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Study of Alosa stock composition and year-class strength in Virginia: Annual Report 1984

Joseph G. Loesch
Virginia Institute of Marine Science

William H. Kriete Jr.
Virginia Institute of Marine Science

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Prepared by

Joseph G. Loesch and William H. Kriete, Jr.

Virginia Institute of Marine Science

School of Marine Science

College of William and Mary

Gloucester Point, Virginia 23062

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PREFACE

This presentation is the annual report for P. L. 89-304, AFC 13-1 project "Study of Alosa stock composition and year-class strength in Virginia," for the period 1 January 1984 to 31 December 1984. The fishes of concern were the alewife (Alosa pseudoharengus), American shad (A. sapidissima), and the blueback herring (A. aestivalis).

The Alosa species were once an important component of the landings of Virginia fisheries. In the last decade, however, there has been a dramatic decrease in American shad and river herring landings. The 1981 landings of Alosa species in Virginia were the lowest ever recorded. American shad and river herring are also sought by recreational fishermen in Virgina; however, data are few and the extent of this activity is unknown. Additionally, these species have a vital ecological role. Young-of-the-year Alosa are the dominant pelagic prey species in their extensive freshwater and upper estuarine nursery grounds. After spawning, adults return to the sea and are prey of many marine piscivores. It is important that studies of the Alosa stocks in Virginia be continued. Current data, as well as historical data, are needed in order that analyses are constructive contributions to rational management strategies.

The research presented herein directly addresses research concerns stated in the Shad and River Herring Action Plan and augments on-going monitoring research and extant data bases. These data will be a pertinent contribution to the total data base that is being constructed to assist in the formulation of management strategies for the east coast Alosa stocks.

The following jobs were contracted by the Virginia Institute of Marine Science.

Job 1: Evaluation of the Alosa Stocks and Fisheries in Virginia

Objectives

1. Estimate fishing effort, landings, and catch-per-unit-of-effort (CPUE) of adult river herring (alewife and blueback herring) and American shad in Virginia during the 1984 fisheries.
2. Determine the present status of the stocks relative to former years by comparison of landings and CPUE.
3. Estimate current biological statistics (age and size frequencies, species composition, etc.) of river herring and American shad.
4. Estimate the total contributions of year classes to the river herring fishery.

Job 2: A Study of Juvenile Alosa Abundance Growth and Mortality

Objectives

1. Determine an index of abundance for juvenile river herring and American shad.
2. Estimate growth and mortality rates of juveniles in tidal freshwater.

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The project was funded, in part, by the United States National Marine Fisheries Service, Northeast Region, through Public Law 89-304.

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EXECUTIVE SUMMARY

1. Landings in Virginia of all Alosa species increased in 1984 relative to 1983. Since overall effort declined, catch-per-unit-of-effort (CPUE) also increased. It was the third successive year that Alosa landings in Virginia increased.
2. Five hundred and seventy-two metric tons (MT) of river herring and 8.2 MT of American shad were landed from pound nets in the York and Rappahannock rivers.
3. Gill net fishermen landed an estimated 478 MT of American shad in the James, York and Rappahannock rivers.
4. Age 6 blueback herring remained a strong component of the pound net catches in 1984 whereas age 6 alewife comprised less than 9% of the catches.
5. Mean estimates of total mortality ($\bar{Z}$) were 1.47 and 1.61 for alewife and blueback herring, respectively.
6. Juvenile indices of abundance for alewife and American shad were again higher in the Mattaponi River than in the Pamunkey River.
7. Data indicate higher mortality rates of juvenile Alosa in the Pamunkey River than in the Mattaponi River.

Job 1. Evaluation of the Alosa Stocks and Fisheries in Virginia

INTRODUCTION

The Virginia Institute of Marine Science (VIMS) continued its annual assessment of the Alosa stocks and fisheries in Virginia inshore waters. These data are essential for any eventual consideration of an Alosa management plan in Virginia, and for the State-Federal coastwide management plan presently being developed.

MATERIALS AND METHODS

Samples of river herring were collected biweekly in the months of April and May from the York River and in March, April, and May from the Rappahannock River. American shad samples were collected in April from the James, York, and Rappahannock fisheries (Table 1.1).

When available, 22.7 kg of river herring were randomly sampled from commercial pound net catches in the York and Rappahannock rivers. These nets employ a 50.8 mm stretched mesh in their entrapment section, and are assumed to be nonselective for herring age 3 or older.

Random samples of up to 100 American shad were taken from commercial catches. The fishery primarily employs gill nets with 12.4 to 14.0 cm stretched mesh which favor the capture of females, the larger of the sexes.

River herring samples were returned to VIMS where species, sex, body length (fork length), and weight were recorded. These data were used to partition the log-book estimates of landings in each sampling period into biomass and numbers-at-age. American shad data, except for age, were collected at the sampling site. Ages were determined from otoliths for river herring. American shad were aged 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. A sonic digitizer microcomputer complex was used to "read" American shad scales (Loesch and Kriete, 1983).

Pound net catch estimates for the fisheries in York and Rappahannock rivers were determined by multiplying the catch-per-unit-of-effort (CPUE) (kg/net per half-month) of the index nets by the number of nets actively fishing (weighted by net size) in each strata of the river. Index nets are those for which daily records were kept by cooperating fishermen. Effort was determined by semi-monthly aerial counts of active pound nets (Table 1.2 and Fig. 1.1). Seasonal pound net CPUE was determined by dividing total landings by the average number of nets fished, adjusted for the length of the fishing season for each species.

Pound net fishermen in the lower strata of the Rappahannock River did not supply catch and effort data in 1983 and 1984. An estimate of the missing data for the lower portion of the river was made from its average proportion of the total catch in the years 1978-1982.

The catch-and-effort data for alewife and blueback herring were pooled because the fishery does not target one species or the other and both federal and state agencies report all river herring landings as alewife.

Stake gill net catch estimates for the fisheries in the James, York, and Rappahannock rivers were determined by multiplying the CPUE (kg/m of net per half-month) of index nets by meters of stake gill netting in 5-nautical mile strata of the river. Effort was determined by a count of stake gill nets during the peak of the American shad fishing season (Table 1.3). Yearly stake gill net CPUE was determined by dividing total landings by total netting fished for shad.

Because of the close proximity of all the nets to adjoining strata, nets in the mile 10-15 stratum in the James River (four gill net stands in

the lower and two in the upper portion of the stratum) were assigned to respective adjoining strata.

Annual Alosa landings data from all Virginia waters and the Potomac River for the years 1965-1972 were obtained from the respective U.S. Fishery Statistical Digests. The 1973-1976 data were from the annual summaries of Current Fisheries Statistics, NMFS, Division of Statistics and Market News. Since 1976, total landings data for Virginia have been obtained from the Virginia Marine Resources Commission (VMRC). The VMRC preliminary report for the 1984 landings did not have a complete compilation of river herring catches in the Rappahannock and York rivers. However, estimates of the 1984 catches of river herring in the two rivers were made from VIMS Logbook data and, subsequently, were used to adjust the reported preliminary total catch.

The PRIME 750 computer system at VIMS was used in conjunction with a "package program," SPSS (Nie et al. 1975) to analyze data, and to construct tables and figures.

