ABUNDANCE, AGE, AND FECUNDITY OF SHAD, YORK RIVER, VA., 1953–59

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ABSTRACT

A study of the American shad fishery of the York River, Va. during 1959 showed an estimated total catch of 463,000 pounds, a fishing rate of 55.2 percent, and a total population of 839,000 pounds. Additional estimates of catch and effort were used to calculate fishing rate and population size for each year 1953 through 1958. Analyses of scales showed that most shad spawn at 3, 4, and 5 years of age and approximately 23 percent of the fish caught during the 1957–59 seasons had spawned the previous year. The number of ova produced by York River shad ranged from 169,000 to 436,000 per fish.

The commercial yield of American shad (*Alosa sapidissima*) on the Atlantic coast declined from a peak of 50 million pounds in 1896 to 8 million pounds in 1950. In 1950 the Bureau of Commercial Fisheries, acting as the primary research agency of the Atlantic States Marine Fisheries Commission, began an investigation of the fishery to determine causes for the decline, conditions favoring recovery, and management measures necessary to obtain maximum continuing yields.

Since funds and personnel were not sufficient for a study of all shad producing streams of the Atlantic coast, it was necessary to limit the investigation to certain areas each year. This report concerns the shad population of the York River, Va. In this study the York, which includes the Pamunkey and Mattaponi Rivers, was termed the York River system.

During the spring spawning run of 1959, personnel of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C., in cooperation with the Virginia Institute of Marine Science, Gloucester Point, Va., conducted an investigation of the fishery to estimate total catch, fishing rate, total population entering the river for each year in which catch and effort data were available, and to obtain certain life history information.

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LIFE HISTORY

American shad are the largest members of the herring family in the United States. They are anadromous, spending most of their life in the sea, but ascending coastal rivers to spawn. On the Atlantic coast, shad range from the St. Lawrence River, Canada, to the St. Johns River, Fla. Spawning migrations begin in Southern rivers as early as November and progressively later in Northern rivers. The number of eggs produced by females sampled from Atlantic coast rivers ranges from 116,400 to 659,000 (Lehman, 1953; Walburg, 1960). The young spend the first summer of life in the rivers and usually migrate to sea in the fall of the same year, at which time they are from 3 to 6 inches in length. In 3 to 6 years, they reach sexual maturity and return to the stream of origin to spawn.

Adult shad enter the York River as early as January, and the run usually continues until mid-May. It is during this time that they become available to the fishery. The bulk of the catch is usually made in a 6-week period from early March until mid-April. Massmann and Pacheco

(1957), in a study of the relationship of water temperature and shad catch in Virginia, showed that the greatest catches were made at water temperatures ranging from 45° to 59° F., and that below 40° F. very few shad were caught. The major spawning areas in the Pamunkey River are 20 to 25 miles above West Point and in the Mattaponi River 15 to 20 miles above West Point (Massmann, 1952). York River shad normally do not die after spawning, and if they survive natural and fishing hazards, they return to spawn in successive years (Talbot and Sykes, 1958).

DESCRIPTION OF RIVER AND SHAD FISHERY

The York River is formed by the union of the Pamunkey and Mattaponi at West Point, Va. (fig. 1). It flows southeasterly for a distance of 28 miles and empties into Chesapeake Bay at Tue Point. In this study an imaginary line drawn between Tue Point and Guinea Marshes marks the mouth of the river. The Pamunkey is formed by the junction of North Anna and South Anna Rivers in central Virginia and flows approximately 100 miles to its union with the Mattaponi. The Mattaponi is formed by the Matta, the Po, and the Ni Rivers in northeastern Virginia and flows approximately 120 miles to unite with the Pamunkey. Tidal waters extend about 45 miles up the Pamunkey and 30 miles up the Mattaponi. The change from brackish to fresh water occurs from 5 to 10 miles above West Point in each river.

