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A FIVE-YEAR STUDY OF THE STRIPED BASS FISHERY OF MARYLAND, BASED ON ANALYSES OF THE SCALES

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A FIVE-YEAR STUDY OF THE STRIPED BASS FISHERY OF MARYLAND, BASED ON ANALYSES OF THE SCALES *

RICHARD E. TILLER **

INTRODUCTION

The striped bass, or rock as the species is called in the Chesapeake area, ranks high in value and volume among the commercially important fish taken in Maryland waters and, in addition, is highly prized as a game fish by sportsmen. Interest in the marked fluctuations characteristic of the species stimulated this investigation begun in October, 1941 under the joint sponsorship of the University of Maryland Graduate School and the Fish and Wildlife Service. The study was continued on that basis until 1943 when I joined the staff of the Maryland Department of Research and Education. From 1943 until 1947 the investigation was conducted under the auspices of that organization.

My investigation was designed as a general study, presenting simply a description of the fishery, an outline of techniques of investigation, and a recommendation of further study required. I collected and analyzed scales from fish of the 1940, 1941, 1942, 1943, and 1944 broods of striped bass to determine the rate of growth, contribution to the commercial catches, the rate of utilization of successive year classes of striped bass and the possibility of using the scales as an index of origin for the Atlantic stocks of striped bass.

* The data used in this paper were presented in thesis form at the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy in 1947.

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THE MARYLAND STRIPED BASS FISHERY

Striped bass are taken during the entire year in Maryland waters, with seasonal peaks of abundance in the late fall and spring months. The gear used in this fishery varies with the season, and to a lesser extent with the area fished. Pound nets which operate in the Bay and larger rivers during the spring, summer, and fall account for the greater portion of the catch. Gill nets, drifted or anchored in the Bay and larger rivers during the winter and early spring or fished as stake nets on or near the spawning grounds in the spring, are next in production. Lowest in value of the larger commercial gears are the haul seines, fished principally during the spring and summer. Fyke nets, typically used in the upper regions of rivers for perch and catfish, make only a relatively small seasonal contribution to the total catch of rock. The table following (Table I) was obtained from records compiled by the Maryland Department of Research and Education, and presents the most recent available data on the catch by gear of this species.

TABLE I

MARYLAND STRIPED BASS CATCH BY GEAR FOR 1944 AND 1945. CHESAPEAKE BAY AND TRIBUTARIES ONLY, ATLANTIC OCEAN CATCH NOT INCLUDED

YEAR	POUND NETS (Lbs)	GILL NETS Drift (Lbs)	GILL NETS Anchor (Lbs)	GILL NETS Stake (Lbs)	HAUL SEINES (Lbs)	FYKE NETS (Lbs)	TOTAL (Lbs)
1944	768.595	522,115	86,622	689,583	502,888	6,315	2,576,118
1945	565,538	196,521	42,460	483,303	186,324	5,709	1,479,855

Records compiled by the U. S. Bureau of Fisheries covering the period from 1887 to 1942 (Table II) show marked variations in the abundance of striped bass taken in Maryland. A complete series for every year during that time is not available, but the following table presents the total catch for all years in which statistics were collected.

TABLE II

TOTAL CATCH OF STRIPED BASS IN MARYLAND FOR VARIOUS YEARS FROM 1887 TO 1942

YEAR	POUNDS	YEAR	POUNDS	YEAR	POUNDS
1887	1,140,000	1920	1,040,000	1935	927,700
1888	1,123,000	1925	1,414,000	1936	1,864,100
1890	1,366,000	1929	1,291,695	1937	2,011,300
1891	1,265,000	1930	1,227,990	1938	1,714,400
1897	935,000	1931	634,909	1939	1,728,500
1901	824,000	1932	433,811	1940	1,180,100
1904	721,000	1933	313,795	1941	1,223,300
1908	640,000	1934	332,700	1942	2,507,800

According to these statistics, Maryland produced in 1940 approximately 40% of the total catch of rock in the United States. Although conclusive proof from tagging is still lacking, there is strong evidence that the Chesapeake Bay is the point of origin for most of the striped bass found along the Middle and North Atlantic Coast. On the basis of tagging experiments during 1936, Vladykov and Wallace (1937) state that only a very small number of the Chesapeake rock leave the Bay or about 2.5% of the total recaptures from over 1,500 tagged fish. It is, however, interesting to note that in 1934 and in 1940 dominant broods of rock were produced and these "bumper crops" were easily traced up the coast during the early spring months following their first appearance in the Chesapeake catches. Merriman's work on the 1934 brood revealed that scales from northern catches had about the same values for the width of the first and second growth zones as scales from that same year class taken in the Chesapeake area.

METHODS

Collection of Samples

To minimize variations due to environmental or physiological peculiarities which might alter the scale pattern of populations from different areas uniform procedures were used in every collection. All specimens for a single sample were taken from the same area on the same day, and successive samples were made from the same nets whenever possible.

The areas selected for collection of the samples for this study were two representative centers of pound net operations, one at Galesville, Maryland, and the other at Flag Pond, near Lusby, Maryland. All samples were taken at random from the catches, usually during the return trip from the nets, although some collections were made as the fish were landed, before they were sorted according to size.

The scales were removed from the fish with forceps, and placed in small envelopes on which the length of the fish, the body area from which the scales were taken, and any other necessary data were recorded. All specimens were measured from the snout to the fork of the tail, using a measuring board equipped with an offset scale divided into half-centimeter units.

Two problems became evident in the early phases of the study; first, the selection of a fishing gear which would be least selective in the size of fish taken, and which would therefore present a more uniform cross-section of the total population; and second, the selection of the most reliable body area for the collection of scale samples.

