	6/25	31	1000	11	15.0	21.0	16.1	1	9	2	0	9	0	0
			Subtotals		50				11		28	7	11	4	0
			% of Subtotals						22		56	14	22	8	0
10	17	6/16	22	1000	12	8.0	13.0	10.7	2	17	9	2	0	1	0
10	17	6/19	25	1000	12	10.5	15.0	13.0	11	92	0	0	7	5	0
10	17	6/22	28	1000	13	12.0	18.0	15.0	1	8	4	6	0	3	0
10	17	6/25	31	900	13	14.0	19.5	16.3	4	31	11	0	2	0	0
			Subtotals		50				18		24	8	9	9	0
			% of Subtotals						36		48	16	18	18	0
10	15	6/16	22	1500	13	9.0	12.5	10.4	6	46	6	3	0	4	0
10	15	6/19	25	1500	11	10.0	12.0	11.3	3	27	9	2	0	0	0
10	15	6/22	28	1500	11	12.0	14.0	13.0	1	9	1	0	2	8	0
10	15	6/25	31	1000	12	13.5	19.0	15.6	6	50	8	0	2	2	0
			Subtotals		47				16		24	5	4	14	0
			% of Subtotals						34		51	11	9	29	0
12	10	6/16	22	1000	16	9.0	13.5	11.2	0	0	11	0	4	1	0
12	10	6/19	25	1000	11	10.5	14.5	12.6	1	9	7	4	0	0	0
12	10	6/22	28	1000	10	12.0	15.0	13.5	0	0	0	0	4	6	0
12	10	6/25	31	900	12	14.0	19.0	15.7	1	8	10	0	2	0	0
			Subtotals		49				2		28	4	10	7	0
			% of Subtotals						4		57	8	21	14	0
12	11	6/16	22	1000	14	9.5	13.0	10.7	1	7	10	3	1	0	0
12	11	6/19	25	1000	14	10.0	15.0	12.2	2	14	11	3	0	0	0
12	11	6/22	28	1000	11	12.0	14.0	13.0	0	0	0	2	2	7	0
12	11	6/25	31	900	15	13.5	19.5	16.0	2	13	15	0	0	0	0
			Subtotals		54				4		36	8	3	7	0
			% of Subtotals						7		67	15	5	13	0

Table E-1 (Contd)

