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Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction (1 October, 1976 to 30 September, 1977)

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Preface

This is a joint presentation by the North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries (DMF) and the Virginia Institute of Marine Science (VIMS), Department of Ichthyology. It is for the period October 1, 1976 to September 30, 1977, and is the first of three annual reports for the P. L. 89-304 project "Biology and Management of Mid-Atlantic Anadromous Fishes Under Extended Jurisdiction."

The following jobs were contracted for by DMF and/or VIMS.

Job 1: Catch-Effort Statistics - Inshore Alosine Fishery

Objectives

1. Estimate catch-effort statistics of alosine spawning stocks.
2. Detect changes in the stocks and changes in the intensity and success of the river fishery.
3. Initiate a catch-effort river herring program for the North Carolina pound net fishery.

Agencies: DMF and VIMS

Job 2: Population Dynamics of Adults - Inshore Alosine Fishery

Objective

Determine mortality rates, age specific sizes, sex ratios, and ratios of abundance of alosine fishes from commercial fishery samples.

Agencies: DMF and VIMS

Job 3: Annual Index of Alosine Juvenile Abundance

Objective

Determine an index of abundance for each species of juvenile Alosa in Virginia and North Carolina.

Agencies: DMF and VIMS

Job 4: Assessment of the Alosine Winter and Early Spring Fishery by Drift Net and Sport Fishermen - Pilot Program

Objectives

1. Measure fishing effort and catch of adult Alosa spp. by drift gill-netters and sport fishermen.

2. Estimate basic statistics (species composition, sex ratio, age composition, etc.) of the early spawning runs of alosine fishes.

Agency: VIMS

Job 5: The Ocean Phase of Anadromous Fishes - Pilot Program

Objectives

1. Determine by inspection the species composition of the river herring catch by the foreign offshore fishery in divisions 6B and 6C of ICNAF statistical area 6.

2. Investigate by sampling: (a) the occurrence of anadromous fishes in the Atlantic Ocean from Cape Lookout, North Carolina to Little Machipongo Inlet, Virginia; (b) determine certain biological characteristics of the offshore stocks of anadromous fishes (species, sex, year-class composition, length, and weight); (c) investigate the offshore distribution of anadromous fishes in relation to temperature; and (d) sample among foreign vessels to investigate the species composition susceptible to the foreign fishery.

Agencies: DMF and VIMS

Job 6: Kepone Concentrations in Anadromous Alosine Fishes and its Possible Function as a Chemical Tag

Objectives

1. Collect adult alosine fishes returning to spawn in the major rivers of Virginia for Kepone analysis.

2. Collect young-of-the-year alosine fishes in the James River for Kepone analysis.

Agency: VIMS

Job 7: Sturgeon - A General Pilot Study

Objectives

1. Determine fishing effort and catch of the Atlantic sturgeon in Virginia.

2. Determine age structure and sex ratio of the catch, fecundity, and time of spawning in Virginia.

3. Determine distribution and migration of sturgeon offshore Virginia and North Carolina.

4. Determine if shortnose sturgeon still exist inshore in North Carolina and Virginia.

Agencies: DMF and VIMS

Job 8: Anadromous Fish Tagging

Objective

To determine migration and utilization and to make a population estimate of river herring in Scuppernong River system.

Agency: DMF

Job 9: Spawning Area Survey

Objective

To determine time and areas of spawning by anadromous fishes.

Agency: DMF

Job 10: Development of Management Alternatives

Objective

To develop, on a continuing basis, alternative management schemes to restore the anadromous fisheries and maintain them at the optimum level.

Agencies: DMF and VIMS

The North Carolina contributors were as follows: Jobs 1, 2, 3, 7, 8, and 9 by Harrel B. Johnson; Job 5 by Benjamine F. Holland, Jr. and Scott G. Keefe; and Job 10 by Michael W. Street. The Virginia contributors were: Jobs 1 and 4 by William H. Kriete, Jr.; and Jobs 2, 3, 6, and 10 by Joseph G. Loesch.

VIMS did not execute their segment of Job 5. Enactment of the 200 mile limit greatly increased the duties of NMFS, Division of Law Enforcement, and the two agencies were unable to coordinate their activities. VIMS also did not fully participate in Job 7 because the NMFS permit to investigate the endangered shortnose sturgeon was not received until mid-August, 1977.

The time and effort not expended in Jobs 5 and 7 were redirected to additional Kepone sampling (Job 6) and to a study of the diel migration of juvenile alosines (Job 3).

ACKNOWLEDGMENTS

The North Carolina Division of Marine Fisheries is indebted to the following people for their invaluable assistance: Douglas W. Crocker, John Gillikin, Captain Robert Guthrie and the crew of the R/V Dan Moore, Robert C. Harriss, Henry W. Stevens, and the fisheries inspectors of the First District.

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Finally, the researchers of both institutions wish to acknowledge the cooperation extended by many commercial and recreational fishermen.

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Job 1. Catch-Effort Statistics, Inshore Alosine Fishery

SUMMARY

North Carolina

1. The total catch of river herring for the pound net fishery in the Albemarle Sound area was 3,644,836 kg (8,035,488 lb.).
2. A peak catch occurred during week 15 when a total of 1,380,599 kg (3,043,699 lb.) of river herring was landed.
3. The total number of pound nets fished during week 15 was 624. The catch-per-unit-of-effort (c/f) for week 15 was 2,12.5 kg (4,877.7 lb.) of river herring.

Virginia

1. The 1977 fishing season was delayed several weeks because of ice conditions in the Chesapeake Bay and its tributaries.
2. Pound net effort decreased relative to 1976 while gill net effort increased.
3. The American shad and river herring c/f by pound nets increased in the Rappahannock River compared to 1976, but decreased in the Potomac River.
4. Gill net c/f for American shad decreased in the James and Potomac rivers 73% and 32%, respectively, compared to 1976, while increasing 117% and 30% in the York and Rappahannock rivers, respectively.

5. Stake gill nets in the James River caught an estimated 0.2 million kg (0.4 million lb.), a decrease of 0.4 million kg (0.9 million lb.) compared to 1976.

6. Pound nets in the York River landed an estimated 12,100 kg (26,676 lb.) of American shad and 98,300 kg (216,714 lb.) of river herring in 1977 and stake gill nets landed an estimated 141,100 kg (311,072 lb.) of American shad.

7. Pound nets in the Rappahannock River landed an estimated 4,200 kg (9,259 lb.) of American shad and 293,900 kg (647,939 lb.) of river herring in 1977. Stake gill nets yielded an estimated 24,400 kg (53,793 lb.) of American shad.

8. Pound nets in the Potomac River landed an estimated 6,200 kg (13,669 lb.) of American shad in 1977 and 0.2 million kg (0.4 million lb.) of river herring in 1977. Gill nets landed an estimated 32,400 kg (71,430 lb.) of American shad.

Job 1. Catch-Effort Statistics, Inshore Alosine Fishery

INTRODUCTION

Estimates of total landings by gear type are obtained from the product of catch-per-unit-of-effort (c/f) and the total units of gear fished.

A unit of effort (gear) can be expressed as whole units, such as pound nets or haul seine, or as a part of the whole unit such as catch per linear ft of gill net. Recently, Crochet et al. (1976), Friedersdoff (1976), Klauda et al. (1976), and Jones et al. (1976) expressed c/f as catch per million ft of net per hr, catch per 1000 ft of net per hr, catch per million yards of net per hr and catch per ft of net per hr, respectively.

The c/f and the estimated landings can also be used as a relative indicator (index) of stock abundance by a simple comparison with such estimates in prior years.

MATERIALS AND METHODS

North Carolina

In North Carolina weekly pound net landings were obtained from cooperating dealers. The number of pound nets fished each week was obtained bi-weekly. The c/f (kg/pound net week) was calculated by dividing the total number of kilograms landed by the total weekly number of active pound nets (Table 1.1).

Virginia

The 1977 catch estimates of adult alosines were computed by the method of Hoagman and Kriete (1975). Pound net catch

estimates were determined by multiplying the c/f (kg per net) of the index nets by the number of actively fishing nets (by net size) in each section of the river. Index nets are those for which daily records were kept by cooperating fishermen.

Stake gill net catch estimates were determined by multiplying the c/f of index nets by meters of stake gill netting in five mile (nautical) sections of the river.

Effort was determined by semi-monthly aerial counts of active pound nets (Table 1.2 and Fig. 1.1) and a count of stake gill nets during the peak of the American shad fishing season (Table 1.3).

RESULTS AND DISCUSSION

North Carolina

Pound net catch-effort statistics for the Albemarle Sound river herring fishery are presented in Table 1.1 for each week sampled. Weeks were serially numbered beginning with the first full week in January. No significant catches of river herring were made prior to week 9 or after week 17.

Virginia

The 1977 fishing season for adult alosine fishes was delayed several weeks because of ice conditions in the Chesapeake Bay and its tributaries. Virtually all of the pound net and gill net stands that remained at the end of 1976 were destroyed by the severe ice conditions in January 1977. Few fish were landed until the second half of March because

low water temperatures persisted through late February and delayed the spawning runs.

Prices for American shad remained high during most of the shad fishing season; however, the season was terminated prematurely by rapidly rising water temperatures. By mid-April American shad retained in gill nets more than 12 hr softened and some buyers rejected such catches for shipment to markets.

Pound net effort decreased in 1977 relative to 1976 effort. The reduction in total effort is believed to be directly related to the severe ice conditions. However, pound net effort did increase in the Potomac River.

Effort by gill netters increased in the James River but declined in the York and Rappahannock rivers. Overall effort by gill netters increased 15% relative to 1976.

Pound net c/f for American shad increased 70% in the Rappahannock River compared to 1976 (Loesch and Kriete, 1976), while the c/f in the Potomac River decreased 50%. River herring c/f of pound nets reflected an increase of 66% in the Rappahannock River and a 72% decrease in the Potomac River. While the c/f of 98 kg (216 lb.) and 4,817 kg (10,621 lb.) for American shad and river herring, respectively, on the Rappahannock River are increases over 1976, they represent only 3% of the American shad c/f and 7% of the river herring c/f by pound nets in the late 1960's for that river.

Gill net c/f for American shad decreased in the James and Potomac rivers 73% and 32%, respectively, compared to 1976.

The York and Rappahannock rivers showed an increase of 117% and 30%, respectively.

James River

No pound net records were obtained from the James River. Stake gill nets in the James River caught an estimated 0.2 million kg (0.4 million lb.) of American shad during March and April of 1977. This represents a decrease of 0.4 million kg (0.9 million lb.) compared to 1976 (Loesch and Kriete, 1976), although there was a marked increase in effort. However, the decrease in landings was attributed to large amounts of floating eel grass or algae that fouled the nets within a few hours after being set. Fishermen felt the fish were in the river, but the fouling prevented large catches.

The c/f by gill nets declined 72% for female American shad from 25.15 kg/m (16.9 lb/ft) to 6.94 kg/m (4.7 lb/ft) compared to 1976 (Loesch and Kriete, 1976). Male c/f declined 77% from 1.88 kg/m (1.3 lb/ft) to 0.43 kg/m (0.3 lb/ft) during the same period.

Peak landings of American shad occurred during the first half of April (65% of total landings) after a rather slow start in March (Table 1.4). The fishing season quickly terminated, following the peak, in the second half of April. Females accounted for 94% of the total landings (by weight) during the American shad fishing season.

York River

Pound nets in the York River landed an estimated 12,100 kg (26,676 lb.) of American shad and 98,300 kg (216,714 lb.) of river herring during the 1977 spring fishing season. This is the first year of our assessment that estimated pound net landings have been computed for the river.

The c/f for American shad by pound nets in the York River (1,309.3 kg [2,886.5 lb.]) was 13.4 times larger than the c/f in the Rappahannock River (98.07 kg [216.2 lb.]) and 10.1 times larger than the c/f in the Potomac River (1,309.3 kg [2,886.5 lb.]). The c/f by pound nets for river herring of 10,623.14 kg (23,420.0 lb.) was also greater than in either the Rappahannock or Potomac rivers.

Peak catches from pound nets of American shad and alewife occurred in the first half of May (Table 1.5). The ratio of male to female American shad (2:1) was similar to landings of pound nets in the Rappahannock River. However, the ratio of blueback to alewife landed was much higher in the York River (8.5:1 vs. 2.5:1).

Stake gill net effort decreased in 1977 compared to 1976 (Loesch and Kriete, 1976), while estimated landings of American shad increased 49% from 72,200 kg (159,174 lb.) in 1976 to 141,100 kg (311,072 lb.) in 1977. Peak landings occurred in the second half of March (Table 1.6). Few males were landed after April 1, probably due to a change in mesh size from 12.38 cm-12.70 cm (4 7/8 inches-5 inches) to 13.34 cm-13.97 cm

(5 1/4 inches-5 1/2 inches), a practice by fishermen to cull the less marketable males.

The overall c/f by stake gill nets in the York River for American shad increased 117% compared to 1976 c/f, the largest increase of any river surveyed, from 3.73 kg/m (2.3 lb/ft) to 7.30 kg/m (4.9 lb/ft)(Loesch and Kriete, 1976). The decrease of 49% in c/f of males, offset by an increase of 135% for females reflects the above mentioned shift in gill net mesh sizes.

Rappahannock River

Pound nets in the Rappahannock River landed an estimated 4,200 kg (9,259 lb.) of American shad, 84,700 kg (186,732 lb.) of alewife and 209,200 kg (461,207 lb.) of blueback from March through May. Peak landings of all species occurred in the first half of April (Table 1.7). The apparent increase in landings of all species for 1977 compared to 1976 (Loesch and Kriete, 1976) may not be as large as it appears, because nets below mile 10 were added into the calculations for 1977. Prior to 1977, only those nets above mile 10 were included.

The c/f for American shad and river herring increased 70% and 66%, respectively. The male shad c/f increased 218% from 21.58 kg (47.6 lb.) to 68.58 kg (151.2 lb.) while female shad c/f declined 18%. The alewife c/f of 1,788.05 kg (3,942.0 lb.) and blueback c/f of 3,029.70 kg (6,679.3 lb.) represent increases of 60% and 72%, respectively, but are still far below prior years.

Stake gill nets yielded an estimated 24,400 kg (53,793 lb.) of American shad, an increase of 22% over 1976 (Table 1.8). Peak landings occurred during the second half of March and first half of April representing 79% of the total landings for stake gill nets in the Rappahannock River.

As in 1976, most stake gill nets were set primarily to capture striped bass. Meshes (15.24-22.86 cm [6-9 inches]) were too large to effectively capture American shad. In 1977, no nets above mile 35 and only 60% of the nets below mile 35 were set primarily for the capture of American shad (personal communication via J. Owens).

Although the c/f for American shad did increase 30% over 1976, it represents only about 25% of the c/f in both the James and York rivers. Following the pattern in the York River, the c/f of male shad declined from 0.18 kg/m (0.1 lb/ft) to 0.17 kg/m (>0.1 lb/ft), while the c/f of female shad increased from 1.20 kg/m (0.8 lb/ft) to 1.62 kg/m (1.1 lb/ft).

Potomac River

Pound nets landed an estimated 6,200 kg (13,669 lb.) of American shad, a decrease of 33% compared to 1976 (Loesch and Kriete, 1976), with the greatest proportion of the decrease attributed to landings of females (Table 1.9). River herring landed by pound nets decreased from 0.5 million kg (1.1 million lb.) in 1976 to 0.2 million kg (0.4 million lb.) in 1977, a reduction of 63%.

Since logbooks are not obtained from Potomac River fishermen, c/f is derived from total landings divided by gear (number of licenses sold for that year). This eliminates comparisons of data with other rivers because effort is measured differently (net count vs. total net length).

The c/f for American shad and river herring also decreased drastically relative to 1976 (Loesch and Kriete, 1976). The c/f for shad declined from 259 kg (571 lb.) to 130 kg (281 lb.) with the greatest portion (57%) of the decrease attributed to the male American shad c/f. River herring c/f decreased from 15,939 kg (35,140 lb.) in 1976 to 4,472 kg (9,858 lb.) in 1977. The largest portion of the decrease (82%) in river herring c/f was attributed to alewife c/f.

Total shad landings by stake gill nets continued a decline which began in 1975. Of the 32,400 kg (71,430 lb.) landed by gill nets, 20,300 kg (44,754 lb.) were attributed to stake gill nets, 8,900 kg (19,621 lb.) to anchor gill nets and 3,100 kg (6,834 lb.) to drift gill nets. Only catches by the latter type gill net increased relative to 1976 (Table 1.9). Peak landings by all gill net gear occurred during the month of April.

The c/f of stake and anchor gill nets for American shad declined relative to 1976 (Loesch and Kriete, 1976), and drift gill net c/f increased slightly. The c/f of American shad by stake gill nets declined from 90.43 kg (199.4 lb.) to 68.49 kg (151.0 lb.). Anchor gill net c/f exhibited the greatest decline (43%) compared to stake gill nets, from 23.01 kg

(50.7 lb.) to 13.08 kg (28.8 lb.). Eighty-seven percent of the decrease in anchor gill net c/f was attributed to a decrease in landings of males. The overall drift gill net c/f for American shad increased from 84.74 kg (186.9 lb.) to 89.85 kg (198.1 lb.), yet the c/f for males decreased 35%. However, the increase in c/f for females compensated for the decreased male c/f to reflect an overall increase for the year.

A change in mesh sizes of anchor gill nets is reflected in the American shad ratio of females to males landed. The ratio of 9.4:1, females to males, as opposed to 1.5:1 in 1976 reflects a switch to slightly larger netting to cull the smaller, less valuable males.

Although there was an increase of river herring landed by gill nets relative to 1976, their catch is still insignificant compared to pound net landings.

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Table 1.1. Catch-effort statistics for river herring taken in the North Carolina pound net fishery.

Week	Weekly Landings (kg)	Number of Pound Nets	c/f(kg)
9	5,563	348	16.0
10	16,242	542	30.0
11	91,018	428	212.7
12	69,483	530	131.1
13	417,627	544	767.7
14	592,119	615	962.8
15	1,380,599	624	2,212.5
16	951,130	620	1,534.1
17	121,055	603	200.8
Total	3,644,836		

Table 1.2. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during January-June, 1977.

Area		Jan. 15	Feb. 25	Mar. 14	Mar. 25	Apr. 15	May 16	June 2	June 20
A	James R.	0	0	0	0	0	1	1	1
B	Back R.	0	0	3	4	7	5	6	6
C	Poquoson R.	0	0	0	0	0	0	0	0
D	York R.	0	0	3	3	11	10	13	12
E	Mobjack Bay	0	0	1	2	7	6	7	7
F	Piankatank R.	0	0	1	2	2	3	5	4
G	Rappahannock R.	0	0	30	46	50	46	41	35
H	Great Wicomico R.	0	0	1	3	6	6	6	5
I	Potomac R.	0	0	11	22	56	65	62	73
J	Cape Henry to Fort Wool	2	2	2	2	3	4	4	3
K	Old Point to Tue Marsh	0	0	5	5	8	7	7	4
L	York Spit	0	0	1	1	3	2	4	4
M	New Point to Stingray Point	0	0	1	5	19	18	16	20
N	Windmill Point to Smith Point	0	0	2	15	36	41	39	41
O	Above Hungar Creek	0	0	0	0	0	0	0	0
P	Below Hungar Creek	0	3	2	2	15	21	24	21
	Total	2	5	63	112	223	235	235	236

Table 1.3. Number of stake gill net stands fished in Virginia rivers 1975-1977 (A) and number of linear meters per five mile block (B) in 1977. Figures in parentheses represent nets set for American shad.

A.

River System	Number of Gill Net Stands 1975	1976	1977
James	148	113	168
York	146	140	123
Rappahannock	121	127	121

B.

River	Mile	Number of Stands	Number of Sections	Average Length/Section	Total Meters
James	05-10	37	808	9	7,388
	10-15	5	61	9	558
	15-20	74	1,278	9	11,686
	20-25	38	601	9	5,496
	25-30	6	74	9	677
	30-35	8	118	9	1,079
	Total	168	2,940		26,884
York	05-10	8 + 274 m AGN(a)	139	9	1,545
	10-15	53	1,105	9	10,104
	15-20	32	485	9	4,435
	20-25	8	161	7	1,178
	25-29	22	366	6	2,064
	Total	123	2,256		19,326
Rappa-hannock	20-25	6	110	18	2,012 (1,207)
	25-30	32	724	18	13,241 (7,944)
	30-35	21	405	18	7,407 (4,444)
	35-40	18	463	13	6,068
	40-45	12	233	13	3,054
	45-50	14	241	13	3,159
	50-55	8	98	13	1,284
	55-60	8	57	13	747
	60-65	1	3	13	39
	65-70	1	3	13	39
	Total	121	2,337		37,050

(a) AGN = Anchor Gill Net

Table 1.4. Estimated catch of American shad by stake gill nets for 5-mile sections in the James River 1977 in kg, by half-month intervals and by sex. Effort from Table 1.3B. Index in kg/m of net.

		American Shad				
		Male		Female		Total
Half-Month Period	River Mile	Index	Estimated Catch	Index	Estimated Catch	Estimated Catch
Mar. 1st	05-10	[.1117]	825	[.5402]	3,991	4,816
	10-15		62		301	363
	15-20	[.0804]	939	[.4956]	5,791	6,730
	20-25		442		2,724	3,166
	25-30		54		336	390
	30-35		87		535	622
Total			2,409		13,678	16,087
Mar. 2nd	05-10	[.1057]	781	[.8527]	6,300	7,081
	10-15		59		476	535
	15-20	[.1309]	1,530	[1.0507]	12,278	13,808
	20-25		719		5,775	6,494
	25-30		89		711	800
	30-35		141		1,134	1,275
Total			3,319		26,674	29,993
Apr. 1st	05-10	[.1205]	890	[5.3561]	39,571	40,461
	10-15		67		2,989	3,056
	15-20	[.1815]	2,121	[4.3157]	50,433	52,554
	20-25		998		23,719	24,717
	25-30		123		2,922	3,045
	30-35		196		4,657	4,853
Total			4,395		124,291	128,686
Apr. 2nd	05-10	[.0491]	363	[.8632]	6,377	6,740
	10-15		27		482	509
	15-20	[.0580]	678	[.7917]	9,252	9,930
	20-25		319		4,351	4,670
	25-30		39		536	575
	30-35		63		854	917
Total			1,489		21,852	23,341
Total by Sex			11,612		186,495	
Grand Total						198,107

Table 1.5. Estimated catch of American shad and river herring by pound nets in the York River 1977 in kg, by half-month intervals.

Half-Month Period	Number Nets	American Shad				River Herring						Total Number Days Index Nets Hauled	Number of Index Nets
		Female		Male				Alewife		Blueback			
		Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total		
Mar. 2nd	3	107.3	322	127.9	384	193	579	50	289	50	290	3	2
Apr. 1st	11	211.2	2,323	356.3	3,919	1,999	21,989	41	9,015	59	12,974	14	5
Apr. 2nd	11	44.9	494	232.2	2,554	2,471	27,181	1	272	99	26,909	15	5
May 1st	10	7.3	73	105.3	1,053	3,319	33,190	1	332	99	32,858	12	5
May 2nd	10	.5	5	88.5	885	1,435	14,350	0		100	14,350	14	5
June 1st	13			7.6	99	75	975	40	390	60	585	5	3
			3,217		8,894				10,298		87,966		
				12,111			98,264						

Table 1.6. Estimated catch of American shad by stake gill nets for 5-mile sections in the York River 1977 in kg, by half-month intervals. Effort from Table 1.3B. Index in kg/m of net.

Half-Month Period	River Mile	American Shad Male Index	American Shad Male Estimated Catch	American Shad Female Index	American Shad Female Estimated Catch	Total Estimated Catch
Mar. 1st	05-10	[.0583]	90	[1.6744]	2,587	2,677
	10-15		589		16,918	17,507
	15-20		259		7,426	7,685
	20-25	.0654	77	1.7258	2,033	2,110
	25-29	.1890	390	1.8067	3,729	4,119
Total			1,405		32,693	34,098
Mar. 2nd	05-10	[.0472]	73	[2.4511]	3,787	3,860
	10-15		477		24,766	25,243
	15-20		209		10,871	11,080
	20-25	.1248	147	4.0603	4,783	4,930
	25-29	.4138	854	7.3779	15,228	16,082
Total			1,760		59,435	61,195
Apr. 1st	05-10	[.0032]	5	[1.8621]	2,877	2,882
	10-15		32		18,815	18,847
	15-20		14		8,258	8,272
	20-25	.0518	61	2.6307	3,099	3,160
	25-29	.0402	83	4.0877	8,437	8,520
Total			195		41,486	41,681
Apr. 2nd	05-10	[None		[	228	228
	10-15	Report-		.1476	1,491	1,491
	15-20	ed]		]	655	655
	20-25	.0136	16	1.3557	1,597	1,613
	25-29	None Reported		.0790	163	163
Total			16		4,134	4,150
Total by Sex			3,376		137,748	
Grand Total						141,124

Table 1.7. Estimated catch of American shad and river herring by pount nets in the Rappahannock River 1977 in kg, by half-month intervals.

Half-Month Period	Mile	Number Nets	American Shad: Female Index	American Shad: Female Estimated Total	American Shad: Male Index	American Shad: Male Estimated Total	River Herring Index	River Herring Estimated Total	Alewife Percent	Alewife Estimated Total	Blueback Percent	Blueback Estimated Total	Total Number Days Index Nets Hauled	Number of Index Nets
Mar. 1st	0-30	9	1.8	68	0.4	4	28.8	259	100	259	0		6	4
	31-55	21	8.3	174	5.5	116	210.8	4,427	100	4,427	0		12	14
Mar. 2nd	0-30	20	9.1	182	3.8	76	45.6	912	75	684	25	228	7	5
	31-55	26	5.1	133	17.1	445	974	25,324	93	23,551	7	1,773	12	18
Apr. 1st	0-30	28	7.6	213	11.7	328	3,440	96,320	9	8,669	91	87,651	9	5
	31-55	22	8.7	191	19.7	433	2,170.5	47,751	50	23,876	50	23,875	12	18
Apr. 2nd	0-30	28	6.0	168	6.7	188	1,633	45,724	17	7,773	83	37,951	8	5
	31-55	22	3.4	75	16.7	367	3,033.2	66,730	22	14,681	78	52,049	14	18
May 1st	0-30	30	2.4	72	9.1	273							5	3
	31-55	22	0.4	9	22.7	499	291.1	6,404	12	768	88	5,636	7	9
May 2nd	0-30	31	(a)		3.6	112	(a)						2	1
	31-55	14	2.5	35	7.7	108	(a)						2	2
				1,268		2,949				84,688		209,163		
					4,217			293,851						

(a) None reported by index fishermen

Table 1.8. Estimated catch of American shad by stake gill nets in the Rappahannock River 1977 in kg, by half-month intervals. Effort from Table 1.3 B. Index in kg/m of net.

Half-Month Period	River Mile	American Shad Male Index	Male Estimated Catch	Female Index	Female Estimated Catch	Total Estimated Catch
Mar. 1st	20-25	[.0124]	15	[.1044]	126	141
	25-30		99		829	928
	30-35		55		464	519
	35-70 (a)					
Total			169		1,419	1,588
Mar. 2nd	20-25	[.0837]	101	[.6098]	736	837
	25-30		665		4,844	5,509
	30-35		372		2,710	3,082
	35-70 (a)					
Total			1,138		8,290	9,428
Apr. 1st	20-25	[.0447]	54	[.6694]	808	862
	25-30		355		5,318	5,673
	30-35		199		2,975	3,174
	35-70 (a)					
Total			608		9,101	9,709
Apr. 2nd	20-25	[.0282]	34	[.2386]	288	322
	25-30		224		1,895	2,119
	30-35		125		1,060	1,185
	35-70 (a)					
Total			383		3,243	3,626
Total by Sex			2,298		22,053	
Grand Total						24,351

(a) None reported by index fisherman

Table 1.9. Total catch of alosine fishes by gill nets (A) and pound nets (B) in the Potomac River 1977 in kg.

A. Stake Gill Nets

Months	American Shad Female	American Shad Male	River Herring Alewife	River Herring Blueback
March	1,120	335	244	49
April	17,239	1,034	10	33
May	565	33	0	1
Total	18,924	1,402	254	83
Grand Total	20,326		337	

Anchor Gill Nets

January	0	0	1	0
February	0	0	0	0
March	2,348	436	5	1
April	5,698	414	1	2
May	11	6	0	0
Total	8,057	856	6	3
Grand Total	8,913		9	

Stake & Anchor Gill Nets
(not reported separately by fishermen)

March	67	1
April	15	35
Total	82	36
Grand Total	118	

Drift Gill Nets (allowed only during April and May)

Months	American Shad Female	American Shad Male	River Herring Alewife	River Herring Blueback
April	1,980	329	39	137
May	665	81	1	8
Total	2,645	410	40	145
Grand Total	3,055		185	

Total of Gill Nets by Species

	29,708	2,704	300	231
Grand Total	32,412		531	

B. Pound Nets

March	73	43	2,896	583
April	1,557	676	29,399	104,232
May	816	2,504	2,155	71,464
June	12	552	221	3,682
Total	2,458	3,775	34,671	179,961
Grand Total	6,233		214,632	

Total by Species, All Gear Combined

	32,166	6,479	34,971	180,192
Grand Total	38,645		215,163	

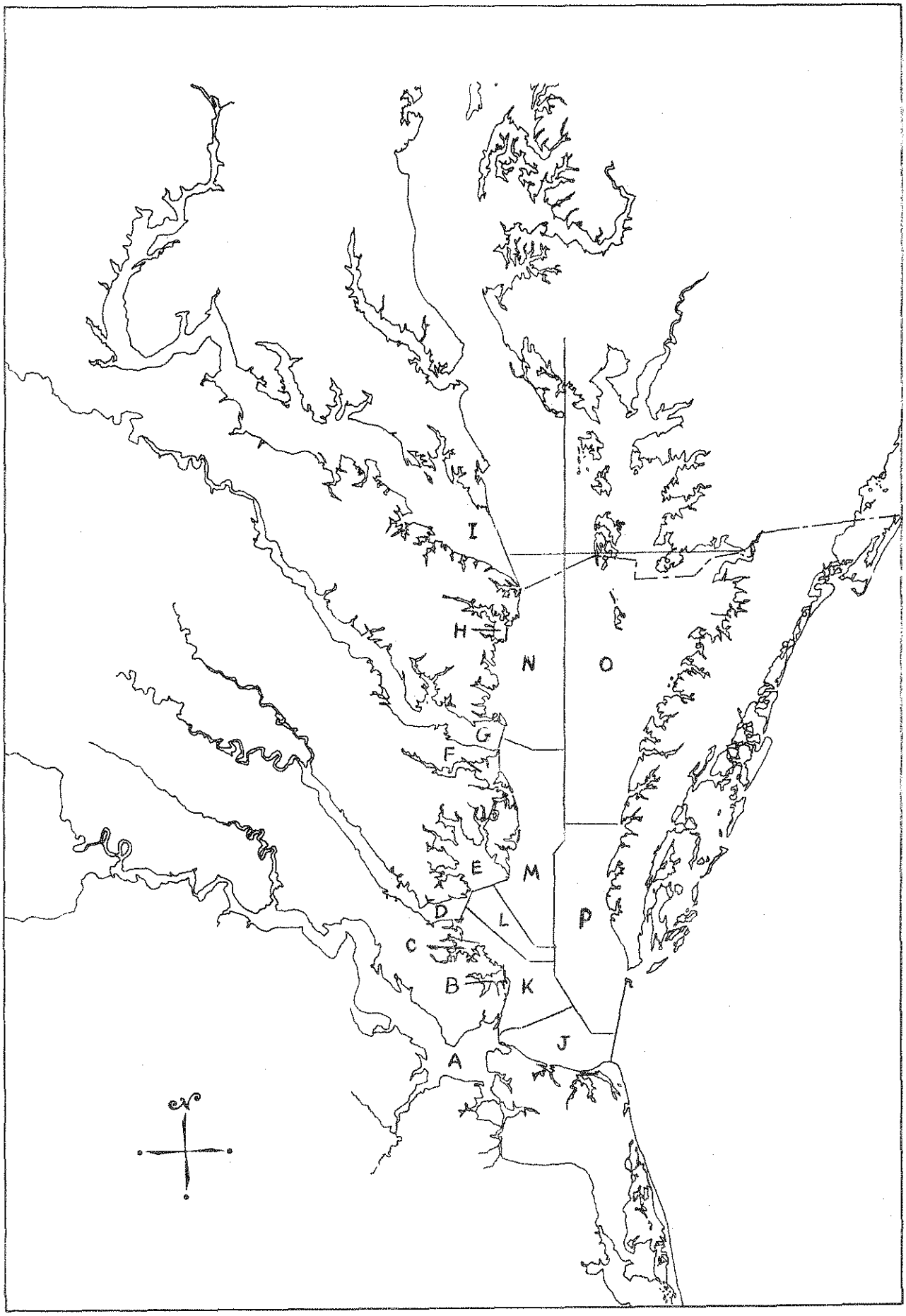

Figure 1.1. Area designations utilized during aerial pound net counts.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

SUMMARY

North Carolina

1. Blueback herring comprised 96% of the river herring samples in 1977, although alewife dominated the earliest catches.
2. The male to female sex ratio for blueback herring was 1.09:1, while that for alewife was 1.14:1.
3. The age ranges for male and female blueback herring were age 3 to age 8 and age 4 to age 8, respectively.
4. Ages 4, 5, and 6 constituted 96% of the male blueback herring and 99% of females sampled.
5. The 1977 spawning population of blueback herring was composed of 80% virgin males and 74% virgin females.
6. The age ranges for male and female alewife were age 3 to age 7 and age 3 to age 8, respectively.
7. Ages 4, 5, and 6 constituted 98% of the male alewife and 97% of the females sampled.
8. The 1977 spawning population of alewife was composed of 78% virgin males and 77% virgin females.
9. The age ranges for both male and female American shad were age 4 to age 7. Ages 4 and 5 comprised 88% of the males sampled, while ages 5 and 6 constituted 96% of the females sampled.
10. Hickory shad ages ranged from 4 to 7 years for both sexes. Eighty-five percent of the hickory shad (sexes combined) sampled were virgin fish.

