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Preliminary Observations On Spawning Potential in the Striped Bass

(*Roccus saxatilis* Walbaum)

H. W. JACKSON
and
R. E. TILLER

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PRELIMINARY OBSERVATIONS ON SPAWNING POTENTIAL IN THE STRIPED BASS

(*Roccus saxatilis* Walbaum)

H. W. JACKSON[1] *and* R. E. TILLER

INTRODUCTION

The life history, migration and fluctuations in abundance of the striped bass have been rather extensively studied. However, little has been done on the analysis of the ovaries, or on the interpretation of their condition in terms of season, location, or proximity of spawning.

This study was initiated during the summer of 1940 with the following objectives:

(1) To determine at what age sexual maturity begins in striped bass of the Chesapeake Bay.
(2) To determine whether the potential of reproduction declines with increasing age in Chesapeake Bay fish.
(3) To determine whether striped bass in northern waters have a spawning cycle similar to that found in the Chesapeake Bay fish.

REVIEW OF PAST WORK

The earliest work pertaining to spawning of striped bass was done in hatcheries operated by the U. S. Bureau of Fisheries. Worth (1882) reported 90% fertilization of eggs from a fifty-seven pound female stripped by hand. In a later report (1904), he presented egg counts for fish ranging in weight from 3-70 pounds. The smallest yield was 14,000 eggs from a three pound fish, and the largest 3,220,000 from a fish that weighed fifty pounds. No mention was made of the percentage of hatchability of eggs from fish of different sizes, but he did mention achieving a 69% hatch from slightly over 10,000,000 mixed eggs. Pearson (1938) mentioned a thirteen pound striped bass taken in 1932 at Havre de Grace, Maryland from which an egg count of 1,337,000 was obtained. He also quotes from the U. S. Bureau of Fisheries Manual of Fish Culture (1900) an observation in 1897 of a twelve pound striped bass taken in the Susquehanna River which yielded 1,280,000 eggs.

Scofield (1931) presented a detailed analysis of egg production of striped bass from California waters. He examined 1,015 ovaries, and found two types of eggs present, distinguishable on a basis of size. A small percentage of females was found to spawn first in their fourth year and all matured by their sixth year. This work indicated that only one spawning occurs in any one season, and that the number of eggs increased with the size and age of the fish. No data were included pertaining to the question of whether each female spawns annually after reaching maturity.

[1] Biologist, U. S. Public Health Service; former Associate Professor of Biology, Virginia Polytechnic Institute, where most of this study was carried on.

Merriman (1941) collected 109 sets of ovaries from striped bass of the Atlantic Coast. These fish ranged in size from 14-43 inches, and weighed from 1-30 pounds. He found mature eggs only in fish of four years or older ranging four pounds and upward in weight. His work was concerned primarily with age at first maturity, and no reference was made to the comparative fecundity of large and small fish. He did observe two types of eggs in the ovaries, distinguishable on a basis of size, as Scofield found in the earlier work. Merriman also noted the presence of large fish in spring and early summer in the Niantic River, Connecticut, in which the ovaries were not "ripe," thus indicating that this species may not be an annual spawner, at least in that area.

MATERIAL AND METHODS

This project was begun at the Chesapeake Biological Laboratory at Solomons, Maryland. The staff of this agency had the cooperation of the U. S. Fish and Wildlife Service in the collection of specimens. Analyses were done by personnel of the Virginia Polytechnic Institute at Blacksburg, Virginia.

One hundred and eleven ovaries from Chesapeake Bay and northern coastal waters were examined, but complete collection data and suitable developmental stages were not obtainable for all specimens. This study, then, is based on analysis of fifty-eight ovaries from striped bass caught in Chesapeake Bay, and two ovaries from fish taken off the coast of New York. Table I presents all available data for these specimens. The locality, date, length and weight were recorded when the ovaries were collected, and in most cases scale samples were taken for age determination. When scales were not available, or were unsuitable for microscopic examination, ages were estimated from length and weight, using tables given by Merriman (1941) and Scofield (1931), and from data for specimens used in this study.

A small sample taken from the center of the ovary was weighed in a moist chamber, and the number of eggs it contained was counted. This figure was converted into eggs per gram; and when multiplied by the weight of the entire ovary, gave an estimate of the total number of eggs in the ovary.

