FINAL REPORT

State: Georgia Project Number: AFS-9

Project Type: Research or Survey Study Number: I

Project Title: Evaluation of Stocking Fingerling Striped Bass

Project Covered: July 1, 1970 - June 30, 1974

Study Title: Investigation of Techniques for Differentiating Stocked Hatchery Reared and Native Fingerling Striped Bass

Study Objective: To determine a distinguishing characteristic and/or suitable tagging or marking technique for differentiating stocked hatchery reared striped bass fingerlings from native river populations of striped bass fingerlings.

Abstract:

Fish culture techniques were developed at Richmond Hill Fish Hatchery for rearing fingerling striped bass, Morone saxatilis (Walbaum), from small size (1.5 to 2 inches) to advanced size (4 to 6 inches). Average survival of 121,585 small fingerlings reared to advanced size was 54.0 percent during the study period. Survival was highest (73%) during the fourth year as rearing techniques improved.

Use of scale growth increment and length frequency comparisons between hatchery reared and native striped bass were unsuccessful for identifying hatchery fish reared under controlled growth conditions. Difficulty in scale interpretation and variation in scale growth increment and size distribution between both groups of fish were the primary reasons for this.

Of the various external tags or marks compared relative to their suitability for identifying large numbers of stocked hatchery reared fingerlings, the modified Floy anchor tag gave best results; however, tag loss did occur. The standard FD-68 Floy was the next best tag. The Carlin tag was determined to be unsuitable because of difficulty of application

and higher mortality from bacterial infections after tagging. The fin-clip as a mark was unsuccessful due to fin regeneration.

Preliminary work using a micro-magnetic tag (1 mm color-coded wire filament) gave promising results. Indications are that this tag will be useful for tagging large numbers of striped bass fingerlings.

Background:

Based on work by Smith (1970) which indicated a low population of striped bass in the Ogeechee River, a pilot project was set up in AFS-9 to evaluate stocking of fingerling striped bass as a means of increasing the population in the lower end of the river. It was essential that sufficient numbers of striped bass fingerlings be produced and reared to sizes suitable for tagging and stocking in order to carry out this evaluation. Little work had been done on rearing advanced fingerling striped bass utilizing artificial diets (Ray and Wirtanen, 1970). Proper culture techniques needed to be developed for rearing striped bass in hatchery ponds to an advanced size.

In addition, some type of identifying characteristic, mark, or tag was needed for distinguishing the stocked hatchery reared fingerlings from the native river fingerlings. The ability to distinguish between the two groups of fish was an essential requirement in order to monitor the growth and survival of hatchery-reared fish in the river and their recruitment in the native population and in the creel. This study was performed to develop fish culture practices for rearing fingerling striped bass to advanced sizes (4-6 inches) and to determine the best means for distinguishing stocked hatchery-reared fish from native river striped bass in the Ogeechee River.

Procedures:

Culture of Advanced Fingerling Striped Bass (Jobs 1-3)

Small size (1.5 to 2-inch) fingerling striped bass, Morone saxatilis (Walbaum), produced at Richmond Hill Fish Hatchery under projects F-21 and F-30 were reared in one or more 0.6-acre or one 1.2-acre earthen ponds to advanced size fingerlings (4 to 6-inch). All fingerlings were reared on an artificial diet of Purina Trout Chow (#2 and #4 sinking granules, #5 floating pellets) and fed at a rate of 3% to 7% body weight. A total of 121,585 available small size fingerlings were stocked in hatchery ponds for advanced rearing during the 4-year period of the study.

Preliminary work on advanced rearing: The first year of the study was devoted to preliminary work on rearing striped bass fingerlings to a larger size suitable for experimental tagging and/or marking and stocking. A total of 4,845 small size fingerlings were stocked in two 0.6-acre rearing ponds during June 1970 at stocking rates of 4,740 and 3,325 per acre. The fish were fed a 5% body weight ration for approximately eight months at which time the ponds were harvested.

In addition, small size fingerlings were also placed in three 1,140-gallon plastic pools at the Demeries Creek Office of the Department of Natural Resources located adjacent to a brackish water tidal creek (Demeries Creek). The pools were equipped for a flow-through water supply from the brackish water creek. The three pools were stocked at rates of 1,000, 500, and 250 fish per pool and fed Purina Trout Chow at 3, 5, and 7% body weight, respectively. The purpose of this work was to obtain preliminary information on intensive tank culture of striped bass in brackish water and also provide a facility for evaluating tag retention and

survival after tagging. The fish being reared in the pools died 50 days later because of oxygen depletion from pump and filter failure.

Controlled growth rate: During the second year of the study, experiments were conducted to manipulate the growth rate of cultured striped bass by stocking and feeding fingerlings at different rates. If the growth rate of hatchery-reared fingerlings could be controlled, a mark characteristic might be established for identifying hatchery-reared fish from the native river fish. It was hypothesized that a rapidly growing hatchery-reared fish could be distinguished from a slow growing native river fish, or a slow growing (stunted) hatchery-reared fish could be distinguished from a more rapidly growing native river fish by looking at differences in the scale growth increments.

