RACES OF THE STRIPED BASS, *ROCCUS SAXATILIS* (WALBAUM), IN SOUTHEASTERN UNITED STATES

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A knowledge of the origin of the stock or stocks exploited in a fisheries is basic to sound management. A study to determine the racial structure of Atlantic Coast striped bass is under way and recent investigations of southeastern stocks have produced tentative concepts. The results should be considered preliminary because specimens from too few year classes are available for study. As used here the term "race" implies a lower level of differentiation than that of a subspecies.

The major published findings concerning racial problems to date are as follows: Merriam (1937 and 1941) and Vladykov and Wallace (1938) showed that some Chesapeake Bay striped bass, two years and older, undertake a non-spawning coastal migration northward in the spring. In the fall they return to Chesapeake Bay by approximately the same route although some migrants may enter and winter over in northern coastal rivers. Vladykov and Wallace (1952) indicated that different sub-races may make up the Chesapeake Bay race although adequate substantiating data are not presented. Raney and de Sylva (1953) showed that fin ray counts in young striped bass were lower in samples from the Hudson River than those from Chesapeake Bay. The degree of differentiation was approximately 80%, based on a character index combining dorsal, anal and total pectoral soft ray counts. They also suggested that the Hudson River may contain an upstream and a downstream population. Raney, Woolcott and Mehring (1954) concluded that: (a) The Hudson River race migrates to the western quarter of Long Island Sound and the region near the mouth of the Hudson River including the northeastern New Jersey shore and the south shore of Long Island east to Jones Beach; (b) Fin ray counts of young of the 1953 year class confirmed the findings based on other year classes concerning the racial separation of Chesapeake and Hudson River striped bass; (c) In fin ray counts, samples from Rhode Island and northward are close to the Chesapeake race; (d) Although shifts in the fin ray counts occur from year to year, the change is slight compared to the degree of differentiation between races and usually has little effect on the percentage of separation; and (e) Albemarle Sound samples differ from South Carolina series in lateral-line scale counts. The senior author was supported by the U. S. Fish and Wildlife Service as part of the Atlantic States Cooperative Striped Bass Program sponsored by the Atlantic States Marine Fisheries Commission. A modified version of this paper was presented as part of a panel on striped bass at the Eighth Annual Conference of the Southeastern Association of Game and Fish Commissioners, New Orleans, November 1, 1954. The junior author was a recipient of a Sport Fishing Institute Fellowship, 1953-54.

MATERIALS

Samples from Albemarle Sound were mostly young of several year classes but include some juvenile and adult specimens. Those from the Santee-Cooper River, South Carolina, are mostly young (Lake Marion) and yearlings of the 1954 and 1953 year classes which were made available by George D. Scruggs, Jr. and Jefferson C. Fuller, Jr. of the South Carolina Wildlife Resources Department. Prior to this, our South Carolina sample consisted of only ten young and small adults which were loaned by E. Milby Burton and Albert Schwartz of the Charleston Museum. An adequate sample of adult striped bass from the St. Johns River system in eastern Florida was counted during September, 1954, by William M. McLane of the Florida Game and Freshwater Fish Commission and the authors. Only four specimens of striped bass have been examined from the Gulf of Mexico drainages of Florida and Mississippi. It is hoped that additional specimens will be made available by Gulf Coast fishery biologists. Figure 1 shows the localities in South Carolina referred to below.