Selection of Gear for Sampling

A brief discussion of the four major types of commercial gear used in Maryland was included in the introductory section, together with a table (Table I) indicating the contribution of each to the total catch of striped bass in the state. In addition to exceeding all other individual types of gear in total production, pound nets have certain other advantages which make them a desirable source from which to obtain the most typical samples of a fish population. The regularity characteristic of pound net operations is a highly important factor in their favor. Lifted daily, except in exceptionally bad weather, pounds fish the same waters in the same way throughout the entire fishing season. Under favorable conditions the pound net season may run from March through November, with only a short midsummer break in operations. The previously-mentioned table shows stake gill nets to be second in total production of striped bass, but this gear, and also drift and anchor gill nets, exerts very definite size selectivity, for the mesh size captures only fish falling within a relatively narrow size range. Stake nets, and all other types of gill netting, are fished only during the winter and spring, and their operations are necessarily irregular. Drift nets are the most irregular of this class of gear, since they characteristically work from one area to another, following the movements of the fish.

The last of the commercial gears to be considered is the haul seine. This type of net might well be termed a gear of "feast or famine." Seine operations are usually limited to the late spring, summer, and fall months, and like drift nets, characteristically follow the fish. Days or weeks may pass without a catch, or several tons may be landed in a single haul. Although less selective in operation than gill nets, haul seines occasionally make almost pure catches from a single year class, particularly when fished in rivers. Table III presents an age composition analysis of samples made from various types of commercial gear outside of the Galesville and Flag Pond areas on which this study is based.

Selection of Reliable Body Area for Sampling

To determine the comparative reliability of scales from different body areas, preliminary studies were conducted which indicated that scales from the region used by Merriman and by Scofield in their studies gave values for calculated length which approached very closely the average of the values from extreme body areas.

The original formula is given as:

$$\frac{s_x}{S} = \frac{l_x}{L} \quad \text{.......... (1)}$$

Where s_x = length of scale to annulus year_x,
S = total scale length,
l_x = body length at end of year_x, and
L = body length when captured.

This formula was used in a somewhat more convenient form of:

$$\frac{L}{S} \cdot s_x = lx. \quad \text{.......... (2)}$$

These calculations showed that the short, broad scales of the anterio-dorsal region gave consistently lower values than the regular, symmetrical scales of the middle body area, and the large, long scales of the ventral region yielded values which were consistently higher. The variation in calculated length was therefore determined to be a function of scale size. Table IV, prepared from calculations made on the 89 fish used in the preliminary study, indicates this fact. Three body areas were selected and designated as areas A, B, and C. Area A was located very high on the body, between the bases of the spiny and soft dorsal fins, at the extreme point where reasonably symmetrical scales can be found. Area B (used by Merriman and by Scofield), was located on the second and third row above the lateral line, between the dorsal fins, and yielded the most symmetrical scales. Area C was located very low on the body, one row below the lateral line. The scales were very large and noticeably longer than those of the mid-body region.

ANALYSIS OF DATA

Rate of Growth

The growth of rock, as indicated from length frequencies of the age classes observed in this study, appears to be highly variable (Table V).

TABLE III

AGE COMPOSITION OF COLLECTIONS FROM MISCELLANEOUS GEARS AND AREAS

Date			1940 Brood		1941 Brood		1942 Brood		1943 Brood		R. F., others		Total
(Month)	Gear	Area	No.	%	No.	%	No.	%	No.	%	No.	%	No.
1942													
Mar.	Pounds	Potomac R.	58	72.5							22	27.5	80
July	Seine	Patuxent R.											
Oct.	Pounds	Ches. Beach	95	95.0							5	5.0	100
Oct.	Pounds	York R.	50	59.5	31	36.9					3	3.6	84
Oct.	Pounds	James R.	29	52.7	24	43.6					2	3.6	55
Oct.	Pounds	Rappahannock R.	69	72.6	23	24.2					3	3.2	95
1943													
Jan.	Dr. Gill	Rock Hall	45	90.0	1	2.0					4	8.0	50
Feb.	Dr. Gill	Kent Island	110	94.0	3	2.6					4	3.4	117
May	Pounds	Cedar Pt.	29	81.5	2	7.4					3	11.1	27
1944													
Jan.	Dr. Gill	Rock Hall	3	2.1	9	6.4	127	90.7			1	.7	140
Feb.	Dr. Gill	Kent Island	1	3.8			25	96.1					26
June	Seine	Flag Pond					1	3.3	29	96.7			30

Although samples were obtained from the least selective of fishing gears, and in every case were taken at random from unsorted catches, occasional values from mean length occurred which were quite different from the expected values. In some instances, the composition of the catch was such that only a very few samples from certain broods were obtained.

TABLE IV

	Body Length (cm/2)	(mm./00) Total Scale Radius	Average Calc. Length
AREA "A"			
	49-53	243	18
	54-56	271	21
	57-59	282	21
	60-62	313	21
	63-65	303	26
	66-69	334	29
AREA "B"			
	49-53	284	20
	54-56	315	22
	57-59	325	22
	60-62	350	23
	63-65	355	27
	66-69	377	30
AREA "C"			
	49-53	312	21
	54-56	332	25
	57-59	337	25
	60-62	371	25
	63-65	379	30
	66-69	409	32

Average increase in calculated length
Between A & B — 1.14 cm/2
Between B & C — 2.01 cm/2

The occasional discrepancies in the length frequencies of samples from Galesville and Flag Pond area might at first be taken as evidence of sub-populations in the Chesapeake Bay, but statistical analysis of the data fails to substantiate such an interpretation. While bass from Flag Pond did grow significantly larger in 1940 than those from the Galesville area, in the 1941 and 1942 year class, the bass from Flag Pond were actually smaller, contradicting any indication of "sub-populations" based on growth analysis.

