1-2-1992

A Stock Assessment Program for Chesapeake Bay Fisheries: Development of an Alosa Juvenile Index of Abundance: Annual Report 1990

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Recommended Citation

Dixon, D. A., & Loesch, J. G. (1992) A Stock Assessment Program for Chesapeake Bay Fisheries: Development of an Alosa Juvenile Index of Abundance: Annual Report 1990. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/xjvm-mt48

ANNUAL REPORT

A Stock Assessment Program for Chesapeake Bay Fisheries: Development of an Alosa Juvenile Index of Abundance

Contract No. NA90AA-H-SF671

Project Period:

May 1, 1990 - July 31, 1991

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January 3, 1992

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PREFACE

This presentation is the annual report for Contract No. NA90AA-H-SF671 "A Stock Assessment Program for Chesapeake Bay Fisheries: Development of an Alosa Juvenile Index of Abundance," for the period 15 June 1990 to 31 July 1991. 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, have 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 fisherman in Virginia, however, 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 data analyses may make constructive contributions to rational management strategies.

The research presented herein directly addresses many of the 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.

ACKNOWLEDGMENTS

We are indebted to the following Virginia Institute of Marine Science personnel for their assistance in this project: Loisirene Blumberg, Steffany Dawson, Joice Davis, Steve Gornak, Bruce Hill, Curtis Leigh, James Owens, Phil Sadler, Paula Williams, and Hank Wooding. We also express our thanks to the VIMS Vessel Operations Support Staff without whose help our ambitious sampling program would not have been possible.

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INTRODUCTION

Historical Background

Prior to the arrival of the colonists in Virginia, American shad (Alosa sapidissima) were caught in large quantities by the Indians using crude nets made of bushes (Walburg and Nichols 1967). The Virginia Commission of Fisheries (1875) reported that shad were once so abundant that children could easily spear them in shoal water. River herring, collectively the alewife (A. pseudoharengus) and the blueback herring (A. aestivalis), were also very abundant. In 1588, Thomas Hariot (cited by de Bry 1590), wrote that during the months of February through May, herring were "most plentiful, and in best season, which we found to be most delicate and pleasant meat." The early settlers pursued these Alosa species with more efficient seine nets and traps, and blocked stream passage with hedges, dams and other obstructions. By the latter half of the 18th century there was a conspicuous decline in the Alosa stocks; nevertheless, these species continued to support major fisheries. In 1880 the tributaries of the Chesapeake Bay yielded more than 2,268 metric tons (MT) of shad. In 1896 Virginia ranked second to New Jersey in shad production with 4,990 MT. Usually Virginia ranked first or second in shad production in the early 1900's. In 1908, Virginia's shad catch of 3,311 MT made it the most important fish caught in Virginia, and the catch comprised about one fourth of all shad taken in the United States. The catch of American shad, however, has critically declined since the mid-1970's.

River herring catches in Virginia have had a pattern very similar to that for the shad. In 1920, river herring in Virginia ranked first in quantity and fourth in value, with a catch of 7,258 MT worth 253 thousand dollars. As late as 1969 river herring in Virginia ranked third in quantity and fifth in value, with a catch of 13,608 MT worth 608 thousand dollars (NMFS 1972). Since the early 1970's, however, the fishery has also steadily declined.

Historically, the construction of dams, degradation of the environment, and over-fishing were cited as causes for the decline of fish stocks. To varying degrees, the same explanations are offered as contemporary explanations for further declines in stocks.

Dams built in the 19th and 20th centuries have blocked the upstream passage of anadromous fishes and substantially reduced the amount of available spawning grounds. In the James River, for example, American shad originally migrated about 540 km upstream, but access was limited to the Richmond area, about 155 km, with the construction of Bosher Dam in the early 1800's. There are now five low head dams in an eight mile reach in this area of the James River, three of which were constructed in the early 1900's. The lower two dams were recently breached as a first step toward giving <u>Alosa</u> fishes access to historical spawning grounds. A low head dam was built in 1943 on the Chickahominy River at Walker, about 35 km above its junction with the James River. The area below the dam was formerly the lower limit of shad spawning in the Chickahominy River, today it is the only spawning area. As a consequence, a major shad fishery that existed before the construction of Walker Dam has since vanished. A fish ladder over Walker Dam was recently constructed and first operated in Spring 1989. A number of impoundments without fish passage facilities also have been built on Virginia tributaries of the Potomac River.

