STATUS AND ARTIFICIAL REPRODUCTION OF STRIPED BASS FROM KEYSTONE RESERVOIR, OKLAHOMA [1]

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ABSTRACT

The investigation to verify striped bass, *Morone saxatilis* (Walbaum), reproduction in Keystone Reservoir utilized egg sampling and shoreline seining methods. Conditions in the Arkansas River throughout the egg sampling period were unfavorable and seemed to indicate little chance for a successful spawn. However, on June 21, 1971, natural reproduction was verified. The total 1971 fingerling survival was calculated at 975,000.

Ten mature females and four male striped bass were taken below Keystone dam by electrofishing during the period May 24 to June 3, 1971. These fish were transported 150 miles to hatchery facilities where artificial spawning was conducted. One seven-pound female was successfully spawned and fry were produced. Problems, procedures and resulting recommendations are discussed. Age and growth determinations and length-weight relationsips are presented.

INTRODUCTION

Since the initiation of the striped bass program in 1965, the Oklahoma Department of Wildlife Conservation has developed a successful rearing program for the production of striped bass fingerlings (Jarman and Harper, 1969). As a result of the fingerling stocking program, a reproducing population of striped bass has developed in Keystone Reservoir (Mensinger, 1970).

Initially, striped bass of various size and age groups were obtained from South Carolina, North Carolina, Virginia and California. Introductions were made in those lakes which appeared to possess the requirements necessary for natural reproduction. Keystone Reservoir, located on the Arkansas River, was selected for this experimental program. A complete chemical description of the reservoir has been given by the U. S. Geological Survey (1960-61) and physical data has been presented by Mensinger (1970).

Approximately 2.75 million striped bass ranging from fry to adults were stocked in Keystone Reservoir from 1965-1969. A project financed in part by the Federal Aid in Fish and Wildlife Restoration, Project F-29-R, was initiated in March, 1969, to determine if a spawning population of striped bass had developed. Natural reproduction was not found in 1969. The project was continued in 1970 and natural reproduction was verified with survival of 1.45 million fingerling fish (Mensinger, 1970).

The project was expanded in 1971 to compare various methods for obtaining striped bass broodstock. Culture of Striped Bass, Project F-25-R, was rewritten to include a comparison of broodstock transport methods and initial artificial reproduction procedures.

NATURAL REPRODUCTION

Investigations to identify natural reproduction consisted of egg sampling and shoreline seining as described by Mensinger (1970).

Egg Sampling

Systematic egg sampling was conducted April 26 to May 17, 1971, from primary stations on the Arkansas River, upstream from Keystone Reservoir.

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Sampling sites were located at Blackburn and Ralston bridges. The 10-inch egg nets were used for 193 hours and the one-half meter nets for 27 hours and 45 minutes. Although eggs were collected during the sampling period, no striped bass eggs were identified. Egg sampling terminated May 17, 1971, after river temperature remained above 75° for several days.

Shoreline Seining

From June 21 to July 15, 1971, a total of 15,260 feet of shoreline was seined and 157 young-of-year striped bass were captured. Seining results indicated spawning activity occurred in the Arkansas River. The 1971 fingerling survival was calculated to be approximately 975,000 as compared to 1.45 million in 1970.

It was observed during egg sampling that river conditions were unfavorable for a successful spawn. Despite the lack of normal spring rises and turbulent water conditions, the first seine haul revealed the presence of young striped bass. Based on growth of striped bass in Oklahoma culture ponds, these fish were estimated to be approximately 14 days old. This placed the time of spawning activity at June 5, 1971. Inflow records from the U. S. Army Corps of Engineers revealed a significant rise in computed inflow into the reservoir from 5,786 cfs on June 3, 1971, to 16,440 cfs on June 5, 1971. Apparently, spawning activity had occurred approximately three weeks after the termination of egg sampling.

BROODSTOCK COLLECTION

Capture methods for striped bass during the spawning season are varied and well documented. These methods included pound nets and haul seines (Merriman, 1941; Dickson, 1957; and Grant *et al.*, 1969), and fyke nets reported by Grant, *et al.*, 1969. Electro-fishing was used for striped bass collection by Neal (1967), Keith (1969) and Bayless (personal communication).

