of Black River and Clearwater Lake, Missouri, Univ. Mo. Studies, 26:25-41.
Pennak, Robert W. 1953. Fresh-water invertebrates of the United States. The Ronald Press Company. 769 pp.
Pierce, Phillip C., John E. Frey and Henry M. Yawn. 1963. An evaluation of fishery management techniques utilizing winter drawdowns. Proc. S. E. Assoc. Game and Fish Comm. 17:347-363.
Schmulbach, James C. and Hallace A. Sandholm. 1962. Littoral bottom fauna of Lewis and Clark Reservoir. Proc. South Dakota Acad. Sci. 41:101-112.
Welch, Paul S. 1952. Limnology. McGraw-Hill Book Co., Inc. 538 pp.

PRELIMINARY EXPERIMENTS IN THE ARTIFICIAL PROPAGATION OF STRIPED BASS, *ROCCUS SAXATILIS* *

BUFORD L. TATUM, JACK D. BAYLESS,
EDWARD G. MCCOY, AND WILLIAM B. SMITH

Division of Inland Fisheries
North Carolina Wildlife Resources Commission
Raleigh, North Carolina
1965

ABSTRACT

Adult striped bass purchased from commercial fishermen on Albemarle Sound, N. C. were transported to the Fayetteville and Weldon Hatcheries, injected with hormones, and spawned. In addition to ripe fish brought into the Weldon Hatchery by fishermen, sexually mature striped bass were obtained from the Roanoke River by electro-fishing gear. These fish, like those from Albemarle Sound, were injected with hormones, held in glass-front plywood aquaria (32" x 24" x 16"), and spawned. Excellent hatches were obtained from these eggs.

Laboratory experiments, confirmed by actual practice, indicated that striped bass eggs following six to 28 hours of incubation can be transported up to 12 hours in plastic bags containing water and oxygen with no significant increase in mortality.

Attempts to rear fry in aquaria failed although limited success was obtained in outdoor concrete pools. The fry in these pools began taking artificial food 28 days after hatching.

Several hundred fry also were reared in earthen ponds. Predation by *Chaoborus* spp. in these ponds proved especially serious during the sac-fry stage.

From various observations, it appeared that rapid changes in pH and/or other chemical characteristics were lethal to fry.

The 24-hour TL_m values were determined for Quinaldine, MS-222, salt, and pH using striped bass fingerlings as the test fish. The two-hour TL_m values also were determined. Quinaldine appeared to be superior to MS-222 as a tranquilizer for striped bass.

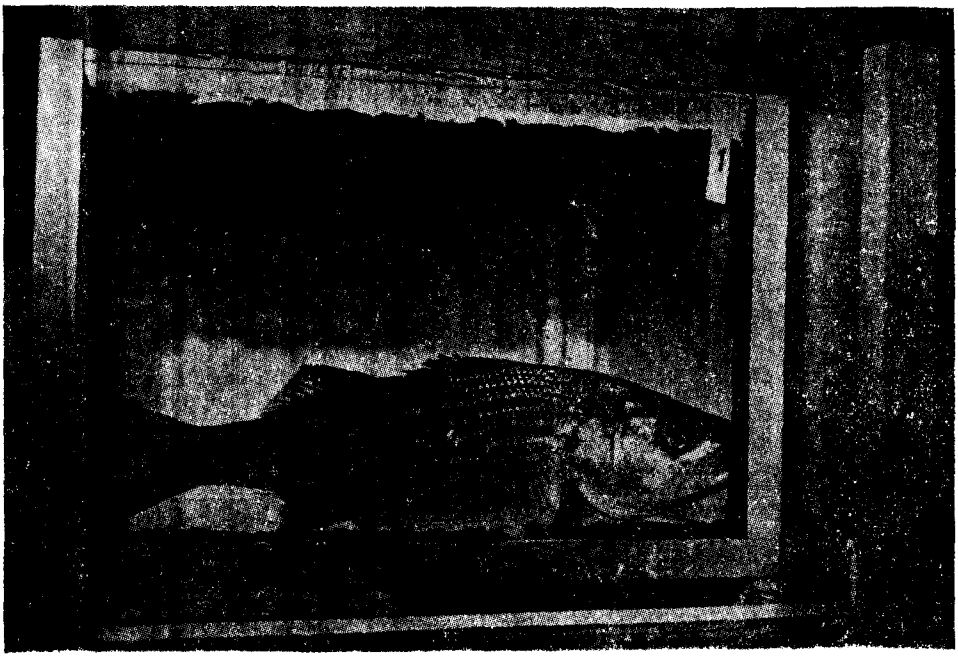
Experiments indicated that no mortality could be attributed to the handling of striped bass fingerlings per se.

Was presented at the annual meeting of the Southern Division of the American Fisheries Society, Tulsa, Oklahoma, October 1965.

INTRODUCTION

The first striped bass hatchery was established by Mr. S. G. Worth in 1879 on the banks of the Roanoke River near Weldon, North Carolina.

* This study was financed, in part, by North Carolina Federal Aid in Fish Restoration Project F-16-R.