Three 0.6-acre hatchery ponds equipped with one Nielsen automatic fish feeder per pond were stocked with small size fingerlings in June 1971 (Table 1) at rates ranging from 7,000 – 18,000 per acre. The fingerlings were started on artificial feed in hatchery holding vats prior to stocking. The fish in each pond were fed a different feed ration. The feed rations were 3, 5, or 7% body weight. It was assumed that fish receiving the 7% body weight ration would all attain a larger size than native young-of-year fish at the end of the growing season and that those receiving the 3% body weight ration would stunt below the size of native, young-of-year fish. Since physical characteristics of all three automatic feeders (1 master and 2 slave units) required that they disperse equal quantities of feed at each feeding, the ponds were stocked with different numbers of fish in order to achieve the proper percent body weight ration. The feeding rates were adjusted on August 2, 1971 (Table 2) as a results of a partial

Table 1. Numbers of striped bass fingerlings stocked in 0.6-acre hatchery ponds and feeding rates during the controlled growth experiment.

Pond Number	Theoretical Growth Rate	Number Stocked	Feeding Rate Based On Body Weight (%)
1	Rapid (Large Fish)	4,250	7
2	Slow (Stunted Fish)	10,854	3
3	Average (Average Fish)	7,856	5

Table 2. Adjusted feeding rates of striped bass fingerlings during controlled growth experiment.

Pond Number	Theoretical Growth Rate	Number Stocked	Feeding Rate Based On Body Weight (%)
1	Rapid (Large Fish)	4,250	5
2	Slow (Stunted Fish)	7,600 [1/]	3
3	Average (Average-Slow Fish)	7,856	3

[1/] Low oxygen resulted in mortality of a portion of the fish in Pond 2.

fish kill in Pond 2 on July 4, 1971 from low oxygen and failure of fish receiving the 7 percent treatment to consume all feed.

Feeding techniques: During the third year of the study, techniques were evaluated in an attempt to attain a uniform fingerling size in all ponds. This was to be accomplished by training all fingerlings to take artificial feed and insuring that all fingerlings had access to artificial feeds through improved feed dispersion methods. Striped bass fingerlings (38 – 50 mm T.L.) were stocked in six earthen hatchery ponds (0.6-acres each) during June 1972. Each pond was stocked with 6,060 fingerlings (10,000/acre). All fingerlings were started on a mixture of trout chow and canned mackerel in the holding vats prior to stocking for conditioning the fish to an artificial diet. Feeding the mixture by hand was continued for a short while after stocking assuming that the scent of the mackerel might attract more fish to the trout chow and produce better initial feeding response. After the conditioning period, the fish were fed Purina Trout Chow only. The initial feeding rate was 5% body weight, but later adjusted to 3% body weight based on consumption of feed by fish. Two ponds were fed twice daily by hand, two ponds were fed six times per day by one automatic feeder per pond, and two ponds were fed six times per day by two automatic feeders per pond. All ponds received the same quantity of feed each day. Comparisons were made between treatments to determine the most effective method of feeding for fingerling growth and survival.

This work was continued during the last year of the study. Striped bass fingerlings (35 – 50 mm T.L.) were again stocked at 10,000 per acre in seven 0.6-acre and one 1.2-acre ponds during June 1973. This time the fingerlings were graded as closely as possible before stocking in each pond to reduce potential cannibalism. The fish were fed initially at 5% body

weight decreasing to a 3% rate as the fish grew larger. Except for one large pond, feed was dispersed by two automatic feeders per pond. As before, the fingerlings were started on a mixture of trout chow and canned mackerel in the holding vats prior to stocking and were fed this mixture for a short while after stocking to obtain maximum initial feeding response.

Rather than stocking into ponds completely filled with water as was previously done, fingerlings in 1973 were stocked into partially filled ponds (1-4 feet of water). Project personnel believed that this method of stocking might tend to increase initial feeding response on trout chow concentrating the fingerlings in the deeper area of the pond near the catch basin and possibly limiting the amount of available natural foods which might normally be utilized by the fish for a short time after stocking. When the fingerlings began to feed on larger size pellets, the two sizes of feed were mixed for a short period until all fingerlings were sufficiently large enough to take the larger size feed.

Assessment of Scale Growth Increment (Job 1)

The validity of using scale growth increment was investigated during the first three years of the study as a possible means of differentiating stocked hatchery reared fingerlings from young-of-year native fish. Scales from fingerlings produced at Richmond Hill Fish Hatchery and native fingerlings were collected and impressions were made on plastic slides.

During the first two years of the study, only a hand operated, roller-type scale press was available for project use. The scale impressions made from this press were of poor quality and made scale interpretation virtually impossible. In addition, insufficient numbers of young-of-year fingerlings from the Ogeechee River population were

successfully collected at the time they were needed for comparing the distance from the focus to first annulus between hatchery-reared and native river striped bass. A total of 37 young-of-year or year class I native river fish were collected during the first two years of the study (see Study II) of which 26 were examined for annulus formation.

In the third year sufficient numbers of native, river fingerlings were collected for comparison with hatchery-reared fingerlings. Lengths and weights of sampled fish were recorded and plastic impressions of scales from 100 native and 100 hatchery-reared young-of-year and year class I fish were made using a hydraulic press. Scales were examined for annulus formation and distance from scale focus to first annulus was measured using an Eberbach projector.

