Literature Review of the Striped Bass
Roccus saxatilis (Walbaum)

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ABSTRACT

For many years the striped bass, Roccus saxatilis (Walbaum), has played an important role in the sport fisheries of the Atlantic and Pacific Coasts. With increasing advances in hatchery production, it may soon become a major game fish of inland waters. This report reviews the literature dealing with the life history, past research projects, and hatchery production of striped bass, in preparation for study of a striped bass population of the Colorado River between Davis and Parker Dams.

When possible, anadromous populations were compared with the land-locked population of Santee-Cooper Reservoir, North Carolina. A section on hatchery production is included, due to the increasing interest in establishment of land-locked populations.

TAXONOMY

The striped bass, Roccus saxatilis (Walbaum), is a bony fish, order Perciformes, belonging to the sea bass family, Serranidae. It has three relatives in North America, the white bass Roccus chrysops (Rafinesque), white perch Roccus americanus (Gmelin), and the yellow bass Roccus interruptus (Gill).

RANGE AND DISTRIBUTION

The striped bass is native to the Atlantic coast of North America, from the St. Lawrence River, Canada, to the St. Johns River, northeastern Florida, and in tributaries of the Gulf of Mexico from western Florida to Lake Pontchartrain, Louisiana. Its center of abundance is from Cape Cod to northern North Carolina, including Chesapeake Bay (Raney, 1952). In 1957, establishment of a land-locked striped bass population in Santee-Cooper Reservoir in South Carolina and Kerr Reservoir in North Carolina and Virginia was discovered, and these have become important as a stock from which additional inland populations have been derived (Scruggs and Fuller, 1957).

This species is coastal in habit, seldom found more than a few miles from shore. It is highly euryhaline, frequenting brackish or fresh water, and has a wide temperature tolerance, but becomes inactive at temperatures below 40°F. Spawning is in fresh water, where a rather extensive spawning ground is required. Ova drift in current, and young remain in fresh water for a time, then typically move to sea.

In 1879 and 1882, striped bass from New Jersey were planted in the Sacramento River, California. From these, the fish dispersed widely, and now lives from San Diego, California, to the Columbia River, Oregon. Since 1929, attempts have been made to establish striped bass in various inland waters such

as the Salton Sea, California, the Colorado River below Davis Dam, Arizona-California, and Lake Bardwell, Ellis County, Texas. The results of these introductions range from complete failures to partial successes.

FOODS AND FEEDING

Striped bass are voracious, carnivorous fish, the amounts and kinds of food taken appear a function of availability more than any other factor. One exception was reported by Hollis (1952), in Chesapeake Bay, where silversides (Atherinidae) were more numerous than anchovies (Engraylidae), yet the anchovy occurred at a higher frequency in stomachs. There are no indications of striped bass feeding on its own young. Feeding intensity varies with time of day and with the season. In general, they feed most heavily in summer (Johnson and Calhoun, 1952), and in early evening and morning (Raney, 1952). Ontogenetic change in foods and feeding of striped bass is pronounced. Young feed largely near the bottom, on crustaceans and other small invertebrates. During their second summer they begin to school, and to feed heavily on other species of schooling fish (Raney, 1952).

Food of Striped Bass of the Atlantic Coast - The first food analysis of striped bass from the east coast was reported by Hildebrand and Schroeder (1928). Stomachs from the Chesapeake Bay region contained fishes, crustaceans, annelid worms and insects. Larger bass fed principally on fishes, whereas the smaller ones had eaten mainly crustaceans. Hollis (1952) later analysed 1,736 stomachs taken from Chesapeake Bay in the period June, 1936 to April, 1938. The results of his study are as follows:

(1) 969 (55%) contained some food;

(2) By weight, fishes comprised 95.5% of the food;

(3) ~~twenty six~~ 2 different fishes were identified;

(4) food of individual bass sometimes consisted of only a single species;

(5) crustaceans varied from 0 to 46.3% in occurrence, but made up less than than 2% of the total weight.

Food of Striped Bass of the Pacific Coast - Johnson and Calhoun (1952) analysed three-~~hundred eighty seven~~ 387 2 stomachs from striped bass taken by anglers in the course of one year's fishing in and around San Francisco Bay, California. The stomachs were divided into a summer and winter sample, and results by season were as follows:

Summer

(1) foods of some sort were found in 72% of the samples;

(2) shrimp (Crago) were present in 35% of the fish, and made up 53% of all identifiable organisms by volume;

(3) anchovies (Engraulis mordax) were next to shrimp in importance;

(4) other foods included isopods, mysid shrimp, bullheads (Leptocottus armatus), flatfish and smelt.

