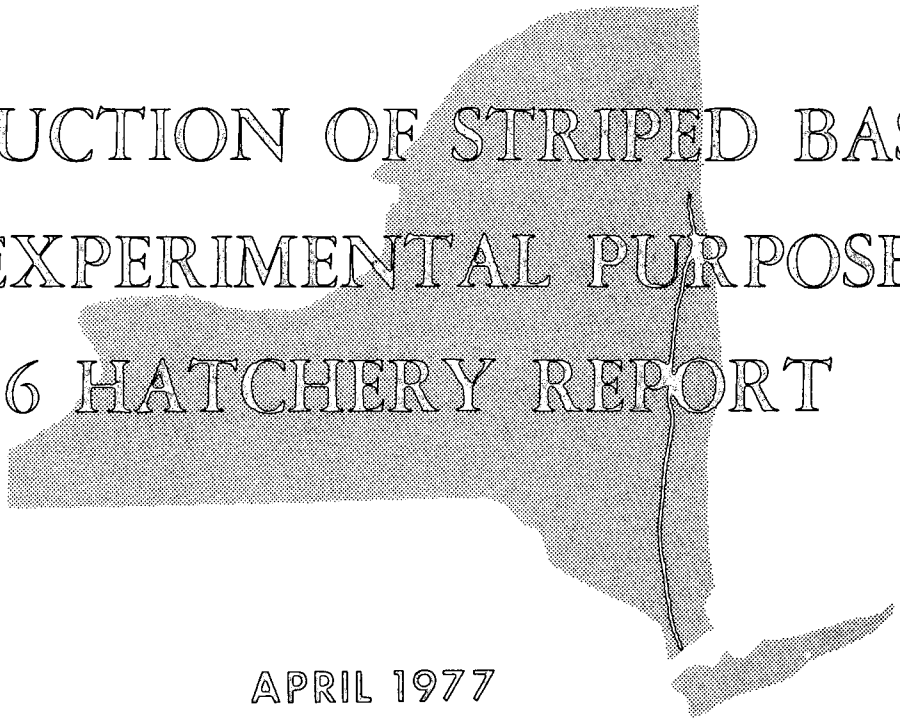
PRODUCTION OF STRIPED BASS FOR EXPERIMENTAL PURPOSES 1976 HATCHERY REPORT



APRIL 1977

Prepared for

CONSOLIDATED EDISON COMPANY
OF NEW YORK, INC.
4 Irving Place
New York, New York 10003

by

TEXAS INSTRUMENTS INCORPORATED
ECOLOGICAL SERVICES
P.O. Box 5621
Dallas, Texas 75222

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FOREWORD

This report was prepared for Consolidated Edison Company of New York, Inc. (Con Edison) by Texas Instruments Incorporated (TI) and summarizes the methods and results of the 1976 hatchery program conducted by TI. In previous years (1973-1975), this study was directed towards assessing the feasibility of artificially culturing and stocking Hudson River striped bass as a means of mitigating losses to the wild striped bass population resulting from power plant operations. In 1976, however, emphasis was placed on efficient artificial production of striped bass eggs and larvae for distribution to various research agencies for experimental purposes related to mitigation of power plant impact. Recipients of striped bass larvae in 1976 were the Cooperative Fisheries Research Laboratory of Southern Illinois University (SIU), Ecological Analysts, Inc., Icthyological Associates, Inc., New York University, University of Rhode Island, and the Gulf Coast Research Laboratory (GCRL). Both SIU and GCRL utilized these larvae for experimental studies designed to increase intensive culture fingerling production efficiency and survival.

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SECTION I

INTRODUCTION

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 (km 90). Under Article 36 of the *Terms and Conditions* of this license, the FPC stipulated that a study program be developed to include consideration of artificial propagation facilities, as well as implementation of a pilot hatchery. A study plan to fulfill this requirement was prepared by Con Edison and contracted to Texas Instruments Incorporated (TI) in 1973.