RESULTS

Total Virginia Landings

Approximately 1,120 metric tons (MT) of river herring were landed in Virginia in 1984. The landings were a 34% (287 MT) increase relative to the 1983 catch, and were the highest since 1976 (Fig. 1.2). Nineteen eighty-four was the third consecutive year of increased river herring landings. American shad landings in Virginia also increased in each of the last three years (Fig. 1.2). In its preliminary 1984 annual summary of Virginia landings, VMRC reported that about 576 MT of American shad were landed, a 99% increase relative to the 1983 landings of 289 MT. The 1984 landings of American shad were the highest since 1977, and were 89% of the mean landings for the decade preceding the historic low (226 MT) in 1981.

Some specific contributions to the total 1984 landings of alosids are considered below.

James River Landings

Our aerial observations of pound net effort showed that only one pound net was set in the James River during 1984. The capture of finfishes is severely restricted as a result of kepone contamination, making pound net operations in the river unprofitable.

It was determined from the logbooks of cooperating fishermen that stake gill nets caught about 206 MT of American shad in 1984 (Table 1.4), an increase of 12 MT relative to 1983 (Table 1.5). As in 1983, most of the landings are attributable to the lower stratum of the river (miles 05-10) where 46% of the catch was made during April. An unknown proportion of the catch in the upper strata (miles 20-60) was sold to local markets, and it is possible that, as in 1982 and 1983, landings for that portion of the river were underestimated.

Following the pattern of 1983 (Loesch and Kriete 1983), peak landings in 1984 occurred during the first half of April.

Chickahominy River Landings

Landings data collected by VMRC showed that approximately 187 MT of river herring were caught in the haul seine fishery in the Chickahominy River in 1984. The landings were about 100 MT more than the 1983 catch, and represented the third successive year of increased river herring landings in the river. No other alosid fisheries are conducted in the Chickahominy River.

York River Landings

Logbook data, in conjunction with commercial sample data, indicated that alewife pound net landings increased from 2.7 MT in 1983 to 4.1 MT in

1984 (Table 1.5). In contrast, there was a slight decrease in the blueback herring catch in 1984 relative to 1983 (40 MT and 41 MT, respectively); thus the net change was a 0.5 MT increase in river herring landings. Effort continued to decline but CPUE for river herring increased relative to 1983 (Table 1.6). Peak landings of river herring, primarily blueback herring, occurred during the first half of May (Table 1.7). Peak landings of American shad from pound nets occurred in the second half of May. However, since no female American shad were reported for that period by index fishermen, it is probable that the spent females were included in landings of male American shad.

Our logbook data showed a substantial increase in both stake gill net landings of American shad and the associated CPUE in 1984 relative to 1983 (Tables 1.5 and 1.6). Peak landings of 99 MT of shad occurred during the first half of April (Table 1.8).

Rappahannock River Landings

Analysis of the logbook data indicated that pound net fishermen in the Rappahannock River landed about 3 MT of American shad and 527 MT of river herring in 1984 (Table 1.9). The landings represent increases of 33% and 26%, respectively, relative to landings in 1983 (Table 1.5).

Stake gill netters in the Rappahannock River landed 18 MT of American shad in 1984 (Table 1.10), the highest landings since 1979 (Table 1.5). The increase occurred despite a reduction in effort below mile 38, and the closure of the river to fishing from mile 38 to mile 68.

Age Composition

The 1984 age frequencies of river herring (sexes pooled) and American shad determined from samples of the commercial catches in the James, York, and Rappahannock River fisheries are presented in Tables 1.11-1.15. Loesch

and Kriete (1982 and 1983) noted that the rise in river herring catches in 1982 and 1983 was due, at least in part, to a strong contribution to the total landings by the 1978 year class. Sample data in 1984 indicate that the 1978 year class at age 6 was less than 9% of the pound net catches of alewife, but the year class was still a strong component of the blueback herring catches.

Past and present American shad data (Loesch and Kriete 1980, 1981, 1982, 1983 and Table 1.15 herein) consistently reflect gill-net selectivity for ages 5 and 6. Therefore, the modality of the 1978 year class of American shad was not unexpected at ages 5 and 6. Its co-modality at age 4 (Loesch and Kriete 1982), however, offers some evidence that it may be among the stronger year classes of American shad in the last decade.

The river herring age composition data were used in conjunction with sex ratio and mean weight-at-age data to estimate year-class contributions to the total landings.

Length and Weight Analysis

Mean values for fork length and total body weight for river herring, derived from samples of the pound net catches in the York and Rappahannock rivers, are presented in Table 1.16. Similar data for American shad, derived from samples of gill net catches in the James, York, and Rappahannock rivers, are presented in Table 1.17.

As stated above, river herring mean weight-at-age data were used in conjunction with age composition and sex ratio data to estimate year-class contributions to the annual landings.

Species Composition

Alewife constituted 31% of the 2,098 river herring sampled in the York and Rappahannock rivers in 1984 (Table 1.1), but were only 20.6% of the

total landings in these two rivers (Table 1.5). The apparent discrepancy is because the samples are a constant weight (22.7 kg) rather than a constant proportion of the catch. Alewife are the major proportion of the river herring samples only in periods when landings are low (March and early April). The proportion of blueback herring in the samples is superior when landings are much greater. Thus, the proportion of alewife in our total sample is enhanced relative to the actual contribution to the biomass of river herring landed. Each estimate of species percentages was therefore weighted by landings in the sampling period. The weighted estimates were then summed throughout the season to obtain the contribution of each species to the total biomass landed.

Sex Ratios

The sex ratio data (Table 1.1) were used in conjunction with species age structure and mean weight-at-age data to estimate year-class contributions to the total landings.

Mortality Estimates

Estimates of instantaneous total mortality rates (Z) for the 1969-1975 year classes in the Rappahannock River were previously made (Loesch and Kriete 1983). Using assumed instantaneous natural rate (M=1.1), annual rates of mortality (A), survival (S), and exploitation (E) were also made. Herein, with the additional 1984 data, some previous estimates were revised and "first cut" estimates of mortality were made for the 1976 and 1977 year classes.

The mean estimate of total mortality ($\bar{Z}$) was 1.47 for alewife and 1.61 for blueback herring, (Table 1.18) thus, the estimates of the mean annual mortality rates ($\bar{A}$) were 77% and 80% and the mean exploitation rates ($\bar{E}$) were 31% and 40%, respectively (Table 1.18).

DISCUSSION

An apparent improvement in the abundance of alosid stocks in Virginia was indicated by three successive increases in annual landings. This premise was supported by catch-effort statistics in 1984 when effort declined but CPUE increased in both the York and Rappahannock shad and river herring fisheries. These results could occur if effort were reduced in periods of marginal availability. However, a comparison of active pound nets in 1984 with those nets in 1983 (Loesch and Kriete 1983) showed that the decrease in effort was consistent throughout the river herring season.

The range in annual mortality rates for alewife (70% to 87%) and blueback herring (67% to 89%) in Virginia are similar to alewife mortality rates in New England. DiCarlo (1981) reported annual mortalities of 73% and 80% for spawning alewife in 1980 and 1981 in Massachusetts, while Walton (1981) reported that alewife fishing mortalities ranged from 80% to 95% in Maine.

Since the New England river herring stocks have not exhibited the decline of some southern stocks, it appears that the stocks can maintain a reasonably high level of abundance when subjected to high levels of annual mortality.

Job 2. Annual Index of Juvenile Alosa Abundance

INTRODUCTION

The VIMS annual study of juvenile migratory Alosa was continued in 1984. The intent of the study was to estimate relative abundance, growth, and mortality. Long-term objectives are to assess any relationship between the annual index of abundance and future recruitment, and to determine if there is a periodicity of strong year classes.