Assessment of Length Frequency (Job 2)

In efforts to develop other techniques for distinguishing hatchery-reared fingerling striped bass from young-of-year native fish, project personnel investigated the possibility of using length frequency to achieve this goal. Again, inability to collect sufficient numbers of young-of-year fingerlings from the Ogeechee River for comparison with hatchery-reared fingerlings was a factor. Thirty-one young-of-year striped bass were collected from the Ogeechee River during segment 1 and only six young-of-year fish were obtained during segment 2. These specimens were compared with fingerlings being reared in hatchery ponds in an effort to distinguish differences between the two.

Investigations of Different Type Tags or Marks (Job 3)

Experiments were performed to determine the feasibility of marking advanced size (4 to 6-inch) fingerling striped bass with external tags or fin-clip for later identification in river populations after stocking.

Other than the fin-clip mark the various external tags investigated were the FD-68 standard Floy anchor tag, the modified Floy anchor tag, and the Carlin pennant tag.

The standard Floy anchor tag, as it will be referred to, basically consists of a heavy monofilament T-bar anchor connected to a 3-inch long monofilament streamer. The monofilament streamer is surrounded by a "spaghetti-like", soft, plastic band on which a legend is printed. The modified Floy anchor tag, as it will be referred to, is identical to the standard Floy tag except that there is no "spaghetti-like" plastic band around the monofilament streamer and no legend. Both tags can be purchased in a variety of colors, and both are applied in the musculature of the fish just below the posterior dorsal fin by a small, hand operated, needle-gun. The Carlin tag consists of an oval plastic pennant on which a legend may be printed. This pennant is attached to two 1.5-inch lengths of stainless steel wire. This tag is applied to the fish by using a specialized pair of needles which are inserted completely through the musculature of the posterior dorsal area of the fish just below the dorsal fin. The two wires connected to the tag are simply inserted through the needles from the opposite side of the fish and the needles are withdrawn, leaving the two wires to be tied off snugly with a small pliers.

A preliminary investigation was also conducted on the suitability of using the recently developed, micro-magnetic wire tag. The micro-magnetic tag is simply a 1 mm stainless steel wire filament which may be coded by colored stripes for later identification. This tag is sheared off a roll of similar wire and injected in the snout of a fish by a specialized, 12-volt, battery powered, tag injector unit manufactured by Technical Research Company, Seattle, Washington. The method requires that fingerlings be

graded into respective inch-groups prior to tagging. A silicone rubber tagging mold which attaches to the injector unit is made for each respective size group of fingerlings. The mold is formed around the head of a fish from each size group. In the actual tagging operation, fingerlings are partially anesthetized. As the snout of the fingerling to be tagged is pressed into the tagging mold, a small needle enters the cartilaginous area of the snout. This activates the machine which shears off a tag and injects it through the needle into the cartilaginous area. The wire filament is then magnetized by ring magnets positioned around a flow through pipe which carries the fish to the holding vat after the tagging operation is completed. The tagged fish can be later identified by the use of an electronic detector, which detects the magnetic wire filament and emits an audible "beep".

No tag evaluation could be performed during the first year because of mortality in the three brackish water pools described under the section on preliminary advanced rearing. In the second year of the study, two 1,000-gallon circular fiberglass raceways with a venturi flow-through system were set up adjacent to the same tidal, brackish water creek (Demeries Creek) where the plastic pools had been located the previous year. A better designed water intake pumping system and gravel filter were incorporated into the system for supplying a constant flow of brackish water (10-20 ppt salt).

Equal numbers of 65 graded (approximately 125 mm T.L.) hatchery-reared fingerlings were either tagged with a standard Floy anchor tag, modified Floy tag, Carlin tag, or marked by fin-clipping. All tags were applied to the left side of the fish just below and to the rear of the dorsal fin. The left pectoral fin was removed on all fin-clipped fish.

After tagging or marking, these fingerlings were stocked along with a control of equal number and size fish on October 21, 1971 in the two raceway units for observation. The fingerlings were fed a daily diet of Purina Trout Chow (#5 floating pellets) at a rate of 3% body weight for sixty days until power failure from a storm resulted in total mortality from oxygen depletion and caused premature termination of the experiment.

In the third year of the study a similar experiment was performed for comparative evaluation of fish survival and tag/mark retention utilizing both a brackish and fresh water system. Four 500-gallon circular fiberglass raceways were set up on the water supply system at Skidaway Institute of Oceanography. The system was boosted by an auxiliary power source. The four raceways were supplied with a constant flow of filtered brackish water (10-20 ppt salt) from the Skidaway River. In addition, one available 1,000-gallon circular raceway was set up at Richmond Hill Fish Hatchery on a fresh water supply (constant flow) from a shallow well.

Equal numbers of 100 graded (approximately 125 mm T.L.) hatchery reared fingerling were again tagged or marked using the same tags, fin-clips and techniques employed in the previous year's experiment at Demeries Creek. These fish were stocked along with a control into the four brackish water raceways on November 29, 1972 and fed a 3% body weight ration of #5 floating Purina Trout Chow for 255 days. This procedure was repeated the following day in one available freshwater raceway except that 50 fish were used instead of a 100. These fish were fed a 3% body weight ration of size #5 floating Purina Trout Chow for a period of 375 days.