During the first 3 years (1973-1975) of TI's hatchery study, primary emphasis was placed on evaluating the feasibility of culturing and stocking Hudson River striped bass to mitigate losses to the wild striped bass population resulting from power plant operations. In 1973, it was successfully demonstrated that striped bass could be artificially propagated from wild Hudson River brood fish and reared to fingerling size (3 in. [76 mm]) for stocking. During that year, over 28,000 hatchery-reared fingerlings were stocked into the Hudson River (TI, 1974). Because greater numbers of stocked hatchery fish were required to assess their survival relative to that of wild striped bass of the same year class, fingerling production was increased during the 1974 and 1975 hatchery programs. Approximately 100,000 and 190,000 hatchery-reared striped bass fingerlings were stocked in 1974 (TI, 1975) and 1975 (TI, 1977), respectively. Throughout the 1973-1975 Hudson River striped bass hatchery programs,

considerable progress was made in refining culture techniques, increasing production efficiency, and acquiring an understanding of the requirements and problems associated with the development of a mitigative hatchery operation.

In 1976, TI hatchery efforts were directed towards artificially producing eggs and larvae of Hudson River striped bass for various experimental purposes including intensive culture and assessment of survival of passage through power plants on the Hudson River. An important use of the striped bass larvae produced at the Verplanck, New York, hatchery in 1976 was to support further experiments in intensive (tank) culture in an attempt to increase survival results with this rearing method. Agencies which received shipments of Hudson River striped bass larvae for intensive culture studies included the Cooperative Fisheries Research Laboratory of Southern Illinois University (SIU), Carbondale, Illinois, and the Gulf Coast Research Laboratory (GCRL), Ocean Springs, Mississippi. New York University, Ichthyological Associates, and Ecological Analysts used eggs and larvae for entrainment survival studies.

Striped bass hatchery efforts conducted by TI in 1976 consisted of four basic operations: capture and selection of Hudson River brood fish, induced spawning, egg hatching, and shipment of larvae to various research agencies. Data pertaining to these operations are summarized in the Appendix.

SECTION II

BROOD FISH CAPTURE

During early May 1976, 38 adult striped bass were captured in the Hudson River, transported to the Verplanck hatchery facility, and examined for use as hatchery brood stock. Of these fish, 7 females and 7 males were selected for induced spawning. All striped bass used as brood fish were caught by TI crews*; collection gear were gill nets, 1.5 to 4 in. (38 to 102 mm) bar mesh, staked or anchored in water 10 to 23 ft (3 to 7 m) deep, and haul seines, 0.375 in. (9.5 mm) mesh (Figure II-1). The remaining 24 adult striped bass that were not used as brood fish were captured in gill nets and haul seines or obtained from commercial fishermen. These fish were rejected for spawning purposes because they were immature, spent, or in poor condition. All striped bass collected for the hatchery program were subsequently used in other aspects of the overall Hudson River ecological studies being conducted by TI.

Brood fish capture and utilization data are summarized in appendix Tables A-1 and A-2.