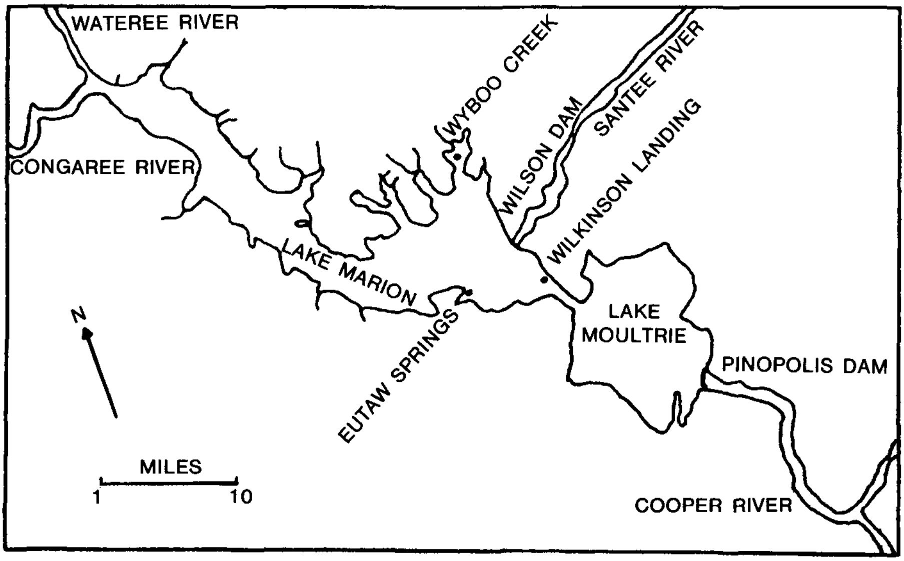

Fig. 1. Outline map showing collecting stations in the Santee-Cooper reservoir system, South Carolina.

CHARACTERS STUDIED

Fin ray and lateral line scale counts of young have been emphasized to date. Body proportions and scale structure may show differences from place to place but large specimens are as yet too few in our collections to prove this.

RESULTS

Lateral-line scale counts are shown in Table 1 and illustrated for southern samples in Figure 2. Northern stocks may differ from each other on a low level. Frequency distributions approximate normal except for the Hudson and Cooper rivers where two types seem to be present. The Albemarle Sound sample differs on a relatively high level from the South Carolina composite sample; the average separation is 76% when a line is drawn between 60 and 61 scales (see Ginsburg, 1938). The St. Johns River, Florida, sample averages lower than the composite South Carolina sample; 85% average separation is obtained when a line drawn between 56 and 57 scales. The St. Johns River sample is separated 93% on the average from the Albemarle Sound sample.

An examination of the South Carolina samples indicates two stocks may be present. One is represented by the four samples from Lake Marion and a small sample from Lake Moultrie. Here the lateral line counts are relatively high, usually 58 to 60. Fig. 2 illustrates that within Lake Marion samples, which consisted only of young of the 1954 year class, differ somewhat from place to place as did samples taken at the same locality (Wilkinson Landing) at different times. It is to be noted that these differences are not significant.

A down-river population seems to be represented by the Ashley and Edisto rivers composite sample, which unfortunately is small and which represents juvenile and small adult specimens not of the same year class as the Cooper River or Lake Marion samples. The Cooper River samples which consists of juvenile and adult specimens is intermediate between the Lake Marion population and the South Carolina Coastal Plain population. It also shows a bimodal distribution (Table 1). These specimens were taken below Pinopolis Dam and seem to represent both spawning migrants from downstream and Lake Marion bass which perhaps came downstream through the navigation locks. The lowland or Coastal Plain population of South Carolina appears to occupy an intermediate position in lateral line scales between the Cooper River and St. Johns River, Florida, populations.

A cline is observable in the distributions shown in Fig. 1; they vary from low counts in the south to high counts in the Albemarle Sound samples. No cline is represented by our samples from north of Albemarle Sound.

Fin Ray Counts

Anal Ray counts are given in Table 2. There seems to be little difference in anal ray counts in samples from Albemarle Sound and southward. Anal rays seem rather stable except perhaps for the New Brunswick, Canada, sample. The upper Hudson River race averages low also. Dorsal ray counts are shown in Table 3. The count is modally 12 in the geographic area between Albemarle Sound and Mississippi. A slight difference is found in comparing those from Lake Marion with the sample from Cooper River below Pinopolis Dam. The Hudson River race is unique; samples have 11 rather than 12 as the modal number.

The total pectoral ray count is given in Table 4. There is an indication of population differentiation within the Santee-Cooper River system in this character; the upstream population has the higher count. The St. Johns River, Florida, population has the highest count found along the Atlantic Coast and approaches the values for New Brunswick and Nova Scotia samples (Fig. 3).

