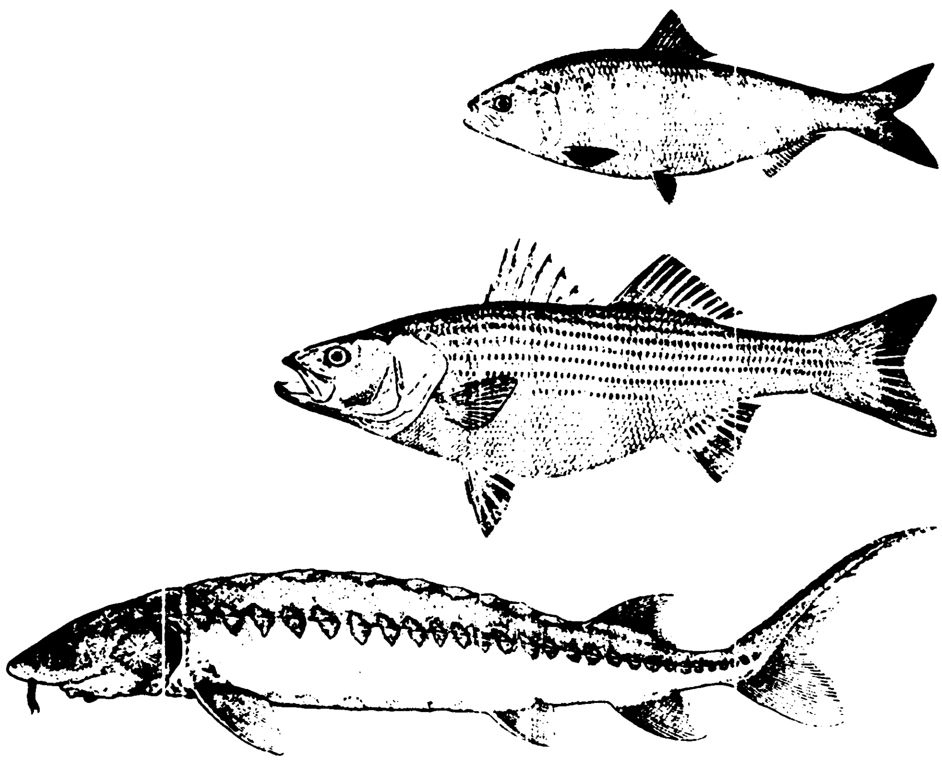
1-1-1980

Biology and Management of Mid-Atlantic Anadromous Fishes Under Extended Jurisdiction

North Carolina Department of Natural Resources and Community Development Division of Marine Fisheries

Virginia Institute of Marine Science

Biology and Management of Mid-Atlantic Anadromous Fishes Under Extended Jurisdiction



COMPLETION REPORT,
ANADROMOUS FISH PROJECT, 1977-1979

Part I, North Carolina Department of Natural Resources and Community Development
Morehead City, North Carolina 28557

Part II, Virginia Institute of Marine Science
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

BIOLOGY AND MANAGEMENT OF MID-ATLANTIC ANADROMOUS FISHES

UNDER EXTENDED JURISDICTION

Part I: North Carolina

Prepared by

Harrel B. Johnson, Sara E. Winslow, Douglas W. Crocker
Benjamin F. Holland, Jr., John W. Gillikin and
David L. Taylor

North Carolina Department of Natural Resources
and Community Development
Division of Marine Fisheries
Morehead City, North Carolina 28557

Special Scientific Report No. 36

Part II: Virginia

Prepared by

Joseph G. Loesch, William H. Kriete, Jr., Jack G. Travelstead,
Eric J. Foell and Marion A. Hennigar

Virginia Institute of Marine Science
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

Special Report No. 236 in Applied Marine
Science and Ocean Engineering

This project was funded, in part, by the US Department of Commerce, NOAA, National Marine Fisheries Service, Northeast and Southeast Regions, and the US Department of Interior, Fish and Wildlife Service, Southeast Region, under the Anadromous Fish Conservation Act (PL 89-304, as amended), Project AFCS-9.

Part I

North Carolina Division of Marine Fisheries

TABLE OF CONTENTS

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

PREFACE

This is a joint presentation by the North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries (DMF) (Part I) and the Virginia Institute of Marine Science (VIMS), Department of Ichthyology (Part II). It is for the period October 1, 1976 to September 30, 1979, and is the completion report for the P. L. 89-304 project "Biology and Management of Mid-Atlantic Anadromous Fishes Under Extended Jurisdiction." Species of concern are: 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 Concentration 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 ageing 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

Job 13. Assessment of Racial Stocks of River Herring

Objective

1. Determine and classify racial stocks of river herring along the Atlantic coast.

Agency: VIMS

Appendices I, II, and III follow Job 12 in Part II (Virginia). Appendices I and II are manuscripts that were direct products of the funded research. These manuscripts were submitted to peer-review, scientific journals. Appendix III summarizes other activities conducted during the three years of research. Some of these activities were directly related to the research project while others were axillary to it. Examples of the latter were student theses. Students received financial support for assisting in project work (20/week); in turn, because of the financial support, the students were able to continue their studies and research. Their research was related to, but not part of, the contractual obligations.

Appendices I and II and potential manuscripts from Appendix III data are subject to review and possible revision. Thus, inclusion of these data in this completion report does not constitute final publication.

The Virginia contributors were as follows: Jobs 1, 4, and 7 by William H. Kriete, Jr., Jobs 2, 3, 6, and 10 by Joseph G. Loesch; Jobs 4 and 13 by Jack G. Travelstead; Jobs 6 and 12 by Eric J. Foell; and Job 12 by Marion A. Hennigar.

The North Carolina contributors were as follows: Jobs 1, 2, 7 by Harrel B. Johnson and Sara E. Winslow; Job 3 by Sara E. Winslow and Douglas W. Crocker; Job 5 by Benjamin F. Holland, Jr., John W. Gillikin and David L. Taylor; Job 8 by Harrel B. Johnson; Job 9 by Sara E. Winslow; Job 10 by Harrel B. Johnson.

ACKNOWLEDGMENTS

The Virginia Institute of Marine Science research was ably assisted by: J. Bristow, J. Davis, K. Friedland, J. Gourley, J. Johnson, D. Lipton, C. Leigh, D. Ludi, J. Millen, T. Mosca, C. Orselli, J. Owens, C. Peet, N. Peters, A. Polizos, T. Scott, D. Simmons, B. Taylor, J. Zernes and the personnel of the Potomac River Fisheries Commisssion and NOAA Division of Statistics and Market News. We are also indebted to Robert E. Taber, Wakefield, R.I. for his assistance with determining net opening areas which were vital to jobs 3 and 12.

The North Carolina Division of Marine Fisheries is indebted to the following people for their invaluable assistance: Captain Robert Guthrie and the crew of the R/V DAN MOORE, Scott G. Keefe, Robert C. Harriss, Olivia Reeves, Jackie Davis, Margaret Stafford and the fisheries inspectors of the First District.

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

LIST OF TABLES

List of Tables (continued) Page Number

List of Tables (continued) Page Number

List of Tables (continued) Page Number

LIST OF FIGURES

List of Figures (Continued)

List of Figures (Continued)

Job 1. Catch-Effort Statistics, Inshore Alosine Fishery

SUMMARY

1. The total catch of river herring for the pound net fishery in Albemarle Sound area was 3,644,836 kg in 1977, 2,554,986 kg in 1978 and 2,226,656 kg in 1979.

2. A peak catch occurred during week 15 in 1977, when a total of 1,380,599 kg of river herring was landed. The peak catch for 1978 occurred during week 16 when a total if 828,081 kg was landed, and the peak catch occurred during week 16 in 1979 when 521,284 kg of river herring was landed.

3. The total number of pound nets fished during week 15, 1977 was 624. The catch-per-unit-of-effort (c/f) for week 15 was 2,212.5 kg of river herring. In 1978 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. During week 16, 1979, the total number of pound nets fished was 501. For week 16, the catch-per-unit-of-effort (c/f) was 1,040.4 kg of river herring.

Job 1. Catch-Effort Statistics, Inshore Alosine Fishery

INTRODUCTION

Estimates of total landings by gear type were 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

In North Carolina weekly pound net landings were obtained from cooperating dealers. The number of pound nets fished each week was obtained biweekly. The c/f (kg/pound net week) was calculated by dividing the total number of kilograms landed by the total weekly number of active pound nets (Table 1.1-1977- Loesch et al. 1977), (Table 1.2-1978 - Johnson et al, 1978), (Table 1.3-1979).

RESULTS AND DISCUSSION

Pound net catch-effort statistics for the Albemarle Sound river herring fishery are presented in Table 1.3 for each week sampled in 1977 (Loesch et al. 1977). Table 1.2 shows the pound net c/f statistics for each week in

1978 for the Albemarle Sound river herring fishery (Johnson et al. 1978). Albemarle Sound river herring fishery c/f statistics for 1979 are presented in Table 1.3. Weeks were serially numbered beginning with the first full week in January. No significant catches of river herring were made in 1977 prior to week 9 or after week 17 (Loesch et al. 1977), in 1978 prior to week 10 or after week 20 (Johnson et al. 1978). In 1979 no significant catches were made prior to week 8 or after week 19. The total catch for the 1978 period was down some 1,089,850 kg (29%) compared to 1977 (Johnson et al. 1978) (Loesch et al. 1977). For 1979, the total catch was down 1,418,180 kg (38%) compared to 1977, and 328,330 kg (12%) compared to the catch for 1978 (Loesch et al. 1977) (Johnson et al. 1978). It should be noted however, that effort was also reduced in 1978 and 1979, as the result of winter ice destroying many active pound net sets.

LITERATURE CITED

Crochet, D. W., D. W. Allen and M. L. Hornberger. 1976. Evaluation of commercial fisheries for American shad in South Carolina and status of the species in selected waters. Proc. Workshop on American Shad. U.S. Fish Wildl. Serv. and Nat. Mar. Fish. Serv. Amherst, MA. p.4.

Friedersdoff, J. W. 1976. Population estimates and relative abundance work on adult American shad stocks in the Delaware River (1969-1976). Proc. Workshop on American Shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p.83.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 p.

Jones, Robert A., Peter Minta, and Victor Crecco. 1976. A review of American shad studies in the Connecticut River. Proc. Workshop on American Shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 135.

Klauda, Ronald J., Marcia Nittel, and K. Perry Campbell. 1976. The commercial fishery for American shad in the Hudson River: Fishing effort and stock abundance trends. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 107.

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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Table 1.1. Catch-effort statistics for river herring taken in the North Carolina pound net fishery, 1977.

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

Table 1.2 Catch-effort statistics for river herring taken in the North Carolina pound net fishery, 1978.

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
	2,554,986		

Table 1.3 Catch-effort statistics for river herring taken in the North Carolina pound net fishery, 1979.

Week	Weekly landings (kg)	Number of pound Nets	c/f(kg)
8	14,832	140	105.9
9	28,940	300	96.4
10	34,944	320	109.2
11	61,231	375	163.2
12	131,565	402	327.2
13	477,310	455	1049.0
14	319,705	500	639.4
15	290,843	502	579.3
16	521,284	501	1040.4
17	213,439	501	426.0
18	95,783	501	191.1
19	36,780	499	73.7
	2,226,656		

Job 2. Population Dynamics of Adults-Inshore Alosine Fishery

SUMMARY

1. Blueback herring comprised 96% of river herring samples in 1977, 77% in 1978, and 51% in 1979, although alewife dominated the earliest catches each year.

2. The male to female sex ratio for blueback herring in 1977 was 1.09:1. while that for alewife was 1.14:1. In 1978, blueback was 1.5:1, while alewife was 1.7:1. In 1979, the blueback sex ratio was 1.5:1, while alewife was 2.5:1.

3. The age ranges for male and female blueback herring in 1977 were age 3 to age 8 and age 4 to age 8, respectively. The 1978 age ranges were age 3 to age 7 for both sexes. The ranges were age 3 to age 8 in 1979 for both sexes.

4. Ages 4, 5, and 6 constituted 99% of the male blueback herring and 96% of females sampled in 1977. For 1978 the same age groups accounted for 94% of the males and 96% of the females. In 1979, 89% of the male blueback herring and 93% of the females sampled were of these age groups.

5. The 1977 spawning population of blueback herring was composed of 79.9% virgin males and 74.2% virgin females. The 1978 spawning population of blueback herring was composed of 75.9% virgin males and 69.6% virgin females. For 1979, 47.1% of the males and 32.2% of the females were on their initial spawning run.

6. The age ranges in 1977-78 for male and female alewife were age 3 to age 7 and age 3 to age 8, respectively. Age ranges in 1979 were age 3 to age 8 and age 3 to age 7, respectively.

7. In 1977, age groups 4, 5, and 6 constitued 98% of the alewife males and 97% of the females sampled. The 1978 data showed that 95% of the male alewife and 94% of the female alewife were ages 4, 5, and 6. In 1979, these age groups made up 91% of the male sample and 95% of the female sample.

8. The 1977 spawning population of alewife was composed of 78.2% virgin males and 77.4% virgin females, the 1978 population contained 76.5% virgin males and 68.8% virgin females, and in 1979 65.0% virgin males and 55.9% virgin females.

9. The age range for both male and female American shad in 1977 was age 4 to age 7. For 1978, the age ranges for male and female shad were age 3 to age 7 and age 4 to age 7, respectively. In 1979, ages ranged from

age 4 to age 9 for males, and age 5 to age 10 for females. In 1977, ages 4 and 5 constituted 88% of the males sampled, while ages 5 and 6 constituted 96% of the females sampled. For 1978, ages 4, 5, and 6 comprised 90% of the males sampled and 96% of the females sampled. In 1978, age groups 5, 6, and 7 comprised 77% of the male sample, while age groups 6, 7, and 8 comprised 87% of the female sample.

10. Hickory shad ages ranged in 1977 from 4 to 7 years for both sexes, and in 1978 from 3 to 6 years for both sexes. Ages ranged in 1979 from 3 to 7 years for males, while females ranged from 3 to 8 years. Eighty-five percent of the hickory shad sampled in 1977 (sexes combined) were virgin fish, in 1978, 64% were virgin fish, and in 1979, 82.7% were virgin fish.

Job 2. Population Dynamics of Adults-Inshore Alosine Fishery

INTRODUCTION

The North Carolina Division of Marine Fisheries (DMF) continued its annual assessment of the structure of adult alosine populations.

MATERIALS AND METHODS

Commercial harvest sampling sites were the same as the six stations established during Project AFCS-11 (Johnson et al. 1977) (Figure 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 warrent 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

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. In 1977, unculled samples were also taken in the lower Scuppernong River during tagging operations (Loesch et al. 1977). All early catches of river herring were dominated by alewife; blueback herring became the dominant species at approximately mid-season during 1977 weeks 11 and 12, (Figure 2.2-Loesch et al. 1977). In 1978 blueback became dominant during weeks 12 and 13 (Figure 2.3-Johnson et al. 1978). In 1979, blueback herring dominance was established during weeks 12 and 13 (Figure 2.4). These data agree closely with those reported by Street et al. (1975) and Johnson et al. (1977).

Data taken in 1977 from tagging operations in the lower Scuppernong River probably best estimated the species composition since they are the results of direct counts of all fish captured. However, data taken from sites on the Scuppernong and Chowan Rivers were limited, usually about 100 fish per sample. Species composition for the entire 1977 season determined from tagging operations in the lower Scuppernong River was 96% blueback herring and 4% alewife (Loesch et al. 1977). For the entire 1978 season, using data taken from the Scuppernong and Chowan Rivers, the species composition was 77% blueback herring and 23% alewife (Johnson et al. 1978). The species composition for the entire 1979 season, determined from sampling on Scuppernong and Chowan Rivers, was 51% blueback herring and

49% alewife.

Sex Ratios - River Herring

Sex ratios were obtained from combined data taken at sites located on the Scuppernong, Chowan, Alligator and Meherrin Rivers during 1977-1979. Pound nets at these sites are believed to be nonselective. During 1977 the male to female sex ratios were 1.09:1 for blueback herring and 1.14:1 for alewife. Chi square analysis of the hypothetical 1:1 sex ratio indicated that the alewife ratio was significantly different ($P<0.05$) but the blueback herring ratio was not ($P>0.10$) (Loesch et al. 1977). The male to female sex ratios for 1978 were 1.5:1 for blueback herring and 1.7:1 for alewife. Chi square analysis indicated that both the alewife and blueback herring ratios were highly significant at the 95% confidence level (Johnson et al. 1978). During 1979, the male to female sex ratios were 1.5:1 for blueback herring and 2.5:1 for alewife. The χ^2 analysis of the hypothesis of a 1:1 sex ratio indicated that both species were significant at the 95% level.

Sex Ratios - American Shad

A sex ratio of 1.34:1 (males to females) was obtained from the pooled data of all samples in 1977. The χ^2 analysis of the hypothesis of a 1:1 sex ratio indicated that the ratio was highly significant ($P<0.005$) (Loesch et al. 1977). American shad male to female sex ratio for 1978 was 1.4:1. The χ^2 value was significant at a 95% confidence level (Johnson et al. 1978). A sex ratio of 1.6:1 (males to females) was obtained from pooled data of all samples in 1979. Chi square analysis of the hypothesis of a 1:1 sex ratio indicated that the American shad ratio was significant at 95% confidence level. The estimated sex ratio, however is biased because the gill nets employed are selective for females. The actual sex ratio for the population is unknown.

Sex Ratios - Hickory Shad

Sex ratios for hickory shad were also obtained from the pooled data for each year of the study. In 1977, the male to female sex ratio was 1:1.07. The χ^2 analysis of the hypothesis of a 1:1 sex ratio indicated that the hickory shad ratio was significant at a 95% confidence level (Loesch et al. 1977). Johnson et al. (1978) reported in 1978 that the male to female sex ratio was 0.3:1. The χ^2 analysis of the hypothesis once again indicated significance at the 95% level. The male to female sex ratio was 0.2:1 for 1979. The χ^2 analysis of the hypothesis of a 1:1 sex ratio indicated that the ratio was significant at the 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 1977, 1978, and 1979 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:

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

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

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

N_t = number in the t th age group

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

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 mortality rates higher.

Mortality estimates reported by Johnson et al, (1978) for 1978 were in error. The mortality estimates have been corrected and are given in this report.

The mortality estimate for blueback herring during 1979 was 54%, a lower value than those of 1978 (70%) and 1977 (60%) (Loesch et al. 1977).

Mortality estimates for alewife during 1977 were 72% (Loeach et al. 1977), and 73% for 1978. For 1979, mortality estimates for alewife were 67%, slightly lower than the two previous years.

Loesch et al. (1977) reported that the mortality estimates for American shad in 1977 were 82%. Mortality estimates in 1978 were 89%. For 1979, American shad mortality estimates were 78%, the lowest value for the three years of the study.

Mortality estimates for hickory shad in 1977 were 82%, as reported in Loesch et al. (1977). In 1978, mortality estimates were 58% a significant reduction. Hickory shad mortality estimates for 1979 were 72%. The variability of the mortality is probably due to the biased fishing gear.

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 for 1977 are presented in Tables 2.1 through 2.6 (Loesch et al. 1977). The data for 1978 are presented in Tables 2.7 through 2.12, as reported by Johnson et al. (1978). The 1979 data are presented in Tables 2.13 through 2.18.

The present data were found to agree, in general, with that reported by Street et al. (1975), Johnson et al. (1977 and 1978) and Loesch et al. (1977).

The Alligator River data are probably biased since fishermen there were only active during the early part of the 1977, 1978 and 1979 seasons.

There were 1,009 blueback herring scale samples in 1977, (Loesch et al. 1977), 649 in 1978, (Johnson et al. 1978), and 856 in 1979 which were found suitable for age determination. Ages of males in 1977 ranged from 3 to 8 years, while females ranged from 4 to 8 years in age (Table 2.1 - Loesch et al. 1977). Ages for males and females were found to range from 3 to 7 years in 1978, (Table 2.7 - Johnson et al. 1978). In 1979, ages of both sexes ranged from 3 to 8 years (Table 2.13).

Age groups 4, 5, and 6 made up 96% of the female samples and 99% of the male samples in 1977 as reported by Loesch et al. (1977). In 1978, as reported by Johnson et al. (1978), the same age groups made up 96% of the female samples and 94% of the male samples. In 1979, age groups 4-6 made up 93% of the female samples and 89% of the male samples. The values for 1977 and 1978 are much higher than those reported in Street et al. (1975) but similar to those reported in Johnson et al. (1977), indicating a continued lack of older fish. However, in 1979 the values are closer to those reported in Street et al. (1975). Combined data from all sampling locations showed a spawning population comprised of 79.9% virgin males and 74.2% virgin females in 1977 (Loesch et al. 1977), 75.9% virgin males and 69.6% virgin females in 1978 (Johnson et al. 1978), and 47.1% virgin males, 32.2% virgin females in 1979. Scale samples from female blueback in 1978 had up to three spawn marks as reported by Johnson et al. (1978). Scale samples for 1977 and 1979 from female blueback herring had up to four spawn marks. Male blueback scale samples from 1977-1979 had up to three spawn marks. Only 1% of the fish had spawned more than twice for the years 1977 (Loesch et al. 1977) and 1978 (Johnson et al. 1978), but in 1979, 2.6% of the fish sampled had spawned more than twice. These are lower values than the 4.4% reported by Street et al. (1975), but the 2% reported in Johnson et al. (1977) is very close to that reported for 1979. The proportion of repeat spawners (sexes combined) was 23% for 1977 (Loesch et al. 1977), and 27% for 1978 (Johnson et al. 1978). In 1979, the proportion of repeat spawners was 59%, a much higher value than that for the two previous years.

Data for 1979 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 1978), and Loesch et al. (1977). The spawning population in the Scuppernong River for 1979 was composed of 72.6% virgin fish (Table 2.14), similar to the 1977 value of 71.8% reported by Loesch et al. (1977 - Table 2.2), but lower than the range of 80-87% reported by Street et al. (1975), Johnson et al. (1977, 1978 - Table 2.8). Ages for male blueback herring in the Scuppernong River in 1977 ranged from 3 to 5 years (Table 2.2) while females ranged from 4 to 6 years (Loesch et al. 1977). Johnson et al. (1978) reported that male blueback ranged from 3 to 6 years, while females ranged from 4 to 7 years (Table 2.8). For 1979, male blueback herring ranged from 3 to 8 years and females ranged from 3 to 7 years (Table 2.14). Loesch et al. (1977) found that only 3% of the fish (sexes combined) were over age 5 (Table 2.2), while Johnson et al. (1978) reported that 10% were over age 5 (Table 2.8). In 1979, there were 11% over age 5 (Table 2.14).

Data collected from the haul seine fishery on the Meherrin River for 1977 (Table 2.3) showed that virgin fish comprised 90.8% of the males and 78.8% of the females sampled from the spawning population of blueback herring (Loesch et al. 1977). Johnson et al. (1978) reported that virgin fish comprised 72.8% of the male sample and 61.0% of the female sample in 1978 (Table 2.9). Data collected from the haul seine fishery for 1979 showed that virgin fish comprised 44.9% of the males and 22.6% of the females sampled (Table 2.15). Ages for males in 1977, ranged from 4 to 7 years, while females ranged from 4 to 8 years (Loesch et al. 1977). Johnson et al. (1978) reported that ages for males ranged from 3 to 7 years, while females ranged from 4 to 7 years. Ages for males in 1979 ranged from 3 to 7 years, while females ranged from 3 to 8 years. In 1977 and 1978, 6% of the bluebacks sampled (sexes combined) spawned more than once (Table 2.3 - Loesch et al. 1977) (Table 2.9 - Johnson et al. 1978). In 1979, 17% of the fish (sexes combined) had spawned more than once (Table 2.15), indicating an increase of older fish. There is no explanation for the increase of older fish.

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

Data for the Chowan River showed that 75.9% of the blueback herring in 1977 were virgin fish (sexes combined) (Table 2.4 - Loesch et al. 1977). For 1978, 74.7% of the blueback herring (sexes combined) were virgin (Table 2.10 - Johnson et al. 1978). The 1979 data for the Chowan River shows that only 31.6% of the bluebacks were virgin (sexes combined), (Table 2.16), a sharp decrease from 1977 and 1978. Loesch et al. (1977) reported that ages of males ranged from 4 to 7 years, while females ranged from 4 to 8 years in 1977. Data for 1978 showed that males and females ranged from 3 to 7 years (Johnson et al. 1978). Ages for 1979 males ranged from 3 to 7 years, while females ranged from 3 to 8 years. Age groups 4, 5, and 6 made up 99% of the male sample and 94% of the female sample for 1977, (Table 2.4 - Loesch et al. 1977). In 1978, Johnson et al. (1978) reported that the same age groups made up 95% of the male and female samples (Table 2.10). In 1979, the same age groups made up 91% of the male and female samples (Table 2.16). Loesch et al. (1977) and Johnson et al. (1978) reported that 7% of the sample (sexes combined) had spawned more than once. Data for 1979 showed that 20% of the sample had spawned more than once (sexes combined), a significant increase from that of 1977 and 1978. No explanation can be made for the increase of repeat spawners in 1979.

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. Blueback and alewife samples were obtained in 1977, but only alewife in 1978 and 1979. Combined data for Alligator River, although probably not truly representative of the spawning population of that system, showed that 73.6% (sexes combined) of the blueback herring in that system were virgin fish (Table 2.5). Ages ranged from 4 to 8 years for males and 4 to 7 for females. Age groups 4 and 5 comprised 90% of the male sample and 82% of the female sample. Twenty-six percent of the sample (sexes combined) had spawned previously (Table 2.5 - Loesch et al. 1977).

A total of 965 alewife scale samples in 1977, 679 alewife in 1978, and 665 alewife in 1979 were found suitable for age determination. Combined data for 1977 for all sample sites are presented in Table 2.1 (Loesch et al. 1977), for 1978, Table 2.7 (Johnson et al. 1978), and in Table 2.13 for 1979 data. During 1977 and 1978, ages of male alewife ranged from 3 to 7 years, while females ranged from 3 to 8 years (Loesch et al. 1977), (Johnson et al. 1978). In 1979 ages of male alewife ranged from 3 to 8 years and female alewife ranged from 3 to 7 years. Age groups 4, 5, and 6 made up 98% of the male portion of the sample and 97% of the female portion of the sample for 1977 (Loesch et al. 1977). The same age groups in 1978 accounted for 95% of the males and 94% of the females (Johnson et al. 1978). Age groups 4, 5, and 6 made up 91% of the males and 95% of the females in 1979. Combined data from all locations indicate an alewife spawning population comprised of 78.2% virgin males and 77.4% virgin females in 1977 (Loesch et al. 1977), 76.5% virgin males and 68.8% virgin females in 1978 (Johnson et al. 1978), and 65% virgin males and 55.9% virgin females in 1979. Scales from males had up to two spawn marks, while scales from females had up to three spawn marks in 1977 (Loesch et al. 1977). Johnson et al. (1978) reported that scales from males had up to three spawn marks, while scales from females had up to four spawn marks in 1978. In 1979, scales from males had up to four spawn marks; females had up to three spawn marks. Four percent of the alewife examined in 1977 (sexes combined) had spawned more than once (Table 2.1 -Loesch et al. 1977). In 1978, 7% of the alewife were found to have spawned more than once (Table 2.7 - Johnson et al. 1978). Nine percent of the alewife sampled in 1979 (sexes combined) had spawned more than once (Table 2.13).

Ages of male and female alewife from the Scuppernong River in 1977 ranged from 4 to 6 years (Table 2.2 - Loesch et al. 1977). Too few fish were examined in 1978 to make an attempt at comparing age or frequency of spawning with that of other areas or years. However, data collected are presented in Table 2.8 (Johnson et al. 1978). Again, in 1979 too few alewife were sampled, but data collected are shown in Table 2.14.

Alewife samples obtained from the Meherrin River in 1977 showed age ranged of 3-6 years for males and 3-7 for females (Loesch et al. 1977). Ages of males ranged from 3 to 6 years, and females from 3 to 8 years in 1978 (Johnson et al. 1978). In 1979, too few alewife were sampled from the Meherrin River to make any attempt at comparing age or frequency of spawning with that of other areas. However, data collected are presented in Table 2.15. Eighty-three percent of the sample in 1977 (sexes combined) were virgins (Table 2.3 - Loesch et al. 1977). In 1978, 76.5% of all the samples were virgins (Table 2.9 - Johnson et al. 1978). Loesch et al. (1977) reported that only 5% of the fish in 1977 (sexes combined) had spawned more than once (Table 2.3). Johnson et al. (1978) found that only 6% had spawned more than once in 1978 (Table 2.9).

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.

In 1977, alewife from the Chowan River ranged in age from 3 to 7 years for males and 4 to 8 for females (Table 2.4 - Loesch et al. 1977). Johnson et al. (1978) reported that alewife in 1978 ranged in age from 3 to 6 years for males and 3 to 7 years for females (Table 2.10). Alewife ages in 1979 ranged from 3 to 6 years for males and 3 to 7 years for females (Table 2.16). For 1977, virgin fish comprised 85.6% of the total (sexes combined), while only 4% of the fish had spawned more than once (Table 2.4 - Johnson et al. 1978). Data for 1979 showed that virgin fish comprised 71.4% of the sample (sexes combined), while only 3% of the fish had spawned more than once, (Table 2.16).

Samples taken from Alligator River in 1977 showed that ages of male alewife ranged from 4 to 6 years, while female alewife ranged from 4 to 8 years (Table 2.5 - Loesch et al. 1977). Alewife samples for 1978 showed that males ranged from 3 to 7 years and females ranged in age from 4 to 7 years (Table 2.11 - Johnson et al. 1978). Ages of male alewife ranged from 3 to 8 years, while female alewife ranged from 3 to 6 years in 1979 (Table 2.17). In 1977, 72% of the sample (sexes combined) were virgins and only 7% (sexes combined) had spawned more than once (Table 2.5 - Loesch et al. 1977). Johnson et al. (1978) reported that in 1978, 58.7% of the sample (sexes combined) were virgins while 13% had spawned more than once (Table 2.11). In 1979, 35.2% of the sample (sexes combined) were virgins and 25% had spawned more than once, as shown in Table 2.17.

The gill net fishery in Albemarle Sound accounts for approximately 95% of the American shad taken from that area; the remainder were captured incidental to the pound net fishery for river herring. A total of 401 scale samples were found suitable for age determination in 1977 (Loesch et al. 1977), 490 scale samples in 1978 (Johnson et al. 1978), and 505 scale samples in 1979. Data for 1977 are presented in Table 2.6 (Loesch et al.

1977), in Table 2.12 for 1978 (Johnson et al. 1978), and in Table 2.18 for 1979. Ages in 1977 ranged from 4 to 7 years for both sexes (Loesch et al. 1977). Johnson et al. (1978) reported that in 1978 ages ranged from 3 to 7 years for males and 4 to 7 years for females. In 1979, ages ranged from 4 to 9 years for male American shad, while females ranged from 5 to 10 years. Loesch et al. (1977) reported that age groups 4 and 5 comprised 88% of the male sample in 1977, while age groups 5 and 6 comprised 96% of the female sample. Age groups 4, 5, and 6 comprised 90% of the male sample, and 96% of the female sample in 1978 (Johnson et al, 1978). For 1979, age groups 5, 6, and 7 comprised 77% of the male sample, while age groups 6, 7, and 8 comprised 87% of the female sample. The American shad population (sexes combined) was comprised of 92.3% virgin fish in 1977 (Loesch et al. 1977), 93.9% virgin fish in 1978 (Johnson et al. 1978), and 87.9% virgin fish in 1979. Data for 1977 showed that only 1% of the fish sampled (sexes combined) had spawned more than once (Loesch et al. 1977), only 0.2% in 1978 (Johnson et al. 1978), and only 0.9% in 1979. It should be noted that considerable concern has developed because of declining landings of American shad in the southeastern states.

Scales from a total of 220 hickory shad were found suitable for determining age and spawning history in 1977 (Loesch et al. 1977). Johnson et al. (1978) reported that a total of 166 scales were found suitable in 1978. Hickory shad scales from 196 fish were found suitable in 1979. Data are presented for 1977 in Table 2.6 (Loesch et al. 1977), for 1978 in Table 2.12 (Johnson et al. 1978), and in Table 2.18 for 1979. Loesch et al. (1977) reported that ages ranged from 4 to 7 years for both males and females in 1977. Johnson et al. (1978) found that ages ranged from 3 to 6 years for both sexes in 1978. Ages in 1979 ranged from 3 to 7 for males while females ranged in age from 3 to 8 years. Data for 1977 showed that 85% of the sample (sexes combined) were virgin fish (Loesch et al. 1977). In 1978, 64% of the fish sampled (sexes combined) were virgin (Johnson et al. 1978). For 1979, 82.7% of the sample were virgin, (sexes combined). Only 3% of the sample (sexes combined) for 1977 had spawned more than once (Loesch et al. 1977). The same results were noted in 1979. Johnson et al. (1978) reported that 13% of the fish sampled in 1978 had spawned more than once.

LITERATURE CITED

Johnson, H. B., B. F. Holland, Jr., and S. G. Keefe. 1977. Anadromous fisheries research program, northern coastal area. Completion Rep., Proj. AFCS-11. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 97 + 40 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Ricker, W. W. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. Can. Bull. 191. 382 p.

Street, M. W., P. P. Pate, B. F. Holland, Jr., and A. B. Powell. 1975. Anadromous fisheries research program, northern coastal region.

Completion Rep., Proj. AFCS-8. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 173 + 62 + append.

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

Blueback herring

Age	Number of Times Spawned 0 M	0 F	1 M	1 F	2 M	2 F	3 M	3 F	4 M	4 F	Total M	Total F
III	2										2	
IV	152	97	5	2							157	99
V	267	258	74	59							341	317
VI	1	2	15	23	9	22					25	47
VII					1	12	1	3			2	15
VIII							1	2		1	1	3
Total	422	357	94	84	10	34	2	4		1	528	481
Percent	79.9	74.2	17.8	17.5	1.9	7.1	0.4	1.0		0.2		
Percent Sexes Combined	77.2		17.6		4.3		0.7		0.2			

Alewife

Age	Number of Times Spawned 0 M	0 F	1 M	1 F	2 M	2 F	3 M	3 F	4 M	4 F	Total M	Total F
III	6	1									6	1
IV	225	125									225	125
V	171	222	81	61		1					252	284
VI		1	13	17	16	9					29	27
VII					2	7		3			2	10
VIII								4				4
Total	402	349	94	78	18	17		7			514	451
Percent	78.2	77.4	18.3	17.3	3.5	3.8		1.5				
Percent Sexes Combined	77.8		17.8		3.6		0.8					

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

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	2										2	
IV	48	25	5								53	25
V	58	48	33	25							91	73
VI				5		3						8
VII												
VIII												
Total	108	73	38	30		3					146	106
Percent	74.0	68.9	26.0	28.3		2.8						
Percent Sexes Combined	71.8		27.0		1.2							

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	24	18									24	18
V	38	47	33	18							71	65
VI			2	2							2	2
VII												
VIII												
Total	62	65	35	20							97	85
Percent	63.9	76.5	36.1	23.5								
Percent Sexes Combined	69.8		30.2									

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

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	54	38		2							54	40
V	64	95	7	12							71	107
VI	1	1	2	8	2	8					5	17
VII						1	1	3			1	4
VIII								1		1		2
Total	119	134	9	22	2	9	1	4		1	131	170
Percent	90.8	78.8	6.9	12.9	1.5	5.3	0.8	2.4		0.6		
Percent Sexes Combined	84.1		10.3		3.6		1.7		0.3			

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	2	1									2	1
IV	77	50									77	50
V	38	80	8	21		1					46	102
VI		1	1	6	5	5					6	12
VII						2		1				3
VIII												
Total	117	132	9	27	5	8		1			131	168
Percent	89.3	78.6	6.9	16.0	3.8	4.8		0.6				
Percent Sexes Combined	83.3		12.1		4.3		0.3					

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

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	39	20									39	20
V	99	80	16	18							115	98
VI		1	13	6	7	7					20	14
VII					1	7					1	7
VIII								1				1
Total	138	101	29	24	8	14		1			175	140
Percent	78.8	72.1	16.6	17.2	4.6	10.0		0.7				
Percent Sexes Combined	75.9		16.8		7.0		0.3					

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	4										4	
IV	69	14									69	14
V	45	35	14	2							59	37
VI			4		2	2					6	2
VII					2						2	
VIII								2				2
Total	118	49	18	2	4	2		2			140	55
Percent	84.3	89.2	12.9	3.6	2.8	3.6		3.6				
Percent Sexes Combined	85.6		10.3		3.1		1.0					

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

Blueback herring

Age	Number of Times Spawned: 0 M	0 F	1 M	1 F	2 M	2 F	3 M	3 F	4 M	4 F	Total M	Total F
III												
IV	11	14									11	14
V	46	35	18	4							64	39
VI				4		4						8
VII						4						4
VIII							4				4	
Total	57	49	18	8		8	4				79	65
Percent	72.1	75.4	22.8	12.3		12.3	5.1					
Percent Sexes Combined	73.6		18.1		5.5		3.8					

Alewife

Age	Number of Times Spawned: 0 M	0 F	1 M	1 F	2 M	2 F	3 M	3 F	4 M	4 F	Total M	Total F
III												
IV	55	43									55	43
V	50	60	26	20							76	80
VI			6	9	9	2					15	11
VII						5		2				7
VIII								2				2
Total	105	103	32	29	9	7		4			146	143
Percent	71.9	72.0	21.9	20.3	6.2	4.9		2.8				
Percent Sexes Combined	72.0		21.1		5.5		1.4					

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

American shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	53	2									53	2
V	140	89	10	5							150	94
VI	19	66	8	5							27	71
VII		1		2		1						4
VIII												
Total	212	158	18	12		1					230	171
Percent	92.2	92.4	7.8	7.0		0.6						
Percent Sexes Combined	92.3		7.5		0.2							

Hickory shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III												
IV	72	66									72	66
V	17	31	13	12							30	43
VI		1		1	3	2					3	4
VII						1	1				1	1
VIII												
Total	89	98	13	13	3	3	1				106	114
Percent	84.0	86.0	12.3	11.4	2.8	2.6	0.9					
Percent Sexes Combined	85.0		11.8		2.7		0.5					

Table 2.7. Age and spawning frequency of blueback herring and alewife from the Albemarle Sound area 1978. Data are combined from all sample sites (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	75.9	69.6	19.0	22.9	4.3	5.4	0.8	2.1				
Percent Sexes Combined	73.2		20.6		4.8		1.4					

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	76.5	68.8	17.8	22.6	5.5	5.4	0.2	2.1		1.1		
Percent Sexes Combined	73.3		19.7		5.5		1.1		0.4			

Table 2.8. Age and spawning frequency of blueback herring and alewife from the 1978 Scuppernong River pound net fishery (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	84.7	85.0	10.6	10.0	4.7	2.5	2.5					
Percent Sexes Combined	84.8		10.4		4.0		0.8					

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
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 2.9. Age and spawning frequency of blueback herring and alewife from the 1978 Meherrin River haul seine fishery (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	72.8	61.0	22.1	31.9	3.8	5.0	1.3	2.1				
Percent Sexes Combined	67.2		26.8		4.3		1.7					

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	76.8	76.0	18.3	16.3	4.9	5.4				2.3		
Percent Sexes Combined	76.5		17.4		5.1				1.0			

Table 2.10. Age and spawning frequency of blueback herring and alewife from the 1978 Chowan River pound net fishery (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	73.8	75.8	20.6	15.2	4.8	7.1	0.8	2.0				
Percent Sexes Combined	74.7		18.2		5.8		1.3					

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
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		1			125	57
Percent	86.4	70.2	8.8	24.6	4.8	3.5		1.7				
Percent Sexes Combined	81.3		13.7		4.4		0.6					

Table 2.11. Age and spawning frequency of alewife from the 1978 Alligator River pound net fishery (M = male, F = female).

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	62.1	54.7	29.1	32.5	7.8	7.0	1.0	5.8				
Percent Sexes Combined	58.7		30.7		7.4		3.2					

Table 2.12. Age and spawning frequency for American shad and hickory shad from Albemarle Sound area 1978 (M = male, F = female).

American shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
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						1	8
VIII												
Total	266	194	18	11	1						285	205
Percent	93.3	94.6	6.3	5.4	0.4							
Percent Sexes Combined	93.9		5.9		0.2							

Hickory shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
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	76.5	60.6	17.6	24.2	5.9	15.2						
Percent Sexes Combined	63.9		22.9		13.2							

Table 2.13. Age and spawning frequency of blueback herring and alewife from the Albemarle Sound area, 1979. Data are combined from all sample sites (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	39	8									39	8
IV	161	70	10	8							171	78
V	35	34	163	129	5	3					203	166
VI		3	21	35	47	50	1	1			69	89
VII			1	2	3	3	12	6			16	11
VIII					1	2		1		2	1	5
Total	235	115	195	174	56	58	13	8		2	499	357
Percent	47.1	32.2	39.1	48.7	11.2	16.3	2.6	2.2		0.6		
Percent Sexes Combined	40.9		43.1		13.3		2.5		0.2			

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	33	8									33	8
IV	241	86	16	5							257	91
V	27	19	100	55	2						129	74
VI			4	13	29	13	2				35	26
VII						1	8	2			8	3
VIII									1		1	0
Total	301	113	120	73	31	14	10	2	1		463	202
Percent	65.0	55.9	25.9	36.1	6.7	6.9	2.2	1.0	0.2			
Percent Sexes Combined	62.3		29.0		6.8		1.8		0.1			

Table 2.14. Age and spawning frequency of blueback herring and alewife from the 1979 Scuppernong River pound net fishery (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	14	2									14	2
IV	59	33	2								61	33
V	13	7	16	13							29	20
VI		2	2	4		8					2	14
VII			1	1		1					1	2
VIII					1						1	0
Total	86	44	21	18	1	9					108	71
Percent	79.6	62.0	19.4	25.4	0.9	12.7						
Percent Sexes Combined	72.6		21.8		5.6							

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	3	2									3	2
IV	15	9		1							15	10
V	2	1	6	2							8	3
VI			1			1					1	1
VII								2			0	2
Total	20	12	7	3		1		2			27	18
Percent	74.1	66.7	25.9	16.7		5.6		11.1				
Percent Sexes Combined	71.1		22.2		2.2		4.4					

Table 2.15. Age and spawning frequency of blueback herring and alewife from the 1979 Meherrin River haul seine fishery (M = male, F = female)

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	14	3									14	3
IV	40	17	5	6							45	23
V	8	14	48	69	4	3					60	86
VI		1	6	13	9	22	1	1			16	37
VII					1	1	2	1			3	2
VIII						2		1		1	0	4
Total	62	35	59	88	14	28	3	3		1	138	155
Percent	44.9	22.6	42.8	56.8	10.1	18.1	2.2	1.9		0.6		
Percent Sexes Combined	33.1		50.2		14.3		2.0		0.4			

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
IV	1	1									1	1
V	1		1	2							2	2
VI				1							0	1
Total	2	1	1	3							3	4
Percent	66.7	25.0	33.3	75.0								
Percent Sexes Combined	43		57									

Table 2.16. Age and spawning frequency of blueback herring and alewife from the 1979 Chowan River pound net fishery (M = male, F = female).

Blueback herring

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	12	3									12	3
IV	63	19	3	2							66	21
V	13	11	102	47	1						116	58
VI			12	18	36	20		1			48	39
VII				1	2	1	9	6			11	8
VIII										1	0	1
Total	88	33	117	68	39	21	9	7		1	253	130
Percent	34.8	25.4	46.2	52.3	15.4	16.1	3.6	5.4		0.8		
Percent Sexes Combined	31.6		48.3		15.6		4.2		0.3			

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	24	5									24	5
IV	189	68	10	4							199	72
V	20	16	49	41	1						70	57
VI				10	8	5					8	15
VII						1					0	1
Total	233	89	59	55	9	6					301	150
Percent	77.4	59.3	19.6	36.7	3.0	4.0						
Percent Sexes Combined	71.4		25.3		3.3							

Table 2.17. Age and spawning frequency of alewife from the 1979 Alligator River pound net fishery (M = male, F = female).

Alewife

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	6	1									6	1
IV	36	8	6								42	8
V	4	2	44	10	1						49	12
VI			3	2	21	7	2				26	9
VII							8				8	0
VIII									1		1	0
Total	46	11	53	12	22	7	10		1		132	30
Percent	34.8	36.7	40.2	40.0	16.7	23.3	7.6		0.7			
Percent Sexes Combined	35.2		40.1		17.9		6.2		0.6			

Table 2.18. Age and spawning frequency for American shad and hickory shad from Albemarle Sound area 1979 (M = male, F = female).

American shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
IV	8										8	0
V	79	6	9								88	6
VI	93	61	25	3	2						120	64
VII	56	90	6	6	2		1				65	96
VIII	13	29	1	6							14	35
IX	3	5									3	5
X		1									0	1
Total	252	192	41	15	4		1				298	207
Percent	84.6	92.8	13.8	7.2	1.3		0.3					
Percent Sexes Combined	87.9		11.1		0.8		0.2					

Hickory shad

	Number of Times Spawned											
	0		1		2		3		4		Total	
Age	M	F	M	F	M	F	M	F	M	F	M	F
III	4										4	0
IV	12	17									12	17
V	10	64	1	11							11	75
VI	5	47	1	13		2					6	62
VII		3	1	1		3					1	7
VIII								1			0	1
Total	31	131	3	25		5		1			34	162
Percent	91.2	80.9	8.8	15.4		3.1		0.6				
Percent Sexes Combined	82.7		14.3		2.5		0.5					

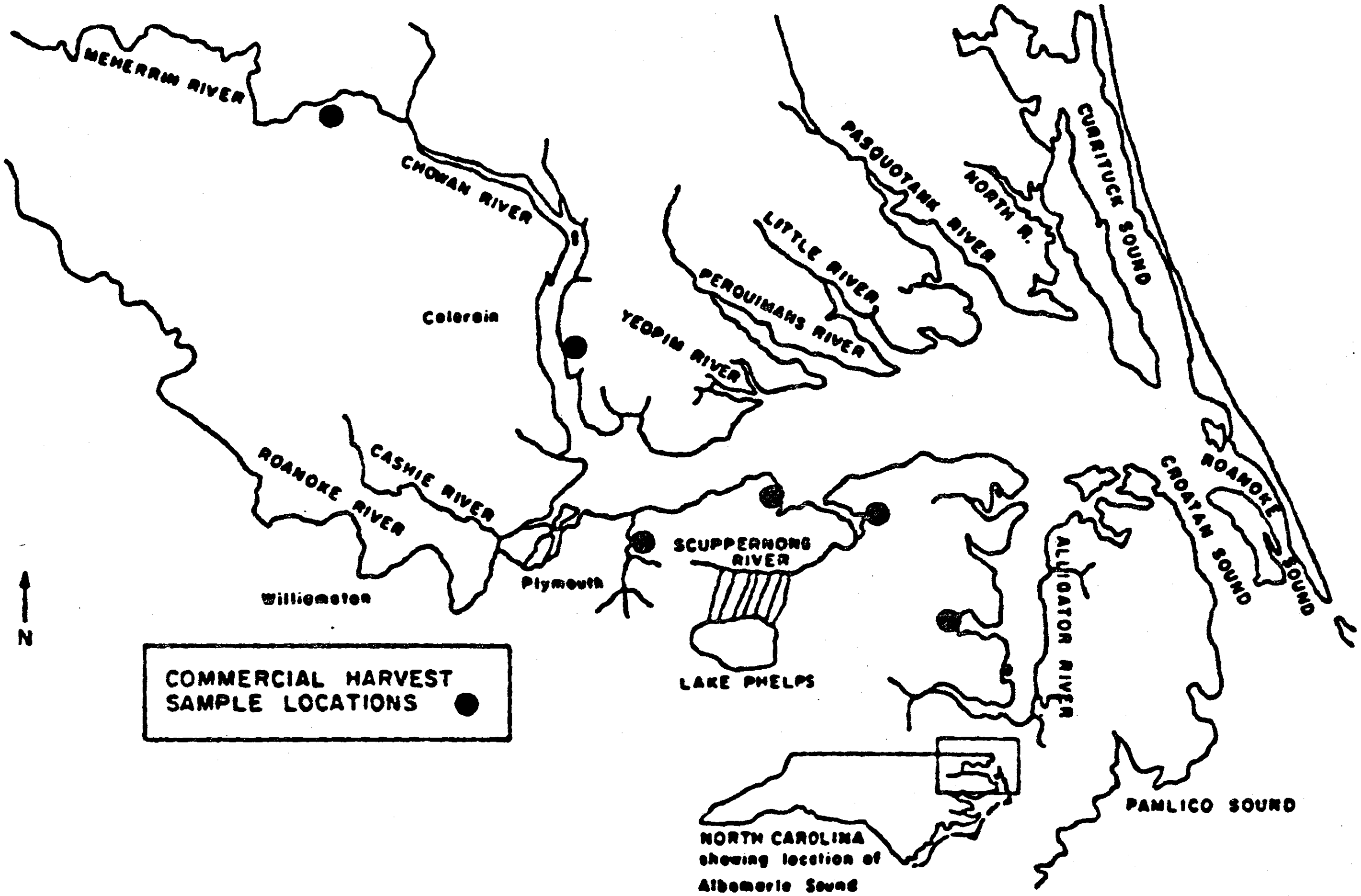


Figure 2.1. Location of Albemarle Sound commercial harvest sampling sites.

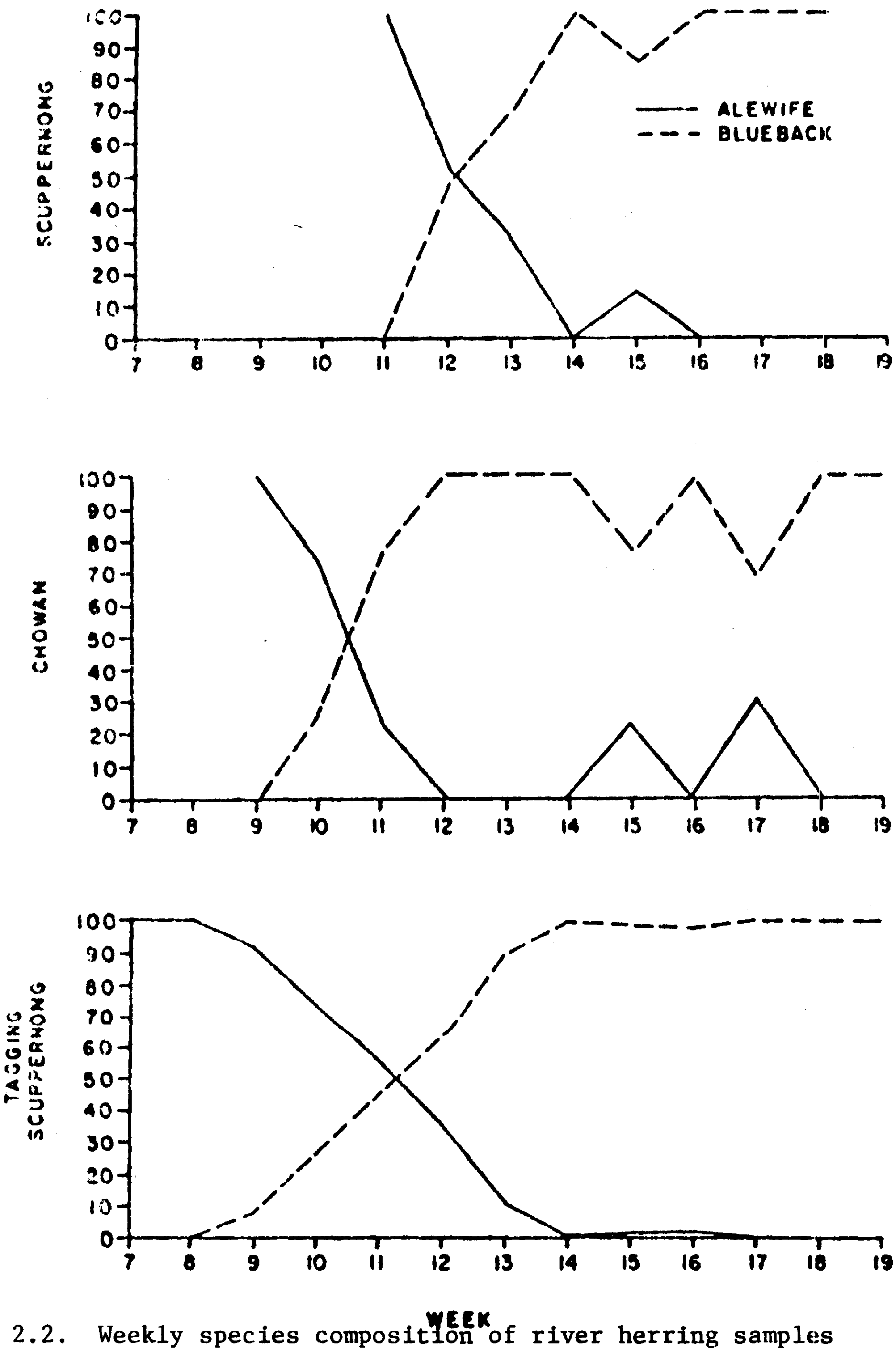
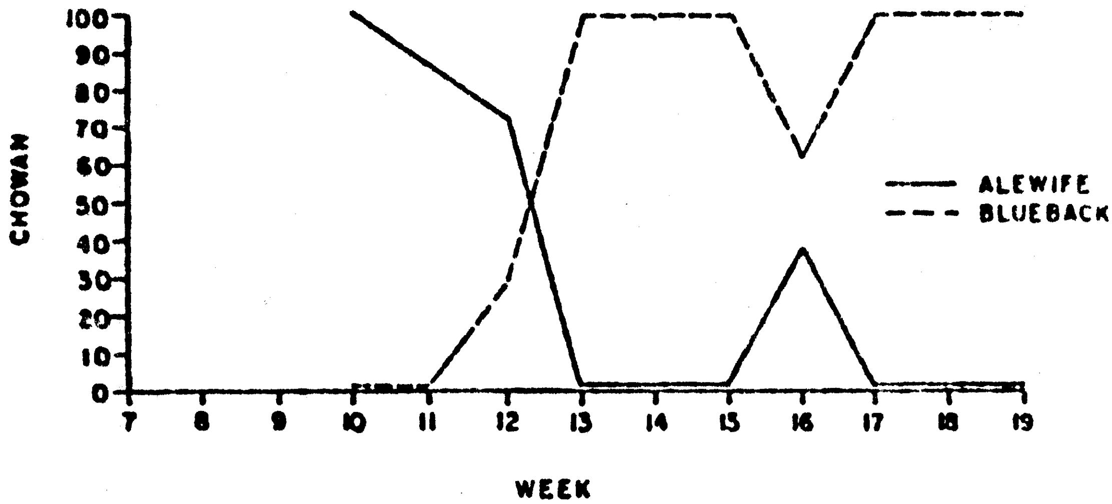


Figure 2.2. Weekly species composition of river herring samples from the Scuppernong River pound net fishery, the Chowan River pound net fishery and the Scuppernong River tagging operations, 1977



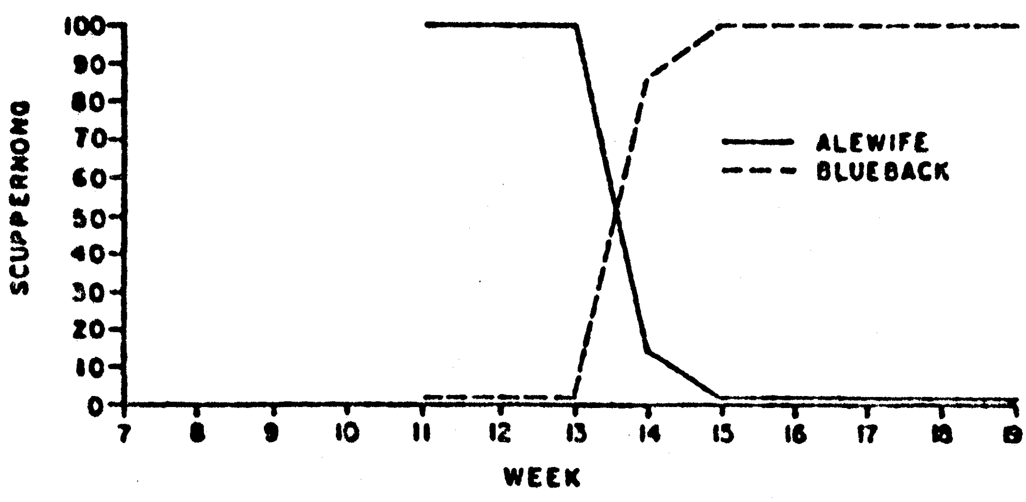


Figure 2.3. Weekly species composition of river herring from the Scuppernong River pound net fishery and the Chowan River pound net fishery, 1978.

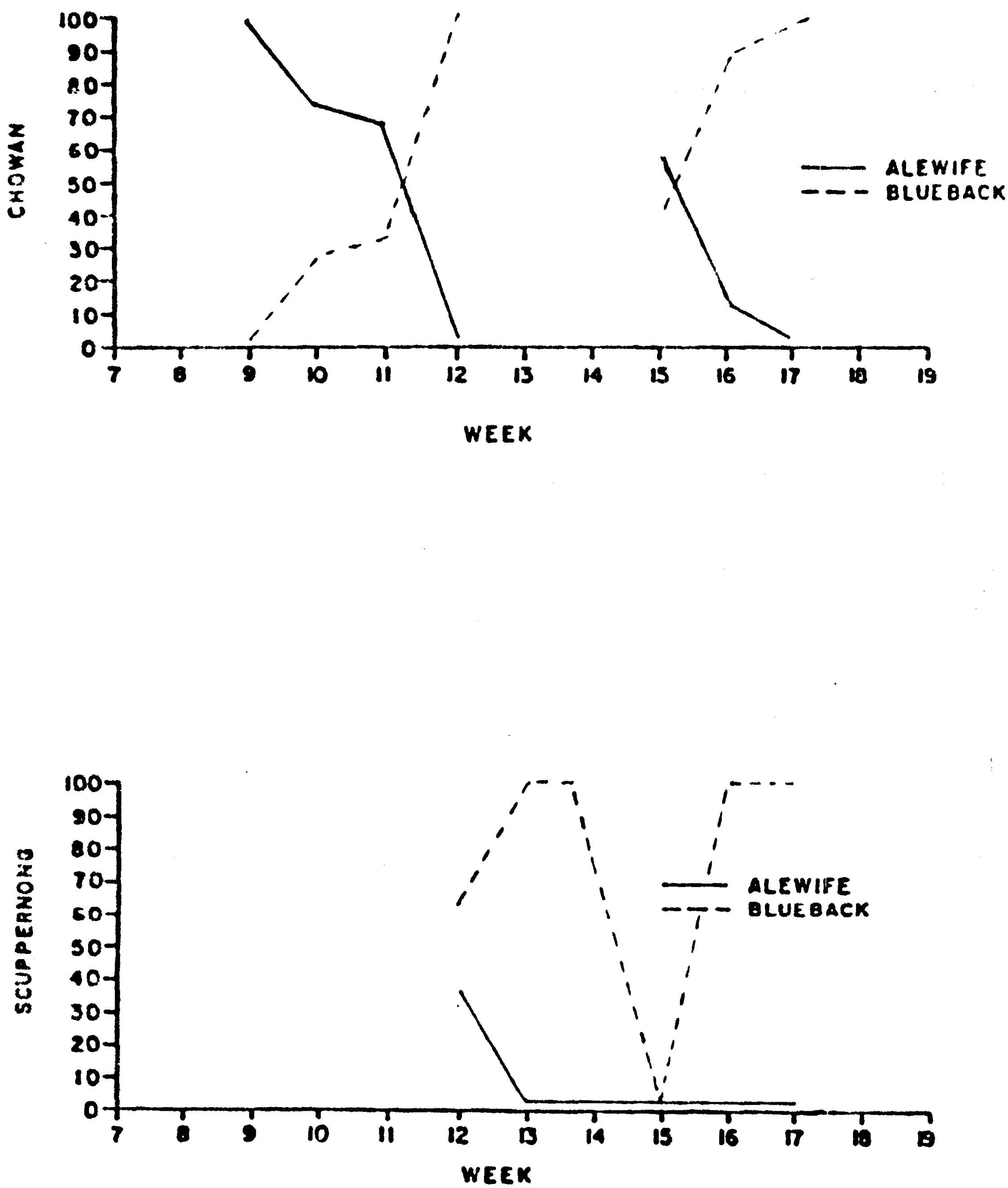


Figure 2.4. Weekly species composition of river herring from the Scuppernong River pound net fishery and the Chowan River pound net fishery, 1979. (Nets were not fished regularly due to lack of fish).

Job 3. Annual Index of Alosine Juvenile Abundance

SUMMARY

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

2. A total of 21,142 juvenile alosine fish was captured during sampling in 1977, 17,339 during 1978, and 13,607 during 1979.