*New York State Scientific Collector's License No. 1861

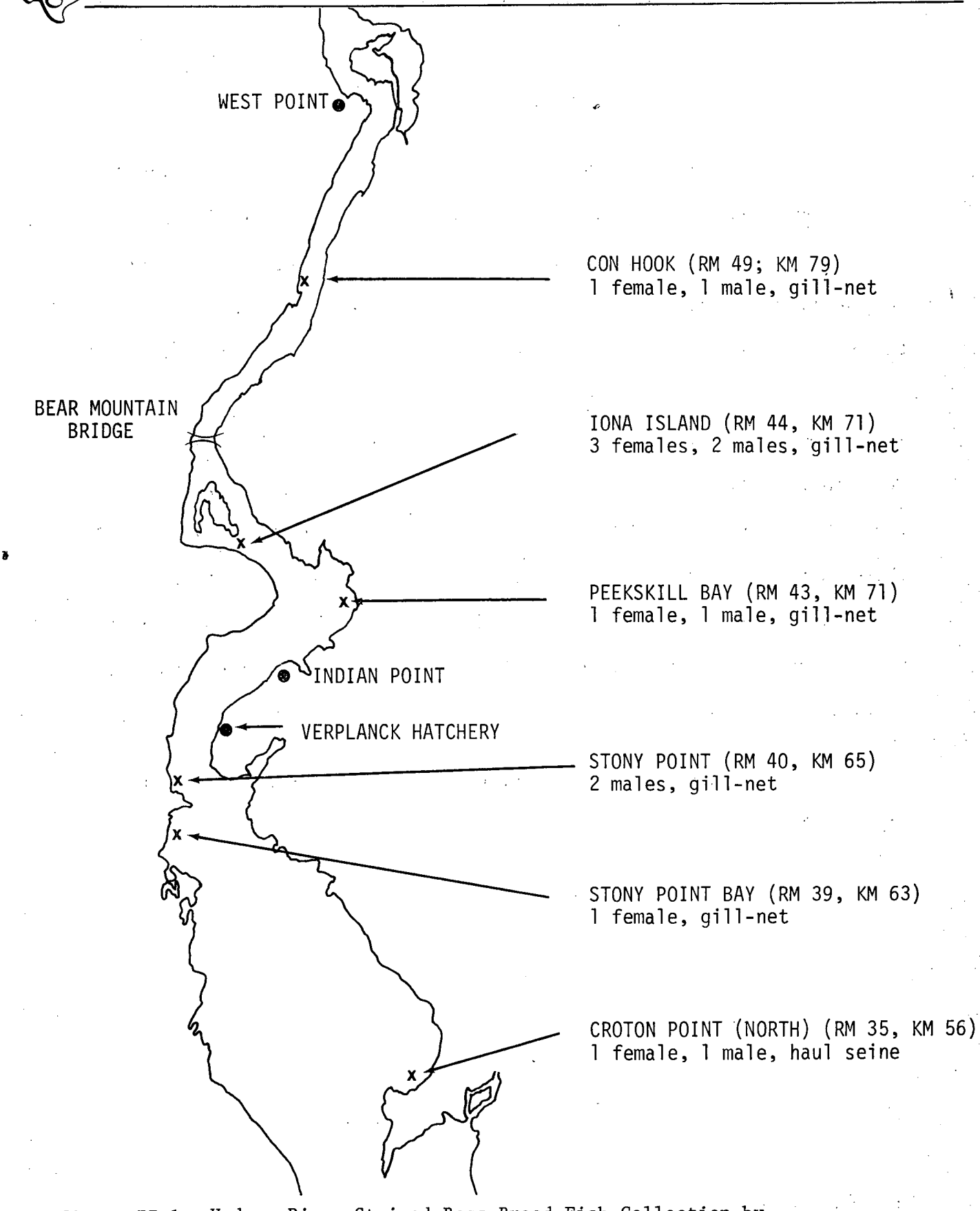

Figure II-1. Hudson River Striped Bass Brood Fish Collection by TI Field Crews, Sites and Corresponding Yields, 1976

SECTION III

INDUCED SPAWNING

Upon arrival at the Verplanck hatchery, potential brood fish were segregated by sex and placed in 3.7-m diameter, 6400-litre tanks fitted with nylon mesh lift-net liners. Each tank was supplied with a mixture of 50% rock quarry water and 50% river water at flow rates of 40-50 litres/min and temperatures from 12.0 to 15.2°C. Males used as brood fish were selected on the basis of expulsion of milt from the vent after palpation of the abdomen. To determine the ovarian maturation of each female, a 3-mm OD polished glass catheter was inserted through the oviduct and a sample of eggs withdrawn from an ovary for examination under 20X magnification. Based on the maturity of eggs, current water temperature, and immediate hormone injection, the time to ovulation was predicted for each female (Bayless, 1972; TI, 1974; 1975; 1977).

Generally, females determined to be less than 40 hours from ovulation were selected as brood fish and injected intramuscularly with chorionic gonadotropin at rates of 210 to 320 International Units per kg of body weight (weights were estimated to reduce handling stress). One female which was close to ovulation needed no injection, and two females over the 40-hour limit but in good condition were also selected as brood fish. Females were placed one to a tank to minimize stress during subsequent examinations. Individual brood fish were identified by color-coded plastic streamers attached to the first ray of the first dorsal fin and numbered Petersen disc tags attached by field crews at the time of capture.

Progress of ovarian maturation was monitored by subsequent egg examinations (usually limited to two because removal of the fish from the tanks and catherization caused additional stress). The predicted ovulation time for each female was then revised by noting the relative polarization of the oil globule and translucence of the ova. As the predicted ovulation time neared, the abdomen was palpated at intervals until free flowing eggs indicated complete ovulation.

Of the 7 females selected as brood fish, all were induced to ovulate partially or completely (88% to 100%). After ovulating, each female was removed from the tank and sacrificed by a blow on the head. As many eggs as possible were stripped into one or more dry pans, after which the ovaries were dissected from the female and further stripped to maximize egg procurement.

