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A preliminary assessment of the river herring stocks of lower Chesapeake Bay : a progress report to the herring industry

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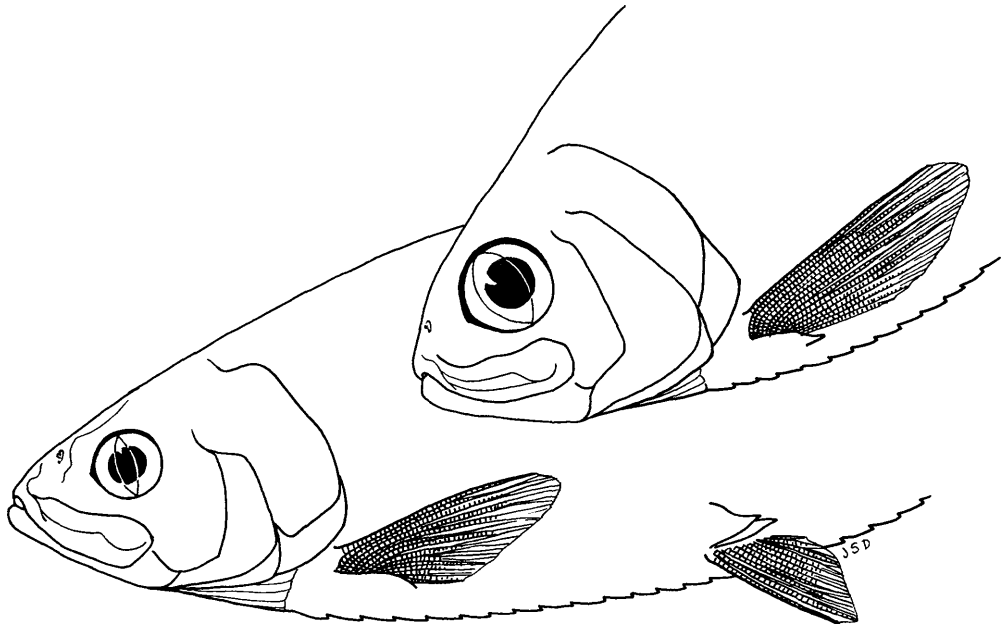

A PROGRESS REPORT TO THE HERRING INDUSTRY

VIRGINIA INSTITUTE OF MARINE SCIENCE
SPECIAL SCIENTIFIC REPORT NO. 51

FEBRUARY, 1965

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INTRODUCTION

In October 1963, members of the herring industry of Virginia, Maryland and North Carolina conferred with the U. S. Bureau of Commercial Fisheries and Virginia Institute of Marine Science seeking means of improving the economic condition of the industry. One of the questions which arose was whether or not the stocks of river herrings could support an expanded fishery. VIMS has embarked on a program to answer this question, with respect to Virginia waters.

This report summarizes the results of a study of the herring run of 1964. This was a preliminary study aimed at working out some of the details that are basic to the primary problem of assessing the ability of the stocks to withstand heavier fishing. An analysis of a single season's run is inadequate to provide final answers. This is a progress report and the information contained herein must be interpreted in that context. Considerable progress was made during the year and the direction of future research is clearly indicated. It should be emphasized that at the time of the aforementioned meeting, no one from the Virginia laboratory was in any position to give even a partial answer to this question, nor did any other laboratory on the Middle-Atlantic Coast possess such information.

The successful conduct of this research and any future work that may be undertaken depends in large part on the degree of

cooperation that is rendered by the industry. We found all segments of the industry--fishermen, processors and packers--to be most cooperative and we gladly acknowledge their assistance. We also thank Mr. Woodrow Wilson, fisheries technician, for his efficient collection of field data.

The primary products of the herring industry are canned fish, canned roe and pet food. The roe is obtained from both alewife and blueback herring. These two species and a lesser quantity of sea herring are canned. The industry does not separate the species, since in the processed form they are essentially identical and little would be gained by separation.

The fishery is pursued in late winter and spring when the fish enter Chesapeake Bay and its tributaries from the Atlantic Ocean. Most of the fish are caught in pound nets with a relatively small quantity taken by haul seines. Two kinds of river herring are caught. Also caught in the same nets in the spring are sea herring (Labrador herring), American shad, hickory shad, and small numbers of other kinds of fish. The two kinds of river herring, alewife and blueback, are illustrated in Figure 1. Fishermen recognize the two species as distinct kinds but use several different names. The multiplicity of names has given rise to some confusion. In this discussion we will use the name alewife (Alosa pseudoharengus) for the deep-bodied, big-eyed, greenbacked fish that runs early (Fig. 1a). The menhaden, or bunker, is also called alewife or oldwife, but we are not here concerned with menhaden. We will use the name blueback (Alosa

