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Study of Alosa stock composition and year-class strength in Virginia - Annual Report 1985

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PREFACE

This presentation is the annual report for P. L. 89-304, AFC 13-2 project "Study of Alosa stock composition and year-class strength in Virginia," for the period 15 February 1985 to 14 February 1986. The fishes of concern were the alewife (Alosa pseudoharengus), American shad (A. sapidissima), and the blueback herring (A. aestivalis).

The abundance of the Alosa stocks, once an important component of the landings of Virginia fisheries, dramatically decreased in the last decade. The 1981 landings of Alosa species in Virginia were the lowest ever recorded. American shad and river herring are also pursued by recreational fishermen in Virginia, but the extent and success of this activity is largely 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 1985 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.

Job 3: Analysis of American Shad Growth: Circa 1970 versus Circa 1980

Objectives

Assess the possible existence of density dependent growth by:

1. Back calculate length-at-age from scales collected in a period of high American shad abundance (Circa 1970), and from scales collected in a period of low abundance (1980).
2. Statistically compare the length-at-age relationships of the two groups.

ACKNOWLEDGMENTS

We are indebted to the following Virginia Institute of Marine Science personnel for their assistance in this project: Loisirene Blumberg, Joice Davis, Deane Estes, Carol Furman, Lillian Hudgins, Curtis Leigh, James Owens, and Gloria Rowe. We also express our thanks to the many commercial fishermen who have so kindly helped us when we asked for their assistance. The Virginia Landings data were supplied by the Virginia Marine Resources Commission.

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, except alewives in the York River, decreased in 1985 relative to 1984. The decrease followed three successive years of increasing Alosa landings in Virginia.
2. Three hundred and eighty-nine metric tons (MT) of river herring and 2.7 MT of American shad were landed from pound nets in the York and Rappahannock rivers.
3. Gill net fishermen landed an estimated 255 MT of American shad in the James, York and Rappahannock rivers.
4. Mean estimates of total mortality (Z) were unchanged from 1984, 1.47 and 1.61 for alewife and blueback herring, respectively.
5. Juvenile indices of abundance for alewife, American shad, blueback herring were, as in 1984, higher in the Mattaponi River than in the Pamunkey River.
6. 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 weekly from mid-March to the first week of May from the York River and weekly from mid-March to mid-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 favors 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 of river herring were determined from otoliths. 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 fisheries in the 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 have not supplied catch and effort data since 1982. 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.

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, National Marine Fisheries Service (NMFS), Division of Statistics and Market News. Since 1976, total landings data for Virginia have been obtained from the Virginia Marine Resources Commission (VMRC). As was reported in 1984, estimates of the 1985 catches of river herring in the Rappahannock and York rivers were made from VIMS logbook data. The total catch in Virginia was determined by adding our estimates to the landings reported by VMRC for river herring fisheries other than in the Rappahannock and York rivers.

The PRIME 850 computer at VIMS was used in conjunction with the statistical package SPSS (Nie et al. 1975) to analyze data, and to construct tables and figures.

RESULTS AND DISCUSSION

Total Virginia Landings

We estimate that approximately 951 metric tons (MT) of river herring were landed in Virginia in 1985. The landings were a 15% decrease relative to our estimated 1984 catch (1,120 MT), and the decrease ended a three-year series of annual increases begun in 1982 (Fig. 1.2). VMRC data indicate that American shad landings in Virginia decreased 50% in 1985 (287 MT) relative to 1984 (576 MT).

Decline in Alosa landings in 1985 probably did not reflect decreases in stock sizes. The onset of cold weather shortly after the commencement of spawning reduced Alosa availability. River herring landings also decreased because of reduced pound net fishing effort in the York and Rappahannock rivers (Table 1.4).

Some specific contributions to the total 1985 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 1985. The capture of finfishes is severely restricted as a result of Kepone contamination, making pound net operations in the river unprofitable.

It was estimated from the logbooks of cooperating fishermen that stake gill nets caught about 88 MT of American shad in 1985 (Table 1.5), a 57% decrease relative to 1984 (Table 1.6). As a result of depressed landings, an unknown proportion of the catch in the upper strata (miles 20-60) was sold to local markets, and it is possible that landings for that portion of the river are underestimated.

Following the pattern of 1983 and 1984 (Loesch and Kriete 1983), peak landings in 1985 occurred during the first half of April.

Chickahominy River Landings

Landings data collected by VMRC showed that approximately 55 MT of river herring were caught in the haul seine fishery in the Chickahominy River in 1985. The landings were about 132 MT less than the 1984 catch, and represented a substantial decrease following three successive years of

increased river herring landings in the river. No other alosid fisheries are conducted in the Chickahominy River.

York River Landings

Alewife pound net landings increased slightly from 4.1 MT in 1984 to 5.1 MT in 1985, continuing a trend begun in 1983 (Table 1.6). In contrast, there was a dramatic decrease in the blueback herring catch in 1985 relative to 1984 (14.8 MT and 40 MT, respectively) reflecting a net decrease of 24.1 MT in river herring landings. Effort and CPUE declined relative to 1984 (Table 1.4). Peak landings of river herring, primarily blueback herring, occurred during the first half of April (Table 1.7).

Estimated landings from logbook data showed a substantial decrease in both stake gill net landings of American shad and the associated CPUE in 1985 relative to 1984 (Tables 1.4 and 1.6). Peak landings of 56 MT of shad occurred during the second half of March (Table 1.8).

Rappahannock River Landings

Analysis of logbook data from cooperating pound net fishermen indicated that about 0.8 MT of American shad and 369 MT of river herring were landed in the Rappahannock River in 1985 (Table 1.9).

Stake gill netters in the Rappahannock River landed 9 MT of American shad in 1985 (Table 1.10). The decrease in landings may be in part due to a decrease in effort as a result of the closure of the river to striped bass fishing from mile 38 to mile 68.