The decline in <u>Alosa</u> landings since the 1970's may be the joint result of the heavy exploitation in the late 1960's, the decimation of the 1972 year class by Tropical Storm Agnes (Loesch and Kriete, 1976), and continued poor recruitment in recent years. Although landings have increased since 1981, they are still low. The use of pesticides and, in particular, the use of herbicides in conjunction with no-till farming may also be, in part, responsible for the reduction of *Alosa* stocks in the Chesapeake Bay region.

It is important that the basic biology and population dynamics of the *Alosa* stocks in the Chesapeake Bay region be studied. Anadromous fishes are a renewable natural resource which have a vital ecological role in addition to their economic importance. Juvenile (young-of-the-year) *Alosa* are the dominant pelagic species in their extensive freshwater and upper estuarine nursery grounds and thus, are important prey for resident piscivores. Durbin et al. (1979) noted that anadromous alewives entering ponds in Rhode Island were an important nutrient source to a system through spawning mortality. After spawning, adults return to the sea and are prey of many predatory marine fishes. Because of the ecologic and economic importance of *Alosa*, it is in the interest of both the State of Maryland and the Commonwealth of Virginia (and other Atlantic coastal states) to conduct *Alosa* studies. Current data, as well as historical data, are needed for constructive contributions to the formulation and application of rational management strategies.

Estimates of relative year-class strength (indices), the subject herein, are an important facet in the studies of stock recruitment. Indices are particularly sensitive to large changes in juvenile (young-of-the-year) abundance, thus, an expectation of a strong or weak year class can be established. If a juvenile index can be shown to vary directly with the spawning stock size over a large range in stock sizes, the index can be used as a surrogate for actual year-class recruitment. Thus, the relationship between spawning stock size and recruitment can be analyzed without waiting years for the completion of recruitment.

Program Background and Objectives

The establishment of juvenile *Alosa* indices by using a pushnet is a modification to a methodology previously used in Virginia waters. A pushnet was used at night to determine a maximal catch-per-unit-of-effort (maximal CPUE; explained in Procedures). The research was conducted at night in the Mattaponi and Pamunkey rivers for nine years, and a correlation between the river herring index and CPUE of subsequent recruits to the fishery was about 73%. This activity was not continued in 1988 because of a lack of funding. In 1990, however, NMFS provided the necessary funds to renew the program as well as expand it in future years to include the James and Rappahannock rivers.

Future expansion of sampling activities to include the James and Rappahannock rivers necessitated an assessment of day-time sampling for several reasons. First, it is often difficult to obtain a boat operator who could navigate the Mattaponi and Pamunkey rivers at night. This personnel problem would increase because it will be necessary to use two pushet vessels in the future to sample all the rivers weekly. It is believed that the precision and accuracy of indices can be greatly influenced by the time lapse between sampling periods. Turner and Chadwick (1972) reported deficiencies in the interpretation of their juvenile striped bass index when data were collected at two-week intervals. Secondly, sampling can be conducted at a faster pace in the day-time. This is important because all four rivers will be sampled weekly, and the *Alosa* species sorted and counted before the start of the next week's sampling. It is important to establish each weekly CPUE promptly so as to recognize the maximal CPUE two to three weeks after its occurrence and, thereby, avoid costly extra weeks of sampling. Finally, the James and Rappahannock rivers, unlike the Mattaponi and Pamunkey rivers, are hosts to large commercial vessel traffic both day and night. Thus, night-time sampling in small boats in the James and Rappahannock rivers incurs greater safety risk then does daytime sampling.

The shift from night-time to day-time sampling, the future expansion of the scope of the effort to other rivers, and the establishment of a long-term data base necessitates both short-term and long-term objectives. The short-term objectives, the results of which are discussed in this report, are as follows:

1. Establish a conversion factor for the extant data base of Alosa indices so as to be compatible with indices from daytime sampling.

2. Establish a conversion factor for the difference in fishing power between a new pushnet vesssel (**R/V TEAL**) and the old vessel (**R/V ALBATROSS**) from which most of the historical was obtained.

3. Concurrently with short-term objectives 1 and 2, resume the sampling of juvenile Alosa in the Mattaponi and Pamunkey rivers in June 1990 in order to estimate relative abundance, growth, and mortality.

4. Initiate a data base of light intensity values taken with a submersible photometer at the time of sampling.

5. Initiate comparative sampling with Maryland's Department of Natuaral Resources (DNR) trawl catches of juvenile Alosa.

The long-term objectives are to provide a methodology for establishing a long-term data base of juvenile Alosa indices for the nursery zones of the James, Mattaponi, Pamunkey, and Rappahannock rivers (Figure 1) in order to:

1. Develop juvenile *Alosa* indices based on daytime sampling that are (at the very least) sensitive to good and poor reproductive success.