Two hundred or more eggs from the sample were then measured to the nearest ten microns by means of an ocular micrometer. Only one sample was taken, since Merriman (1941), and Scofield (1931) and de Armon (1948) showed the composition of the egg population to be identical in all parts of the ovary. When large eggs were present, it was necessary to measure at least 400 eggs to determine accurately the percentage composition of the egg population.

RESULTS AND DISCUSSION

The two types of eggs identified on the basis of size by Scofield (1931) and Merriman (1941) will be designated in this report as "small" and "large" eggs. The former are obviously immature, as all of them are small and include little or no yolk material. The latter are the eggs which would have been

TABLE I

DETAILED DATA FOR 49 BREEDING FISH FROM CHESAPEAKE BAY

			Whole Fish			Large Eggs Dimensions (mm.)			Small Eggs			
Lab. No.	Date Collected	Place Collected	Age In Years	Length (cm.)	Weight In Lbs.	% Of Total	Maximum Diameter	Mean Diameter	Minimum Diameter	Max. Diam. (mm.)	Total Ovary Wt. (Gms.)	Total Eggs Per Gram
6	10-39	Cedar Pt., Md.	4	56.0		4.00	.355	.300			19.0	22,728
7	5-40	Cedar Pt., Md.	4	54.5		9.50	.925	.830			144.8	3,421
8	5-40	Solomons, Md.	8	82.5	15.5	8.30	.996	.996			1020.0	19,650
12	11-36	Broad Crk., Md.	4	48.5		1.01	.426	.320			9.2	4,422
13	8-38	Solomons, Md.	4	53.5		2.60	.227	.200			10.7	22,100
14	3-38	Popes Crk., Md.	4	51.0		2.00	.782	.500			17.2	6,036
16	4-37	Flag Pond	4	47.5		2.50	.489	.456			10.4	10,745
21	5-36	Havre-de Grace	6	65.0		6.78	1.090	.996			469.6	18,306
22	4-38	Potomac River	6	73.6		6.08	1.190	1.057			522.0	18,726
23	3-38	Choptank River	4	49.5		3.90	.697	.658			101.8	22,074
52	5-41	Solomons, Md.	4	52.5	4.4	5.00	.564	.460	.369		23.4	20,000
53	3-38	Secretary, Md.	4	49.0		13.50	.998	.677	.347		44.0	12,900
56	5-41	Galesville, Md.	5		8.0	17.25	1.194	.947	.651		176.3	10,000
60	5-41	Cedar Pt.	9	85.5	21.0	15.00	1.302	1.158	1.020		1601.5	9,327
61	6-41	Cedar Pt.	8	87.0	18.5	15.00	1.302	1.108	.890		1182.7	11,850
62	4-41	Galesville, Md.	8		15.0	25.00	1.194	.922	.716		826.7	6,250
63	5-41	N. E. Pt.	13		32.0	9.90	1.324	1.160	1.042		2750.0	14,730
73	Spr. 45-46	Chesapeake Bay	8	85.6	15.0	12.70	1.200	1.000	.900	.190	1007.0	17,285
74	"	"	8	82.0	15.0	30.40	1.200	1.050	.900	.300	768.0	4,256
75	"	"	9	85.1	17.0	25.60	1.100	1.000	.900	.200	869.0	6,144
76	"	"	7	77.5	14.5	19.10	1.100	1.000	.850	.300	804.0	8,690
77	"	"	8	82.5	17.5	2.50	1.130	.980	.850	.190	1115.0	6,250
78	"	"	7	72.5	11.0	32.70	1.120	1.000	.950	.330	647.0	3,106
79	"	"	14	110.5	35.0	14.30	1.100	1.000	.900	.220	2605.0	12,179
80	"	"	5	63.5	8.0	17.50	1.100	.950	.800	.200	375.0	9,625
81	"	"	7	79.0	15.0	28.00	1.100	1.000	.900	.250	1649.0	5,040
82	"	"	8	87.7	17.0	25.20	1.300	1.100	.900	.170	1120.0	6,121
83	"	"	8	86.4	16.0	8.90	1.200	1.000	.900	.300	982.0	14,277
85	"	"	8	84.5	17.5	21.40	1.150	1.000	.900	.350	739.0	11,786