Several interesting facts are indicated in Table V and Figure 1. First, a close agreement is seen in the size of all year classes at the time of their entry into the commercial catches. The 1940 and 1941 broods tend to be slightly faster in their rate of growth, and show slightly higher values for corresponding intervals of time. This tendency is not, however, clearly defined in all instances. Trend lines were prepared showing the growth rate of the four year classess under observation, using the method of least squares. The slight variation in the slope (Figure 1) indicates the slight degree of variation in the growth rate of the four broods after their entrance into the commercial fishery.

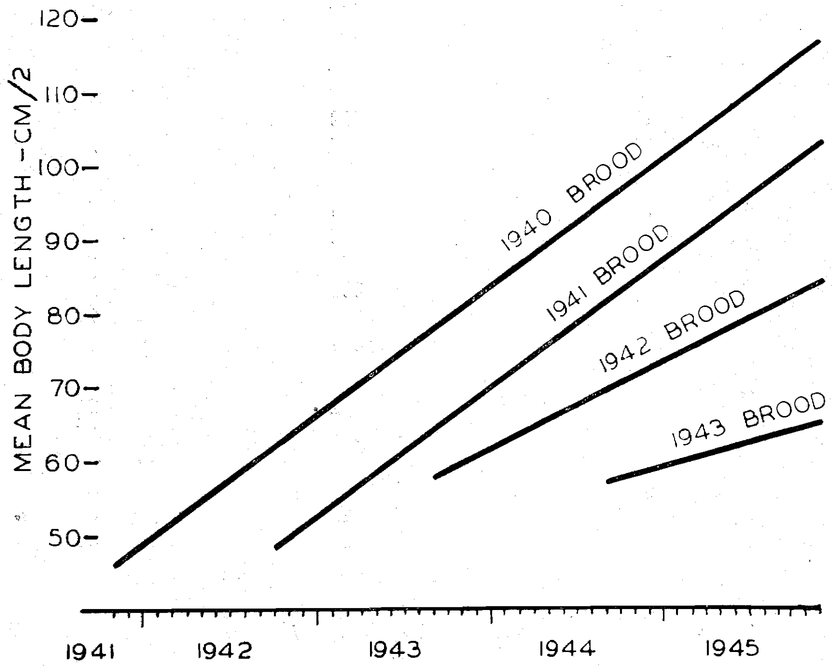

FIGURE 1. Rate of Growth of Striped Bass, Based on Length Frequencies of Four Successive Year Classes in the Chesapeake Bay.

EVIDENCE OF CHESAPEAKE ORIGIN OF ATLANTIC STOCKS OF STRIPED BASS

The possibility of using scale analyses as an index to origin of the stocks of striped bass of the Middle Atlantic Coast was stated as one of the objectives of this study. The introductory section summarized the conclusions derived from extensive tagging experiments conducted by Vladykov and Wallace (1937), and indicated the existence of a coincidence in size frequencies between Chesapeake and coastal runs of bass following the appearance of a dominant year class in the Chesapeake Bay. Body length measurements and scale readings for samples were obtained from the Galesville and Flag Pond areas of Chesapeake Bay in March and June, 1942, and from Great South Bay and Montauk Long Island, New York, during the months of May and June, 1942. All samples used were from the 1940 brood of rock, which had appeared in great abundance in the Chesapeake catches during the preceding fall. The mean values for body length and calculated length were determined for all of the Chesapeake samples, and for a significant number of the Long Island samples. A very close agreement was observed in total body length between the two series collected in the latter area, and in view of the proximity of the two localities from which the samples were obtained. Length calculations were made only for the Montauk collection. Table VI presents these data, and indicates the close coincidence in body length and calculated length between the northern fish and those collected in the Galesville area of the Chesapeake Bay. Although the calculated mean body lengths for the Flag Pond collection is greater than the Galesville sample, the difference is not sufficiently great to be statistically significant. ($t = 1.2153$; d. f. $= 422$; $P > 0.20$). These data are presented graphically in Figure 2, which shows the striking similarity in percentage frequencies for the two areas.

TABLE VI

COMPARISON OF GROWTH DATA OBTAINED FROM CHESAPEAKE AND NORTHERN COLLECTIONS OF STRIPED BASS OF THE 1940 YEAR CLASS

Area	Date (Month) 1942	Mean Body Length (cm/2)	Mean Calc. Length—end of first year (cm/2)	Number of Samples
Flag Pond	March	57.7	23.9	36
Galesville	June	56.4	18.0	388
Great So. Bay	May	56.7		190
Montauk	May	53.5	18.0	91

TABLE V

GROWTH RATE OF STRIPED BASS INDICATED BY MEAN LENGTHS OF SAMPLES COLLECTED FROM POUND NETS IN THE GALESVILLE AND FLAG POND AREAS OF CHESAPEAKE BAY