2. Assess the utility of juvenile indices, over a large range in stock sizes, as a surrogate for actual year-class recruitment in stock-recruitment models.

3. Determine if species-specific indices exhibit a common pattern of change.

4. Determine if patterns of index changes differ among rivers.

5. Integrate the year-class assessments in Virginia with those in Maryland to provide a Bay wide estimation of *Alosa* year-class strength.

METHODS AND MATERIALS

Initiation of activities in 1990 was delayed until late June -early July because of the late receipt of program funding. This start-up time, as expected, seriously affected the catch results and mitigated the probability of obtaining reasonably objective estimates of juvenile Alosa relative abundance. Historically, the maximal CPUE, as discussed below, occurs in early to mid-June. This is particularly true for the American shad and alewife which precede the blueback herring to the freshwater spawning grounds. Loesch and Kriete (1983) reported that the quest for an unambiguous juvenile Alosa indices must begin, at the latest, in the first week of June. Differences in the time of the maximal CPUE occurrences stem from the differences in time when the bulk of each species spawns. Also, different species-specific growth rates, effects of density, and environmental variation affecting diet will affect size at age, ergo, availability at age.

The initial action in 1990 was to refurbish the vessel-pushnet complex previously used to estimate the relative abundance of juvenile Alosa. That vessel (**R/V ALBATROSS**) was old (about 22 years) and needed replacement. The new vessel (**R/V TEAL**) and pushnet frame complex is a 21 foot open cockpit/center console Privateer. Details of the pushnet design, with a schematic diagram, are given by Kriete and Loesch (1980). The pushnet, like trawls, can be used in randomized sampling schemes. In contrast, beach seines are limited to sites of access within the sampling area. Kriete and Loesch (1980) reported the following pushnet attributes: (1) the catch efficiency of the pushnet far exceeded that of a Cobb trawl previously used to capture juvenile Alosa in daytime sampling (averaging about 15:1); (2) the pushnet, like small trawls, 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 pushnet frame, multiple nets of the same mesh size may be installed to estimate within-replicate variability, or different mesh sizes used and contrasted; (4) set and retrieval times for the pushnet are brief; (5) the high cruising speed (22 knots) with good stability and the ability to trailer the vessel and gear as a unit greatly diminished the time needed to sample large and disjunct river systems.

Sampling for juvenile Alosa in the nursery zones of the Mattaponi and Pamunkey rivers began on 25 June and 27 June, 1990, respectively. The nursery zone in the Mattaponi River was sampled weekly during the day-time through 31 July (6 sampling cruises) and through 14 August (8 sampling cruises) on the Pamunkey River. In addition, following a day-time sampling cruise, night-time sampling was conducted on four occasions on the Pamunkey River, and once each on the Mattaponi and James rivers to obtain day-night catch conversion data. Concurrently with the index and day-night data collection efforts, paired sampling between the **R/V ALBATROSS** and **R/V TEAL**, to compare the relative fishing powers of the two vessels, was conducted. Paired sample data was collected on 13 occasions and encompassed a total of 175 sampling pairs. The methodology for data collection is discussed below.

A stratified random sampling plan (SRS) was employed. Each nursery zone was divided into a series of strata, each 9.3 km (5 nautical miles), and each stratum further divided into five 1.9 km substrata. Perpendicular to this stratification, the 9.3 km sections were divided into three nearly equal parts, a center section and two shoreward sections bounded by the 1.8 m depth contour lines at mean low water (MLW) indicated on the respective navigation charts. Thus, each 9.3 km stratum was partitioned into 15 sites. Sampling sites were randomly chosen from the 15 in each stratum. The number of replications per stratum was in accordance with the area of the stratum. The mean number of replications per stratum was 4.2 with no fewer than 2 replications in a strata. This effort allocation design is a modification to the original statement of work and reflects comments received on the original design from the NMFS (see letter dated February 21, 1990 from H. Mears, Chief - Stae/Federal Relations Branch, NMFS, Woods Hole, MA. and response dated March 23, 1990 from J.G. Loesch, Principal Investigator, VIMS, Gloucester Point VA.).

