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# Monitoring Relative Abundance of American Shad in Virginia's Rivers Annual Report 1999

John E. Olney Sr.  
*Virginia Institute of Marine Science*

John M. Hoenig  
*Virginia Institute of Marine Science*

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Monitoring Relative Abundance of American Shad  
in Virginia's Rivers

1999 Annual Report

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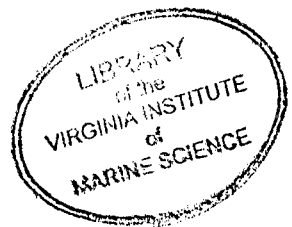
John E. Olney, Sr. and John M. Hoenig

Department of Fisheries Science  
School of Marine Science  
Virginia Institute of Marine Science  
The College of William and Mary  
Gloucester Point, VA 23062-1346

Submitted To:

Virginia Marine Resources Commission  
P.O. Box 756  
Newport News, VA 23607-0756

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## Executive Summary

- A staked gill net was set and fished two days per week on the James, York and Rappahannock rivers in the spring of 1999. This was the second year of monitoring in a stock assessment program for American shad that was initiated in spring 1998. The primary objective was to establish a time series of catch rates that could be compared to historical catch rates recorded in logbooks voluntarily submitted by commercial fishers prior to the imposition of the current moratorium. The monitoring effort provides information on the current status of shad stocks relative to conditions prior to the moratorium.
- Sampling occurred for 12 weeks on the York River (24 February - 10 May 1999), 11 weeks on the James River (24 February - 5 May 1999) and 11 weeks on the Rappahannock River (24 February - 5 May 1999).
- A total of 575 female American shad (796.1 kg total weight) were captured in 1999. The 1999 catch was lower than that in 1998 when a total of 1,009 females were captured and the total weight was 1,450.9 kg (Olney and Hoenig 2000).
- Total numbers of females in 1999 were highest on the York River (313) and lowest on the Rappahannock River (90). Catches on the James River were intermediate (172). Total numbers of males were low on all rivers (James, 21; York, 20; Rappahannock, 13).
- Estimates of age as determined by scales and otoliths in samples collected in 1998 and 1999 were compared using a  $\chi^2$  test of symmetry. Scale and otolith methods were in agreement 41% of the time (125 of 305 comparisons) in 1998 samples and 45% of the time (82 of 182 comparisons) in 1999 samples. Differences were significant in each year. We concluded that the two methods of determining age are not interchangeable and that further work to validate and compare the methods is required.
- Based on age estimates from scales using the methods of Cating (1953), the 1993 and 1994 year classes of American shad were the most abundant on all three rivers. Total instantaneous mortality rates of females calculated from age-specific catch rates were: York River, 1.04; James River, 1.17; and Rappahannock River, 1.89. Males were rare in collections and mortality rates were unestimable.
- Otoliths of 227 adult American shad were scanned for hatchery marks. The proportion of the catch with hatchery marks on the James and York rivers were 4.5% (8 of 177 fish) and 2.0 % (1 of 50 fish), respectively. The otolith of one adult male captured in the James River had a feed tag indicating that the fish was released as a juvenile in the Patuxent River in 1992 or 1994.
- Otoliths of juvenile American shad collected during pushnet cruises in 1998 and 1999 on the Pamunkey River were scanned for hatchery marks. The proportion of the 1998 catch with hatchery marks was 1.5 % (6 of 413 fish). The proportion of the 1999 catch with hatchery marks was 6.0 % (3 of 50 fish).