Date	1940 Brood		1941 Brood		1942 Brood		1943 Brood		1944 Brood		
(month)	cm/2	No.	cm/2	No.	cm/2	No.	cm/2	No.	cm/2	No.	Area
1941											
Oct.	52.5	23									Flag Pond
Nov.	58.9	87									Flag Pond
1942											
Mar.	57.7	36									Flag Pond
June	56.4	387									Galesville
June	59.6	107									Flag Pond
July	57.6	91									Galesville
Aug.	58.9	18	52.0	2							Flag Pond
Sept.	59.8	52	58.3	3							Flag Pond
Oct.	66.9	67	57.3	3							Flag Pond
Nov.	70.0	96	58.0	3							Galesville
Nov.	73.3	92	57.0	1							Flag Pond
1943											
May	62.1	75	57.8	18							Galesville
Aug.	72.8	103	62.7	66	57.6	327					Flag Pond
Sept.	76.7	4	64.4	14	58.7	87					Flag Pond
Sept.	75.1	7	69.3	6	61.6	42					Galesville
Oct.	82.7	59	68.7	8	62.3	105					Flag Pond
Oct.	83.0	3	61.7	4	61.0	43					Galesville
Nov.	78.4	7	55.0	2	60.1	46					Flag Pond

TABLE V—Continued

Date	1940 Brood		1941 Brood		1942 Brood		1943 Brood		1944 Brood		
(month)	cm/2	No.	cm/2	No.	cm/2	No.	cm/2	No.	cm/2	No.	Area
1944											
Mar.	91.2	20	68.0	3	59.0	10					Galesville
May	96.2	5	77.2	4	64.8	24					Flag Pond
June	101.8	5	76.0	2	57.3	12					Galesville
June	95.7	13	86.2	18	66.0	23					Flag Pond
Aug.	90.1	6	79.3	3	71.1	44	56.2	6			Flag Pond
Sept.	97.0	1	80.3	3	66.9	11	56.9	21			Flag Pond
Oct.		0	77.0	1	66.9	8	60.1	26			Flag Pond
Nov.	101.1	26	84.5	13	77.7	79	62.2	45			Flag Pond
1945											
May	101.5	15	87.2	10	78.2	34	63.1	12			Flag Pond
June	105.2	5	87.5	2	79.3	6	57.1	34			Flag Pond
Aug.		0		0	76.0	1	60.0	4	53.2	8	Flag Pond
Oct.	112.0	1		0	80.8	10	68.1	66	55.5	36	Flag Pond
Nov.	127.0	1	101.0	5	84.7	24	70.4	61	58.1	58	Flag Pond

Age Composition of Commercial Catches

The marked fluctuations in abundance characteristic of the striped bass were discussed in my introductory discussion of the fishery. Occasionally, extremely successful spawning has resulted in the production of what is termed a "dominant year class," so called because its members dominate the commercial catches for several reasons. A "bumper crop" of this type occurred in 1940. Tables VII, VIII, IX, and X show

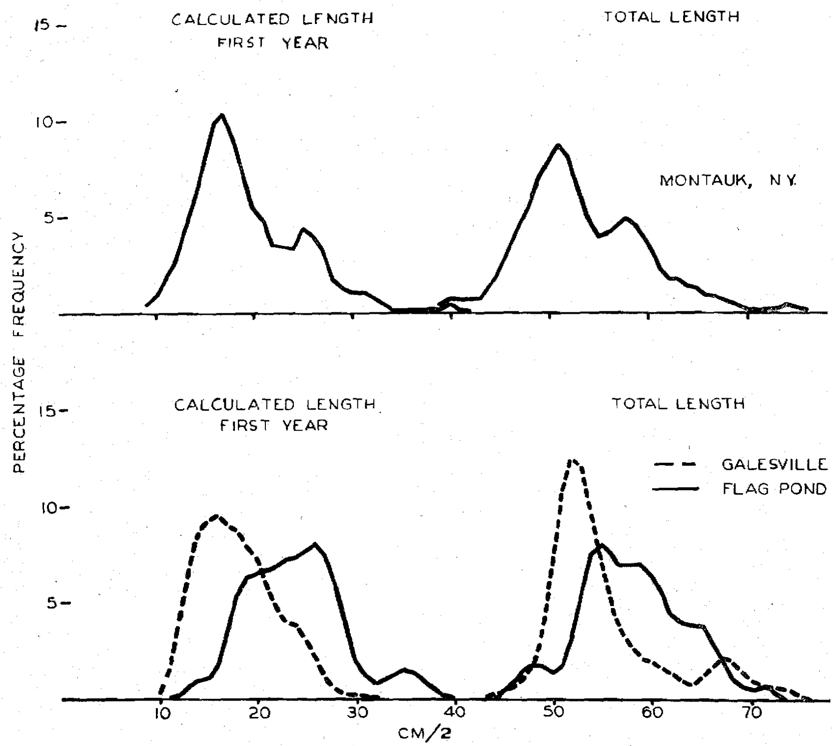

FIGURE 2. Percentage Frequencies of Calculated Length at the End of First Year and Total Body Length at Time of Capture, Determined from Chesapeake Bay and Atlantic Ocean Catches.

the appearance of the 1940, 41, and 42 and 43 broods in the commercial pound net catches of Maryland waters, and their rate of utilization. Table III, referred to previously in the section devoted to the selection of a reliable gear for sampling, presents the age composition of collections from various other types of gears and other areas. Figure 3 is a graphical representation of the material included