Throughout the intervening years, fry have been hatched in this vicinity in intermittently-operated hatcheries.

Each year, the magnitude of the hatchery operations has been entirely dependent upon fishermen voluntarily bringing females and males in spawning condition to the hatchery. The infrequency of encountering ripe females, excepting one or two peak spawning flurries of a few hours duration, automatically limited the number of eggs obtained. This dependency upon fishermen for eggs rendered the operation both inefficient and uneconomical.

In 1965, hatchery operations were expanded to include the collection of gravid females both from Albemarle Sound and the Roanoke River, plus the use of hormones for ovulating striped bass.

The over-all objectives were:

1. To salvage eggs from commercially caught fish from Albemarle Sound by accelerating time of ovulation by hormones.
2. To develop effective techniques for collecting gravid females.
3. To gain experience in the use of hormones to ovulate striped bass.
4. To develop and evaluate effective techniques for handling and transporting adults, eggs, fry, and fingerlings.
5. To rear striped bass fry and fingerlings in sufficient quantities to effectively stock inland reservoirs for the purpose of establishing and maintaining this highly desirable game species.
6. To utilize the striped bass as a biological control of forage-fish populations.

This study began as a simple experiment to determine if fish taken from Albemarle Sound—some 150 miles from their major spawning ground and three to four weeks before natural spawning—could be ovulated by the use of hormones. It developed, however, into a series of exploratory studies to the extent that time permitted. Needless to say, project personnel were inexperienced, and facilities, materials, and manpower were in short supply. This preliminary report outlines the methods employed and points out the major problems encountered as a guide for future studies.

Between April 23 and May 1, a total of 152 adult striped bass were purchased from commercial fishermen in Albemarle Sound and transported to the Fayetteville Hatchery — a trip involving some four hours traveling time. The fish were collected from pound nets, carried in a boat "live-well" to a holding tank (4'x8'x3') on the shore and held for periods of 4 to 24 hours. All fish were weighed, and 56 of the 107 females each were injected with 2,000 International Units of human chorionic gonadotropin prior to transfer to the hatchery truck. Forty-three other females were injected with a similar dose of hormone upon arrival at Fayetteville. Eight females received no hormone treatment. No appreciable difference could be detected between the mortality of fish injected with the hormone before being loaded, those injected upon reaching their destination, and those receiving no injection.

An attempt was made to determine whether gravid females could be transported more successfully under the influence of a tranquilizer. Simultaneously, the benefits of water circulation and aerating with oxygen during transit were evaluated. Quinaldine at a concentration of 7.5 ppm, MS-222 at a concentration of 15.0 ppm, mechanical agitation, and oxygen were used in four separate compartments of a hatchery distribution unit. All of the fish arrived at Fayetteville in good condition and subsequent observations indicated no appreciable difference in the rates of mortality; therefore, the use of tranquilizers during transport was discontinued.

Generally, methods outlined by Stevens (1964) for examining and handling the fish and for determining the ripeness of the eggs, were followed. The females were held in glass-front plywood aquaria (24" x

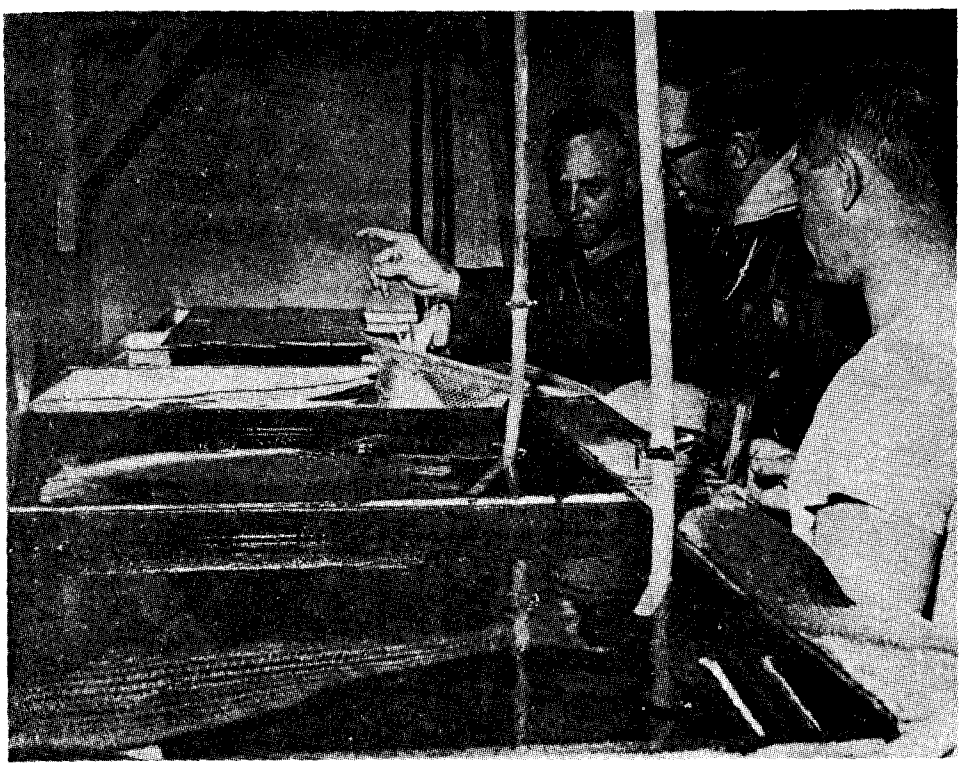


Figure 1. Sampling eggs from a female held in a small aquarium.