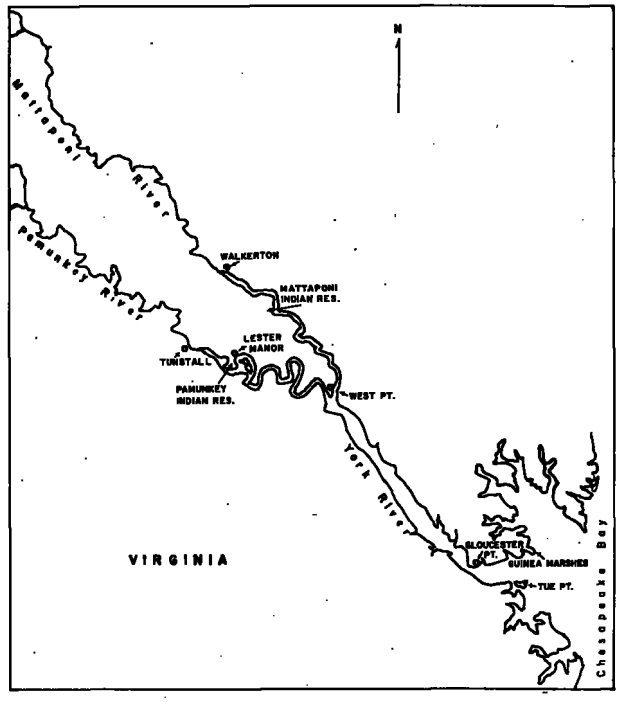

FIGURE 1.—York River system, Virginia.

Stake gill, drift gill, pound, and fyke nets, and haul seines were the gears employed in the fishery, named in order of their importance as determined by pounds of fish taken. The locality and miles of river fished by each gear are shown in table 1. Stake gill nets fished in the York were suspended from poles, spaced about 20 feet apart, driven into the river bottom. These nets were fished continuously during the shad season and were lifted on high and low tides. Pound nets, haul seines, and fyke nets, also employed in the York, were fished from early spring until fall. After the shad season these gears were fished for other species. Drift gill nets employed in the Mattaponi and Pamunkey were fished during periods of high and low slack waters, which permitted about 3 hours fishing on each tide. Regulations established by the Virginia Commission of Fisheries licensed stake gill nets by 600-foot rows, limited the length of drift gill nets to 600 feet, and permitted the taking of shad from inlets and rivers during the period from October 16 to May 25. Because of navigational difficulties from the mouth of the river to West Point, the location fished by stationary gears was designated by the U.S. Army Corps of Engineers so that shipping channels were unobstructed.

TABLE 1.—*Water area and location of shad gear fished, York River system, 1959*

Water area	Gear	Miles of river	Location of area
York River	Pound net	6	Mouth of river to Gloucester Point.
York River	Haul seine	6	Mouth of river to Gloucester Point.
York River	Fyke net	20	Gloucester Point to West Point.
York River	Stake gill net	20	Gloucester Point to West Point.
Pamunkey River	Drift gill net	26	West Point to Tunstall.
Mattaponi River	Drift gill net	21	West Point to Walkerton.

STATISTICS OF THE FISHERY, 1929–59

Estimated shad catches in the York River system for years 1929 through 1959 are shown in figure 2. The annual yield was at a low level during the years 1930 through 1943, with the

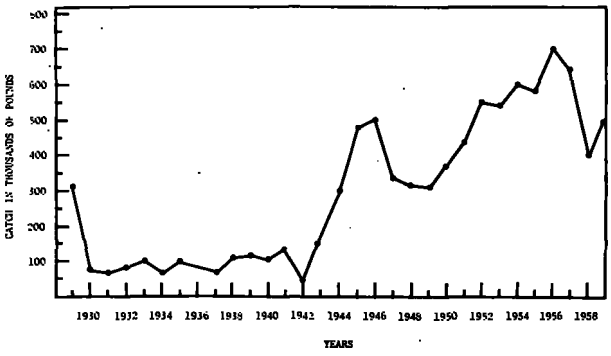

FIGURE 2.—Estimated shad catch, York River system, 1929–59.

least production of 23,800 pounds in 1936. After 1943 the yield increased rapidly and was approximately one-half million pounds by 1946. Then in the following 3 years the catch declined to less than one-third million pounds, after which it again increased with a peak production of more than two-thirds million pounds in 1956. The 1959 yield was more than that of 1958, but was less than the catch for any of the years from 1953 through 1957.

