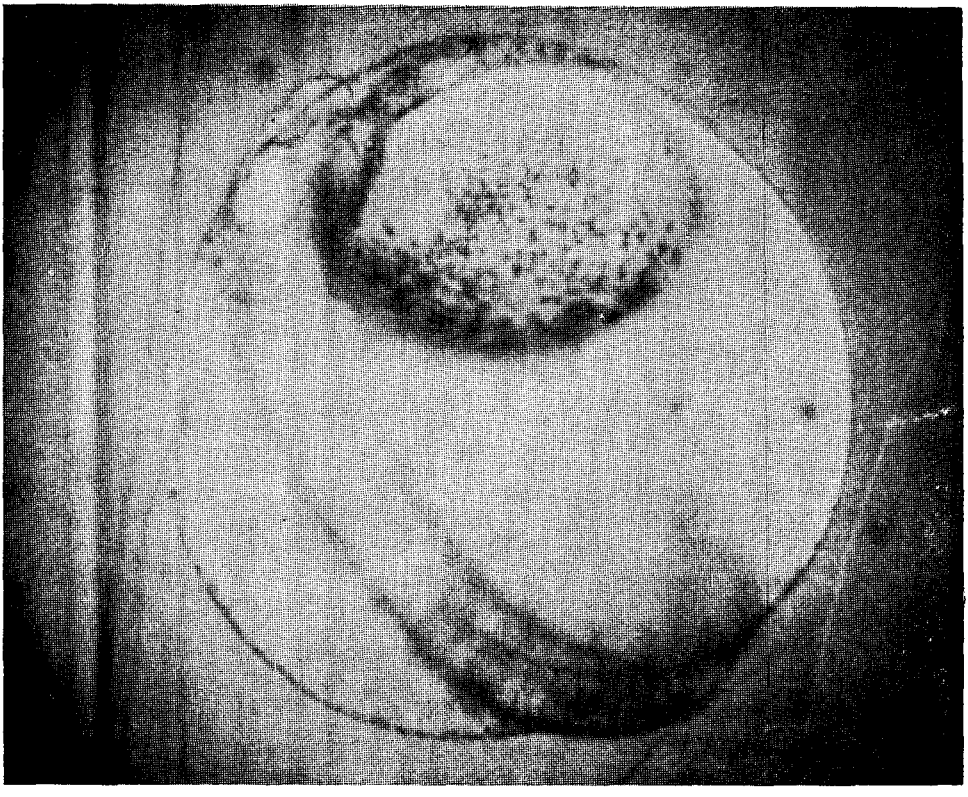

STRIPED BASS HATCHING AND HYBRIDIZATION EXPERIMENTS*

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ABSTRACT

Laboratory studies to determine the effect of striped bass egg sedimentation were conducted and a mean hatch of 35.7 percent was recorded for eggs placed on coarse sand while eggs placed on plastic had an average hatch of 36.4 percent. In comparison, the average hatch on silt-sand was 13.1 percent and 3.2 percent on silt-clay-sand substrate. None of the eggs deposited on a muck-detritus substrate hatched. Further egg studies indicated that the percent hatch improved with the period of time eggs were suspended prior to sedimentation.

Preliminary observations concerning white bass egg development and notes useful in approximating the time of ovulation are presented.

Larvae from the striped bass female X white bass male cross are compared with larvae resulting from the reciprocal cross (white bass female X striped bass male). Meristic measurements useful in distinguishing fingerling hybrids (striped bass female X white bass male) from

*This study financed, in part, by South Carolina Federal Aid in Fish Restoration Project F-1-R-15.

fingerling striped bass or white bass are listed and meristic characters for the back-cross (hybrid male X striped bass female) and the striped bass female X white bass male hybrid are described for the first time.

INTRODUCTION

The possibility of establishing striped bass in land-locked reservoirs has attracted the attention of fishery workers throughout the United States. The obvious benefits of providing an excellent additional sport fish and a biological control of shad have prompted intensified study during the past ten years. The development of techniques for hormone-induced ovulation in striped bass, Stevens (1965) provided a reliable source of larvae. Promising work in hybridization of striped bass with white bass and other species of *Roccus* is well underway. Many problems remain, however, and diverse approaches to their solution are progressing in several states.

