

# INDICATIONS OF A FRESHWATER POPULATION OF STRIPED BASS, *MOXOSTOMA SAXATILIS* (WALBAUM), IN SANTEE-COOPER RESERVOIRS

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*Abstract:* Since February of 1954, as an integral part of an investigation of fish populations in the Santee-Cooper Reservoirs, special emphasis has been placed on a study of the striped bass to determine whether a resident or migratory population is present. Evidence collected during the past several months, based on spawning ground location, samples taken of fish movement through the navigation lock, and recent recoveries from a tagging study, emphasize the possibility that a resident population is established. Striped bass spawning, based on the collection of eggs and larvae, was found to occur in the Tailrace Canal and Cooper River, below the reservoirs; in the Diversion Canal, between the reservoirs; and in the Congaree and Wateree Rivers, tributary streams of the reservoirs. Periodic samples, collected through the use of a trammel net, does not reflect an extensive striped bass movement through the navigation lock, the only passage way available to fish in relation to the reservoir area. Recapture data from the tagging study does not indicate an extensive recruitment of striped bass from Cooper River to the reservoirs. The results of this work are still tentative and must be judged from a preliminary basis.

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Studies of striped bass have been pursued to considerable extent in California, Calhoun and Woodhull (1950), and along the Atlantic Coast by Merriman (1941), and Raney, Tresselt, Hollis, Vladikov, and Wallace (1952), the results of which have substantially contributed to a knowledge of the general biology of the species. However, a review of the available literature failed to reveal a study made which indicated that a striped bass population was established and reproducing in a freshwater environment without returning to salt water to complete part of their life cycle.

The impoundment of the Santee-Cooper Reservoirs, located in the tidewater region of South Carolina, has created a unique condition which involves the possibility that a resident population of striped bass has been established within the confines of the reservoir area (Fig. 1).

The development of the Santee-Cooper Reservoir System was made possible by taking advantage of the power potentially due to a 35-foot difference in elevation between the Santee and Cooper Rivers. The project was developed by the S. C. Public Service Authority to provide for hydroelectric power and navigation. Construction was completed with a spillway dam across the Santee River to divert the flow down Cooper River. The reservoir area consists of two lakes with a combined area, when filled, of 160,500 acres and a total shoreline of 415 miles. The two lakes are connected by a diversion canal 7.5 miles long. The hydroelectric plant, located on the lower lake at Pinopolis Dam, discharges water into the Tailrace Canal and on into Cooper River for a distance of 40 miles to the Atlantic