32" x 16"), as shown in Figure 1, or in concrete troughs. Contrary to popular belief, the small aquaria proved entirely satisfactory for holding gravid female striped bass, weighing up to 18 pounds, for periods up to 48 hours. Observation and examination of the females for egg development were simplified when the female was held in these small aquaria.

A total of 11 females were induced to ovulate by the use of hormones. At Fayetteville, eight females survived until ovulation. About 1,500,000 eggs were obtained from these fish, and the resultant hatch approximated 10,000 fry. Eggs taken from six of these females which had lost equilibrium were a total loss.

Three of 17 females transported to the Weldon Hatchery via Fayetteville were induced to spawn. Two of these fish had lost equilibrium before the eggs were taken and, although all of the eggs water hardened, no fry developed in the 300,000 eggs produced. The third fish, however, while spawning only 200,000 eggs, produced 50,000 fry. The unfavorable results of these experiments might be attributed to the inexperience of hatchery personnel in determining the exact time to take the eggs, and/or to the possibility of having used impotent males.

WELDON HATCHERY OPERATIONS

In addition to ripe fish brought to the Weldon Hatchery by fishermen, brood fish were collected with an electro-fishing device using alternating current. The unit was powered by a 230-volt, 180-cycle, Homelite generator connected to a multitap, step-up transformer. Voltage was increased until the current approximated four amperes.

After collection with the "shocker," the fish were placed in water containing approximately 5.0 ppm Quinaldine and transported to the hatchery. Egg samples were checked for stage of development, and the fish injected with 2,000 International Units of human chorionic gonadotropin and held in a small aquarium. The females taken from the Roanoke River ovulated in less than 24 hours after injection. Male striped bass were kept in an aquarium for periods of six to eight days.

Artificial light appeared to have a tranquilizing effect upon striped bass in the aquaria. Early in the season, it was noted that the fish reacted violently when the lights were turned off. Thereafter, the lights remained on.

To evolve the most efficient method of checking egg development within the gravid female and to determine the time of ovulation, one of the following techniques was employed:

1. The female was held within a net while a sample of eggs was removed from the ovarian sac with a catheter (3mm. O.D.). This method was easy for the worker, but the excitement and the physical abuse (loss of scales, etc.) suffered by the fish caused it to weaken visibly each time an egg sample was taken. This method produced the highest mortality of females.
2. As the calculated time of ovulation approached, a buck was placed in the aquarium with the female. If the female was ready to spawn, she would frequently begin extruding eggs, whereupon she was collected with a net which immediately stopped the flow of eggs. This method had two serious drawbacks: It was not reliable because some females would not react to the buck; secondly, when the female did react and start to release eggs, the buck made no attempt to fertilize them. Two attempts to fertilize the eggs by manually stripping the male as the eggs were being extruded produced very few fertilized eggs.
3. As ovulation approached, the females became torpid, and because of the limited movement in the aquarium, it was a simple matter to insert a catheter into the vent and obtain an egg sample without disturbing the fish. This method definitely appeared to be the most efficient way of determining the stage of egg development.

At the time of ovulation, fish were removed from aquaria and the same procedure as used by Stevens (1964) for taking eggs was employed.

The percentage hatch of eggs taken from 25 hormone injected

females was 55.7 percent. The percentage hatch of eggs taken from 41 naturally ripened females was 70.0 percent.

EGG EXPERIMENTS

Anticipating future needs for transporting eggs, several experiments were conducted to determine the optimum stage at which eggs should be transported. The eggs used in these experiments were of either of two categories: (1) eggs immediately following fertilization; or (2) eggs after six to 28 hours of incubation. A plastic bag was the conveyor used in all experiments. A measured amount of water (with temperatures ranging from 61° to 67° F.) was placed into the bag, eggs were added, and the remaining volume of the bag filled with oxygen (see Table 1). The bag was then sealed with rubber bands.

For use as controls in all experiments reported herein, some eggs from each group were subjected to normal hatchery incubation wherein fertilized eggs are placed into McDonald jars and gently agitated by water until hatched.

In the experiments using eggs immediately following fertilization, the eggs were placed into plastic bags containing varying amounts of water and oxygen. The bags were floated, for periods of six to eight hours, in aquaria receiving a constant flow of water for temperature control. They were then transferred to McDonald jars for hatching. The mortality of eggs handled in this manner invariably was greater than in the controls.

In experiments using eggs following six to 28 hours of normal incubation, the eggs were placed into plastic bags and treated in the same manner as described for those immediately following fertilization. The success of the latter was confirmed when eggs were actually transported in plastic bags by a hatchery distribution truck for four to six hours, and by airplane for approximately 12 hours. At destination, the eggs were returned to McDonald jars for hatching. There was no appreciable increase in mortality of these eggs when compared with the controls.