Virginia

1. The Virginia river herring landings of 630 metric tons were a record low and only 37% of the previous record low in 1976.
2. Age structure analysis showed that there was extremely poor recruitment in 1977. This was the second successive year that the usually dominant age 4 fish failed to enter the fishery.
3. The dominant age group increased for the second successive year. Alewife data indicated a co-dominance of ages 5 and 6; the modal group of blueback was age 6. The upward shift is due to a paucity of younger fish rather than the presence of strong year classes of older fish. Precocious age 3 river herring, often a harbinger of successful recruitment the next year, were not present in the 1977 samples.
4. The mean number of spawning checks for alewife was approximately 0.4 and about 0.6 for blueback herring. Although gill nets select for larger and older American shad, 83% of the females were virgin spawners. It is not known if the low frequency of repeat spawners reflects a biological constraint or low escapement from the fishery.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

INTRODUCTION

Sensible fishery management necessitates a body of knowledge concerning the dynamics of fish populations (Ricker, 1977). Toward this end, the North Carolina Division of Marine Fisheries (DMF) and the Virginia Institute of Marine Science (VIMS) has continued its annual assessment of the structure of adult alosine populations.

MATERIALS AND METHODS

North Carolina

Commercial harvest sampling sites were the same as the six stations established during Project AFCS-11 (Johnson et al., 1977)(Fig. 2.1). Data collected at each of the established sites were assumed to be representative of total commercial landings in the Albemarle Sound area. Sampling sites were visited each week beginning in mid-February and continuing until catches dropped to a level which did not produce sufficient samples to warrant sampling. Types of gear used by fishermen included anchor gill nets, haul seines, and pound nets.

Data from each site were obtained from unculled samples of the day's catch, when possible, for determining species composition and sex ratios. If an unculled sample was not available, data were recorded from as many fish as possible without interruption of normal operations of the fishermen and

dealers. Although sample size often varied with the numbers of fish, samples usually did not exceed 100 fish.

Fork lengths (FL) were measured to the nearest millimeter (mm) and scales were taken and processed in the same manner as described previously in the AFCS-8 Project Completion Report (Street et al., 1975).

Virginia

Sampling of the Virginia alosine commercial fisheries commenced in early March, 1977, and continued weekly for river herring and semi-monthly for American shad until the near cessation of the runs in late June.

When available, 23 kg (50 lb.) of river herring were randomly sampled from commercial pound net or fyke net catches. These nets employ a 50.8 mm (2 inches) stretched mesh in their entrapment section. This mesh size, required by Virginia law for these nets when taking "food fish", is assumed nonselective for river herring age 3 and older.

Random samples of 50 (or less) American shad were taken from commercial catches. The fishery primarily employs gill nets with mesh sizes which favor the capture of females, the larger of the sexes. Employment of large mesh nets, in addition to biasing the sex ratio, results in overestimates of the parameters of mean length, mean weight, proportion of older fish and the proportion of repeat spawners.

River herring samples were returned to VIMS where they were sorted by species and sex, body length and weight recorded

and scales removed from random subsamples. American shad data were collected at the sampling site, except for age and spawning frequency data which were derived from subsequent scale analysis. Ages of all species were determined by the method Cating (1953) employed with American shad, i.e., counting the number of annuli and spawning check marks, and adding a year for the scale edge. Beal (1968) and Marcy (1969) found the method applicable for river herring. During the 1977 spawning season, 2,049 alewife, 5,262 blueback, and 940 American shad samples were taken (Table 2.7).

Domestic river herring landing data for the years 1966-1972 were obtained from the respective U.S. Fishery Statistical Bulletins; subsequent data were from the annual summaries of Current Fisheries Statistics, NMFS, Division of Statistics and Market News. Offshore foreign landing data were obtained from the respective ICNAF Statistical Bulletins.

RESULTS AND DISCUSSION

North Carolina

River Herring Composition

Weekly river herring sampling for species composition began in mid-February; for consistency, weeks were numbered as in Job 1. Unculled samples of commercial catches were taken at sites on the Scuppernong River, Chowan River, and tagging operations in lower Scuppernong River. All early catches of river herring were dominated by alewife; blueback herring became the dominant species at approximately mid-season (11-12th week;

Fig. 2.2). These data agree closely with those reported by Street et al. (1975) and Johnson et al. (1977).

Data taken from tagging operations in the lower Scuppernong River probably best estimated species composition since these are the results of direct counts of all fish captured. However, data taken from sites on the Scuppernong and Chowan rivers were limited, usually about 100 fish per sample. Species composition for the entire 1977 season determined from tagging operations in the lower Scuppernong River was 96% blueback herring and 4% alewife.

Sex Ratios - river herring

Sex ratios were obtained from combined data taken at sites located on the Scuppernong, Chowan, Alligator and Meherrin rivers during 1977. Pound nets at these sites are believed to be nonselective. During 1977 the male to female sex ratios were 1.09:1 for blueback herring and 1.14:1 for alewife. Chi square (χ^2) analysis of the hypothesis of a 1:1 sex ratio indicated that the alewife ratio was significantly different ($P<0.05$) but the blueback herring ratio was not ($P>0.10$).

Sex Ratios - American shad

A sex ratio of 1.34:1 (males to females) was obtained from the pooled data of all samples. The χ^2 value of 8.68 was highly significant ($P<0.005$). The estimated sex ratio, however, is biased because the gill nets employed are selective for females.

Sex Ratios - hickory shad

Sex ratios for hickory shad were also obtained from the pooled data. The male to female sex ratio was 1:1.07. A χ^2 value of 0.28 was highly insignificant (P>0.50). Again it should be noted that gill nets are the predominant fishing gear for hickory shad, and thus are selective for the larger females.

Mortality

Survival estimates for 1977 were computed by using the Robson and Chapman methods (Ricker, 1975). Robson and Chapman showed that estimates of annual rates of survival can be made from the catch curve of a single season if the population is exposed to unbiased fishing gear beyond the age of recruitment, and if year-class strength and survival rate remain constant from year to year. Assuming these two characters as constant, survival rates of alewife, blueback herring, American shad, and hickory shad, were computed using the formula:

$$S = \frac{T}{\Sigma N + T - 1}$$

where: $T = N_1 + 2N_2 + 3N_3 + \ldots;$

$\Sigma N = N_0 + N_1 + N_2 + \ldots;$

N_t = number in the t th age group

Mortality rates were calculated as the difference between the survival rate and unity.

In this procedure the initial age in the data (age III - 0) cannot be used since significant recruitment of that year class

has not occurred, instead the data for age IV - 0 must be coded to 0, V - 1 coded to 1, etc. This will probably make the survival rates lower and the mortality rates higher.

Mortality estimates for blueback herring during 1977 were 60%, a value very similar to that by Street et al. (1975).

Mortality estimates for alewife during 1977 were found to be 72% and agree closely with data presented during AFCS-8 and AFCS-11 by Street et al. (1975) and Johnson et al. (1977).

Total mortality for American shad during 1977 was calculated to be 82%.

The 1977 mortality for hickory shad was also 82%.

Age and Spawning Class Composition

Data for age and spawning class composition of the total commercial harvest, and the commercial harvest of each of the areas sampled are presented in Tables 2.1 through 2.6 and Figures 2.3 through 2.14.

The present data were found to agree, in general, with that reported by Street et al. (1975) and Johnson et al. (1977).

The Alligator River data are probably biased because fishermen there were only active during the early part of the 1977 season.

A total of 1,009 blueback herring scale samples was found suitable for age determination. Ages of males were found to range from 3 to 8 years, while females ranged from 4 to 8 years in age (Table 2.1). Age groups 4, 5, and 6 made up 96% of the

female samples and 99% of the male samples. These values are much higher than those reported in AFCS-8 but similar to those reported in AFCS-11, indicating a lack of older fish in 1977. Combined data from all sampling locations show a spawning population comprised of 80% virgin males and 74% virgin females. Scales sampled from female blueback had up to four spawn marks, while those sampled from males had up to three spawn marks; however only 1% of the fish had spawned more than twice. This is lower than the 4.4% reported by Street et al. (1975) and the 2% reported by Johnson et al. (1977). The proportion of repeat spawners (sexes combined) was 23%.

Data for 1977 for each of the areas sampled in the commercial harvest surveys showed much the same situation as reported in AFCS-8 and AFCS-11. The spawning population in the Scuppernong River was composed of 72% virgin fish (sexes combined, Fig. 2.4). The proportion of virgin fish is similar to the 80% virgin fish in the Scuppernong River reported by Street et al. (1975) and lower than the 87% reported by Johnson et al. (1977). Ages for male blueback herring in the Scuppernong River ranged from 3 to 5 years, while females ranged from 4 to 6 years; but, only 3% of the fish (sexes combined) were over age 5 (Table 2.2). This is higher than that reported in AFCS-11 and lower than the reported 5.3% in AFCS-8.

Data collected from the haul seine fishery of the Meherrin River (Table 2.3) showed, for both sexes, that virgin fish

comprised 84% of the spawning blueback population which is much higher than the 49% reported by Johnson et al. (1977). Ages for males ranged from 4 to 7 years, while females ranged from 4 to 8 years. Data showed that 6% (sexes combined) had spawned more than once (Fig. 2.5).

Approximately 85% of the total landings of river herring in Albemarle Sound are made by the pound net fishery of Chowan River. Consequently, data from the Chowan River sample site (Fig. 2.1) are more likely to reflect population parameters of the total river herring run in Albemarle Sound.

Data for the Chowan River showed that 76% of the blueback herring were virgin fish (sexes combined, Fig. 2.6). Ages of males ranged from 4 to 7 years, while ages of females ranged from 4 to 8 years. Age groups 4, 5, and 6 made up 99% of the male sample and 94% of the female sample (Table 2.4). Seven percent of the sample (sexes combined) were found to have spawned more than once.

Combined data for Alligator River, although probably not truly representative of the spawning population of that system, showed that 74% (sexes combined) of the blueback herring in that system were virgin fish (Fig. 2.7). Ages ranged from 4 to 8 years for males and 4 to 7 for females. Age groups 4 and 5 comprised 90% of the male sample and 82% of the female sample. Twenty-six percent of the sample (sexes combined) had spawned previously (Table 2.5).

A total of 965 alewife were found suitable for age determination. Combined data for 1977 for all sample sites are

presented in Table 2.1 and agree closely with data presented in the AFCS-8 and AFCS-11 completion reports. Ages of male alewife ranged from 3 to 7 years, while ages of female alewife ranged from 3 to 8 years. Age groups 4, 5, and 6 made up 98% of the male proportion of the sample and 97% of the female proportion of the sample.

Combined data from all locations indicate a spawning alewife population composed of 78% virgin males and 77% virgin females. Scales from male samples had up to two spawn marks, while scales from females had up to three spawn marks. Four percent of the alewife (sexes combined) were found to have spawned more than once (Fig. 2.8).

It was estimated that approximately 85% of the alewife landings in the Albemarle Sound area occur in the Chowan River; therefore, Chowan River samples probably best represent the Albemarle Sound area.

Ages of male and female alewife from the Scuppernong River ranged from 4 to 6 years (Table 2.2). Ages 4 and 5 comprised 98% of the male and female samples. Data showed that 70% (sexes combined) of the fish were virgins (Fig. 2.9). Thirty percent (sexes combined) had spawned previously.

Again, as during 1976, alewife samples were obtained from the Meherrin River. Ages for male alewife ranged from 3 to 6 years, and 3 to 7 years for females. Eighty-three percent of the sample (sexes combined) were virgins (Table 2.3). Only 5% of the fish (sexes combined) had spawned more than once (Fig. 2.10).

Alewife from the Chowan River ranged in age from 3 to 7 years for males and 4 to 8 for females (Table 2.4). Virgin fish comprised 86% (sexes combined) while only 4% of the fish (sexes combined) had spawned more than once (Fig. 2.11). This is much lower than the 23% reported in AFCS-11 by Johnson et al. (1977). As previously stated, these data are probably the most representative age and spawning class data for Albemarle Sound alewife.

Samples taken from Alligator River showed that ages of male alewife ranged from 4 to 6 years, while alewife females ranged from 4 to 8 years (Table 2.5). Seventy-two percent of the sample (sexes combined) were virgins and only 7% (sexes combined) had spawned more than once (Fig. 2.12).

The gill net fishery in Albemarle Sound accounts for approximately 95% of the American shad taken from that area; the remainder were captured incidental to the pound net fishery for river herring. A total of 401 scale samples were found suitable for age determination. Data for 1977 are presented in Table 2.6. Ages ranged from 4 to 7 years. Age groups 4 and 5 comprised 88% of the male sample, while age groups 5 and 6 comprised 96% of the female sample. The American shad population was comprised of 92% virgin fish (sexes combined, Fig. 2.13), a much higher value than reported in AFCS-11. Data showed that only 1% (sexes combined) had spawned more than once. It should be noted that considerable concern

has developed because of declining landings of American shad in the southeastern states.

Scales from a total of 220 hickory shad were found suitable for determining age and spawning history. Data are presented in Table 2.6. Ages ranged from 4 to 7 years for both males and females. Data showed that 85% of the sample (sexes combined) were virgin fish. Only 3% of the sample (sexes combined) had spawned more than once (Fig. 2.14). Again, data for AFCS-9 generally agree with that in AFCS-11 by Johnson et al. (1977) and in AFCS-8 by Street et al. (1975) except that the proportion of virgin fish (sexes combined) seemed to be somewhat higher.

Virginia

River Herring Landings

The 1977 Virginia river herring landings of 630 metric tons were only 34% of those in 1976 (Table 2.8). In turn, the landings in 1976 were only 37% of the mean landings for the previous 5 years. A general decline in Virginia landings starting in 1970 was attributed to the heavy exploitation of river herring by the foreign offshore fishery in the late 1960's (Hoagman et al., 1973). Declining river herring landings may also be attributed to poor recruitment; strong recruitment to the fishery has not occurred since the 1966 year class first became vulnerable in 1969.

The precipitous drop in landings in 1976 was attributed to the decimation of the 1972 year class by Tropical Storm Agnes (Loesch and Kriete, 1976). The paucity of 4-year-old river herring in the 1977 landings indicates that the 1973 year class also was extremely weak and, in conjunction with the weak 1972 year class, was responsible for the further decline in Virginia landings in 1977.

It is recommended that a contingency management plan for river herring be formulated by the Virginia Marine Resources Commission in the event that the estimated strong 1975 year class (Hoagman and Kriete, 1975) does not materialize in the fishery in 1979.

Age Composition and Spawning Frequency

Historical data of Virginia river herring age structure (Hoagman and Kriete, 1975) show, in general, that age 4 river herring were the dominant (modal) age group. Occasionally, a strong year class at age 5 was dominant, or co-dominant with age 4 fish, e.g. the 1966 year class. In 1974 and 1975 the commercial catch consisted primarily of age 4 fish (Loesch and Kriete, 1976); however, in 1976, relatively few of the 1972 year class (assumed decimated by Tropical Storm Agnes) entered the fishery. Age frequency data in 1977 (Tables 2.9-2.18) also indicate extremely poor recruitment by the 1973 year class.

The dominant alewife age group shifted from age 4 to age 5 in 1976; the blueback modal age rose to age 5 and/or age 6, varying with sex and river (Loesch and Kriete, 1976). There was a further increase in the age of the dominant year class in 1977. The alewife data indicate a co-dominance of ages 5 and 6 while the modal group of blueback was exclusively age 6 (Table 2.19).

The increased age of dominant year class may be an anticipatory sign of a further decline in Virginia river herring abundance because the shift is due to a paucity of young fish rather than the presence of strong year classes of older fish. In addition, the low percentages of precocious 3-year-olds in the 1974, 1975, and 1976 commercial samples (Loesch and Kriete, 1976) and their complete absence in the 1977 samples (Tables 2.9-2.18) may also portend a further decline in abundance. Historical data for Virginia river herring (Hoagman and Kriete, 1975) indicate that strong year classes, i.e., those whose strong relative abundance persisted through ages 5 and 6, were preceded by a relatively strong 3-year-old representation in the fishery. Hoagman and Kriete (1975) estimated an extremely strong 1975 blueback year class, so its abundance at age 3 in the 1978 fishery might be a harbinger of the degree of expected recruitment to the fishery in 1979 and 1980.

The age increase in the dominant year class was accompanied by an age increase in the modal group of virgin spawners. Age 4 river herring were the dominant virgin spawners, prior to 1976.

In 1976 the modal virgin group advanced to age 5 and/or age 6 (Loesch and Kriete, 1976) and it remained at that level in 1977 (Tables 2.9-2.18). The average number of spawning checks for river herring (sexes pooled) ranged from 0.33 to 0.68; the mean age ranged from 5.15 to 6.01 (Table 2.20). Neither variable exhibited a relationship with river systems. The mean number of spawning checks by river for blueback was consistently higher than that for alewife; also, blueback mean age was generally greater but not consistently so. A distribution-free sign test indicated that the former differences were marginal but significant ($0.10>P>0.05$), but the latter differences were not ($P>0.10$). Since there are no strong year classes presently in the fishery, the data probably reflect a tendency of blueback to spawn at an earlier age than alewife. Marcy (1969) reported differential spawning ages for river herring in Connecticut waters.

American shad samples are biased toward larger and older fish because of gill net selectivity and the discard of males at the net when market prices are low. One exception is the VIMS Potomac River samples which were obtained from pound nets. The difference in year-class structure between the Potomac River samples and those from the other rivers is apparent (Table 2.21). In the former sample, age 4 male and female shad were 63.9 and 39.1% of the sample while for the other rivers (pooled) age 4 male and female shad were 24.5 and 5.4%.

The two age 3 American shad in the York River were taken in a pound net at the river mouth and may not have been mature fish.

Although the gill nets used were selective for older fish, male and female virgin and single spawning checked American shad consitituted 90.8 and 95.3% of the catches, respectively (Table 2.22). It is not known if the low frequency of repeat spawners reflects a biological constraint or low escapement from the fishery.

Length and Weight Analysis

The overall unweighted mean fork length and mean weight for male and female alewife were 243.4 mm and 198.9 g, and 254.8 mm and 236.1 g, respectively (Table 2.23). Similarly, for blueback the estimates were 242.0 mm and 175.0 g, and 252.5 mm and 204.2 g for male and females, respectively. Thus, the mean length difference between alewife and blueback is slight; however, the average weight difference is prominent and a function of the greater body depth in alewife. The ranges in lengths were small relative to those of weights; Loesch and Kriete (1976) previously reported that coefficients of variation for weight were over three times those of length for river herring.

Annual trends in mean length and mean weight of Potomac River river herring (sexes pooled) were used in previous reports as a general indicator of the Virginia stocks (Hoagman et al., 1973, 1974; Hoagman and Kriete, 1975). In 1976 the format was modified by determining the estimates from only April and May

samples, a time frame common to all sampling years (Loesch and Kriete, 1976). There were modest changes but no apparent trend in these estimates between 1976 and 1977 (Table 2.24). The averages in 1976 and 1977 are high relative to the minimum observed lows in 1974, but are less than the maximum highs in 1972 (Loesch and Kriete, 1976). Cycle-like changes in mean length and mean weight of river herring are not well understood. The decline of these estimates in 1969 was attributed to the offshore harvest by foreign vessels which peaked in 1969 (Hoagman et al., 1973, 1974; Hoagman and Kriete, 1975). The measured attributes, however, quickly recovered and reached record highs in 1972. These were followed by record lows in 1974. Changing age-class structure and the presence of a strong year class are probably the causative agents. In 1969 the extremely strong 1966 year class was first partially recruited to the fishery in 1969 in relatively high abundance (Hoagman and Kriete, 1975). In 1972, the year of record mean highs, the 1966 year class at age 6 still contributed strongly to the commercial catch. The averages declined with the demise of the 1966 year class after 1972 and in the absence of a succeeding strong 1973 year class. With continued poor recruitment, especially the failure of the 1972 and 1973 year classes to recruit at age 4, the means have now increased again.

Average lengths and weights of American shad were estimated from random samples from pound nets in the Potomac River (Table 2.25). Female American shad had a mean length of 422 mm

(16.6 inches), about 16 mm (0.6 inches) greater than males. Female mean weight was 989 (2.2 lb.), about 152 (0.3 lb.) heavier than males. As with river herring, the coefficients of variation indicated a greater precision in estimating length than in estimating weight. The greater variability in weight measurements is due to the gonads which may range from a pre-spawned to a post-spawned condition.

Sex Ratios and Species Composition

Chi square (χ^2) analysis indicates that male river herring were significantly more abundant than females except in the Potomac River (Table 2.26). Overall, the ratio of males to females was 1.3:1 and 1.2:1 for alewife and blueback, respectively.

Sampling data (Table 2.7) show that blueback comprised about 72% of the river herring stocks in 1977. This estimate is about 10% higher than that for the preceding three years (Loesch and Kriete, 1976). Potomac River Fisheries Commission (PRFC) data (Job 1, Table 1.8) indicate that in the Potomac River blueback comprised about 84% of the pound net catch by weight and 85% by count. The conversion of weight to count utilized the mean weight (sexes pooled) of alewife (213.3 g) and blueback (190.3 g).

Our only unbiased data for American shad were the Potomac River pound net samples (Table 2.7). The observed sex ratio difference was not significant ($P>0.30$), however the data were few. PRFC data show that males were 60% of the catch by weight. Conversion of weight to count by mean weights of the sexes

(Tables 2.27, 2.28) indicates that males constituted about 64% of the catch by count; therefore, there was a sex ratio of 1.8:1, males to females.

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Table 2.1. Age and spawning frequency of blueback herring and alewife from the area of Albemarle Sound, N.C. Data are combined from all sample sites, 1977 (M = male, F = female).

Blueback herring

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	2										2	
IV	152	97	5	2							157	99
V	267	258	74	59							341	317
VI	1	2	15	23	9	22					25	47
VII					1	12	1	3			2	15
VIII							1	2		1	1	3
Total	422	357	94	84	10	34	2	5		1	528	481
Percent	80	74	18	17	2	7	<1	1		<1		

Alewife

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	6	1									6	1
IV	225	125									225	125
V	171	222	81	61		1					252	284
VI		1	13	17	16	9					29	27
VII					2	7		3			2	10
VIII								4				4
Total	402	349	94	78	18	17		7			514	451
Percent	78	77	18	17	4	4		2				

Table 2.2. Age and spawning frequency of blueback herring and alewife from the Scuppernong River pound net fishery for 1977 (M = male, F = female).

Blueback herring

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	2										2	
IV	48	25	5								53	25
V	58	48	33	25							91	73
VI				5		3						8
VII												
VIII												
Total	108	73	38	30		3					146	106
Percent	74	69	26	28		3						

Alewife

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	24	18									24	18
V	38	47	33	18							71	65
VI			2	2							2	2
VII												
VIII												
Total	62	65	35	20							97	85
Percent	64	76	36	24								

Table 2.3. Age and spawning frequency of blueback herring and alewife for the haul seine fishery on Meherrin River for 1977 (M = male, F = female).

Blueback herring

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	54	38		2							54	40
V	64	95	7	12							71	107
VI	1	1	2	8	2	8					5	17
VII						1	1	3			1	4
VIII								1		1		2
Total	119	134	9	22	2	9	1	4		1	131	170
Percent	91	79	7	13	2	5	<1	2		<1		

Alewife

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	2	1									2	1
IV	77	50									77	50
V	38	80	8	21		1					46	102
VI		1	1	6	5	5					6	12
VII						2		1				3
VIII												
Total	117	132	9	27	5	8		1			131	168
Percent	89	79	7	16	4	5		<1				

Table 2.4. Age and spawning frequency of blueback herring and alewife from the pound net fishery in the Chowan River for 1977 (M = male, F = female).

Blueback herring

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	39	20									39	20
V	99	80	16	18							115	98
VI		1	13	6	7	7					20	14
VII					1	7					1	7
VIII								1				1
Total	138	101	29	24	8	14		1			175	140
Percent	79	72	17	17	5	10		<1				

Alewife

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	4										4	
IV	69	14									69	14
V	45	35	14	2							59	37
VI			4		2	2					6	2
VII					2						2	
VIII								2				2
Total	118	49	18	2	4	2		2			140	55
Percent	84	89	13	4	3	4		4				

Table 2.5. Age and spawning frequency of blueback herring and alewife from the pound net fishery in Alligator River for 1977 (M = male, F = female).

Blueback herring

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	11	14									11	14
V	46	35	18	4							64	39
VI				4		4						8
VII						4						4
VIII							4				4	
Total	57	49	18	8		8	4				79	65
Percent	72	75	23	12		12	5					

Alewife

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	55	43									55	43
V	50	60	26	20							76	80
VI			6	9	9	2					15	11
VII						5		2				7
VIII								2				2
Total	105	103	32	29	9	7		4			146	143
Percent	72	72	22	20	6	5		3				

Table 2.6. Age and spawning frequency for American shad and hickory shad from Albemarle Sound for 1977 (M = male, F = female).

American shad

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	53	2									53	2
V	140	89	10	5							150	94
VI	19	66	8	5							27	71
VII		1		2		1						4
VIII												
Total	212	158	18	12		1					230	171
Percent	92	92	8	7		1						

Hickory shad

	Number of Times Spawned										Total	
	0		1		2		3		4			
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	72	66									72	66
V	17	31	13	12							30	43
VI		1		1	3	2					3	4
VII						1	1				1	1
VIII												
Total	89	98	13	13	3	3	1				106	114
Percent	84	86	12	11	3	3	<1					

Table 2.7. Summary of sample data from the alosine commercial fisheries during the 1977 spawning run in major Virginia tributaries to Chesapeake Bay.

River and Half-Month	Alewife		Blueback		American shad	
	Male	Female	Male	Female	Male	Female
James						
March						
1st					18	32
2nd					5	45
April						
1st	65	31	62	34	11	66
2nd	36	7	105	58	53	74
May						
1st	4	1	142	74		
2nd	22	12	41	36		
June						
1st	5	4	16	17		
2nd	1	1	1			
York						
March						
1st	25	18	5		4	46
2nd	12	28	23	17	10	89
April						
1st	111	78	127	87	12	130
2nd	7	3	93	70	2	71
May						
1st	3	2	125	115	1	
2nd			69	40		
June						
1st	3	1	2	4	12	10
Rappahannock						
March						
1st	41	52			5	4
2nd	225	109	45	19	17	34

Table 2.7. (continued)

River and Half-Month	Alewife Male	Alewife Female	Blueback Male	Blueback Female	American shad Male	American shad Female
Rappahannock (continued)						
April						
1st	66	70	188	125	1	50
2nd	46	52	213	192	5	45
May						
1st	54	16	238	161		
2nd	93	104	235	185	1	
June						
1st	87	36	45	55		
2nd	75	45	67	78		
Potomac						
March						
2nd	85	84	24	10		
April						
1st	60	60	105	87		
2nd	23	32	209	223	3	9
May						
1st	6	7	244	232		
2nd	8	11	280	272		
June						
1st	6	8	108	106	31	30
2nd	4	4	70	83	5	9
Totals (M+F)	2,049		5,262		940	

Table 2.8. River herring catches in the North Carolina and Virginia inshore fisheries and the foreign offshore fishery in ICNAF Area 6.

Year	Catch (metric tons)		
	North Carolina	Virginia	Foreign
1966	5,677	12,941	
1967	8,383	12,746	981
1968	7,040	14,657	1,075
1969	8,962	13,807	10,474
1970	5,225	8,637	6,052
1971	5,769	4,664	9,442
1972	5,096	4,740	4,974
1973	3,594	4,203	2,452
1974	2,816	6,050	2,817
1975	2,699	5,152	1,341
1976	2,903	1,839	1,554
1977	3,855	630	

ALOSA, JAMES RIVER, 1977

FILE ALOSA (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE ALEWIFEM ALEWIFEF

* CROSSTABULATION OF * * *
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEARCLAS
* *

SPAWNCHK	YRCLASS 70.1	71.1	72.1	73.1	ROW TOTAL
0.	0	3	36	4	43
	0.0	7.0	83.7	9.3	57.3
	0.0	14.3	80.0	100.0	
	0.0	4.0	48.0	5.3	
1.	0	16	9	0	25
	0.0	64.0	36.0	0.0	33.3
	0.0	76.2	20.0	0.0	
	0.0	21.3	12.0	0.0	
2.	3	2	0	0	5
	60.0	40.0	0.0	0.0	6.7
	60.0	9.5	0.0	0.0	
	4.0	2.7	0.0	0.0	
3.	2	0	0	0	2
	100.0	0.0	0.0	0.0	2.7
	40.0	0.0	0.0	0.0	
	2.7	0.0	0.0	0.0	
COLUMN TOTAL	5	21	45	4	75
	6.7	28.0	60.0	5.3	100.0

CHI SQUARE = 64.78529 WITH 9 DEGREES OF FREEDOM SIGNIFICANCE = 0.0000

NUMBER OF MISSING OBSERVATIONS = 16

Table 2.9. Year-class and spawning check mark frequencies of alewife (sexes pooled) in the James River commercial fishery, 1977.

ALOSA, JAMES RIVER, 1977

FILE ALOSA (CREATION DATE = 12/01/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE BLUBACKM BLUBACKF

* CROSSTABULATION OF *
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEAR
* *

SPAWNCHK	YRCLASS 69.	70.	71.	72.	73.	ROW TOTAL
0.	1	1	54	77	5	138
	0.7	0.7	39.1	55.8	3.6	53.1
	33.3	6.3	38.3	82.8	71.4	
	0.4	0.4	20.8	29.6	1.9	
1.	0	0	76	14	2	92
	0.0	0.0	82.6	15.2	2.2	35.4
	0.0	0.0	53.9	15.1	28.6	
	0.0	0.0	29.2	5.4	0.8	
2.	0	9	11	1	0	21
	0.0	42.9	52.4	4.8	0.0	8.1
	0.0	56.3	7.8	1.1	0.0	
	0.0	3.5	4.2	0.4	0.0	
3.	1	6	0	0	0	7
	14.3	85.7	0.0	0.0	0.0	2.7
	33.3	37.5	0.0	0.0	0.0	
	0.4	2.3	0.0	0.0	0.0	
4.	1	0	0	0	0	1
	100.0	0.0	0.0	0.0	0.0	0.4
	33.3	0.0	0.0	0.0	0.0	
	0.4	0.0	0.0	0.0	0.0	
5.	0	0	0	1	0	1
	0.0	0.0	0.0	100.0	0.0	0.4
	0.0	0.0	0.0	1.1	0.0	
	0.0	0.0	0.0	0.4	0.0	
COLUMN TOTAL	3	16	141	93	7	260
	1.2	6.2	54.2	35.8	2.7	100.0

CHI SQUARE = 288.74316 WITH 20 DEGREES OF FREEDOM SIGNIFICANCE = 0.0

NUMBER OF MISSING OBSERVATIONS = 111

Table 2.10. Year-class and spawning check mark frequencies of blueback herring (sexes pooled) in the James River commercial fishery, 1977.

ALEWIFE, PAMUNKEY RIVER, 1977

FILE ALEWIFE (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE ALEWIFEM ALEWIFEF

* C R O S S T A B U L A T I O N O F *
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEARC
* *

SPAWNCHK	YRCLASS 69.	70.	71.	72.	ROW TOTAL
0.	0	1	15	19	35
	0.0	2.9	42.9	54.3	68.6
	0.0	20.0	60.0	95.0	
	0.0	2.0	29.4	37.3	
1.	0	2	10	1	13
	0.0	15.4	76.9	7.7	25.5
	0.0	40.0	40.0	5.0	
	0.0	3.9	19.6	2.0	
2.	0	2	0	0	2
	0.0	100.0	0.0	0.0	3.9
	0.0	40.0	0.0	0.0	
	0.0	3.9	0.0	0.0	
3.	1	0	0	0	1
	100.0	0.0	0.0	0.0	2.0
	100.0	0.0	0.0	0.0	
	2.0	0.0	0.0	0.0	
COLUMN TOTAL	1	5	25	20	51
	2.0	9.8	49.0	39.2	100.0

CHI SQUARE = 79.13399 WITH 9 DEGREES OF FREEDOM SIGNIFICANCE = 0.0000

NUMBER OF MISSING OBSERVATIONS = 34

Table 2.11. Year-class and spawning check mark frequencies of alewife (sexes pooled) in the Pamunkey River commercial fishery, 1977.

ALOSA, PAMUNKEY RIVER, 1977

FILE ALOSA (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 197
SUBFILE BLUBACKM BLUBACKF

* C R O S S T A B U L A T I O N O F
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEA
* *

SPAWNCHK	YRCLASS 70.	71.	72.	ROW TOTAL
0.	1	30	8	39
	2.6	76.9	20.5	61.9
	11.1	65.2	100.0	
	1.6	47.6	12.7	
1.	3	13	0	16
	18.8	81.3	0.0	25.4
	33.3	28.3	0.0	
	4.8	20.6	0.0	
2.	5	3	0	8
	62.5	37.5	0.0	12.7
	55.6	6.5	0.0	
	7.9	4.8	0.0	
COLUMN TOTAL	9	46	8	63
	14.3	73.0	12.7	100.0

CHI SQUARE = 23.52719 WITH 4 DEGREES OF FREEDOM SIGNIFICANCE = 0.000

NUMBER OF MISSING OBSERVATIONS = 11

Table 2.12. Year-class and spawning check mark frequencies of blueback herring (sexes pooled) in the Pamunkey River commercial fishery, 1977.

ALE A, YORK RIVER, 1977

FILE ALOSA (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 197
SUBFILE ALEWIFEM ALEWIFEF

* C R O S S T A B U L A T I O N O F
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEA
* *

SPAWNCHK	YRCLASS 70.	71.	72.	73.	ROW TOTAL
0.	COUNT 0	9	79	18	106
	ROW PCT 0.0	8.5	74.5	17.0	69.7
	COL PCT 0.0	25.0	84.0	94.7	
	TOT PCT 0.0	5.9	52.0	11.8	
1.	COUNT 1	24	15	1	41
	ROW PCT 2.4	58.5	36.6	2.4	27.0
	COL PCT 33.3	66.7	16.0	5.3	
	TOT PCT 0.7	15.8	9.9	0.7	
2.	COUNT 2	3	0	0	5
	ROW PCT 40.0	60.0	0.0	0.0	3.3
	COL PCT 66.7	8.3	0.0	0.0	
	TOT PCT 1.3	2.0	0.0	0.0	
COLUMN TOTAL	3 2.0	36 23.7	94 61.8	19 12.5	152 100.0

CHI SQUARE = 88.64029 WITH 6 DEGREES OF FREEDOM SIGNIFICANCE = 0.000

NUMBER OF MISSING OBSERVATIONS = 13

Table 2.13. Year-class and spawning check mark frequencies of alewife (sexes pooled) in the York River commercial fishery, 1977.