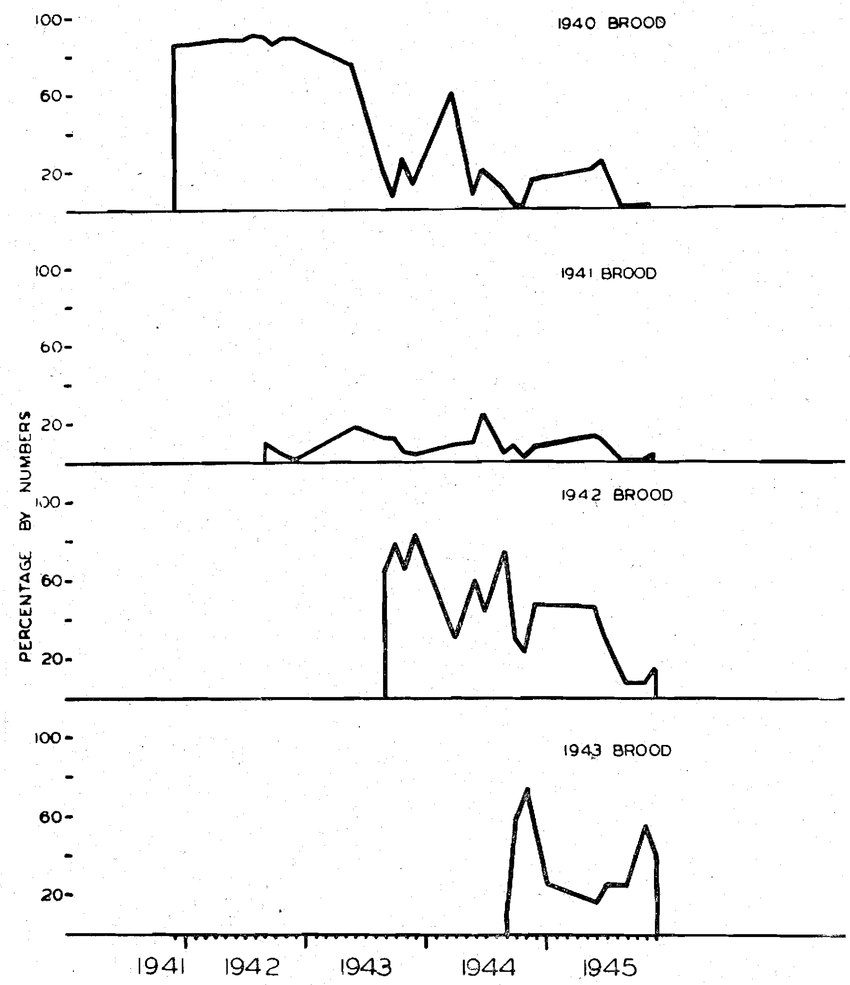

FIGURE 3. Age Composition of Pound Net Catches from Flag Pond and Galesville Areas of Chesapeake Bay, October, 1941 to November, 1945.

in the first four tables listed above, and shows clearly the variation in size of succeeding year classes.

The 1940 brood, which entered the fishery in the fall of 1941 as ten to eleven inch yearlings, survived to dominate the catch during 1942 and 1943, and made up a significant part of the catch during 1944 and 1945. The 1941 year class showed a typical variation in the success of spawning, and remained consistently low from the time it appeared in the fall of 1942, until it had virtually disappeared in 1945. Only once during the four years in which the members of this brood appeared in the samples did they comprise more than 20 per cent of the total catch. The 1942 brood again showed the marked fluctuation characteristic of this species, and although not as large as the 1940 group, made a considerable contribution during the fall of 1943 and the entire year of 1944. A sharp drop, indicating nearly complete utilization of the brood, occurred in 1945. Only a relatively few samples were obtained for the 1943 year class, but they indicated relatively successful spawning, considerably better than the 1941 brood, and nearly on a par with the 1942 year class.

The reason for these fluctuations in abundance, characterized by the occasional appearance of dominant broods, has been the subject of much study by fishery biologists. Merriman (1941) found agreement between the production of such broods, and below-mean temperatures preceding and following the spawning season. Data indicating the deviations from normal in air temperature and precipitation are summarized in Table XI. These figures were obtained from the records of the U. S. Weather Service station at Solomons, Maryland, and from the Maryland-Delaware area reports. Water temperature records in the Solomons area are not of sufficiently long duration to establish a reliable mean, but on the basis of a seven-year average, the trends were as follows:

Year	*April*	*May*	*June*
1940	cool	cool	cool
1941	warm	warm	average
1942	warm	warm	average
1943	cool	average	warm

TABLE VII

AGE COMPOSITION OF SCALE COLLECTIONS FROM POUND NETS IN THE FLAG POND AND GALESVILLE AREAS OF CHESAPEAKE BAY

Date (Month)	1939 Brood No.	1939 Brood %	1940 Brood No.	1940 Brood %	1941 Brood No.	1941 Brood %	R. F., others No.	R. F., others %	Total No. Samples	Area
1941 Collections.										
Nov.	12	10.9	94	85.4			4	3.6	110	Flag Pond
1942 Collections.										
Mar.	5	12.2	36	87.8					41	Flag Pond
June	43	9.7	387	87.3			13	2.9	443	Galesville
June	8	6.9	107	93.1					115	Flag Pond
July	4	4.0	91	91.0			5	5.0	100	Galesville
Aug.			18	90.0	2	10.0			20	Flag Pond
Sept.	3	4.9	52	85.3	3	4.9	3	4.9	61	Flag Pond
Oct.	1	1.3	67	89.1	3	3.9	4	5.2	75	Flag Pond
Nov.	5	4.5	96	87.3	3	2.7	6	5.5	110	Galesville
Nov.	6	6.0	92	92.0	1	1.0	1	1.0	100	Flag Pond