The purpose of the work included in this paper is to provide additional reference points from which further studies will progress toward the establishment of striped bass and hybrids wherever the ecology suggests an improvement in sport fishing will result.

One of the major problems remaining is the establishment of reproducing striped bass populations in land-locked habitat. Mansuetti (1958) infers that suspension of striped bass eggs by water current is necessary for survival. Laboratory experiments by Albrecht (1964) showed no survival of eggs resting on a gravel substrate without aeration and only an average of eight percent of eggs resting on gravel substrate with aeration at the surface hatched. With the emphasis currently being placed on the reproduction of striped bass in reservoirs, it was felt that more detailed studies of egg suspension requirements were needed.

Laboratory experiments were set up to determine the minimum period of suspension necessary for a significant hatch of striped bass eggs and the effect of various substrates on sedimented striped bass eggs.

In addition, artificial hybridization experiments with striped bass, *Roccus saxatilis* (Walbaum), and white bass, *Roccus chrysops* (Rafinesque), were continued. Hybrid larvae were hatched for the third successive year at the Moncks Corner Hatchery by fertilizing striped bass eggs with white bass sperm and for the second year by making the reciprocal cross. Two-year-old male hybrids (striped bass female X white bass male) were successfully back crossed to a striped bass female and an undetermined number of larvae were reared to fingerling size.

In conjunction with these experiments, meristic measurements were made on hybrid and back-cross fingerlings. These data will be useful in evaluating future stockings of these fishes and in detecting natural hybridization.

METHODS

Striped bass brood fish used in these studies were obtained from the Cooper River, downstream from Lake Moultrie in South Carolina. White bass brood fish were collected from Wateree Reservoir and Lake Murray in South Carolina. Tennessee furnished male white bass and hybrids (white bass male X striped bass female) for further hybridization experiments.

All females were treated with chorionic gonadotropin to induce ovulation. Eggs were stripped from roe fish, fertilized and incubated in the hatchery.

The experiment to determine the period of suspension required for successful hatching was begun immediately after fertilization, by placing an egg sample in a plastic bag containing water and oxygen. Egg samples were removed from the hatching jars and similarly placed in bags at three-hour intervals until the 15th hour following fertilization. Each bag was floated in hatchery water to minimize temperature fluctuation. The bags were opened when hatching was complete and the number of fry and dead eggs in each bag was recorded.

In the studies to determine variation in percent hatch of eggs placed on various bottom types, the substrates were placed in plastic pans (9" x 14" x 6") and subjected to a flow of hatchery water for eight hours prior to the introduction of eggs to minimize the effect of water quality factors associated with the soil types. All substrates were stirred thoroughly just before the fertilized eggs were introduced. Thereafter, any movement of the pans which might result in disturbance of the eggs was avoided. Oxygen for the developing eggs was supplied by placing O_2 tablets in each pan. Water flow was maintained around the exterior of each pan to minimize temperature fluctuation. Floating dead eggs were removed frequently and, when hatching was complete, live fry and dead eggs adhering to the substrate were enumerated and recorded. Eggs suspended by water movement in McDonald type hatching jars were used as a control for each experiment.

Dissolved oxygen content was analyzed with a Hach modification of the Winkler method. A Hach color-comparator kit was used for pH determination.

Estimation of ovulation in white bass was made by noting changes in eggs removed from the ovary with a catheter and by palpating the abdominal region of females suspected to be near ovulation. White bass eggs were stripped into a dry plastic pan and mixed with sperm before water was added. Eggs, sperm and water were stirred for approximately one minute to insure fertilization before excess water and milt were decanted. Loose eggs were then distributed over saran screen and placed in an aquarium. Eggs which adhered to the plastic pan were subjected to a constant supply of fresh water with the overflow situated above the aquarium containing the eggs placed on saran screen.

During the back-cross experiments, eggs from a given female striped bass were separated into three groups and the percent fertilization and hatch were compared for eggs fertilized with striped bass, hybrid and white bass sperm.