Table 1. Frequency distribution of lateral-line scales in striped bass. The last column (%) indicates the percentage of specimens with 60 or fewer scales.

	Lateral-Line Scales																		
Locality	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	No.	Mean	%
St. Lawrence River[a]						4	7	11	14	16	14	14	17	2			99	61.3	36
New Brunswick			1	1	4	3	12	16	29	20	25	14	7	6	6		144	60.9	46
Rhode Island					1	4	2	5	9	10	12	13	4	7	1	1	69	61.6	30
Hudson River			1	2	5	6	8	10	6	13	8	2	3	1			65	59.6	58
Delaware River							2	4	9	19	17	10	12	5	3	2	83	62.2	18
Chesapeake Bay		1		2	9	14	14	26	31	27	33	13	8	2			180	60.1	54
N.C., Albemarle Sound							2	4	6	11	8	3	3	4	2		43	61.7	28
S.C., Lake Marion	1		4	9	14	24	25	41	39	33	20	9	4				223	59.2	70
Wyboo Cr.			1	4	4	9	12	16	23	11	11	7	3				101	59.6	68
Eutaw Sp.	1			1	3	2	2	4	3	3	1	2	1				23	59.0	70
Wilkinson Ld.																			
Sept. 10		1	2	4	7	9	9	16	10	5	5						68	58.3	85
Sept. 27			1			4	2	5	3	4	3						22	59.2	68
Lake Moultrie				2		1	1	1	2	1	1	1					10	59.9	70
Cooper River	1	5	7	5	9	5	11	11	7								61	56.8	100
Ashley and Edisto Rivers	1	1		4			1		1								8	55.4	100
Fla., St. Johns River	4	4	8	4	3	1	1										25	54.2	100

[a] Counts on St. Lawrence samples furnished by V. D. Vladykov.

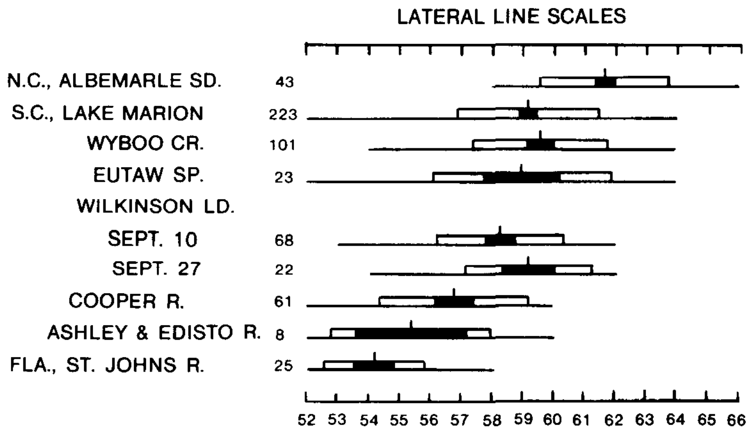

Fig. 2. Lateral-line scale counts of stripped bass. For each locality the range of variation is shown by a heavy horizontal line; the mean by a vertical line. The blackened part of each bar comprises two standard errors of the mean on either side of the mean. One-half of each black bar plus the white bar at either end, outline one standard deviation on either side of the mean. Considerable reliance can be placed on the significance of the difference between samples if the corresponding black bars are separated or only slightly overlap. Method of representation adapted from Hubbs and Hubbs (1953: 51).