Age Composition

The age frequencies of river herring (sexes pooled) and American shad determined from the 1985 samples of commercial catches in the James, York, and Rappahannock River fisheries are presented in Tables 1.11-1.15. The 1981 year class (age 4) of alewife was the modal age group in the York River pound net fishery, and was co-modal with the 1982 year class (age 3) in the Rappahannock River. The 29.5% and 31.2% representations of the 1982 year class in the York and Rappahannock catches (Tables 1.11 and 1.13) exceed the highest occurrence of age 3 alewives previously reported (Hoagman and Kriete 1975). In contrast, the blueback herring had older modal year classes: the 1980 year class (age 5) in the York River, and the 1979 year class (age 6) in the Rappahannock River.

As in past years, American shad data reflect gill-net selectivity for large females (Table 1.15). Since females are larger at age than males, the female age structure is older.

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 44.5% of the 2,452 river herring sampled in the York and Rappahannock rivers in 1985 (Table 1.1), but were only 24.2% of the total landings in these two rivers (Table 1.6). The difference 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 1969-1977 year classes in the Rappahannock River were previously made (Loesch and Kriete 1984). Using an assumed instantaneous natural rate (M=1.1), annual rates of mortality (A), survival (S), and exploitation (E) were also made. Herein, with the additional 1985 data, Z, A, S and E values were calculated for the 1978 alewife year class. The Z for the 1978 blueback herring year class, however, was anomalously low, and, therefore, omitted from the long-term average.

The mean estimate of total mortality (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).

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; which range from 73% to 95% (DiCarlo 1981; Walton 1981). 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 1985. 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 seven times between 3 June and 15 July 1985 and the Pamunkey river was sampled five times between 30 May and 25 June 1985.

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-à-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 AND DISCUSSION

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. The time of occurrence and the magnitude of maximal CPUE values in 1985 followed patterns previously noted (Loesch and Kriete 1983, 1984). The maximal CPUE values for alewife and American shad occurred earlier than those for

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 occurred in the Mattaponi River in 1984 and 1985. This is a reversal of a previous pattern in which the blueback herring index was always larger in the Pamunkey River.

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.

Growth

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 principal use herein of 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 are not considered reliable (Loesch and Kriete 1983).

In 1985, five of the six estimates of mortality were made from catch curves: the M_d value for blueback herring in the Mattaponi River was obtained from the $\log_e$ of the ratio of two successive CPUE values.

As in previous years, the data indicate that the rates of mortality differ between the Pamunkey and Mattaponi rivers. All three mean ($\bar{M}_d$) mortality rates and 13 of 15 estimates of M_d were higher in the Pamunkey River (Table 2.2).

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.

Job 3. Analysis of American Shad Growth: Circa 1970 versus Circa 1980

INTRODUCTION

Growth of American shad, Alosa sapidissima, has been described by La Pointe (1957), Cating (1953) and Judy (1961). Leim (1924) established that growth in American shad scale radii was proportional to the growth in fish length. Fish growth can be affected by many factors (Everhart and Youngs 1981), one of which is population density. Density of American shad in the James and York rivers of Virginia was high during the era 1968 through 1972, relative to the last decade. Conversely, low population densities were reported during the era 1979 through 1983 (Loesch and Kriete 1983). Although decreases in effort may have resulted in reduced landings, it appears that these changes in effort were not large enough to explain the drastic decline in landings over the past decade (Richkus and DiNardo 1984).

The objective herein was to compare American shad growth during periods of high population densities (1968-1972) with growth during low population densities (1979-1983).

MATERIALS AND METHODS

Samples of American shad were collected in March, April and May from the fisheries of the James and York rivers during the periods under discussion. A total of 753 shad were aged from the 1968-1972 period, and 497 from the 1979-1983 period. Only those scales judged to be of good quality were used. Samples were obtained from stake gill nets, the dominant gear used in the American shad fishery: landings from other gear types are

negligible, particularly when population densities are low. The American shad fishery primarily employs stake gill nets with 12.4 to 14.0 cm stretched mesh. These mesh sizes select for the larger, economically more important females. Consequently, this study used data obtained from females only.

Scales were removed from each fish and fork length (in mm) and weight (in g) were recorded. The scales were mounted and pressed onto acetate sheets using a method similar to Merriman's (1941). A sonic digitizer-microcomputer complex was used to age each fish from the impressions (Loesch and Kriete 1983). Age was determined by Cating's (1953) method, i.e., counting the number of annuli and adding a year for the scale edge. Each specimen's collection number, fork length and age were entered into the microcomputer. The distance from the focus to each successive annulus was then established through the use of the sonic digitizer, and entered into the computer. All these data were subsequently transferred into a Prime 850 computer system.

Analysis of variance was used to determine the validity of pooling scale radius-body length data within each era.

RESULTS

To date, 1250 scales have been read. Derivation of the Von Bertalanffy growth function has been delayed due to incompatibility of the program available to us (IBM compatible), with the VIMS Prime 850 computer system. Growth curves and comparisons of the two periods will be presented in the next annual report.

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Table 1.1. Summary of sample data from the Alosa commercial fisheries during the 1985 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					14	101
York						
March	79	70	96	68		
April	96	103	186	207	13	90
May	3	1	69	54		
Rappahannock						
March	186	158		1		
April	191	147	175	108	36	64
May	31	25	215	183		
Totals (M&F)	1,090		1,362		318	

Table 1.2. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during March-June, 1985.