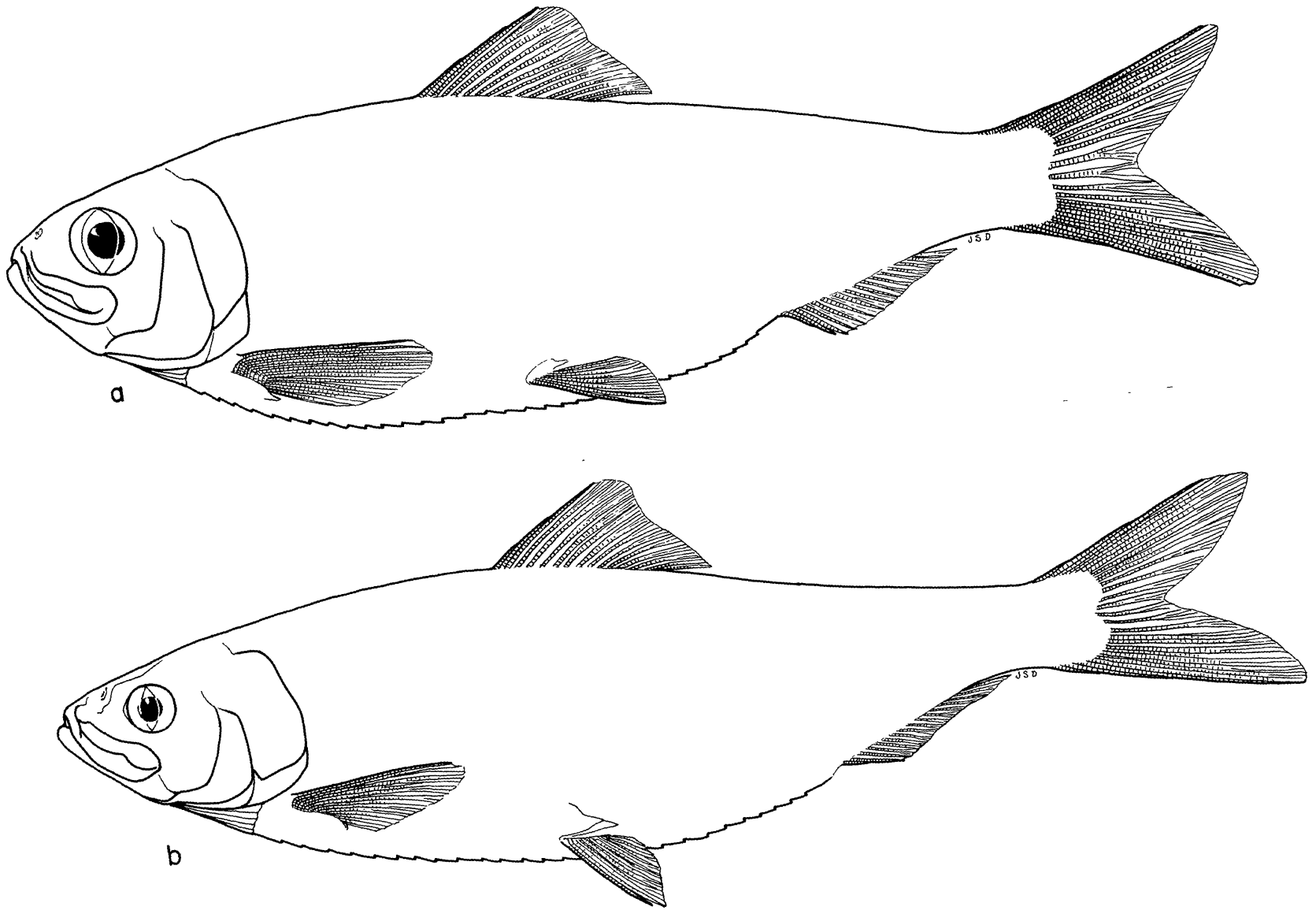

Figure 1. River Herring. a. Alewife b. Blueback

aestivalis) for the slender, small-eyed, bluebacked fish that runs later (Fig. 1b). The sea herring, also known as Labrador herring by most fishermen in this area, is more slender than either alewife or blueback. The sea herring also has a blue back, but the scales on the midline of its belly are smooth. Both alewife and blueback have a line of saw-tooth-like scales on the midline of the belly. Sea herring leave the area in March. They do not spawn in Chesapeake Bay; therefore, their roes and milts are poorly developed at the time they are caught.