Catch statistics for the years 1929 through 1952 were compiled by the Branch of Statistics of the Bureau of Commercial Fisheries,[3] those for 1953 through 1958 were estimated from logbook records collected by the Virginia Institute of Marine Science, and the 1959 data were obtained from the present study.

To obtain the 1959 statistics a letter explaining the study was mailed prior to the start of the season to each shad fisherman licensed on the York River system during 1958. A logbook was enclosed, and each fisherman was asked to record his catch and effort each day. Biologists contacted fishermen throughout the season to learn the amount of each type of gear fished, to collect tags recovered from the tagging study conducted simultaneously with the statistical study, to encourage the recording of catch and effort data, and to help with the logbook records. At the end of the season, all fishermen were contacted personally or by letter for logbook and tag returns. Catch and effort data were obtained for all pound-net, haul-seine, and fyke-net fishermen; 94 percent of the stake gill-net fishermen; and 56 percent of the drift gill-net fishermen. Total catch and effort for the gill-net fisheries were estimated from information obtained from the logbooks.

In 1959 the shad catch was reported in pounds and the effort recorded in number of nets fished each day. Number of nets fished each day was converted to net days, i.e., a pound net, haul seine, or fyke net-day was defined as one net fished for 1 day, and a stake and drift gill net-day was defined as 100 linear yards of net fished for 1 day. The estimated total catch and effort for all gears was 463,124 pounds in 24,112 net-days (table 2). Gill nets accounted for 94 percent of the total catch and 84 percent of the total effort.

TABLE 2.—*Estimated total catch and effort of shad fishery, York River system, 1959*

Gear	Nets fished	Effort	Catch		
			Males	Females	Total
	Number	*Net-days*	*Pounds*	*Pounds*	*Pounds*
Pound nets	20	1,204	6,679	8,809	15,488
Haul seines	2	20	700	800	1,500
Fyke nets	64	2,575	6,591	4,114	10,705
Stake gill nets	5,003	11,308	58,975	164,209	223,184
Drift gill nets	524	9,005	96,247	114,000	212,247
Total	5,613	24,112	171,192	291,932	463,124

Logbook data, collected each season from 1953 to 1958 by the Virginia Institute of Marine Science, were made available for this study. Analysis of the logbook data, kept by the same fishermen each year, accounted for approximately 25 percent of the total catch and effort in 1959. Catch per unit of effort for the major gears remained relatively constant from 1953 to 1959. Data for the years 1953 through 1958 were therefore adjusted, based on the results of the 1959 study. The estimated catch and effort by gear for 1953 through 1959 are given in table 3.

TAGGING STUDY, 1959

During the 1959 season, a tagging and recovery program was conducted to estimate the rate of exploitation and the size of the shad population. Fish for marking were obtained from pound nets located near the mouth of the river in the vicinity of Tue Point. Tagging began on March 9 and was discontinued on May 3 when the run terminated. During this period 842 shad were marked with streamer tags, similar to those used by Davis (1959). The tag was a red plastic disk, with an identification number on one side

[3] Unpublished data. Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C.

TABLE 3.—*Estimated shad catch and effort by gear, York River system, 1953–59*

Year	Pound net		Haul seine		Fyke net		Stake gill net		Drift gill net		Total catch
	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	
	Net-days	*Pounds*	*Net-days*	*Pounds*	*Net-days*	*Pounds*	*Net-days*	*Pounds*	*Net-days*	*Pounds*	*Thousands of pounds*
1953	46	4,544	23	17,764	6,102	16,451	12,614	231,727	9,801	283,069	552
1954	138	4,544	69	13,525	3,821	20,911	8,980	300,139	9,064	262,709	602
1955	49	3,416	25	8,115	3,274	9,639	11,509	251,484	8,005	264,923	538
1956	79	5,404	40	8,115	5,372	14,483	10,843	398,114	7,706	290,392	716
1957	75	4,866	38	7,304	4,339	15,393	10,060	399,844	6,845	211,033	638
1958	77	4,555	39	5,000	4,247	14,500	8,777	215,289	6,328	146,772	386
1959	1,204	15,488	20	1,500	2,575	10,705	11,308	223,184	9,005	212,247	463

and return address and reward notice on the other, to which a loop of nylon twine was tied. The nylon loop was fastened under the origin of the dorsal fin, which allowed the disk to trail immediately behind the fin, not interfering appreciably with the normal activity of the fish.