FILE ALOSA (CREATION DATE = 12/21/77) COMMERCIAL FISHERY SAMPLES, 197
SUBFILE BLUBACKM BLUBACKF

* C R O S S T A B U L A T I O N O F
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEA
* *

SPAWNCHK	YRCLASS 70.	71.	72.	73.	ROW TOTAL
0.	3	57	68	1	129
	2.3	44.2	52.7	0.8	50.4
	11.5	37.5	88.3	100.0	
	1.2	22.3	26.6	0.4	
1.	6	74	9	0	89
	6.7	83.1	10.1	0.0	34.8
	23.1	48.7	11.7	0.0	
	2.3	28.9	3.5	0.0	
2.	8	21	0	0	29
	27.6	72.4	0.0	0.0	11.3
	30.8	13.8	0.0	0.0	
	3.1	8.2	0.0	0.0	
3.	9	0	0	0	9
	100.0	0.0	0.0	0.0	3.5
	34.6	0.0	0.0	0.0	
	3.5	0.0	0.0	0.0	
COLUMN TOTAL	26	152	77	1	256
	10.2	59.4	30.1	0.4	100.0

CHI SQUARE = 154.85405 WITH 9 DEGREES OF FREEDOM SIGNIFICANCE = 0.0

NUMBER OF MISSING OBSERVATIONS = 260

Table 2.14. Year-class and spawning check mark frequencies of blueback herring (sexes pooled) in the York River commercial fishery, 1977.

FILE ALOSA (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE ALEWIFEM ALEWIFEF

* C R O S S T A B U L A T I O N O F * * *
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEARCLASS
* *

	YRCLASS						
COUNT / ROW PCT / COL PCT / TOT PCT	68.	69.	70.	71.	72.	73.	ROW TOTAL
SPAWNCHK							
0.	0	0	6	117	167	15	305
	0.0	0.0	2.0	38.4	54.8	4.9	58.2
	0.0	0.0	22.2	45.9	74.6	100.0	
	0.0	0.0	1.1	22.3	31.9	2.9	
1.	0	0	9	128	57	0	194
	0.0	0.0	4.6	66.0	29.4	0.0	37.0
	0.0	0.0	33.3	50.2	25.4	0.0	
	0.0	0.0	1.7	24.4	10.9	0.0	
2.	0	0	10	10	0	0	20
	0.0	0.0	50.0	50.0	0.0	0.0	3.8
	0.0	0.0	37.0	3.9	0.0	0.0	
	0.0	0.0	1.9	1.9	0.0	0.0	
3.	0	1	2	0	0	0	3
	0.0	33.3	66.7	0.0	0.0	0.0	0.6
	0.0	100.0	7.4	0.0	0.0	0.0	
	0.0	0.2	0.4	0.0	0.0	0.0	
4.	2	0	0	0	0	0	2
	100.0	0.0	0.0	0.0	0.0	0.0	0.4
	100.0	0.0	0.0	0.0	0.0	0.0	
	0.4	0.0	0.0	0.0	0.0	0.0	
COLUMN TOTAL	2	1	27	255	224	15	524
	0.4	0.2	5.2	48.7	42.7	2.9	100.0

CHI SQUARE = 862.86890 WITH 20 DEGREES OF FREEDOM SIGNIFICANCE = 0.0

NUMBER OF MISSING OBSERVATIONS = 290

Table 2.15. Year-class and spawning check mark frequencies of alewife (sexes pooled) in the Rappahannock commercial fishery, 1977.

FILE ALOSA (CREATION DATE = 12/20/77) COMMERCIAL FISHERY SAMPLES, 19
SUBFILE BLUBACKM BLUBACKF

* C R O S S T A B U L A T I O N O F
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YE
* *

SPAWNCHK	YRCLASS 70.	71.	72.	73.	ROW TOTAL
0.	COUNT 3	92	136	9	240
	ROW PCT 1.3	38.3	56.7	3.8	49.8
	COL PCT 15.0	37.2	67.0	75.0	
	TOT PCT 0.6	19.1	28.2	1.9	
1.	COUNT 1	132	66	3	202
	ROW PCT 0.5	65.3	32.7	1.5	41.9
	COL PCT 5.0	53.4	32.5	25.0	
	TOT PCT 0.2	27.4	13.7	0.6	
2.	COUNT 10	23	1	0	34
	ROW PCT 29.4	67.6	2.9	0.0	7.1
	COL PCT 50.0	9.3	0.5	0.0	
	TOT PCT 2.1	4.8	0.2	0.0	
3.	COUNT 6	0	0	0	6
	ROW PCT 100.0	0.0	0.0	0.0	1.2
	COL PCT 30.0	0.0	0.0	0.0	
	TOT PCT 1.2	0.0	0.0	0.0	
COLUMN TOTAL	20 4.1	247 51.2	203 42.1	12 2.5	482 100.0

CHI SQUARE = 251.61485 WITH 9 DEGREES OF FREEDOM SIGNIFICANCE = 0.0

NUMBER OF MISSING OBSERVATIONS = 362

Table 2.16. Year-class and spawning check mark frequencies of blueback herring (sexes pooled) in the Rappahannock River commercial fishery, 1977.

FILE ALOSA (CREATION DATE = 12/22/77) COMMERCIAL FISHERY SAMPLES, 19
SUBFILE ALEWIFEM ALEWIFEF

* C R O S S T A B U L A T I O N O F
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YE
* *

		YRCLASS				
	COUNT / ROW PCT / COL PCT / TOT PCT	70.	71.	72.	73.	ROW TOTAL
SPAWNCHK						
0.		0	46	44	9	99
		0.0	46.5	44.4	9.1	68.8
		0.0	63.0	75.9	100.0	
		0.0	31.9	30.6	6.3	
1.		1	24	14	0	39
		2.6	61.5	35.9	0.0	27.1
		25.0	32.9	24.1	0.0	
		0.7	16.7	9.7	0.0	
2.		3	3	0	0	6
		50.0	50.0	0.0	0.0	4.2
		75.0	4.1	0.0	0.0	
		2.1	2.1	0.0	0.0	
COLUMN TOTAL		4	73	58	9	144
		2.8	50.7	40.3	6.3	100.0

CHI SQUARE = 59.29774 WITH 6 DEGREES OF FREEDOM SIGNIFICANCE = 0.00

NUMBER OF MISSING OBSERVATIONS = 127

Table 2.17. Year-class and spawning check mark frequencies of alewife (sexes pooled) in the Potomac River commercial fishery, 1977.

FILE ALOSA (CREATION DATE = 12/22/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE BLUBACKM BLUBACKF

* CROSSTABULATION OF *
SPAWNCHK SPAWNING CHECK MARKS BY YRCLASS YEAR
* *

SPAWNCHK	YRCLASS 70.	71.	72.	73.	ROW TOTAL
0.	6	139	127	8	280
	2.1	49.6	45.4	2.9	61.7
	21.4	49.5	92.7	100.0	
	1.3	30.6	28.0	1.8	
1.	6	122	10	0	138
	4.3	88.4	7.2	0.0	30.4
	21.4	43.4	7.3	0.0	
	1.3	26.9	2.2	0.0	
2.	12	19	0	0	31
	38.7	61.3	0.0	0.0	6.8
	42.9	6.8	0.0	0.0	
	2.6	4.2	0.0	0.0	
3.	4	1	0	0	5
	80.0	20.0	0.0	0.0	1.1
	14.3	0.4	0.0	0.0	
	0.9	0.2	0.0	0.0	
COLUMN TOTAL	28	281	137	8	454
	6.2	61.9	30.2	1.8	100.0

CHI SQUARE = 190.66238 WITH 9 DEGREES OF FREEDOM SIGNIFICANCE = 0.0

NUMBER OF MISSING OBSERVATIONS = 619

Table 2.18. Year-class and spawning check mark frequencies of blueback herring (sexes pooled) in the Potomac River commercial fishery, 1977.

Table 2.19. Chi square (χ^2) analysis of the hypothesis of equal dominance of the 1971 and 1972 year classes in the Virginia commercial river herring fishery, 1977.

	Year Class Counts					
	Alewife			Blueback		
River	1971	1972	χ^2	1971	1972	χ^2
James	21	45	8.02*	141	93	9.44*
Pamunkey	25	20	0.36	46	8	25.35*
York	36	94	24.99*	152	77	23.91*
Rappahannock	255	224	1.88	247	203	4.11*
Potomac	73	58	1.50	281	137	48.92*
Pooled	410	441	1.06	867	518	87.44*

*Significant χ^2 ($\alpha \leq 0.05$)

Table 2.20. Mean age and mean number of spawning check marks for river herring in the Virginia commercial fishery, 1977.

River	Alewife		Blueback	
	Age	Spawning Checks	Age	Spawning Checks
James	5.36	0.54	5.67	0.60
Pamunkey	5.74	0.39	6.01	0.45
York	5.15	0.33	5.79	0.68
Rappahannock	5.58	0.47	5.57	0.56
Potomac	5.50	0.35	5.72	0.48

Table 2.21. Year-class frequency of American shad in the Virginia commercial fishery, 1977.

Sex	Year class	River				Total	Frequency (%)
		James	York*	Rapp.	Potomac		
Male	≤1969	2	0	0	0	2	1.5
	1970	5	0	0	0	5	3.8
	1971	10	7	0	0	17	13.1
	1972	8	18	19	13	58	44.6
	1973	0	14	9	23	46	35.4
	1974	0	2	0	0	2	1.5
	Total	25	41	28	36	130	
Female	≤1969	0	2	0	0	2	0.3
	1970	3	12	0	0	15	2.2
	1971	62	100	26	2	190	27.4
	1972	104	207	96	26	433	62.5
	1973	4	22	9	18	53	7.6
	Total	173	343	131	46	693	

*Data pooled for York and Pamunkey rivers.

Table 2.22. Spawning frequency of American shad in the Virginia commercial fishery, 1977.

Sex	Spawning Checks	River				Total	Frequency (%)
		James	York*	Rapp.	Potomac		
Male	0	7	24	27	13	71	54.6
	1	9	15	1	22	47	36.2
	2	4	2	0	1	7	5.4
	3	3	0	0	0	3	2.3
	≥4	2	0	0	0	2	1.5
	Total	25	41	28	36	130	
Female	0	155	271	129	22	577	83.3
	1	15	43	1	24	83	12.0
	2	3	25	1	0	29	4.2
	3	0	2	0	0	2	0.3
	≥4	0	2	0	0	2	0.3
	Total	173	343	131	46	693	

*Data pooled for York and Pamunkey rivers.

Table 2.23. Mean length (mm) and weight (g) of river herring in the Virginia commercial fishery, 1977.

River		Alewife		Blueback	
		Male	Female	Male	Female
James	Length	245.2	256.6	243.5	253.7
	Weight	190.0	230.6	178.3	206.4
Pamunkey	Length	243.8	254.9	241.9	252.6
	Weight	212.5	246.7	186.8	229.7
York	Length	240.8	255.3	241.0	251.9
	Weight	207.1	257.6	166.2	187.4
Rappahannock	Length	243.4	253.4	240.9	251.1
	Weight	186.8	217.3	168.1	192.6
Potomac	Length	243.9	253.8	242.5	253.4
	Weight	198.3	228.1	175.5	205.0
Unweighted mean	Length	243.4	254.8	242.0	252.5
	Weight	198.9	236.1	175.0	204.2
Range	Length	4.4	3.2	2.5	2.6
	Weight	25.7	40.3	20.6	42.3

Table 2.24. Estimated mean length (mm) and mean weight (g) of alewife and blueback (sexes pooled) in the Potomac River fishery, 1976-1977. Only April and May data utilized.

	Mean length		Mean weight	
	1976	1977	1976	1977
Alewife	246.2	249.1	194.2	202.1
Blueback	250.4	246.9	183.6	185.6

Table 2.25. Estimated mean length (mm) and mean weight (g) of American shad in the Potomac River fishery, 1977.

Sex	Mean length	Coeff. variation	Mean weight	Coeff. variation
Male	405.8	0.08	837.3	0.29
Female	422.0	0.08	989.1	0.31

Table 2.26. Sex ratios of river herring in the Virginia commercial fishery, 1977.

River	Alewife			Blueback		
	Male	Female	Ratio	Male	Female	Ratio
James	133	56	2.4:1**	367	219	1.7:1**
York[+]	161	130	1.2:1*	444	333	1.3:1**
Rappahannock	687	484	1.4:1**	1,031	815	1.3:1**
Potomac	192	206	0.9:1	1,040	1,013	1.0:1
Pooled (sex)	1,173	876	1.3:1**	2,882	2,380	1.2:1**
Pooled (species)	2,049			5,262		

[+]Data pooled for York and Pamunkey rivers.

*χ^2 significant ($\alpha = 0.10$).

**χ^2 significant ($\alpha \leq 0.05$).

ALOSA, POTOMAC RIVER, 1977

FILE ALOSA (CREATION DATE = 11/04/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE AMSHADM

WEIGHT

CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT
534.50	1	3	3	694.50	2	5	41	984.50	1	3	77
544.50	1	3	5	704.50	2	5	46	1024.50	1	3	79
554.50	1	3	8	744.50	1	3	49	1044.50	1	3	82
604.50	1	3	10	784.50	1	3	51	1054.50	1	3	85
614.50	1	3	13	824.50	1	3	54	1104.50	2	5	90
624.50	3	8	21	834.50	1	3	56	1214.50	1	3	92
634.50	1	3	23	844.50	1	3	59	1224.50	1	3	95
644.50	1	3	26	884.50	2	5	64	1344.50	1	3	97
664.50	2	5	31	894.50	3	8	72	1604.50	1	3	100
684.50	2	5	36	964.50	1	3	74				

MEAN	837.320	STD ERR	38.770	MEDIAN	784.500
MODE	624.500	STD DEV	242.117	VARIANCE	58620.707
KURTOSIS	0.927	SKEWNESS	1.096	RANGE	1070.000
MINIMUM	534.500	MAXIMUM	1604.500		

VALID CASES 39 MISSING CASES 0

Table 2.27. Weight (g) statistics of male American shad in the Potomac River commercial fishery, 1977.

ALOSA, POTOMAC RIVER, 1977

FILE ALOSA (CREATION DATE = 11/04/77) COMMERCIAL FISHERY SAMPLES, 1977
SUBFILE AMSHADF

WEIGHT

CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT
504.50	1	2	2	864.50	1	2	35	1194.50	1	2	77
554.50	2	4	6	904.50	3	6	40	1204.50	2	4	81
584.50	2	4	10	944.50	2	4	44	1214.50	1	2	83
604.50	1	2	13	964.50	2	4	48	1304.50	1	2	85
614.50	1	2	15	974.50	1	2	50	1404.50	1	2	88
654.50	1	2	17	984.50	2	4	54	1424.50	1	2	90
664.50	1	2	19	1004.50	3	6	60	1444.50	1	2	92
674.50	1	2	21	1024.50	1	2	63	1514.50	1	2	94
704.50	1	2	23	1044.50	1	2	65	1604.50	1	2	96
744.50	2	4	27	1054.50	3	6	71	1644.50	1	2	98
784.50	1	2	29	1134.50	1	2	73	1664.50	1	2	100
814.50	1	2	31	1144.50	1	2	75				

MEAN	959.083	STD ERR	43.751	MEDIAN	979.500
MODE	904.500	STD DEV	303.110	VARIANCE	91880.312
KURTOSIS	-0.448	SKEWNESS	0.461	RANGE	1160.000
MINIMUM	504.500	MAXIMUM	1664.500		

VALID CASES 48 MISSING CASES 0

Table 2.28. Weight (g) statistics of female American shad in the Potomac River commercial fishery, 1977.

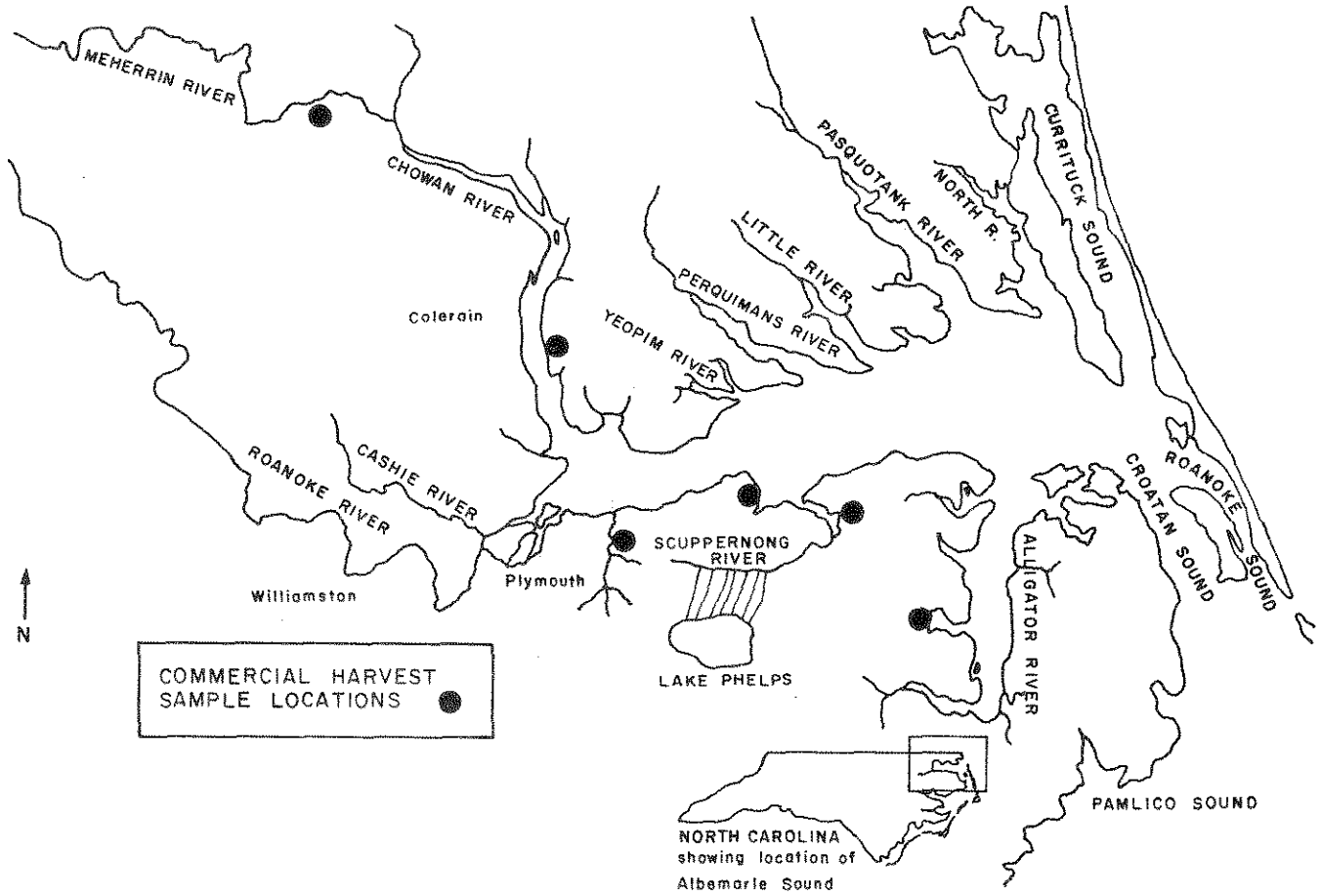

Figure 2.1. Location of Albemarle Sound commercial harvest sampling sites.

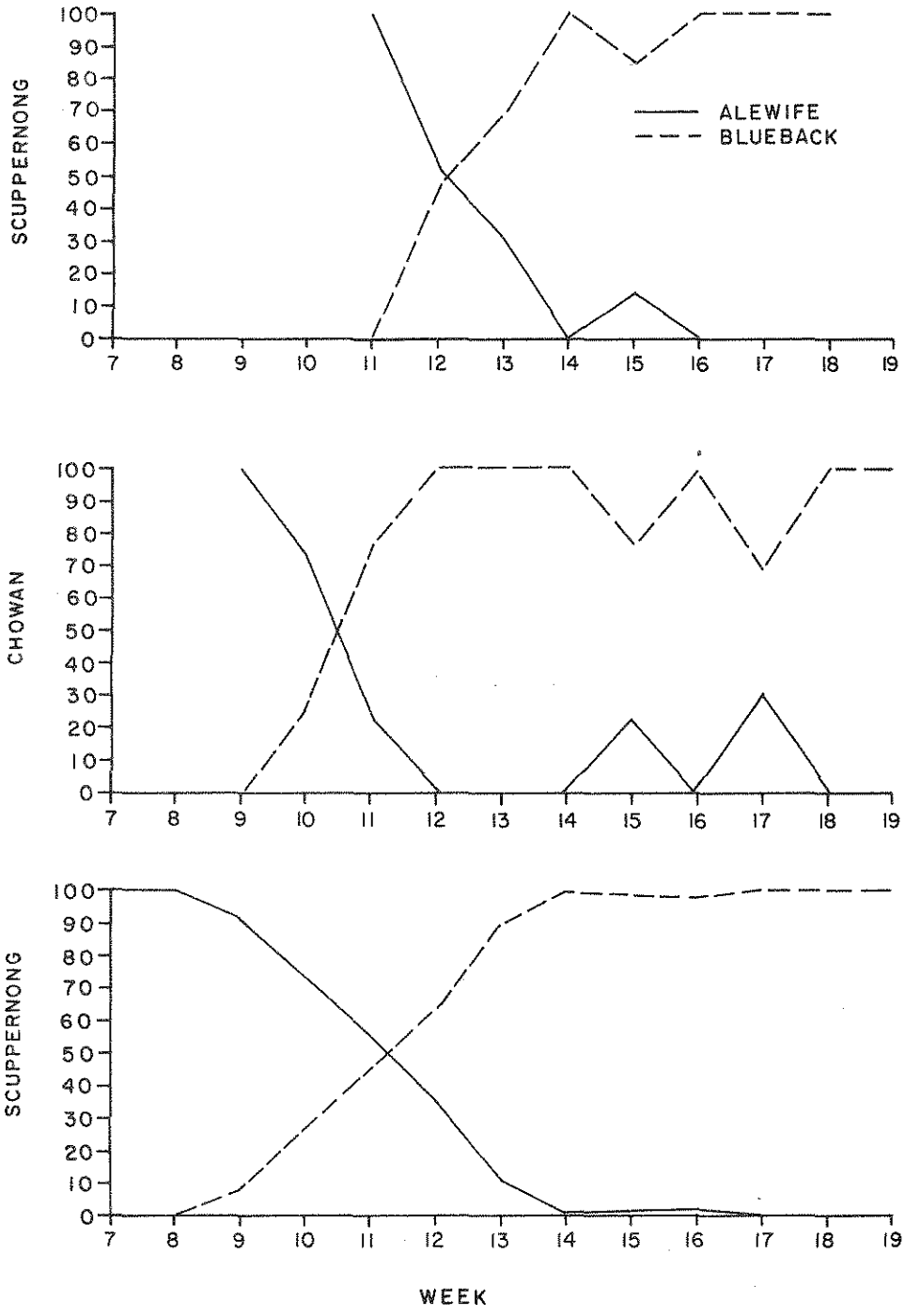

Figure 2.2. Weekly species composition of the 1977 samples from the Scuppernong River pound net fishery, the Chowan River pound net fishery and the Scuppernong River tagging operations.

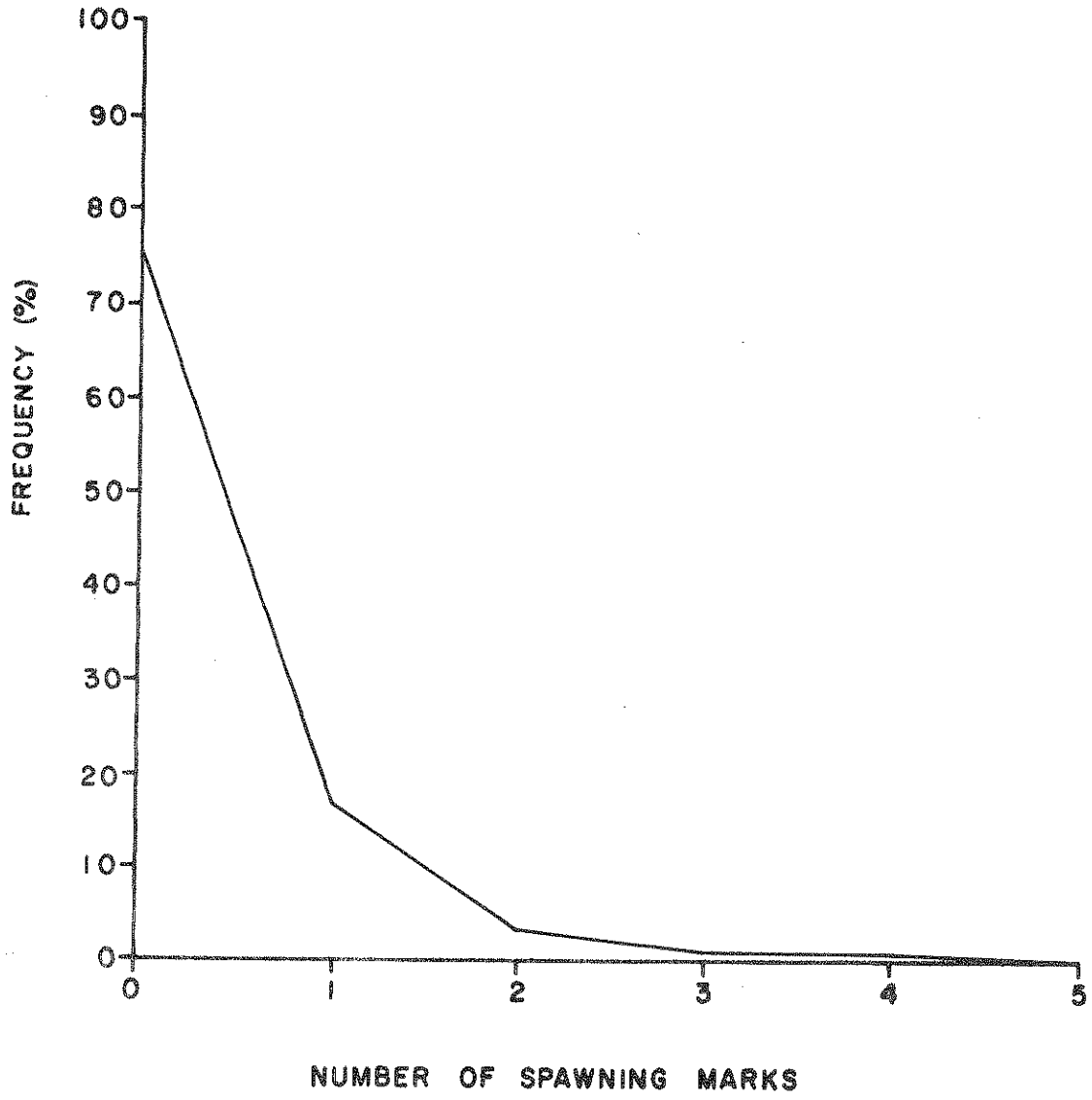

Figure 2.3. Frequency of virgin and repeat spawners for the 1977 commercial landings of blueback herring from the area of Albemarle Sound, North Carolina. Data were combined for all sample sites.

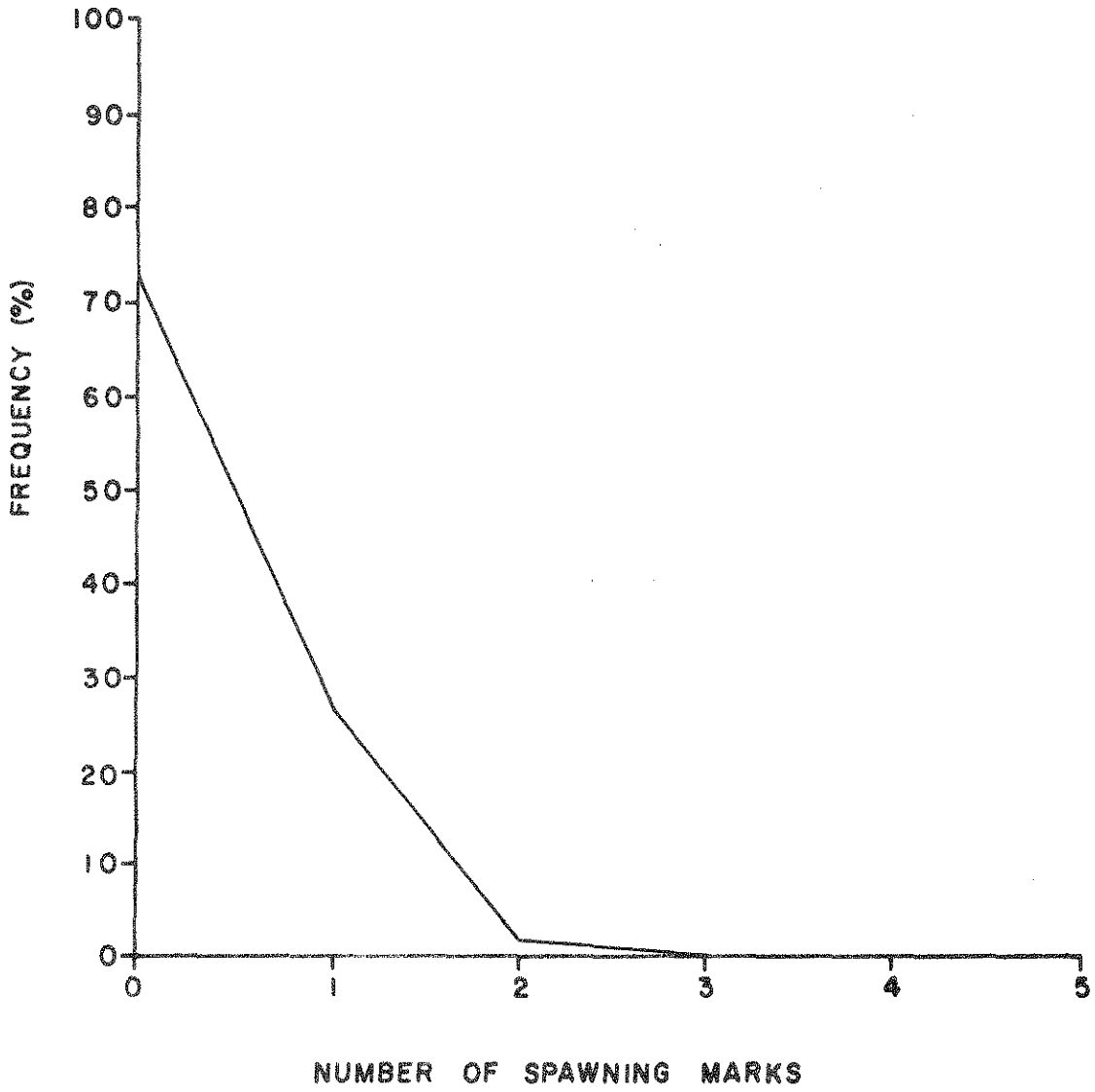

Figure 2.4. Frequency of virgin and repeat spawners in the 1977 commercial landings of blueback herring from the Scuppernong River.

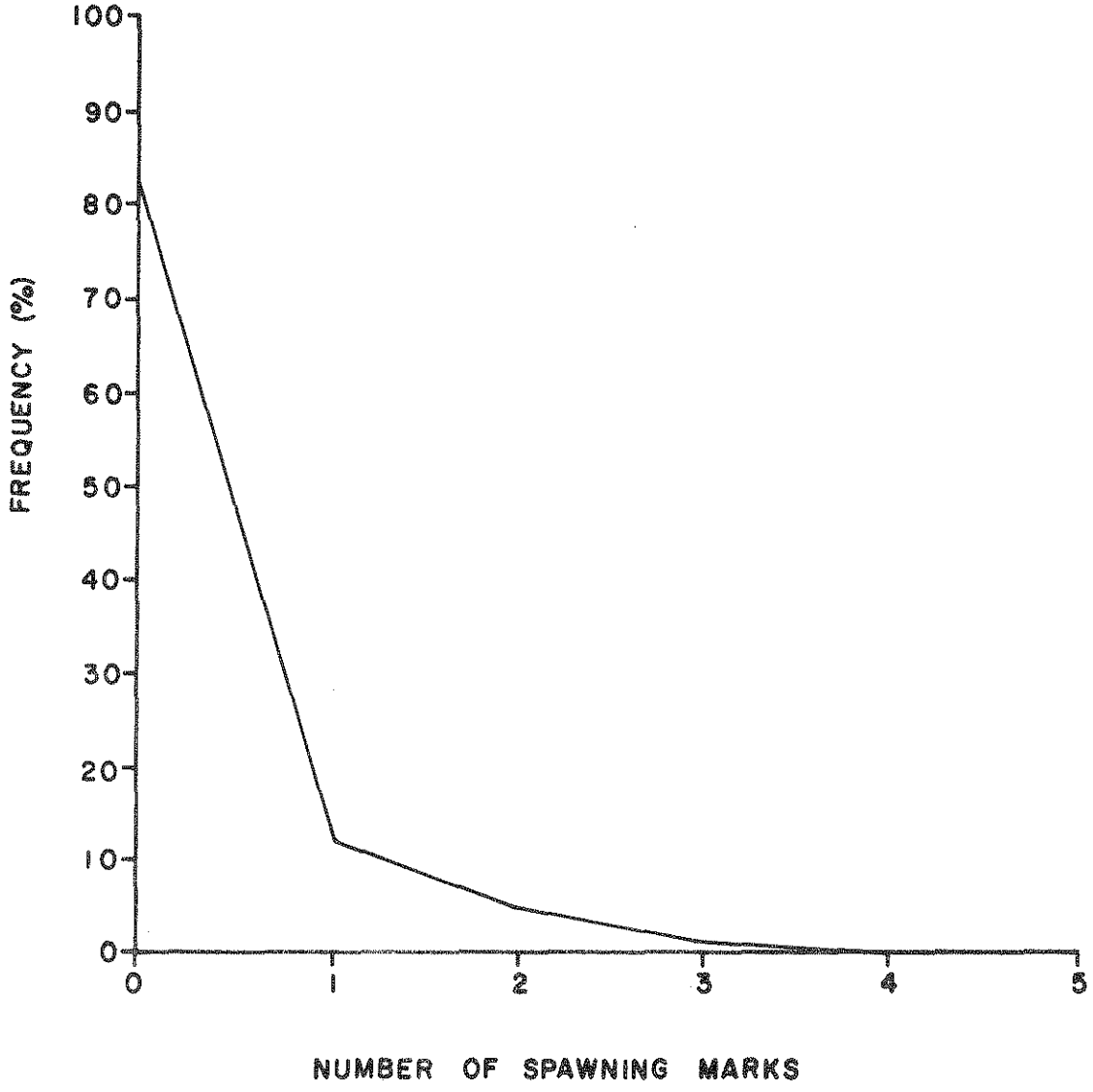

Figure 2.5. Frequency of virgin and repeat spawners in the 1977 commercial landings of blueback herring from the haul seine fishery on Meherrin River.