TABLE VIII

AGE COMPOSITION OF SCALE COLLECTIONS FROM POUND NETS IN THE FLAG POND AND GALESVILLE AREAS OF CHESAPEAKE BAY

Date (Month)	1940 Brood No.	1940 Brood %	1941 Brood No.	1941 Brood %	1942 Brood No.	1942 Brood %	R. F., others No.	R. F., others %	Total No. Samples	Area
1943 Collections.										
May	75	75.0	18	18.0			7	7.0	100	Galesville
Aug.	103	20.2	66	12.9	327	64.1	14	2.7.	510	Flag Pond
Sept.	4	3.7	14	13.0	87	80.6	3	2.7	108	Flag Pond
Sept.	7	12.7	6	10.9	42	76.4			55	Galesville
Oct.	59	33.5	8	4.5	105	59.7	4	2.3	176	Flag Pond
Oct.	3	6.0	4	8.0	43	86.0			50	Galesville
Nov.	7	12.7	2	3.6	46	83.6			55	Flag Pond

Salinity variations were also considered, and on the basis of short term records from the Solomons area, the variations in salinity from the mean are as follows:

Year	*April*	*May*	*June*
1940	low	low	average
1941	high	high	high
1942	high	high	average
1943	low	low	low

Water temperatures and salinity values at Solomons appear to be somewhat influenced by weather conditions, but in the shallower areas of the spawning grounds, water conditions might be expected to follow the weather more closely.

The low air temperature obtained from both the Solomons and Maryland-Delaware records corresponds very well with the appearance of the dominant 1940 brood of rock. Sub-normal temperatures are indicated for April and May in both sets of records, and values which were only slightly above normal were obtained for the month of June. The water temperature records from the Solomons area give even a better correlation, and tend to support Merriman's hypothesis mentioned in the preceding paragraph. The very markedly sub-normal production in 1941 further supports this idea. Both air and water temperature records show above normal values for April and May, and almost exactly average values for June. There is, however, some contradiction in the more successful spawning which occurred in 1942 and 1943. Although neither of these two broods was large enough to be considered dominant, both were very considerably larger than the 1941 brood, and both made major contributions to the commercial catches. With the exception of the air and water temperature values obtained for the month of April, 1943, average or above-average temperatures were obtained in all instances.

A factor not considered by Merriman in his investigations is the possible effect of salinity variations on the success of spawning. Abnormally high or low precipitation during the spawning season could unquestionably cause salinity variations in the shallow waters of the spawning grounds. Heavy rainfall, and correspondingly low salinity values are indicated for the months of April and May, 1940, in the Solomon's area, and average values for June. A correlation supporting the possible importance of salinity fluctuations appears in the 1941 data. In April, May, and June, 1941, the salinity values were all above normal. Again, however, the relatively successful spawning in 1942 and 1943, is somewhat contradictory. Both of these seasons were almosts equally productive, yet conditions of salinity were almost exactly opposite.

DISCUSSION

Rate of Growth

Merriman, from analyses of Connecticut collections (1941), found that the members of the dominant year class of striped bass of 1934 were consistently smaller than the fish of the 1933 or 1935 year classes. His observations also indicated that this below-average length was developed before the fish became two years old. These facts would tend to support the idea of competition, an idea which has been advanced by investigators studying the dominant year class phenomenon in other species. Jensen (1932) in the course of studies on the plaice (*Pleuronectes platessa*) of the North Sea found that retarded growth was characteristic of dominant year classes in that species. He advanced the theory of competition for food among fish of the same size group as a possible explanation of the growth effect.

Definite conclusions regarding controlling factors in growth can not be drawn from the data included in this study. Theoretically, on the basis of competition, the 1941 brood should have achieved much greater growth than the 1940 fish, and both the 1942 and 1943 classes should have been in closer coincidence with the 1940 brood. However, it is of some interest to note that although the length calculated from samples taken at Flag Pond in June 1942 had a preponderance of small individuals (though not attaining a significant deviation from normality with $G_1 = 0.17998$ and $G_2 = -0.66726$), the sample from the Galesville area was significantly skewed and kurtotic ($G_1 = 1.05648$; $G_2 = 0.53472$; $P = 1\%$, d. f. $= \infty$). This indicates that the collection from Galesville consisted of a large number of below-average size fish; a situation frequently found where competition results in a stunted population.

Data on the relative abundance in the Chesapeake area of plankton and small forage fish which constitute the food of young rock is unfortunately not available, and until such information is obtained, only

TABLE IX

AGE COMPOSITION OF SCALE COLLECTIONS FROM POUND NETS IN THE FLAG POND AND GALESVILLE AREAS OF CHESAPEAKE BAY

1944 Collections.

Date	1940 Brood		1941 Brood		1942 Brood		1943 Brood		R. F., others		Total No.	
(Month)	No.	%	No.	%	No.	%	No.	%	No.	%	Samples	Area
Mar.	20	60.6	3	9.0	10	30.3					33	Galesville
May	3	7.5	4	10.0	24	60.0			9	22.5	40	Flag Pond
June	5	20.0	2	8.0	12	48.0			6	24.0	25	Galesville
June	13	23.6	18	32.1	23	40.7			2	3.4	56	Flag Pond
Aug.	6	10.2	3	5.1	44	74.6	6	10.2			59	Flag Pond
Sept.	1	2.8	3	8.3	11	30.5	21	58.3			36	Flag Pond
Oct.			1	2.9	8	22.9	26	74.6			35	Flag Pond
Nov.	25	15.1	13	7.9	79	47.9	44	26.7	4	2.4	165	Flag Pond