In order to determine the most applicable method of obtaining striped bass broodstock, various gear was used in Keystone Reservoir and Keystone tailwaters. Research was conducted in the headwaters of the reservoir during what was considered the normal spawning migration period. Due to cold water discharges, tailwater research did not begin until later in the Spring.

Keystone Reservoir

During the period March 23 to April 9, 1971, trap nets, hoop nets and fyke nets were set in the reservoir along possible striped bass migration routes.

Fifteen trap net nights produced one male striped bass. The fish was taken from a 4-foot trap net set 13 feet deep in the Arkansas River arm. All other netting effort was unsuccessful.

Entrapment gear used in the reservoir has potential for taking adult striped bass, but additional research is necessary before effective broodstock collection procedures can be defined.

Keystone Tailwaters

Physical conditions in the tailwaters area limited the use of entrapment gear, however, electrofishing appeared to have practical application.

An electro-shocker was constructed and designed after a unit used by Bayless (personal communication) at Moncks Corner, South Carolina.

A 230-volt AC, single phase, generator supplied current for two electrodes which were extended from either side of the bow. These electrodes were made of 25′ x ¾″ stainless steel cable.

Electrofishing was conducted during daytime and nighttime hours in generating and non-generating periods.

Utilization of the electro-shocker in the tailwaters was considered successful. During the period May 24 to June 11, 1971, approximately 60 hours sampling time produced 17 adult striped bass. Fourteen striped bass were collected during daytime generating periods in the swift water of the tailrace. Three adults were taken along the flood gate wall during the late evening. No striped bass were taken in non-generating periods.

Electrofishing below the dam will be continued as a method of obtaining striped bass broodstock. It was observed the productiveness of this method decreased with continual day after day shocking effort. Reasons for this decrease were not known, however, depletion of fish numbers should not have been a factor. Additional data should be collected to identify conditions of maximum production.

ARTIFICIAL REPRODUCTION

After broodstock were obtained, methods of artificial propagation as used by Bayless (*personal communication*) and Stevens (1966) were modified to suit the existing situation.

Since the nearest hatchery was located 150 miles from the capture site, various transport techniques were investigated. Adult striped bass were transported by means of a wooden agitator unit equipped with supplemental oxygen. Ice was added to maintain the water temperature below 71°F. Quinaldine and sodium chloride were added to the agitator unit in all but two trials. Six females were injected with gonadotropic hormone at the capture site, while three others were injected upon arrival at the hatchery. The antibiotic, oxytetracycline, was injected into three fish in an effort to reduce mortality.

The water supply at the Byron Fish Hatchery is an artisan well. The water temperature during the project period ranged from 62°-66°F. A circular concrete tank, 20 feet in diameter, was divided in half and used for holding broodstock. A 3mm. glass tube was inserted into the urogenital opening of females to obtain egg samples for microscopic examination. Egg maturation was identified by stages presented by Stevens (1966).

During the collection period, 14 brooders were transported to the Byron Fish Hatchery. Those fish transported in untreated water apparently suffered no greater stress nor shock than those hauled with salt and Quinaldine.

Ripe female striped bass responded similarly to the gonadotropic injection, whether reciving it before or after transportation. Overall, transport procedures did not appear to be a limiting factor. A major problem encountered in all striped bass brooders was a bacterial infection of the eyes. All fish taken to the hatchery developed a white film over their eyes and eventually became blind if held for more than three or four days. Two bacterial cultures were grown from the eye of one female. One culture was taken from deep within the eye and the other from the cornea. The culture from within the eye was identified as *Pseudomonas fluorescens*. The cornea culture was identified as a member of the *Citrobacter* group.

A summary of collection dates and other pertinent data concerning the processing of broodstock are presented in Table 1.

Females #1 and #6 were immature and provided little pertinent data relative to the study. Female #2 was not ripe when injected at the capture site. She matured to stage V-VI and died approximately one hour before final egg maturation.