The nursery zone in each sampling period was demarcated by the last upstream and the last downstream stratum in which juvenile Alosa were captured. A dynamic nursery zone, rather than a static one, and an SRS were chosen because there is a shift in availability of juvenile Alosa within the nursery zone. For example, in the Pamunkey River in 1979, juvenile Alosa were captured between river miles 45 to 70 on June 20. On July 30, the lower limit of the nursery zone, as defined by the last stratum of capture, extended downriver to mile 35. Due to low river flows and the encroachment of saline water, the lower limit of the nursery zone had moved upriver to mile 45 by August 20. The upper limit of the zone moved down river in September and October. Within the limits of the nursery zone, juvenile abundance is generally greatest in the central or near central strata, and this pattern of the distribution of density also shifts as the nursery zone limits change. The use of a SRS design where there is a shift in availability and/or the density distribution avoids the inherent possibilities in a CR design of expending a large proportion of the sampling effort either in an area where the fish were previously, but not presently, available, or in a limited area of heavy concentration.

To calculate the volume of water sampled, a calibrated flowmeter was mounted in the mid-point of the net. All samples were collected against the current. Previous trials with this arrangement, however, indicated that there was no significant difference in volume of water filtered when samples were taken with or against the current, and the overall mean volume was 655 m^3 (Loesch et al. 1982). In practice, samples of 5-min duration are taken, and adjusted, as flowmeter values indicate, to the standard of 655 m^3 of water filtered (i.e., 1 unit of effort).

Juvenile catch data were also adjusted for a minimum fish size. Small juvenile Alosa capable of passing through the 12.7 mm stretched mesh of the pushnet codend are retained to varying degrees by larger fish and debris in the net. To ascertain escapement, a sleeve of 6.36 mm stretched mesh was loosely fitted over the codend in a series of 25 samples in 1979 (Loesch and Kriete 1983). Only 5.4% of the fish $\leq$ 26 mm were retained in the codend, and a fork length of 27 mm was chosen as a lower limit for catch-effort considerations. It is believed that this limit increases the reliability of the estimates, but it is also recognized that the effect of masking (see Pope et al. 1975) could be confounded in the data. However, the effect is believed to be nonsignificant because the larger counts in the sleeve occurred before the maximal CPUE was attained.

The index that is used is defined as the maximal average catch-per-unit-of-effort (maximal CPUE), i.e., the mean CPUE (by species) in a sampling period that exceeds the mean CPUE in all other weekly sampling periods. Annual indexes of juvenile Alosa abundance were at one time derived from a single, daytime, surface-trawl survey in the major Virginia tributaries to Chesapeake Bay. That sampling scheme implied that the proportion of juvenile stock available to the gear at the time of sampling was constant year to year, and fish availability was independent of light intensity. However, Loesch et al. (1982) reported diel migratory activities by juvenile anadromous Alosa, and an association between sky-opacity index values and surface catch of blueback herring. Their findings suggest that the juveniles (or their prey) are negatively phototropic, and the catches made by the surface trawls were inversely related to the degree of light attenuation. Originally, a submercible photometer to measure light intensity at a constant depth, say, 3 m, with each sample was planned. The intent is to eventually develop a model for adjusting catches to a standard light intensity. Because of late program funding and subsequent ordering of the equipment, the photometer supplier was unable to provide the meters until after the sampling season had ended.

An overall mean CPUE was calculated for each sampling period. The largest of these CPUE values would, normally, be defined as the index of abundance, and referred to as the maximal CPUE. A maximal CPUE was chosen as an index, in preference to a seasonal mean CPUE, for several reasons. First, a general downstream drift of the larger juveniles in the summer and fall, ahead of the mass migration associated with decreasing river temperatures, has been reported for blueback herring and American shad (Loesch 1969, Marcy 1976). Thus, emigration affects late-season availability in the nursery zones. Second, the effect of increased gear avoidance with increased size is minimized with a maximal CPUE index since it occurs relatively early in the total period of juvenile availability in the nursery zones. Thirdly, there are economic considerations. Field programs, and the subsequent laboratory work are labor intensive and costly. To isolate the maximal CPUE, it is necessary to sample before and after its occurrence. Sampling starts in late May or early June, and for alewife and American shad the maximal CPUE occurs between late June and early July, and in late July or early August for blueback herring. However, relatively large catches of juvenile blueback herring can be made in surface waters (day or night) in September and October (Kriete and Loesch 1980; Loesch et al. 1982). Thus, with a maximal CPUE index, sampling of juvenile blueback herring would be completed about late August. In contrast, a seasonal index would require sampling through

October, possibly through November. Because of the late receipt of program funding and, consequently late start of field sampling, a reasonably objective index for 1990 could not be estimated.