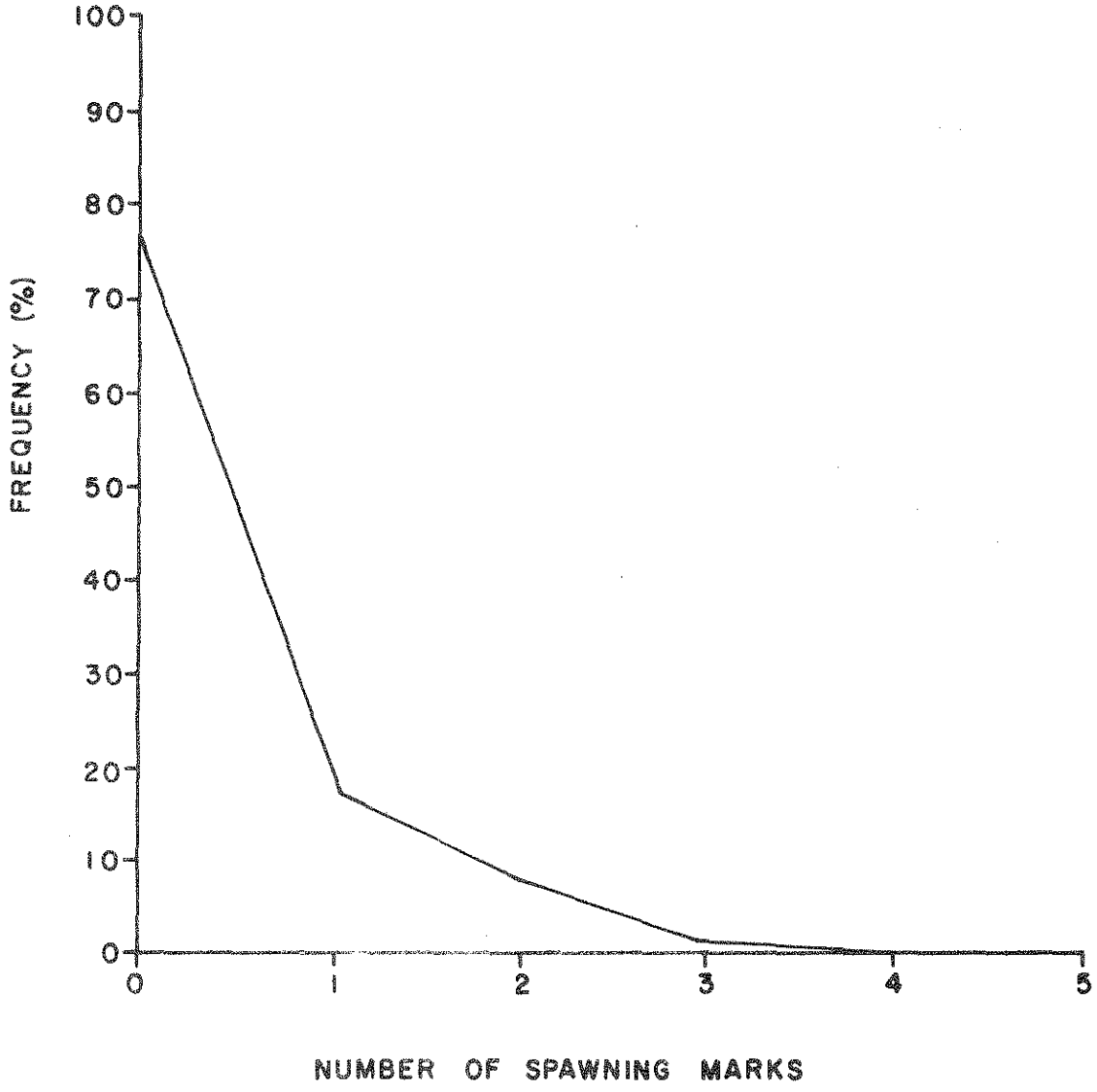

Figure 2.6. Frequency of virgin and repeat spawners in the 1977 commercial landings of blueback herring from Chowan River.

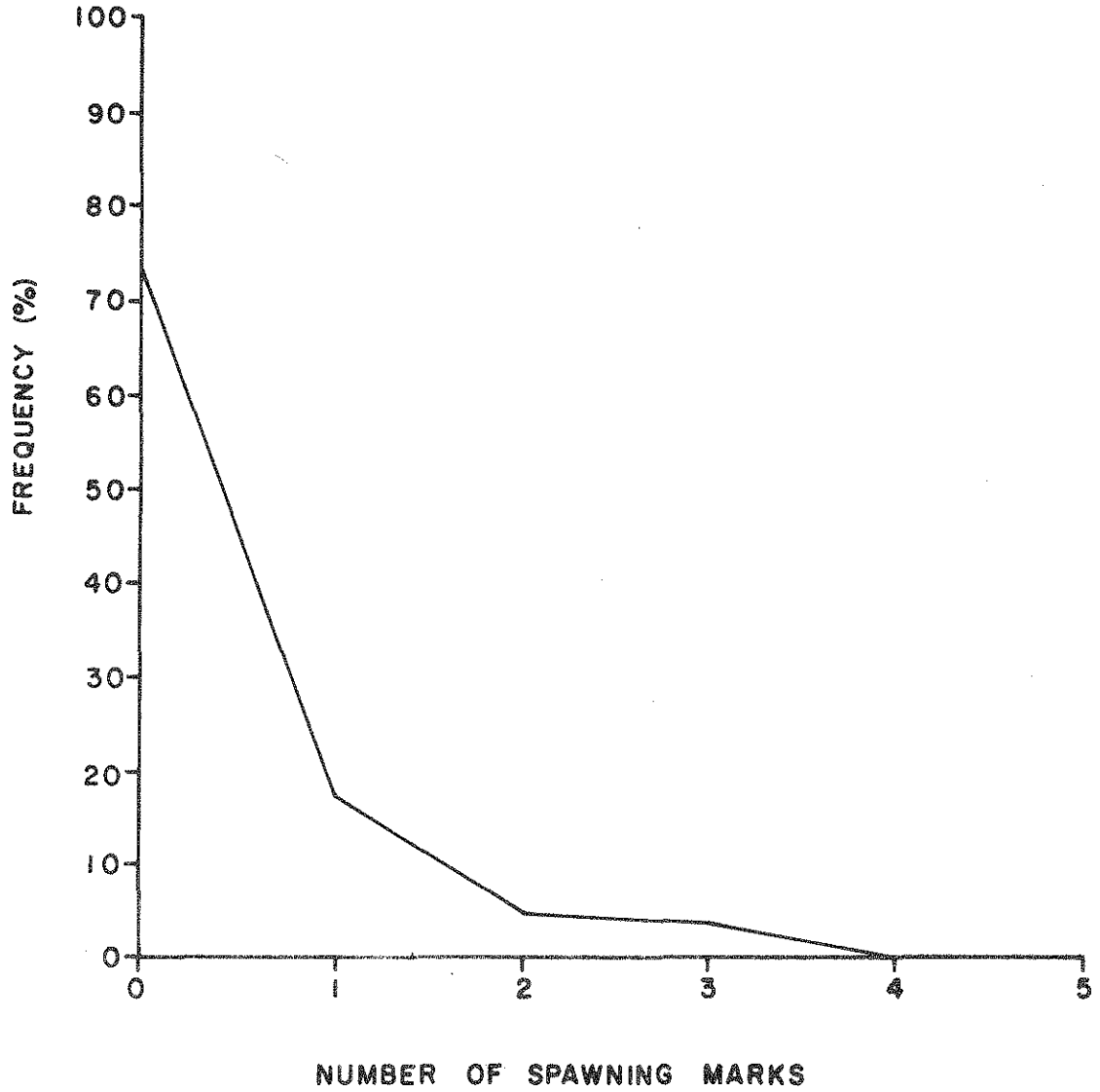

Figure 2.7. Frequency of virgin and repeat spawners in the 1977 commercial landings of blueback herring from Alligator River.

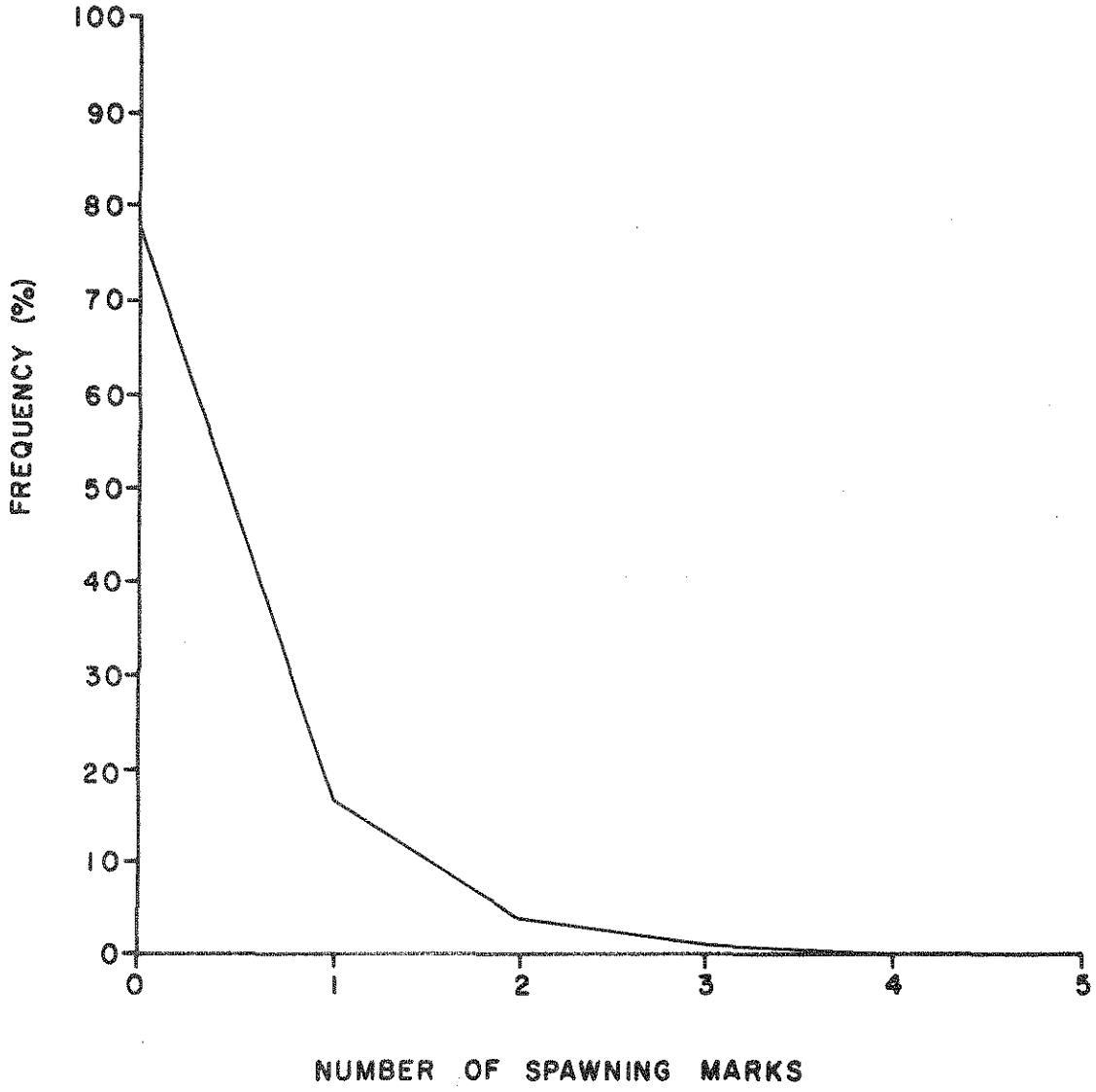

Figure 2.8. Frequency of virgin and repeat spawners in the 1977 commercial landings of alewife from the area of Albemarle Sound, North Carolina. Data are combined for all sample sites.

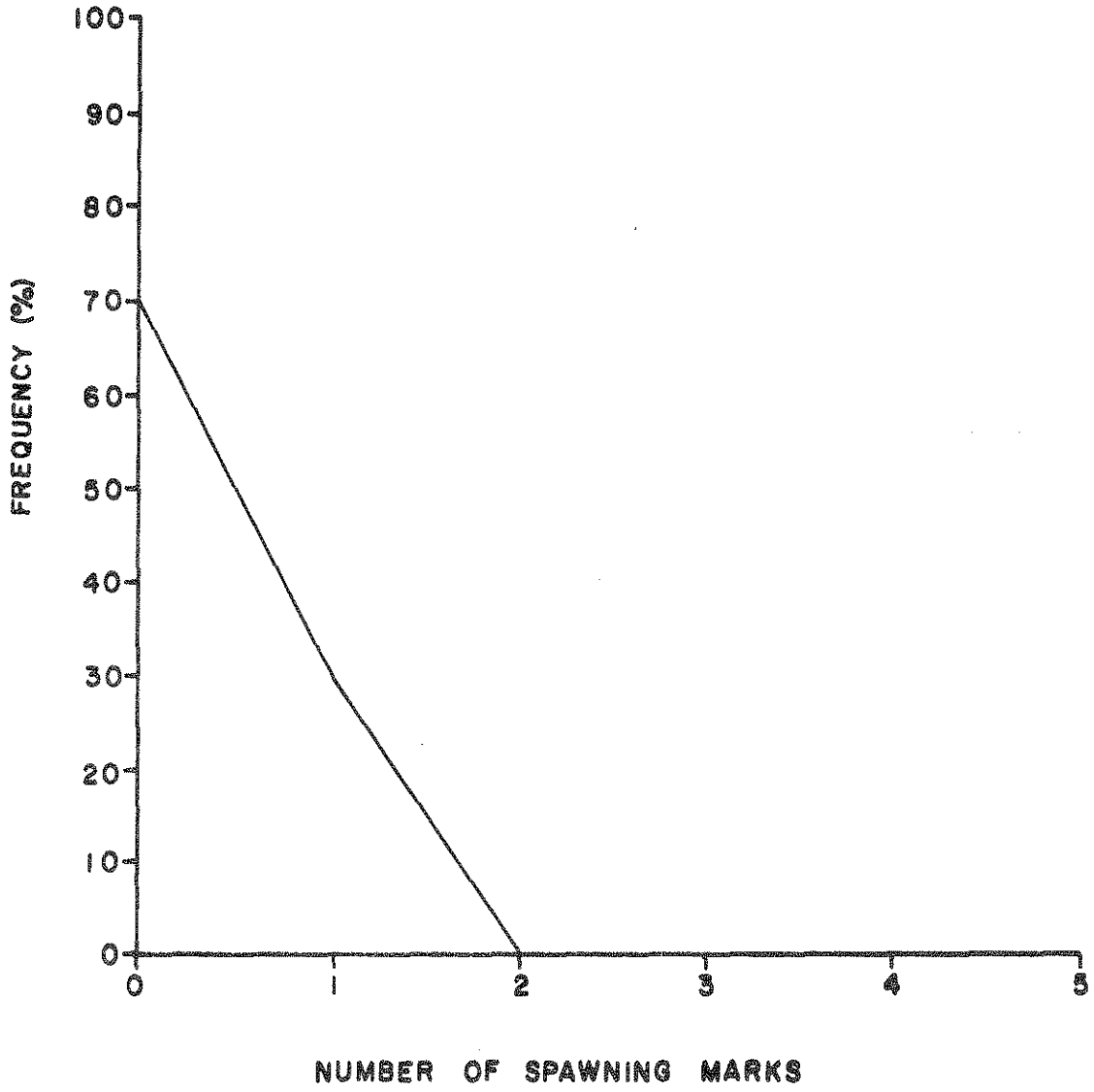

Figure 2.9. Frequency of virgin and repeat spawners in the 1977 commercial landings of alewife from Scuppernong River.

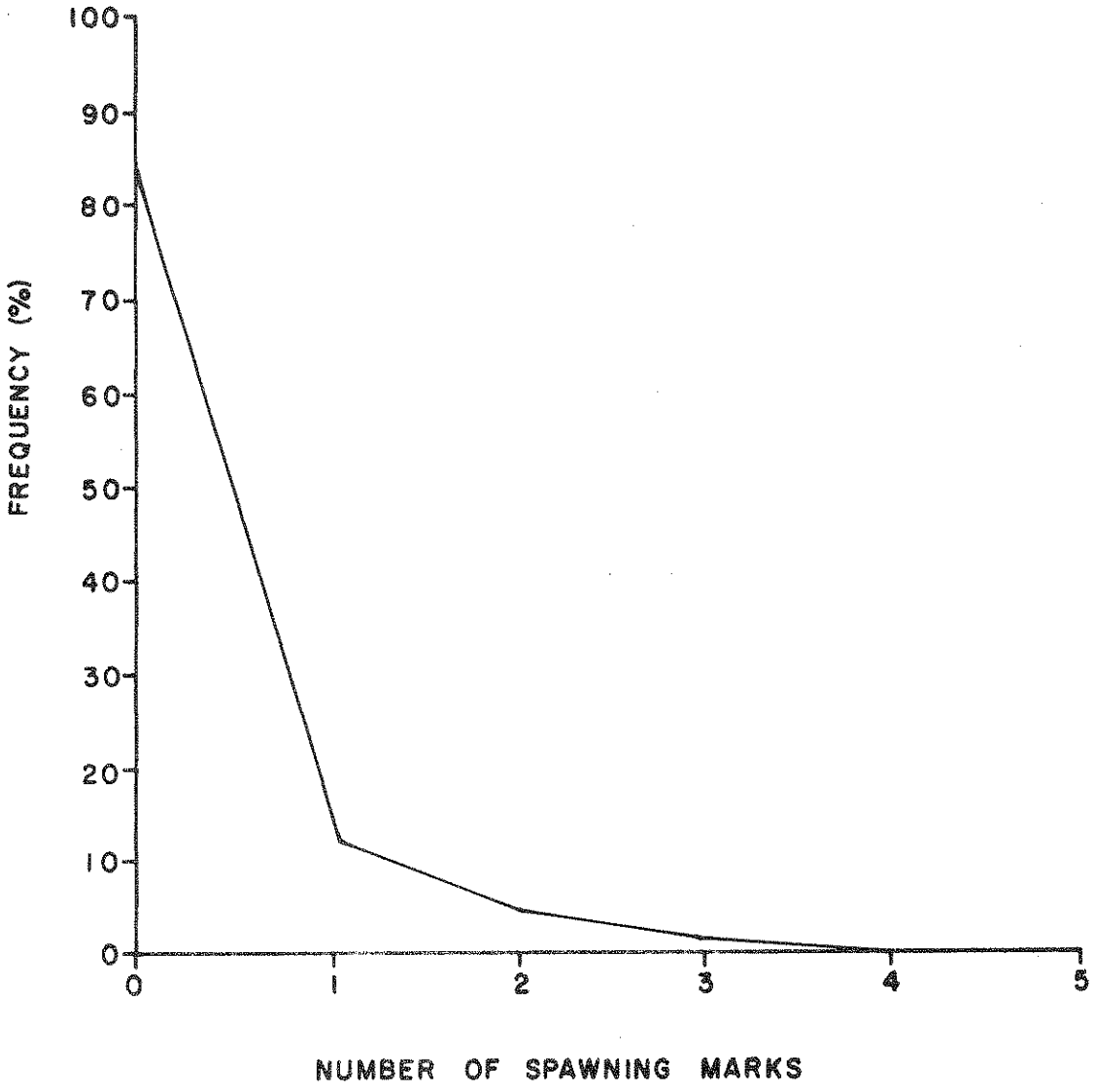

Figure 2.10. Frequency of virgin and repeat spawners in the 1977 commercial landings of alewife from the haul seine fishery in Meherrin River.

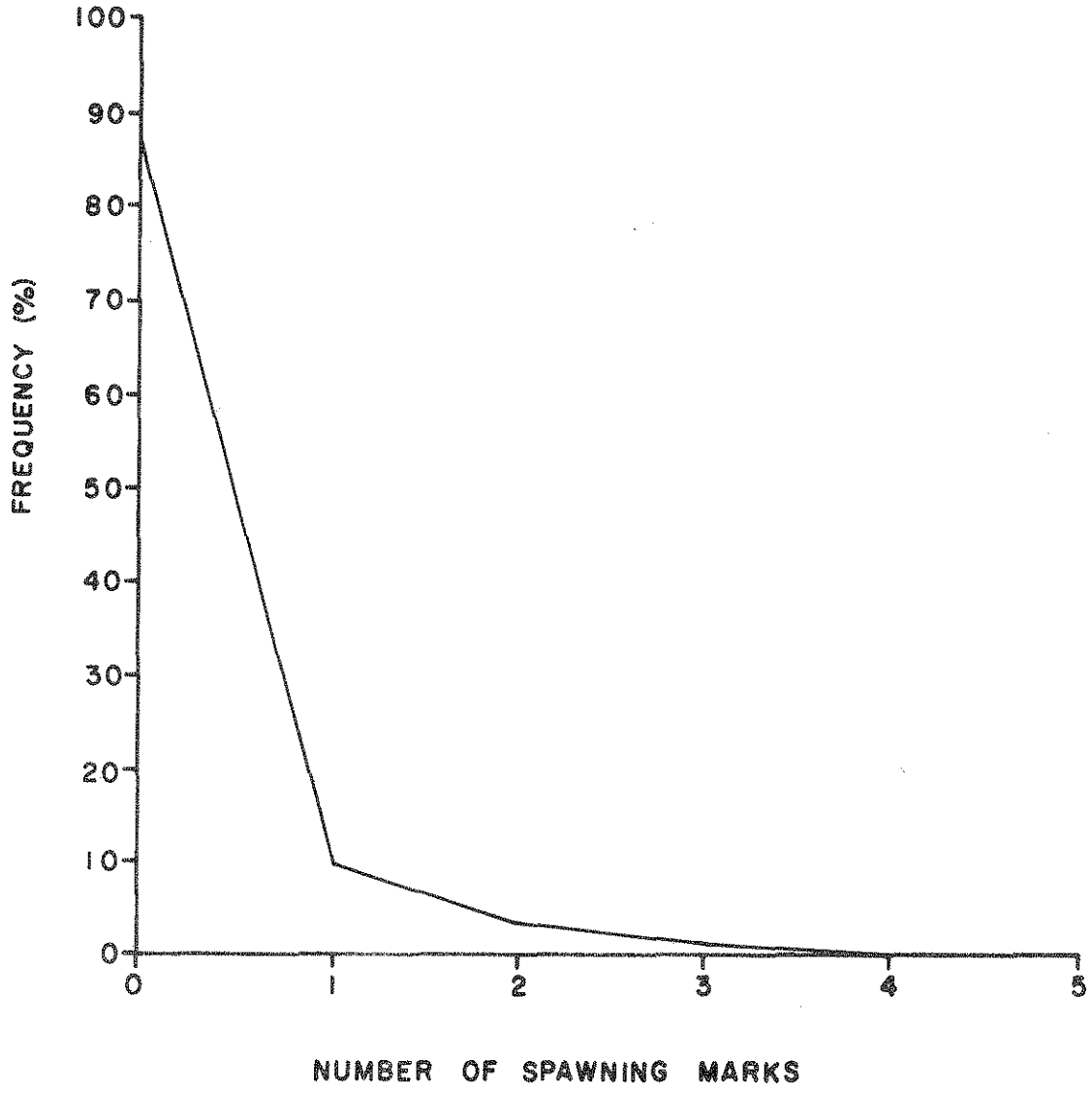

Figure 2.11. Frequency of virgin and repeat spawners in the 1977 commercial landings of alewife from Chowan River.

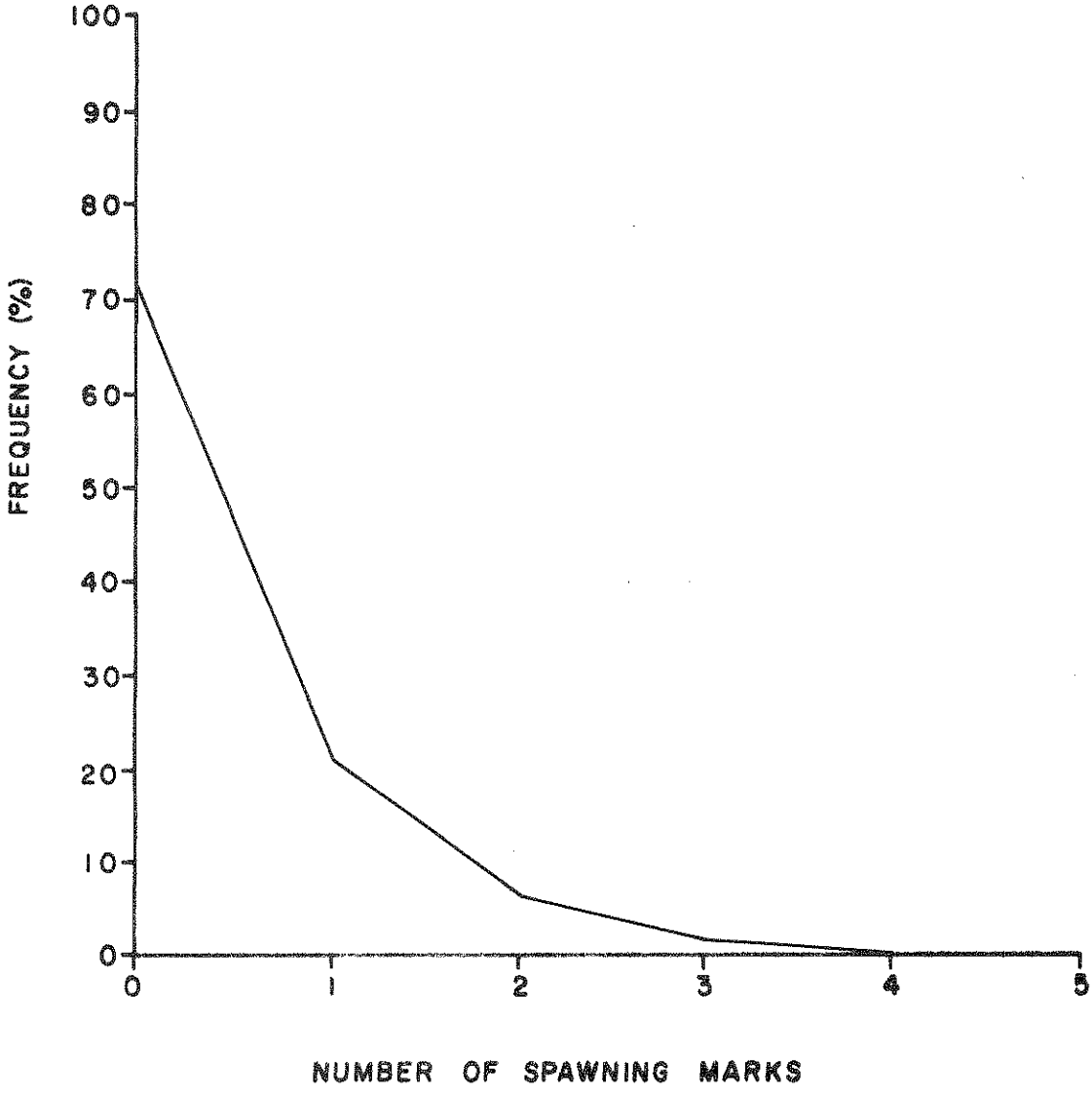

Figure 2.12. Frequency of virgin and repeat spawners in the 1977 commercial landings of alewife from Alligator River.

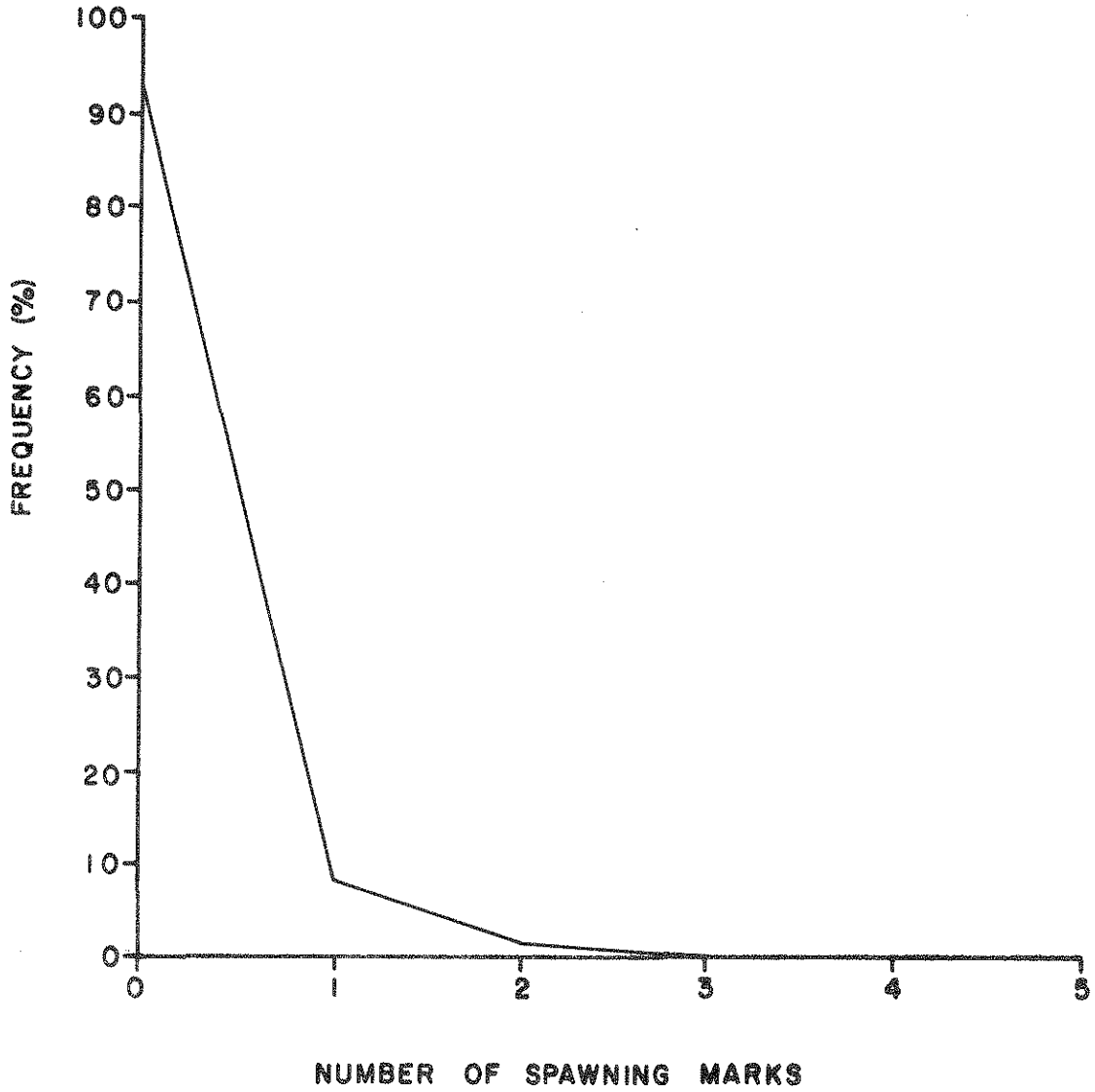

Figure 2.13. Frequency of virgin and repeat spawners in the 1977 commercial landings of American shad from the area of Albemarle Sound.

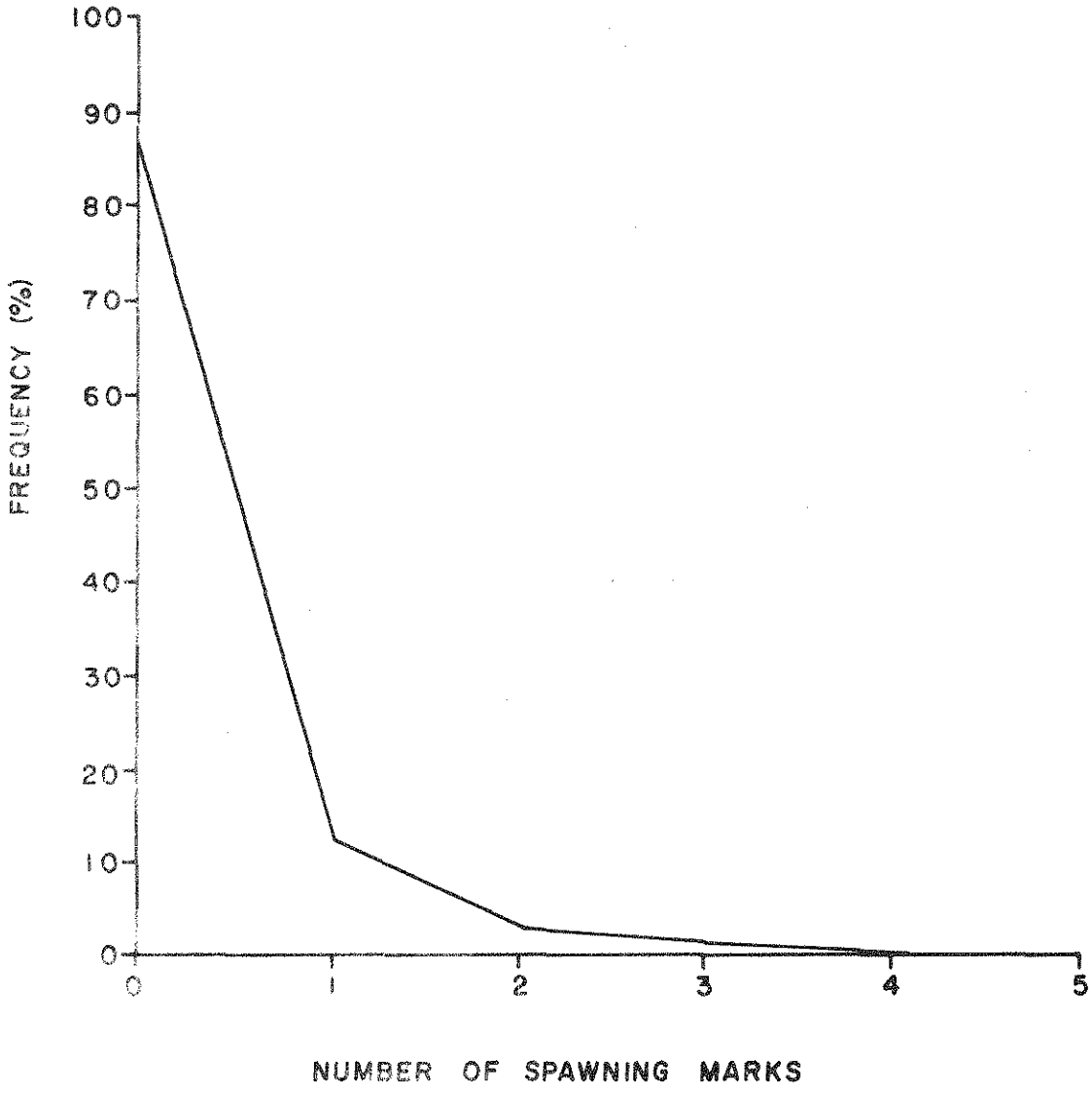

Figure 2.14. Frequency of virgin and repeat spawners in the 1977 commercial landings of hickory shad from the area of Albemarle Sound.