In the case of the alewife, the diameter of the eye is equal to or slightly greater than the distance from the front edge of the eye to the tip of the upper jaw. The eye of a blueback is smaller, the diameter being less than the distance from the front edge of the eye to the tip of the upper jaw. The lining of the body cavity is another distinguishing feature, being gray or silvery in the alewife and sooty black in the blueback. On the average, the alewife is deeper bodied than the blueback. The length of the alewife is about 3-1/3 times its greatest depth. The length of a blueback is about 3-1/2 times its greatest depth. However, this character varies as the roes and milts mature and can be used only when several fish are available for comparison. For example, alewives are deeper-bodied than bluebacks of the same sex, but a roe blueback may be deeper-bodied than a buck alewife. Of course both kinds are much more slender after spawning than before.

The fish enter Chesapeake Bay in late winter and early spring and swim up the rivers into fresh water to spawn. The

eggs and milt are broadcast in the water. No nest is constructed. Eggs sink and stick to whatever they touch. Incubation requires 2 to 6 days, depending on temperature. Young fish spend the first summer near the spawning grounds. As they grow larger they move downstream and by winter are in Chesapeake Bay or the Atlantic Ocean. When they leave the bay, bluebacks are about 3 inches long and alewives are about 4 inches long. Alewives return to spawn after spending about 3 years at sea. We are not yet certain how many years bluebacks remain at sea before the first spawning run, but it seems to vary from 2 to 4 years. After spawning for the first time, the fish return to sea and then come back to fresh water the following spring to spawn again. The number of times a fish returns to spawn is discussed later in this report. Our samples indicate that males and females occur in nearly equal numbers in the two species.

HISTORY OF THE RIVER HERRING FISHERY

The statistical history of a fishery is a valuable basis for interpretation of its present condition. The usefulness of historical records depends on their accuracy and the number of years covered. A record of total landings is useful but is an insufficient basis for detailed analysis. Some indication of the amount of fishing effort expended is required in addition to total landings. The value of historical analysis depends almost entirely on the reliability of the statistics on which it is based.

The published record of the Virginia herring fishery leaves much to be desired and must be interpreted with care.

Several factors contribute to the unreliability of the statistics. Records of the early years of the fishery are scattered or non-existent. Moreover, in recent years the waters around Northern Neck and Mathews County, which contribute the bulk of the herring catch, seem to be the least well covered statistically. During all years, a substantial percentage of the catch is utilized for meal, oil and crab bait and thus often is not entered in the statistical record, which considers food-fish primarily. Perhaps the major weakness of the statistics is that the two species of river herring are not listed separately. Even if the landings did portray accurately the abundance of fish from year to year, there would be no way of determining which of the two species contributed to a particular high or low, as they may flucuate independently. Unfortunately, it seems impractical under current industry practices to distinguish between alewife and blueback in the records.

Despite the shortcomings listed above, we cannot afford to overlook the existing statistics. The total landings by year and area are given in Table A in the appendix and are shown for Virginia waters in Figure 2. After many years of low catches in New England, sizable runs of alewives have been re-established since the mid-fifties. The return of river herring in that area is due, at least in part, to the activities of various fishery agencies in reducing pollution and opening streams that were formerly blocked by dams and other obstructions. This demonstrates that herring populations have responded very well to management practices,