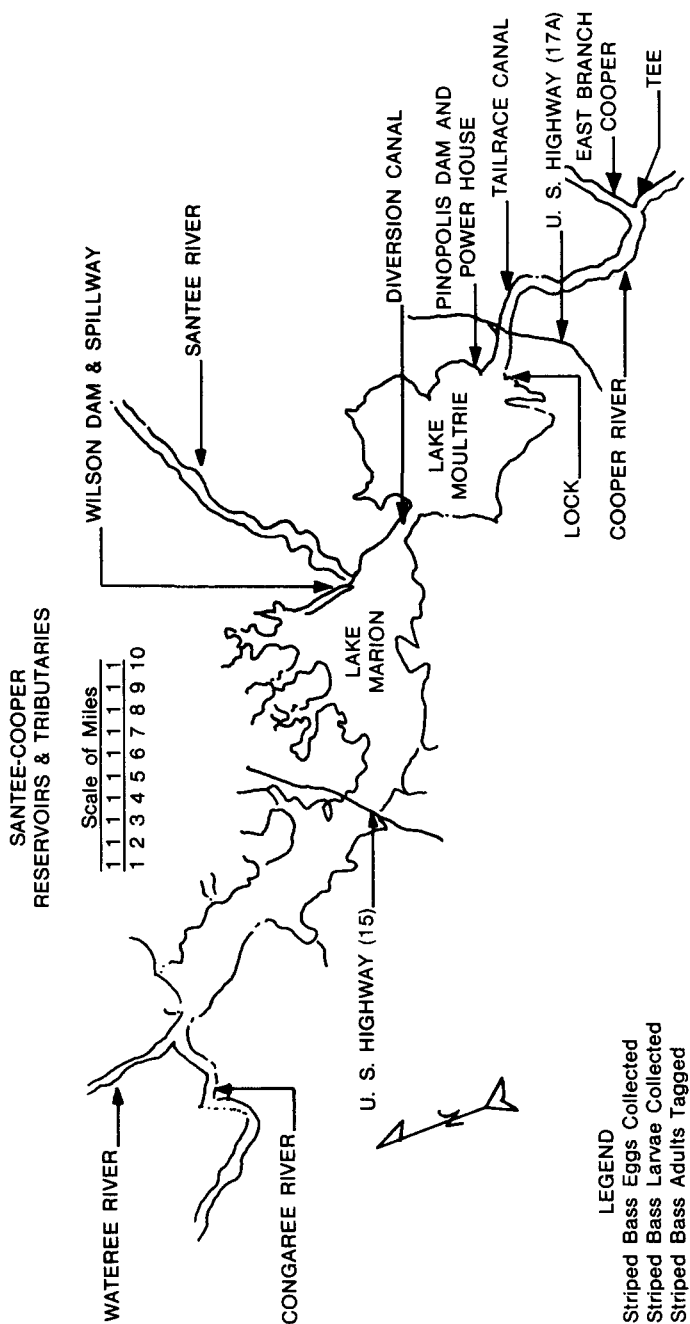


Fig. 1. Locations of striped bass study sites. (Editor's Note: The legend on this figure was illegible.)

Ocean. Impoundment of the reservoirs began in November, 1941, and was completed on February 17, 1942.

Prior to construction of the Santee-Cooper Reservoirs, striped bass were reportedly confined to runs up Santee River. The species was insignificant in relation to the sport fisherman's catch and has never played an important role in the commercial catch. Migrating fish traveling up Santee River are now confronted by low water conditions which discourage or even prevent movement during certain times of the year. Wilson Dam prevents access to the reservoirs. The diversion of water flow from Santee River to the Tailrace Canal has resulted in transforming Cooper River from a sluggish tidewater stream of lowland origin to a type more characteristic of upland origin. The increased discharge has apparently created, or at least stimulated, a large run of striped bass up Cooper River. This results in a considerable concentrating of fish in the Tailrace Canal below the Pinopolis Dam at various times of the year. After reaching the Tailrace Canal area, fish are prevented from gaining access to the reservoirs except by taking advantage of the operation of the Pinopolis Navigation Lock. An arbitrary schedule has been in effect for a number of years to operate the lock so that migratory fish such as striped bass might gain access to the reservoirs. No efforts have previously been made to determine the effectiveness of the lock as a fish passageway.

A large population of striped bass is now present in the reservoirs throughout the year and, according to reports, has steadily increased during the past ten years. There has been a growing belief among fishermen that the increase in numbers, plus the presence of thousands of small juvenile striped bass in the reservoirs, could not altogether be attributed to the recruitment of ocean-running fish coming in through the lock.

The present investigation was designed to find the answers to questions surrounding this condition by pursuing the following objectives: (1) determine the location of striped bass spawning ground, and (2) measure the degree and direction of movement through the navigation lock.

The writers wish to express appreciation to the persons who have cooperated and assisted in the various phases of the investigation. To: D. L. Warren, project assistant, for helping with the field work; Mr. Kenneth Ellis, of Richmond Plantation, for his assistance in collecting samples for the spawning ground survey, and to various personnel of the South Carolina Public Service Authority for their excellent cooperation in providing information and help on the tagging operation and lock investigation. Special thanks to Dr. E. C. Raney of Cornell University for the identification of the striped bass larvae collected in the Diversion Canal.

## LOCATION OF STRIPED BASS SPAWNING GROUNDS

The locations of known spawning areas of striped bass have previously been described by Merriman (1941); Vladikov and Wallace (1952). Judged on the basis of these descriptions, the spawning areas range from relatively quiet tidal areas of slow current to turbulent riffle areas in the upper part of rivers.

During the spring of 1954, efforts were made to determine the principle spawning grounds of striped bass in the Santee Cooper System. Prior to actual work, a reconnaissance was made to determine the location of the most promising areas which would best conform to the type of habitat normally preferred by striped bass for spawning purposes. The areas selected for investigation were also

considered because of the known present of concentrations of fish during the early spring months.