All work during the final year of the study (segment 4) was related to preliminary investigation of the micro-magnetic wire nose tag previously described. Observations were made on the speed and ease of this technique

and the effect it has on striped bass fingerlings in terms of short-term mortality. Approximately 48,588 striped bass fingerling (50 mm – 202 mm T.L.) were tagged by this technique and stocked into the Ogeechee River.

An experiment on short-term mortality was carried out on fish tagged with the micro-magnetic tag (Table 3). Groups of 25 tagged fish and 25 controls ranging in size from 100 – 137 millimeters were stocked in live boxes positioned in hatchery ponds or in the Ogeechee River, an outdoor circular raceway, or "Living Stream" aquaria units. The live boxes were rectangular (.91 x .91 meters) and were constructed of 3/8-inch hardware cloth to which flotation material was attached. The circular raceways were 1,000-gallon capacity and were equipped with a flow-through fresh water system (79^0F.) from a shallow well. The "Living Stream" aquaria units were 120-gallon capacity and measured 1.78 x .62 x.62 meters in size. Each unit contained a filter and a water chiller for controlling the environment in the tanks.

Findings:

Culture of Advanced Fingerling Striped Bass (Jobs 1-3)

Of 121,585 small size striped bass fingerlings stocked in hatchery ponds during the 4-year study period, 65,690 advanced fingerlings were recovered for an overall average survival of 54% (Table 4). Average survival was highest (73%) during the fourth year as improved rearing techniques were developed.

Preliminary work on advanced rearing: Of the 4,845 small size (1.5 to 2-inch) fingerlings stocked in two 0.6-acre hatchery rearing ponds during segment 1, a total of 3,100 advanced (4 to 6-inch) fingerlings were recovered upon draining (Table 5). Average survival of fingerlings

Table 3. Stocking rates and duration of tests for micro-magnetically tagged striped bass fingerlings (100 - 137 millimeters) being held for evaluation of short-term mortality from handling and/or tagging.

Date Tagged and Stocked	Type Holding Facility	Number of Days Held	Number of Experimentals	Number Controls
7 Dec. 73	Pond Live Box	8	25	--
7 Dec. 73	Pond Live Box	10	25	--
14 Dec. 73	Raceway	6	25	--
14 Dec. 73	Pond Live Box	6	25	--
21 Dec. 73	Living Stream	10	25	25
21 Dec. 73	River Live Box	10	25	25
21 Dec. 73	Living Stream	10	25	25
21 Dec. 73	River Live Box	10	25	25
8 Feb. 74	Living Stream	21	25	25
1 Mar. 74	Living Stream	10	25	25

Table 4. Production of striped bass fingerlings to advance size at Richmond Hill Hatchery from July 1, 1970 to June 30, 1974.

Period	Number Stocked in Ponds	Number Recovered	Percent Recovered
1 July 1970 - 30 June 1971	4,845	3,100	63.9
1 July 1971 - 30 June 1972	22,960	6,746	29.4
1 July 1972 - 30 June 1973	36,360	14,090	38.6
1 July 1973 - 30 June 1974	57,420	41,754	72.7
Totals	121,585	65,690	54.0

Table 5. Production of striped bass fingerlings stocked in 0.6-acre earthen ponds at an average size of 60 mm (T.L.) and fed Purina Trout Chow for eight months.

Pond Number	Date Stocked	Number Stocked per Pond	Feeding Rate	Date Harvested	Number Harvested	Percent Average Survival	Fish Size Time of Draining
#2	6-17-70	2,850	5% body weight	2-20-71	2,200	77	Range(T.L.)100-162 mm; Mean(T.L.)137 mm
#7	6-17-70	1,995	5% body weight	2-17-71	900	45	Range(T.L.)100-162 mm; Mean(T.L.)125 mm
TOTALS		4,845			3,100		

between the two ponds was 64 percent. The fingerlings averaged 61 mm (T.L.) when stocked and 139 mm (T.L.) when removed. Average growth over the 8-month period was 78 mm (T.L.). The fish apparently did not begin to feed on the trout chow until approximately two month after stocking and fed sporadically throughout the entire rearing period.

All fingerlings in the brackish water pools at the Demeries Creek office died fifty days after stocking due to oxygen depletion from pump and filter failure. All the fish in each pool began to feed on the trout chow immediately after stocking and continued to actively take the respective diets until the mortality occurred. During the 50-day rearing period, average fingerling growth was 41 mm (T.L.) for those receiving the higher 5 to 7% body weight ration and 30 mm (T.L.) for those receiving the lower 3% body weight ration. The fish appeared healthy throughout the experiment except for a light, protozoan infestation (Oodinium sp.) in two pools which was treated with formalin with negligible fingerling mortality. The pools themselves were destroyed by vandals shortly after the pump and filter failure thus preventing any salvage of the experiment.

Controlled growth rate: Efforts to control growth rate of striped bass fingerlings stocked in hatchery ponds by regulating feeding rates were unsuccessful (Table 6). As experienced in the previous year, acceptable feeding response did not occur in the three rearing ponds until one to two months after stocking, even though the small fingerlings were started on the trout chow with fair success in the holding vats prior to stocking. Although ponds were fed at different rates, the fish remaining in all the ponds were similar in size range at the end of the experiment. A larger, rapidly growing fish was not produced in the pond receiving the higher rate of feed nor were all stunted fish (less than 100 mm in size at

Table 6. Data on growth rates of striped bass upon termination of the controlled growth experiment including number and percent of stunted fish at end of experiment.