Job 3. Annual Index of Alosine Juvenile Abundance

SUMMARY

North Carolina

1. Nursery areas for alewife and blueback herring were again determined and mapped for the Albemarle Sound area.
2. A total of 21,142 juvenile alosine fish was captured during sampling.
3. The annual index of alosine juvenile abundance for 1977 showed a marked increase over 1974, 1975, and 1976.

Virginia

1. The alosine catch-per-unit-of-effort (c/f) rose sharply in 1977 relative to 1976. Blueback herring c/f compared favorably with those reported since 1970. The c/f for alewife and American shad, however, was relatively low in comparison to estimates made between 1970 and 1975.
2. Standing crop estimates greatly increased in 1977 relative to 1976 for all rivers except the James River. Differences in the methods of calculating nursery area may account for the exception.
3. Night and day paired comparison tows between surface and bottom trawls indicated a high degree of diel periodicity for juvenile alosines.

Job 3. Annual Index of Alosine Juvenile Abundance

INTRODUCTION

Quantitative determination of year-class strength is a major study element in population biology. Important long term objectives are to: (1) estimate the relationship (if any) between year-class strength and future recruitment; and (2) observe the periodicity (if any) of strong year classes.

MATERIALS AND METHODS

North Carolina

In North Carolina approximately 60 stations were sampled monthly with seine or trawl nets from June through December 1977. A maximum of 30 specimens per species was measured and the total catch by species recorded. Species other than anadromous fishes were also noted, as were environmental parameters such as water temperature and salinity at each station.

Virginia

The R/V Langley, the R/V Restless, and an outboard vessel (Thunderbird*) were used to collect samples of juvenile alosines and striped bass. The former two vessels employed identical 1.5 m x 1.5 m (5 ft x 5 ft) Cobb trawls. The latter vessel had a bow-mounted 1.5 m x 1.5 m framed net which was developed by VIMS personnel. It is referred to as a push net.

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*Use of trade name "Thunderbird" does not constitute endorsement.

Surface and subsurface samples were collected with Cobb trawls, but only surface samples were obtained with the push net. All samples were standardized at 5 min.

A stratified random sampling plan with proportional allocation of effort was employed. The nursery area (Fig. 3.6) in each river was divided into 9.3 km (5 nautical miles) sections. From a grid superimposed on the respective navigation charts, 50% of all possible sample stations between the 1.8 m (6 ft) depth contour lines (MLW) of opposite shores in each section were randomly selected. A subsample of 25% of the initially chosen stations was, in turn, randomly selected and designated as subsurface sampling sites; the remaining stations were reserved for surface sampling.

The general boundaries of each nursery zone were determined from salinity evaluations and pilot sampling "buffer" sections were included and constituted the upper and lower boundaries. After completion of the surveys, juvenile catch data were examined by species for density patterns within a nursery zone; if present, the zone was stratified and estimates of catch-per-unit-of-effort and standing crop were made for each stratum. When no density pattern was obvious for a species, as was generally the case when catches were few, the zone was not stratified. The initially constructed nursery zone was also modified for a given species if it was not caught in the upper and/or lower portions of the zone. New boundaries for the species of concern corresponded to the upper or lower limit of the first 9.3 km section in which it was first caught.

The same sectional boundaries were generally used to divide changing density patterns into nursery zone strata.

The annual index of abundance is the catch-per-unit-of-effort (c/f) derived after any necessary data adjustments for vessel-catch efficiency. The standing crop of juveniles is defined as the estimated number present at the time of sampling. It was calculated by the method of Hoagman et al. (1973) in which:

$$N = (VZ/VT)(c/f)$$

where N = the standing crop; VZ = the volume of water (km^3) in the nursery zone; VT = 5.31 $km^3 \times 10^{-4}$ of water, i.e., the estimated volume of water strained by a 1.5 m x 1.5 m Cobb trawl net in a 5 min tow with a vessel speed of 2 knots. VZ was estimated from the product of nursery zone area (km^2) and a conservative estimate that the mean depth in nursery zones was 4 m. Historically, with the exception of 2 years, 5 min tows were the standard unit of effort, but the catch data in past reports were doubled and VT = 10.62 $km^3 \times 10^{-4}$ used to simulate 10 min tows. This practice is now discontinued. Catch-per-unit-of-effort previously reported must be halved for general comparison to those reported herein. Also, the general magnitude of past and present estimates of N are comparable but absolute differences are inaccurate. Prior to 1976, effort was constant for all 9.3 km river sections regardless of the greater area in the lower sections of most nursery zones. In 1976, proportional allocation of effort was instituted except fewer tows were made in the lower sections where few, if any,

alosines occurred; also, the traditional nursery zone boundaries were used. The effect of having static nursery zone boundaries with extraneous area and constant effort in river sections is a reduced estimate of c/f; also, N could be under- or over-estimated depending upon the actual size of the nursery zones and whether extraneous areas were small or large relative to extraneous effort. Thus in 1977, minor changes in estimates may be more apparent than real.

Comparison tows to evaluate catch efficiency among vessels were made in September, 1977 in the Hopewell area of the James River using the R/V Brooks, R/V Langley, R/V Restless, and the Thunderbird. All but the latter vessel with its push net employed 1.5 m x 1.5 m Cobb trawls. In one test, 73 surface comparison tows were made using the Brooks, Langley and Restless. In another series of 55 replicate samples, the Langley, Restless and Thunderbird were employed. In each sampling series the vessels fished simultaneously for 5 min at the same river location. Each vessel's inshore-offshore position relative to the other vessels was randomized for each replication.

In the Mattaponi River, the least turbid of those sampled, 90 paired tows were made to evaluate diel periodicity of juvenile alosine abundance. The R/V Langley, equipped with a 9.1 m (30 ft) bottom trawl, and the R/V Restless, with a 1.5 m x 1.5 m Cobb trawl for surface towing, were used simultaneously to obtain 55 day, and 34 night comparison tows.

RESULTS AND DISCUSSION

North Carolina

From October 1976 to September 1977 a total of 20,307 juvenile anadromous fishes was captured in 532 samples. The main purpose of sampling was to determine the relative abundance of the 1976 and 1977 year classes. Numbers of samples taken by each sampling gear are shown in Table 3.1. The first three months (July-September) of 1976 were actually collected under project AFCS-11 but are also presented in this report in order to show a complete year class. Since relatively few American shad, hickory shad, and Atlantic sturgeon were taken during 1976 (2, 3, and 0, respectively) and during 1977 (21, 31, and 0, respectively) these species will not be considered further in the discussion of juveniles.

In contrast to AFCS-8 and AFCS-11 the seine did not prove to be the most effective gear for the capture of juvenile blueback herring during the 1976 and 1977 sampling periods, except during August, 1977 (Fig. 3.1).

As during projects AFCS-8 and AFCS-11, the wing trawl proved to be most effective in the capture of juvenile alewife for both the 1976 and 1977 sampling periods (Fig. 3.2).

Nursery Areas

As in projects AFCS-8 and AFCS-11, nursery areas for alewife generally coincided with those for blueback herring. Nursery areas established during AFCS-8 and AFCS-11 again were found to be important for young anadromous fishes. Nursery

areas are shown in Figure 3.3. As stated by Street et al. (1975), those areas identified as nursery areas are extremely important for the maintenance of blueback herring and alewife populations and should be protected from alteration and pollution.

Growth

During this project segment, the 1976 and 1977 year classes of blueback herring and alewife were followed through their first season of growth. Figure 3.4 shows the mean fork length of juvenile blueback herring and alewife for each month of sampling for each year. These data generally agree with that reported by Street et al. (1975) and Johnson et al. (1977).

Movement

Movement of the 1976 and 1977 year classes of fish was virtually the same as those reported by Street et al. (1975) and Johnson et al. (1977).

Relative Abundance

Sampling with seines and trawls was conducted by standardized procedures in order to compare results from different samples taken with the same gear. Such data should show any changes in juvenile abundance from year to year.

Data have been collected on six year classes (1972-1977) of blueback herring and alewife. For comparative purposes, data are presented on a growth year basis rather than by calendar year; that is, June through the following May, rather than January through December.

Street et al. (1975) and Johnson et al. (1977) reported that blueback herring were far more numerous than alewife for years 1972-1976. This trend was continued in 1977 (Fig. 3.5).

Virginia

General catch-effort statistics are presented in Table 3.2. The range in catches was most often dramatic when the density of a species was relatively high. A large catch range is expected because of the well known contagious distribution of these species in estuaries; therefore, occasional large catches were not omitted from consideration as "statistical outliers."

Index of Abundance

The alosine c/f, with a few exceptions, rose sharply in 1977 relative to 1976 (Table 3.3). Blueback herring c/f also compares favorably with those reported since 1970 (Loesch and Kriete, 1976). In contrast, the c/f estimates for alewife and American shad were relatively low in comparison to those prior to 1976.

The pooled (all rivers) c/f for alewife in 1977 was 1.48, with the highest estimates for strata and river occurring in the Potomac River (Table 3.4). For blueback, the pooled c/f was 110.66, with the highest estimates for strata and river occurring in the Rappahannock River. The American shad pooled c/f was 0.19 and the highest estimate occurred in the unstratified Mattaponi River. Striped bass juveniles were caught in only the James, Rappahannock and Potomac rivers.

The pooled striped bass c/f was 0.15 with the Potomac River having the highest river estimate of 0.20. The latter value was slightly exceeded by one of 0.25 in the lower stratum of the James River.

Standing Crop

Standing crop (N) estimates greatly increased in 1977 relative to 1976 for all rivers with the exception of the James River (Table 3.5). In the latter river the relatively low magnitude of change makes the significance of the difference questionable. Although the James River estimates of c/f for alewife and blueback greatly increased in 1977 relative to 1976 (about 700 and 260%, respectively), the magnitude of change was not reflected in the estimates of N. This apparent paradox illustrates the effect of different methodologies for determining nursery zone area. Previously, the James River nursery zone boundaries were assumed constant between miles 35 to 80 with an area of 190.8 km^2. In 1977, juvenile alewife were found only between miles 60 to 80, blueback between miles 50 to 80, and American shad between miles 50 to 70 with areas of 19.1, 33.7, and 30.8 km^2, respectively. The 1977 estimates of nursery zone areas for the Pamunkey and Potomac rivers are approximately 40 to 47% of those previously used, while those for the Mattaponi and Rappahannock rivers are relatively unchanged.

The relative abundance and descending rank order of the four species of concern are: Blueback (98.6%), Alewife (1.2%), Striped bass (0.12%), and American shad (0.08%). Although

American shad were captured in five of the six rivers sampled and striped bass were taken in only three rivers, the slightly smaller c/f for the latter species was associated with a larger nursery zone area (Table 3.4).

The 1977 pooled estimate of N for alewife, 2.10 million, is inferior to all previous estimates since 1970 except for those of 1974 and 1976. However, when individual rivers are considered, the 1977 N's are superior to 13 of the 35 estimates made from 1970 to 1976 (Loesch and Kriete, 1976). Previous estimates of the pooled N are suspected of being inflated because of the inclusion of large extraneous areas, primarily in the lower James and Potomac rivers.

Abundance of alewife in 1977 by river and strata was highest in the Potomac River which accounted for about 78% of the pooled N (Table 3.4).

The pooled estimate of N for blueback, 171 million, also exceeded the 1974 and 1976 estimates; however, individual river N's were superior to 20 of the 35 estimates made from 1970 to 1976. Blueback, by river and strata, were most abundant in the Rappahannock River. Estimated abundance was only slightly less in the Potomac River, and, together, the two nursery zones accounted for about 90% of the pooled N (Table 3.4).

The 1977 pooled N for American shad, 0.13 million, exceeded only the 1976 estimate, and only four of the individual N's by river were larger than those previously

reported by Loesch and Kriete (1976). Abundance estimates, as indicated by the N's at the time of sampling in 1977, infer that another poor year class was produced.

An N of 0.201 million was estimated for juvenile striped bass in 1977 with the greatest abundance in the Potomac River. Previous estimates are not available for judging the relative significance of these statistics.

Gear Comparisons

Catch statistics for the first series of 73 comparison tows indicated a very high catch efficiency of juvenile alosines by the Thunderbird-push net combination relative to the Cobb trawl catches of the R/V Langley and R/V Restless (Table 3.6). The statistical significance of the observed differences was readily established by a Friedman Rank Sums Test and subsequent nonparametric multiple comparisons (Table 3.7). After adjustment of the R/V Langley's catches (because preliminary time-distance comparison tests indicated it traveled about 19.5% further than the other two vessels) the Langley:Restless:T-Bird catch ratio was 1:4.04:14.76.

A second series of comparison tows was conducted among the R/V Langley, R/V Restless and R/V Brooks (used in previous years). Statistical analysis (as above) indicated no significance between the median catches of the R/V Brooks and the R/V Restless; their median catches were, however, significantly greater than that of the R/V Langley (Tables 3.8 and 3.9). After the appropriate adjustment of the latter vessel's catch, the Langley:Brooks-Restless catch ratio was 1:4.63 which is

similar to the Langley:Restless ratio in the first series. A Langley:Brooks-Restless:T-Bird catch ratio was established from consideration of both sets of data as 1:4.29:14.76.

Diel Periodicity

Intermittent bottom trawling with a 9.1 m semi-balloon trawl during the 1977 juvenile survey often produced larger catches of alewife and American shad than did corresponding surface tows with a Cobb trawl. The data sets could not be directly compared because the fishing configuration of the bottom trawl is unknown. The bottom trawl certainly filters a greater volume of water than the Cobb trawl in a standard tow. The apparent differential catches, however, prompted a series of day-night comparison tows.

Hoagman et al. (1973) concluded that juvenile alewife and American shad exhibited a preference for the "middle depths" while blueback favored a higher position in the water column. Statistical analysis of their data, derived from surface and subsurface Cobb trawl tows, did not support their conclusion. Discrete vertical separation between surface and subsurface Cobb trawl tows, as employed in VIMS sampling, does not occur; i.e., subsurface tows partially overlap the depth of surface tows.

In our diel periodicity tests, bottom and surface trawls were employed to maximize the vertical distance between paired samples. The Mattaponi River, one of the least turbid systems of those in our survey, was selected as the study site in order

to maximize any possible light effect on the vertical distribution of the juvenile fish.

Data from 90 paired surface and bottom tows indicated a greater density of alosine juveniles in bottom water during daylight hours and, conversely, a greater concentration in surface waters at night (Table 3.10). Obviously, there is a diel periodicity exhibited by juvenile alosines, at least in relatively clear water. The investigation will be pursued in 1978.

If further investigations confirm both diel periodicity and a high catch efficiency for the push net, future juvenile sampling may be conducted at night with two or more push nets. The benefits would be increased accuracy and precision in population estimates, and, possibly a reduction of operational costs.

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Table 3.1. Number of samples and catch of juvenile alosines by trawl and seine in North Carolina in 1976-1977.

	Trawl		Seine	
	1976	1977	1976	1977
Number of Samples	299	249	156	130
Blueback herring	4,447	11,044	2,830	4,825
Alewife	879	4,812	48	409
American shad	2	0	0	21
Hickory shad	2	11	1	20
Total	5,330	15,867	2,879	5,275

Table 3.2. Juvenile alosine and striped bass catch-effort statistics, 1977.

River	Species	Strata (Miles)	Effort (No. tows)	Catch Statistics Catch	Min.	Max.
James	Alewife	70-80	23	2	0	2
		60-70	22	10	0	4
		50-60	24	0		
	Blueback	70-80	23	616	0	271
		60-70	22	1,759	0	290
		50-60	24	640	0	473
	American shad	70-80	23	0†		
		60-70	22	1	0	1
		50-60	24	1	0	1
	Striped bass	70-80	23	0		
		60-70	22	1	0	1
		50-60	24	6	0	3
Chickahominy	Alewife	7-21*	21	0		
	Blueback	7-21*	21	2	0	2
	American shad	7-21*	21	1	0	1
	Striped bass	7-21*	21	0		
Pamunkey	Alewife	60-65	7	0		
		50-60	17	4	0	4
		40-50	16	5	0	2
	Blueback	60-65	7	2	0	1
		50-60	17	1,104	0	688
		40-50	16	5		
	American shad	60-65	7	0		
		50-60	17	10	0	7
		40-50	16	2	0	1
	Striped bass	40-65*	40	0		
Mattaponi	Alewife	40-60*	31	1	0	1
	Blueback	45-60	23	289	0	55
		40-45	8	5	0	3
	American shad	45-60	23	21	0	6
		40-45	8	0		
	Striped bass	40-60*	31	0		
Rappahannock	Alewife	50-85*	60	86	0	20
	Blueback	70-85	26	1,138	0	481
		60-70	17	10,727	3	7,038
		50-60	17	13	0	8
	American shad	50-85*	60	3	0	1
	Striped bass	50-85*	60	1	0	1
Potomac	Alewife	84-94	18	19	0	12
		73-84	44	158	0	18
		68-73	44	25	0	9
	Blueback	84-94	18	41	0	14
		73-84	44	9,303	2	985
		68-73	44	39	0	9

†Strata with zero catch were omitted from subsequent calculations.

*No stratification.

Table 3.2. (continued)

River	Species	Strata (Miles)	Effort (No. tows)	Catch Statistics		
				Catch	Min.	Max.
Potomac (cont'd)	American shad	68-94*	106	0		
	Striped bass	68-94*	106	21	0	4

†Strata with zero catch were omitted from subsequent calculations.

*No stratification.

Table 3.3. Comparison of 1976 and 1977 estimates of catch-per-unit-of-effort (c/f) of juvenile alosines.

River	Species	c/f 1976*	c/f 1977	Difference (%)
James	Alewife	0.05	0.40	700
	Blueback	14.4	52.30	260
	American shad	0.05	0.04	-25
Pamunkey	Alewife	0.05	0.28	460
	Blueback	0.10	30.01	30,000
	American shad	0.05	0.35	600
Mattaponi	Alewife	0	0.03	
	Blueback	0.1	9.59	45,000
	American shad	0.05	0.91	17,000
Rappahannock	Alewife	0.2	1.43	620
	Blueback	46.7	321.57	590
	American shad	0	0.05	
Potomac	Alewife	0.15	1.98	1,200
	Blueback	0.50	89.77	18,000
	American shad	0	0	

*Source: Loesch and Kriete, 1976 (Table 3.5 adjusted to 5 min tows).

Table 3.4. Estimates of catch-per-unit-of-effort (c/f) and standing crop (N) of juvenile alosines and striped bass by strata, nursery zones, and rivers, 1977.

Species	River	Strata (Miles)	Area (km^2)	Volume (km^3)	c/f		N (X 10^6)	
					Strata	Zone*	Strata	Zone*
Alewife	James	70-80	2.90	11.60	0.09		0.002	
		60-70	16.18	64.72	0.46	0.40	0.056	0.060
	Pamunkey	50-60	6.83	27.32	0.24		0.012	
		40-50	6.92	27.68	0.31	0.28	0.016	0.028
	Mattaponi	40-60	10.36	41.44		0.03		0.025
	Rappahannock	50-85	33.02	132.08		1.43		0.356
	Potomac	84-94	31.63	126.52	1.06		0.252	
		73-84	45.86	183.44	3.59		1.240	
		68-73	31.64	126.56	0.57	1.98	0.136	1.629
					All rivers:	1.48		2.098
Blueback	James	70-80	2.90	11.60	26.78		0.585	
		60-70	16.18	64.72	79.96		9.746	
		50-60	14.58	58.32	26.67	52.30	2.929	13.260
	Chickahominy	7-21	4.29	17.16		0.1		0.003
	Pamunkey	60-65	1.11	4.44	0.29		0.002	
		50-60	6.83	27.32	64.94		3.341	
		40-50	6.92	27.68	0.31	30.01	0.016	3.360
	Mattaponi	45-60	7.78	31.12	12.56		0.736	
		40-45	2.58	10.32	0.62	9.59	0.012	0.748
	Rappahannock	70-85	5.69	22.76	43.77		1.876	
		60-70	16.42	65.68	631		78.049	
		50-60	10.91	43.64	0.76	321.57	0.062	79.988
	Potomac	84-94	31.63	126.52	2.28		0.543	
		73-84	45.86	183.44	211.43		73.041	
		68-73	31.64	126.56	0.89	89.77	0.212	73.796
					All rivers:	110.66		171.155
American shad	James	50-70	30.75	123.04		0.04		0.009

Table 3.4. (continued)

Species	River	Strata (Miles)	Area (km^2)	Volume (km^3)	c/f		N (X 10^6)	
					Strata	Zone*	Strata	Zone*
American shad (continued)	Chickahominy	7-21	4.29	17.16		0.05		0.002
	Pamunkey	50-60	6.83	27.32	0.59		0.030	
		40-50	6.92	27.68	0.12	0.35	0.036	0.037
	Mattaponi	40-60	10.36	41.44		0.91		0.071
	Rappahannock	50-85	33.02	132.08		0.05		0.012
					All rivers:	0.19		0.131
Striped bass	James	60-70	16.18	64.72	0.04		0.005	
		50-60	14.58	58.32	0.25	0.14	0.027	0.032
	Rappahannock	50-85	33.02	132.08		0.02		0.005
	Potomac	68-94	109.13	436.52		0.20		0.164
					All rivers:	0.15		0.201

*When rivers are stratified, c/f and N in nursery zones are weighted by strata area.

Table 3.5. Comparison of 1976 and 1977 estimates of standing crop (N) of juvenile alosines.

River	Species	N ($\times 10^6$) 1976*	N ($\times 10^6$) 1977	Difference (%)
James	Alewife	0.04	0.06	50
	Blueback	20.7	13.26	-36
	American shad	0.05	0.01	-80
Pamunkey	Alewife	0.01	0.03	200
	Blueback	0.02	3.36	1,700
	American shad	0.01	0.04	300
Mattaponi	Alewife	0	0.02	
	Blueback	0.01	0.75	7,400
	American shad	0.01	0.07	600
Rappahannock	Alewife	0.05	0.36	620
	Blueback	11.4	80.00	600
	American shad	0	0.01	
Potomac	Alewife	0.2	1.63	720
	Blueback	0.8	73.80	9,100
	American shad	0	0	

*Source: Loesch and Kriete, 1976 (Table 3.7).

Table 3.6. Juvenile alosine catch statistics for 73 comparison trawls each by the R/V Langley, R/V Restless, and Thunderbird in the James River, September, 1977.

	Langley	Restless	Thunderbird
Catch	2,663	8,666	31,637
c/f	36.5	118.7	433.4
Std. Dev.	62.79	148.77	537.63

Table 3.7. Summary of the Friedman Rank Sums and multiple comparison analysis of 1977 comparison trawl data of Table 3.6.

Friedman statistic	Critical χ^2 (α = 0.001)	Probability (P)
105.3	13.8	P<0.001

Multiple Comparisons*

Comparison	Difference in ranked sums	Critical value (α's as indicated)	Probability (P)
Restless vs. Langley	62	28.3 (α = 0.05)	P<0.001
T-Bird vs. Langley	124	35.2 (α = 0.01)	P<0.001
T-Bird vs. Restless	62	43.2 (α = 0.001)	P<0.001

*see Hollander and Wolfe, 1973.

Table 3.8. Catch statistics for 55 comparison trawls each by the R/V Langley, R/V Restless, and the R/V Brooks in the James River, September, 1977.

	Langley	Restless	Brooks
Catch	4,625	19,279	15,250
c/f	84.1	350.5	277.3
Std. Dev.	153.58	471.03	420.40

Table 3.9. Summary of the Friedman Rank Sums and multiple comparison analysis of the 1977 comparison trawl data of Table 3.8.

Friedman statistic	Critical χ^2 (α = 0.001)	Probability (P)
42.3	13.8	P<0.001

Multiple Comparisons*

Comparison	Difference in ranked sums	Critical value (α's as indicated)	Probability (P)
Restless vs. Langley	66	37.5 (α = 0.001)	P<0.001
Restless vs. Brooks	18	24.5 (α = 0.05)	P>0.05
Brooks vs. Langley	48	37.5 (α = 0.001)	P<0.001

*see Hollander and Wolfe, 1973.

Table 3.10. Alosine juvenile catch statistics for 90 paired surface and bottom trawls in the Mattaponi River, September, 1977, employing a 9.1 m bottom trawl and a 1.5 m x 1.5 m surface trawl.

Date	Trawl type	No. tows		Catch-per-unit-of-effort	
		Day	Night	Day	Night
26 Sep.	Bottom	14	12	105.4	1.2
	Surface	14	12	3.4	85.4
27 Sep.	Bottom	22	12	80.5	0.9
	Surface	22	12	1.6	105.2
28 Sep.	Bottom	20	10	30.9	2.5
	Surface	20	10	2.8	155.5

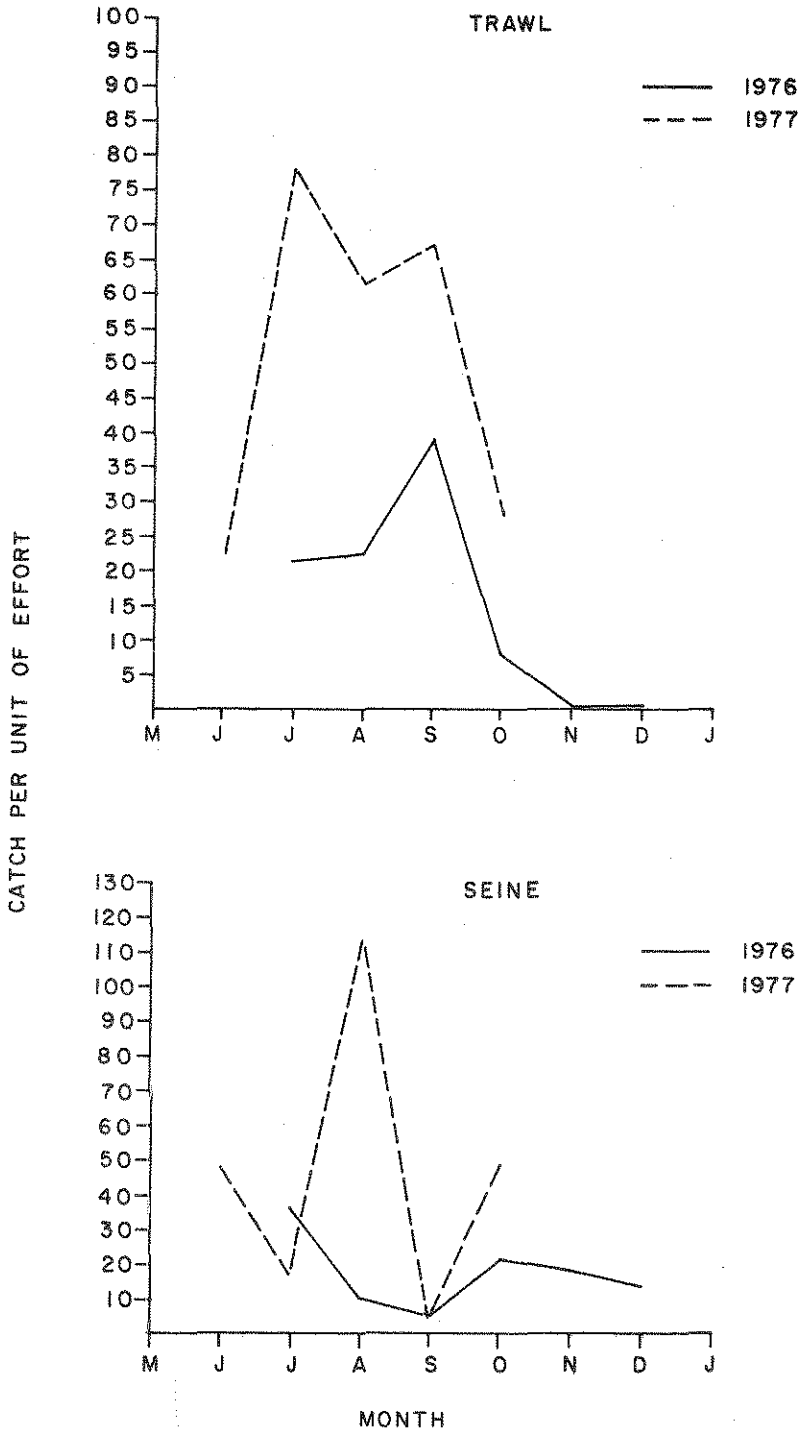

Figure 3.1. Monthly catch-per-unit-of-effort for blueback herring by trawl and seine in 1976 and 1977.

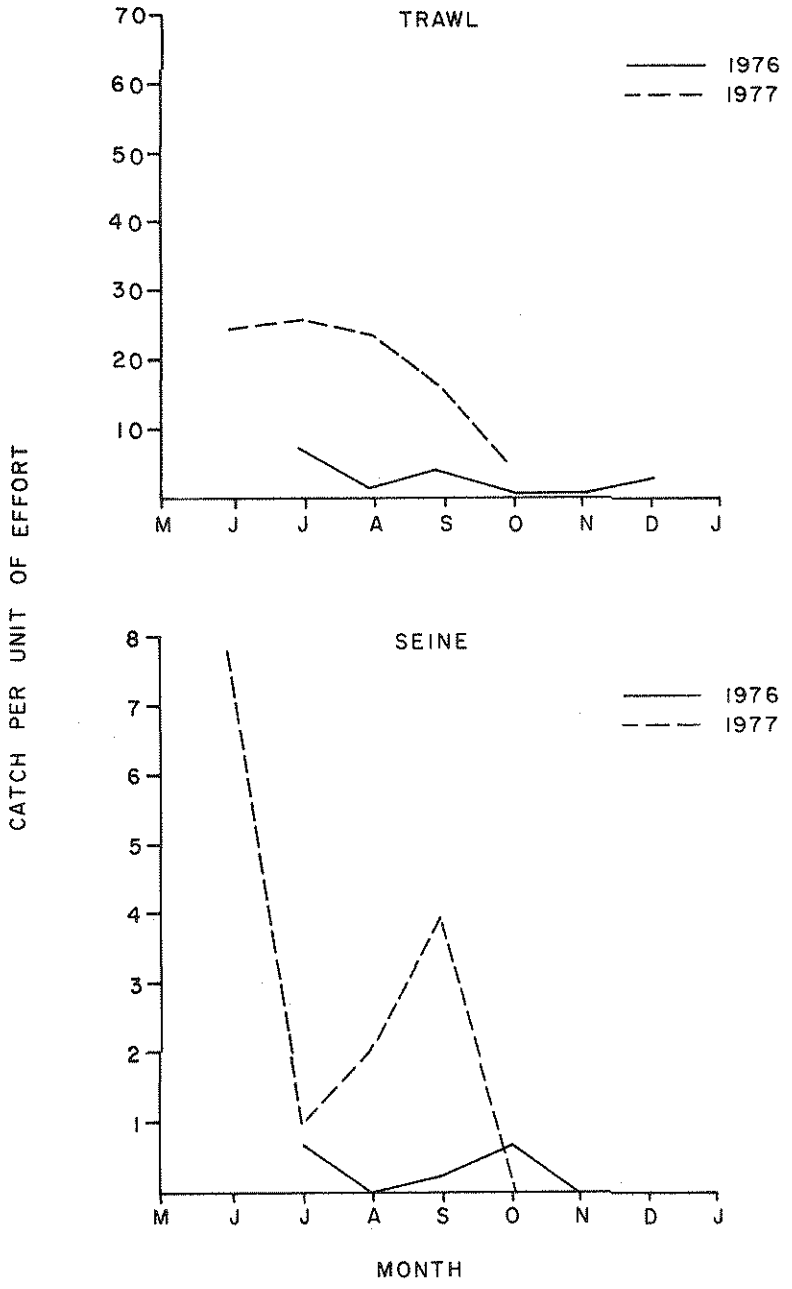

Figure 3.2. Monthly catch-per-unit-of-effort for alewife by trawl and seine in 1976 and 1977.