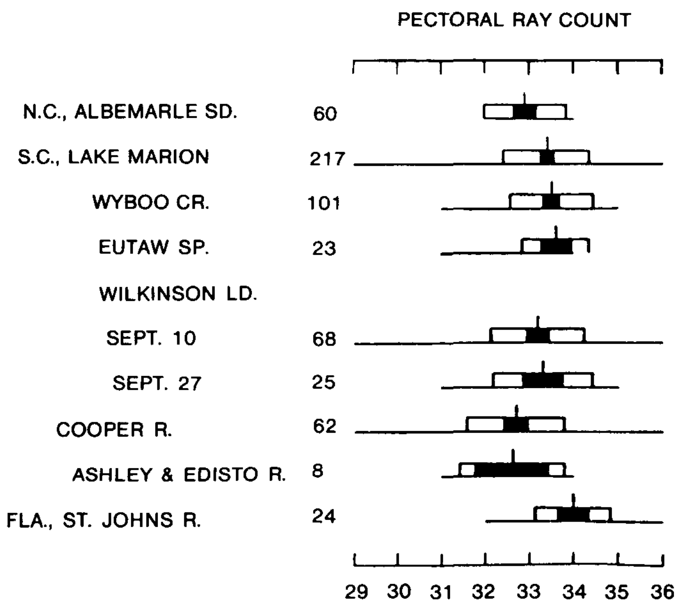

Fig. 3. Total pectoral ray counts of striped bass.

Table 2. Number of anal soft rays in striped bass. The last column (%) gives the percentage of specimens with 10 or fewer rays.

Locality	Anal Rays									
	7	8	9	10	11	12	13	No.	Mean	%
St. Lawrence River				21	79			100	10.8	21
New Brunswick	1	1	13	61	66	1	1	144	10.4	53
Nova Scotia					39			39	11.0	0
Hudson River (upper)			8	107	142	3		260	10.6	44
Delaware Bay			2	46	190	2		240	10.9	20
Chesapeake Bay				124	825	3		952	10.9	13
N.C., Albemarle Sound				4	56			60	10.8	10
S.C., Lake Marion				6	218	1		225	11.0	3
Wyboo Cr.				3	98			101	11.0	3
Eutaw Sp.					23			23	11.0	0
Wilkinson Ld.										
Sept. 10				3	64	1		68	11.0	4
Sept. 27					25			25	11.0	0
Lake Moultrie					8			8	11.0	0
Cooper River				7	55			62	10.9	11
Ashley and Edisto Rivers				1	7			8	10.9	13
Florida, St. Johns River				1	22	2		25	11.0	0
West Florida and Mississippi				1	3			4	10.8	25

Table 3. Number of dorsal soft rays in striped bass. The last column (%) given the percentage of specimens with 11 or fewer soft rays.

	Dorsal Rays								
Locality	9	10	11	12	13	14	No.	Mean	%
St. Lawrence River		1	30	69			100	11.7	31
New Burnswick		10	17	124	1		144	11.9	13
Nova Scotia			1	38			39	12.0	3
Hudson River (upper)	2	24	183	38	1	1	249	11.1	84
Delaware Bay		6	99	128	7		240	11.6	44
Chesapeake Bay		7	248	687	8	1	951	11.8	27
N.C., Albemarle Sound			9	51			60	11.8	15
S.C., Lake Marion			70	146	1		217	11.7	32
Wyboo Cr.			28	73			101	11.7	28
Eutaw Sp.			5	18			23	11.8	22
Wilkinson Ld.									
Sept. 10			27	40	1		68	11.6	41
Sept. 27			10	15			25	11.6	40
Lake Moultrie			4	12			16	11.8	25
Cooper River		5	16	40	1		62	11.6	34
Ashley and Edisto Rivers				8			8	12.0	0
Florida, St. Johns River			2	23			25	11.9	1
West Florida and Mississippi				4			4	12.0	0

Table 4. Number of pectoral rays (both sides) in striped bass. The last column (%) gives the percentage of specimens with 32 or fewer rays.

	Pectoral Rays														
Locality	27	28	29	30	31	32	33	34	35	36	37	38	No.	Mean	%
New Brunswick						13	14	112	5				144	33.8	9
Nova Scotia						3	7	25	4				39	33.8	8
Hudson River (upper)		2	7	14	29	134	33	36	1				256	32.1	73
Delaware Bay			4		18	55	53	73	29	2			234	33.1	33
Chesapeak Bay	1	4	6	23	27	182	168	406	75	37	6	1	936	33.4	26
N.C., Albemarle Sound						26	10	24					60	32.9	43
S.C., Lake Marion			1		8	35	43	120	9	1			217	33.4	20
Wyboo Cr.					4	15	16	60	6				101	33.5	19
Eutaw Sp.					1	1	4	17					23	33.6	8
Wilkinson Ld.															
Sept. 10			1		2	13	18	32	1	1			68	33.2	23
Sept. 27					1	6	5	11	2				25	33.3	28
Lake Moultrie						2	8						10	32.8	20
Cooper River			1	1	2	25	17	14	1	1			62	32.7	47
Ashley and Edisto Rivers					1	4		3					8	32.6	63
Florida, St. Johns River						1	4	16	1	2			24	34.0	0
West Florida and Mississippi							2	2					4	33.5	0