Of the total number of fish tagged, 118 were recaptured from areas outside the York River system. Of these, 105 were recaptured in the Chesapeake Bay system, 4 in North Carolina, 4 off the New England coast, 3 in the Hudson River, and 2 tags were returned from fish markets in Philadelphia, Pa. Approximately 89 percent of the outside returns were recaptured in the Chesapeake Bay system. On the basis of previous studies in the bay by Walburg (1955) and Walburg and Sykes (1957), an outside fishing rate of 50 percent was estimated. Therefore, 236 shad tagged at the mouth of York River were considered as en route to other river systems and were subtracted from the number tagged. Using criteria established by Talbot and Sykes (1958), one tagged fish recaptured in Chesapeake Bay on June 8 was not included since it was not known whether this fish had spawned in the York. This left 605 tagged fish which entered the York River for the purpose of spawing. Of this total, 334 were recaptured: 173 in the York, 104 in the Pamunkey, and 57 in the Mattaponi.

To obtain valid estimates from our tagging program certain factors, which may be sources of error, must be examined and their consequences satisfied (Ricker, 1958).

(1) *Differential mortality.*—Extra mortality among the tagged fish, either as a direct result of the tag or indirectly from effects of exertion by the fish during capture and handling incidental to the marking operation, may result in a biased fishing rate and population estimate. Sykes (1951) successfully handled and moved adult fish for distances up to 95 miles, and they remained alive and active for some time after transfer. This was considered as adequate demonstration that shad can survive rigorous handling. Atkinson (1951) handled and held adult shad in experimental ponds for several weeks without appreciable mortality. During the present experiment, only fish in apparent good physical condition and those unabraded in the process of capture were marked. Every precaution was taken to prevent damage to the fish which could result in extra mortality from handling and marking.

(2) *Loss of tags by detachment.*—The tag and attachments are completely durable. Approximately 25 percent of the catches were examined for scars that would be left from detachment, and no evidence was found of nonpermanent attachment. No unattached tags were reported taken in the nets. Therefore, loss of tags by detachment was considered negligible.

(3) *Tagged fish more, or less, vulnerable to fishing than untagged fish.*—If tags made shad more vulnerable to fishing, a higher proportion of tagged to untagged fish would occur in the catch of the lower fishery than at locations further upstream. The proportion of tagged to untagged fish in the lower river catch was no greater than that found further upstream, and the rate of capture of tagged fish was approximately the same as that for untagged fish by each gear at the different locations. Pound nets and haul seines in the lower York took 3.7 percent of the total catch and 3.6 of the tagged fish recaptured. Fyke and stake gill nets employed in the upper York took 50.5 percent of the total catch and 48.2 percent of the tagged fish recaptured, and drift gill nets operated in the tributaries took 45.8 percent of the total catch and 48.2 percent of the tagged fish recaptured.

The point of insertion of the tag and type streamer used did not make the tagged fish more vulnerable to gill nets than untagged fish by reason of the tag entangling in the net. For the first 5 weeks the weekly rate of recapture of tagged fish and untagged fish indicated no difference in behavior of the fish, i.e., in the first week 6.9 percent of the recaptures of tagged fish was made and 5.0 percent of the catch was made; in the second week the rate was 10.0 and 10.0; in the third week 15.0 and 15.1; in the fourth week 20.0 and 20.0; and in the fifth week 24.4 and 25.0.

Length measurements of shad caught in previous seasons indicated that fish more than 14.3 inches fork length were liable to capture by all types of gear fished in the York system; therefore, no fish less than this length were tagged. Fish less than this length were of no market value and were released or eliminated from the catch.