Winter

(1) 42% were empty;

(2) remains of small fish comprised 64% of the total volume;

(3) mysid shrimp (Neomysis) were present in more stomachs than any other food, making up 20% of the volume.

Young-of-the-year striped bass in the Sacramento-San Joaquin Delta region fed primarily on shrimp (Neomysis)$_A$ copepods (Cladacerais), Corophium and tendiped larvae (Heubach, Toth and McCready, 1963). Fishes were unimportant in the diet. Food habits by area sampled appeared a function of the factors controlling plankton distribution.

Stomachs from striped bass caught in Coos Bay, Oregon, during 1948-50 were examined by Morgan and Gerlach (1950). During most of the year, fishes that occurred in large schools predominated in the stomachs. During April,

May and June, numerous trout and salmon fry and fingerlings were eaten.

Food of Land-locked Striped Bass - In a completely different situation, Santee-Cooper Reservoir, North Carolina, stomachs of adult bass contained foods basically similar to those eaten by marine or estuarine populations. A summary of the information compiled by Stevens (1958) follows:

(1) clupeid fish principally Dorosoma support striped bass population, except in spring;

(2) in April, May and June, mayfly nymphs become dominant foot item;

(3) species other than clupeids are taken in insignificant numbers.

GROWTH

In general, young striped bass grow most rapidly in late spring and early summer; older bass increase rapidly in length in summer and early autumn, and growth is slowed greatly in late autumn and winter.

Age Determination - Scale analysis has been validated as the best method for age determination of striped bass. The scales are ctenoid, with radii only on the anterior field. Scofi (1931) reported formation of twenty five to eite trandrtni-f-i-f-ta- circuli during the course of one year's growth. Younger bass formed more circuli than older individuals. Circuli cease to form in early winter. Some difficulties have been encountered in scale analysis. Scales from large bass (more than eight years of age) are more difficult to read than those from small individuals (Merriman, 1941), probably as a result of marked thickening of the central part of the scales; Merriman also found false annuli.

Age and Growth - In Chesapeake Bay, male and female bass grow at about the same rate for the first three years of life (Mansueti, 1961). After age

four, females grow at a significantly greater rate, and a consistent difference in size is maintained between the sexes. Mansueti also found the greatest annual increment for both sexes, 160 mm. for males and 165 mm. for females, occurred in the second year of life.

In the Santee-Cooper Reservoir, Stevens (1957) found that the greatest growth increment occurred in the first year. He attributed this to the long spawning season in the reservoir, but the reasons for such a relationship seem obscure.

Growth rates in California waters are similar to that in most other striped bass populations. Robinson (1960) found a significant increase in growth rate of California striped bass in the last thirty years. This occurs after the second year, and is greater in females than in males, presently representing about a 1 increase in length and 25% in weight.

Some comparisons by areas of average lengths for each age class of bass are given in Table I.

TABLE I. AVERAGE LENGTH FOR EACH AGE CLASS OF BASS

AREA	AGE CLASSES								
	I	II	III	IV	V	VI	VII	VIII	IX
Santee-Cooper Reservoir (Stevens, 1957)	8.5	15.7	19.4	22.9	25.8	28.5	30.2		
San Francisco Bay (Robinson, 1960)	--	16.2	19.4	22.4	25.0	26.2	27.7	29.0	31.1
Chesapeake Bay (Mansueti, 1961)	6.4	12.5	15.8	16.6	24.0	25.5	29.0		31.0

Length - Weight Relationship - Length - weight relationships for the various populations appear quite similar. The relationship augmented with approximate age designation for the sexes, shows identical slope; however, there is a slight, but consistent, difference in location of the fitted line for each sex (Mansueti, 1961). Males of a given length weigh less than females of the length.