3. The annual index of alosine juvenile abundance for 1979 was greater than that for 1974 through 1978.

Job 3. Annual Index of Alosine Juvenile Abundance

INTRODUCTION

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

MATERIALS AND METHODS

In North Carolina approximately 60 stations were sampled monthly with seines or trawls from June through December in 1977 and 1978. In 1979, the number of stations sampled monthly was reduced to 34 stations because of statistical reasons and to improve sampling efficiency. 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

From October 1976 through September 1977, a total of 20,307 juvenile anadromous fishes were captured in 532 samples in North Carolina (Loesch et al. 1977). Johnson et al. (1978) reported that 17,339 juvenile anadromous fishes were captured in 451 samples from October 1977 through September 1978. From October 1978 through September 1979, a total of 13,607 juvenile anadromous fishes were captured in 165 samples. The main purpose of sampling was to determine the relative abundance of the 1977, 1978, and 1979 year classes. Numbers of samples taken by each sampling gear are shown in Table 3.1 for 1977 (Loesch et al. 1977), Table 3.2 for 1978 (Johnson et al. 1978), and Table 3.3 for 1979. Data for July - September 1976 were actually collected under project AFCS-11 (Johnson et al. 1977) but are also presented in this report in order to show a complete year class. Since so few American shad, hickory shad, and Atlantic sturgeon were taken during 1977 (21, 31, and 0 respectively), 1978 (21, 12, and 0 respectively) and 1979 (14, 2, and 9 respectively) these species will not be considered further in the discussion of juveniles.

Seining was the most effective capture gear for blueback herring during 1972-76 (Street et al. 1975, Johnson et al. 1977). The seine was not the most effective gear for the capture of juvenile blueback herring during the 1977 sampling period (Loesch et al. 1977) and the 1978 sampling period (Johnson et al. 1978). However, the seine proved to be the most effective gear in 1979 for juvenile blueback herring. Data for the 60 stations sampled monthly in 1977 and 1978 are shown in Figure 3.1. Figure 3.2 shows the data for the 34 stations being sampled during 1977-79.

The wing trawl, as reported by Street et al. (1975) and Johnson et al. (1977), again proved to be the most effective in the capture of juvenile alewife during 1977-79 sampling periods. Alewife data for the 60 stations sampled in 1977 and 1978 are shown in Figure 3.3 (Loesch et al. 1977, Johnson et al. 1978). Data for the 34 stations during 1977-79 are shown in Figure 3.4.

Nursery Areas

As reported by Street et al. (1975) and Johnson et al. (1977), nursery areas for alewife generally coincided with those for blueback herring. Nursery areas established during 1972-74 again were very productive for young anadromous fishes (Street et al. 1975). Nursery areas are shown in Figure 3.5. 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 natural and unaltered and should be protected from pollution.

Growth

During 1977-1979, the year classes of blueback herring and alewife were followed from June through December of each year and measured for growth. Figure 3.6 shows the mean fork length of juvenile blueback herring and alewife for each month of sampling in 1977 and 1978. Figure 3.7 shows the mean fork length using data from 34 monthly stations for each month of sampling, 1977-1979. The reduction in the number of samples did not significantly alter growth data. Data presented in Loesch et al. (1977) for 1977 generally agree with that reported by Street et al. (1975) and Johnson et al. (1977). However, the 1978 and 1979 data show slight increases in growth compared to those reported in Street et al. (1975) and Johnson et al. (1977).

Movement

Movement of the 1977, 1978, and 1979 year classes of fish was virtually the same as that reported by Street et al. (1975) and Johnson et al. (1977) for 1972-76.

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 changes in juvenile abundance from year to year.

Data have been collected on eight year classes (1972-1979) of blueback herring and alewife. For comparative purposes, data are presented in a growth year basis rather than by calendar year; that is, June through December, rather than January through December.

Street et al. (1975), Johnson et al. (1977), Johnson et al. (1978) and Loesch et al. (1977) reported that blueback herring were far more numerous than alewife during 1972-1978. This trend was continued in 1979. Figure 3.8 shows the catch-per-unit-of-effort using data from 26 monthly seine stations during 1972-1978. The catch-per-unit-of-effort is shown in Figure 3.9 using data from the 11 monthly seine stations, 1974-79.

As shown in Figure 3.9 year class strength for blueback herring in 1979 was greater than that reported by Johnson et al (1978) in 1978, while 1979 alewife abundance decreased slightly from that of 1978.

LITERATURE CITED

Johnson, H. B., B. F. Holland, Jr., and S. G. Keefe. 1977. Anadromous fisheries research program northern coastal area. Completion Rep., Proj. AFCS-11. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 97 + 40 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucestet Point, Virginia. 183 p.

Street, M. W., P. P. Pate, B. F. Holland, Jr., and A. B. Powell. 1975. Anadromous fisheries research program, northern coastal region. Completion Rep., Proj. AFCS-8. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 173 + 62 + append.

Table 3.1. Number of samples and catch of juvenile alosines by trawl and seine in the Albemarle Sound area, NC,1977.

	Trawl	Seine
Number of samples	249	130
Blueback herring	11,044	4,825
Alewife	4,812	409
American shad	0	21
Hickory shad	11	20
TOTAL	15,867	5,275

Table 3.2. Number of samples and catch of juvenile alosines by trawl and seine in the Albemarle Sound area, N.C., 1978.

	Trawl	Seine
Number 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

Table 3.3. Number of samples and catch of juvenile alosines by trawl and seine in the Albemarle Sound area, NC, 1979.

	Trawl	Seine
Number of samples	113	52
Blueback herring	4,390	7,617
Alewife	1,416	168
American shad	0	14
Hickory shad	2	0
Atlantic sturgeon	0	0
	5,808	7,799

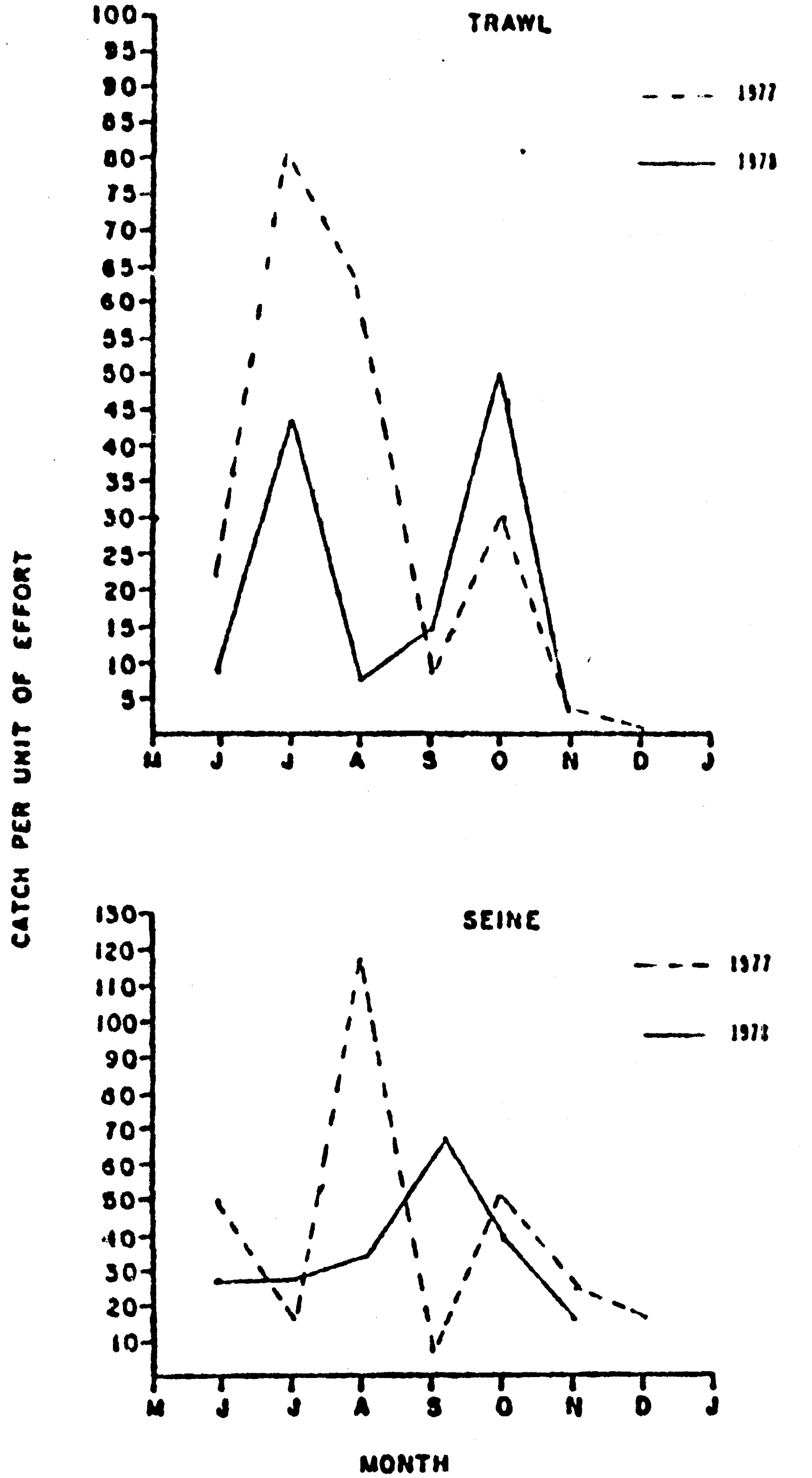


Figure 3.1 Monthly catch-per-unit-of-effort for blueback herring by trawl and seine in 1977 and 1978 (60 monthly stations).

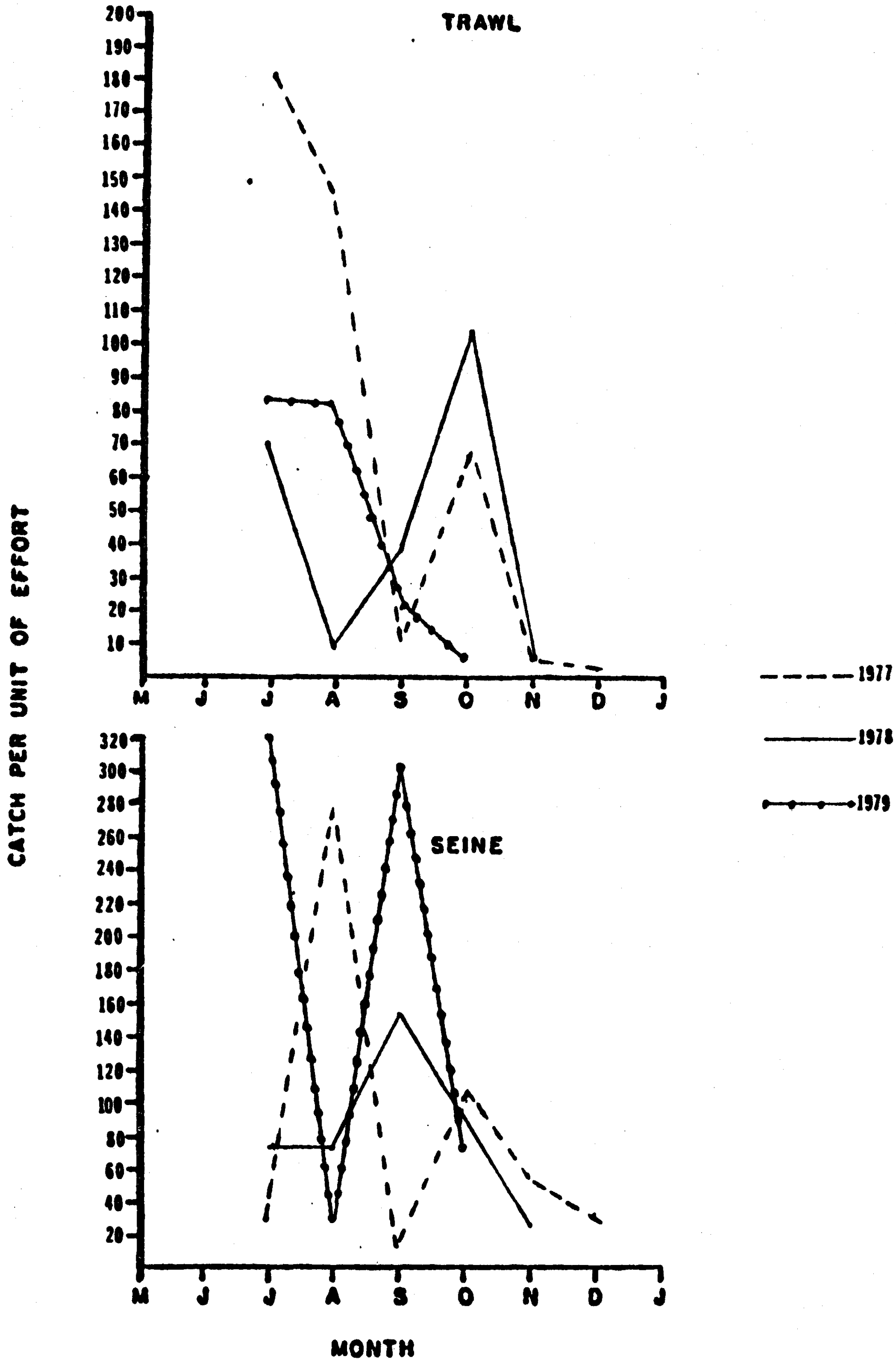


Figure 3.2. Monthly catch-per-unit-of-effort for blueback herring by trawl and seine for 1977 through 1979 (34 monthly stations).

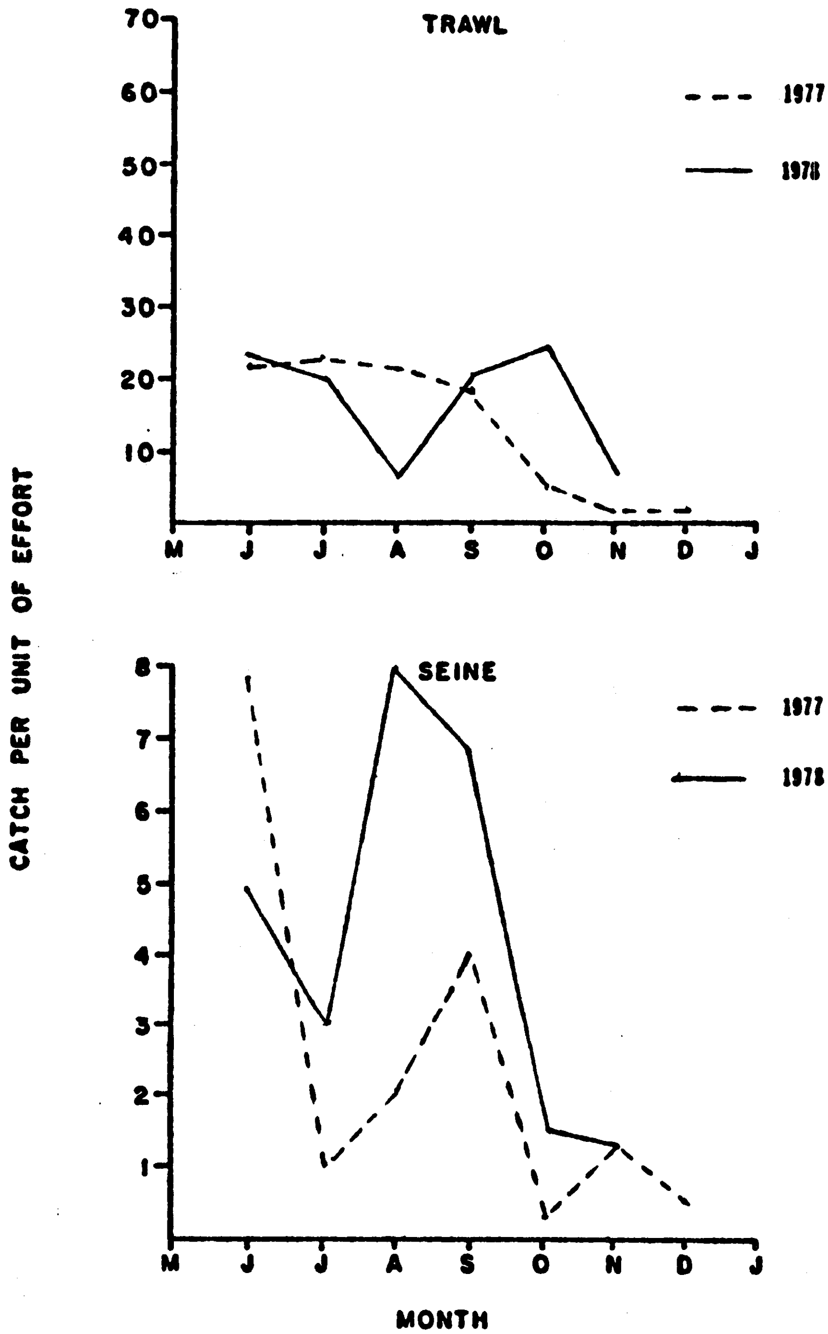


Figure 3.3 Monthly catch-per-unit-of-effort for alewife by trawl and seine in 1977 and 1978 (60 monthly stations).

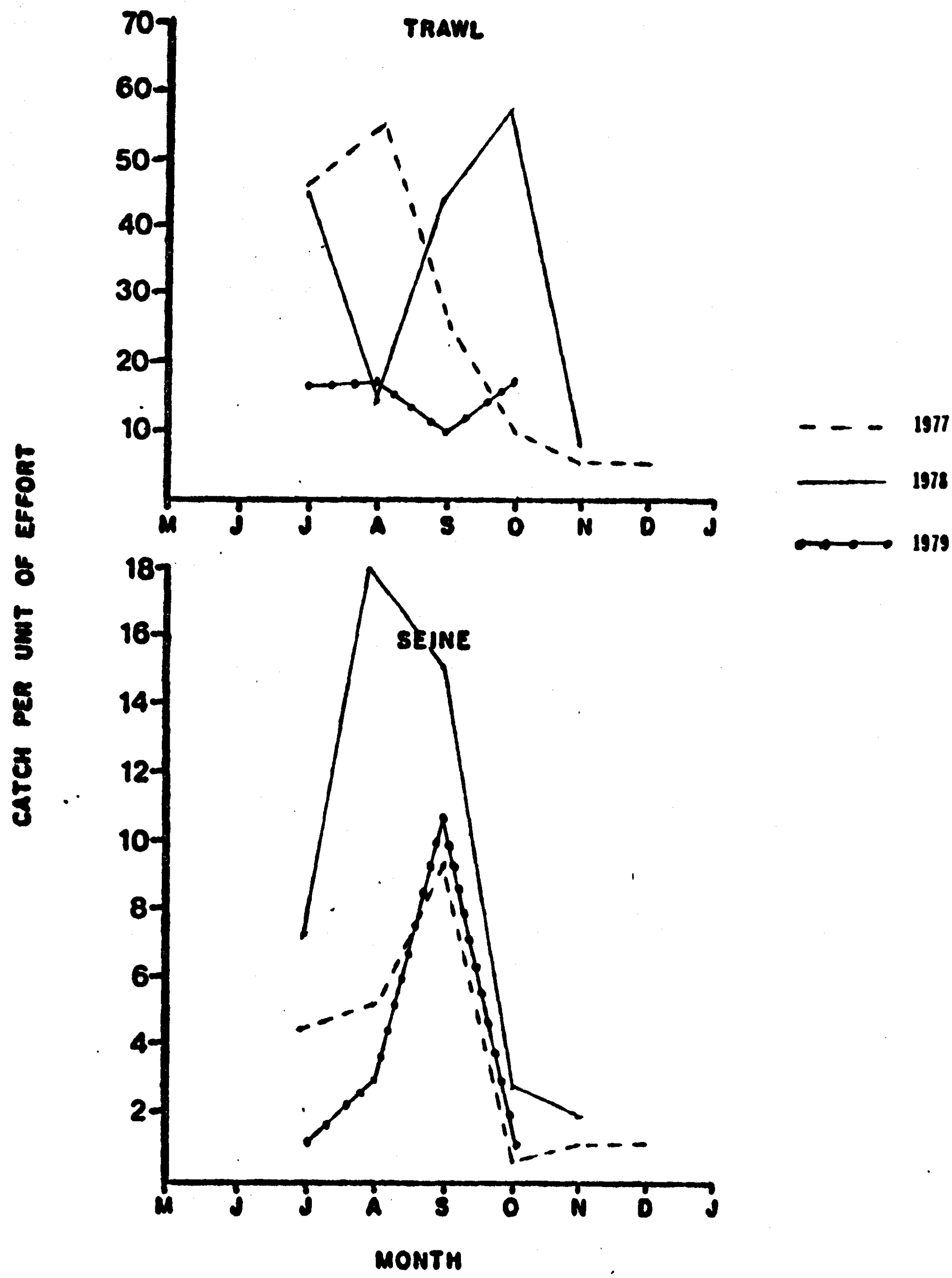


Figure 3.4 Monthly catch-per-unit-of-effort for alewife by trawl and seine for 1977 through 1979 (34 monthly stations).

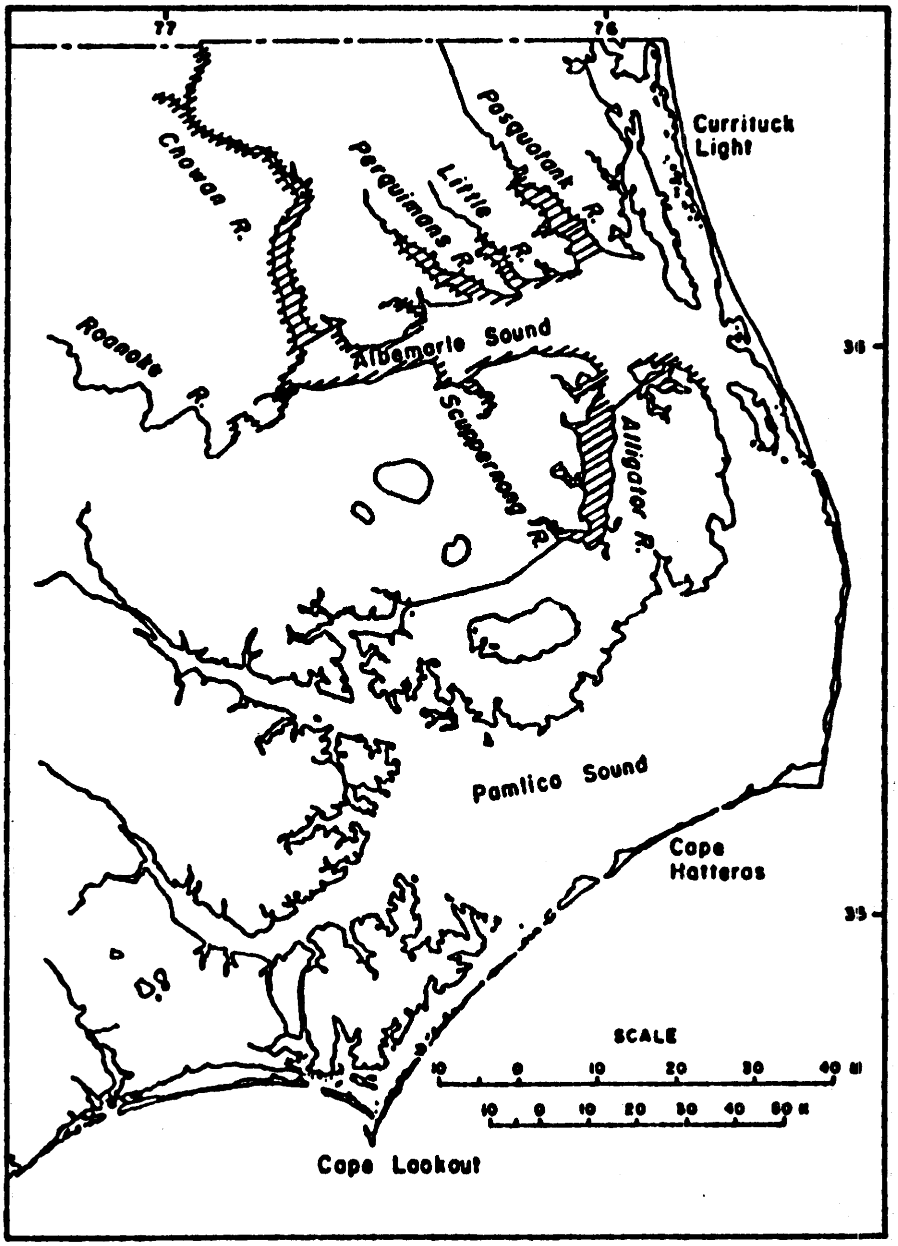


Figure 3.5 Nursery areas of blueback herring and alewife in Albemarle Sound and tributaries, NC.

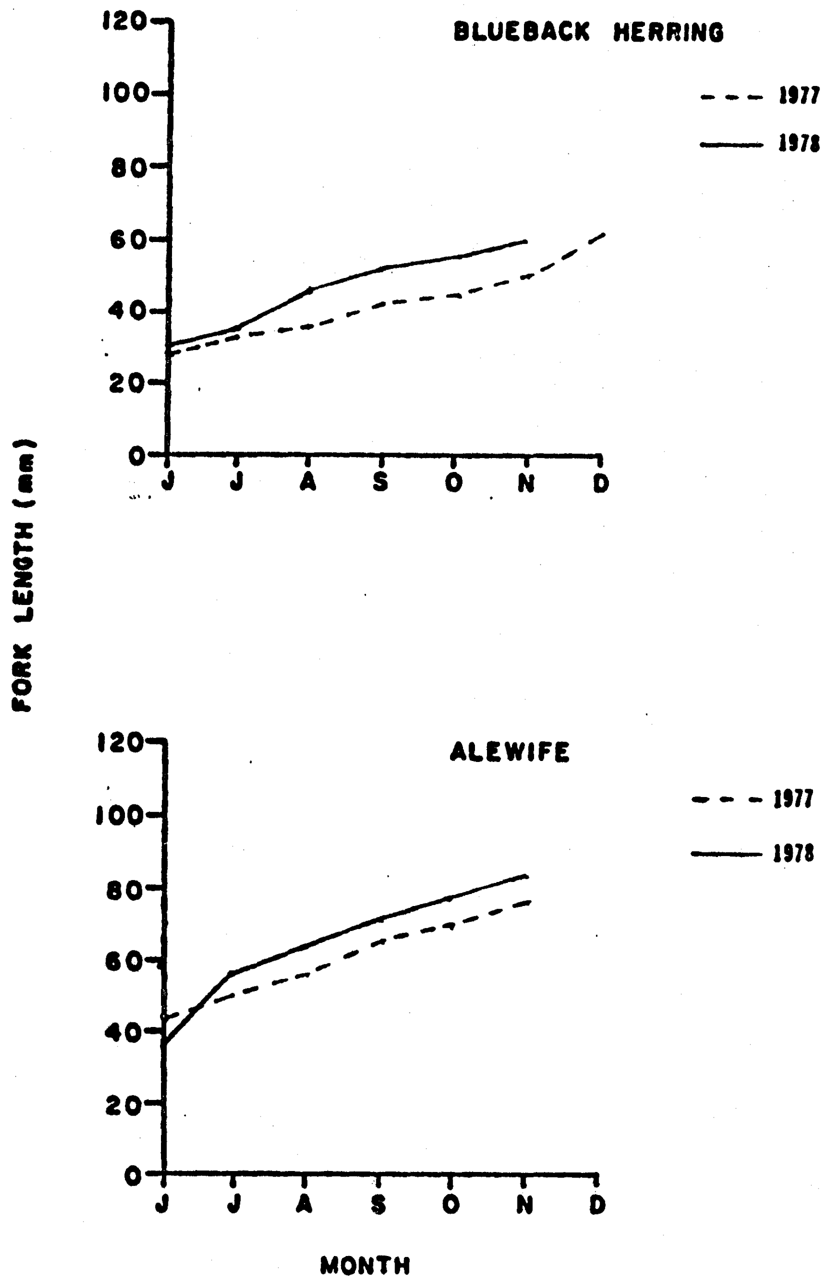


Figure 3.6 Mean fork length of alewife and blueback herring by month for 1977 and 1978 (60 monthly stations).

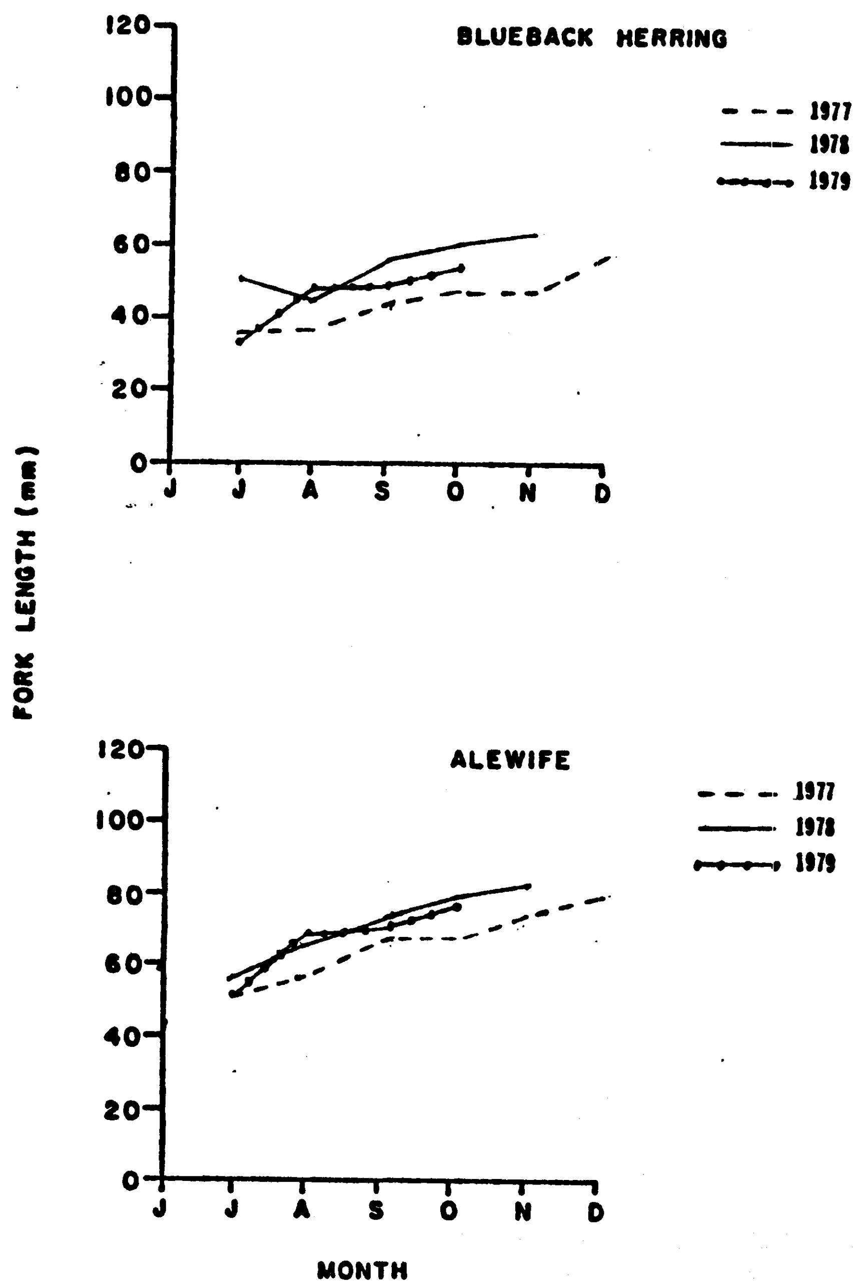


Figure 3.7 Mean fork length of alewife and blueback herring by month for 1977 through 1979 (34 monthly stations).

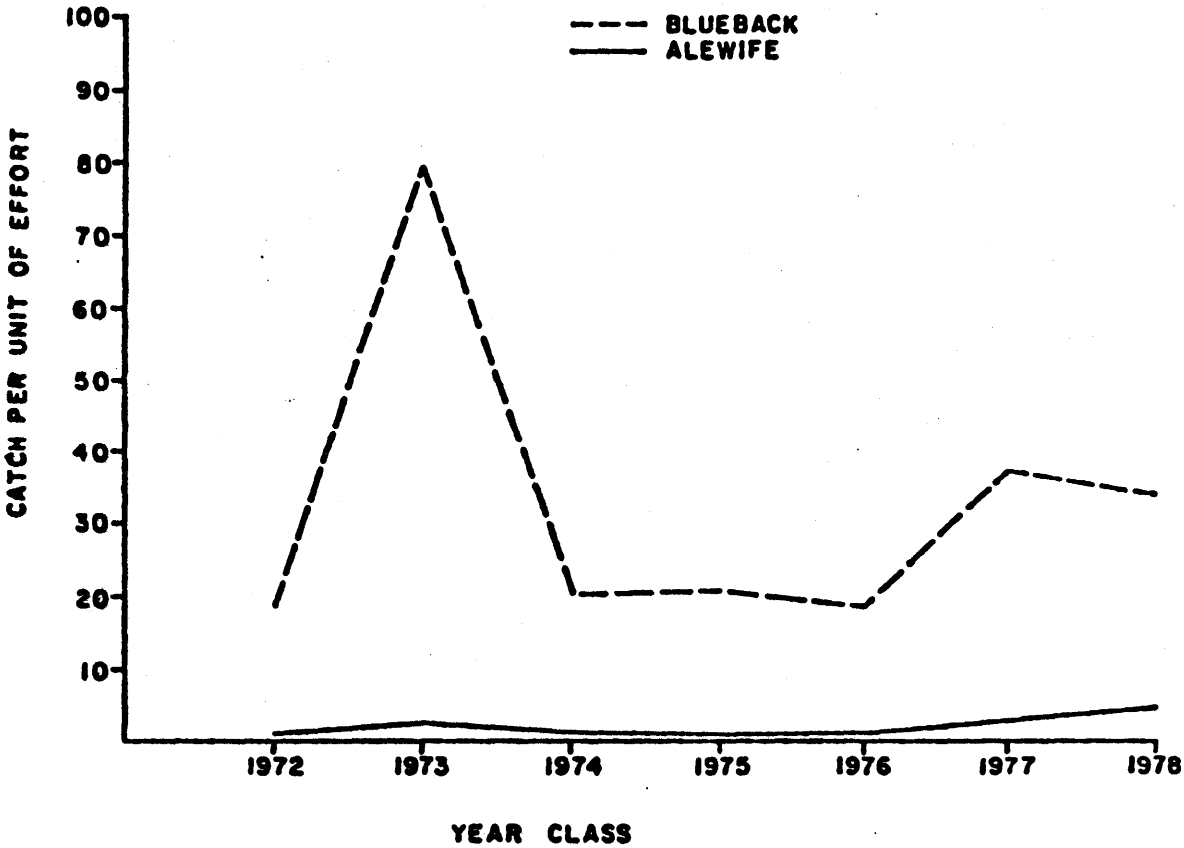


Figure 3.8 Catch-per-unit-of-effort for blueback herring and alewife year classes 1972 through 1978 by seine (26 monthly stations).

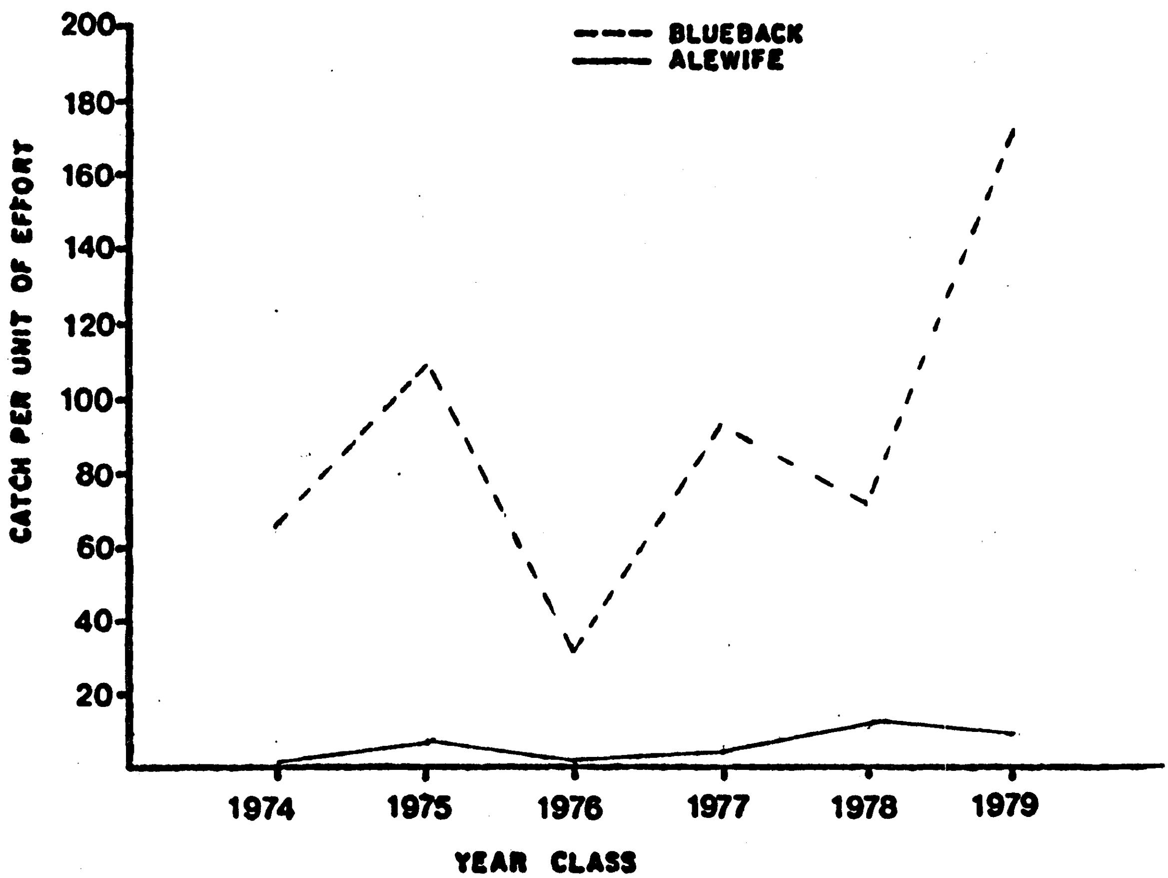


Figure 3.9 Catch-per-unit-of-effort for blueback herring and alewife year classes 1974 through 1979 by seine (11 monthly stations).

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

No North Carolina participation.

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

SUMMARY

1. A total of 795 (1977), 1,308 (1978) and 7,086 (1979) anadromous fishes, predominately blueback herring, was captured.

2. During all three seasons, anadromous fishes were found in greatest numbers between Cape Hatteras and Little Michipongo Inlet, Virginia.

3. During the 1977 season, the inshore (0-18.3m) zone accounted for 92.2% of all anadromous species captured. However, during the 1978 and 1979 seasons the midshore (19.8 - 36.0m) zone accounted for 71.3% and 96.5% respectively of the total anadromous catch.

4. Most anadromous fishes captured in 1977 were taken in the inshore zone chiefly because of favorable water temperatures there. During the 1978 and 1979 seasons however, extremely low water temperatures inshore influenced a shift in distribution and hence sampling effort to the midshore zone where most of the captures occurred.

5. During the 1977 season, a total of 10 Atlantic sturgeon was tagged and released. One was recaptured. During the 1978 season, a total of 5 Atlantic sturgeon was tagged and released. None were recaptured. During the 1979 season no Atlantic sturgeon were captured.

6. Analysis of blueback herring length-frequency distributions revealed trimodal peaks for all three seasons. Three-year-olds dominated offshore catches in 1977, but in 1978 and 1979 the dominant group became the $\geq$4-year-olds.

7. During 1977, examination of female blueback herring for ovary maturation revealed that 74.1% were immature, 22.9% were capable of spawning before the end of the 1977 season, and 3.0% were spent. During 1978, examination revealed that 53.2% were immature, 46.8% were capable of spawning before the end of the 1978 season, and none were spent. During 1979, examination revealed that 77.6% were immature, and only 2.2% were capable of spawning before the end of the 1979 season, and none were spent.

8. No foreign fishing activity by any nation was observed within the study area during the entire project period.

METHODS AND MATERIALS

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 were required only in Areas III and IV, however, limited sampling was conducted in Area II.

Sampling during the 1977 season (Segments 1 and 2) was conducted from just outside the surf zone to depths of 36.6 m (120 ft) (midshore zone, Figures 1 and 2). During Segment 3, to increase chances of locating concentrations of anadromous fishes, trawling operations were conducted from just outside the surf zone along transects out to the 131 m (430 ft) contour, (offshore zone) every 20 minutes of latitude, between Cape Lookout and Little Machipongo Inlet, Va. (Figure 3).

Sampling during the 1978 season was conducted from just outside the surf zone to depths of 183 m (600 ft) (offshore zone, Figures 4, 5, and 6).

Sampling during the 1979 season was conducted from just outside the surf zone to depths of 42.1 m (138 ft) (offshore zone, Figures 7, 8, 9). However, bad weather throughout both the 1978 and 1979 sampling periods precluded any significant effort in the offshore zone.

During all three seasons, predetermined sampling stations, located within 10 minute latitude and longitude grids were occupied in Areas II,

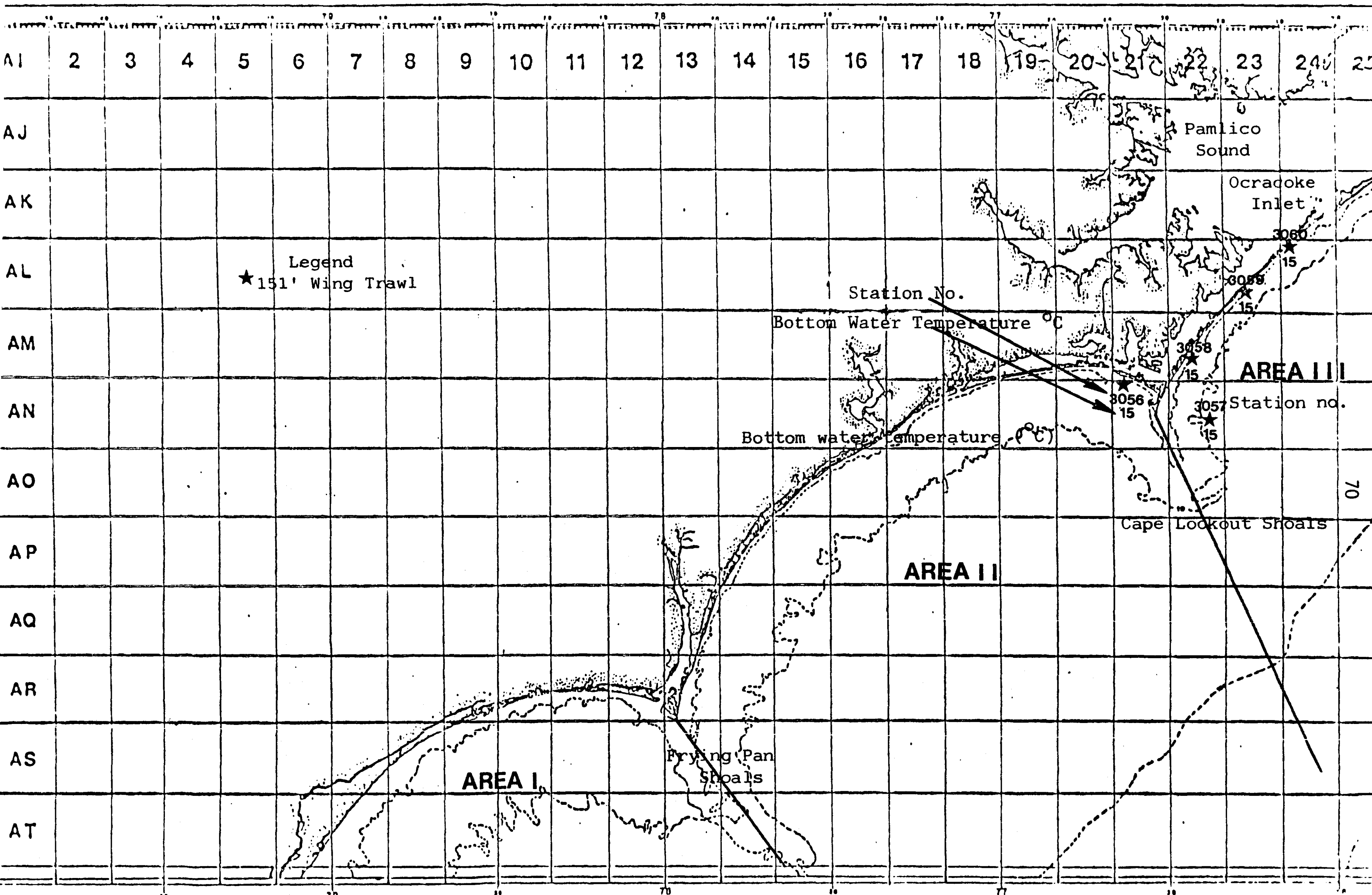


Figure 1. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (°C), and gear type utilized during Segment 1. Grids represent areas of 10 minute latitude and longitude.

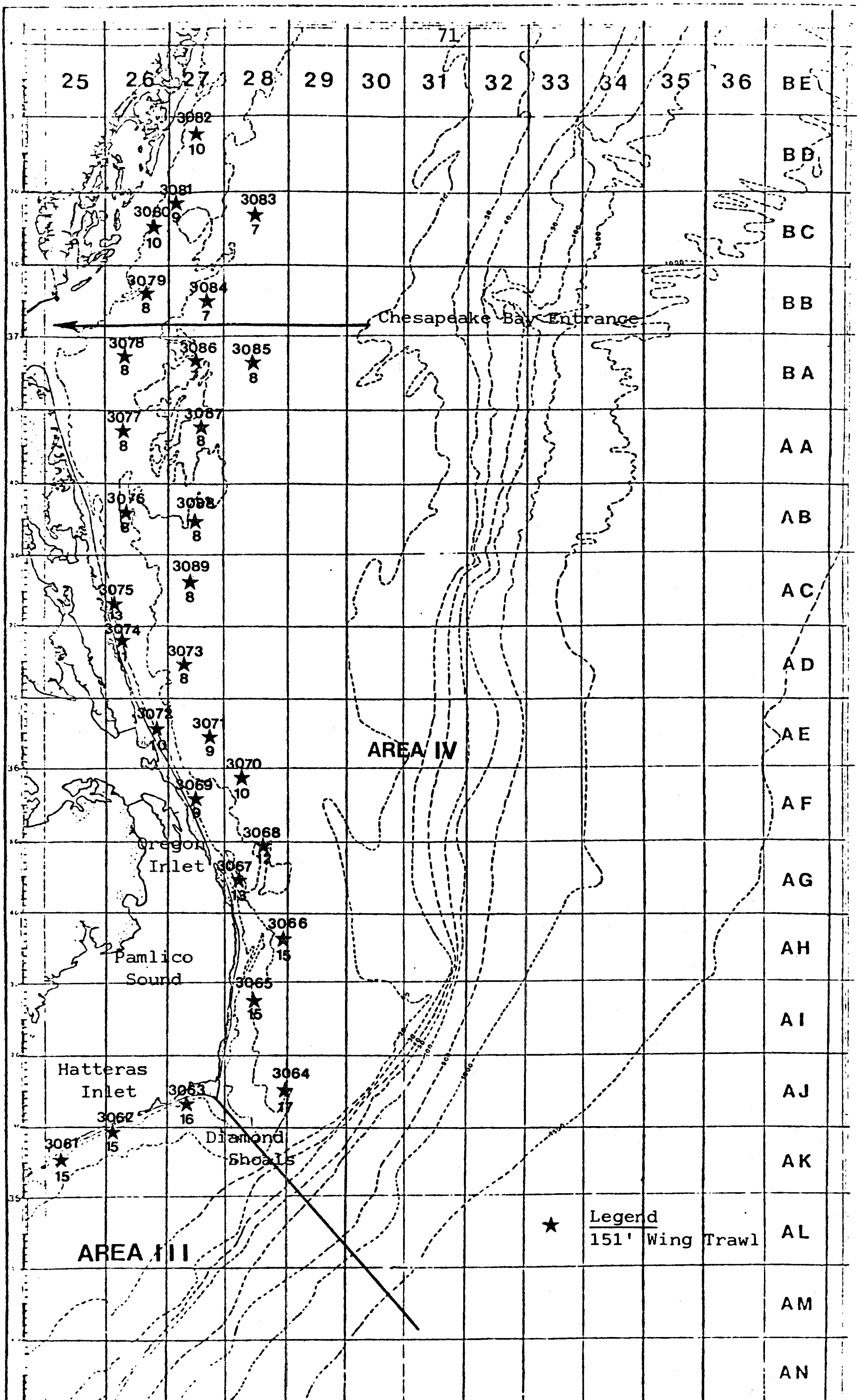


Figure 1. continued

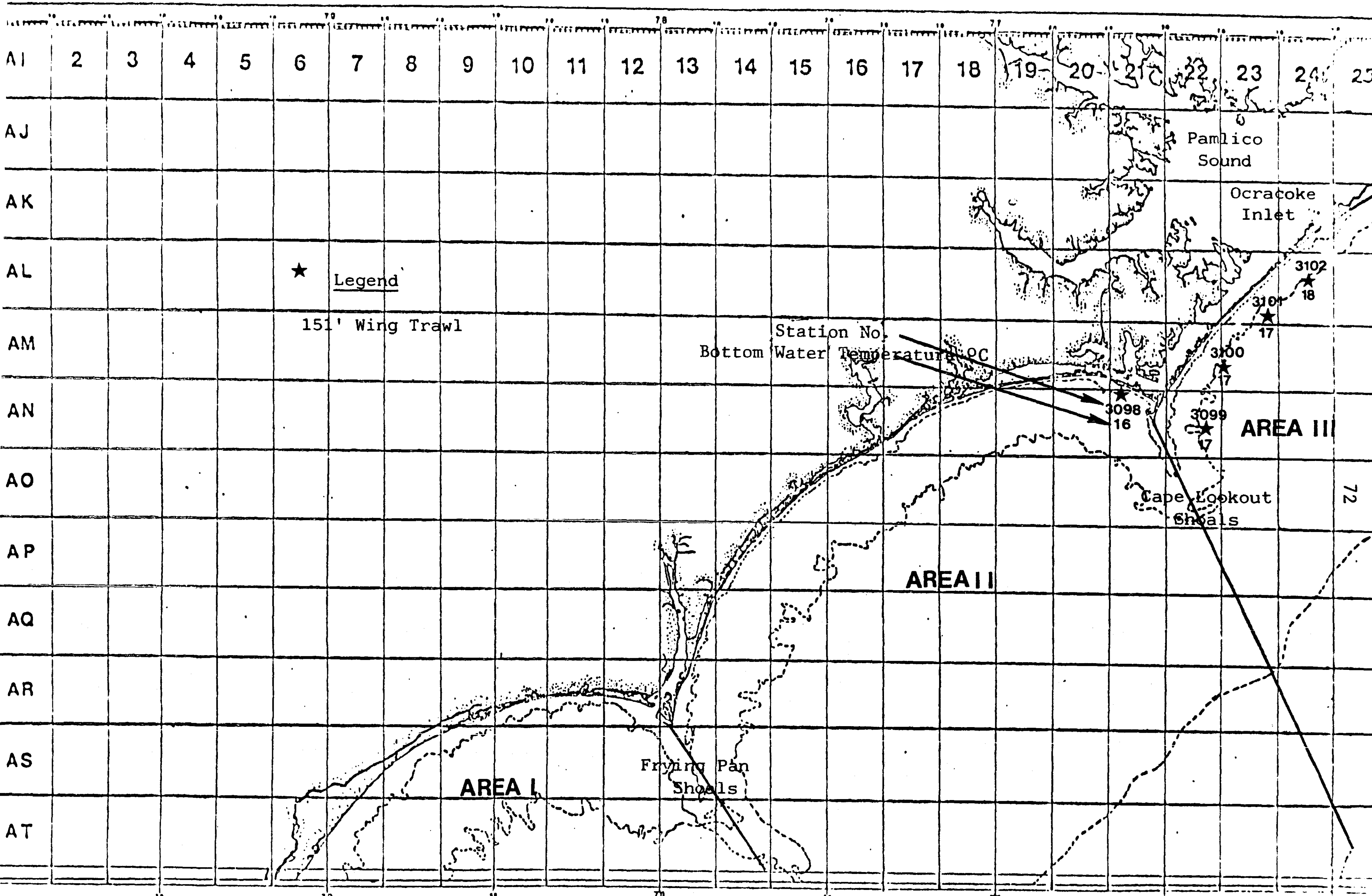


Figure 2. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (°C), and gear type utilized during Segment 2. Grids represent areas of 10 minute latitude and longitude.

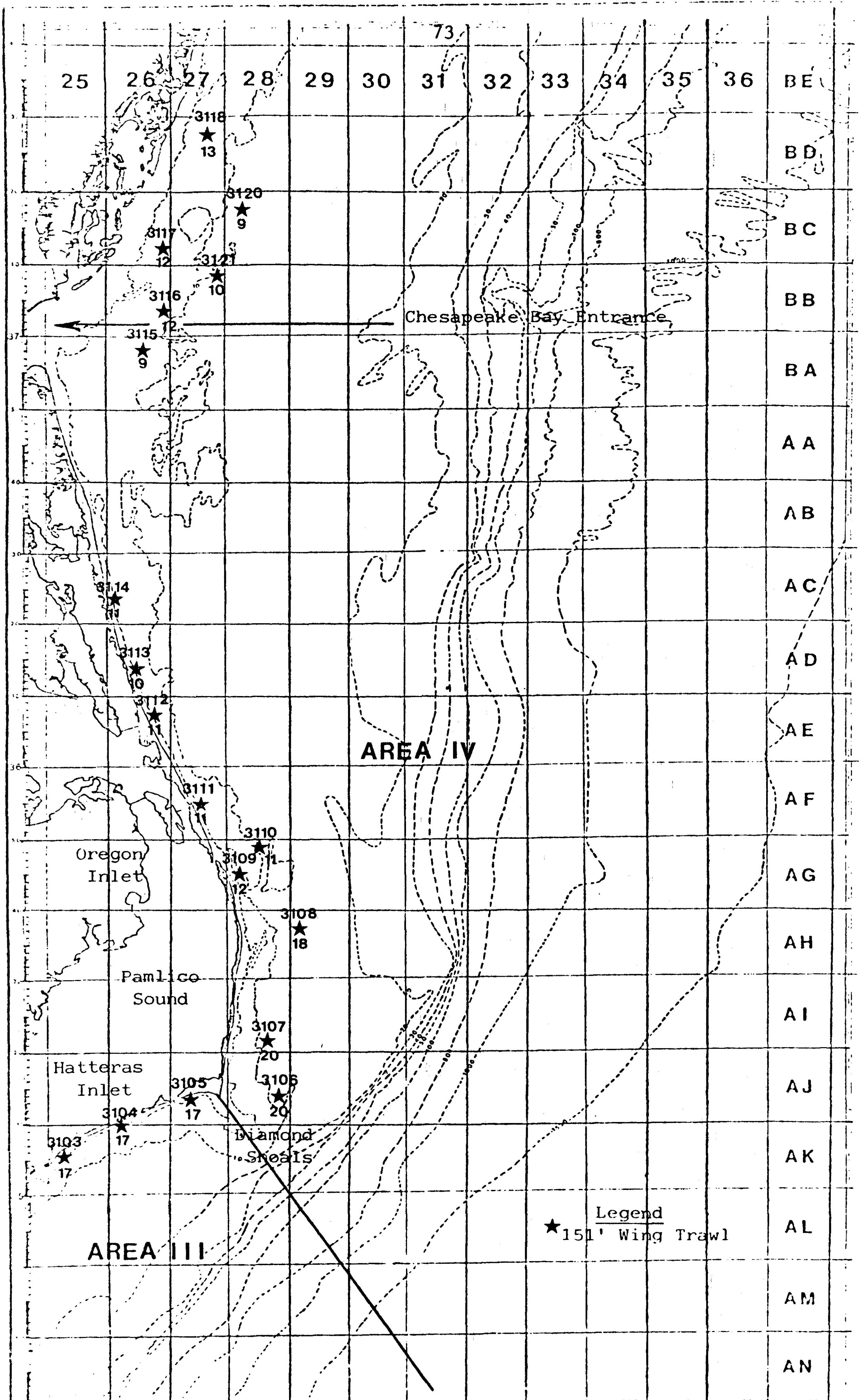


Figure 2. continued

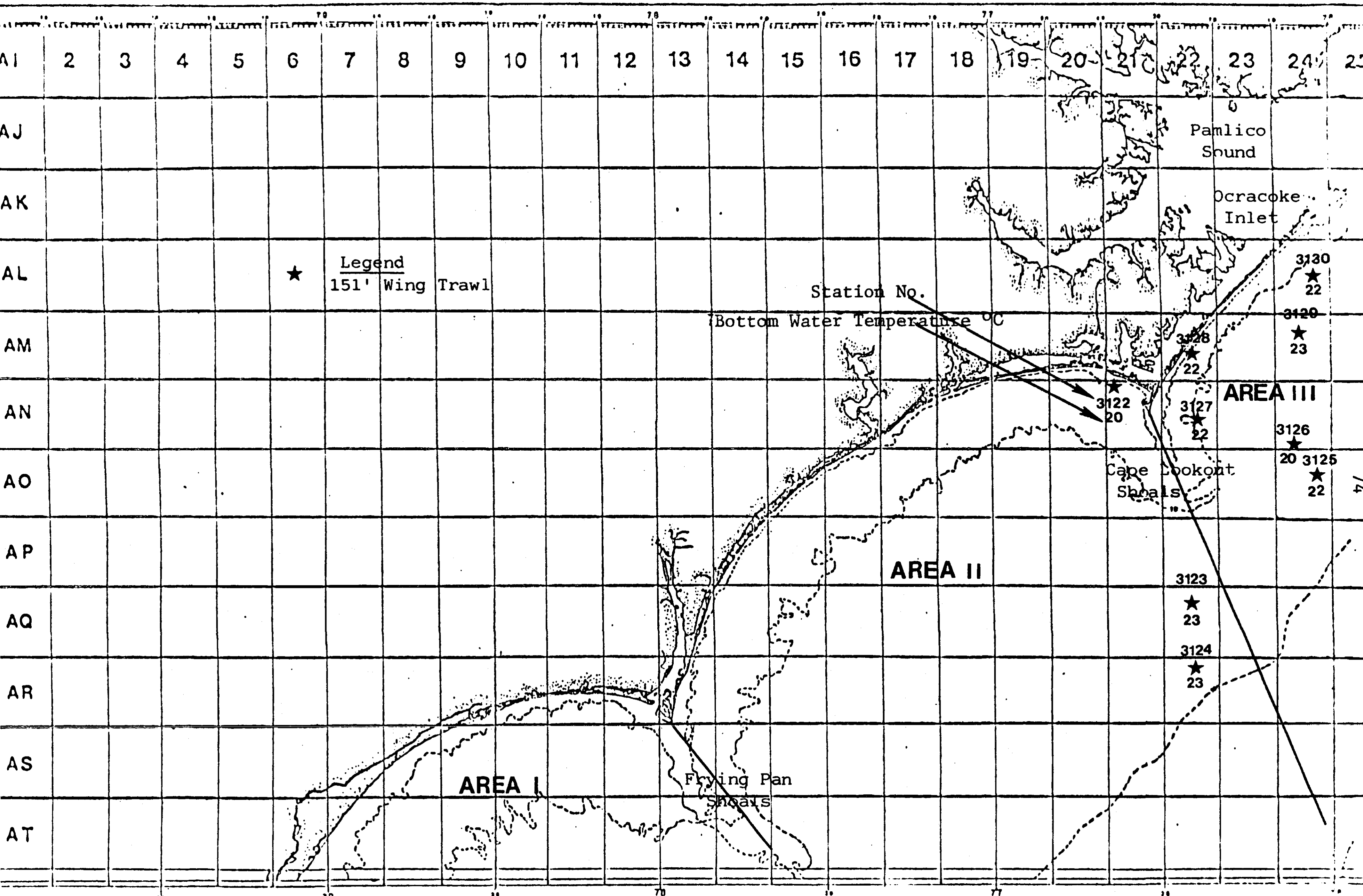


Figure 3. Ocracoke Inlet to South Carolina. Station localities, bottom-water temperature (°C), and gear type utilized during Segment 3. Grids represent areas of 10 minute latitude and longitude.