Substrates used in the egg sedimentation studies were analyzed and classified by Mr. Robert Long, soil scientist for the U. S. Department of Agriculture. The classification of the soil types and analysis of each follows:

Assigned Classification	*Analysis*
Coarse sand	98-99% white quartz sand
Silt-sand	95% fine loamy sand, 3% silt, 2% clay
Silt-clay-sand	40% silt, 30% clay, 30% very fine sand
Muck-detritus	60% organic matter, 35% sand, 5% silt and clay

RESULTS AND DISCUSSION

Sedimentation of Developing Striped Bass Eggs

Three experiments with eggs distributed on various substrates were begun. Due to an unfortunate choice of eggs, the first experiment was abandoned when losses in the control approximated 90 percent. However, the results are presented to indicate some survival of the sedimental eggs despite the problem (Table I).

Results of the completed experiments show that eggs placed in the pan with no substrate had a mean hatch of 36.4 percent and eggs placed on coarse sand had an average hatch of 35.7 percent. In comparison, an average of 13.1 percent of the eggs hatched on silt-sand and the mean hatch of eggs placed on silt-clay-sand was only 3.2 percent. None of the eggs resting on muck-detritus hatched.

The calculated percent hatch of viable eggs subjected to sedimentation and associated factors such as fungus and suffocation was considered to be more significant than the actual percent hatch which was affected by egg mortality due to factors associated with aritificial spawning. These losses were tabulated as losses due to other factors and subtracted from the total number of eggs before the percent mortality of viable eggs was calculated. Results indicate that 56 to 61 percent of viable

TABLE I — EGG SEDIMENTATION STUDIES—EXPERIMENT NO. 1—BEGUN AT 0830 HOURS APRIL 18, 1967.

Bottom type	No. of eggs in sample*	Dead eggs removed from surface	Dead eggs trapped on bottom	No. of fry hatched	Percent hatch	Water temp.
Coarse sand	....	153	....	22	....	65-68° F.
Silt-sand	....	229	....	30	....	65-68° F.
Silt-clay-sand	....	267	....	7	....	65-68° F.
Muck-detritus	....	223	....	0	....	65-68° F.
Plastic pan	....	299	....	17	....	65-68° F.
Agitated control	200,000 (est.)	....	None	20,000 (est.)	10 (est.)	65-67° F.

eggs deposited on coarse sand would hatch. On the silt-sand substrate 18 to 24 percent hatch could be expected and 8 percent or less of the viable eggs deposited on silt-clay-sand would hatch. No survival could be expected from striped bass eggs deposited on muck-detritus substrate. The percent hatch of viable eggs placed on plastic (59-61%) was in the same general range as those placed on coarse sand while survival decreased sharply on the other substrates. This suggests that the excessive mortality in sedimented striped bass eggs is due to factors associated with the water quality and soil type rather than sedimentation. It is assumed that suffocation by silt, fungal infection resulting from direct contact of the chorion with a contaminated substrate and undetected water-quality factors in the immediate perimeter of the eggs contributed to the additional mortality.

Temperature fluctuation during the experiments did not exceed three degrees Fahrenheit and the variation between suspended and sedimentary eggs was less than two degrees Fahrenheit. There was some variation in dissolved oxygen content and pH; however, neither factor is believed to have contributed significantly to egg mortality (Table II).

Studies to determine the minimum time of suspension required for successful hatching of striped bass eggs were terminated when it became apparent that eggs would hatch without any period of suspension. Results of the single experiments completed indicate that the percent hatch increases with the length of suspension period during the first 15 hours following fertilization (Table III).

*Eggs poured out when experiment abandoned.

TABLE II — EGG SEDIMENTATION STUDIES—EXPERIMENT NO. 2—BEGUN AT 2130 HOURS APRIL 19, 1967.