A survey was made, based on the collection of eggs and larvae, to obtain evidence of spawning in the Tailrace Canal and Cooper River; Diversion Canal and the Congaree and Wateree Rivers. The work was carried out through the use of large plankton nets as described by Tresselt (1952), and demonstrated by J. B. Sykes of the U. S. Fish and Wildlife Service. The nets were made of nylon marquisett of about 25 meshes per inch. Two types of nets were used, one with a diameter of 1 meter; the other of one-half meter. Instead of making stationary sets, the nets were towed with a motor boat by means of a rope attached to the bridle of the net. This allowed a larger area to be explored. Since the spawning coincided with the concentration of striped bass available for a marking and recovery study, the two phases of work had to be operated concurrently; consequently, no attempt was made to delimit the actual spawning sites or determine intensity of spawning in the various areas. The results of the spawning ground survey are depicted in Table 1.

The locations of the stations used on the areas selected for exploratory survey are listed as follows:

Tailrace Canal and Cooper River:

Station No.	Location
I.	2.5 miles down Tailrace Canal below Pinopolis Dam
II.	5.5 miles down Cooper River below Pinopolis Dam
III.	8 miles down Cooper River below Pinopolis Dam
IV.	11 miles down Cooper River below Pinopolis Dam
V.	13 miles down Cooper River below Pinopolis Dam
VI.	15 miles down Cooper River below Pinopolis Dam
VII.	17 miles down Cooper River below Pinopolis Dam at Tee

Diversion Canal:

- I. At mouth of canal leading into Lake Moultrie (lower lake)
- II. Midway point between the two lakes

Congaree River:

- I. 1 mile upstream from confluence with Wateree River

Wateree River:

- I. 1 mile upstream from confluence with Congaree River

Tailrace Canal and Cooper River

The Tailrace Canal and Cooper River were selected as potential spawning areas due to the presence of a large concentration of fish during early spring months and because the physical characteristics made this area seem especially well suited as spawning habitat. The rate of flow in this area is governed by the volume of discharge from the turbine units at Pinopolis Dam. The velocity of flow in the Tailrace Canal was estimated at around four miles per hour during the spring months and somewhat slower down the Cooper River. The contrast in bottom types range from a marl formation in the canal to a sand and mud type in Cooper River. Tidal action prevails all the way to Pinopolis Dam, although the

Table 1. Striped bass spawning ground survey - Santee-Cooper System.

Location	Date	Type net	Water		Depth	Time towed	No. eggs collected	No. fry or larvae
			Current	Temp. (F°)				
Tailrace Canal and Cooper River <sup>a</sup>								
Station I	4/22/54	½ M	Very fast	67	sur.	30 min.	0	0
	5/1/54	1 M	Very fast	71	sur.	15 min.	0	0
Station II	4/22/54	½ M	Fast	67	sur.	30 min.	1	0
	5/1/54	½ M	Fast	72	12 ft.	15 min.	22	0
Station III	5/1/54	½ M	Fast	72	12 ft.	15 min.	5	0
Station IV	5/1/54	½ M	Fast	72	12 ft.	15 min.	12	0
Station V	4/29/54	1 M	Fast	72	sur.	30 min.	27	0
Station VI	4/29/54	1 M	Fast	72	sur.	30 min.	13	0
Station VII	5/1/54	1 M	Fast	72	12 ft.	15 min.	9	0
	5/3/54	½ M	Fast	72	12 ft.	15 min.	26	1
	5/8/54	½ M	Fast	73	12 ft.	30 min.	0	0
	5/11/54	½ M	Fast	74	12 ft.	30 min.	0	0
Diversion Canal								
Station I	5/4/54	1 M	Very slow	74	sur.	30 min.	0	4
Station II	5/4/54	1 M	Very slow		sur.	30 min.	0	2
Wateree River								
Station I	5/3/54	1 M	Moderate	72	sur.	30 min.	120	0
Congaree River								
Station I	5/3/54	1 M	Slow	76	sur.	30 min.	105	0

<sup>a</sup> All eggs collected around the Tee in Cooper River were in an advanced stage of development and were on the verge of hatching.

chloride content of the water is very low even at a considerable distance below the sampling sites.

Samples were made at from two- to three-mile intervals in the Tailrace Canal and Cooper River to the confluence with the East Branch of Cooper River, known as the Tee. Eggs were collected in a twelve-mile stretch, from Station II to Station VI, at distance of five and five-tenths miles to seventeen miles below the Pinopolis Dam. The advanced stage of development of the eggs collected around the Tee suggests that actual spawning probably took place in the Tailrace Canal or upper part of Cooper River. The length of the spawning period was not definitely determined but it is believe to have begun around April 15 and ended around May 3. Striped bass began congregating in the Tailrace Canal around April 15 and reached a peak of abundance during the following three-week period. External examination of fish caught for the marking and recovery study during the early part of April revealed that around 85 percent were composed of small size, ripe males. The larger size fish began moving into the area around the first part of May and the majority of these fish were spent females.