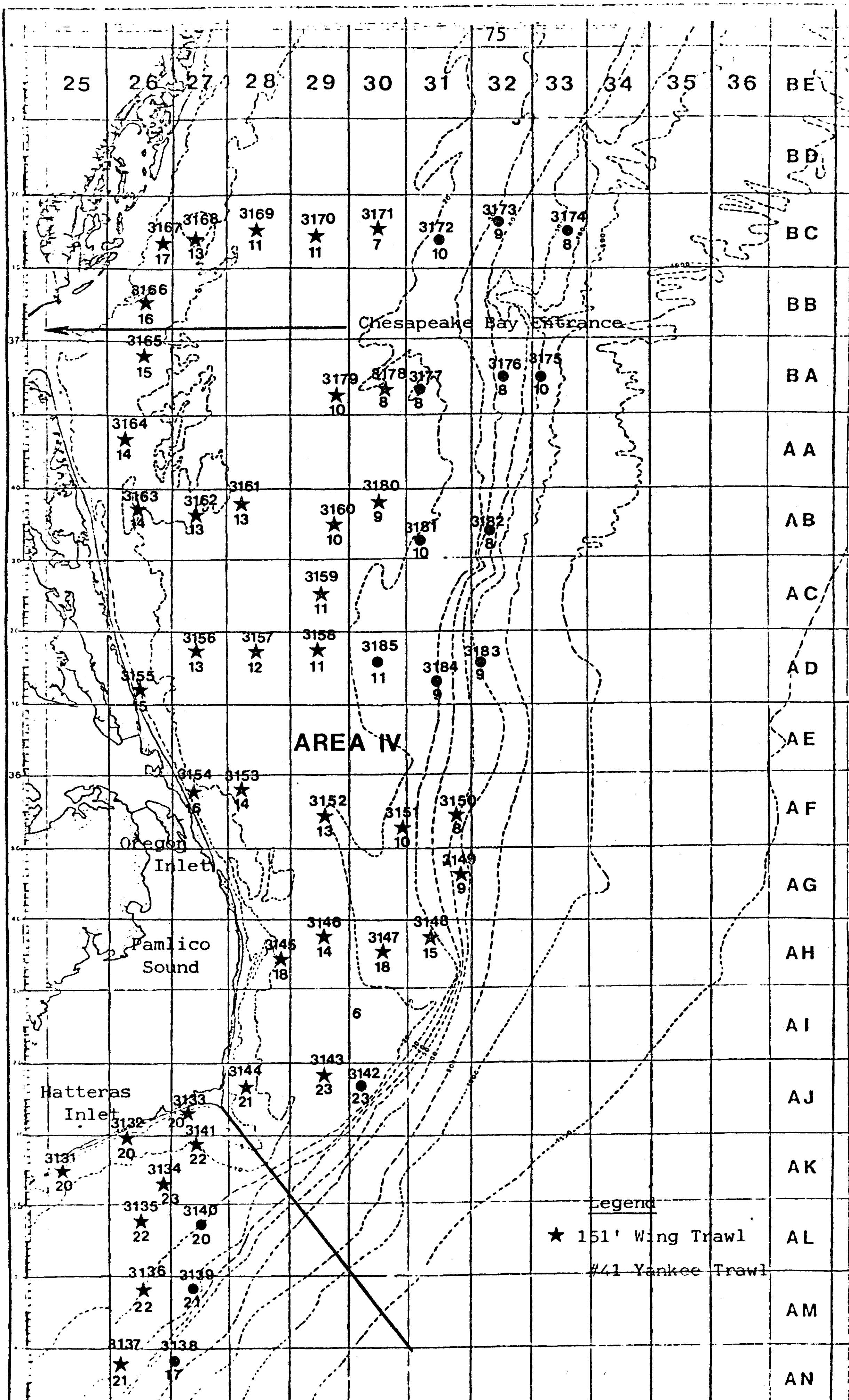


Figure 3. continued

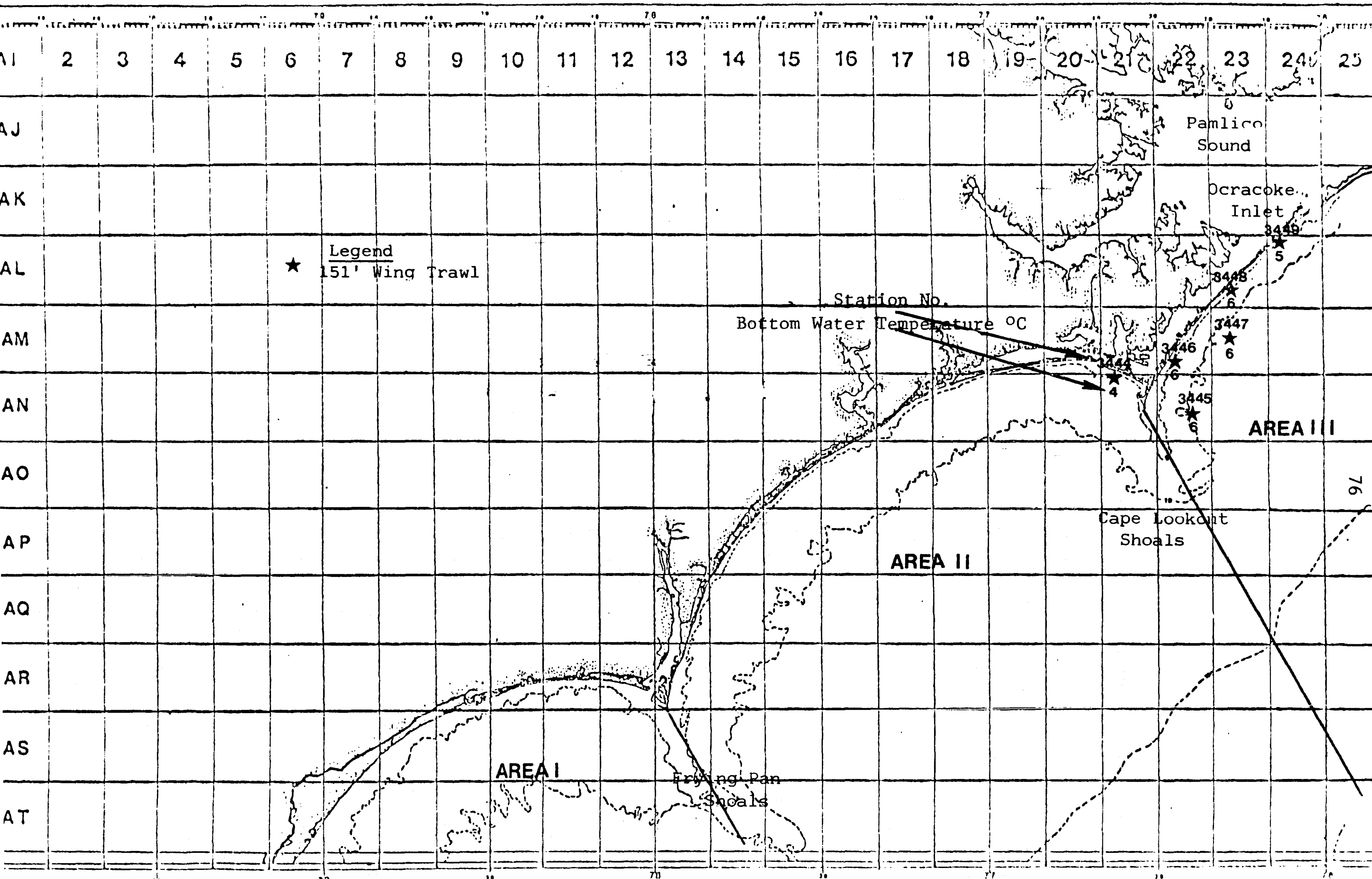


Figure 4. Ocracoke Inlet to South Carolina. Station localities, bottom water temperature (°C), and gear type utilized during February, 1978. Grids represent areas of 10 minute latitude and longitude.

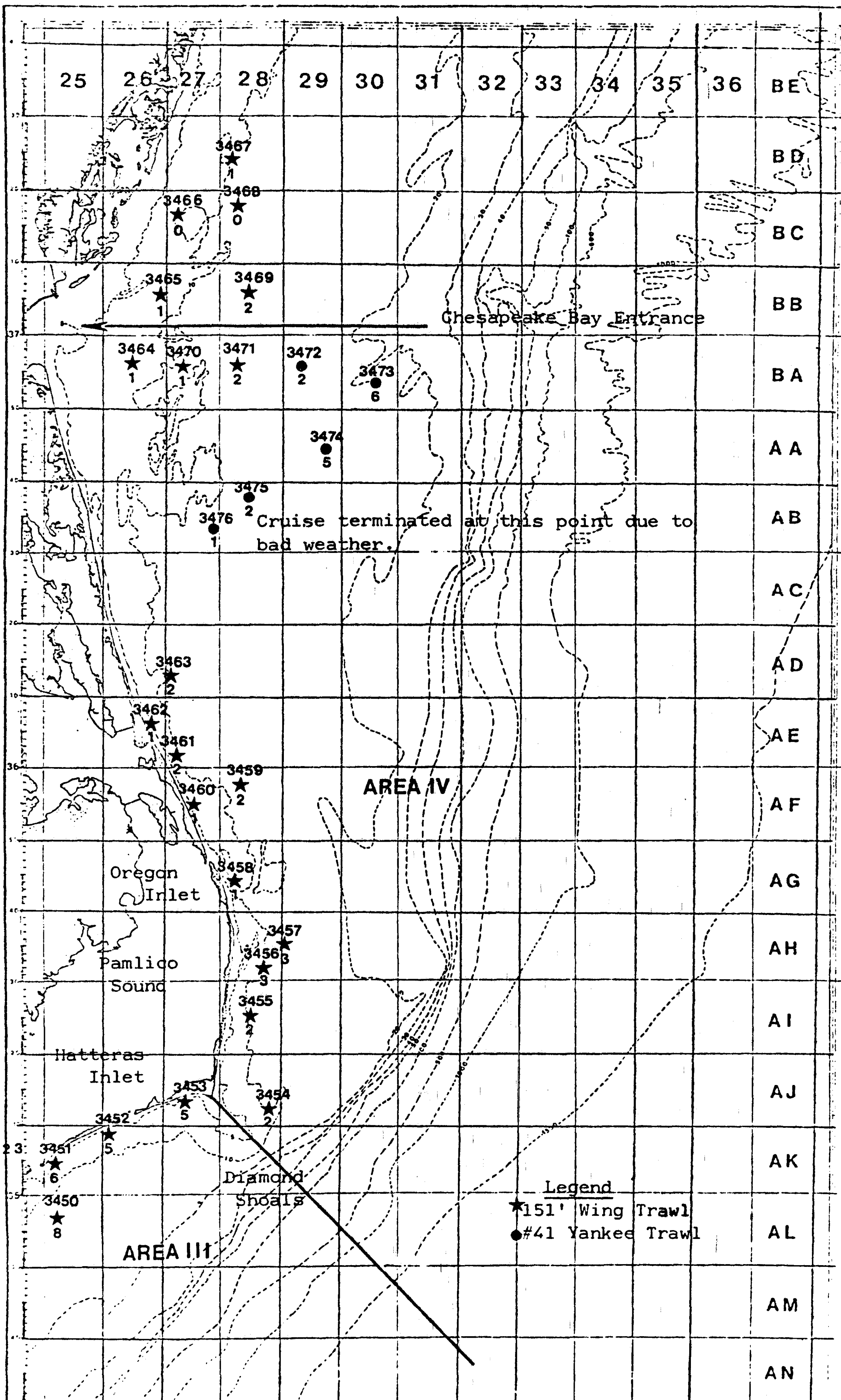


Figure 4. continued

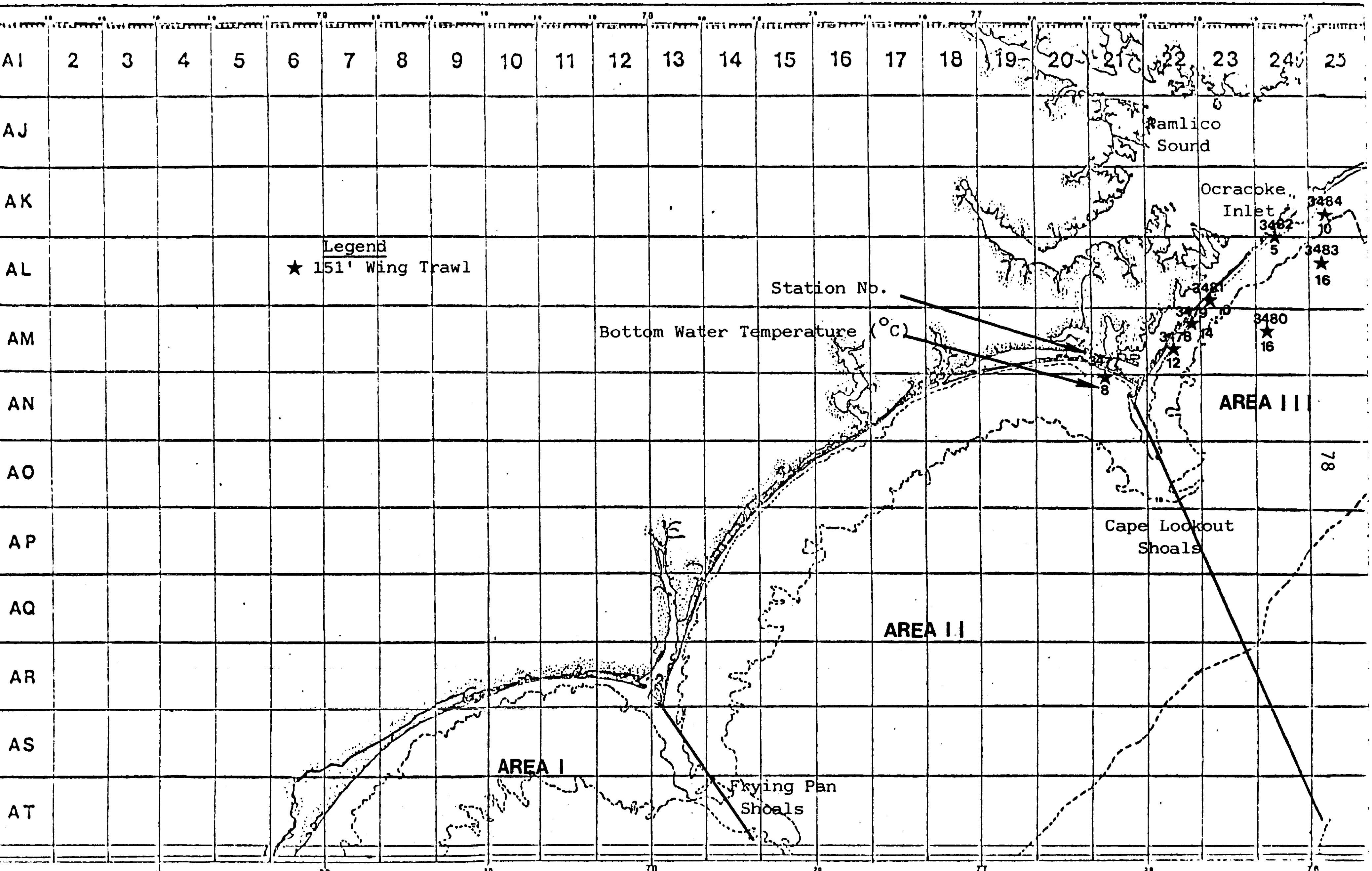


Figure 5. Ocracoke Inlet to South Carolina. Station localities, bottom water temperature (°C), and gear type utilized during March, 1978. Grids represent areas of 10 minute latitude and longitude.

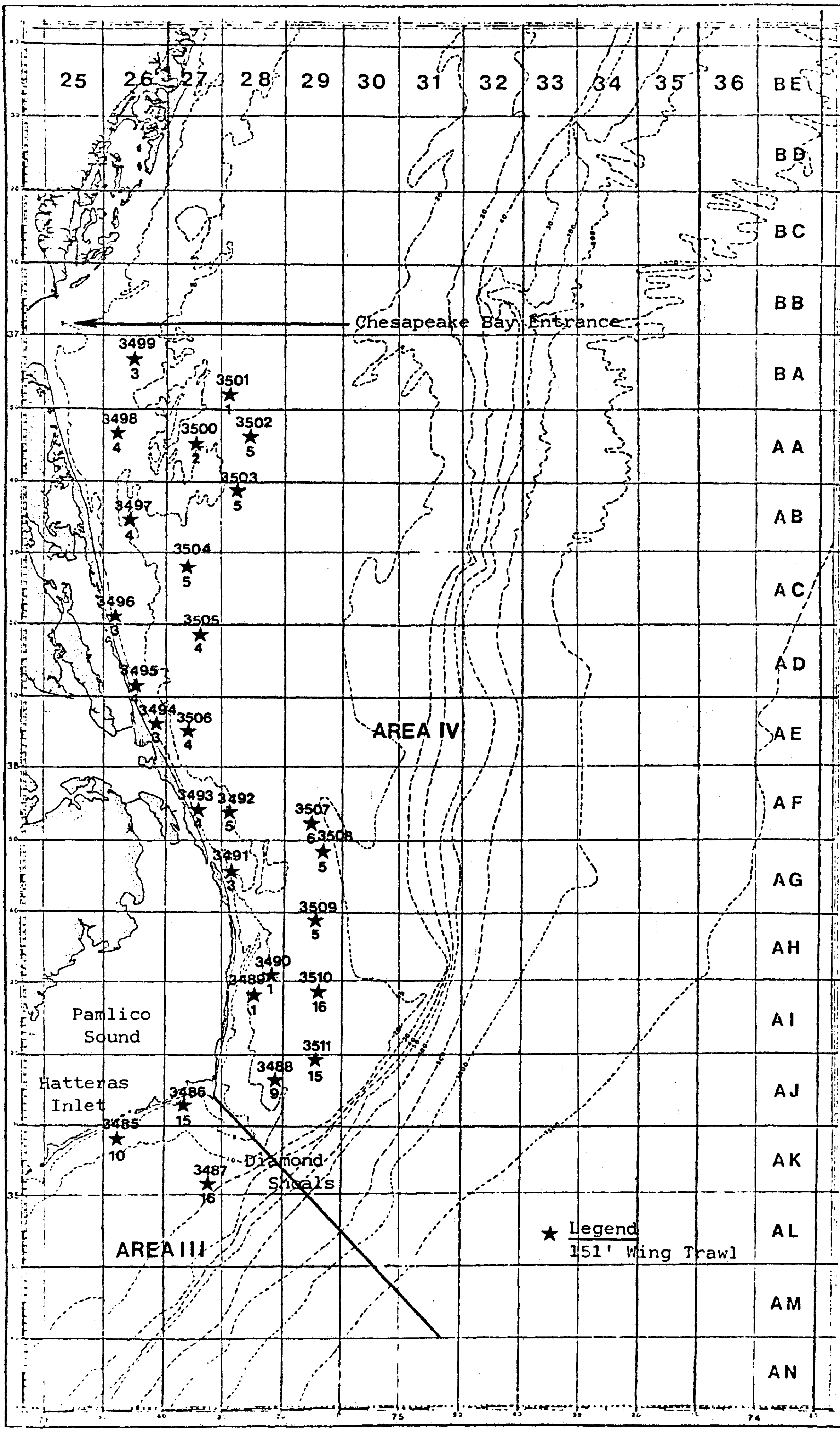


Figure 5. continued.

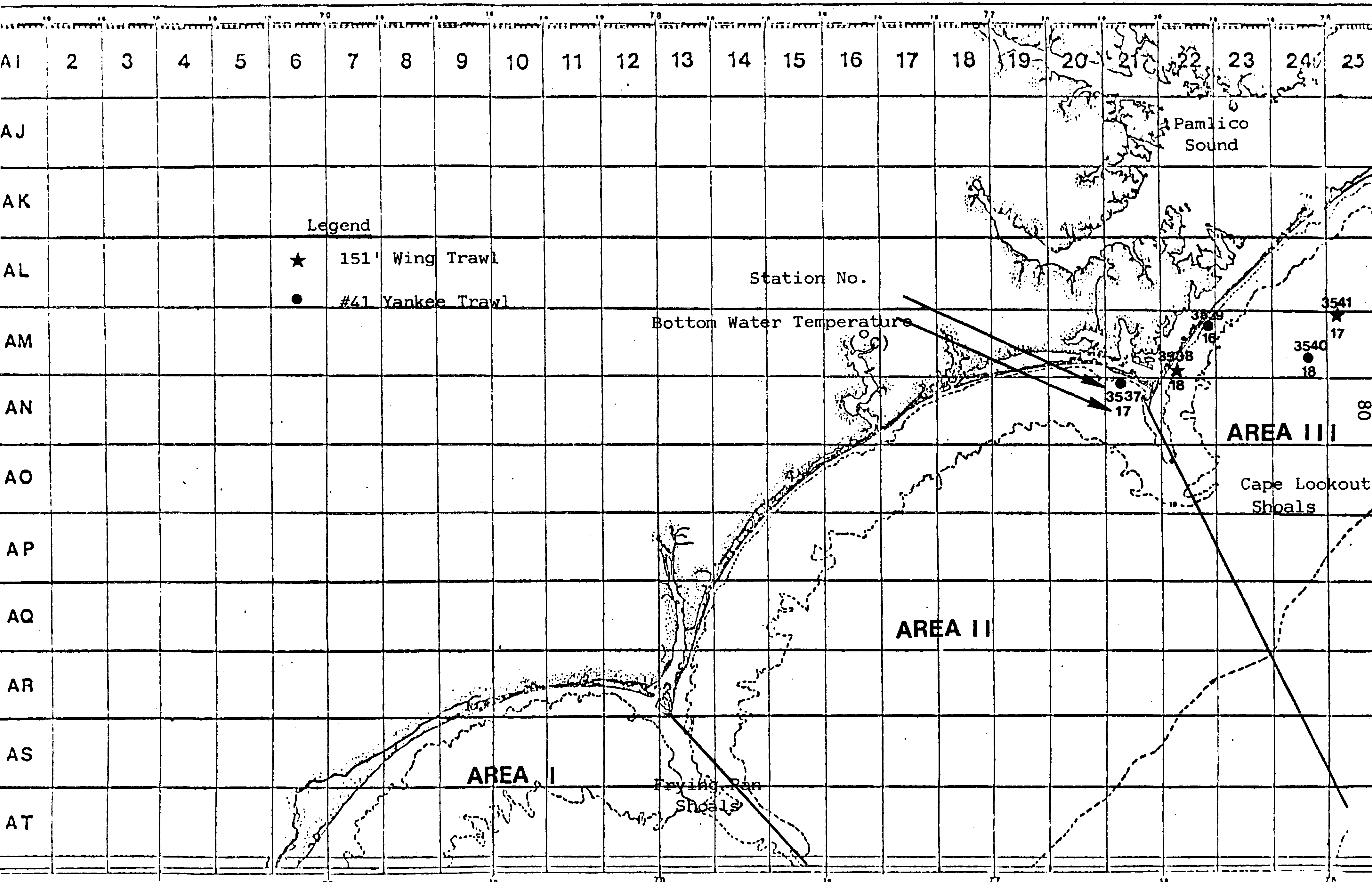


Figure 6. Ocracoke Inlet to South Carolina. Station localities, bottom water temperatures (°C), gear type utilized during April, 1978. Grids represent areas of 10 minute latitude and longitude.

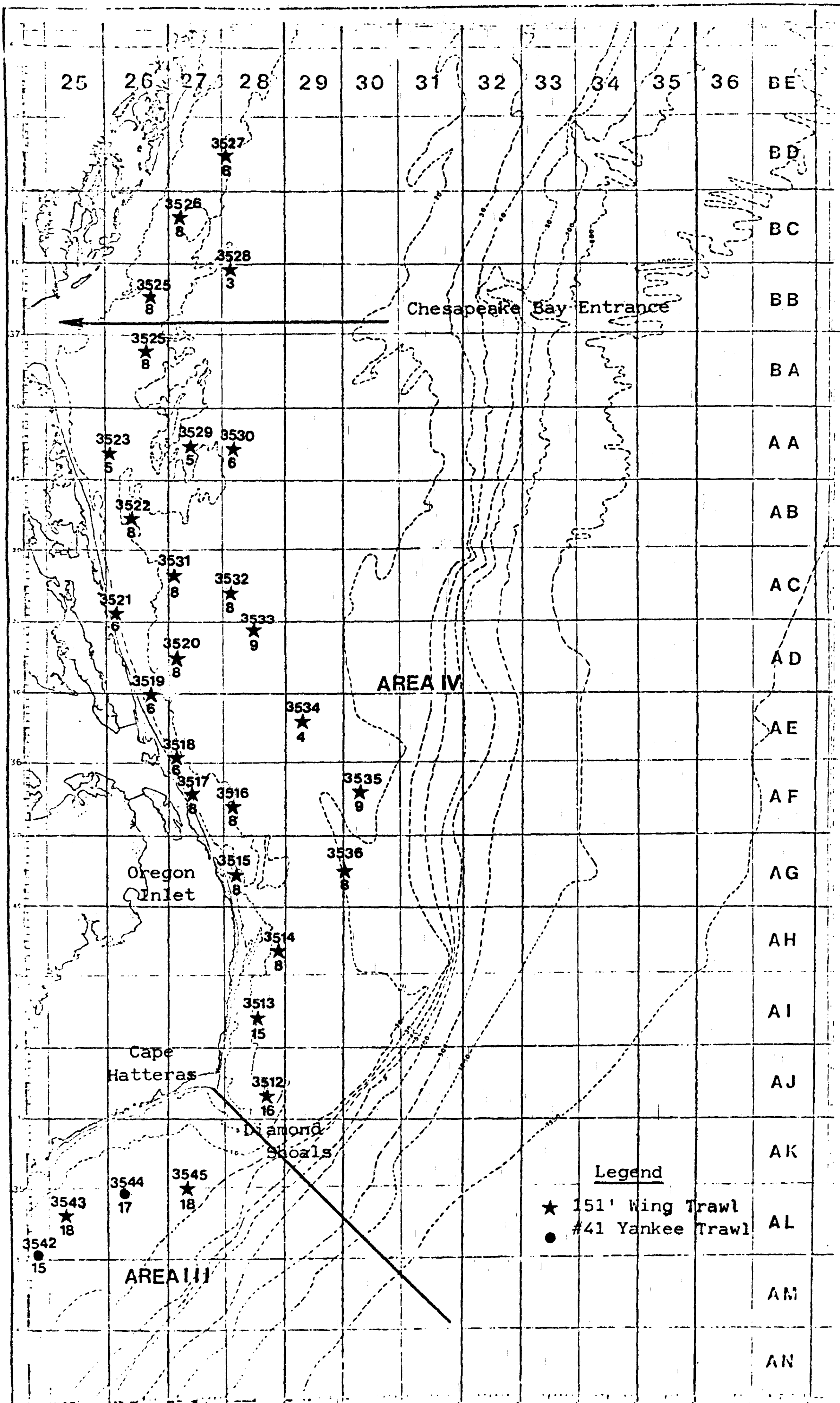


Figure 6. continued.

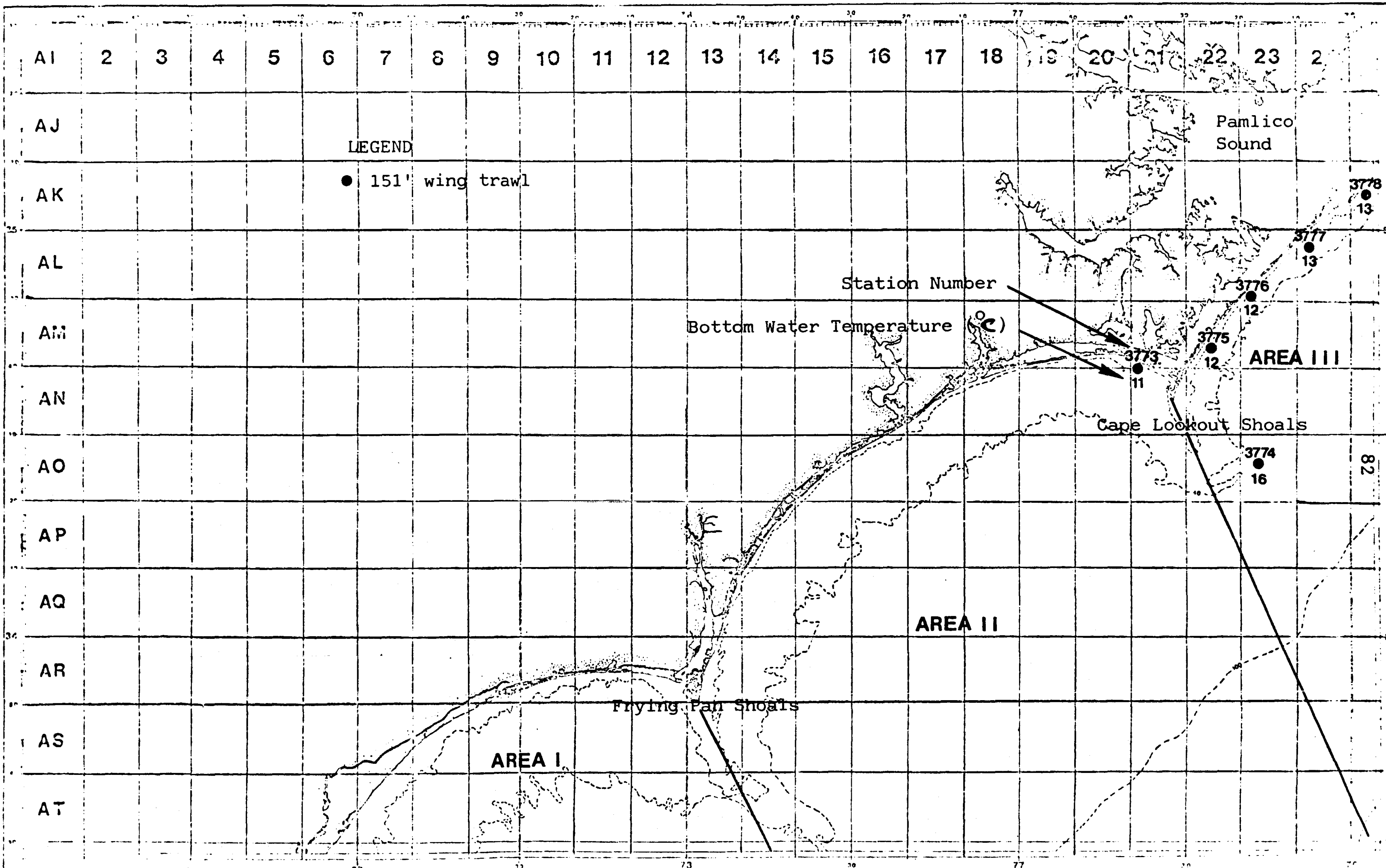


Figure 7. - Ocracoke Inlet to South Carolina. Station localities, bottom water temperatures (°C), and gear type utilized during January, 1979. Grids represent areas of 10 minute latitude and longitude.

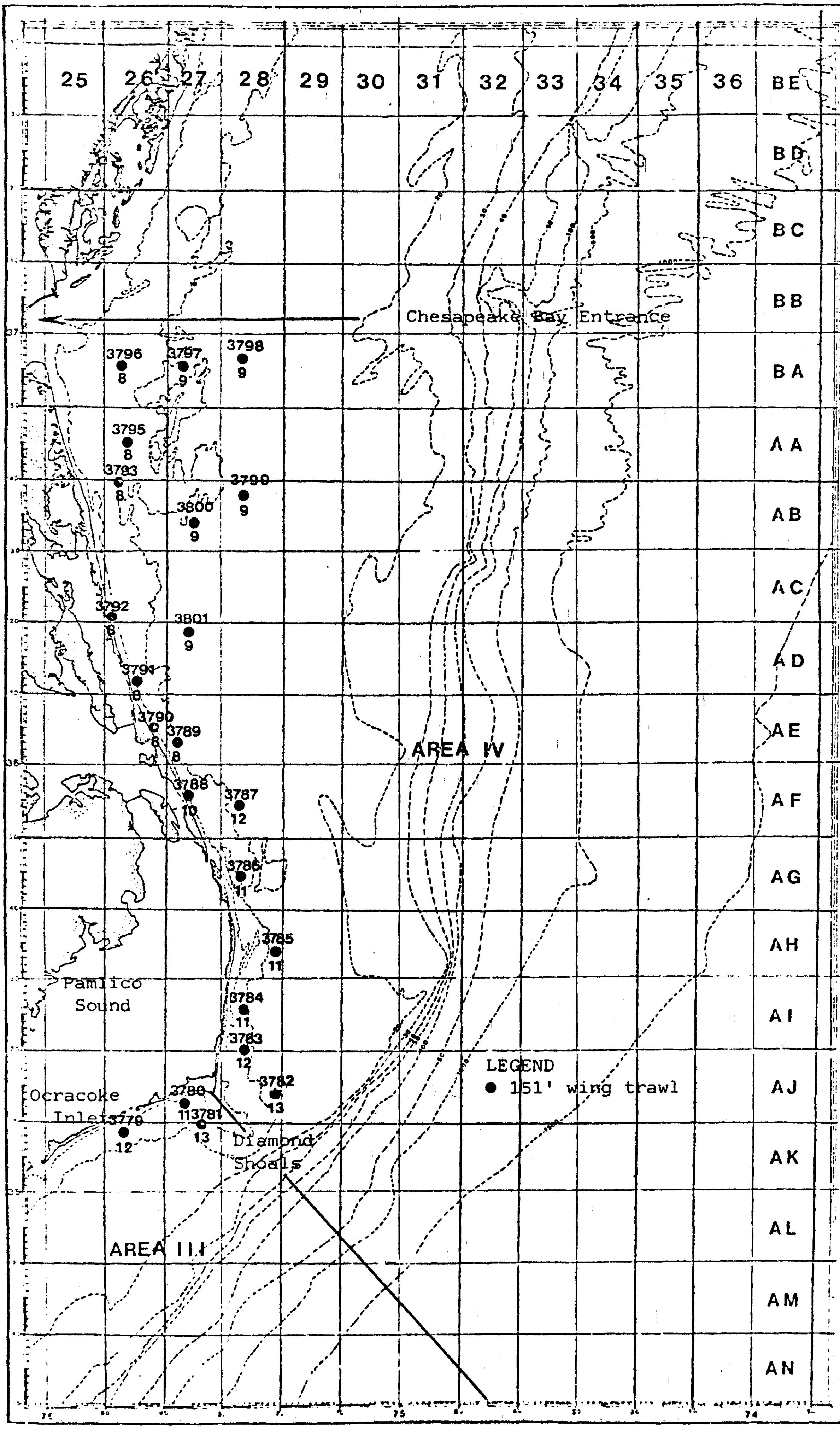


Figure 7. - continued.

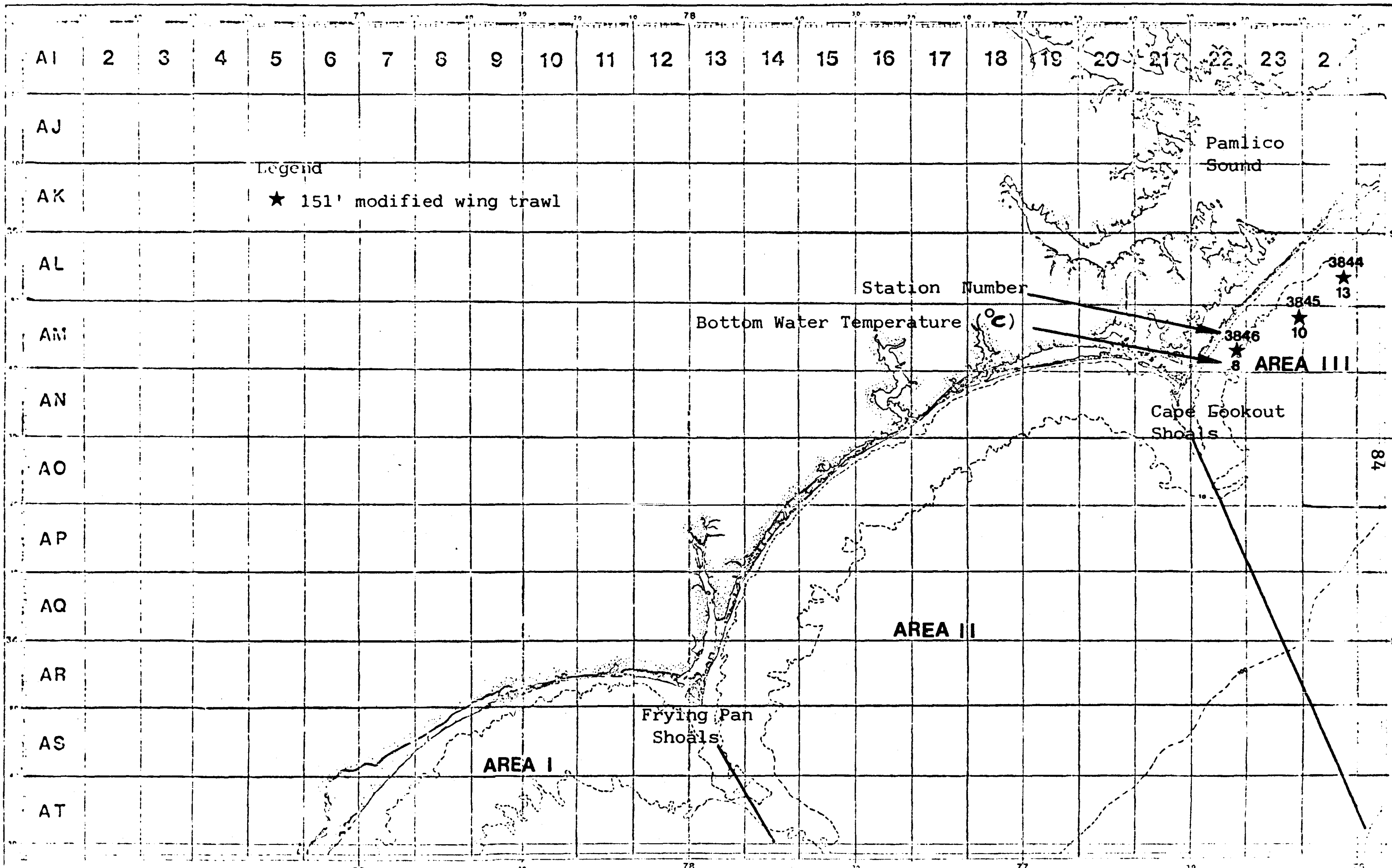


Figure 8. Ocracoke Inlet to South Carolina. Station localities, bottom water temperatures (°C), and gear type utilized during February-March, 1979. Grids represent areas of 10 minute latitude and longitude.

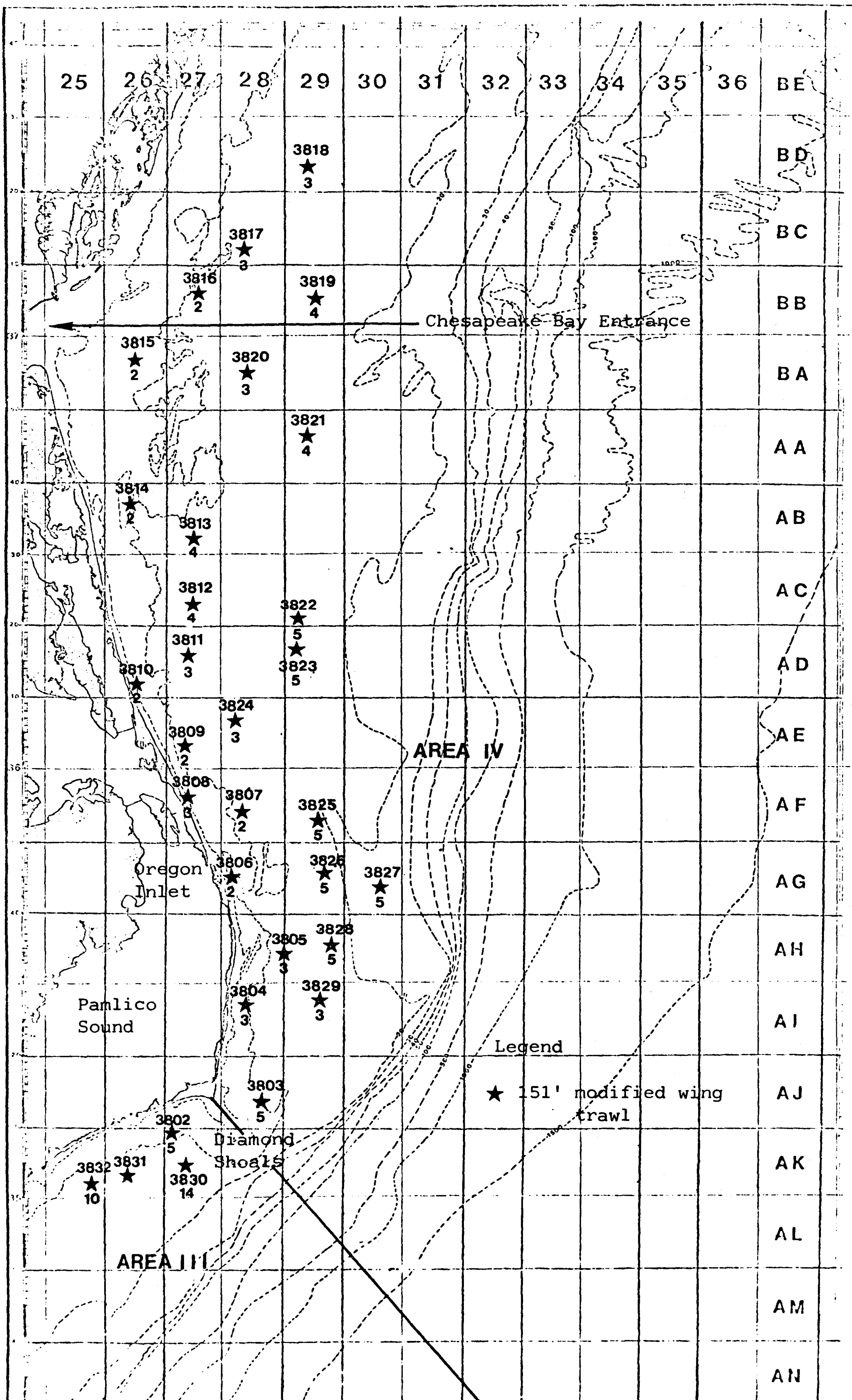


Figure 8. Continued.

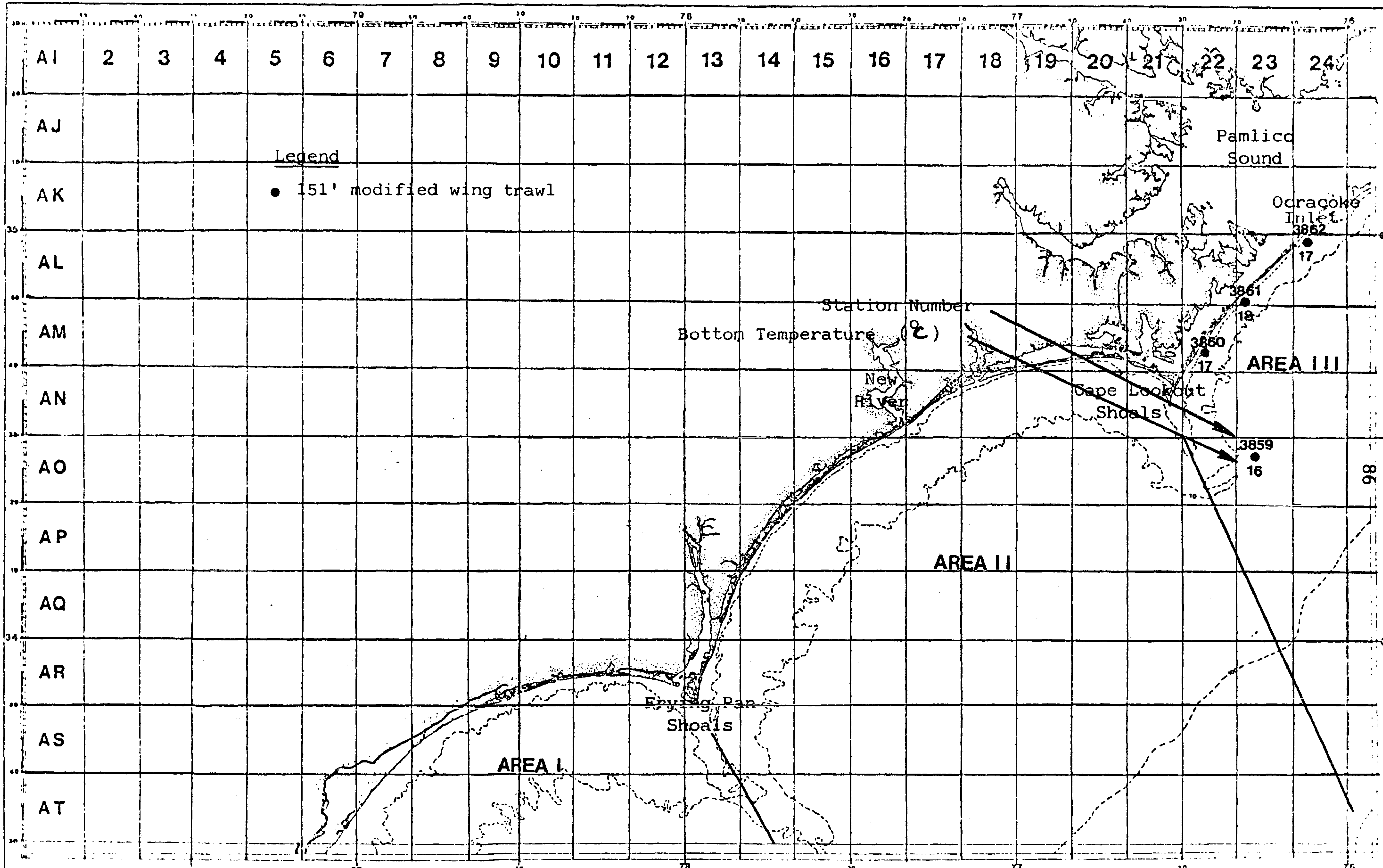


Figure 9. Ocracoke Inlet to South Carolina. Station localities, bottom water temperatures (°C), and gear type utilized during April, 1979. Grids represent areas of 10 minute latitude and longitude.

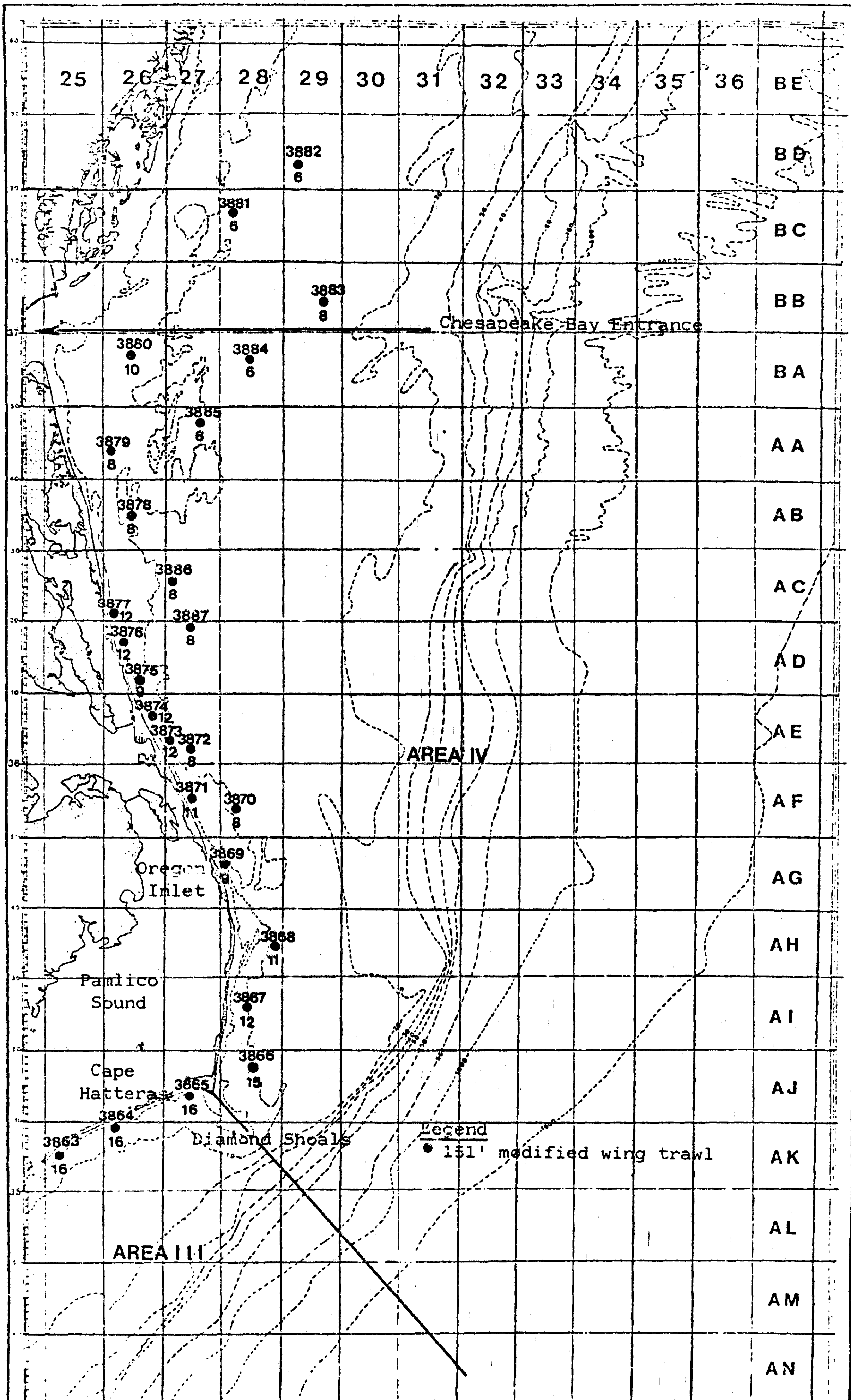


Figure 9. - continued.

III, and IV. To increase the chances of locating concentrations of anadromous fishes, electronic fish - detecting equipment was monitored continually during and between all stations.

Sampling Gear

From 11 April through 31 May 1977, and from 13 February through 24 April 1978, a 46.1 m (151 ft) (headrope) modified wing trawl described by Holland and Powell (1975) and a standard No. 41 Yankee trawl with a 21.4 m (70 ft) headrope and a 27.5 m (90 ft) sweep (equipped with 15.2 cm (6 in) 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 the 1977 and 1978 seasons the 46.1 m modified wing trawl was used throughout the survey, except in the offshore zone where the use of the heavier No. 41 Yankee trawl was occasionally required to negotiate rough bottom.

During the 1979 season, the 46.1 m modified wing trawl was utilized exclusively throughout the survey. During January, however, steel suberkrub midwater doors 2.4 x 1.1 m (8 ft x 3.5 ft) were used rather than 2.6 m x 1.3 m (8.5 ft x 4.3 ft) bracket doors normally used in conjunction with all trawls during the project.

The cod ends of all nets were constructed of 38 mm (1.5 in) stretched mesh, and 45.7 m (150 ft) scissors rig was utilized in conjunction with all trawls and with both bracket and midwater doors.

Collection of Materials

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

Tagging

We planned to tag and release striped bass and sturgeon, as available, in order to better assess their recent declines in abundance as indicated by our previous sampling and landing statistics.

Floy FT-1 dart tags were utilized[1]. 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 777, 969, and 6,705 blueback herring were taken during 1977, 1978, and 1979 respectively from trawl catches and examined for sex and female maturity. The paucity of alewife, American shad, and hickory shad precluded the determination of sex and female

---

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

maturity for these species.

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

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

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

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

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

Stage V. - Ovaries flabby, 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 bathy thermograph (XBT) or a Mondedoro Whitney thermistor was utilized to obtain both surface and bottom temperatures at each sampling station.

RESULTS AND DISCUSSION

Sampling Success

During the fall of 1976, it was discovered that the two main propulsion engines in the R/V DAN MOORE would have to be overhauled. The inability to obtain parts resulted in numerous delays and precluded the initiation of any anadromous activity until April, 1977. Evidence from previous studies had determined that the offshore anadromous season was normally over after April or when water temperatures exceeded 12°C. Even though trawling operations were extended to a depth of 131 meters, anadromous fishes were only sporadically encountered. Only 795 anadromous fishes were captured in 130 samples. More specifically, 3 American shad, 2 hickory shad, 10 Atlantic sturgeon, 3 alewife and 777 blueback herring contributed to the total anadromous catch. No striped bass were captured.

Significant declines in river herring and shad have been noted since 1973. Despite these declines, February and March have usually proven to be periods of maximum abundance offshore North Carolina and Virginia. During the 1978 season, however, anadromous fishes were again only sporadically encountered throughout the study area. Only 1,308 juvenile and adult anadromous fishes were captured in 102 samples. The total anadromous catch consisted of 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).

Blueback herring were found to be slightly more abundant during the 1979 season than in any other segment during this project period.

Unfortunately, this was not the case for other anadromous species and catches still remained far below levels experienced prior to 1974. A total of 7,086 anadromous fishes were captured in 92 samples. More specifically, 7 striped bass, 59 American shad, 3 hickory shad, 6,705 blueback herring and 312 alewife contributed to the total anadromous catch. Atlantic sturgeon were totally absent in catches during this project segment.

Species captured other than anadromous fishes are listed in Appendix Tables 1 - 5 for all three seasons.

Coastal Distribution

During this project period, blueback herring was the only anadromous species captured in any appreciable number in each area. Striped bass, American shad, hickory shad, Atlantic sturgeon and alewife did not contribute significantly and/or were totally absent in catches.

As indicated by data in Tables 1, 2 and 3 anadromous fishes were found in greatest numbers within Area IV. Although, unequal effort between Areas II, III and IV may have influenced catches, 78.7% (1977), 79.1% (1978), and 99.4% (1979) of all anadromous fishes were captured within Area IV.

During the 1977 season, hickory shad (2) were captured exclusively in Area III. Blueback herring were encountered in all three areas and were the only anadromous species captured in Area II (Area II 135, Area III 31, Area IV 611). American shad (3), Atlantic sturgeon (10) and alewife (3) were captured exclusively in Area IV. No striped bass were captured; however, sampling was not initiated until April. Historically, from April

TABLE 1.--Relative abundance of offshore anadromous fishes by sampling area (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes). April-May, 1977.

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

*less than 0.1 fish

Table 2. Relative abundance of offshore anadromous fish by sampling area, February - April, 1978 (as indicated by total catch, average catch per sample, and percent of samples taken offshore anadromous fish).

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 3. Relative abundance of offshore anadromous fish by sampling area, January - April, 1979 (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish).

	Area II			Area III			Area IV			Total		
	1 Sample			22 Samples			69 Samples			92 Samples		
Species	Total catch No.	Avg. catch	Pct. with fish	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*	0	0	0	2	*	9.0	5	*	1.4	7	*	3.2
American Shad *Alosa sapidissima*	0	0	0	0	0	0	59	.86	15.9	59	.64	11.9
Hickory Shad *Alosa mediocris*	0	0	0	1	*	4.5	2	*	2.9	3	*	2.2
Atlantic Sturgeon *Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0	0	0	0
Blueback Herring *Alosa aestivalis*	0	0	0	36	1.6	36.4	6,669	96.7	52.2	6,705	72.9	47.8
Alewife *Alosa pseudoharengus*	0	0	0	0	0	0	312	4.5	14.5	312	3.4	10.9
Totals	0			39			7047			7086		

* Less than 0.1 fish

through June striped bass have not been taken in the ocean offshore North Carolina.

During the 1978 season, 12 striped bass were captured, all in Area IV. Five Atlantic sturgeon were encountered, one in Area II and four in Area III. Of the river herring captured during the 1978 season, 2.7% (32 blueback herring and 1 alewife) were encountered in Area II, 17.5% (161 blueback herring and 50 alewife) were captured in Area III, and 79.8% (776 blueback herring and 189 alewife) were captured in Area IV. Of the total American shad captured, 22 (28.2%) were captured in Area III and 56 (71.8%) were captured in Area IV. Only four hickory shad were captured, all of which were encountered in Area III.

During the 1979 season, only one sample was taken in Area II, and no anadromous fishes were captured. A total of seven striped bass were encountered; two in Area III, and five in Area IV. American shad (59) were captured exclusively in Area IV. Only three hickory shad were captured, one in Area III and two in Area IV. As in 1977 and 1978, the vast majority of blueback herring (6,669-99.5%) were captured in Area IV.

The remaining 36 blueback herring were captured in Area III. Alewife (312) were captured exclusively in Area IV. No Atlantic sturgeon were captured during the 1979 season.

Seasonal Distribution

Sampling was conducted from 11 April through 31 May 1977, from 13 February through 25 April 1978, and from 15 January through 9 April during the 1979 season.

The short duration of the 1977 sampling period and the paucity of anadromous fishes during that period precluded the accumulation of any seasonal distribution data for the 1977 season.

During the 1978 season, a total of 1,308 anadromous fishes were captured. Data presented in Table 4 indicate that hickory shad and Atlantic sturgeon were present off the North Carolina and Virginia Coast during February; striped bass, American shad, and alewife from February through March; blueback herring from February to the last week in April. The greatest numbers of alewife and American shad were captured in February while blueback herring were found to be more available during March. Juvenile blueback (58 - 108 mm) were present in catches from February through March, however, juvenile alewife (69 - 118 mm) were captured only during February.

During the 1979 season, a total of 7,086 anadromous fishes were captured. Data presented in Table 5 indicate that hickory shad were present off the North Carolina and Virginia coast only during January; American shad and blueback herring from January through mid-April; alewife from mid-February through mid-April; striped bass from mid-February through early March. No Atlantic sturgeon were captured. Blueback herring, alewife, and American shad were found to be most available during February and March. Not apparent in Table 5, however, is the relatively even distribution of blueback herring from ENE of Bodie Island, NC to the NC/VA State line during April 1979. Catches, though small, were consistent and evenly distributed along the bottom from 8 to 13 fathoms, where water temperatures ranged from 7^{o} to $9^{o}C$. However, when the $9^{o}C$ isotherm was followed offshore north of the NC/VA State line, fish concentrations gradually shifted upward in the water column and were no longer susceptible to the 151' modified wing trawl being utilized.

Table 4. Number of anadromous fishes captured, average catch per sample, and percent of samples taking anadromous fishes by months, February - 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. Number of anadromous fishes captured, average catch per sample, and percent of samples taking anadromous fishes by months, January - April, 1979.

Species	January 29 Samples			February-March 34 Samples			April 29 Samples		
	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*	0	0	0	7	.20	*	0	0	0
American Shad *Alosa sapidissima*	5	0.17	0.10	45	1.3	0.10	9	0.31	0.17
Hickory Shad *Alosa mediocris*	3	0.10	*	0	0	0	0	0	0
Atlantic Sturgeon *Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0
Blueback Herring *Alosa aestivalis*	48	1.7	.45	6235	183.4	.44	422	14.5	.55
Alewife *Alosa pseudoharengus*	0	0	0	288	8.5	.15	24	0.83	0.20
Totals	56			6575			455		

* Less than 0.1 fish

Juvenile blueback herring (61-108 mm) were captured throughout the sampling period while juvenile alewife (84-104 mm) were encountered only once in February and once in April.

The differences in occurrence of river herring by month were analyzed in relation to water temperature. Figures 10 and 11 depict mean surface and bottom temperatures by month for Areas III and IV for the 1978 and 1979 seasons. Approximately 97.1% (1978) and 93.0% (1979) of all river herring were captured during February and March of both seasons.

During February and March of the 1978 season, surface and bottom temperatures within the study area ranged from 0°C to 12°C and from 0°C to 17°C respectively. Mean monthly surface and bottom temperatures ranged from 1.8°C and 11.2°C (February) and from 1.9°C and 12.6°C (March). Of the 1,174 river herring captured during February and March, 77.3% were encountered in Area IV where surface temperatures ranged from 1.0°C to 5.8°C and bottom temperatures ranged from 1.0°C to 5.1°C. Mean surface and bottom temperatures for Area IV were both calculated to be 2.8°C.

During the February - March cruise of the 1979 season, surface and bottom temperatures within the study area ranged from 2.0°C to 8.0°C and from 2.0°C to 14.0°C respectively. Mean monthly surface and bottom temperatures were 4.1°C and 16.6°C respectively. Of the 6,523 river herring captured during the 1979 February-March cruise 92.7% were encountered in Area IV where surface temperatures ranged from 2.6°C to 5.6°C. Mean temperatures for Area IV were 3.7°C (surface) and 4.2°C (bottom).

Mean surface and bottom temperatures during February and March of the 1978 and 1979 seasons were lower than any recorded during any previous season back to, and including the 1968 season (the first season the R/V DAN MOORE operated in the study area).

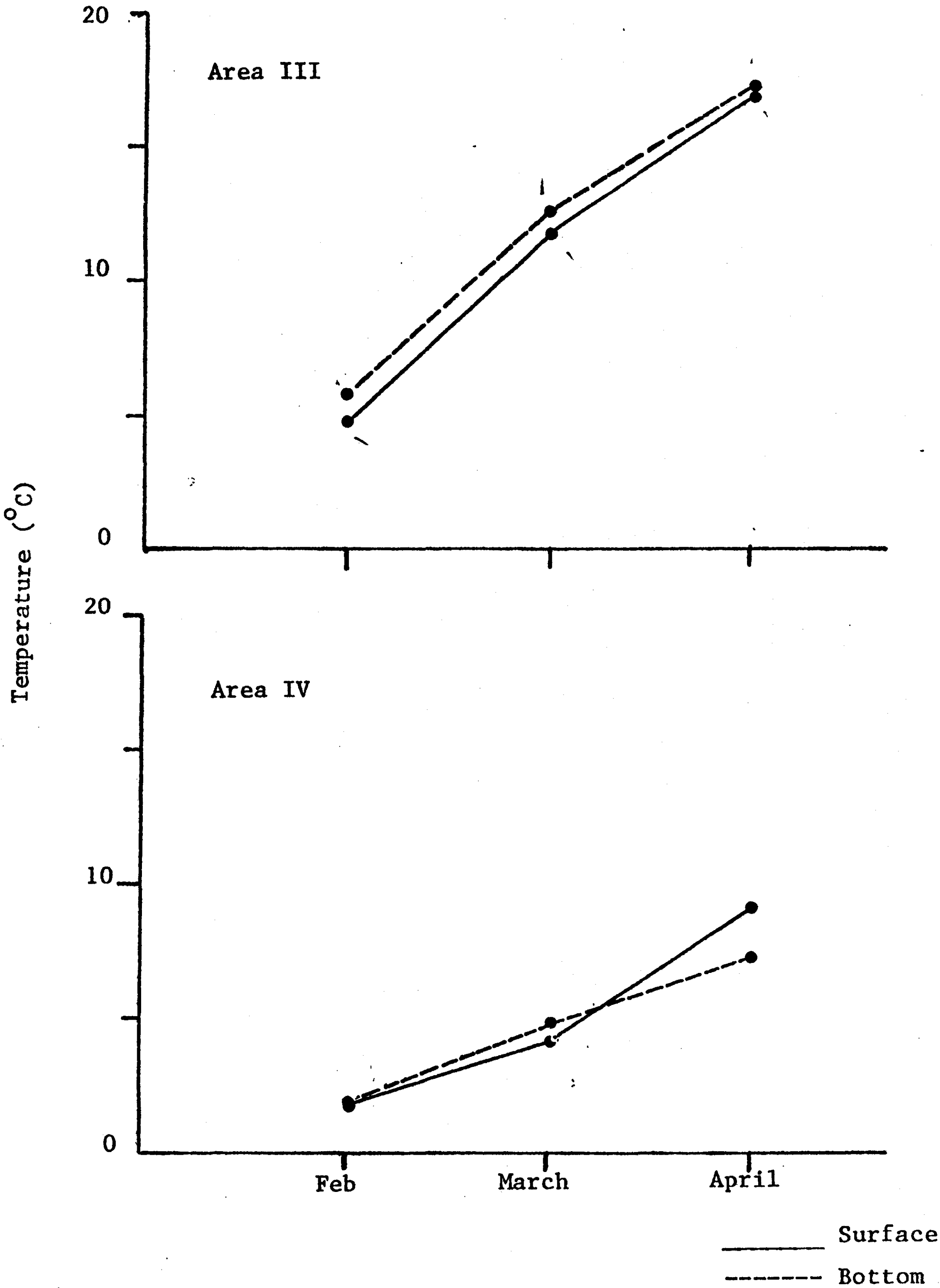


Figure 10. Monthly mean surface and bottom temperatures in Areas III and IV, February through April 1978.