The number of eggs stripped from each female was estimated volumetrically by taking a 3-mℓ sample midway through the process of transferring the eggs from the pans into hatching jars. The number of eggs in the sample was counted and the total number stripped per female was calculated using the following equation:

$$\hat{N} = n \frac{V}{v}$$

where

$\hat{N}$ = total number of eggs stripped from a given female

n = number of eggs counted in 3-mℓ sample

V = total volume of eggs stripped from a given female

v = the volume of eggs in a sample (in this case the sample volume was a constant 3 mℓ)

These estimates totaled 15,330,000 eggs stripped from all female brood fish and ranged from 1,305,000 to 2,976,000 eggs stripped per female (Table III-1).

The percentage of unripe eggs retained in ovarian tissue was estimated for each female using the equation:

$$\text{Percentage unripe eggs} = \frac{a}{a + c} \times 100$$

where

$$a = b - 0.11\ (b+c)$$

and

a = calculated weight of unripe eggs

b = weight of stripped (empty) ovaries

c = weight of stripped eggs

0.11 = approximate fraction of full ovarian weight that is ovarian tissue based on previously collected data

These percent values were used to calculate the total number of eggs (stripped eggs plus retained, unripe eggs) from each female, which ranged from 1,466,000 to 3,270,000 per female and totaled 16,176,000 for all females (Table III-1). The number of unripe eggs retained in ovarian tissue totaled 846,000 (5% of total eggs).

Fertilization was effected by using the dry method (Bayless, 1972) in which milt is stripped onto the eggs and the mixture is then agitated with a stream of water. When possible, at least two males per female were used to insure a high probability of fertilization. Males, after being stripped, were transferred to a tank for possible further use. Seven males were stripped a total of 11 times.

Table III-1

Results of the Induced Ovulation of 7 Female Hudson River Striped Bass at the Verplanck, New York, Hatchery, 1976

	Estimated Total No.	% of Total	Estimated Eggs per Female		
			Average No.	Range (%)	Range (no.)
Stripped eggs					
Overripe (nonviable)	386,000	2	55,000	0 - 5	4,000 - 165,000
Viable	14,944,000	93	2,135,000	86 - 100	1,285,000 - 2,811,000
Subtotal	15,330,000	95	2,190,000	88 - 100	1,305,000 - 2,976,000
Unripe eggs attached to ovarian tissue	846,000	5	121,000	0 - 12	0 - 306,000
Total Eggs	16,176,000	100	2,311,000		1,466,000 - 3,270,000

Percent fertilization was estimated by sampling eggs from hatching jars 4 hours after ovulation. Fertilization, as indicated by normal cleavage observed under 20X magnification, ranged from 67 to 91% (weighted mean: 75%).

Ovulation data for each female brood fish is presented in appendix Table A-3.

SECTION IV

HATCHING

Once fertilized, eggs remained in the pans with the milt-water mixture for 1 to 2 min. The milt-water mixture was decanted, the total egg volume measured, and the eggs poured through a large long-stemmed funnel into modified MacDonald hatching jars. A 3-mℓ sample of eggs was taken to estimate the number of eggs placed in each hatching jar and the total number stripped from the female (as described in Section III). Estimated number of eggs per hatching jar ranged from 80,000 to 290,000, averaging 165,000. Variations in estimated number of eggs per jar were caused by number of eggs, number of jars available, and random error in pouring eggs into jars.

Water from a rock quarry (pH 8.5, temperature 12 to 16°C) adjacent to the Verplanck hatchery facility was used for incubation. Initial water flow (2 litres/min) through each hatching jar was sufficient to agitate the eggs, but required periodic reduction due to the gradual increase in buoyancy of the eggs during water-hardening.

During the first 4 hours in the hatching jars, nearly all overripe, damaged, and immature eggs died and turned white (opaque). Due to their higher buoyancy, these dead eggs flowed out of the jars into the receiving aquaria where they remained suspended. After this initial runoff of nonviable eggs, a 1-gal (3.8-litre) sample of water was removed from each aquarium and the suspended eggs contained in the sample were counted to determine the number of nonviable eggs stripped from the female and hence, the number of viable eggs remaining in the hatching jars. Of the