Estimates of mean CPUE that followed the maximal CPUE, but clearly preceded the onset of the seaward migration, would normally be used in conjunction with the maximal value to estimate the instantaneous natural mortality rate (M_d). The $\log_e$ of the ratio of maximal CPUE to a subsequent CPUE would be 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) would be used to derive M_d.

Increases in mean fork length were used to calculate juvenile Alosa "apparent growth". All juveniles in samples of size N < 50 were measured; for N > 50, a random subsample of 50 fish was taken. Difficulties in interpreting "apparent growth" are discussed in the next section.

RESULTS AND DISCUSSION

As previously discussed, late receipt of funding and consequent late start-up (25 June 1990) of sampling efforts prevented the derivation of reasonably objective estimates of relative abundance, growth, and mortality. Preliminary information on the feasibility of day-time sampling was obtained, conclusive results, however, must await additional sampling in 1991. The relative fishing powers of the two vessels was successfully compared and no significant difference was detected. As such, current and future data are directly comparable to historical data. Each of these subjects are discussed below.

Relative Abundance

Mean CPUE values were calculated for each weekly day-time cruise and, when they occurred, night-time cruise. These data are presented in Table 1. Significant day-time catch data were only obtained in the Pamunkey River and only for blueback herring. No alewife were collected in 1990 and only a few incidental American shad. Daytime catches of blueback herring during the first two weeks of sampling on the Pamunkey River were limited to a 10-mile section (RM 45-55) that is historically the center of juvenile abundance. By the third week of sampling, blueback herring were essentially no longer available to the pushnet gear. This was probably the result of gear avoidance with increased size of the blueback herring.

The reasons for the extremely limited day-time catches are unknown. Juvenile Alosa, particularly the blueback herring, have been shown to be available to the pushnet gear in significant numbers during the late 1970s (Loesch et al. 1982). They also found that although both the blueback herring and alewife exhibited a diel periodicity (negative phototrophism), the blueback herring remain higher in the water column than do alewives. The vertical density distribution of juvenile American shad, relative to the other alosids is unknown. It is possible that the low day-time catch rate is a function of juvenile population density. The fact that what catch was made was limited to the center of juvenile abundance, as confirmed by night-time sampling, is strongly suggestive. Other factors, such as light penetration as affected by water turbidity may also have an important influence. Further insight must await continued sampling in 1991.

Although a reasonably objective index could not be estimated for 1990, catch results from night-time samples do not suggest that a strong year-class for any of the Alosa sp. was produced. In fact, the virtual lack of catch of alewives and American shad could indicate that recruitment of juveniles of these species may be less than observed throughout the 1980s (Table 2).

Day-Night Catch Comparison

Day-night catch comparisons for juvenile Alosa were made on 6 occasions during 1990. Summary statistics for these efforts are presented in Table 3. As previously discussed, day-time catch results were extremely limited. After mid-July, essentially no Alosa were captured during day-time sampling. Decreasing catch during day-time sampling probably results from their negative phototrophic behavior, increased gear avoidance with increasing size, and natural mortality. The relative importance of each, however, is not known. When blueback herring were captured by the pushnet gear during day-time hours, the corresponding evening's mean CPUE was at least an order-of-magnitude greater than during the day. Based on the extremely limited day-night catch comparison results, no objective day-night conversion factor can be developed at this time. Further day-night comparison data, to be collected in 1991, are required to assess the feasibility of day-time pushnet sampling for juvenile Alosa and for developing the day-night conversion factor.

Natural Mortality

The daily rate of instantaneous natural mortality could only be estimated for blueback herring in the Pamunkey River. A rate of 0.129 was estimated from the $\log_e$ of the ratio of mean CPUE for consecutive nightime cruises in mid-July (July 10 and 18) divided by the number of days elapsed (9). There were insufficient catch data for the other Alosa sp. and virtually no data for the Mattaponi River. The estimated instantaneous natural mortality rate of 0.129 for blueback herring should be interpreted with caution for two reasons: (1) because the maximal CPUE for blueback herring generally occurs in June, as previously discussed, it was assumed that the catch results for July 10 and 18 were post maximal CPUE or on the decsending limb of the seasonal catch curve, and (2) sampling in the Pamunkey River on these two nights was limited to a restricted area of the juvenile nursery zone as construction on the Norfolk-Southern railrod bridge at RM 56 prevented upstream sampling on the river. The rate of 0.129, however, is consistent with that observed for 1987 (0.14) but nearly 3 times greater than the average rate (0.044) observed for the period 1979-1986. Estimates of daily instantaneous natural mortality rates (M_d) for the period 1979-1990 are presented in Table 4. Because of three-week intervals between sampling, the 1980 and 1981 data are not considered reliable (Loesch and Kriete 1983).

