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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, 1977 to September 30, 1978, and is the second of three annual reports for the P. L. 89-304 project "Biology and Management of Mid-Atlantic Anadromous Fishes Under Extended Jurisdiction." The presentation will include the alewife (Alosa pseudoharengus), blueback herring (Alosa aestivalis), hickory shad (Alosa mediocris), American shad (Alosa sapidissima), striped bass (Morone saxatilis), Atlantic sturgeon (Acipenser oxyrhynchus) and the shortnose sturgeon (Acipenser brevirostrum).

The following jobs were contracted 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 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.

Agency: DMF (VIMS participation dropped by admendment to the grant)

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 the Scuppernong River.

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

Job 11. Report Publication

Objective

To publish a report on comparison of methods and validity of aging river herring using otoliths and scales.

Agency: DMF

Job 12. Analysis of the Historical Catch Data of Anadromous Juveniles in Virginia Nursery Areas

Objectives

1. Determine nursery areas based on salinity and site of first-capture data.
2. Recalculate catch per unit of effort and standing crop estimates.

Agency: VIMS

The North Carolina contributors were as follows: Jobs 1, 2, 7, and 8 by Harrel B. Johnson; Job 3 by Douglas W. Crocker; Job 5 by Benjamin F. Holland, Jr., John W. Gilliken and David L. Taylor; Job 9 by Harrel B. Johnson and Douglas W. Crocker and Job 10 by Michael W. Street. The Virginia contributors were : Jobs 1, 4, and 7 by William H. Kriete, Jr.; Jobs 2, 3, 6, 10, and 12 by Joesph G. Loesch; and Job 4 by Jack G. Travelstead.

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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

Virginia

1. Stake gill nets in the James River yielded an estimated 0.7 million kg of American shad in 1978.

2. The catch-per-unit-of-effort (c/f) for stake gill nets in the James River increased from 7.3 kg in 1977 to 24.5 kg in 1978.

3. Pound nets in the York River landed an estimated 29,817 kg of American shad and 151,975 kg of river herring in 1978.

4. Stake gill nets in the York River landed an estimated 206,446 kg of American shad, an increase of 46% compared to 1977.

5. Pound nets in the Rappahannock River landed an estimated 3,967 kg of American shad and 512,538 kg of river herring in 1978.

6. Stake gill nets in the Rappahannock River caught an estimated 56,779 kg of American shad, an increase of 133% compared to 1977.

7. Pound nets in the Potomac River landed 3,527 kg of American shad and 659,411 kg of river herring in 1978, a decrease of 43% for American shad and 207% increase in landings of river herring compared to 1977.

8. Gill nets in the Potomac River (stake, anchor and drift) yielded 23,402 kg of American shad in 1978.

North Carolina

1. The total catch of river herring for the pound net fishery in Albemarle Sound area was 2,554,986 kg.

2. A peak catch occurred during week 16 when a total of 828,081 kg of river herring was landed.

3. The total number of pound nets fished during week 16 was 383. The catch-per-unit-of-effort (c/f) for week 16 was 2,162.1 kg of river herring.

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

Virginia

The 1978 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 (weighted 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 (kg/m of net) of index nets by meters of stake gill netting in five nautical mile sections of the river (Hoagman and Kriete 1975).

Effort was determined by semi-monthly aerial counts of active pound nets (Table 1.1 and Fig. 1.1) and a count of stake gill nets during the peak of the American shad fishing season (Table 1.2). Potomac River catch and effort data were supplied by the Potomac River Fisheries Commission. Pound net and gill net c/f were determined by dividing landings by the average number of nets fished and the number of meters of net based on the licenses sold, respectively.

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 1.12).

RESULTS AND DISCUSSION

Virginia

The 1978 fishing season for adult alosine fishes was delayed several weeks because of ice conditions in the Chesapeake Bay and its

tributaries. As in 1977, virtually all of the pound net and gill net stands that remained at the end of the 1977 fishing season were destroyed by the ice. Few fish were landed until the second half of March because of late installation of fishing gear and low water temperatures which partially delayed spawning runs.

Rapidly rising water temperatures in mid-April terminated the fishing season for American shad prematurely. Prices never equalled those of 1977 (.17/lb vs .34/lb) and dropped even more with the approach of warm weather and rising water temperatures. Few fish from upper reaches of the rivers were accepted by buyers because of the advanced stage of the roe. Although the price per pound received by fishermen has increased since 1967, the 1978 adjusted price per pound received for American shad is actually less than in 1967 (Table 1.3).

Pound net effort increased in 1978 (245 nets), relative to 1977 effort (236 nets), however it is still far below the effort of 1967 which peaked that year at 332 active pound nets (Loesch and Kriete 1976).

Effort by gill netters decreased 3% in 1978 relative to 1977 (Loesch et al. 1977); yet the number of gill net stands increased 3% during the same period (Table 1.2).

Pound net c/f in the Potomac River for alewife and blueback increased in 1978 following a decline that began in 1975 (Table 1.4).

Pound net c/f in the Rappahannock River had been increasing since 1976.

Stake gill net c/f for American shad, male and female, increased in 1978 relative to 1977 in all rivers except the Potomac River. In the latter river, c/f has declined since 1975; conversely, it has steadily increased in the York and Rappahannock rivers (Table 1.4).

James River

No pound net records were obtained from the James; however, records were obtained from fyke net landings. Sparse data suggest that these nets are ineffective for capturing American shad and river herring (Table 1.5). The ineffectiveness of this gear is attributed to the shallow depth in which these nets are set and relatively low alosine stocks in recent years.

Stake gill nets in the James River yielded an estimated 0.7 million kg of American shad during the spring fishing season (Table 1.6). This represents an increase of 250% in landings compared to 1977 with only a 5% increase in effort (Loesch et al. 1977).

Peak landings, sexes combined, occurred in the first half of April, also the peak for females. The peak landings of males occurred during the second half of March.

The c/f by gill nets for American shad in the James River increased from 7.3 kg in 1977 (Loesch et al. 1977) to 24.5 kg in 1978.

York River

Pound nets in the York River landed an estimated 29,817 kg of American shad and 151,975 kg of river herring in 1978 (Table 1.7). These landings represent increases of 146% and 55% for American shad and river herring, respectively, compared to 1977 (Loesch et al. 1977). Male American shad constituted 56% of the catch in 1978 compared to 27% in 1977 with blueback herring constituting 90% of the river herring catch in both years.

The c/f for American shad by pound nets increased from 1,211 kg in 1977 to 2,485 in 1978. The c/f for river herring increased 29% from 9,826 kg to 12,665 kg during the same period. The increase in c/f for American shad was the largest increase in c/f for all rivers surveyed.

Landings of American shad by pound nets peaked during the first half of April in 1977 and 1978. Likewise, peak landings of river herring occurred during the first half of April in 1978, much earlier than in 1977 when river herring landings peaked in the first half of May.

Stake gill net effort in the York River decreased in 1978 compared to 1977, as did 1977 effort compared to 1976 (Loesch et al. 1977). Estimated landings of American shad increased 46% from 141,124 kg in 1977 to 206,446 kg in 1978. Peak landings of males increased during the second half of March while landings for females peaked

during the first half of April (Table 1.8). As in past years, the cutting of females for the roe and the discarding of males at the nets continued in 1978 as the fishing season progressed and prices decreased.

The c/f by stake gill nets in the York River for American shad increased 77% compared to 1977, from 7.3 kg/m to 12.9 kg/m (Loesch et al. 1977).

Rappahannock River

Pound nets in the Rappahannock River landed an estimated 3,967 kg of American shad and 512,538 kg of river herring during the 1978 spring fishing season (Table 1.9). This represents a 6% decrease in landings of American shad, yet an increase of 74% for river herring compared to 1977 (Loesch et al. 1977). The smaller nets upriver landed 60% of the American shad as in 1977, yet only 18% of the river herring, compared to 51% in 1977.

The c/f by pound nets in the Rappahannock River increased from 93 kg to 95 kg for American shad and from 6,530 kg to 12,203 kg for river herring compared to 1977. Pound net effort decreased 11% during the same period. The c/f of female American shad increased 61% from 28 kg while the c/f for males decreased 23% from 65 kg to 50 kg compared to 1977.

Stake gill nets caught an estimated 56,779 kg of American shad with peak landings during the first half of April (Table 1.10). This

represents an increase of 133% in landings compared to 1977 with <1% increase in effort (Loesch et al. 1977).

Stake gill nets above mile 35 were set primarily for striped bass due to the high ex-vessel prices of striped bass ($1.00-$1.50/lb) and the scarcity of American shad on the Rappahannock River in 1978.

The c/f for American shad increased from 1.8 kg/m to 4.2 kg/m compared to 1977.

Potomac River

Pound nets in the Potomac River landed 3,527 kg of American shad, a decrease of 43% compared to 1977 (Loesch et al. 1977). This was the only river of those surveyed with a decrease in shad landings. However, river herring landings by pound nets increased 207% during the same period, the largest increase among the rivers surveyed. American shad landings were near equally high in the months of April and May while river herring landings peaked during May (Table 1.11). Virginia pound nets yielded 95% of the American shad and river herring taken in pound nets in the Potomac River.

The c/f for American shad in the Potomac River by pound nets was 78 kg per net, a 36% decrease relative to 1977 (Loesch et al. 1977). River herring c/f increased 248% compared to 1977 from 4,209 kg per net to 14,654 kg per net.

Stake gill nets yielded 13,167 kg of American shad in 1978 with 10,664 kg (81%) landed by Maryland fishermen. This represents a 35% decrease in landings for stake gill nets compared to 1977. Anchor gill nets caught 4,151 kg of American shad. As with stake gill nets, Maryland fishermen reported the majority of the landings (91%). On the other hand, Virginia fishermen recorded 100% of the 5,119 kg of American shad landed by drift gill nets.

Peak landings of American shad by stake and anchor gill nets occurred during April, while drift gill net landings peaked during May.

Stake gill net c/f for American shad declined from 0.4 kg to 0.3 kg, compared to 1977. Anchor gill nets also exhibited a decline in c/f from 0.05 kg to 0.03. Drift gill nets, however, exhibited an increase in c/f from 0.3 kg to 0.9 kg during the same period.

North Carolina

Pound net catch-effort statistics for the Albemarle Sound river herring fishery are presented in Table 1.12 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 10 or after week 20. The total catch for the period was down some 1,089,850 kg from the previous year; however, it should be noted that effort was also reduced, as the result of winter ice destroying many active pound net sets.

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Table 1.1. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during January-June, 1978.

	Area	Jan. 24	Feb. 24	Mar. 13	Mar. 22	April 14	May 2	May 17	June 1	June 13
A	James R.	0	0	0	0	0	0	1	1	1
B	Back R.	0	0	0	0	8	7	8	7	6
C	Poquoson R.	0	0	0	0	1	1	2	2	2
D	York R.	0	0	0	3	12	15	15	14	15
E	Mobjack Bay	0	0	0	0	5	6	7	6	7
F	Piankatank R.	0	0	0	2	3	3	3	4	3
G	Rappahannock R.	0	0	10	27	48	57	54	49	40
H	Great Wicomico R.	0	0	0	1	1	2	3	7	7
I	Potomac R.	2	0	1	4	44	58	71	72	67
J	Cape Henry to Fort Wool	0	0	0	1	4	6	6	4	5
K	Old Point to Tue Marsh	0	0	0	4	7	4	4	2	2
L	York Spit	0	0	0	1	3	5	4	4	5
M	New Point to Stingray Point	0	0	0	0	12	17	14	14	14
N	Windmill Point to Smith Point	0	0	0	6	32	30	35	31	31
	Eastern Shore									
O	Above Hungar Creek	0	0	0	0	0	1	1	0	0
P	Below Hungar Creek	0	0	0	0	9	13	17	19	19
	Total	2	0	11	49	189	225	245	236	224

Table 1.2. Number of stake gill net stands fished in Virginia rivers 1976-1978 (A) and number of linear meters per five mile block (B) in 1978. Figures in parentheses represent nets set for American shad.

A.

River System	Number of Gill Net Stands 1976	1977	1978
James	113	168	181
York	140	123	118
Rappahannock	127	121	124

B.

River	Mile	Number of Stands	Number of Sections	Average Length/Section	Total Meters
James	05-10	26	546	9	4,914
	10-15	26	473	9	4,257
	15-20	84	1,305	9	11,745
	20-25	30	485	9	4,365
	25-45	15	317	9	2,853
	Total	181	3,126		28,134
York	10-15	37	725	9	6,525
	15-20	31	505	9	4,545
	20-25	13	197	6	1,182
	25-29	37	617	6	3,702
	Total	118	2,044		15,954
Rappahannock	20-25	7	83	15	1,245 (1,008)
	25-30	32	619	15	9,285 (7,521)
	30-35	24	424	15	6,360 (5,152)
	35-65	61	1,213	13	15,769
	Total	124	2,339		32,659

Table 1.3. Dock-side value and adjusted value of American shad landings in Virginia for the years 1967-1978. Pounds and value in thousands.

Year	Pounds	Value	Consumer Price Index	Adjusted Value	Adjusted Price/lb. (¢)
1967	2138	181	1	181.0	8.46
1968	2550	161	1.04	154.8	6.07
1969	2248	166	1.10	150.9	6.71
1970	4112	315	1.16	271.6	6.60
1971	1520	135	1.21	111.6	7.34
1972	2057	225	1.25	180.0	8.75
1973	2436	366	1.33	275.2	11.30
1974	1569	230	1.48	155.4	9.90
1975	1136	308	1.61	191.3	16.84
1976	896	284	1.70	167.0	18.64
1977	1468	498	1.81	275.1	18.74
1978	1234	211	2.03	103.9	8.42

Table 1.4. Yearly catch-per-unit-of-effort for American shad and river herring 1975-1978 in kg by species for stake gill net and pound net. Stake gill net effort in meters. Pound net effort in number of nets.

		Stake Gill Net			Pound Net				
			American shad			American shad		River Herring	
	Year	Effort	♂	♀	Effort	♂	♀	Alewife	Blueback
James River	1975	25,832	2.7	8.8	[(a)]	[(a)]	[(a)]	[(a)]	[(a)]
	1976	20,464	1.9	25.1					
	1977	26,884	0.4	6.9					
	1978	28,134	4.1	20.4					
York River	1975	22,106	0.5	4.5	[(a)]	[(a)]	[(a)]	[(a)]	[(a)]
	1976	21,424	0.3	3.0					
	1977	19,326	0.2	7.1	10	889	322	1,030	8,797
	1978	15,954	2.0	10.9	12	1,390	1,095	1,335	11,330
Rappahannock River	1975	28,973	0.1	0.8	30	42	60	2,408	5,732
	1976	32,517	0.1	0.5	25	33	55	1,754	2,716
	1977	13,595	0.2	1.6	45	65	28	1,882	4,648
	1978	13,681	0.8	3.4	42	50	45	3,114	9,089
Potomac River	1975	76,553	0.1	0.5	23	149	43	16,625	89,071
	1976	78,858	<0.1	0.3	32	208	83	4,430	13,502
	1977	75,017	<0.1	0.3	51	74	48	680	3,529
	1978	56,839	<0.1	0.2	45	41	37	1,088	13,566

(a) Data not available

Table 1.5. Estimated landings of alosine fishes, in kg, by fyke nets in the James River 1978.

	Number Nets	Index	Estimated Total
March			
Alewife	6	136	816
Blueback		(a)	
American shad		5	30
April			
Alewife	12	39	468
Blueback		117	1,404
American shad		10	120
May			
Alewife	15	16	240
Blueback		111	1,665
American shad		(a)	
Total by species			
Alewife			1,524
Blueback			3,069
American shad			150

(a) none reported by index fishermen

Table 1.6. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the James River 1978 by half-month intervals and by sex. Effort from Table 1.2. 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
March 1st	05-10	.1217	598	.0425	209	807
	10-15		518		181	699
	15-20	.0245	288	.0050	59	347
	20-25		107		22	129
	25-45		70		14	84
	Total		1,581		485	2,066
March 2nd	05-10	4.3251	21,254	6.6709	32,781	54,035
	10-15		18,412		28,398	46,810
	15-20	2.5834	30,342	4.6889	55,071	85,413
	20-25		11,277		20,467	31,744
	25-45		7,370		13,377	20,747
	Total		88,655		150,094	238,749
April 1st	05-10	.7636	3,752	12.4472	61,166	64,918
	10-15		3,251		52,988	56,239
	15-20	.6659	7,821	6.7349	79,101	86,922
	20-25		2,907		29,398	32,305
	25-45		1,900		19,215	21,115
	Total		19,631		241,868	261,499
April 2nd	05-10	.2959	1,454	8.9342	43,903	45,357
	10-15		1,260		38,033	39,293
	15-20	.1826	2,145	4.6529	54,648	56,793
	20-25		797		20,310	21,107
	25-45		521		13,275	13,796
	Total		6,177		170,169	176,346
May 1st	05-10	(a)		(a)		
	10-15					
	15-20	.0160	188	.6496	7,630	7,818
	20-25		70		2,836	2,906
	25-45		46		1,853	1,899
	Total		304		12,319	12,623
Total by Sex			116,348		574,935	
Grand Total						691,283

(a) None reported by index fishermen.

Table 1.7. Estimated catch in kg of American shad and river herring by pound nets in the York River 1978 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		
March 2nd	3	147.4	442	102.1	306	465.0	1,395	50	698	50	697	1	2
April 1st	12	564.1	6,769	599.9	7,199	5,397.8	64,774	9	5,830	91	58,944	13	4
April 2nd	15	232.9	3,494	308.8	4,632	1,974.3	29,615	27	7,996	73	21,619	12	6
May 1st	15	86.4	1,296	114.5	1,718	1,663.2	24,948	6	1,497	94	23,451	13	6
May 2nd	15	74.2	1,113	118.1	1,772	1,735.0	26,025			100	26,025	14	6
June 1st	14	1.9	27	74.9	1,049	372.7	5,218			100	5,218	13	6
Total			13,141		16,676				16,021		135,954		
				29,817			151,975						

Table 1.8. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the York River 1978 by half-month intervals. Effort from Table 1.2. 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
March 1st	10-15	.0635	414	.1788	1,167	1,581
	15-20		289		813	1,102
	20-25	.0224	26	.0303	36	62
	25-29		83		112	195
	Total		812		2,128	2,940
March 2nd	10-15	1.2330	8,045	2.8851	18,825	26,870
	15-20		5,604		13,113	18,717
	20-25	.7903	934	3.1818	3,761	4,695
	25-29		2,926		11,779	14,705
	Total		17,509		47,478	64,987
April 1st	10-15	.5980	3,902	5.9067	38,541	42,443
	15-20		2,718		26,846	29,564
	20-25	.4300	508	5.0600	5,981	6,489
	25-29		1,592		18,732	20,324
	Total		8,720		90,100	98,820
April 2nd	10-15	.2390	1,559	2.0540	13,402	14,961
	15-20		1,086		9,335	10,421
	20-25	.4054	479	2.5259	2,986	3,465
	25-29		1,501		9,351	10,852
	Total		4,625		35,074	39,699
Total by Sex			31,666		174,780	
Grand Total						206,446

Table 19. Estimated catch in kg of American shad and river herring by pound nets in the Rappahannock River 1978 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
March 1st	0-30	2	20.4	41	17.2	34	4,535.9	9,072	100	9,072			6	1
	31-65	8	(a)		(a)		29.2	234	100	234			6	6
March 2nd	0-30	12	20.1	241	17.5	210	4,536.0	54,432	88	47,900	12	6,532	8	2
	31-65	15	9.1	137	7.8	117	123.6	1,854	84	1,557	16	297	12	15
April 1st	0-30	27	7.7	208	9.3	251	5,669.9	153,087	22	33,679	78	119,408	8	4
	31-65	21	28.5	599	18.1	380	923.5	19,394	37	7,176	63	12,218	14	17
April 2nd	0-30	36	7.7	277	9.3	335	5,669.9	204,116	9	18,370	91	185,746	8	4
	31-65	21	10.6	223	29.5	620	1,160.5	24,371	30	7,311	70	17,060	12	17
May 1st	0-30	36	(a)		(a)		(a)							
	31-65	21	6.6	139	4.8	101	1,747.6	36,700	15	5,505	85	31,195	13	17
May 2nd	0-30	34	(a)		(a)		(a)							
	31-65	20	.3	6	2.4	48	463.9	9,278			100	9,278	9	11
Total				1,871		2,096				130,804		381,734		
					3,967			512,538						

(a) None reported by index fishermen

Table 1.10. Estimated catch in kg of American shad by stake gill nets in the Rappahannock River 1978 by half-month intervals. Effort from Table 1.2. 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
March 2nd	20-25	.4655	469	.4339	437	906
	25-30		3,501		3,263	6,764
	30-35		2,398		2,235	4,633
	35-65(a)					
	Total		6,368		5,935	12,303
April 1st	20-25	.2551	257	1.5446	1,557	1,814
	25-30		1,919		11,617	13,536
	30-35		1,314		7,958	9,272
	35-65(a)					
	Total		3,490		21,132	24,622
April 2nd	20-25	.0481	48	.9446	952	1,000
	25-30		362		7,104	7,466
	30-35		248		4,867	5,115
	35-65(a)					
	Total		658		12,923	13,581
May 1st	20-25	.0287	29	.4298	433	462
	25-30		216		3,233	3,449
	30-35		148		2,214	2,362
	35-65(a)					
	Total		393		5,880	6,273
Total by sex			10,909		45,870	
Grand Total						56,779

(a) None reported by index fishermen

Table 1.11. Total catch in kg of alosine fishes by gill nets (A) and pound nets (B) in the Potomac River 1978.

	American Shad					River Herring				
	Virginia		Maryland			Virginia		Maryland		
	Female	Male	Female	Male	Total	Alewife	Blueback	Alewife	Blueback	Total
A. Anchor Gill Nets										
March	1	2	26	6	35	1		115	4	120
April	132	156	2,613	877	3,778	24	85	7	27	143
May	67	11	260		338					
Total	200	169	2,899	883	4,151	25	85	122	31	263
Stake Gill Nets										
February								1		1
March	1	3	2	5	11	185	6	42	1	234
April	1,563	260	5,704	188	7,715	160	566	74	261	1,061
May	656	20	4,712	53	5,441	16	392	2	47	457
Total	2,220	283	10,418	246	13,167	361	964	119	309	1,753
Anchor and Stake Gill Nets (not reported separately by fishermen)										
March	5	5			10	24	1			25
April	519	328	5		852	105	374	24	87	590
May	83	20			103					
Total	607	353	5		965	129	375	24	87	615
Drift Gill Nets										
April	1,068	479			1,547	18	65			83
May	3,127	445			3,572	2	38			40
Total	4,195	924			5,119	20	103			123
B. Pound Nets										
March		2	3	1	6	156	5	386	12	559
April	667	402	48	48	1,165	30,036	106,492	2,024	7,176	145,728
May	857	504	54	10	1,425	15,637	375,300	703	16,861	408,501
June	45	886			931		96,563		8,060	104,623
Total	1,569	1,794	105	59	3,527	45,829	578,360	3,113	32,109	659,411
Total	8,791	3,523	13,427	1,188		46,364	579,887	3,378	32,536	
Grand Total					26,929					662,165

Table 1.12. 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)
11	11,471	301	38.1
12	20,625	326	63.3
13	60,126	354	169.9
14	192,992	369	523.0
15	478,164	383	1248.5
16	828,081	383	2162.1
17	495,764	383	1294.4
18	396,056	380	1042.3
19	31,319	383	81.8
20	40,388	383	105.5
Total	2,554,986		

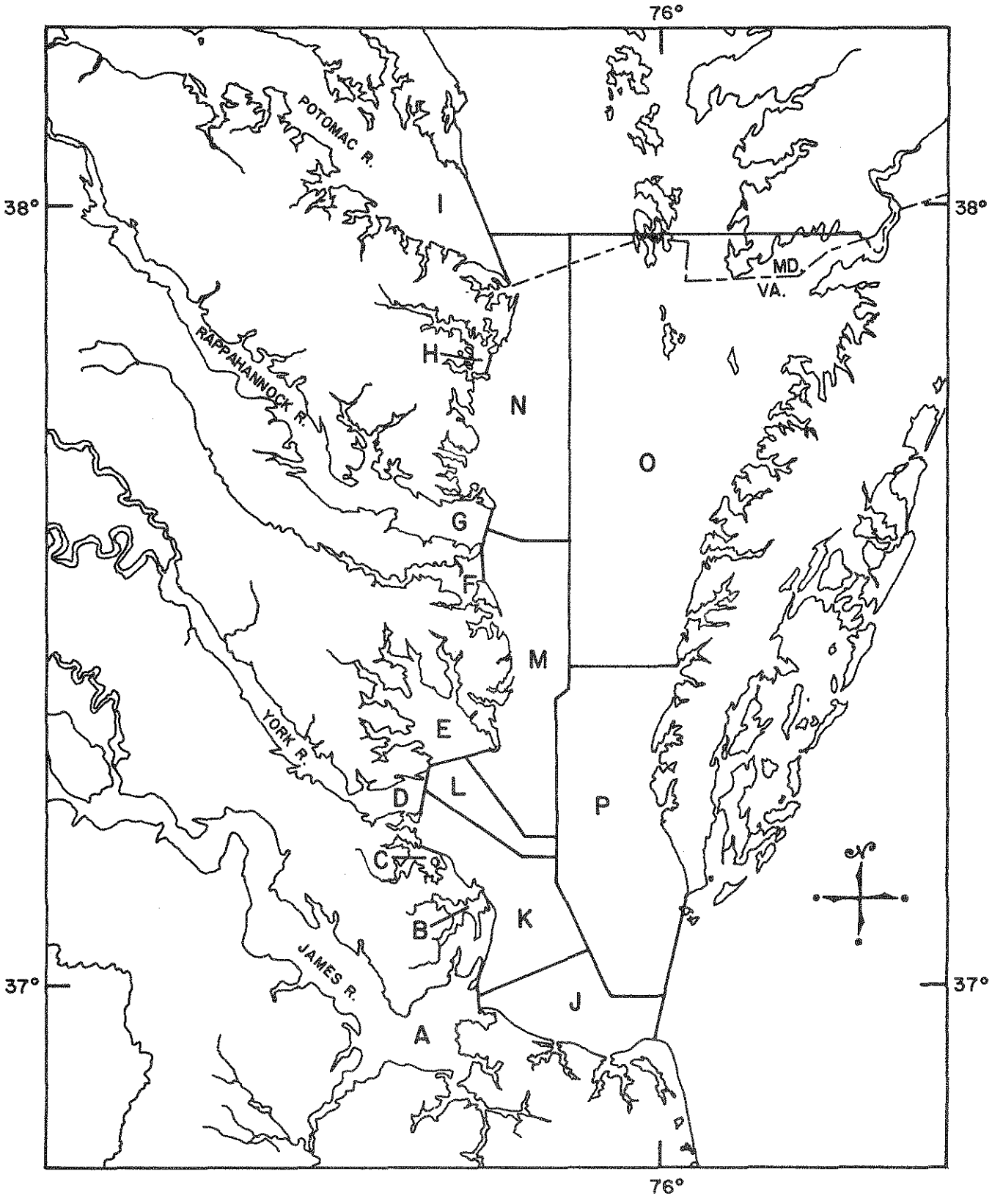

Figure 1.1. Area designations utilized during aerial pound net counts.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

SUMMARY

Virginia

1. In 1978, Virginia river herring landings (965 metric tons) increased 53% relative to 1977; however, the 1978 landings were still the second lowest commercial catch since 1966.