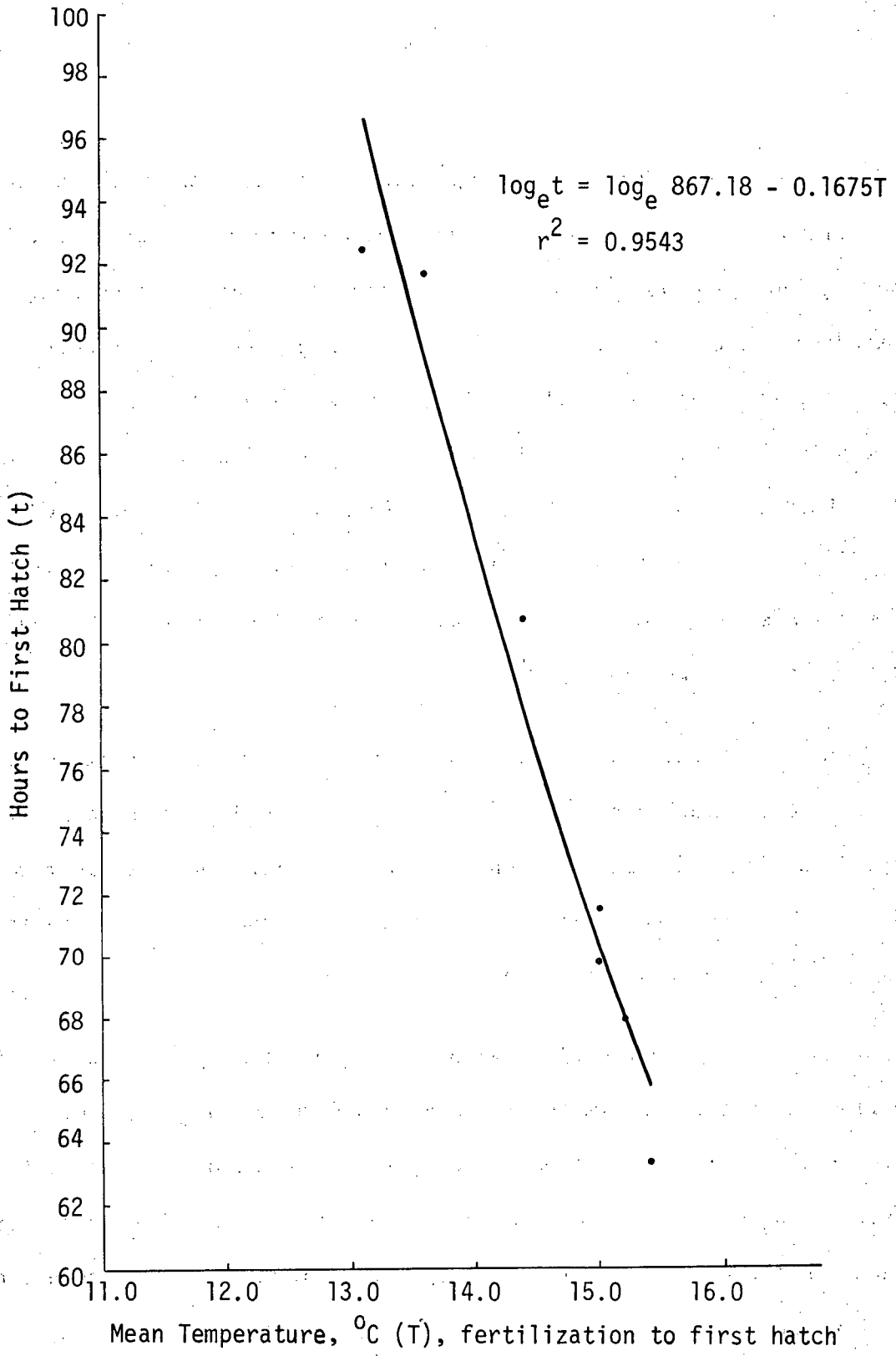

Figure IV-1. Relationship of Incubation Time to Water Temperature for Roe Batches Hatched from 7 Hudson River Female Striped Bass Brood Fish at Verplanck, New York, 1976

eggs stripped from all 7 females, only 2% were not viable. Total nonviable eggs (stripped nonviable plus unripe retained eggs) amounted to 7% of the total number of eggs from all females (Table III-1).

Hatching percent of viable eggs was computed volumetrically. Shortly after the initial runoff of nonviable (white) eggs had ceased and viable eggs had fully water-hardened and expanded, the water flow into each hatching jar was temporarily shut off, the eggs were allowed to settle, and the volumes of the resulting egg masses in the hatching jars were recorded. This procedure was repeated after reintroducing the water flow for 55-85 hours during which unfertilized and/or additional dead eggs flowed out of the hatching jars. At the time of the second egg volume measurement, practically all eggs within the hatching jars contained developing embryos and would soon hatch. Thus, hatching percent of viable eggs was computed as the ratio of the two volumes multiplied by 100. The number of larvae that hatched within each jar was estimated by multiplying the number of viable eggs within a jar by the percent hatch.