Bottom type	No. eggs in sample	Dead eggs removed from surface	Dead eggs trapped on bottom	No. fry hatched	Percent hatch	Losses due to non-suspension	Estimated losses due to other factors	Percent hatch viable eggs	Water temp.	pH.	D.O. ppm.
Coarse sand	285	90	56	139	48.7	31.3%	20%	61 %	64-67° F.	8.0	7.8
Silt-sand	246	61	139	46	18.7	61.3%	20%	23.4%	64-67° F.	8.0	8.2
Silt-clay-sand	204	157	34	13	6.4	73.6%	20%	8 %	64-67° F.	7.8	7.4
Muck-detritus	234	6	228	0	0	80 %	20%	0 %	64-67° F.	7.5	6.4
Plastic pan	211	83	24	104	49.3	30.7%	20%	61.5%	64-67° F.	8.0	8.8
Agitated control	200,000 (est.)	..	..	160,000 (est.)	80 (est.)	0%	20%	100 %	64-66° F.	8.0	7.2

TABLE II — EGG SEDIMENTATION STUDIES—EXPERIMENT NO. 3—BEGUN AT 1320 HOURS APRIL 22, 1967.

Bottom type	No. eggs in sample	Dead eggs removed from surface	Dead eggs trapped on bottom	No. fry hatched	Percent hatch	Losses due to non-suspension	Estimated losses due to other factors	Percent hatch viable eggs	Water temp.	pH.	D.O. ppm.
Coarse sand	263	115	88	60	22.8	17.2%	60%	56.7%	65-68° F.	8.0	8.0
Silt-sand	214	37	161	16	7.5	32.5%	60%	18.6%	65-68° F.	8.0	8.2
Silt-clay-sand	228	47	181	0	0	40.0%	60%	0%	65-68° F.	8.0	7.0
Muck-detritus	247	8	239	0	0	40.0%	60%	0%	65-68° F.	7.5	6.6
Plastic pan	268	176	29	63	23.5	16.5%	60%	59 %	65-68° F.	8.0	8.4
Agitated control	200,000 (est.)	..	..	80,000 (est.)	40.0	0%	60%	100 %	65-67° F.	8.0	7.4

TABLE III — DETERMINATION OF MINIMUM SUSPENSION PERIOD—BEGUN AT 1130 HOURS APRIL 20, 1967.

No. of hours suspended	No. of eggs in sample	No. of fry hatched	No. of dead eggs	Hatching Percent
none	72	11	61	15.3
3	43	31	12	72.1
6	50	27	23	54.0
9	70	55	15	78.6
12	71	58	13	81.7
15	70	64	6	91.4
44*	100,000	90,000 (est.)	10,000 (est.)	90.0 (est.)

*Control (suspended for entire incubation period).

The direct proportion between percent hatch and suspension time is somewhat misleading and should be considered in light of at least two factors which are believed to have influenced the results: (1) eggs confined for longer periods were subjected to a greater probability of excessive biological oxygen demand, and (2) the percentage of viable eggs removed from the hatching jars was higher in the latter samples.

In general, these experiments demonstrate that suspension of striped bass eggs by water current is not necessary for a successful hatch provided the eggs are not subjected to suffocation by silt or water quality. This is not to infer that successful reproduction can be expected in ponds, lakes or reservoirs. Only one facet of a complicated process has been examined and much more work is needed before accurate prediction of successful reproduction in a new area will be possible. Experience has shown that successful striped bass spawning areas are rare and should be protected at all costs. However, potential spawning grounds should not be overlooked simply because of insufficient water velocity to maintain egg suspension.

HYBRIDIZATION

Striped Bass Female X White Bass Male and Back-Cross

An estimated 4,100,000 hybrid larvae were obtained by fertilizing striped bass eggs with white bass sperm. The embryonic and prolarval development of the hybrids closely paralleled that of striped bass. They were held in hatchery troughs for five days and then 3,500,000 were stocked in Clark Hill Reservoir, 500,000 in Hartwell Reservoir and 100,000 in Lake Robinson. Survival checks made with a 50′ x 4′ minnow seine four months after the stocking indicate significant survival in Clark Hill Reservoir and Lake Robinson. The specimens recovered averaged 142 millimeters in length. As of this writing, no survival checks have been made in Hartwell Reservoir.

In the back-cross experiment, a portion of the eggs from a striped bass female was fertilized with sperm from sexually mature hybrids furnished by the Tennessee Game and Fish Commission. A second portion was fertilized with striped bass sperm and a third with white bass sperm. No difference between percent fertilization or hatch could be detected between eggs fertilized with hybrid sperm and those fertilized with striped bass sperm. The percent fertilization and hatch was considerably lower in eggs fertilized with white bass sperm, but the quality of white bass sperm used in this experiment was poor. Previous comparisons indicate no difference in percent fertilization or hatch if good quality white bass sperm is utilized. Further observations indicated no appreciable difference in incubation period, embryonic or prolarval development between the back-cross and striped bass.