A chi-square test between catch and number of tags recovered by gear type showed that no tag selectivity occurred within the size range tagged

$$(\chi^2=2.16;\ P=0.71).$$

(4) *Nonreturn of tags.*—Each fisherman was contacted prior to the season to acquaint him with the tagging program. Then four biologists canvassed the fishery daily throughout the entire season for tag returns. At the end of the season each fisherman was contacted to collect the recovered tags. The number of recaptured tags not recovered probably would not appreciably bias the estimates.

(5) *Nonrandom distribution of tagged fish.*—Marked fish were randomly distributed throughout the population being sampled by tagging uniformly throughout the season from the first gear the fish encounter in the river, so that, as nearly as possible, tags were affixed in proportion to the number of shad migrating upstream. Close agreement of the ratio of tagged to untagged fish taken in the tributaries (spawning grounds) provided evidence that tagging was random with respect to the destination of the shad.

Based on the tagging study the calculated fishing rate was 55.2 percent and the estimated population size 838,892 pounds. To determine the total population of shad entering the river in 1959, Chapman's (1948) formula $N=\frac{nt}{s}$ was used, where N=total population, n=total catch (463,124 pounds), t=number of fish tagged (605), and s=number of tagged fish recaptured (334). Escapement from the fishery was 375,768 pounds. The limits within which the population estimate fell with 95 percent confidence were 900,000 and 800,000 pounds (Chapman, 1948).

GEAR EFFICIENCY AND STANDARDIZATION OF EFFORT

To determine total fishing effort in standard units required to make the 1959 shad catch, the fishing efficiency of the various gears must be determined. Fishing efficiency was defined as the ability of one unit of effort to remove a certain fraction of the available population in a specified interval of time. The method used to determine fishing efficiency was similar to that used by Talbot (1954), in which fishing gears fish different areas. As previously noted, however, pound nets and haul seines fished the lower river, stake gill and fyke nets fished the central section of the river, and drift gill nets were fished upriver. Before the efficiency of gears fished in different areas could be determined, it was necessary to combine the effort of those gears fishing in the same area.

The unweighted average catch per unit of effort by haul seines 1953 through 1959 was found to be 4.60 times that of pound nets, and the unweighted average catch per unit of effort by fyke nets 1953 through 1959 was 0.12 times that of stake gill nets. Haul-seine effort was converted to pound-net effort by multiplying haul-seine effort (table 3) by 4.60. Fyke-net effort was converted to stake gill-net effort by multiplying fyke-net effort (table 3) by 0.12. The effort and catch of these gears as combined will henceforth be included under pound nets and stake gill nets as given in table 4. We now have three standardized gears, each fishing a different area of river.

TABLE 4.—*Estimated catch and effort, York River system, 1953–59*

Year	Pound nets		Stake gill nets		Drift gill nets		Total	
	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
	Net-days	*Pounds*	*Net-days*	*Pounds*	*Net-days*	*Pounds*	*Net-days*	*Thousands of pounds*
1953	152	22,308	13,346	248,178	9,801	282,069	23,299	552
1954	455	18,069	9,438	321,050	9,064	262,709	18,957	602
1955	164	11,531	11,902	261,123	8,005	264,923	20,071	538
1956	263	13,519	11,488	412,597	7,706	290,392	19,457	716
1957	249	12,170	10,581	415,237	6,845	211,033	17,675	638
1958	256	9,555	9,287	229,789	6,328	146,772	15,871	386
1959	1,296	16,988	11,617	233,889	9,005	212,247	21,918	463