Female #3 was injected with 1200 units of gonadotropin at the capture site. Upon arrival at the hatchery, 4½ hours later, the female had developed to stage II (Stevens, 1966). Ovulation was complete 38 hours after the injection. Approximately 750,000 eggs were collected and fertilized. Hatching was completed within 59 hours and 500,000 fry were produced: 400,000 fry survived to 12 days of age and were stocked into culture ponds.

Female #4 was transported to the hatchery and injected with 2000 units of gonadotropin 6 hours after capture. This fish underwent extensive stress while egg sampling to follow egg maturation. However, she did mature to stage IV-V before dying.

TABLE 1. Striped bass broodstock transport data

Female No.	Female Weight	Date of Capture	Site of Hormone Injection	Oxytetracycline Injection	Stage of Eggs when Captured
# 1	5.3	5-24-71	None		Immature
# 2	14.7	5-24-71	Hatchery–1200 units	Lake—4cc	Green—Advanced to VI died before spawning.
# 3	7.0	5-24-71	Lake—1200 units	Lake—5cc	III—750,000 eggs were taken
# 4	11.2	5-26-71	Hatchery—2000 units		Advanced to V & VI
# 5	12.4	5-26-71	Lake—Inactive Ingredients		III—No Advance
# 6	5.1	5-26-71	Lake—Inactive Ingredients		Immature
# 7	11.9	5-26-71	Lake—Inactive Ingredients		I & II—Advanced to IV
# 8	14.1	5-27-71	Lake—Inactive Ingredients		I—Advanced to III
# 9	7.9	6-03-71	Lake—2000 units	Lake—5cc	III—Advanced to V
#10	17.0	6-03-71	Hatchery—2000 units		III—Advanced to VI

Females #5, 7 and 8 were injected with inactive ingredients at the lake. Twenty-four hours later, each fish was injected with 2000 units of gonadotropin. Egg maturation continued until mortality (Table 1).

Female #9 was transported to the hatchery before being injected with hormone. At the time of capture, this fish received an injection of oxytetracycline into the musculature of the belly. An open wound developed at the injection site allowing the viscera to protrude from the body cavity. The eggs matured from stage II to stage V before death occurred.

Female #10 received 2000 units of gonadotropic hormone at the hatchery. This fish became blind while being held at the hatchery. Thereafter, she was hyper-active, swimming repeatedly into the side of the pen. She advanced from stage III to VI and died approximately thirty-minutes before final egg maturation.

The information obtained from this limited number of fish should help develop a more successful hatching program. The injection of inactive material into the four females, the resulting time delay and the bacterial infection decreased production by an estimated 3,000,000 fry.

Due to the limited data, it was not possible to determine if the bacterial infection was directly responsible for mortality of the brooders. However, due to the amount of stress to which a gravid female is subjected (i.e. electrical shock, transportation, confinement, handling, natural stress of egg production and hormone injection) any disease organism could definitely be a limiting factor in broodstock survival. All broodstock displayed symptoms of the bacterial infection. If this factor can be eliminated, egg production would be greatly enhanced.

Confinement of females in smaller ponds would have aided periodic observation and reduced the stress to which they were subjected. Hormonal injections at the time of capture might have produced spawns despite the excessive disturbance.

In future projects, it is believed egg samples should be staged from all females as soon as they are captured. If in stage I or advanced, the female should be injected with 2000 units of gonadotropic hormone and transported to the hatchery. Data collected indicated a three to four hour delay of this injection can determine successful fry production.

All fish should be injected with a suitable antibiotic at the time of capture. Quinaldine should be used in combination with an antiseptic solution for transportation purposes. It is believed the fish undergo less trauma during transport if narcotized. Upon arrival at the hatchery, brooders should be maintained in 6-foot pens so they can be recaptured for observation with a minimal effort.

LIFE HISTORY OBSERVATIONS

Supplemental data concerning certain life history information was collected from Keystone Reservoir.