Area	Mar		Apr		May		Jun	
	1	27	12	23	14	30	13	20
A. James River	1	1	1	1	0	1	1	1
B. Back River	0	0	0	0	0	0	2	2
C. Poquoson River	0	0	0	0	0	0	0	0
D. York River	2	5	10	14	16	11	13	13
E. Mobjack Bay	0	0	2	4	5	6	6	6
F. Piankatank River	0	1	2	2	2	2	2	2
G. Rappahannock River	5	21	31	36	31	19	18	20
H. Great Wicomico River	0	0	0	0	0	0	0	0
I. Potomac River	10	19	41	70	79	80	87	79
a. Virginia tributaries to Potomac River	4	4	4	4	6	3	2	2
J. Cape Henry-Fort Wool	0	2	5	7	9	9	9	9
K. Old Point-Tue Marsh Point	1	1	2	2	2	0	1	1
L. York Spit	0	1	4	6	9	9	11	10
M. New Point-Stingray Point	5	10	14	17	22	20	19	19
N. Windmill Point-Smith Point	3	4	9	14	17	15	15	13
Eastern Shore								
O. Above Hungar Creek	0	0	5	8	8	10	10	11
P. Below Hungar Creek	0	9	10	11	24	22	27	27
TOTAL	31	78	140	196	230	207	223	215

*No Pound net counts were made in January or February due to severe weather conditions.

Table 1.3. Number of stake gill net stands fished in Virginia rivers 1983-1985 (A) and linear meters of gill netting fished primarily for American shad per 5-mile block (B) in 1985. Figures in parentheses represent the total meters of gill netting in the James, York and Rappahannock rivers.

A.

River	Number of Gill Net Stands 1983	1984	1985
James	151	107	109
York	149	121	124
Rappahannock	46	37	27

B.

River	Mile		Number of Stands	Number of Sections	Average Length/Section	Meters of Net	
James	05-10		26	759	9.1	(6,907)	6,601
	10-15		1	22	9.1	(200)	191
	15-20		47	813	9.1	(9,756)	9,710
	20-25		17	267	12	(3,204)	3,189
	25-60		18	289	12	(3,468)	3,452
		Total	109	2,150		(23,535)	23,143
York	0-05		4	74	18.6	(1,376)	1,365
	05-10		5	55	14.2	(781)	775
	10-15		36	679	14.2	(9,642)	9,562
	15-20		28	484	14.2	(6,873)	6,816
	20-25		13	257	7.6	(1,953)	1,933
	25-30		38	684	7.6	(5,198)	5,144
		Total	124	2,233		(25,823)	25,595
Rappahannock	25-30		9	127	15.7	(1,994)	1,994
	30-35		7	134	15.7	(2,104)	2,104
	35-40		0	0			
	40-60		11	39	9.1	(355)	355
		Total	27	300		(4,453)	4,453

Table 1.4. Yearly catch-per-unit-of-effort for American shad in stake gill nets and river herring in pound nets for the years 1975-1985. 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	M	F	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		
1985	23,143	0.7	3.1		
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
1985	25,595	1.2	4.7	7.34	2,189
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	11,981
1984	5,742	0.9	2.3	34.26	15,401
1985	4,453	0.7	1.4	15.24	13,241

(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 1985 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
March 1st	05-10	0.4938	3,259	0.5613	3,705	6,964
	10-15		94		107	201
	15-20		625		921	1,546
	20-25	0.0644	205	0.0948	302	507
	25-60		222		327	549
	Total		4,405		5,362	9,767
March 2nd	05-10	0.5266	3,476	0.8376	5,529	9,005
	10-15		101		160	261
	15-20		1,787		3,516	5,303
	20-25	0.1840	587	0.3621	1,155	1,742
	25-60		635		1,250	1,885
	Total		6,586		11,610	18,196
April 1st	05-10	0.2757	1,820	1.9478	12,858	14,678
	10-15		53		372	425
	15-20		2,040		13,912	15,952
	20-25	0.2101	670	1.4327	4,569	5,239
	25-60		725		4,946	5,671
	Total		5,308		36,657	41,965
April 2nd	05-10	0.0427	282	1.1581	7,645	7,927
	10-15		8		221	229
	15-20		198		5,782	5,980
	20-25	0.0204	65	0.5955	1,899	1,964
	25-60		70		2,056	2,126
			623		17,603	18,226
	Total		16,922		71,232	
	Grand Total					88,154

Table 1.6. 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	
	M	F	M	F	Alewife	Blueback
James						
1977	11,612	186,495	[		(a)	]
1978	116,348	574,935				
1979	17,328	263,203				
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				
1985	16,922	71,232				
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
1985	36,786	120,951	1,336	645	5,175	14,850
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	313,873
1984	5,043	12,949	2,225	936	113,787	413,839
1985	3,284	6,152	602	248	49,104	152,696

(a) Data not available.

Table 1.7. Estimated catch in kg of American shad and river herring by pound nets in the York River 1985 by half-month intervals.

		American Shad				River Herring						
		Male		Female				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	87.7	350	57.0	228	790.1	3,160	47.6	1,504	52.4	1,656	4
April 1st	10	11.8	118	41.7	417	1,606.7	16,067	21.9	3,515	78.1	12,552	6
April 2nd	14	49.0	686	(a)		57.0	798	19.6	156	80.4	642	6
May 1st	12	15.2	182	(a)		(a)						6
Total			1,336		645				5,175		14,850	
Grand Total			1,981						20,025			