MATERIALS AND METHODS

Indices of juvenile Alosa abundance were estimated by sampling in their nursery zones (tidal freshwater) in the Mattaponi and Pamunkey rivers. The nursery zone in the Mattaponi River was sampled six times between 6 June and 9 July 1984 and the Pamunkey river was sampled five times between 7 June and 3 July 1984.

Loesch and Kriete (1983) established a standardized sampling unit and a minimum size limit for catch-effort considerations, and detailed the stratifed sampling plan employed. A bow-mounted 1.5 m x 1.5 m pushnet (Kriete and Loesch 1980) was used to capture the juveniles (young-of-the-year). Because juvenile Alosa, or their prey, exhibit negative phototropic responses (Loesch et al. 1982), samples were collected at night to minimize the effects of varying intensities of incident light.

A weighted overall mean CPUE, where stations were replicates per stratum, was calculated for each sampling period. The largest of these CPUE values was defined as the index of abundance, and is referred to as the maximal CPUE. The advantages of a maximal CPUE vis-a-vis a seasonal mean CPUE were also discussed by Loesch and Kriete (1983). Sampling was conducted weekly to enhance the accuracy of the estimate of maximal relative

abundance. Turner and Chadwick (1972) reported serious deficiencies in their annual index of juvenile striped bass when the index was developed from catch data collected at two-week intervals.

Estimates of mean CPUE that followed the maximal CPUE, but clearly preceded the onset of the seaward migration, were used in conjunction with the maximal value to estimate the instantaneous natural mortality rate (M). The $\log_e$ of the ratio of maximal CPUE to a subsequent CPUE was used to calculate M when there was only one usable CPUE subsequent to the maximal value. Division by the number of days elapsed from the maximal CPUE (day 1) to the subsequent CPUE gave the daily instantaneous rate of natural mortality (M_d). With two or more usable CPUE values following the maximal CPUE, catch curves (Ricker 1975) were used to derive M_d.

Increases in mean fork length were used to calculate juvenile Alosa growth. All juveniles in samples of size $N \leq 50$ were measured; for $N > 50$, a random subsample of 50 fish was taken.

RESULTS

Index of Abundance

Maximal CPUE values for alewife, blueback herring, and American shad in the Mattaponi and Pamunkey rivers are given in Table 2.1. With the exception of the value for American shad in the Pamunkey River, where few shad were caught, the time of occurrence and the magnitude of maximal CPUE values in 1984 followed patterns previously noted (Loesch and Kriete 1983). The maximal CPUE values for alewife and American shad occurred earlier than those for the blueback herring. However, the blueback herring index was of greater magnitude (Table 2.1). Also, the maximal CPUE values for American shad and alewife again occurred in the Mattaponi River. The maximal CPUE

for blueback herring also occurred in the Mattaponi River, but this was an exception to the general pattern.

Growth

There is considerable "noise" in the growth data (Figs. 2.1, 2.2, 2.3) and, because of recruitment of smaller fish and emigration of larger individuals (Loesch and Kriete 1983), observed growth in length underestimates true growth.

The principal use of the juvenile length data is to note salient changes in the growth rate. In conjunction with apparent changes in the slope of the catch curves, the observed changes in the growth rate aid in the selection of CPUE values for the estimation of juvenile mortality.

Natural Mortality

Estimates of daily instantaneous natural mortality rates (M_d) have been made since 1979 (Table 2.2). Because of three-week intervals between sampling, the 1980 and 1981 values (which contain the most extreme M_d's) are not considered reliable (Loesch and Kriete 1983).

In 1984, four of the six estimates of mortality were made from catch curves; the M_d values for American shad in the Mattaponi River and blueback herring in the Pamunkey River were obtained from the $\log_e$ of the ratio of two successive CPUE values.

The data indicate that the rates of mortality differ between the Pamunkey and Mattaponi rivers. All three mean ($\bar{M}_d$) differences and 10 of the 12 estimates of M_d were higher in the Pamunkey River (Table 2.2).

DISCUSSION

The data base of juvenile indices of abundance and the subsequent contributions of year classes to the fisheries are not large enough for a thorough analysis. At present, only the 1978 year class has, for all

practical purposes, exited from the fisheries. The overall index of river herring in 1978, the initial year for pushnet sampling, was obtained from a single survey in each river during August and September (Loesch et al. 1979). Regardless of the lateness of the survey the index is the highest of record. At this time, the 1978 index appears to have been a harbinger of the strong contributions made by that year class to the fisheries in the past few years. The next highest juvenile indices of river herring since 1978 occurred in 1982, when there was strong recruitment by the 1978 year class.

Loesch and Kriete (1983) discussed in detail the problems of estimating juvenile alosid growth from observed mean lengths. Briefly, two major sources of error that result in an underestimation of growth are the tendency for the precocious juveniles to migrate downstream (Loesch 1969, Marcy 1976), and protracted recruitment due to a lengthy spawning period. These two aspects of alosid behavior result in apparent periods of little or no growth or even "negative growth."

The reason(s) for the general occurrence of higher juvenile mortality rates in the Pamunkey River relative to the rates in the Mattaponi River is not known. It does not appear to be density related since the larger catches and larger maximal CPUE values for alewives and American shad most often occur in the Mattaponi River.

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Table 1.1. Summary of sample data from the Alosa commercial fisheries during the 1984 spawning run in the major Virginia tributaries to Chesapeake Bay.

River and Month	Alewife		Blueback		American Shad	
	Male	Female	Male	Female	Male	Female
James						
April					20	80
York						
April	7	33	131	176	33	80
May	25	17	172	348		
Rappahannock						
March	151	131				
April	107	126	126	132	30	71
May	29	23	202	162		
Totals (M&F)	649		1,449		314	

Table 1.2. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during January-June, 1984.

Area	Jan 23	Feb*	Mar 1	Mar 27	Apr 12	Apr 26	May 14	May 23	Jun 14	Jun 28
A. James River	0		1	1	1	1	1	1	1	1
B. Back River	0		0	0	0	1	1	1	3	1
C. Poquoson River	0		0	0	0	0	0	0	0	0
D. York River	1		1	1	6	8	10	12	10	10
E. Mobjack Bay	0		0	2	6	6	7	8	8	7
F. Piankatank River	0		1	1	1	3	4	4	3	4
G. Rappahannock River	0		1	33	37	40	40	42	31	28
H. Great Wicomico River	0		0	0	0	1	4	3	3	3
I. Potomac River	0	1	1	15	31	55	75	77	78	80
a. Virginia tributaries to Potomac River	0		0	0	1	2	3	4	4	4
J. Cape Henry to Fort Wool	0		0	3	3	3	6	8	8	8
K. Old Point-Tue Marsh Point	0		2	6	6	8	9	9	8	8
L. York Spit	0		0	0	1	5	7	8	9	10
M. New Point-Stingray Point	0		1	5	8	10	16	17	16	17
N. Windmill Point-Smith Point	0		0	5	10	13	13	12	12	12
Eastern Shore										
O. Above Hungar Creek	0		0	0	3	4	7	8	8	8
P. Below Hungar Creek	0	—	1	1	9	11	17	21	24	24
TOTAL	1	1	9	73	123	171	220	235	226	225

Table 1.3. Number of stake gill net stands fished in Virginia rivers 1982-1984 (A) and linear meters of gill netting fished primarily for American shad per 5-mile block (B) in 1984. Figures in parentheses represent the total meters of gill netting in the James, York and Rappahannock rivers.