For the most part the fin ray counts vary in the same direction and an index formed by adding anal, dorsal, and pectoral soft rays gives a total picture of the trend (Table 5, Fig. 4). The Albemarle Sound and the composite South Carolina population do not differ significantly. The St. Johns River, Florida, population differs significantly from the South Carolina and Albemarle samples. Within the Santee-Cooper River system, South Carolina, there seems to be an indication of two different populations. The upstream population has the higher index.

DISCUSSION

In view of the differentiation in lateral-line scales found in the North Carolina, South Carolina and east Florida stocks it seems pertinent to consider the possible causes of these differences. The authors favor the hypothesis that scale counts and fin ray characters are gentically fixed in striped bass but may fluctuate within a narrow range in response to environmental changes such as temperature at the time these characters are determined in the embryo. Experimental evidence to date (see Taning, 1952, for references) with other fishes usually indicates an increased number of parts with lower water temperatures. The data on lateral line scale counts (Table 2) show a gradual or clinical increase from St. Johns River, Florida, northward to Albemarle Sound. However, no such cline is noted in comparing samples from Chesapeake Bay to the St. Lawrence River, an area which certainly experiences varied temperature conditions. An increase occurs in an upstream direction within the Santee-Cooper River system. A slight decrease is noted upstream in the Hudson River.

Under experimental conditions, fin ray counts normally shift in the same direction as do lateral line scales; a higher number at lower water temperatures. Where differences do occur in fin ray counts in the region from the St. Johns River, Florida, to Albemarle Sound, a reverse trend, a slight decrease toward the north exists. Within the Santee-Cooper River system there is a slight increase in an upstream direction. Perhaps the water temperatures at spawning time are lower downstream below Pinopolis Dam. Upstream in the Hudson River the number of dorsal rays definitely decreases.

For the most part critical temperature data at spawning time are lacking so that we do not know that shifts in the fin ray and scale counts in the striped bass are correlated with temperature. Furthermore in nature, spawning does not usually occur in striped bass until a threshold temperature of about 58°F is reached. The incubation period is short; 48 hours at 64.2°F (Pearson, 1938: 831). The "supersensitive" period when the embryo is especially sensitive is not known but is likely to be of short duration, seemingly a matter of hours. It seems probable that widely separated populations of striped bass along the Atlantic Coast may undergo early development at about the same water temperature. Pronounced changes in temperature due to sudden storms might cause shifts which could result in an unusual distribution of counts for part of a year class. Such differences would tend to balance out if samples including several year classes are used. These problems may be clarified by researches to be carried on over the next three years.

Whether the cause of the differences which have been found to exist is primarily genetic or is a result of environmental modification of the phenotype, makes relatively little difference as long as the variations in a given area are

Table 5. Frequency distribution of the character index (sum of dorsal, anal and pectoral soft rays) in striped bass. The last column (%) indicates the percentage of specimens with an index of 55 or less.

	Character Index																	
Locality	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	No.	Mean	%
New Brunswick						2	4	11	22	50	48	7				144	56.0	23
Nova Scotia									3	8	24	4				39	56.7	8
Rhode Island					1			5	12	16	26	4	2	1		67	56.3	27
Hudson River			1	5	13	27	49	74	59	23	22	1				274	54.0	83
Delaware River	1				1	1	4	15	15	18	18	9	1			83	55.6	45
Chesapeake Bay					1	5	9	25	80	127	219	55	27	2	1	551	56.4	22
N.C., Albemarle Sound							2	4	12	11	14					43	55.7	42
S.C., Lake Marion						1	6	13	40	68	81	7	1			217	56.1	28
Wyboo Cr.							4	6	13	27	46	5				101	56.2	23
Eutaw Sp.								1	3	5	14					23	56.4	17
Wilkinson Ld.																		
Sept. 10						1	2	3	19	24	16	2	1			68	55.8	37
Sept. 27								3	5	12	5					25	55.8	32
Lake Moultrie									1	3	4					8	56.4	13
Cooper River					1	1	5	11	18	14	10	2				62	55.2	58
Ashley and Edisto Rivers								1	4	1	2					8	55.5	62
Florida, St. Johns River									1	6	12	4	1			24	56.9	4
West Florida and Mississippi									1	1	2					4	56.2	25