Percent hatch per female was based on the total number of stripped eggs (both viable and nonviable) per female and ranged from 52 to 81%. Of all eggs stripped, 69% hatched, producing an estimated 10,601,000 larvae. Incubation time, defined as the time interval from fertilization to the observation of the first hatched larvae, varied from 63 to 93 hours per roe batch (eggs from a single female brood fish) (appendix Table A-4) and was inversely proportional to water temperature (Figure IV-1). Hatching duration, i.e., time interval from beginning to end of hatch, ranged from 8 to 17 hours per roe batch, averaging 12 hours.

Aquaria were drained and replugged shortly before hatching was expected. Larvae, upon hatching, swam upward and were carried with the water flow into the aquaria. Four or five hatching jars ordinarily supplied each 75-litre aquarium, resulting in initial densities up to 10,000 larvae/litre of water. Each holding aquarium was supplied with a water flow of 4 to 8 litres/min and was equipped with a standpipe drain surrounded by a brass screen (170 holes/cm^2) to prevent loss of larvae. An air-bubbler collar placed around the base of each screen prevented impingement of larvae.

Larvae were frequently observed until their removal from the aquaria for shipping. Dead larvae were removed and the estimated number of dead larvae recorded. If larvae were scheduled to be held for more than 4 days before being shipped to designated research agencies, feeding was initiated using brine shrimp (*Artemia* sp.) nauplii. Some 6 day old larvae were observed eating brine shrimp, and nearly all 9 day old larvae fed actively.

Hatching data for each female brood fish are summarized in appendix Table A-4.

SECTION V

SHIPPING OF LARVAE

Striped bass eggs and larvae produced at the Verplanck hatchery in 1976 were supplied to various rearing and experimental agencies (Table V-1). Those sent to distant agencies were air-shipped, whereas those transported relatively short distances were shipped by truck. In preparation for shipping, 100,000 to 200,000 eggs or larvae were packed in double 2-mil plastic bags containing approximately 15 litres of quarry water (14.5 - 16.0°C). Each bag was then inflated with industrial grade oxygen, sealed with a castrating band, and placed in a styrofoam-lined cardboard carton. Cartons containing larvae to be air-shipped were immediately trucked to New York City airports and dispatched on scheduled flights. Shipping mortality, estimated by the receiving agency upon arrival of the larvae, ranged from 2 to 10% (4% arithmetic mean).

Once all commitments to supply striped bass eggs and larvae to designated research agencies had been met, approval was granted by the New York State Department of Environmental Conservation to release remaining (surplus) larvae into the Hudson River.

Detailed data pertaining to the disposition of striped bass eggs and larvae produced at the Verplanck hatchery are presented in appendix Table A-5.

Table V-1

Distribution and Utilization of Hudson River Striped Bass Eggs and Larvae Produced at Verplanck, New York, 1976

Destination	Developing Eggs	Yolk-Sac Larvae	Post Yolk-Sac Larvae	Utilization
Cooperative Fisheries Research Laboratory, Southern Illinois University	0	2,600,000	0	Intensive culture experiments
Gulf Coast Research Laboratory	0	1,000,000	0	Intensive culture of fingerlings
Ecological Analysts	505,000	912,000	500,000	Power plant entrainment study
Ichthyological Associates	0	700,000	0	Rearing of test fish for power-plant studies
New York University	500	63,000	0	Chromosome study
University of Rhode Island	55,000	15,000	0	Test fish for experiments
Surplus larvae stocked in Hudson River	---	1,500,000	0	---
Mortality during holding (not feeding) of surplus larvae and during culture of post yolk-sac larvae for Ecological Analysts	---	2,650,000	---	---
TOTALS	560,500	9,440,000	500,000	

SECTION VI

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APPENDIX A

HUDSON RIVER STRIPED BASS BROOD FISH COLLECTION, SPAWNING, EGG HATCHING, AND DISPOSITION OF EGGS AND LARVAE DATA, VERPLANCK, NEW YORK, HATCHERY, 1976