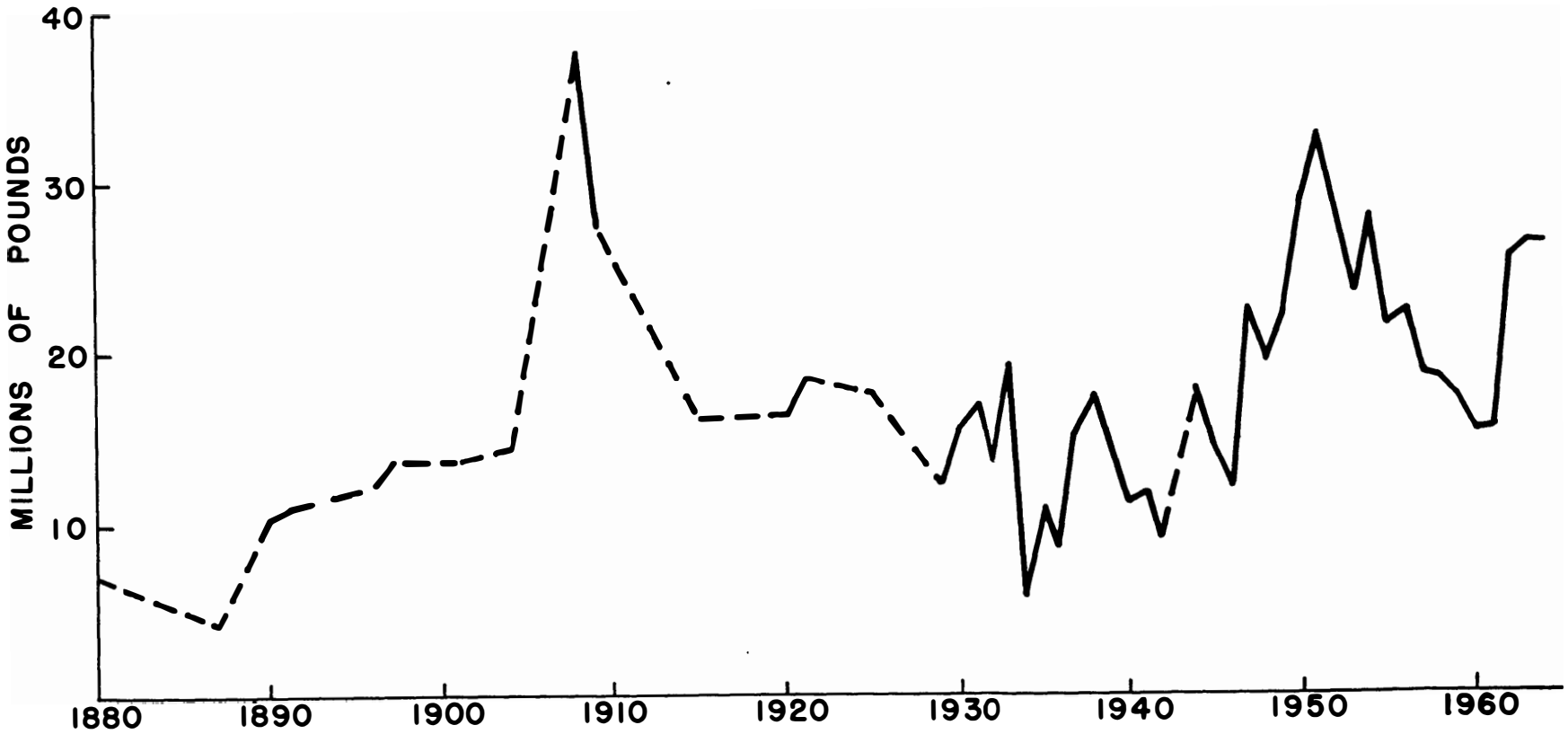

Figure 2. Total Landings of River Herring in Virginia.

especially stocking adult fish to re-establish former runs.

Herring landings in Maryland waters as shown in Table A (Appendix) differ surprisingly from those of Virginia. Landings in Maryland dropped considerably after 1920 and never regained their former importance. At the present time we have not determined whether this decline represents a real change in abundance of fish or reflects economic or marketing changes. Other areas are included in Table A for purposes of comparison.

Virginia landings are shown graphically in Figure 2. The dashed lines covering the earlier period of the fishery indicate that statistics are available only for scattered years. One of the more significant features of Figure 2 is a long period of relative stability lasting from about 1915 through 1946 during which time landings fluctuated about a mean of approximately 15 million pounds. This period of stability was followed by a pronounced upward trend culminating in landings of over 32 million pounds in 1951. Although catches declined during the fifties, landings of the last three years have returned to a high level. In only nine years for which records are available has the catch exceeded 25 million pounds. The fact that seven of these nine years have occurred since 1950 would suggest that during the last decade herring have been as abundant as at any time since records have been kept.

As has been pointed out, interpretations of abundance based solely upon total landings are not especially reliable. This is particularly true if fishing effort has changed in the

period covered by the statistics. The pound net has been, since shortly after its introduction, the principal gear used for the capture of herring. Unfortunately, no accurate information exists on the number of pound nets fished during the herring season each year. The best estimate of pound net effort that is available comes from scattered counts during early years and the number of licenses issued, a record of which is available since 1929. The estimate is given in Table B in the appendix. Briefly, the pound net was introduced in Virginia waters between 1870 and 1875. The number of nets rose rapidly so that in 1915 over 2000 nets were fishing on the western shore of Chesapeake Bay. As late as 1935, 2000 pound nets were licensed to fish in Virginia waters. Thereafter, the number of pound nets declined steadily to the 600 to 700 licensed in recent years. Of course many licensed sites are not fished during the herring season and some are not fished at all so the total number licensed per year is not a good estimate of effort, but it is the only estimate available.