A.

River	Number of Gill Net Stands 1982	1983	1984
James	124	151	107
York	174	149	121
Rappahannock	55	46	37

B.

River	Mile	Number of Stands	Number of Sections	Average Length/Section	Meters of Net	
James	05-10	26	752	9.1	(6,843)	6,843
	10-15					
	15-20	42	711	12	(8,532)	4,266
	20-25	19	321	12	(3,852)	1,926
	25-60	20	323	12	(3,876)	3,876
	Total	107	2,107		(23,103)	16,911
York	10-15	37	673	14.2	(9,557)	9,366
	15-20	28	434	14.2	(6,163)	6,040
	20-25	18	389	7.6	(2,956)	2,779
	25-29	38	746	7.6	(5,670)	5,330
	Total	121	2,242		(24,346)	23,515
Rappahannock	15-20	3	47	15.7	(738)	487
	20-25	3	47	15.7	(738)	487
	25-30	9	164	15.7	(2,575)	1,698
	30-35	14	198	15.7	(3,109)	2,050
	35-40	5	126	9.1	(1,147)	756
	40-60	3	44	9.1	(400)	264
	Total	37	626		(8,707)	5,742

Table 1.4. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the James River 1984 by half-month intervals and by sex. Effort from Table 1.3. 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
February 2nd	05-10	0.4043	2,767	0.3235	2,214	4,981
	10-15					
	15-20		768		502	1,270
	20-25	0.1799	347	0.1177	227	574
	25-60		697		456	1,153
	Total		4,579		3,399	7,978
March 1st	05-10	0.1730	1,184	0.1832	1,254	2,438
	10-15					
	15-20		463		285	748
	20-25	0.1085	209	0.0668	129	338
	25-60		420		259	679
	Total		2,276		1,927	4,203
March 2nd	05-10	0.9126	6,245	1.9415	13,285	19,530
	10-15					
	15-20		3,132		6,127	9,259
	20-25	0.7341	1,414	1.4362	2,766	4,180
	25-60		2,845		5,567	8,412
	Total		13,636		27,745	41,381
April 1st	05-10	0.8988	6,150	6.6173	45,282	51,432
	10-15					
	15-20		2,161		13,058	15,219
	20-25	0.5065	976	3.0608	5,895	6,871
	25-60		1,963		11,864	13,827
	Total		11,250		76,099	87,349
April 2nd	05-10	0.3847	2,639	5.8785	40,227	42,866
	10-15					
	15-20		488		8,726	9,214
	20-25	0.1143	220	2.0454	3,939	4,159
	25-60		443		7,928	8,371
			3,790		60,820	64,610
	Total		35,531		169,990	
	Grand Total					205,521

Table 1.5. 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.

	Stake Gill Net		Pound Net			
	American Shad		American Shad		River Herring	
	o	o	o	o	Alewife	Blueback
James						
1977	11,612	186,495				
1978	116,348	574,935				
1979	17,328	263,203		(a)		
1980	59,003	343,026				
1981	12,056	105,550				
1982	21,811	37,731				
1983	46,822	146,715				
1984	35,531	169,990				
York						
1977	3,376	137,748	8,894	3,217	10,298	87,966
1978	31,666	174,780	16,676	13,141	16,021	135,954
1979	23,460	186,074	5,492	10,224	22,256	195,150
1980	25,012	246,719	2,267	6,453	43,391	176,955
1981	23,453	158,905	2,361	630	5,454	189,769
1982	23,811	134,676	5,236	179	15,499	197,621
1983	45,717	167,590	2,780	2,157	2,714	40,979
1984	58,104	196,550	2,469	1,056	4,131	40,066
Rappahannock						
1977	2,298	22,053	2,949	1,268	84,688	209,163
1978	10,909	45,870	2,096	1,871	130,804	381,734
1979	2,199	21,619	2,046	1,562	56,016	423,633
1980	1,366	8,831	614	1,038	23,283	195,354
1981	2,621	10,015	824	832	33,767	287,963
1982	2,616	5,256	2,395	1,487	87,689	327,893
1983	2,113	4,969	1,629	747	103,066(b)	313,873(b)
1984	5,043	12,949	2,225	936	113,787(b)	413,839(b)

(a) Data not available.
(b) See text for explanation.

Table 1.6. Yearly catch-per-unit-of-effort for American shad in stake gill nets and river herring in pound nets for the years 1975-1984. Stake gill net effort is in meters of netting. Pound net effort is in number of nets per season.

	Stake Gill Net			Pound Net	
		American Shad			
	Effort	o	o	Effort	River Herring
James River					
1975	25,832	2.7	8.8		
1976	20,464	1.9	25.1		
1977	26,884	0.4	6.9		
1978	28,134	4.1	20.4	(a)	
1979	37,207	0.5	7.1		
1980	41,739	1.4	8.2		
1981	38,250	0.3	2.8		
1982	15,088	1.4	2.5		
1983	18,485	2.5	7.9		
1984	16,911	2.1	10.0		
York River					
1975	22,106	0.5	4.5		
1976	21,424	0.3	3.0	(a)	
1977	19,326	0.2	7.1	9.88	9,946
1978	15,954	2.0	10.9	12.74	11,929
1979	13,968	1.7	13.3	12.00	18,117
1980	19,940	1.3	12.4	15.95	13,815
1981	21,298	1.1	7.5	17.50	11,156
1982	28,262	0.8	4.8	21.05	10,124
1983	30,404	1.5	5.5	11.82	3,696
1984	23,515	2.5	8.4	8.33	5,306
Rappahannock River					
1975	28,973	0.1	0.8	50.67	4,819
1976	32,517	0.1	0.5	35.09	3,185
1977	13,595	0.2	1.6	32.01	6,534
1978	13,681	0.8	3.4	27.28	18,788
1979	13,497	0.2	1.6	34.93	13,732
1980	8,758	0.2	1.0	28.00	7,808
1981	11,591	0.2	0.9	45.53	7,066
1982	6,736	0.4	0.8	32.44	12,811
1983	6,836	0.3	0.7	34.80(b)	11,981(b)
1984	5,742	0.9	2.3	34.26(b)	15,401(b)

(a) Data not available.
(b) See text for explanation.

Table 1.7. Estimated catch in kg of American shad and river herring by pound nets in the York River 1984 by half-month intervals. Figures in parentheses are estimated species composition.

Half-Month Period	Number Nets	American Shad				River Herring						Number of Index Nets
		Male		Female				Alewife		Blueback		
		Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total	
April 1st	6	31.1	187	130.7	784	74.4	446	5.1	23	94.9	423	6
April 2nd	8	9.5	76	34.0	272	323.2	2,585	24.8	641	75.2	1,944	6
May 1st	10	98.2	982	(a)		4,030.8	40,308	8.6	3,467	91.4	36,841	6
May 2nd	12	102.0	1,224	(a)		71.5	858			100.0	858	6
Total			2,469		1,956				4,131		40,066	
Grand Total			3,525						44,197			

(a) none reported by index fishermen.

Table 1.8. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the York River 1984 by half-month intervals. Effort from Table 1.3. Index in kg/m of net.