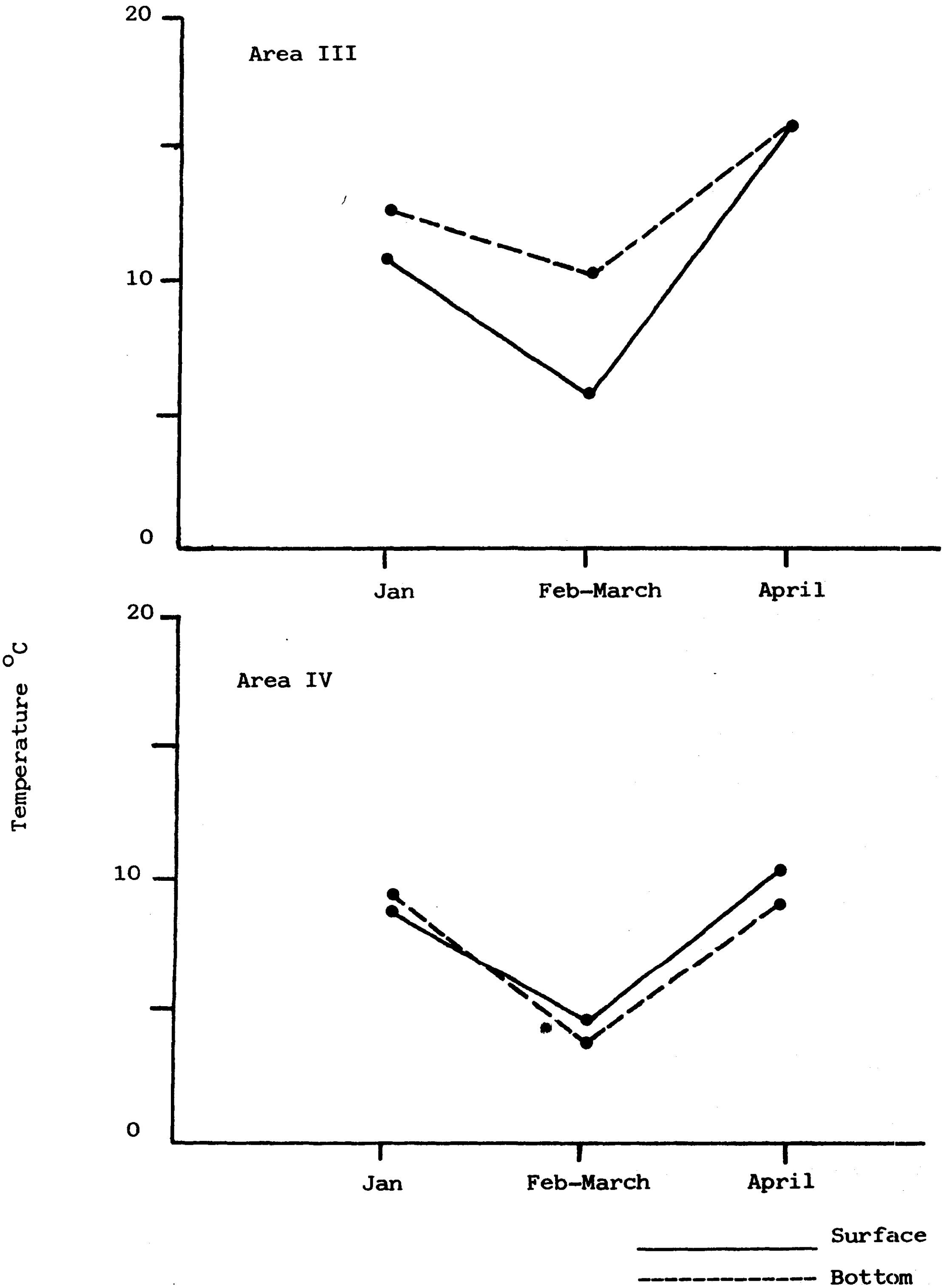


Figure 11. Monthly mean surface and bottom temperatures in Areas III and IV, January through April 1979.

Depth Distribution

Sampling effort and relative abundance of anadromous fishes during the 1977 through 1979 seasons in relation to depth zones are shown in Tables 6, 7, and 8.

During the 1978 and 1979 seasons, anadromous fishes were encountered sporadically in the inshore zone (0-18.3 m) because of extremely low water temperatures (as low as 0^oC in February 1978 and 2.2^oC in February 1979). In 1977, however, the inshore zone accounted for 733 fish, or 92.2% of the total anadromous catch that year. The 1977 inshore catch consisted of 3 American shad, 2 hickory shad, 2 alewife, 1 Atlantic sturgeon and 725 blueback herring (93.3% of the total blueback herring captured that year).

In 1978, 376 anadromous fishes were captured in the inshore zone (only 28.7% of the 1978 anadromous catch). Twenty-six American shad, 4 hickory shad, 52 alewife, 5 Atlantic sturgeon, 7 striped bass and 282 blueback herring contributed to the total taken.

Only 249 anadromous fishes were captured in the inshore zone in 1979 (3.5% of the total 1979 catch). More specifically, 9 American shad, 3 hickory shad, 1 alewife and 236 blueback herring were taken.

Within the inshore zone, the greatest number of samples (65)were taken with the best results in 1977, when water temperatures inshore were the most favorable for anadromous fish (5^o - 9^oC).

Because of extremely low water temperatures in the inshore zone and very favorable weather conditions in the other zones during the 1978 and 1979 seasons, effort was concentrated mainly in the midshore and offshore zones (20.1 - 183.0 M). In 1977 however, the midshore zone accounted for

TABLE 6.--Relative abundance and depth distribution of offshore anadromous fishes (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fishes). 11 April through 31 May 1977.

	Inshore 0 - 18.3 m 65 Samples			Mid-Shore 20.1 - 36.6 m 44 Samples			Off-Shore 38.4 - 183.0 m 21 Samples		
Species	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*	0	0	0	0	0	0	0	0	0
American shad *Alosa sapidissima*	3	*	4.6	0	0	0	0	0	0
Hickory shad *Alosa mediocris*	2	*	3.1	0	0	0	0	0	0
Atlantic sturgeon *Acipenser oxyrhynchus*	1	*	1.5	9	0.2	9.1	0	0	0
Blueback herring *Alosa aestivalis*	725	11.2	35.4	52	1.2	15.9	0	0	0
Alewife *Alosa psuedoharengus*	2	0.3	3.1	1	*	2.3	0	0	0
	733			62			0		

* Less than 0.1 fish

Table 7. 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 fish).

	Inshore			Midshore			Offshore		
	0-18.0 m			19.8-36.0 m			37.8-180.0 m		
	36 Samples			65 Samples			1 Sample		
Species	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 8. Relative abundance and depth distribution of offshore anadromous fishes, January-April, 1979 (as indicated) by total catch, average catch per sample, and percent of samples taking offshore anadromous fish).

	Inshore			Midshore			Offshore		
	0-18.3 m			20.1-36.0 m			38.4-183.0 m		
	38 Samples			53 Samples			1 Sample		
Species	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*	0	0	0	7	0.13	5.7	0	0	0
American Shad *Alosa sapidissima*	9	.24	13.2	50	.94	11.3	0	0	0
Hickory Shad *Alosa mediocris*	3	*	5.3	0	0	0	0	0	0
Atlantic Sturgeon *Acipenser oxyrhynchus*	0	0	0	0	0	0	0	0	0
Blueback Herring *Alosa aestivalis*	236	6.2	47.4	6,469	122.0	49.05	0	0	0
Alewife *Alosa pseudoharengus*	1	*	2.6	311	5.9	17.0	0	0	0
Totals	249			6837			0		

* Less than 0.1 fish

only 62 anadromous fishes (7.8% of the total 1977 anadromous catch). The midshore catch consisted of 1 alewife, 9 Atlantic sturgeon and 52 blueback herring.

The 1978 midshore zone catch totalled 932 fish (71.3% of the total 1978 anadromous catch) consisting of 52 American shad, 188 alewife, 5 striped bass and 687 blueback herring.

Midshore zone sampling in 1979 yielded 6,837 fish (96.5% of the anadromous catch). More specifically, 50 American shad, 311 alewife, 7 striped bass and 6,469 blueback herring were captured.

Sampling in the offshore zone, restricted in 1978 and 1979 due to unfavorable weather conditions, yielded no anadromous species at all in 23 samples during the entire study period.

In conclusion, most of the anadromous fishes captured in 1977 were taken in the inshore zone chiefly because of favorable water temperatures there. During the 1978 and 1979 seasons however, extremely low water temperatures inshore influenced a shift in distribution and hence sampling effort to the midshore zone where most of the captures occurred. Sampling in the offshore zone was made virtually impossible due to high winds and rough seas and no anadromous species were taken in that zone.

Tagging

A total of ten Atlantic sturgeon were captured during April of the 1977 season. Nine of these were taken in the vicinity of Platt and Wimble Shoals and one was captured 43.3 km NNE of the Chesapeake Light Tower. All sturgeon were tagged and released at the site of capture. Fork lengths ranged from 87.4 to 208.3 cm (34.4 in to 82.0 in) and weights ranged from

5.4 to 101.3 kg (12 to 223 lbs). Only one sturgeon was recaptured, by fish trawl, three miles off Cape May, New Jersey after being at large 26 days and traveling 316.6 km in a northerly direction. That fish weighed 101.3 kg and was reportedly full of roe.

No striped bass were captured during the 1977 season.

Five Atlantic sturgeon were tagged and released during February of the 1978 season. One sturgeon was captured 6.4 km SW of Beaufort Bar, two were taken 3.2 km NE of Ocracoke Inlet, another 4.0 km NE of Drum Inlet, and the remaining one in Cape Hatteras Bight. Fork lengths ranged from 58.4 to 86.5 cm (23.4 in to 34.6 in) and weights ranged from 1.1 to 5.4 kg (2.4 to 11.9 lb). A total of 12 striped bass were captured during February and March, 1978 from the vicinity of Wimble Shoals north to the Chesapeake Light Tower. Of these twelve fish, ten were tagged and released. Fork lengths ranged from 46.4 to 118.0 cm (18.6 to 47.2 in) and weights ranged from 1.4 to 23.4 kg (2.7 to 51.5 lb).

There were no tag returns from either the Atlantic sturgeon or the striped bass tagged during the 1978 season.

No Atlantic sturgeon were encountered from January through April of 1979. Seven striped bass were captured during the 1979 season. These fish were not tagged because of their poor physical condition associated with heavy bycatches of spiny dogfish; however, they were retained for biological analysis. These seven striped bass (6 females and 1 male) ranged from 70.8 to 110.0 cm in length, from 5.5 to 20.0 kg in weight, and from 6 to 13 years in age.

Size Composition

Blueback Herring

During the 1977 through 1979 seasons, only blueback herring were captured in sufficient numbers to analyze size and age composition. Of the 777 bluebacks captured in 1977, 302 (38.9%)were males ranging in size from 83 to 283 mm, 413 (53.1%) were females ranging from 84 to 273 mm, and 62 (8%) were small, sexually immature fish ranging from 70 to 121 mm for which sex was not determined. Of the 715 sexed fish, 30.5% were sexually mature.

In 1978 a total of 969 blueback herring were taken. Of these, 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 sexually immature fish ranging from 58 to 110 mm. Of the 584 fish for which sex was determined, 296 (50.7%) were sexually mature.

Sampling during the 1979 season yielded a total of 6,705 blueback herring. A total of 6,684 individuals was analyzed. Of these fish, 2,950 (44.1%) were males ranging in size from 120 to 280 mm, 3,514 (52.6%) were females ranging from 100 to 300 mm, and 220 (3.3%) were sexually immature fish ranging from 61 to 111 mm. Of the 6,464 blueback herring which were sexed, 4,245 (65.7%) were sexually mature.

Length-frequency distributions of blueback herring, sexes combined, for the 1977 through 1979 seasons are presented in Figures 12, 13, and 14. In 1977 trimodal peaks representing both young and adult bluebacks are discernible with modes at 90-99.9 mm, 170-179.9 mm, and 240-249.9 mm. According to age-frequency data compiled previously (Holland and Yelverton, 1974; Holland and Powell, 1975), these modes represent yearlings, 3-year-olds and ≥4-year-olds, respectively.

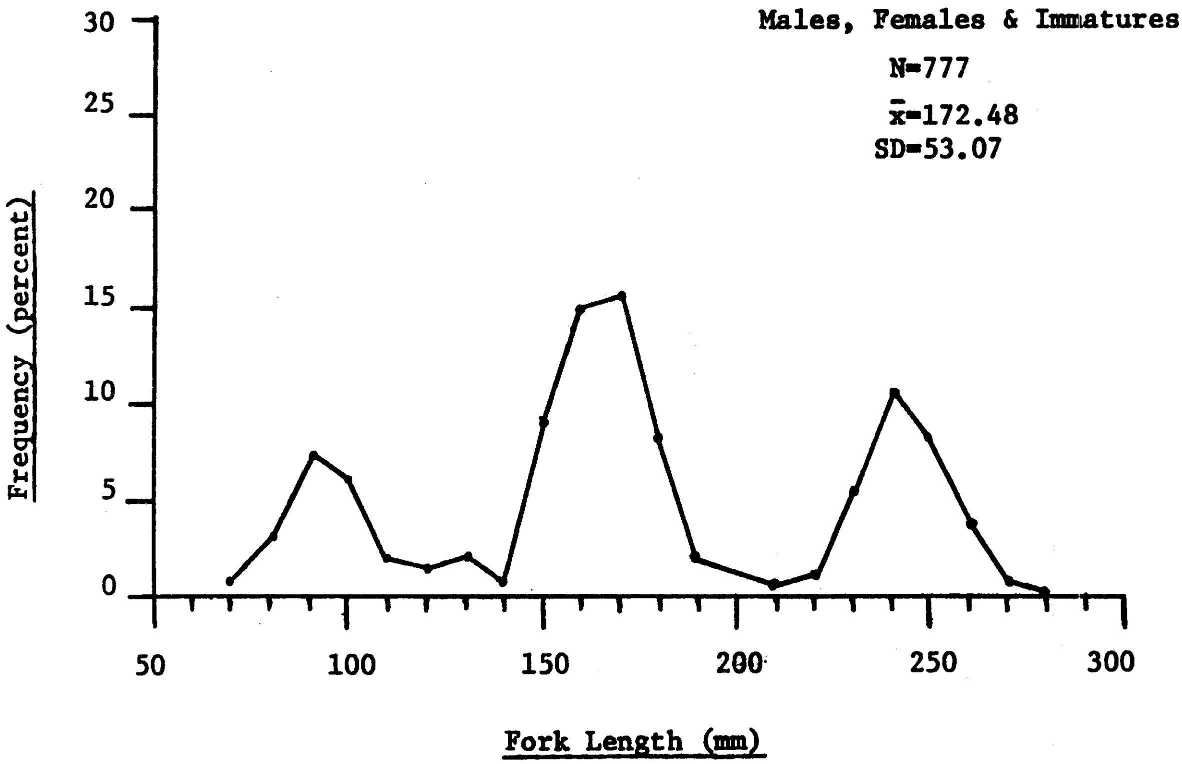


Figure 12 --Length-frequency distribution, sexes combined, of blueback herring *(Alosa aestivalis)* during 11 April through 24 May 1977.

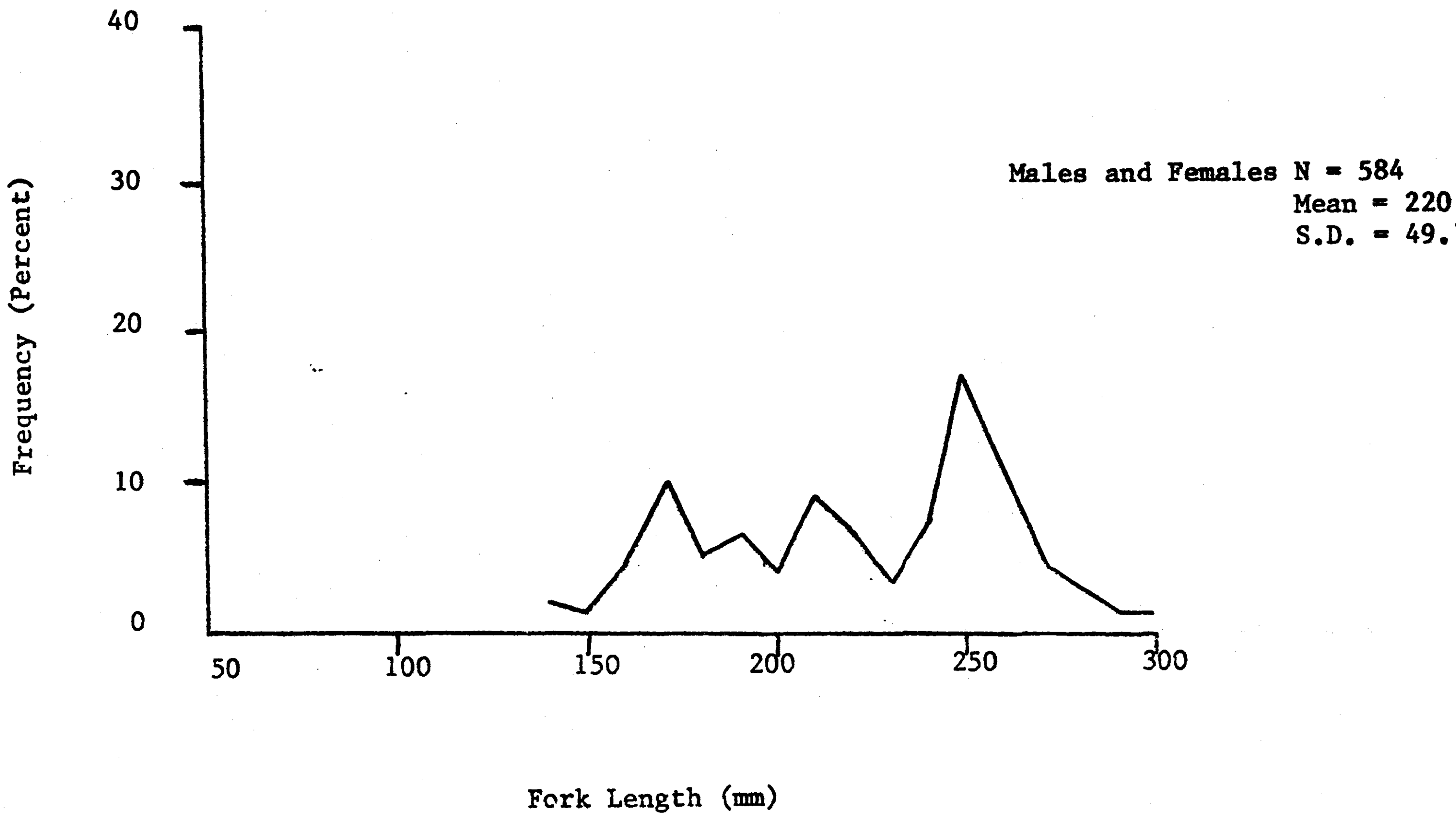


Figure 13. - Length frequency, sexes combined, of blueback herring captured during the 1978 season.

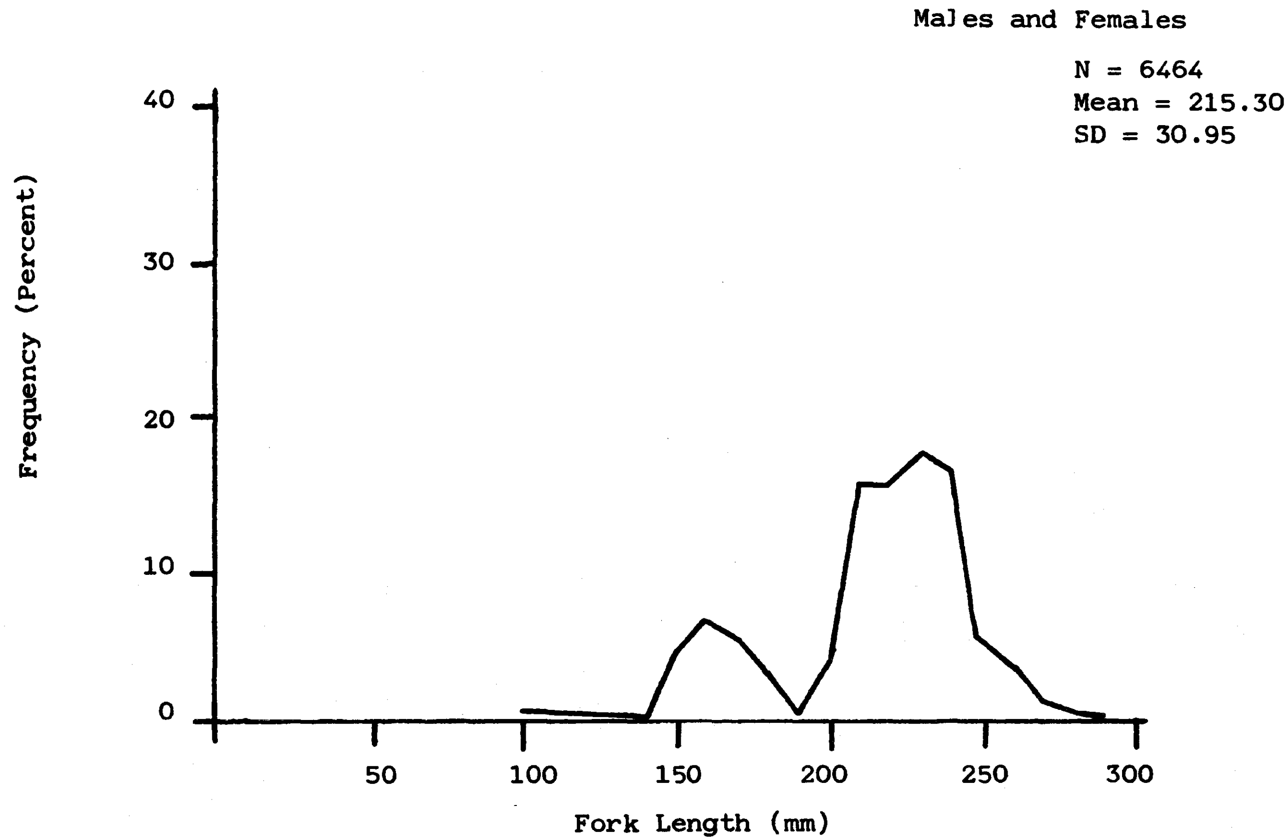


Figure 14. - Length frequency distribution, sexes combined, of blueback herring captured during the 1979 season.

Trimodal peaks representing adult bluebacks can be seen in the 1978 length-frequency distribution. Modes at 170-179.9 mm representing 3-year olds, and both 210-219.9 mm and 250-259.9 mm representing ≥4-year-olds were evident.

In 1979 trimodal peaks representing adult bluebacks are discernible with modes at 160-169.9 mm, 210-219.9 mm, and 230-239.9 mm. These modes represent 3-year olds and ≥4-year-olds, respectively.

The dominant modal group in 1977 was the 170-179.9 mm (3-year-olds), but in 1978 and 1979 the dominant group became the ≥4-year-olds with modes at 250-259.9 mm and 230-239.9 mm respectively. During the 1979 season, the first and third peaks decreased slightly from the 1978 values. The first peak, representing 3-year-olds, decreased one modal group while the third peak, representing ≥4-year-olds decreased two modal groups.

Length frequency distributions of blueback herring, by sex,captured during the 1977 - 1979 seasons are presented in Figures 15-17. Both young and adult male and female blueback herring showed modes of similar lengths each year.

Alewife

During the study period, 1979 was the only season in which alewife were captured in sufficient quantities and sizes to be analyzed. During the previous two years the alewife catch consisted mostly of yearlings and juveniles. In 1979 a total of 312 alewife were captured, including three hermaphroditic fish. Of the remaining 309 fish, 269 (87.1%) were males ranging from 104 to 290 mm in size, 35 (11.3%) were females ranging from 108 to 297 mm, and 5 (1.6%) were sexually immature fish which ranged from 84 to

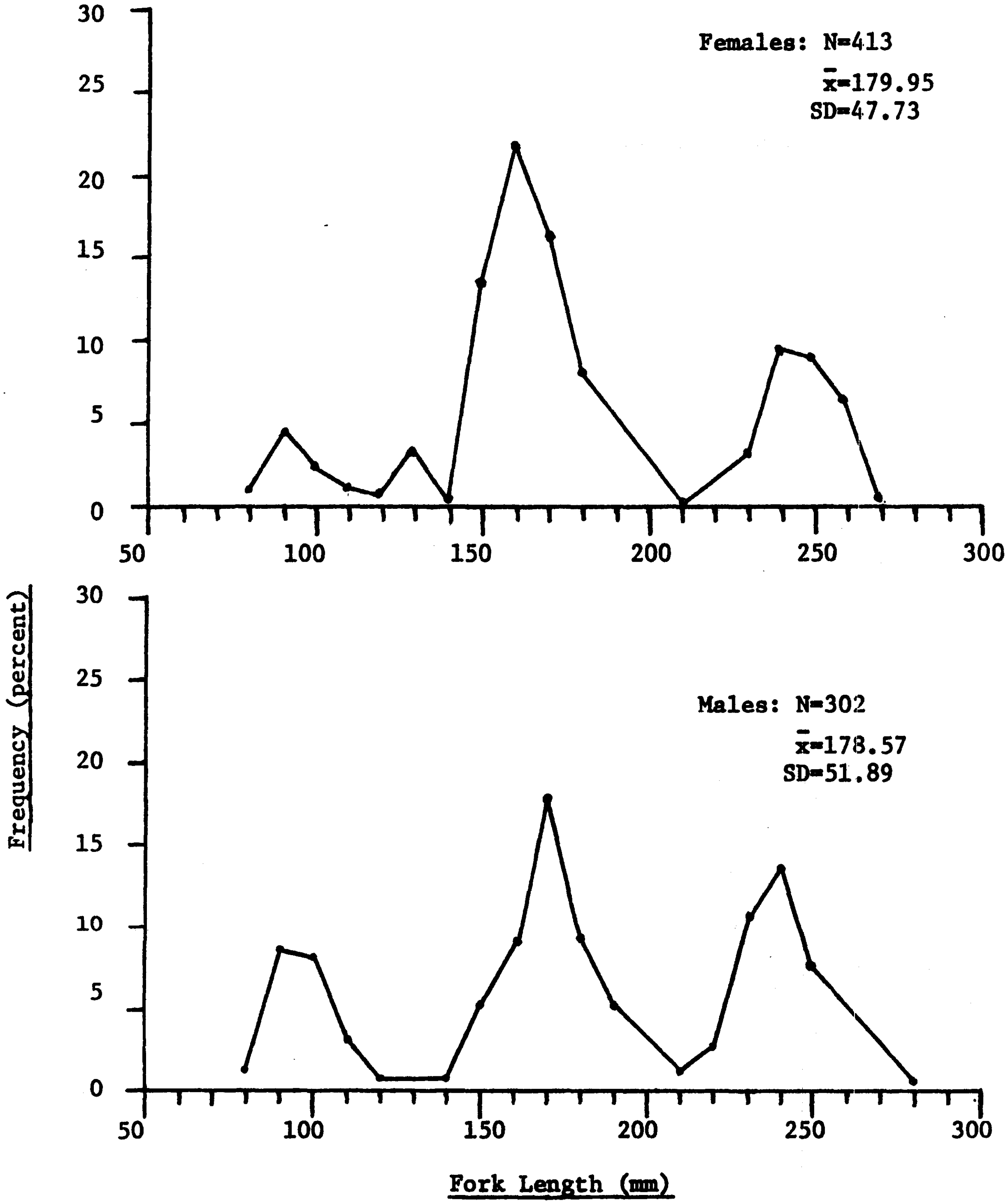


Figure 15. --Length-frequency distributions, by sex, of blueback herring *(Alosa aestivalis)* captured during 11 April through 24 May 1977.

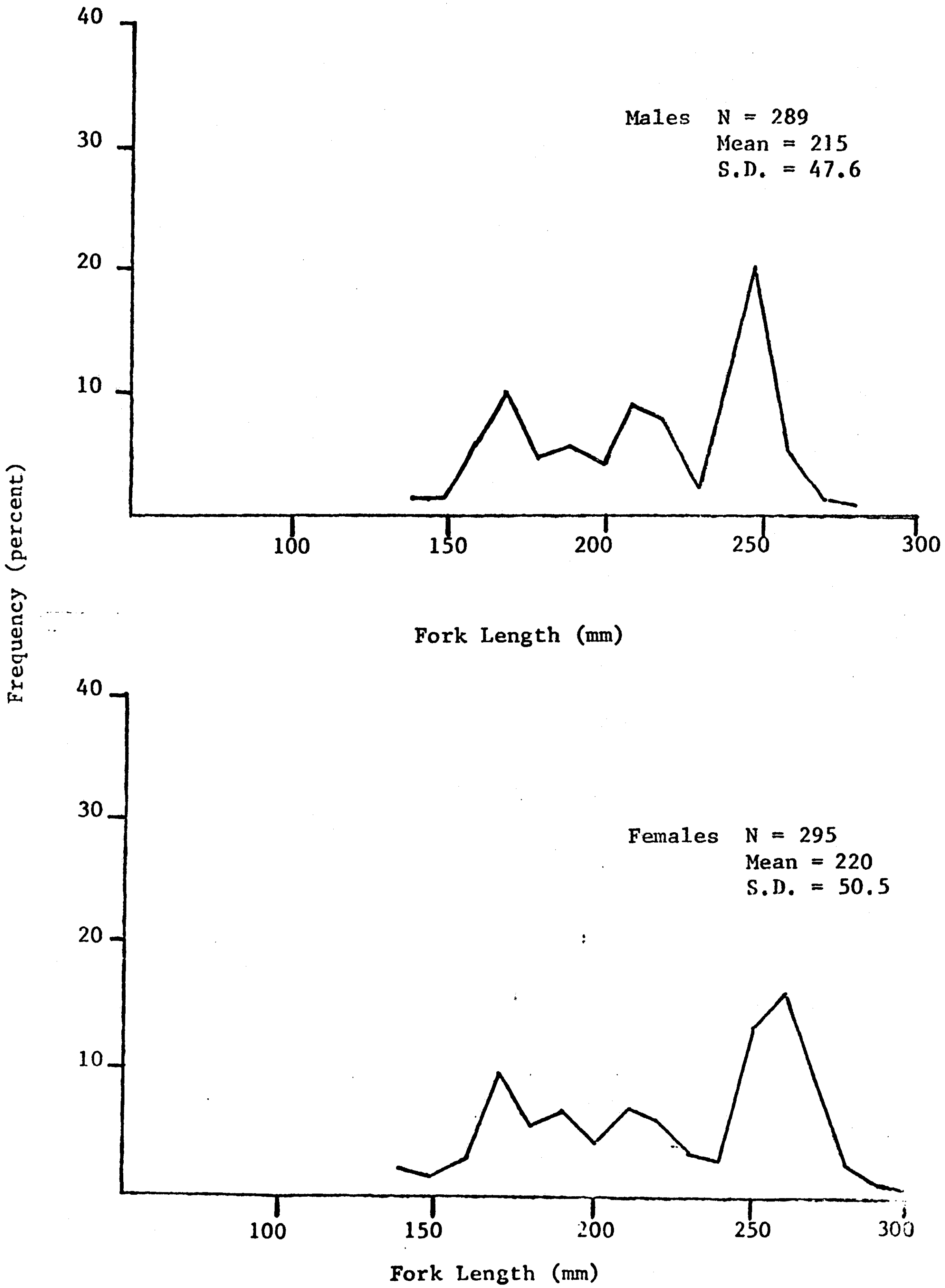


Figure 16. - Length frequency distributions, by sex, of blueback herring captured during the 1978 season.

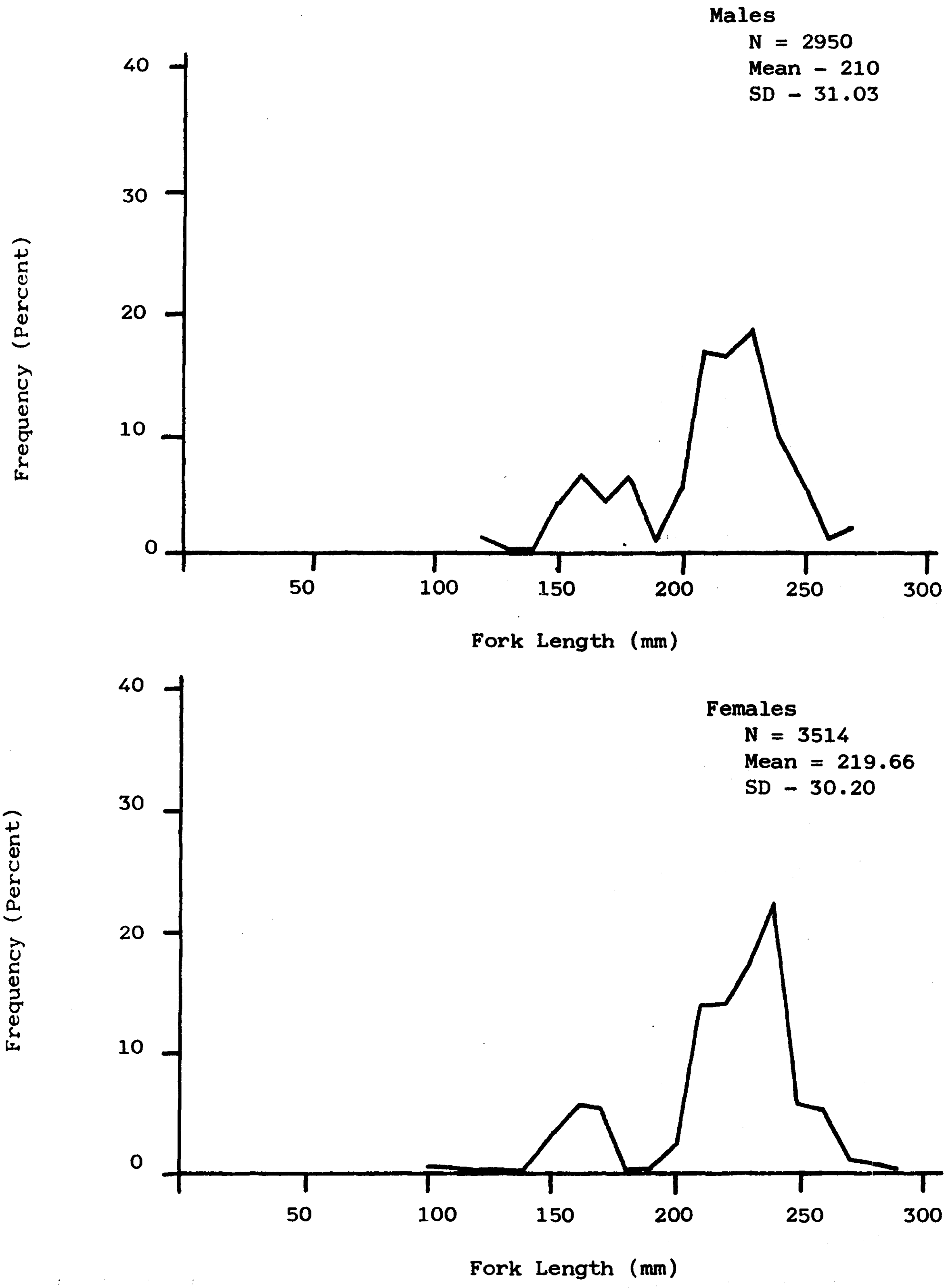


Figure 17. - Length frequency distribution, by sex, of blueback herring captured during the 1979 season.

to 104 mm in size. Of the 309 alewife for which sex was determined, 119 (38.5%) were found to be sexually mature.

Length-frequency distributions of alewife for the 1979 season appear in Figure 18. Alewife ranging from 2-year-olds to $\geq$ 4-year-olds were present in samples.

Sex and Female Maturity

Ovarian stages for blueback herring captured during the 1977 through 1979 seasons are presented in Tables 9, 10, and 11. Ovarian stages are not shown by month due to the paucity of the females encountered that were staged during the study period.

In 1977, female blueback herring ovaries ranged from early maturing to spent. Aproximately 74.1% of the total females examined contained ovaries designated as Stage I which would not have spawned during the 1977 season. Stage II females (3.5%) may or may not have been capable of spawning during the remainder of the 1977 season. Stage III females (19.4%) were capable of spawning before the season terminated. Twelve of the females examined in 1977 were spent (Stage V). No female blueback herring less than 230 mm (FL) was observed as being sexually mature.

Of the 295 female blueback herring examined during the 1978 season, 53.2% contained ovaries designated as Stage I. Only 8.8% of the females were designated as Stage II and the remaining 38.0% were designated as Stage III. None of the females examined were ripe (Stage IV) or spent (Stage V). Again in 1978, no female less than 230 mm (FL) was observed as being sexually mature.

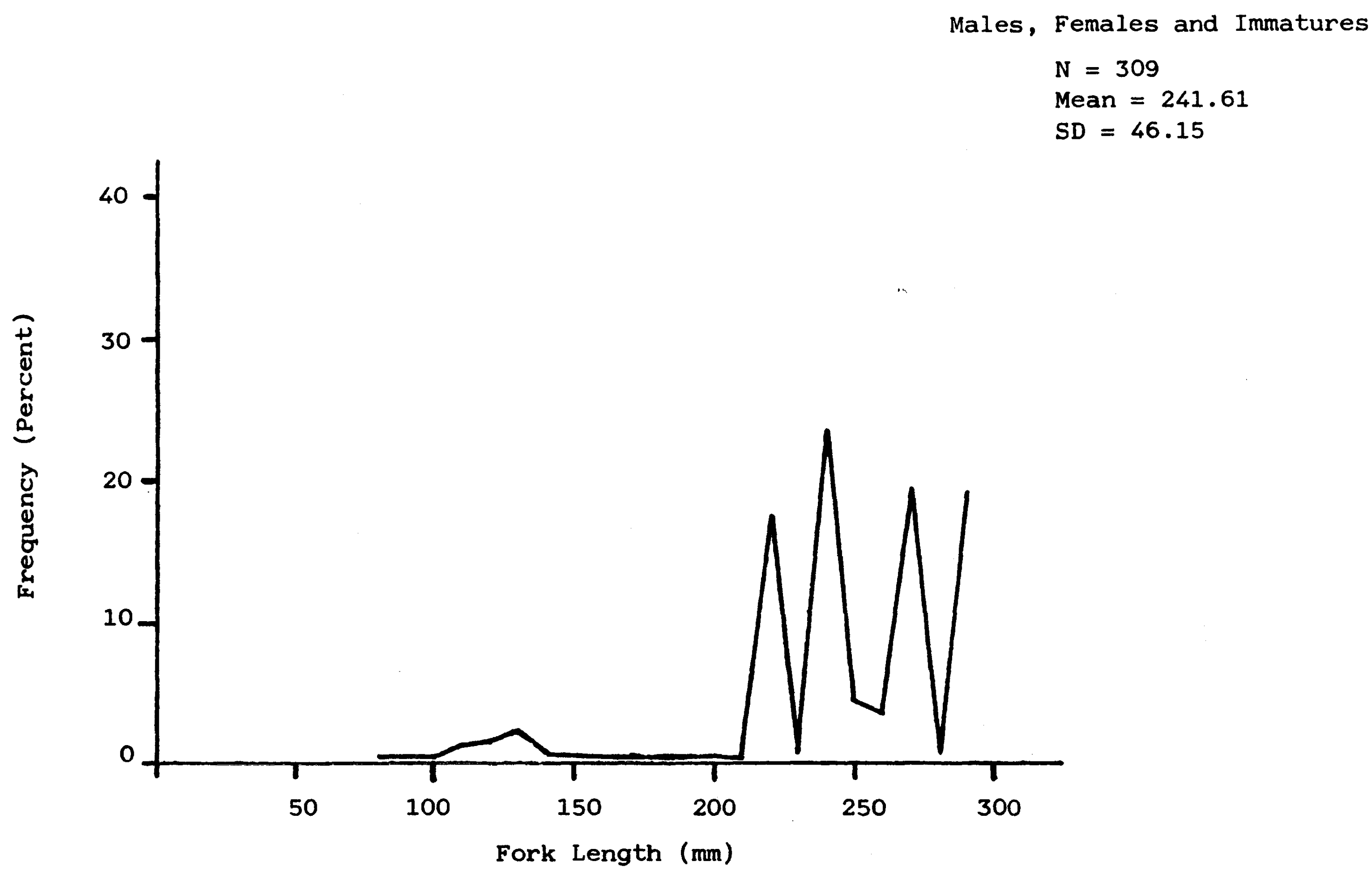


Figure 18. - Length-frequency distribution, sexes combined, of alewife captured during the 1979 season.

TABLE 9.--Ovarian stage, by size range, of captured female blueback herring *(Alosa aestivalis)* during 11 April through 24 May 1977.

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

Table 10. 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 11. Ovarian stage, by size range, of captured female blueback herring *(Alosa aestivalis)* during January through April 1979.

Fork Length range (mm)	Stage I	Stage II	Stage III
110-109	1		
110-119			
120-129	1		
130-139	1		
140-149	15		
150-159	125		
160-169	208		
170-179	200		
180-189	9		
190-199	11		
200-209	98		
210-219	492		
220-229	498		
230-239	464	153	10
240-249	435	306	19
250-259	41	153	6
260-269	93	91	7
270-279	5	4	34
280-289	31	1	1
290-299			1
Totals	2728	708	78

In 1979, a total of 3,514 female blueback herring were examined to determine the extent of ovarian maturation. Of these, 77.6% were designated Stage I and would not have spawned during the 1979 season. Of the females examined, 20.2% were designated to be Stage II and may or may not have contributed to the 1979 inshore spawning run. Only 2.2% of the females' ovaries were designated as Stage III and were capable of spawning before the season ended. Ripe and spent female blueback herring (Stage IV and V) were totally absent from the 1979 catch. As in the previous two seasons, no sexually mature females less than 230 mm (FL) were observed in the 1979 samples.

Even though there is a designation for ripe (Stage IV) ovaries, one would not expect to encounter these offshore since spawning takes place inshore.

Sex Ratio

The sex ratios, by month, for blueback herring captured during the 1978 and 1979 seasons appear in Tables 12 and 13. Sex ratios were not computed for the 1977 season due to the relatively few blueback herring encountered during that period.

In 1978, no significant deviations from a 1:1 ratio were found except during April when the male:female ratio was 1:1.29. However, when the months were combined, a male to female ratio of 1:1.02 was computed.

In 1979, no significant deviations from a 1:1 ratio was noted. A 1:1.19 overall sex ratio was computed when the months of the 1979 season were combined.

Table 12. Monthly sex composition for 584 blueback herring captured offshore, February - April, 1978.

Month	Total	No. males	Percent	No. females	Percent	Sex ratio
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

Table 13. Monthly sex composition for 6,464 blueback herring captured offshore, January through April 1979.

Species	Month	Total	No. males	Percent	No. females	Percent	Sex Ratio
Blueback herring (Alosa aestivalis)	January	38	15	39.5	23	60.5	1.53
	February-March	6,073	2,756	45.4	3317	54.6	1.20
	April	353	179	50.7	174	49.3	.97
	Total	6,464	2,950	45.6	3514	54.4	1.19

LITERATURE CITED

Higham, Joseph R. and William R. Nicholson. 1974. Sexual maturation and spawning of Atlantic menhaden. U.S. Fish and Wildl. Serv. Fish. Bull. 63(2): 255-271.

Holland, B. F., Jr. and Scott G. Keefe, 1977. Anadromous Fisheries research program, northern coastal area. Completion Report. Proj. AFCS-9. N.C. Div. Mar. Fish. 27

______________________ and Allyn B. Powell. 1975. Anadromous Fisheries research program, northern coastal area. Completion report. Proj. AFCS-8. N.C. Div. Mar. Fish. 304 37.

______________________ and George F. Yelverton. 1973. Distribution and biological studies of anadromous fishes offshore North Carolina. N.C. Dept. Nat. & Econ. Res. Div. Mar. Fish. Spec. Sci. Rep. No. 24: 132.

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

No North Carolina Participation

Job 7. Sturgeon - A general Pilot Study

SUMMARY

1. No shortnose sturgeon were found in commercial landings of sturgeon examined in the Albemarle Sound area of North Carolina, during 1 October 1976 through 30 September 1979.

Job 7. Sturgeon - A General Pilot Study

INTRODUCTION

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

MATERIALS AND METHODS

Commercial landings of sturgeon were examined at two commercial landings sites in the Albemarle Sound area. The frequency of sampling was semi-monthly during the period October 1976 through September 1979.

RESULTS AND DISCUSSION

A total of 86 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. The number of fish examined do not reflect the commercial catch, but those fish that were present at the time of sampling. Table 7.1 shows the month, number, and species of sturgeon examined at each location during October 1976 - September 1977 (Loesch et al. 1977). For October 1977 - September 1978, the month, number, and species of sturgeon examined at each location are shown in Table 7.2 (Johnson et al. 1978). Table 7.3 shows the month, number, and species of sturgeon examined at each location during October 1978 - September 1979.

LITERATURE CITED

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 p.

Loesch, H. 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Table 7.1. Numbers and species of sturgeon examined at two sampling sites in the Albemarle Sound area, NC, October 1976 - September 1977.

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

Table 7.2. Number and species of sturgeon examined at two sampling sites in the Albemarle Sound area, NC, October 1977 - September 1978.

	Site A		Site B	
Month	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			
Sep. 1978	6			
Total	18		11	

Table 7.3. Number and species of sturgeon examined at two sampling sites in the Albemarle Sound area, NC, October 1978 - September 1979.

	Site A		Site B	
Month	Atlantic sturgeon	Shortnose sturgeon	Atlantic sturgeon	Shortnose sturgeon
Oct. 1978	1			
Nov. 1978	1		1	
Dec. 1978			1	
Jan. 1979				
Feb. 1979				
Mar. 1979	1		1	
Apr. 1979	2		2	
May. 1979			1	
Jun. 1979				
Jul. 1979				
Aug. 1979	1			
Sep. 1979	1			
Total	7		6	

Job 8. Anadromous Fish Tagging

SUMMARY

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

2. A total of 6,643 river herring was tagged and released in the mouth of the Scuppernong River in 1977. Estimates of population size, based on 673 tag returns, ranged from 2.3 million to 3.2 million river herring.

Job 8. Anadromous Fish Tagging

INTRODUCTION

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

MATERIALS AND METHODS

A total of 6,643 river herring was tagged and released during the spring run in 1977 (approximately February-May). Recaptures were made primarily by pound nets; some fish were taken by gill nets. Rewards of $1.00 to $25.00 were offered for returned tags and information about tagged fish. Special efforts were made to collect detailed, accurate catch and effort data from the commercial and recreational fisheries of the Scuppernong River system in order to calculate the magnitude of the river herring run. The objective was to estimate the population size.

RESULTS AND DISCUSSION

Tagging

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

The number of river herring tagged and recaptured as reported by Johnson et al. (1977) was in error. The correct figures are given in this report for the formula.

From 15 February through 15 May 1977 a total of 6,643 river herring was tagged, and 673 tagged river herring were recaptured during the same period.

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

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

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

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

Estimates using the Schnabel method showed a population of 1,300,291 in 1976. Confidence limits (95%) were again calculated and the population was found to range between 1,201,055 and 1,417,401 river herring. During 1977, the population was estimated at 2,276,906 fish. Confidence limits (95%) were again calculated and found to range between 2,107,191 and 2,476,356 (Johnson et al. 1977).

The Schaefer method for the stratified populations estimated the total number of river herring to be 2,886,801 during 1976 and 3,194,062 during 1977.

Considering the three estimates, a reasonable estimate of the number of river herring in the Scuppernong River spring spawning run was probably around 3 million fish each year (Johnson et al. 1977).

LITERATURE CITED

Johnson, H. B., B. F. Holland, Jr., and S. G. Keefe. 1977. Anadromous fisheries research program northern coastal area. Completion Rep., Proj. AFCS-11. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 97 + 40 p.

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

Table - 8.1. Formulas used for population estimates

Petersen

$N - MC/R = C/u$ Ricker (3.5)

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

Schnabel

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

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

Schaefer

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

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

Job 9. - Spawning Area Survey

SUMMARY

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

2. Water quality has deteriorated in the Chowan River and Albemarle Sound area in the last decade. A comparison of preliminary hydrological data taken from samples in 1973 was made with those for 1979. The North Carolina Division of Environmental Management found lower dissolved oxygen levels than the Division of Marine Fisheries. The Chowan River and its tributaries have experienced severe algal blooms in the last several years. Algal blooms have not yet been proven to directly affect juvenile river herring.

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 seasons of 1977-1979 (approximately March-May), project personnel sampled the Alligator River (1977), Roanoke River (1978), Chowan River (1979) and their tributaries to determine utilization of these systems 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. Environmental 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 for the three years of study were: (1) capture or observation of running-ripe females (2) observation of spawning activity and (3) capture of eggs or larvae.

Alligator River and Tributaries

The spawning area survey for Alligator River and its tributaries was conducted during 1977. Table 9.1 shows the dates of capture, location, number and species of running-ripe females taken by gill nets during this study. Figure 9.1 shows the location of observed running-ripe female fish. Figure 9.2 shows the relationship of temperature and time to catches of eggs and larvae for the study area. Table 9.2 shows the number and general location of capture for eggs and larvae in the study area (Loesch et al. 1977).

Roanoke River and Tributaries

In 1978, a spawning area survey was conducted on the Roanoke River and its tributaries. Table 9.3 shows the dates of capture, location, number and species of running-ripe females taken by gill nets during this study. For this study area, Figure 9.3 shows the relationship of temperature and time to catches of eggs and larvae. Tables 9.4 - 9.6 show the number and general locations of capture of alosine eggs and larvae for the Roanoke River and its tributaries. Figure 9.4 shows the approximate spawning area locations for alewife, blueback herring, and American shad. Figure 9.5 shows the approximate spawning area locations for river herring as indicated by the capture of eggs and larvae (Johnson et al. 1978).

Chowan River and Tributaries

The spawning area survey for the Chowan River and its tributaries was conducted in 1979. Table 9.7 shows the dates of capture, location, number and species of running-ripe females taken by gill nets during this study. The relationship of temperature and time to catches of eggs and larvae for the

Chowan River area are shown in Figure 9.6. Tables 9.8 - 9.10 show the number and general locations of capture of alosine eggs and larvae in the study area. The approximate spawning area locations for alewife, blueback herring, and American shad are shown in Figure 9.7. Figure 9.8 shows the approximate spawning area locations for river herring as indicated by the capture of eggs and larvae.

Decline in Water Quality and Algal Blooms in Relation to Juvenile River Herring

Water quality has deteriorated in the Chowan River and Albemarle Sound area in the last decade. The water quality of the Chowan River is below that of other tributaries of the Albemarle Sound; thus, the following comparisons were made.

A comparison of preliminary hydrological data taken from spawning area samples in 1973 were made with those for 1979. For each sample the following data was recorded: water temperature, pH, dissolved oxygen and the number of eggs and larvae captured. The areas sampled, dates, and temperature readings were relatively the same for the two years of data. Based on data collected in 1973 by the Division of Marine Fisheries (DMF), all areas surveyed on the Chowan River had dissolved oxygen levels exceeding 4 ppm. This is the level that generally is required for the maintenance of a healthy fish population. Dissolved oxygen levels of 3 ppm or below were found for many of the same areas sampled in 1979. The North Carolina Division of Environmental Management (DEM) utilizes some of the same sampling locations as DMF for water quality monitoring. However, DEM data indicated dissolved oxygen levels to be as low as 1 ppm in some of the areas. These findings are probably more accurate than DMF data because of better sampling equipment. It should be noted that all samples were daytime samples.

In years past when egg net samples were poured into a preserving jar, larvae were observed swimming around vigorously (Street et al. 1975). In 1979, large numbers of dead or weakened larvae were observed in samples. These larvae were either so feeble that the capture method killed them, or they were dead when captured. These incidents of dead or weakened larvae coupled with unsatisfactory dissolved oxygen levels clearly indicates a decline in water quality.

The Chowan River and its tributaries have experienced severe algal blooms in the last several years during mid-summer. Algal blooms are symptomatic of advanced eutrophication and are evidence that there are high concentrations of nutrients in the river. With such high levels of nutrients in the system, the Chowan River has been designated as Nutrient Sensitive Water by the North Carolina Environmental Management Commission(NC Dept. Nat. Resources and Community Development 1979).

Algal blooms have not yet been proven to directly affect the spawning of alosine fishes. However, the blooms could cause fertilized eggs and newly hatched larvae to experience significant mortalitîes as a result of oxygen depletion or by the production of toxins (NC Dept. Nat. Resources and Community Development). The major blooms occur after spawning, possibly affecting juveniles.

A build-up of Anacystis firma, a toxic blue-green alga, was observed early in 1979 on the Chowan River. The main area of build-up was from the U.S. Highway 17 Bridge upriver to the first day marker (#4), with the highest concentration in the mouth of Rockyhock Creek (Figure 9.7). The algae build-up was first observed 13 May 1979 (Bob Holman, NC DEM, personal communication) during week 19, one week after the last capture of alosine eggs and larvae during the project.

The decline in the dissolved oxygen levels found in 1979 as compared to those of 1973 for the Chowan River indicate a definate deterioration in water quality. The high concentrations of nutrients, and dense algal blooms may also be contributing to the further deterioration of the water quality. Efforts are now being made at both state and local levels to improve the water quality of the Chowan River.

LITERATURE CITED

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. B. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

North Carolina Department of Natural Resources and Community Development. 1979 Chowan River Restoration Project (CHORE). Raleigh, NC.

Street, M. W., P. P. Pate, B. F. Holland, Jr., and A. B. Powell. 1975. Anadromous fisheries research program, northern coastal region. Completion Rep., Proj. AFCS-8. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 173 + 62 + append.

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

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

Table 9.1.(continued)

4/22/77	Alligator River Northwest Fork	1	Alewife
4/26/77	Alligator River Northwest Fork	1	Blueback
4/27/77	Kilkenny Landing	1	Alewife
4/28/77	Kilkenny Landing	1	Alewife

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

Water body	Number of samples	River herring eggs	River herring larvae	Alewife larvae	Blueback herring larvae
Alligator River	89	37	163	35	0

Table 9.3. 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 9.4. River herring eggs collected by egg net in Roanoke River area, 1978.

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 9.5. River herring larvae collected by egg net in Roanoke River area,1978.

Date	Location	Number 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 9.6. American shad larvae collected by egg net in Roanoke River area, 1978.

Date	Location	Number 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

Table 9.7. Observations of running-ripe females and spawning activity of river herring in the Chowan River and its tributaries during 1979.

Date	Location	Number of fish	Species
3/30/79	Chowan River (Salmon Creek) US Hwy 17	1	Alewife
4/04/79	Wiccacon River (Chinkapin Creek) NC Hwy 561	4	Blueback
4/04/79	Chowan River (Bennetts Creek) NC Hwy 37	2	Blueback
4/04/79	Wiccacon River SSR* 1427	6	Blueback
4/24/79	Chowan River (Rockyhock Creek) SSR 1222	spawning observed	Blueback
4/25/79	Chowan River (Tunis) SSR 1402	spawning observed	Blueback

*SSR: State secondary road

Table 9.8. River herring eggs collected by egg net in Chowan River area,1979.

Date	Location	Number of eggs
4/06/79	Wiccacon River (Chinkapin Creek) NC Hwy 561	7
4/09/79	Wiccacon River SSR* 1427	2
4/12/79	Wiccacon River SSR 1427	3
4/17/79	Wiccacon River SSR 1427	2
4/27/79	Wiccacon River SSR 1427	3
4/27/79	Wiccacon River (Chinkapin Creek) SSR 1432	14

*SSR: State secondary road

Table 9.9. River herring larvae collected by egg net in Chowan River area, 1979.

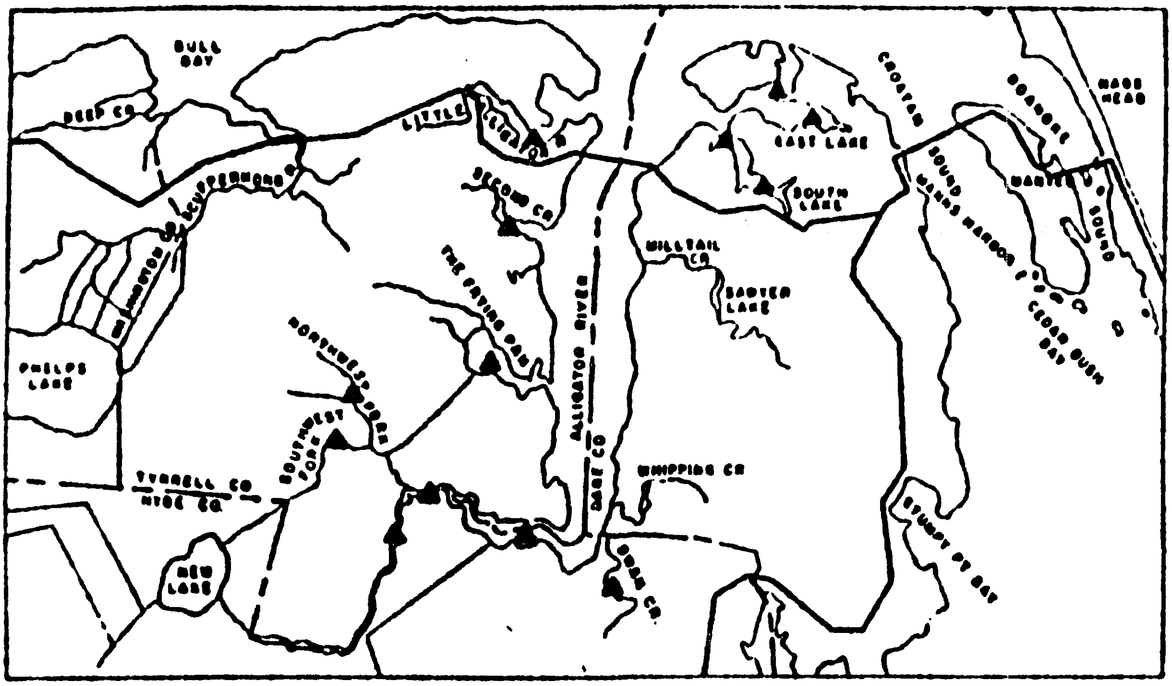
Date	Location	Number of larvae
4/17/79	Wiccacon River SSR* 1427	2
4/27/79	Chowan River (Salmon Creek) US Hwy 17	1
5/07/79	Chowan River (Spikes Creek)	34
5/07/79	Chowan River (Sarem Creek)	16
5/07/79	Chowan River (Barnes Creek)	43
5/07/79	Chowan River (Cole Creek)	15

*SSR: State secondary road

Table 9.10. American shad larvae collected by egg net in Chowan River area, 1979.

Date	Location	Number of larvae
5/07/79	Chowan River (Spikes Creek)	1
5/07/79	Chowan River (Cole Creek)	3

A.



Spawning Areas --- ▲

B.