From these experiments, it was concluded that striped bass eggs should be normally incubated for a minimum of six hours before transportation. It is suggested that, for optimum results, the eggs be agitated for 12 to 16 hours before transportation. At this stage of development, the unfertilized eggs have become opaque and more buoyant than fertilized eggs, hence they are easily removed by siphoning.

FRY EXPERIMENTS

To develop techniques for rearing striped bass fry, experiments were conducted in earthen ponds, outdoor concrete pools, plywood aquaria, and hatchery troughs. Zooplankton, trout starter meal, trout starter meal combined with liver, #00 Silvercup starter feed, and #2 Purina trout pellets were used in various feeding experiments.

Earthen Ponds

Three one-tenth acre ponds were drained, the seepage areas treated with rotenone and detoxified with potassium permanganate. They were refilled with water filtered through Saran screen, and fertilized one week prior to stocking. On 10 May, two of the ponds were stocked with two-day old fry and the third received one-day old fry. On 22 May, an additional 15,000 two-day old fry were stocked into each pond.

Despite all precautions, mosquitofish (*Gambusia affinis*) and dense populations of phantom midge larvae (*Chaoborus* spp.) developed in the ponds. Suspicions that the larvae might be preying upon the fry were confirmed in laboratory experiments in which the *Chaoborus* spp. were actually observed killing the fry. These larvae, like the mosquitofish, apparently prey upon sac-fry to the extent that they can be a serious problem.

A total of 990 striped bass fingerlings, ranging from 2" to 4½", were reared from sac-fry in the three ponds. The most probable reason for the poor survival to fingerlings is that the fry were stocked before

TABLE 1

EXPERIMENTS ON TRANSPORTING EGGS IN PLASTIC BAGS

EGGS IMMEDIATELY AFTER FERTILIZATION

NUMBER OF EXPERIMENTS	ESTIMATED NUMBER OF EGGS	NUMBER OF HOURS IN PLASTIC BAG	SIZE OF PLASTIC BAG	AMOUNT OF WATER IN BAG	ESTIMATED PERCENT MORTALITY IN CONTROLS	ESTIMATED PERCENT MORTALITY IN TEST EGGS
1	5,000	6	Pint	1/3 Pint	20	50
1	5,000	8	Pint	1/3 Pint	25	50
1	5,000	6	Pint	½ Pint	30	40
1	5,000	8	Pint	½ Pint	30	50
1	10,000	6	½ Gallon	Pint	15	30
1	10,000	8	½ Gallon	Pint	20	40
1	25,000	6	½ Gallon	Quart	20	30
1	25,000	8	½ Gallon	Quart	25	30
1	50,000	8	15"X 15"X 23"	1 Gallon	20	100
1	50,000	6	15"X 15"X 23"	2 Gallons	25	40
1	50,000	8	15"X 15"X 23"	2 Gallons	25	50
1	100,000	6	15"X 15"X 23"	1 Gallon	25	100
1	100,000	6	15"X 15"X 23"	2 Gallons	20	30
1	100,000	8	15"X 15"X 23"	2 Gallons	25	40

EGGS AFTER WATER HARDENING

NUMBER OF EXPERIMENTS	AGE OF EGGS AT BEGINNING OF EXPERIMENTS IN HOURS	ESTIMATED NUMBER OF EGGS	NUMBER OF HOURS IN PLASTIC BAG	SIZE OF PLASTIC BAG	AMOUNT OF WATER IN BAG	ESTIMATED PERCENT MORTALITY IN CONTROLS	ESTIMATED PERCENT MORTALITY IN TEST EGGS
			LABORATORY EXPERIMENTS				
3	28	2,500	6	Pint	1/3 Pint	1	1
3	12	2,500	6	Pint	1/3 Pint	10	10
3	12	2,500	8	Pint	1/3 Pint	15	15
3	18	2,500	6	Pint	1/3 Pint	10	10
3	18	2,500	8	Pint	1/3 Pint	10	10
			EGGS ACTUALLY TRANSPORTED BY HATCHERY TRUCK				
1	24	100,000	4	15"X 15"X 23"	2 Gallons	95	95
1	6	100,000	4	15"X 15"X 23"	2 Gallons	30	35
1	6	50,000	4	15"X 15"X 23"	2 Gallons	37	45
1	12	65,000	6	15"X 15"X 23"	2 Gallons	10	10
1	12	70,000	6	15"X 15"X 23"	2 Gallons	25	25
			EGGS ACTUALLY TRANSPORTED BY AIRPLANE				
1	9	20,000	12	15"X 15"X 23"	2 Gallons	20	25

During these experiments, water temperature ranged between 61^{o} to 67^{o} F.

they were swimming horizontally and, therefore, were very susceptible to predation by *Chaoborus* spp. and *Gambusia* spp.

Striped bass fry in the three ponds were fed twice daily beginning ten days after the initial stocking. Trout starter meal was fed for ten days and then changed to #00 Silvercup starter feed until the ponds were drained 60 to 75 days later. At no time was there any visible evidence that the food was being taken.