Half-Month Period	River Mile	American Shad Male Index	Male Estimated Catch	American Shad Female Index	Female Estimated Catch	Total Estimated Catch
February 2nd	10-15	0.1339	1,254	0.1342	1,257	2,511
	15-20		809		811	1,620
	20-25	0.8075	2,244	0.6927	1,925	4,169
	25-30		4,304		3,692	7,996
	Total		8,611		7,685	16,296
March 1st	10-15	0.2003	1,876	0.2758	2,583	4,459
	15-20		1,210		1,666	2,876
	20-25	0.6249	1,737	0.6426	1,786	3,523
	25-30		3,331		3,425	6,756
	Total		8,154		9,460	17,614
March 2nd	10-15	0.7749	7,258	2.0170	18,891	26,149
	15-20		4,680		12,183	16,863
	20-25	1.064	2,957	2.3429	6,511	9,468
	25-30		5,671		12,488	18,159
	Total		20,566		50,073	70,639
April 1st	10-15	0.6594	6,176	3.727	34,908	41,084
	15-20		3,983		22,511	26,494
	20-25	0.6382	1,774	3.267	9,079	10,853
	25-30		3,402		17,413	20,815
	Total		15,335		83,911	99,246
April 2nd	10-15	0.3122	2,924	2.204	20,642	23,566
	15-20		1,886		13,312	15,198
	20-25	0.0774	215	1.414	3,930	4,145
	25-30		413		7,537	7,950
			5,438		45,421	50,859
	Total		58,104		196,550	
	Grand Total					254,654

Table 1.9. Estimated catch in kg of American shad and river herring by pound nets in the Rappahannock River 1984 by half-month intervals.

Half Month Period	Mile	Number Nets	American Shad Male Index	American Shad Male Estimated Total	American Shad Female Index	American Shad Female Estimated Total	River Herring Index	River Herring Estimated Total	Alewife %	Alewife Estimated Total	Blueback %	Blueback Estimated Total	Number of Index Nets
March 1st	31-70	1	0.4	0.4			38.1	38	100.0	38			5(a)
March 2nd	31-70	21	3.9	82	0.9	19	60.0	1,260	100.0	1,260			8
April 1st	31-70	22	3.0	66	5.0	110	58.2	1,280	83.8	1,073	16.2	207	9
April 2nd	31-70	23	4.5	104	10.5	242	733.5	16,871	38.2	6,444	61.8	10,427	11
May 1st	31-70	22	14.8	326	3.0	66	1,879.8	41,356	19.2	7,940	80.8	33,416	12
May 2nd	31-70	24	13.0	312	0.7	17	211.5	5,076	1.3	66	98.7	5,010	6
Total				890.4		454				16,821		49,060	
Grand Total					1,344.4			65,881					
Estimated landings mile 0-30				1,335		480				96,966(b)		364,779(b)	
					1,815(c)			461,745(c)					
Grand Total for Rappahannock River					3,159.4			527,626					

(a) Index nets installed after pound net count.
(b) Species ratio estimated from 1977-1979 commercial landings data.
(c) Landings for miles 0-30 estimated from 1978-1982 commercial landings data.

Table 1.10. Estimated catch in kg of American shad by stake gill nets in the Rappahannock River 1984 by half-month intervals. Effort from Table 1.3. Index in kg/m of net.

Half-Month Period	River Mile	American Shad Male Index	American Shad Male Estimated Catch	American Shad Female Index	American Shad Female Estimated Catch	Total Estimated Catch
February 2nd	15-25	0.0313	15	0.0035	2	17
	25-30		53		6	59
	30-35		64		7	71
	35-40		24		3	27
	40-65(a)					
	Total		156		18	174
March 1st	15-25	0.1055	51	0.0524	26	77
	25-30		179		89	268
	30-35		216		107	323
	35-40		80		40	120
	40-65(a)					
	Total		526		262	788
March 2nd	15-25	0.3314	161	0.3410	166	327
	25-30		563		579	1,142
	30-35		679		699	1,378
	35-40		251		258	509
	40-65(a)					
	Total		1,654		1,702	3,356
April 1st	15-25	0.4366	213	1.2221	595	808
	25-30		741		2,075	2,816
	30-35		895		2,505	3,400
	35-40		330		924	1,254
	40-65(a)					
	Total		2,179		6,099	8,278
April 2nd	15-25	0.0900	44	0.8805	429	473
	25-30		153		1,495	1,648
	30-35		185		1,805	1,990
	35-40		68		666	734
	40-65(a)					
	Total		450		4,395	4,845
May 1st	15-25	0.0158	7	0.0947	46	53
	25-30		27		161	188
	30-35		32		194	226
	35-40		12		72	84
	40-65(a)					
	Total		78		473	551
Total			5,043		12,949	
Grand Total						17,992

(a) see text for explanation

Table 1.11. Year-class frequency of alewife (sexes pooled) in the York River commercial fishery samples, 1984.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	76.	3	4.2	4.3	4.3
	77.	4	5.6	5.7	10.0
	78.	6	8.3	8.6	18.6
	79.	21	29.2	30.0	48.6
	80.	28	38.9	40.0	88.6
	81.	8	11.1	11.4	100.0
	9.*	2	2.8	MISSING	100.0
	TOTAL	72	100.0	100.0	

MEAN	79.300	STD ERR	0.146	MEDIAN	79.536
MODE	80.000	STD DEV	1.220	VARIANCE	1.488
KURTOSIS	0.851	SKEWNESS	-0.997	RANGE	5.000
MINIMUM	76.000	MAXIMUM	81.000		

VALID CASES 70 MISSING CASES 2

*Age codes

0 - includes some age $\geq$ 7 or 1975 or older

9 - missing age data

Table 1.12. Year-class frequency of blueback herring, (sexes pooled) in the York River commercial fishery samples, 1984.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
AGE 7+	0.*	26	3.5	10.1	10.1
	76.	2	0.3	0.8	10.9
	77.	23	3.1	8.9	19.8
	78.	85	11.4	32.9	52.7
	79.	65	8.7	25.2	77.9
	80.	50	6.7	19.4	97.3
	81.	7	0.9	2.7	100.0
	9.*	485	65.3	MISSING	100.0
	TOTAL	743	100.0	100.0	

MEAN	70.756	STD ERR	1.479	MEDIAN	78.418
MODE	78.000	STD DEV	23.753	VARIANCE	564.216
KURTOSIS	5.131	SKEWNESS	-2.659	RANGE	81.000
MINIMUM	0.000	MAXIMUM	81.000		

VALID CASES	258	MISSING CASES	485

*Age codes

0 - includes some age $\geq$ 7 or 1975 or older

9 - missing age data

Table 1.13. Year-class frequency of alewife (sexes pooled) in the Rappahannock River commercial fishery samples, 1984.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
AGE 7+	0.*	2	0.3	0.6	0.6
	77.	6	1.0	1.9	2.5
	78.	23	3.6	7.3	9.8
	79.	94	14.9	29.7	39.6
	80.	148	23.5	46.8	86.4
	81.	43	6.8	13.6	100.0
	9.*	315	49.9	MISSING	100.0
	TOTAL	631	100.0	100.0	

MEAN	79.130	STD ERR	0.359	MEDIAN	79.723
MODE	80.000	STD DEV	6.385	VARIANCE	40.774
KURTOSIS	149.586	SKEWNESS	-12.156	RANGE	81.000
MINIMUM	0.000	MAXIMUM	81.000		