The best index of catch-per-unit-of-effort that we can derive is to compare the catch in a given season with the number of pound nets known to have been fished or licensed in that year. This catch-per-unit-of-effort is shown in thousands of pounds per net per year in Figure 3. (See also Appendix Table B.) This graph suggests even more strongly than do the total landings that the herring stocks are as abundant as they have been at any time since statistics have been available. The

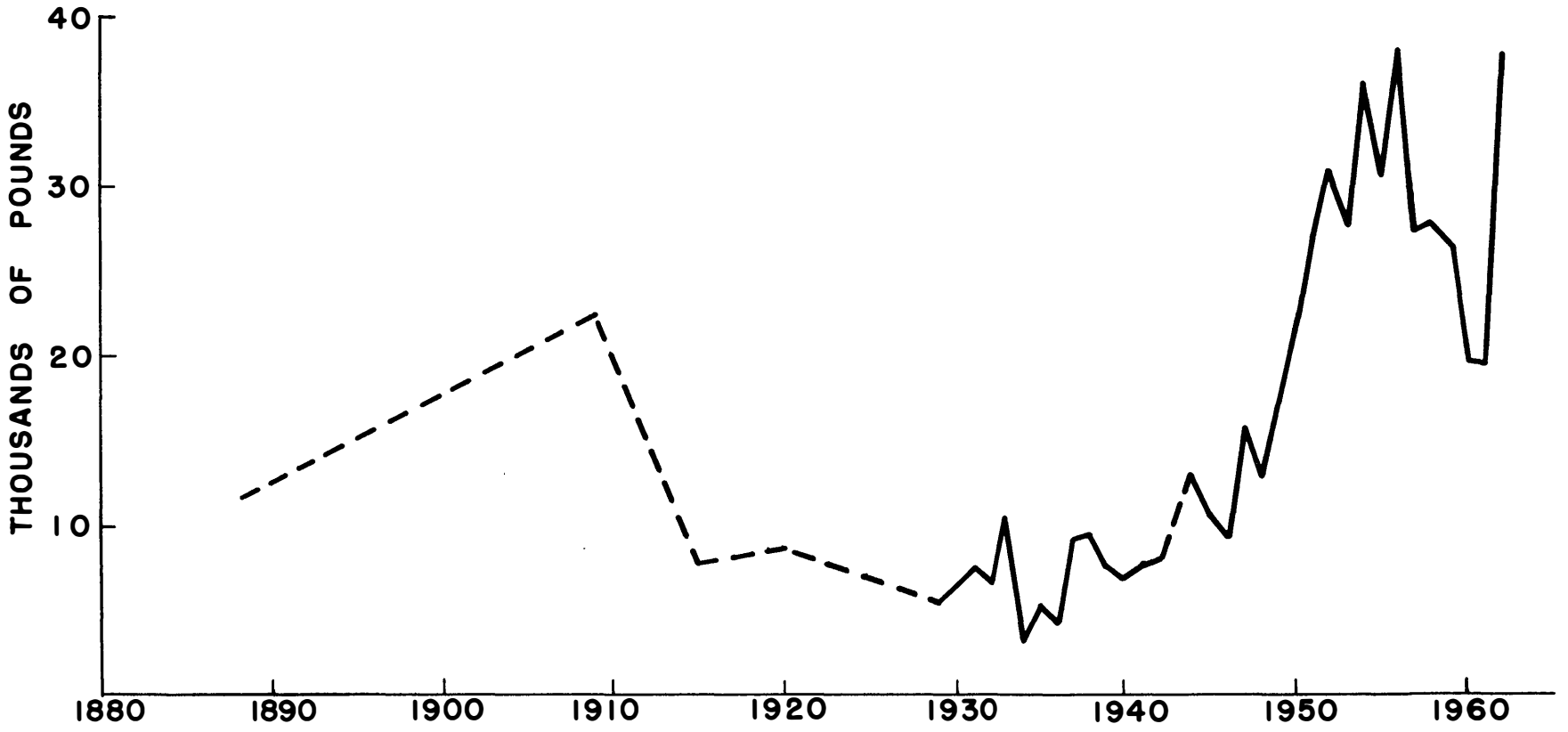

Figure 3. Herring Landings per Licensed Pound Net per Year.

ten highest catches-per-unit-of-effort have all occurred since 1950.

This analysis, although admittedly based on a weak statistical record, suggests that the present stocks of river herring are at a high level of abundance. Certainly the statistical record shows no evidence to the contrary.

AGE COMPOSITION AND SPAWNING HISTORY OF LOWER CHESAPEAKE BAY HERRING STOCKS

One of the more reliable means of assessing the condition of a stock of fishes is through an examination of the age composition of the catch. If the catch contains a significant number of fish that have spawned one or more times, then the stock can be assumed to be in reasonably good condition. If, on the other hand, very few old fish appear in the catch, then probably the stock is being endangered by overfishing or some other factors.

The alewife and blueback must be treated separately. Also, each major river system can be expected to have its own stock of each kind, and these must also be separated. In this preliminary study it was not feasible to cover all rivers, but three sites were sampled throughout the season and a few samples were obtained elsewhere. The York River was selected for one sampling area because of the ease of coverage from the Gloucester Point laboratory and because we could be sure that we were dealing with a single river system. The Reedville area and a site near Gwynn's Island were sampled to provide a general idea of fish going to areas above the James and York rivers as a basis for comparison.