Age and Growth

The scale method was utilized to age 100 striped bass from Keystone Reservoir in 1970 and 1971. Samples were taken from fish captured in gill nets, trammel nets, trap nets and by electrofishing. Additional fish samples were provided by sport fishermen. Whenever possible, scales were taken from the mid-dorsal area as used by Scofield (1931), Merriman (1941), Tiller (1950), Robinson (1960) and Mansueti (1961). The direct body-length scale-length relationship was used to calculate growth. A minimum of four scales per fish were analyzed using an Eberbach scale projector. Damaged or regenerated scales were discarded.

The average calculated growth in total length at the end of each of the first five years is as follows: year I (11.1 inches), year II (18.7 inches), year III (23.1 inches), year IV (26.8 inches), year V (29.4 inches) (Table 2). The greatest increment of growth appears in the first year of life (Figure I). For comparative purposes, total lengths were

TABLE 2. Average calculated lengths and annual length increments in inches of striped bass from Keystone Reservoir, 1970-71

Age Group	No. of Fish	Calculated total length at end of year 1	2	3	4	5
1970	11	6.6				
1969	19	12.0	19.3			
1968	29	11.0	17.9	22.4		
1967	31	11.8	19.3	24.0	27.1	
1966	10	12.4	18.4	22.5	25.9	29.4
Grand Avg. and Total ...	100	11.1	18.7	23.1	26.8	29.4
Increments of Growth		11.1	7.6	4.4	3.7	2.6
Number of Fish		100	89	70	41	10

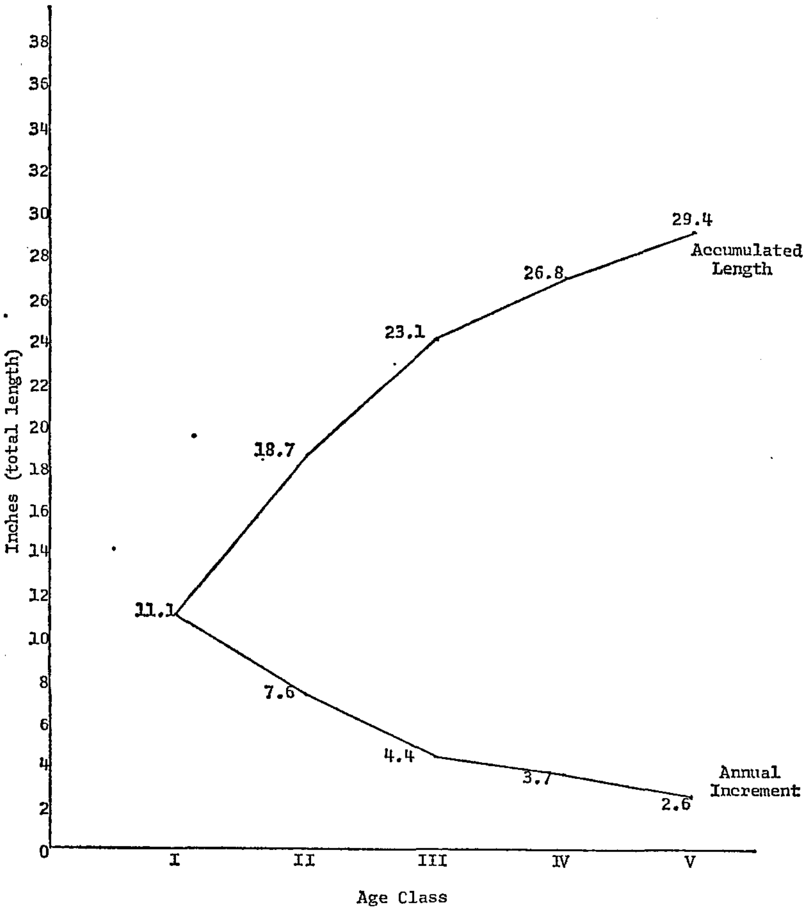

FIGURE 1. Annual length increments and accumulated lengths of striped bass from Keystone Reservoir