VALID CASES 316 MISSING CASES 315

*Age codes

0 - includes some age $\geq$ 7 or 1975 or older

9 - missing age data

Table 1.14. Year-class frequency of blueback herring (sexes pooled) in the Rappahannock River commercial fishery samples, 1984.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
AGE 7+	0.*	3	0.5	1.3	1.3
	76.	1	0.2	0.4	1.7
	77.	13	2.1	5.4	7.1
	78.	45	7.2	18.8	25.9
	79.	94	15.1	39.3	65.3
	80.	81	13.0	33.9	99.2
	81.	2	0.3	0.8	100.0
	9.*	384	61.6	MISSING	100.0
	TOTAL	623	100.0	100.0	

MEAN	78.054	STD ERR	0.573	MEDIAN	79.112
MODE	79.000	STD DEV	8.865	VARIANCE	78.589
KURTOSIS	74.651	SKEWNESS	-8.672	RANGE	81.000
MINIMUM	0.000	MAXIMUM	81.000		

VALID CASES	239	MISSING CASES	384

*Age codes

0 - includes some age $\geq$ 7 or 1975 or older

9 - missing age data

Table 1.15. Year-class frequency of American shad in the Virginia commercial gill net fishery, 1984.

Sex	Year Class	James	York	Rappahannock	Total	Frequency (%)
Male	1977	2		2	4	5.0
	1978	5	7	7	19	23.75
	1979	10	26	21	57	71.25
Total		17	33	30	80	
Female	1976	1		1	2	0.86
	1977	21	2	9	32	13.73
	1978	50	33	40	123	52.79
	1979	9	44	18	71	30.5
	1980	1	1	3	5	2.15
Total		82	80	71	233	

Table 1.16. Length (mm) and weight (g) statistics for river herring in the York and Rappahannock rivers, 1984.

Species	Sex		York N	York Mean	York Std. Error	Rappahannock N	Rappahannock Mean	Rappahannock Std. Error
Alewife	Male	Length	22	242.2	2.863	327	237.4	0.628
		Weight	22	178.1	9.749	327	209.3	2.203
	Female	Length	50	252.3	2.144	302	248.5	0.807
		Weight	50	213.3	5.998	301	243.4	2.849
Blueback	Male	Length	273	238.7	0.762	329	228.6	0.710
		Weight	273	167.0	1.959	329	144.9	1.546
	Female	Length	469	250.9	0.709	293	241.7	0.771
		Weight	469	192.1	1.890	292	172.4	2.294

Table 1.17. Length (mm) and weight (g) statistics for American shad in the James, York and Rappahannock gill net fisheries, 1984.

Sex		James			York			Rappahannock		
		N	Mean	Std. Error	N	Mean	Std. Error	N	Mean	Std. Error
Male	Length	17	425.1	3.028	33	418.1	2.295	30	429.5	2.867
	Weight	17	1340.4	27.984	35	1292.7	20.860	30	1329.5	31.282
Female	Length	82	465.0	2.242	80	455.6	2.420	71	465.2	2.435
	Weight	83	1877.9	27.499	80	1747.9	28.159	71	1891.7	31.326

Table 1.18. Estimated rates of instantaneous total mortality (Z), annual mortality (A), survival (S), and exploitation (E) for alewife and blueback herring in the Rappahannock River. A natural mortality rate of 1.1 was assumed.

Year Class	Alewife				Blueback			
	Z	A	S	E	Z	A	S	E
1969	2.06	0.87	0.13	0.62	2.22	0.89	0.11	0.67
1970	1.38	0.75	0.25	0.24	1.72*	0.82	0.18	0.46
1971	1.21	0.70	0.30	0.10	1.90	0.85	0.15	0.55
1972	1.65*	0.81	0.19	0.42	1.74	0.82	0.18	0.47
1973	3.01*+	-	-	-	1.47	0.77	0.23	0.31
1974	1.32	0.73	0.27	0.20	1.11	0.67	0.33	0.01
1975	1.20*	0.70	0.30	0.10	1.65	0.81	0.19	0.42
1976	1.58	0.79	0.21	0.38	1.31	0.73	0.27	0.19
1977	1.42*	0.76	0.24	0.27	1.72	0.82	0.18	0.46
Mean	1.47	0.77	0.23	0.31	1.61	0.80	0.20	0.40

*Z estimated from the $\log_e$ of the ratio of CPUE values at ages 5 and 6. All other Z values were estimated from catch curves (regression of CPUE or age).

+The Z value for the 1973 year class, a statistical outlier, was omitted from the calculations.

Table 2.1. Maximal catch-per-unit-of-effort (CPUE) values for juvenile Alosa in the Mattaponi and Pamunkey rivers, 1979-1984.

	Maximal CPUE					
	Mattaponi			Pamunkey		
Year	Alewife	Blueback	Amer. Shad	Alewife	Blueback	Amer. Shad
1979	6.0	73.0	38.1	6.7	224.8	57.4
1980	2.9*	4.6*	38.8*	3.6	87.9	7.1
1981	10.0*	11.6	18.0*	6.5*	16.7	5.3*
1982	38.0	289.0	21.1	28.3*	408.2	3.0*
1983	36.2	36.1	16.5	4.2	120.7	7.5
1984	28.1	220.8	34.4	7.1*	88.9	2.5

*Maximal CPUE occurred in the first sampling period.

Table 2.2. Estimates of instantaneous daily mortality for juvenile Alosa in the Mattaponi (M) and Pamunkey (P) rivers, 1979-1984.

Species	River	1979	1980	1981	1982	1983	1984	Mean*
Alewife	M	0.036	0.330	0.105	0.036	0.038	0.042	0.037
	P	0.040	0.041	0.058	0.043	0.068	0.036	0.046
American shad	M	0.040	0.056	0.080	0.042	0.030	0.056	0.042
	P	0.060	0.080	0.043	0.050	0.078	0.057	0.061
Blueback	M	0.034	0.022	(+)	0.077	0.041	0.030	0.045
	P	0.040	0.031	0.016	0.046	0.052	0.078	0.054

*The 1980 and 1981 data were omitted (see text).
(+)Data were too few for a reasonably objective estimate of mortality.