2. The increased landings are not attributable to increased effort or good recruitment. Possibly, the low river water temperatures delayed the entire spawning season and, overall, subjected the stock to a greater density of pound nets than normally encountered in an earlier spawning season. Thus, effective effort would be more intense than nominal effort would indicate.

3. Data indicate an increasing, older age structure for river herring and probably, American shad. In the absence of a strong, mature year class, the increased means of age, length, and weight, and the increased proportion of females reflect poor recruitment in recent years.

North Carolina

1. Blueback herring comprised 81% of the river herring samples in 1978, although alewife dominated the earliest catches.

2. The male to female sex ratio for blueback herring was 1.5:1, while that for alewife was 1.7:1.

3. The age ranges for male and female blueback herring were age 3 to age 7 years.

4. Ages 4, 5, and 6 constituted 94% of the male blueback herring and 96% of females sampled.

5. The 1978 spawning population of blueback herring was composed of 76% virgin males and 70% 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 95% of the male alewife and 94% of the females sampled.

8. The 1978 spawning population of alewife was composed of 77% virgin males and 69% virgin females.

9. The age ranges for both male and female American shad were age 3 to age 7 and age 4 to age 7, respectively. Ages 4, 5 and 6 comprised 90% of the males sampled, and 96% of the females sampled.

10. Hickory shad ages ranged from 3 to 6 years for both sexes. Sixty-four percent of the hickory shad (sexes combined) sampled were virgin fish.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

INTRODUCTION

The North Carolina Division of Marine Fisheries (DMF) and the Virginia Institute of Marine Science (VIMS) continued their annual assessment of the structure of adult alosine populations.

MATERIALS AND METHODS

Virginia

Sampling of the Virginia alosine commercial fisheries commenced in mid-March, 1978 and continued weekly for river herring and semi-monthly for American shad until late May in the James and York rivers and late June in the Rappahannock and Potomac rivers.

When available, 14 kg of river herring were randomly sampled from commercial pound net or fyke net catches. These nets employ a 50.8 mm stretched mesh in their entrapment section. This mesh size is required by Virginia law (Sec. 28.1-51) for pound nets when taking "food fish" and is assumed to be nonselective for river herring age 3 and older.

Random samples of up to 50 American shad were taken from commercial catches. The fishery primarily employs gill nets with mesh sizes (12.4-14.0 cm) 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 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.

Domestic river herring landings 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 landings data were obtained from the respective ICNAF Statistical Bulletins.

A computer "package program", SPSS (Nie et al. 1975), was used to construct Tables 2.3 through 2.12.

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).

RESULTS AND DISCUSSION

Virginia

Sampling Effort

During the 1978 spawning season, 956 alewife, 3,617 blueback herring and 895 American shad were sampled (Table 2.1).

River Herring Landings

The 1978 Virginia river herring landings of 965 metric tons were a 53% increase relative to the 1977 landings, nevertheless, 1978 landings were the second lowest recorded since 1966 (Table 2.2). The increased landings are not attributable to increased effort. For example, Potomac River pound net landings in 1978 (Job 1) were up about 66% relative to the 1977 landings (Loesch et al. 1977) but effort, mean number of pound nets per day (March-June), decreased from 51.2 in 1977 to 45.1 in 1978. Also, the 1978 age structure and size and weight data (discussed below) indicate that Virginia stocks have aged due to poor recruitment in the last several years. Thus, the increased landings cannot be attributed to recruitment. A speculative explanation is that the cold winter of 1977-1978 and the resulting low water temperatures delayed the entire spawning season. This would result in greater fishing pressure because the fish entered when all of the pound nets were set rather than some entry in late February and March when the number of nets are at a minimum. Thus, effective effort may have been more intensive than nominal effort would indicate.

Age Composition

The age frequency of river herring (sexes pooled) by river by species was determined from samples of the commercial fisheries catches (Tables 2.3 - 2.12). Mean and modal age data are summarized in Table 2.13.

There was an increasing trend in the mean age of alewife relative to 1977 except in the Rappahannock and Pamunkey rivers where no appreciable changes occurred (Table 2.13). In 1977, age 5 and/or age 6 were the dominant (modal) alewife age group but in 1978 ages 5 and 6 were codominant in all the fisheries. There was also a general increase in blueback herring mean age with the exception of the Pamunkey River estimate. Age 6, with the above noted exception, was the modal group in both 1977 and 1978 for blueback herring.

There is no strong, mature age class in the Virginia river herring stocks to account for the increasing age trend in recent years. The trend is apparently due to the poor recruitment of four-year-olds in the last several years. The last strong year class to enter the fishery was the 1966 year class; Hoagman and Kriete (1975) reported a very high density of juvenile bluebacks in 1975 and this year class may bolster the river herring stocks in 1979 or 1980.

The American shad fishery is primarily a gill net fishery and catches are biased toward larger and older fish, mostly females, because of net selectivity; also males are discarded at the net when their market price is low. Therefore, data of age structure, sex ratio, etc. have relevancy only to fish landed.

American shad age frequency data are summarized in Table 2.14. The modal group for both sexes was age 6. Relative to 1977 (Loesch et al. 1977), the percentage of shad age 6 and older increased and, conversely, the percentage age 5 and younger decreased. Thus,

American shad stocks may be exhibiting an ageing trend similar to river herring. Since the three alosine species have overlapping spawning seasons and all are estuarine dependent during their first-year development, the many nursery variables influencing year-class success may equally affect the three species.

Length and Weight Analysis

Mean fork length and total body weight data of river herring are summarized by river and species for 1977 and 1978 in Table 2.15.

Nineteen of each 20 estimates of mean fork length and mean total body weight exceeded their respective mean estimates in 1977. Data for the one exception, female alewife in the York River, are from pound nets fished at the mouth of the river. Some of the smaller females in this area may not participate in the upriver, spawning runs.

Averaged across rivers, the 1978 data indicate that the means for male alewife length, 249.5 mm, and weight, 223.9 g, increased 6.1 mm and 25.0 g; and female mean length, 258.4 mm, and mean weight, 254.1 g, increased 3.6 mm and 18.0 g, relative to 1977. Male blueback herring means of length, 250.8 mm, and weight, 204.0 g, increased 8.8 mm and 29.0 g; and female mean length, 259.3 mm, and mean weight, 231.2 g, increased 6.8 mm and 27.0 g.

The absence of strong, mature river herring year classes indicates that the increased means of age, length, and weight are a reflection of the poor recruitment in recent years.

Our only unbiased source of American shad data is specimens obtained from the Potomac River pound nets. The 1978 Potomac River pound net catch of shad (Job 1) declined about 43% relative to 1977 (Loesch et al. 1977) and only 11 fish were obtained; therefore, no analyses were attempted. Data of 1977 indicated that male shad had a mean length and mean weight of 405.8 mm and 837.3 g, and the means for females were 422.0 mm and 989.1 g.

Sex Ratios and Species Composition

Sex ratios of river herring in 1977 and 1978 Virginia river herring fishery are contrasted in Table 2.16.

Chi square (x^2) analysis of the hypothesis of a 1:1 sex ratio for the 1977 data indicated that in six of 10 male to female ratios, males were significantly more abundant. In 1978, only three of the 10 ratios indicated a superior number of males, and, conversely, female blueback herring were significantly more abundant in the Rappahannock and Potomac river samples. Increased female representation can be associated with the increased age of the river herring stocks. VIMS historical age data for river herring indicate that females live somewhat longer than males.

Sampling data (Table 2.1) show that blueback herring comprised about 73% of the river herring catch in 1978. This percentage is nearly identical to that in 1977 (72%) but about 10% higher than those for the years 1974, 1975, and 1976 (Loesch and Kriete 1976).

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, and Chowan River. All early catches of river herring were dominated by alewife; blueback herring became the dominant species at approximately mid-season (12-13th week; Fig. 2.2). These data agree closely with those reported by Street et al. (1975) and Johnson et al. (1977) and Loesch et al. (1977). Species composition for the entire 1978 season was 81% blueback herring and 19% alewife.

Sex Ratios - River Herring

Sex ratios were obtained from combined data taken at sites located on the Scuppernong and Chowan rivers during 1978. Pound nets at these sites are believed to be nonselective. During 1978 the male to female sex ratios were 1.5:1 for blueback herring and 1.7:1 for alewife. Chi square (X^2) analysis of the hypothesis of a 1:1 sex ratio indicated that both the alewife ratio and blueback herring ratio were highly significant at 95% confidence level.

Sex Ratios - American Shad

A sex ratio of 1.4:1 (males to females) was obtained from the pooled data of all samples. The X^2 value of 11.0 was highly significant at a 95% confidence level. 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 0.3:1. A X^2 value of 56.0 was highly significant at a 95% confidence level. 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 1978 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:

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

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

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

N_t = number in the t th age group

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

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 1978 were 41%, a much lower value than the 60% value reported in the AFCS-9 Segment 1 (Loesch et al. 1977) report and to that reported by Street et al. (1975).

Mortality estimates for alewife during 1978 were found to be 42%, again much lower than those values presented during the AFCS-9 Segment 1 report and those reported by Street et al. (1975) and Johnson et al. (1977).

Total mortality for American shad during 1978 was calculated to be 36%, less than half the 1977 rate.

The 1978 mortality for hickory shad was 47%, also a significant reduction from 1977.

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 2.17 through 2.22.

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

The Alligator River data are probably biased because fishermen there were only active during the early part of the 1978 season.

A total of 649 blueback herring scale samples was found suitable for age determination. Ages for males were found to range from 3 to 7 years, while females also ranged from 3 to 7 years in age (Table 2.17). Age groups, 4, 5, and 6 made up 94% of the male sample and 96% of the female samples. These values are much higher than those reported in Street et al. (1975) but similar to those reported by Johnson et al. (1977) and Loesch et al. (1977) indicating a lack of older fish again in 1978. Combined data from all sampling locations show a spawning population comprised of 76% virgin males and 70% virgin females. Scales sampled from female blueback had up to 3 spawn marks, while those sampled from males also had up to 3 spawn marks; however only 1% of the fish had spawned more than twice. The proportion of repeat spawners (sexes combined) was 27%.

Data for 1978 for each of the areas sampled in the commercial harvest surveys showed much the same situation as reported by Street et al. (1975), Johnson et al. (1977) and Loesch et al. (1977). The spawning populaton in the Scuppernong River was composed of 85% virgin fish (sexes combined); Table 2.18. The proportion of virgin fish is similar to the 80% virgin fish in the Scuppernong River reported by Street et al. (1975), slightly lower than the 87% reported by Johnson et al. (1977), and much higher than the 72% reported by Loesch et al. (1977). Ages for male blueback herring in Scuppernong River ranged from 3 to 6 years, while females ranged from 4 to 7 years; 10% of the fish (sexes combined) were over age 5 (Table 2.18).

Data collected from the haul seine fishery of the Meherrin River (Table 2.19) showed that virgin fish comprised 73% of the male sample and 61% of the female sample for the spawning blueback population. Ages for males ranged from 3 to 7 years, while females ranged from 4 to 7 years. Data showed that 6% (sexes combined) had spawned more than once. (Table 2.19).

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 likely to reflect population parameters of the total river herring run in Albemarle Sound.

Data for the Chowan River showed that 75% of the blueback herring were virgin fish (sexes combined), (Table 2.20). Ages of males and

females ranged from 3 to 7 years. Age groups, 4, 5 and 6 made up 95% of the male and female samples (Table 2.20). Seven percent of the sample (sexes combined) were found to have spawned more than once.

Again, as reported by Johnson et al. (1977) fishermen in the Alligator River area concentrated their effort in that system only during the early part of the season; consequently, samples for alewife only were obtained from that sample site.

A total of 679 alewife scale samples were found suitable for age determination. Combined data for 1978 for all sample sites are presented in Table 2.17. Ages of male alewife ranged from 3 to 7 years; while females ranged from 3 to 8 years. Age groups 4, 5, and 6 made up 95% of the male portion of the sample and 94% of the female portion of the sample.

Combined data from all locations indicate an alewife spawning population composed of 77% virgin males of the male sample and 69% virgin females of the female sample. Scales from males had up to three spawn marks, while scales from females had up to four spawn marks. Seven percent of the alewife (sexes combined) were found to have spawned more than once (Table 2.17).

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. The total sample size during 1978 was about one-third smaller than during 1977,

probably the result of the destructive effects of late winter ice and abnormally high flood conditions at practically all fishing areas which severely reduced fishing effort by fishermen.

Very few alewife were sampled from the Scuppernong River. Too few fish were examined to make any attempt at comparing age or frequency of spawning with that of other areas. However, data collected are presented in Table 2.18.

Alewife samples obtained from the Meherrin River showed the ages for the males to range from 3 to 6 years, and 3 to 8 years for the females. Seventy-seven percent of the samples (sexes combined) were virgins (Table 2.19). Only 6% of the fish (sexes combined) had spawned more than once (Table 2.19).

Alewife from the Chowan River ranged in age from 3 to 6 years for males and 3 to 7 for females (Table 2.20). Virgin fish comprised 81% of the sample (sexes combined), while only 4% of the fish (sexes combined) had spawned more than once (Table 2.20). 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 3 to 7 years, while alewife females ranged from 4 to 7 years (Table 2.21). Fifty-five percent of the sample (sexes combined) were virgins and 13% (sexes combined) had spawned more than once (Table 2.21).

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 490 scale samples were found suitable for age determination. Data for 1978 are presented in Table 2.22. Ages ranged from 3 to 7 years for males and 4 to 7 years for females. Age groups 4, 5, and 6 comprised 90% of the male sample, and 96% of the female sample. The American shad population was comprised of 95% virgin fish (sexes combined), and only 0.2% (sexes combined) had spawned more than once.

Scales from a total of 166 hickory shad were found suitable for determining age and spawning history. Data are presented in Table 2.22. Ages ranged from 3 to 6 years for both males and females. Data showed that 64% of the fish sampled (sexes combined) were virgin. Only 13% of the fish sampled (sexes combined) had spawned more than once (Table 2.22).

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Table 2.1 Summary of sample data from the alosine commercial fisheries during the 1978 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						
2nd	19	4	8	0	31	32
April						
1st	66	31	69	56	24	22
2nd	2	0	8	1	0	0
May						
1st	9	16	50	31	3	47
2nd	0	0	0	0	0	0
June						
1st	1	0	0	0	0	0
2nd	0	0	0	0	0	0
York*						
March						
1st	9	8	0	0	1	0
2nd	54	24	51	28	73	75
April						
1st	20	21	100	94	17	133
2nd	26	25	49	81	4	108
May						
1st	6	10	90	94	14	52
2nd	0	0	93	46	0	0
June						
1st	0	0	0	0	3	0
Rappahannock						
March						
1st	44	36	0	0	0	0
2nd	120	42	26	3	28	48

*York and Pamunkey river data pooled.

Table 2.1 (continued)

River and Half-month	Alewife Male	Alewife Female	Blueback Male	Blueback Female	American shad Male	American shad Female
Rappahannock (continued)						
April						
1st	30	39	68	108	29	46
2nd	23	32	69	133	0	44
May						
1st	20	29	174	253	6	44
2nd	3	4	166	155	0	0
June						
1st	2	1	108	78	0	0
Potomac						
March						
2nd	42	45	1	2	0	0
April						
1st	29	23	51	39	0	4
2nd	7	10	56	97	0	0
May						
1st	4	8	154	186	0	0
2nd	4	7	119	154	0	0
June						
1st	0	0	69	168	0	0
2nd	1	0	18	32	0	1
July						
1st	0	0	57	74	2	4
2nd	0	0	19	31	0	0
Totals (M+F)	956		3617		895	

Table 2.2 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	
1978	2,996	965	

Table 2.3. Year-class frequency of alewife (sexes pooled) in the James River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	1	0.7	0.9	0.9
	71.	11	7.4	10.2	11.1
	72.	42	28.4	38.9	50.0
	73.	43	29.1	39.8	89.8
	74.	11	7.4	10.2	100.0
	0.	40	27.0	MISSING	100.0
	TOTAL	148	100.0	100.0	

MEAN	72.481	STD ERR	0.082	MEDIAN	72.500
MODE	73.000	STD DEV	0.848	VARIANCE	0.719
KURTOSIS	-0.204	SKEWNESS	-0.172	RANGE	4.000
MINIMUM	70.000	MAXIMUM	74.000		
VALID CASES	108	MISSING CASES	40		

Table 2.4. Year-class frequency of blueback herring (sexes pooled) in the James River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	69.	4	1.8	3.3	3.3
	70.	12	5.4	9.9	13.2
	71.	26	11.7	21.5	34.7
	72.	59	26.5	48.8	83.5
	73.	18	8.1	14.9	98.3
	74.	2	0.9	1.7	100.0
	0.	102	45.7	MISSING	100.0
	TOTAL	223	100.0	100.0	

MEAN	71.669	STD ERR	0.092	MEDIAN	71.814
MODE	72.000	STD DEV	1.012	VARIANCE	1.023
KURTOSIS	0.325	SKEWNESS	-0.563	RANGE	5.000
MINIMUM	69.000	MAXIMUM	74.000		
VALID CASES	121	MISSING CASES	102		

Table 2.5. Year-class frequency of alewife (sexes pooled) in the York River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	1	0.7	1.2	1.2
	72.	36	25.9	41.9	43.0
	73.	44	31.7	51.2	94.2
	74.	5	3.6	5.8	100.0
	0.	53	38.1	MISSING	100.0
	TOTAL	139	100.0	100.0	

MEAN	72.616	STD ERR	0.067	MEDIAN	72.636
MODE	73.000	STD DEV	0.617	VARIANCE	0.380
KURTOSIS	-0.456	SKEWNESS	0.155	RANGE	3.000
MINIMUM	71.000	MAXIMUM	74.000		

VALID CASES 86 MISSING CASES 53

Table 2.6. Year-class frequency of blueback herring (sexes pooled) in the York River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	9	1.5	2.3	2.3
	71.	37	6.1	9.4	11.6
	72.	224	37.2	57.2	68.9
	73.	111	18.3	28.1	97.0
	74.	12	2.0	3.0	100.0
	0.	213	35.0	MISSING	100.0
	TOTAL	608	100.0	100.0	

MEAN	72.203	STD ERR	0.037	MEDIAN	72.170
MODE	72.000	STD DEV	0.740	VARIANCE	0.548
KURTOSIS	0.889	SKEWNESS	-0.228	RANGE	4.000
MINIMUM	70.000	MAXIMUM	74.000		
VALID CASES	395	MISSING CASES	213		

Table 2.7. Year-class frequency of alewife (sexes pooled) in the Pamunkey River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	1	2.1	2.3	2.3
	71.	1	2.1	2.3	4.7
	72.	21	44.7	48.8	53.5
	73.	18	38.3	41.9	95.3
	74.	2	4.3	4.7	100.0
	0.	4	8.5	MISSING	100.0
	TOTAL	47	100.0	100.0	

MEAN	72.442	STD ERR	0.112	MEDIAN	72.429
MODE	72.000	STD DEV	0.734	VARIANCE	0.538
KURTOSIS	1.456	SKEWNESS	-0.523	RANGE	4.000
MINIMUM	70.000	MAXIMUM	74.000		
VALID CASES	43	MISSING CASES	4		

Table 2.8. Year-class frequency of blueback herring (sexes pooled) in the Pamunkey River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	7	6.0	8.0	8.0
	72.	45	38.8	51.1	59.1
	73.	33	28.4	37.5	96.6
	74.	3	2.6	3.4	100.0
	0.	28	24.1	MISSING	100.0
	TOTAL	116	100.0	100.0	

MEAN	72.364	STD ERR	0.073	MEDIAN	72.322
MODE	72.000	STD DEV	0.681	VARIANCE	0.464
KURTOSIS	-0.228	SKEWNESS	0.063	RANGE	3.000
MINIMUM	71.000	MAXIMUM	74.000		
VALID CASES	88	MISSING CASES	28		

Table 2.9. Year-class frequency of alewife (sexes pooled) in the Rappahannock River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	4	0.9	1.4	1.4
	71.	25	5.8	8.7	10.1
	72.	120	27.7	41.8	51.9
	73.	125	28.9	43.6	95.5
	74.	13	3.0	4.5	100.0
	0.	146	33.7	MISSING	100.0
	TOTAL	433	100.0	100.0	

MEAN	72.411	STD ERR	0.045	MEDIAN	72.454
MODE	73.000	STD DEV	0.770	VARIANCE	0.593
KURTOSIS	0.342	SKEWNESS	-0.437	RANGE	4.000
MINIMUM	70.000	MAXIMUM	74.000		
VALID CASES	287	MISSING CASES	146		

Table 2.10. Year-class frequency of blueback herring (sexes pooled) in the Rappahannock River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	69.	1	0.1	0.1	0.1
	70.	5	0.4	0.5	0.7
	71.	187	14.0	20.5	21.2
	72.	504	37.7	55.3	76.5
	73.	202	15.1	22.2	98.7
	74.	12	0.9	1.3	100.0
	0.	426	31.9	MISSING	100.0
	TOTAL	1337	100.0	100.0	

MEAN	72.029	STD ERR	0.024	MEDIAN	72.021
MODE	72.000	STD DEV	0.715	VARIANCE	0.511
KURTOSIS	0.108	SKEWNESS	0.012	RANGE	5.000
MINIMUM	69.000	MAXIMUM	74.000		
VALID CASES	911	MISSING CASES	426		

Table 2.11. Year-class frequency of alewife (sexes pooled) in the Potomac River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	13	7.2	11.3	11.3
	72.	46	25.6	40.0	51.3
	73.	52	28.9	45.2	96.5
	74.	4	2.2	3.5	100.0
	0.	65	36.1	MISSING	100.0
	TOTAL	180	100.0	100.0	

MEAN	72.409	STD ERR	0.069	MEDIAN	72.467
MODE	73.000	STD DEV	0.736	VARIANCE	0.542
KURTOSIS	-0.478	SKEWNESS	-0.277	RANGE	3.000
MINIMUM	71.000	MAXIMUM	74.000		
VALID CASES	115	MISSING CASES	65		

Table 2.12. Year-class frequency of blueback herring (sexes pooled) in the Potomac River commercial fishery samples, 1978.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	25	2.0	3.5	3.5
	71.	181	14.2	25.5	29.1
	72.	375	29.4	52.9	81.9
	73.	126	9.9	17.8	99.7
	74.	2	0.2	0.3	100.0
	0.	568	44.5	MISSING	100.0
	TOTAL	1277	100.0	100.0	

MEAN	71.858	STD ERR	0.028	MEDIAN	71.896
MODE	72.000	STD DEV	0.752	VARIANCE	0.566
KURTOSIS	-0.122	SKEWNESS	-0.218	RANGE	4.000
MINIMUM	70.000	MAXIMUM	74.000		
VALID CASES	709	MISSING CASES	568		

Table 2.13. Summary of mean and modal [( )] age data for river herring in the Virginia commercial fishery, 1977-1978.

River	Alewife		Blueback	
	1977	1978	1977	1978
James	5.4(5)	5.5(5-6)	5.7(6)	6.3(6)
Pamunkey	5.7(5-6)	5.6(5-6)	6.0(6)	5.6(5-6)
York	5.2(5)	5.4(5-6)	5.8(6)	5.8(6)
Rappahannock	5.6(5-6)	5.6(5-6)	5.8(6)	6.0(6)
Potomac	5.5(5-6)	5.6(5-6)	6.0(6)	6.1(6)

Table 2.14. Year-class frequency of American shad in the Virginia commercial fishery, 1978.

Sex	Year Class	River					Total	Frequency (%)
		James	York	Pamunkey	Rapp.	Potomac		
Male	1970	0	0	0	1	0	1	0.5
	1971	0	5	2	6		13	6.9
	1972	26	34	17	24	1	102	54.2
	1973	12	35	9	11	1	68	36.2
	1974	1	0	1	1	0	3	1.6
	1975	0	0	1	0	0	1	0.5
	Total	39	74	30	43	2	188	
Female	1971	8	9	12	12	1	42	7.3
	1972	60	123	101	102	3	389	67.9
	1973	29	39	36	34	0	138	24.1
	1974	2	1	0	1	0	4	0.7
	Total	99	172	149	149	4	573	

Table 2.15. Mean fork length (mm) and total body weight (g) of river herring in the 1977 and 1978 Virginia commercial fishery.

River		Alewife				Blueback			
		Male		Female		Male		Female	
		1977	1978	1977	1978	1977	1978	1977	1978
James	Length	245.2	249.2	256.2	258.8	243.5	252.6	253.7	263.1
	Weight	190.0	225.7	230.6	250.0	178.3	217.5	206.4	250.1
Pamunkey	Length	243.8	249.6	254.9	260.0	241.9	248.8	252.6	256.7
	Weight	212.5	218.6	246.7	253.9	186.8	210.1	229.7	235.0
York	Length	240.8	248.1	255.3	253.2	241.0	247.3	251.9	256.1
	Weight	207.1	216.0	257.6	235.7	166.2	196.4	187.4	225.4
Rappahannock	Length	243.4	249.9	253.4	261.9	240.9	250.9	251.1	258.8
	Weight	186.8	227.8	217.3	267.4	168.1	192.1	192.6	223.6
Potomac	Length	243.9	250.9	253.8	258.2	242.5	254.4	253.4	261.9
	Weight	198.3	232.5	228.1	263.5	175.5	204.2	205.0	221.9
Unweighted grand mean	Length	243.4	249.5	254.8	258.4	242.0	250.8	252.5	259.3
	Weight	198.9	223.9	236.1	254.1	175.0	204.0	204.2	231.2
Grand mean increases	Length	6.1		3.6		8.8		6.8	
	Weight	25.0		18.0		29.0		27.0	

Table 2.16. Sex ratios of river herring in the 1977 and 1978 Virginia river herring fishery.