Striped bass taken most commonly by sport and commercial fishermen on the Atlantic Coast weigh from ~~one~~ to ~~twenty~~ 10 pounds, but fish of ~~twenty five~~ 30 ~~thirt~~ pounds are not rare. Larger fish, caught on occasion in abundance according to old records, weighed ~~fifty~~ 50 pounds or more, but such are uncommon at present. Fish of more than ~~s~~ 60 pounds are exceedingly rare (Merriman, 1941). The two largest striped bass on record weighed 12 pounds each, and were taken at Edenton, North Carolina, in commercial nets (Raney, 1942). Calhoun (1948) reported that no striped bass weighing more than ~~one hundred~~ 100 pounds is known to have been caught on the Pacific Coast. However, there is a record of 75 fish taken in 1910, and in 1911 an angler caught a ~~sixty two~~ 62 pound specimen near Napa, California.

REPRODUCTION

The striped bass is anadramous (disregarding land-locked populations), spawning from April to July.

Sexual Dimorphism - No exact method has been found of distinguishing externally between the sexes in striped bass, except when they are running ripe. A method of gonadal biopsy was described by Ritchie (1965), which proved accurate in 94.7% of the fish examined.

Age at Maturity - Only 25% of the female bass taken in Connecticut, spawn at an age of four years, while 75% are mature at five years, and 95% are mature at the end of six years (Merriman, 1941). Most males are mature at two years, and all were mature at age three. This coincides closely with data gathered on the striped bass populations in Chesapeake Bay (Raney, 1952), and Santee-Cooper Reservoir (Scruggs, 1957).

In Coos Bay, Oregon, Morgan and Gerlach (1950) found all females of the second year class were immature, 18.2% of the third year class and 67.9% of the fourth year class were mature. Males were mature from year class one.

Determination of Maturity - Maturity of males is easily determined, due to the free flow of milt from the testes when nearing ripeness. Ova diameters have been used with good success in the determination of maturity of females. Lewis (1962) classified ova of striped bass from the Albemarle Sound - Roanoke River System, North Carolina, into three groups: (1) translucent ova between 0.03 mm. and 0.23 mm. in diameter, in which the yolk had not begun to form; (2) translucent ova between 0.16 and 0.30 mm., in which yolk had begun to form; (3) opaque ova 0.33 to approximately 1.00 mm. in diameter. Females were separable into three categories: those with type 1 eggs only, those with type 1 and 2 eggs only, and those with type 1, 2, and 3 eggs. He concluded that fish with types 2 and or 3 ova were maturing, and would spawn in the next spawning season.

These criteria were unsatisfactory for defining the state of maturity of female striped bass from San Francisco Bay (Chadwick, 1965). Eggs of the California bass appeared to develop a year or more before ripening and many ova were intermediate in size between Lewis' categories.

Sex Ratio at Spawning - On both the Atlantic and Pacific Coasts the male striped bass is disproportionately abundant on the spawning grounds (Raney, 1952; Morgan and Gerlach, 1950). Merriman (1942) mentioned that ~~ten~~ 9 to ~~fifty~~ 2 small males may accompany a single larger female (weighing from 4 to pounds).

Fecundity - The number of eggs varies individually, but averages near 100,000 eggs per pound of body weight. In fifteen females from Coos Bay, the number of eggs ranged from 900,000 in an 8.8 pound fish to 4,775,000 in a 60 pound fish (Morgan and Gerlach, 1950). Jackson and Tiller (1952) reported the number of eggs per female increases with size, up to at least ~~fourteen~~ 14 2 years of age.

Spawning Conditions - Spawning occurs in fresh water, in or near the mouths of rivers in spring. Striped bass on both the Atlantic and the Pacific Coasts show a preference for rapids or strong current.

The dates at which the spawning activity reaches a peak varies with latitude. In Coos Bay, Oregon, the spawning season extends from about the middle of May to the end of June. The greatest percentage of ripe females were present in the week ending June 10 (Morgan and Gerlach, 1952). In California the spawning season extends from late March to early July, with its peak in May (Calhoun, 1950). In Santee-Cooper Reservoir, eggs were collected from April 8 to June 2, with a peak between April 21 and May 5 (Scruggs, 1954).

Water temperature appears the principal factor controlling the time of spawning. The minimal temperature at which spawning is known to occur is about 58°F. Peak reproductive activity occurs between 60 - 65°F., and declines rapidly thereafter (Albercht, 1964)

Spawning Activities - Courtship prior to the actual spawning does not appear to take place in the striped bass. A good account of spawning activity is provided by Morgan and Gerlach (1950). During the spawning act a group of ~~three~~ 4 or ~~four~~ fish, or many times that number, mill in a circle, at which time they splash for about a minute and throw water as high ~~as five~~ feet into the air. Shortly afterward they submerge abruptly. released gametes

EGGS, LARVAE AND YOUNG

The most detailed description of the early development of the striped bass, summarized below, is abstracted from Mansueti (1958).