Roe No.	Tank No.	Date (days)	Age	Approx. No.	Sample Size	Total Length (mm) Shortest	Longest	Mean	Inflated Gas Bladder No.	%	Stomach Contents No. >20% Full, Nauplii	No. >20% Full, Nauplii Plus Egg Shells	No. Empty or < 20% Full	No. with Egg Shells Only	No. Cannibals
12	16	6/16	22	2000	17	8.0	11.0	9.0	7	41	0	5	8	4	0
12	16	6/19	25	2000	14	9.5	12.5	10.7	0	0	0	4	10	0	0
12	16	6/22	28	2000	18	8.0	15.0	11.2	2	11	2	0	9	7	0
12	16	6/25	31	Not enough to test											
			Subtotals		49				9		2	9	27	11	0
			% of Subtotals						18		4	18	55	22	0
12	18	6/16	22	1000	19	7.5	10.5	8.3	1	5	11	0	5	3	0
12	18	6/19	25	1000	10	10.5	15.0	12.2	3	30	0	0	9	1	0
12	18	6/22	28	1000	14	13.0	15.0	14.0	0	0	0	5	3	6	0
12	18	6/25	31	900	16	14.0	19.5	16.0	2	13	15	1	0	0	0
			Subtotals		59				6		26	6	17	10	0
			% of Subtotals						10		44	10	29	17	0
26	2	6/16	17	25000	17	8.5	10.5	9.2	1	6	16	0	1	0	0
26	2	6/19	20	25000	12	11.0	12.0	11.5	1	8	0	0	10	2	0
26	2	6/22	23	25000	12	10.0	14.0	12.0	1	8	1	7	4	0	0
26	2	6/25	26	25000	14	12.0	15.5	13.6	2	14	1	8	5	0	0
26	2	6/30	31	0											
			Subtotals		55				5		18	15	20	2	0
			% of Subtotals						9		33	27	36	4	0
26	3	6/16	17	2500	20	8.0	10.0	9.6	0	0	20	0	0	0	0
26	3	6/19	20	2500	14	10.5	13.0	11.7	0	0	0	0	13	1	0
26	3	6/22	23	2500	10	11.5	13.0	12.3	0	0	4	5	1	0	0
26	3	6/25	26	1000	12	14.0	18.0	15.6	0	0	1	0	8	3	0
			Subtotals		56				0		25	5	22	4	0
			% of Subtotals						0		45	9	39	7	0
27	5	6/16	18	15000	19	8.0	10.0	9.0	6	32	0	0	6	13	0
27	5	6/19	21	15000	15	8.5	10.5	9.7	0	0	0	0	3	11	0
27	5	6/22	24	15000	18	9.0	13.0	11.0	4	22	1	10	7	0	0
27	5	6/25	27	10000	18	10.5	14.0	11.8	1	6	16	0	0	2	0
			Subtotals		69				11	60	17	10	16	26	0
			% of Subtotals						16		25	14	23	38	0
28	1	6/16	17	50000	11	5.0	6.0	5.6	3	27	2	2	6	1	0
28	1	6/19	20	50000	10	6.5	8.0	7.0	5	50	0	0	8	2	0
28	1	6/22	23	50000	14	8.0	10.0	9.0	2	14	9	4	1	0	0
28	1	6/25	26	1000	11	11.0	16.0	12.8	6	55	7	0	4	0	0
			Subtotals		46				16		18	6	19	3	0
			% of Subtotals						35		39	13	41	7	0
28	6	6/16	17	50000	12	5.0	7.0	6.0	6	50	0	0	5	7	0
28	6	6/19	20	50000	16	6.0	8.0	7.2	14	88	0	0	16	0	0
28	6	6/22	23	50000	13	8.0	10.0	9.0	11	85	7	0	6	0	0
28	6	6/25	26	1000	10	13.5	16.5	15.4	9	90	10	0	0	0	0
			Subtotals		51				40		17	0	27	7	0
			% of Subtotals						78		33	0	53	14	0
34	7	6/16	14	15000	16	9.0	11.0	9.8	0	0	16	0	0	0	0
34	7	6/19	17	5000	12	7.5	11.0	10.0	3	25	0	0	10	2	0
34	7	6/22	20	5000	12	10.0	12.0	11.0	0	0	0	8	2	2	0
34	7	6/25	23	5000	15	11.0	14.0	12.3	0	0	9	6	0	0	0
			Subtotals		55				3		25	14	12	4	0
			% of Subtotals						5		45	25	22	8	0
34	8	6/25	23	5000	12	11.5	14.5	12.6	0	0	11	0	0	1	0
34	9	6/25	23	5000	12	12.0	14.0	12.9	0	0	12	0	0	0	0
			Subtotals		24				0		23	0	0	1	0
			% of Subtotals						0		96	0	0	4	0
34	19	6/16	14	1500	13	9.0	12.0	10.7	1	8	11	0	2	0	0
34	19	6/19	17	1500	12	11.5	14.0	13.4	0	0	0	0	11	1	9
34	19	6/22	20	1500	16	12.0	15.0	14.0	0	0	6	0	5	5	0
34	19	6/25	23	1000	12	16.5	19.0	17.7	0	0	12	0	0	0	0
			Subtotals		53				1		29	0	18	6	0
			% of Subtotals						2		55	0	34	11	0
			Totals		969				159		408	141	264	154	0
			% of Totals						16		42	15	27	16	0

Table E-2

Lengths and Weights of 90-Day-Old Striped Bass Cultured in Aquaria at Verplanck, New York