River	Species	Ratio of males to females 1977	1978
James	Alewife	2.4:1*	2.1:1*
	Blueback	1.7:1*	1.6:1*
York	Alewife	1.:1.2 NS	1.2:1 NS
	Blueback	1.4:1*	1.1:1 NS+
Pamunkey	Alewife	2.7:1*	1.6:1 NS+
	Blueback	1.7:1 NS	1:1 NS
Rappahannock	Alewife	1.4:1*	1.4:1*
	Blueback	1.3:1*	1:1.2*+
Potomac	Alewife	1:1.1 NS	1:1.1 NS
	Blueback	1:1.0 NS	1:1.4*+

* x^2 significant ($\alpha<0.05$); Hypothesis tested: equal sex ratio
+ Increased representation of females in 1978
NS = nonsignificance

Table 2.17. Age and spawning frequency of blueback herring and alewife from the area of Albemarle Sound, NC. Data are combined from all sample sites, 1978 (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
II												
III	20	1									20	1
IV	177	112	3	1							180	113
V	79	78	59	58	5						143	136
VI	4	4	8	5	11	11					23	20
VII						4	3	6			3	10
Total	280	195	70	64	16	15	3	6			369	280
Percent	76	70	19	23	4	5	1	2				
Percent Sexes Combined	73		21		5		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
II												
III	21	9									21	9
IV	259	152	4	3							263	155
V	25	31	65	58	2						92	89
VI	1		2	2	20	15					23	17
VII							1	6			1	6
VIII										3		3
Total	306	192	71	63	22	15	1	6		3	400	279
Percent	77	69	18	23	6	5	<1	2		1		
Percent Sexes Combined	73		20		5		1			<1		

Table 2.18. Age and spawning frequency of blueback herring and alewife from the Scuppernong River pound net fishery for 1978 (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	8										8	0
IV	34	12									34	12
V	28	19	7	3	2						37	22
VI	2	3	2	1	2						6	4
VII						1		1			0	2
Total	72	34	9	4	4	1		1			85	40
Percent	85	85	11	10	5	3		3				
Percent Sexes Combined	85		10		4			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	1	3									1	3
IV	6	4									6	4
V	1										1	0
VI												
Total	8	7									8	7
Percent	100	100										
Percent Sexes Combined	100											

Table 2.19. Age and spawning frequency of blueback herring and alewife for the haul seine fishery on Meherrin River for 1978 (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	7										7	0
IV	97	69	2	1							99	70
V	11	17	32	42	1						44	59
VI			1	2	5	6					6	8
VII						1	2	3			2	4
VIII												
Total	115	86	35	45	6	7	2	3			158	141
Percent	73	61	22	32	4	5	1	2				
Percent Sexes Combined	67		27		4		2					

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	7	2									7	2
IV	103	81									103	81
V	16	15	28	21							44	36
VI			2		8	7					10	7
VII											0	0
VIII										3	0	3
Total	126	98	30	21	8	7				3	164	129
Percent	77	76	18	16	5	5						
Percent Sexes Combined	77		17		5							

Table 2.20. Age and spawning frequency of blueback herring and alewife from the pound net fishery in the Chowan River for 1978 (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	5	1									5	1
IV	46	31	1								47	31
V	40	42	20	13	2						62	55
VI	2	1	5	2	4	5					11	8
VII						2	1	2			1	4
VIII												
Total	93	75	26	15	6	7	1	2			126	99
Percent	74	76	21	15	5	7	.8	2				
Percent Sexes Combined	75		18		6		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	9	3									9	3
IV	94	33	3	3							97	36
V	5	4	8	9	2						15	13
VI				2	4	2					4	4
VII								1			0	1
VIII												
Total	108	40	11	14	6	2	0	1			125	57
Percent	86	70	9	25	5	4		2				
Percent Sexes Combined	81		14		4		<1					

Table 2.21. Age and spawning frequency of alewife from the pound net fishery in Alligator River for 1978 (M = male, F = female).

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	1									4	1
IV	56	34	1								57	34
V	3	12	29	28							32	40
VI	1				8	6					9	6
VII							1	5			1	5
VIII												
Total	64	47	30	28	8	6	1	5			103	86
Percent	62	55	29	33	8	7	1	6				
Percent Sexes Combined	59		31		7		3					

Table 2.22. Age and spawning frequency for American shad and hickory shad from Albemarle Sound for 1978 (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	3										3	0
IV	53	9	1								54	9
V	180	109	8	1							188	110
VI	30	71	9	7							39	78
VII		5		3	1						8	1
VIII												
Total	266	194	18	11	1						292	198
Percent	91	98	6	5	.34							
Percent Sexes Combined	94		6		<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	15	17									15	17
IV	11	30	6	2							17	32
V		32		24	1	3					1	59
VI		1		6	1	17					1	24
VII												
VIII												
Total	26	80	6	32	2	20					34	132
Percent	76	61	18	24	6	15						
Percent Sexes Combined	64		23		13							

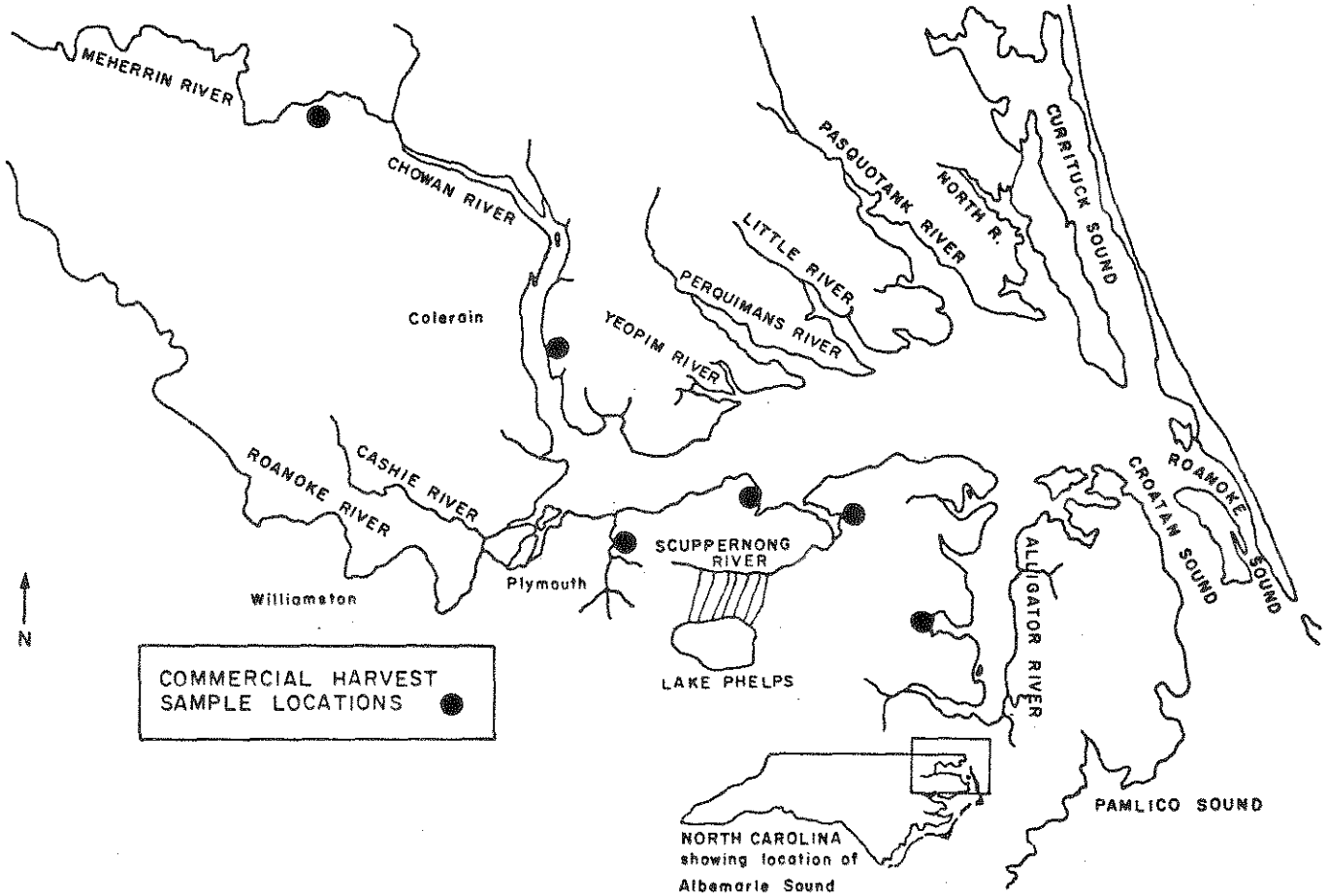

Figure 2.1. Location of Albemarle Sound commercial harvest sampling sites.

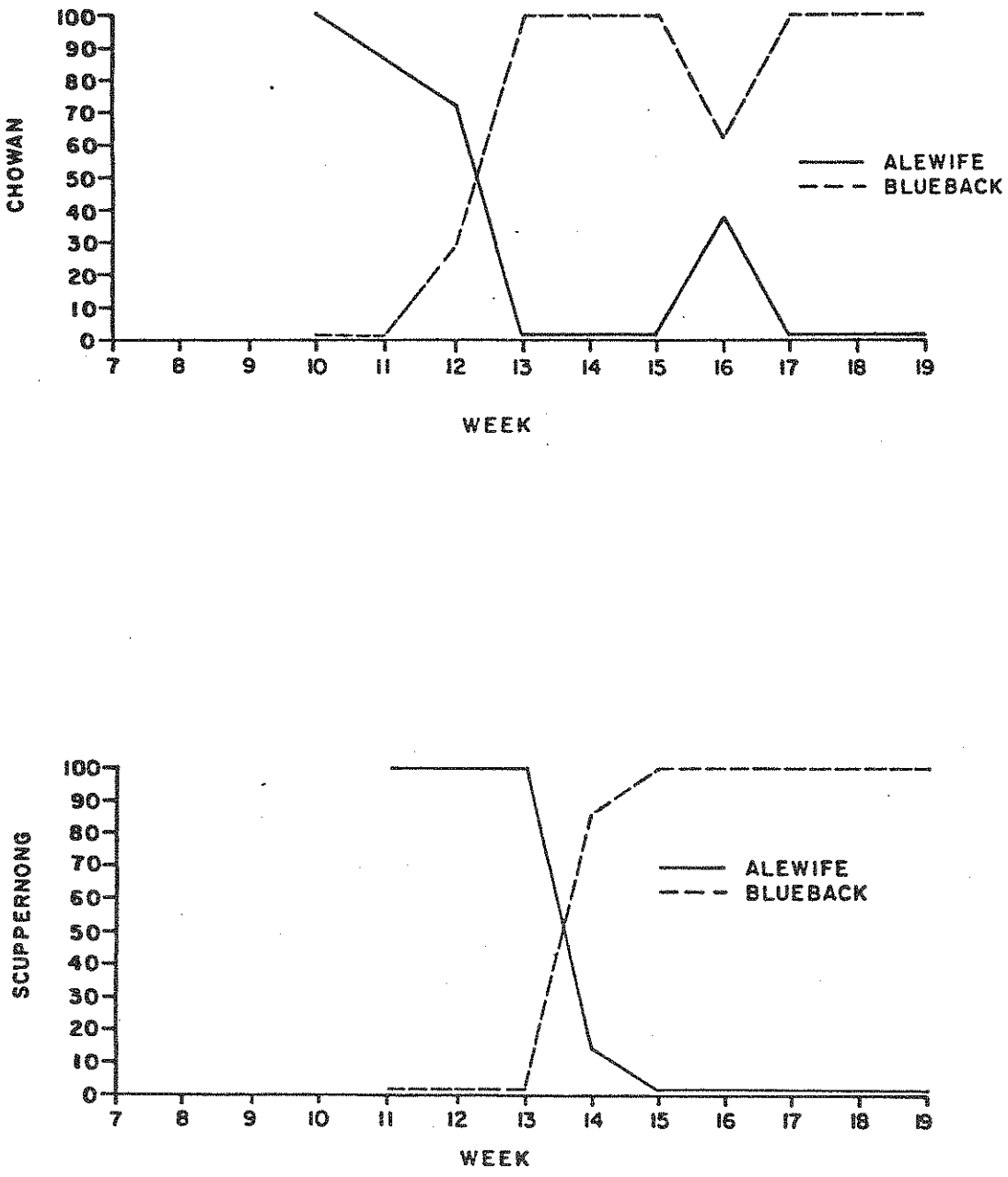

Figure 2.2. Weekly species composition of the 1978 samples from the Scuppernong River pound net fishery and the Chowan River pound net fishery.

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.

In addition to pursuing the above objectives, VIMS continued its pilot testing of the effect of light attenuation on sample catches. The amount of light entering the sea and subsequently attenuated (reduced in intensity) is a function of sky condition, sun angle, sea surface state and clarity of the water. In part, for fish that exhibit phototaxis, these variables will determine the fishes' position in the water column and, thus, their availability to sampling gear in a static sampling scheme.

MATERIALS AND METHODS

Virginia

To minimize the effect of light attenuation, all sampling was conducted at night. Also, no samples were collected when the sea surface was rough and presumed to effect the availability of fishes in the uppermost part of the water column ($\leq$ 1.5 m).

The R/V Langley, the R/V Restless, and two outboard vessels, 5.8 m and 4.9 m, were used with standardized 5 minute samples to collect

Job 3. Annual Index of Alosine Juvenile Abundance

SUMMARY

Virginia

1. The volume of water sampled by several gear employed was calculated and all catches adjusted to a standard push net sample (896 m^3).

2. The alewife index of abundance ($\overline{c/f}$, the weighted mean catch per unit of effort) was greatest in the Mattaponi and Rappahannock nursery zones, but the standing crop estimate ($\hat{N}$) was highest in the James River, due, in part, to its large nursery zone. Blueback herring $\overline{c/f}$ was greatest in the Chickahominy River while N was highest in the Potomac River, again, by virtue of its large nursery zone. Both $\overline{c/f}$ and N for American shad were superior in the Mattaponi River. Striped bass $\overline{c/f}$ estimates were consistent relative to those for the alosine species, but the overall $\overline{c/f}$ and N were the lowest of the target species.

3. Day-night comparison sampling in 1977 and 1978 indicate that the alosine juveniles exhibit a negative phototaxis. One important implication of this behavior is that estimates of abundance may be very erroneous if the effect of light attenuation at the time of sampling is not considered. In 1978, we reduced, but did not eliminate, the effect of light attenuation by night sampling.

North Carolina

1. Nursery areas for alewife and blueback herring were again determined and mapped for the Albemarle Sound area.

2. A total of 17,339 juvenile alosine fish was captured during sampling.

3. The annual index of alosine juvenile abundance for 1978 was greater than that for 1974, 1975, 1976, but less than 1977.

juvenile alosines and striped bass. The R/V Langley employed a 9.1 m semi-balloon lined bottom trawl which filtered, on the average, 1,659 m^3 of water; the RV Restless employed a 1.5 m x 1.5 m Cobb trawl which filtered 971 m^3 of water; the 5.8 m outboard vessel had a bow-mounted 1.5 m x 1.5 m framed net developed by VIMS personnel (referred to as a push net) which filtered 896 m^3 of water; and the 4.9 m outboard vessel employed a 4.9 m two panel trawl which filtered 877 m^3 of water. All catch data were adjusted relative to the push net catches on the basis of water volume strained.

A stratified random sampling plan with proportional allocation of effort was employed. The nursery areas (Fig. 3.1) in each river were divided into 9.3 km strata. Each stratum was further divided into five 1.9 km substrata. Perpendicular to this stratification, the 9.3 km sections were divided into three nearly equal parts, a center section and two shoreward sections bounded by the 1.8 m depth contour lines (MLW) indicated on the respective navigation charts. Thus, each 9.3 km stratum was partitioned into 15 "cells." Allocation of effort was a function of the surface areas of the stratum with a minimum restriction of five replications per stratum, one in a randomly chosen cell in each substratum. Above the minimum, effort increased in multiples of five with all replication in the randomly chosen cell of each substratum. On each side of the river, shoreward of the 1.8 m depth contour, the definition of substratum resulted in 10 cells, five for each shore area. These sites were sampled with the 4.9 m trawl which virtually swept the entire water column. Effort was that

allocated for the surface and mid-water samples; and cell location, i.e., shore side of a substratum, was randomly decided. The 9.1 m bottom trawl was fished from the R/V Langley in the deep navigation channels with one replication per substratum (one per 1.9 km).

Preliminary boundaries of each nursery zone were established on the basis of past experience, salinity readings, and pilot sampling; upper and lower "buffer" river sections were included. After completion of the surveys, juvenile catch data were examined and nursery zone boundaries determined for each species. Proceeding upriver, the lower boundary was defined as the lower limit of the stratum of first catch; the upper boundary was the upper limit of the stratum of last catch.

The volumes of water in nursery zone strata at high and low tide (Cronin 1971) were averaged and the catch-per-unit-of-effort (c/f) in each stratum was weighted by its respective mean water volume. A weighted mean index of abundance ($\overline{c/f}$) for each nursery zone was then determined as the sum of the weighted $\overline{c/f}$ divided by the sum of the strata weights (volume). Standing crop ($\hat{N}$) was then determined as:

$$\hat{N} = \frac{V}{v} \cdot \overline{c/f}$$

where V = water volume of the nursery zone; and v = water volume strained in a standardized sample (896 m^3 water).

Pilot testing of the effects of light attenuation on catch indicies was continued by sampling with the push net at night and two successive days which were overcast and clear, respectively.

North Carolina

In North Carolina approximately 60 stations were sampled monthly with seine or trawl nets from June through December, 1978. 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.

RESULTS AND DISCUSSION

Virginia

Abundance

Catch-effort statistics are presented in Table 3.1. The weighted mean catch-per-unit-of-effort ($\overline{c/f}$) for alewives in the Mattaponi and Rappahannock nursery zones was about two or more times the $\overline{c/f}$ in the others rivers. Standing crop ($\hat{N}$), however, was greatest in the James River due, in part, to its large nursery zone.

Blueback herring $\overline{c/f}$ and $\hat{N}$ (with one exception) exceeded those estimates for all the other target species. The $\overline{c/f}$ was greatest in the Chickahominy River while $\hat{N}$ was largest in the Potomac River, again, by virtue of its large nursery zone.

As in 1977 (Loesch et al. 1977), American shad $\overline{c/f}$ and $\hat{N}$ were greatest in the Mattaponi.

Striped bass $\overline{c/f}$ estimates were relatively consistent in comparison to those for the alosine species, but the overall $\overline{c/f}$ and $\hat{N}$ were the lowest of the target species.

The relative abundance in descending rank order of the four species of concern are: blueback herring (97.7%), alewife (1.9%), American shad (0.3%), and striped bass (0.1%). It is reasonable to assume from the above statistics that blueback herring young-of-the-year are more abundant than the other three species. However, the magnitude of the differences are probably exaggerated. For example, consider the river herring (alewife and blueback); alewife juveniles were only 1.91% of the river herring collected. However, Loesch and Kriete (1976) reported that alewives constituted about 37% of the commercial catch of adult river herring in the years 1974 through 1976; in 1977 and 1978 alewives were about 28% and 21% of the commercial river herring catch, respectively (Table 2.1). The apparent paradox between the two species juvenile and adult ratios suggests that alewife juveniles, and perhaps those of the American shad and striped bass, are not as available to the sampling gear as are blueback herring. Differences in species catchability may be related, in part, to species specific phototactic responses. This subject and some implications are discussed below.

Effects of Light Attenuation on Catch Indices

Data from 90 paired surface and bottom tows in 1977 indicated a greater concentration of alosine juveniles in bottom water during daylight hours and, conversely, a greater density in surface waters at night (Loesch et al. 1977). The data are now adjusted for the volume of water strained (Table 3.2) but the conclusion is unchanged, i.e., juvenile alosines exhibit a diel periodicity.

In 1978, the pilot study of the effects of light on $\overline{c/f}$ was continued. Twenty push net samples were taken in each of three successive sampling periods with varying light conditions (night, overcast day, and clear day). The data (Table 3.3) for blueback herring, the most abundant species in the surface samples, indicate a negative phototaxis behavior in addition to the previously demonstrated diel periodicity.

The implication of the two pilot studies is that estimates of abundance may be very erroneous if the effect of light attenuation is not considered. Parrish, Blaxter and Hall (1964) reported that the vertical distribution of fishes in relation to light intensity is often the most dominant factor affecting catches with a given gear. By night sampling we have reduced but not eliminated the effect of light. It is our intent in the future to determine, by employment of a underwater photometer, a corrective model for adjusting catches at variable light intensities to a baseline intensity.

Another implication of our research is that estimating standing crop (N) is an exercise in futility. To obtain a reliable estimate of N it would be necessary to know the vertical density distribution in the water column of each species for each significant change in ambient light. It would also be necessary to know the volume of water present in the area (substratum) sampled at the existing tide level. The choice of mean water volume (this report) or high or low water volumes is arbitrary, and each results in a different estimate of $\hat{N}$. Because of the arbitrary choice of water volume, estimates of $\hat{N}$ are but an index of abundance and, thus, redundant with $\overline{c/f}$; the latter statistic only will be used in the future. Elimination of $\hat{N}$ estimates will result in a reduction in sampling effort which can be confined to a limited area in each nursery zone. VIMS historical catch data are detailed and readily adapted to the proposed future format.

North Carolina

From October 1977 to September 1978, a total of 17,339 juvenile anadromous fishes was captured in 451 samples. The main purpose of sampling was to determine the relative abundance of the 1978 year class. Numbers of samples taken by each sampling gear are shown in Table 3.4. Since relatively few American shad, hickory shad and Atlantic sturgeon were taken during 1978 (21, 12 and 0 respectively), these species will not be considered further in the discussion of juveniles.

As in 1977, the wing trawl was the most effective gear for the capture of juvenile blueback herring during the 1978 sampling period (Fig. 3.2).

The wing trawl, as during projects AFCS-8 and AFCS-11 proved to be most effective in the capture of juvenile alewife for the 1978 sampling period (Fig. 3.3).

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-9 again were found to be very productive for young anadromous fishes. Nursery areas are shown in Figure 3.4. As stated by Street et al. (1975), those areas identified as nursery areas are vitally important for the maintenance of blueback herring and alewife populations and should remain unaltered and in their natural state and protected from pollution.

Growth

During this project segment, the 1978 year classes of blueback herring and alewife were followed from June through December and measured for growth. Figure 3.5 shows the mean fork length of juvenile blueback herring and alewife for each month of sampling. These data show slight increases in growth over those reported by Johnson et al. (1977), and comparable to Street et al. (1975).

Movement

Movement of the 1978 year class 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 seven year classes (1972-1978) 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 December, 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 the years 1972-1977. This trend was continued in 1978 (Fig. 3.6).

As shown in Figure 3.6 year class strength for blueback herring in 1978 was less than reported by Johnson et al. in 1977, while 1978 alewife abundance increased slightly over 1977.

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Table 3.1 Juvenile alosine and striped bass catch-effort statistics, 1978.

Species	River	Nursery zone (miles)	Effort (no. tows)	Nursery zone ($10^6 m^3$)	Mean catch (c/f)	Standing crop (in millions)
Alewife	James	35-84	235	518.29	2.45	1.42
	Chickahominy	0-19	71	56.02	5.16	0.32
	Pamunkey	35-65	103	86.31	4.91	0.47
	Mattaponi	35-61	89	47.40	15.09	0.80
	Rappahannock	45-90	166	156.90	17.36	3.04
	Potomac	60-95	232	854.96	7.64	7.29
					All rivers:	13.34
Blueback	James	35-84	235	518.29	388.71	224.85
	Chickahominy	0-19	71	56.02	612.80	38.31
	Pamunkey	35-70	106	87.75	258.73	25.34
	Mattaponi	35-61	89	47.40	64.82	3.43
	Rappahannock	45-90	166	156.90	369.30	64.67
	Potomac	60-95	232	854.96	339.99	324.42
					All rivers:	681.02
American shad	James	40-84	215	382.58	1.17	0.50
	Chickahominy	0-15	55	50.10	0.11	0.01
	Pamunkey	35-70	106	87.75	4.90	0.48
	Mattaponi	35-61	89	47.40	22.44	1.19
	Rappahannock	60-90	108	73.42	0.11	0.01
	Potomac	60-65	43	195.42	0.02	<0.01*
					All rivers:	2.19

Table 3.1. (continued)

Species	River	Nursery zone (miles)	Effort (no. tows)	Nursery zone ($10^6 m^3$)	Mean catch (c/f)	Standing crop (in millions)
Striped bass	James	35-80	228	513.33	0.38	0.22
	Chickahominy	0-15	55	50.10	0.29	0.02
	Pamunkey	35-65	103	86.31	0.45	0.04
	Mattaponi	35-50	60	39.56	0.50	0.02
	Rappahannock	45-80	129	144.96	0.44	0.07
	Potomac	60-95	232	854.96	0.56	0.53
					All rivers:	0.90

* Standing crop = 0.004

Table 3.2 Alosine juvenile catch statistics for 90 paired surface and bottom trawls in the Mattaponi River in September, 1977. Catch data have been adjusted to a standard volume of water strained.

Date	Trawl type	No. of tows		Mean c/f	
		Day	Night	Day	Night
26 Sep.	Bottom	14	12	61.4	0.7
	Surface	14	12	3.4	85.4
27 Sep.	Bottom	22	12	46.9	0.5
	Surface	22	12	1.6	105.2
28 Sep.	Bottom	20	10	18.0	1.4
	Surface	20	10	2.8	155.5

Table 3.3. Push net catch of blueback in three successive sampling periods with varying light conditions. The collections were made in the James River in October, 1978.