86	"	"	10	92.8	22.0	19.80	1.100	.950	.800	.180	945.0	13,162
87	"	"	7	83.0	19.5	15.10	1.100	.920	.750	.150	2127.0	7,587
88	"	"	10	91.5	21.0	11.10	1.100	1.000	.900	.210	1693.0	13,613
89	"	"	7	72.5	12.0	11.10	1.200	1.050	.900	.300	682.0	12,322
90	"	"	6	73.5		24.20	1.000	.860	.700	.200	637.0	7,468
91	"	"	8	81.5	17.3	14.30	1.150	1.070	.990	.260	1117.0	10,564
93	"	"	8	85.5	15.5	15.80	1.150	1.020	.900	.230	1284.0	12,875
94	"	"	7	81.3	16.0	18.00	1.220	1.900	.990	.330	721.0	9,594
98	"	"	12	98.0	29.3	21.70	1.100	1.000	.900	.300	1875.0	7,228
99	"	"	6	71.2	13.0	13.70	1.300	1.150	1.000	.300	987.0	10,034
100	"	"	6	77.0	14.0	6.40	1.100	1.000	.900	.310	577.0	30,433
103	"	"	9	89.0	20.0	6.20	1.240	1.240	1.100	.990	1063.0	18,500
104	"	"	6	69.5	12.0	14.50	1.230	1.230	1.070	.910	531.0	8,543
105	"	"	11	94.0	23.0	9.80	1.160	1.160	1.080	.990	1479.0	12,971
106	"	"	8	74.5	13.5	20.60	1.070	1.070	.950	.830	946.0	7,416
107	"	"	7	79.0	15.0	20.80	1.150	1.150	.990	.830	1092.0	2,442
108	"	"	8	77.0	13.5	12.30	1.150	1.150	1.000	.850	705.0	14,022
109	"	"	7	73.0	12.0	13.00	1.250	1.250	1.070	.900	735.0	13,650
110	"	"	4	53.0		20.30	1.200	1.200	1.000	.950	255.0	7,900
111	"	"	6	69.0		28.00	1.100	1.100	.950	.800	435.0	4,354

DETAILED DATA FOR SUPPLEMENTAL SPECIMENS

1	3-38	Secretary	5	56.0	.....	48.00	.864	.735	.....	.....	60.0*	3,852
19	4-37	James River	3	35.0	.....	.005	.412	.401	.390	.....	1.15	.....
32	5-38	Secretary	10	95.0	.....	1.50	.967	.512	.....	.....	4.9	90,000
35	5-38	Cooke's Pt., Md.	10	.	.....	2.50	.768	.515	.....	.....	15.4	21,875
36	5-38	Secretary	12	101.0	.....	5.50	.782	.600	.....	.....	54.7	19,250
37	5-38	Secretary	12	102.0	.....	7.25	.583	.360	.....	.....	21.8	18,125
44	11-40	Montauk Pt., N. Y.	5	57.4	.....	.005	.412	.401	.390	.....	26.9	1,728,649
46	10-40	Montauk Pt.	....	....	.....	11.000	.499	.400	.282	.....	87.4	50,000
54	5-41	Flag Pond	13	108.5	29.3	2.500	.998	.862	.651	.....	211.7	225,800
55	5-41	Flag Pond	14	109.0	35.0	0.250	.803	.803	.803	.....	279.5	.....
57	4-40	Annapolis, Md.	5	61.5	10.0	91.00	1.215	.994	.651	.....	246.0*	.....

* One ovary only.

released at the next spawning, and have begun to enlarge and accumulate yolk material.

Small Ova

The small eggs average .07 mm. in diameter, and range from .01 to .23, a somewhat wider range than that found by Merriman (1941). They comprised from 70% to 100% of all eggs in the ovary, and averaged about 85% in the specimens examined in this study. The composition of this small egg population is surprisingly constant, being almost identical qualitatively regardless of whether there are any large ova present in the ovary or not. (See Figure 1