Fish No.	Total Length (mm)	Weight (g)	Fish No.	Total Length (mm)	Weight (g)
1	No Data	—	46	68	No Data
2	No Data		47	63	
3	78	3.6	48	57	
4	69	2.8	49	81	
5	70	3.1	50	76	
6	70	3.3	51	77	
7	71	3.5	52	79	
8	71	3.2	53	73	
9	69	3.0	54	77	
10	71	3.6	55	75	
11	61	2.1	56	72	
12	66	2.6	57	75	
13	70	3.3	58	81	
14	64	2.4	59	78	
15	69	2.9	60	81	
16	72	3.7	61	79	
17	67	2.8	62	78	
18	64	2.4	63	71	
19	72	3.3	64	74	
20	71	3.4	65	67	
21	63	2.3	66	75	
22	72	3.9	67	61	
23	70	No Data	68	77	
24	65		69	83	
25	68		70	76	
26	71		71	80	
27	67		72	77	
28	58		73	85	
29	55		74	82	
30	68		75	62	
31	72		76	66	
32	64		77	82	
33	60		78	78	
34	66		79	81	
35	61		80	67	
36	67		81	78	
37	69		82	77	
38	66		83	80	
39	57		84	87	
40	64		85	84	
41	77		86	73	
42	64		87	67	
43	65		88	73	
44	70		89	87*	
45	60	No Data	90	82*	
			91	83*	No Data

Mean length = 72 mm (2.8 inches); length range = 55-87 mm (2.3-3.4 inches)

*Fish with uninflated gas bladder

APPENDIX F

DATA PERTAINING TO GROWTH, PERCENT OCCURRENCE OF GAS BLADDER INFLATION, AND STOMACH CONTENTS OF STRIPED BASS CULTURED IN POOLS AT VERPLANCK, NEW YORK

Table F-1

Growth, Percent Occurrence of Gas Bladder Inflation, and Stomach Contents of Striped Bass Larvae Cultured in Pool System at Verplanck, New York

	System No. 1					Total	% of Total
Roe No.	26	26	26	26	26		
Date	6/17	6/19	6/22	6/26	7/3		
Age (days)	18	20	23	27	34		
Approximate No.	90,000	85,000	80,000	70,000	60,000		
Sample Size	24	17	10	49	39	139	
Total Length (mm)							
Shortest	8.5	11.0	10.0	12.0	14.5		
Longest	11.0	14.0	13.0	16.0	21.0		
Mean	9.9	12.0	11.5	14.0	17.5		
Inflated Gas Bladder							
No.	6	1	1	26	19	53	38
%	33	6	10	53	49		
Stomach Contents							
No. >20% full nauplii	24	0	2	29	13	66	47
No. >20% full nauplii plus egg shells	0	0	0	11	21	32	23
No. empty or <20% Full	0	17	3	9	3	32	23
No. with eggs shells only	0	0	5	0	2	7	7
No. Cannibals	0	0	0	0	0	0	0
No. Containing TetraMin	-	-	-	10	13		
% Containing TetraMin	-	-	-	20	33		

Table F-2

Lengths and Weights of Random Sample of 106-Day-Old Striped Bass from Pool Culture System 2 (Larger Grade)

Fish No.	Total Length (mm)	Weight (g)	Fish No.	Total Length (mm)	Weight (g)
1	66	2.2	37	57	2.1
2	71	5.3	38	63	2.9
3	60	3.4	39	60	2.4
4	62	3.6	40	66	3.1
5	61	2.4	41	55	2.0
6	62	2.7	42	62	2.8
7	62	3.3	43	62	2.6
8	75	5.3	44	65	3.1
9	65	3.4	45	62	3.5
10	59	2.4	46	73	4.0
11	58	2.6	47	60	2.1
12	62	2.6	48	72	3.8
13	70	3.6	49	58	3.1
14	73	4.4	50	58	2.2
15	57	2.2	51	70	3.6
16	69	3.3	52	66	3.1
17	61	2.3	53	73	4.0
18	65	3.0	54	62	2.4
19	65	3.0	55	68	2.1
20	66	3.1	56	72	4.0
21	65	2.8	57	69	3.3
22	60	2.2	58	61	2.3
23	63	2.7	59	63	2.6
24	59	2.3	60	74	4.3
25	55	1.8	61	61	2.4
26	60	2.1	62	69	3.5
27	60	2.1	63	65	2.7
28	63	2.7	64	66	3.3
29	62	2.5	65	59	2.1
30	55	1.9	66	67	3.2
31	61	2.3	67	58	2.2
32	61	2.4	68	54	1.7
33	61	2.6	69	56	2.0
34	60	2.4	70	62	2.9
35	62	2.8	71	69	3.7
36	61	2.4	72	64	2.8

Range of total lengths: 55 mm - 75 mm
Mean of total lengths = 63.3 mm
Range of weights: 1.7 g - 5.3 g
Mean of weight = 2.86 g

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