OUTDOOR CONCRETE PONDS

Two outdoor concrete pools (30′ x 8′ x 3′) were filled with water filtered through Saran screen. Five days later, 10,000 two-day old fry, hatched from eggs obtained by the use of hormones, were stocked into one pool. Fifty thousand three-day old fry, also obtained by the use of hormones, were stocked into the second pool.

For a period of three weeks, zooplankton were placed into the two pools each day. The fry developed mouth parts in four days and were observed feeding on the zooplankton at five days of age.

Trout starter meal was fed twice daily starting when the fry were two weeks old. The fry were observed feeding on the trout starter meal at four weeks of age, one week after feeding zooplankton had been discontinued and four days after no zooplankton could be observed. At five weeks of age, the trout starter meal was discontinued and #00 Silvercup starter feed was fed twice daily. The change of food did not decrease feeding activity.

In addition to the fry experiments, fingerlings from the earthen ponds were transferred to outdoor concrete pools for feeding experiments. They were fed twice daily and, in one week, were actively feeding on a mixture of ground liver and trout starter meal. During the second week, the liver was gradually removed from the diet and #2 Purina trout pellets were added at the same rate that liver was removed. By the end of the second week, the diet had been changed completely. The fish fed actively and attained total lengths ranging from 2½″ to 5″ at age 14 to 16 weeks, with an over-all mortality estimated at 15 percent, when finally removed and stocked.

PLYWOOD AQUARIA

At the Fayetteville Laboratory, experiments were conducted to: (1) rear striped bass fry in plywood aquaria (24″ x 32″ x 16″) using artificial food and zooplankton and (2) compare the results of two feeding methods in three chemically different waters. The three sources of water were the Fayetteville Hatchery water supply (Lake Rim), water in fertilized hatchery ponds, and well water. Lake Rim, pond, and well waters varied little, chemically, during the experiments except for the pH of Lake Rim water, which varied from 5.1 to 5.7 during this period (see section on bioassays Table 3). The range of water temperatures was: Lake Rim — 70° to 76° F; pond — 73° to 76° F; well — 65° to 68° F.

Approximately 10,000 fry (one to three days old) were placed into each aquarium. The fry in one-half of the aquaria, in each series of experiments, were fed trout starter meal once each hour during daylight hours and the other aquaria received zooplankton. Each aquarium was cleaned by siphoning at least every other day. Many fry were lost or injured while cleaning the aquaria.

A total of 120,000 fry were used in 12 separate attempts to rear striped bass in aquaria supplied with Lake Rim water. Although the fry in one experiment survived for 34 hours, total mortality occurred at an average of 22 hours.

In experiments using well water, food was observed in the stomachs of some fry at eight days of age. The number of surviving fry decreased daily thereafter until, at the end of 15 days, all fry were dead. The average time required for 100 percent mortality in the well water was 9.7 days.

In the aquaria supplied with pond water, food was observed in the stomachs of fry on the seventh and eighth day but all were dead at the end of eight days. The accelerated mortality that occurred in Lake Rim