TABLE X

AGE COMPOSITION OF SCALE COLLECTIONS FROM POUND NETS IN THE FLAG POND AND GALESVILLE AREAS OF CHESAPEAKE BAY

1945 Collections.

Date	1940 Brood		1941 Brood		1942 Brood		1943 Brood		1944 Brood		R. F., Others		Total No.	
(Month	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Samples	Area
May	15	20.5	10	13.7	34	46.6	12	16.4			2	2.7	73	Flag Pond
June	5	25.0	2	10.0	6	30.0	5	25.0			2	10.0	20	Flag Pond
Aug.					1	8.3	3	25.0	8	66.7			12	Flag Pond
Oct.	1	.8			10	8.0	66	55.9	36	30.5	5	4.2	118	Flag Pond
Nov.	1	.7	5	3.2	24	15.4	61	39.1	58	37.2	7	4.5	156	Flag Pond

TABLE XI

	MEAN AIR TEMPERATURE AND DEPARTURE FROM NORMAL						MONTHLY PRECIPITATION AND DEPARTURE FROM NORMAL					
	April		May		June		April		May		June	
Year	Mean	Dep.	Mean	Dep.	Mean	Dep.	In.	Dep.	In.	Dep.	In.	Dep.
Normal Solomons	54.1	—	64.9	—	73.4	—	2.98	—	2.86	—	3.12	—
1940	50.6	3.5	64.0	0.9	74.6	1.2	5.92	2.94	3.15	0.29	1.13	— 1.99
1941	57.4	3.3	67.7	2.8	73.4	0.	4.26	1.28	1.61	1.25	3.66	+ 0.54
1942	58.0	3.9	69.0	4.1	75.4	2.0	0.58	2.40	2.35	0.51	4.13	+ 1.01
1943	52.2	1.9	68.2	3.3	79.5	6.1	3.14	0.16	4.92	2.06	3.13	+ 0.11
1944	54.4	0.3	70.7	5.8	75.6	2.2	4.80	1.82	0.47	2.39	2.71	0.41
Normal Md.-Del.												
1940	48.1	4.0	62.0	0.7	71.8	1.1	5.89	2.31	4.60	1.10	2.16	1.82
1941	56.8	4.6	64.3	1.6	70.5	0.2	2.97	0.59	2.26	1.22	4.92	0.92
1942	55.7	3.4	66.3	3.5	72.2	1.4	1.10	2.41	3.88	0.39	4.01	0.01
1943	48.6	3.6	64.6	1.8	76.6	5.7	3.23	0.28	4.67	1.15	2.75	1.22
1944	51.0	1.2	68.4	5.5	72.5	1.6	4.18	0.66	2.31	1.18	3.06	0.89

Solomons Normals are for 47-year period, 1892-1936.

Maryland-Delaware Normals are calculated for period up to year given and so vary slightly from year to year.
Dep. — departure from normal In. — inches

hypothetical conclusions can be drawn in regard to the importance of food competition as a controlling factor in growth rate.

Evidence of Chesapeake Origin of Atlantic Stocks of Striped Bass

Several facts indicate rather conclusively a northward migration of rock from the Chesapeake Bay: :

(1) A coincidence of dominant year classes between the northern waters and Chesapeake Bay.

(2) An absence in northern waters of sufficient juvenile and yearling fish to account for the volume of the catches.

(3) The appearance of two-year-old bass in northern catches in the spring following their appearance as yearlings in the Chesapeake during the fall.

A tagging experiment giving conclusive returns from outside the Bay would be the only method by which this hypothesis could be proved.

Merriman's study included a comparison of the width of the growth zones of scales of striped bass taken in three northern areas, and in the northern and southern regions of Chesapeake Bay. All had markedly similar first growth zones, but since his samples included fish having three and four growth zones on the scales, there was a possibility that the Chesapeake collections might have been composed of migrants from the outsisde. It has already been indicated that migrant rock apparently leave the Bay when two-year-olds, and a collection of four-year-old fish might well contain individuals entering from other areas, as well as returning Chesapeake populations.

Occurrence of Dominant Year Classes

The wide variations in abundance of striped bass in succeeding seasons is not restricted to the populations of the Chesapeake Bay. Merriman (1941) and Scofield (1931) working with the striped bass of the Atlantic and Pacific coasts, respectively, found marked variations characteristic of the year classes which they investigated.

Dominant year classes apparently occur with little relation to the parental stock. The 1934 brood was the largest to be produced on the Atlantic coast during th eepriod for which catch records are available, although in that year the brood reserve was unusually low. The 1940 brood, under discussion in this study, although not as large as the 1934 class, was certainly a dominant one, and also arose from a small parental stock.

The data presented in the preceding section do not wholly support the hypothesis of Merriman, which showed a possible relationship between low temperatures and the production of dominant broods. The fact that such broods were produced in only 5 of 18 years in which sub-normal temperatures occurred, indicates that the role of low temperature is a questionable one. It is true that the dominant brood of 1940 was produced during a season of below-mean temperatures, but the very insignificant 1941 year class had exactly opposite conditions. The more successful broods produced in 1942 and 1943, under similar conditions to those which obtained for the 1941 group, tend to contradict Merriman's hypothesis. A correlation between low salinity and the production of the 1940 year class seemed to be indicated, and consistently high salinity values were observed for the 1941 spawning season. Again, however, the more productive spawning of 1942 and 1943 were contradictory. There might well be other environmental factors that play an important part in the production of dominant year classes.

No definite conclusions can be drawn from the available data regarding the importance of these two factors in question, although there is strong evidence of correlation. The probable solution may be found in a complex of these and other factors. Temperature and rainfall, with the accompanying variations in salinity, turbidity and current, influence the planktonic populations which provide foor for the juvenile fish. The problem may therefore be not only one of spawning and hatching of larval bass, but also one of competition and survival among juveniles.