The fishing efficiency of each gear, designated as p, was determined using Fredin's (1954) formula $q^n N=E$,[4] from which we derive

$$\log q=\frac{\log E/N}{n}$$

where $q=1-p$, E=escapement from a fishery, N=size of run available to a fishery, and n=units of effort in net-days. From our tagging and recovery program, the estimated size of run (N) available to pound nets was 838,892 pounds. The catch (c) was 16,988 pounds; hence, the escapement (E) from these nets was 821,904 pounds. The units of effort (n) were 1,296. Solving the above equation, the q value obtained was 0.999984. Since $p=1-q$, the fishing efficiency of pound nets was 0.000016. Shad that escaped the pound nets were available to the stake gill nets. The fish available to this gear were 821,904 pounds, of which 233,889 pounds were removed by 11,617 units of effort. Solving the equation, the q value obtained was 0.999971, and therefore $p=0.000029$. Fish that escaped both pound and stake gill nets were available to the drift gill nets. The shad available to these nets amounted to 588,015 pounds, of which 212,247 pounds were removed by 9,005 units of effort. Solving the equation for this gear, the q value obtained was 0.999950, and therefore $p=0.000050$.

After a measure of the fishing efficiency of each gear was determined, it was possible to convert fishing effort in net-days to standard-fishing-unit days (Talbot, 1954). A standard-fishing-unit (s.f.u.) day was defined as 100 linear yards of drift gill net fished for 1 day. The fishing efficiency of the pound net and stake gill net was 0.32 and 0.58 that of the drift gill net. This was determined by dividing the fishing efficiency of the pound and stake gill net by that of the drift gill net. Fishing effort of pound nets and stake gill nets was converted to standard-fishing-units by multiplying the effort of each net in net-days by these conversion factors. Total catch, effort, and catch per unit of effort are listed in table 5.

TABLE 5.—*Estimated effort in standard-fishing-unit (s.f.u.) days by gear, York River system, 1953–59*

Year	Effort in s.f.u. days				Total catch	Catch per s.f.u. day
	Pound net	Stake gill net	Drift gill net	Total		
					Thousands of pounds	*Pounds*
1953	49	7,741	9,801	17,591	552	31.4
1954	146	5,474	9,064	14,684	602	41.0
1955	52	6,903	8,005	14,960	538	36.0
1956	84	6,663	7,706	14,453	716	49.5
1957	80	6,137	6,845	13,062	638	48.8
1958	82	5,386	6,328	11,796	386	32.7
1959	415	6,738	9,305	16,158	463	28.6

[4] Modification of Beverton and Holt's (1957) model for estimating relative fishing power of vessels and standardization of commercial statistics of fishing effort.

ESTIMATE OF POPULATION SIZE, 1953–59

The relative population of shad entering the river can be estimated for any year in which catch and effort statistics are available provided: (1) fishing effort is uniform throughout the season, (2) fishing efficiency remains constant within and between seasons, and (3) the migration pattern of the fish is similar each year (Ricker, 1940).

Available records indicated that fishing was carried out essentially in the same areas using the same types of gear as when the fishery was first investigated in 1953. The main part of the run lasted about 6 weeks, and fishermen fished every day possible. Fishing effort and efficiency, therefore, tended to be uniform throughout the season and between seasons. Water level, turbidity, or water temperature may have affected migration routes within the river for short periods of time, but not necessarily over the entire season. Even though the length of runs and time of fish passage through the fishing areas may have varied from year to year, there was no indication that the York River shad, once in the river, migrated differently in different seasons. Based on these assertions, it was assumed that the above provisions given by Ricker were satisfied for this fishery.

The population for each year 1953–59 was estimated by Talbot's (1954) formula:

$$N=\frac{C}{1-q^n}$$

where C=catch, $q=1-p$, and n=fishing effort in standard-fishing-unit days. The estimated population for these years is listed in table 6. Fishing rate ranged from 58.3 percent in 1953 to 44.4 percent in 1958. The population fluctuated between 1.4 million pounds in 1956 and 0.8 million pounds in 1959. Escapement reached a peak of 0.7 million pounds in 1957 compared to a low of 0.4 million pounds in 1959.

TABLE 6.—*Estimated shad population parameters, York River system, 1953–59*

Year	Catch	Effort	Fishing rate	Total population	Escapement
	Thousands of pounds	*s.f.u. days*	*Percent*	*Thousands of pounds*	*Thousands of pounds*
1953	552	17,591	58.3	947	395
1954	602	14,684	51.8	1,162	560
1955	538	14,960	52.5	1,025	487
1956	716	14,453	51.3	1,396	680
1957	638	13,062	47.8	1,335	697
1958	386	11,796	44.4	869	483
1959	463	16,158	55.2	839	376

AGE COMPOSITION

Each season 1957 through 1959 scales were collected from fish taken in stake and drift gill nets. Plastic impressions were made of two symmetrical scales from each fish, and age was determined using the method described by Cating (1953).