Date	Light condition	No. of samples	Mean c/f
18 Oct.	Night	20	1,189.3
19 Oct.	Day (overcast)	20	836.5
20 Oct.	Day (clear)	20	385.6

Table 3.4. Number of samples and catch of juvenile alosines by trawl and seine, 1978.

	Trawl	Seine
	1978	1978
No. of Samples	296	155
Blueback herring	6,151	5,495
Alewife	4,984	676
American shad	8	13
Hickory shad	2	10
Atlantic sturgeon	0	0
Total	11,145	6,194

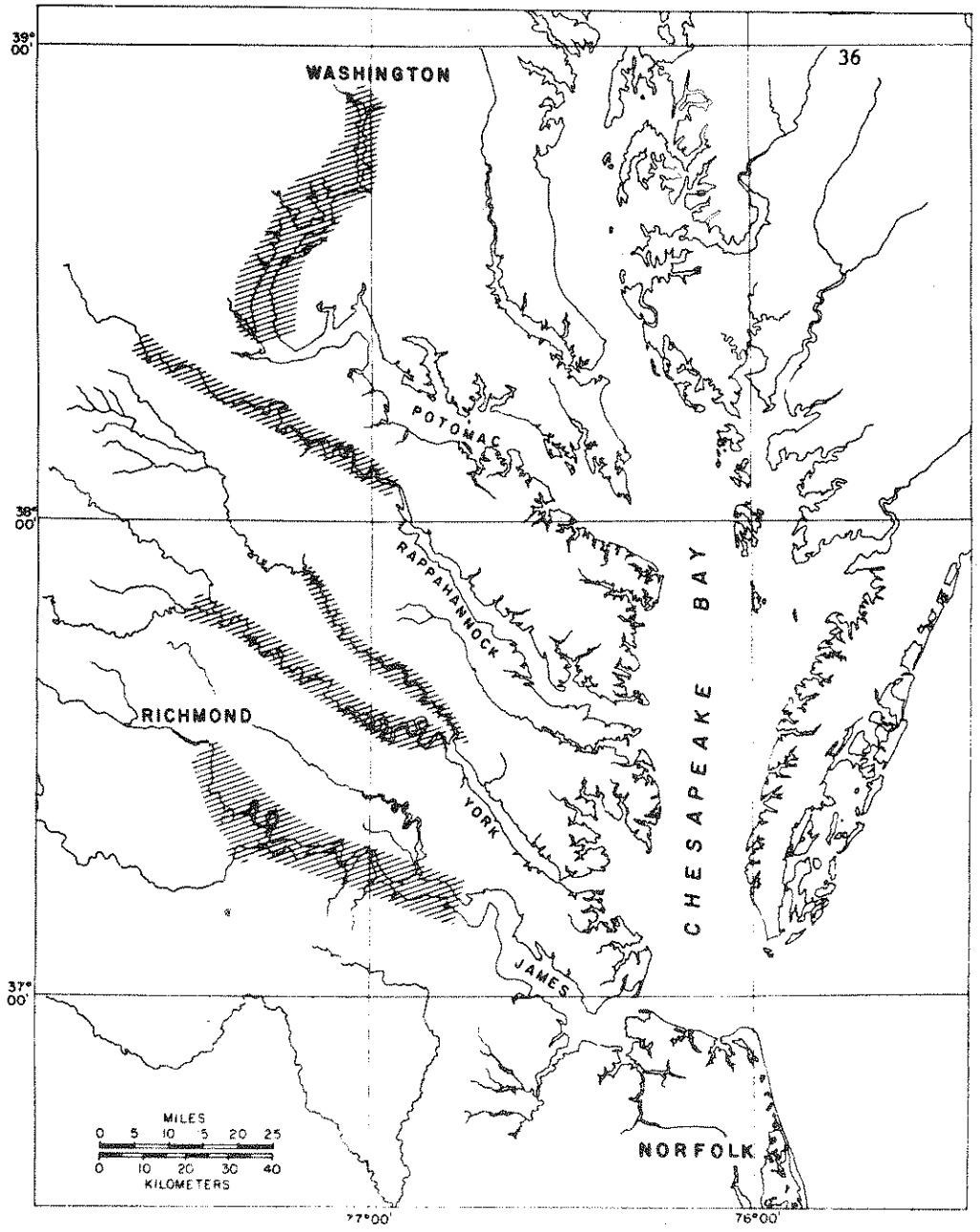

Figure 3.1. Lower Chesapeake Bay and tributaries with major freshwater nursery zones shaded.

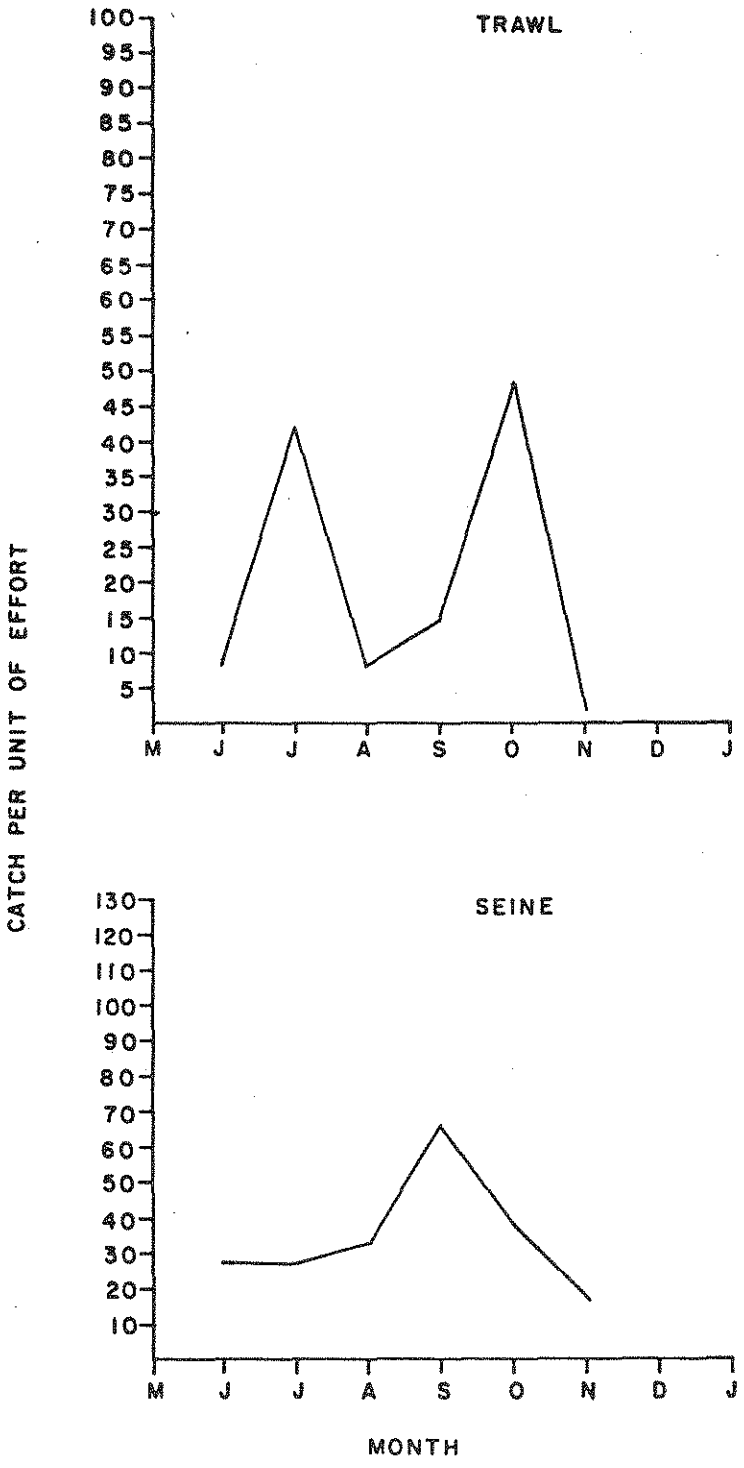

Figure 3.2. Monthly catch-per-unit-of-effort for blueback herring by trawl and seine in 1978.

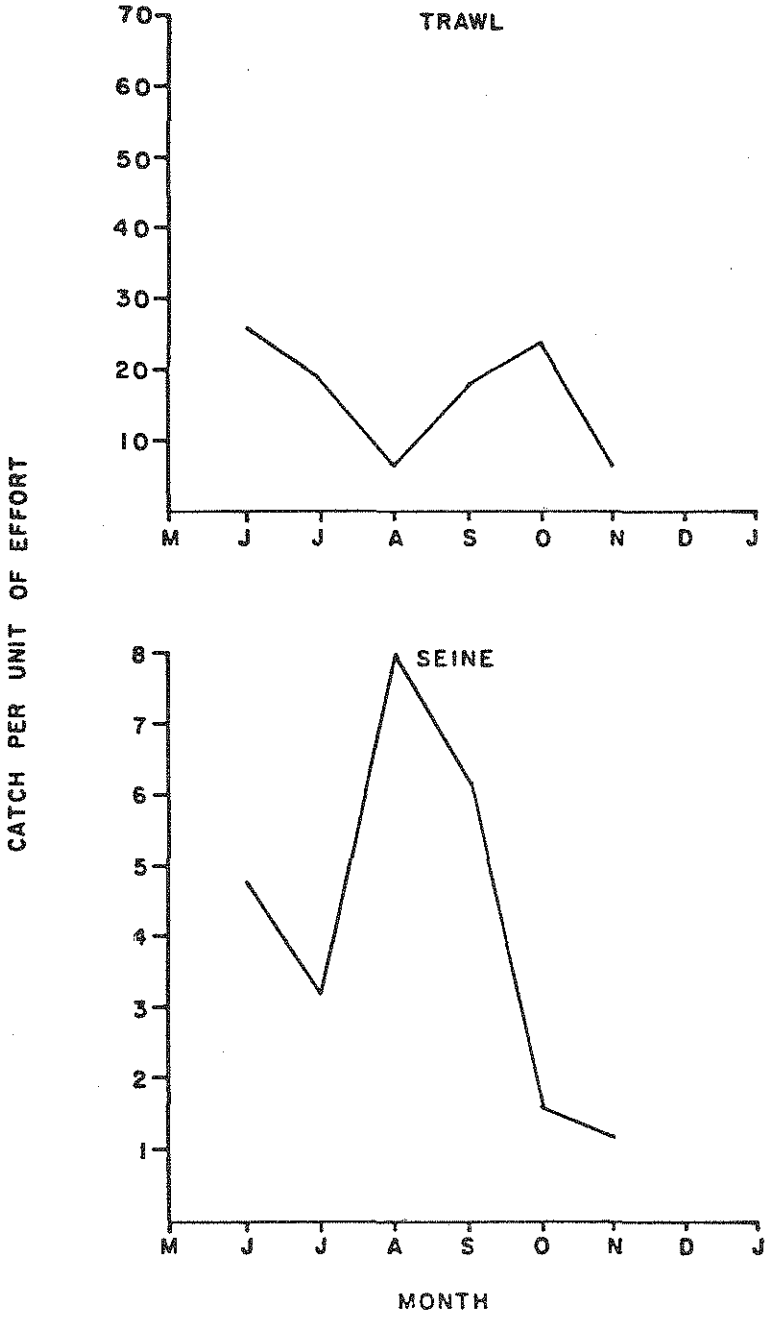

Figure 3.3. Monthly catch-per-unit-of-effort for alewife by trawl and seine in 1978.

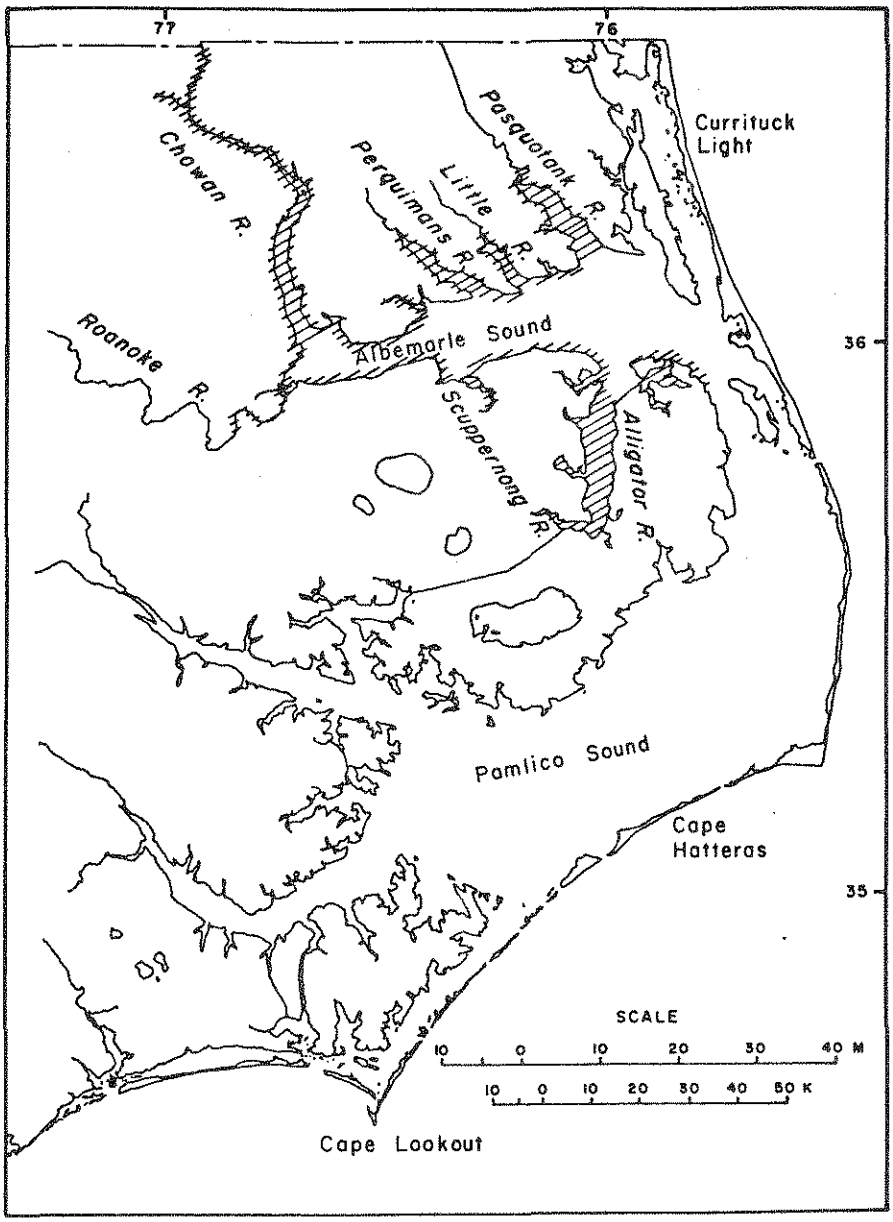

Figure 3.4. Nursery areas of blueback herring and alewife in Albemarle Sound and tributaries.

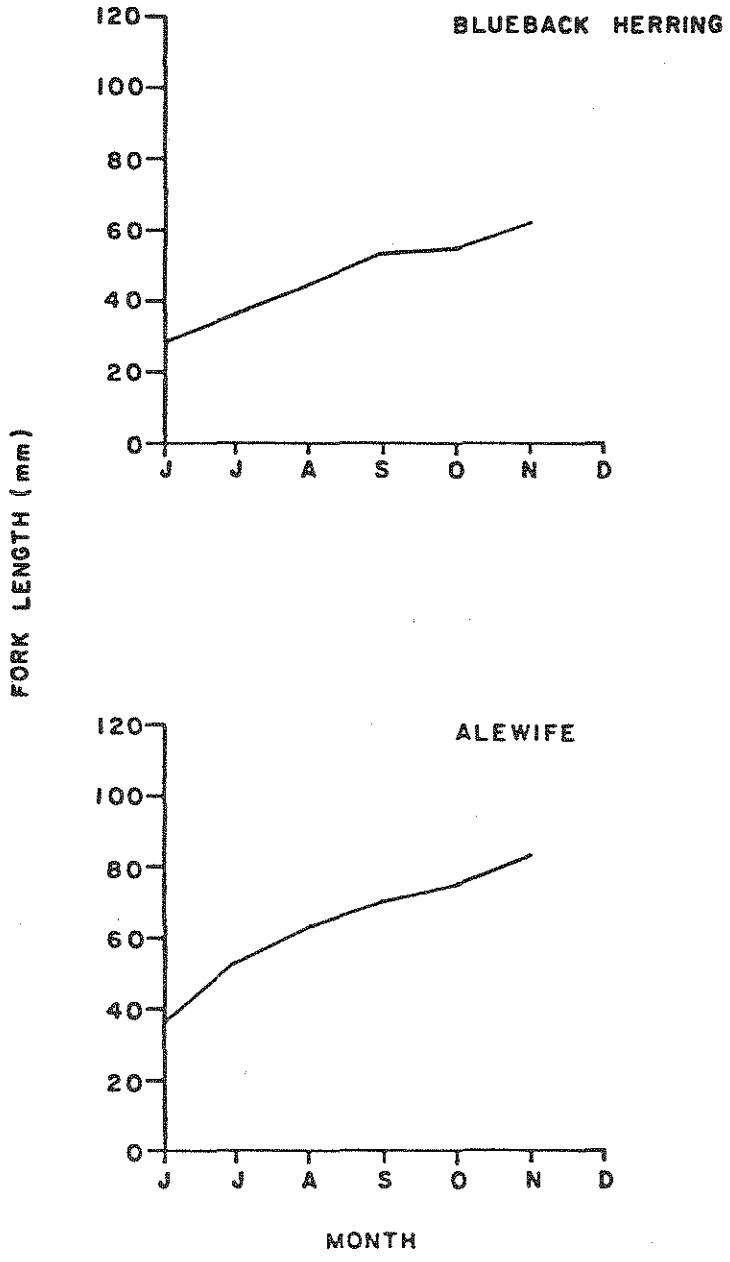

Figure 3.5. Mean fork length of alewife and blueback herring by month for 1978.

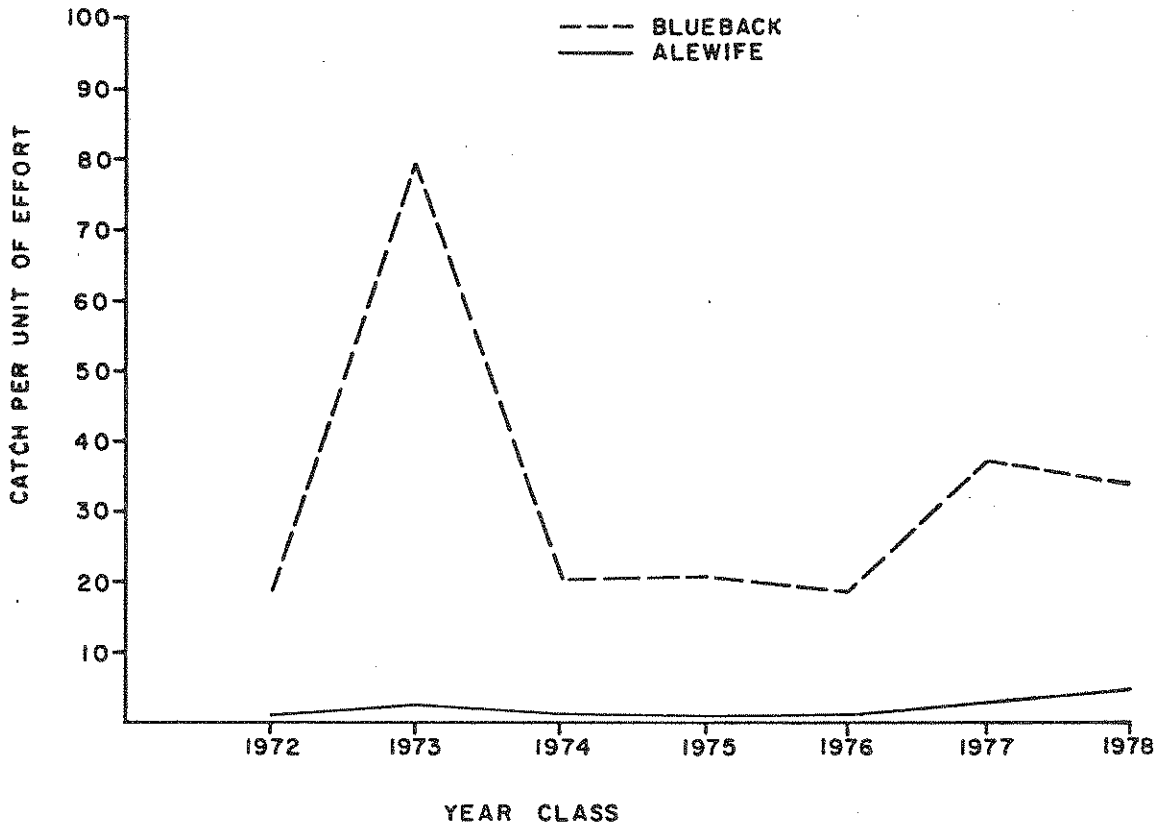

Figure 3.6. Catch-per-unit-of-effort for blueback herring and alewife year classes 1972 through 1978 by seine net.

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

SUMMARY

1. Drift gill nets yielded an estimated 6,775 kg of American shad on the Pamunkey River and 2,989 kg of American shad on the Mattaponi River in 1978.

2. Drift gill nets on the Potomac River caught 5,119 kg of American shad in 1978.

3. Dip net fishermen at Richmond, Virginia had landed 30-80 blueback per fisherman during a dip net site visit.

4. Dip net fishermen at Herring Creek on the James River averaged 400 blueback per fisherman during dip net site visits.

5. Interviews with dip net fishermen on the Pamunkey and Mattaponi rivers indicated that fishermen averaged 9-36 kg of river herring per fishing trip.

6. The spawning run lasted 54 days at Herring Creek on the James River during which time 394 blueback and 32 alewife were collected.

7. Upstream ratios of males to females for blueback at Herring Creek on the spawning run was 18:1 while downstream the ratio was 3:1.

8. Modal age for male bluebacks was age 6. Ages 6 and 7 were codominant for females.

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

INTRODUCTION

Drift gill nets have been used in the American shad fishery in Virginia since the early 1800's. In 1896, 264,301 m of drift gill net landed 1,380,512 kg of American shad (Walburg and Nichols 1967). By 1960 drift gill nets had decreased to 82,992 m and the catch by drift gill nets had decreased proportionately to 139,667 kg.

All major river systems in Virginia have supported active drift net shad fisheries. Walburg and Nichols (1967) reported that as late as 1960, 7,681 m, 2,012 m, and 4,298 m of net were fished on the Chickahominy, Appomattox and Rappahannock rivers, respectively. Today there are no known active drift gill net fisheries on these rivers, weekend or part-time fishermen excluded. The remaining river systems have limited drift gill net fisheries of approximately 37,000 m of netting (Loesch et al. 1977).

As per Walburg and Nichols (1967) in 1896 dip nets yielded 0.2 million kg of American shad from Georgia to Pennsylvania; by 1960, only three states, Georgia, South Carolina and North Carolina still had dip net fisheries. However, no dip net fisheries for American shad were reported in Virginia for 1896 or 1960.

Dip nets are employed in the recreational fishery for river herring in Virginia, mostly in the small creeks which are utilized as spawning areas.

This pilot study documents the extent of the drift gill net and dip net fisheries for alosines and estimates total landings by each gear.

MATERIALS AND METHODS

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

An index of kg/m of netting for male and female American shad was obtained by dividing the number of kilograms of shad landed by sex by the number of meters of netting utilized by cooperating fishermen. The index was then multiplied by the number of meters of netting fished for half month periods to obtain estimated landings. Drift gill net records for the Potomac River were obtained from the Potomac River Fisheries Commission.

Total effort for drift gill nets was undetermined because licenses for drift and anchor gill nets are issued under a single combined license in Virginia.

Age composition and sex ratio were determined as in Job 2, of this report.

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 1978 drift gill net fishery for American shad was only active during the month of April for full-time fishermen, except on the Potomac River where it lasted through May.

No records were obtained from drift net fishermen on the James River.

There were six full-time and eleven part-time drift net fishermen on the Pamunkey River and four full-time and seven part-time drift net fishermen on the Mattaponi River.

Net mesh sizes ranged from 12.7 cm to 14 cm (stretched mesh), and nets averaged 137 m in length.

Full-time fishermen on the Pamunkey River landed an estimated 4,957 kg of American shad in 1978, and part-time fishermen landed an estimated 1,818 kg of shad during the same period (Table 4.1).

Full-time and part-time fishermen on the Mattaponi River landed an estimated 2,215 kg and 774 kg, respectively, of American shad in 1978 (Table 4.1).

Although the total landings for 1978 are far below landings for 1977, no direct comparison can be made because no drift gill net records were obtained in 1977.

Drift gill nets on the Potomac River yielded 5,119 kg of American shad in 1978 compared to 3,055 kg in 1977 (Loesch et al. 1977). All of the landings were reported by Virginia fishermen (Table 1.11). Peak landings occurred during May, one month later than peak landings in the Pamunkey and Mattaponi rivers.

Two hundred American shad were sampled from drift gill nets on the Pamunkey River. The 1972 year class was dominant, representing 66% of the fish samples (Table 4.2). Due to the selective nature of gill netting, 83% of fish samples and 86% of the 1972 year class were females.

Dip Nets

Interviews with dip net fishermen indicated mixed results concerning the magnitude and duration of the river herring spawning run.

Two dipping sites on the James River were visited in April 1978, one at Richmond, Virginia, and one on Herring Creek. There were six fishermen at the Richmond site and each fisherman had landed 30-80

fish. All fish observed were blueback. Interviews at this site indicated the run had just begun a few days earlier. Fourteen fishermen at the Herring Creek site averaged 400 blueback per fisherman on the day the site was visited. No alewife were observed.

One site on the Pamunkey River, Totopotomy Creek, and one site on the Mattaponi River, Walkerton Branch, were visited twice in May 1978. Interviews at the Totopotomy Creek site indicated that 15-20 fishermen averaged 36 kg per fisherman on the first visit and 8-10 fishermen averaged 20 kg per fisherman on the second visit. Interviews at the Walkerton Branch site indicated 4-5 fishermen averaged 15 kg per fisherman on the first visit and 3-4 fishermen averaged 9 kg per fisherman on the second visit. Species were undetermined at both sites. Interviewed fishermen indicated that it was generally a good year for the Totopotomy Creek site and a bad year at the Walkerton Branch site.