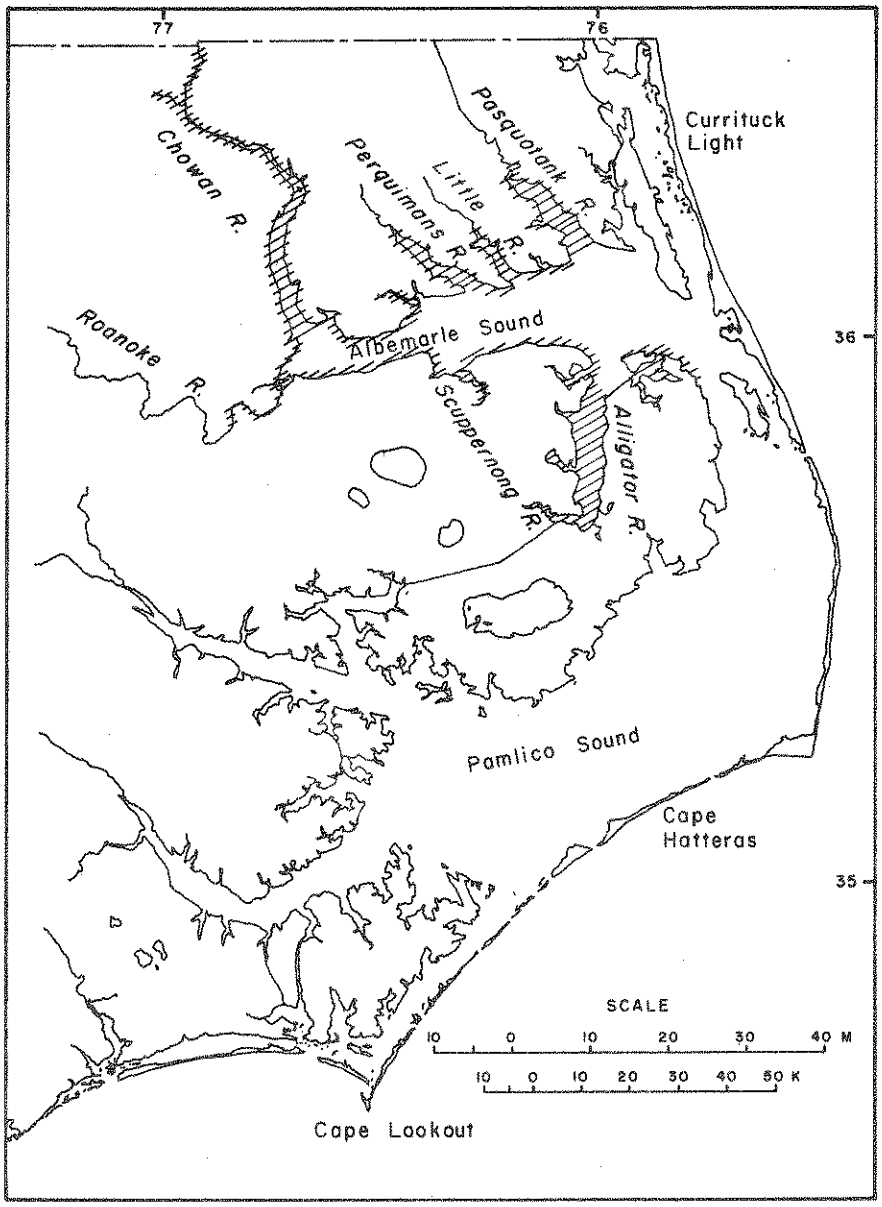

Figure 3.3. Nursery areas of blueback herring and alewife in Albemarle Sound and tributaries.

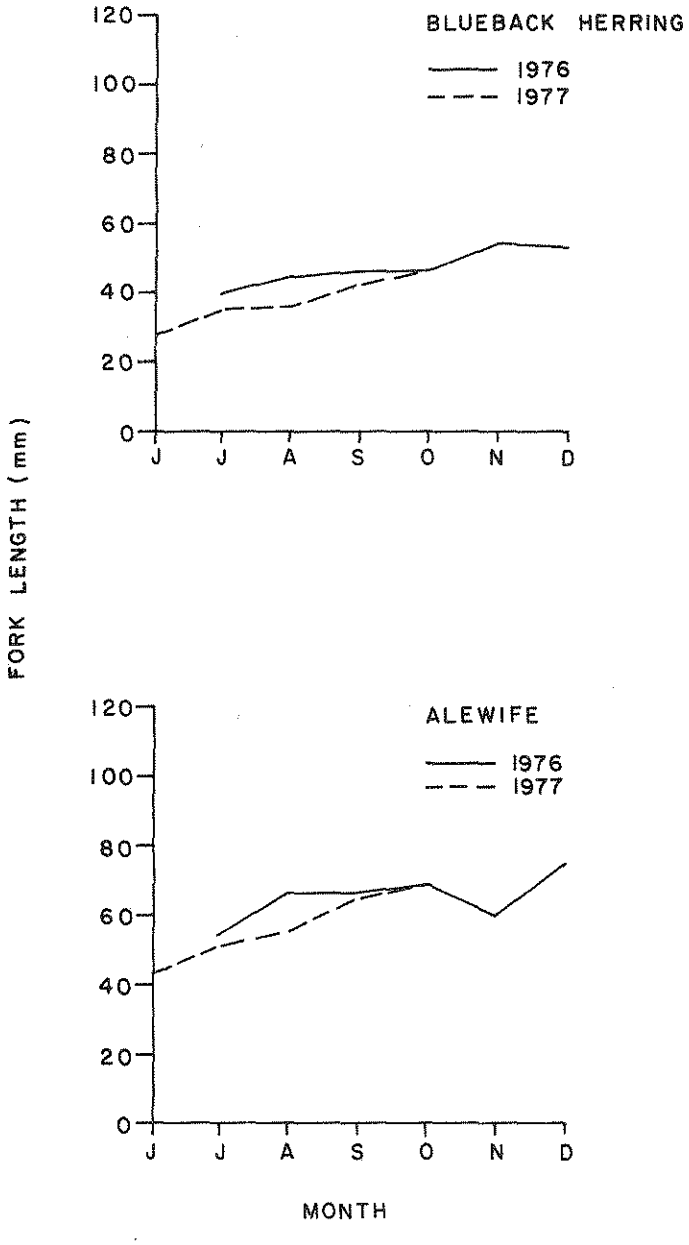

Figure 3.4. Mean fork length of alewife and blueback herring by month for 1976 and 1977.

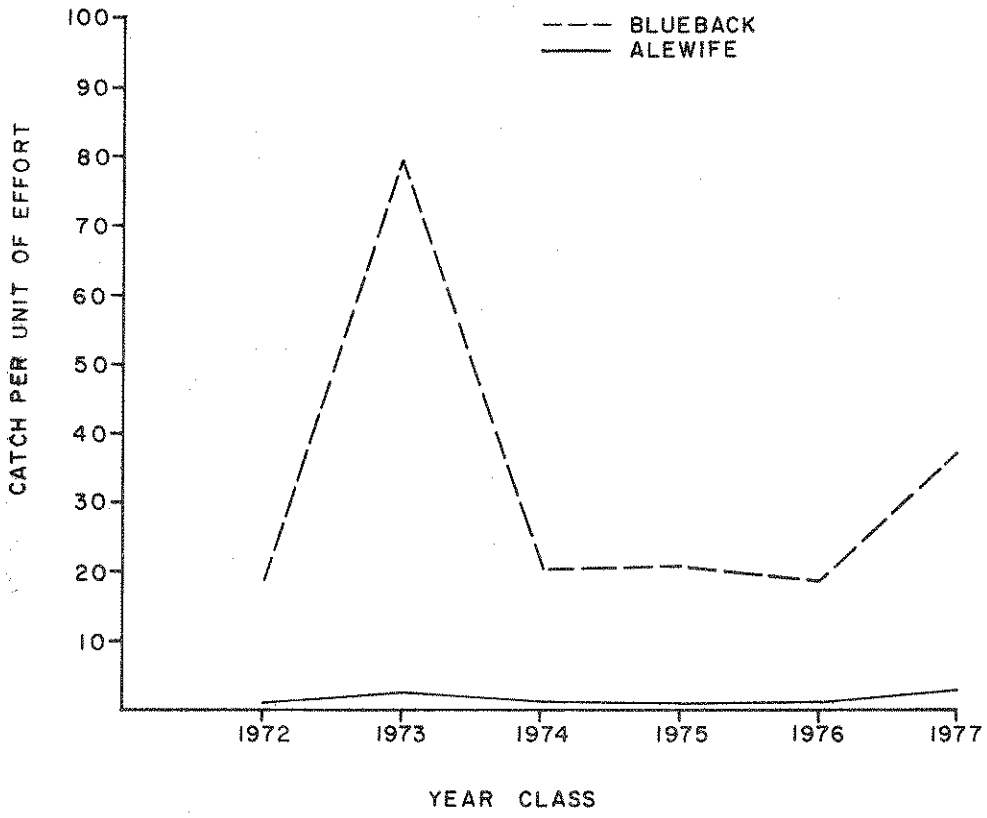

Figure 3.5. Catch-per-unit-of-effort for blueback herring and alewife year classes 1972 through 1977 by seine net.

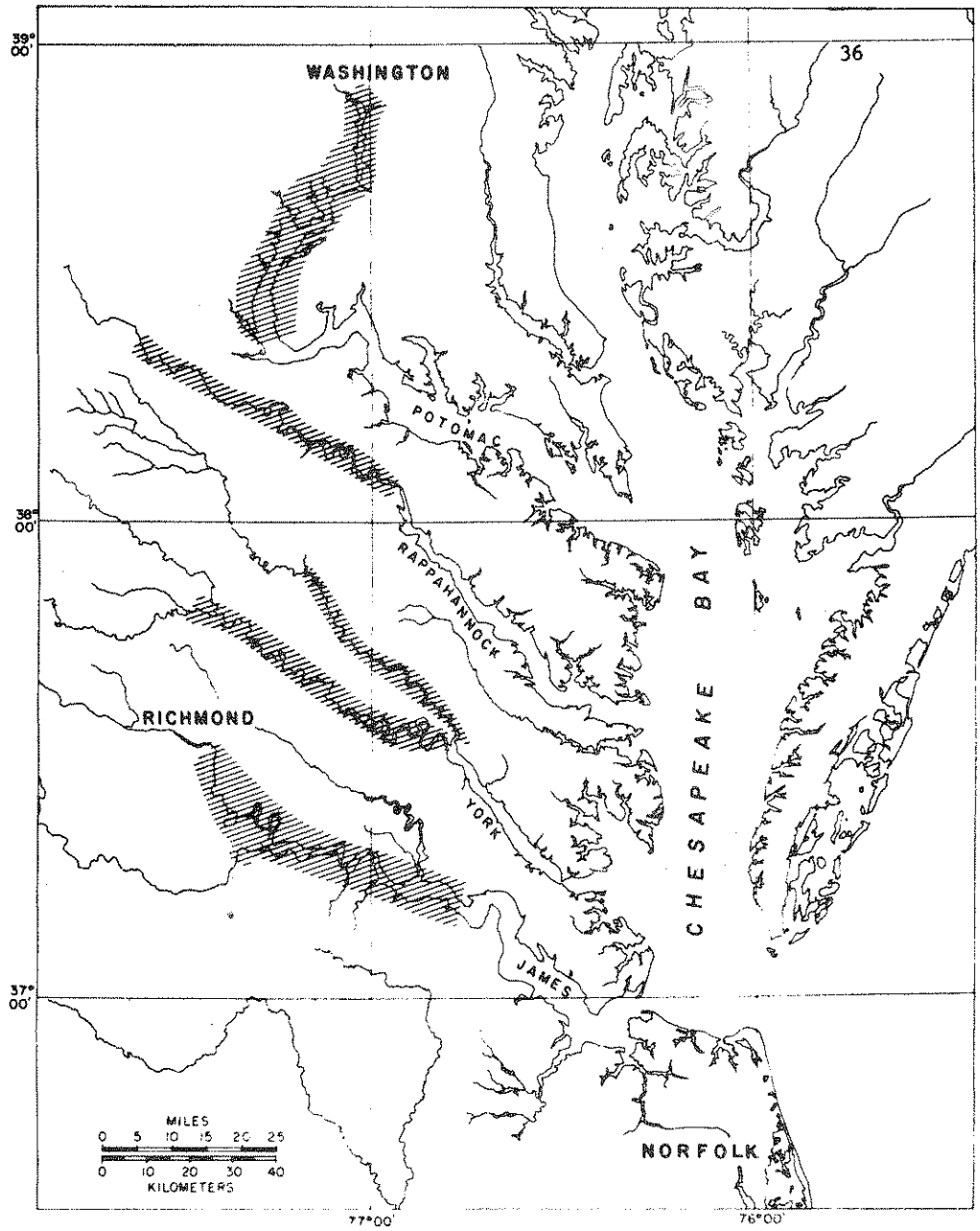

Figure 3.6. Lower Chesapeake Bay and tributaries with major freshwater nursery zones shaded.

Job 4. Assessment of Alosine Winter and Early Spring Fishery by Drift Net and Sport Fishermen - Pilot Program

SUMMARY

1. Landings by Virginia drift gill net fishermen in the Mattaponi and Pamunkey rivers were estimated to be between 22,680 and 24,948 kg (50,000 to 55,000 lb.).
2. Dip net fishermen, dipping at night, averaged 50 river herring per night and 30 river herring during daylight.

Job 4. Assessment of Alosine Winter and Early Spring Fishery by Drift Net and Sport Fishermen - Pilot Program

INTRODUCTION

Drift gill nets and dip nets have been used extensively to take American shad and river herring on the Atlantic coast of the United States. There was an active drift gill net shad fishery in Maine between the years 1820 and 1830. In 1896, the year of an extensive study of the shad fishery on the Atlantic Coast, drift nets caught 46% of the 22.7 million kgs (50 million lb.) of shad landed along the Atlantic Coast (Walburg and Nichols, 1967). In the same year, 33% of all American shad landed in the Chesapeake Bay came from drift nets. By 1960, however, only 28% of the shad landed on the Atlantic Coast were from drift gill nets.

Drift gill nets caught 42% of the American shad landed in the State of Virginia in 1896, but only 22% in 1960. During the same period the total meters of drift gill nets decreased from 272,531 m to 82,992 m (894,131 ft to 272,283 ft)(Walburg and Nichols, 1967).

Today the number of drift gill nets and the areas fished in Virginia are greatly reduced, compared to 1896, or even 1960. The Appomattox, Chickahominy and Rappahannock rivers no longer have an active shad drift net fishery; and the drift net area in the James River is reduced to a 15 nautical mile reach below the Benjamin Harrison bridge near Hopewell. Although there is no drift net fishery in the York River, its two main tributaries have a limited fishery, as does the Potomac River.

Commercial and recreational drift netting for river herring is very limited. The only known source of information on drift gill netting of river herring in Virginia is the Potomac River Fisheries Commission. Information supplied by the Commission in 1976 showed a steady decline in landings of river herring by drift nets since 1967 (Loesch and Kriete, 1976).

Dip nets or bow nets, while popular for taking American shad in most of the Atlantic Coast states, were only employed on a limited basis in Virginia. In recent years, dip nets have been almost exclusively used for river herring in Virginia. Most dipping is conducted on a recreational basis at many small creeks utilized as spawning areas by river herring.

The purpose of this pilot study is to document the extent of the drift gill net and dip net fisheries for American shad and river herring in Virginia.

MATERIALS AND METHODS

Logbooks placed with cooperating drift net fishermen at the beginning of the shad fishing season yielded only limited results. Many fishermen operate only part-time and live 48-80 km (30-50 miles) from the fishing area. Personal contacts are thus difficult and produce comments on average catches, but no written records.

The most productive period for dip netting is during the hours of darkness. Thus, dip net fishermen are even more difficult to contact.

Netters were contacted during daylight and darkness and were questioned as to their total catch by species for the day, their average number of hours spent fishing per day, the average number of days per week spent fishing, and their estimate of the average number of dip netters at the site.

RESULTS AND DISCUSSION

Drift Gill Nets

The 1977 drift gill net fishery for American shad in the Mattaponi and Pamunkey rivers began during the first half of March and continued through April. Most fishermen only fished about five weeks during that period. There were approximately seven full-time and 18 part-time fishermen on the Pamunkey River and 10 full-time and 10 part-time fishermen on the Mattaponi River. Each fisherman set an average of three nets per drift during slack tide, six days a week. Mesh sizes ranged from 12.7 cm to 14 cm (5 inches to 5.5 inches) and nets averaged 137.2 m (450 ft) in length.

Full-time fishermen on the Pamunkey River averaged 7-8 fish per net per tide fished, with an average of 40 fish landed per day. Sex ratio favored females over males 20:1. Full-time fishermen related that many of the part time fishermen on the Pamunkey River lived in the Richmond, Virginia, area. Part-time gill netters fished on weekends or as time permitted from their other jobs. Their catches were probably similar to those of the part-time fishermen on the Mattaponi River.

Full-time fishermen on the Mattaponi River averaged 33% fewer fish than fishermen on the Pamunkey River. Drift nets were only set at slack tide at night because the less turbid Mattaponi River made day fishing impractical.

We estimate the total landings by drift net fishermen in both rivers were between 22,680 and 24,948 kgs (50,000 to 55,000 lb); however, the estimates are based on limited data, primarily fisherman interviews.

Dip Nets

The dip net fishery for river herring in Virginia begins in the latter half of March, or as soon as the weather is pleasant and continues into the first of May.

Interviewed fishermen indicated that the 1977 river herring run was small compared to previous years. One site visited on the Pamunkey River had become a commercial venture for the owner. The area used for dipping was fenced, and for parking and fishing privileges a fee was charged. The owner estimated the site averaged 50 people per night and most fishermen averaged 50 fish per night.

A spot check of six dipping sites on the Rappahannock River system during daylight hours revealed dippers at three of the sites, a maximum catch of 30 fish/fisherman and the maximum number of four dippers at a site.

In conjunction with their master's thesis problems, Herring Creek on the James River system was visited regularly by two VIMS graduate students, who set fyke nets below a dipping

site on Herring Creek. They also set a trap net upstream of the dip netters. Due to the nonselective nature of all gears (dip net, fyke net and trap net) it is assumed the species composition of the fyke and trap nets would reflect that of the dip nets. The number of dip netters at the Herring Creek site and the species composition of the fyke and trap nets are given in Table 4.1. Most of the netters concurred that the 1977 season was very poor for river herring. Data were inadequate to estimate total river herring landings by dip netters in Herring Creek.

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Loesch, J. G. and W. H. Kriete, Jr. 1976. Biology and management of river herring and shad in Virginia. Va. Inst. Mar. Sci. Comp. Rep. Nat. Mar. Fish. Serv. Proj. No. AFC 8-1 to 8-3. 226 p.

Table 4.1. Number of dip netters and species composition in fyke nets on Herring Creek, James River, 1977.

Date	No. of Dip Netters	Species Composition in Fyke and Trap Nets		
		Blueback	Alewife	Ratio
25-31 Mar 77	1	0	2	
01-07 Apr 77	6	2	5	0.4:1
08-14 Apr 77	24	20	11	1.8:1
15-21 Apr 77	40	72	9	8.0:1
22-28 Apr 77	12	254	5	50.8:1
29 Apr-05 May 77	6	73	0	
	No dip netters seen after 3 May 1977			

Job 5. The Ocean Phase of Anadromous Fishes - Pilot Program

SUMMARY

1. A total of 795 anadromous fishes, predominantly blueback herring, was captured.
2. Anadromous fishes were found in greatest numbers between Cape Hatteras and Little Machipongo Inlet, Virginia.
3. The inshore (0-18.3 m [0-60 ft]) zone accounted for 92.2% of all anadromous species captured.
4. A total of 10 Atlantic sturgeon was tagged and released. One was recaptured.
5. Analysis of blueback herring length-frequency distributions revealed trimodal peaks representing yearlings, 3-year-olds, and $\geq$ 4-year-olds. The 3-year-olds dominated offshore catches.
6. Examination of 413 female blueback herring for ovary maturation revealed that 74.1% were immature, 22.9% were capable of spawning before the end of the 1977 season, and 3.0% were spent.
7. No foreign fishing activity by any nation was observed within the study area.

Job 5. The Ocean Phase of Anadromous Fishes - Pilot Program

INTRODUCTION

North Carolina has collected data from the oceanic phase of anadromous fishes since 1968. With the advent of P. L. 94-265, these data and that forthcoming will continue to aid in establishing an offshore data base necessary to form and evaluate management policies regarding foreign and domestic fishing and vital to understanding fluctuations in the inshore spawning populations.

VIMS personnel were unable to participate in the offshore cruises because of schedule problems. The salary and travel funds of Job 5 were reallocated to intensify the collection of alosine fishes for Kepone analysis (Job 6), and to investigate the diel migrations of juvenile alosines (Job 3).

MATERIALS AND METHODS

Sampling Areas

Anadromous fish sampling for the 1977 season was conducted during three cruise segments. Segment 1 was conducted from 11 April through 18 April, Segment 2 from 25 April through 30 April, and Segment 3 from 16 May through 31 May.

The coastal area of North Carolina and adjacent states was divided into four major sampling areas. Area I extended south from Cape Fear; Area II from Cape Fear to Cape Lookout; Area III from Cape Lookout to Cape Hatteras; Area IV from Cape Hatteras northward to Little Machipongo Inlet, Virginia. For this project segment, trawl samples were required only in Areas III and IV;

however, five trawl samples were taken in Area II. Sampling during segments 1 and 2 was conducted from just outside the surf zone to depths of 36.6 m (120 ft)(midshore zone, Figs. 5.1 and 5.2). During Segment 3, to increase chances of locating concentrations of anadromous fishes, trawling operations were conducted from just outside the surf zone along transects out to the 131 m (430 ft) contour, (offshore zone) every 20 minutes of latitude, between Cape Lookout and Little Machipongo Inlet, Virginia (Fig. 5.3).

Predetermined sampling stations, located within 10-minute latitude and longitude grids, were occupied in Areas II, III, and IV, and along transects. Electronic fish detecting equipment was monitored continually during and between the predetermined stations to further increase chances of locating concentrations of anadromous fishes.

Sampling Gear

From 11 April through 31 May 1977, a 46.1 m (151 ft) (headrope) modified wing trawl described by Holland and Powell (1975) and a standard No. 41 Yankee trawl with a 21 m (69 ft) headrope and a 27 m (89 ft) sweep (equipped with 15.2 cm [6 inches] rubber discs) were utilized. Based on previous experience it was apparent that traditional trawl gear was inadequate for sampling river herring, shad, and other pelagic and neritic species. The modified wing trawl has proven to be an excellent sampling gear for these species (Holland and Powell, 1975). The 46.1 m modified wing trawl was used throughout the survey except in the offshore zone where the

use of the heavier No. 41 Yankee trawl was occasionally required to negotiate rough bottom. The cod ends of both nets were constructed of 38 mm (1.5 inches) stretch mesh. Bracket doors (2.6 m X 1.3 m [8.5 ft X 4.3 ft]) and 45.7 m (150 ft) scissors were utilized in conjunction with both trawls.

Collection of Materials

Tows varied from 30 to 60 minutes; however, the majority of tows were of 30 minutes duration. The presence of all species was noted and total number and weight of each species were recorded. All anadromous fishes captured were sexed, measured to the nearest millimeter (FL), and weighed. These data were used to determine sex ratio, female maturity, and length-frequency distributions. The 38 mm stretch mesh utilized in the cod ends of both nets precluded any quantitative data on fishes smaller than 100 mm (3.9 inches); however, they were noted as present or numerous and a sample was measured.

Tagging

We planned to tag and release striped bass, as available, in order to better assess their recent declines in abundance as indicated by our previous sampling and landing statistics. However, no striped bass were captured. Sturgeon were tagged and released.

Floy FT-1 dart tags were utilized. The station number, location, date, weight, fork length, and tag number were recorded for all tagged specimens prior to their release. Rewards of $1.00 and $25.00 were offered for the return of tags and information concerning the recapture of tagged fish.

Sex and Female Maturity

Random samples and subsamples of 777 blueback herring were taken from trawl catches and examined for sex and female maturity. The paucity of alewife, American shad, and hickory shad precluded the determination of sex and female maturity for these species.

Females were examined for maturity according to appearance of the ovaries and body cavity, a method similar to that used by Higham and Nicholson (1964) for menhaden, and by Holland and Yelverton (1973) for river herring. There are five stages, ranging from immature (Stage I) to spent (Stage V). The arbitrary stages of maturity assigned in the field were as follows:

Stage I. - Ovaries small, occupying only a small fraction of the body cavity. Ova invisible to the naked eye.

Stage II. - Ovaries occupying about one-third to one-half of the body cavity. Ova invisible to the naked eye.

Stage III. - Ovaries occupying about two-thirds of the body cavity. Ova visible through ovarian membrane.

Stage IV. - Ovaries occupying about three-fourths or more of the body cavity. Ova readily separated from follicles when the ovarian wall is pressed (ripe).

Stage V. - Ovaries flabby, blood shot, occupying less than one-half of the body cavity (spent).

Environmental Parameters

In accordance with standard oceanographic procedures, various climatic conditions were recorded at each sampling station. Recognizing the importance of water temperatures, particularly

bottom temperatures, an expendable bathythermograph (XBT) or a Montedoro Whitney Thermistor* was utilized to obtain both surface and bottom temperatures at each sampling station.

RESULTS AND DISCUSSION

Sampling Success

During the fall of 1976, it was discovered that the two main propulsion engines in the R/V Dan Moore would have to be overhauled. The inability to obtain parts resulted in numerous delays and precluded the initiation of any anadromous activity until April, 1977. Evidence from previous studies has determined that the offshore anadromous season is essentially over after April or when water temperatures exceed 12 C. Even though trawling operations were extended to 131 meters anadromous fishes were only sporadically encountered. Only 795 anadromous fishes were captured. More specifically, three American shad, two hickory shad, ten Atlantic sturgeon, three alewife and 777 blueback herring contributed to the total anadromous catch. No striped bass were captured.

Coastal Distribution

Anadromous fishes were found in greatest numbers within Area IV (Table 5.1). Although unequal effort between Areas II, III, and IV may have influenced catches, 78.7% of all anadromous fishes were captured within Area IV. Hickory shad were captured exclusively in Area III. Blueback herring were encountered in all three areas and were the only anadromous species captured in Area II.

*Use of trade name "Montedoro Whitney Thermistor" does not constitute endorsement.

Depth Distribution

Sampling effort and relative abundance of anadromous fishes from 11 April through 31 May 1977 in relation to depth zones are shown in Figures 5.1, 5.2 and 5.3 and Table 5.2, respectively. Sampling in the offshore (38.4-183.0 m [126-600 ft]) zone yielded no fish. The inshore (0-18.3 m) zone accounted for 92.2% of all anadromous species captured. American shad and hickory shad were captured exclusively in the inshore zone. The inshore zone also accounted for 93.3% (725) of all the blueback herring captured, one Atlantic sturgeon and two alewife. The midshore (20.1-36.6 m [66-120 ft]) zone accounted for 9 Atlantic sturgeon (90%), 52 blueback herring and one alewife, species which were also found in the inshore zone.

Seasonal Distribution

The paucity of anadromous fishes in samples from 11 April through 31 May 1977 precluded the accumulation of any seasonal distribution data. The most productive catch (531 blueback herring) occurred approximately 6 miles east of Quinby Inlet, VA (Lat. 37°28'N, Long. 75°33'W) the most northern area sampled, on 16 April 1977. Water temperatures for this particular station were isothermal, with 10 C (50 F) being recorded at both surface and bottom in a depth of 14.6 m (48 ft). The last recorded incidence of any anadromous species being captured was on 24 May 1977 when one blueback herring was captured 1 mile offshore and 13 miles north of Kitty Hawk Monument (Lat. 36°13'N, Long. 75°45'W). Water temperatures for this particular

station were recorded at 20 C (68 F)(surface) and 15 C (59 F) (bottom) at a depth of 7.3 m (24 ft).

Tagging

A total of ten Atlantic sturgeon was captured during 13-28 April 1977. The majority (nine) were captured in the vicinity of Platt and Wimble Shoals. The other sturgeon was encountered 26 miles NNE of the Chesapeake Light Tower. Sturgeon were tagged and released at the site of capture. Fork lengths ranged from 87.4 to 208.3 cm (34.4 inches to 82.0 inches) and weights ranged from 5.4 to 101.3 kg (12 lb to 223 lb). One sturgeon was recaptured by fish trawl three miles off Cape May, New Jersey, after being at large 26 days and traveling 190 miles in a northerly direction. The fish weighed 101.3 kg and was reported full of roe.

No striped bass were captured in the study area.

Size Composition

Only blueback herring were captured in sufficient numbers to analyze size and age composition. A total of 777 blueback herring was captured; however, 68.3% of the total blueback herring catch was captured at one trawl station (see Seasonal Distribution, this section). Analysis of 777 blueback herring revealed that 302 (38.9%) were males ranging from 83-283 mm (3.3-11.1 inches), 413 (53.1%) were females ranging from 84-273 mm (3.3-10.7 inches), 62 (8.0%) were small sexually immature fish ranging from 70-121 mm (2.8-4.8 inches), (sex was not discernible), in both sexes 30.5% were sexually mature.

Length-frequency distributions of blueback herring, sexes combined, are presented in Figure 5.4. Trimodal peaks representing both young and adult blueback herring are discernible, with modes at 90-99.9 mm (3.5-3.9 inches), 170-179.9 mm (6.7-7.1 inches), and 240-249.9 mm (9.4-9.8 inches). According to age-frequency data compiled previously (Holland and Yelverton, 1973; Holland and Powell, 1975), these modes would represent yearlings, 3-year-olds, and $\geq$ 4-year-olds, respectively. The mesh size of the cod ends (38 mm stretch mesh) of both nets precluded any quantitative data on blueback herring smaller than 100 mm; however, they were noted as being present or numerous and a sample was measured.

Length-frequency distributions of blueback herring, by sex, are presented in Figure 5.5. Both young and adult male and female blueback herring showed modes of similar lengths. These modes represent the same age composition discussed above. The modal size of 3-year-old males was slightly larger than (10 mm [0.4 inch] difference) 3-year-old females.

Female Maturity

Ovarian stages for blueback herring from 11 April through 24 May 1977 are shown in Table 5.3. Approximately 75.6% (304) of the total number of females included in Table 5.3 were captured on the aforementioned single most productive station. (See Seasonal Distribition, this section.) The remaining individuals were captured sporadically throughout the more southern portion of the study area. No ripe blueback herring were captured.

As shown in Table 5.3, blueback herring captured during April and May were composed of females with ovaries which ranged from early maturing to spent. Approximately 74.1% of the total females examined contained ovaries designated as Stage I which would not have spawned during the 1977 season. Stage II females (3.5%) may or may not have been capable of spawning during the remainder of the 1977 season. However, Stage III females (78), which accounted for 19.4% of the total females examined were capable of spawning before the 1977 season terminated. Only 12 (3.0%) of the females examined were spent. Spent female river herring were encountered in both Areas III and IV from 12 April through 27 April 1977. Spent females were also captured with Stage I, II, and III females.

No female blueback herring of less than 230 mm (9.1 inches) (FL) were observed as sexually mature.

Foreign Fishing

In order to obtain added protection for river herring stocks, the United States negotiated bilateral agreements with Poland, Romania, and USSR during 1975 and 1976. These agreements have been briefly described by Holland and Keefe (1977). During the 1977 season, only the agreement with the Soviet Union was in effect. The restrictions of this agreement relative to this report were: (1) Soviet vessels will refrain from fishing during February and March in an area from Little Machipongo Inlet (Lat. 37°30'N) south to Ocracoke Inlet (Lat. 35°00'N) offshore to approximately Long. 74°48'W; (2) Vessels shall limit catches of river herring to incidental

catches only, and to 210 metric tons (231.5 tons) for all vessels and to 10 metric tons (11.0 tons) per vessel; (3) Vessels shall cease fishing operations for the year when the 210 metric ton limit is reached, and any individual vessel reaching the 10 metric ton limit shall refrain from fishing for the remainder of the year. However, with the implementation of the Fishery Conservation and Management Act of 1976 (P. L. 94-265) on 1 March 1977, Governing Internation Fisheries Agreements (GIFA) were in effect with all nations fishing within the United States Fishery Conservation Zone. Under the agreements foreign nations must abide by regulations published by National Marine Fisheries Service (NMFS) from time to time in the Federal Register.

No observations of foreign fishing activity by any nation were noted within the study area.

Data obtained during previous anadromous fish projects (AFCS-5, AFCS-8, and AFCS-11) have been instrumental in negotiating these agreements.

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Table 5.1. Relative abundance of offshore anadromous fishes by sampling area (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes). 11 April through 31 May 1977.

Species	Area II 5 Samples			Area III 31 Samples			Area IV 94 Samples			Total 130 Samples		
	Total catch (no.)	Avg. catch	% with fish	Total catch (no.)	Avg. catch	% with fish	Total catch (no.)	Avg. catch	% with fish	Total catch (no.)	Avg. catch	% with fish
Striped bass *(Morone saxatilis)*	0	0	0	0	0	0	0	0	0	0	0	0
American shad *(Alosa sapidissima)*	0	0	0	0	0	0	3	*	3.2	3	*	2.3
Hickory shad *(Alosa mediocris)*	0	0	0	2	*	6.5	0	0	0	2	*	1.5
Atlantic sturgeon *(Acipenser oxyrhynchus)*	0	0	0	0	0	0	10	0.1	5.3	10	*	3.8
Blueback herring *(Alosa aestivalis)*	135	27.0	40.0	31	1.0	16.1	611	6.5	24.5	777	6.0	23.1
Alewife *(Alosa pseudoharengus)*	0	0	0	0	0	0	3	*	2.1	3	*	1.5
Total	135			33			627			795		

*less than 0.1 fish

Table 5.2. Relative abundance and depth distribution of offshore anadromous fishes (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes). 11 April through 31 May 1977.

Species	Inshore 0 - 18.3 m 65 Samples			Mid-Shore 20.1 - 36.6 m 44 Samples			Off-Shore 38.4 - 183.0 m 21 Samples		
	Total catch (no.)	Avg. catch	% with fish	Total catch (no.)	Avg. catch	% with fish	Total catch (no.)	Avg. catch	% with fish
Striped bass *(Morone saxatilis)*	0	0	0	0	0	0	0	0	0
American shad *(Alosa sapidissima)*	3	*	4.6	0	0	0	0	0	0
Hickory shad *(Alosa mediocris)*	2	*	3.1	0	0	0	0	0	0
Atlantic sturgeon *(Acipenser oxyrhynchus)*	1	*	1.5	9	0.2	9.1	0	0	0
Blueback herring *(Alosa aestivalis)*	725	11.2	35.4	52	1.2	15.9	0	0	0
Alewife *(Alosa pseudoharengus)*	2	0.3	3.1	1	*	2.3	0	0	0
Total	733			62			0		

* Less than 0.1 fish

Table 5.3. Ovarian stage, by size range, of captured female blueback herring *(Alosa aestivalis)* during 11 April through 24 May 1977.