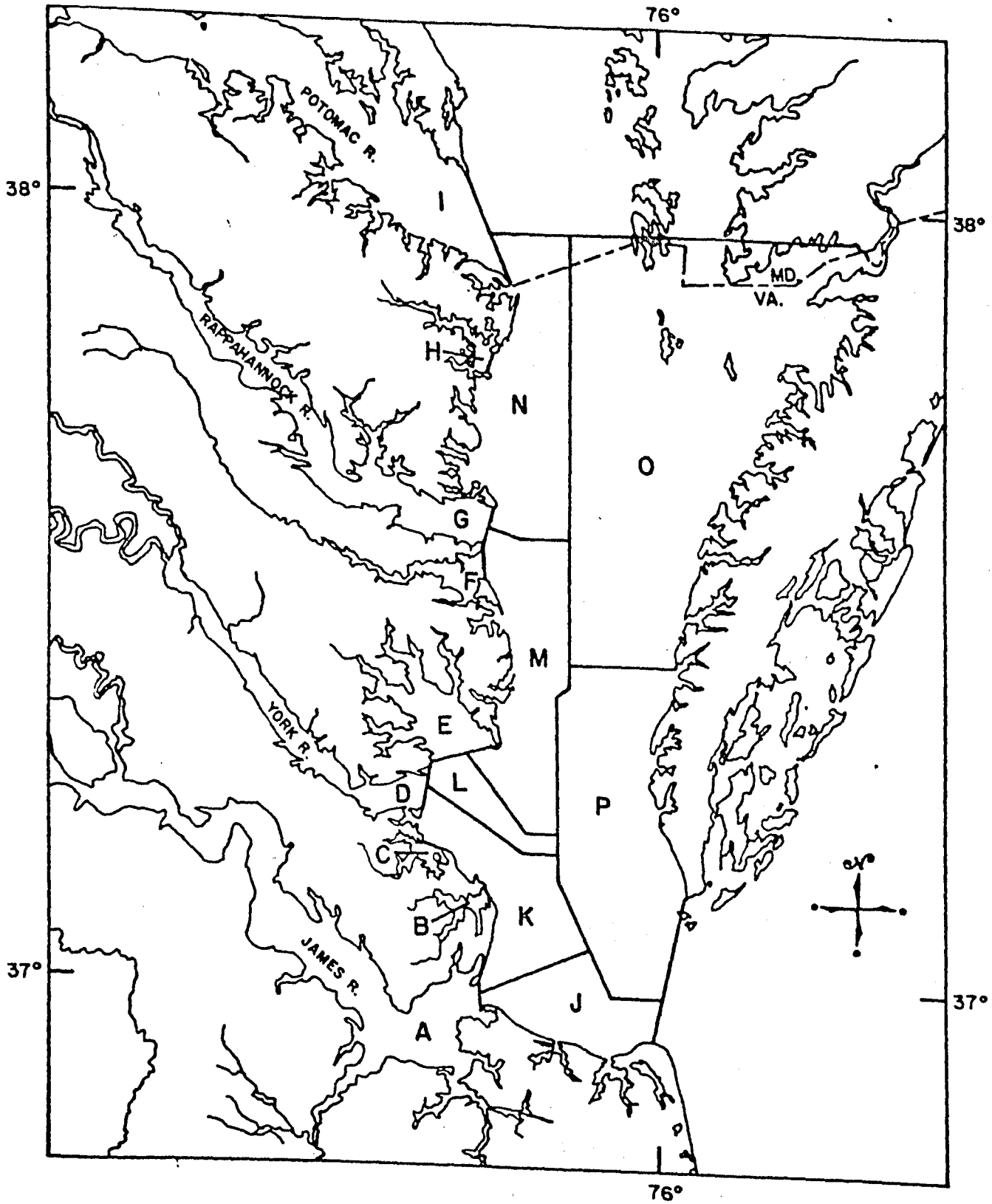
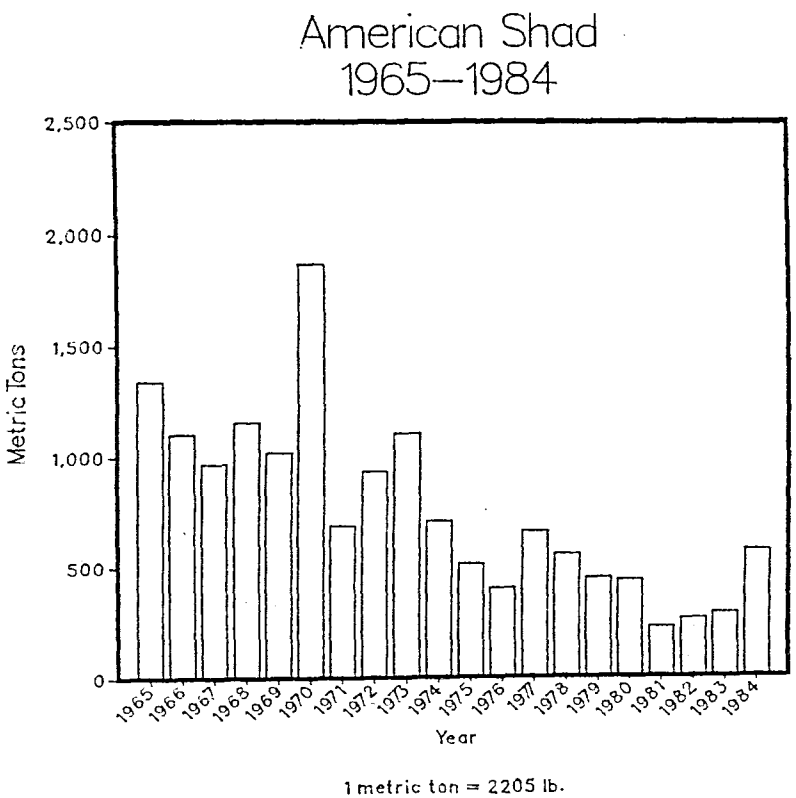


Figure 1.1. Area designations utilized during aerial pound net counts.

Figure 1.2. Virginia Landings 1965–1984.