Table A-1

Capture Data for Hudson River Striped Bass Female Brood Fish Utilized for Artificial Propagation, 1976

Female No.	Catch Location (RM)	Date of Capture May 1976	Time of Capture	Resulting Condition**	Approx.Weight* (kg)
1	49	6	0340	Good	13.1
2	44	6	0420	Fair	12.6
3	44	11	0010	Good	13.0
4	44	11	1430	Good	10.6
5	43	12	0930	Good	12.6
6	35	10	2120	Good	7.2
7	39	13	0730	Good	18.9
Total Weight					88.0
Mean Weight					12.6

* Computed by totaling weights of stripped eggs, empty ovaries, and dead fish

** Refers to state of health, indicated primarily by depth of swimming and maintenance of proper orientation and equilibrium

Table A-2

Capture and Utilization Data for Hudson River Striped Bass Male Brood Fish Utilized for Artificial Propagation, 1976

Male No.	Petersen Tag No.	Catch Location (RM)	Date of Capture May 1975	Time of Capture	Condition at Time of Use*	Fertilized Roe from Female No.	Quality of Milt†
1	521	40	4	1320	Poor	1	Poor
2	518	49	6	0340	Good	1,3,4	Good
3	511	43	6	2330	Good	2	Fair
4	507	40	7	0304	Good	2	Poor
5	552	35	12	2315	Poor	4	Poor
6	986	44	13	0450	Good	5,6,7	Good
7	919	44	13	1430	Good	7	Good

* Refers to state of health, indicated primarily by depth of swimming and maintenance of proper orientation and equilibrium.

† Refers to a visual assessment of both quantity and viscosity of milt.

Table A-3

Hudson River Striped Bass Ovulation Data, 1976

Female No.	Estimated 66° F-Hours to Ovulation (Bayless, 1972)	Units of Gonadotropin Injected	Actual Hours to Ovulation after Injection‡	Date of Ovulation May 1976	No. of Stripped Eggs*	No. Eggs Unripe**	% Eggs Unripe	Total Eggs per Female
1	10	4000	38.9	7	2,244,000	306,000	12	2,550,000
2	10	4000	41.4	8	2,458,000	0	0	2,458,000
3	<6	0	0.7	11	2,304,000	0	0	2,304,000
4	10	3000	34.5	13	2,028,000	85,000	4	2,113,000
5	9-10	3000	19.5	13	2,015,000	0	0	2,015,000
6	14+	2000	58.0	13	1,305,000	161,000	11	1,466,000
7	13	4000	51.2	15	2,976,000	294,000	9	3,270,000
Totals					15,330,000	846,000		16,176,000
Mean					2,190,000	121,000	5†	2,311,000

* The total number of stripped eggs from each female was estimated using the egg count from a 3-mℓ sample taken when pouring and volumetrically measuring the eggs into the hatching jars. Counts ranged from 430-967 eggs mℓ, averaging 601 eggs/mℓ

** Unripe eggs calculated on a percent basis using the formulas:

$$\% \text{ eggs unripe} = \frac{a}{c + a} \times 100, \quad a = b - 0.11 (b + c)$$

where

a = weight unripe eggs (calculated)
b = weight stripped (empty) ovaries
c = weight stripped eggs
0.11 = constant: approximate percent weight of full ovary that is ovarian tissue.

† Weighted mean

‡ Female no. 3 was not injected since time to ovulation was obviously short at the time of examination.

Table A-4

Hudson River Striped Bass Hatching Data, 1976

Female No.	Stripped Eggs: Total No.	Stripped Eggs: No. Nonviable*	Stripped Eggs: % Nonviable	Stripped Eggs: No. Viable	No. of Males Used	Estimated % ** Fertilized	Estimated %*** Hatch	No. Larvae Hatched Out	Hatching Date May 1976	Mean Incubation Temp. (°C)	Incubation Time (Hours to 1st Hatch)	Hatching Duration
1	2,244,000	45,000	1.8	2,199,000	2	67	52	1,166,000	11	13.1	92.50	16.00
2	2,458,000	4,000	0.2	2,454,000	2	74	75	1,857,000	11	13.6	91.75	17.00
3	2,304,000	20,000	0.9	2,284,000	1	87	77	1,768,000	14	14.4	80.75	12.50
4	2,028,000	120,000	5.7	1,908,000	2	74	57	1,163,000	16	15.0	71.50	10.25
5	2,015,000	12,000	0.6	2,003,000	1	70	78	1,581,000	16	15.0	69.80	11.40
6	1,305,000	20,000	1.4	1,285,000	1	91	81	1,087,000	16	15.2	68.00	8.90
7	2,976,000	165,000	5.0	2,811,000	2	69	66	1,979,000	18	15.4	63.30	8.15
Total	15,330,000	386,000		14,944,000	11 uses			10,601,000				
Mean	2,190,000	55,000	2.4†	2,135,000	of 7 males	75†	69 †	1,514,000		14.5	76.8	12.0