Eggs - The eggs, which are pelagic, buoyant, but slightly heavier than fresh water, are spherical, transparent, non-adhesive and relatively large when compared to the eggs of other estuarine and anadromous fishes. When unfertilized,

they are about 1.3 mm. in diameter, and 3.4 mm. when fertilized and fully water hardened. The granular yolk sac is green in living eggs and whitish yellow when preserved, and is about 1.2 mm. in diameter. The single, amber-colored oil globule is about 0.6 mm. in diameter.

Stages of Development - Striped bass prolarvae hatch in ~~thirty six~~ 36 to ~~forty eight~~ 48 hours at an average water temperature of about 63 F., and range from 2.9 - 3.7 mm. in total length. They are relatively undeveloped, with no mouth opening, unpigmented eyes and a greatly enlarged yolk sac and oil globule projecting beyond the head. When about 5 - 6 mm. long, the yolk sac and oil globule are partially or wholly assimilated, and they become postlarvae. The jaws and teeth, digestive tract, air bladder, gills, circulatory system, and other internal structure are clearly distinguishable at this stage.

Postlarvae transform to juveniles at lengths of 7 - 10 mm. when the fin folds are lost except in the dorsal, anal and caudal regions. Fin rays then begin to differentiate in the larger fish. The larger individuals in the size range possess well-formed, but partially ossified skeletons, with the full complement of ~~wenty five~~ 25 vertebrae. Melanophores are more concentrated on the head, sides of the abdomen, and along both sides of the body posterior to the anus.

Between 10 - 20 mm. in length all postlarvae complete metamorphis, with segmented fin-rays in the various fins. Muscular bands of tissue have by this time obscured the skeletal structure and internal viscera, and myotomes can no longer be counted. At this stage they are obviously distinguishable as serranids and most meristic characters are well developed.

Between 20 - 30 mm., scales are found on all young, and with the exception of pectoral fin-rays, a full complement of meristic structures is attained. The body is spotted with many small melanophores, but striping found in older and larger fish is not yet evident.

Larval Activity - Immediately after hatching movements and position of prolarval are directed largely by the anterior part of the yolk sac (Mansueti, 1958). After a period of one to two days, their swimming ability develops to the point where they can remain near the surface. When placed in an aquarium, the larva are positively phototactic.

Egg and Larval Survival - Egg suspension appears to be one of the most important factors to egg survival (Albrecht, 1964). A current velocity of about ~~one~~ foot per second is required to insure egg suspension in fresh water. When this is considered in conjunction with the hatching period of two days, about miles of channel flowing at ~~one~~ foot per second would be required to maintain suspension throughout development.

Temperature fluctuations and exposure to constant sunlight do not appear to limit egg and larval survival (Albrecht, 1964).

Mansueti (1958) believes starvation is the principal cause of larval mortality. This is substantiated by the extensive work of Anderson (1966) at the Edenton National Fish Hatchery, North Carolina, on rearing of striped bass fry. The key to production of fingerlings appears to be provision of a food the fish will consume. The extremely small size of striped bass fry requires a very small food particle.

MOVEMENTS AND MIGRATIONS

The striped bass is gregarious, and travels in large schools in the latter part of its life. During the first and second years they remain in small feeding groups, but by the end of the second summer they form into large schools (Raney, 1952). Some populations undertake migrations that are not associated with spawning. Spawning migrations, however, do take place, and during this period the bass run upstream.

Methods of Tagging - Most information available on bass migrations is based on the return of tagged individuals. Several types of tags have been used. Lewis (1961) compared the Petersen disk, nylon streamers and jaw ring-tags to determine which one was the most durable and would neither tangle in gear nor hamper the activity of the fish. Petersen tag returns were significantly greater in selective gear than streamer and jaw ring tags. There was no significant difference in non-selective gear in the return of the three tags. Wallace and Neville (1942) concluded that an internal tag (inserted through the gill cover) is preferable for long-term studies.