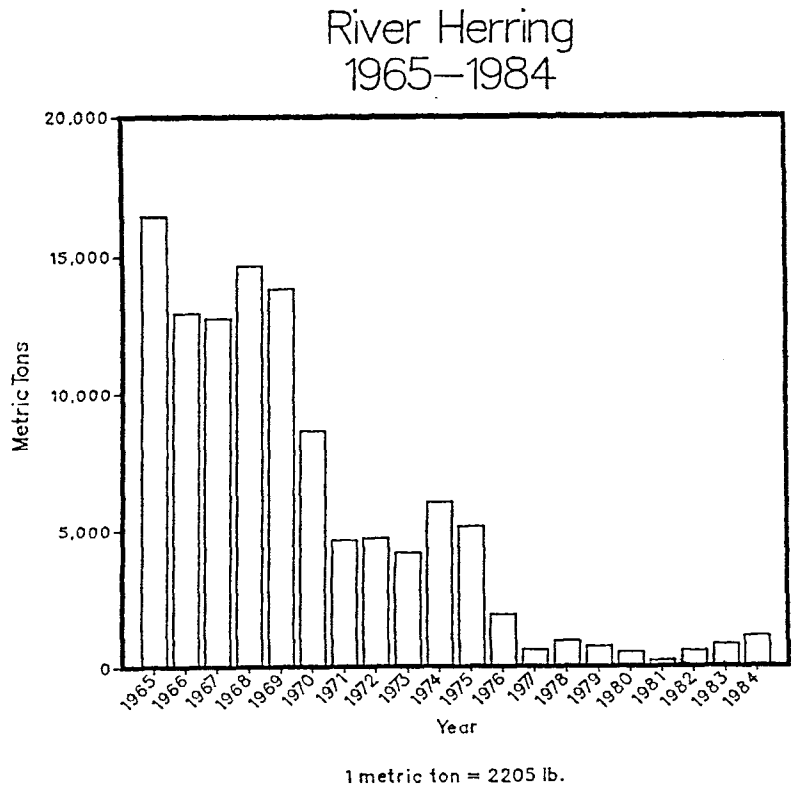


Figure 2.1. Growth Curves for Juvenile Alewives, 1984

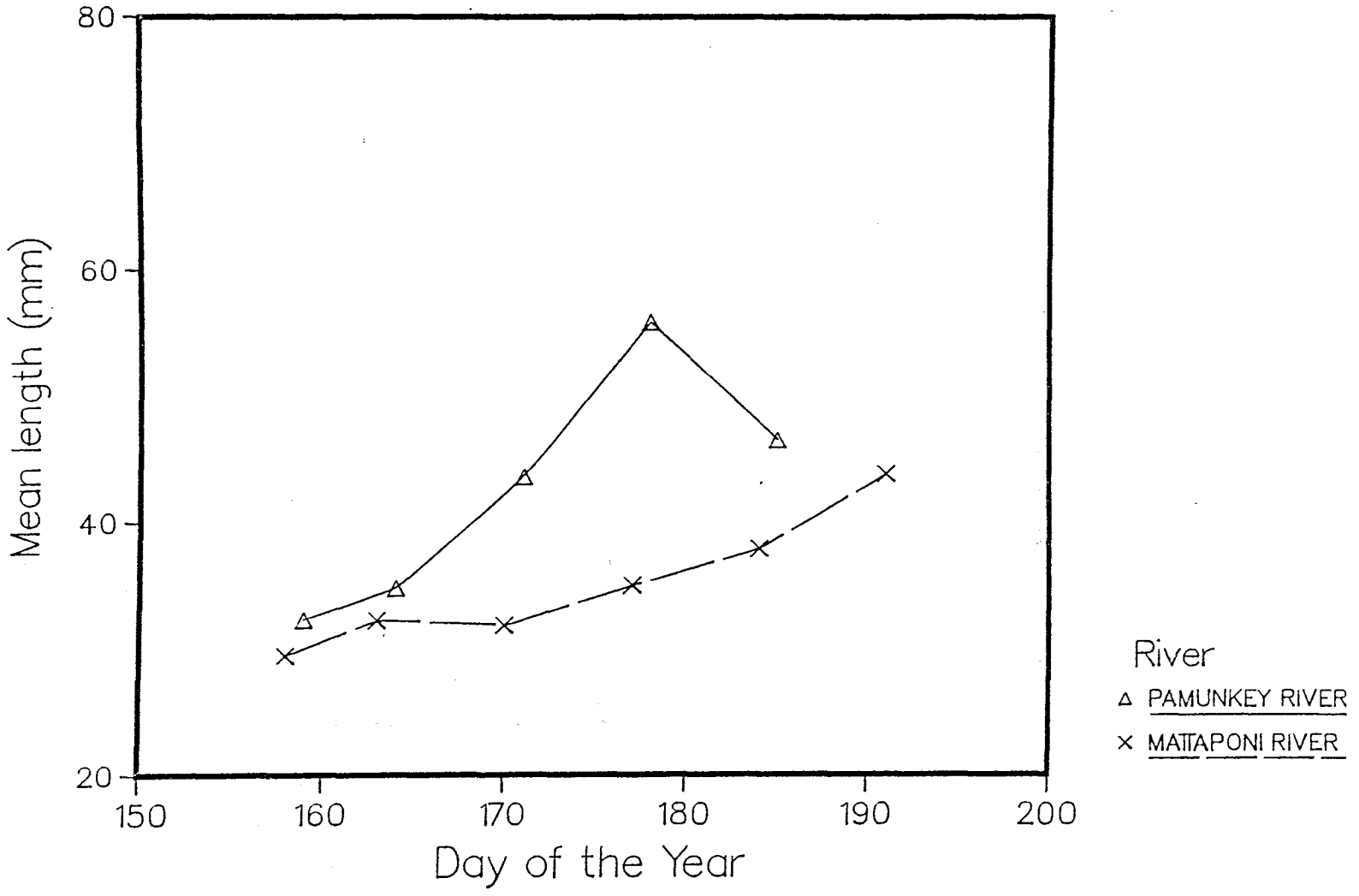


Figure 2.2. Growth Curves for Juvenile Blueback Herring, 1984

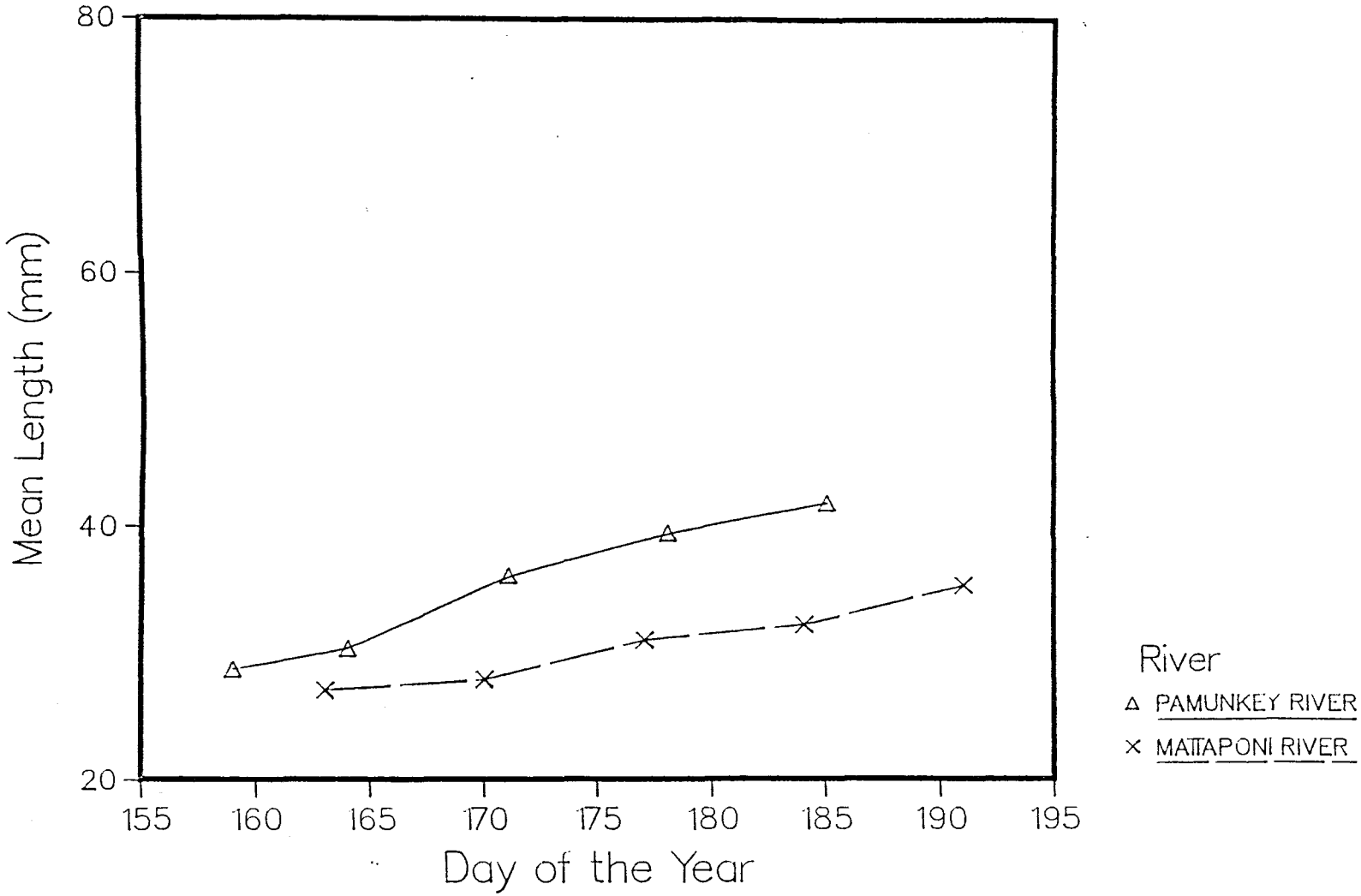


Figure 2.3. Growth Curves for Juvenile American Shad, 1984