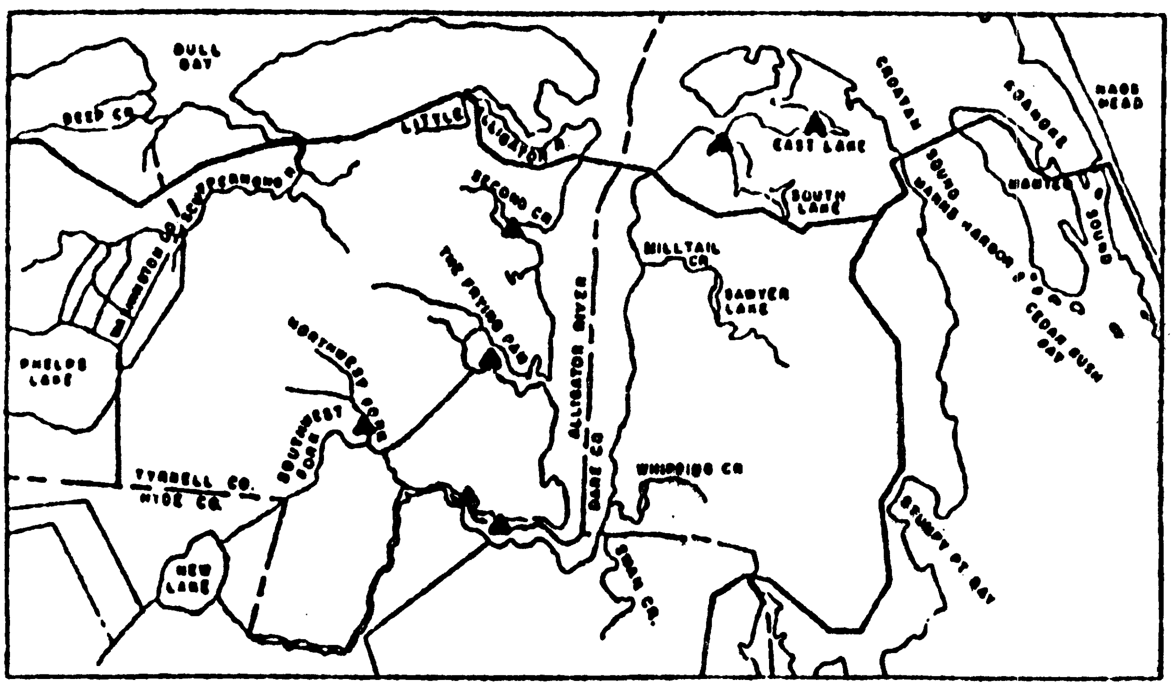


Figure 9.1. Spawning areas of alewife (A) and blueback herring (B) in the Alligator River, North Carolina, 1977.

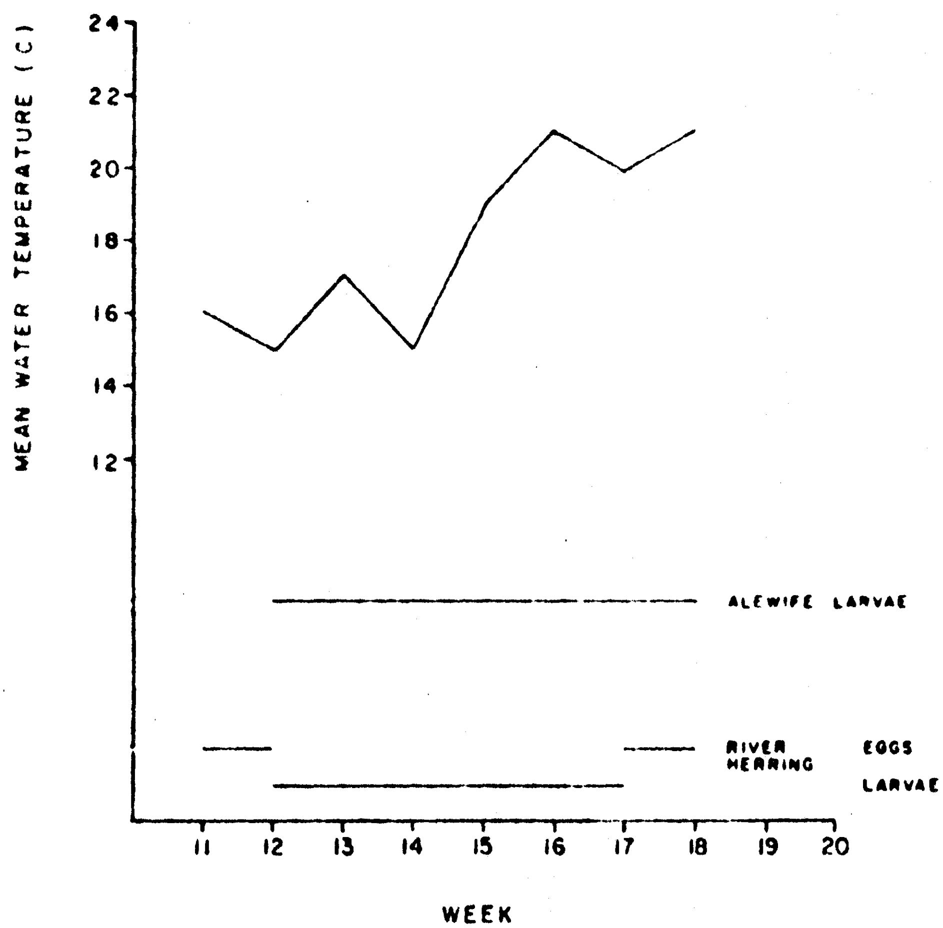


Figure 9.2. Spawning times and temperatures associated with the capture of river herring eggs and larvae in the Alligator River, NC, 1977.

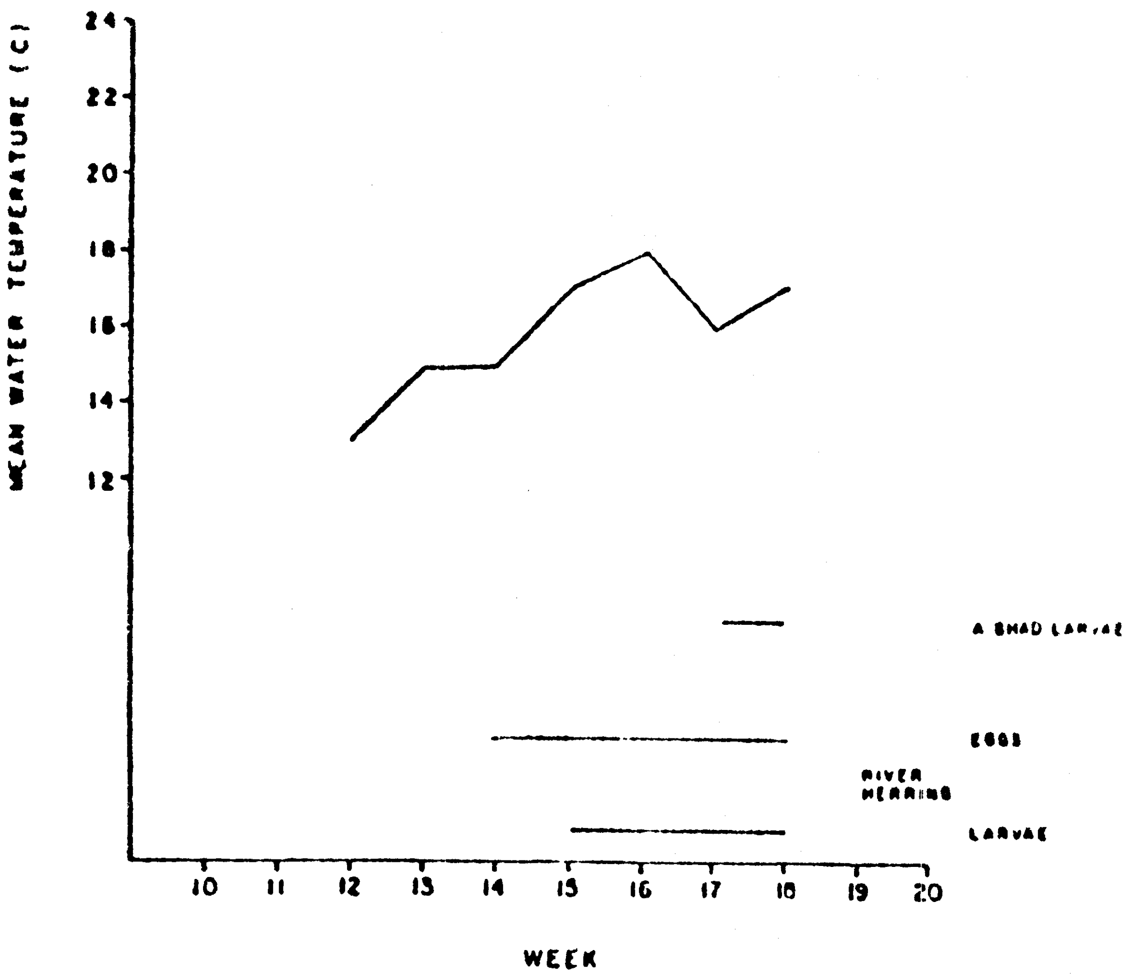


Figure 9.3. Spawning times and temperatures associated with the capture of river herring eggs and larvae in the Roanoke River, NC, 1978.

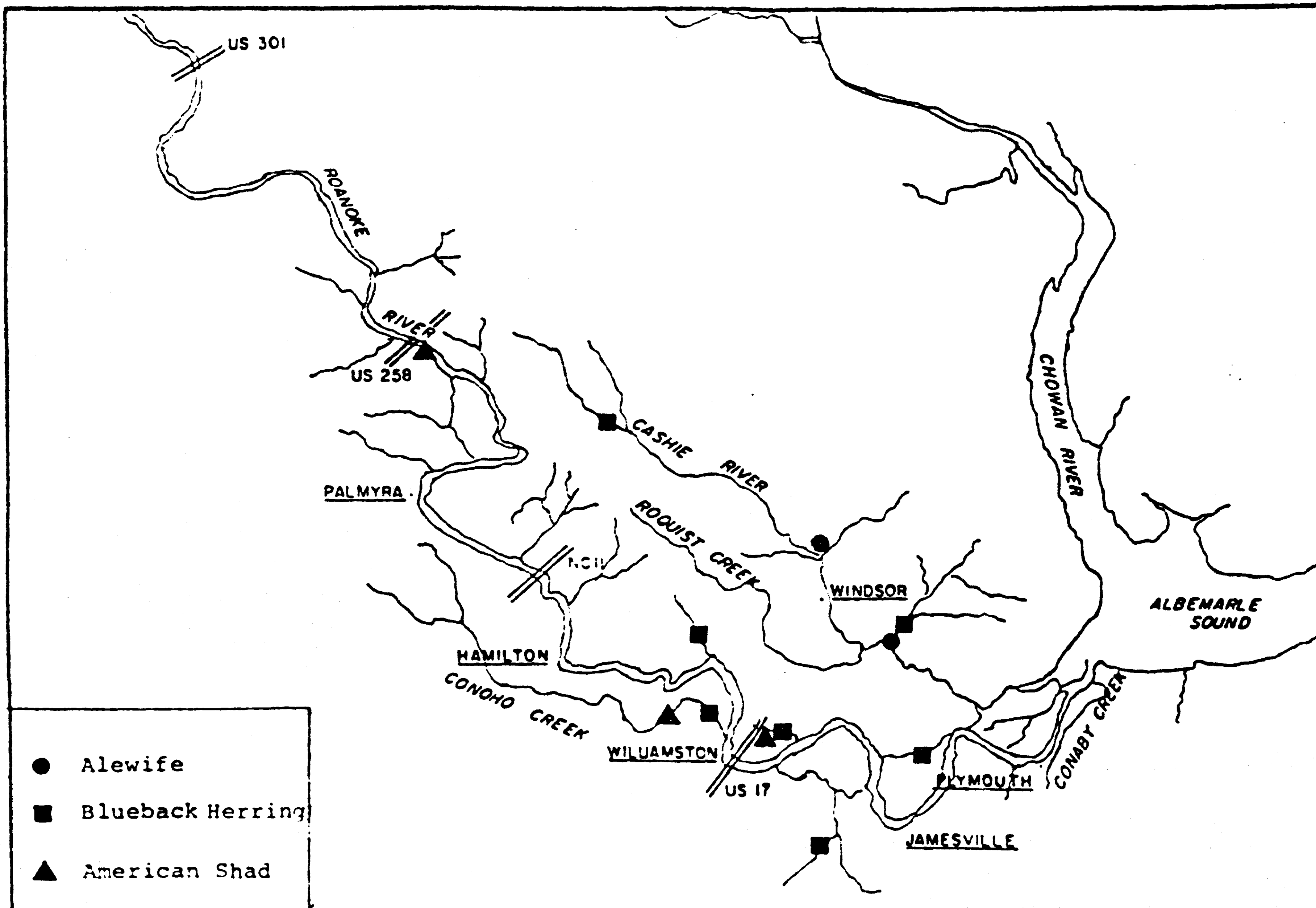


Figure 9.4. Spawning areas of alewife and blueback herring in Roanoke River as shown by observations of running-ripe females or spawning activity and spawning of American shad as shown by capture of eggs and larvae, 1978.

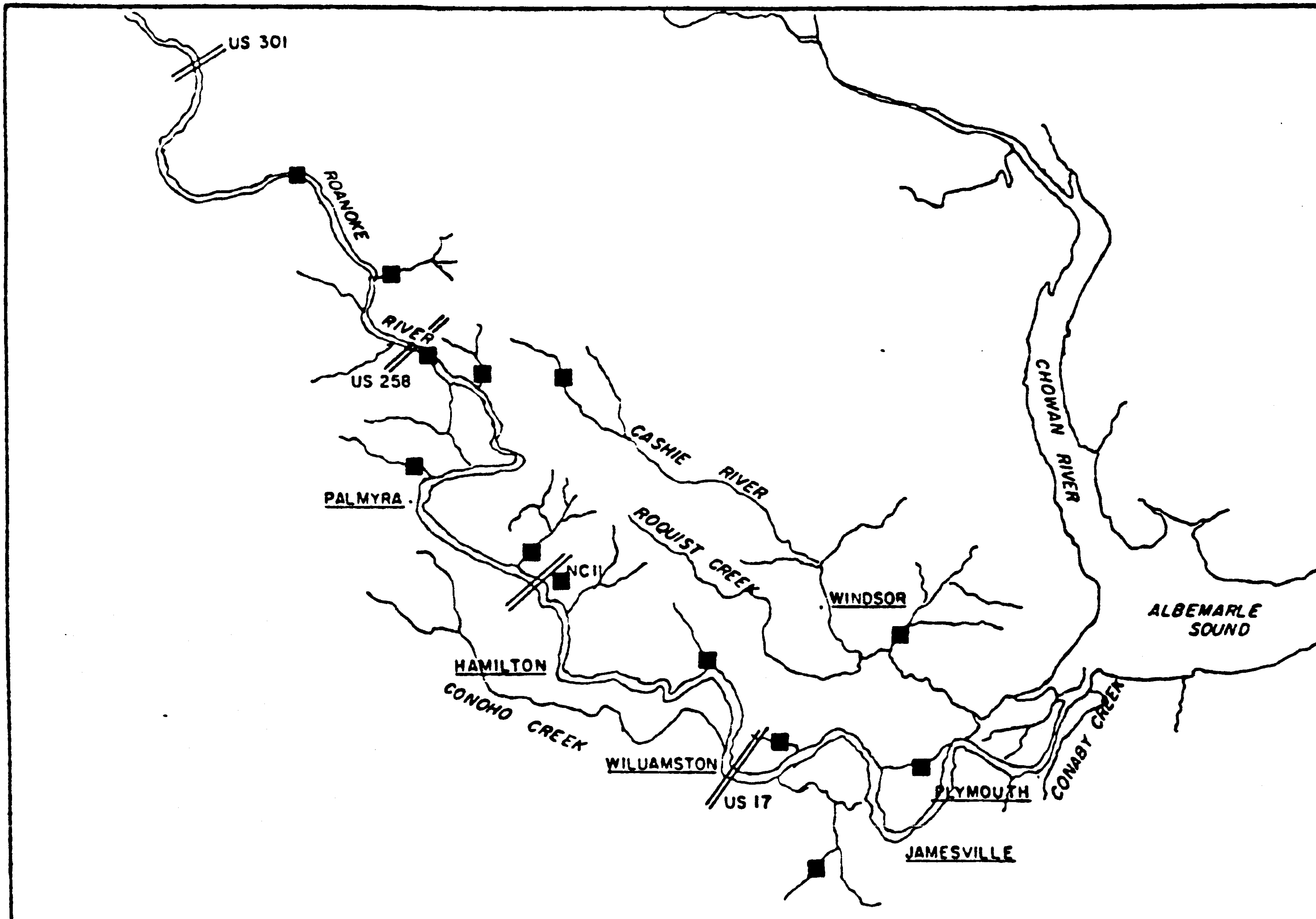


Figure 9.5. Spawning areas of river herring in Roanoke River area as shown by capture of river herring eggs and larvae, 1978.

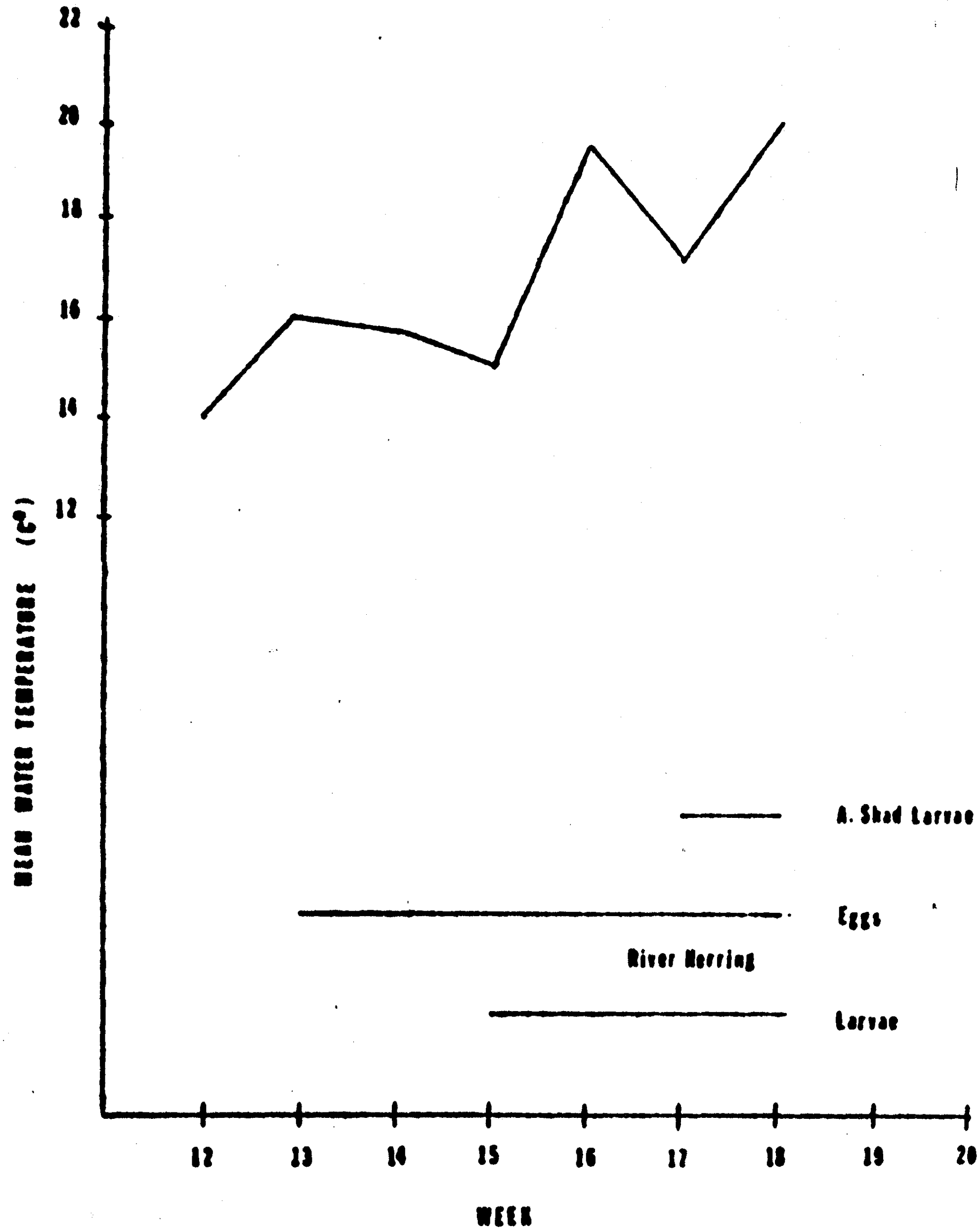


Figure 9.6. Spawning times and temperatures associated with the capture of river herring fish eggs and larvae in the Chowan River, 1979.

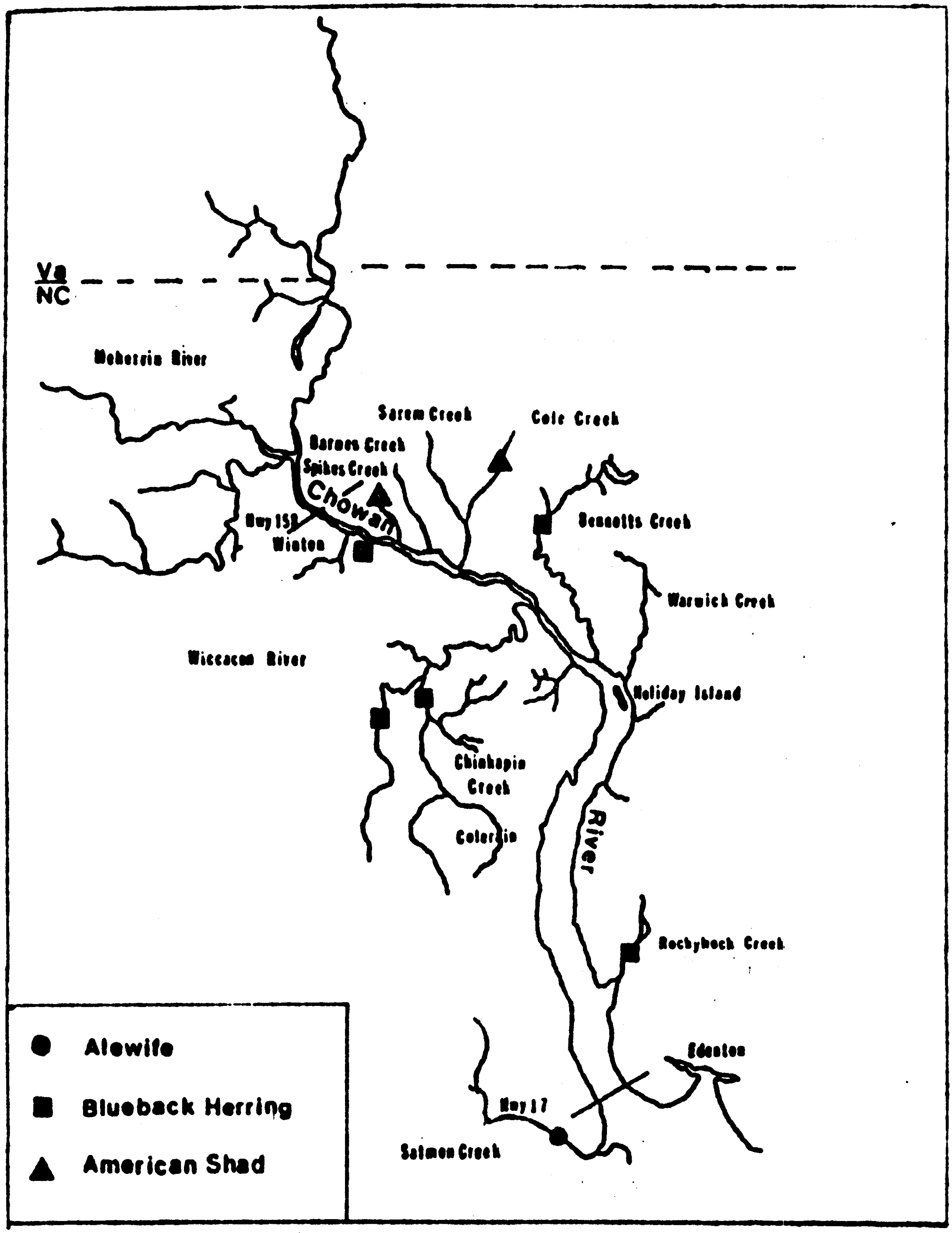


Figure 9.7. Spawning areas of alewife and blueback herring in the Chowan River as shown by observations of running-ripe females or spawning activity and spawning of American shad as shown by capture of eggs and larvae, 1979.

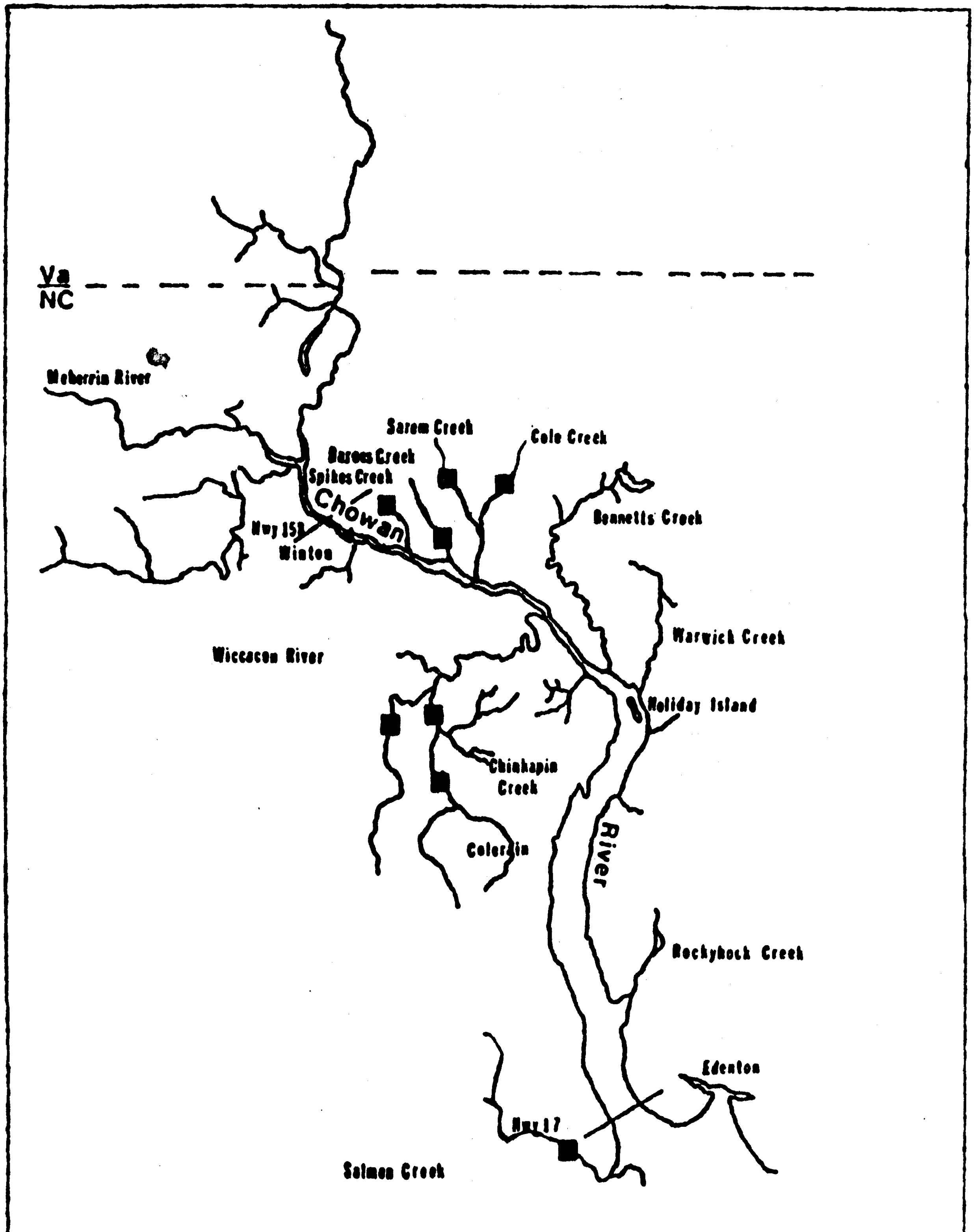


Figure 9.8. Spawning areas of river herring in Chowan River area as shown by capture of river herring eggs and larvae, 1979.

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 bycatch allocation to 100 metric tons or less beginning in 1981.

2. It is recommended in North Carolina that appropriate research programs be initiated to determine the effects of water quality on the reproductive success of river herring.

Job 10. Development of Management Alternatives

INTRODUCTION

North Carolina and Virginia have the major river herring fisheries for the Atlantic Coast. Thus, the condition of their stocks determines the overall status of the United States fishery. Landings for both fisheries have exhibited, with minor variations, a declining trend since 1970, and the Virginia landings in the years 1977-1979 were the lowest recorded. North Carolina landings in the years 1977-1979 were among the lowest on record. (Table 10.1). The present poor state of the stocks is attributed to heavy exploitation of the stocks by the foreign offshore fishery in the late 1960s and early 1970s, and the absence of a strong year class since 1969. Deteriorating water quality in North Carolina may also have contributed to reproductive failure of the Albemarle Sound area river herring stocks.

DISCUSSION

National Marine Fisheries Service statistics indicated that 1977-1979 foreign vessel bycatches were 44.0, 28.3, and 11.9 metric tons (MT), respectively. It is significant to note that in 1977 the first seizures of foreign vessels for violations of US fishing regulations under the Fishery Conservation and Management Act were for excessive catches of river herring.

The 1977-1979 bycatches were far below the respective annual bycatch allocations of 500, 453, and 409 MT respectively. Thus, it is obvious that the foreign vessels were able to avoid river herring. Considering the facts that river herring stocks are greatly depressed and foreign vessels can operate successfully with very little river herring bycatches, it is recommended that the Regional Fishery Management Councils work with the Secretary of Commerce to reduce the river herring bycatch allocation to 100 MT or less beginning in 1981. A bycatch allocation should be made in order to require data on river herring from foreign vessels. No allocation would result in fish being discarded without collection of any data.

In North Carolina it is recommended that appropriate research programs be initiated to determine the effects of water quality on the reproductive success of river herring.

Table 10.1. River herring catches in the North Carolina and Virginia inshore fisheries and the foreign offshore fishery in ICNAF Statistical Area 6. (Data from NMFS and ICNAF).

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	44
1978	2,996	965	28
1979	2,322	766	12

*MT = 2,205 lb.

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 radius relations; and to compare growth curves derived from scale and otolith data.

Levels of agreement between scale and otolith ages were 56.19% (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. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Spec. Sci. Rep. No. 30, 51 p.

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

No North Carolina Participation

Job 13. Assessment of Racial Stocks of River Herring.

No North Carolina Participation

A P P E N D I X

Lists of Species Captured Offshore North Carolina and Virginia, 1977-1979

Appendix Table 1. 1977 species list.

Finfish

Odontaspididae
    Sand tiger shark *(Odontaspis taurus)*

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

Squalidae
    Spiny dogfish *(Squalus acanthias)*

Squatinidae
    Atlantic angel shark *(Squatina dumerili)*

Rajidae
    Clearnose skate *(Raja eglanteria)*

Myliobatidae
    Bullnose ray *(Myliobatis freminvillei)*

Acipenseridae
    Atlantic sturgeon *(Acipenser oxyrhynchus)*

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

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

Synodontidae
    Inshore lizardfish *(Synodus foetens)*

Lophiidae
    Goosefish *(Lophius americanus)*

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

Serranidae
    Black sea bass *(Centropristis striata)*

Pomatomidae
    Bluefish *(Pomatomus saltatrix)*

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

Appendix Table 1.--continued

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

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

Labridae
Tautog *(Tautoga onitis)*

Ammodytidae
American sand lance *(Ammodytes americanus)*

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

Stromateidae
Butterfish *(Peprilus triacanthus)*

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

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

Tetraodontidae
Northern puffer *(Sphoeroides maculatus)*

Invertebrates

Clionidae
Sulfur sponge *(Cliona celata)*

SCYPHOZOA
Jellyfish

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

Cancridae
Rock crab *(Cancer irroratus)*

Majidae
Spider crab *(Libinia emarginata)*

Xiphosuridae
Horseshoe crab *(Limulus polyphemus)*

Appendix Table 1.—continued

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

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

Appendix Table 2. 1977. -- Segment II species list

Finfish

Odontaspididae
Sand tiger shark *(Odontaspis taurus)*

Alopiidae
Thresher shark *(Alopias vulpinus)*

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

Sphyrnidae
Scalloped hammerhead *(Sphyrna lewini)*

Squalidae
Spiny dogfish *(Squalus acanthias)*

Squatinidae
Atlantic angel shark *(Squatina dumerili)*

Rajidae
Clearnose skate *(Raja eglanteria)*

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

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

Acipenseridae
Atlantic sturgeon *(Acipenser oxyrhynchus)*

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

Engraulidae
Striped anchovy *(Anchoa hepsetus)*

Synodontidae
Inshore lizardfish *(Synodus foetens)*

Lophiidae
Goosefish *(Lophius americanus)*

Gadidae
Spotted hake *(Urophycis reqius)*

Serranidae
Black sea bass *(Centropristis striata)*

Appendix Table 2.--continued

Pomatomidae
    Bluefish *(Pomatomus saltatrix)*

Echeneidae
    Remora *(Remora remora)*

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

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

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

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

Stromateidae
    Butterfish *(Peprilus triacanthus)*

Triglidae
    Striped searobin *(Prionotus evolans)*

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

Pleuronectidae
    Winter flounder *(Pseudopleuronectes americanus)*

Balistidae
    Orange filefish *(Aluterus schoepfi)*

Tetraodontidae
    Northern puffer *(Sphoeroides maculatus)*

Diodontidae
    Striped burrfish *(Chilomycterus schoepfi)*

<u>Other vertebrates</u>

Cheloniidae
    Atlantic loggerhead turtle *(Caretta caretta)*

Appendix Table 2.--continued

<u>Invertebrates</u>

Clionidae
    Sulfur sponge *(Cliona celata)*

SCYPHOZOA
    Jellyfish

Portunidae
    Ovalipes crab *(Ovalipes guadulpensis)*

Xiphosuridae
    Horseshoe crab *(Limulus polyphemus)*

Neptuneidae
    Channeled welk *(Busycon canaliculata)*

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

Appendix Table 3. 1977. -- Segment III species list

Finfish

Odontaspididae
    Sand tiger shark *(Odontaspis taurus)*

Alopiidae
    Thresher shark *(Alopias vulpinus)*

Scyliorhinidae
    Chain dogfish *(Scyliorhinus retifer)*

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

Sphyrnidae
    Scalloped hammerhead *(Sphyrna lewini)*

Squatinidae
    Atlantic angel shark *(Squatina dumerili)*

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

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

Myliobatidae
    Bullnose ray *(Myliobatis freminvillei)*

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

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

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

Lophiidae
    Goosefish *(Lophius americanus)*

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

Appendix Table 3.--continued

Zeidae
    American john dory *(Zenopsis ocellata)*

Caproidae
    Deepbody boarfish *(Antigonia capros)*

Fistulariidae
    Bluespotted cornetfish *(Fistularia tabacaria)*

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

Pomatomidae
    Bluefish *(Pomatomus saltatrix)*

Rachycentridae
    Cobia *(Rachycentron canadum)*

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

Pomadasyidae
    Tomtate *(Haemulon aurolineatum)*

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

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

Labridae
    Pearly razorfish *(Hemipteronotus novacula)*

Ammodytidae
    American sand lance *(Ammodytes americanus)*

Trichiuridae
    Atlantic cutlassfish *(Trichiurus lepturus)*

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

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

Appendix Table 3.--continued

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

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

Pleuronectidae
- Winter flounder *(Pseudopleuronectes americanus)*

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

Ostraciidae
- Honeycomb cowfish *(Lactophrys polygonia)*

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

<u>Invertebrates</u>

Demospongiae
- Sponge

Echinoidea
- Sea urchins

Holothuroidea
- Sea cucumber

Sicyoninae
- Rock shrimp *(Sicyonia brevirostris)*

Nephropside
- American lobster *(Homarus americanus)*

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

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

Majidae
- Arrow crab *(Stenorynchus seticornis)*

Xiphosuridae
- Horseshoe crab *(Limulus polyphemus)*

Appendix Table 3.--continued

Pectinidae
    Atlantic deepsea scallop *(Placopecten magellanicus)*

Mactridae
    Surf clam *(Spisula solidissima)*

Naticidae
    Atlantic moon snail *(Polinices duplicatus)*

Neptuneidae
    Knobbed whelk *(Busycon carica)*

Fasciolariidae
    Florida horse conch *(Pleuroploca gigantea)*

Sepiolidae
    Squid *(Rossia tenera)*

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

Ommastrephidae
    Short-finned squid *(Illex illecebrosus)*

Appendix Table 4. 1978 -- 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 Table 4. 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 Table 4. Continued

Bothidae
    Summer flounder *(Paralichthys dentatus)*
    Windowpane *(Scopththalmus 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 guadulpensis)*
    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)*

Appendix Table 5 - 1979 total species list

Finfish

Carcharchinidae

Sandbar shark *(Charcharchinus milberti)*
Smooth dogfish *(Mustelus canis)*
Atlantic sharpnose *(Rhizoprionodon Terraenovar)*

Sphyrinidae

Scalloped hammerhead *(Sphyrna lewini)*

Squalidae

Spiny dogfish *(Squalus acanthias)*

Rajidae

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

Anguillidae

American eel *(Anguilla rostrata)*

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)*

Engraulidae

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

Synodontidae

Inshore lizardfish *(Synodus foetens)*

Lophiidae

Goosefish *(Lophius americanus)*

Gadidae

Atlantic cod *(Gradus morhua)*
Silver hake *(Merluccius bilinearis)*
Longfin hake *(Phycis chesteri)*
Red hake *(Urophycis chuss)*
Spotted hake *(Urophycis regius)*

Appendix Table 5 (continued)

Syndnathidae

Northern pipefish *(Syngnathus fuscus)*
Chain pipefish *(Syngnathus louisianae)*
Bull pipefish *(Syngnathus springeri)*

Serranidae

Bank sea bass *(Centropristis ocyurus)*
Rock sea bass *(Centropristis philadelphica)*

Percichthyidae

Striped bass *(Morone saxatilis)*

Pomatomidae

Bluefish *(Pomatomus saltatrix)*

Carangidae

Round scad *(Decapterus punctatus)*

Pomadasyidae

Pigfish *(Orthoropristis chrysoptera)*

Sparidae

Sheepshead *(Archosargus probatocephalus)*
Pinfish *(Lagodon rhomboides)*

Sciaenidae

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

Labridae

Tautog *(Tautoga onitis)*

Trichiuridae

Atlantic cutlassfish *(Trichiurus lepturus)*

Scombridae

Atlantic mackerel *(Scomber scombrus)*

Appendix Table 5 (continued)

Stromateidae

Harvestfish *(Peprilus alepidotus)*
Butterfish *(Peprilus triacanthus)*

Trigladae

Northern searobin *(Prionotus carolinus)*
Striped searobin *(Prionotus evolans)*
Bandtail searobin *(Prionotus ophryas)*
Bluespotted searobin *(Prionotus roseus)*
Leopard searobin *(Prionotus scitulus)*

Bothidae

Ocellated flounder *(Ancylopsetta quadrocellata)*
Summer flounder *(Paralichthys dentatus)*
Windowpane flounder *(Scophthalmus aquosus)*
Dusky flounder *(Syacium papillosum)*

Soleidae

Naked sole *(Gymnachirus melas)*

Cynoglossidae

Spottedfin tonguefish *(Symphurus diomedianus)*

Tetraodontidae

Northern puffer *(Sphoeroides maculatus)*

PART II

Virginia Institute of Marine Science

TABLE OF CONTENTS

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

LIST OF TABLES

List of Tables (continued) Page Number

List of Tables (continued) Page Number

List of Tables (continued) Page Number

List of Tables (continued) Page Number

LIST OF FIGURES

Job 1. Catch-Effort Statistics, Inshore Alosine Fishery

SUMMARY

1. Stake gill nets in the James River yielded an estimated 0.3 million kg of American shad in 1979.

2. The catch-per-unit-of-effort (CPUE) for stake gill nets in the James River decreased from 24.5 kg/m in 1978 to 7.6 kg/m in 1979.

3. Pound nets in the York River landed an estimated 15,716 kg of American shad and 217,406 kg of river herring in 1979.

4. Stake gill nets in the York River landed an estimated 209,534 kg of American shad.

5. Pound nets in the Rappahannock River landed an estimated 3,608 kg of American shad and 479,649 kg of river herring in 1979.

6. Stake gill nets in the Rappahannock River caught an estimated 23,818 kg of American shad, a decrease of 58% compared to 1978.

7. Pound nets in the Potomac River landed 1,783 kg of American shad and 448,668 kg of river herring in 1979, a decrease of 49% for American shad and 32% decrease in landings of river herring compared to 1978.

8. Gill nets in the Potomac River (stake, anchor and drift) yielded 10,392 kg of American shad in 1979, a decrease of 55% compared to 1978.

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 (CPUE) 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 CPUE 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 CPUE 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

The 1979 catch estimates of adult alosines were computed by the method of Hoagman and Kriete (1975). Pound net catch estimates were determined by multiplying the CPUE (kg/net/half-month) 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 CPUE (kg/m of net/half-month) of index nets by meters of stake gill netting in 5-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 CPUE was determined by dividing landings by the average number of nets fished.

RESULTS AND DISCUSSION

The 1979 fishing season for adult alosine fishes was delayed several weeks because of ice conditions in the Chesapeake Bay and its tributaries. As in 1978, virtually all of the pound net and gill net stands that remained at the end of the 1979 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.

Large numbers of blue crabs in gill nets and rapidly rising water temperatures in mid-April terminated the fishing season for American shad prematurely. Prices of 1979, like those of 1978 never equaled prices of 1977 (.24 and .17/lb vs .34/lb) and dropped even more with the approach of warm weather and rising water temperatures. Although the price per pound received by fishermen has increased since 1967, the

1979 price per pound received for American shad, adjusted by the consumer price index, is actually only slightly higher than in 1967 (Table 1.3).

Pound net effort increased in 1979 (267 nets), relative to 1977 effort (236 nets) and 1978 effort (245) (Loesch et al. 1977; Johnson et al. 1978); however, it is still far below the effort of 1967 (332 active pound nets, Loesch and Kriete 1976).

Effort by gill netters increased 12% in 1979 relative to 1978 (Johnson et al. 1978); the number of gill net stands increased 4% during the same period (Table 1.2).

Pound net CPUE in the Potomac River for alewife and blueback exhibited a dramatic decrease in 1979 following an increase in 1978 (Table 1.4). Pound net CPUE in the Rappahannock River continued to increase for blueback, yet decreased for alewife in 1979.

Stake gill net CPUE for American shad, male and female, declined in 1979 relative to 1978 in all instances except CPUE for female shad in the York River (Table 1.4).

<u>James River</u>

No pound net records were obtained from the James; however, records were obtained from fyke net landings. As reported in 1978 (Johnson et al. 1978), these nets are ineffective for capturing American shad and river herring. Fyke nets landed an estimated 4,311 kg of alewife and 6,459 kg of blueback. Although this is an increase compared to 1978, it is insignificant when compared to the spawning population.

Stake gill nets in the James River yielded an estimated 0.3 million kg of American shad during the spring fishing season (Table 1.5). This represents a decrease of 59% in landings compared to 1978 (Johnson et al. 1978). Peak landings, sexes combined, occurred in the second half of March.

The CPUE by gill nets for American shad in the James River decreased dramatically from 24.5 kg in 1978 (Johnson et al. 1978) to 7.6 kg in 1979 (Table 1.4).

York River

Pound nets in the York River landed an estimated 15,716 kg of American shad and 217,406 kg of river herring in 1979 (Table 1.6). These landings represent a decrease of 47% for American shad and an increase of 43% for river herring, compared to 1978 (Johnson et al. 1978). Female American shad constituted 65% of the catch in 1979 compared to 44% in 1978. Blueback herring consistently constituted 90% of the river herring catch.

The CPUE for American shad by pound nets decreased from 2,485 kg in 1978 to 1,310 kg in 1979. The CPUE for river herring increased 43% from 12,665 kg to 18,117 kg during the same period.

Peak landings of American shad by pound nets shifted from the first half of April in 1977 and 1978 to the second half of April in 1979. Peak landings of river herring occurred during the first half of May in 1979, much later than in 1978 when river herring landings peaked in the first half of April.

Stake gill net effort in the York River continued to decline in 1979. This decline in effort began in 1975 (Loesch and Kriete 1976). Estimated landings of American shad increased slightly from 206,446 kg in 1978 to 209,534 kg in 1979. Peak landings occurred during the second half of March

(Table 1.7). The practice of cutting females for the roe and the discarding of males at the nets was partially discontinued in 1979 possibly due to stable prices until the end of the fishing season.

The CPUE by stake gill nets in the York River for American shad increased 16% compared to 1978, from 12.9 kg/m to 15.0 kg/m (Table 1.4).

Rappahannock River

Pound nets in the Rappahannock River landed an estimated 3,608 kg of American shad and 479,649 kg of river herring during the 1979 spring fishing season (Table 1.8). This represents a decrease in landings of 9% for American shad, and 6% for river herring compared to 1978 (Johnson et al. 1978).

The CPUE by pound nets in the Rappahannock River increased from 95 kg to 97 kg for American shad and from 12,203 kg to 12,963 kg for river herring compared to 1978. The CPUE of female American shad decreased from 45 kg to 42 kg while the CPUE for males increased from 50 kg to 55 kg compared to 1978 (Table 1.4).

Stake gill nets caught an estimated 23,818 kg of American shad with peak landings during the first half of April (Table 1.9). This represents a decrease of 58% in landings compared to 1978 (Johnson et al. 1978).

As in 1978, stake gill nets above mile 35 were set primarily for striped bass due to their high ex-vessel prices ($1.00-$1.50/lb) and the scarcity of American shad on the Rappahannock River in 1979.

The CPUE for American shad decreased from 4.2 kg/m to 1.8 kg/ m compared to 1978 (Table 1.4).

Potomac River

Pound nets in the Potomac River landed 1,783 kg of American shad, a decrease of 49% compared to 1978 (Johnson et al. 1978), continuing a downward trend that began in 1976 (Loesch and Kriete 1976). River herring landings by pound nets also declined from 659,411 kg to 448,668 kg compared to 1978. Peak landings for American shad and river herring occurred during May with the bulk of the pound net catch landed by Virginia-based pound nets (Table 1.10).

The CPUE for American shad in the Potomac River by pound nets decreased 58% from 78 kg to 33 kg per net relative to 1978 (Johnson et al. 1978). River herring CPUE decreased 44% compared to 1978, from 14,654 kg to 8,157 kg per net (Table 1.4).

Stake gill net and anchor gill net landings from the Potomac River are no longer reported separately; therefore, no direct comparisons can be made with prior data.

Gill nets (stake and anchor combined) yielded 7,838 kg of American shad in 1979 (a decrease of 57% from 1978) with 85% landed by Maryland fishermen (Table 1.10). Virginia drift gill netters landed 94% of the 2,554 kg of shad caught by that gear.

1977-1979: Catch-Effort Evaluation

Stocks of alosine fishes have been declining since 1967 (Loesch and Kriete 1976). However, during the period 1977-1979 landings and CPUE have not consistently reflected this continued decline.

Landings of American shad by pound nets in 1978 increased relative to 1977 in the York River, yet declined in the Rappahannock and Potomac rivers. Landings in the York River also declined in 1979 (Table 1.11). River herring peak landings occurred in 1978 in the Rappahannock and Potomac rivers, but peaked in 1979 in the York River. The increased landings in the York River were principally due to large catches of river herring by pound nets placed in shallow water.

Yearly CPUE of American shad by pound nets in the York River exhibited a substantial recovery in 1978 compared to 1977 but declined again in 1979. Yearly CPUE of American shad by pound nets in the Rappahannock and Potomac rivers remained insignificant for all years reported (Table 1.4). Catch-per-unit-of-effort for river herring increased yearly in the York and Rappahannock rivers but was highest in 1978 in the Potomac River.

Peak landings during 1977-1979 of American shad by stake gill nets occurred in 1978 in the James and Rappahannock rivers, and 1979 in the York River (Table 1.11). Landings declined yearly in the Potomac River after 1977.

The CPUE of American shad by stake gill nets oscillated from 1977 to 1979 in the James and Rappahannock rivers but continually increased in the York River during the same period (Table 1.4). The James River had the highest CPUE of all rivers with 24.5 kg/m in 1978. The Potomac River Fisheries Commission no longer reports stake and anchor gill net catches separately, therefore no CPUE was determined for that river.

Landings and CPUE can be used as an indicator of relative stock abundance; however, both statistics must be regarded with caution. Subtle changes may occur in the fisheries which, unless otherwise noted, can produce erroneous estimates of landings and CPUE. A case in point is the change in stake gill net effort on the Rappahannock River. Prior to 1977 all stake gill nets were assumed to have been set for American shad.

In 1977 all of the nets above mile 35 and 40% of the nets below mile 35 were large-mesh nets set primarily to capture striped bass (Loesch et al. 1977).

Similar changes in the pound net fishery have been noted in recent years. Because of diminishing numbers and fluctuating prices of American shad, coupled with increased net costs, pound net stands set primarily to capture American shad have been discontinued. Pound net stands are now either set for summer species, such as weakfish, croaker and spot, or scrap fish which are used for crab bait and fish meal (personal communication via J. Owens).

Both cases mentioned above could, if not corrected, bias estimated landings and CPUE data. These data coupled with data from Job 2 are an essential tool used in fisheries management.

It is important, therefore, for this data base coupled with increased coverage to be continued to insure that these management tools will be available.

LITERATURE CITED

Crochet, D. W., D. W. Allen and M. L. Hornberger. 1976. Evaluation of commercial fisheries for American shad in South Carolina and status of the species in selected waters. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 4.

Friedersdoff, J. W. 1976. Population estimates and relative abundance work on adult American shad stocks in the Delaware River (1969-1976). Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 83.

Hoagman, W. J. and W. H. Kriete, Jr. 1975. Biology and management of river herring and shad in Virginia. Annu. Rep. Virginia AFC 8-2. Virginia Institute of Marine Science, Gloucester Point, Virginia. 105 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 p.

Jones, Robert A., Peter Minta, and Victor Crecco. 1976. A review of American shad studies in the Connecticut River. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 135.

Klauda, Ronald J., Marcia Nittel, and K. Perry Campbell. 1976. The commercial fishery for American shad in the Hudson River: Fishing effort and stock abundance trends. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv. Amherst, MA. p. 107.

Loesch, J. G. and W. H. Kriete, Jr. 1976. Biology and management of river herring and shad in Virginia. Completion Rep. 1974-1976. Virginia AFC 8-1 to 8-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. pp. 1-36.

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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Table 1.1. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during January-June, 1979.

	Area	Jan	Feb	Mar		April		May	June	
		23	23	8	26	16	30	18	12	27
A	James R.	0	0	0	0	0	0	0	0	0
B	Back R.	0	0	2	4	4	4	5	5	4
C	Poquoson R.	0	0	0	1	1	1	1	1	1
D	York R.	0	0	0	4	8	14	16	16	16
E	Mobjack Bay	0	0	0	3	9	6	4	5	5
F	Piankatank R.	0	0	0	1	1	1	1	1	2
G	Rappahannock R.	0	0	10	26	42	45	43	45	42
H	Great Wicomico R.	1	0	0	2	3	6	6	5	4
I	Potomac R.	1	0	1	16	38	66	76	83	82
J	Cape Henry to Fort Wool	0	0	0	1	2	3	5	4	4
K	Old Point to Tue Marsh Point	0	0	0	4	5	4	5	5	1
L	York Spit	0	0	0	0	0	3	3	3	3
M	New Point to Stingray Point	0	0	0	6	9	16	18	21	20
N	Windmill Point to Smith Point	10	0	1	14	28	33	36	43	37
	Eastern Shore									
O	Above Hungar Creek	0	0	0	0	0	0	0	0	0
P	Below Hungar Creek	5	0	0	3	12	19	26	30	32
	Total	17	0	14	85	162	221	245	267	253

Table 1.2. Number of stake gill net stands fished in Virginia rivers 1977-1979 (A) and number of linear meters per five mile block (B) in 1979. Figures in parentheses represent nets set for American shad.

A. River System	Number of Gill Net Stands 1977	1978	1979
James	168	181	168
York	123	118	117
Rappahannock	121	124	155

B. River	Mile	Number of Stands	Number of Sections	Average Length/Section	Total Meters
James	05-10	40*	856	9	7,704
	10-15	18	447	9	4,023
	15-20	76	1,224	14	17,136
	20-25	21	341	14	4,774
	25-45	13	255	14	3,570
		Total 168	3,123		37,207
York	05-10	1	8	9	72
	10-15	30	506	9	4,554
	15-20	35	498	9	4,482
	20-25	18	310	6	1,860
	25-29	33	500	6	3,000
		Total 117	1,822		13,968
Rappahannock	15-20	1	10	17	170 (90)
	20-25	11	141	17	2,397 (1,270)
	25-30	44	767	17	13,039 (6,911)
	30-35	33	580	17	9,860 (5,226)
	35-70	66	1,244	13	16,172
		Total 155	2,742		41,638 (13,497)

*Includes anchor gill net converted to stands.

Table 1.3. Dock-side value and adjusted value of American shad landings in Virginia for the years 1967-1979. 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
1979	994	235	2.17	108.3	10.89

Table 1.4. Yearly catch-per-unit-of-effort for American shad and river herring 1975-1979 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)				
	1976	20,464	1.9	25.1					
	1977	26,884	0.4	6.9					
	1978	28,134	4.1	20.4					
	1979	37,207	0.5	7.1					
York River	1975	22,106	0.5	4.5	(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
	1979	13,968	1.7	13.3	12	458	852	1,855	16,262
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
	1979	13,497	0.2	1.6	37	55	42	1,514	11,449
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
	1979	(a)			55	21	12	209	7,948

(a) Data not available.

Table 1.5. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the James River 1979 by half-month intervals and by sex. Effort from Table 1.2. Index in kg/m of net.

		American Shad				
		Male		Female		Total
Half-Month Period	River Mile	Index	Estimated Catch	Index	Estimated Catch	Estimated Catch
March 1st	05-10	0.210	1,618	0.580	4,468	6,086
	10-15		845		2,333	3,178
	15-20		428		1,559	1,987
	20-25	0.025	119	0.091	434	553
	25-45		89		325	414
	Total		3,099		9,119	12,218
March 2nd	05-10	0.400	3,082	4.746	36,563	39,645
	10-15		1,609		19,093	20,702
	15-20		2,296		26,064	28,360
	20-25	0.134	640	1.521	7,261	7,901
	25-45		478		5,430	5,908
	Total		8,105		94,411	102,516
April 1st	05-10	0.121	932	4,088	31,494	32,426
	10-15		487		16,446	16,933
	15-20		1,285		27,006	28,291
	20-25	0.075	358	1.576	7,524	7,882
	25-45		268		5,626	5,894
	Total		3,330		88,096	91,426
April 2nd	05-10	0.047	362	2.692	20,739	21,101
	10-15		189		10,830	11,019
	15-20		1,114		19,552	20,666
	20-25	0.065	310	1.141	5,447	5,757
	25-45		232		4,073	4,305
	Total		2,207		60,641	62,848
May 1st	05-10	0.011	85	0.259	1,995	2,080
	10-15		44		1,042	1,086
	15-20		308		5,312	5,620
	20-25	0.018	86	0.310	1,480	1,566
	25-45		64		1,107	1,171
	Total		587		10,936	11,523
Total by Sex			17,328		263,203	
Grand Total						280,531

Table 1.6. Estimated catch in kg of American shad and river herring by pound nets in the York River 1979 by half-month intervals.

		American Shad				River Herring						
		Female		Male				Alewife		Blueback		
Half-Month Period	Number Nets	Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total	Number of Index Nets
March 2nd	4	146	584	62	248	209	836	10	84	90	752	2
April 1st	8	194	1,552	110	880	1,350	10,800	14	1,512	86	9,288	8
April 2nd	14	260	3,640	146	2,044	4,587	64,218	18	11,559	82	52,659	10
May 1st	16	180	2,880	92	1,472	5,050	80,800	6	4,848	94	75,952	11
May 2nd	16	76	1,216	33	528	3,558	56,928	7	3,985	93	52,943	11
June 1st	16	22	352	20	320	239	3,824	7	268	93	3,556	11
	Total		10,224		5,492				22,256		195,150	
				15,716			217,406					

Table 1.7. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the York River 1979 by half-month intervals. Effort from Table 1.2. Index in kg/m of net.

Half-Month Period	River Mile	American Shad: Male Index	Male Estimated Catch	Female Index	Female Estimated Catch	Total Estimated Catch
March 1st	05-10	1.427	103	3.217	232	335
	10-15		6,498		14,650	21,148
	15-20		6,396		14,418	20,814
	20-25	0.031	58	1.117	2,078	2,136
	25-29		93		3,351	3,444
	Total		13,148		34,729	47,877
March 2nd	05-10	0.785	56	5.507	396	452
	10-15		3,575		25,079	28,654
	15-20		3,518		24,682	28,200
	20-25	0.110	205	4.003	7,445	7,650
	25-29		330		12,009	12,339
	Total		7,684		69,611	77,295
April 1st	05-10	0.196	14	4.285	308	322
	10-15		892		19,514	20,406
	15-20		878		19,205	20,083
	20-25	0.022	41	5,517	10,262	10,303
	25-29		66		16,551	16,617
	Total		1,891		65,840	67,731
April 2nd	05-10	0.054	4	1.102	79	83
	10-15		246		5,018	5,264
	15-20		242		4,939	5,181
	20-25	(a)		1.136	2,113	2,113
	25-29				3,408	3,408
	Total		492		15,557	16,049
Winter Fishery (Jan & Feb)	10-20[b]	0.821	245	1.128	337	582
Total by Sex			23,460		186,074	
Grand Total						209,534

(a) None reported by index fishermen.
(b) Total meters of gill net adjusted for winter fishery.

Table 1.8. Estimated catch in kg of American shad and river herring by pound nets in the Rappahannock River 1979 by half-month intervals.

			American Shad				River Herring						
			Female		Male				Alewife		Blueback		
Half-Month Period	Mile	Number Nets	Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total	Number of Index Nets
March 1st	0-30	0	(a)		(a)		(a)						4
	31-65	10	.3	3	.2	2	74	740	61	451	39	289	10
March 2nd	0-30	13	3.8	49	7.8	101	1,701.0	22,113	51	11,278	49	10,835	4
	31-65	13	6.7	87	14.2	185	155.4	2,020	66	1,333	34	687	13
April 1st	0-30	21	18.0	378	16.0	336	2,268.0	47,628	35	16,670	65	30,958	4
	31-65	21	6.4	134	5.7	120	238.0	4,998	28	1,399	72	3,599	14
April 2nd	0-30	24	29.0	696	27.7	665	3,402.0	81,648	9	7,348	91	74,300	4
	31-65	21	3.7	78	3.6	76	1,549.8	32,546	13	4,231	87	28,315	14
May 1st	0-30	26	4.3	112	8.3	216	4,762.7	123,830	2	2,477	98	121,353	4
	31-65	17	1.5	25	6.3	107	2,142.8	36,428	7	2,550	93	33,878	14
May 2nd	0-30	26	(a)		5.7	148	3,628.7	94,346	8	7,548	92	86,798	4
	31-65	17	(a)		5.1	87	94.1	1,600	6	96	94	1,504	14
June 1st	0-30	28	(a)		(a)		1,134.0	31,752	2	635	98	31,117	4
	31-65	17	(a)		.2	3	(a)						14
Total				1,562		2,046				56,016		423,633	
					3,608					479,649			

(a) None reported by index fishermen.

Table 1.9. Estimated catch in kg of American shad by stake gill nets in the Rappahannock River 1979 by half-month intervals. Effort from Table 1.2. Index in kg/m of net.

		American Shad				
		Male		Female		Total
Half-Month Period	River Mile	Index	Estimated Catch	Index	Estimated Catch	Total Estimated Catch
March 1st	15-20	0.018	2	0.029	3	5
	20-25		23		37	60
	25-30		124		200	324
	30-35		94		151	245
	35-70[a]					
	Total		243		391	634
March 2nd	15-20	0.065	6	0.417	37	43
	20-25		82		529	611
	25-30		449		2,882	3,331
	30-35		340		2,179	2,519
	35-70[a]					
	Total		877		5,627	6,504
April 1st	15-20	0.035	3	0.651	58	61
	20-25		44		827	871
	25-30		242		4,499	4,741
	30-35		183		3,402	3,585
	35-70[a]					
	Total		472		8,786	9,258
April 2nd	15-20	0.019	2	0.377	34	36
	20-25		24		479	503
	25-30		131		2,605	2,736
	30-35		99		1,970	2,069
	35-70[a]					
	Total		256		5,088	5,344
May 1st	15-20	0.026	2	0.128	11	13
	20-25		33		162	195
	25-30		180		885	1,065
	30-35		136		669	805
	35-70[a]					
	Total		351		1,727	2,078
Total by Sex			2,199		21,619	
Grand Total						23,818

(a) None reported by index fishermen.

Table 1.10. Total catch in kg of alosine fishes by gill nets (A) and pound nets (B) in the Potomac River 1979.

	American Shad					River Herring				
	Virginia		Maryland			Virginia		Maryland		
	Female	Male	Female	Male	Total	Alewife	Blueback	Alewife	Blueback	Total
A. Anchor and Stake Gill Nets										
March	39	20	64	14	137	411	67	141	23	642
April	819	142	5,184	347	6,492	61	1,467	30	718	2,276
May	94	48	1,025	42	1,209	1	66	1	7	75
Total	952	210	6,273	403	7,838	473	1,600	172	748	2,993
Drift Gill Net										
April	497	67	86	26	676	2	43			45
May	1,650	177	34	17	1,878	1	40			41
Total	2,147	244	120	43	2,554	3	83			86
B. Pound Net										
March	72	21	4	2	99	549	89	266	43	947
April	280	84	28	19	411	3,380	81,117	145	3,472	88,114
May	261	749			1,010	7,144	350,078	32	1,570	358,824
June	4	259			263		763		20	783
Total	617	1,113	32	21	1,783	11,073	432,047	443	5,105	448,668
Total	3,716	1,567	6,425	467		11,549	433,730	615	5,853	
Grand Total					12,175					451,747

Table 1.11. Yearly landings in kg of American shad by pound nets and stake gill nets and river herring by pound nets. Landings for the James, York and Rappahannock rivers are estimations. Landings for the Potomac River are reported by the Potomac River Fisheries Commission.