TABLE II

EGG DISTRIBUTION DATA

No. 62 — A fish with a typical large egg population.		No. 46 — A fish with large egg population just beginning to differentiate, but none of which are "mature."		No. 19 — An immature fish (3 yrs. old) no indication of large eggs.	
Diameter of eggs in mm.	Frequency/ 1000	Diameter of eggs in mm.	Frequency/ 1000	Diameter of eggs in mm.	Frequency/ 1000
.02	13.2	.02	11.7	.01	25.0
.04	40.3	.04	42.5	.02	90.
.06	86.0	.06	92.5	.04	173.
.08	122.	.08	149.9	.06	218.
.1	140.	.1	172.4	.08	213.
.13	130.0	.13	162.4	.1	149.
.15	96.5	.15	114.1	.13	90.
.17	59.0	.17	74.1	.15	30.
.19	30.5	.19	40.8	.17	12.
.2	15.0	.21	20.8	.19	
.24	6.5	.24	7.5	.21	
.26	1.5	.26	.8	.24	
.28	2.5	.28	1.7	.26	
.3	1.0	.3	5.8	.28	
.71	2.0	.33	8.3	.3	
.85	7.5	.35	10.8		
.87	8.2	.37	11.7		
.89	15.8	.39	14.2		
.91	20.	.41	16.7		
.93	20.8	.43	15.8		
.95	38.0	.45	10.0		
.97	22.5	.47	7.5		
.99	30.0	.49	3.3		
1.01	17.3	.52	3.3		
1.04	16.3				
1.06	22.5				
1.08	16.3				
1.1	14.0				
1.12	1.				

and Table II.) It would be virtually impossible to distinguish between the total egg population of a three year old fish, and the "small egg population" of a ten year old fish (actually composing perhaps only 85% of all eggs present) on the basis of average size, size range, or appearance of eggs. These eggs constitute the reservoir from which the large eggs are annually drawn, and their numbers are kept up or increased from year to year. The number of these small ova per gram ranged from 587,000 with an average diameter of .084 mm. to 2,800,000 with an average diameter of .050 mm.

Disturbances were observed in this reservoir population in only two instances. Ovaries 1 and 57 (Table I) by repeated counts contained 48% and 91% large eggs, respectively, with correspondingly low ratios of small eggs.