Pond Number	Theoretical Growth Rate	Number Harvested	Number Fish >100 mm	Average Length	Average Weight	Number Stunted[1/] Fish <100 mm	Percent of Stunted Fish
1	Rapid (Larger fish)	2,454	1,841	180 mm	67 gms	613	25
2	Slow (Stunted fish)	690	514	183 mm	69 mm	176	26
3	Average	3,602	2,736	185 mm	78 mm	866	24

[1/] Fingerlings averaging less than 100 mm in size at end of growing season.

the end of growing season) produced in the pond receiving the lower rate of feed. This irregularity in growth is attributed to the fact that a percentage of the fish would take the artificial diet and the remaining ones would not. Also, some of the fish exhibited more aggressive feeding behavior as compared to others. In addition, of all stunted fish that were produced in the ponds, almost total mortality usually occurred soon after harvest as a result of poor condition from stunting, handling stress, and disease outbreaks.

Feeding techniques: Survival and growth of striped bass fingerlings in hatchery ponds were evaluated by three feed dispersion methods during the third year of the study. Slightly better initial feeding response occurred in ponds where the mackerel mixture was continued in the feed for a short period after stocking. Fingerlings that were hand-fed twice daily (Pond 1) or fed six times daily by automatic feeders (Pond 3) exhibited the best growth and survival (Table 7). However, results were inconclusive since treatment replication data was missing from two other ponds due to mortality caused by oxygen depletion.

Both hand feeding and the use of two automatic feeders per 0.6-acre pond produced a broader range of feed dispersion over the pond, thus making the artificial diet more available to the fish. However, the variation associated with the results of the hand fed method and the time required to feed the fish by hand suggest that this approach is impractical. The time required for hand feeding versus the other methods was considerably longer. Project personnel observed that feed dispersion with one automatic feeder was inadequate since the application generally was concentrated in a small area. Even though the data are inconclusive,

Table 7. Data on survival and growth of striped bass fingerlings in ponds at Richmond Hill Hatchery utilizing three feeding techniques.

Pond Number	Method of Feeding	Number Stocked	Number Recovered	Percent Survival	Average Size	Percent Fish Stunted [1] <100 mm (%)
1	Hand Fed	6,060	4,307	71	147 mm/44 gms	0
2	One Feeder	6,060	2,890	48	133 mm/33 gms	15
3	Two Feeders	6,060	3,569	59	151 mm/41 gms	1
4	One Feeder	6,060	0[2]	0	N/A	N/A
5	Two Feeders	6,060	0[3]	0	N/A	N/A
6	Hand Fed	6,060	3,322	55	133 mm/27 gms	19
TOTALS		36,360	14,090			

[1] Fingerlings too small (<100 mm) to tag with modified Floy tag

[2] Total mortality as a result of fish kill

[3] Total mortality as a result of fish kill

it was readily observed that ponds equipped with two automatic feeders had better feed dispersion and was the optimum method for the feeding of striped bass fingerlings in hatchery ponds.

In the final year of the project (segment 4), the highest overall average survival (73%) of any of the previous study years was obtained (Table 8). The fingerlings were held in rearing ponds until attaining a length of 102-152 mm at which time they were removed for tagging with the micro-magnetic wire nose tag and stocked in the Ogeechee River. The fingerlings first attained a taggable size (>75 mm) during the month of September. The average size and size range by month for fingerlings reared during this study segment are presented in Table 9.

Several factors are thought to cause the increased survival of fish stocked and the absence of stunted fingerlings encountered upon harvesting the rearing ponds during this study segment. First, initial cannibalism was probably reduced somewhat by grading fingerlings into similar size groups before stocking. Secondly, the fact that all fingerlings were stocked into only partially filled ponds resulted in their concentration in the deeper, 3 to 4-foot water around the catch basins. Excellent initial feeding response was obtained in all ponds by offering the newly stocked fingerlings the mixture of trout chow and canned mackerel in these locations. Thirdly, trout chow pellets were dispersed by two automatic feeders per pond instead of only one after the water was gradually raised to normal level. This procedure enabled feed to be dispersed in a much larger area at each single feeding than before. Finally, the mixing of two different sizes of trout chow pellets as the fingerlings in the ponds were changed from one size pellet to another

Table 8. Numbers stocked, recovered, average size, and date recovered for fingerlings stocked in hatchery ponds during AFS-9-4.

Pond Number	Number Stocked	Number Recovered	Percent Survival	Average Size Recovered Fish	Date Recovered
8 (0.6 ac)	6,060	3,089	51	127.5 mm	7 Dec 73
3 (0.6 ac)	6,060	4,387	72	218.0 mm	7 Dec 73
2 (0.6 ac)	6,060	4,746	78	118.7 mm	14 Dec 73
4 (0.6 ac)	6,060	4,147	68	125.0 mm	14 Dec 73
5 (0.6 ac)	6,060	4,623	76	123.0 mm	21 Dec 73
7 (0.6 ac)	6,060	6,256	103	127.3 mm	21 Dec 73
6 (0.6 ac)	6,060	5,260	86	134.4 mm	8 Feb 74
1 (1.2 ac)	15,000	9,246	61	136.7 mm	1 Mar 74
TOTALS	57,420*	41,754*	73.8(Avg)		

*$\frac{\text{Number Recovered}}{\text{Number Stocked}} = \frac{41,754}{57,420}$ = 0.73 or 73% of those fish stocked in hatchery ponds were recovered for tagging and stocking in the Ogeechee River.