	Stake Gill Net		Pound Net			
	American Shad		American shad		River Herring	
	♀	♂	♀	♂	Alewife	Blueback
James						
1977	186,495	11,612	(a)			
1978	574,935	116,348				
1979	263,203	17,328				
York						
1977	137,748	3,376	3,217	8,894	10,298	87,966
1978	174,780	31,666	13,141	16,676	16,021	135,954
1979	186,074	23,460	10,224	5,492	22,256	195,150
Rappahannock						
1977	22,053	2,298	1,268	2,949	84,688	209,163
1978	45,870	10,909	1,871	2,096	130,804	381,734
1979	21,619	2,199	1,562	2,046	56,016	423,633
Potomac (stake, anchor and drift gill net combined)						
1977	29,708	2,704	2,458	3,775	34,671	179,961
1978	20,544	2,858	1,674	1,853	48,942	610,469
1979	9,492	900	649	1,134	11,516	437,152

(a) Data not available.

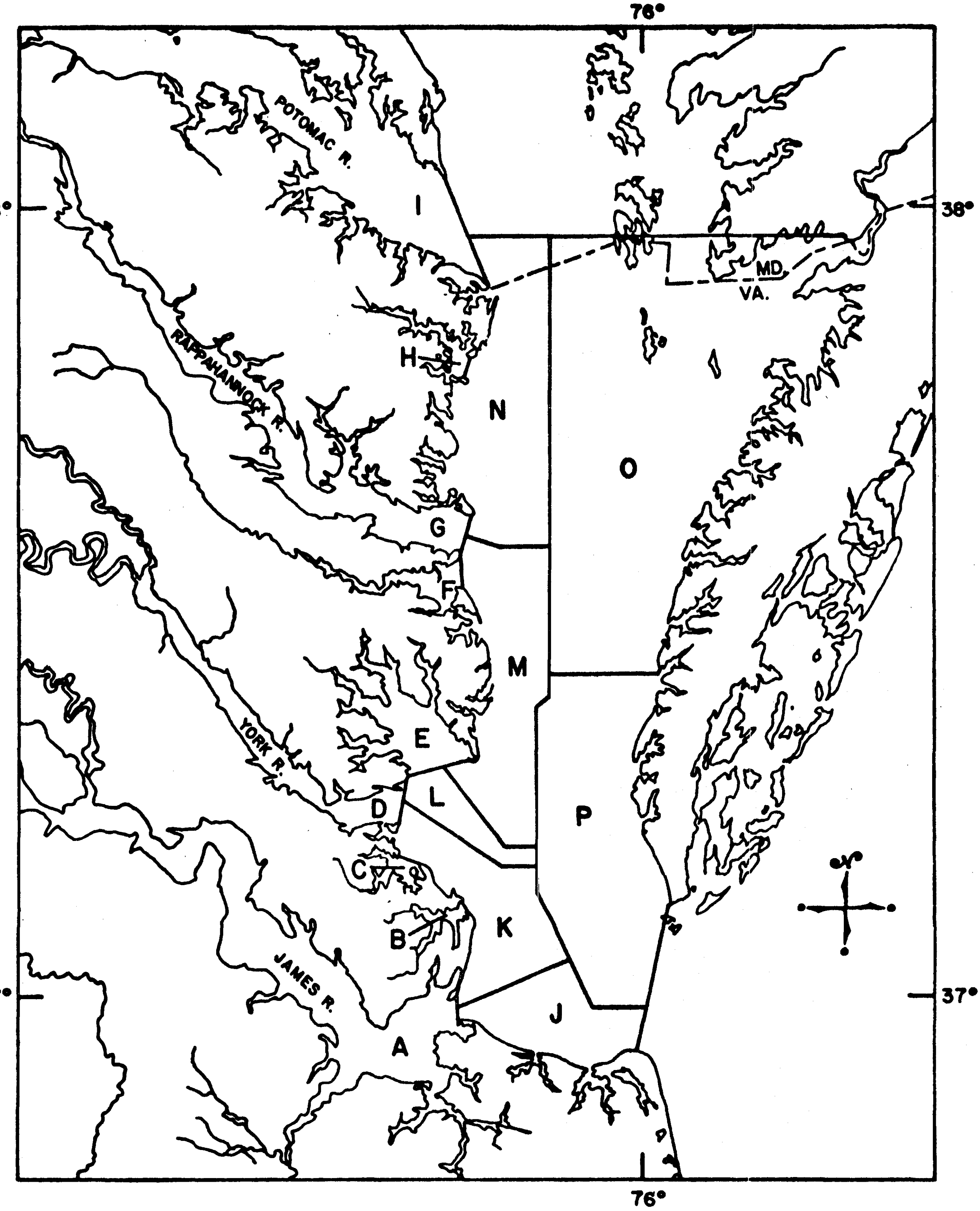


Figure 1.1. Area designations utilized during aerial pound net counts.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

SUMMARY

1. Virginia river herring landings of 630 metric tons (MT), 965 MT, and 766 MT in 1977, 1978, and 1979 were the lowest recorded over the last 15 years.

2. The extremely low landings in the years 1977-1979 are a continuation of a decline that began in 1970. The decline is attributed to heavy exploitation of river herring in the late 1960's and 1970's and recurring poor recruitment in the last decade.

3. The most notable features of the 1979 river herring samples of the Virginia commercial landings were the high percentages of ages 3 and 4. These ages were absent or rare in samples from 1973 to 1978.

4. At this time, the high percentages of age 3 and 4 in the fishery cannot be interpreted as an anticipatory sign of strong 1975 and 1976 year classes. Their relative strength in the 1979 samples is due to a paucity of older fish. Analysis of the 1980 landings, catch-per-unit-of-effort, and age structure should indicate the true relative strength of recruitment by these year classes.

5. The modal age of American shad increased from age 5 in 1977 to age 6 in 1978, but did not decrease in 1979, as did the modal age of river herring. However, the American shad fishery is primarily a gill net fishery directed at the larger and more valuable females. The data are, therefore, biased.

6. The low landings of American shad (Job 1), similar to the low river herring landings, probably reflect recurring poor recruitment. The three alosine species have overlapping spawning seasons and all are, in part, estuarine-dependent during their first-year development. Thus, similar year-class success could be expected.

Job 2. Population Dynamics of Adults - Inshore Alosine Fishery

INTRODUCTION

The Virginia Institute of Marine Science (VIMS) continued its annual assessment of the structure of adult alosine populations in Virginia inshore waters. These data are essential for any consideration of an alosine management plan.

MATERIALS AND METHODS

Methods of sampling the Virginia alosine commercial fisheries in 1977 and 1978 were reported by Loesch et al. (1977) and Johnson et al. (1978). The methods remained unchanged in 1979 except for a reduction in sampling frequency due to a reduced funding level.

Sampling of the Virginia alosine commercial fisheries in 1979 commenced in March, and continued semi-monthly for river herring and American shad until late May in the James, York, and Rappahannock rivers and early June in the Potomac River.

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 biases the sex ratio, and 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 and otoliths removed from random subsamples. American shad data were collected at the sampling site, except for age and spawning frequency data which were derived from laboratory analysis of scales. Ages of river herring were determined from otoliths and American shad age from scales by the method of Cating (1953), i.e., counting the number of annuli and spawning check marks, and adding a year for the scale edge. Beal (1968) and Marcy (1969) used scales and found the method applicable for river herring. Kornegay (1979) in North Carolina and Lipton (1979) and Travelstead (1980) in Virginia validated the use of otoliths for ageing 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 2.10.

RESULTS AND DISCUSSION

Sampling Effort

During the 1979 spawning season, 556 alewife, 2,386 blueback herring and 701 American shad were sampled (Table 2.1). The number of river herring collected was considerably less than in 1977 and 1978 (Loesch et al. 1977; Johnson et al. 1978). A savings in time, effort, and money was accrued due to the use of otoliths. Very few otoliths were unreadable. In contrast, large samples were needed in past years to obtain a relatively small proportion of useable scales due to their loss or damage in the pound net fishery. Anticipated samples from the James, York and Rappahannock rivers in June and from the Potomac River in July did not materialize because of an early cessation of the spawning runs in 1979.

1979: River Herring Landings

The 1979 Virginia river herring landings of 766 metric tons (MT) were a 21% decrease relative to the 1978 landings, and were the second lowest landing recorded since 1966 (Table 2.2). The estimated strong 1975 year class (Hoagman and Kriete 1975) did not recruit in sufficient numbers to bolster this declining fishery.

1977-1979: River Herring Landings

Virginia river herring landings in the years 1977-1979 were the lowest recorded over the last 15 years (Table 2.2). These extremely low landings are a continuation of a decline that began in 1970. Although the 1978 landings of 965 MT were a 53% increase relative to the 1977 landings catch again declined in 1979. The increased 1978 landings are not attributable to increased effort or improved recruitment. For example, the Rappahannock and Potomac River pound net landings in 1978 increased, but mean effort for the two rivers decreased from 48 pound nets per day (average) in 1977 to 43.5 in 1978 (Table 1.4). Also, in 1978, age structure and size and weight data (Johnson et al. 1978) indicated that Virginia stocks aged due to poor recruitment in the last several years. Thus, the increased 1978 landings could not be attributed to recruitment. A speculative explanation is that the cold winter of 1977-1978 with resulting low water temperatures delayed the entire river herring spawning season. This would result in greater fishing pressure because the fish entered the rivers when all of the pound nets were in place rather than the usual protracted entry in late February and March when the number of nets were at a minimum. Therefore, effective effort may have been greater in 1978 than nominal effort would indicate. Similarly, the decreased 1979 landings do not appear to be related to effort since mean effort for the Rappahannock and Potomac rivers increased to 46 (Table 1.4).

The general decline in Virginia landings starting in 1970 is attributed to poor recruitment (Loesch et al. 1977) and heavy exploitation of river herring by the foreign offshore fishery in the late 1960's and early 1970's (Hoagman et al. 1973). Strong recruitment to the inshore fishery has not occurred since the 1966 year class first became vulnerable in 1969.

The offshore river herring fleets operated east of the Virginia Capes and the Delmarva Peninsula from January to May; river herring harvested there would have returned to spawn in the tidal freshwaters of the mid-Atlantic states (Hoagman and Kriete 1975).

There is an apparent correlation between the commencement of the offshore river herring fishery and the decline of the inshore North Carolina and Virginia landings (Table 2.2). From 1966 through 1969, Virginia river herring landings remained relatively constant, averaging about 13,500 MT. In 1969 the reported offshore landings by foreign fisheries, primarily the USSR, greatly increased, and the total river herring landings from both inshore Virginia and offshore were approximately 24,300 MT. In 1970 the Virginia landings decreased to 8,637 MT. From 1971 to 1975 Virginia landings ranged from 4,203 to 6,050 MT and averaged about 5,000 MT. There was a similar decrease in North Carolina landings (Table 2.2).

In 1976 inshore landings of river herring again decreased (Table 2.2). The states of North Carolina and Virginia traditionally have had the major river herring fisheries. The North Carolina effort and landings in 1976 remained constant relative to the previous 3 years (Harrel Johnson, N. C. Div. Mar. Fish., personal communication). Virginia landings in 1976 were only about 36% of that in 1975 and 37% of the mean landings for the previous 5 years. Effort was not a factor, since in 1976 relative to 1975 effort remained, in general, constant; e.g., decreasing slightly in the Rappahannock River but increasing slightly in the Potomac River (Loesch and Kriete 1976). The 1976 decline in Virginia landings was probably due to the near absence of the 1972 year class which is believed to have been decimated by Tropical Storm Agnes. North Carolina fisheries were little affected by this storm and 4-year-old river herring were reasonably represented in their 1976 inshore fishery (Harrel Johnson, personal communication). The differences in age 4 representation in the 1976 commercial catches of North Carolina and Virginia imply separate inshore stocks for the two states.

Bilateral agreements between the USA and several foreign countries in the early 1970's and the enactment of the 200 mile limit (PL 94-265) in 1977 have resulted in relatively low offshore catches since 1973. However, the North Carolina and Virginia stocks appear to have been overharvested from 1969 through 1972. In the absence of strong recruitment the stocks have continued to decline.

1979: Age Composition

The age frequency of river herring (sexes pooled) by river by species determined from samples of the commercial fisheries catches is presented in Tables 2.3-2.10. Mean and modal age data are summarized in Table 2.11. Age 4 (1975 year class) was the modal age group for alewife and blueback herring in all rivers except the Potomac River where alewife ages 4 and 5 were codominant (Table 2.9). Alewife and blueback herring mean ages ranged from 4.0 to 4.4 and 4.3 to 4.8, respectively (Table 2.11). The lower mean and modal ages in 1979 are a reversal of the ageing trend in Virginia river herring reported by Johnson et al. (1978). Blueback herring mean age exceeded alewife mean age, with two exceptions in the commercial fishery sample in the years 1977-1979 (Table 2.11). The data probably reflect a tendency of blueback herring to spawn at an earlier age than alewife. Marcy (1969) reported differential spawning ages for river herring in Connecticut waters.

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 often discarded at the net when their market price is low. Therefore, data on age structure, sex ratio, and other vital statistics based on gill net samples, are relevant only to fish landed.

American shad age frequency data by river for 1979 are summarized in Table 2.12. Age frequencies by sex for all rivers for the years 1977-1979 were analyzed by a chi square test of independence. The tests were significant (P<0-001 for both males and females), indicating that age frequency was not independent of years. The significance is due to a shift from an age 5 mode in 1977 to age 6 in 1978 and 1979 and also to a large increase in the percentage of age 6 and older shad in the catches of the latter two years. Johnson et al. (1978) attributed the shift to an ageing trend as observed for the river herring. Since all three alosine species have overlapping spawning seasons and all are estuarine-dependent during their first-year development, similar year-class success could be expected. This reasoning is plausible, but mean and modal ages of American shad did not decrease in 1979 as those values did for river herring. The apparent paradox may be due to gill net mesh size changes during the shad season. Logbook data and personal communications with gill net fishermen revealed that when early sparse catches indicated a poor shad season, fishermen used larger mesh sizes to fish for the also scarce but more valuable striped bass. Thus, age frequency changes in the fishery cannot be interpreted until gill net catches can be partitioned by mesh sizes. Inferences about the population age structure cannot be made until the selectivity of each gill net size is estimated. The nature of gill net selectivity is such that the proportion of fish retained in a given mesh size is maximum at a specific fish size, and decreases for larger or smaller fish (Gulland 1969). Gill net selectivity of American shad is a consideration for near future research.

1977-1979: Age Composition

There was a trend of increasing mean age of alewife relative to 1977 data except in the Rappahannock and Pamunkey rivers where no appreciable changes occurred (Table 2.11). 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 (Table 2.11). 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 and the increasing age trend in the stocks observed from 1976 (Loesch and Kriete 1976) to 1978 (Table 2.11) was due to poor recruitment of 4-year-olds since 1976. The last strong year class to enter the fishery was the the 1966 year class.

The most notable features of the 1979 river herring age frequencies were the high percentages of ages 3 and 4 (Tables 2.3-2.10). Age 3 river herring were absent or rare in samples from the pound net fisheries in the Rappahannock and Potomac rivers from 1975 to 1978 (Tables 2.13-2.16). Similarly, age 4 was poorly represented from 1976 to 1978.

At this time, the high percentages of ages 3 and 4 in the fishery cannot be interpreted as an anticipatory sign of strong 1975 and 1976 year classes entering the river herring fisheries. Their relative strength in the 1979 samples is due to a paucity of older fish (Tables 2.3-2.10). The majority of the 1976 year class and nearly all of the

1975 year class will be recruited in 1980. Analyses of the 1980 landings, CPUE, and age structure should indicate the true relative strength of recruitment by the 1975 and 1976 year classes.

American shad age structure in the gill net fishery was discussed above and, as indicated, the data are biased. Pound nets may be non-selective for American shad, but our data (Job 1) are obtained from the Potomac River Fisheries Commission and commercial fishermen logbooks. Thus, we have no "hands on" unbiased samples for estimates of stock age structure.

1979: Length and Weight Analysis

Mean fork length and total body weight of river herring, with two exceptions, decreased in 1979 in comparison to the 1978 values (Table 2.17) due to a paucity of older fish. One exception was female alewife in the Potomac River, and the exception was associated with their older mean age structure (Table 2.11). The other exception, York River female alewife, may be sampling error due to the small sample size (27). Also, mean weight for the 27 females was very low relative to their mean fork length (Table 2.17), because 15 (55.6%) of the 27 fish examined had already spawned. The gonad condition in our alosine samples was highly variable; previously, Loesch and Kriete (1976) reported that coefficients of variation for weight were over three times those of length for river herring.

Our only unbiased data for American shad were a limited number (87) of fish from Potomac River pound nets in 1977. We obtained 11 fish in 1978 and a total of 16 from three rivers in 1979. Data from 1977 (39 males and 48 females) indicated that male shad had a mean fork length and mean weight of 405.8 mm and 837.3 g, and the respective means for females were 422.0 mm and 989.1 g.

1977-1979: Length and Weight Analysis

Increases in river herring mean lengths and weights in 1977 and 1978 (Table 2.17) continued a trend of increasing size since 1974. This trend was a reflection of the ageing of the stock due to several successive years of poor recruitment. Termination of the trend in 1979 resulted from the demise of the older year classes and thus, an enhancement of the relative abundance of ages 3 and 4.

Annual trends in mean length and weight of Potomac River river herring were used in previous reports as a general indicator of the Virginia stocks (Hoagman et al. 1973, 1974; Hoagman and Kriete 1975). In 1976 the format was modified by determining the estimates from only April and May samples, a time frame common to all sampling years (Loesch and Kriete 1976). The estimates of mean length and weight in 1976, 1977, and 1978 were high relative to the minima observed in 1974, but were less than the maximum estimates in 1972 (Loesch and Kriete 1976). Cycle-like changes in mean length and weight of river herring are not well understood. The decline of these estimates in 1969 was attributed to the offshore harvest by foreign vessels which peaked in 1969 (Hoagman et al. 1973, 1974; Hoagman and Kriete 1975). It is a reasonable postulate since it is common for an unfished, or little fished, stock to decrease in average size and age when significant fishing pressure is instituted. The measured attributes, however, quickly recovered and reached record highs in 1972. This was followed by dramatic decreases to record mean size minima which cannot be directly attributed to the offshore harvest. The 1973 and 1974 offshore catches were, respectively, only 29% and 42% of those in 1969 (Loesch and Kriete 1976). The implication is that the observed cyclic-like changes in annual mean length and weight could in part be, a natural phenomenon. Changing age-class structure and the presence of a strong year class are probably causative agents. The extremely strong 1966 year class was first partially recruited to the fishery in 1969 in relatively high abundance (Hoagman and Kriete 1975). In 1972, the year of record high mean sizes, the 1966 year class, at age 6, still contributed strongly to the commercial catch. The average sizes declined with the demise of the 1966 year class after 1972 and in the absence of succeeding strong year classes. With continued poor recruitment, especially the near failures of the 1972, 1973, and 1974 year classes to recruit at age 4 (Tables 2.13-2.16) the general trend of annual increases in mean length and mean weight persisted until 1979.

In summary, age class analysis, and record low landings in the last 3 years, indicate that the Virginia river herring stock is extremely low. It will remain low if the high relative abundance (%) of the 1975 and 1976 year classes is not transposed to high absolute abundance by strong recruitment in 1980. If depletion of the stock continues, it is possible that the spawning biomass will reach an unknown but critically depressed level. From that level it will be physically impossible for the stock to produce reasonably strong year classes. Thus, recovery of the Virginia river herring stock would require a protracted period and, probably, very restrictive management actions.

1979: Sex Ratio and Species Composition

Chi square (χ^2) analysis of the hypothesis of a 1:1 sex ratio for the 1979 data indicated that in three of eight male to female ratios, males were significantly more abundant (Table 2.18). Four ratios were nonsignificant, and in one ratio females were significantly more abundant. The dominance of females was in the Potomac River alewife sample and resulted from one large occurrence of females (60) in a relatively small (87) total sample (Table 2.1).

Sampling data (Table 2.1) showed that blueback herring comprised about 81% of the river herring catch in 1979.

1977-1979: Sex Ratio and Species Composition

Data show that male river herring dominate the younger age classes. Females are more abundant in the older age classes and have somewhat greater longevity (Loesch and Lund 1977; Loesch et al., ms. in preparation). Thus, changes in sex ratio are expected when shifts in age structure occur.

In 1977, χ^2 analysis of equal sex representation indicated in 6 of 10 male to female ratios, males were significantly more abundant (Table 2.18). In 1978, only 30% (3 of 10) of the ratios indicated a superior number of males; female blueback herring were significantly more abundant in the Rappahannock and Potomac river samples. Increased female representation in 1978 was associated with the increased age of the river herring stock (Johnson et al. 1978). In 1979, the percentage of ratios in which males were significantly more abundant increased to

37.5% (3 of 8) (Table 2.18). The greater percentage is associated with the general decrease in mean ages (Table 2.11).

Loesch and Kriete (1976) concluded that males predominated over females in the commercial catches of river herring, although their dominance was not consistent from year to year. In Connecticut and Rhode Island studies of alewife and blueback, males were also more abundant, particularly in the first half of the spawning season (Cooper 1961; Kissil 1974; Loesch and Lund 1977). Conversely, Joseph and Davis (1965) reported a 1:1 sex ratio for blueback herring in Virginia. The New England samples were taken on or adjacent to spawning grounds while those of Joseph and Davis (1965) were mostly from commercial catches near river mouths. Male river herring, in general, mature and spawn 1 year earlier than females, (Cooper 1961; Havey 1961; Marcy 1969) therefore, a predominance of males on or near the spawning grounds is expected. In the present study, samples were obtained from commercial sources throughout the rivers, and would account for the large variation in sex ratios we observed from sample to sample (Table 2.1).

Alewife spawn about 3 to 4 weeks earlier than blueback herring in the Chesapeake drainage (Hildebrand and Schroeder 1928). However, VIMS sampling of the commercial catches indicate a large overlap in the two species spawning periods (Loesch and Kriete 1976; Loesch et al. 1977; Johnson et al. 1978; Table 2.1). Although blueback herring initiate spawning somewhat later, they have a more protracted spawning season than the alewife. If river herring samples are not collected from the time spawning first occurs, or sampling is terminated before the cessation or near cessation of spawning, the estimated proportion of alewife to blueback could be severely biased. To avoid this source of error, our river herring sampling program generally commenced in early March, and since 1976, continued through the entire spawning season.

The annual percentage of blueback herring relative to alewife was significantly greater in the Virginia commercial catches from 1974 to 1979 (Table 2.19). In addition, the data indicated a 6-year trend of increasing dominance of blueback herring over alewife. A distribution free test for the trend slope (see Hollander and Wolfe 1973) was significant ($P<0.01$). Thus, as the Virginia river herring stock declined since the early 1970's, the rate of decline for alewife appears to have been greater than the rate for blueback herring.

LITERATURE CITED

Beal, K. L. 1968. Age and growth of the blueback herring *Alosa aestivalis* (Mitchill). M.A. Thesis, College of William and Mary, Williamsburg, Virginia. 93 p.

Cating, J. P. 1953. Determining age of Atlantic shad from their scales. U.S. Fish Wildl. Serv. Fish. Bull. 85:187-199.

Cooper, R. A. 1961. Early life history and spawning migration of the alewife, *Alosa pseudoharengus*. M.S. Thesis. Univ. of Rhode Island, Kingston, Rhode Island. 58 p.

Gulland, J. A. 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. FAO Manuals in Fisheries Science No. 4. FRS/M4. Rome. 154 p.

Havey, K. A. 1961. Restoration of anadromous alewife in Long Pond, Maine. Trans. Amer. Fish. Soc. 90:281-286.

Hildebrand, S. F. and W. C. Schroeder. 1928. Fishes of Chesapeake Bay. U.S. Bur. Fish. Bull. 43 (Part 1).

Hoagman, W. J., J. V. Merriner, R. St. Pierre, and W. L. Wilson. 1973. Biology and management of river herring and shad in Virginia. Completion Rep. 1970-1973. Virginia AFC 7-1 to 7.3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 210 p.

Hoagman, W. J., J. V. Merriner, W. H. Kriete, Jr., and W. L. Wilson. 1974. Biology and management of river herring and shad in Virginia. Annu. Rep. 1974. Virginia AFC 8-1. Virginia Institute of Marine Science, Gloucester Point, Virginia. 69 p.

Hoagman, W. J. and W. H. Kriete, Jr. 1975. Biology and management or river herring and shad in Viringia. Annu. Rep. 1975. Virginia Institute of Marine Science, Gloucester Point, Virginia. 105 p.

Hollander, M. and D. A. Wolfe. 1973. Nonparametric statistical methods. John Wiley & Sons, New York. 503 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 p.

Joseph, E. B. and J. Davis. 1965. A preliminary assessment of the river herring stocks of lower Chesapeake Bay. A progress report to the herring industry. Spec. Sci. Rep. 51. Virginia Institute of Marine Science, Gloucester Point, Virginia. 23 p.

Kissil, G. W. 1974. Spawning of the anadromous alewife, Alosa pseudoharengus, in Bride Lake, Connecticut. Trans. Amer. Fish. Soc. 103(2):312-317.

Kornegay, J. W. 1979. Comparison of ageing methods for alewife and blueback herring. North Carolina kept. Nat. Res. and Community Development. Spec. Sci. Rep. No. 30.

Lipton, D. W. 1979. Comparison of scales and otoliths for determining age and growth of the alewife (Alosa pseudoharengus, Wilson). M.A. Thesis. College of William and Mary, Williamsburg, Virginia. 37 p.

Loesch, J. G. and W. H. Kriete, Jr. 1976. Biology and management of river herring and shad on Virginia. Completion Rep. 1974-1976. Virginia AFC 8-1 to 8-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 226 p.

Loesch, J. G. and W. A. Lund, Jr. 1977. A contribution to the life history of the blueback herring, *Alosa aestivalis* (Mitchill). Trans. Amer. Fish. Soc. 106(6):583-589.

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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Marcy, B. C., Jr. 1969. Age determination of *Alosa pseudoharengus* (Wilson) and *Alosa aestivalis* (Mitchill) in Connecticut waters. Trans. Amer. Fish. Soc. 98:622-630.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill Book Co., New York. 675 p.

Travelstead, J. G. 1980. Age determination and growth of the blueback herring, *Alosa aestivalis*. M.A. Thesis. College of William and Mary, Williamsburg, Virginia. 60 p.

Table 2.1. Summary of sample data from the alosine commercial fisheries during the 1979 spawning run in major Virginia tributaries to Chesapeake Bay.

River and	Alewife		Blueback		American shad	
Half-month	Male	Female	Male	Female	Male	Female
James						
March						
1st	0	0	0	0	14	36
2nd	0	0	0	0	3	47
April						
1st	0	0	0	0	1	49
2nd	50	22	14	20	1	36
May						
1st	14	7	62	38	0	0
2nd	11	8	63	48	0	0
York*						
March						
1st	0	0	0	0	24	26
2nd	5	5	53	39	5	45
April						
1st	0	0	0	0	11	7
2nd	9	14	50	55	30	90
May						
1st	6	5	98	91	3	0
2nd	1	3	27	23	5	0
Rappahannock						
March						
2nd	84	98	71	44	12	95
April						
1st	39	31	97	54	3	47
2nd	13	14	108	104	0	34
May						
1st	10	3	140	119	5	3
2nd	4	13	158	68	0	0

*York and Pamunkey river data pooled.

Table 2.1 (continued)

River and Half-month	Alewife		Blueback		American shad	
	Male	Female	Male	Female	Male	Female
Potomac						
March						
2nd	8	60	7	3	0	0
April						
1st	0	0	0	0	4	15
2nd	0	4	54	57	0	50
May						
1st	6	5	174	90	0	0
2nd	2	2	155	74	0	0
June						
1st	0	0	58	70	0	0
Totals (M&F)	556		2,386		701	

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	
1979	2,322	766	

*MT = 2,205 lb.

Table 2.3. Year-class frequency of alewife (sexes pooled) in the James River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	70.	1	0.9	1.3	1.3
	71.	1	0.9	1.3	2.7
	72.	1	0.9	1.3	4.0
	73.	3	2.7	4.0	8.0
	74.	7	6.3	9.3	17.3
	75.	34	30.4	45.3	62.7
	76.	28	25.0	37.3	100.0
	0.	37	33.0	MISSING	100.0
	TOTAL	112	100.0	100.0	

MEAN	75.040	STD ERR	0.132	MEDIAN	75.221
MODE	75.000	STD DEV	1.144	VARIANCE	1.309
KURTOSIS	6.117	SKEWNESS	-2.138	RANGE	6.000
MINIMUM	70.000	MAXIMUM	76.000		

VALID CASES 75 MISSING CASES 37

Table 2.4. Year-class frequency of blueback herring (sexes pooled) in the James River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	72.	5	2.0	4.4	4.4
	73.	23	9.4	20.4	24.8
	74.	36	14.7	31.9	56.6
	75.	49	20.0	43.4	100.0
	0.	132	53.9	MISSING	100.0
	TOTAL	245	100.0	100.0	

MEAN	74.142	STD ERR	0.084	MEDIAN	74.292
MODE	75.000	STD DEV	0.895	VARIANCE	0.801
KURTOSIS	-0.575	SKEWNESS	-0.665	RANGE	3.000
MINIMUM	72.000	MAXIMUM	75.000		
VALID CASES	113	MISSING CASES	132		

Table 2.5. Year-class frequency of alewife (sexes pooled) in the York River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	73.	3	6.3	7.7	7.7
	74.	6	12.5	15.4	23.1
	75.	21	43.8	53.8	76.9
	76.	9	18.8	23.1	100.0
	0.	9	18.8	MISSING	100.0
	TOTAL	48	100.0	100.0	

MEAN	74.923	STD ERR	0.134	MEDIAN	75.000
MODE	75.000	STD DEV	0.839	VARIANCE	0.704
KURTOSIS	0.318	SKEWNESS	-0.695	RANGE	3.000
MINIMUM	73.000	MAXIMUM	76.000		

VALID CASES 39 MISSING CASES 9

Table 2.6. Year-class frequency of blueback herring (sexes pooled) in the York River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	72.	9	2.1	4.2	4.2
	73.	19	4.4	8.8	13.0
	74.	62	14.2	28.8	41.9
	75.	115	26.4	53.5	95.3
	76.	10	2.3	4.7	100.0
	0.	221	50.7	MISSING	100.0
	TOTAL	436	100.0	100.0	

MEAN	74.456	STD ERR	0.060	MEDIAN	74.652
MODE	75.000	STD DEV	0.879	VARIANCE	0.773
KURTOSIS	0.841	SKEWNESS	-0.989	RANGE	4.000
MINIMUM	72.000	MAXIMUM	76.000		

VALID CASES 215 MISSING CASES 221

Table 2.7. Year-class frequency of alewife (sexes pooled) in the Rappahannock River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	72.	1	0.3	0.5	0.5
	73.	9	2.9	4.3	4.7
	74.	56	18.1	26.5	31.3
	75.	75	24.3	35.5	66.8
	76.	69	22.3	32.7	99.5
	77.	1	0.3	0.5	100.0
	0.	98	31.7	MISSING	100.0
	TOTAL	309	100.0	100.0	

MEAN	74.972	STD ERR	0.063	MEDIAN	75.027
MODE	75.000	STD DEV	0.910	VARIANCE	0.828
KURTOSIS	-0.483	SKEWNESS	-0.403	RANGE	5.000
MINIMUM	72.000	MAXIMUM	77.000		
VALID CASES	211	MISSING CASES	98		

Table 2.8. Year-class frequency of blueback herring (sexes pooled) in the Rappahannock River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	72.	7	0.7	1.8	1.8
	73.	40	4.2	10.0	11.8
	74.	120	12.5	30.1	41.9
	75.	216	22.5	54.1	96.0
	76.	16	1.7	4.0	100.0
	0.	563	58.5	MISSING	100.0
	TOTAL	962	100.0	100.0	

MEAN	74.486	STD ERR	0.040	MEDIAN	74.650
MODE	75.000	STD DEV	0.798	VARIANCE	0.637
KURTOSIS	0.546	SKEWNESS	-0.833	RANGE	4.000
MINIMUM	72.000	MAXIMUM	76.000		
VALID CASES	399	MISSING CASES	563		

Table 2.9. Year-class frequency of alewife (sexes pooled) in the Potomac River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	73.	6	6.9	9.8	9.8
	74.	23	26.4	37.7	47.5
	75.	22	25.3	36.1	83.6
	76.	10	11.5	16.4	100.0
	0.	26	29.9	MISSING	100.0
	TOTAL	87	100.0	100.0	

MEAN	74.590	STD ERR	0.113	MEDIAN	74.568
MODE	74.000	STD DEV	0.883	VARIANCE	0.779
KURTOSIS	-0.690	SKEWNESS	0.017	RANGE	3.000
MINIMUM	73.000	MAXIMUM	76.000		
VALID CASES	61	MISSING CASES	26		

Table 2.10. Year-class frequency of blueback herring (sexes pooled) in the Potomac River commercial fishery samples, 1979.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	1	0.1	0.5	0.5
	72.	2	0.3	1.0	1.5
	73.	16	2.1	7.8	9.3
	74.	44	5.9	21.5	30.7
	75.	129	17.3	62.9	93.7
	76.	13	1.7	6.3	100.0
	0.	540	72.5	MISSING	100.0
	TOTAL	745	100.0	100.0	

MEAN	74.644	STD ERR	0.056	MEDIAN	74.806
MODE	75.000	STD DEV	0.795	VARIANCE	0.632
KURTOSIS	2.566	SKEWNESS	-1.279	RANGE	5.000
MINIMUM	71.000	MAXIMUM	76.000		

VALID CASES 205 MISSING CASES 540

Table 2.11. Summary of mean and modal ( ) age data for river herring in the Virginia commercial fishery, 1977, 1978, and 1979.

	Alewife			Blueback		
River	1977	1978	1979	1977	1978	1979
James	5.4(5)	5.5(5-6)	4.0(4)	5.7(6)	6.3(6)	4.8(4)
Pamunkey[1]	5.7(5-6)	5.6(5-6)		6.0(6)	5.6(5-6)	
York	5.2(5)	5.4(5-6)	4.1(4)	5.8(6)	5.8(6)	4.5(4)
Rappahannock	5.6(5-6)	5.6(5-6)	4.0(4)	5.8(6)	6.0(6)	4.5(4)
Potomac	5.5(5-6)	5.6(5-6)	4.4(4-5)	6.0(6)	6.1(6)	4.3(4)

[1]No river herring fishery in 1979.

Table 2.12. Year-class frequency of American shad in the Virginia commercial fishery, 1979.

Sex	Year Class	River					Total	Frequency (%)
		James	York	Pamunkey	Rapp.	Potomac		
Male	1971	0	0	0	1	0	1	1.0
	1972	3	3	3	0	0	9	9.5
	1973	9	17	18	8	1	53	55.8
	1974	5	3	11	5	1	25	26.3
	1975	0	1	4	1	1	7	7.4
	Total	17	24	36	15	3	95	
Female	1971	2	1	0	2	0	5	1.5
	1972	28	12	4	11	1	56	17.4
	1973	61	27	3	66	22	179	55.8
	1974	11	9	2	41	12	75	23.4
	1975	1	0	0	5	0	6	1.9
	Total	103	49	9	125	35	321	

Table 2.13. Alewife catch and age frequency in the Rappahannock River pound net fishery, 1975-1979.

Year	Number of Individuals	Age Frequency (%)					
		3	4	5	6	7	8
1975	325,816	0.5	83.9	13.5	1.1	0.4	0.6
1976	235,620		3.2	49.3	42.2	5.1	0.2
1977	380,001		3.6	42.3	45.8	7.7	0.6
1978	514,462		7.8	53.1	34.1	5.0	
1979	233,600	34.6	35.0	28.2	2.2		

Note: Total numbers and age frequencies were derived from the age proportions in samples weighted by landings in the sampling period (see Job 1).

Table 2.14. Blueback herring catch and age frequency in the Rappahannock River pound net fishery, 1975-1979.

Year	Number of Individuals	Age Frequency (%)						
		3	4	5	6	7	8	9
1975	874,551	0.6	87.3	11.2	0.5	0.4		
1976	400,828	0.2	5.7	52.5	37.3	4.1	0.2	
1977	1,090,476		1.6	35.0	53.7	9.7		
1978	1,522,337		0.3	19.0	51.6	27.9	0.6	0.6
1979	2,382,362	1.3	53.6	32.5	10.7	1.9		

Note: See Table 2.13 comment.

Table 2.15. Alewife catch and age frequency in the Potomac River pound net fishery, 1975-1979.

Year	Number of Individuals	Age Frequency (%)					
		3	4	5	6	7	8
1975	2,067,350	0.5	78.4	16.3	1.9	2.8	
1976	719,702		1.4	36.5	50.8	10.3	1.0
1977	161,485		9.8	39.2	45.8	5.1	0.1
1978	205,276		5.3	40.7	36.9	17.0	
1979	154,968	17.8	34.4	37.8	10.0		

Note: See Table 2.13 comment.

Table 2.16. Blueback herring catch and age frequency in the Potomac River pound net fishery, 1975-1979.

Year	Number of Individuals	Age Frequency (%) 3	4	5	6	7	8	9
1975	12,209,245	0.04	77.3	15.8	5.2	1.6	0.03	
1976	2,403,333		1.0	20.6	54.3	22.3	1.0	0.7
1977	933,437		1.0	21.8	59.9	16.8	0.5	
1978	2,746,964		0.3	17.9	53.0	24.9	3.9	
1979	2,557,193	7.3	67.7	17.6	7.4			

Note: See Table 2.13 comment.

Table 2.17. Mean fork length (mm) and total body weight (g) of river herring in the 1977, 1978 and 1979 Virginia commercial fishery.

		Alewife						Blueback					
		Male			Female			Male			Female		
		1977	1978	1979	1977	1978	1979	1977	1978	1979	1977	1978	1979
James	Length	245.2	249.0	241.6	256.2	259.0	252.9	243.5	252.6	239.3	253.7	263.1	253.0
	Weight	190.0	224.1	202.8	230.6	252.5	242.3	178.3	217.0	164.9	206.4	250.7	202.2
Pamunkey *	Length	243.8	249.7		254.9	260.0		241.9	248.8		252.6	256.7	
	Weight	212.5	218.6		246.7	253.9		186.8	210.2		229.7	235.0	
York	Length	240.3	248.1	246.4	255.3	253.2	260.4	241.0	247.3	244.3	251.9	256.2	253.8
	Weight	207.1	216.0	212.6	257.6	235.8	238.2	166.2	196.4	179.5	187.4	225.5	205.6
Rappahannock	Length	243.4	249.9	245.9	253.4	261.9	260.5	240.9	251.0	242.4	251.1	258.9	253.0
	Weight	186.8	227.5	218.8	217.3	267.4	273.7	168.1	192.4	177.7	192.6	223.7	208.2
Potomac	Length	243.9	250.9	249.5	253.8	258.3	263.4	242.5	254.4	241.5	253.4	262.0	252.8
	Weight	198.3	232.5	211.4	228.1	263.5	288.4	175.5	204.1	161.7	205.0	222.0	189.9
Unweighted Grand Mean	Length	243.4	249.5	245.8	254.7	258.5	259.3	242.0	250.8	241.9	252.5	259.4	253.1
	Weight	198.9	223.7	211.4	236.1	254.6	260.6	175.0	204.0	170.9	204.2	231.4	201.5

*No Pamunkey river herring fishery in 1979.

Table 2.18. Sex ratios in the 1977, 1978, and 1979 Virginia river herring fishery.

River	Species	Ratio of males to females 1977	1978	1979
James	Alewife	2.4:1*	2.1:1*	2.0:1*
	Blueback	1.7:1*	1.6:1*	1.3:1 NS
York	Alewife	1:1.2 NS	1.2:1 NS	1:1.3 NS
	Blueback	1.4:1*	1.1:1 NS+	1.1:1 NS
Pamunkey[1]	Alewife	2.7:1*	1.6:1 NS+	
	Blueback	1.7:1 NS	1:1 NS	
Rappahannock	Alewife	1.4:1*	1.4:1*	1:1.1 NS
	Blueback	1.3:1*	1:1.2*+	1.5:1*
Potomac	Alewife	1:1.1 NS	1:1.1 NS	1:4.4*+
	Blueback	1:1.0 NS	1:1.4*+	1.5:1*

* x^2 significant ($\alpha<0.05$); Hypothesis tested: equal sex ratio.
+ Increased representation of females relative to previous year.
NS = nonsignificance.
[1]No river herring fishery in 1979.

Table 2.19. Percentages of alewife and blueback herring in samples from the Virginia commercial catches from 1974 to 1979.

Species	Species Proportion (%)					
	1974	1975	1976	1977	1978	1979
Alewife	36.2	35.2	38.4	28.0	20.9	18.9
Blueback	63.8	64.8	61.6	72.0	79.1[1]	81.1

[1]Erroneously reported as 73% in 1978 report.

Job 3. Annual Index of Alosine Juvenile Abundance

SUMMARY

1. The major Virginia alosine nursery zones in 1979 were each sampled six times between 21 June and 11 October.

2. Juvenile alosines in 1979 were widely distributed in the nursery zone in June and early July, had greater upriver concentrations in the summer, and then moved downstream in September and October.

3. Blueback herring catch-per-unit-of-effort (CPUE) in 1979 greatly exceeded alewife and American shad CPUE. The CPUE for blueback herring reached a maximum in July and early August, and then declined.

4. Blueback herring relative abundance in 1979 was highest in the Rappahannock River, strong in the Chickahominy and Pamunkey rivers, poor in the James and Mattaponi rivers, and especially low in the Potomac River.

5. Alewife CPUE in 1979 was greatest in June or early July, but they were relatively abundant only in the Rappahannock River.

6. American shad CPUE in 1979 was also greatest in June or early July, and they were relatively abundant only in the Pamunkey and Mattaponi rivers.

7. A comparison of 1978 and 1979 pushnet estimates of CPUE indicated that the abundance of juvenile alosines was low in 1979 relative to 1978.

8. Estimated instantaneous natural mortality rates (M) for alewife, blueback herring, and American shad were similar ($M = 0.020$, 0.028, and 0.025, respectively).

9. Catches of juvenile striped bass in 1979 were few and scattered. The low catch is not, however, an indicator of their spawning success. The pushnet employed in 1979 was found to be inefficient as a sampling gear for juvenile striped bass relative to bottom trawls when both gears were employed in 1978.

10. The pushnet was found to be highly efficient for the capture of juvenile alosines relative to trawls formerly employed. A manuscript based on comparison studies and containing a detailed description of the pushnet was submitted for publication. It is presented herein as Appendix I.

11. Studies of the effect of varying light intensities on estimates of CPUE indicated negative phototactic behavior by juvenile alosines. Thus, estimates of CPUE may be erroneous if light intensity is not considered. A manuscript derived from these studies was submitted for publication, and is included herein as Appendix II.

Job 3. Annual Index of Alosine Juvenile Abundance

INTRODUCTION

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

MATERIALS AND METHODS

The 1977-79 annual assessments of juvenile (young-of-the-year) alosine and striped bass abundance were conducted on the major Virginia rivers in the freshwater nursery zones (Fig. 3.1). Sampling procedures were modified during the project period to increase sampling precision and cost efficiency. Annual sampling methods are described as follows:

1977

The R/V *Langley*, the R/V *Restless*, and a 5.8 m outboard vessel were used to collect samples during daylight hours. The former two vessels employed identical 1.5 m x 1.5 m Cobb trawls. The latter vessel had a bow-mounted 1.5 m x 1.5 m framed net developed by project personnel (referred to as a pushnet). Surface and subsurface samples were collected with Cobb trawls, but only surface samples were obtained with the pushnet. All sampling effort was standardized at 5 min.

A stratified random sampling plan with proportional allocation of effort was employed in 1977. The nursery area in each river was divided into 5 nautical mile (9.3 km) strata. From a grid superimposed on the respective navigation charts, 50% of all possible sample stations in each stratum were randomly selected between the 1.8 m depth contour lines (MLW) of opposite shores. A subsample of 25% of the initially chosen stations was, in turn, randomly selected and designated as subsurface sampling sites; the remaining stations were reserved for surface sampling.

The general boundaries of each nursery zone were determined from salinity evaluations and pilot sampling, and "buffer" sections were included to constitute the upper and lower boundaries. After completion of the surveys, juvenile catch data were examined by species for density patterns within a nursery zone; if present, the zone was restratified by combining contiguous strata of similar density. Estimates of catch-per-unit-of-effort (CPUE) and standing crop were thus made for each redefined stratum. When no density pattern was obvious for a species, as was generally the case when catches were few, the zone was not stratified. The initially constructed nursery zone was also modified for a given species if it was not caught in the upper and/or lower strata of the zone. New boundaries for the species of concern corresponded to the upper or lower limit of the first 5 mile stratum in which it was caught.

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

$$N = (VZ/VT)\ (CPUE)$$

where N = the standing crop; VZ = the volume of water (m^3) in the nursery zone; VT = 531 m^3 of water, i.e., the estimated volume of water strained by a 1.5 m x 1.5 m Cobb trawl net in a 5 min tow with a vessel speed of 2 knots. VZ was estimated from the product of nursery zone area (m^2) and a conservative estimate that the mean depth in nursery zones was 4 m.

1978

Sampling was conducted at night to minimize the effect of varying light intensities. No samples were collected when the sea surface was rough and presumed to affect the availability of fishes in the uppermost part of the water column ($\leq$ 1.5 m); similarly no samples were collected during and immediately after strong freshets.

The R/V Langley, the R/V Restless, and two outboard vessels were used to collect standard 5 min samples. 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 R/V Restless employed a 1.5 m x 1.5 m Cobb trawl which filtered 971 m^3 of water; a 5.8 m outboard vessel employed a pushnet which filtered 896 m^3 of water; and a 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 pushnet catches on the basis of water volume strained.

Modifications to the previous year's stratified sampling plan were made and proportional allocation of effort was employed. The nursery areas in each river were again divided into 5 nautical mile strata. Each stratum was further divided into five 1 mile substrata. Perpendicular to this stratification, the 5 mile strata 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 5 mile 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. Allocation of effort was the same as for the surface and mid-water samples, and cell location, i.e., shore side of a substratum, was randomly selected. 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 naut. mile).

Preliminary boundaries of each nursery zone were established on the basis of past surveys, 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 CPUE in each stratum was weighted by its respective mean water volume. An overall weighted mean index of abundance (CPUE*) for each nursery zone was then determined as the sum of the weighted CPUE of strata divided by the sum of the strata weights (volume). Standing crop ($\hat{N}$) was then determined as:

$$\hat{N} = \frac{V}{v} \cdot CPUE^*$$

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

1979

As in 1978, all sampling was conducted at night with the same precautionary restrictions, i.e., no sampling during or immediately after storms, etc. Two 5.8 m outboard vessels, each equipped with a pushnet, were used to collect standard 5 min samples. Flowmeters were secured to each pushnet and the volume of water strained was recorded for each sample. On the average, one vessel-pushnet sample filtered 655 m^3 of water, while the other filtered 743 m^3 of water. Flowmeters were also employed with the trawl nets used in previous years and all catch data were adjusted to 655 m^3 of water strained.

The nursery areas of each river were stratified as in 1978, but the two sections of each substratum shoreward of the 1.8 m depth contour lines were excluded. Thus, each 5 mile stratum was divided into five 1-mile substrata, each containing 3 "cells" for a total of 15 cells per stratum. Each substratum and its corresponding cell that was sampled during the course of the survey, was randomly selected.

The main objective in 1979 was to monitor the juvenile alosine and striped bass populations over time. Each river was sampled tri-weekly beginning the third week of June through the second week of October. This resulted in a total of six sampling periods over 17 weeks. Pilot sampling was conducted on each river prior to the first sampling segment, and general boundaries in each nursery zone were established with buffer zones as in 1978. A stratified random sampling plan was employed in which the allocation of effort was based on stratum area for the initial sampling period. A maximum of 12 samples was taken in the larger strata and a minimum of three samples in the smaller strata. In subsequent sampling periods minor modifications were made in effort allocation based on the distribution of juveniles and their degree of concentration in the previous sampling period. In addition, randomly selected contingency sampling sites were allocated to strata in the event that major shifts in juvenile density were apparent at the time of sampling. When contingent samples were taken, overall effort was kept relatively constant by deleting some stations in strata of apparent sparse density.

Occasionally, samples were collected during twilight but the general procedure was to halt sampling before its occurrence because of the effect of light on catch (Appendix II). Sampling began in the upper strata of the nursery zones and proceeded downriver; therefore, it was not always possible to sample the lowest strata because of approaching daylight. The truncation of sampling must be taken into account when comparing overall CPUE between time periods; i.e., comparative CPUE's must be derived from the same strata unless an obvious shift in distribution occurred.

The practice of estimating standing crop (N) was discontinued in 1979 after evaluation of our simulataneous surface and bottom, and day and night comparison sampling. To obtain a reliable estimate of N it would be necessary to estimate the vertical density distribution in the water column of each species for each significant change in ambient light. In addition, the volume of water present in the substratum sampled must be known at the existing tide level. The use of mean water volume (Johnson et al. 1978) was arbitrary, and therefore, N was relative. Thus, N was redundant with CPUE.

RESULTS AND DISCUSSION

1979: Relative Abundance

Juvenile CPUE data by strata and date for each of the six rivers sampled in 1979 are presented in Tables 3.1-3.6. From the overall data set we concluded: (1) blueback herring CPUE greatly exceeded those for alewife and American shad; (2) blueback herring CPUE reached a maximum in July or early August then declined. In contrast, alewife and American shad CPUE were generally greatest in June or early July; and (3) juveniles were more widely distributed in June and early July, had greater upriver concentrations in the summer, and then moved downriver in September and October as a first stage of their seaward migration.

Striped bass CPUE is also presented in Tables 3.1-3.6. However, comparisons cannot be made to CPUE in previous years. The pushnet was relatively inefficient as a sampling gear for juvenile striped bass relative to bottom trawls when both gears were simultaneously employed in 1978. Thus, no conclusions are made about the relative abundance of striped bass in 1979.

James River

The relative abundance of alewife and American shad was very low and incidence of capture was dispersed in the James River (Table 3.1). Therefore, no conclusions were made about the dynamics of their distribution.

Blueback herring CPUE estimates (for all strata, data pooled) were maximal in both July sampling periods, 59.3 and 53.2, respectively; a t-test indicated the observed difference, 6.1, was not significant ($P>0.10$).

June and July mean catches by strata indicated a relatively widespread distribution of blueback herring, primarily between miles 45-80. In contrast, the blueback herring were concentrated further upriver during August and September, between miles 55-80. However, the larger mean catches by strata in August occurred between miles 60-75, but in September the estimates were reasonably similar throughout the upper 25 miles of the nursery zone. By October most of the juvenile blueback herring had moved downriver and were concentrated between river miles 40-60. The larger mean CPUE in October (17.7) relative to September (9.9) may be due to juveniles concentrating downriver prior to their seaward migration; also, additional juveniles may have entered the James River from its tributaries.

Chickahominy River

The nursery zone sampled in the Chickahominy River was restricted (Table 3.2). It began at about mile 40 on the James River and ended at Walker's Dam, mile 20 on the Chickahominy River. Relatively few alewife and American shad were taken in the Chickahominy River. Blueback herring CPUE (Table 3.2) was very high in the first three sampling periods relative to the James River (Table 3.1). In the later sampling periods the CPUE in both rivers were of the same order of magnitude, probably due to the migration of some juveniles from the Chickahominy River into the James River. The only apparent pattern in the blueback distribution in the Chickahominy River was that minimal CPUE occurred in the lowest stratum, miles 0-5, except in the last sampling period. Maximum CPUE occurred on 12 July, and thereafter continually declined.

York River (Pamunkey and Mattaponi)

Juvenile striped bass were captured in only two strata during the first sampling period in the Pamunkey River (Table 3.3). However, alewife, American shad, and blueback herring were captured in all sampling periods. Alewife CPUE were maximal in the late June and early July sampling periods (6.1 and 6.3, respectively) when estimated from similar strata (miles 45-70). The alewife were concentrated between miles 40-60 until the last two sampling periods. On 12 September alewife were caught between miles 30-55, and on 9 October specimens were captured only between miles 30-40.

The overall unweighted mean catch ($\overline{\text{CPUE}}$, determined from the CPUE of all sampling periods) of 15.4 for American shad in the Pamunkey River was the highest for all rivers except for the near equal value in the Mattaponi River ($\overline{\text{CPUE}}$ = 15.0). The maximum American shad CPUE in the Pamunkey River occurred on 20 June (CPUE = 53.1). Juvenile shad were mainly concentrated between miles 50-65 in the first two sampling periods then were spread somewhat more upriver until the last sampling period when the only catch in occurred in stratum 30-35.

Blueback herring were the dominant species caught. Maximum CPUE occurred on 20 June and 9 July with CPUE = 198 and 191.4, respectively; the mean difference was not significant ($P>0.35$). The largest mean catches of blueback herring occurred between miles 45-60 in the first three sampling periods, between miles 60-70 in the fourth period, and then downriver between miles 35-45 in September and October.

Juvenile alewife in the Mattaponi River were captured in all six sampling periods but, all CPUE estimates were low relative to the American shad and blueback herring (Table 3.4). The maximum alewife CPUE (5.1) occurred on 9 July. Alewife were concentrated between miles 35-50 in the first two sampling periods; data are few for the subsequent sampling periods but the larger mean catches occurred in the lower strata in September and October. The maximum American shad CPUE in the Mattaponi River occurred on 20 July as it did in the Pamunkey River. The shad juveniles were captured between miles 35-62 in the first two sampling periods, but there were no exceptionally dense concentrations in any stratum. The largest mean catch occurred between miles 55-62 in each of the next three periods, and on 9 October all catches were made below mile 55.

Rappahannock River

Few juvenile American shad were captured in the Rappahannock River (Table 3.5). The only apparent pattern for the catches was that all American shad were caught in the first two sampling periods between miles 55-90. In contrast, the overall mean catch of alewife and blueback herring ($\overline{\text{CPUE}}$ = 17.7 and 400.4, respectively) was maximum in the Rappahannock River. Maximal alewife CPUE occurred in the late June and early July sampling period with CPUE = 44.1 and 39.5 (omitting the lowest stratum miles 35-40); the difference was not significant (P>0.15). Alewife were widespread in the first two sampling periods with larger mean catches occurring between miles 65-90. There was a very dense concentration of alewife in stratum miles 85-90 in early August, however, in late August no exceptionally large catches of alewife were made and the larger mean catches, with one exception, were between miles 65-85. In September no alewife were caught above mile 80, and in October none were captured above mile 70. The maximum blueback herring CPUE occurred on 10 July. Blueback herring were widely spread between miles 40-90 in the first two sampling periods. In the third sampling period, 1 August, the denser concentrations of blueback herring occurred between miles 65-90. On 21 August, the largest mean catch occurred in stratum miles 60-65. Subsequently, on 18 September and 15 October, the largest mean catch occurred further downriver in the stratum miles 50-55.

Potomac River

The relative abundance of all juvenile alosines was low in the Potomac River (Table 3.6). American shad were captured only in the first sampling period, but alewife and blueback herring were caught in all periods. The maximum alewife CPUE occurred in the 26 June sampling period. Although the alewife data were sparse, the general pattern of higher mean catches in upriver strata persisted until September. In September and October no alewife catches were made in the highest stratum, miles 90-95. The larger mean catches of alosines in the October sampling period were made between miles 65-75, as well as the only catches of alewife in the lowest stratum, miles 60-65.

In summary, blueback herring relative abundance was high in the Rappahannock River, strong in the Chickahominy and Pamunkey rivers, poor in the James and Mattaponi rivers and especially low in the Potomac River. Alewife were relatively abundant only in the Rappahannock River and American shad in the Pamunkey and Mattaponi rivers. Catches of juvenile striped bass in the survey were too few and scattered to consider a ranking of relative abundance.

Relative abundance estimates are an indicator of the spawning success of a species in the six rivers investigated. However, they are not an indicator of spawning success among the four species. Gear selectivity and differential species behavior affect catch.

1977-1979: Relative Abundance

The period 1977-1979 was one of transition from trawl to pushnet sampling, from daytime to nighttime sampling, and from a single survey of each river to multiple surveys of each river. Gear comparisons and the effects of light intensity on catch were studied to improve sampling precision and cost efficiency (Loesch et al. 1977; Johnson et al. 1978). Use of flowmeters and pushnets in 1979 further enhanced sampling procedures and precision. The information gained in gear efficiency tests and the more accurate definition of a sampling unit obtained with flowmeters were also used to adjust the historical catch data for juvenile alosines (Job 12).

A major obstacle in comparing alosine relative abundance in 1978 and 1979 to previous estimates is that the relationship of daytime catches (with varying light intensities) to nighttime catches is not known. This is an important consideration since CPUE data are used in other fishery data analysis, and it may also influence managerial decisions.

The 1978 pushnet estimates of CPUE were extracted from the total data presented in Johnson et al. (1978) and are contrasted with the 1979 pushnet estimates in Table 3.7. All estimates of CPUE in 1978 exceeded their respective estimates in 1979 with the exceptions that no American shad catches were made in both years in the Chickahominy and Potomac rivers. In addition , the 1978 CPUE estimates exceeded the respective maximum CPUE estimates in 1979 in all but four comparisons. Since maximal CPUE were observed about two months prior to the onset of seaward migration, we conclude that the abundance of juvenile alosines was low in 1979 relative to 1978.

The determination of maximum CPUE by multiple census in 1979 is considered superior to the point estimate of juvenile alosine CPUE used in previous years. Annual variation in environmental factors can influence the times of spawning and juvenile seaward migration. Thus, size, catchability, and availability of the juveniles can differ considerably for similar calendar dates in different years.

The multiple census technique allows calculation of instantaneous rates of total mortality (Z) from estimates of CPUE that are subsequent to the maximum CPUE but prior to the migration from the nursery zone. Since there is no fishing mortality on juvenile alosines, estimates of Z are also estimates of natural mortality (M), and

$$M = \log_e (CPUE_o/CPUE)$$

where $CPUE_o$ is the maximum estimate. Preliminary estimates of M based on the unweighted CPUE for data in Tables 3.1-3.6 indicated similar daily rates for the alewife, blueback herring, and American shad (M = 0.020, 0.028, and 0.025, respectively). Turner and Chadwick (1972) used this method of analysis and reported a daily rate of M = 0.053 for striped bass in the Sacramento-San Joaquin estuary. Natural mortality was not estimated for Virginia striped bass because data were few.

Gear Comparisons

The efficiency of the pushnet relative to trawls for sampling juvenile alosines was presented by Loesch et al. (1977). A manuscript based on these data and a detailed description of the pushnet design has been submitted to a peer-review, scientific journal. For completeness of this report, the manuscript is presented herein as Appendix I.

Effects of Light Intensity 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).

In 1978, the pilot study of the effects of light on CPUE was continued (Johnson et al. 1978). Twenty pushnet samples were taken in each of three successive sampling periods with varying light conditions (night, overcast day, and clear day). The study indicated negative phototactic behavior.

The implication of the two pilot studies is that estimates of abundance may be erroneous if the effect of light intensity is not considered.

A manuscript derived from these two studies has been submitted to a peer-review, scientific journal, and is included in this report as Appendix II.

LITERATURE CITED

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

Hoagman, W. J., J. V. Merriner, R. St. Pierre, and W. L. Wilson. 1973. Biology and utilization of anadromous alosids. Completion Rep. AFC 7-1 to 7-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 212 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Turner, J. G. and H. K. Chadwick. 1972. Distribution and abundance of young-of-the-year striped bass, *Morone saxatilis*, in relation to river flow in the Sacramento-San Joaquin estuary. Trans. Amer. Fish. Soc. 101:442-452.

Table 3.1. Juvenile alosine and striped bass catch-per-unit-of-effort (CPUE) in the James River for the period 21 June-11 October, 1979.

Species	River Miles	CPUE					
		June 21	July 10	July 31	Aug 22	Sept 17	Oct 11
Alewife	75-80	0	0	0.3	0	0	
	70-75	0	0	0.3	0	0	
	65-70	0	0.2	0	0	0	0.3
	60-65	0	0.1	0	0	0	0
	55-60	0	0	0.2	0	0	0
	50-55	0	0	0	0	0	0
	45-50		0	0	0	0	0
	40-45		0	0	0		0
Blueback	75-80	11.0	32.0	50.7	14.3	6.7	
	70-75	19.3	63.0	49.5	79.8	10.0	
	65-70	51.5	30.2	98.8	96.7	18.5	4.1
	60-65	12.3	34.5	59.8	62.8	10.0	6.2**
	55-60	26.0*	76.3	17.3	22.2	19.0	36.0
	50-55	33.5**	99.7	119.4	3.5	3.0	28.0
	45-50		135.7	26.4	2.8	2.0*	16.0
	40-45		3.0**	3.5	0		16.0
American shad	75-80	0	0	0	0	0	
	70-75	0.3	0	0	0	0	
	65-70	0.2	0	0	0	0	0
	60-65	0	0	0	0	0	0.4**
	55-60	0	0	0	0	0	0
	50-55	0.5**	0	0.3	0	0	0
	45-50		0	0	0	0	0
	40-45		0	0	0		0
Striped bass	75-80	0	0	0.3	0	0	
	70-75	0	0	0	0	0	
	65-70	0	0	0	0	0	0
	60-65	0	0	0	0	0	0
	55-60	0	0	0	0	0	0
	50-55	0	0	0	0	0	0
	45-50		0.5	0	0	0	0
	40-45		0	0.3	0		0

*Based on 1 sample
**Based on 2 samples

Table 3.2. Juvenile alosine and striped bass catch-per-unit-of-effort (CPUE) in the Chickahominy River for the period 21 June-11 October, 1979.