(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 1985 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	0-05		3		1	4
	05-10		2		<1	2
	10-15	0.0020	19	0.0005	5	24
	15-20		14		4	18
	20-25		127		51	178
	25-30	0.0658	339	0.0262	135	474
	Total		504		196	700
March 1st	0-05		425		560	985
	05-10		241		318	559
	10-15	0.3114	2,978	0.4100	3,920	6,898
	15-20		2,123		2,795	4,918
	20-25		1,392		1,562	2,954
	25-30	0.7204	3,706	0.8079	4,156	7,862
	Total		10,865		13,311	24,176
March 2nd	0-05		611		1,708	2,319
	05-10		347		970	1,317
	10-15	0.4478	4,282	1.2511	11,963	16,245
	15-20		3,052		8,528	11,580
	20-25		2,160		4,597	6,757
	25-30	1.1175	5,748	2.3779	12,232	17,980
	Total		16,200		39,998	56,198
April 1st	0-05		271		2,183	2,454
	05-10		154		1,239	1,393
	10-15	0.1989	1,902	1.5591	15,290	17,192
	15-20		1,356		10,899	12,255
	20-25	0.5582	1,079	1.9760	3,820	4,899
	25-30		2,872		10,165	13,037
	Total		7,634		43,596	51,230
April 2nd	0-05		75		1,212	1,287
	5-10		43		688	731
	10-15	0.0552	528	0.8875	8,487	9,015
	15-20		376		6,050	6,426
	20-25	0.0793	153	1.0475	2,025	2,178
	25-30		408		5,388	5,796
	Total		1,583		23,850	25,433
	Total		36,786		120,951	
	Grand Total					157,737

Table 1.9. Estimated catch in kg of American shad and river herring by pound nets in the Rappahannock River 1985 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	River Herring Alewife %	River Herring Alewife Estimated Total	River Herring Blueback %	River Herring Blueback Estimated Total	Number of Index Nets
March 1st	31-70	3	(a)		(a)		23	69	100	69			1
March 2nd	31-70	15	(a)		(a)		75.4	1,131	99.5	1,125	0.5	6	6
April 1st	31-70	19	4.6	87	1.2	23	219.8	4,176	68.7	2,869	31.3	1,307	11
April 2nd	31-70	19	1.1	21	1.1	21	1,044.7	19,849	40.1	7,960	59.9	11,889	5
May 1st	31-70	13	8.5	110	3.8	49	(b)						3
Total				218		93				12,023		13,202	
Grand Total				311						25,225			
Estimated landings mile 0-30				81		28				37,081		139,494	
				109						176,575			
Grand Total for Rappahannock River				420						201,800			

(a) No American shad landings were reported by index fishermen.
(b) No river herring landings were reported by index fishermen.

Table 1.10. Estimated catch in kg of American shad by stake gill nets in the Rappahannock River 1985 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
March 1st	25-30		199		121	320
	30-35	0.0999	210	0.0608	128	338
	35-60(a)					
	Total		409		249	658
March 2nd	25-30		605		629	1,234
	30-35	0.3034	638	0.3153	663	1,301
	35-60(a)					
	Total		1,243		1,292	2,535
April 1st	25-30		559		1,502	2,061
	30-35	0.2805	590	0.7533	1,585	2,175
	35-60(a)					
	Total		1,149		3,087	4,236
April 2nd	25-30		235		755	990
	30-35	0.1181	248	0.3786	796	1,044
	35-60(a)					
	Total		483		1,551	2,034
	Total		3,284		6,179	
	Grand Total					9,463

(a) see text for explanation

Table 1.11. Year-class frequency of alewife (sexes pooled) in the York River commercial fishery samples, 1985.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	76.	2	0.7	0.8	0.8
	77.	1	0.4	0.4	1.2
	78.	15	5.4	6.1	7.4
	79.	20	7.2	8.2	15.6
	80.	42	15.2	17.2	32.8
	81.	91	32.9	37.3	70.1
	82.	72	26.0	29.5	99.6
	83.	1	0.4	0.4	100.0
	9.*	33	11.9	MISSING	100.0
	TOTAL	277	100.0	100.0	

MEAN	80.725	STD ERR	0.080	MEDIAN	80.962
MODE	81.000	STD DEV	1.252	VARIANCE	1.566
KURTOSIS	1.130	SKEWNESS	-1.106	RANGE	7.000
MINIMUM	76.000	MAXIMUM	83.000		

VALID CASES	244	MISSING CASES	33

*Age code

9 - missing age data

Table 1.12. Year-class frequency of blueback herring, (sexes pooled) in the York River commercial fishery samples, 1985.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	1	0.1	0.2	0.2
	72.	1	0.1	0.2	0.5
	73.	6	0.8	1.4	1.9
	74.	10	1.3	2.4	4.3
	75.	12	1.6	2.9	7.1
	76.	7	0.9	1.7	8.8
	77.	9	1.2	2.1	11.0
	78.	57	7.5	13.6	24.5
	79.	92	12.2	21.9	46.4
	80.	142	18.8	33.8	80.2
	81.	68	9.0	16.2	96.4
	82.	15	2.0	3.6	100.0
	9*	335	44.4	MISSING	100.0
	TOTAL	755	100.0	100.0	

MEAN	79.186	STD ERR	0.091	MEDIAN	79.606
MODE	80.000	STD DEV	1.868	VARIANCE	3.488
KURTOSIS	2.875	SKEWNESS	-1.551	RANGE	11.000
MINIMUM	71.000	MAXIMUM	82.000		

VALID CASES 420 MISSING CASES 335

*Age code

9 - missing age data

Table 1.13. Year-class frequency of alewife (sexes pooled) in the Rappahannock River commercial fishery samples, 1985.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	76.	1	0.1	0.2	0.2
	77.	3	0.4	0.6	0.9
	78.	16	2.2	3.4	4.3
	79.	44	6.0	9.5	13.8
	80.	107	14.5	23.0	36.8
	81.	148	20.0	31.8	68.6
	82.	145	19.6	31.2	99.8
	83.	1	0.1	0.2	100.0
	9.*	274	37.1	MISSING	100.0
	TOTAL	739	100.0	100.0	

MEAN	80.757	STD ERR	0.054	MEDIAN	80.916
MODE	81.000	STD DEV	1.157	VARIANCE	1.340
KURTOSIS	0.461	SKEWNESS	-0.831	RANGE	7.000
MINIMUM	76.000	MAXIMUM	83.000		

VALID CASES	465	MISSING CASES	274

*Age code

9 - missing age data

Table 1.14. Year-class frequency of blueback herring (sexes pooled) in the Rappahannock River commercial fishery samples, 1985.