TABLE 3. *Comparison of striped bass growth rate studies*

Investigator	State	Date	Sex	Unit	I	II	III	IV	V	VI	VII	VIII	IX	X
Scofield	Calif.	1931	comb.	CFL	4.2	9.8	14.6	17.8	20.8	23.2	24.5			
Pearson	Maryland	1938	comb.	freq. dist.	4.0	10.0	15.0	18.5						
Merriman	N. Eng.	1941	comb.	CFL—4 yr.	4.9	9.2	14.4	17.7						
				mfl othr					20.9	24.0	27.0	29.5	32.3	
Morgan & Gerlach	Oregon	1950	comb.	MFL			14.5	19.0	22.7	25.0	27.3	28.8	30.0	
Scruggs	S. Car.	1957	comb.	CFL	6.7	14.0	18.3	20.8	23.6	25.8	28.3	30.4	32.5	
Stevens	S. Car.	1957	comb.	CFL	8.0	14.8	18.6	21.5	24.2	26.8	28.4			
Fitzpatrick & Cookson	Mass.	1958	comb.	MFL	8.9	11.2	12.5	15.0	17.6	19.9	21.9	23.1	24.1	25.1
Robinson	Calif.	1960	comb.	CFL	4.1	9.8	15.3	19.6	22.9	25.7	27.9	29.9	32.3	
Mansueti	Maryland	1961	female	CFL	4.9	11.5	15.3	18.4	21.9	25.4	28.5	30.8	33.7	35.4
Mensinger	Okla.	1970	comb.	CFL	9.5	16.7	19.8	22.2						
Ware	Fla.	1970	comb.	CFL	10.3	16.8								
Present Study	Okla.	1971	comb.	CFL	10.3	17.4	21.5	24.9	27.3					

CFL — Calculated fork length.
MFL — Measured fork length.

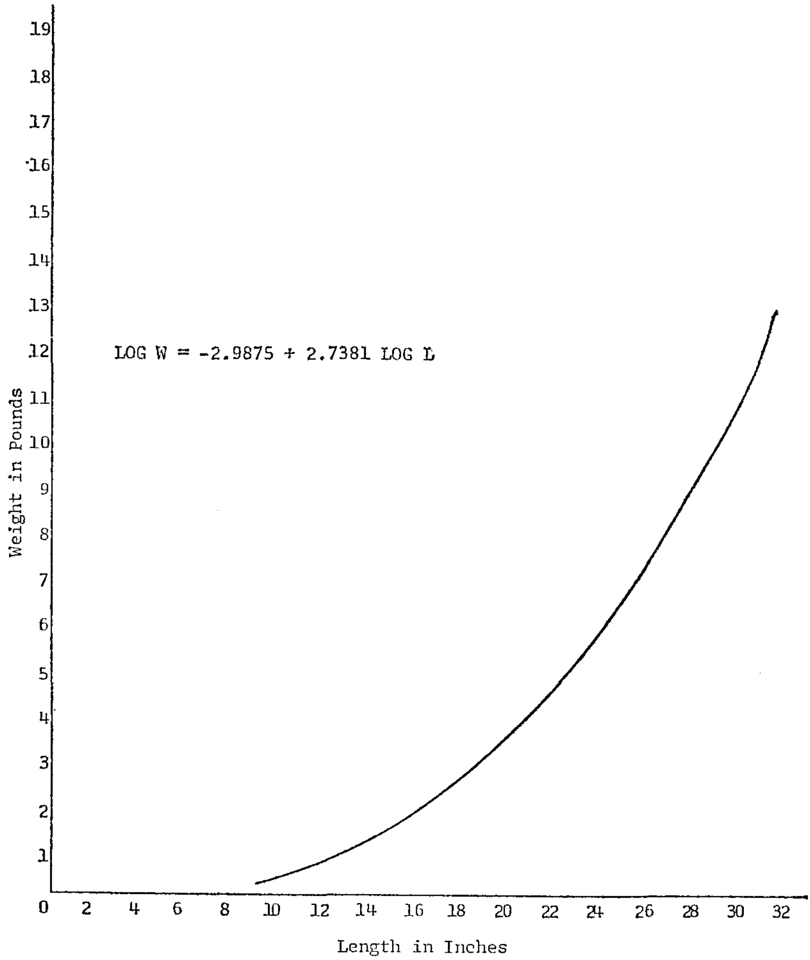

FIGURE II. Striped bass, length-weight relationship, 1969-1971, Keystone Reservoir

converted to fork length by the factor 0.93 (Mansueti, 1961). Striped bass growth rates from eleven other studies appear in Table 3.