The back-cross fry were placed in a hatchery pond and an undetermined number of fingerlings were transferred to another pond in June. Three specimens were preserved for meristic measurements and abnormal spine curvature was noted in all three specimens (Figure 1).

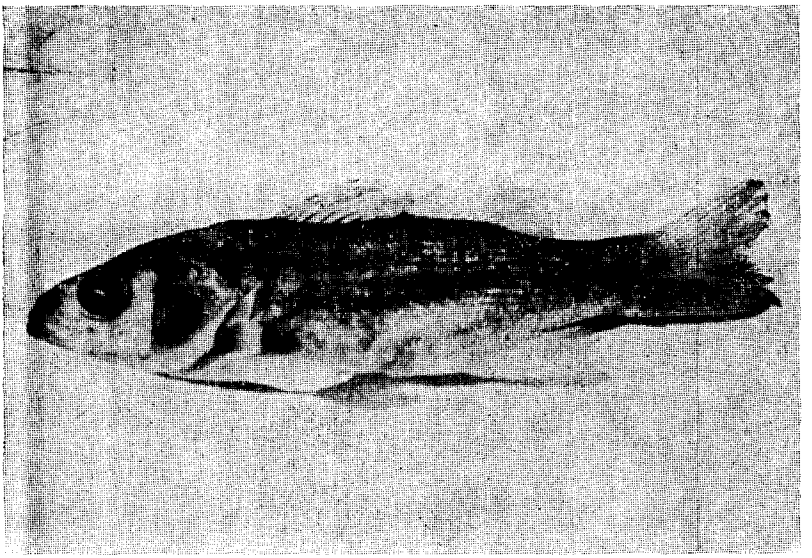

Figure 1 — Back-cross. Note: Deformed spine curvature.

The introduction of hybrids into reservoirs containing either white bass or striped bass immediately poses the problem of evaluating survival from the stocking and, within a few years, an attempt should be made to determine the degree and type of natural hybridization occurring. To do this, it will be necessary to distinguish between the various fishes; therefore, comparative meristic measurements were made on the types available for study.

Meristic characters for 67 striped bass fingerlings (40 to 68 mm.), 74 hybrids (44 to 72 mm.), 17 white bass (46 to 62 mm.) and three back-crosses (50 to 65 mm.) were examined. The information obtained along with notes useful in identification of unknown specimens is presented in Table IV.

Lateral line scale counts were terminated at the anterior end of the caudal fin. Body depth was measured from the anterior base of the dorsal spine to the base of the pelvic fins. The length of the second anal spine relative to the length of the third anal spine and the length of the second anal spine to the head length appear to be the most reliable characteristic for separating hybrids from striped bass. The length of the second anal spine relative to the head length and the parr marks are most useful in separating hybrids from white bass. The limited number of specimens and the close proximity of the back-cross characters to those of striped bass limit the reliability of distinguishing between these fishes. Once the fingerlings attain a length of 150 millimeters, the intensity and broken pattern of the longitudinal lines on the hybrids become a satisfactory field character for separating them from white bass. The broken pattern is useful in distinguishing hybrids from striped bass, but the length of the second anal spine relative to the head length is more important since a small percentage of striped bass also exhibit a broken line pattern.

Reciprocal Cross: White Bass Female X Striped Bass Male.

During the spring of 1966, a single white bass female was successfully ovulated using chorionic gonadotropin. The eggs were fertilized with striped bass sperm and the resulting hatch approximated 40 percent. Prior to spawning, observations of egg development based on samples removed from the ovary at regular intervals, between hormone injection and ovluation, indicated mixed development; i.e., 30 to 40 percent of the eggs were transparent with well formed nucleus while the remainder of the sample was opaque and showed no progress toward ripening.

TABLE IV — DESCRIPTION OF MERISTIC CHARACTERS FOR *ROCCUS* SPP. AND HYBRIDS. JULY, 1967.