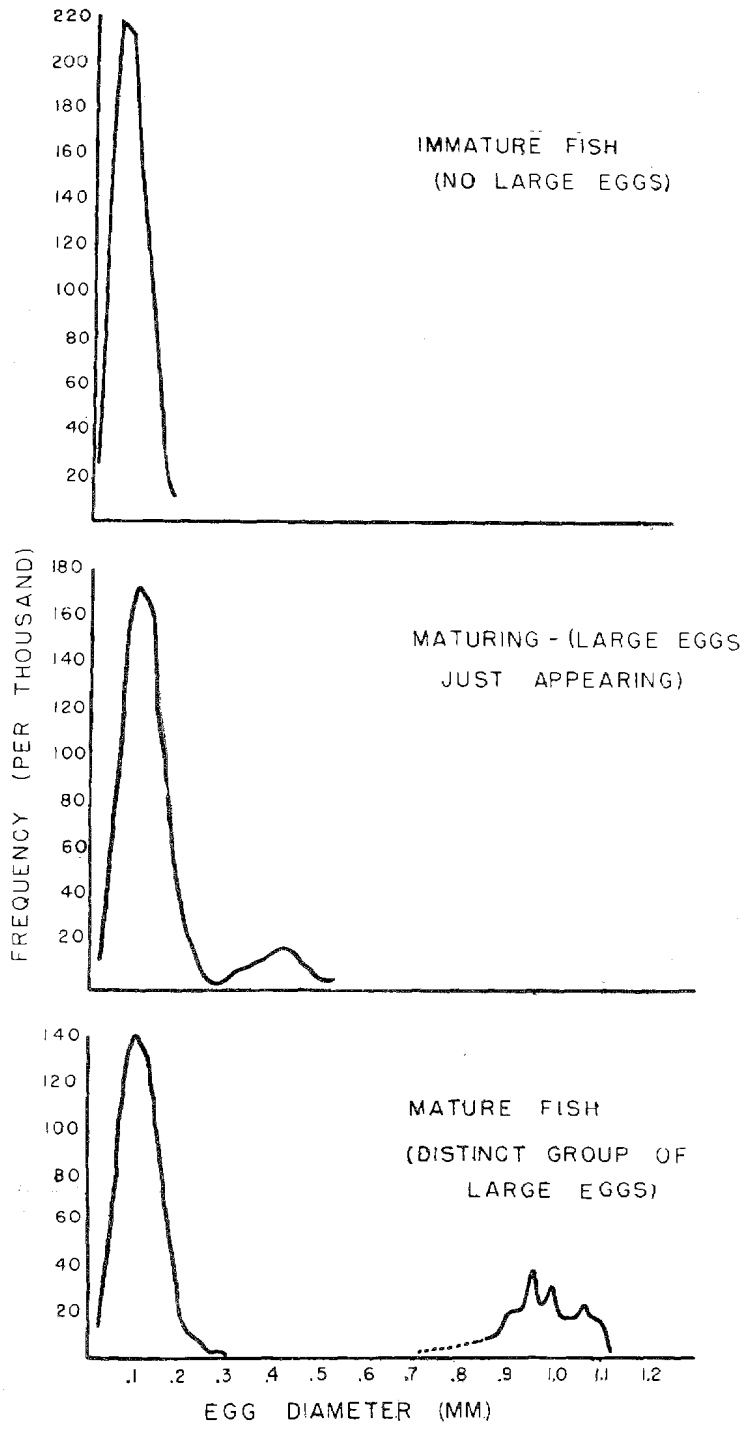

Figure 1.—Egg composition of ovaries of immature, maturing and mature striped bass.

Data are too scanty to warrant more than a note of this irregularity; no explanation is attempted.

Large Ova

The large ova first become evident during the summer of the third or fourth year with the appearance of yolk material in some of the "small" ova. Some ova grow as large as .240 mm. before acquiring yolk material, but the average is .180 mm. to .190 mm. These large ova simply accumulate yolk material and enlarge, becoming differentiated from the numerically larger population of immature eggs surrounding them. The connections with the fibrous arborescent structures to which the immature ova are attached gradually loosen as the yolk material accumulates. By the time spawning occurs, the large ova are easily detached, and can be discharged readily from the ovary. With the two exceptions cited above (Nos. 1 and 57), this sub-population of large ova averaged approximately 15% and ranged up to 28% of the entire egg population. The number of large ova per gram of ovary material is a function of their actual size and the percentage of the total egg population which they comprise. The average was 1489 large ova per gram, and the number ranged up to approximately 2600 per gram.

Growth of the large eggs appeared slow in its early phases, but became more rapid as spawning approached. Table III and Figure 2 present the limited data available from this study. Scofield (1931) presents excellent monthly data for egg development which follows a similar pattern. After the appearance of the first maturing eggs in the ovary, no specimens were observed without a distinct sub-population of large eggs. In older specimens collected in the spring, two populations of large eggs can frequently be identified—one about to be spawned; the second, just beginning to enlarge in preparation for the following year.

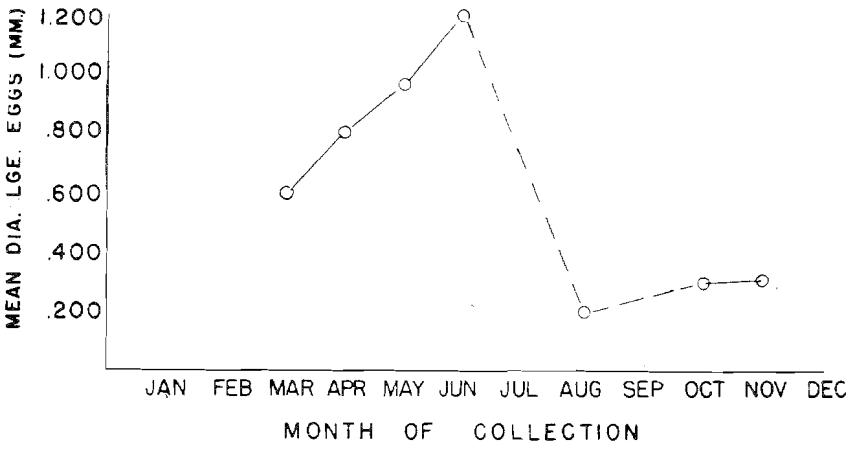

Figure 2.—Growth of eggs of striped bass.

TABLE III

GROWTH RATE OF "LARGE EGGS," BASED ON 49 MATURE FISH FROM CHESAPEAKE BAY

	Mar.	Apr.	May	June	Aug.	Oct.	Nov.
Mean Diam. (mm.)	.608	.812	.975	1.108	.200	.300	.320
No. Specimens	3	3	39	1	1	1	1

No data available for months not listed.

The diameter of eggs at spawning is said to range from 1.1 to 1.3 mm. (Scofield, 1931; Merriman, 1941). In this study eggs from ovaries about to be spawned were observed as large as 1.160 mm., but many obviously ripe ovaries taken in the spring contained ova averaging no more than .800-.900 mm., and eggs from two recently spawned ovaries were observed to have mean diameters of .826 mm. and .803 mm. It appears, therefore, that fish with large ova averaging .750 mm. or more during the early spring could reasonably be expected to spawn that year.