These last two areas are not ideal in that they probably contain fish on their way to spawning grounds in the Rappahannock and the Potomac, as well as in the rivers draining into the upper bay. The results from analysis of the Gwynn's Island and Reedville samples were so similar that they were treated together. Some samples were obtained from the Chickahominy River drainage late in the season.

In determining the maximum safe level of fishing on anadromous fishes such as the river herrings, the major feature of concern is escapement of sufficient spawning fish to assure future stocks. A knowledge of the age composition gives some indication of the percentage of fish which escape to spawn in successive years.

The technique for age determination in herring is based on examination of the scales and is essentially the same as is used on menhaden. Each time a herring enters fresh water to spawn a distinct spawning mark, in addition to the annual ring, is left on the scale. This is especially important because all herring do not enter the fishery at the same age. Spawning marks indicate the number of times a fish has been exposed to the fishery and escaped to spawn. In the case of the alewives, both age and spawning history were determined. With the blueback herring some problems of age determination have not yet been resolved but the spawning record seems to be clear.

Age and spawning history of alewife

A few alewives enter the spawning run for the first time when they are 3 years old; the great majority, approximately 90%, spawn for the first time at age 4 and a few do not spawn until they are 5. The age composition of the alewife catch for the York River and Reedville-Gwynn's Island area is given in Table 1. In the York River catch, approximately 60% of the fish were 5 years of age or older, while in the Reedville-Gwynn's Island samples about 50% were in that category. This suggests that at present levels of fishing more than half of the alewives entering the spawning run for the first time evade the nets, spawn, and return in the spawning run the following year.

TABLE 1

Year Class Composition

by Percent for the Alewife Catch - 1964

Year Class	1961	1960	1959	1958	1957	1956
York River	2.4	38.4	32.1	23.9	1.6	1.6
Reedville-Gwynn's Island	5.9	44.5	28.4	19.8	1.4	0.0

Sizable escapement is also shown by the spawning history of the alewife run as given in Table 2. In this analysis we are examining the number of times the fish have participated in the spawning run, irrespective of their age. Approximately 60% of the

York River alewives were repeat spawners and approximately 50% of the fish in the Reedville-Gwynn's Island area were spawning for at least the second time. The percentage of the population which spawns in any one year is even higher than the figures suggest, since during the latter part of the season many spent fish are caught. Thus, 40% of the fish caught in the York River were on their first spawning run, but some of these were caught after having spawned. Therefore, slightly more than 60% spawned once, although only 60% survived to return to the ocean.

TABLE 2

Spawning History by Percent for Alewife Catch in Two Areas

Spawning History	Virgin Run	1st Repeat Run	2nd Repeat Run	3rd Repeat Run	4th Repeat Run
York River	39.3	35.7	20.3	3.0	1.7
Reedville-Gwynn's Island	50.6	31.3	14.3	3.3	0.5

Spawning history of blueback herring

As mentioned earlier, there are still some unsolved problems associated with age determination of this herring. Preliminary work suggests that the bluebacks are more variable in the age at which they first enter the spawning run than are alewives. Although we cannot determine the ages of bluebacks with certainty at this time, we can determine the number of times they

have spawned. The spawning history of the blueback herring from the York River and the Reedville-Gwynn's Island area is shown in Table 3. The differences between the areas are more apparent with this herring than with the alewife. In the York River catch over 65% of the blueback herring were repeat spawners, whereas in the Reedville-Gwynn's Island area about 44% of the fish were spawning for at least the second time. In both areas some fish had escaped the fishery and returned to spawn at least six times.

TABLE 3

Spawning History by Percent for Blueback Herring in Two Areas

Spawning History	Virgin Run	1st Repeat Run	2nd Repeat Run	3rd Repeat Run	4th Repeat Run	5th Repeat Run	6th Repeat Run
York River	34.0	23.9	18.7	13.5	7.7	2.1	0.1
Reedville-Gwynn's Island	56.8	24.2	10.3	7.2	1.1	0.6	0.0

Meaning of age composition and spawning history

Fishing is not the only cause of the decline of numbers of a year class in successive years. Both kinds of herring spend at least eight months of the year at sea, and losses due to natural causes are constantly occurring. So little is known of the offshore phase of life that we cannot estimate what percentage of the loss is natural and what percentage is due to fishing.

Also, it should be emphasized that no one knows what level of escapement is necessary to insure future stocks of reasonable

size. The apparent high level of return spawners in the 1964 fishing season suggests to us that the margin of safety at the present time may be quite large. In determining the number of times a fish had spawned we have deliberately been conservative. If it were not clear whether a given fish had spawned three or four time, we took the lower figure.