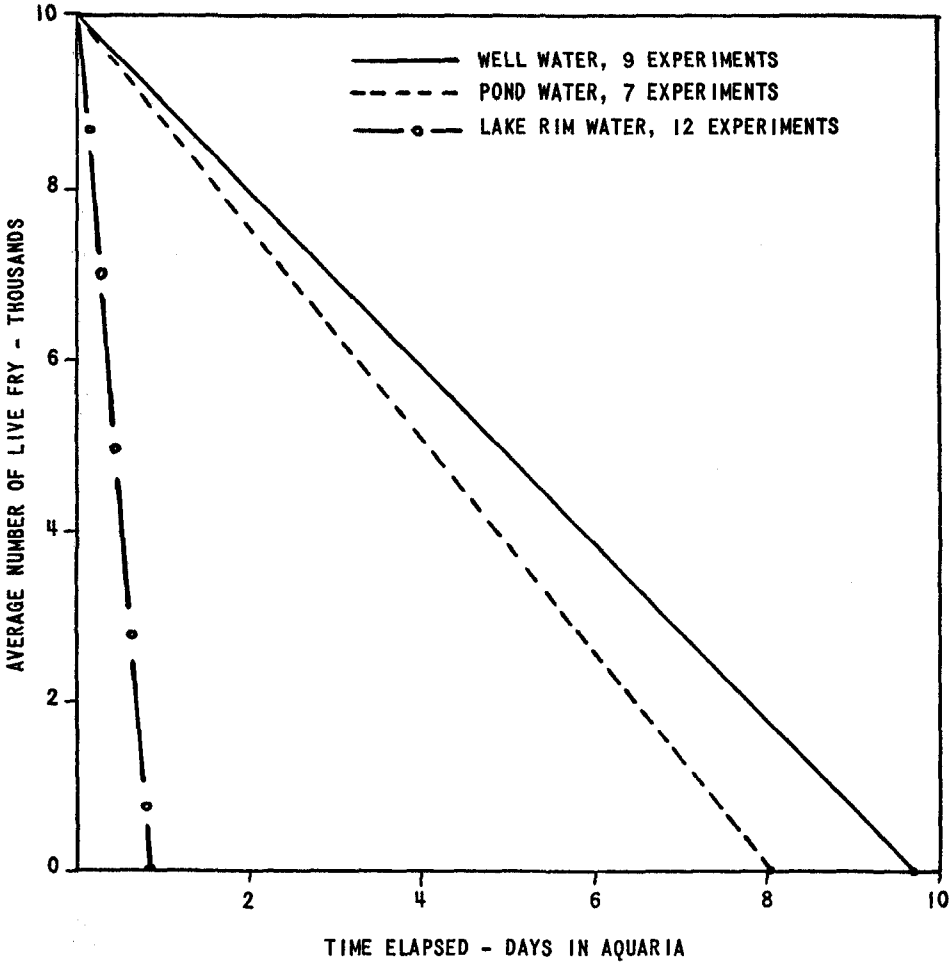


Figure 2. Graphic Presentation of Effect of Water Quality on Fry Survival in Aquaria

water is depicted graphically in Figure 2. This water, however, is suitable for the propagation of many freshwater fishes. The apparent lethal effects of Lake Rim water quality was further demonstrated by the following experiment:

> Approximately 15,000 advanced striped bass fry were placed into troughs (8' x 3' x 1') for feeding experiments. These fish, three to four weeks of age, were reared in concrete pools and transferred to Lake Rim water. The fry were collected with a seine, placed into containers of water from the pools, carefully tempered for 30 minutes with Lake Rim water, and gently poured into the troughs. A total mortality occurred within 24 hours but no mortality was observed in the pools. The chemical analyses of the two waters are presented in Table 2.

BIOASSAYS AND HANDLING EXPERIMENTS

Bioassays

Bioassays were conducted because no information concerning the

Table 2. Chemical Analyses of Waters Used in Hatchery Trough Feeding Experiments

	LAKE RIM	CONCRETE POOLS	
Temperature	76° F	78° F	78° F
Dissolved Oxygen	6.2 ppm	6.8 ppm	6.6 ppm
pH	5.1	7.2	6.9
Alkalinity	12 ppm	24 ppm	20 ppm
Acidity	15 ppm	6 ppm	8 ppm

toxicity of pH, Quinaldine, MS-222, or salt (NaCl) to striped bass was available. These were selected because each will be associated with future studies. The objectives were: (1) to determine the 24-hour TL_m values of pH, Quinaldine, MS-222, and salt; (2) to determine the two-hour TL_m values of Quinaldine and MS-222 (estimated maximum exposure time for transport between the spawning grounds and the hatchery); and (3) to determine the effects of repeated exposures to Quinaldine.

Generally, methods and procedures described by the American Public Health Association (1960) were employed in all bioassays. Advanced striped bass fry, averaging one inch in total length, were used in the pH experiment. The fingerlings used in the 24-hour Quinaldine, MS-222, and salt bioassays averaged two inches in total length. The fingerlings used in the two-hour Quinaldine and MS-222 experiments ranged from 2½" to 4¾". Three-gallon, widemouth glass jars, each containing ten liters of test solution, were used as the bioassay containers. The dilution water was taken from the pond in which the fish, used in each experiment, had been reared. The temperature ranged from 72° to 84° F. The striped bass were collected with an Ace minnow seine and no mortality occurred during handling prior to introduction into the test solutions. All surviving fish at the end of each experiment were placed into fresh water from the pond in which they were reared and observed for an additional 24 to 96 hours.

In the pH bioassay, the pH of the water was adjusted to the desired value with citric acid and disodium phosphate buffers. A preliminary test to determine the effects of the buffer solutions on the test fish in pool water indicated that neither was toxic. The 24-hour TL_m value was found at pH 5.3. Water from Lake Rim (pH 5.5), used as an additional control in the pH bioassay, caused an 80-percent mortality, No mortality occurred in pool water following pH adjustment as low as 5.5. However, all test fish died in 14½ hours in pool water adjusted to pH 5.1. The results of this experiment indicate that pH, per se, was not the cause of all mortality experienced with fry in water from Lake Rim.

Therefore, chemical analyses of well, pond, and Lake Rim waters for possible toxic substances, were made by the North Carolina State Stream Sanitation Committee Laboratory (Table 3).

Table 3. Chemical Analyses of Waters as Conducted by the North Carolina State Stream Sanitation Committee Laboratory

	WELL	POND	LAKE RIM
pH	8.4	8.8	6.0
Alkalinity	119.0 ppm	14.0 ppm	6.0 ppm
Chlorides	3.0 ppm	4.0 ppm	3.0 ppm
Total chromium	<0.05 ppm	<0.05 ppm	<0.05 ppm
Copper	<0.04 ppm	<0.04 ppm	<0.04 ppm
Zinc	<0.05 ppm	<0.05 ppm	0.07 ppm
Nitrate nitrogen	<0.1 ppm	0.1 ppm	0.2 ppm
Total hardness (as $CaCO_3$)	38.0 ppm	30.0 ppm	8.0 ppm

The concentration of zinc (0.07 ppm) found in Lake Rim water was reported by the California Water Pollution Control Board (1954) as toxic to young rainbow trout and trout eggs. However, the lethal concentra-

tions of zinc for various species of fish as reported ranged from 0.01 to 200.0 ppm.