Migration Along the Atlantic Coast - From their tagging operations within Chesapeake Bay and in North Carolina waters, Vladykov and Wallace (1952) showed that each area generally maintained its own bass populations. However, during certain years some Chesapeake and North Carolina bass vacate their respective, native waters and undertake northward coastal migrations. A rapid increase in the catch in northern waters coincides with previous productions of a strong year-class in Chesapeake Bay.

In New Jersey waters, Wallace and Nevitle (1942) found that winter populations of bass begin to move as early as the first part of March, migrating to New England, and remaining there during the summer.

Migrations Along the Pacific Coast - Studies by Calhoun (1952) in California showed a mass movement of bass up into the fresh water of the Sacramento - San Joaquin Delta. In the spring they disperse throughout the Delta and spawn, returning to salt water for the summer. Based on tag returns from Coos Bay, Oregon (Morgan and Gerlach, 1950), there appears two migrations of striped bass. The spawning migration upstream in the spring, and a migration into sloughs is in the autumn. There is no evidence of alongshore migrations on the Pacific Coast.

POPULATIONS

Races - The striped bass along the Atlantic Coast has differentiated into a number of "races". Based on meristic studies, Raney (1957) concluded that three sub-populations are present within the tributaries of Chesapeake Bay. In North Carolina (Raney, 1955), the stock of striped bass is an endemic race which is differentiated into an upstream form which may not go to sea, and a downstream form that does. Striped bass in the Gulf of Mexico have formed a very distinctive race separated from the southeastern Atlantic by the Florida peninsula (Raney, 1955). At present, no comparisons have been made between Pacific coast populations and those on the Atlantic Coast.

Abundance - The abundance of striped bass is a relative matter and the numbers vary geographically. Some general conclusions made by Raney (1952) are that the bass was once common between North Carolina and Canada, but its recent history has been one of decline, broken occasionally by short periods of abundance resulting from production of a large class. In most San Francisco Bay areas, seasonal patterns of fishing quality and average weight are repeated year after year. Until at least 1950, the populations of striped bass appear to have remained constant, with a slight downward trend (Calhoun, 1950).

Cause of Depletion and Decline - Pollution, dam building, and possibly over-fishing are important factors that have contributed to the decrease of the striped bass population along the Atlantic Coast.

In the past, striped bass used the lower reaches of practically all the large rivers along the Atlantic Coast as spawning areas (Raney, 1952). Pollution and silting of these as a result of increased human population, industrial growth, and general destruction on the watershed has greatly reduced spawning areas and forage grounds of young bass.

Over-fishing as a reason for decline in the populations, may have some merit. Bigelow and Welsh (1925) pointed out that the striped bass is a vulnerable fish, easily caught, always close inshore, and always found in relatively shallow water, and that there is no offshore reservoir upon which to draw. Of the 1934 spawn (a dominant year class), Merriman (1941) generalized that about 40% were taken during the first year in the fishery (1936), and that at least 25% to 30% of the remainder were caught in 1937.

In California the development of large water diversions from striped bass nursery grounds appear to be threatening the fishery. From Calhoun's (1953) study of certain water developments in the Sacramento-San Joaquin Delta, it was concluded that all the diversions together might ultimately destroy as many as 25% of the fish-of-the-year,, when they are about 25 mm. long.

It is understood that in the last few years, young fry have been collected from these diversion developments; and have been relocated in California and adjoining states.

It is felt by many, that standardization of a sixteen-inch legal limit may be the answer for the most efficient use of the supply of striped bass for all concerned.

RELATIONS TO MAN

Although individual fishermen may disagree, the striped bass is probably the outstanding anadromous sport fish along the Atlantic Coast. All along the Atlantic Coast the striped bass supports extensive commercial and recreational fisheries, yielding more than 5,000,000 pounds annually to market fishermen, and about the same to sport fishermen (Raney, 1952).

Commercial fishing for striped bass was abolished in California in 1935. Since then, the numbers taken by sport fishermen have exceeded the highest

commercial

catches ever made for market (Curtis, 1949). It is estimated that in 1948 A 160,000 anglers, or about 16% of all fishermen in the state, fished successfully at one time or another for striped bass, and captured over 1,650,000. In the San Francisco Bay area, trolling and surf-casting are both successful fishing methods, but the greatest part of the catch is made still-fishing with sardines. In 1953, California biologists valued the State's striped bass sport fishery at $18,000,000 based on an average of expenditure of $9.00 per-angler-day (Raney, 1958).