The scales were read for age at capture, age at first spawning, and number of times previously spawned (table 7). Shad entering the river for the first time were predominately 3- and 4-year-old males and 4- and 5-year-old females. Approximately 23 percent of the fish in the samples (14.8 percent of the females and 37.6 percent of the males) had spawned the previous year. The small percentage of fish returning to spawn the second or more times is probably due to exploitation outside the river and to ocean mortality. In 1952 Walburg and Sykes (1957) found that 27 percent of the James River shad and 17 percent of the Potomac River shad had spawned previously.

The size by sex was determined. Mean weight was 2.3 pounds for males and 3.2 pounds for females. Fork length ranged from 12.6 to 17.3 inches for males and 14.0 to 20.0 inches for females.

TABLE 7.—*Age composition of shad, York River system, 1957–59*

Group	1957		1958		1959	
	Females	Males	Females	Males	Females	Males
Total age at capture:						
2 years	2	3	0	0	0	0
3 years	7	21	5	23	19	35
4 years	71	62	63	73	398	190
5 years	77	25	80	34	154	99
6 years	15	3	27	2	25	21
7 years	2	2	9	1	3	4
8 years	0	0	0	0	0	1
Total	174	115	184	133	599	350
Age at first spawning:						
2 years	2	3	0	0	0	0
3 years	14	35	12	42	32	128
4 years	89	65	83	77	447	211
5 years	67	12	78	14	112	11
6 years	2	0	11	0	8	0
Total	174	115	184	133	599	350
Number of times previously spawned:						
0	137	88	152	92	526	193
1 time	29	18	21	24	58	83
2 times	5	8	7	15	15	65
3 times	3	0	3	2	0	5
4 times	0	1	1	0	0	4
Total	174	115	184	133	599	350
Total	289		317		949	

OVA PRODUCTION

Ova production was determined by sampling the ovaries from 18 females captured during April 1959. Fish were taken from stake gill nets located in the lower section of the river approximately 50 miles below the spawning ground. Fish were chosen selectively so that different size and age groups were represented. They ranged from 14.9 to 19.0 inches in fork length, 2.1 to 5.0 pounds in weight, and 4 to 7 years in age. Ova estimates were made using the method described by Lehman (1953) and modified by Davis (1957). Ova counts ranged from 169,000 to 436,000 (table 8).

TABLE 8.—*Estimated ova production of 18 female shad, York River, 1959*

Specimen No.	Fork length	Total weight	Weight of ovaries	Mean number of ova	Estimated total ova
	Inches	*Ounces*	*Grams*	*Per gram*	*Thousands*
1	14.9	34	120.5	2,090	252
2	15.2	37	133.2	1,696	226
3	15.4	43	141.4	1,488	210
4	15.7	39	217.7	778	169
5	15.8	39	146.1	1,412	206
6	16.0	42	126.0	1,542	194
7	16.0	44	155.4	1,956	304
8	16.8	48	214.0	966	207
9	16.8	53	164.4	1,698	279
10	17.0	52	224.6	1,322	297
11	17.3	59	210.4	1,169	246
12	17.5	56	164.4	1,540	253
13	17.9	64	213.1	1,977	421
14	18.2	65	233.3	1,675	391
15	18.3	67	280.8	1,318	370
16	18.5	73	303.5	1,436	436
17	18.7	62	220.3	1,636	360
18	19.0	80	391.7	914	358

The relation between ova production and length, or weight, or age of the York River shad is shown in figure 3. Linear regressions showed that there was an increase in ova production with increase in each of these variables within the size and age range sampled. Ova production was somewhat more highly correlated with weight (r=0.820) than with length (r=0.795) or with age (r=0.740).