The differences between the York River and the Reedville-Gwynn's Island area are as expected. The herring fishery is more intensively prosecuted in the latter area and the lower escapement is probably a reflection of this fact.

A further note of caution should be interjected at this point. We have been dealing in percentages rather than in pounds or in individuals. Therefore, a decrease in one category makes an apparent increase in another category. Our data can be interpreted in either of two ways. One interpretation is that escapement is in the range of 50-60%. The other interpretation is that the spawning success in 1960 was poorer than in 1959 and 1958; that is, that the 1960 year class was relatively small. Figs. 2 and 3 indicate that the catch in 1960 was indeed slightly less than in 1959 and 1958. We do not know to what extent the size of the catch is indicative of success of spawning. If the number of young produced is directly related to the number of adults spawning, then the escapement indicated in the preceding paragraphs could be in part the result of a weak 1960 year class. Therefore, although these preliminary data suggest that escapement is in the neighborhood of 50-60%, we must be cautious; it may be

somewhat less. Conclusive data are lacking at this time.

GROWTH OF THE ALEWIFE

Alewives go to sea at the end of their first year of life at an average length of 4 inches. They return to spawn when four years old having increased to 9.6 inches in length, a growth of 5.6 inches in 3 growing seasons. We know little about the yearly rate at which this growth occurs. After the fish become sexually mature, it is possible to catch them in their spawning runs and determine their annual growth. Table 4 shows that once alewives attain sexual maturity, growth is moderate. The gain in weight between ages 4 and 5 is approximately 12%. Of greater interest than gain in weight by one fish is the net change in the population in the course of a year. This net change results from the addition of weight by growing individuals and the subtraction of weight by natural deaths and by fishing. At the present time, we have no estimate of natural mortality (deaths not resulting from fishing) but we can predict with some confidence that the annual loss exceeds 12%. Thus we can be reasonably certain that the weight gain between ages 4 and 5 would be more than offset by natural losses during the same time period. Therefore, harvesting fish at age 4 rather than age 5 would not reduce the total weight of the catch so long as an adequate reproductive stock were allowed to spawn.

TABLE 4

Size of Alewife at Each Age in the Catch

Age	Buck Length (in.)	Buck Weight* (lb.)	Roe Length (in.)	Roe Weight* (lb.)
3	9.0	0.37	9.4	0.45
4	9.4	0.44	9.8	0.52
5	9.8	0.49	10.2	0.59
6	10.0	0.51	10.4	0.60
7	10.2	0.54	10.8	0.64
8	-	-	11.1	0.70

* Before spawning. Spent males weigh 15-20% less and spent females weigh 20-30% less.

CONCLUSIONS

Inasmuch as this is a progress report, our conclusions are tentative and subject to change with the accumulation and analysis of additional data. From the biological standpoint the fishery seems to be in sound condition. We have made no analysis of the economic condition of the fishery and do not anticipate undertaking such a study. The sample from the 1964 run indicated that the York River herring stocks could be more heavily fished. Data are insufficient to ascertain whether or not fisheries of other rivers could be intensified. An increase in fishing intensity will result in reducing the average age of fish in the catch, because greater numbers of the catch will consist of fish

on their first spawning run. Since loss of pounds of fish through natural mortality exceeds gain in pounds between ages 4 and 5, reduction of the average age of the catch could result in a slight increase in total weight of the catch.

We do not know what proportion of a run must be allowed to spawn in order to assure adequate subsequent runs.

SUMMARY

1. The Virginia Institute of Marine Science has undertaken investigations of the two species of river herring to learn if the stocks can withstand more intensive fishing than is now being exerted.

2. Although the statistical record is inadequate for historical analysis of the catch of each species, it indicates that total catch has been reasonably stable and that catch-per-unit-of-effort has increased somewhat in the last decade.

3. Much of the present confusion would be reduced if a single name were used for each species. The American Fisheries Society recommends alewife for the early-running species and blueback herring for the later-running kind.

4. In samples from the York River 60% of the alewives and 65% of the bluebacks had spawned at least once. In samples from the Reedville-Gwynn's Island area 50% of the alewives and 44% of the bluebacks had spawned at least once.

5. Alewives become sexually mature at 4 years of age. Males are then 9.4 inches in fork length and weigh 0.44 pounds; females are 9.8 inches in fork length and weigh 0.52 pounds.

6. Age-growth of the blueback herring is under study.

7. The fishery of the York River could be intensified without overfishing. Data are not sufficient to allow us to state whether the fisheries of other river systems could be intensified, but there is nothing in the records to suggest that any area is being overfished.