Table 9. The average size and size range by month of striped bass fingerlings recovered from ponds at Richmond Hill Hatchery during AFS-9-4.

Date	Average Size	Range
July 1973	52.8 mm	37.5 – 84.0 mm
August 1973	67.7 mm	47.0 – 89.0 mm
September 1973	96.1 mm	86.0 – 173.0 mm
December 1973	124.4 mm	102.0 – 202.0 mm
February 1974	134.4 mm	111.0 – 165.0 mm
March 1974	136.7 mm	116.0 – 176.0 mm

insured that all fingerlings in the total size range were offered a pellet which they could effectively consume.

Assessment of Scale Growth Increment (Job 1)

Scales from 100 native and 100 hatchery-reared, young-of-year and year class I striped bass fingerlings were examined during the third year for annulus formation and distance (mm) from scale focus to first annulus. A "t"-test of the difference between the means of a random sample of 31 hatchery reared and 31 native river fish was not significant at the 0.05 level of significance (Table 10).

There were no obvious detectable differences between the seasonal spacing of circuli and no "cutting over" was observed. The annuli on scales collected from native Ogeechee River striped bass were identified by a slight narrowing of the width of circuli and closer spacing between circuli. This is not an obvious characteristic making the reading of native striped bass scales not only very difficult, but often completely subjective. It was concluded that differentiating native striped bass fingerlings from stocked individuals through examination of growth by scale examination was not feasible.

Assessment of Length Frequency (Job2)

The growth of 31 native Ogeechee River fingerlings (avg. 66.0 mm T.L.) collected in July and August 1970 were compared to a random sample of hatchery-reared fingerlings (avg. 61.0 mm T.L.) collected over the same time period. The small sample (31) of native river fish averaged slightly larger (5.0 mm) in size then the hatchery-reared population. Other efforts to obtain young-of-year native fish during the year by the various sampling techniques being utilized (Study II) were unsuccessful.

Table 10. Measurement (mm) of focus to first annulus distance (magnified 28x) for a random sample of 31 native river fish and 31 hatchery reared striped bass fingerlings.

Native Fish	Hatchery Fish
31	64
33	26
47	48
40	65
32	39
40	47
32	32
48	50
40	36
45	48
47	39
42	40
48	41
30	35
29	44
64	63
57	26
44	39
66	37
49	35
34	43
37	59
75	37
35	49
33	43
81	46
56	44
36	39
42	52
39	36
45	48
Total = 1,377	1,340
Mean = 44.4 [1/]	43.2 [1/]

[1/] A "t"-test of the difference between the means (t=0.41) was not significant at the 0.05 level of significance.

Of the six young-of-year native river striped bass collected from October 1971 to March 1972 (segment 2), size range varied from 133 - 210 mm (T.L.) with an average length of 190 mm (T.L.). Hatchery-reared young-of-year fish during the same period ranged in size from 99 to 271 mm (T.L.) with an average length of 160 mm (T.L.). Considerable overlap was observed in the two size ranges. The small sample size of native fish and the considerable overlap in the size ranges make it difficult to properly evaluate the use of length frequency. Nevertheless, it seems that the size dispersion for the young-of-year fish known to exist in the river and in the hatchery ponds would make this method ineffective. Further assessment of this technique was abandoned.

Investigations of Different Type Tags or Marks (Job 3)

At the time that the external tag and fin-clip experiment in the two brackish water raceways at the Demeries Creek office was terminated as a result of mortality described earlier, the fingerlings tagged with the modified Floy anchor tag had a slightly higher survival than those with other tags or marks (Table 11). It should be noted, however, that a protozoan infestation occurred shortly after stocking causing mortality in all groups of fish in both raceways before it was brought under control with formalin flush treatments. The controls were affected the least, possibly indicating that the tagging or marking wound had caused these fish's resistance to be lower. Of the fish remaining, all but three fish retained the tags. The Floy tags were the ones lost. Since the study was terminated earlier than planned, conclusions were not reached relative to long-term tag retention and long-term survival.

Table 11. Number fingerlings tagged with each type tag or mark and the number remaining at the premature termination (50 days) of this experiment.

Pool No. 1			
Number Tagged or Marked	Tag or Mark	Number Fish Remaining	Percent(%) Survival
65	Modified Floy	58	89
65	Floy	47	72
65	Carlin	51	78
65	Fin Clip	55	84
65	Controls	62	95
Pool No. 2			
Number Tagged or Marked	Tag or Mark	Number Fish Remaining	Percent(%) Survival
65	Modified Floy	53	82
65	Floy	37	57
65	Carlin	43	66
65	Fin Clip	50	77
65	Controls	59	91

Results of the tag evaluation in the brackish water raceways at Skidaway Island Institute (255 days duration) showed that fingerlings tagged with the modified Floy tag again had higher survival than those with the other tags or mark (Table 12). No tag losses occurred in these fish. It was observed, however, that many of the standard Floy and modified Floy anchor tags had begun to either work out of or through the musculature of the fish, or as the fish grew in size the flesh had begun to grow around or cover the tag. Although the Carlin tag was the more difficult and time-consuming to apply, none of these tags appeared to be working out of the fish. Fish tagged with the Carlin tag, however, had the lowest survival. Fin regeneration was observed on all remaining fish.