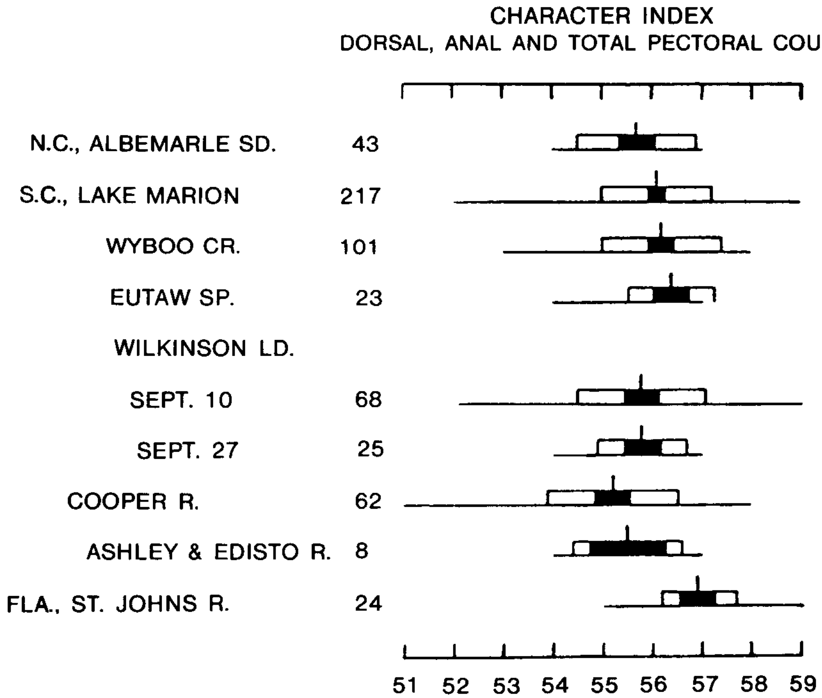

Fig. 4. Character indices for samples of striped bass. The index was obtained by adding dorsal, anal and total pectoral soft rays.

approximately the same from year to year. To date an insufficient number of year classes of striped bass have been studied from the southeastern United States, but in the Hudson River where studies have been made of several year classes since 1949 relatively small differences in counts have been noted from year to year.

The meristic data presented here which indicate an upstream vs. a downstream population in the Santee-Cooper River system, South Carolina, are strengthened by the findings of Scruggs and Fuller (1955), regarding migration within the river system. We assume that the Lake Marion stock was derived from an upriver stock which had already been differentiated much as has the upstream Hudson River race. When the rivers were dammed, the upstream form apparently found a suitable habitat and now represents a fishery of great potential value.

We still lack samples of striped bass from many coastal areas where populations are known to occur and a future study of material from several Georgia rivers as well as other waters in North and South Carolina will further clarify the picture of racial structure of the stocks. Counts of the relatively few and inadequate samples from west Florida and Mississippi give indications of significant scale differences. There is little chance that there has been general exchange between these and Atlantic populations since the emergence of the Florida peninsula from the sea.

SUMMARY

It is tentatively concluded that the South Carolina stock of striped bass is an endemic race which in turn is differentiated into an upstream form which may not go to the sea and a downstream form which at least goes downstream to brackish water. Certainly there is little interchange between South Carolina stock and that of Albemarle Sound, North Carolina, or the St. Johns River, Florida. The latter is a good race but its relationships with populations immediately to the north in Georgia rivers are unknown.

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