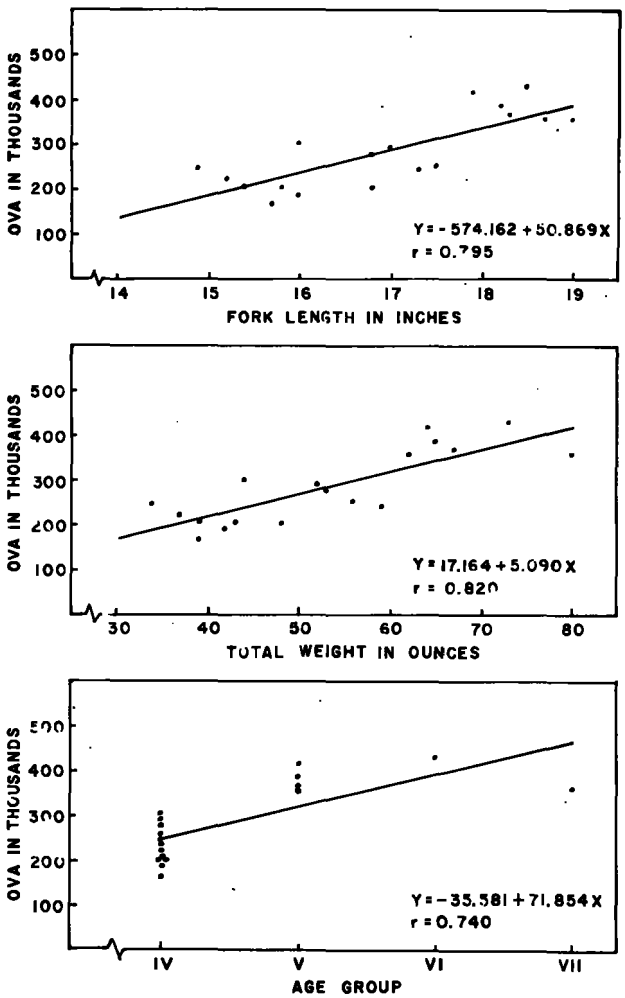

FIGURE 3.—Relation between ova production and length, weight, and age in female shad, York River, 1959.

SUMMARY AND CONCLUSIONS

The Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C., in cooperation with the Virginia Institute of Marine Science, Gloucester Point, Va., conducted a study on the shad population of the York River system in 1959 as part of an investigation of the Atlantic coast shad fishery. This river system includes the York, Pamunkey, and Mattaponi Rivers. The purposes were to determine total catch, fishing rate, population entering the river system for each year in which catch and effort data were available, and certain life history information.

Estimated total catch in 1959 was 463,000 pounds, of which gill nets accounted for 94 percent. The fishing rate was estimated to be 55.2 percent, estimated population 839,000 pounds, and spawning escapement 376,000 pounds. Ninety-five percent confidence limits on the population estimate were 900,000 and 800,000 pounds. With catch and effort statistics available for the years 1953 through 1958, it was possible to estimate population size, fishing rate, and spawning escapement for each of these years, based on information obtained during the 1959 study. Estimates showed that the commercial yield reached a peak of 716,000 pounds in 1956 and a low of 386,000 pounds in 1958; fishing rate ranged from 44.4 percent in 1958 to 58.3 percent in 1953; population reached a peak 1.4 million pounds in 1956 compared to a low of 0.8 million pounds in 1959; and escapement reached an estimated high of 0.7 million pounds in 1957 compared to a low of 0.4 million pounds in 1959.

Shad that entered the York River for the first time were predominantly 3- and 4-year-old males and 4- and 5-year-old females. Twenty-three percent of the catch had spawned the previous year. Ova production ranged from 169,000 to 436,000, and linear regressions showed an increase in number of eggs with an increase in weight, length, and age of the fish.

In this investigation, a method was presented to estimate the shad population of the York River system, provided catch and effort statistics are collected each year. Population estimates were calculated on this shad fishery for seven consecutive years. The value of this study for scientific management of the fishery will not be realized, however, until population estimates have been obtained for an additional number of years.

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