In carrying out the experiment at Skidaway Institute, bacterial disease was a persistent problem. In addition, a spinal deformity, apparently the result of Vitamin C deficiency in trout chow, developed in many of the fish. The deformity was evident before the fish were tagged and stocked in the raceways and was not the result of tagging or marking. The deformity became more pronounced as the fish grew resulting in some mortality during the latter part of the experiment.

Results on external tag or mark evaluation at Richmond Hill Fish Hatchery (375 days duration) are presented in Table 13. Thirteen fish were recovered that had lost either a standard Floy tag or a modified Floy tag. The distinction could not be made as to which type tag a particular fish had lost. Of the fish retaining tags, the group tagged with the standard Floy tag had the highest survival. This in inconclusive, however, because of tag losses. In addition, many of the

Table 12. Survival of fingerling striped bass tagged with various types of tags/mark after holding in brackish water raceways at Skidaway Institute of Oceanography, Georgia, for 255 days.

Number Tagged or Marked	Tag or Mark	Number Fish Remaining w/Tags
100	Modified Floy	30
100	Fly	18
100	Carlin	12
100	Fin Clip	22
100	Controls	44

Table 13. Survival of striped bass fingerlings tagged with various types of tags/marks after holding in freashwater raceway at Richmond Hill Hatchery for 375 days.

Number Tagged or Marked	Tag or Mark	Number Fish Remaining w/Tags
50	Modified Floy	17 [1/]
50	Floy	29 [1/]
50	Carlin	23 [2/]
50	Fin Clip [3/]	
50	Control [3/]	76

[1/] Thirteen fish were found that had lost either a modified Floy tag or a standard Floy tag. The distinction could not be made as to which tag had been lost.

[2/] Five fish were found that had lost Carlin tags.

[3/] Fin-clipped fish could not be distinguished from controls due to fin regeneration.

other standard Floy and modified Floy tags had begun to work out of the fish. On those fish retaining tags, the flesh had begun to grow over the tag, concealing part of the streamer and legend. In some cases, only a small portion of the streamer was visible externally. The flesh was not growing over the Carlin tags. Of the 23 fish surviving at the end of the experiment, no tags appeared to be working out. The fin-clipped fish and the controls could not be positively segregated at the end of the experiment because of fin regeneration on the fin-clipped fish.

The preliminary work with the micro-magnetic tag gave promising results (Table 14). Few problems were encountered (excluding mechanical failure of the tag injector) in tagging fingerling above 75 mm size. Three men working a normal eight-hour day with no mechanical failure of equipment were able to easily tag 6,000 fingerlings. It was observed that tagging mold size is critical to correct placement of the tag in the cartilaginous area of the snout. As the size of fingerlings tagged with a particular mold size increased, more problems were encountered in correct placement of the tag. Tagging fingerlings below 75 mm T.L. appeared to be slightly more difficult and somewhat more time consuming than originally expected using the micro-magnetic tagging system. More time was required to position these smaller fingerlings in the tagging mold. Also the danger of injury when pressing the snout into the tagging mold appeared to be greater for these smaller fingerlings. Preliminary work indicates that at least one mold should be made for each inch-class (25 mm) of fish tagged.

Table 14. Date, number tagged and stocked, average size, and immediate mortality from tagging of pond-reared fingerlings during AFS-9-4.

Date	Number Tagged and Stocked	Average Size	Immediate Mortality from Tagging
13 Aug 73	2,560	N/A	N/A
7 Sep 73	3,518	100.5 mm	N/A
7 Dec 73	3,887	119.6 mm	5
7 Dec 73	4,358	128.0 mm	0
13 Dec 73	4,741	118.7 mm	0
14 Dec 73	4,139	125.0 mm	0
19 Dec 73	4,617	123.0 mm	0
21 Dec 73	6,176	127.3 mm	0
8 Feb 74	5,225	134.4 mm	7
1 Mar 74	9,187	136.7 mm	1
Total	48,588		13*

* $\frac{\text{Mortality}}{\text{Tagged}} = \frac{13}{48,588} = 0.0003$ or 0.03%

As can be seen in Table 14, immediate mortality attributable to tagging of large numbers of fingerlings was negligible (0.03%). Results from the short-term tagging mortality experiments conducted appear in Table 15. It was observed that neither the live boxes positioned in the river or hatchery ponds, nor the outdoor circular raceways with the flow through freshwater system were satisfactory for evaluating short term mortality from handling and tagging. Bacterial disease, not attributable to tag application, was prevalent among fish stocked in those units where temperature and other water chemistry conditions could not be controlled. Those fingerling held in the "Living Stream" units (up to 21 days) where the aquatic environment could be controlled suffered little mortality (<1%). From this preliminary work, it appears that little or no short-term mortality could be attributed to the micro-magnetic tagging process.

Analysis:

A secondary objective of this study was the development of suitable techniques for rearing large numbers of small size (1.5 to 2-inch) striped bass fingerlings to advanced size (4 to 6-inch) in hatchery ponds. Procedures for culturing large numbers of advanced fingerlings in hatchery ponds were developed.