		CPUE					
Species	River Miles	June 21	July 12	Aug 2	Aug 21	Sept 17	Oct 11
Alewife	15-20	0.4	0.3	0.2	0.2	0.2	0
	10-15	0	0	0.3	0	0	0
	5-10	0	0	0.2	0	0	0
	0- 5	0	0	0	0	0	0
Blueback	15-20	562.4	514.8	61.7	37.6	26.8	6.0
	10-15	187.9	604.2	111.8	29.0	9.4	4.3
	5-10	77.2	172.0	179.2	21.0	4.8	2.0
	0- 5	26.0	72.0	22.0	4.2	3.3	2.7
American shad	15-20	0	0	0	0	0	0
	10-15	0	0	0	0	0	0
	5-10	0.3	0	0	0	0	0
	0- 5	0	0	0	0	0	0
Striped bass[a]							

[a] No striped bass taken

Table 3.3. Juvenile alosine and striped bass catch-per-unit-of-effort (CPUE) in the Pamunkey River for the period 20 June-9 October, 1979.

Species	River Miles	CPUE					
		June 20	July 9	July 30	Aug 20	Sept 12	Oct 9
Alewife	65-70	0.3	2.3	0.3	0	0	
	60-65	1.0	0	1.7	1.0	0	
	55-60	13.9	6.9	1.3	4.5	0	0
	50-55	12.9	14.5	5.8	1.6	0.5	0
	45-50	2.5	7.7	5.3	1.1	0	0
	40-45		5.3	0.7		0.7	0
	35-40		0.3**	0		0.3	2.0**
	30-35					0.3	1.0**
Blueback	65-70	2.6	2.6	21.3	90.6	18.5	
	60-65	31.1	9.3	20.3	181.0	26.0	
	55-60	447.5	151.6	93.2	27.7	8.0	1.0
	50-55	428.8	660.7	129.8	54.2	48.3	8.0**
	45-50	80.0	132.6	136.3	70.2	17.3	10.0**
	40-45		29.3	12.7		65.7	18.0**
	35-40		0	33.0*		82.0	12.0**
	30-35					16.3	2.0**
American shad	65-70	5.5	16.1	11.3	31.3	3.3	
	60-65	63.8	9.3	20.0	24.3	4.0	
	55-60	106.7	39.2	20.3	6.0	2.3	0.3
	50-55	66.6	16.1	9.0	2.7	1.0	0
	45-50	23.1	4.7	13.3	0.8	0	0
	40-45		9.4	0.3		0.7	0
	35-40		0.3**	1.0*		0	0
	30-35					1.0	0.5**
Striped bass	65-70	0	0	0	0	0	
	60-65	0	0	0	0	0	
	55-60	0.6	0	0	0	0	0
	50-55	0	0	0	0	0	0
	45-50	0.3	0	0	0	0	0
	40-45		0	0		0	0
	35-40		0	0		0	0
	30-35					0	0

*Based on 1 sample
**Based on 2 samples

Table 3.4. Juvenile alosine and striped bass catch-per-unit-of effort (CPUE) in the Mattaponi River for the period 20 June-9 October, 1979.

		CPUE					
Species	River Miles	June 20	July 9	July 31	Aug 20	Sept 12	Oct 9
Alewife	60-62	1.0	2.5**	0.6		0	
	55-60	0.7	0	0	1.3	0	0
	50-55	0.8	2.0	0	0	0	0
	45-50	2.2	12.0	0.7	0	0.4	0
	40-45	6.0+	10.5	1.8*	0	0.4	0.6
	35-40	8.0+	8.0		0	1.8	1.1
	30-35		0.5**			1.8*	0.0
Blueback	60-62	4.7	5.5**	17.6		0.4**	
	55-60	3.7	22.3	30.8	24.6	7.9	1.0*
	50-55	6.8	129.3	32.8	30.1	6.9	4.0**
	45-50	16.2	102.5	34.8	20.7	4.7	4.8**
	40-45	54.8+	0	51.0*	2.8	21.4	12.3
	35-40	59.0+	0		0.4**	17.0	26.7
	30-35		0			6.2*	7.0
American shad	60-62	61.0	25.0**	31.7		0.4**	
	55-60	29.3	18.3	12.3	18.7	12.8	0
	50-55	40.7	17.0	15.2	4.0	4.0	2.6**
	45-50	32.8	18.5	12.8	4.4	2.0	0.9**
	40-45	43.0+	18.0	7.9*	3.5	2.9	0.3
	35-40	56.0+	7.3		0	2.0	0
	30-35		0			1.8*	0
Striped bass (a)							

*Based on 1 sample
**Based on 2 samples
+Twilight sampling
(a)No striped bass taken

Table 3.5. Juvenile alosine and striped bass catch-per-unit-of-effort (CPUE) in the Rappahannock River for the period 26 June-15 October, 1979.

Species	River Miles	CPUE					
		June 26	July 10	Aug 1	Aug 21	Sept 18	Oct 15
Alewife	85-90	22.0*	53.7	138.0	2.5	0	
	80-85	65.2	88.7	39.0	7.2	0	
	75-80	70.8	55.3	22.0	8.0	1.5	0
	70-75	67.5	29.3	3.3	7.0	1.0	0
	65-70	88.7	17.3	9.0	5.5	2.0	1.0**
	60-65	23.0	26.2	3.0	1.0	3.0	0.3
	55-60	21.2	16.5	3.8	1.6	4.0	0.5**
	50-55	43.0	29.5	1.3	0.6	2.7	2.3
	45-50	22.0	8.8	3.0**	4.0**	0.5**	0
	40-45	17.5**	4.8			4.0**	0
	35-40		0.4**				
Blueback	85-90	556.0*	852.5	919.5	307.5	7.0	
	80-85	222.5	972.4	1229.5	215.5	8.7	
	75-80	401.8	1734.7	1533.0	145.5	28.5	0.5**
	70-75	333.3	846.8	1537.3	203.2	54.3	0
	65-70	655.7	892.5	1012.3	448.5	69.0	14.0**
	60-65	773.3	354.4	169.8	608.5	121.5	24.3
	55-60	546.2	288.6	115.8	309.3	228.8	12.5**
	50-55	873.3	1769.9	31.8	49.0	346.0	33.0
	45-50	330.0	175.6	8.0**	0	60.5**	18.0**
	40-45	196.5**	16.3			51.5**	4.5**
	35-40		0				
American shad	85-90	0	1.6	0	0	0	
	80-85	0.3	0	0	0	0	
	75-80	0.5	0	0	0	0	0
	70-75	0	0	0	0	0	0
	65-70	0.3	0.4	0	0	0	0
	60-65	0	0	0	0	0	0
	55-60	2.0	0	0	0	0	0
	50-55	0	0	0	0	0	0
	45-50	0	0	0	0	0	0
	40-45	0	0			0	0
	35-40		0				
Striped bass	85-90	0	0	0.3	0	0	
	80-85	0	0.3	0	0	0	
	75-80	0	0	0	0	0	0
	70-75	0	0	0	0	0	0
	65-70	0	0	0	0	0	0
	60-65	0	0	0	0	0	0
	55-60	0	0.3	0	0	0	0
	50-55	0.7	0	0	0	0	0
	45-50	0	0	0	0	0	0
	40-45	0	0			0	0
	35-40		0				

*Based on 1 sample
**Based on 2 samples

Table 3.6. Juvenile alosine and striped bass catch-per-unit-of-effort (CPUE) in the Potomac River for the period 26 June-17 October, 1979.

Species	River Miles	CPUE					
		June 26	July 16	Aug 6	Aug 28	Sept. 19	Oct 17
Alewife	90-95	3.5	0.7		3.7	0	
	85-90	2.7	1.0	0.8	0.5	0.3	0.5**
	80-85	3.6	1.4	0.5	0.8	0.2	0.5
	75-80	5.5	0.5	0.6	0.1	0.1	0
	70-75	0.2	0.8	0.5	0	0	1.2
	65-70	0.1	0.3	0	0	0	1.0
	60-65	0	0				0.3
Blueback	90-95	31.8	13.2		1.0	0	
	85-90	30.4	32.2	22.0	6.5	1.7	0.5**
	80-85	16.8	11.0	6.1	7.5	4.8	1.0
	75-80	16.9	8.6	10.2	2.9	7.5	1.0
	70-75	13.1	22.6	3.2	0.2	2.5	4.0
	65-70	13.2	14.7	1.0**	0	0	1.0
	60-65	0.6	0				4.8
American shad	90-95	0	0		0	0	
	85-90	0	0	0	0	0	0
	80-85	0	0	0	0	0	0
	75-80	0.1	0	0	0	0	0
	70-75	0	0	0	0	0	0
	65-70	0	0	0	0	0	0
	60-65	0	0				0
Striped bass	90-95	0	0.2		0	0	
	85-90	0	0	0.2	0	0	0
	80-85	0.2	0	0	0	0	0
	75-80	0	0.3	0	0	0	0
	70-75	0	0	0	0	0	0
	65-70	0	0.4	0	0	0	0
	60-65	0	0				0

**Based on 2 samples

Table 3.7. Estimated catch-per-unit-of-effort (CPUE) of juvenile alosines by pushnets in 1978 and 1979.

		1978			1979		
Species	River	Date	Effort	CPUE	Date	Effort	CPUE
Alewife	James	18-21 Sep	66	10.1*	17 Sep	26	0
	Chickahominy	21-22 Sep	18	19.0*	17 Sep	6	0.2
	Pamunkey	5- 7 Sep	25	6.8*	12 Sep	19	0.3
	Mattaponi	11-13 Sep	26	23.7*	12 Sep	12	0.9
	Rappahannock	28-31 Aug	44	35.9	21 Aug	32	4.4
	Potomac	14-31 Aug	71	20.2*	28 Aug	23	0.9
Blueback	James	(Dates as above)	66	1965.7*	(Dates as above)	26	11.3
	Chickahominy		18	1795.1*		19	25.2
	Pamunkey		31	505.6*		31	34.3
	Mattaponi		26	151.4*		22	10.1
	Rappahannock		44	934.0*		30	293.0
	Potomac		44	732.4*		29	3.8
American shad	James	(Dates as above)	56	0.3	(Dates as above)	26	0
	Chickahominy		18	0		19	0
	Pamunkey		31	6.4		31	1.6
	Mattaponi		26	48.3*		22	4.3
	Rappahannock		5	1.6*		32	0
	Potomac		71	0		31	0

*Exceeded maximum CPUE in 1979.

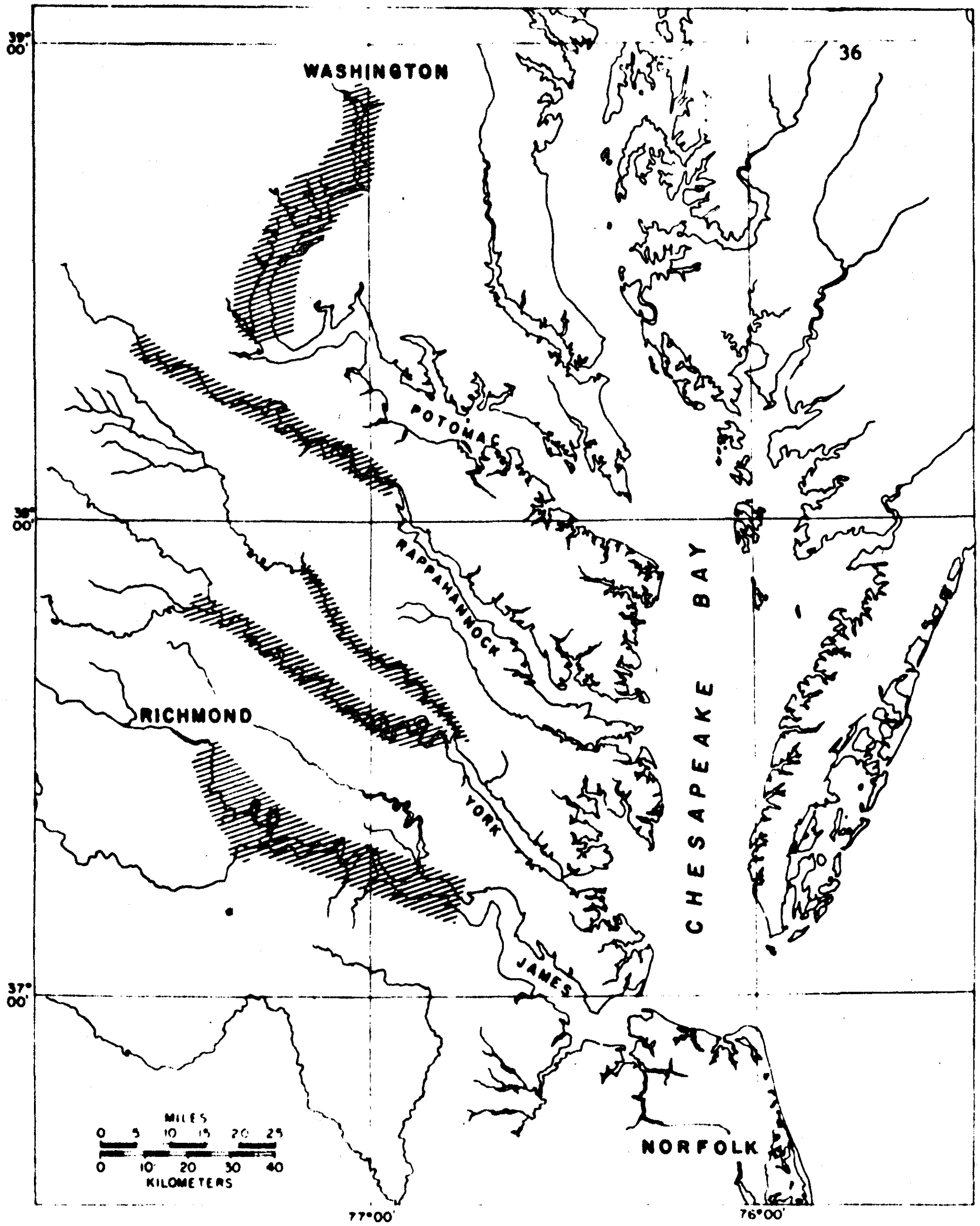


Figure 3.1. Lower Chesapeake Bay and tributaries with major freshwater nursery zones shaded.

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

SUMMARY

1. Landings of American shad by Virginia drift gill net fishermen in the Mattaponi and Pamunkey rivers were estimated to be between 22,680 and 24,948 kg in 1977.

2. 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.

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

4. Dip net fishermen in 1977, dipping at night, averaged 50 river herring per night and 30 river herring during daylight.

5. Dip net fishermen at Richmond, Virginia landed 30-80 blueback per fisherman during a dip net site visit in 1978.

6. Dip net fishermen at Herring Creek on the James River in 1978 averaged 400 blueback per fisherman during dip net site visits.

7. Interviews with dip net fishermen on the Pamunkey and Mattaponi rivers in 1978 indicated that fishermen averaged 9-36 kg of river herring per fishing trip.

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

9. 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.

10. Modal age for male blueback 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 their catch had decreased 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, objective 1 of Job 4, documents the extent of the drift gill net and dip net fisheries for alosines and estimates total landings by each gear.

For continuity, the objective 2 study, estimating some vital statistics of a typical alosine spawning run, is presented in its entirety after the presentation of the pilot study of the drift gill net and sport fisheries.

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

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

RESULTS AND DISCUSSION

1977: Drift Gill Nets

The 1977 drift gill net fishery for American shad in the Mattaponi and Pamunkey rivers began during the first half of March and continued through April. Full-time fishermen on the Pamunkey River averaged 7-8 fish per net per tide fished, with an average of 40 fish landed per day. Sex ratio favored females over males 20:1. Full-time fishermen related that many of the part-time fishermen on the Pamunkey River lived in the Richmond, Virginia, area and only fished on weekends or as time permitted from their other jobs. Their catches were probably similar to those of the part-time fishermen on the Mattaponi River.

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

We estimate that the total landings by all drift net fishermen in both rivers were between 22,680 and 24,948 kg. However, the estimates are based on limited data, primarily fisherman interviews.

1978: Drift Gill Nets

The 1978 drift gill net fishery for American shad in the York River system was only active during the month of April for full-time fishermen; on the Potomac River it lasted through May.

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

There were 6 full-time and 11 part-time drift net fishermen on the Pamunkey River and 4 full-time and 7 part-time drift net fishermen on the Mattaponi River.

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 of American shad, respectively, 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. 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.

1977: Dip Nets

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

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

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

In conjunction with two VIMS graduate students' Master's thesis problems, Herring Creek on the James River system was visited regularly and sampled by fyke nets below a dipping site on Herring Creek. They also set a trap net upstream of the dip netters. Due to the nonselective nature of all gears (dip net, fyke net and trap net) it is assumed that the species composition of the fyke and trap nets would reflect that of the dip nets. The number of dip netters at the Herring Creek site and the species composition of the fyke and trap nets are given in Table 4.3. Most of the netters concurred that the 1977 season was very poor for river herring. Data were inadequate to estimate total river herring landings by dip netters in Herring Creek.

1978: 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 Herring Creek averaged 400 blueback per fisherman on the day the site was visited. No alewife were observed.

Totopotomy Creek on the Pamunkey River, and Walkerton Branch on the Mattaponi River 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.

Data from the drift gill net fishery for American shad and the dip net fishery for river herring could prove invaluable providing there was total commitment to the collection of these data. Both fisheries are conducted on or near the spawning grounds for the species involved and could provide much needed data concerning structure of the spawning populations. Due to the sporatic nature of the fisheries, the collections are expensive, both in terms of monies and time. However, these costs are far less than would be incurred by collecting these data by other means.

HERRING CREEK POPULATION DYNAMICS

STUDY AREA

This study was based on data obtained from blueback herring collected from Herring Creek, Charles City County, Virginia, between March 19 and June 3, 1977. Herring Creek is one of the smaller tributaries to the James River with a surface area of about 1.3 km^2 and runs a distance of 8.3 km from Harrison Lake to Ducking Stool Point (Fig. 4.1). The creek is well within the spawning ground boundaries of the blueback herring, entering the James River between river miles 58 and 59.

METHODS

Two sampling sites were established in Herring Creek. A weir was set, with wings completely blocking the stream, approximately 0.7 km above the fall line. Downstream, 5.5 km from the mouth of the creek, two fyke nets were set side by side. At low tide, the fyke nets blocked about 75% of the cross section of the creek. All nets were checked every other day until April 11, after which the nets were checked daily. All blueback herring were bagged, iced, and returned to the laboratory for processing. Surface water temperature was recorded for each collection. It was assumed that the fyke nets and weir used in this study were non-selective for blueback herring.

Individual total length, fork length, total weight, eviscerated weight (weight less gonads), sex, and gonadal condition (unspawned, spawned) were recorded. Length was measured to the nearest mm; total length was measured with the upper lobe of the caudal fin depressed parallel to the long axis of the body. Weight was recorded to the nearest 0.1 g.

RESULTS

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.

Male blueback herring were first captured at Herring Creek collection site A (Fig. 4.1) on March 21, 1977 and upstream at site B on April 14, when water temperatures were 12.8°C and 19.0°C, respectively. The first females did not enter site A until April 9 and were not taken upstream until April 15. Water temperatures on these dates were 13°C and 19.4°C, respectively. Surface water temperature is plotted for the spawning run duration in Figure 4.2.

Only one spawning wave was observed during this period with peak catches of 63 blueback herring at site A on April 22 and 104 blueback herring at site B on April 27. Chi square analysis indicated that male blueback herring were significantly more abundant than females ($P<0.001$) for the entire spawning migration. The ratio of males to females was 3:1 at site A and 14:1 at site B. Females outnumbered males in only three collections from site A, but these catches were usually preceded by larger numbers of males. Upstream, males were always significantly more abundant than females, with sex ratios reaching 18:1 at the peak of the spawning wave.

Age composition was derived from scale analysis and is presented in Table 4.4. The modal age for blueback males taken during the spawning run was age 6, but the data indicated a codominance of ages 6 and 7 for females. Mean ages were 6.35 and 6.43 for males and females, respectively. The average number of spawning checks was 1.35 for males and 1.30 for females. The percentage of male virgin spawners was 65.2, 38.0 and 6.0 for age classes V, VI, and VII, respectively; percentages for females first spawning were 100.0, 57.1, 28.0, and 10.0 for age classes IV, V, VI, and VII. Only 28.0% of the Herring Creek blueback population were virgin spawners. The maximum number of spawning checks was 4 for 7-, 8-, and 9-year-old males and 3 for 8- and 9-year-old females.

Mean total lengths and total weights for male and female blueback were 276 mm and 182.3 g, and 287 mm and 202.3 g, respectively (Table 4.5). Ranges of length and weight (sexes pooled) were 249 to 314 mm total length, 217 to 278 mm fork length, 140.7 to 312.6 g total weight, and 130.4 to 255.9 g eviscerated weight. Average gonad weight was 15.0 g for males and 22.7 g for females.

Weekly changes in mean total length, mean total weight, and mean eviscerated weight are summarized in Table 4.6. Regression analysis indicated no significant change in total lengths for females ($P>0.50$), however the regression coefficient was marginally significant for males ($.01<P<.05$) and indicated a decrease in total length as the spawning season progressed. Changes in total weight were also significant for males ($P<0.001$) and females ($P<.01$) with total weight decreasing during the sampling period. Eviscerated weights also decreased significantly for males ($P<0.001$) and marginally for females ($.01<P<.05$).

DISCUSSION

The spawning run of blueback herring in Herring Creek for 1977 was extremely poor and indicative of total state landings. Virginia river herring landings were a record low and only 37% of the previous record low in 1976 (Loesch et al. 1977). Personal communication with dipnetting fishermen concurred that the seasonal run was very poor.

Peak catches of blueback herring were taken when water temperatures approximated the range of 21 to 24°C reported by Bigelow and Welsh (1925). However, spawning blueback were first taken when surface water temperatures were considerably lower (12°C). Spawning blueback were also taken when temperatures fell below this range during the first week of May at the end of the spawning season in Herring Creek. Loesch and Lund (1977) also report spawning of blueback in Connecticut at temperatures considerably below this range.

The high ratios of males to females taken in Herring Creek (3:1 site A; 14:1 site B) may indicate that males remain on the spawning grounds for a longer period of time while females return to sea immediately after spawning. Loesch and Lund (1977) reported temporal and spatial variation in the sex ratio of spawning blueback herring in Connecticut, and based on day of spawning run entry, they estimated a 2:1 ratio of males to females on or near the spawning ground. Joseph and Davis (1965) previously reported an equal sex ratio in blueback herring in the lower Chesapeake Bay while Loesch et al. (1977) reported a sex ratio of 1.7:1 for blueback herring in the James River.

The high frequency of six-year-old blueback herring and the absence of four-year-olds are further evidence of the decline of blueback herring in Virginia reported by Loesch et al. (1977). Prior to 1976, age 4 blueback herring were generally the dominant year class in the fishery (Hoagman and Kriete 1975). A mean age of 6.4 determined from scales (sexes combined) is slightly higher than the 5.6 mean age reported by Loesch et al. (1977) for commercial samples of blueback herring taken from the James River (Table 4.4).

The mean fork lengths and mean total weights of 243.5 mm and 178.3 g, and 253.7 mm and 206.4 g reported for male and female blueback herring, respectively, in the James River commercial fishery (Loesch et al. 1977) are in reasonable agreement with the mean lengths and weights reported in this study.

The decrease in total length of males as the spawning season progressed is possibly attributed to the late arrival of smaller fish. Cooper (1961) found the same relationship with spawning alewife in Rhode Island. He felt this indicated that the larger adults become ripe at an earlier date than do the smaller adults. Changes in total weight may be attributed to an increase in the number of partially spent fish, especially since males remain on the spawning grounds for extended periods. Cooper (1961) also found changes in average weight for male and female alewife as the spawning run progressed. Changes in eviscerated weight are supported by the fact that blueback herring do not feed during the spawning run.

LITERATURE CITED

Bigelow, H. B. and W. W. Welsh. 1925. Fishes of the Gulf of Maine. U.S. Bur. Fish. Bull. 40 (Part I).

Cooper, R. A. 1961. Early life history and spawning migration of the alewife, Alosa pseudoharengus. M.S. Thesis. University of Rhode Island, Kingston, Rhode Island. U.S.A.

Hoagman, W. J. and W. H. Kriete, Jr. 1975. Biology and management of river herring and shad in Virginia. Annu. Rep. Virginia AFC-2. Virginia Institute of Marine Science, Gloucester Point, Virginia. 105 p.

Joseph, E. B. and J. Davis. 1965. A preliminary assessment of the river herring stocks of lower Chesapeake Bay. A progress report to the herring industry. Spec. Sci. Rep. No. 51. Virginia Institute of Marine Science, Gloucester Point, Virginia.

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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Loesch, J. G. and W. A. Lund, Jr. 1977. A contribution to the life history of the blueback herring, Alosa aestivalis. Trans. Amer. Fish. Soc. 106:583-589.

Walburg, C. H. and P. R. Nichols. 1967. Biology and management of American shad and status of the fisheries, Atlantic coast of the United States, 1960. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. No. 550. pp. 12-52.

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 year class in 1978.

SEX	COUNT / ROW PCT / COL PCT / TOT PCT	YRCLASS 71.	72.	73.	74.	75.	ROW TOTAL
MALE	1.	2	17	9	1	1	30
		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	
FEMALE	2.	12	101	36	0	0	149
		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. Number of dip netters and species composition in fyke and trap nets on Herring Creek, James River, 1977.

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

Table 4.4. Age by sex of blueback herring from Herring Creek and James River samples for 1977.

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
Mean age (sexes pooled)	6.37		6.37	

Table 4.5. Mean lengths and weights of blueback herring from Herring Creek for 1977.

Age	Mean Total Length		Mean Fork Length		Mean Total Weight		Mean Eviscerated Weight	
	Males	Females	Males	Females	Males	Females	Males	Females
IV		265		236		166.3		150.2
V	267	279	237	246	163.0	194.8	149.7	167.1
VI	273	285	242	252	177.0	200.9	162.5	178.2
VII	281	290	249	252	192.8	206.5	177.0	183.8
VIII	286	293	252	261	198.9	207.8	182.7	188.0
IX	293	314	257	275	209.5	214.1	193.6	198.8
$\bar{X}$	276	287	244	254	182.3	202.3	167.3	179.6
Pooled $\bar{X}$	278		246		185.5		169.4	

Table 4.6. Weekly changes in mean total length, mean total weight, and mean eviscerated weight of blueback herring from Herring Creek.

Date	Mean Total Length		Mean Total Weight		Mean Eviscerated Weight	
	Males	Females	Males	Females	Males	Females
3/21 - 3/27	295		262.1		234.9	
3/28 - 4/03	289		240.8		211.0	
4/04 - 4/10	293	297	256.4	259.2	229.9	211.2
4/11 - 4/17	280	281	205.4	212.9	184.8	180.6
4/18 - 4/24	277	288	186.2	108.0	167.8	184.2
4/25 - 5/01	275	286	176.0	192.8	162.8	172.8
5/02 - 5/08	277	292	178.1	181.1	163.6	172.3
5/09 - 5/15	283		179.8		167.0	

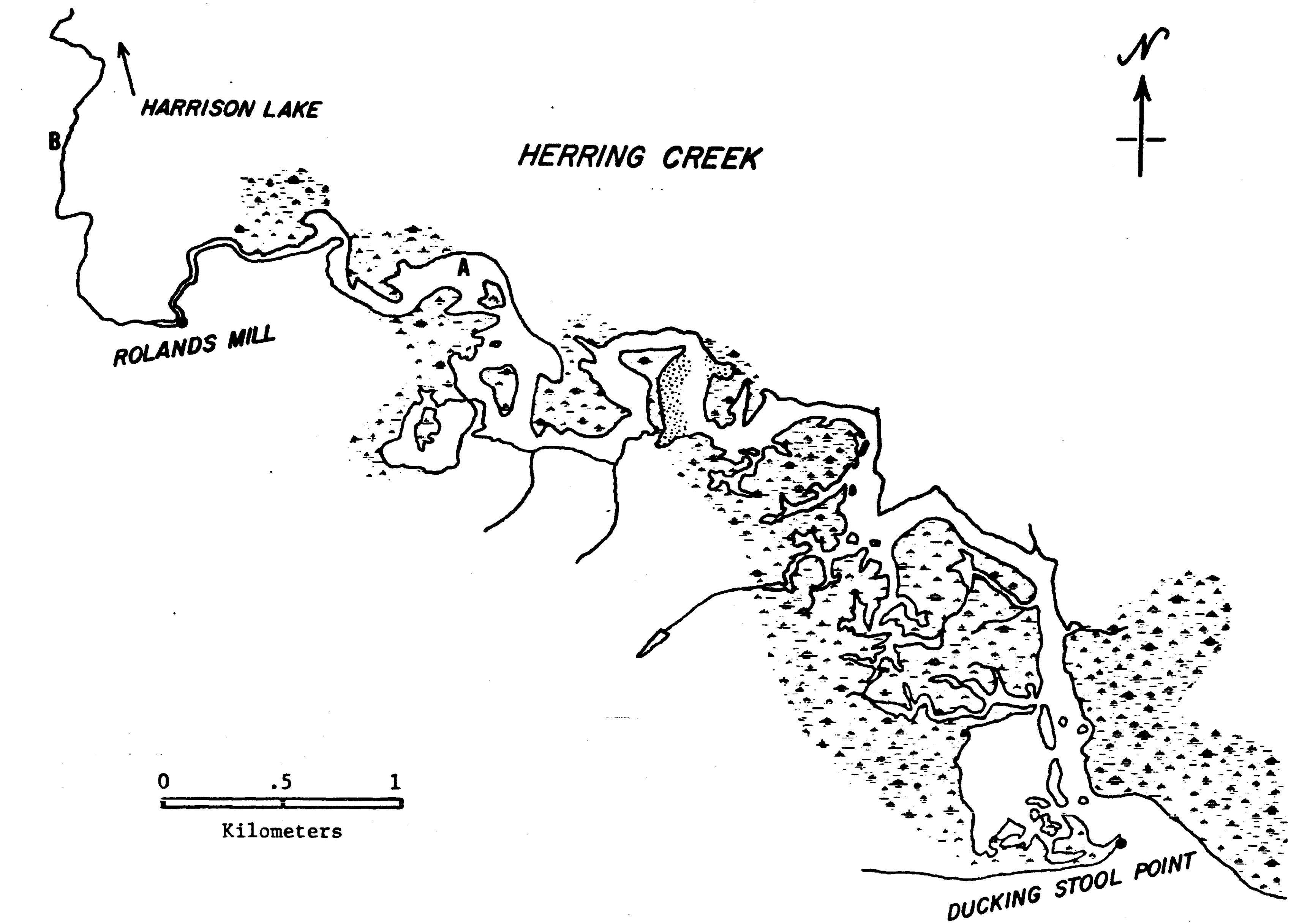


Figure 4.1. Location of fyke nets (A) and weir (B) sampling stations in Herring Creek.

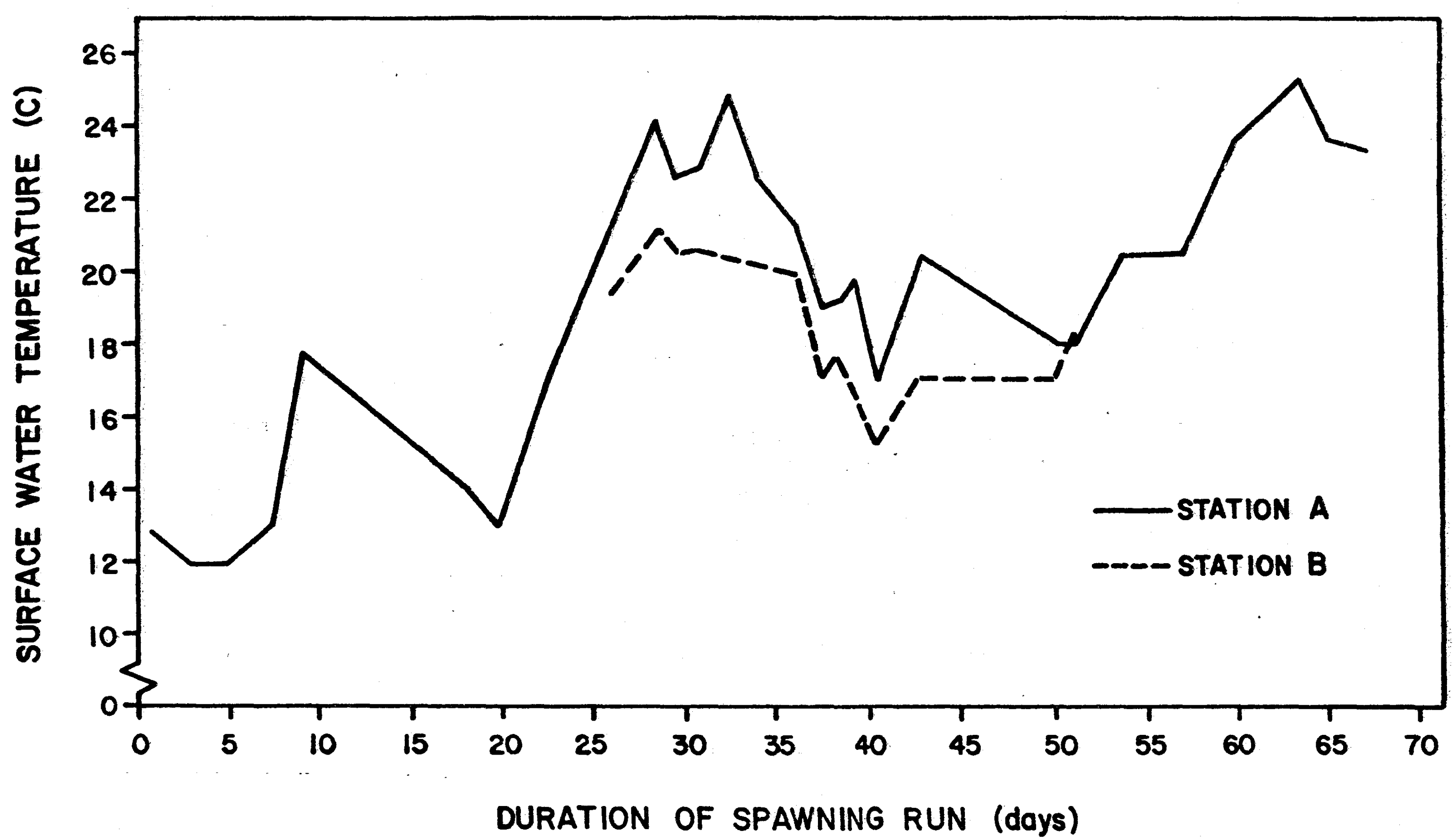


Figure 4.2. Surface water temperatures in Herring Creek during the blueback herring spawning run in 1977 starting March 21 and ending May 13.

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

No Virginia participation.

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

SUMMARY

1. Kepone analyses of adult alosine body and ovarian tissues collected from March through June in the James and Chickahominy rivers and lower Chesapeake Bay indicated little or no contamination. The highest mean levels of Kepone detected in these samples (0.03 ppm in 1977, 0.05 ppm in 1978, and 0.11 ppm in 1979) were well below the action level of 0.3 ppm.

2. The Kepone action level was exceeded by 29% of adult male hickory shad and 28% of the females in samples collected from the lower Chesapeake Bay area in August and September, 1977.

3. The mean Kepone concentration in 33 adult striped bass taken from the James River in March, 1978, was 0.50 ppm, and in six adults collected from the same area in March, 1979, was 0.80 ppm.

4. Samples of juvenile alosines and striped bass which contained above action level Kepone concentrations were obtained from the James and Chickahominy rivers. In general, concentrations above the action level were found in samples collected between mile 35 and mile 65 on the James River and in the lower portion of the Chickahominy River, a tributary to the James River at mile 40. Juvenile samples from the upper Chickahominy River and from the James River above mile 65 and below mile 35 had concentrations below the action level.

5. Kepone levels in juvenile alosines and striped bass from the York River and its tributaries (Mattaponi and Pamunkey rivers) were either nondetectable or very low and probably are attributable to aeolian contamination of the York River watershed rather than juvenile migration. All juveniles from the Potomac and Rappahannock rivers had nondetectable Kepone concentrations.

6. Data for above action level juvenile 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 increase 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 (Hoagman et al. 1973). The 1966 and 1970 striped bass year classes were also "successful" (Grant and Joseph 1968; Merriner and Hoagman 1973). 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 catfishes; 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 year classes exposed to contamination as juveniles in the estuary return to spawn after three to four years at sea.

MATERIALS AND METHODS

Sampling Methods

Adult alosines were obtained in 1977 and 1978 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 from known collection sites were analyzed.

Juveniles were collected in 1977 with a 27.4 m beach seine, a 1.5 m X 1.5 m Cobb trawl, and 1.5 m X 1.5 m pushnet described in Loesch et al. (1977). Beach seine sampling for young-of-the-year alosines and striped bass commenced in mid-August and continued until late November; as weather permitted, occasional samples were taken in December. Sampling was conducted on a weekly basis in the James River and biweekly in the York River. Additional juvenile samples were collected from the major Virginia tributaries to Chesapeake Bay during the execution of the juvenile abundance survey (Job 3).

During June, August, and September, 1978, juveniles were again collected from the major Chesapeake Bay tributaries with the pushnet and trawl nets (Johnson et al. 1978).

All 1979 juvenile samples were collected with the pushnet from various sites in the James and Chickahominy rivers during the period of June through October.

Analytical Methods

All alosine Kepone analyses were conducted by the VIMS Department of Ecology-Pollution (1977-79) and the Virginia State Water Control Board (1977 and 1979). In addition, at no expense to the project, adult and juvenile striped bass were analyzed for Kepone content.

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

In preparation for analysis, samples were ground in a meat grinder into hamburger consistency. A mixture of anhydrous sodium sulfate and Quso^R G-30 (precipitated silica, Philadelphia Quartz Co.[1]) was then added for desiccation. The proportions of sample to the desiccants were: 30 g fish - 54 g Na_2SO_4 - 6 g Quso^R. Samples were then frozen at -5°C for 24 hours to rupture the cells. After thawing, the desiccated samples were ground with a blender to a powdery consistency and transferred to pre-extracted paper thimbles for Soxhlet extraction. Extraction was carried out using 1:1 (v/v) ethyl ether-petroleum ether for 16 hours. Extracts were then concentrated by evaporation and cleaned by activated Florisil column chromatography. The Kepone-containing elutriate was analyzed by electron capture gas chromatography utilizing packed columns with one or more of the following liquid phases: 1.5% OV-17/1.95% QF-1 or 3% OV-1.

[1]Use of company name does not constitute endorsement.

RESULTS AND DISCUSSION

1979 Kepone Samples

A total of 52 adult alosines collected from the James and Chickahominy rivers in March and April, 1979, were analyzed for Kepone contamination (Table 6.1). One blueback herring taken in the upper Chickahominy River had a Kepone body burden of 0.82 parts per million (ppm). All other samples ranged from nondetectable Kepone levels to a maximum of 0.12 ppm, well below the established action level of 0.3 ppm.

The mean Kepone concentration found in body tissue of six adult striped bass (400-500 mm in length) taken from the James River (mile 40, at the mouth of the Chickahominy River) was 0.8 ppm with a range of 0.29 to 1.25 ppm. Based on length-age data (Mansueti 1961) it was concluded that four of the six fishes tested were probably migratory adults. Consequently, such high levels of contamination reflect either rapid seasonal bioaccumulation of Kepone by this piscivorous species or, assuming previous residence in the James River system, a low rate of depuration at sea.

A total of 19 juvenile alosine samples and one juvenile striped bass sample collected from June through October, 1979, in the James and Chickahominy rivers were analyzed for Kepone content (Table 6.2). Although the number of samples was small due to limited availability of juveniles in the James River nursery zone during the summer and fall, a tendency toward increasing Kepone contamination with time is evident. The mean concentration in blueback herring collected between mile 35 and mile 69 was 0.32 ppm in June and increased to 0.69 ppm in October.

Mean body burdens also increased in the upper Chickahominy River from 0.02 ppm in June to 0.17 ppm in October, although the action level was not exceeded.

A single blueback herring sample taken above the Hopewell area (mile 76-82) in late August had a low concentration of 0.06 ppm while another blueback sample from the lower Chickahominy River was close to the action level in mid-July (0.25 ppm). Two early June alewife samples and a late June striped bass sample from the Hopewell area (mile 65) showed little contamination. A single American shad sample from the same region exceeded the action level in late June (0.41 ppm).

1977-1978 Kepone Samples

Kepone analysis of adult American shad sampled in March, 1977, indicated there was little or no contamination of this species (Table 6.3). Nine of 11 ovarian tissue samples analyzed did not contain a detectable level of Kepone; two others had concentrations of only 0.02 and 0.04 ppm. Kepone was not detected in four of nine American shad body tissue samples. In the other five samples the concentration (mean of 0.05 ppm) was well below the action level of 0.3 ppm. A single American shad collected from Chesapeake Bay in late September had a concentration of 0.29 ppm.

Hickory shad (Table 6.3) were collected from early August through September, 1977, in the lower Chesapeake Bay area. Edible meat of 24 males and 18 females was analyzed. The action level was exceeded by 29% of the males (mean of 0.71 ppm) and 28% of the females (mean of 0.66 ppm). The means for the samples not exceeding the action level were 0.10 and 0.13 ppm for males and females, respectively. The overall means for males, females, and sexes combined were in each case 0.28 ppm. Eight hickory shad collected from the mouth of the York River in September and October, 1977, had a mean level of 0.03 ppm.

The greater concentration of Kepone in lower Chesapeake Bay hickory shad relative to lower James River American shad may have been due to the later collection dates of the hickory shad. The single available American shad collected from the lower Bay during September indicated a concentration within the range of the hickory shad collected during approximately the same time frame. The low mean levels detected in hickory shad from the mouth of the York River during September and October provide additional evidence for possible aeolian contamination of this system as discussed in Loesch et al. (1977) and Johnson et al. (1978).

All juvenile alosines, except one lower James River blueback herring sample, and striped bass found to exceed the action level in Kepone concentration were from samples taken in the James River nursery zone (Table 6.4). In comparison, analyses of samples taken below the James River nursery zone and from the York River were below the action level.

Four juvenile alewife samples from the James River nursery zone had a mean concentration of 1.34 ppm while a single York River sample had nondetectable contamination.

Eight juvenile blueback herring samples from the James River nursery zone averaged 0.80 ppm compared to means of 0.20 ppm for samples from the lower James and 0.02 ppm for samples from the York River.

The mean concentration for juvenile American shad samples from the James River nursery zone was 1.38 ppm while samples from the York River averaged only 0.02 ppm.

A single juvenile hickory shad sample from the York River had a Kepone concentration of 0.03 ppm.

Five juvenile striped bass samples from the James River nursery zone had a mean of 1.02 ppm and five York River samples had a mean of 0.02 ppm. A single sample from the lower James had a concentration of 0.09 ppm.

Kepone analyses data for adults and juveniles collected in 1978 are summarized in Tables 6.5 and 6.6, respectively. Analyses of adult alosine body and ovarian tissue were made on samples collected primarily from the lower Chesapeake Bay between mid-March and early June (Table 6.5). The highest level of Kepone present in adult alosine body tissue, 0.09 ppm, was less than a third of the action level, 0.3 ppm, while the highest level detected in ovarian tissue, 0.14 ppm, was less than half of the action level.

Thirty-three adult striped bass samples were taken from the James River in March, 1978. Six of 11 males (54.4%) and four of 22 females (18.1%) had Kepone levels greater than 0.3 ppm. Five of the six contaminated striped bass males and two of the four contaminated females were less than age 3 based on the age-length relationship of Mansueti (1961) and probably were resident (pre-migratory) fish. The lengths of the 23 striped bass below the Kepone action level ranged from 440 to 690 mm (ages about 4-6); they are believed to have been recent arrivals.

Sixty-four samples of juvenile alosines and striped bass were analyzed for Kepone content in 1978 (Table 6.6). 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 from the James River and its tributary, the Chickahominy River. Juvenile alewife, blueback herring and striped bass Kepone averages above the action level ranged from 0.50 to 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 for 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 (≤ 0.01 ppm) occurred in five striped bass and three American 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 aeolian contamination of the rivers' watersheds 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) indicate that the fish were not migrants from the James River.

Although area and time specific data are often few, several generalizations can be made from the Kepone data obtained during the three-year period (1977-79).

Samples of adult alosines (alewife, blueback herring and American shad) collected in the Chesapeake Bay and its tributaries from March through June generally had nondetectable or well below action level Kepone contamination in both their body and ovarian tissues. A single sample of American shad collected in Chesapeake Bay during September, 1977, had a body burden of 0.29 ppm. This supports a supposition of proportional increases in body Kepone levels with length of residency in the contaminated portions of the estuary.

Further evidence for acquisition of Kepone by adult alosines during their stay in the estuary for spawning is provided by a fourth alosine species, the hickory shad. Although samples from the first six months of the year were not available for comparison, 29% of the males and 28% of the females collected from lower Chesapeake Bay in August and September, 1977, exceeded the action level of 0.3 ppm. In contrast, all samples of this species taken in September and October, 1977, from the mouth of the York River had low body burdens ranging from 0.01 to 0.06 ppm.

In contrast to the low Kepone concentrations detected in adult alosines during the spring, ten of 33 (30.3%) and five of six (83.3%) adult striped bass collected in the James River during March of 1978 and 1979, respectively, had body burdens in excess of the action level. This may indicate a rapid uptake of Kepone while feeding in the contaminated portions of the estuary or a low depuration rate at sea if previous Kepone contamination is assumed. Samples of adult striped bass collected during migration from the James River during the fall were not available for comparison.

All samples of juvenile alosines and striped bass found to exceed the action level in Kepone body burden were collected in the James River nursery zone (between mile 35 and mile 65) and in the lower Chickahominy River, a tributary to the James River at mile 40. Samples from the James River above mile 65 and below mile 35, and from the upper Chickahominy River in general had Kepone concentrations well below the action level.

All samples of juvenile alosines and striped bass collected in the Potomac and Rappahannock rivers (1978) had nondetectable Kepone levels. However, samples from the York River (1977) and its tributaries, the Mattaponi and Pamunkey rivers (sampled in 1978), had a range of concentrations from nondetectable to 0.16 ppm. Aeolian contamination of the York River system watershed is believed to be the primary cause of the low levels of Kepone detected in samples from these sites.

Addendum

A manuscript resulting from this study has been accepted for publication in Estuaries (see p. 198).

LITERATURE CITED

Grant, G. C. and E. B. Joseph. 1968. Comparative strength of the 1966 year class of striped bass, Roccus saxatilis (Walbaum), in three Virginia rivers. Proc. Annu. Conf. S.E. Assoc. Game and Fish Comm. 22:501-509.

Hoagman, W. J., J. V. Merriner, R. St. Pierre, and W. L. Wilson. 1973. Biology and management of river herring and shad in Virginia. Completion Rep. 1970-1973. Virginia AFC 7-1 to 7-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 215 p.

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 p.

Loesch, J. G., W. H. Kriete, Jr., H. B. Johnson, B. F. Holland, Jr., and M. W. Street. 1977. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

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.

Merriner, J. V. and W. J. Hoagman. 1973. Feasibility of increasing striped bass populations by stocking of underutilized nursery grounds. Completion Rep. 1970-1973. FA-Virginia AFS 6-1 to 6-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 197 p.

Table 6.1. Kepone concentration (ppm) in adult alosines and striped bass from the James and Chickahominy rivers, 1979. Samples were collected and analyzed by the Virginia State Water Control Board (SWCB).

Species	Collection site	Date	Tissue analyzed	No. of samples	Concentration Mean	Concentration Range
Alewife	Chickahominy (upper)	16 Mar	body	15	0.01	ND*-0.03
Blueback	James (mile 85)	12 Apr	body	6	0.04	0.02-0.12
	Chickahominy (upper)	5 Apr	body	10	0.11	0.02-0.82
American shad	James (mile 40)	23 Mar	body	21	0.01	ND-0.03
Striped bass	James (mile 40)	23 Mar	body	6	0.80	0.29-1.25

*ND = Nondetectable; assumed zero for data analysis.

Table 6.2. Kepone concentration (ppm) in juvenile alosines and striped bass from the James and Chickahominy rivers, 1979.

Species	Collection site	Date	No. of samples	Concentration Mean	Concentration Range
Alewife	James (mile 56-69)	10-11 Jul	2	0.05	0.05-0.06
Blueback	James (mile 76-82)	22 Aug	1	0.06	
	James (mile 56-69)	22 Jun	1	0.32	
		10-11 Jul	2	0.42	0.14-0.70
		1 Aug	1	0.51	
		22 Aug	1	0.59	
	James (mile 45-66)	11 Oct	1	0.51	
	James (mile 35)	11 Oct	1	0.69	
	Chickahominy (upper)	21 Jun	2	0.02	0.01-0.03
		12 Jul	1	0.03	
		2 Aug	1	0.02	
		21 Aug	1	0.14	
		17 Sep	1	0.16	
		11 Oct	1	0.17	
	Chickahominy (lower)	12 Jul	1	0.25	
American shad	James (mile 56-69)	22 Jun	1	0.41	
Striped bass	James (mile 56-69)	22 Jun	1	0.10	

Table 6.3. Kepone concentration (ppm) in adult alosines from the lower Chesapeake Bay and tributaries, 1977.

Species	Collection site	Date	Tissue analyzed	No. of samples	Concentration Mean	Concentration Range
American shad	Ches. Bay	27 Sep	body	1	0.29	
	James (lower)	15 Mar	body	9[a]	0.03	ND*-0.17
			ovary	11[a]	0.01	ND -0.04
Hickory shad	Ches. Bay	1 Aug	body	9	0.32	0.05-1.30
		16 Aug	body	5	0.23	0.02-0.64
		24 Aug	body	9	0.23	0.04-0.92
		26 Aug	body	5	0.07	0.04-0.09
		16 Sep	body	5	0.50	0.08-1.19
		19 Sep	body	5	0.20	0.02-0.56
		23 Sep	body	1	0.05	
		27 Sep	body	3	0.55	0.53-0.57
	York (mouth)	27 Sep	body	4	0.03	0.01-0.06
		3 Oct	body	4	0.03	0.01-0.04

*ND = Nondetectable; assumed zero for data analysis.

[a] Samples collected and analyzed by the Virginia State Water Control Board (SWCB).

Table 6.4. Kepone concentration (ppm) in juvenile alosines and striped bass from the James and York rivers, 1977.

Species	Collection Site	Date	No. of samples	Concentration Mean	Concentration Range
Alewife	York	13 Oct	1	ND*	
	James (nursery)	11 Aug	1	2.67	
		7 Sep	1	0.85	
		12 Oct	1	1.30	
		5 Dec	1	0.55	
Blueback	York	18 Oct	1	0.02	
		15 Nov	2	0.02	ND -0.04
	James (nursery)	11 Aug	1	2.76	
		31 Aug	1	0.22	
		5 Oct	1	0.77	
		12 Oct	1	0.54	
		19 Oct	1	0.35	
		16 Nov	1	1.34	
		22 Nov	1	0.11	
		5 Dec	1	0.29	
	James (lower)	19 Oct	1	0.15	
		16 Nov	1	0.42	
		22 Nov	1	0.08	
		5 Dec	1	0.16	
American shad	York	10 Aug	1	0.05	
		20 Sep	1	0.02	
		4 Oct	1	0.02	
		18 Oct	1	ND	
		15 Nov	2	0.03	0.02-0.03
	James (nursery)	11 Aug	1	2.71	
		31 Aug	1	0.23	
		12 Oct	1	1.21	
Hickory shad	York	20 Sep	1	0.03	
Striped bass	York	10 Aug	1	0.02	
		20 Sep	1	0.02	
		4 Oct	1	0.02	
		18 Oct	1	0.02	
		15 Nov	1	0.04	
	James (nursery)	11 Aug	1	1.80	
		7 Sep	1	0.72	
		14 Sep	1	1.60	
		5 Oct	1	0.22	
		12 Oct	1	0.76	
	James (lower)	22 Nov	1	0.09	

*ND = Nondetectable; assumed zero for data analysis.

Table 6.5. 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	
			ovary	1	ND	
		17 May	body	2	<0.01	ND-0.01
			ovary	1	0.01	
		23 May	body	1	0.01	
			ovary	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
			ovary	6	<0.01	ND-0.01
		12 Apr	body	11	<0.01	ND-0.01
			ovary	6	<0.01	ND-0.01
		17 May	body	7	0.01	ND-0.04
			ovary	4	0.01	ND-0.01
		23 May	body	9	0.03	0.01-0.06
			ovary	5	0.05	0.02-0.09
		7 Jun	body	4	0.01	ND-0.02
			ovary	3	<0.01	ND-0.02
American shad	Ches. Bay	12 Apr	body	6	ND	
		7 Jun	body	5	0.04	ND-0.07
			ovary	2	0.05	0.05-0.06
	York (mouth)	9 Jun	body	3	0.04	0.02-0.05
			ovary	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 6.6. 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

1. An estimated 5,214 kg of Atlantic sturgeon were caught and released in Virginia in 1979, compared to 2,500 kg in 1978.

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

3. No shortnose sturgeon were reported from Virginia waters.

Job 7. Sturgeon - A General Pilot Study

INTRODUCTION

Sturgeon are infrequent inclusions in pound and gill net catches of Virginia inshore commercial fisheries. In Virginia both the Atlantic and shortnose sturgeon are protected species and by law must be released alive. The shortnose sturgeon is listed as endangered in the Endangered Species Act of 1973.

MATERIALS AND METHODS

Logbooks were placed with cooperating fishermen. An index of catch-per-unit-of-effort (CPUE) 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 average number of pound nets or total meters of gill netting in a stratum (effort see Job 1 this report). 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.

RESULTS AND DISCUSSION

Pound net and gill net fishermen in the James, York, and Rappahannock rivers caught and released an estimated 5,214 kg of Atlantic sturgeon during the late winter and spring fishing season of 1979 (Table 7.1), a 107% increase compared to 1978 (Table 7.2).

This increase can be attributed to increased effort, as well as increased abundance in the James River. Stake gill nets on the James River caught 79% of all sturgeon reported by fishermen in Virginia. The remaining river systems exhibited little change in 1979 compared to 1978. As in 1978, there were no reports of shortnose sturgeon caught by any of the cooperating fishermen.

All but a few of the sturgeon reported were immature fish. Average weights reported by the fishermen were as follows: James River 1.6 kg, York River 3.8 kg and Rappahannock River 2.9 kg. The largest was a 13.6 kg sturgeon caught and released in the York River.

Mr. William L. Dovel of the Oceanic Society has tagged and released 4,264 Atlantic and 1,726 shortnose sturgeon in the Hudson River. Sixty Atlantic and 161 shortnose tagged sturgeon have been recaptured. Of the 60 Atlantic sturgeon returns, 22 were captured by Virginia fishermen. All of the tagged shortnose sturgeon were recovered from the Hudson River (W. L. Dovel 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 shornose sturgeon (Section 28.1-49.1, Code of Virginia). 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.

Table 7.1. Estimated catch in kg of Atlantic sturgeon in Virginia rivers by gear in 1979. 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	0.1328	11,727		1,557
	Stake Gill Net	15-45	0.1000	25,480		2,548
	Total					4,105
York	Stake Gill Net	05-20	0.0586	9,108		534
	Stake Gill Net	20-29	0.0316	4,860		154
	Pound Net	00-29	3.7000		12	44
	Total					732
Rappahannock	Stake Gill Net	15-35	0.0238	13,497		321
	Pound Net	00-30	1.8144		20	36
	Pound Net	31-65	1.1793		17	20
	Total					377
			Grand Total			5,214

Table 7.2. 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	2.2000		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

Job 8. Anadromous Fish Tagging

No Virginia participation.

Job 9. Spawning Area Survey

No Virginia participation.

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 1981.

2. It is recommended that a contingency management plan for river herring be formulated by the Virginia Marine Resources Commission that would provide for increased escapement from the fishery until the advent of strong recruitment.

Job 10. Development of Management Alternatives

INTRODUCTION

North Carolina and Virginia have the major river herring fisheries for the Atlantic Coast. Thus, the condition of their stocks determines the overall status of the total fishery. Landings for both fisheries have exhibited, with minor variations, a declining trend since 1970, and the Virginia landings in the years 1977-1979 were the lowest recorded (Part II: Table 2.2). The present poor state of the stocks is attributed to heavy exploitation of the stocks by the foreign offshore fishery in the late 1960's and early 1970's, and the absence of a strong year class since 1969.

DISCUSSION

National Marine Fishery statistics indicated that in the years 1977-1979 foreign vessel by-catches were 44.0, 28.3, and 11.9 metric tons (MT), respectively. It is significant to note that in 1977 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.

The 1977-1979 by-catches were far below the respective annual by-catch allocations of 500, 453, and 409 MT. Thus, it is obvious that the foreign vessels were able to avoid herring. Considering the facts that river herring stocks are greatly depressed and foreign vessels can 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 to 100 MT or less beginning in 1981.

It is further recommended that a contingency management plan for river herring be formulated by the Virginia Marine Resources Commission that would provide for increased escapement from the fishery until the advent of strong recruitment.

Job 11. Report Publication

No Virginia participation.

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

SUMMARY

1. Reevaluation of the VIMS historical catch data (1972-1977) resulted in 71 changes in the 91 species-specific nursery zones (27 increased, 44 decreased, and 20 were unchanged).

2. Recalculated CPUE resulted in increases in every case.

3. A positive correlation was detected in the Rappahannock and Potomac rivers between juvenile blueback CPUE and blueback landings 4 years later.

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 in underestimates of catch-per-unit-of-effort (CPUE). VIMS historical data for the 1972-1977 period were sufficiently detailed to reevaluate estimates of CPUE with a consideration of species-specific nursery area boundaries.

METHODS

The methods used to compare the initial and adjusted catch data for the years 1972-1977, as described in Johnson et al. (1978), were modified in 1979. Estimates of standing crop and mean nursery zone water volume were omitted from analyses. The estimate of water volume strained by a standard 5 min pushnet sample is 655 m^3 (see Job 3) as opposed to 896 m^3 in 1978 (Johnson et al. 1978). Present volume strained is the mean product of net opening area and water flow rates, while past volume was determined from net opening area and estimates of the average distance sampled.

The inclusion of bottom trawl data and exclusion of upper and lower strata of no alosine catch data remained unchanged. Similarly the nursery zone boundaries reported in Johnson et al. (1978) remained unchanged.

The initial and adjusted CPUE were recalculated in terms of one standard pushnet unit, 655 m^3 of water sampled.

RESULTS AND DISCUSSION

Initial and adjusted estimates of the extent of nursery zones, number of samples, and CPUE of three alosine species (alewife, blueback herring, and American shad) in the years 1972 through 1977 are presented in Tables 12.1-12.6. Corresponding data for 1978 (a year in which sampling was conducted at night) are included in the tables for reader convenience and are not intended for comparison with the 1972-1977 data.

Redefinition of the lower and upper boundaries of nursery zones resulted in 71 changes in the estimated extent (river miles) of the previously static nursery grounds (Johnson et al. 1978).

Reevaluation of the number of samples collected within the adjusted nursery zones resulted in 53 increases in effort, 37 decreases, and no change in one instance (alewife in the Mattaponi River in 1972, Table 12.4). The changes resulted from the inclusion of bottom trawl catches and the elimination of effort in strata with no alosine catches.

Subsequent recalculation of CPUE for the 91 data sets resulted in increased estimates of CPUE in every case. The increases were due to the redefinition of a standard sampling unit, the inclusion of bottom trawl data, and the exclusion of extraneous strata noted above.

Attempts were made to correlate estimates of juvenile abundance with estimates of adult landings (in kg) in the Rappahannock and Potomac rivers, assuming 3, 4, and 5 year lag intervals for recruitment to the fishery.

Positive correlations were detected in both the Rappahannock and Potomac rivers (r = 0.75 and r = 0.99, respectively) between juvenile blueback herring CPUE (1972-1975) and the landings of these year classes 4 years later (1976-1979). Correlation coefficients for alewife and American shad were low. We believe these low correlations are due to the phototropic behavior of these two species which makes these juveniles less available to daytime capture than are blueback herring (Appendix II). In addition, prior to 1979, a single survey was conducted in late August or September, a period in which alewife and American shad have already commenced their migration (Appendix I; Job 3). The relative abundance of juvenile blueback herring as a possible indicator of alewife and American shad year-class success will be investigated. It should be noted that although correlations are strong for blueback herring, the data are presently few.

Historical data are insufficiently detailed to allow reevaluation of juvenile abundance data prior to 1972. However, pending the availability of funds, continued increase of precision in estimating historical (1972+) relative juvenile abundance may be possible. Utilization of site-specific degree-of-cloud-cover data obtained from the U.S. Weather Bureau (National Climatic Center, Asheville, N.C.) has proven to be an important consideration in increasing the accuracy of relative abundance estimates based upon field survey collections (Appendix II). These data are relative measures of light incident upon the water surface which presumably, affect the vertical distribution of fishes and, consequently, their availability to sampling gear. The possibility of adjusting catch data to a constant light intensity appears to be a significant refinement in improving juvenile abundance indices.