FL range (mm)	Stage I	II	III	V
80-89	3			
90-99	18			
100-109	10			
110-119	4			
120-129	2			
130-139	14			
140-149	1			
150-159	55			
160-169	88			
170-179	67			
180-189	33			
190-199				
200-209				
210-219	1			
220-229				
230-239	1	1	7	
240-249		5	30	
250-259		2	27	4
260-269	1	6	13	7
270-279			1	1
TOTAL	298	14	78	12

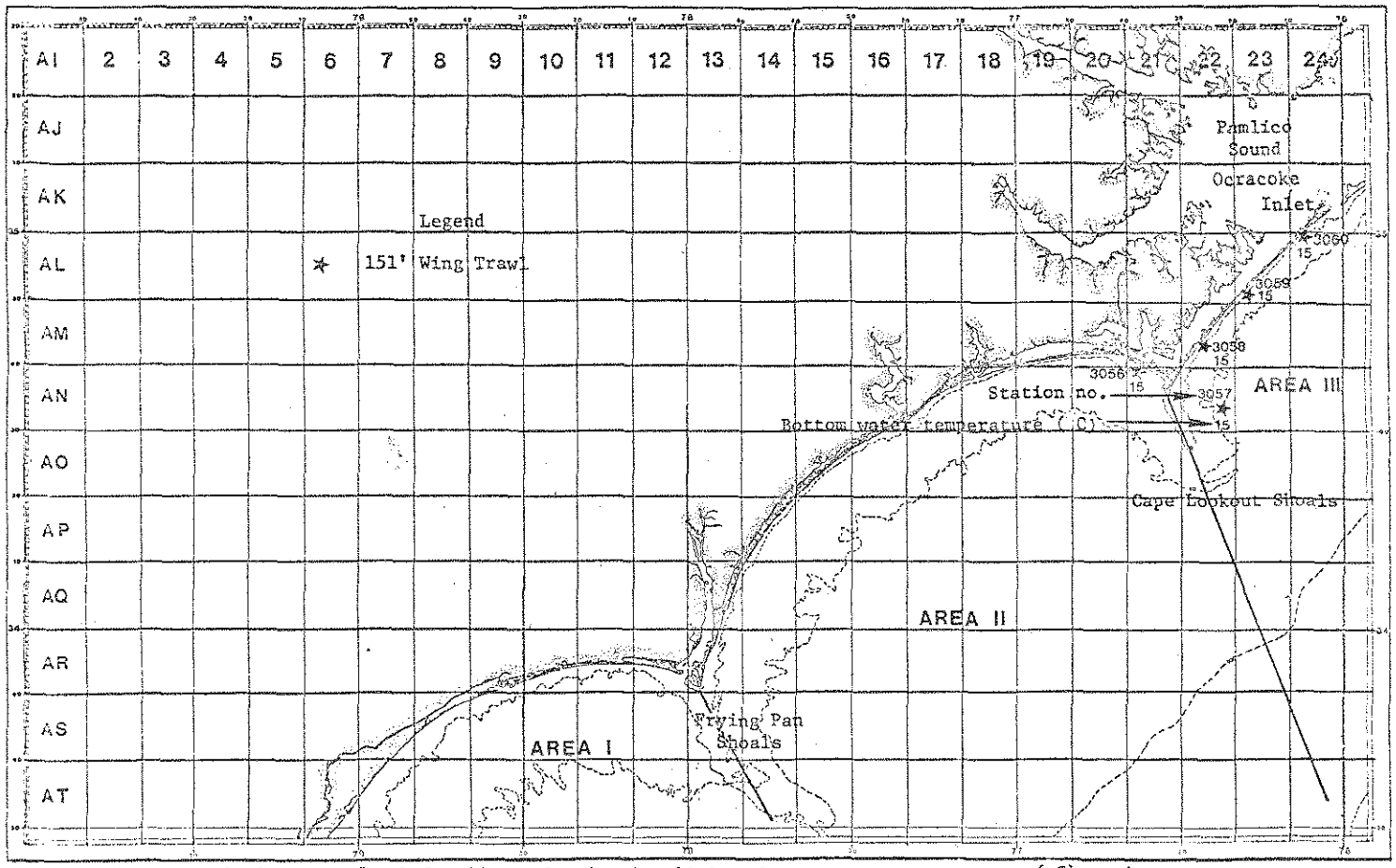


Figure 5.1. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (C), and gear type utilized during Segment 1. Grids represent areas of 10' minute Latitude and Longitude.

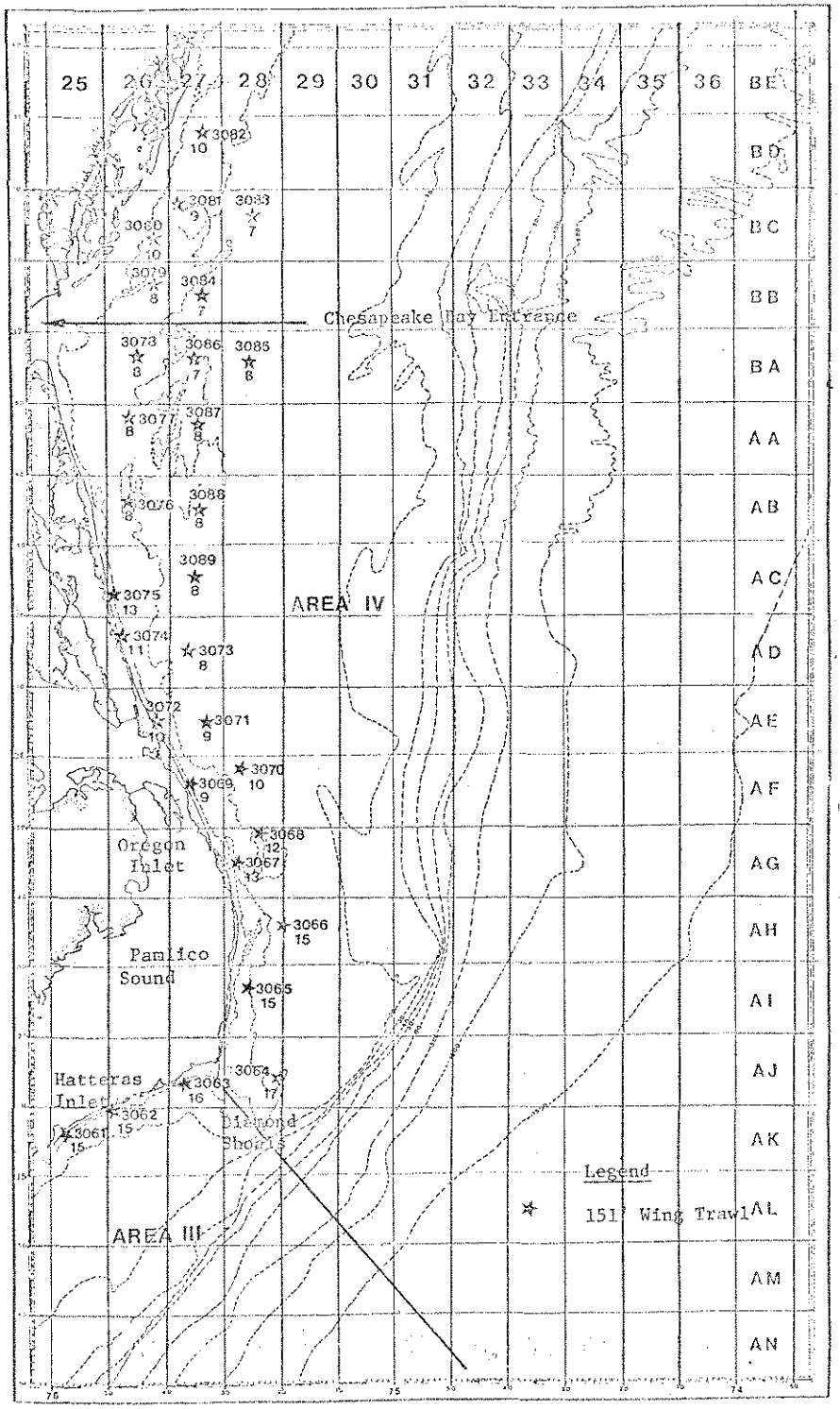


Figure 5.1. (continued)

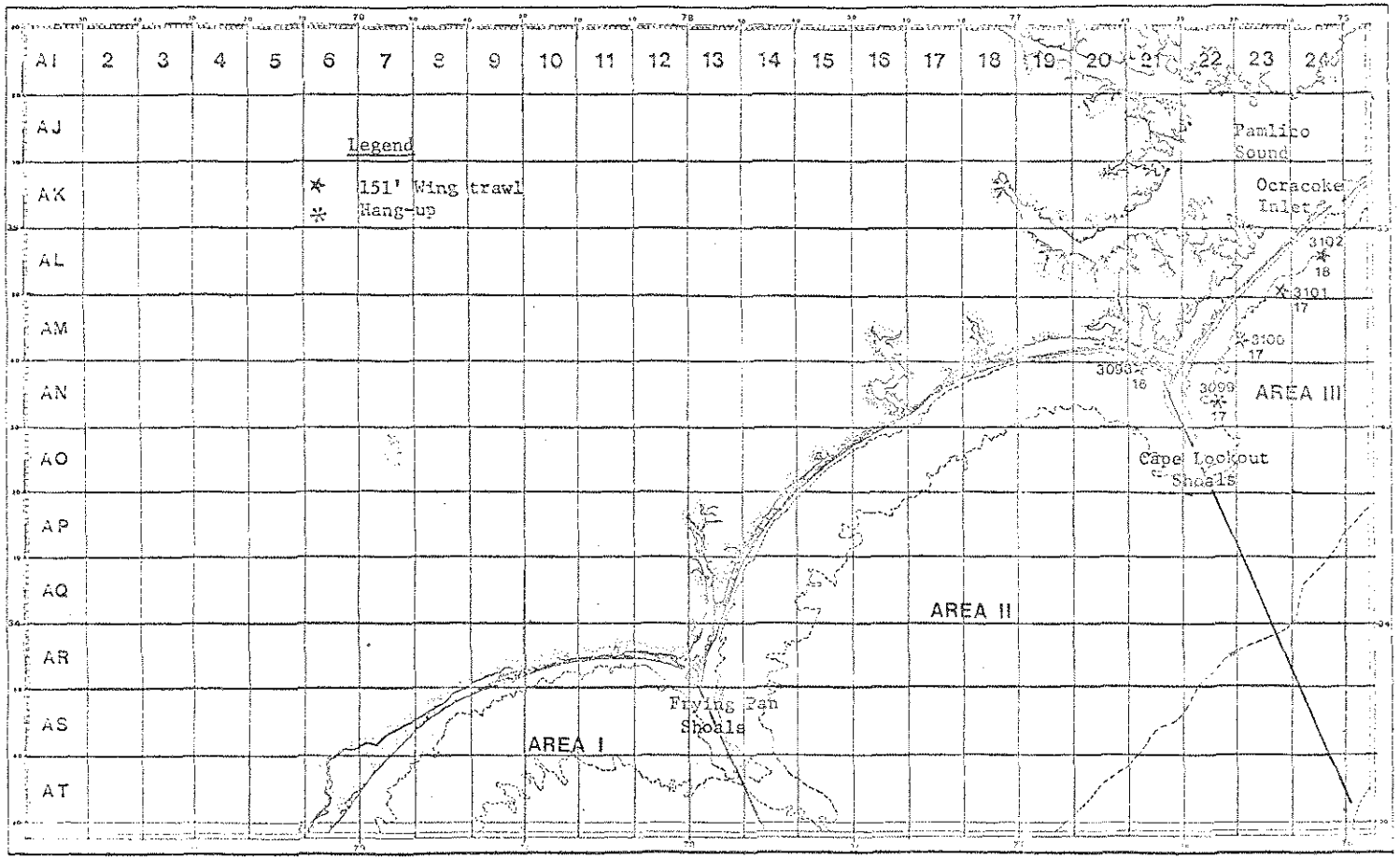


Figure 5.2. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (C), and gear type utilized during Segment 2. Grids represent areas of 10' minute Latitude and Longitude.

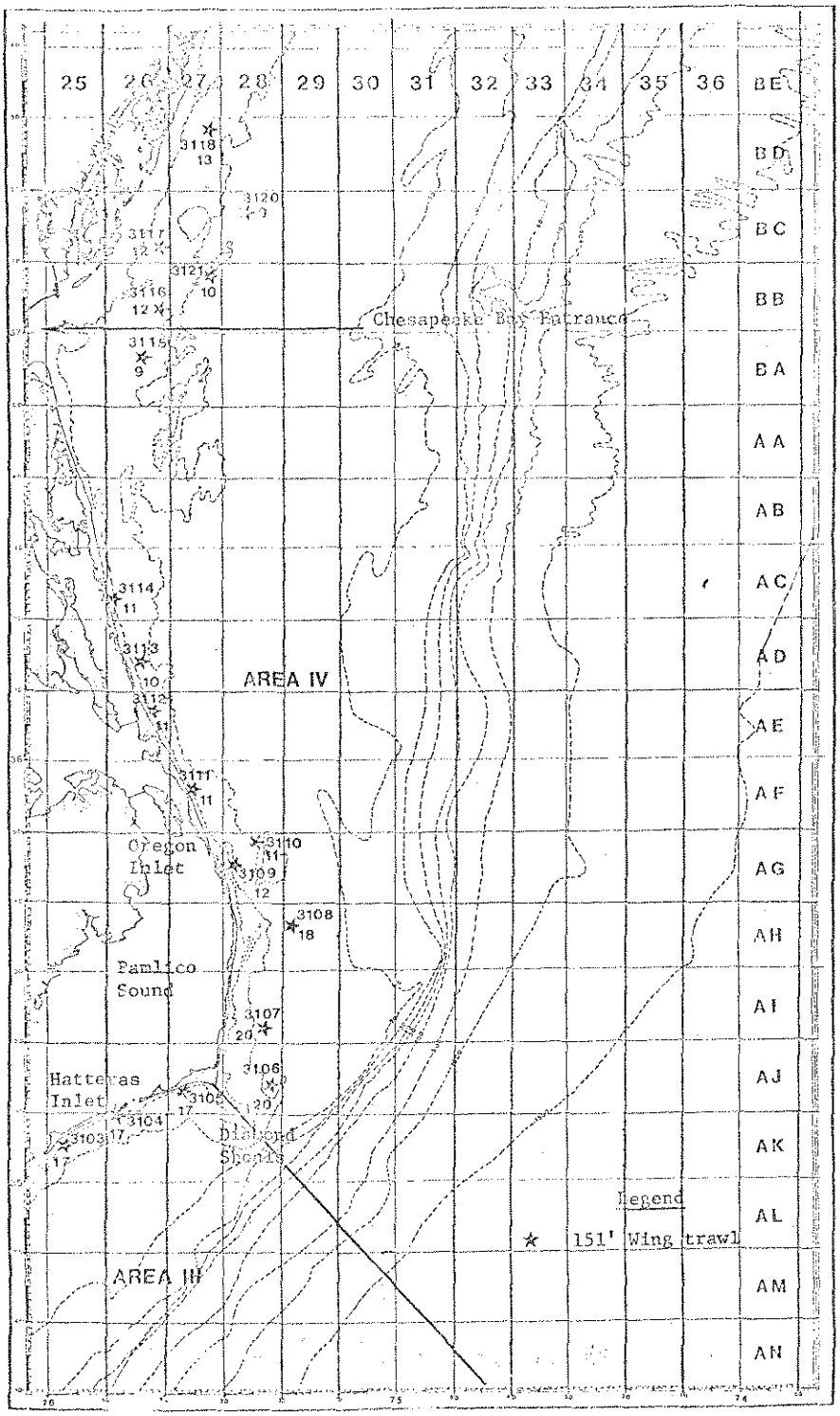


Figure 5.2. (continued)

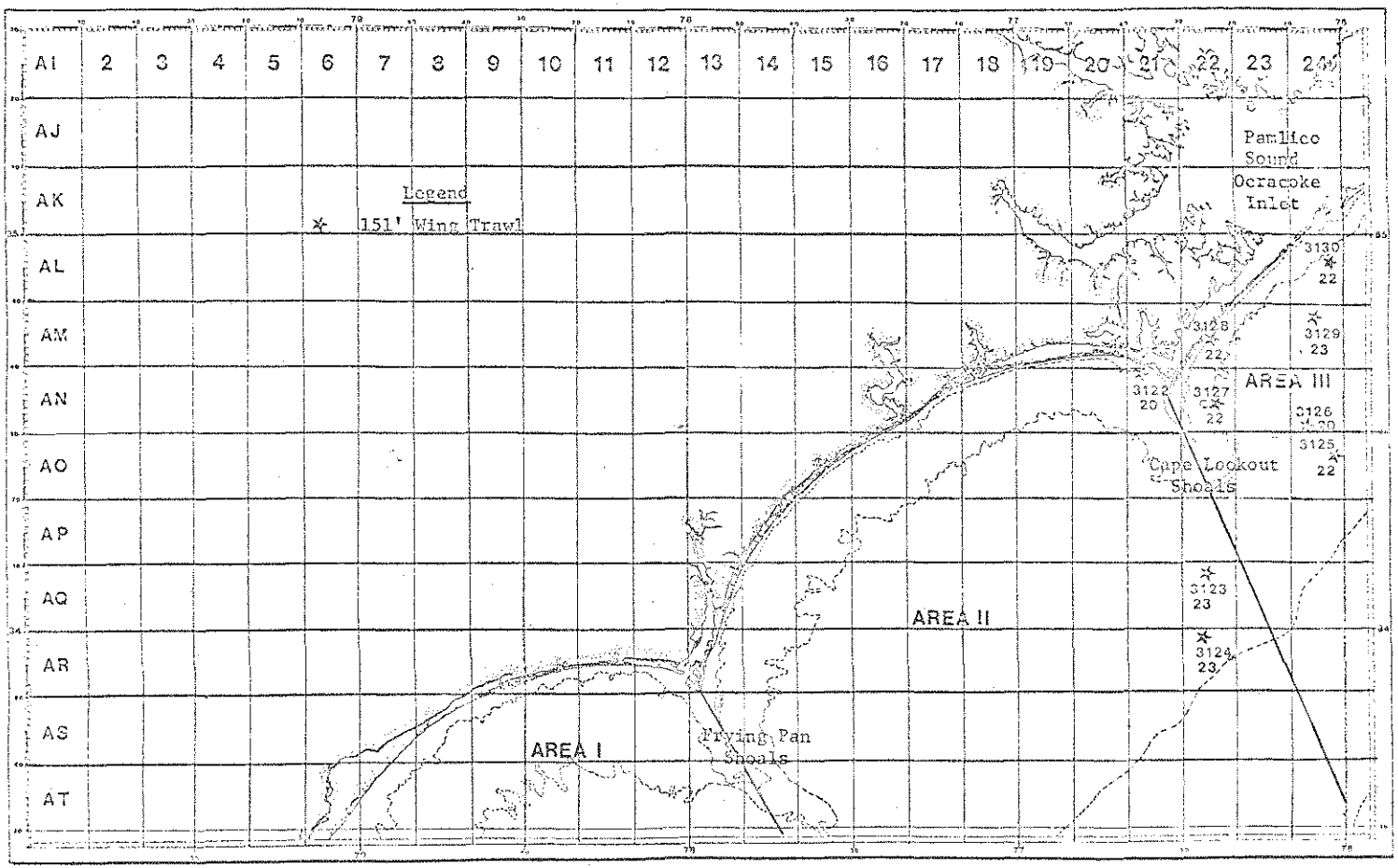


Figure 5.3. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (C) and gear type utilized during Segment 3. Grids represent areas of 10' minute Latitude and Longitude.

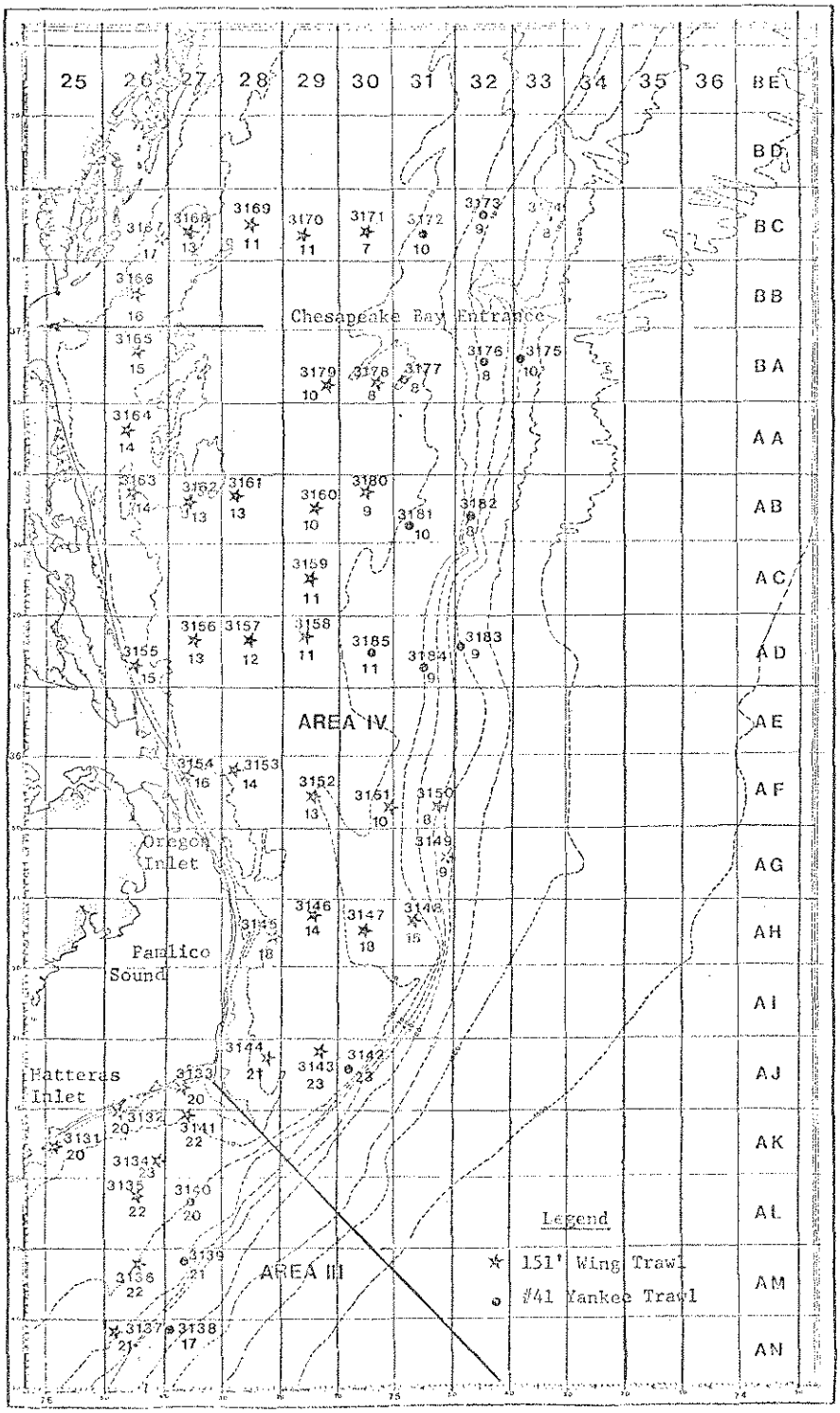


Figure 5.3. (continued)

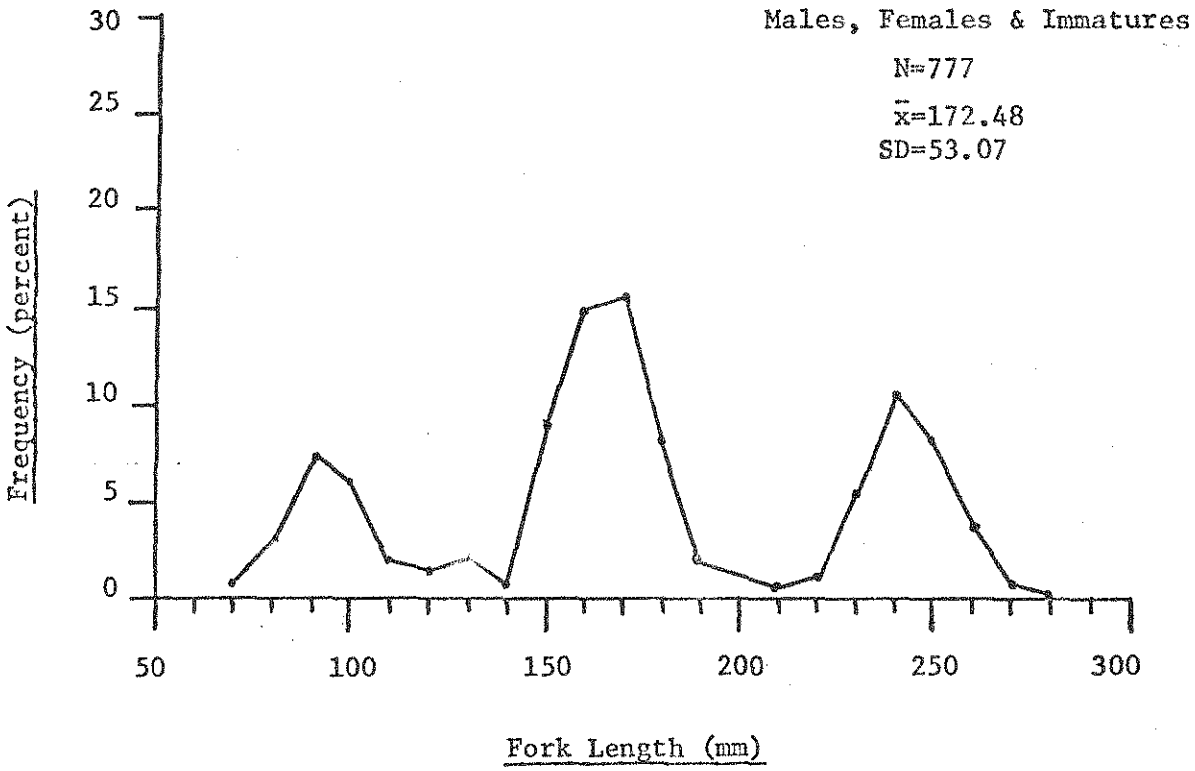


Figure 5.4. Length-frequency distribution, sexes combined, of blueback herring *(Alosa aestivalis)* during 11 April through 24 May 1977.

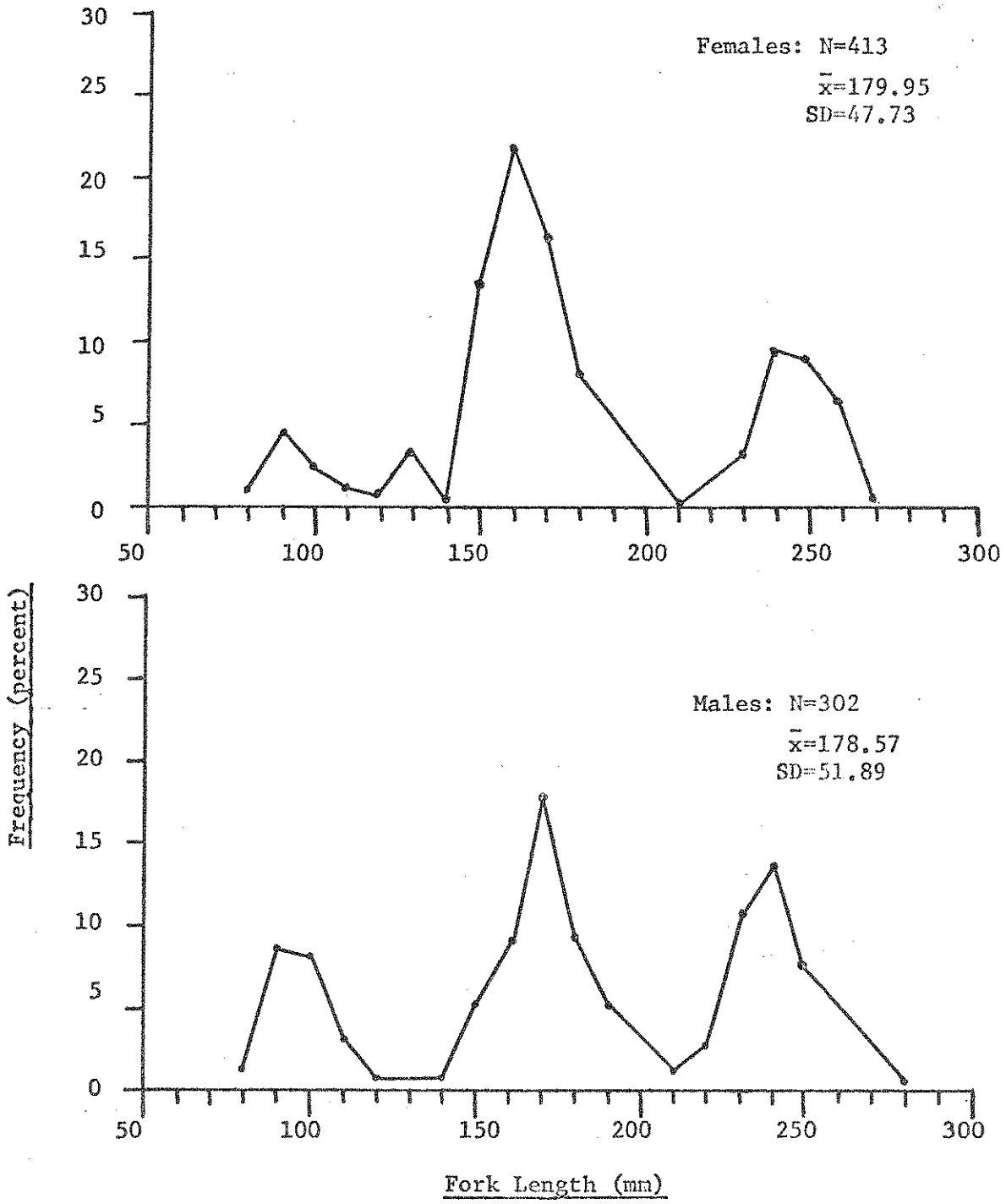


Figure 5.5. Length-frequency distributions, by sex, of blueback herring *(Alosa aestivalis)* captured during 11 April through 24 May 1977.