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	72.	1	0.1	0.3	0.3
	74.	3	0.4	1.0	1.3
	75.	1	0.1	0.3	1.6
	76.	5	0.7	1.6	3.2
	77.	6	0.9	1.9	5.2
	78.	38	5.6	12.3	17.4
	79.	125	18.3	40.3	57.7
	80.	99	14.5	31.9	89.7
	81.	30	4.4	9.7	99.4
	82.	2	0.3	0.6	100.0
	9.*	372	54.5	MISSING	100.0
	TOTAL	682	100.0	100.0	

MEAN	79.239	STD ERR	0.070	MEDIAN	79.308
MODE	79.000	STD DEV	1.228	VARIANCE	1.509
KURTOSIS	6.470	SKEWNESS	-1.666	RANGE	10.000
MINIMUM	72.000	MAXIMUM	82.000		

VALID CASES	310	MISSING CASES	372

*Age code

9 - missing age data

Table 1.15. Year-class frequency of American shad in the Virginia commercial gill net fishery, 1985.

Sex	Year Class	James	York	Rappahannock	Total	Frequency (%)
Male	1978	3	2	2	7	14.59
	1979	4	9	15	28	58.33
	1980	1	1	10	12	25.0
	1981			1	1	2.08
Total		8	12	28	48	
Female	1976	10		1	11	5.70
	1977	11	5	5	21	10.88
	1978	30	16	15	61	31.61
	1979	23	29	22	74	38.34
	1980	6	15	5	26	13.47
Total		80	65	48	193	

Table 1.16. Length (mm) and weight (g) statistics for river herring in the York and Rappahannock rivers, 1985.

Species	Sex		York N	York Mean	York Std. Error	Rappahannock N	Rappahannock Mean	Rappahannock Std. Error
Alewife	Male	Length	119	236.3	1.257	388	240.3	0.742
		Weight	119	190.2	3.648	389	207.4	2.437
	Female	Length	121	256.2	1.616	309	253.1	0.830
		Weight	121	251.6	5.966	309	256.7	3.445
Blueback	Male	Length	360	241.5	0.741	344	236.4	0.529
		Weight	360	177.0	1.774	344	150.0	1.340
	Female	Length	314	254.1	0.864	265	247.6	0.667
		Weight	314	202.7	2.477	265	173.6	1.980

Table 1.17. Length (mm) and weight (g) statistics for American shad in the James, York and Rappahannock gill net fisheries, 1985.

		James			York			Rappahannock		
Sex		N	Mean	Std. Error	N	Mean	Std. Error	N	Mean	Std. Error
Male	Length	12	442.0	3.917	13	422.9	9.188	36	431.2	3.034
	Weight	12	1503.7	41.642	13	1325.3	41.347	36	1416.4	30.242
Female	Length	103	474.2	2.188	89	458.4	2.330	62	469.5	3.159
	Weight	103	1976.2	29.891	89	1806.1	32.763	63	1991.2	47.877

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
1978	1.40	0.75	0.25	0.26	0.59+	-	-	-
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 ln CPUE on age).

+The Z value was a statistical outlier, and omitted from the calculations.

Table 2.1. Maximal catch-per-unit-of-effort (CPUE) values for juvenile Alosa in the Mattaponi and Pamunkey rivers, 1979-1985.

	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
1985	31.3	206.2	35.9	12.6	154.6	15.5

*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, 1979-1985.

Species	River	1979	1980	1981	1982	1983	1984	1985	Mean*
Alewife	M	0.036	0.330	0.105	0.036	0.038	0.042	0.038	0.038
	P	0.040	0.041	0.058	0.043	0.068	0.036	0.067	0.050
American shad	M	0.040	0.056	0.080	0.042	0.030	0.056	0.053	0.044
	P	0.060	0.080	0.043	0.050	0.078	0.057	0.098	0.068
Blueback	M	0.034	0.022	(+)	0.077	0.041	0.030	0.035	0.043
	P	0.040	0.031	0.016	0.046	0.052	0.078	0.055	0.054