A telephone interview with a dip net fisherman at Mill Creek on the Rappahannock River revealed that several pick-up trucks had been loaded with river herring at different times during the dipping season.

Most of the fish landed were being salted, pickled, or used for fertilizer for home gardens after having been cut for the roe.

Other trips to contact dip net fishermen during the dipping season proved unsuccessful and additional trips were canceled because of the expense of the trips and prior negative results.

Herring Creek: Biology and Dynamics

Project personnel regularly sampled Herring Creek on the James River system to determine the population structure and utilization of the spawning ground by river herring. Fyke nets were set at a downstream site about 5.5 km from the mouth of the creek. A trap net was also set further upstream approximately 0.7 km above the fall line.

The migration of the adult herring lasted 54 days (March 21-May 13) and 394 blueback and 32 alewife were collected. The small number of alewife is indicative of the spatial separation of the spawning grounds of the two species of river herring. There was no analysis of alewife age and sex data because of the paucity of samples.

Only one spawning wave was observed during the season, with a peak catch of 104 blueback occurring on April 27. Throughout the sampling period male blueback were significantly more abundant than females. At the upstream collection site the ratio of males to females reached 18:1 during the peak of the spawning run. Downstream, sex ratios averaged 3:1, compared to 1.8:1 for the James River.

Age composition was derived from scale analysis. The modal age for blueback males was age 6, but the data indicated a co-dominance of

ages 6 and 7 for females (Table 4.3). The modal age for blueback from James River was likewise, age 6; however, no co-dominance of ages 6 and 7 was observed in females.

The overall unweighted mean fork length and mean weight for male and female blueback were 244 mm and 182.3 g, and 254 mm and 202.3 g, respectively. Average gonad weight was 15.0 g for males and 22.7 g for females.

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Table 4.1. Estimated catch in kg, of American shad by drift gill nets in the Pamunkey and Mattaponi rivers 1978 by half-month intervals and by sex. Index in kg/m of net.

	River	Meters of Net	Female Index	Female Estimated Catch	Male Index	Male Estimated Catch	Estimated Total Catch
Full-time Fishermen							
April 1st	Pamunkey	2,743	1.2648	3,469	.2451	672	4,141
	Mattaponi	1,829	.8474	1,550	.1642	300	1,850
April 2nd	Pamunkey	2,743	.2779	762	.0197	54	816
	Mattaponi	1,829	.1862	341	.0132	24	365
				6,122		1,050	7,172
Part-time Fishermen							
April 1st	Pamunkey	3,014	.4219	1,272	.0818	247	1,519
	Mattaponi	1,918	.2827	542	.0548	105	647
April 2nd	Pamunkey	3,014	.0927	279	.0066	20	299
	Mattaponi	1,918	.0621	119	.0044	8	127
				2,212		380	2,592

Table 4.2. Total number of American shad sampled from drift gill nets on the Pamunkey River by sex and yearclass.

		YRCLASS					
	COUNT / ROW PCT / COL PCT / TOT PCT	71.	72.	73.	74.	75.	ROW TOTAL
SEX							
	1.	2	17	9	1	1	30
MALE		6.7	56.7	30.0	3.3	3.3	16.8
		14.3	14.4	20.0	100.0	100.0	
		1.1	9.5	5.0	0.6	0.6	
	2.	12	101	36	0	0	149
FEMALE		8.1	67.8	24.2	0.0	0.0	83.2
		85.7	85.6	80.0	0.0	0.0	
		6.7	56.4	20.1	0.0	0.0	
	COLUMN TOTAL	14	118	45	1	1	179
		7.8	65.9	25.1	0.6	0.6	100.0

CHI SQUARE = 10.80171 WITH 4 DEGREES OF FREEDOM SIGNIFICANCE = 0.0289

NUMBER OF MISSING OBSERVATIONS = 21

Table 4.3. Age by sex of blueback herring from Herring Creek and James River samples.

Age	Herring Creek		James River	
	Male	Female	Male	Female
IV		1	2	
V	46	7	5	5
VI	158	25	27	13
VII	98	20	12	7
VIII	29	6	7	3
IX	3	1	—	2
	334	60	53	30
Percent of Total	85	15	64	36

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

SUMMARY

1. A total of 1,308 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 midshore (19.8-36.0 m) zone accounted for 71.3% of all anadromous species captured.

4. A total of 5 Atlantic sturgeon was tagged and released.

5. Analysis of blueback herring length-frequency distributions revealed trimodal peaks representing 3-year-olds, and $\geq$ 4-year-olds. The $\geq$ 4-year-olds dominated offshore catches.

6. Examination of 295 female blueback herring for ovary maturation revealed that 53.2% were immature, 46.8% were capable of spawning before the end of the 1978 season, and none 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.

MATERIALS AND METHODS

Sampling Areas

The coastal waters of North Carolina and adjacent states were 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, and Area IV from Cape Hatteras northward to Little Machipongo Inlet, Virginia. Trawl samples for this project segment were required only in Areas III and IV, however, three trawl samples were taken in Area II. Sampling was conducted from just outside the surf zone to depths of 183 meters (Fig. 5.1-5.6).

Predetermined sampling stations, located within 10 minute latitude and longitude grids, were occupied in Areas II, III, and IV. To increase chances of locating concentrations of anadromous fishes and detecting foreign fishing activity, sampling in Area IV was extended into the offshore (38.4-183.0 m) zone. In addition,

electronic fish-detecting equipment was monitored continually during and between these predetermined stations to increase chances of locating concentrations of anadromous fishes.

Sampling Gear

From 13 February through 24 April 1978, a 46.1 m (headrope) modified wing trawl described by Holland and Powell (1975) and a standard No. 41 Yankee trawl with a 21.4 m headrope and a 27.5 m sweep (equipped with 15.2 cm 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). During February and March, 1978, the 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. During April, the modified wing trawl was used exclusively in Area IV. In Areas II and III the modified wing trawl and the No. 41 Yankee trawl were alternately utilized in an effort to detect other species which may have been in these areas.

The cod ends of both nets were constructed of 38 mm stretch mesh. Bracket doors (2.6 mm x 1.3 m) and 45.7 m scissors were utilized in conjunction with both trawls.

Collection of Materials

All tows were of 30-minute duration except two, which were terminated early due to "hang-ups." The total number and weight of all species captured were recorded. All anadromous fishes captured were sexed and measured to the nearest millimeter (FL). These data were used to determine sex ratios, female maturity, and length - frequency distributions. The 38 mm stretched mesh utilized in the cod ends of both trawls, precluded any quantitative data on fishes smaller than 100 mm; however, they were noted as present or numerous and a sample was measured.

Tagging

Sturgeon and striped bass were tagged in an attempt to elucidate their recent declines in abundance as indicated by our previous sampling and landing statistics.

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 to $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 955 blueback herring (Alosa aestivalis) were taken from trawl catches and examined for sex and female maturity. The paucity of alewife (Alosa pseudoharengus), and

hickory shad (Alosa mediocris) 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.

State 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, bloodshot, 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[1] was utilized to obtain both surface and bottom temperatures at each sampling station.

RESULTS AND DISCUSSION

Sampling Success

Significant declines in river herring and shad have been noted since 1973. Despite these declines, February and March have traditionally proven to be the periods of maximum abundance offshore North Carolina and Virginia. During the 1978 season, however, anadromous fishes were only sporadically encountered throughout the study area. Only 1,308 juvenile and adult anadromous fishes were captured. More specifically, 12 adult striped bass, 78 American shad (mostly yearlings and juveniles), 4 hickory shad (juveniles), 5 adult Atlantic sturgeon, 969 blueback herring (mostly adults), and 240 alewife (mostly yearlings and juveniles) contributed to the total anadromous catch. Species captured other than anadromous fishes are listed in Appendix 5.1.

Coastal Distribution

Anadromous fishes were found in greatest numbers within Area IV (Table 5.1). Although unequal effort between Areas II, III, and IV influenced catches (approximately 70% of all effort was in Area IV), 79.1% of all anadromous fishes were captured within Area IV.

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[1] Use of a trade name does not constitute an endorsement.

No striped bass (Morone saxatilis) were encountered in Areas II or III. Only twelve striped bass were captured, all in Area IV. Four striped bass were taken during February. Two were captured 4.8 km ENE of Kitty Hawk monument (latitude 36°02' N) at a depth of 19.8 m (11 fm), and another was taken 4.8 km NW of Chesapeake Light Tower (latitude 36°56' N) at a depth of 14.4 m (8 fm). The fourth striped bass was encountered at Platt Shoals, 5.6 km SE of Bodie Island Lighthouse (latitude 36°45' N) at a depth of 21.6 m (12 fm).

The remaining eight striped bass were captured during March. Three striped bass were taken just south of Wimble Shoals, 22.4 km NNE of Cape Hatteras Lighthouse (latitude 35°28' N) at a depth of 18.0 m (10 fm). Two were encountered 1.6 km off Currituck Beach (latitude 36°22' N) at a depth of 10.8 m (6 fm) and two more were taken 8.0 km off False Cape, VA., (latitude 36°46' N) at a depth of 16.2 m (9 fm).

Only five Atlantic sturgeon (Acipenser oxyrhynchus) were encountered, one in Area II and four in Area III. All were taken within 1.6 km of the beach during February. In Area II, the Atlantic sturgeon was captured 6.4 km SW of Beaufort Bar, (latitude 34°40' N) at a depth of 12.6 m (7 fm). In Area III, two Atlantic sturgeon were taken 3.2 km NE of Ocracoke Inlet (latitude 35°05' N) at a depth of 7.2 m (4 fm), and another was taken 4.0 km NE of Drum Inlet (latitude 34°52' N) at a depth of 10.8 m (6 fm). The remaining Atlantic sturgeon were encountered in Cape Hatteras Bight (latitude 35°13' N) at a depth of 7.2 m (4 fm).

Of the river herring captured during the 1978 season, only 2.6% (33) were encountered in Area II (Table 5.1). Thirty-two blueback herring and one alewife were captured in one sample 5.4 km SW of the Beaufort Bar (latitude 34°40') at a depth of 12.6 m (7 fm) during March.

Only 18.2% (211) of the river herring captured were encountered in Area III. Blueback herring were taken throughout the area from 12.5 km SW of Cape Lookout Lighthouse (latitude 34°33' N) to Cape Hatteras Bight (latitude 35°13' N). The largest single catch in Area III (112 individuals) occurred in Cape Hatteras Bight during March. A total of 50 alewife and 22 American shad were also taken in this area. These were distributed from 4 km SE of Ocracoke Inlet (latitude 34°52' N) to Cape Hatteras Bight.

Only four hickory shad (Alosa mediocris) were captured, all within 1.6 km of the beach in Area III during February. These fish were taken 4.0 km NE of Drum Inlet (latitude 34°52' N) at a depth of 10.8 m (6 fm), and the other was captured 8.0 km SW of Hatteras Inlet (latitude 35°09' N) at a depth of 14.4 m (8 fm).

Area IV accounted for 80.1% (776) of all blueback herring taken during the 1978 season. These were distributed from 18.4 km NNE of Cape Hatteras Lighthouse (latitude 35°26' N) to Chesapeake Bay Entrance (latitude 36°55' N). The largest single catch (221 individuals) occurred 41.6 km east of Bodie Island (latitude 35°53' N) during March.

Area IV also contributed 78.8% (189) of all alewife and 71.8% (56) of all American shad captured during the 1978 season. These fish were distributed from 18.4 km NNE of Cape Hatteras Lighthouse (latitude 35°26' N) to the Chesapeake Bay Entrance (latitude 36°55' N). The largest single catch of alewife (110 individuals) and all the American shad (56 individuals) occurred 35.2 km east of Chesapeake Light Tower (latitude 36°54' N) during February.

Depth Distribution

Sampling effort and relative abundance of anadromous fishes from 13 February through 24 April, 1978 in relation to depth zones are shown in Figures 5.1 through 5.6 and Table 5.2. Due to several factors, however, effort was concentrated in the midshore zone (19.8-36.0 m). The major factor influencing effort in the inshore zone (0-18.0 m) was the extreme low water temperatures during February and March. In the offshore zone (37.8-180.0 m), where the water temperature in February and March were more favorable for river herring, sampling was made virtually impossible due to high winds (sometimes in excess of 50 knots) and in some cases ice and snow, caused by a constant influx of low pressure fronts. Because of the extremely low water temperatures in the inshore zone and the unfavorable weather conditions in the offshore zone, effort was concentrated in the midshore zone in order to capture as many anadromous species as possible.

The inshore zone accounted for only 28.7% of all anadromous fishes captured. Hickory shad and Atlantic sturgeon were to be exclusively in the inshore zone. This zone was accounted for 29.1% (282) of all blueback herring 21.7% (52) of all alewife, 58.3% (7) of all striped bass, and 33.3% (26) of all American shad captured during the 1978 season.

The midshore zone accounted for all of the remaining anadromous fishes captured: 70.9% (687) of the blueback herring, 78.3% (188) of the alewife, 41.7% (7) of all striped bass, and 66.7% (52) of the American shad.

No anadromous fishes were taken in the offshore zone.

Seasonal Distribution

The anadromous fish catch during February consisted of 346 blueback herring, 236 alewife, 74 American shad, 4 hickory shad, 4 striped bass, and 5 Atlantic sturgeon. During March, the catch consisted of 588 blueback herring, 4 alewife, 4 American shad, and 8 striped bass. Blueback herring (35 individuals) was the only anadromous species encountered during April (Table 5.3).

The paucity of anadromous fishes in samples from 13 February through 24 April 1978 appeard to be caused by several factors (see Depth Distribution - above).

The mean surface water temperatures during February was 4.8°C for Area III and 1.8°C in Area IV (Fig. 5.7). The bottom water

temperature in Area IV, which has always been the area of greatest abundance of river herring, was as low as 0.2°C during February. The mean surface water temperature during March was 11.2°C for Area III and 4.1°C for Area IV (Fig. 5.7), with a low of 0.4°C (bottom temperature) in Area IV. Because of these low temperatures, no significant concentrations of any anadromous species were encountered during February and March except beyond the inshore zone and in Hatteras Bight, where water temperature reached 5°C and above.

Several occurrences lend support to the supposition that water temperature is the major controlling factor in the distribution of anadromous fishes. First, gizzard shad and silverside were captured in oceanic waters where they have never before been encountered by the R/V Dan Moore. Small striped bass (3-4 years old), also endemic to inshore waters were taken offshore due to the extremely low water temperatures inside, as was the case in the winter of 1969-70. Atlantic cod and pollock were captured in this area, the extreme southern limit of their range. Finally, there was a lack of any commercial quantities of species normally encountered in the study area during February and March (spot, croaker, bluefish, and weakfish).

Tagging

Five Atlantic sturgeon were tagged and released during February. Fork lengths ranged from 58.4 cm to 86.5 cm, and weight ranged from 1.1 to 5.4 kg.

Twelve striped bass were captured, to which ten were tagged and released. Fork lengths ranged from 46.4 cm to 118.0 cm, and weights ranged from 1.4 to 23.4 kg.

There were no tag returns from either Atlantic sturgeon or striped bass.

Size Composition

Only blueback herring were captured in sufficient numbers (969) to analyze size and age composition. Of these fish, 289 (29.8%) were males ranging from 140 to 293 mm, 295 (30.4%) were females ranging from 140 to 310 mm, and 385 (39.7%) were small, sexually immature fish ranging from 58 to 110 mm (sex was not determined). Of the 584 blueback herring for which sex was determined, 296 (50.7%) were sexually mature.

Length-frequency distributions of blueback herring, sexes combined, are presented in Figure 5.8. Trimodal peaks representing adult blueback herring are discernable with modes at 170-179 mm, 210-219 mm, and 250-259 mm. According to the age-frequency data compiled previously (Holland and Yelverton, 1973; Holland and Powell, 1975), the first mode represents 3-year-olds while the second and third modes represent fish $\geq$ 4 years old. The mesh size of the cod ends (38 mm stretch mesh) of both nets precluded any quantitive data on blueback herring 100 mm or smaller, and therefore such data were not included in Figure 5.8. They were, however, noted as being

present or numerous and a sample was measured to determine a size range, which was 58 to 100 mm.

Sex and Female Maturity

Ovarian stages for Alosa aestivalis from 13 February through 24 April, 1978 are shown in Table 5.4. Ovarian stages of the blueback herring are now shown by month due to the paucity of females that could be staged encountered in February and April. Of the 295 females examined, approximately 53.2% contained ovaries designated as stage I, which would not have spawned during the 1978 season. Only 8.8% of the females examined were designated as stage II, which may or may not have been capable of spawning during the remainder of the 1978 season. Those designated as stage III, which accounted for 38% of the total females examined, were capable of spawning before the 1978 season terminated. None of the females examined were ripe (stage IV) or spent (stage V).

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

Sex Ratio

The sex ratios, by month, for 584 bluebacks are depicted in Table 5.5. No significant deviations from a 1:1 ratio were found except during April when the male:female ratio was 1:2.89. However, when the months were combined, a male to female sex ratio of 1:1.02 was computed.

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Appendix 5.1. Total Species List

Finfish

Alopiidae
- Thresher shark *(Alopias vulpinus)*

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

Sphyrinidae
- Scalloped hammerhead *(Sphyrna lewini)*

Squalidae
- Spiny dogfish *(Squalus acanthias)*

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

Dasyatidae
- Southern stingray *(Dasyatis americana)*
- Spiny butterfly ray *(Gymnura altavela)*

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)*
- Gizzard shad *(Dorosoma cepedianum)*

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

Lophiidae
- Goosefish *(Lophius americanus)*

Gadidae
- Atlantic cod *(Gadus morhua)*
- Silver hake *(Merluccius bilinearis)*
- Pollock *(Pollachius virens)*
- Red hake *(Urophycis chuss)*
- Spotted hake *(Urophycis regius)*

Appendix 5.1. (continued).

Atherinidae
Atlantic silverside *(Menidia menidia)*

Syngnathidae
Pipefish *(Synagnathus sp.)*

Percichthyidae
Striped bass *(Morone saxatilis)*

Pomatomidae
Bluefish *(Pomatomus saltatrix)*

Carangidae
Rough scad *(Trachurus lathami)*

Pomadasyidae
Pigfish *(Orthropristis chrysoptera)*

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

Sciaenidae
Silver perch *(Bairdiella chrysura)*
Weakfish *(Cynoscion regalis)*
Spot *(Leiostomus xanthurus)*
Southern kingfish *(Menticirrhus americanus)*
Atlantic croaker *(Micropogonias undulatus)*

Mugilidae
Striped mullet *(Mugil cephalus)*

Ammodytidae
American sand lance *(Ammodytes americanus)*

Scombridae
Chub mackerel *(Scomber japonicus)*
Atlantic mackerel *(Scomber scombrus)*

Stromateidae
Spotted driftfish *(Ariomma regulus)*
Harvestfish *(Peprilus alepidotus)*
Butterfish *(Peprilus triacanthus)*

Triglidae
Striped searobin *(Prionotus evolans)*

Appendix 5.1. (continued).

Bothidae
Summer flounder *(Paralichthys dentatus)*
Windowpane *(Scopthalmus aquosus)*
Dusky flounder *(Syacium papillosum)*

Pleuronectidae
Winter flounder *(Pseudopleuronectes americanus)*

Other Vertebrates

Cheloniidae
Atlantic loggerhead turtle *(Caretta caretta)*

Invertebrates

SCYPHOZOA
Jellyfish

Echinoidea
Sand dollar *(EXOCYCLICA)*

Holothuroidea
Sea Cucumber

Portunidae
Ovalipes crab *(Ovalipes quadulpensis)*
Portunid *(Portunus gibbesii)*

Cancridae
Rock crab *(Cancer irroratus)*

Majidae
Spider crab *(Libinia sp.)*

Xiphosuridae
Horseshoe crab *(Limulus polyphemus)*

Naticidae
Atlantic Moon snail *(Polinices duplicatus)*

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

Table 5.1. Relative abundance of offshore anadromous fishes by sampling area, February - April, 1978 (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes).

Species	AREA II			AREA III			AREA IV			TOTAL		
	3 Samples			27 Samples			72 Samples			102 Samples		
	Total catch no.	Avg. no.	Pct. with fish	Total catch no.	Avg. no.	Pct. with fish	Total catch no.	Avg. no.	Pct. with fish	Total catch no.	Avg. no.	Pct. with fish
Striped Bass *Morone saxatilis*	0	0	0	0	0	0	12	0.17	8.3	12	0.11	5.9
American Shad *Alosa sapidissima*	0	0	0	22	0.8	18.5	56	0.8	40.7	78	0.76	15.7
Hickory Shad *Alosa mediocris*	0	0	0	4	0.15	7.0	0	0	0	4	*	2.0
Atlantic Sturgeon *Acipenser oxyrhynchus*	1	0.3	33.3	4	.15	14.8	0	0	0	5	*	3.9
Blueback Herring *Alosa aestivalis*	32	10.7	33.3	161	6.0	48.0	776	10.8	34.7	969	9.4	37.3
Alewife *Alosa pseudoharengus*	1	0.3	33.3	50	1.8	29.6	189	2.6	16.7	240	2.4	16.7
Totals	34			241			1033			1308		

* Less than 0.1 fish

Table 5.2. Relative abundance and depth distribution of offshore anadromous fishes, February - April, 1978 (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes).

Species	Inshore 0-18.0 m 36 Samples			Midshore 19.8-36.0 m 65 Samples			Offshore 37.8-180.0 m 1 Sample		
	Total catch no.	Avg. catch	Pct. with fish	Total catch no.	Avg. catch	Pct. with fish	Total catch no.	Avg. catch	Pct. with fish
Striped Bass *Morone saxatilis*	7	0.19	11.1	5	*	6.2	0	0	0
American Shad *Alosa sapidissima*	26	0.72	16.7	52	0.8	15.4	0	0	0
Hickory Shad *Alosa mediocris*	4	*	3.0	0	0	0	0	0	0
Atlantic Sturgeon *Acipenser oxyrhynchus*	5	0.14	11.1	0	0	0	0	0	0
Blueback Herring *Alosa aestivalis*	282	7.8	47.2	687	10.6	32.3	0	0	0
Alewife *Alosa pseudoharengus*	52	1.4	25.0	188	2.9	6.5	0	0	0
Totals	376			932			0		

* Less than 0.1 fish

Table 5.3. Number of anadromous fishes captured, average catch per sample, and percent of samples taking anadromous fishes by months, 13 February through 24 April, 1978.

Species	February 33 Samples			March 35 Samples			April 34 Samples		
	Total catch no.	Avg. no.	Pct. with fish	Total catch no.	Avg. no.	Pct. with fish	Total catch no.	Avg. no.	Pct. with fish
Striped Bass *Morone saxatilis*	4	0.1	9.1	8	0.2	8.6	0	0	0
American Shad *Alosa sapidissima*	74	2.2	39.4	4	0.1	8.6	0	0	0
Hickory Shad *Alosa mediocris*	4	0.1	6.1	0	0	0	0	0	0
Atlantic Sturgeon *Acipenser oxyrhynchus*	5	0.2	12.1	0	0	0	0	0	0
Blueback Herring *Alosa aestivalis*	346	10.5	51.1	588	16.8	45.7	35	1.0	11.8
Alewife *Alosa pseudoharengus*	236	7.2	45.4	4	0.1	11.4	0	0	0
Totals	669			604			35		

Table 5.4. Ovarian stage, by size range, of captured female blueback herring *(Alosa aestivalis)* during February - April, 1978.

Fork length (mm)	Stage I	Stage II	Stage III
140-149	6		
150-159	2		
160-169	9		
170-179	30		
180-189	19		
190-199	22		
200-209	12		
210-219	22		
220-229	20		
230-239	7	2	1
240-249	3	1	5
250-259	3	6	34
260-269		8	46
270-279	2	4	20
280-289		3	5
290-299		1	1
300-309		1	
Totals	157	26	112

Table 5.5. Monthly sex composition for 584 blueback herring captured offshore, February - April, 1978.

Species	Month	Total	No. males	Percent	No. females	Percent	Sex ratio
Blueback herring *(Alosa aestivalis)*	February	87	46	52.9	41	47.1	0.89
	March	462	234	50.7	228	49.3	0.97
	April	35	9	25.7	26	74.3	2.89
	Total	584	289	49.5	295	50.5	1.02

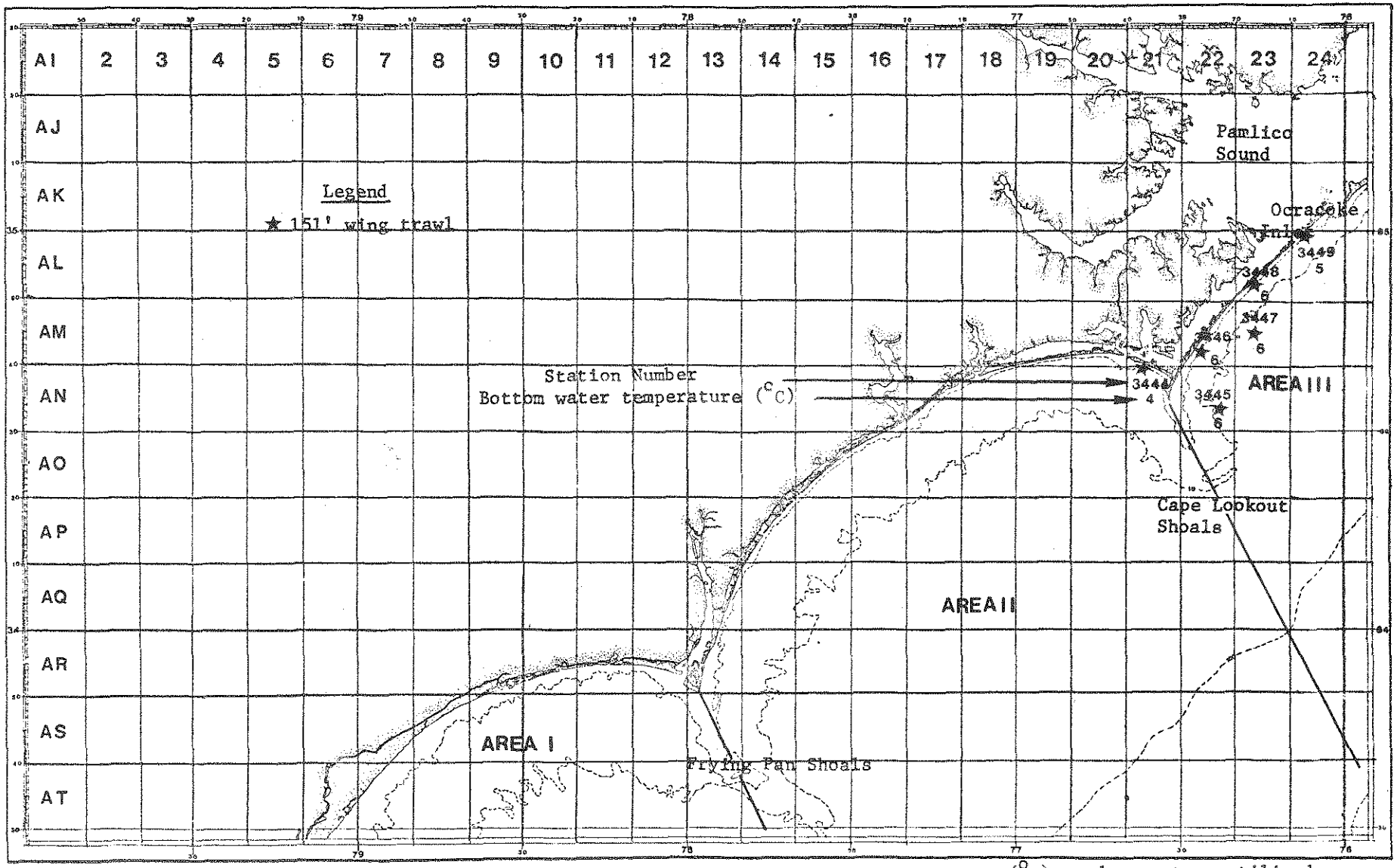

Figure 5.1.-Ocracoke Inlet to South Carolina. Station localities, bottom water temperature (°C), and gear type utilized during February, 1978. Grids represent areas of 10 minute latitude and longitude.