A stocking rate of 10,000 fish/acre seems to be the best stocking density for maximum production and survival of advanced fingerlings in un-aerated ponds. This can usually be accomplished by maintaining suitable pond environments, training all fingerlings to take artificial diets prior to stocking, and insuring that all fingerlings have sufficient access to artificial feed pellets.

Table 15. Results of short-term mortality tests from micro-magnetically tagged striped bass held in various type live boxes.

Date Tagged and Stocked	Type Holding Facility	Number of Day Held	Number of Experimentals	Number of Controls	Number of Experimental Fish Alive	Number of Controls Alive
7 Dec 73	Pond Live Box	8	25	N/A	13	N/A
7 Dec 73	Pond Live Box	10	25	N/A	0	N/A
14 Dec 73	Raceway	6	25	N/A	0	N/A
14 Dec 73	Pond Live Box	6	25	N/A	11	N/A
21 Dec 73	Living Stream	10	25	25	25	24
21 Dec 73	River Live Box	10	25	25	0	0
21 Dec 73	Living Stream	10	25	25	25	25
21 Dec 73	River Live Box	10	25	25	1	3
8 Feb 74	Living Stream	21	25	25	Unk.[1/]	Unk.[1/]
1 Mar 74	Living Stream	10	25	25	22	24

[1/] Detector malfunctioned, no distinction could be made between experimentals and controls.

Before stocking, all fingerlings should be frequently fed small quantities of artificial feeds in holding vats. The size starter feed to use depends on the size of the fingerlings. Mixing small quantities of canned fish such as salmon or mackerel in the feed aids in obtaining a quicker feeding response both in the vats and immediately after stocking in ponds. Fingerlings should be held in a 1% salt solution with sufficient aeration during this time to reduce mortality from stress, parasites, and disease. Fingerlings should be carefully graded by size prior to stocking to reduce initial cannibalism. Ponds should be partially filled (1 to 4-foot depth) in order to concentrate the fingerlings in the deeper area of the ponds and reduce the amount of available natural foods which fingerlings apparently prefer at the start. The water levels should then be gradually raised over a period of a few weeks. Fingerlings in the ponds should be started at a feeding rate of 7% body weight and reduced to 5% or 3% as feed consumption dictates.

If automatic feeders are used to conserve labor time, at least two units per 0.5-acre of pond area are required. These units should be spaced for optimum feed dispersion. Feeding twice daily (early morning and late evening) is sufficient. As fingerlings are being changed from one size feed to another, the two sizes should be mixed for a short period until all fingerlings reach sufficient size to take the larger size feed. The desired size fingerling reared should be determined by the length of the growing season and not by varying the rate of feed.

Efforts to develop a method for differentiating hatchery-reared fish from native fish in a river population had limited success. It was determined that scale growth increment and length frequency could not be

used as distinguishing characteristics for hatchery-reared and native river striped bass fingerlings. The difficulty in maintaining uniform growth rate, over-lap on size dispersion, and the subjectivity in reading of scales makes these two methods ineffective.

The fin-clip was not found to be a suitable mark because of fin-regeneration. Of the external tags investigated relative to their suitability for making hatchery-reared striped bass for supplemental stocking evaluations, several useful observations were made. Overall, the standard Floy and modified Floy anchor tags appear to be good tags for short-term use of approximately eight months and can be applied to moderately large numbers of fish without a high degree of mortality and without too much difficulty. The Carlin tag seems to be usefull for a longer term ($12 months); however, mortality may be higher than with other tags because of the severity of the tagging wound. This tag, however, cannot efficiently be used on large numbers of fingerlings (100,000 or more) for stocking because of the time-consuming nature of its application. The smallest size that striped bass can be effectively tagged, using Floy type tags, is approximately 125mm and 150 mm for the Carlin tag.

The micro-magnetic wire tag gave the best success of the various methods evaluated. It appears that the increased efficiency of this technique over that of conventional tags will enable significantly larger numbers of fish of the same size or smaller sizes to be tagged. Short-term mortality was negligible in fish tagged with a micro-magnetic tag. Other apparent advantages of this tag include: no external tag presence which might hinder the fish's movement or attract predators, tag can be

color-coded for later identification of age class, and retention may last for the life of the fish. Apparent disadvantages include: tag return data cannot be obtained directly from sport anglers, identifying color code of tag requires dissection and sacrifice of the fish, tagging equipment is expensive (—$10,000) and prone to periodic failure when tagging fish.

Recommendations:

1. All striped bass rearing ponds at Richmond Hill Fish Hatchery should be equipped with a minimum of two automatic feeders per pond. The suggested pond feeding and rearing techniques brought forth in this study should be followed in subsequent years if project guidelines continue to call for production of advanced fingerling (4 to 6-inch) fish for stocking in the Ogeechee River.
2. Stocking of smaller size fingerlings in lieu of advanced fingerlings might possibly be considered since the technology now appears to exist with the development of the micro-magnetic tag for tagging these smaller fish.
3. The micro-magnetic tag should be used for tagging all fish stocked under this project in subsequent years. All other tagging or marking techniques should be abandoned. However, future investigations should be conducted for the purpose of evaluating this tagging technique relative to proper tag placement and long-term retention.

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