APPENDIX

TABLE A

Catch of River Herring for Selected Areas of the Atlantic Coast in Thousands of Pounds

Year	New England	Middle Atlantic	Maryland	Virginia	Potomac River	North Carolina
1880	-	-	9,204	6,925	-	-
1887	-	4,085	11,062	4,402	-	17,000
1888	-	3,881	11,512	6,453	-	16,000
1890	-	-	19,767	10,642	-	-
1891	-	-	17,419	11,013	-	-
1894	7,128	5,021	17,418	-	-	16,481
1896	-	-	17,667	12,198	2,565	-
1897	-	-	17,139	13,690	-	-
1901	-	5,961	13,747	13,914	2,979	-
1904	-	-	14,485	14,604	1,397	-
1908	-	-	28,805	37,885	-	-
1909	-	-	23,637	27,778	765	-
1915	-	-	12,568	16,054	684	-
1920	-	-	7,072	16,665	1,980	-
1921	-	-	6,505	18,834	1,160	-
1922	-	-	-	-	4,029	-
1923	-	-	-	-	3,722	8,989
1924	4,683	-	-	-	5,319	-
1925	-	-	7,701	17,910	2,968	-
1926	-	2,490	-	-	5,000	-
1927	-	-	-	-	4,136	13,911
1928	4,557	-	-	-	5,182	7,808
1929	4,393	1,223	5,924	12,570	2,730	10,768
1930	4,106	3,856	5,741	15,387	2,780	9,839
1931	5,162	3,615	7,827	17,239	6,961	7,994
1932	3,572	2,191	7,753	13,852	6,360	6,584
1933	2,817	1,381	6,550	19,177	6,407	-
1934	-	-	5,234	5,846	2,007	14,897
1935	4,406	555	4,229	10,974	4,234	-
1936	-	-	3,369	8,689	4,356	11,929
1937	4,207	715	3,819	15,064	2,817	5,818
1938	4,307	121	5,397	17,691	3,309	11,219
1939	3,937	244	4,398	14,831	3,065	7,714
1940	3,193	220	4,679	11,433	2,691	8,708
1941	-	-	5,061	11,951	3,387	-
1942	3,765	468	3,422	9,258	2,064	-
1943	8,156	346	-	-	-	-

TABLE A (Cont'd)

Year	New England	Middle Atlantic	Maryland	Virginia	Potomac River	North Carolina
1944	5,197	83	3,504	17,841	5,767	-
1945	2,529	365	2,584	14,619	4,216	8,022
1946	2,857	227	3,497	12,029	3,344	-
1947	2,961	425	2,746	22,173	10,398	-
1948	3,408	308	3,720	19,365	9,415	-
1949	5,067	145	4,965	22,003	11,116	-
1950	5,696	206	5,926	28,702	11,618	6,422
1951	5,150	118	6,752	32,604	14,522	12,534
1952	5,930	213	4,494	28,841	11,708	6,511
1953	8,534	170	4,653	23,976	11,206	13,842
1954	7,306	160	3,981	27,930	13,110	12,758
1955	7,336	726	5,145	21,843	9,012	12,648
1956	13,644	91	5,026	22,107	9,386	12,554
1957	23,167	72	3,410	18,758	9,118	11,773
1958	36,992	67	4,391	18,361	8,873	14,914
1959	13,678	48	4,484	17,447	7,289	14,154
1960	19,178	44	3,525	15,464	5,788	12,815
1961	22,611	51	2,444	15,526	6,000	11,951
1962	10,102	58	2,378	25,300	11,000	14,302
1963	-	-	1,466	26,085	-	-
1964	-	-	1,180	26,251	-	-

TABLE B

Number of Pound Nets and Estimated Catch of Herring per Net*

Year	No. Nets	Catch/Net
1880	162	
1883	412	
1888	550	11,723
1889	991	
1896	738	
1902	1,200	
1903	1,200	
1909	1,244	22,329
1915	2,000	8,027
1920	1,882	8,854
1929	2,190	5,739
1930	2,262	6,802
1931	2,208	7,807
1932	2,019	6,861
1933	1,880	10,200
1934	1,810	3,229
1935	2,000	5,487
1936	1,902	4,568
1937	1,656	9,097
1938	1,871	9,455
1939	1,932	7,676
1940	1,626	7,037
1941	1,515	7,888
1942	1,146	8,078
1943	-	-
1944	1,363	13,089
1945	1,332	10,975
1946	1,311	9,175
1947	1,401	15,826
1948	1,490	12,996
1949	1,293	17,017
1950	1,323	21,694
1951	1,208	26,990
1952	936	30,813
1953	858	27,944
1954	782	35,716
1955	720	30,337
1956	584	37,854
1957	685	27,384
1958	664	27,652
1959	656	26,596
1960	778	19,876
1961	796	19,505
1962	666	37,987

*Number of nets licensed or fishing prior to 1920 based on scattered estimates. After 1920 based on USFWS statistics.