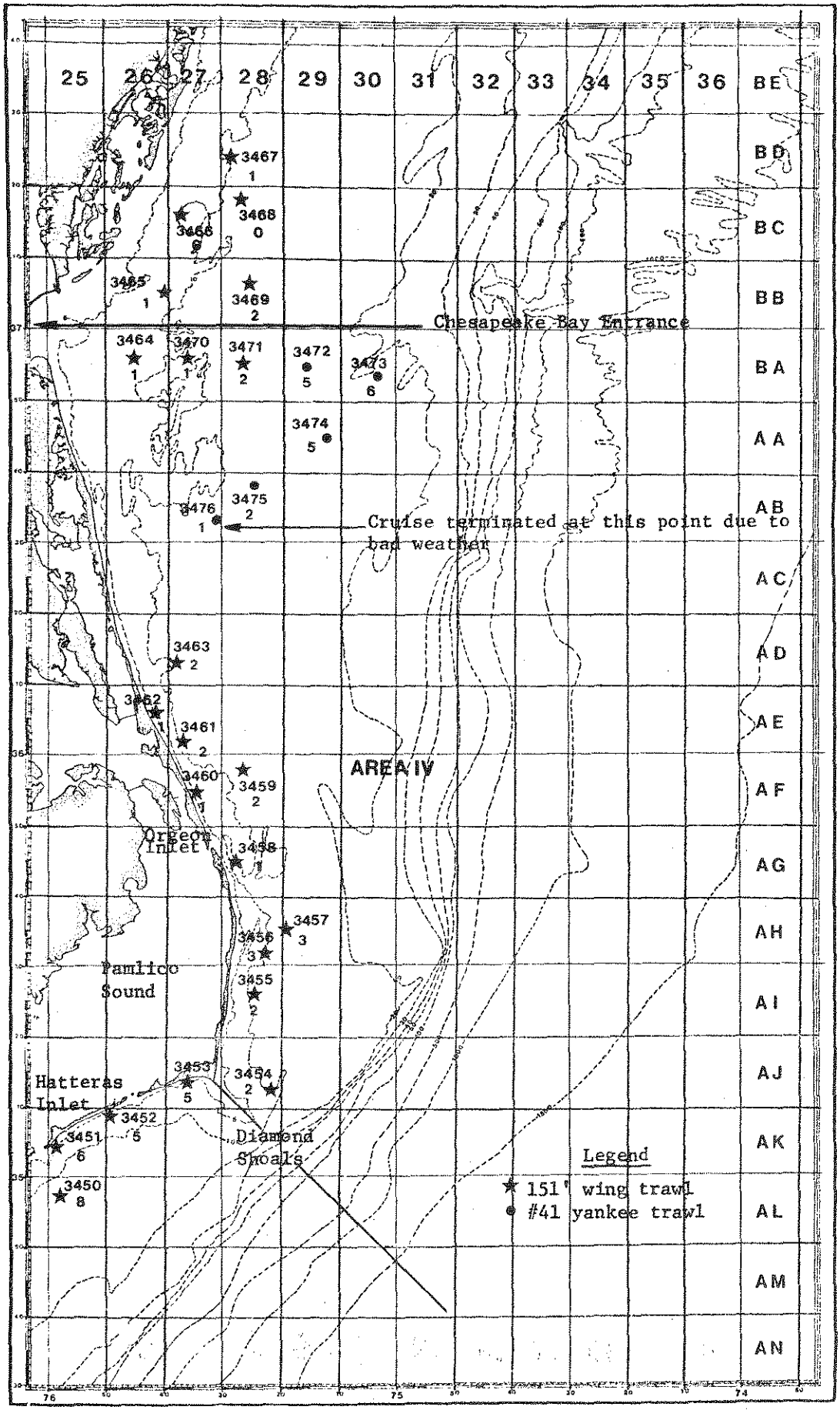

Figure 5.2. Hatteras Inlet to Chesapeake Bay Entrance. Station localities, bottom water temperature ($^{\circ}C$), and gear type utilized during February, 1978. Grids represent areas of 10 minute latitude and longitude.

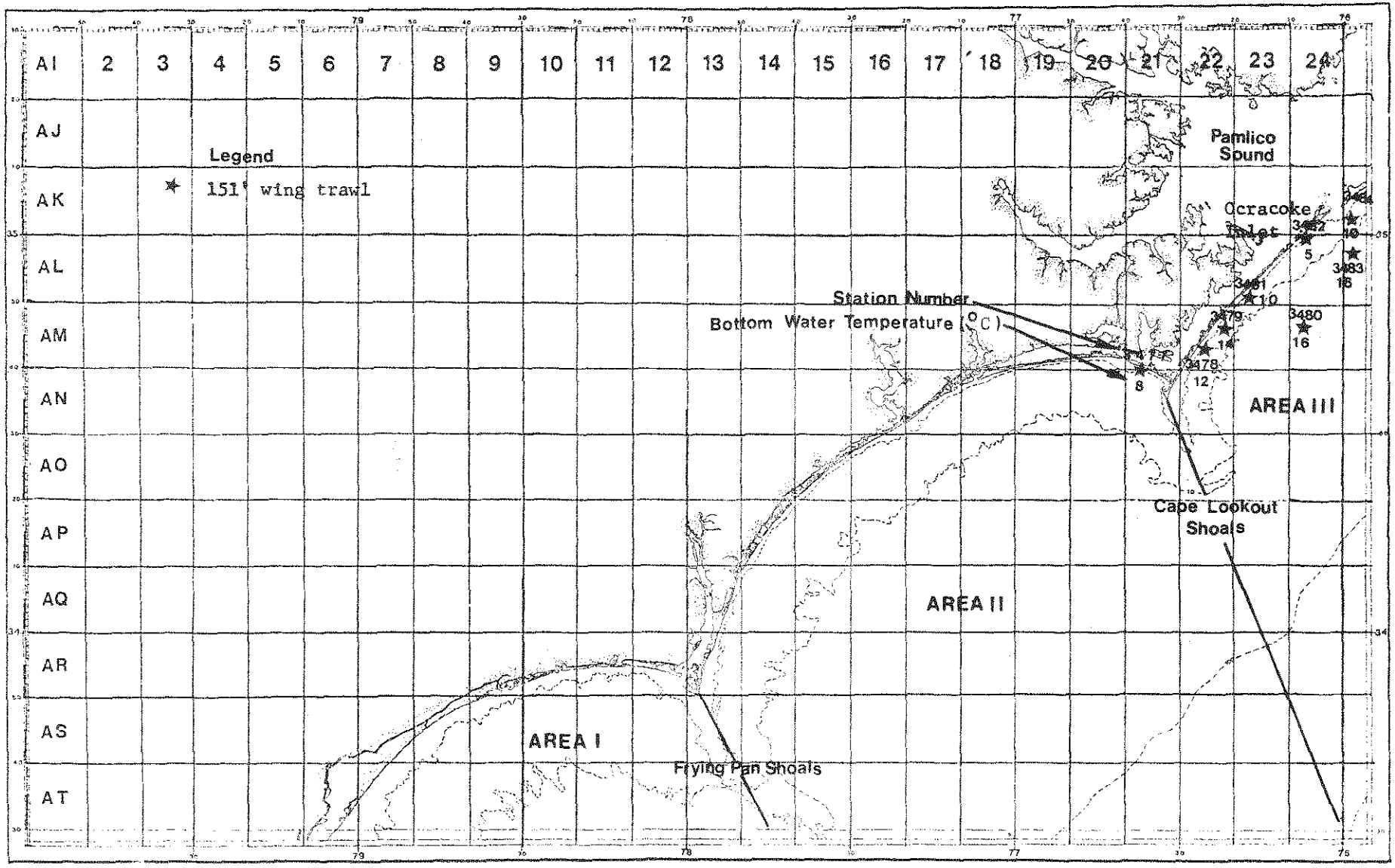

Figure 5.3. Ocracoke Inlet to South Carolina. Station localities, bottom water temperature (°C), and gear type utilized during March, 1978. Grids represent areas of 10 minute latitude and longitude.

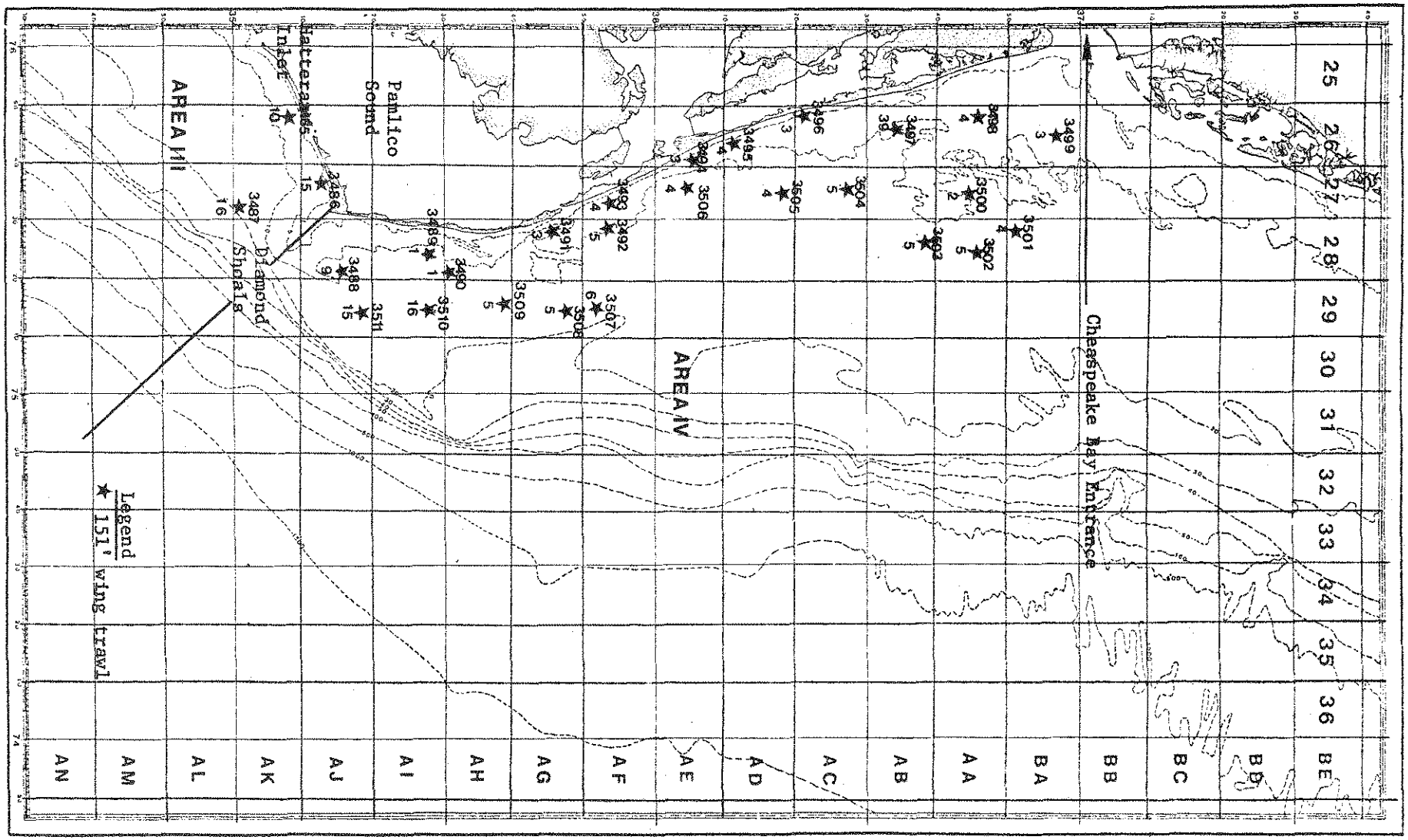

Figure 5.4. Hatteras Inlet to Chesapeake Bay Entrance. Station localities, bottom water temperature (°C), and gear type utilized during March, 1978. Grids represent areas of 10 minute latitude and longitude.

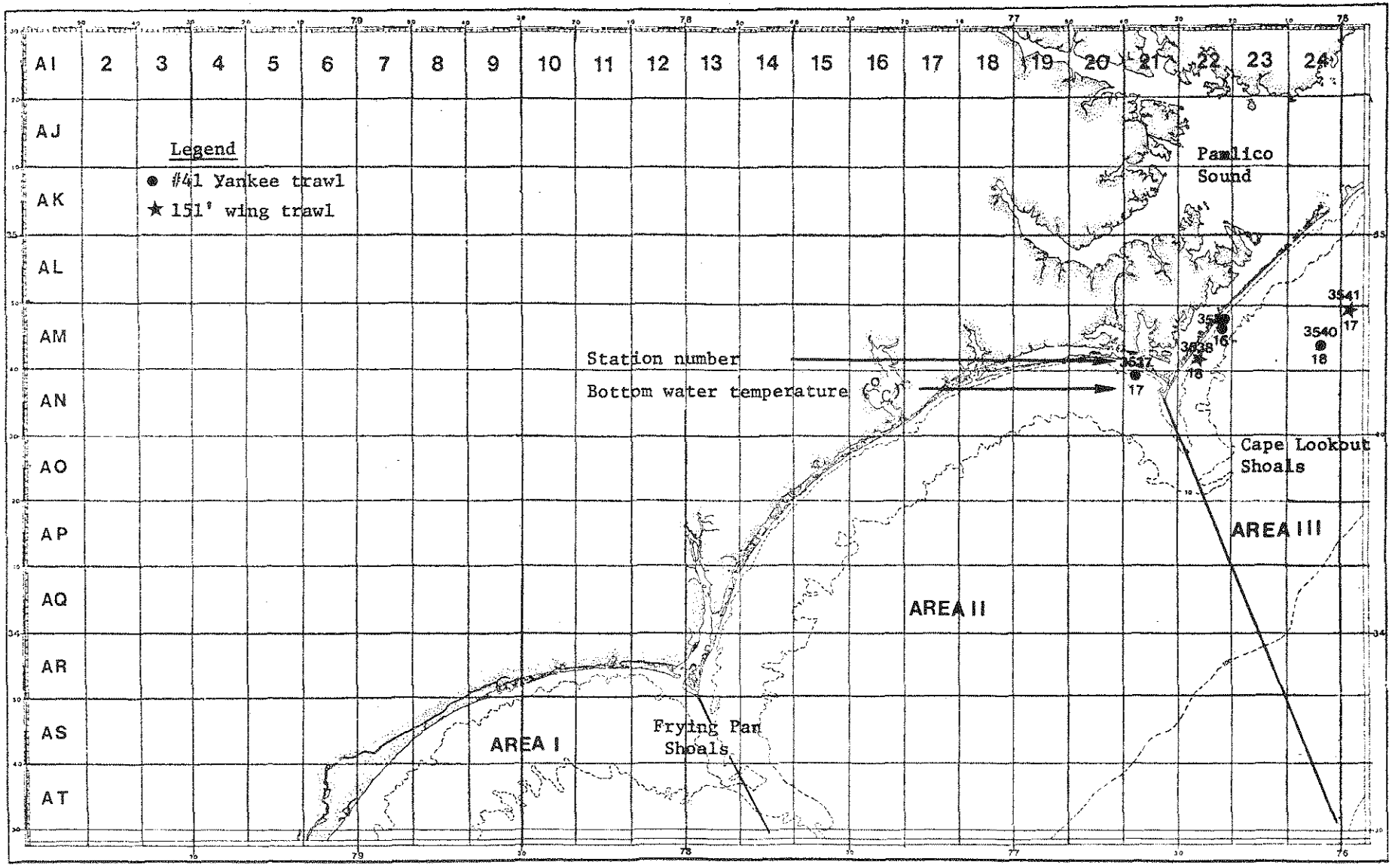

Figure 5.5. --Ocracoke Inlet to South Carolina. Station localities, bottom water temperature (°C), and gear type utilized during April, 1978. Grids represent areas of 10 minute latitude and longitude.

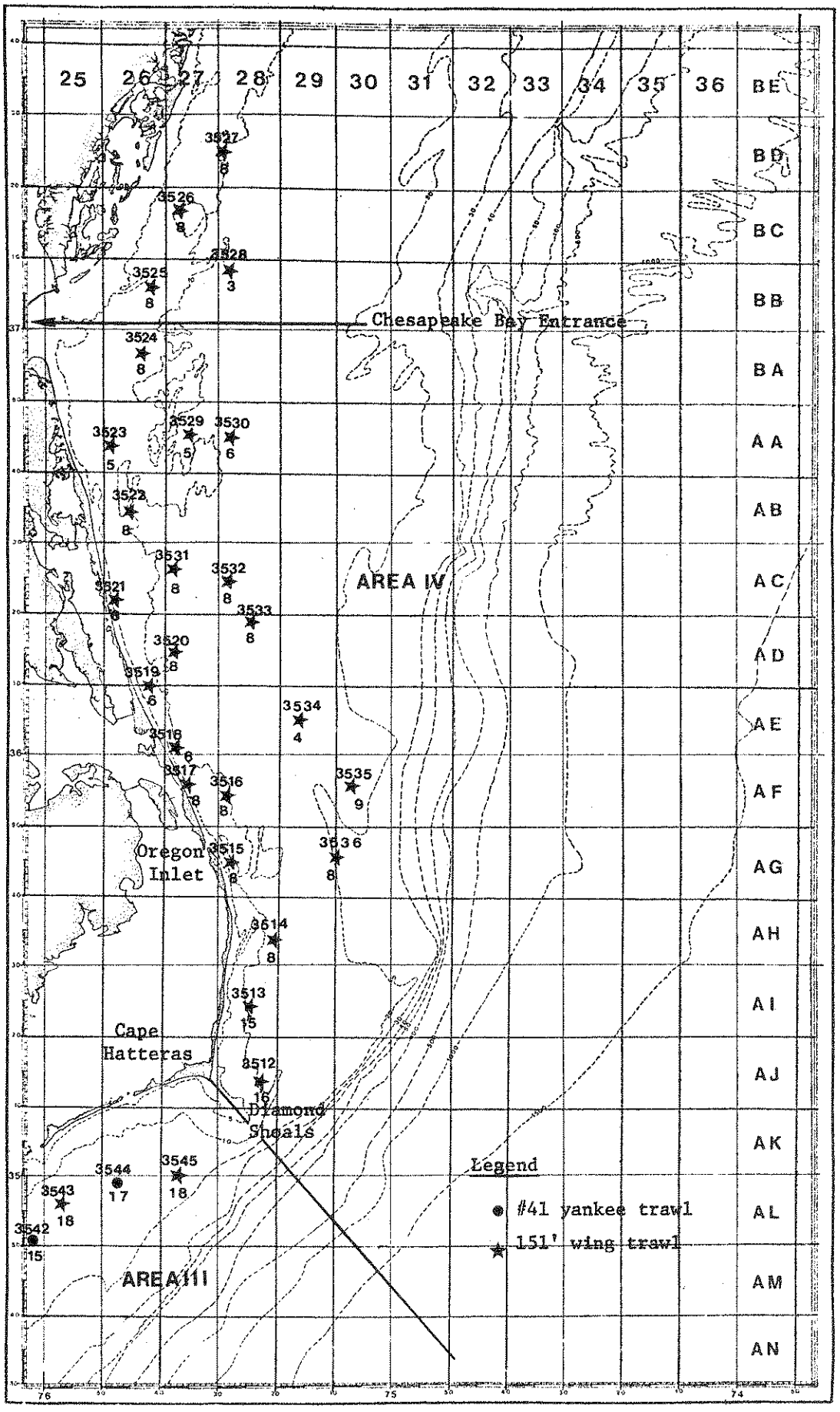

Figure 5.6 . Hatteras Inlet to Chesapeake Bay Entrance. Station localities, bottom water temperature (^{o}C), and gear type utilized during April, 1978. Grids represent areas of 10 minute latitude and longitude.

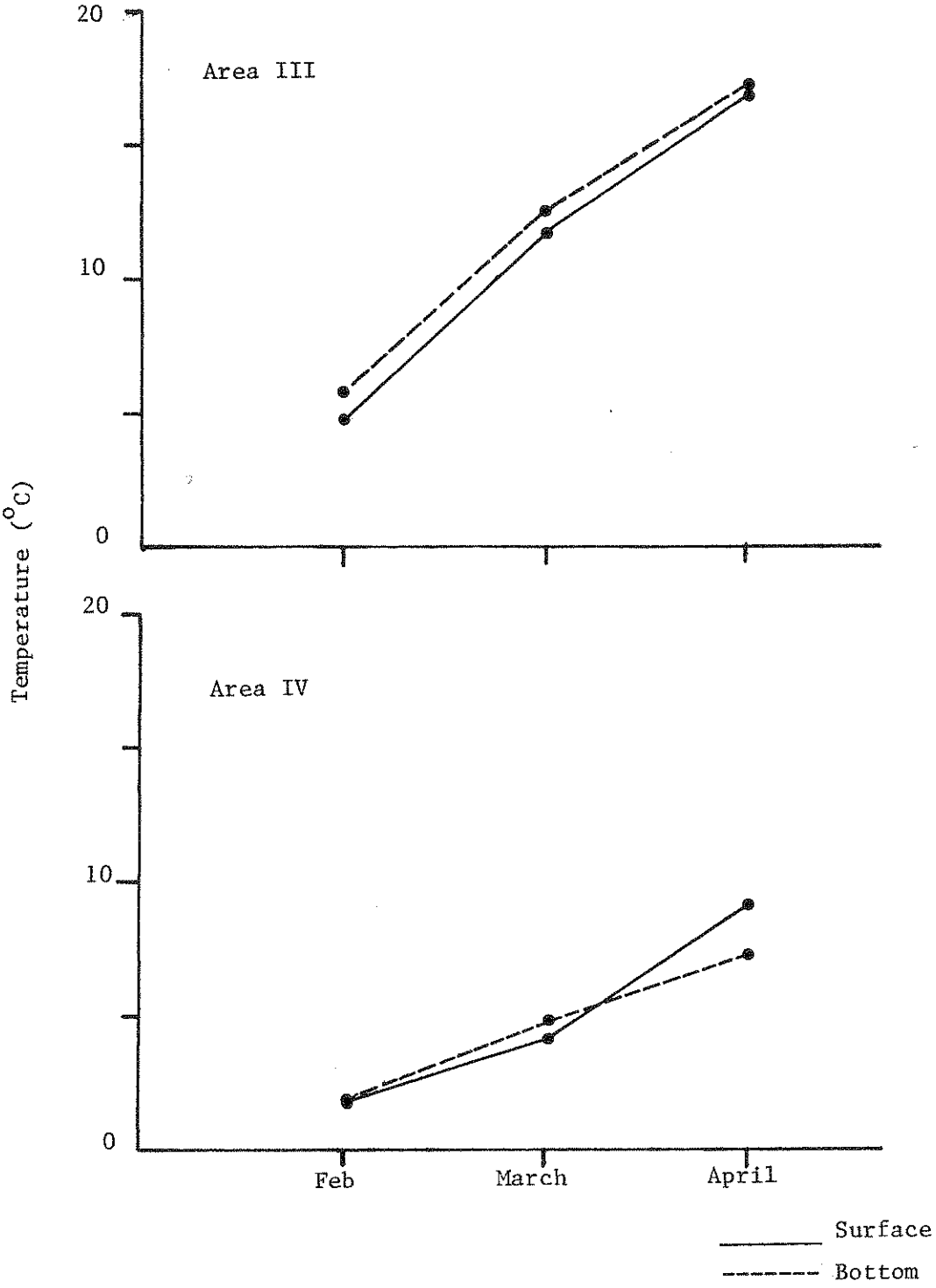

Figure 5.7. Monthly mean surface and bottom temperatures in Areas III and IV, February through April 1978.