PRODUCTION OF STRIPED BASS

Although hatchery production is not normally included in a life history of a species, it is felt that in the light of ever-increasing demands by various states for the introduction of striped bass into their waters, a short discussion is warranted.

With establishment of landlocked striped bass populations in Santee-Cooper Reservoir, a widespread interest has developed in attempting to establish bass in reservoirs throughout the United States. Although the problems encountered in hatchery production of striped bass fry have apparently been overcome (Andersen, 1966) attempts to establish populations from hatchery fry have met with general failure (Bonn, 1968). This is probably due to predation and a lack of essential requirements for early fry development (Regan, Willborn and Bowker, 1968). One solution may be the introduction of fingerlings instead of fry.

The most extensive program of striped bass production, and experimental production of hybrid Roccus, carried on by the Edenton National Fish Hatchery, South Carolina (Regan, Wellborn and Bowker, 1968). The percentage hatch on eggs fertilized with striped bass spawn was 26.3%, compared to a 12% hatch from eggs fertilized with white bass sperm. The hybrids had an average survival rate

of 72.2%, and the striped bass had an average of 72.5%. The striped bass had a better percent gain in weight than did the hybrids. The best gains in hatchery ponds, 1,438.2 pounds per acre, was obtained from ponds stocked at the rate of 25,000 fish per acre, and fed ground herring, a food much more acceptable by the fish than pellets. With regards to zooplankton, stomach analyses showed that striped bass preferred Cyclops over Bosmina. Daphnia was not used as frequently as it occurred. No correlation could be established between production and water quality. Of striped bass examined, only four genera of ectoparasites, Trichodina, Scyphidia, Chilodnella, and Trichophrya were found. High mortalities, up to 100%, were obtained when fry were reared in troughs and concrete holding tanks. Of therapeutic and herbicidal compounds tested, copper sulfate was the most toxic, with polyotic being the least.

SUMMARY

The striped bass, Roccus saxatilis (Walbaum) is found along the Atlantic and Pacific Coast, and inland waters of some states. It is a carnivorous fish, feeding primarily on shrimp, anchovies, and shad. Growth occurs in young striped bass most rapidly in late spring and early summer. After age four, females grow at a significantly greater rate than males. Striped bass have been taken up to 125 pounds, but the average size taken by anglers is between ~~one~~ a and pounds.

The striped bass is anadromous, spawning from April to July. Some females mature at four years of age, and all are mature at the end of six years. Most males mature at two years of age. Spawning occurs in fresh water, at water temperatures between 60 - 65°F. The eggs are pelagic and hatch in 34 to hours at an average water temperature of 63°F. Egg suspension appears to be one of the most important factors to egg survival and starvation is the principal cause of larval mortality. Between 10 - sO mm. postlarvae

complete metamorphosis and are easily distinguishable as serranids.

The striped bass is gregarious and undertakes upstream spawning migrations. Based on meristic characteristics, the striped bass along the Atlantic Coast has been differentiated into several sub-populations or "races".

Its history on both the Atlantic and Pacific Coasts has been one of declines over the last ~~t r fi~~ 5 years. Pollution, dam building and over fishing have played a role in this decline. During the last five years, great gains have been made in hatchery production of striped bass fry and fingerlings. It appears that the striped bass will continue to be an outstanding sport fish along the coasts as well as inland waters throughout the United States.

LITERATURE CITED

Albrecht, A. B. 1964. Some observations on factors associated with survival of striped bass eggs and larvae. Calif. Fish & Game, 50(2):100-113

Anderson, James C. 1966. Production of striped bass fingerlings. Progr. Fish-Cult., 28(3):162-164.

Bigelow, Henry B. and William W. Welsh. 1925. Fishes of the Gulf of Maine. Bull. U.S. Bur. Fish., 40:1-567****

Bonn, E. W. 1968. Striped bass introduction in Texas. Completion report, Fed. Aid Proj. F-8-R-14.

Calhoun, Alex J. 1949. California's angling catch records from the party boat fishery: 1938-1948. Calif. Fish & Game, 35(4): 211-253.

Calhoun, Alex J. 1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish & Game, 36:178-234.

Calhoun, Alex J. 1952. Annual migrations of California striped bass. Calif. Fish & Game, 38:391-403.