Appendix 5.1. Segment I Species List

Finfish

Odontaspididae
Sand tiger shark *(Odontaspis taurus)*

Carcharhinidae
Sandbar shark *(Carcharhinus milberti)*
Dusky shark *(Carcharhinus obscurus)*
Smooth dogfish *(Mustelus canis)*

Squalidae
Spiny dogfish *(Squalus acanthias)*

Squatinidae
Atlantic angel shark *(Squatina dumerili)*

Rajidae
Clearnose skate *(Raja eglanteria)*

Myliobatidae
Bullnose ray *(Myliobatis freminvillei)*

Acipenseridae
Atlantic sturgeon *(Acipenser oxyrhynchus)*

Clupeidae
Blueback herring *(Alosa aestivalis)*
Hickory shad *(Alosa mediocris)*
Alewife *(Alosa pseudoharengus)*
American shad *(Alosa sapidissima)*
Atlantic menhaden *(Brevoortia tyrannus)*
Atlantic herring *(Clupea harengus harengus)*
Round herring *(Etrumeus teres)*
Spanish sardine *(Sardinella anchovia)*

Engraulidae
Striped anchovy *(Anchoa hepsetus)*
Bay anchovy *(Anchoa mitchilli)*

Synodontidae
Inshore lizardfish *(Synodus foetens)*

Lophiidae
Goosefish *(Lophius americanus)*

Gadidae
Silver hake *(Merluccius bilinearis)*
Spotted hake *(Urophycis regius)*

Serranidae
Black sea bass *(Centropristis striata)*

Pomatomidae
Bluefish *(Pomatomus saltatrix)*

Pomadasyidae
Tomtate *(Haemulon aurolineatum)*
Pigfish *(Orthopristis chrysoptera)*

Appendix 5.1. (continued)

Sparidae
- Sheepshead *(Archosargus probatocephalus)*
- Pinfish *(Lagodon rhomboides)*
- Longspine porgy *(Stenotomus caprinus)*

Sciaenidae
- Weakfish *(Cynoscion regalis)*
- Banded drum *(Larimus fasciatus)*
- Spot *(Leiostomus xanthurus)*
- Northern kingfish *(Menticirrhus saxatilis)*
- Atlantic croaker *(Micropogon undulatus)*
- Black drum *(Pogonias cromis)*

Labridae
- Tautog *(Tautoga onitis)*

Ammodytidae
- American sand lance *(Ammodytes americanus)*

Scombridae
- Atlantic mackerel *(Scomber scombrus)*
- King mackerel *(Scomberomorus cavalla)*

Stromateidae
- Butterfish *(Peprilus triacanthus)*

Triglidae
- Northern searobin *(Prionotus carolinus)*
- Leopard searobin *(Prionotus scitulus)*

Bothidae
- Summer flounder *(Paralichthys dentatus)*
- Windowpane *(Scophthalmus aquosus)*

Tetraodontidae
- Northern puffer *(Sphoeroides maculatus)*

Invertebrates

Clionidae
- Sulfur sponge *(Cliona celata)*

SCYPHOZOA
- Jellyfish

Portunidae
- Ovalipes crab *(Ovalipes ocellatus)*
- Ovalipes crab *(Ovalipes guadulpensis)*

Cancridae
- Rock crab *(Cancer irroratus)*

Majidae
- Spider crab *(Libinia emarginata)*

Xiphosuridae
- Horseshoe crab *(Limulus polyphemus)*

Appendix 5.1. (continued)

Pinnidae
Sea-pen shells *(Atrina sp.)*

Loliginidae
Atlantic long-finned squid *(Loligo pealei)*
Brief squid *(Lolliguncula brevis)*

Appendix 5.2. Segment II Species List

Finfish

Odontaspididae
- Sand tiger shark *(Odontaspis taurus)*

Alopiidae
- Thresher shark *(Alopias vulpinus)*

Carcharhinidae
- Sandbar shark *(Carcharhinus milberti)*
- Smooth dogfish *(Mustelus canis)*
- Atlantic sharpnose shark *(Rhizoprionodon terraenovae)*

Sphyrnidae
- Scalloped hammerhead *(Sphyrna lewini)*

Squalidae
- Spiny dogfish *(Squalus acanthias)*

Squatinidae
- Atlantic angel shark *(Squatina dumerili)*

Rajidae
- Clearnose skate *(Raja eglanteria)*

Dasyatidae
- Southern stingray *(Dasyatis americana)*
- Roughtail stingray *(Dasyatis centroura)*
- Spiny butterfly ray *(Gymnura altravela)*
- Smooth butterfly ray *(Gymnura micrura)*

Myliobatidae
- Bullnose ray *(Myliobatis freminvillei)*
- Cownose ray *(Rhinoptera bonasus)*

Acipenseridae
- Atlantic sturgeon *(Acipenser oxyrhynchus)*

Clupeidae
- Blueback herring *(Alosa aestivalis)*
- Hickory shad *(Alosa mediocris)*
- Atlantic menhaden *(Brevoortia tyrannus)*
- Round herring *(Etrumeus teres)*
- Spanish sardine *(Sardinella anchovia)*

Engraulidae
- Striped anchovy *(Anchoa hepsetus)*

Synodontidae
- Inshore lizardfish *(Synodus foetens)*

Lophiidae
- Goosefish *(Lophius americanus)*

Gadidae
- Spotted hake *(Urophycis regius)*

Serranidae
- Black sea bass *(Centropristis striata)*

Appendix 5.2. (continued)

Pomatomidae
Bluefish *(Pomatomus saltatrix)*

Echeneidae
Remora *(Remora remora)*

Carangidae
Mackerel scad *(Decapterus macarellus)*
Greater amberjack *(Seriola dumerili)*

Sparidae
Whitebone porgy *(Calamus leucosteus)*
Spottail pinfish *(Diplodus holbrooki)*
Pinfish *(Lagodon rhomboides)*
Longspine porgy *(Stenotomus caprinus)*

Sciaenidae
Silver perch *(Bairdiella chrysura)*
Weakfish *(Cynoscion regalis)*
Spot *(Leiostomus xanthurus)*
Southern kingfish *(Menticirrhus americanus)*
Atlantic croaker *(Micropogon undulatus)*
Black drum *(Pogonias cromis)*
Red drum *(Sciaenops ocellata)*

Scombridae
Mackerel *(Juv.) (Scomber spp.)*
King mackerel *(Scomberomorus cavalla)*

Stromateidae
Butterfish *(Peprilus triacanthus)*

Triglidae
Striped searobin *(Prionotus evolans)*

Bothidae
Summer flounder *(Paralichthys dentatus)*
Windowpane *(Scophthalmus aquosus)*

Pleuronectidae
Winter flounder *(Pseudopleuronectes americanus)*

Balistidae
Orange filefish *(Aluterus schoepfi)*

Tetraodontidae
Northern puffer *(Sphoeroides maculatus)*

Diodontidae
Striped burrfish *(Chilomycterus schoepfi)*

Other vertebrates

Cheloniidae
Atlantic loggerhead turtle *(Caretta caretta)*

Appendix 5.2. (continued)

Invertebrates

Clionidae
Sulfur sponge *(Cliona celata)*

SCYPHOZOA
Jellyfish

Portunidae
Ovalipes crab *(Ovalipes guadulpensis)*

Xiphosuridae
Horseshoe crab *(Limulus polyphemus)*

Neptuneidae
Channeled welk *(Busycon canaliculata)*

Loliginidae
Atlantic long-finned squid *(Loligo pealei)*
Brief squid *(Lolliguncula brevis)*

Appendix 5.3. Segment III Species List

Finfish

Odontaspididae
- Sand tiger shark *(Odontaspis taurus)*

Alopiidae
- Thresher shark *(Alopias vulpinus)*

Scyliorhinidae
- Chain dogfish *(Scyliorhinus retifer)*

Carcharhinidae
- Sandbar shark *(Carcharhinus milberti)*
- Dusky shark *(Carcharhinus obscurus)*
- Tiger shark *(Galeocerdo cuvieri)*
- Smooth dogfish *(Mustelus canis)*
- Atlantic sharpnose shark *(Rhizoprionodon terraenovae)*

Sphyrnidae
- Scalloped hammerhead *(Sphyrna lewini)*

Squatinidae
- Atlantic angel shark *(Squatina dumerili)*

Rajidae
- Clearnose skate *(Raja eglanteria)*
- Little skate *(Raja erinacea)*
- Rosette skate *(Raja garmani)*

Dasyatidae
- Roughtail stingray *(Dasyatis centroura)*
- Spiny butterfly ray *(Gymnura altavela)*

Myliobatidae
- Bullnose ray *(Myliobatis freminvillei)*

Clupeidae
- Blueback herring *(Alosa aestivalis)*
- Atlantic menhaden *(Brevoortia tyrannus)*
- Round herring *(Etrumeus teres)*
- Atlantic thread herring *(Opisthonema oglinum)*
- Spanish sardine *(Sardinella anchovia)*

Engraulidae
- Striped anchovy *(Anchoa hepsetus)*
- Bay anchovy *(Anchoa mitchilli)*

Synodontidae
- Inshore lizardfish *(Synodus foetens)*
- Offshore lizardfish *(Synodus poeyi)*

Lophiidae
- Goosefish *(Lophius americanus)*

Gadidae
- Silver hake *(Merluccius bilinearis)*
- Red hake *(Urophycis chuss)*
- Spotted hake *(Urophycis regius)*

Appendix 5.3. (continued)

Zeidae
American john dory *(Zenopsis ocellata)*

Caproidae
Deepbody boarfish *(Antigonia capros)*

Fistulariidae
Bluespotted cornetfish *(Fistularia tabacaria)*

Serranidae
Rock sea bass *(Centropristis philadelphica)*
Black sea bass *(Centropristis striata)*

Pomatomidae
Bluefish *(Pomatomus saltatrix)*

Rachycentridae
Cobia *(Rachycentron canadum)*

Carangidae
Horse-eye jack *(Caranx latus)*
Mackerel scad *(Decapterus macarellus)*
Round scad *(Decapterus punctatus)*
Bigeye scad *(Selar crumenophthalmus)*
Greater amberjack *(Seriola dumerili)*

Pomadasyidae
Tomtate *(Haemulon aurolineatum)*

Sparidae
Porgy *(Stenotomus sp.)*
Longspine porgy *(Stenotomus caprinus)*

Sciaenidae
Silver perch *(Bairdiella chrysura)*
Weakfish *(Cynoscion regalis)*
Spot *(Leiostomus xanthurus)*
Southern kingfish *(Menticirrhus americanus)*
Black drum *(Pogonias cromis)*

Labridae
Pearly razorfish *(Hemipteronotus novacula)*

Ammodytidae
American sand lance *(Ammodytes americanus)*

Trichiuridae
Atlantic cutlassfish *(Trichiurus lepturus)*

Scombridae
Atlantic mackerel *(Scomber scombrus)*
King mackerel *(Scomberomorus cavalla)*
Spanish mackerel *(Scomberomorus maculatus)*

Stromateidae
Silver-rag *(Ariomma bondi)*
Butterfish *(Peprilus triacanthus)*

Appendix 5.3. (continued)

Triglidae
- Streamer searobin *(Bellator egretta)*
- Armored searobin *(Peristedion miniatum)*
- Spiny searobin *(Prionotus alatus)*
- Northern searobin *(Prionotus carolinus)*
- Striped searobin *(Prionotus evolans)*

Bothidae
- Whiff *(Citharichthys sp.)*
- Fourspot flounder *(Paralichthys oblongus)*
- Dusky flounder *(Syacium papillosum)*

Pleuronectidae
- Winter flounder *(Pseudopleuronectes americanus)*

Balistidae
- Orange filefish *(Aluterus schoepfi)*
- Gray triggerfish *(Balistes capriscus)*
- Planehead filefish *(Monacanthus hispidus)*

Ostraciidae
- Honeycomb cowfish *(Lactophrys polygonia)*

Tetraodontidae
- Marbled puffer *(Sphoeroides dorsalis)*
- Northern puffer *(Sphoeroides maculatus)*

Invertebrates

Demospongiae
- Sponge

Echinoidea
- Sea urchins

Holothuroidea
- Sea cucumber

Sicyoninae
- Rock shrimp *(Sicyonia brevirostris)*

Nephropside
- American lobster *(Homarus americanus)*

Portunidae
- Ovalipes crab *(Ovalipes ocellatus)*
- Ovalipes crab *(Ovalipes guadulpensis)*
- Portunid crab *(Portunus spinicarpus)*

Cancridae
- Jonah crab *(Cancer borealis)*
- Rock crab *(Cancer irroratus)*

Majidae
- Arrow crab *(Stenorynchus seticornis)*

Xiphosuridae
- Horseshoe crab *(Limulus polyphemus)*

Appendix 5.3. (continued)

Pectinidae
Atlantic deepsea scallop *(Placopecten magellanicus)*

Mactridae
Surf clam *(Spisula solidissima)*

Naticidae
Atlantic moon snail *(Polinices duplicatus)*

Neptuneidae
Knobbed whelk *(Busycon carica)*

Fasciolariidae
Florida horse conch *(Pleuroploca gigantea)*

Sepiolidae
Squid *(Rossia tenera)*

Loliginidae
Atlantic long-finned squid *(Loligo pealei)*

Ommastrephidae
Short-finned squid *(Illex illecebrosus)*

Job 6. Kepone Concentrations in Anadromous Alosine Fishes and its Possible Function as a Chemical Tag

SUMMARY

1. Kepone analysis of adult American shad sampled in the lower James River in March, 1977, indicated there was, in general, little or no contamination at that time.
2. The Kepone action level (0.3 ppm) was exceeded by 29% of adult male hickory shad and 28% of the females in samples collected in August and September, 1977.
3. All juvenile alosines and juvenile striped bass analyzed from samples taken in the nursery zone of the James River near Hopewell, Virginia exceeded the action level. Samples collected downriver were below the action level.
4. Mean Kepone concentrations of juveniles collected in the York River were very low. Aeolian contamination of the York River water shed, rather than juvenile migration, probably accounts for the presence of Kepone in these fishes.

Job 6. Kepone Concentrations in Anadromous Alosine Fishes and its Possible Function as a Chemical Tag

INTRODUCTION

The contamination of the James River by Kepone resulted in the closure of the river for commercial fishing in 1975. The river was reopened to alosine fishing for an abbreviated fishing season in 1976-77 and a Kepone "action level" of 0.3 ppm established.

Kepone analysis of adult alosines is important for: (1) establishing a baseline for estimating the rate and amount of Kepone uptake by alosines spawning in the James River; (2) determining if returning adults have retained or completely depurated Kepone while at sea; and (3) supplying the State with information pertinent to managerial decisions about the alosine fishery in the James River. The juvenile Kepone data are important for: (1) determining if juveniles migrate within the Chesapeake Bay system; (2) estimating the rate of Kepone uptake and its concentration carried seaward in the fall migration; and (3) estimating the Kepone concentration, if any, when the 1977 year class first return to spawn in three to four years.

The Job 6 commitment was only the collection of specimens; however, as funds permitted, some Kepone analyses were performed. Additional analyses, at no cost to the project, were conducted by the VIMS Department of Ecology-Pollution and the Virginia State Water Control Board.

MATERIALS AND METHODS

Samples of adult American shad and hickory shad were obtained from various sites throughout the Chesapeake Bay region. The samples were obtained from commercial fishermen and commercial seafood buyers. Only specimens were collected whose sites of capture were known. Juveniles were collected with a 27.4 m (90 ft) beach seine and with the trawl nets and push net described in Job 3. Seine net sampling for young-of-the-year alosines and striped bass commenced in mid-August and continued until late November; as weather permitted, occasional samples were taken in December. Sampling was conducted on a weekly basis in the James River and biweekly in the York River. Additional juvenile samples were collected from the major Virginia tributaries to Chesapeake Bay during the execution of Job 3.

Kepone analysis was made by electron capture gas chromotography. Individual adults were analyzed but most often a blend of several juveniles, subsampled from the catch, was used.

RESULTS AND DISCUSSION

Kepone analysis of American shad sampled in March, 1977, indicated there was, in general, little or no contamination of this species. Nine of 11 roe analyzed did not contain a detectable level of Kepone; two others had concentrations of only 0.02 and 0.04 parts per million (ppm). Kepone was not detected in four of nine American shad fillet samples. In the other five samples the concentration ranged from 0.02 to 0.17 ppm, with a mean of 0.05 ppm, well below the action level of 0.3 ppm.

Hickory shad were collected from early August through September, 1977, in the lower Chesapeake Bay area (Lynnhaven-Ocean View). Edible meat of 24 males and 18 females was analyzed. The action level was exceeded by 29% of the males and 28% of the females, with means of 0.71 and 0.66 ppm, respectively. The means for the samples not exceeding the action level were 0.10 and 0.13 ppm for males and females, respectively. The overall means for males, females, and sexes combined were all 0.28 ppm.

The greater concentration of Kepone in hickory shad relative to the American shad may be due to the later collection dates of the hickory shad. As available, all adult alosine species will be collected from April through the spawning season in 1978.

All juvenile alosines and striped bass analyzed from samples taken in the nursery zone of the James River near Hopewell, Virginia exceeded the action level. Conversely, analysis of samples taken below the nursery zone in the area of Hog Island and also those from the York River near West Point, Virginia, were below the action level.

Seven juvenile American shad analyzed from samples in the nursery zone had a mean concentration of 1.38 ppm Kepone; none were collected below the nursery zone. In the York River, 186 juveniles were collected and analysis of subsamples indicated a Kepone concentration of 0.02 ppm.

Only one juvenile hickory shad was collected. It was from the York River and had a Kepone concentration of 0.03 ppm.

Analysis of 111 juvenile blueback herring from the nursery zone indicated a mean Kepone concentration of 0.80 ppm. Forty-two specimens below the nursery zone had a mean concentration of 0.19 ppm, and the mean for 174 specimens collected in the York River was 0.02 ppm.

Ten juvenile alewife collected in the James River nursery zone had a mean Kepone concentration of 1.34 ppm. None were captured below the nursery zone, and no Kepone was detectable in one specimen taken in the York River.

The mean Kepone concentration for 28 juvenile striped bass in the nursery zone was 0.99 ppm. Only one specimen was collected below the nursery zone; its Kepone concentration was 0.09 ppm. In the York River, 66 specimens had a mean Kepone concentration of 0.02 ppm.

It is not known if the low Kepone concentration in James River juveniles below the nursery zone is due to depuration or a lesser exposure to the higher upriver concentrations. The very low concentration of Kepone in the York River juveniles is probably a result of aeolian contamination of the river's water shed rather than migration of the juveniles from the James River.

The Kepone concentration in juveniles did not exhibit a pattern of change with time; however, the data are relatively few. It is expected that night sampling in 1978 will result in a larger number of samples.

Job 7. Sturgeon - A General Pilot Study

SUMMARY

1. No shortnose sturgeon were found in commercial landings of sturgeon examined in the Albemarle Sound area of North Carolina.

Job 7. Sturgeon - A General Pilot Study

INTRODUCTION

Sturgeon are infrequent inclusions in pound and gill net catches of North Carolina and Virginia inshore commercial fisheries. In Virginia both the Atlantic and shortnose sturgeon are endangered species. In North Carolina only the shortnose sturgeon is considered an endangered species.

MATERIALS AND METHODS

Commercial landings of sturgeon were examined at two commercial landings sites in Albemarle Sound area. The frequency of sampling was semi-monthly during the period October 1, 1976 through September 30, 1977. In Virginia, logbooks were distributed to cooperating fishermen.

RESULTS AND DISCUSSION

During the period October 1, 1976 through September 30, 1977 44 sturgeon were examined to determine if any of those landed were shortnose sturgeon (Acipenser brevirostrum), an endangered species. None of the samples examined contained shortnose sturgeon. Table 7.1 shows the month, number, and species of sturgeon examined at each location during the sampling period.

VIMS did not receive its permit from NOAA, Marine Mammal and Endangered Species Division, until mid-August, 1977. Thus, there was no sturgeon analysis. Salary and travel funds were spent for the placement of logbooks with cooperative fishermen; there were similar expenses in the process of collecting the logbooks and informing the fishermen that the research was postponed.

Table 7.1. Numbers and species of sturgeon examined at two sampling sites in North Carolina October 1, 1976 - September 30, 1977.

Month	Site A		Site B	
	Atlantic Sturgeon	Shortnose Sturgeon	Atlantic Sturgeon	Shortnose Sturgeon
Oct. 1976	5		3	
Nov. 1976	7		4	
Dec. 1976	1		1	
Jan. 1977				
Feb. 1977				
Mar. 1977			1	
Apr. 1977	2		4	
May. 1977	5		2	
Jun. 1977	1			
Jul. 1977				
Aug. 1977	3		5	
Sep. 1977				
Total	24		20	

Job 8. Anadromous Fish Tagging

SUMMARY

1. In spring 1976, 8,737 river herring were tagged in the Scuppernong River. Estimates of population density, based on 493 tag returns, ranged from 1.3 million to 3.1 million river herring.

2. A total of 7,998 river herring was tagged and released in the mouth of the Scuppernong River in 1977. Estimates of population density, based on 566 tag returns, ranged from 2.3 million to 3.2 million river herring.

Job 8. Anadromous Fish Tagging

INTRODUCTION

The Scuppernong River and its pound net fishery for river herring provided an ideal opportunity to test the value of tagging studies in estimating the numbers of river herring in the spring spawning run in that system.

MATERIALS AND METHODS

A total of 7,998 river herring was tagged and released during the spring run (approximately February-May). Recaptures were made primarily by pound nets and some by gill nets. Rewards of $1.00 to $25.00 were offered for returned tags and information about tagged fish. Special efforts were made to collect detailed, accurate catch and effort data from both commercial and recreational fisheries of the Scuppernong River system in order to calculate the magnitude of the river herring run. The objective was to estimate the population size.

RESULTS AND DISCUSSION

Tagging

Prior to 1977 (15 February through 15 May 1976) a total of 8,737 river herring was tagged, and 493 tagged river herring were recaptured during the same period.

From 15 February through 15 May 1977 a total of 7,998 river herring was tagged, and 566 tagged river herring were recaptured during the same period.

Daily catch estimates were made from each fisherman's landings. Herring from randomly selected 100 lb. samples were counted and total number of catch estimated by multiplying number of fish per lb. by total lbs. Season catch estimates were calculated by totaling the estimates of each fisherman's daily landings. The total number of fish landed in the Scuppernong River during Spring 1976 was estimated to be 210,959; the catch estimate for 1977 was 302,036.

It is difficult for fishermen to check each fish as daily pound net catches can be quite large. Therefore, recovery efficiency of tagged fish was tested by placing a known number of tagged fish in pound nets prior to the nets being fished, and the percentage of tag recovery was calculated.

Three methods of making population estimates described by Ricker (1975) were used to evaluate data from the tag and recapture study. The three methods selected were the Petersen (single census) method, the Schnabel, and the Schaefer method for stratified populations (Appendix 8.1). Data used in each method were adjusted for the returns recaptured outside of the Scuppernong River and for tag recovery efficiency from pound nets.

Estimates using the Petersen (single census) method indicated a Scuppernong River population of 3,139,947 in 1976. Calculated 95% confidence limits were 2,900,313 and 3,422,746. The 1977 data indicated a Scuppernong River population of 2,981,315. Calculated 95% confidence limits were 2,873,988 and 3,088,642.

Estimates using the Schnabel method showed a population of 1,300,291 in 1976. Confidence limits (95%) were again calculated

and the population was found to range between 1,201,055 and 1,417,401 river herring. During 1977, the population was estimated at 2,276,906 fish. Confidence limits (95%) were again calculated and found to range between 2,107,191 and 2,476,356.

The Schaefer method for the stratified populations estimated the total number of river herring to be 2,886,801 during 1976 and 3,192,062 during 1977.

Considering the three estimates, a reasonable estimate of river herring density in the Scuppernong River spring spawning run was probably around 3 million fish each year.

LITERATURE CITED

Ricker, W. E. 1975. Computation and interpretations of biological statistics of fish populations. Fish. Res. Board Can. Bull. 191, 382 p.

Appendix 8.1. Formulas used for population estimates

Petersen

$$N = MC/R = C/u \qquad \text{Ricker (3.5)}$$

where:
- N - is the size of population at time of marking
- M - is the number of marked fish
- C - is the catch or sample taken for census
- R - is the number of recaptured marks in sample
- u - is the rate of exploitation of the population (u=R/M)

Schnabel

$$N = \frac{\Sigma\ (C_t\ M_t)}{R} \qquad \text{Ricker (3.15)}$$

where:
- N - is the size of the population
- C_t - is total sample taken on day t
- M_t - is total marked fish at large at the start of the tth day (or other internal)
- R - is the total recaptures during the experiment

Schaefer

$$N = \Sigma N_{ij} = \Sigma\left(R_{ij} \cdot \frac{M_i}{R_i} \cdot \frac{C_j}{R_j}\right) \qquad \text{Ricker (3.18)}$$

where:
- N - is the size of the population
- R_{ij} - is the number of fish marked in the ith marking period which are recaptured in the jth recovery period
- M_i - is the number of fish marked in the ith period of marking
- C_j - is the number of fish caught and examined in the jth period of recovery
- R_i - is total fish recaptured in the ith period
- R_j - is the total recaptures during the jth period

Job 9. Spawning Area Survey

SUMMARY

1. River herring spawning areas in the Alligator River were determined from observations of spawning activity, capture of running-ripe females, and collections of eggs and larvae. Approximate spawning times were noted.

Job 9. Spawning Area Survey

INTRODUCTION

Those areas identified as spawning sites are extremely important for the maintenance of river herring populations and should be protected from alteration and pollution.

MATERIALS AND METHODS

During the spawning season (approximately March-May), project personnel sampled the Alligator River and its tributaries to determine utilization of this system by anadromous fishes for spawning. Sampling gear consisted of egg nets (half-meter plankton nets), gill nets, and dip nets.

Samples of eggs and larvae from egg nets were preserved in the field and returned to the laboratory where the eggs and larvae were identified, counted, and measured. Gill nets were used to capture spawning adults which were identified, sexed, counted and examined for spawning condition. Collection of eggs, larvae, running-ripe females, and visual observations of spawning activity were considered as confirmation of spawning at a given location. Hydrological data (water temperature, salinity, etc.) were taken for each spawning area sample.

RESULTS AND DISCUSSION

Spawning Area Sampling

The criteria used to identify spawning areas were: (1) capture or observation of running-ripe females; (2) observation of spawning activity; and (3) the capture of eggs or larvae.

Table 9.1 shows the dates of capture, location, number and species of running-ripe females taken by gill nets during this study. Figure 9.1 shows the location of observed running-ripe female fish. Figure 9.2 shows the relationship of temperature and time to catches of eggs and larvae for the study area. Table 9.2 shows the number and general location of capture for the study area.

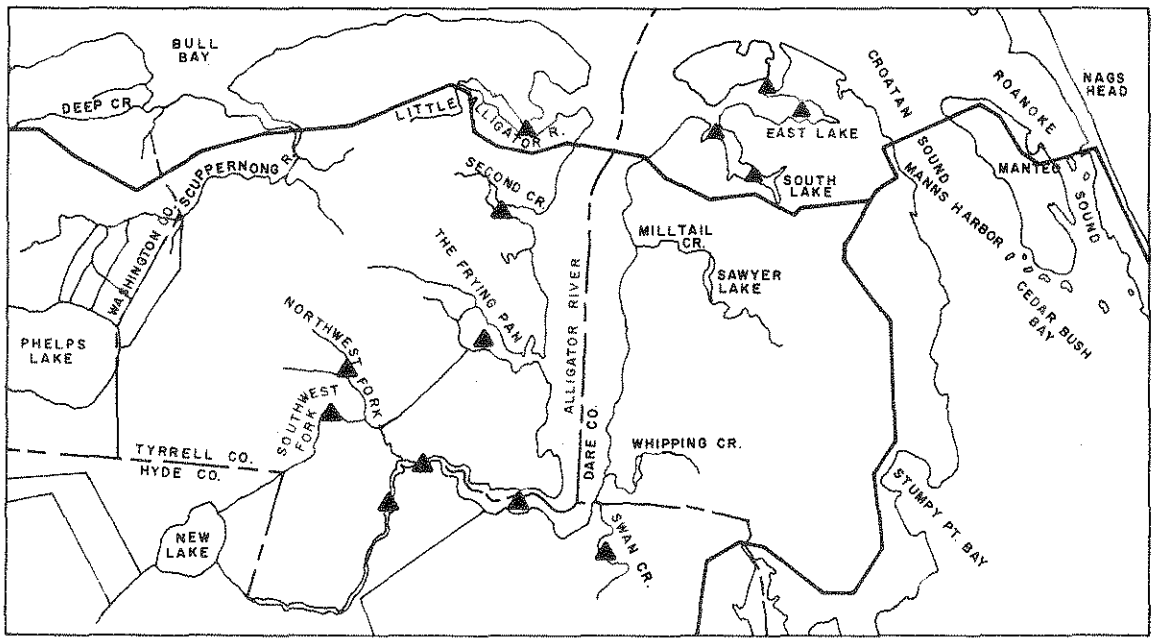
Table 9.1. Observations of running-ripe females and spawning activity by anadromous river herring in the Alligator River during 1977. All captures were by gill nets.

Date	Location	Number of fish	Species
3-11-77	Gum Neck Landing	1	Alewife
3-15-77	Alligator River Southwest Fork	1	"
3-15-77	Alligator Creek	2	"
3-17-77	Alligator River Southwest Fork	1	"
3-29-77	East Lake (lower)	1	"
3-29-77	Frying Pan	1	Blueback
3-30-77	East Lake (lower)	4	Alewife
3-30-77	Second Creek	1	"
3-30-77	Frying Pan	6	"
3-31-77	East Lake (lower)	1	"
3-31-77	South Lake (middle)	1	"
4-01-77	East Lake (lower)	1	"
4-01-77	Second Creek	2	"
4-06-77	Cherry Ridge Landing	1	Blueback
4-07-77	East Lake (upper)	1	Alewife
4-08-77	Kilkenny Landing	2	"
4-08-77	Alligator River Northwest Fork	6	"
4-13-77	East Lake (lower)	2	"
4-13-77	South Lake (upper)	1	"
4-13-77	Swan Lake	1	"
4-13-77	Gum Neck (pumping station)	2	Blueback
4-14-77	East Lake (lower)	1	"
4-14-77	South Lake (upper)	5	"
4-14-77	Second Creek	2	"
4-15-77	South Lake (upper)	1	"
4-15-77	Alligator River Northwest Fork NC 94	1	Alewife
4-19-77	Cherry Ridge Landing	1	"
4-20-77	Gum Neck Landing (pumping station)	1	Blueback
4-20-77	Alligator River Fork NC 94	3	Alewife
4-21-77	Alligator River Northwest Fork NC 94	2	"
4-22-77	Alligator River Northwest Fork	1	"
4-26-77	Alligator River Northwest Fork	1	Blueback
4-27-77	Kilkenny Landing	1	Alewife
4-28-77	Kilkenny Landing	1	"

Table 9.2. Eggs and larvae collected by egg nets in the Alligator River, 1977.

Water Body	Number of Samples	River Herring		Alewife	Blueback Herring
		Eggs	Larvae	Larvae	Larvae
Alligator River	89	37	163	35	0

A.



B.

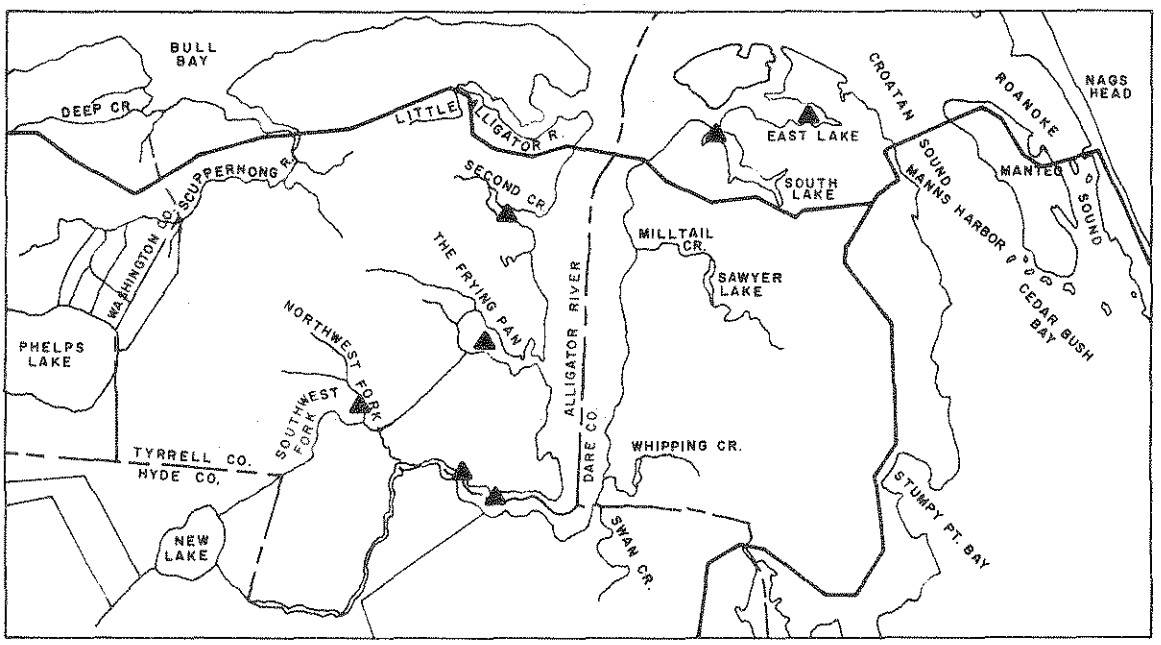


Figure 9.1. Spawning areas of alewife (A) and blueback herring (B) in the Alligator River, North Carolina.

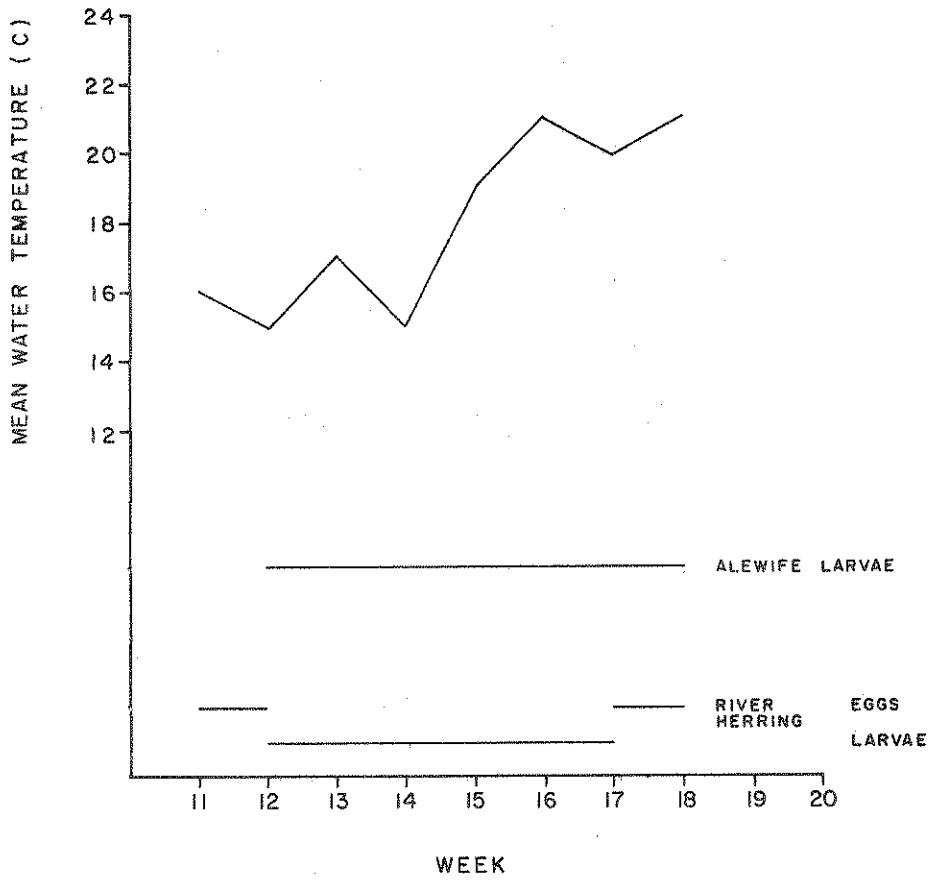


Figure 9.2. Spawning times and temperatures associated with the capture of river herring fish eggs and larvae in the Alligator River, North Carolina.

Job 10. Development of Management Alternatives

SUMMARY

1. It is recommended that the regional fishery management councils work with the Secretary of Commerce to reduce the foreign fleet's offshore river herring by-catch allocation to 100 metric tons (110.2 tons) or less beginning in 1979.
2. It is recommended that the Virginia Marine Resources Commission formulate a contingency management plan for the Virginia river herring fishery.

Job 10. Development of Management Alternatives

INTRODUCTION

Virginia and North Carolina are the center of river herring production for the Atlantic coast. As such, condition of their stocks and fisheries determines the overall condition of the total fishery. Considering the two States together, the fishery has not significantly recovered from the decline apparently caused by overfishing on the high seas by foreign vessels. Reproductive success of river herring in Virginia has declined since the mid-1960's and in the Albemarle Sound area, North Carolina since 1973. In Virginia, the 1972 year class was decimated, apparently due to Tropical Storm Agnes. The 1973 year class failed, as well, for unknown reasons. No reasons can be given for poor year classes in the Albemarle Sound area, either. Reproductive failures, however, have been far more drastic in Virginia than in North Carolina.

DISCUSSION

National Marine Fisheries Service statistics indicate that a total of 44 metric tons (MT)(48.5 tons) of river herring was taken by foreign vessels along the Atlantic coast during 1977, all as by-catch by the Soviet Union. It is significant to note that the first seizures of foreign vessels for violations of U. S. fishing regulations under the Fishery Conservation and Management Act were for excessive catches of river herring.

Since the yearly total was only 44 MT when the by-catch allocation was 500 MT (551.2 tons), it is obvious that the foreign vessels are able to avoid river herring, and that future allocations do not need to be so large. Considering the facts that river herring stocks are still quite depressed and that foreign vessels are able to operate successfully with very little river herring by-catch, it is recommended that the regional fishery management councils work with the Secretary of Commerce to reduce the river herring by-catch allocation from 468 MT (515.9 tons) in 1978 to 100 MT or less beginning in 1979.

It is further recommended that the Virginia Marine Resources Commission formulate a contingency management plan for river herring. This recommendation is based on a review of VIMS data which show a decline in river herring landings and c/f since the late 1960's and successive recruitment failures in 1976 and 1977.