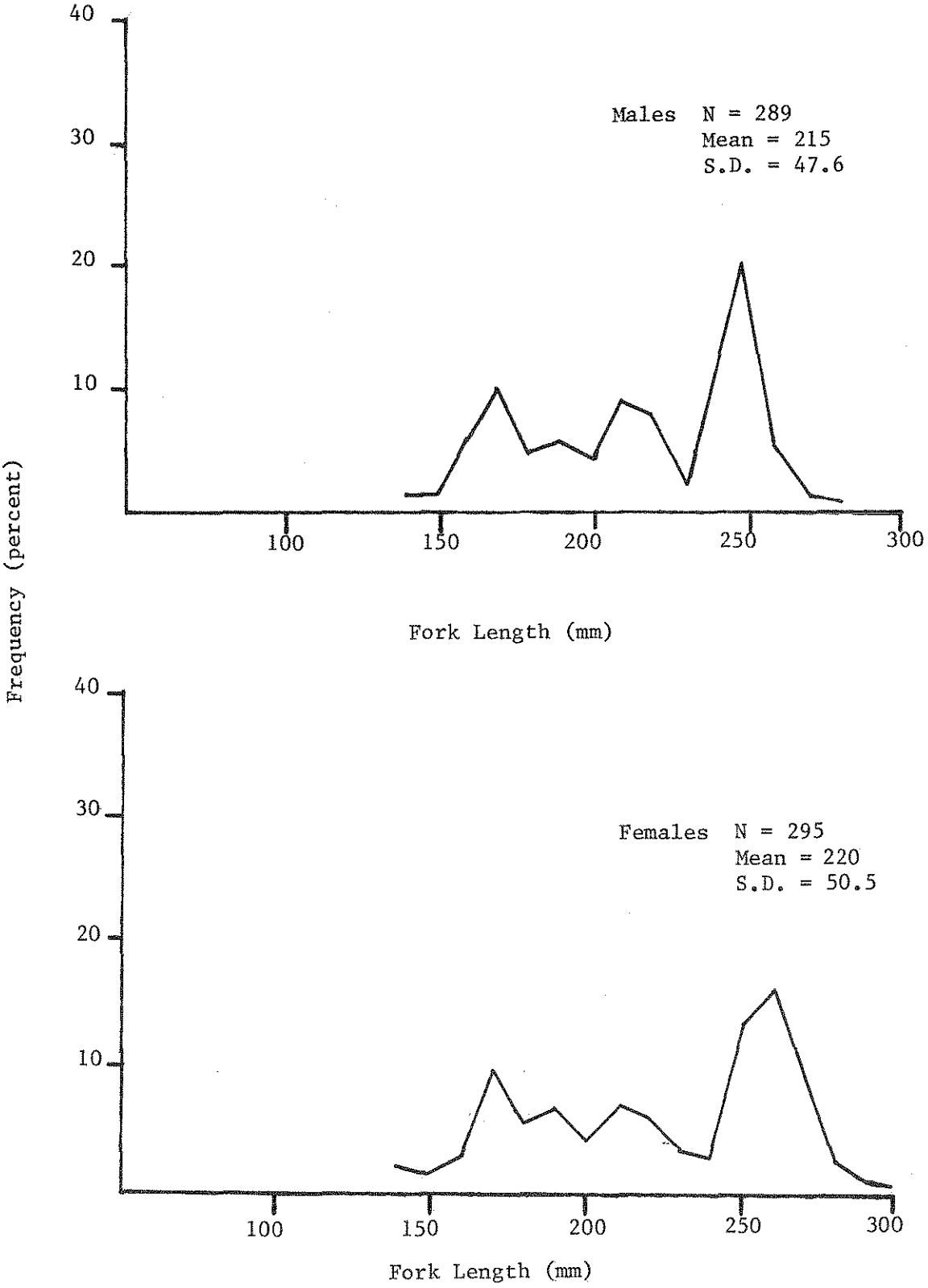

Figure 5.8. Length frequency distributions, by sex, of blueback herring captured during the 1978 season.

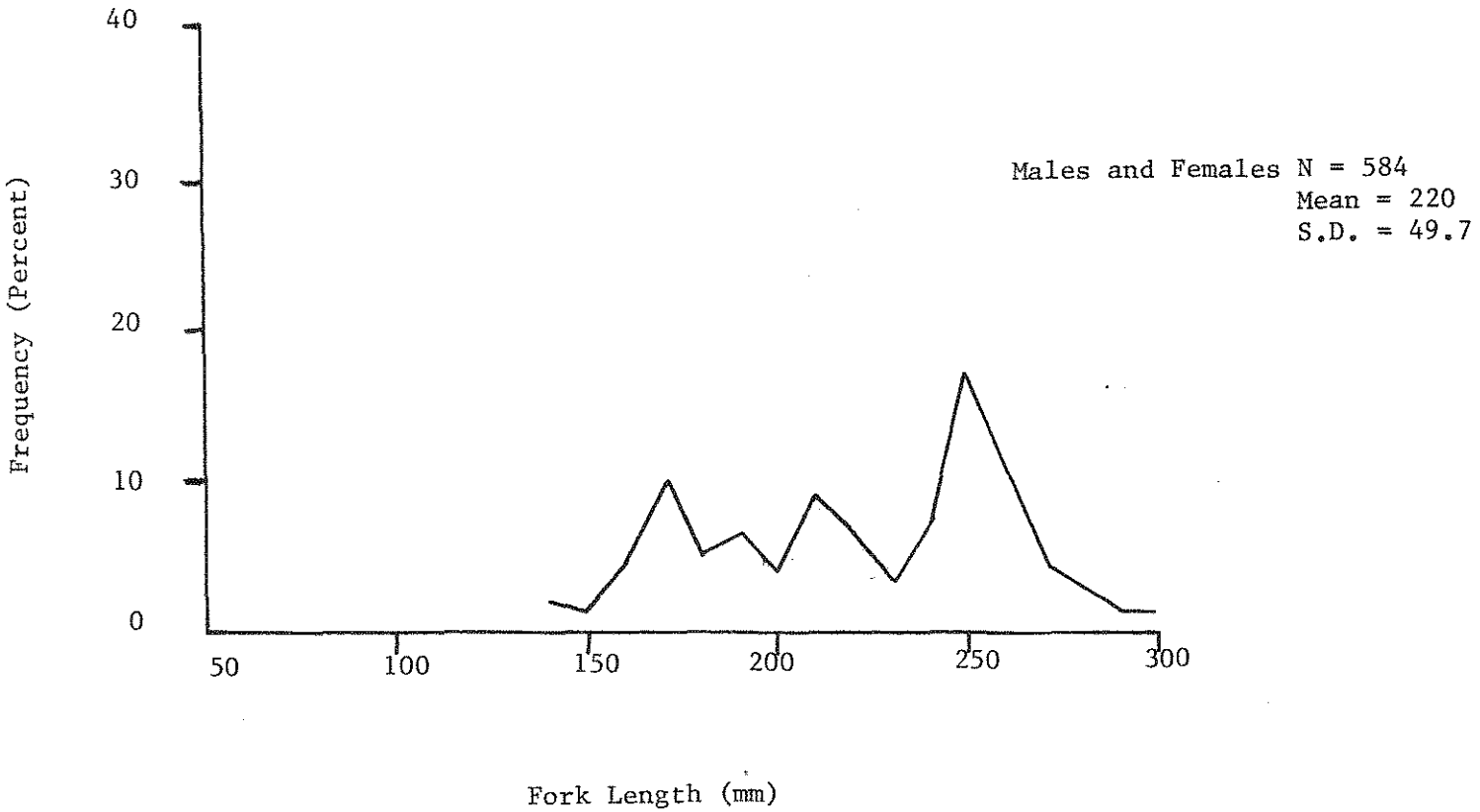

Figure 5.8. (con't)

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

SUMMARY

1. Ninety-nine Kepone analyses of adult alosine body tissue and roe were made on samples collected primarily from the lower Chesapeake Bay between mid-March and early June, 1978. The highest level of Kepone detected, 0.14 ppm, was less than half the action level of 0.3 ppm.

2. Thirty-three adult striped bass taken in the James River were analyzed for Kepone contamination. Approximately 30% had a Kepone concentration above the action level.

3. Sixty-four samples of juvenile alosines and striped bass were analyzed. All samples which contained Kepone above the action level were obtained from the James and Chickahominy rivers. Data for above action level samples collected in late June and late September were not significantly different. This suggests that the Kepone concentration per unit body weight reaches a saturation level early in their development, and further increases in juvenile Kepone body burden is proportional to growth.

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

INTRODUCTION

It is not known if alosines have a natural cycle of varying abundance. The last strong recruitment to the Virginia alosine fishery occurred in 1970 and 1971 with the entry of the 1966 year class. The 1966 striped bass year class was also "successful." Historically, striped bass density has been cyclic with a strong year class following years of poor reproductive success. Both striped bass and the alosines are estuarine dependent for spawning and, in part, for juvenile development.

With increased industrialization in the Chesapeake Bay area and its tributaries and the introduction of chlorinated hydrocarbons, heavy metals, and other contaminants, there is concern that man-induced stresses are now superimposed on natural environmental stresses. The James River was closed to all forms of fishing in December 1975 as a result of Kepone contamination. The ban was later modified to allow fishing for American shad, river herring, and one species of catfish (Ictalurus punctatus) and a Kepone "action level" of 0.3 ppm was established. However, the river remains closed for the taking of other species.

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 State agencies 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 returns to spawn in three to four years.

MATERIALS AND METHODS

Adult alosines were obtained from various sites throughout the Chesapeake Bay region, with emphasis on the collection of samples at the bay-mouth area when the spawning runs entered. The samples were purchased from commercial fishermen and commercial seafood buyers. Only those specimens were collected whose sites of capture were known. Juveniles were collected with the push and trawl nets described in Job 3 during June, August, and September, 1978. However, unforeseen logistic problems prevented the systematic biweekly collection of juveniles in the James River. This will be attempted in 1979 at no expense to this project.

All alosine Kepone analyses were conducted by the VIMS Department of Ecology-Pollution. In addition, at no expense to the project, adult and juvenile striped bass were analyzed for Kepone content.

Adult fish were individually analyzed but it was necessary to blend juveniles (≃50) to obtain a sufficient amount of body tissue for analysis.

In preparation of Kepone analysis samples are ground in a meat grinder into hamburger consistency. A mixture of anhydrous sodium sulfate and Quso^{R} G-30 (precipitated silica, Philadelphia Quartz Co.) is then added for desiccation. The proportions of sample to the desiccants are 30 g fish: 54 g Na_2 So_4: 6 g Quso^{R}. Samples are then frozen at -5°C for 24 hours to rupture the cells. After thawing, the desiccated samples are ground with a blender to a powdery consistency and transferred to pre-extracted paper thimbles for Soxhlet extraction. Extraction is carried out using 1:1 ethyl ether-petroleum ether for 16 hours. Extracts are then concentrated by evaporation and cleaned by activated fluorosil column chromatography. The Kepone containing elutriation is then analyzed by electron capture gas chromatography utilizing packed columns with one or more of the following liquid phases: 4% SE-30 + 6% OV 210; 1.5% OV-17 + 1.95% QF-1 + 3% CV-1.

RESULTS AND DISCUSSION

Kepone analysis data for adults and juveniles are summarized in Tables 6.1 and 6.2, respectively. Ninety-nine Kepone analyses of adult alosine body tissue and roe were made on samples collected primarily from the lower Chesapeake Bay between mid-March and early June (Table 6.1). The highest level of Kepone present in adult

alosine body tissue, 0.09 ppm, was over three times less than the level of concern, 0.3 ppm, while the highest level detected in roe, 0.14 ppm, was less than half of the action level.

In the James River, 33 adult striped bass samples were taken in March. Six of 11 males (54.4%) and four of 22 females (18.1%) had Kepone levels greater than 0.3 ppm. Mansueti's (1961) length-age relationship for stripers indicates that five of the six contaminated males and two of the four contaminated females were less than age 3 and thus, resident (pre-migratory) fish. The lengths of the 23 stripers below the Kepone action level ranged from 440 to 690 mm, and are believed to have been recent arrivals, approximately between ages 4 and 6.

Sixty-four samples of juvenile alosines and striped bass were analyzed for Kepone content (Table 6.2). No detectable levels of Kepone were present in juvenile samples from the Potomac and Rappahannock rivers. All samples which contained Kepone above the action level were obtained in the James and Chickahominy rivers, the latter river a tributary to the former. Juvenile alewife, blueback herring and striped bass Kepone averages above the action level ranged from 0.50 and 0.58 ppm; the American shad mean was notably higher, 0.80 ppm. Three samples each from the James and Chickahominy rivers which had means below the action level were collected at sites relatively distant from the original point source of Kepone at Hopewell, Virginia, mile 65 on the James River. The mean Kepone level

for six James River juvenile alewife samples, 0.58 ppm, obtained in late June exceeded the above-action mean levels of alewife and blueback collected in late September but the differences in means were not significant ($P>0.50$). However, these data, albeit few, suggest that the Kepone concentration per unit body weight reaches an asymptotic (saturation) level early in their development.

Trace amounts of Kepone ($\leq$0.01 ppm) occurred in five striped bass and three shad samples from the Mattaponi River and, also, in three striped bass samples from the Pamunkey River. However, these very low concentrations are suspect (R. Huggett, VIMS Dept. of Ecology and Pollution; personal communication) and may be due to the presence of another compound or contamination of the samples. It is also possible that the low concentrations result from the aeolian contamination of the rivers' water sheds due to their juxtaposition to the James River. Regardless, the extremely low levels of Kepone in the Mattaponi and Pamunkey river samples relative to those from the James River and the time of collection (pre-migration) indicates that the fish were not migrants from the James River.

LITERATURE CITED

Mansueti, R. J. 1961. Age, growth, and movements of the striped bass, Roccus saxatilis, taken in size selective fishing gear in Maryland. Chesapeake Sci. 2:9-36.

Table 6.1. Kepone concentration (ppm) in adult alosines and striped bass from the lower Chesapeake Bay and tributaries, 1978.

Species	Collection site	Date	Tissue analyzed	No. of samples	Concentration Mean	Concentration Range
Alewife	Ches. Bay	6 Apr.	body	1	ND*	
		12 Apr.	body	1	ND	
			roe	1	ND	
		17 May	body	2	<0.01	ND-0.01
			roe	1	0.01	
		23 May	body	1	0.01	
			roe	1	0.01	
Blueback	Ches. Bay	17 Mar.	body	2	ND	
		18 Mar.	body	5	<0.01	ND-0.03
		6 Apr.	body	12	<0.01	ND-0.03
			roe	6	<0.01	ND-0.01
		12 Apr.	body	11	<0.01	ND-0.01
			roe	6	<0.01	ND-0.01
		17 May	body	7	0.01	ND-0.04
			roe	4	0.01	ND-0.01
		23 May	body	9	0.03	0.01-0.06
			roe	5	0.05	0.02-0.09
		7 Jun.	body	4	0.01	ND-0.02
			roe	3	<0.01	ND-0.02
American shad	Ches. Bay	12 Apr.	body	6	ND	
		7 Jun.	body	5	0.04	ND-0.07
			roe	2	0.05	0.05-0.06
	York (mouth)	9 Jun.	body	3	0.04	0.02-0.05
			roe	1	0.14	
Striped bass	James	12 Mar.	body	9	0.05	ND-0.38
		16 Mar.	body	4	0.54	0.03-1.47
		20 Mar.	body	8	0.27	ND-1.88
		21 Mar.	body	3	ND	
		23 Mar.	body	6	1.79	ND-3.91
		24 Mar.	body	2	0.02	ND-0.03
		27 Mar.	body	1	1.63	

*ND = Nondetectable; assumed zero for data analysis.

Table 6.2. Kepone concentration (ppm) in juvenile alosines and striped bass from rivers tributary to Chesapeake Bay, 1978.

Species	Collection site	Date	No. of samples	Concentration Mean	Concentration Range
Alewife	Potomac	16 Aug.	3	ND*	
	Rappahannock	28 Aug.	3	ND	
	Mattaponi	12-13 Sep.	3	ND	
	James	28 Jun.	6	0.58	0.39-0.77
	Chickahominy	19-21 Sep.	4	0.50	0.02-0.80
Blueback	Potomac	15 Aug.	3	ND	
	Rappahannock	28 Aug.	3	ND	
	Pamunkey	7 Sep.	3	ND	
	Mattaponi	12-13 Sep.	3	ND	
	James (mile 76-82)	18 Sep.	3	0.24	0.19-0.30
	James (mile 56-69)	19 Sep.	3	0.51	0.38-0.66
	Chickahominy (upper)	21 Sep.	3	0.20	0.17-0.23
	Chickahominy (lower)	21 Sep.	2	0.55	0.52-0.57
American shad	Mattaponi	12-13 Sep.	3	0.01	0
	James	19-20 Sep.	3	0.80	0.64-0.95
Striped bass	Potomac	16 Aug.	2	ND	
	Rappahannock	29-30 Aug.	2	ND	
	Pamunkey	7 Sep.	3	0.01	0
	Mattaponi	11-12 Sep.	5	<0.01	ND-0.01
	James	18-19 Sep.	4	0.57	0.14-0.92

*ND = Nondetectable; assumed zero for data analysis.

Job 7. Sturgeon - A General Pilot Study.

SUMMARY

Virginia

1. An estimated 2,500 kg of Atlantic sturgeon were caught and released in Virginia in 1978.

2. Sixteen tagged sturgeon, released in the Hudson River, have been captured in Virginia waters.

North Carolina

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 strugeon are endangered species. In North Carolina only the shortnose sturgeon is considered an endangered species.

MATERIALS AND METHODS

Virginia

Logbooks were placed with cooperating fishermen. An index of catch-per-unit-of-effort (c/f) was obtained by dividing total landings (in kg) of index fishermen by the number of pound nets or meters of gill netting fished by index fishermen for river strata. The index was then multiplied by the total number of pound nets or total meters of gill netting in a strata. Totals were then summed across strata and gear for a grand total by river.

All sturgeon weights were estimated by fishermen prior to the release of the fish. Logbooks are not placed with Potomac River fishermen, thus no records of incidental sturgeon catches were obtained from that river system.

North Carolina

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, 1977 through September 30, 1978.

RESULTS AND DISCUSSION

Virginia

Pound net and gill net fishermen in the James, York, Pamunkey, Mattaponi and Rappahannock rivers caught and released an estimated 2,500 kg of Atlantic sturgeon during the late winter and spring fishing season (Table 7.1). Stake gill nets on the James River caught 64% of all sturgeon reported by fishermen in Virginia. There were no reports of shortnose sturgeon caught by any of the cooperating fishermen.

Seven tags from Atlantic sturgeon were collected from local fishermen. These tags resulted from the tagging efforts of the New York State Department of Environmental Conservation and the Boyce Thompson Institute for Plant Research, Inc., William L. Dovel, principal investigator. As of July 1978, Mr. Dovel had tagged and released 3,929 sturgeon on the Hudson River, 16 of which had been returned from Virginia fishermen (personal communication).

It was impossible to obtain age structure, sex ratio, fecundity or time of spawning data on the sturgeon caught in Virginia because it

is illegal by Virginia law to possess Atlantic or shortnose sturgeon. Under this constraint, the fishermen immediately returned them to the water. To have obtained these data, it would have been necessary to have VIMS personnel accompany the numerous fishermen each time they tended their nets; we were financially inhibited from pursuing this course of action.

North Carolina

During the period October 1, 1977 through September 30, 1978, 29 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 7.2 shows the month, number, and species of sturgeon examined at each location during the sampling period.

Table 7.1. Estimated catch in kg of Atlantic sturgeon in Virginia rivers by gear in 1978. Index in kg/net and kg/meter of net for pound net and gill nets, respectively.

River	Gear	Mile	Index	Total Gill Net	Number Pound Nets	Estimated kg released
James	Stake Gill Net	05-15	.0547	9,171		502
	Stake Gill Net	15-45	.0578	18,963		1,096
	Total					1,598
York	Stake Gill Net	10-20	.0462	11,070		511
	Stake Gill Net	20-29	.0392	4,884		191
	Pound Net	0-10	2.2		12	26
	Total					728
Pamunkey	Drift Gill Net	30-55	.0098	2,743 (full-time fishermen)		27
	Drift Gill Net	30-55	.0020	3,014 (part-time fishermen)		6
	Total					33
Mattaponi	Drift Gill Net	30-50	.0066	1,829 (full-time fishermen)		12
	Drift Gill Net	30-50	.0013	1,918 (part-time fishermen)		2
	Total					14
Rappahannock	Stake Gill Net	20-35	.0042	16,890		71
	Pound Net	30-65	3.8571		18	69
	Total					140
				GRAND TOTAL		2,513

Table 7.2 Number and species of sturgeon examined at two sampling sites in North Carolina October 1, 1977 - September 30, 1978.

Month	Site A		Site B	
	Atlantic Sturgeon	Shortnose Sturgeon	Atlantic Sturgeon	Shortnose Sturgeon
Oct. 1977	2			
Nov. 1977	5		3	
Dec. 1977	1		1	
Jan. 1978				
Feb. 1978				
Mar. 1978				
Apr. 1978	1		4	
May 1978	1		1	
Jun. 1978	1		2	
Jul. 1978				
Aug. 1978	1			
Sept. 1978	6		—	
Total	18		11	

Job 8. Anadromous Fish Tagging

Job 8 was completed in 1977.

Job 9. Spawning Area Survey

SUMMARY

1. River herring and American shad spawning areas in the Roanoke River and its tributaries 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 Roanoke 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 of running-ripe females; (2) observation of spawning activity; and (3) capture of eggs or larvae. Table 9.1 show the dates of capture, location, number and species of running-ripe females taken by gill nets during this study. Figure 9.1 shows the relationship of temperature and time to catches of eggs and larvae for the study area. Tables 9.2 through 9.4 show the number and general locations of capture of alosine eggs nd larvae in the study area. Figure 9.2 shows the approximate spawning area locations for alewife, blueback herring, and American shad. Figure 9.3 shows the approximate spawning area locations for river herring as indicated by the capture of eggs and larvae.

Table 9.1. Observations of running-ripe females and spawning activity of river herring in the Roanoke River and its tributaries during 1978.

Date	Location	Number of fish	Species
3/21/78	Cashie River (Hoggard Mill Creek) SSR* 1301	1	Alewife
3/28/78	Cashie River (Wading Place Creek) SSR 1514	1	Alewife
4/03/78	Roanoke River (Gardners Creek) SSR 1511	2	Blueback
4/05/78	Roanoke River (Conoho Creek) mouth	1	Blueback
4/05/78	Roanoke River (Conine Creek) mouth	3	Blueback
4/05/78	Roanoke River (Cow Creek)	1	Blueback
4/06/78	Cashie River SSR 1225	2	Blueback
4/10/78	Cashie River SSR 1514	1	Blueback
4/12/78	Roanoke River SSR 1109	3	Blueback

*SSR: State secondary road

Table 9.2. River herring eggs collected by egg net in Roanoke River area.

Date	Location	Number of Eggs
3/27/78	Cashie River (Wading Place Creek) SSR* 1514	3
4/04/78	Roanoke River (Broad Creek) left fork	1
4/07/78	Cashie River (Wading Place Creek) SSR 1514	2
4/07/78	Roanoke River (Indian Creek) SSR 1126	4
4/12/78	Roanoke River (in Swamp) SSR 1109	200
4/12/78	Roanoke River 1 mile above Odom Prison	4
4/14/78	Roanoke River (Unnamed creek) N.C. Hwy 11	1
4/20/78	Roanoke River Coniott Creek at Power Lines	10
4/24/78	Roanoke River N.C. 11 Bridge	100
4/24/78	Roanoke River U.S. 258 Bridge	10
4/25/78	Roanoke River (Keehukee Swamp)	2
4/25/78	Roanoke River (Conine Creek) below U.S. 17	4
4/26/78	Roanoke River (Unnamed creek) Seaboard RR Bridge	1
4/26/78	Roanoke River (Bridgers Creek)	6
4/26/78	Roanoke River (Odom Prison)	5
4/27/78	Roanoke River (Gardners Creek) Tar Landing	20
4/27/78	Cashie River SSR 1225	2
4/27/78	Cashie River (Wading Place Creek) SSR 1514	2
5/01/78	Cashie River SSR 1225	1

*SSR: State secondary road

Table 9.3. River herring larvae collected by egg net in Roanoke River area.

Date	Location	No. of Larvae
4/12/78	Roanoke River (Unnamed creek) Seaboard RR Bridge	2
4/12/78	Roanoke River (Unnamed creek) U.S. 258 Bridge	2
4/14/78	Roanoke River (Indian Creek)	1
4/20/78	Roanoke River (Sweetwater Creek) mouth	3
4/20/78	Roanoke River (Coniott Creek) Power Lines	4
4/21/78	Roanoke River (Unnamed creek) U.S. 258 Bridge	5
4/24/78	Roanoke River U.S. 258 Bridge	3
4/24/78	Roanoke River N.C. 11 Bridge	5
4/25/78	Roanoke River (Conine Creek) U.S. 17	10
5/01/78	Cashie River SSR 1225	1
5/02/78	Cashie River (Roquist Creek) SSR* 1112	1

*SSR: State secondary road

Table 9.4. American shad larvae collected by egg net in Roanoke River area.