The 24-hour TL_m value for Quinaldine was 22.0 ppm. In these bioassays the fish in both the 5.0 and 10.0 ppm. concentrations of Quinaldine were tranquilized for five hours. At that point they recovered while still in the test solutions apparently as the accompanying aeration decreased the effect of Quinaldine. The fish in 15.0 and 20.0 ppm concentrations remained narcotized for the full 24-hour period but fully recovered in less than one hour when returned to fresh water.

The 24-hour TL_m value for MS-222 was 50.0 ppm. The fish in 25.0 and 30.0 ppm were tranquilized but never narcotized while those in 40.0 and 50.0 ppm were narcotized in 15 minutes. All fish in 75.0 ppm died; however, upon the addition of MS-222 the pH of the solution dropped from 6.9 (dilution water) to 5.2 which may have contributed to the mortality.

The 24-hour TL_m value for salt was 4,830 ppm (16 percent sea-water equivalent). Salt, at concentrations up to 3,220 ppm (10 percent sea-water equivalent), had no apparent effect on striped bass fingerlings for the 24-hour period of the experiment.

The two-hour TL_m value for Quinaldine was 42.0 ppm (Table 4). All fish in 25.0 to 40.0 ppm were narcotized in five minutes, remained narcotized for the full two-hour period of the experiment, and recovered following ten minutes in fresh water. No detectable water quality change accompanied the addition of Quinaldine. It is not necessary to use concentrations of Quinaldine greater than 25.0 ppm to narcotize striped bass fingerlings for two-hour periods because, at this concentration, the fish are narcotized just as quickly as in 40.0 ppm.

The two-hour TL_m value for MS-222 was 65.0 ppm (Table 5). Striped bass fingerlings in 40.0 and 50.0 ppm were not narcotized during the two-hour period of the experiment while one hour was required to narcotize those in 60.0 ppm. However, the pH of the 60.0 ppm test solution dropped from 6.9 (dilution water) to 5.3 upon the addition of MS-222. The pH was 5.1 at 70.0 ppm, 4.6 at 100.0 ppm, and 3.8 at 150.0 ppm.

It appears, therefore, that Quinaldine is superior to MS-222 either as a tranquilizer or a narcotic. With Quinaldine, the concentration at which almost immediate narcosis occurs is well under the lethal concentration. On the other hand, lethal concentrations of MS-222 were required for immediate narcosis.

In an effort to determine the effect of multiple exposures of striped bass to Quinaldine, fingerlings were exposed to 10.0 ppm or 30 minutes each day on four successive days. Four fish were exposed to Quinaldine, and four control fish were handled in a similar manner but without Quinaldine. No mortality occurred among any of the test fish during the experiment nor during a 96-hour observation period following the experiment. The results indicate that striped bass fingerlings can be exposed at least four times to 10.0 ppm Quinaldine with no adverse effects.

Handling of Fingerlings

Since handling is required in the propagation of striped bass and reputedly poses a problem, experiments were conducted with fingerlings to investigate the effects of handling under the following conditions:

1. Without changing the water quality by transferring from one container to another, both containing the water in which the fingerlings had been reared.
2. Changing the water quality by transferring from the water in which the fingerlings had been reared to water from Lake Rim, Cape Fear River, or High Rock Lake.
3. Using tranquilizers (Quinaldine and MS-222) and salt (NaCl) for transfers under the above conditions.

The fingerlings used in the handling experiments ranged from 2½" to 5" in total length. All fish were collected with a seine, removed individually and placed directly into the test containers which were three-gallon, widemouth glass jars containing ten liters of test water. During

TABLE 4

THE TWO-HOUR MEDIAN TOLERANCE LIMIT VALUE FOR QUINALDINE

QUINALDINE CONCENTRATION	NUMBER TEST FISH	NUMBER SURVIVING AFTER 2 HOURS	DISSOLVED OXYGEN PPM	pH	TOTAL ALKALINITY PPM	TOTAL ACIDITY PPM
Control	4	4	7.0	6.8	26.0	11.0
25.0 ppm	4	4	6.9	6.8	30.0	11.0
30.0 ppm	4	4	6.9	6.8	30.0	11.0
35.0 ppm	4	4	7.0	6.8	30.0	11.0
40.0 ppm	4	4	7.2	6.8	28.0	10.0
45.0 ppm	4	0	7.2	6.8	35.0	11.0
50.0 ppm	4	0	7.1	6.8	28.0	12.0
60.0 ppm	4	0	7.1	6.8	26.0	10.0
70.0 ppm	4	0	7.0	6.8	24.0	10.0

2-Hour TL_m Value = 42.0 ppm Quinaldine

Constant Temperature During Experiment - 82° F.