The evidence obtained in the survey suggests there is no apparent need for striped bass to migrate beyond the Pinopolis Dam in order to find suitable spawning habitat. Since adequate spawning grounds are provided below Pinopolis Dam, this fact would seem to lessen the incentive for ocean-running fish to try to gain access to the reservoir area during the spawning season.

#### Diversion Canal

The Diversion Canal is a deep channel, approximately 250 yards wide, and seven and five-tenths miles long, which serves as the connecting link between the two lakes. The bottom of the canal is composed of a marl formation. The rate of water flow through the canal is dependent upon the flow from the tributary streams above and also on the amount of water drawn in and discharged at Pinopolis Dam. At the time the samples were made, the current was very slow.

The canal was sampled on May 4 at the mouth leading into Lake Moultrie and also at the approximate mid-point between the two lakes. Although no eggs were collected, several striped bass larvae were obtained, which serve to indicate that some spawning does occur in the canal. There is a possibility that spawning may have taken place some time earlier since the water temperature ranges several degrees higher in the reservoirs than in the Tailrace Canal. The Diversion Canal is known to be a favorite point of concentration for striped bass during spring months as well as during other seasons.

#### Congaree and Wateree Rivers

The Congaree and Wateree Rivers, tributary streams of the reservoirs, were sampled on May 3 at points approximately one mile up from the confluence of the two streams. Both rivers are typical Piedmont streams, usually having very turbid water and a variable rate of flow, governed primarily by the discharge from upstream power dams. Concentrations of striped bass were reported at upstream locations in both rivers during early spring months. The Saluda Dam on the Congaree River and the Wateree Dam on Wateree River represent the final barriers to upstream movement. The sampling stations were around 50 miles below the Saluda Dam and around 60 miles below the Wateree Dam.

Two thirty-minute tows were made in each river over rock and sand bottoms at depths averaging about six feet. Over 100 eggs were collected in each stream. Although the eggs were in an advanced stage of development, they would probably have drifted into the upper part of Lake Marion before hatching. The large number of eggs collected in such a short sampling period indicates that considerable spawning activity occurred in the upper part of the two rivers. Spawning is believed to have started in the tributary streams around the early part of April. Seasonal concentrations are present in both rivers at various times throughout the year.

As a follow up on the spawning ground survey, efforts were made to determine the distribution of young-of-the-year striped bass in the reservoirs during the summer months. Based on reports obtained from bait dealers, and actual seining collections, fingerlings were distributed at widely separated areas along the shore of Lake Marion. A total of 125 fingerlings collected from Lake Marion between July 14 - July 19 averaged 2.9 inches total length. On July 20, several fingerlings were collected around an island in Lake Moultrie. Fingerlings appeared to be more numerous in the upper reservoir.

## FISH MIGRATION THROUGH THE NAVIGATION LOCK

The navigation lock at Pinopolis Dam was intended to provide an industrial water route between the port of Charleston and the Piedmont Region, however, traffic did not materialize to the extent originally expected. During the past several years, the lock has been utilized to accommodate passage of an occasional boat and to comply with the request by the S. C. Wildlife Resources Department to allow for the upstream movement of fish from the Tailrace Canal to the reservoirs. An arbitrary schedule of operations has generally been in effect from January to around the first part of June each year with the number of operations varying from one to three times per day during this period. From January 6 to August 19, 1954, the locks have been operated a total of 438 times, 22 times for the passage of boats, and the remainder for the purpose of bypassing fish. The normal opening and closure period for each lock operation has been around one hour.

The inside dimensions of the lock are 60 feet wide by 180 feet long, with a maximum life of 75 feet. The downstream entrance to the lock is protected from the turbulent discharge area of the tailrace by a guide wall extending out from the dam. When the lower gates of the lock are open, the water inside the lock presents a relatively calm area to fish in contrast to the turbulent discharge section of the tailrace.