Species	Mean fork length	Fork length/ depth	L. l. scales	Scales above L. l.	Soft anal rays	Soft dorsal rays	2nd anal spine/ 3rd anal spine	Head length/ 2nd anal spine	Teeth on tongue	Parr marks
St. Bass	53.5 mm.	4.5	58-61 usually 59	7-9 usually 8	10-11	11-12 usually 12	0.73-0.83 average of 0.74	4.4-5.2 average of 4.54	Two patches	Present
Hybrids	57.7 mm.	4.0	54-58 usually 56	10-12 usually 10	11-12 usually 11	12-13 usually 13	0.89-0.96 average of 0.92	3.4-4.03 average of 4.01	One or two patches	Present
White Bass	56.2 mm.	3.6	52-58	7-9 usually 8	12-13	12-13 usually 13	0.68-0.75 average of 0.72	2.4-3.1 average of 2.9	One patch	Absent
Back-Cross	56.0 mm.	4.4	58-65	9-11	11-12	12-13	0.77-0.89	3.5-4.4	Two patches	Present

Of seven female white bass injected with chorionic gonadotropin in 1967, mixed development was observed in only two fish. Egg development in the remaining five fish closely paralleled that of a typical striped bass female (Table V).

When eggs were removed from the females exhibiting mixed egg development, it was noted that approximately 50 percent of the eggs flowed freely; the remaining eggs adhered to the ovarian wall. It would normally be assumed that the eggs were removed before ovulation was complete, but in each case the females were releasing eggs in the aquarium. It is not clear whether this type of development results in a natural spawn of only a portion of the eggs or complete spawning occurs over a prolonged period.

Three of the five roe fish exhibiting uniform development were spawned. The other two fish were ovulated, but released due to the press of other duties and a shortage of space for the larvae. None of the eggs taken from two of the three females hatched. In retrospect, it appears that both of these fish were stripped before ovulation was complete. The eggs, although free-flowing, were extremely cohesive before coming in contact with water. The eggs that hatched were not cohesive until they came in contact with water.

Further observation indicates that the white bass begins spawning when ovulation occurs whether or not the female is in the presence of a male. It should be possible to determine the correct time to strip a female by observation of egg release in an aquarium.

Embryonic development of white bass eggs appeared to closely parallel that of striped bass eggs and required approximately the same incubation period. Observation of embryo development was hindered by the transluscence of the chorion and by material clinging to the membrane. In general, the fertilized white bass eggs were adhesive and the increase in chorion diameter during water hardening was decidedly less than observed in striped bass eggs (Figure 2).

The hybrid prolarvae from the white bass eggs were generally smaller than striped bass prolarvae. At five hours after hatching, the hybrid prolarvae averaged 2.4 millimeters in length and striped bass prolarvae averaged 3.2 millimeters at the same age. The hybrids were more slender and possessed a smaller yolk sac in proportion to body length (0.6 mm-yolk sac to 2.4 mm total length). At 34 hours of age, the mouth parts were developing, part of the yolk sac absorbed and digestive tract had begun to form. At 48 hours, they were quite slender and the jaws were differentiated. These observations indicate a much faster rate of prolarval development for the reciprocal cross than for the striped bass as described by Mansuetti (1958). The gross differences between striped bass prolarvae and the reciprocal hybrid prolarvae are illustrated in Figure 3.

All of the larvae hatched from the white bass eggs in 1966 died or were lost through the aquarium overflow pipe. Approximately 50,000 of the reciprocal hybrids hatched in 1967 were placed in a hatchery pond, but no fingerling fish were recovered when the pond was drained.

TABLE V — OBSERVATIONS ON MATURATION AND DEVELOPMENT OF WHITE BASS EGGS. APRIL, 1967.