Study specimens having one annulus varied from 5.2 to 14.1 inches in total length. Stevens (1957) noted striped bass from Santee-Cooper of this year class ranged from 2.9 to 12.8 inches total length.

The annulus of immature fish appears to form in December and probably in February for mature groups. Growth of mature fish is very slow from February to late May when spawning is complete. A number of scale samples taken from fish one calendar year old, 5.8-inch average total length, were examined but no annulus could be discerned. Data appear to be contradictory; however, the 1970 year-class was the year-class with the first natural spawn. It is also the year-class exhibiting the slowest growth in year one. Merriman (1941) reports the annulus in striped bass does not appear in winter and only becomes evident by April or May. Compensatory growth as described by Tiller (1943) has not been observed in previous year classes but opportunity for observance may be present in the 1970 year-class.

Length-Weight Relationships

The length-weight relationship was calculated from data of 148 fish assigned to 22 inch classes. Average weight in pounds was assigned to the total length midpoint in each class. The length-weight relationship is described by the equation $\log W = -2.9875 + 2.7381 \log L$ where $N = 22$. This relationship, shown in Figure II, is similar to length-weight studies conducted by Clark (1938), Merriman (1941), Robinson (1960) and Mansueti (1961), although it is based on total length data which would affect a slightly lower weight per unit length relation.

CONCLUSION

This report was presented to update the information available on the Keystone Reservoir striped bass program. Although the program must be considered successful, many of the observations and findings must be substantiated by additional research. Preliminary results and observations were presented which may be beneficial to striped bass research in other states.

Several major areas of intensified research are indicated for the future. They will involve: (1) determining the conditions which have accompanied striped bass spawns in Keystone in 1970 and 1971. The program had neither adequate funding nor personnel numbers to conduct the necessary research. The spawning area, flow rates, temperatures, etc. must be identified if striped bass introductions are to be conducted with the objective of establishing a reproducing population; (2) methods of obtaining broodstock must be further refined. The Keystone tailwater adequately provided numbers for initial investigations, but a full scale striped bass introduction program will require greater numbers of brooders. With the construction of the McClellan-Kerr navigation system, four additional tailwater areas now hold potential as broodstock sources. Two additional tailwater areas have yielded striped bass sportfishing catches and may also hold potential. Further refinement of capture techniques and exploration of new capture sites may provide the necessary broodstock requirements; and (3) transport and artificial propagation methods have been well defined in other states. With experience and slight modifications, Oklahoma fisheries workers will be able to complete the requirements for the striped bass stocking program.

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FOOD HABITS AND FEEDING SELECTIVITY OF STRIPED BASS FINGERLINGS IN CULTURE PONDS

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ABSTRACT

Stomach content analyses were performed on 213 striped bass (11.4-80.0 mm TL) collected from culture ponds at the Front Royal Fish Cultural Station, Virginia, during the 1969 and 1970 rearing seasons. Cladocerans (families Sididae, Daphnidae and Bosminidae) constituted the major portion of the diet of these fish with copepods (family Cyclopidae) and insects (family Chironomidae) also being important food organisms. Cladoceran abundance in the stomachs increased after the bass were 30-40 mm long, while copepod abundance decreased and insect abundance remained relatively stable. The fish negatively selected Brachionidae (rotifers) and copepod nauplii. Daphnidae and Bosminidae were positively selected and Cyclopidae was eaten in relation to its abundance in the ponds. Sididae was positively selected when present in small numbers, but eaten in proportion to its abundance when present in large numbers.