Evaluation of the Scale Method as Applied to the Maryland Striped Bass Fishery

A number of factors must be taken into consideration in evaluating the application of scale analyses to the striped bass fishery of Maryland. The problem of gear selectivity has already been dealt with, and it has been shown that an accurate picture of the population can best be approached from pound net samples. Only this type of gear combines regularity of operation, fixed location, long fishing season and minimum size selectivity. Samples from other types of gear are irregular in interval and locality of operation, and all exert size selectivity to a greater or lesser degree. The variation in size between male and female striped bass might also cause a sex selectivity to result from sampling with these types of gear. Samples from other gears than pound nets afford valuable supplementary data, but cannot be regarded as representative in the composition of their catches.

In addition to this easily recognized gear selectivity there is indication of a seasonal selectivity which must be considered. During August and September, 1943, 560 samples were taken from the same nets, the collections in every case being made entirely at random. A marked decrease was observed in the percentage of 1940 fish. This brood, which during the preceding spring had comprised approximately 75% of the catch by numbers, dropped in one case to as little as 3% of the catch, averaging only about 19% of the catch for the period. In March, 1944, the percentage of 1940 fish rose again to 60%, then dropped during the summer months, and rose again during the following winter and spring. Each successive peak was lower than the preceding one, indicating a gradual utilization of the brood. The seasonal decreases during the summer months did not occur until the third year of life, when the fish had reached an average weight of approximately two pounds. It is common knowledge that striped bass simply do not trap as readily during the summer months as in the colder months of fall and winter. Commercial fishermen firmly maintain that "big rock won't trap," and as a seasonal phenomenon this is unquestionably true. The larger fish are undeniably later in making their appearance in the fall pound net catches.

Haul seines and hand lines took a somewhat greater percentage of the larger fish (1940 brood) than did the pound nets during the summer and fall months of 1943. A satisfactory explanation for this tendency is not available. If water temperature were considered the controlling factor, on the hypothesis that the fish sought deeper, cooler water during the summer, the haul seine and hand-line catches made inshore of pound nets, in even shallower water, would be contradictory. If food were advanced as an explanation, the catches of these two types of gear would again be difficult to explain.

The value of scale analyses in following the trends of fishing intensity in the striped bass fishery of Maryland can readily be seen. The State's rock fishery is prosecuted in what may well be termed a nursery area. Adult fish enter the rivers of Maryland to spawn, and the young remain in those rivers and in the waters of the Chesapeake

Bay for at least two years before even a portion of them begin seaward migrations. The fishery is therefore supported to a considerable extent by small fish. In some years, as indicated by the age-composition tables included in the preceding section, nearly all of the catch is composed of yearling rock, about eleven inches in length, and weighing approximately one-half pound. Those surviving the first year in the fishery reach the "medium" market classification the following year, and during the third or fourth year become "large" rock. Male fish may spawn at two year of age, but females are typically four or five years old when they first spawn. The value of scale analyses in determining the brood stock of a population, and the rate of utilization of successive year classes is obvious. Data of this type, supplemented by accurate statistical records of the catch, yields valuable information for the proper administration of conservation measures.

Possible inaccuracies characteristic of the scale method have already been indicated, in the discussion of the existence of sub-populations of striped bass in Maryland waters. The scales certainly do not provide an accurate index to origin of striped bass, although correlations of calculated length values indicate that a refinement of this method may offer possibilities. After five year of age, the scales become difficult to read. The first annulus is often hard to distinguish, and false annuli are more frequently found than in the scales of younger fish. Regenerated scales are much more numerous on older fish than on younger ones, and decrease the usable number of samples in the collections. Only rarely, however, does a brood survive the high fishing intensity in Maryland for more than four years, and significant numbers of larger fish are seldom found in commercial catches. As a means of studying the normal course of the Maryland striped bass fishery, the scale technique is unquestionably useful and valuable.

CONCLUSIONS

(1) Pound nets are the only type of gear employed in the Maryland fishery which combine regularity of operation, fixed location, long season, and minimum size selectivity, and therefore provide the most reliable source for obtaining representative samples of the striped bass population.

(2) Scales from extreme body areas, either high or low on the body, yield distorted values of calculated length. Scales from the middle region, on the second and third row above the lateral line at a

point between the spinous and soft dorsal fins, give calculated values which closely approximate the averaged values of the extreme areas. The variation is a function of scale size, smaller scales yielding lower values, and larger scales higher values for calculated length.

(3) The rate of growth, indicated by length frequencies of the age classes investigated, is variable. There is a close agreement in the size of the fish at the time of their entry into the fishery, and a degree of agreement is apparent among the rates of growth of successive year classes. Variations which occurred were independent of the size of the year class, since dominant and subnormal broods showed closely parallel rates of growth.

(4) Marked fluctuations in the size of year classes is characteristic of the striped bass, and occasionally dominant broods arise with no apparent relation to the extent of parental stock. There is a possible correlation between the production of dominant year classes and below-mean temperatures preceding and following the spawning season. A correlation between the production of the dominant brood of 1940 and low salinity during the spawning season is also apparent, but contradictory data in both cases renders these correlations questionable.

(5) Seasonal selectivity of age classes occurs in the pound net fishery. During the summer months the percentage of large striped bass taken in pound nets is not as high as in haul seine and hand-line catches. The fact that the catches of these latter types of gear are often made in pound net areas eliminates water temperature and food habits as possible causes for the selectivity.

(6) Thickening of the scales with increasing age tends to obscure the first annulus, and make age determination more difficult, but up to the fifth year the technique is accurate and reliable. The number of regenerated scales increases with age, but neither of these factors is of great consequence in the Maryland fishery since individual year classes, in significant numbers, rarely survive the high fishing intensity for more than four years.

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