Roe No.	Type of maturation	Stage before treatment	Egg stage at various hours following hormone injection						
			15 hours	17 hours	19 hours	23 hours	30 hours	40 hours	72 hours
1	Mixed	6 (Ripe) 17 (24 hrs.+)	7 (Ripe) 15 (24 hrs.+)	....	Cohesive eggs by palpation	Cohesive eggs by palpation	*Spawned* 50% of eggs removed	20% developing	All dead (Fungus)
2	Mixed	4 (Ripe) 22 (24 hrs.+)	3 (Ripe) 15 (24 hrs.+)	....	Cohesive eggs by palpation	Cohesive eggs by palpation	*Spawned* 50% of eggs removed	All dead	....
3	Uniform	13-15 hrs.	2-4 hrs.	*Spawned* eggs cohesive	No cleavage evident	10% developing	Heavy fungus	All dead	....
4	Uniform	7 hrs.	4 hrs.	Few eggs free	*Spawned* eggs cohesive	No cleavage evident	No cleavage evident	All dead (Fungus)	....
5	Uniform	24 hrs.+	15-18 hrs.	15-18 hrs.	....	....	Cohesive eggs by palpation	Spawning in pool (Released)	....
6	Uniform	15-18 hrs.	4-7 hrs.	4-7 hrs.	Few eggs by palpation	Spawning in pool Spawned	50 to 60% developing	40 to 50% developing	Hatching 40% (est.)
7	Uniform	Before treatment	18-24 hrs.	13 hrs.	....	....	....	Spawning in pool (Released)	

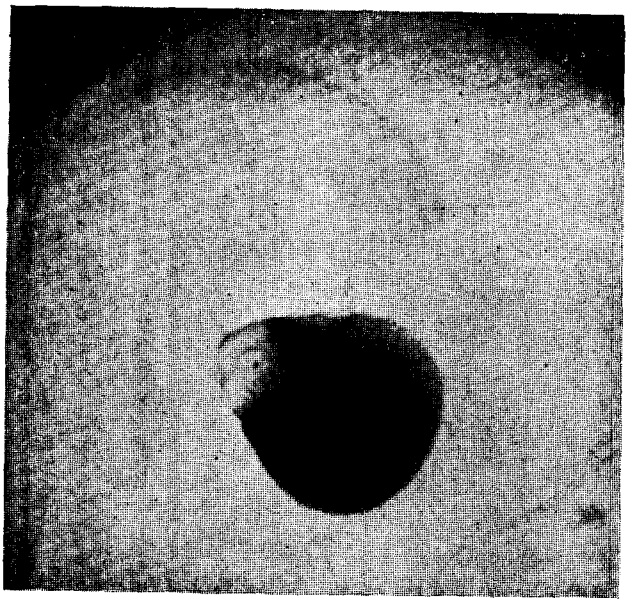

Figure 2 — Developing striped bass eggs.

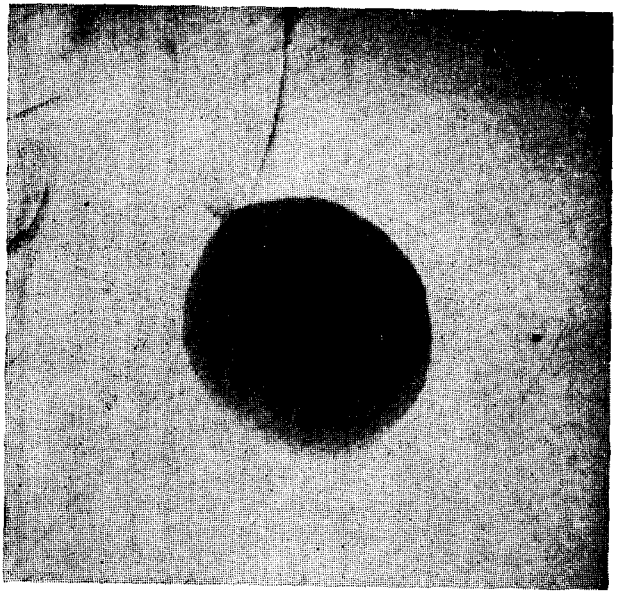

Figure 2 — Developing white bass eggs.

Figure 3 — 5-hour striped bass larvae (left). 5-hour reciprocal hybrid larvae.

ACKNOWLEDGMENTS

The author is indebted to Mr. Jefferson C. Fuller, Jr., Chief of Fisheries, South Carolina Wildlife Resources Department, for his critical review of the manuscript.

The assistance of all the personnel who participated in the hatchery work is greatly appreciated.

For assistance in many areas, I am indebted to Mabel T. Thomas and Elsie Warren, Secretaries.

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