Growth

The growth curve for blueback herring in the Pamunkey River, and for limited data in the James River, are presented in Figure 2. The extremely limited catch of blueback herring in the

Mattaponi River, and for American shad in any of the river systems, precluded a meaningful analysis. Two aspects of these curves must be interpreted from the life history of the *Alosa*. During the season, there is tendency for the larger juveniles to migrate downstream (Loesch 1969, Marcy 1976). Thus, growth will be underestimated if these individuals leave the nursery zone. The other aspect of *Alosa* behavior that affects estimates of juvenile growth (and mortality) is their protracted spawning period. Juveniles collected in June in the Virginia nursery zones are primarily products of the early spawners. From mid-July to mid-August, depending on the time of spawning and the growth rate, the juveniles produced by the bulk of the spawners become susceptible to capture by the pushnet. The result of this recruitment is an apparent decrease in the growth rate or an apparent decrease in the mean fork length. This apparent "negative growth" was reported in the previous annual reports for the juvenile *Alosa* program, for juvenile blueback herring in the Susquehanna River (Whitney 1961), and in the Connecticut River (Loesch 1969); it is also apparent in the juvenile American shad growth curve presented by Marcy (1976). "Negative growth" is readily apparent in Figure 2 for juvenile blueback herring over a 30-day period in the James River. Thus, observed growth determined from body length is only apparent growth because of the effects of recruitment and emigration. Because of these effects, estimates of instantaneous growth rates using body length data are not possible.

Paired Sampling Results

During July, August, and September 1990 a total of 13 cruises (6 day-time and 7 night-time), encompassing a total of 175 sampling pairs were conducted on the Pamunkey (90 pairs), Mattaponi (13 pairs), and James (72 pairs) rivers for juvenile *Alosa*. Of the 175 total pairs, catch data were obtained for 113 pairs of which 100 pairs occurred during night sampling. All paired samples were of 5 minutes duration at approximately 1200 rpms. The distance between the vessels was maintained at approximately one boat length. Vessel positions relative to the shoreline were randomized. Paired sample locations on the Pamunkey and Mattaponi rivers were in accordance with the effort to develop the annual index of abundance (i.e., paired sampling and sampling to collect index data occurred simultaneously). Following completion of the index sampling, paired sampling efforts were switched to an area in the James River where juvenile <u>Alosa</u> abundance historically are much higher. Paired data were obtained only for blueback herring as no American shad or alewife were caught in any of the rivers.

For each sample pair, the CPUE difference (i.e., **R/V TEAL** catch minus **R/V ALBATROSS** catch) was calculated and descriptive statistics computed as follows:

Number of pairs:	113
Minimum difference:	-400.7
Maximum difference:	367.5
Mean difference:	-1.1
Variance	5329
Standard deviation:	73.0

Based on parametric (paired t-test of log X+1 transformed data) and nonparametric (Wilcoxon Signed Rank Test) analysis, it has been concluded that differences in the fishing power of the two vessels could not be detected (P = 0.87 and 0.79 for the parametric and nonparametric tests, respectively). As such, CPUE data collected by the new pushnet vessel (**R/V TEAL**) is directly comparable to historical data.

<u>Gear Comparison Study with MD-DNR</u>

The objective of the gear comparison study was to compare daytime catches of juvenile Alosa by VIMS' pushnet system with that of MD-DNR's trawl system. Results of the gear comparison effort would be used to develop conversion factors such that a Bay-wide annual juvenile Alosa index could be estimated. Because the daytime pushnet catches of juvenile Alosa were extremely low in 1990, comparative sampling with MD-DNR would have yield limited data toward effective comparison of the fishing powers of the two gears. As such, attainment of the objective to compare gear efficiencies will be rescheduled in 1991.

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Table 1. Mean and standard deviation CPUE for blueback herring* and American shad per 1990 sampling cruises on the Mattaponi and Pamunkey rivers.