TABLE 5

THE TWO-HOUR MEDIAN TOLERANCE LIMIT VALUE FOR MS-222

MS-222 CONCENTRATION	NUMBER TEST FISH	NUMBER SURVIVING AFTER 2 HOURS	DISSOLVED OXYGEN PPM	pH	TOTAL ALKALINITY PPM	TOTAL ACIDITY PPM
Control	4	4	6.9	6.9	26.0	11.0
40.0 ppm	4	4	6.7	6.4	15.0	9.0
50.0 ppm	4	4	6.8	6.0	20.0	9.0
60.0 ppm	4	4	6.6	5.3	15.0	12.0
70.0 ppm	4	0	6.8	5.1	14.0	12.0
100.0 ppm	4	0	6.6	4.6	14.0	16.0
125.0 ppm	4	0	6.6	4.1		
150.0 ppm	4	0		3.8		

2-Hour TL_m Value = 65.0 ppm MS-222

Constant Temperature During Experiment - 82° F.

the experiments the temperature ranged from 80° to 84° F—approximating that of the ponds when the fish were collected.

All fish remained under test for eight hours (estimated maximum hauling period). They were then poured into a net, placed into fresh water to simulate the second handling at destination, and observed for an additional 36 to 96 hours. No mortality accompanied any of the above stated transfers.

Striped bass fingerlings obviously can be handled successfully without tranquilizers. These experiments, combined with information from water quality experiments and other observations, indicate that the mortalities previously attributed to handling may have been caused by a rapid change in water quality.

The above experiments were concluded when 800 striped bass (2½" to 5") were transported, without tranquilizer, to High Rock Lake (transit time—4 hours) with no immediate mortality.

CONCLUSIONS

1. Gravid females can be collected from Albemarle Sound—150 river miles from their natural spawning ground and three to four weeks before their normal spawning time—and ovulated by the use of hormones.
2. Tranquilizers did not appear to affect hauling mortality of gravid females.
3. Gravid females, weighing up to 18 pounds, were held successfully in small aquaria until ovulation, the longest time being 48 hours. Males were held—in similar containers—for periods up to eight days with no apparent detrimental effect.
4. Fish on the Roanoke River spawning grounds can be collected by use of an electric shocker, induced to ovulate with hormones, and successfully spawned.
5. Fish held in aquaria appeared more tranquil when the light intensity remained constant.
6. Some females will release eggs when a male is placed into the aquarium.
7. Gravid females become torpid a few hours prior to ovulation and in aquaria egg samples can be taken, without handling the fish, by gently inserting a catheter into the vent.
8. Eggs from Roanoke River fish injected with hormones had an average hatch of 56 percent; eggs from Roanoke River fish that did not receive hormones had an average hatch of 70 percent.
9. Fertilized eggs which have been incubated for six to 28 hours may be transported from four to 12 hours in plastic bags containing water and oxygen with no appreciable increase in mortality.
10. Fry were reared successfully in one-tenth acre earthen ponds but at no time observed taking artificial food.
11. *Chaoborus* spp. prey upon sac-fry.
12. Fry should be swimming horizontally before being stocked.
13. Fry were reared successfully and took artificial food readily in outdoor concrete pools.
14. All attempts to raise fry in aquaria failed.
15. Both fry and fingerlings appear drastically affected by rapid changes in pH and/or other chemical characteristics.
16. The 24-hour median tolerance limit values for Quinaldine, MS-222, salt (NaCl), and pH were 22.0 ppm, 50.0 ppm, 4,830 ppm, and 5.3, respectively.
17. The two-hour median tolerance limit values for Quinaldine and MS-222 were 42.0 and 65.0 ppm, respectively.
18. The use of tranquilizers or saline on fingerlings has no apparent effect on handling mortality.
19. Quinaldine appears to be superior to MS-222 as a tranquilizer or narcotic.
20. Waters to be stocked with fry or fingerlings should be bioassayed with a few fish prior to stocking.

ACKNOWLEDGMENTS

The authors are indebted for the field assistance of Messrs. William R. Bonner, Thomas E. Crowell, Hilton A. Phillips, and Eugene H. Shannon of the North Carolina Wildlife Resources Commission.

The assistance of Dr. Frederic F. Fish of the North Carolina Wildlife Resources Commission, in the critical review of the manuscript, is greatly appreciated.

LITERATURE CITED

American Public Health Association, Inc., 1960. Standard Methods for the Examination o fWater and Wastewater Including Bottom Sediments and Sludges. Eleventh edition. 626 pp.

California Water Pollution Control Board, "Water Quality Criteria." State Water Pollution Control Board Publ. No. 3, 512 pp. (1952) and Addendum No. 1, 164 pp. (1954).

Stevens, Robert E., 1964. A Final Report on the Use of Hormones to Ovulate Striped Bass, *Roccus saxatilis* (Walbaum). Proceedings of the Annual Southeastern Association of Game and Fish Commissioners. Vol. 18.

Worth, S. G., 1884. Report Upon the Propagation of Striped Bass at Weldon, North Carolina, in the Spring of 1884. Bull. U. S. Fish Comm., 4:225-230.