Calhoun, Alex J. 1953. Distribution of striped bass fry in relation to major water diversions. Calif. Fish & Game, 39: 279-300.

Chadwick, Harold K. 1965. Determination of sexual maturity in female striped bass (Roccus saxatilis) in the Sacramento-San Joaquin system. Calif. Fish & Game, 51(3):202-206.

Curtis, Brian. 1949. Striped Bass. (In) The warm-water game fish of California. Calif. Fish & Game, 35:266-268.

Jackson, H. W. and R. E. Tiler. 1952. Preliminary observations on spawning potential in the striped bass (Roccus saxatalis) (Walbaum). Md. Dept. Res. & Ed., No. 93:1-6****

Johnson, W. C. and A. J. Calhoun. 1952. Food habits of California striped bass. Calif. Fish & Game, 38:531-534.

Heubach, W., R. J. Toth and A. M. McCready. 1963. Food of young of the year. Striped bass (Roccus saxatalis) in the Sacramento-San Joaquin River System. Calif. Fish & Game, 49(4): 224-239.

Hilderbrand, Samuel F. and William C. Schroeder. 1928. Fishes of Chesapeake Bay. Full. U.S. Bur. Fish (1927). 43:247-250****

Hollis, E. H. 1952. Variations in the feeding habits of the striped bass (Roccus saxatilis) (Walbaum) in Chesapeake Bay. Bingham Oceanographic Coll. Bull. 14(1):111-131.

Lewis, Robert M. 1961. Comparison of three tags on striped bass in the Chesapeake Bay area. Chesapeake Science, 2:3-8.

Lewis, Robert M. 1962. Sexual maturity as determined from ovum diameters in striped bass from North Carolina. Trans. Amer. Fish. Soc., 91:279-282.

Mansueti, Romeo. 1958. Eggs, larvae and young of the striped bass (Roccus saxatilis). Ches. Biol. Lab. Contr. No. 112, 35 pp.

Mansueti, Romeo. 1961. Age, growth and movements of the striped bass (Roccus saxatilis), taken in selective fishing gear in Maryland. Ches. Sci., 2(1-2)9-36.

Merriman, Daniel. 1941. Studies on the striped bass (Roccus saxatilis) of the Atlantic Coast. U.S. Fish & Wildlife Serv., Fish Bull. 50(35):1-77.

Morgan, Alfred R. and Arthur R. Gerlach. 1950. Striped bass studies on Coos Bay, Oregon in 1949 and 1950. Oregon Fish Comm. 31 pp.

Raney, E. C. 1952. The life history of the striped bass (Roccus saxatilis) (Walbaum). Bull. Bingham Oceanogr. Coll., 14(1): 5-97.

Raney, E. C. 1956. The striped bass in New Jersey. New Jersey Outdoors, Feb. 6(8):9-13.****

Raney, E. C. 1957. Subpopulations of the striped bass (Roccus saxatilis (Walbaum) in tributaries of Chesapeake Bay. U.S. Fish and Wildlife Serv. Spec. Sci. Rept., Fish. No. 208:85-107.

Raney, E. C. 1958. The striped bass. Fish and Wildlife Serv. Bur. of Comm., pp. 70-73.

Ritchie, Douglas E. 1965. Sex determination of live striped bass (Roccus saxatilis) by biopsy technique. Ches. Sci., 6(3): 141-145.

Regan, Danny M., Thomas L. Wellborn and Robert G. Bowker. 1968. Development of essential requirements for production. U.S. Fish and Wildlife Serv. Div. of Fish Hatch., July 1968.

Robinson, John B. 1960. The age and growth of striped bass (Roccus saxatilis) in California. Calif. Fish & Game 46(3): 279-290.

Scruggs, G. D., Jr. 1954. The rock fish puzzle -- are they land-locked? So. Car. Wildlife, Summer 1954. 1(3):4-5.****

Scruggs, G. D., Jr. 1957. Reproduction of resident striped bass in Santee-Copper reservoir, South Carolina. Trans. Amer. Fish. Soc., 85:144159.

Scruggs, G. D., Jr. and J. C. Fuller, Jr. 1954. Indications of striped bass (Roccus saxatilis) (Walbaum) in Santee-Copper reservoir. Proc. of the Southeastern Assn. of Game & Fish Comm., Nov. 12, pp. 64-68.

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****Literature not seen.