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

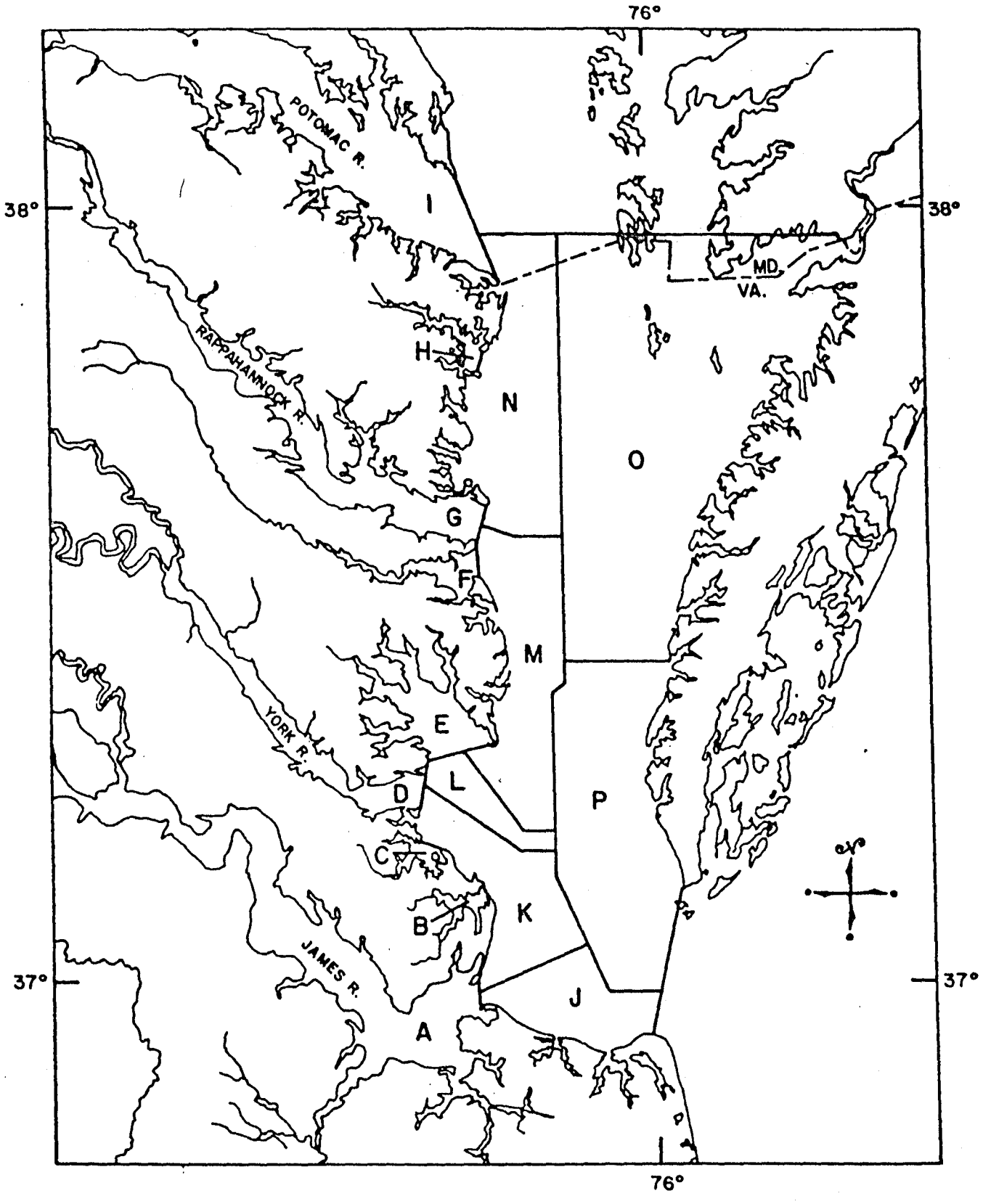
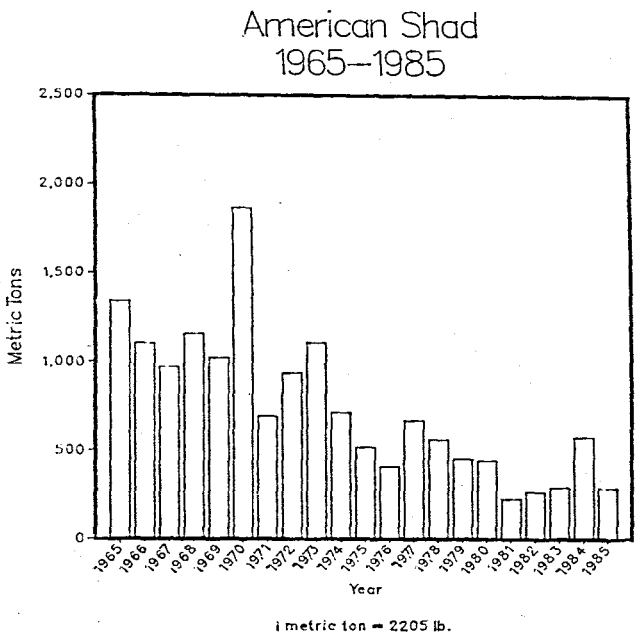
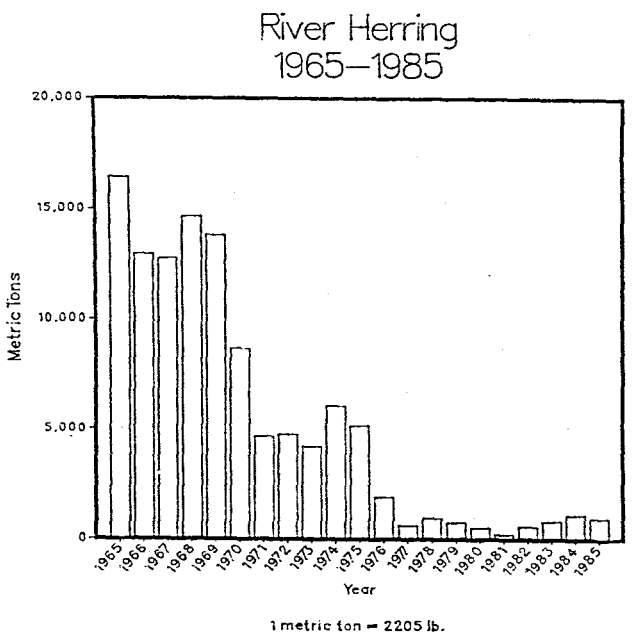


Figure 1.1. Area designations utilized during aerial pound net counts.

Figure 1.2. Virginia Landings 1965–1985.