The original introduction of striped bass to the Santee-Cooper Reservoirs probably resulted from movement through the lock, or else a considerable number were trapped upstream at the time the reservoirs were impounded. During the latter part of 1947 to May of 1949, there was considerable traffic moving through the locks by large barges loaded with rock for rip-rapping the inside of the reservoir dikes. Over 330,000 tons of rock were loaded on barges and guided by tugboats through the lock during this period. The number of lock operations during this period ran as high as 8 times per day. Fishermen, acquainted with the area, contend that the movement of these large barges through the lock resulted in bringing in considerable numbers of striped bass to the reservoirs. Good catches of striped bass were reported made in the wake of the barges moving inside the reservoirs.

In order to determine the extent and direction of striped bass movement through the lock, samples were made through the use of a trammel net, 65 feet long by 25 feet deep, to fit the enclosure at the upper gate of the lock. The net was suspended across the concrete ledge from which the upper lock gate is operated. The bottom and sides of the net were attached to the ledge and sides of the lock wall by means of snaps and eyebolt anchored in the concrete. The net, when properly set, forms an almost perfect seal of the enclosure. Direction of movement was determined by impounding fish on opposite sides of the net. A summary of the trammel net catch by the month is given in Table 2 during the period from April 21 to August 21, 1954. The net was set once a week for a total of 12 weeks during this period. The fishing time for each set was around one hour to conform with the normal opening and closure period for each lock operation.

A total of 4 small striped bass were captured during the 12-week sampling period, and of this number, only one fish was captured while attempting to enter the reservoirs. In view of the large schools of striped bass concentrated below Pinopolis Dam during the spawning season and afterwards engaged in sporadic feeding activities, the catch record does not reflect an extensive amount of movement through the lock. Based on observations and the methods employed in obtaining several hundred fish for a marking and recovery study, striped bass showed a decided preference for the turbulent discharge area of the tailrace rather than the calm water around the lock. Occasionally, striped bass were observed in the act of pursuing schools of gizzard shad and herring inside the lock area. However, this type of movement was sporadic and often resulted in the fish leaving the area before the lock was closed and operated. In general, movement through the lock appears to consist mainly of the accidental impoundment and transfer of fish from either the tailrace or reservoir at the time the lock is being operated.

The trammel net is acknowledged to be a selective type of fishing gear, however, due to the adaptability and variety of fish caught, it is believed that this device is best suited for the sampling purpose.

## MARKING AND RECOVERY STUDY

During the months of April, May, and June, 1954, an intensive bass tagging program was in effect at the base of Pinopolis Dam in the Tailrace Canal. Advantage was taken of the concentrated population of striped bass active in feeding on the abundant supply of herring, gizzard shad and other forage species. The fish were caught through the use of large dip nets and cat nets, operated from the Afterdeck section of the power house. After capture, the fish were marked with Peterson Disk type tags, attached with nickel pins to the body region just below the first dorsal fin. All marked fish were released in the Tailrace Canal.

The first fish was tagged on March 25, 1954, however, large schools did not appear until around April 15. The bulk of the number tagged were caught during the latter part of April and in May. The fish catch declined during the latter part of April and in May. The fish catch declined during the latter part of May and in June, although sizeable schools were still present in the area. The chief reason for this catch decline was the decreased turbidity of the water, which increased the vision distance of the fish and enabled them to evade capture. Also, the feeding activity became more sporadic due to the dispersal of the forage fish. Thus far, a



Table 2. Trammel net catch record for April, May, June, July, and August.

From Tailrace (upstream)		From Reservoir (downstream)	
Species	No.	Species	No.
April (2 sets - 2 hours)			
Striped bass	1	Striped bass	1
Bluegill	1	Bluegill	1
Channel catfish	22	Black crappie	1
Herring	68	Herring	132
		Channel catfish	14
		Needlefish	1
May (4 sets - 4 hours)			
Black crappie	1	Chain pickerel	1
Herring	90	Herring	126
Channel catfish	209	Channel catfish	83
White catfish	1	White catfish	4
Gizzard shad	1	Gizzard shad	1
		Mullet	5
June (2 sets - 2 hours)			
Channel catfish	3	Striped bass	2
Whitefish	1	Bluegill	4
Mullet	1	Black crappie	1
		Channel catfish	2
		Herring	4
		White catfish	2
		Gizzard shad	2
		Needlefish	1
July (2 sets - 2 hours)			
		Bluegill	6
		Channel catfish	1
		Gizzard shad	11
		Needlefish	1
		Longnose gar	1
August (2 sets - 2 hours)			
Longnose gar	5	Largemouth bass	1
White catfish	2	Bluegill	4
Needlefish	2	Gizzard shad	1
		White catfish	3
		Needlefish	2

total of 545 striped bass have been tagged and released. Of this total, there have been nine recaptures reported to data. No reward was offered for the tag returns. Although recaptures have not been high, the percentage is much higher than results obtained from previous studies made in this area. The S. C. Wildlife Resources Department released 237 tagged bass in this area and received only one return. In 1949, the U. S. Fish and Wildlife Service released 300 tagged fish in this same area and also received only one return. Sport fishing intensity has not been great and commercial activities are greatly restricted. Information concerning the nine recaptures to date is given in Table 3.