LITERATURE CITED

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

Table 12.1. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the James River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	35-80	35-70	160	157	2.27	23.85
	1973	35-80	40-70	115	100	2.51	36.67
	1974	35-80	35-70	141	132	0.92	14.69
	1975	35-80	30-70	134	138	2.15	38.42
	1976	35-80	60-65	164	13	0.02	1.62
	1977	60-80	35-75	45	93	0.49	0.91
	1978*	35-84	35-84	235	235	2.82	3.42
Blueback	1972	35-80	35-80	160	173	327.32	3936.98
	1973	35-80	35-80	115	126	520.95	5663.88
	1974	35-80	30-84	141	170	65.21	566.05
	1975	35-80	30-84	134	161	1641.88	16238.98
	1976	35-80	35-75	164	159	13.49	79.33
	1977	50-80	50-80	69	86	64.61	241.98
	1978*	35-84	35-84	235	235	489.19	613.84
American shad	1972	35-80	35-80	160	173	2.71	31.80
	1973	35-80	35-80	115	126	4.17	49.28
	1974	35-80	30-84	141	170	2.76	26.89
	1975	35-80	30-84	134	161	0.80	10.77
	1976	35-80	60-80	164	33	0.06	0.85
	1977	50-70	55-80	46	69	0.04	0.21
	1978*	40-84	40-84	215	215	0.93	0.70

*Night sampling

Table 12.2. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the Chickahominy River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972						
	1973						
	1974						
	1975	0-19	0-15	12	16	0.50	2.25
	1976			31	31	0	0
	1977			26	26	0	0
	1978*	0-19	0-19	71	71	4.99	5.83
Blueback	1972						
	1973						
	1974						
	1975	0-19	0-15	12	16	837.75	3581.89
	1976	0-19	0-10	31	19	6.34	58.95
	1977	7-21	5-10	21	5	0.12	2.80
	1978*	0-19	0-19	71	71	502.17	576.72
American shad	1972						
	1973						
	1974						
	1975	0-19	0-15	12	16	1.23	5.25
	1976			31	31	0	0
	1977	7-21	5-10	21	5	0.06	1.40
	1978*	0-15	0-15	55	55	0.05	0.04

*Night sampling

Table 12.3. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the Pamunkey River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	30-60	30-55	108	102	0.89	10.27
	1973	30-60	30-55	80	85	2.00	32.78
	1974	30-60	30-45	60	48	0.37	8.92
	1975	30-60	40-55	56	38	1.84	48.49
	1976	30-60	55-60	42	2	0.06	3.50
	1977	40-60	35-60	33	40	0.34	1.63
	1978*	35-65	35-65	103	103	2.98	3.02
Blueback	1972	30-60	35-60	108	93	10.64	100.37
	1973	30-60	30-55	80	85	40.03	626.46
	1974	30-60	35-50	60	46	2.15	49.75
	1975	30-60	40-55	56	38	60.18	1406.09
	1976	30-60	50-60	42	7	0.06	2.00
	1977	40-65	40-65	40	46	37.07	167.75
	1978*	35-70	35-70	106	106	162.60	187.67
American shad	1972	30-60	30-60	108	114	1.97	15.70
	1973	30-60	30-55	80	85	2.57	27.81
	1974	30-60	35-50	60	46	0.98	22.72
	1975	30-60	40-55	56	38	0.67	17.02
	1976	30-60	50-55	42	5	0.06	1.40
	1977	40-60	40-60	33	39	0.43	2.15
	1978*	35-70	35-70	106	106	3.81	3.92

*Night sampling

Table 12.4. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the Mattaponi River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	30-50	30-50	94	94	1.78	31.49
	1973	30-50	30-45	62	51	5.40	117.58
	1974	30-50	30-50	60	65	0.01	1.49
	1975	30-50	30-50	37	42	0.24	7.28
	1976			33	33	0	0
	1977	40-60	40-50	31	22	0.04	0.34
	1978*	35-61	35-61	89	89	9.39	10.03
Blueback	1972	30-50	30-45	94	71	9.66	174.79
	1973	30-50	30-50	62	64	3.19	52.71
	1974	30-50	35-50	60	50	2.82	60.97
	1975	30-50	35-50	37	30	9.58	211.88
	1976	30-50	45-50	33	5	0.07	2.80
	1977	40-60	40-60	31	39	11.84	39.10
	1978*	35-61	35-61	89	89	43.75	52.42
American shad	1972	30-50	30-55	94	104	4.04	49.45
	1973	30-50	30-50	62	64	7.43	104.35
	1974	30-50	30-50	60	65	0.55	9.51
	1975	30-50	35-50	37	30	0.55	13.07
	1976	30-50	35-40	33	6	0.06	1.17
	1977	40-60	40-60	31	39	1.12	2.93
	1978*	35-61	35-61	89	89	16.74	18.92

*Night sampling

Table 12.5. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the Rappahannock River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	50-80	40-85	86	136	13.80	91.60
	1973	50-80	40-80	69	96	21.73	223.41
	1974	50-80	50-85	85	99	0.31	5.30
	1975	50-80	45-85	99	132	3.56	45.16
	1976	50-80	60-90	45	34	0.13	1.24
	1977	50-85	50-93	60	93	1.77	11.58
	1978*	45-90	45-90	166	166	12.51	14.49
Blueback	1972	50-80	40-85	86	136	163.52	1049.55
	1973	50-80	40-85	69	105	402.13	3221.82
	1974	50-80	45-85	85	113	29.41	414.65
	1975	50-80	45-85	99	132	391.45	4252.23
	1976	50-80	45-90	45	68	33.16	140.10
	1977	50-85	50-93	60	93	397.26	894.72
	1978*	45-90	45-90	166	166	255.22	302.78
American shad	1972	50-80	40-65	86	105	0.18	2.37
	1973	50-80	45-85	69	93	0.37	4.50
	1974	50-80	70-85	85	39	0.06	2.84
	1975	50-80	45-85	99	132	0.12	2.36
	1976			45	68	0	0
	1977	50-85	65-85	60	45	0.06	0.60
	1978*	60-90	60-90	108	108	0.07	0.11

*Night sampling

Table 12.6. Reevaluation of nursery zone size and juvenile alosine catch-per-unit-of-effort (CPUE) in the Potomac River, 1972-1978.

Species	Year	River miles		No. samples		CPUE	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Alewife	1972	65-95	60-95	125	155	0.75	3.52
	1973	65-95	65-95	99	102	0.24	3.65
	1974	65-95	80-95	90	49	0.18	6.29
	1975	65-95	65-95	97	104	0.24	4.31
	1976	65-95	75-95	155	72	0.18	1.85
	1977	68-94	65-95	106	118	2.45	10.66
	1978*	60-95	60-95	232	232	6.13	7.42
Blueback	1972	65-95	60-95	125	155	17.43	193.16
	1973	65-95	65-95	99	102	2.21	22.91
	1974	65-95	75-95	90	65	0.80	19.46
	1975	65-95	60-95	97	123	144.36	1881.44
	1976	65-95	70-90	155	105	0.61	5.07
	1977	68-94	65-95	106	118	110.90	529.15
	1978*	60-95	60-95	232	232	244.55	284.62
American shad	1972	65-95	60-95	125	155	0.22	1.96
	1973	65-95	75-95	99	68	0.02	0.54
	1974			90	113	0	0
	1975	65-95	85-95	97	30	0.02	1.47
	1976			155	184	0	0
	1977			106	118	0	0
	1978*	60-65	60-65	43	43	0.02	0.01

*Night sampling

Job 13. Assessment of Racial Stocks of River Herring

SUMMARY

1. Young-of-the-year alewife and blueback herring were collected in 1979 from selected tributaries along the Atlantic coast and are now being analyzed for meristic and morphometric characters.

2. Coupled with data which will be obtained in 1980, univariate and multivariate statistical techniques will be performed to ascertain if a reasonable separation of stocks can be accomplished from the characters measured.

Job 13. Assessment of Racial Stocks of River Herring

INTRODUCTION

The ability to identify and separate discrete stocks of river herring will contribute to our knowledge of inshore stocks along the Atlantic coast and their migration patterns.

Several studies have used morphometric or meristic characters to identify discrete populations within a species. Nichols (1966), for example, identified discrete populations of American shad along the Atlantic coast using fin ray and scute counts from juvenile American shad. Carscadden and Leggett (1975) incorporated multivariate statistics into their meristic study of American shad in the tributaries of the St. John River, New Brunswick. Their findings indicated that the meristic characters are strongly influenced by a genetic component suggesting that shad home to natal tributaries within a specific river system. Reed (1964) analyzed meristic characters of blueback herring along the Atlantic coast and found numerous races. However, his data were few and lacked comparable samples from the same year class. Messieh (1977) has examined morphometric and meristic characters of alewife and blueback herring in the St. John River, New Brunswick. Between area comparisons of morphometric characters were nonsignificant within each species, in most cases. His multivariate analysis of meristic characters for alewife, however, showed significant differences between stocks, although the degree of overlap was high.

The morphometric and meristic data collected in this study will be used to ascertain if a reasonable separation of Atlantic coast stocks can be accomplished.

PROCEDURES

Young-of-the-year river herring were sampled in 1979 from selected tributaries along the Atlantic coast. Young fish were chosen because of the ease of handling and because of the known origin within the river of capture and the certainty that only a single year class was involved. Those tributaries from which samples were taken include: Margaree River, Nova Scotia; Damariscotta River, Maine; Pettaquamscutt River, Rhode Island; Connecticut River, Connecticut; Potomac, Rappahannock, Mattaponi, Pamunkey, and James rivers, Virginia; and Cooper and Santee rivers, South Carolina. The distribution of samples by river system is given in Table 13.1.

Meristic data, which are now being collected, include pectoral fin ray counts, dorsal and anal fin ray counts and anterior and posterior pelvic scute counts. Morphometric measurements: total length, fork length, snout length, orbit diameter, post orbital diameter, predorsal length, caudal peduncle depth, and body depth at the insertion of the dorsal fin are also being collected. All counts are made in the manner described by Hubbs and Lagler (1974); all measurements are made to the nearest 0.1 mm.

Meristic and morphometric data will again be collected from 1980 young-of-the-year river herring from the same locations. Univariate analyses will be performed by calculating means and standard errors for each meristic character in each population. Significance of inter- and intrapopulation differences for each character will be tested. Covariance comparisons of log-log regressions of body parts on length will be made.

Multivariate analyses will also be performed between all populations and between year classes for each population. Discriminant function analysis will be used to determine percent overlap between populations.

This research is part of a study intended for partial fulfillment of the requirements for Doctor of Philosophy.

ACKNOWLEDGMENTS

The following people generously contributed samples from their respective coastal areas: B. Jessop (Nova Scotia); D. Libby (Maine); J. Stolgitis (Rhode Island); G. Maltezos (Connecticut); and J. Bulak (South Carolina).

LITERATURE CITED

Carscadden, J. E. and W. C. Leggett. 1975. Meristic differences in spawning populations of American shad, Alosa sapidissima: evidence for homing to tributaries in the St. John River, New Brunswick. J. Fish. Res. Board Can. 32:653-660.

Hubbs, C. L. and K. F. Lagler. 1974. Fishes of the Great Lakes Region. University of Michigan Press, Ann Arbor.

Messieh, S. N. 1977. Population structure and biology of alewives (Alosa pseudoharengus) and blueback herring (A. aestivalis) in the Saint John River, New Brunswick. Env. Biol. Fish. 2:195-210.

Nichols, P. R. 1966. Comparative study of juvenile American shad populations by fin ray and scute counts. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 525.

Reed, J. R., Jr. 1964. A racial study of the blueback herring, Alosa aestivalis (Mitchill). M.S. Thesis, Cornell University, Ithaca, New York.

Table 13.1. Distribution of 1979 river herring samples collected for meristic and morphometric analysis.

River	Species	Number of Specimens
Margaree, NS	Alewife	1000
Damariscotta, ME	Blueback	450
Pettaquamscutt, RI	Alewife	108
Connecticut, CT	Blueback	1200
Potomac, VA	Alewife	400
	Blueback	400
Rappahannock, VA	Alewife	700
	Blueback	1200
Mattaponi, VA	Alewife	120
	Blueback	1000
Pamunkey, VA	Alewife	300
	Blueback	900
James, VA	Alewife	340
	Blueback	1600
Cooper, SC	Blueback	200
Santee, SC	Blueback	120

Appendix I

Design and Relative Efficiency of a Pushnet

by

William H. Kriete, Jr. and Joseph G. Loesch

Design and Relative Efficiency of a Pushnet[1,2,3]

by

William H. Kriete, Jr. and Joseph G. Loesch

Virginia Institute of Marine Science
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

[1] Contribution No. 962 of the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary.

[2] Funded in part by the U.S. National Marine Fisheries Service, Northeast Region, through Public Law 89-304.

[3] Revised and published (see p. 198).

Abstract

A bow-mounted pushnet designed to sample near surface juvenile pelagic fishes is described. Catch efficiency of the pushnet was estimated to be superior to catch efficiency of a Cobb trawl previously employed to sample these fishes in Virginia waters. Other favorable aspects of the pushnet include ability to sample in shoal water, multiple net installation, minimized net handling and increased mobility.

Juvenile (young-of-the-year) alosine fishes in Virginia have been sampled annually for the last two decades in the lower Chesapeake Bay and its major tributaries. Emphasis has centered on the commercially important alewife (Alosa pseudoharengus), American shad (A. sapidissima), and blueback herring (A. aestivalis).

Through the years a variety of beach seines and trawls were employed. Beach seines are limited to accessible beaches free of underwater obstructions. Few such sites exist in the tidal freshwater alosine nursery grounds in the lower Chesapeake Bay region. Further, juvenile alosines are not optimally available to beach seines; Hoagman et al. (1974) reported much greater concentrations of juvenile alosines in channel areas and shoals adjoining the channels than in the beach zones.

Massmann et al. (1952) converted an otter trawl into a surface trawl pulled by two boats. This gear was more effective than a beach seine but doubled the manpower and vessel requirements of single-vessel trawling. Davis et al. (1968) modified a 3 X 3 m Cobb trawl by replacing the otter boards with net spreader bars and fished the net at surface and midwater depths. Later, a 1.5 X 1.5 m Cobb trawl was similarly modified (Davis et al. 1969) and was employed until the development of the pushnet. Other small trawl nets have been developed, e.g., Chapoton (1964) and Trent (1967).

These trawls are all fished in the turbulence and associated noise created by the vessel hull, propeller, and towing gear (warp and bridle). Sound perception by fishes is restricted to frequencies below about 1,000 hertz (Hz) (Saetersdal 1969), the frequency range of most vessel and gear noise. Olsen (1971) reported a noise frequency range of 20 to 10,000 Hz for purse seine vessels, but the low frequency components (< 1,000 Hz) were highly dominant. Most fish exhibit a "fright response" to noise of low frequency, and fish close to the surface will usually sound when a vessel passes over (Mohr 1969, 1971). An echogram recorded by Okonski (1969) showed propeller disturbance beyond 10 m depth at a distance 140 m behind the vessel's stern.

This paper describes a pushnet designed to eliminate or minimize some of the inherent problems in sampling pelagic juvenile fishes in near surface waters with seines and trawls.

Pushnet Design

The pushnet was mounted on a 5.5 m fiberglass cathedral hull powered by two 70 horsepower outboard engines. Trailering, cruising, and sampling positions of the pushnet are shown in Figure 1. Figure 2 is a schematic diagram with specific measurements.

The net is constructed of 1.9 cm stretch mesh No. 110 knotless nylon netting in the body and 1.27 cm stretch mesh No. 126 knotless nylon netting in the codend. The mouth opening measures 1.52 X 1.52 m and the net is 5.2 m in length (body 3.0 m, codend 2.2 m).

The net is lashed to a 1.52 X 1.52 m rigid frame of 1.27 cm (i.d.) galvanized pipe (Fig. 2). An additional 36 cm on either side of the frame were needed to clear the sides of the vessel, giving overall frontal dimensions of 1.52 X 2.24 m. Rearward extensions (top 2.74 m, bottom 3.15 m) from each corner of the frame have 1.59 cm (o.d.) perpendicular rods. The rods fit into a fixed through-hull 1.90 cm (i.d.) pipe and form the pivot points and points of frame attachment to the boat. Bracing was added for rigidity.

The pushnet is suspended over the bow of the boat from a 1.9 X 1.52 m "A" frame of 3.81 cm (i.d.) galvanized pipe which is bolted to the gunwales. The net is raised and lowered by a 12 volt electric boat winch mounted on a 10.16 X 10.16 cm wooden post in the stern of the boat. The winch is elevated to a convenient height for overhead wire clearance. All frame materials are readily available from local plumbing suppliers.

Pushnet Efficiency

Sampling Procedures

The efficiency of the pushnet relative to the 1.5 X 1.5 m Cobb trawl for the capture of juvenile alosines was estimated in a series of 73 samples simultaneously employing both gears. Surface Cobb trawl samples were taken with both the R/V *Langley*, a 24.4 m steel hull ferryboat converted for trawling, and the R/V *Restless*, a 9.7 m wooden Chesapeake Bay deadrise hull. Both vessels were used in earlier annual assessments of juvenile alosine abundance. Sampling was conducted during daylight from 12 to 14 September 1977 in a 3.2 km section of the James River near Hopewell, Virginia. All samples were of 5 minute duration in the channel area, and the inshore-offshore positions of the three vessels were randomized for each sample. Trials with calibrated flow meters indicated that the pushnet sampled, on the average, 655 m^3 of water and the Cobb trawls employed from the Langley and Restless averaged 1187 m^3 and 1259 m^3, respectively. All Cobb trawl catches were adjusted to the pushnet catch on the basis of water volume sampled.

Catch Data

A total of 42,996 juvenile alosines were captured in 219 samples. All but 30 fish (eight alewife and 22 American shad) were blueback herring. Thus, only catch data for the blueback herring were considered. The catch differences among the three species did not indicate spawning success. Annual survey data (unpublished) have indicated that by mid-September relatively few alewife and American shad remain upriver on the spring and summer nursery grounds. Also, different phototropic behavior for the three species (manuscript in preparation) results in greater availability of juvenile blueback herring in daytime surface sampling.

The magnitude by which the total pushnet catch of blueback herring exceeded Cobb trawl catches (Table 1) negated any need for statistical analysis to infer meaningful differences in catch efficiencies. The ratio of catches, pushnet:Cobb trawl (Restless):Cobb trawl (Langley), was 22:7:1. The large difference between Cobb trawl catches is attributed to the larger size and two-propeller propulsion system (fore and aft) of the *Langley* creating a greater disturbance than the single propulsion system of the smaller *Restless*.

Correlation between sample variances and means and the magnitude of the variances relative to the means indicated a contagious (clumped) dispersion of blueback herring. In contagious distributions a large catch variance is to be expected. However, the coefficients of variation (independent of mean values) were very similar (Table 1). The similarity of the coefficients indicates that realtive percentage variation in catches was nearly equal for the three vessel-gear combinations used.

Discussion

Other pushnets designed by Faber (1968), Herke (1969), Miller (1973), and Gale and Mohr (1978) did not meet our sampling program needs. They were either limited to plankton sampling, were mounted aft of the bow, or did not have net frames that are readily raised and stored shipboard for vessel cruising and trailering.

Our experiment indicated several favorable aspects of pushnet sampling relative to gear formerly employed. 1) The pushnet catch efficiency for the pelagic juvenile blueback herring was high relative to the Cobb trawl. Trials encompassing day and night sampling are needed to evaluate pelagic species abundance and diversity relative to other sampling gear.

2) The pushnet can be used in shoal water (minimum water depth of 1.2 m), thus eliminating the need for beach access. 3) With minor modifications to the net frame, multiple nets of the same mesh size may be installed to estimate within replicate variability, or different mesh sizes used and contrasted. Presently a modified pushnet frame with three plankton nets is employed. 4) Set and retrieval times for the pushnet are brief. 5) The high cruising speed and ability to trailer the vessel and gear as a unit greatly diminishes the time needed to sample large and disjunct river systems. We anticipate pushnet sampling will be more cost effective than trawl and seine sampling for juvenile alosines and, possibly, juveniles of other near surface pelagic species.

Acknowledgments

The authors wish to thank James Bristow, John Gourley, Carey Peet, and Jon Zernes for their aid in the construction of the pushnet.

References

Chapoton, R. B. 1964. Surface trawl for catching juvenile American shad. The Progressive Fish-Culturist 26:143-144.

Davis, J., J. E. Warriner, and J. P. Miller. 1968. Biology and utilization of anadromous alosids. Annual Report Virginia AFC 1-2. Virginia Institute of Marine Science, Gloucester Point, Virginia. USA.

Davis, J., J. P. Miller, and J. E. Warriner. 1969. Biology and utilization of anadromous alosids. Annual Report. Virginia FAC 1-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. USA.

Faber, D. J. 1968. A net for catching limnetic fry. Transactions of the American Fisheries Society 97:61-63.

Gale, W. F. and H. W. Mohr, Jr. 1978. Larval fish drift in a large river with a comparison of sampling methods. Transactions of the American Fisheries Society 107:46-55.

Herke, W. H. 1969. A boat-mounted surface trawl for sampling juveniles in tidal marshes. The Progressive Fish-Culturist 31:177-179.

Hoagman, W. J., J. V. Merriner, W. H. Kriete, Jr., and W. L. Wilson. 1974. Biology and management of river herring and shad. Annual Report. Virginia AFC 8-1. Virginia Institute of Marine Science, Gloucester Point, Virginia. USA.

Massmann, W. H., E. C. Ladd, and H. N. McCutcheon. 1952. A surface trawl for sampling young fishes in tidal rivers. Transactions of the North American Wildlife Conference 17:386-392.

Miller, J. M. 1973. A quantitive push-net system for transect studies of larval fish and macrozooplankton. Limnology and Oceanography 18:175-178.

Mohr, H. 1969. Detection of fish and observations of fish behavior by echo analysis and passive listening. Pages 101-112 in A. Ben-Tuvia, and W. Dickson, editors. Proceedings of the FAO conference on fish behaviour relation to fishing techniques and tactics. Food and Agricultural Organization of the United Nations. Fisheries Report FRm/R62.2 (Tri).

Mohr, H. 1971. Behavior patterns of different herring stocks in relation to ship and midwater trawl. Pages 368-371. in H. Kristjonsson, editor. Modern Fishing Gear of the World, Vol. 3. Fishing News Ltd., London.

Okonski, S. 1969. Echo sounding observations of fish behavior in the proximity of the trawl. Pages 377-388 in A. Ben-Tuvia and W. Dickson, editors. Proceedings of the FAO conference on fish behaviour in relation to fishing techniques and tactics. Food and Agricultural Organization of the United Nations. Fisheries Report FRm/R62.2 (Tri).

Olsen, K. 1971. Influence of vessel noise on behavior of herring. Pages 291-294. in H. Kristjonsson, editor. Modern Fishing Gear of the World, Vol. 3. Fishing News Ltd., London.

Saetersdal, G. 1969. Review of information on the behaviour of gadoid fish. Pages 201-215 in A. Ben-Tuvia and W. Dickson, editors. Proceedings of the FAO conference on fish behaviour in relation to fishing techniques and tactics. Food and Agricultural Organization of the United Nations. Fisheries Report FRm/R62.2 (Tri).

Trent, W. L. 1967. Attachment of hydrofoils to otter boards for taking surface samples of juvenile fish and shrimp. Chesapeake Science 8:130-144.

Table 1. Blueback herring catch statistics for 219 pushnet and cobb trawl samples.

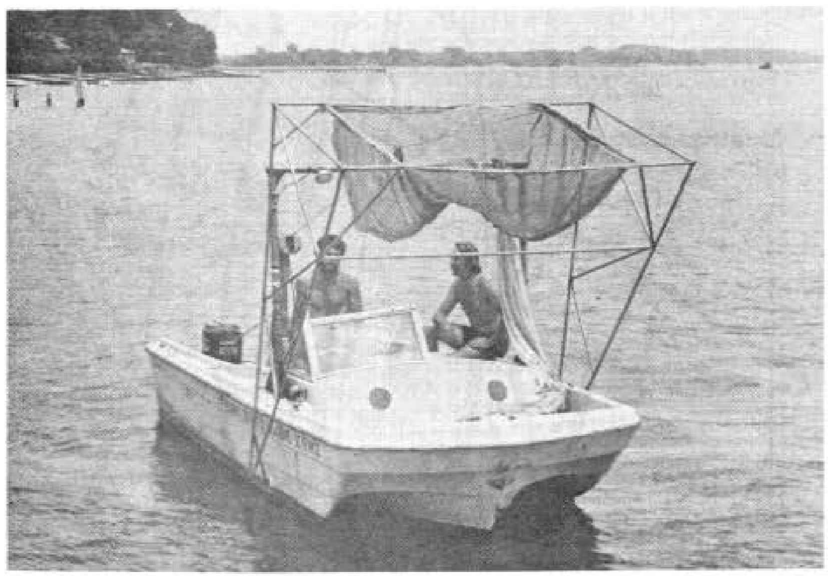
	Net Type		
	Cobb[1]	Cobb[2]	Pushnet
Replications	73	73	73
Total catch	1,465	4,506	31,637
Mean catch	20.0	61.7	433.4
Standard deviation	34.53	77.36	537.62
Coefficient variation	1.7	1.2	1.2

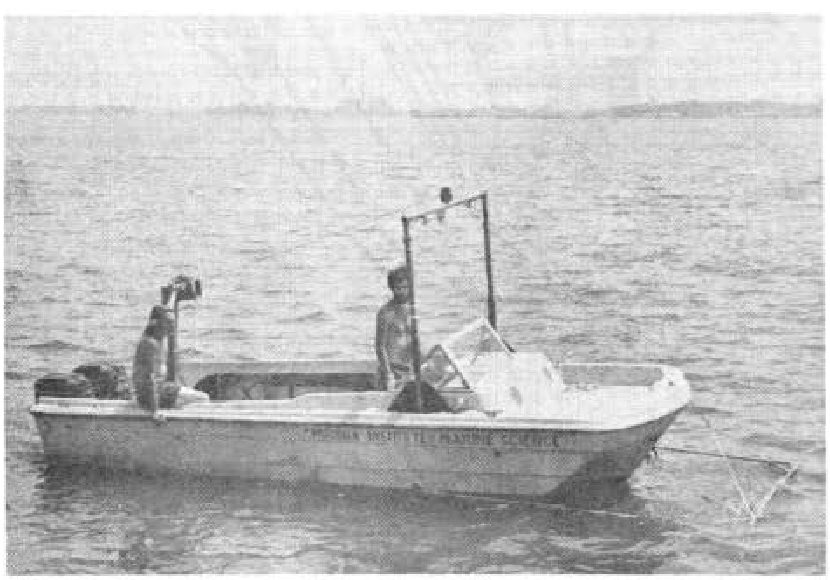
[1] R/V *Langley*

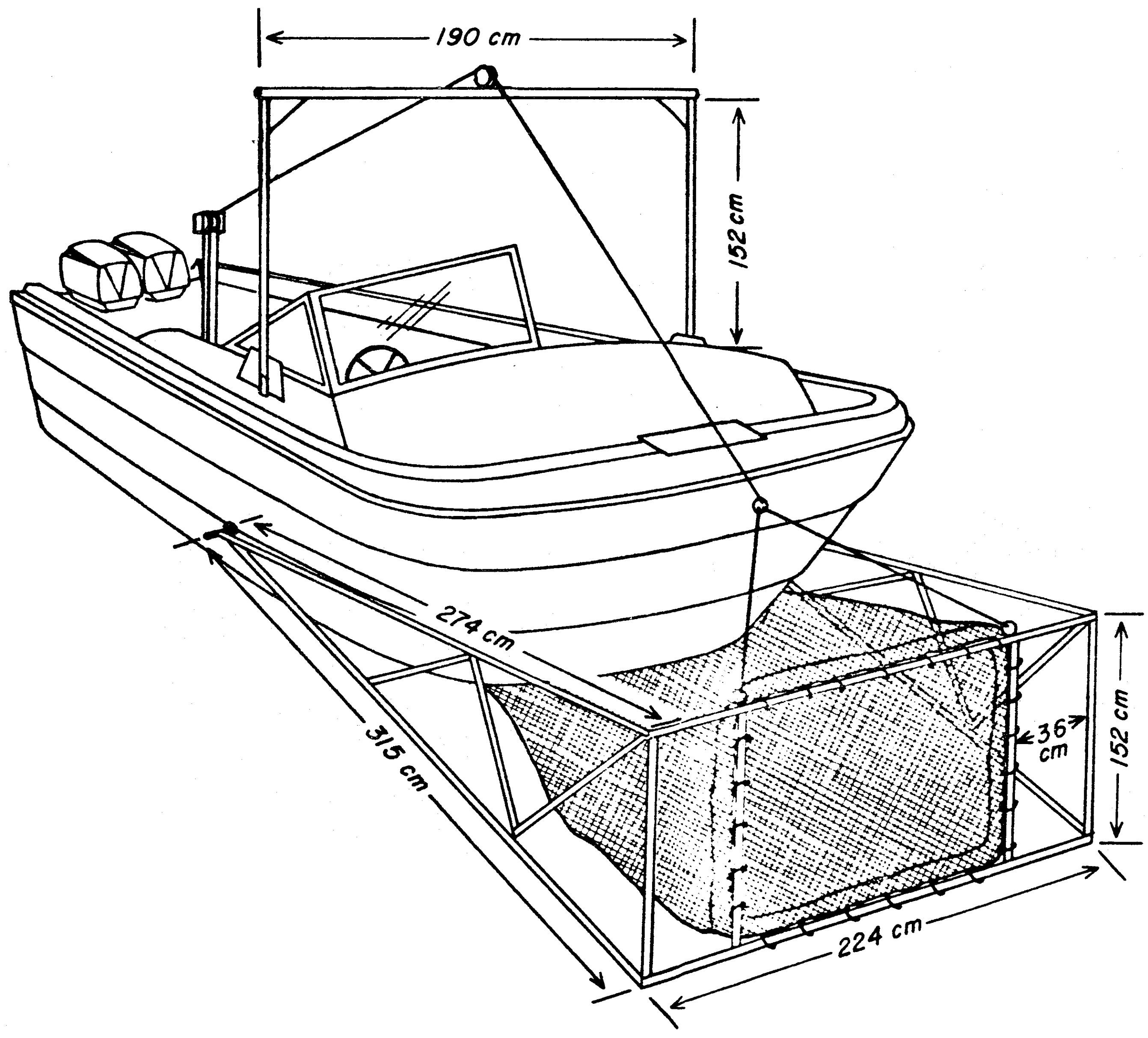
[2] R/V *Restless*

Figure 1. (a) Trailering (b) cruising and (c) sampling positions of the push net.

Figure 2. Schematic diagram of push net.






190 cm
152 cm
274 cm
315 cm
36 cm
152 cm
224 cm

Appendix II

Effects of Varying Light Intensity on the Availability of Anadromous Juvenile *Alosa* to Bottom and Surface Nets.

by

Joseph G. Loesch, William H. Kriete, Jr., and Eric J. Foell

Effects of Varying Light Intensity on the Availability of Anadromous Juvenile *Alosa* to Bottom and Surface Nets.

Joseph G. Loesch, William H. Kriete, Jr.,
and Eric J. Foell

Virginia Institute of Marine Science
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

Abstract

Trawl catches indicated diel migratory activities by young-of-the-year alewife *(Alosa pseudoharengus)*, American shad *(A. sapidissima)*, and blueback herring *(A. aestivalis)*. Catches in the bottom trawl during day were significantly greater than catches at night; conversely, with the surface trawl, catches at night were significantly greater than catches in the day. A spatial separation of the bulk of the alewife and blueback herring stocks which could serve to reduce feeding competition, was also indicated by our findings. An inverse association between pushnet catches and the National Weather Service sky opacity index values indicated that changes in blueback herring availability were due to a negative phototropic behavior of the fish or by dietary species they followed. We concluded that conflicting measures of the relative abundance of juvenile *Alosa* could result from an inappropriate choice of sampling gear relative to day or night sampling, and from the effects of varying light intensity when sampling surface waters.

The anadromous clupeids, alewife *(Alosa pseudoharengus)*, American shad *(A. sapidissima)*, and blueback herring *(A. aestivalis)*, are important commercial species in most east coast states. In Virginia, gill nets, with mesh sizes selective for the larger females, are the principal gear in the American shad fishery. Alewife and blueback herring, collectively referred to as river herring, are primarily caught with pound nets. We believe the pound nets to be nonselective for river herring age 3 and older because of the 50.8 mm stretched mesh used in their entrapment portion (Meyer and Merriner 1976). Annual sampling of adult alewife and blueback herring in Virginia from 1974 to 1979 indicated that blueback herring comprised, on the average, about 70% of the commercial river herring landings (Loesch et al. 1979). However, blueback herring relative to alewives represented 95% of the juveniles (young-of-the-year) in annual collections in surface waters of tidal freshwater nursery zones from 1972 to 1979 (Loesch et al. 1979). These findings indicated either highly differential mortality rates for the alewife and blueback herring or differential availability of the juveniles to the surface trawls employed. Differences in availability were more suspect because of the inability to capture landlocked alewives in the surface waters with gill nets and electrofishing during daylight hours while they were readily collected at night (Lindenberg 1976). More recent studies of landlocked alewives (Brandt 1980; Janssen and Brandt 1980; and Kohler and

Ney 1980) corroborated Lindenberg's findings. The role of light in the vertical migration of marine fishes was reviewed by Woodhead (1966) and Blaxter (1975), however, little is known about the vertical migration of the andromous *Alosa* species.

The purpose of our study was to compare the availability of the anadromous juvenile *Alosa* to surface and bottom gear in daytime and nighttime sampling, as indicated by catches in standardized samples.

Methods

Trawl Sampling

Simultaneous bottom and surface trawl tows were made in the daytime and nighttime in the Mattaponi River, Virginia on 26-28 September 1977 to evaluate the availability of juvenile alewife, American shad, and blueback herring. The Mattaponi, a relatively clear water system, was selected in order to maximize possible light intensity effects on the vertical distribution of these juvenile *Alosa*.

The juvenile *Alosa* were collected in bottom waters with 5-minute tows of a semi-balloon trawl, pulled by the R.V. *Langley*. The bottom trawl had a 9.4-m headrope and a 3.8-cm stretched mesh with a 1.3-cm stretched mesh liner in the cod end. The R.V. *Langley* is a 24.4-m steel hull ferryboat converted for trawling. Juvenile *Alosa* in surface waters were collected with 5-minute tows of a 1.5 x 1.5-m Cobb trawl, pulled by the R.V. *Restless*. The Cobb trawl had a 3.5-m headrope and a 1.9-cm stretched mesh with a 1.3-cm cod end. The R.V. *Restless* is a 9.7-m wooden Chesapeake Bay deadrise hull.

The two vessel-gear combinations were used simultaneously to obtain 56 paired day and 34 paired night samples. Tows were made with and against the current and at slack water in maximum water depth (about 5 m). Vessel positions relative to the shoreline were randomized within a centralized section of the *Alosa* nursery zone in the Mattaponi River, river kilometers 40.8 to 44.5.

Trial sampling was conducted with calibrated flowmeters suspended 38 cm below the midpoint of the top netting of both the bottom and surface trawls. The purpose was to ascertain the effect of sampling direction, relative to current direction, on the mean volume of water filtered.

Pushnet Sampling

The availability of the three juvenile *Alosa* species in surface waters with varying light intensity was also examined in a turbid system, the James River, Virginia, on 18-20 October 1978. Five-minute samples were collected with a rigid bow-mounted 1.5 x 1.5-m framed pushnet mounted on a 5.5-m fiberglass cathedral hulled outboard boat. The net, described in detail by Kriete and Loesch (1980), is constructed of 1.9-cm stretched mesh with a 1.3-cm stretched mesh cod end. Twenty pushnet samples were taken with each of three varying light conditions (night, completely overcast day, and a relatively clear day) during a 38-hour period. Sampling sites were randomly chosen within a centralized section of the *Alosa* nursery zone, river kilometers 115.8 to 119.5, with a shoreward limitation of 2 m water depth. The difference in incident light between the overcast and clear days was appraised from the sky opacity index values recorded by the National Weather Service at Richmond, Virginia. The index values, recorded hourly, can range from zero (completely clear sky) to 10 (completely overcast sky).

Trial sampling was also conducted with a calibrated flow-meter in the pushnet to estimate the mean volume of water filtered relative to sampling direction. The meter was suspended at 0.75 m height and 0.5 m in from the portside.

Data Analysis

Two preliminary concerns were first analyzed. One concern was that mean volume of water filtered by each gear and, thus, the sampling unit, varied with sampling direction relative to the current. The second concern was that repeated sampling and/or downstream migration significantly reduced fish density and subsequently, lead to erroneous conclusions about the availability of a species.

A fixed effects analysis of variance model (ANOVA) was used to analyze trawl and pushnet catches. The Student-Newman-Keuls test (SNK; $\alpha = 0.05$) was used for further comparison of mean catches when the ANOVA analysis indicated significance.

Catches of each species by each gear were analyzed separately. Although the spawning periods of the three *Alosa* species overlap, the bulk of alewife and American shad spawning precedes that of the blueback herring. Data from our previous surveys indicated a tendency for some of the large individuals of juvenile alewife and American shad to move downriver to saline water before any noticeable movement by blueback herring. Thus, comparisons of relative abundance among the three species at the time of our sampling in this study could be misleading. Also, no statistical analysis was made between surface and bottom trawl catches because the relationship between the fishing powers of the two vessel-gear combinations is unknown. Pushnet data were few for American shad (N = 1) and, therefore, omitted.

In all analyses, catch (X_i) was transformed to $\log_{10}(X_i + 1)$. The general linear models routine in the SAS program system (Helwig and Council 1979) was used for the ANOVA analysis.

Results

Preliminary Analyses

The mean volumes of water strained by the semi-balloon bottom trawl in trial 5-minute tows were 2,247 and 2,197 m^3, with and against the current, respectively. A t test indicated that the mean volumes were not significantly different ($P > 0.60$); accordingly, the data were pooled for an overall mean estimate of 2,220 m^3 of water filtered. Similarly, the mean volumes of water strained in 5-minute tows with and against the current with the surface Cobb trawl were not significantly different (1,247 and 1,270 m^3, respectively; $P > 0.70$). The estimated mean volume of water filtered for the pooled data was 1,259 m^3. We concluded that the volume of water filtered by the trawls in samples taken with and against the current was not a variable of concern with respect to catch data analysis. No slack water determinations were made; however, the percentage of slack water tows were near equal in daytime (9%) and nighttime (11%) sampling. Sampling trials with the flowmeter in the pushnet also indicated that the volume of water filtered in 5-minute samples was not a function of sampling direction. On the average, the pushnet strained 654 m^3 of water both with and against the current and 663 m^3 at slack water. An ANOVA test of the mean volumes was not significant ($P > 0.75$). The mean volume of water filtered for the pooled data was 655 m^3.

To test the hypothesis that sampling and/or downriver migration did not produce a declining trend in abundance, log-transformed catches were regressed on time. The significance of the regression coefficient was tested (t test of the Ho: $\beta = 0$) for each sampling period. In all tests, the hypothesis $\beta = 0$ was accepted; probabilities ranged from $P > 0.05$ to $P > 0.90$ with $\bar{P} > 0.30$. We concluded that neither sampling or migration significantly reduced *Alosa* densities.

Trawl Catches

By inspection, the catch statistics (Table 1) indicated that the greatest availability of the three juvenile *Alosa* species to the bottom trawl occurred during the day. Conversely, availability to the surface trawl was greatest at night. ANOVA analyses substantiated these conclusions. The mean catches of alewife, American shad, and blueback herring in the bottom trawl in daytime sampling were each significantly greater than their respective mean catches at night ($P < 0.0001$ for alewife and American shad; $P < 0.04$ for blueback herring). The geometric mean difference ($\bar{G}$) between daytime and nighttime bottom trawl catches of alewives was 7.3 with 95% interval limits of 2.7 and 20. Similarly, for American shad and blueback herring, $\bar{G} = 6.0$ and 1.3, with interval limits of 3.7 and 10, and 0.23 and 2.2, respectively. In contrast, the mean catch of each *Alosa* species with the surface trawl at night was significantly greater than the mean catch in the day ($P < 0.0001$ for all species). For the alewife, $\bar{G} = 1.7$ with interval limits of 1.4 and 2.0; for American shad $\bar{G} = 6.3$ with interval limits of 4.5 and 8.8, and for blueback herring, $\bar{G} = 71$ with interval limits of 53 and 95.

The pattern of alewife and blueback herring availability to the pushnet in the James River was similar to that of the surface trawl-net samples in the Mattaponi River. Blueback herring were captured in both day and night sampling, but alewives were taken only at night and their numbers were few relative to the blueback herring (Table 2). The geometric mean catch of alewives for nighttime catches was 14, with interval limits of 11 and 21.

The magnitude of the blueback herring catches was inversely associated with relative light intensity; 46.7% were taken at night, 34.7% on the overcast day, and 18.6% on the relatively clear day. The difference in the daytime catches can be related to the sky opacity index values. On 19 October during the sampling period 0956 to 1155 h the opacity index had a constant value of 10; in contrast, during the sampling period 0955 to 1255 h on 20 October the index had a constant value of three. The ANOVA analysis of blueback herring catches was significant ($P < 0.0001$), and the subsequent SNK tests were significant for all three contrasts of mean catches. The geometric mean differences between nighttime catches and overcast and clear day catches were 330 and 789, with internal limits of 227 and 476, and 545 and 1,143, respectively. For the overcast and clear day contrast, $\bar{G} = 459$, with interval limits of 317 and 665.

Discussion

Our findings indicated that conflicting measures of the relative abundance of juvenile *Alosa* could result from an inappropriate choice of sampling gear relative to day or night sampling, and from the effects of varying light intensity when sampling surface waters.

The superiority of daytime catches to nighttime catches of *Alosa* with the bottom trawl, and the converse situation with the surface trawl indicated diel migratory activities. Net avoidance in the daytime could account for the decreased catches by the surface gear but it would not account for the decreased catches at night with the bottom trawl. The concentration of alewives in bottom waters during day with an upward migration at night has been reported for landlocked stocks (Lindenberg 1976; Brandt 1980; and Janssen and Brandt 1980). In contrast to our findings and those reported for landlocked alewives, Kernehan (1974) captured more anadromous juvenile alewives in day surface samples than at night; however, the data were few (30 fish).

A spatial separation of the bulk of the alewives and blueback herring was also suggested by our findings. There was a high occurrence of alewives (57%) relative to blueback herring (18%) in the daytime bottom-trawl total catch, while few alewives (1%) relative to blueback herring (90%) were captured in the surface trawl at night. Additionally, and contrary to blueback herring availability, no alewives were captured during the daytime by the surface trawl or the pushnet. Brandt (1980) reported that landlocked alewives did not exhibit offshore-onshore migrations along the bottom. Thus, we suspect that there is also a vertical separation of juvenile anadromous alewives and blueback herring, although the horizontal aspect was not investigated. Regardless of the nature of the separation, it could serve to reduce feeding competition between alewives and blueback herring since their reported diets are identical (Davis and Cheek 1966; Burbidge 1974; Weaver 1975) but differ from the diet reported for American shad (Walburg 1957; Massman 1963; Davis and Cheek 1966; Levesque and Reed 1972; Marcy 1976; Domermuth and Reed 1980).

The 1977 trawl catches indicated general diel migratory activities. However, the inverse association between the 1978 pushnet catches and the opacity index values indicated that changes in blueback herring availability were due to a negative phototropic behavior by the fish or, perhaps, dietary species they followed. Janssen and Brandt (1980) found that the extent and timing of vertical migrations of *Mysis* and landlocked alewife coincided. They concluded from an examination of stomach contents of alewives that *Mysis* was the major food item and alewife vertical migration was a function of their feeding behavior.

Acknowledgments

Funding was provided by the U.S. National Marine Fisheries Service, Northeast Region through Public Law 89-304. We are also indebted to Robert E. Taber, Wakefield, R.I. for his technical assistance in determining net openings.

References

Blaxter, J. H. S. 1975. The rôle of light in the vertical migration of fish--a review. Pages 189-210 *in* G. C. Evans, R. Bainbridge and O. Rackham, editors. Light as an ecological factor: II, British Ecological Society Symposium No. 16, Blackwell Scientific Publications, Oxford, England.

Brandt, S. B. 1980. Spatial segregation of adult and young-of-the-year alewives across a thermocline in Lake Michigan. Transactions of the American Fisheries Society 109: 469-478.

Burbidge, R. G. 1974. Distribution, growth, selective feeding, and energy transformations of young-of-the-year blueback herring, *Alosa aestivalis* (Mitchill), in the James River, Virginia. Transactions of the American Fisheries Society 103:297-311.

Davis, J. R., and R. P. Cheek. 1966. Distribution, food habits, and growth of young clupeids, Cape Fear River System, North Carolina. Proceedings of the 20*th* Annual Conference, Southeastern Association of Game and Fish Commissioners 250-260.

Domermuth, R. B., and R. J. Reed. 1980. Food of juvenile American shad, *Alosa sapidissima*, juvenile blueback herring, *A. aestivalis*, and pumpkinseed, *Lepomis gibbosus*, in the Connecticut River below Holyoke Dam, Massachusetts. Estuaries 3:65-68.

Helwig, J. T., and K. A. Council (editors). 1979. SAS user's guide.

Janssen, J., and S. B. Brandt. 1980. Feeding ecology and vertical migration of adult alewives *(Alosa pseudoharengus)* in Lake Michigan. Canadian Journal of Fisheries and Aquatic Sciences 37:177-184.

Kernehan, R. J. 1974. Early life history and seasonal, horizontal and vertical distribution patterns of ichthyoplankton collected in the Chesapeake and Delaware Canal in 1973. Masters Thesis. University of Massachusetts, Amherst, Massachusetts, USA.

Kohler, C. C., and J. J. Ney. 1980. Piscivority in a landlocked alewife *(Alosa pseudoharengus)* population. Canadian Journal of Fisheries and Aquatic Sciences 37:1314-1317.

Levesque, R. C., and R. J. Reed. 1972. Food availability and consumption by young Connecticut River shad *Alosa sapidissima.* Journal of the Fisheries Research Board of Canada 29:1495-1499.

Lindenberg, J. G. 1976. Seasonal depth distribution of landlocked alewives, *Alosa pseudoharengus* (Wilson), in a shallow, eutrophic lake. Transactions of the American Fisheries Society 105:395-399.

Loesch, J. G., W. H. Kriete, Jr., J. G. Travelstead, E. J. Foell, and M. A. Hennigar. 1979. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Part II: Virginia. Completion Report 1977-1979. National Marine Fisheries Service Project No. AFC 8-1 to 8-3.

Marcy, B. C., Jr. 1976. Early life history studies of American shad in the lower Connecticut River and the effects of the Connecticut Yankee Plant. Pages 141-168 in D. Merriman and L. M. Thorpe, editors. The Connecticut River ecology study. American Fisheries Society Monograph No. 1.

Massman, W. H. 1963. Summer food of juvenile American shad in Virginia waters. Chesapeake Science 4:167-171.

Meyer, H. L., and J. V. Merriner. 1976. Retention and escapement characteristics of pound nets as a function of pound-net mesh size. Transactions of the American Fisheries Society 105:370-379.

Walburg, C. H. 1957. Observations on the food and growth of juvenile American shad, *Alosa sapidissima.* Transactions of the American Fisheries Society 86:302-306.

Weaver, J. E. 1975. Food selectivity, feeding chronology, and energy transformations of juvenile alewife *(Alosa pseudoharengus)* in the James River near Hopewell, Virginia. Doctoral dissertation. University of Virginia, Charlottesville, Virginia, USA.

Woodhead, P. M. J. 1966. The behavior of fish in relation to light in the sea. Pag-s 337-403 *in* H. Barnes, editor. Oceanography and marine biology, an annual review, Volume 4. George Allen and Unwin, London, England.

[1]Contribution No.____, Virginia Institute of Marine Science and School of Marine Science, College of William and Mary, Gloucester Point, Virginia 23062.

Table 1. Data summary of juvenile alewife, American shad, and blueback herring caught in day and night sampling with bottom and surface trawls in the Mattaponi River, Virginia, 26-28 September 1977.

Bottom trawl

Species:	Alewife		American shad		Blueback herring	
Time:	Day	Night	Day	Night	Day	Night
Replications:	56	34	56	34	56	34
Total catch:	2,229	3	962	13	684	35
Mean catch:	40	0.09	17	0.38	12	1.0

Surface trawl

Species:	Alewife		American shad		Blueback herring	
Time:	Day	Night	Day	Night	Day	Night
Replications:	56	34	56	34	56	34
Total catch:	0	34	136	349	20	3,459
Mean catch:		1	2.4	10	0.36	102

Table 2. Data summary of juvenile alewife and blueback herring caught in pushnet surface-water samples with varying light conditions in the James River, Virginia, 18-20 October 1978.

Species:	Alewife			Blueback herring		
Time:	Night	Overcast	Clear	Night	Overcast	Clear
Replications:	20	20	20	20	20	20
Total catch:	378	0	0	23,786	14,979	7,713
Mean catch:	19			1,189	749	386

APPENDIX III

PAPERS PRESENTED

[1]Lipton, D. W. and J. G. Travelstead. 1980. Beach zone fish community structure in the James River, Virginia. Proc. Annu. Conf. S.E. Assoc. Fish Wildl. Agencies. 32:639-647.

[1]Kriete, W. H., Jr., J. V. Merriner and H. M. Austin. 1980. Movement of 1970 yearclass striped bass between Virginia, New York, and New England. Proc. Annu. Conf. S.E. Assoc. Fish Wildl. Agencies. 32:692-696.

[1]Kriete, W. H., Jr. and J. G. Loesch. 1977. Status and distribution of alosine stocks in Chesapeake Bay. Pages 47-82. In Proceedings of a Workshop on American Shad. Dec. 14-16, 1976, Amherst, MA. U. S. Fish Wildl. Serv. Spec. Publ.

[1]Loesch, J. G., J. V. Merriner, and W. H. Kriete, Jr. 1978. Changes in the abundance and age structure of river herring in Virginia. Amer. Soc. Limnol. Oceangr. Presented to the 41st Annual Meeting, Univ. of Victoria. Victoria, British Columbia.

---

[1]Abstract on page 193 , 194 , 195 , 196 .

Beach Zone Fish Community Structure in the James River, Virginia

ABSTRACT

A seining survey of the fish fauna of the beach zone in the James River, Virginia, was conducted from July to December 1977. Weekly collections were made at 4 stations resulting in the capture of 17,602 individuals representing 36 species. Abundance and diversity were influenced by large catches of schooling and migratory species utilizing nearshore areas as a nursery ground. Freshwater species diversity peaked in August and September, while mesohaline species diversity peaked in July, September, and November. Cluster analysis was used to define 3 freshwater station groups representing warm, moderate, and cool water temperatures, but was not helpful in analyzing mesohaline stations.

Movement of 1970 Yearclass Striped Bass, Between Virginia, New York, and New England.

ABSTRACT

Striped bass (Morone saxatilis) were tagged in Virginia beginning in 1968. The 1970 yearclass of striped bass was tagged both in Virginia and New York in 1972. Fish tagged in Virginia were returned from New York to Maine while fish tagged in New York were returned from the Maryland portion of the Chesapeake Bay and the Potomac River. These data indicate that fish migrate from rivers in which they were spawned at different ages and that fish that migrate as 2-year-olds remain together as a group until they are 3+ years. Therefore, within the Chesapeake Bay area there are distinct river populations at least until these populations are 3+ years old.

Status and Distribution of Alosine Stocks in Chesapeake Bay

ABSTRACT

The Virginia Institute of Marine Science has assessed the stocks of alosine fishes in the Virginia waters of Chesapeake Bay since 1967. Total landings have declined from the late 1960's to the present. The number of pound nets fished declined from 332 to 200 units during 1967 to 1973, but has since increased slightly to 245 nets in 1976. Stake gill net effort increased in the James, York and Rappahannock rivers from 1969 to 1975 but declined in 1976 due to a limited fishing season in the James River as a result of Kepone contamination.

The combined American shad catch-per-unit-of-effort (CPUE) by stake gill nets in the James, York, and Rappahannock rivers increased from 1969 to 1972, but then decreased until it rose sharply again in 1976. The CPUE in the James River for shad declined from 30,000 lb. in 1972 to 5,000 lb. in 1975, but increased to 21,000 lb. in 1976. The CPUE for shad in the York and Rappahannock rivers similarly declined from 1971 to 1975 but did not recover in 1976 to the extent observed in the James River. The CPUE of shad by pound nets in the Rappahannock River declined from 7,384 lb. in 1968 to 125 lb. in 1976, and the CPUE of river herring (alewife and blueback) decreased 91% from 1967 to 1976.

All shad fishing gear in the Potomac River reflected a downward trend in CPUE from 1968 to 1976, and river herring CPUE has declined about 87% from 1967 to 1976.

Changes in the Abundance and Age Structure

of River Herring in Virginia.

ABSTRACT

Two events in the recent past affected the abundance and age structure of river herring (alewife and blueback herring) in the Virginia commercial fishery.

The first event was the development of an intense river herring fishery by foreign fishing vessels off the Virginia Capes and Delmarva Peninsula in the late 1960's. A reduction in Virginia landings and the proportion of older fish followed the advent of this fishery. North Carolina river herring landings exhibited a similar decline.

The second event was the occurrence of Tropical Storm Agnes in 1972 which apparently decimated the 1972 river herring yearclass.

A drastic decline in the 1972 year-class recruitment in Virginia in 1976, but not in North Carolina (relatively unaffected by Agnes), implies separate inshore stocks of river herring for the two states.

REPORTS

Johnson, H. B., D. W. Crocker, B. F. Holland, Jr., J. W. Gilliken, D. L. Taylor, M. W. Street, J. G. Loesch, W. H. Kriete, Jr., and J. G. Travelstead. 1978. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. North Carolina-Virginia AFCS 9-2. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 175 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. Annu. Rep. North Carolina-Virginia AFCS 9-1. North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina and Virginia Institute of Marine Science, Gloucester Point, Virginia. 183 p.

PUBLICATIONS

Kriete, W. H., Jr., and J. G. Loesch. 1977. Status and distribution of alosine stocks in Chesapeake Bay. Pages 47-82 in Proceedings of a workshop on American shad, Dec. 14-16, 1976, Amherst, MA. U.S. Fish Wildl. Serv. Spec. Publ.

Kriete, W. H., Jr., and J. G. Loesch. 1980. Design and relative efficiency of a bow-mounted pushnet for sampling juvenile pelagic fishes. Trans. Amer. Fish. Soc. 109:649-652.

Loesch, J. G., R. H. Huggett, and E. J. Foell. 1982. Kepone concentration in juvenile anadromous fishes. Estuaries 5:In press.

MANUSCRIPTS

[1]Johnson, J. G., and J. G. Loesch. Morphometric comparisons between laboratory reared and wild juvenile American shad, *Alosa sapidissima* (Wilson).

[1]Johnson, J. G., J. G. Loesch, and A. Blair. Description of eggs and larvae, and osteological development of laboratory reared American shad, *Alosa sapidissima* (Wilson).

[2]Lipton, D. W., and J. G. Loesch. Comparison of scales and otoliths for determining age and growth of the alewife, *Alosa pseudoharengus* (Wilson).

[2]Loesch, J. G., W. H. Kriete, Jr., and E. J. Foell. Effects of varying light intensity on the avilability of three anadromous juvenile *Alosa* to a pushnet and bottom and surface trawls.

[1]Loesch, J. G., W. H. Kriete, and J. V. Merriner. Changes in the abundance and age structure of alewives and blueback herring in Virginia.

[2]Travelstead, J. G., and J. G. Loesch. A comparison of blueback herring (*Alosa aestivalis*) age and growth estimates from otoliths and scales.

[1]In preparation.
[2]Submitted to professional journals.

STUDENT THESES

Johnson, James R. Description of eggs and larvae, and osteological development of laboratory reared American shad, *Alosa sapidissima* (Wilson). (In preparation).

[1]Lipton, Douglas W. Comparison of scales and otoliths for determining age and growth of the alewife, (*Alosa pseudoharengus*, Wilson).

[1]Travelstead, Jack G. Age determination and growth of the blueback herring, *Alosa aestivalis*.

---

[1]Abstract on pages 200 , 201 .

Comparison of Scales and Otoliths for Determining Age and Growth of the Alewife (*Alosa pseudoharengus*, Wilson).

ABSTRACT

Otoliths were validated for determining the age of alewives, *Alosa pseudoharengus*, in Virginia. Reader agreement was 83% for otoliths and 77% for scales. Agreement was poor (45%) between otolith and scale ages. The age structure established from otoliths was younger than that from scales.

Mean observed lengths-at-age from the two ageing methods were similar. Fork length on otolith and scale radius regressions were linear. Walford lines based on back-calculated lengths were significantly different for males and females when otoliths were used for ageing but not when scales were used.

Von Bertalanffy growth curves were computed for males and females from back-calculations by both ageing methods. Total length-fork length and weight-length relationships were calculated.

It was concluded that otoliths were more precise and efficient than scales for age and growth studies of Virginia alewives because of the inherent reading problems of scales (erosion, regeneration, etc.) and scale loss or damage sustained in the commercial fishery.

Age Determination and Growth of the Blueback Herring, *Alosa aestivalis*.

ABSTRACT

Blueback herring were collected during the 1977 spawning run in Herring Creek, Virginia to: 1) validate the otolith ageing method for this species; 2) compare the level of agreement between scale and otolith ageing methods; 3) establish von Bertalanffy growth curves for each sex; and 4) contribute to the descriptive biology of blueback herring in Virginia. Of the 519 specimens examined, 459 otoliths and 442 scales were suitable for ageing.

Seasonal changes in the appearance of the otolith edge of young-of-the-year blueback herring indicated that one hyaline and one opaque zone are formed annually. In general, mean observed fork lengths-at-age agreed with mean back-calculated lengths-at-age. Agreement in age assignment between two readers was 82% for scales and 84% for otoliths. Scale and otolith ages agreed in 81% of 344 comparisons. There was no significant difference in the two age frequency distributions. The fork length-scale radius and fork length-otolith radius relationships were linear with no significant sexual differences. Mean lengths-at-age back-calculated from otoliths were larger than mean lengths back-calculated from scales, but the differences were not significant for ages 4 through 9. Mean calculated fork lengths-at-age were used to develop von Bertalanffy growth curves. There were no significant differences between these theoretical lengths-at-age and observed lengths-at-age for both scale and otolith ageing methods.

Otoliths were more efficient than scales for ageing blueback herring. The otoliths did not require sectioning or grinding because of their small size. Also, otoliths did not require cleaning, mounting, and pressing as did the scales. Thus, although otoliths required more time for removal, overall preparatory time was much less. One advantage of scales is that they provide a spawning history.

The Herring Creek spawning run lasted 54 days. The age composition and spawning frequency were indicative of the decline of blueback herring in Virginia.

PUBLIC AWARENESS[1]

Leaflet:

Spring Resource...The American Shad. Virginia Institute of Marine Science, Sea Grant Marine Advisory Service and Virginia Seafood Council. 1978.

Shad - A diminishing resource. in Virginia Seascope. Virginia Seafood Council, Spring 1979. 3:(1).

A new roe knife. Marine Resource Advisory. Sea Grant Advisory Service. Virginia Institute of Marine Science. 1979. Adv. No. 15. (This article also appeared in The National Fisherman, Vol. 59, No. 11).

Poster:[2]

Request for information on Sturgeon.

---

[1]Distributed by VIMS Advisory Services, Va. Seafood Council, retail seafood outlets, commercial seafood houses, Virginia State Fair (VIMS Booth).

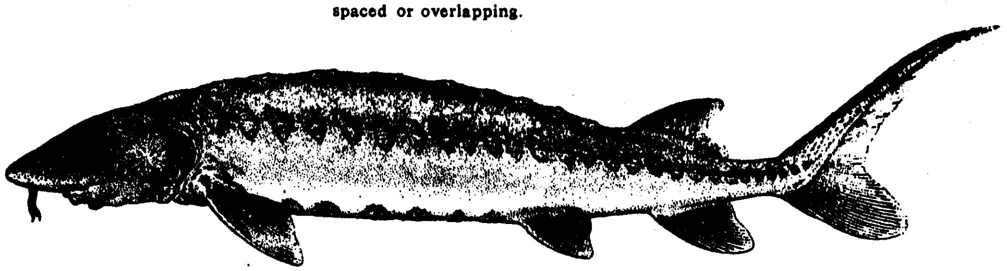
[2]Reproduction on page 204 .

-WANTED-

INFORMATION ON STURGEON

- ATLANTIC STURGEON -

Distinguishing Features: Snout long, pointed, curved upward, narrow at base; Plates on top of back closely spaced or overlapping.



- SHORT-NOSED STURGEON -

Distinguishing Features: Snout short, blunt, wide at base; Plates on top of back with space between them.

PROTECTED SPECIES: It is illegal by Virginia law to take sturgeon from Virginia waters. The short-nosed sturgeon, an endangered species, is also protected by federal law.

INFORMATION NEEDED: The Virginia Institute of Marine Science requests anyone who catches a sturgeon to measure its length (from tip of snout to fork in tail), and weight. Live fish should be returned to the water immediately; Dead fish held for pick-up by VIMS personnel. Date caught, location and type of gear should also be given.

CALL OR WRITE:

VIRGINIA INSTITUTE OF MARINE SCIENCE
Ichthyology - Sturgeon
Gloucester Point, Virginia 23062
(804) 642-2111 ext. 269