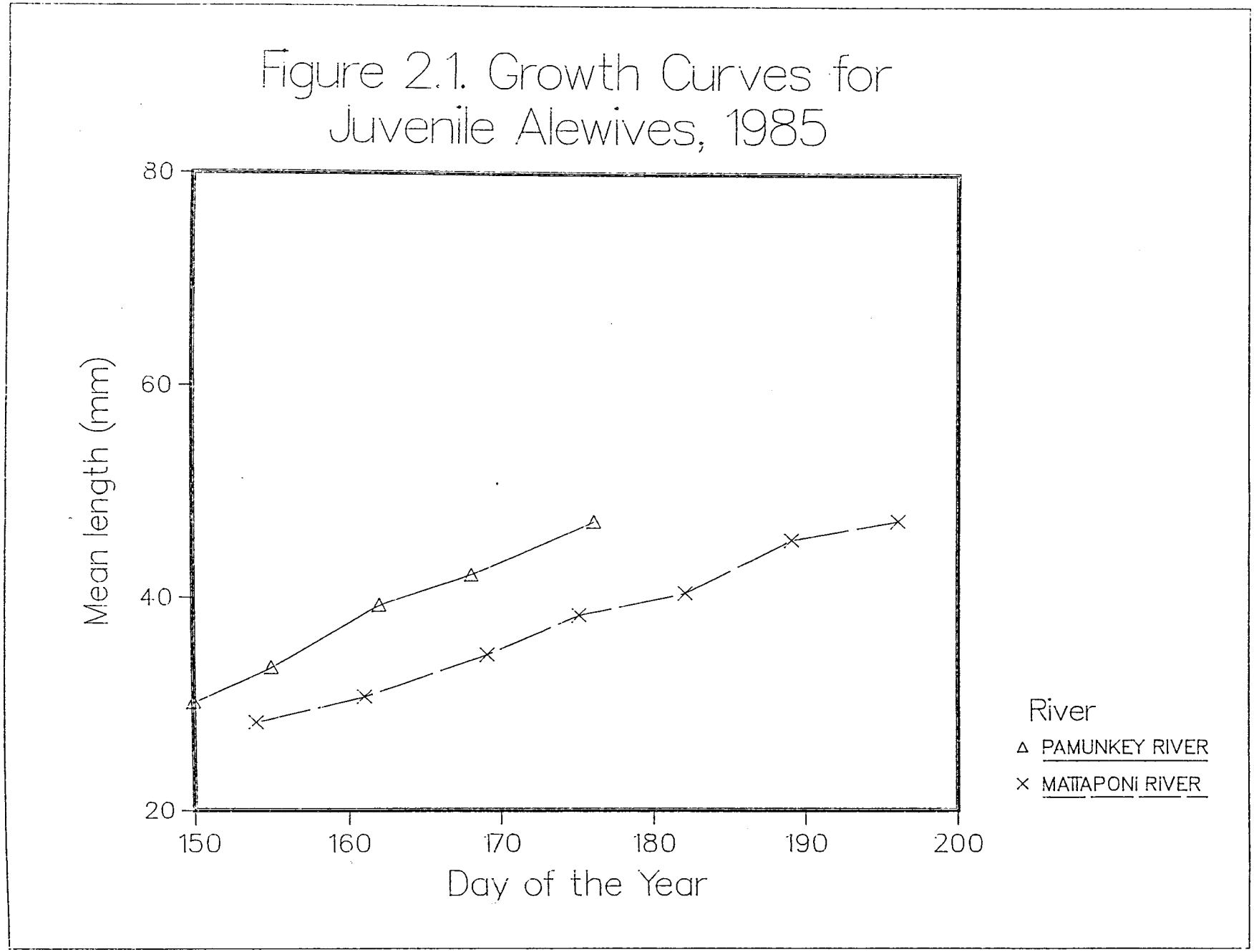


Figure 2.1. Growth Curves for Juvenile Alewives, 1985
Mean length (mm)
80
60
40
20
150
160
170
180
190
200
Day of the Year
River
PAMUNKEY RIVER
MATTAPONI RIVER