Date	Location	No. of Larvae
4/24/78	Roanoke River U.S. 258 Bridge	3
4/25/78	Roanoke River (Conoho Creek) Below N.C. 125	50
4/25/78	Roanoke River (Conine Creek) below U.S. 17	1

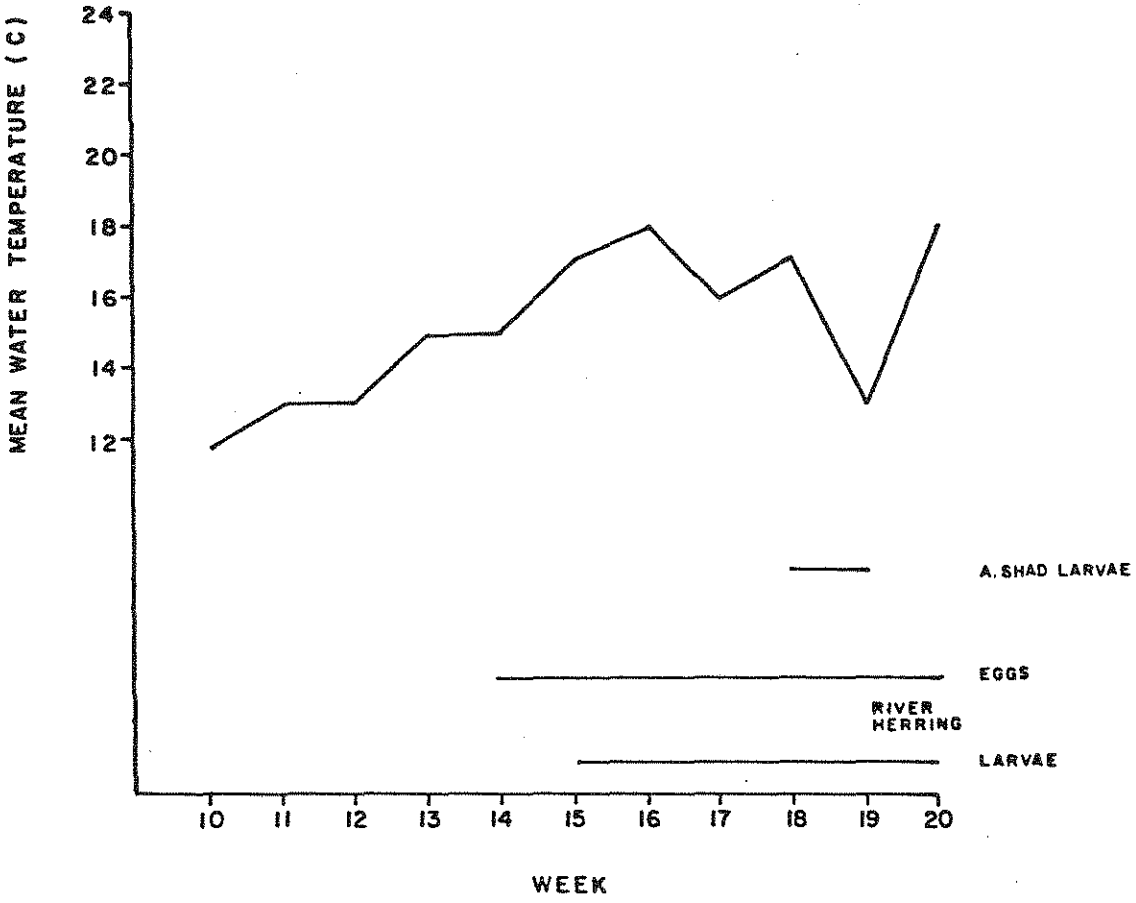

Figure 9.1. Spawning times and temperatures associated with the capture of river herring fish eggs and larvae in the Roanoke River.

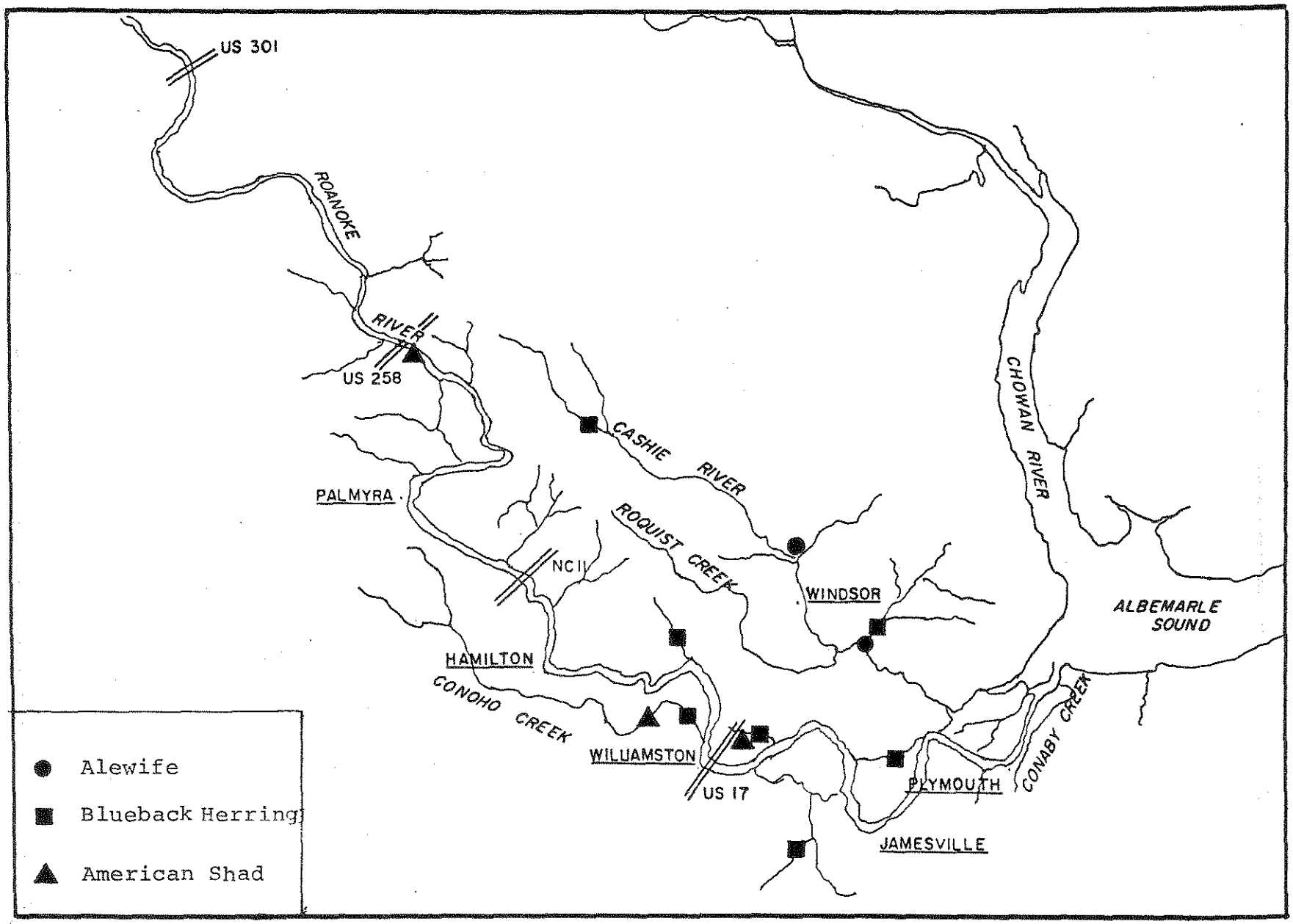

Figure 9.2. Spawning areas of alewife and blueback herring in Roanoke River as shown by observations of running-ripe females or spawning activity and spawning of American shad as shown by capture of eggs and larvae.

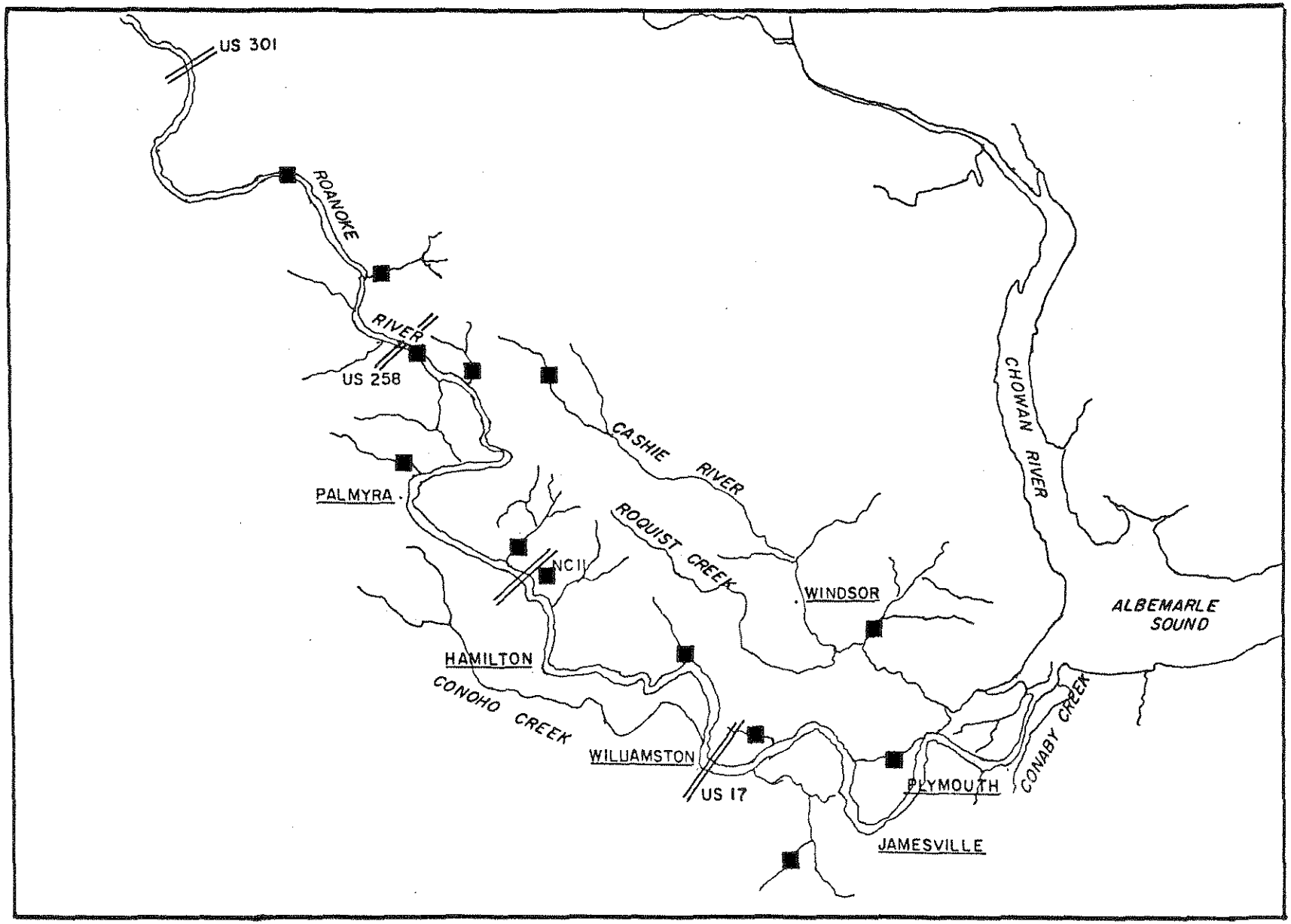

Figure 9.3. Spawning areas of river herring in Roanoke River area as shown by capture of river herring eggs and larvae.

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 or less beginning in 1980.

2. It is recommended that the Virginia Marine Resources Commission in conjunction with VIMS 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 of 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 28.3 metric tons (MT) of river herring was taken by foreign vessels along the Atlantic coast during 1978, all as by-catch by the Soviet Union and Spain. It is significant to note that the first seizures of foreign vessels for violations of U.S. fishing regulations under the Fishery Commission and Management Act were for excessive catches of river herring. Since the yearly total was only 28.3 MT

when the by-catch allocation was 453 MT, 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 453 MT in 1978 to 100 MT or less beginning in 1980.

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 shows a decline in river herring landings and c/f since the late 1960's and successive recruitment failures in recent years.

Job 11. Report Publication

INTRODUCTION

Job 11 was completed and published under separate cover (N.C. Dept. Nat. Res. & Community Development, Div. Mar. Fish. Spec. Sci. Rep. No. 30). Copies were forwarded to the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. The abstract of the publication (Kornegay 1978) is repeated herein.

ABSTRACT

The purposes of this study were to determine levels of agreement between ages obtained from scales and otoliths of alewife and blueback herring; to compare age composition of the sample as determined by both methods; to compare length composition within each scale and otolith age group; to compare fork length/scale radius and fork length/otolith radius relations; and to compare growth curves derived from scale and otolith data.

Levels of agreement between scale and otolith ages were 57.19% (alewife) and 67.96% (blueback herring). Age composition of the alewife sample as determined by both methods was statistically similar; however, differences occurred within the blueback herring sample. Length composition of each scale and otolith age group was determined to be statistically similar except in the age three groups of both species. Fork length/scale radius relations were linear in both species. Fork length/otolith radius relations differed notably.

Mean fork lengths of each scale and otolith age group were plotted as growth curves and appear similar in both species. Fork lengths at each previous scale and otolith age were determined by back calculation of annuli measurements of scales and otoliths. Mean back calculated fork lengths were plotted as growth curves. In both species, growth curves derived from back-calculation of scale annuli measurements tend to estimate values higher than growth derived from otolith annuli measurements.

LITERATURE CITED

Kornegay, J. W. 1978. Comparison of ageing methods for alewife and blueback herring. N.C. Dept. Nat. Resource and Community Development, Div. Mar. Fish., Spec. Sci. Rep. No. 30. 51 p.

Job 12. Analysis of Historical Catch Data of Anadromous Alosine Juveniles in Virginia Nursery Areas

SUMMARY

1. Reevaluation of 91 species-specific nursery zone boundaries resulted in 71 changes; 27 increased, 44 decreased, and 20 were unchanged. Nursery zone water volumes all changed; 30 increased and 61 decreased.

2. Ninety of the 91 recalculated catch-per-unit-of-effort values increased primarily because of the elimination of extraneous river areas and the associated effort. Similarly, all but three of the recalculated estimates of standing crop increased.

3. The adjusted juvenile data base is, at present, too small for analyses of cyclic reproductive success and its relationship to recruitment. However, we believe the precision of our estimates was improved, and the work is to be continued. An attempt will be made to further increase precision of relative abundance estimates by a consideration of climatic data which may affect the availability of fishes to our gear.

Job 12. Analysis of Historical Catch Data of Anadromous Alosine Juveniles in Virginia Nursery Areas

INTRODUCTION

Prior to 1977, the Virginia nursery area boundaries were considered static. Loesch et al. (1977), using site-of-first-catch data, found that the fixed lower boundaries were too far downriver in 1977, a year of low river flow. Thus, the use of fixed boundaries would result in overestimates of nursery area and volume, and an underestimate of catch-per-unit-of-effort (c/f). VIMS historical data were sufficiently detailed to reevaluate estimates of c/f and standing crop ($\hat{N}$) with a consideration of species-specific nursery area boundaries.

METHODS

The present methods for estimating an overall weighted catch-per-unit-of-effort ($\overline{c/f}$) and $\hat{N}$ in each nursery zone are described in Job 3. One difference is that prior to 1978 the river strata were not further subdivided, although in 1977 some nursery zones were subdivided, based on trends in catch data, and a $\overline{c/f}$ was determined. Another difference is that the adjusted (recalculated) data include bottom trawl samples; these catches were not previously considered because the functional measurements of the trawl were not then known. Water volume in a nursery zone was previously based on the assumption that the mean depth was 4 m (Hoagman et al. 1973); in the present report the data of Cronin (1971) were used to determine water volume

(see Job 3). Also, all initial and adjusted estimates of abundance are now expressed in terms of one standard push net sample, 896 m^3 of water sampled.

RESULTS AND DISCUSSION

The initial and adjusted estimates of nursery zone sizes and volumes and $\overline{c/f}$ and $\hat{N}$ are presented in Tables 12.1-12.6 for the years 1972 through 1977.

Delimitation of the lower and upper boundaries of nursery zones by the respective limits of the 9.3 km strata in which first and last catches of each species occurred resulted in 71 changes in the estimated size (river miles) of nursery grounds (27 increased, 44 decreased, and 20 were unchanged). Reevaluated nursery zone water volumes all changed; 30 increased and 61 decreased. Although 20 estimates of nursery zone size were unchanged, the respective water volumes changed because of the difference in the methods of estimation.

All but one of 91 reevaluations of the catch-effort data resulted in an increased $\overline{c/f}$. The increases were mainly due to the elimination of extraneous sampling areas and the associated effort. The inclusion of bottom trawl catches, which were often substantial, also contributed to the increase of $\overline{c/f}$. Similarly, all but three recalculated $\hat{N}$'s increased; the exceptions were due to reductions in nursery zone size and/or water volume.

The adjusted juvenile data base is, at present, too small for considerations of cyclic reproductive success and correlation to recruitment. However, this work is to be continued in the third segment of the contract. Additionally, an attempt will be made to further increase precision in estimating relative abundance by utilizing site-specific degree-of-cloud-cover data obtained from the U.S. Weather Bureau (National Climatic Center, Asheville, N.C.). These data are relative measures of light incident upon the water surface and, presumably, affect the availability of fishes to our sampling gear. The possibility of adjusting catch data to a constant condition, say overcast, will be investigated.

LITERATURE CITED

Cronin, W. B. 1971. Volumetric, areal, and tidal statistics of the Chesapeake Bay estuary and its tributaries. Chesapeake Bay Inst. Spec. Rep. No. 20. 135 p.

Hoagman, W. J., J. V. Merriner, R. St. Pierre and W. L. Wilson. 1973. Biology and utilization of anadromous alosids. Completion Rep. 1970-1973. Nat. Mar. Fish. Serv. Proj. No. AFC 7-1 to 7-3. 212 p.

Loesch, J. G., W. H. Kriete, Jr., H. B. Johnson, B. F. Holland, Jr., S. G. Keefe, and M. W. Street. 1977. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Nat. Mar. Fish. Serv. Proj. No. AFCS 9-1. 183 p.

Table 12.1. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the James River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	35-80	35-70	763.20	485.51	160	158	3.10	13.95	2.640	7.559
	1973	35-80	40-70	763.20	349.80	115	100	3.44	22.24	2.930	8.682
	1974	35-80	35-70	763.20	485.51	141	132	1.26	7.50	1.073	4.063
	1975	35-80	30-70	763.20	620.32	134	138	2.94	18.53	2.504	12.828
	1976	35-80	60-65	763.20	41.58	164	13	0.03	0.93	.025	.043
	1977	60-80	35-75	76.32	502.71	45	93	0.67	0.67	.057	.375
Blueback	1972	35-80	35-80	763.20	513.33	160	173	447.77	2373.41	381.404	1359.757
	1973	35-80	35-80	763.20	513.33	115	126	712.65	2270.71	607.025	1300.919
	1974	35-80	30-84	763.20	653.10	141	170	89.20	263.52	75.979	192.081
	1975	35-80	30-84	763.20	653.10	134	161	2246.07	7941.53	1913.170	5788.630
	1976	35-80	35-75	763.20	502.71	164	159	18.46	37.69	15.723	21.146
	1977	50-80	50-80	134.64	204.93	69	86	88.38	135.57	13.280	31.007
American shad	1972	35-80	35-80	763.20	513.33	160	173	3.71	19.56	3.160	11.206
	1973	35-80	35-80	763.20	513.33	115	126	5.71	23.90	4.863	13.692
	1974	35-80	30-84	763.20	653.10	141	170	3.78	13.22	3.219	9.636
	1975	35-80	30-84	763.20	653.10	134	161	1.09	7.47	.928	5.444
	1976	35-80	60-80	763.20	88.67	164	33	0.08	0.43	.068	.042
	1977	50-70	55-80	123.04	146.17	46	69	0.06	0.19	.008	.030

Table 12.2. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the Chickahominy River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972										
	1973										
	1974										
	1975	0-19	0-15	81.76	50.10	12	16	0.69	1.76	.062	.098
	1976					31	31	0			
	1977					26	26	0			
Blueback	1972										
	1973										
	1974										
	1975	0-19	0-15	81.76	50.10	12	16	1146.03	1554.87	104.570	86.940
	1976	0-19	0-10	81.76	40.52	31	19	8.67	32.46	.791	1.467
	1977	7-21	5-10	17.16	13.05	21	5	0.17	1.64	.003	.023
American shad	1972										
	1973										
	1974										
	1975	0-19	0-15	81.76	50.10	12	16	1.68	3.41	.153	.190
	1976					31	31	0	0		
	1977	7-21	5-10	17.16	13.05	21	5	0.08	0.85	.001	.012

Table 12.3. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the Pamunkey River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	30-60	30-55	102.40	98.77	108	101	1.22	7.09	.139	.781
	1973	30-60	30-55	102.40	98.77	80	85	2.73	23.44	.311	2.583
	1974	30-60	30-45	102.40	65.32	60	48	0.50	6.26	.057	.456
	1975	30-60	40-55	102.40	54.19	56	38	2.52	39.26	.287	2.374
	1976	30-60	55-60	102.40	7.34	42	2	0.08	2.00	.009	.016
	1977	40-60	35-60	55.00	82.45	33	40	0.47	1.64	.028	.150
Blueback	1972	30-60	35-60	102.40	82.45	108	93	14.56	64.56	1.663	5.940
	1973	30-60	30-55	102.40	98.77	80	85	54.76	436.56	6.258	48.123
	1974	30-60	35-50	102.40	61.18	60	46	2.94	33.50	.335	2.287
	1975	30-60	40-55	102.40	54.19	56	38	82.32	1026.85	9.407	62.103
	1976	30-60	50-60	102.40	21.27	42	7	0.08	1.21	.009	.028
	1977	40-65	40-65	59.44	65.39	40	46	50.71	90.62	3.364	6.613
American shad	1972	30-60	30-60	102.40	106.11	108	113	2.70	9.88	.308	1.170
	1973	30-60	30-55	102.40	98.77	80	85	3.52	17.79	.402	1.961
	1974	30-60	35-50	102.40	61.18	60	46	1.34	15.33	.153	1.046
	1975	30-60	40-55	102.40	54.19	56	38	0.92	12.00	.105	.725
	1976	30-60	50-55	102.40	13.93	42	5	0.08	0.80	.009	.012
	1977	40-60	40-60	55.00	61.53	33	39	0.59	0.76	.036	.052

Table 12.4. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the Mattaponi River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	30-50	30-50	47.80	52.92	94	94	2.43	21.57	.129	1.273
	1973	30-50	30-45	47.80	40.83	62	51	7.39	93.48	.394	4.259
	1974	30-50	30-50	47.80	52.92	60	65	0.02	1.50	.001	.088
	1975	30-50	30-50	47.80	52.92	37	42	0.33	7.10	.017	.419
	1976					33	33	0	0		
	1977	40-60	40-50	41.44	26.80	31	22	0.05	0.27	.002	.008
Blueback	1972	30-50	30-45	47.80	40.83	94	71	13.22	108.35	.705	4.937
	1973	30-50	30-50	47.80	52.92	62	64	4.36	39.98	.232	2.361
	1974	30-50	35-50	47.80	39.56	60	50	3.86	49.06	.205	2.166
	1975	30-50	35-50	47.80	39.56	37	30	13.10	177.93	.698	7.855
	1976	30-50	45-50	47.80	12.09	33	5	0.10	1.69	.005	.022
	1977	40-60	40-60	41.44	34.52	31	39	16.20	18.89	.749	.727
American shad	1972	30-50	30-55	47.80	57.81	94	104	5.52	33.37	.294	2.153
	1973	30-50	30-50	47.80	52.92	62	64	10.16	76.76	.542	4.533
	1974	30-50	30-50	47.80	52.92	60	65	0.75	7.64	.040	.451
	1975	30-50	35-50	47.80	39.56	37	30	0.75	11.20	.040	.494
	1976	30-50	35-40	47.80	12.76	33	6	0.08	0.64	.004	.009
	1977	40-60	40-60	41.44	34.52	31	39	1.53	2.44	.070	.094

Table 12.5. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the Rappahannock River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	50-80	40-85	129.40	198.40	86	136	18.88	52.03	2.726	11.520
	1973	50-80	40-80	129.40	191.94	69	96	29.73	149.95	4.293	32.122
	1974	50-80	50-85	129.40	119.26	85	99	0.42	4.22	.060	.561
	1975	50-80	45-85	129.40	151.42	99	132	4.87	33.13	.703	5.598
	1976	50-80	60-90	129.40	73.42	45	34	0.18	4.11	.025	.336
	1977	50-85	50-93	132.08	127.22	60	93	2.42	9.43	.356	1.338
Blueback	1972	50-80	40-85	129.40	198.40	86	136	223.69	566.92	32.305	125.532
	1973	50-80	40-85	129.40	198.40	69	105	550.11	2169.23	79.446	480.329
	1974	50-80	45-85	129.40	151.42	85	113	40.23	321.95	5.810	54.408
	1975	50-80	45-85	129.40	151.42	99	132	535.50	2857.03	77.336	482.825
	1976	50-80	45-90	129.40	156.90	45	68	45.36	98.57	6.550	17.260
	1977	50-85	50-93	132.08	127.22	60	93	543.45	836.71	80.110	118.801
American shad	1972	50-80	40-65	129.40	157.16	86	105	0.25	1.34	.036	.235
	1973	50-80	45-85	129.40	151.42	69	93	0.50	1.88	.072	.317
	1974	50-80	70-85	129.40	23.76	85	39	0.08	2.11	.011	.055
	1975	50-80	45-85	129.40	151.42	99	132	0.16	1.11	.023	.187
	1976					45	68	0	0		
	1977	50-85	65-85	132.08	41.24	60	45	0.08	0.43	.011	.019

Table 12.6. Reevaluation of nursery zone size, juvenile alosine catch-per-unit-of-effort ($\overline{c/f}$) and standing crop ($\hat{N}$) in the Potomac River, 1972-1977.

Species	Year	River miles		Volume ($10^6 m^3$)		No. samples		$\overline{c/f}$		$\hat{N}$ (in millions)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	65-95	60-95	824.80	854.96	125	153	1.02	3.23	.938	3.082
	1973	65-95	65-95	824.80	659.54	99	102	0.33	2.10	.303	1.545
	1974	65-95	80-95	824.80	177.50	90	49	0.25	4.28	.230	.847
	1975	65-95	65-95	824.80	659.54	97	104	0.33	3.06	.303	2.252
	1976	65-95	75-95	824.80	281.43	155	72	0.25	1.42	.230	.446
	1977	68-94	65-95	436.52	659.54	106	118	3.35	5.38	1.632	3.960
Blueback	1972	65-95	60-95	824.80	854.96	125	153	23.85	131.03	21.954	125.028
	1973	65-95	65-95	824.80	659.54	99	102	3.02	14.63	2.780	10.769
	1974	65-95	75-95	824.80	281.43	90	65	1.09	13.64	1.003	4.284
	1975	65-95	60-95	824.80	854.96	97	123	197.48	1316.08	181.787	1255.798
	1976	65-95	70-90	824.80	447.66	155	105	0.84	2.69	.773	1.343
	1977	68-94	65-95	436.52	659.54	106	118	151.71	228.93	73.911	168.513
American shad	1972	65-95	60-95	824.80	854.96	125	153	0.30	1.36	.276	1.297
	1973	65-95	75-95	824.80	281.43	99	68	0.03	0.40	.027	.125
	1974					90	113	0	0		
	1975	65-95	85-95	824.80	110.16	97	30	0.03	1.13	.027	.138
	1976					155	184	0	0		
	1977					106	118	0	0		