Two ovaries (Nos. 54 and 55) were found in the Chesapeake Bay collection which were flabby and apparently spent. The fish from which these were taken were 13 and 14 years old, and the ovaries contained 2.5% and .25% large ova, respectively, in contrast to the usual 10% to 20%. The numbers of large ova per gram were 1250 and 564, in contrast to the normal average of 1500. Maximum diameters were .998 and .803 mm., and the mean diameters were .826 and .803 mm. There apparently had been no appreciable resorption. Since ova measuring 1 mm. or over are frequently observed, it is concluded that there is variation within the limits of a few microns in the diameter of the eggs prior to spawning.

These specimens make an interesting comparison with a specimen (No. 44) taken off Montauk Point, N. Y., in November of 1940. Although this was only a five year old fish, the ovary was firm and well-shaped, but contained only 80-90 shriveled and misshapen "large" ova per gram. These ova had a maximum diameter of .412 mm. and a mean diameter of .401 mm. Apparently they had not been extruded in spawning, and were in the process of resorption.

Age At First Spawning

Fish possessing ovaries with no large ova after January 1st could not spawn for at least another 15 months, as the ova which are to be spawned one year begin enlarging the previous summer or fall (Scofield, 1931), and spawning is not apt to begin earlier than March. This immature condition is seldom found in the ovaries of fish over four years of age. There were twenty-two ovaries found in this condition, twenty from the Chesapeake and two from regions north of the Chesapeake. Of the Chesapeake collection, only one could have been as much as five years of age, and of the two northern ovaries, one might possibly have come from a fish five years of age since its weight was seven pounds.

With these exceptions, no ovaries of fish over four years of age were found to be immature, while twelve specimens estimated to be four years of age were found to be mature. It should be pointed out that maturity in this case simply refers to the presence of a population of large ova, and does not imply ripeness or the immediate proximity of spawning. Although the number of specimens is not large, these data are consistent with observations of Merriman (1941) and others report that most striped bass have spawned at the end of their fifth year.

Once spawning had become established, that is, after about five years of age, no evidence of interruption was observed in any fish less than ten years of age. Two ten-year old (Nos. 32 and 35) and two twelve-year old (Nos. 36 and 37) were examined, however, in which spawning would either have not occurred, or else would have been greatly reduced. These fish, collected during spring months, comprised one-third of all specimens over ten years of age from Chesapeake Bay. All had relatively small percentages of large eggs and small ovary weights. Normal mature fish approximated 15% large ova, but these fish averaged only 4.2%. The average weight of ovary material from other fish of this age group was nearly 1900 grams, but these specimens averaged only 26.2 grams. If all available eggs of these fish had been spawned, the average production per fish would have been approximately 28,000, whereas the normally spawning fish in this age group yielded an average of slightly over 3,000,000 eggs. A single sixteen year-old fish was collected in New Jersey during November in which the ratio of large to small eggs was normal (16%), although the ovaries were small (508 grams). The diameter of the large eggs was .555 mm. This fish appeared to be an exact parallel of the Chesapeake fish discussed above.

It is of interest to note that none of the four ovaries of these older fish which gave indication of curtailed spawning was actually degenerate in internal structure. Under microscopic examination they appeared normal, the ova appeared normal and the ratios of the various sizes were normal. They probably would have spawned a reduced number of eggs, but even so, more than a five or six year-old just beginning to spawn. There is no evidence as to whether or not they might have recovered a reproductive capacity consistent with their age class, but since there were no intermediates found between this group and the normally productive group, the presumption might be made that these were aberrant.

Evidence at hand indicates that striped bass in the Chesapeake require from four to five years to become established spawners. There follows a period of approximately five years during which spawning may be an annual occurrence. After that, degeneration or dimunition may occur in a percentage of the individuals. The greater number, however, continue to spawn normally and produce more and more eggs per fish per year (4,500,000 maximum observed) at least up to fourteen years of age. Although he presented no data for length, weight or age, Merriman (1941) found "large fish that showed no signs of

even approaching ripeness" during spring and early summer months in the Niantic River, Connecticut, which suggested that "this species is not necessarily an annual spawner."

Reproductive Potential

The total number of all ova per fish is a function of the number of eggs per gram and the total weight of the ovaries. Wide variations were observed in this study, ranging from 36,800 in young specimens to over 40,000,000 in some of the older fish. Averages of data compiled from observations on forty-nine fish from Chesapeake Bay are presented in Table IV. The ovaries are seen to increase in size with increased age, and the annual increments of large eggs follow the same upward trend through the fourteenth year.