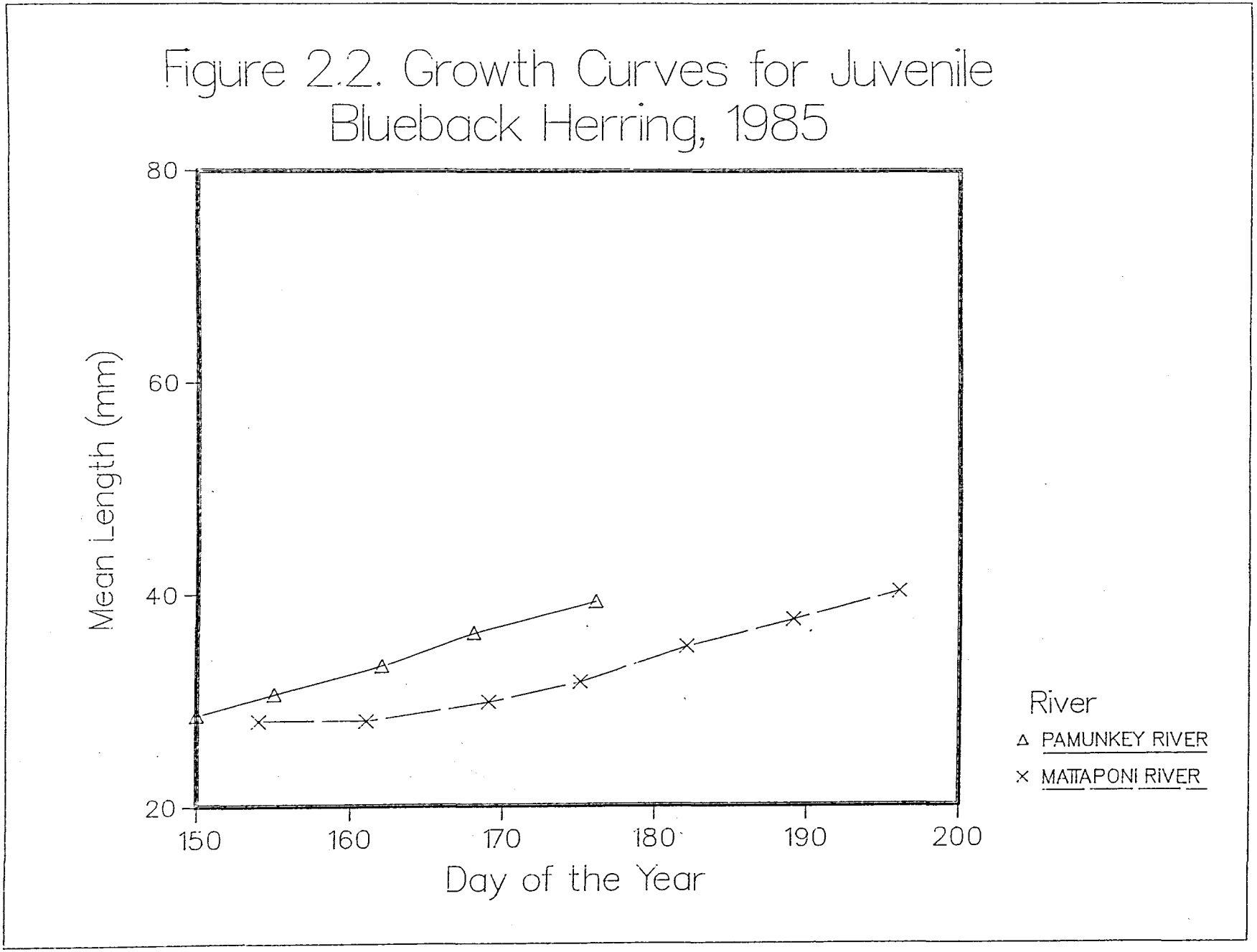


Figure 2.2. Growth Curves for Juvenile Blueback Herring, 1985
Mean Length (mm)
80
60
40
20
150
160
170
180
190
200
Day of the Year
River
PAMUNKEY RIVER
MATTAPONI RIVER

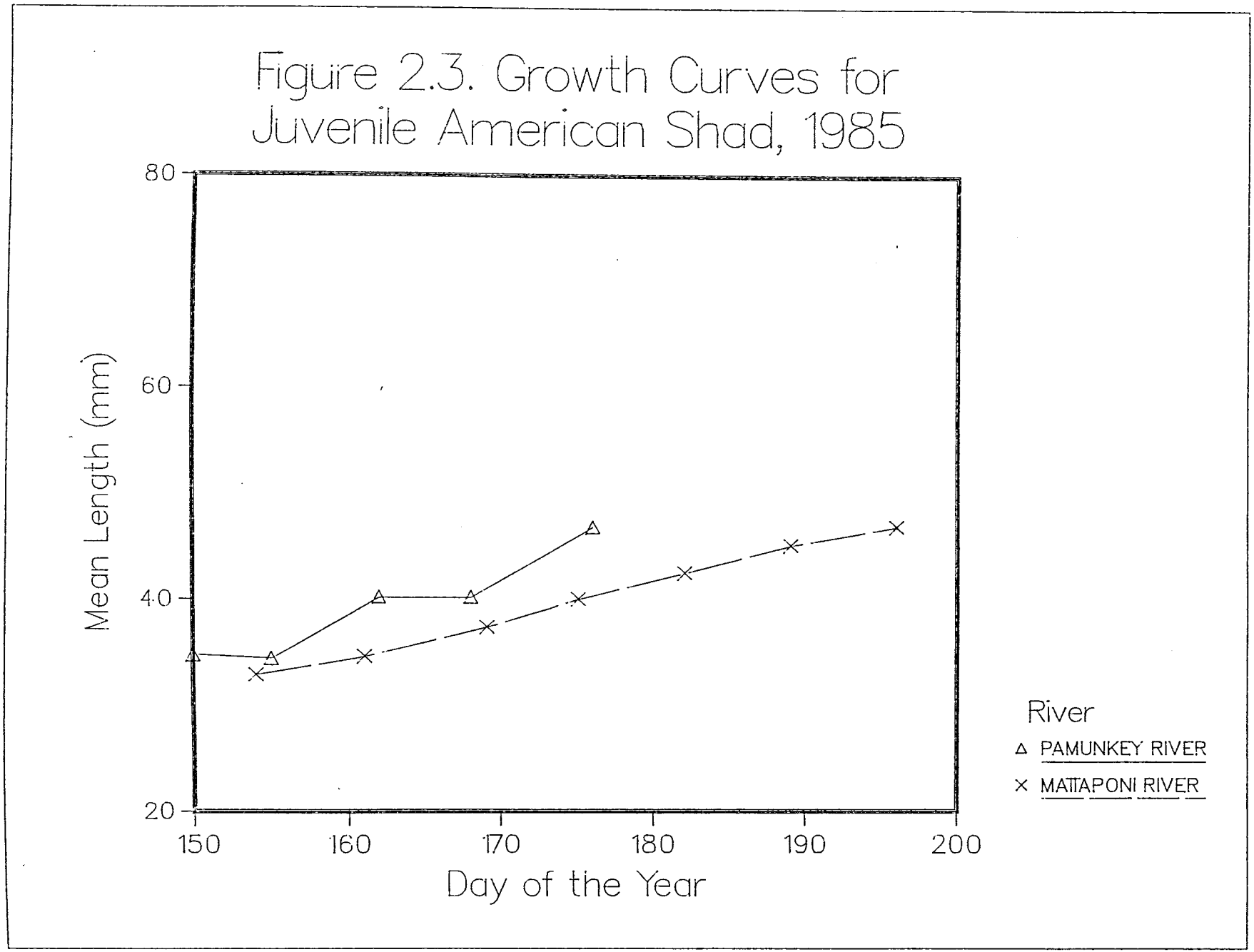


Figure 2.3. Growth Curves for Juvenile American Shad, 1985
Mean Length (mm)
80
60
40
20
150
160
170
180
190
200
Day of the Year
River
PAMUNKEY RIVER
MATTAPONI RIVER