River	Date	Day	Night
Blueback Herring			
Pamunkey	6/27/90	2.8 (6.6)	NS
	7/05/90	0.5 (1.3)	NS
	7/10/90	1.9 (4.3)+	82.1 (60.4)+
	7/18/90	1.0 (1.3)+	25.7 (31.1)+
	7/23/90	0.1 (0.3)+	NS
	8/01/90	0	NS
	8/07/90	0.1 (0.2)	36.5 (47.3)
	8/14/90	0	5.4 (8.8)
Mattaponi	5/30/90	0	NS
	6/25/90	0	NS
	7/06/90	0	NS
	7/11/90	0	NS
	7/16/90	0	NS
	7/24/90	0	0
	7/31/90	0	NS
American Shad			
Pamunkey	6/27/90	0	NS
	7/05/90	0	NS
	7/10/90	0+	0+
	7/18/90	0+	0+
	7/23/90	0+	NS
	8/01/90	0	NS
	8/07/90	0	0
	8/14/90	0	0
Mattaponi	5/30/90	0	NS
	6/25/90	0	NS
	7/06/90	0	NS
	7/11/90	0.1 (0.2)	NS
	7/16/90	0	NS
	7/24/90	0	2.5 (2.3)
	7/31/90	0.1 (0.2)	NS

* No alewife juveniles were collected in 1990
NS = No sample
+ Sampling between RM 46-54 only; upstream access blocked during repairs of Norfolk-Southern RR bridge.

Table 2. Maximal catch-per-unit-effort (CPUE) values for juvenile *Alosa* in the Mattaponi and Pamunkey rivers, 1979-1990.

River	Year	Maximal CPUE Alewife	Maximal CPUE Blueback	Maximal CPUE American Shad
Mattaponi	1979	6.0	73.0	38.1
	1980	2.9*	4.6*	38.8*
	1981	10.0*	11.6	18.0*
	1982	38.0	289.0	21.1
	1983	36.2	36.1	16.5
	1984	28.1	220.8	34.4
	1985	31.3	206.2	35.9
	1986	11.5*	20.7	36.6
	1987	2.8	19.9	18.9
	1988	#	#	#
	1989	#	#	#
	1990	+	+	+
Pamunkey	1979	6.7	224.8	57.4
	1980	3.6	87.9	7.1
	1981	6.5*	16.7	5.3*
	1982	28.3*	408.2	3.0*
	1983	4.2	120.7	7.5
	1984	7.1*	88.9	2.5
	1985	12.6	154.6	15.5
	1986	13.2*	99.3	8.9
	1987	9.1*	217.9	2.1
	1988	#	#	#
	1989	#	#	#
	1990	+	+	+

* Maximal CPUE occurred in the first sampling period
\# No index data available due to lack of program funding
\+ Insufficient data to calculate a meaningful index value

Table 3. Mean and standard deviation CPUE per sampling cruise for 1990 day-night catch comparisons.

River	Date	Time	Bluebacks*	Am. Shad*
Pamunkey	7/10/90	day	3.4 (5.3)	0
		night	88.7 (58.8)	0
Pamunkey	7/18/90	day	1.1 (1.3)	0
		night	25.7 (31.1)	0
Mattaponi	7/24/90	day	0.2 (0.6)	0
		night	0	2.5 (2.3)
Pamunkey	8/7/90	day	0.1 (0.2)	0
		night	36.5 (47.3)	0
Pamunkey	8/14/90	day	0	0
		night	5.4 (8.8)	0
James	8/28/90	day	0.1 (0.2)	0
		night	31.4 (22.8)	0

* No alewife were collected in 1990

Table 4. Estimates of instantaneous daily mortality for juvenile <u>Alosa</u> in the Mattaponi and Pamunkey Rivers, 1979-1990

River	Year	Alewife	Blueback	American Shad
Mattaponi	1979	0.036	0.034	0.040
	1980	0.330	0.022	0.056
	1981	0.105	+	0.080
	1982	0.036	0.077	0.042
	1983	0.038	0.041	0.030
	1984	0.042	0.030	0.056
	1985	0.038	0.035	0.053
	1986	0.036	0.047	0.080
	1987	0.043	0.140	0.063
	1988	#	#	#
	1989	#	#	#
	1990	+	0.129	+
	MEAN*	0.038	0.067	0.052
Pamunkey	1979	0.040	0.040	0.060
	1980	0.041	0.031	0.080
	1981	0.058	0.016	0.043
	1982	0.043	0.046	0.050
	1983	0.068	0.052	0.078
	1984	0.036	0.078	0.057
	1985	0.067	0.055	0.098
	1986	0.050	0.043	0.050
	1987	0.148	0.065	+
	1988	#	#	#
	1989	#	#	#
	1990	+	+	+
	MEAN*	0.065	0.054	0.066

* The 1980 and 1981 data were omitted from the mean value (see text).
\+ Data were too few for a reasonably objective estimate of mortality.
\# No sampling conducted due to a lack of program funding.