TABLE IV

AVERAGES OF DATA FROM 49 BREEDING FISH FROM CHESAPEAKE BAY

Age	No. of Specimens	Total Eggs Per Gram	% Large Eggs	Large Eggs Per Gram	Total Wt. of Ovaries	Total All Eggs	Total Large Eggs	Fish Length (cm)	Fish Wt. (lbs.)
4	10	13233.0	9.86	475.0	58.5	733,601	68,239	51.2	4.4
5	2	9812.5	17.38	1704.7	276.0	2,528,681	467,884	63.5	8.0
6	7	13980.0	14.24	1421.7	594.0	8,304,120	856,267	71.26	13.0
7	8	7803.9	19.7	1326.3	1057.0	8,238,828	1,349,918	77.2	14.4
8	13	10969.3	18.1	1529.6	988.0	10,837,372	1,682,292	83.0	15.9
9	3	11324.0	15.6	1373.0	1177.0	13,328,548	1,607,723	86.5	19.3
10	2	13387.0	15.5	2058.4	1319.0	17,657,353	2,510,349	92.1	21.5
11	1	12911.0	9.8	1226.3	1479.0	19,095,369	1,813,698	94.0	23.0
12	1	7228.0	21.7	1568.5	1875.0	13,552,500	2,940,938	98.0	29.0
13	1	14730.0	9.9	1458.3	2750.0	40,507,500	4,010,325	.....	32.0
14	1	12179.0	14.3	1741.6	2605.0	31,726,295	4,536,868	110.5	35.0

High correlations were found between length, weight and age and the production of large eggs ($r=.9640$, .9298, .9598 respectively). Figure 3 presents the trend of large egg production with respect to increased weight. Little is known regarding the maximum size and age of striped bass. The largest specimen available for this study was thirty-five pounds. Merriman (1941) mentions a sixty-five pound fish caught in Rhode Island which was found to be 29, 30 or 31 years old. Bigelow and Welsh (1925) state that striped bass are "long-lived, for one kept in the New York Aquarium lived to an age of about 23 years."

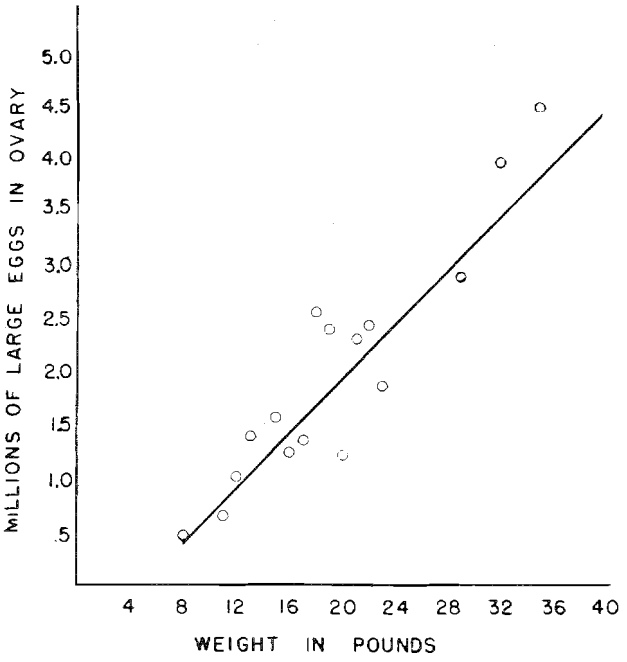

Figure 3.—"Large egg" Production vs. Weight in striped bass.

CONCLUSIONS

1. Striped bass first spawn in Chesapeake Bay during their fourth or fifth year, at a length ranging from 45 to 55 cm., at which time they weigh from four to six pounds.
2. Once established, spawning was observed in all year classes up to the fourteenth year.
3. An indication of curtailed spawning was observed in one-third of all specimens over 10 years of age from the Chesapeake Bay.
4. The production of large eggs increases with age and size, ranging from approximately 65,000 in a four year old to 4,500,000 in a thirteen or fourteen year old.
5. High correlations exist between age, length, weight and the number of large eggs produced.
6. Microscopic examination showed no difference between large eggs of young and old fish. There is, however, no basis for speculation on comparative viability.

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