* Overripe, dead, and damaged eggs turn white almost immediately and flow out of jars within the first 4 hours. These are deposited and remain suspended in each receiving aquarium from which a 1-gallon sample is removed and the eggs counted, to estimate the initial runoff and hence the remaining number of viable eggs.

** Percent fertilization estimated by sampling eggs from jars 4 hours after ovulation; normal cleavage observed under 20X magnification, indicated fertilization.

***Percent hatch determined volumetrically and refers to total number of eggs stripped, not total eggs.

† Represents the weighted mean.

Table A-5

Disposition and Shipping Data for Hudson River Striped Bass Eggs and Larvae Produced at Verplanck, New York, May 1976

Female No.	Larvae: Hatched Out	Larvae: Shipped or Utilized	Larvae: Date Shipped or utilized (1975)	Larvae: Age (hr)	Recipient	Shipping Water: Temp. (°C)	Shipping Water: Temp. on arrival (°C)	Shipping Water: Temp. Acclimated to on arrival (°C)	Shipping Water: pH	Shipping Water: pH Acclimated to on arrival	Average Hours: Spent in containers	Average Hours: Spent in acclimating	% Shipping mortality	Total % mortality after 24 hours
1	1,166,000	1,200,000	5-13	35	Southern Illinois Univ.(SIU)	14.5	16.5	16.5	7.6	7.8	9.5	1.0	2-4	3-5
2	1,857,000	912,000	5-14	60	Ecological Analysts(EA)	15.0	+	+	+	+	+	+	+	+
		5,000	5-14	60	New York Univ.(NYU)	15.0	+	+	+	+	+	+	+	+
		500,000	5-27	377	EA	16.0	+	+	+	+	+	+	+	+
3	1.768,000	200,000	5-15	26	Ichthyological Associates	15.2	19.0	17.5	-	6.9	5	1.0	1	5
		15,000	5-15	26	Univ. of Rhode Island(URI)	15.2	+	+	+	+	-	+	+	-
		1,000,000	5-18	99	Gulf Coast Research Lab	15.5	18.5	20.9	7.0	8.2	10	1.0	10	10
		4,000	5-21	170	NYU	15.0	+	+	+	+	+	+	+	+
4	1,163,000	500,000	5-18	55	SIU	15.5	17.0	16.5	7.5	8.2	10	1.0	2-3	3-30
		400,000	5-28	300	Stocked in Hudson River	16.0								
		177,000			Held by TI for EA									
5	1,581,000	20,000†	5-15	*	URI	15.5	+	+	+	+	+	+	+	+
		11,000	5-21	33	NYU	15.0	+	+	+	+	+	+	+	+
		800,000	5-28	130	Stocked in Hudson River	16.0	+	+	+	+	+	+	+	+
		435,000			Held by TI for EA									
6	1,087,000	500†	5-14	*	NYU	15.0	+	+	+	+	+	+	+	+
		35,000†	5-15	*	URI	15.2	+	+	+	+	+	+	+	+
		16,000	5-21	128	NYU	15.0	+	+	+	+	+	+	+	+
		500,000	5-26	249	Ichthyological Associates	15.3	16.5	16.3	+	+	5	0.5	5-10	10
		300,000	5-28	297	Stocked in Hudson River	16.0								
7	1,979,000	505,000†	5-17	*	EA	15.5	+	+	+	+	+	+	+	+
		600,000	5-21	76	SIU	14.5	19.9	19.9	7.2	8.2	10	0.6	1	2-10
		27,000	5-21	81	NYU	15.0	+	+	+	+	+	+	+	+
		300,000	5-25	176	SIU	15.5	19.5	20.0	6.9	8.2	13	1.3	1-2	2-20
		470,000	5-27	-	Held by TI for EA	16.0	+	+	+	+	+	+	+	+

* Unhatched developing eggs
\+ No data
† Eggs