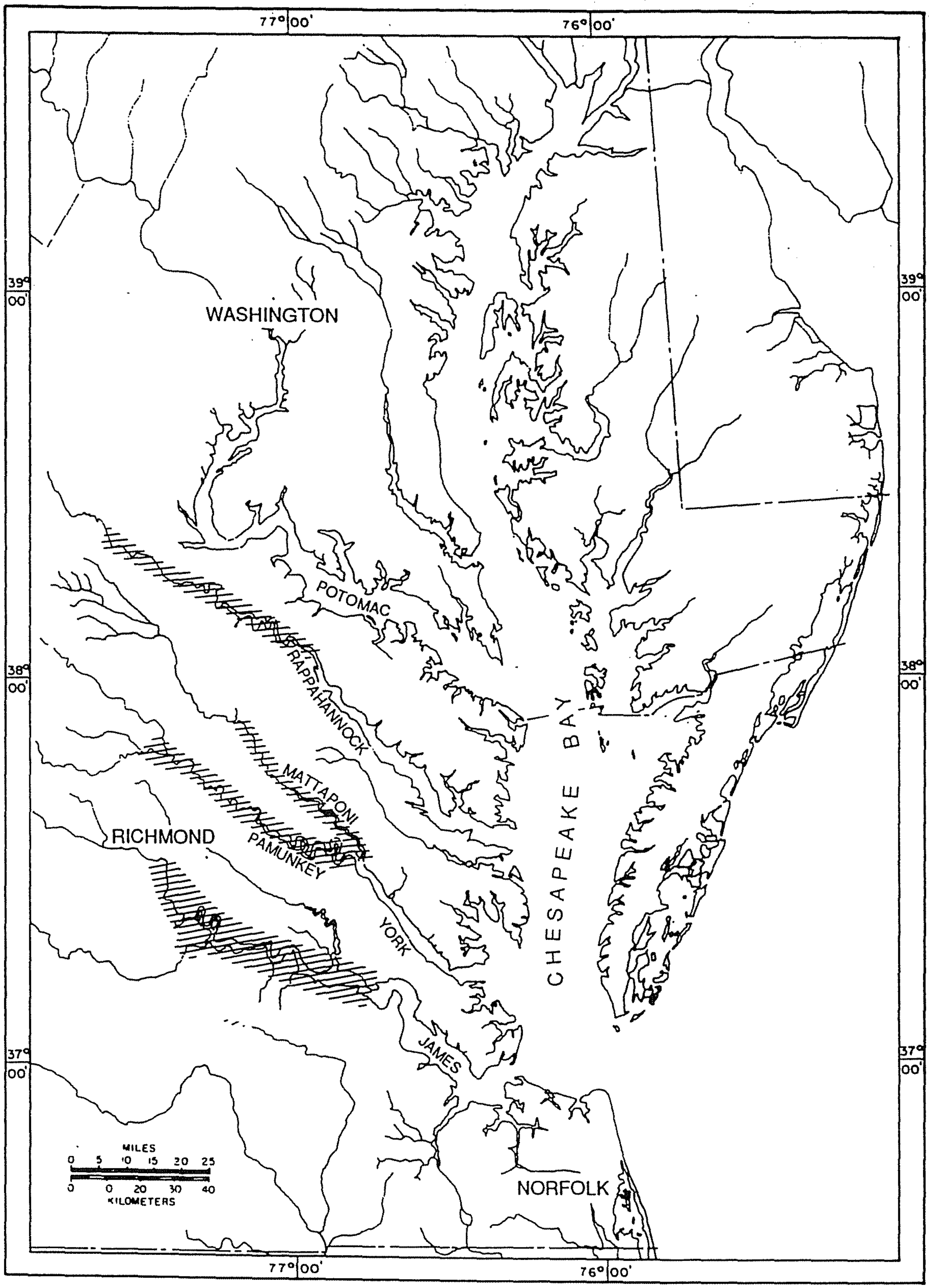

Figure 1. Nursery zone locations for Juvenile *Alosa* Sampling Program. (James and Rappahannock rivers to be sampled in 1991.)

Figure 2. Apparent growth of juvenile blueback herring, 1990