Table 3. Recaptured tagged fish.

Date Tagged	Date Recaptured	Days of Freedom	Location of Recapture
4/12/54	4/18/54	6	3.5 miles down Cooper River
4/19/54	6/19/54	61	13 miles down Cooper River
4/21/54	8/01/54	101	2.5 miles down Tailrace
4/27/54	7/03/54	66	2.5 miles down Tailrace
4/28/54	5/08/54	9	26 miles down Cooper River
4/28/54	5/26/54	27	40 miles down Cooper River
4/28/54	6/11/54	43	Lake Moultrie - through lock
5/10/54	5/21/54	11	40 miles down Cooper River
5/10/54	7/06/54	56	Lake Moultrie - through lock (2 miles)

Since the tagging study is designed to obtain information concerning the migration of striped bass in relation to the Santee-Cooper Reservoirs, the results are being closely correlated to the investigation of fish movement through the navigation lock.

Although the results from the tagging study are by no means complete, the returns thus far indicate the striped bass population in Cooper River does not make extensive migrations. The results compare favorably with work by Vladykov and Wallace (1938), which indicated that only a small portion of the population in the Potomac and James Rivers migrated from the area. The longest distance traveled by any of the recaptured fish was recorded by two returns from the Charleston dry dock, near the mouth of Cooper River. Although no definite pattern of movement can be established, based on the present number of returns, it is of interest that the dates of recapture coincide with points of recapture located progressively farther downstream until May 26, after which, returns were made from points moving back upstream. The two recaptures from Lake Moultrie are significant in showing that some movement occurs through the lock, although the movement is not considered extensive. The greatest distance between points of recapture resulted from two returns from 34 fish tagged and released on May 10. One recapture was made 40 miles downstream 11 days later, while the other was recaptured two miles inside of Lake Moultrie 56 days later.

In order to obtain sufficient information to form definite conclusions, the tagging operation will be continued and increased efforts will be made to obtain a high percentage of returns.

## SUMMARY AND DISCUSSION

1. Evidence of striped bass spawning, based on the collection of eggs and larvae, was found below the reservoirs in the Tailrace Canal and Cooper River; between the reservoirs in the Diversion Canal, and in the tributary streams, the Congaree and Wateree Rivers. A large population of striped bass is known to be present in the reservoirs throughout the year, while the concentration in the Tailrace Canal seems to migrate on a seasonal basis. The division of major spawning areas within the Santee-Cooper System strongly suggest that separate populations must be considered. Freedom of exchange between the reservoir and Cooper River population is restricted to the operating schedule of the navigation lock at Pinopolis Dam.

2. Periodic samples, made through the use of a large trammel net, has not indicated an extensive utilization of the lock operations by striped bass. The calm water area inside the lock, when the gates are open, offers no special inducement except on certain occasions when the presence of schools of forage fish attract them inside, prior to the lock operation. In general, movement through the lock appears to be a matter of accidental impoundment and transfer of fish which happen to be inside during the lifting or lowering operation.

3. A total of 545 adult striped bass have been tagged and released in the Tailrace Canal during recent months to detect migration tendencies in relation to the Santee-Cooper Reservoirs. Tentative results, on the basis of nine recaptures to date, reveal that seven returns came from downstream locations in Cooper River and two returns from the lower reservoir. The recaptures from Cooper River do not indicate an extensive migration beyond the mouth of the River. A seasonal movement up and down the river is suggested. The two recaptures from the lower reservoir indicate that some recruitment of fish from Cooper River to the reservoir population occasionally occurs.

The indications presented in this paper are significant in pointing out the possible establishment of a freshwater population of striped bass in the Santee-Cooper Reservoirs. The results are not conclusive, since the degree of composition of the migratory fish to the total reservoir populations is not yet known. All phases of the study must be explored to greater extent before a final appraisal can be made.

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