- The maximal geometric mean catch of juvenile American shad (based on weekly summer pushnet surveys) was well below the time-series average on the Mattaponi River (average, 32.2; 1999 value, 11.8), and below average on the Pamunkey River (average 6.9; 1999 value 1.7). The geometric mean catch was 2.7 on the Mattaponi River and 1.0 on the Pamunkey River. The combined integrated catch index for the York system (both the Pamunkey and Mattaponi rivers) was well below the time-series average (average, 1,227.8; 1999 value, 377.8).
- Twenty-four species of by-catch were taken in the staked gill net monitoring gear. Almost 4,000 striped bass were captured. Ratios of the total number (both sexes) of American shad to the total number of striped bass taken on each river were: James, 1:13.9; York, 1:1.8; Rappahannock, 1:7.8. The proportions of dead striped bass on each river were: James River, 27.1%; York River, 38.4%; and the Rappahannock River, 36.1%.
- A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for the years 1998, 1999 and for each year of the historical record of staked net catches on each river. On the York River, the seasonal catch index in 1999 (4.9) was well below the 1998 value (13.5) and close to the time-series average (4.7). On the James River, the 1999 value was equivalent to the 1998 value (2.6) and was below the times-series average (8.0). In both 1998 and 1999, the James River catch index was similar to those obtained by the fishery in the years immediately preceding the moratorium. The catch index on the Rappahannock River in 1999 was lower (1.3) than the value obtained in 1998 (1.5) and below the time-series average (1.7).

## Introduction and need

A moratorium on the taking of American shad (*Alosa sapidissima*) in the Chesapeake Bay and its tributaries was established by the Virginia Marine Resources Commission (VMRC) beginning 1 January 1994. The prohibition applied to both recreational and commercial fishers. The moratorium was imposed at a time when commercial catch rates of American shad in Virginia's rivers were experiencing declines. Data from the commercial fishery were the best available for assessing the status of individual stocks. Catch-per-unit-effort (CPUE) data were compiled from logbooks that recorded landings by commercial fishermen using staked gill nets at various locations throughout the middle reaches of the James, York and Rappahannock rivers. The logbooks were voluntarily provided to the Virginia Institute of Marine Science (VIMS) during the period 1980-1993, and subsequently used in an assessment of the status of American shad stocks along the Atlantic coast by the Atlantic States Marine Fisheries Commission (ASMFC) (ASMFC 1999).

Since the moratorium, there have been no monitoring programs that provided direct assessment of stock recovery. The ban on in-river fishing in Virginia remained in effect, creating a dilemma for managers who needed reliable information in order to make a rational decision on when the in-river ban could safely be lifted. To address this deficiency, we proposed a method of scientific monitoring to estimate catch rates relative to those recorded before the prohibition of in-river fishing in 1994. This monitoring program began in 1998 and consisted of sampling techniques and locations that were consistent with, and directly comparable to, those that generated historical logbook data collected by VIMS during the period 1980-1993 in the York, James and Rappahannock rivers. The results of the second year in the sampling program (1999) are reported in this document. The results of the first year of sampling (1998) are reported in Olney and Hoenig (2000).

In addition to the objective of assessment of stock recovery in Virginia's rivers, there are other significant information needs. First, extensive efforts are being made to rehabilitate shad stocks through release of hatchery-raised fish. Evaluating the success of these programs requires determination of the survival of the stocked fish to adulthood. Second, there is an extensive time series of observations on juvenile shad abundance in the York River system. This juvenile index could have utility for predicting future spawning run sizes and confirming the health of the stocks. However, it needs to be critically evaluated since the ASMFC has mandated sampling for juveniles starting in 2000.

These ongoing studies of American shad in Virginia waters are significant for recreational fisheries for at least three reasons.

- American shad fight well when angled using light tackle. The recreational fishery is closed in most of Virginia but is popular in North Carolina, Maryland and several other states. Anecdotal information suggests that there were historical recreational fisheries for American shad on the Mattaponi and Rappahannock rivers. Thus, development of a recreational shad fishery in Virginia could constitute an important opportunity to expand or restore recreational fishing opportunities if the stocks are rehabilitated and managed carefully.

- American shad are important for trophic and ecological reasons. The abundance of juveniles is closely linked to water quality and the availability of good fish habitat. The shads and river herrings (*Alosa* and *Dorosoma*) form an important prey group for striped bass and other recreationally important species in Chesapeake Bay. In recent years, there have been shifts in community structure in the major tributaries to the Bay with striped bass and gizzard shad numbers increasing greatly. Monitoring changes in abundance of key species is essential for understanding community dynamics.
- Monitoring the shad spawning run using historic gear characterizes the bycatch associated with a commercial fishery for shad in Virginia's rivers. This is important for determining the impact of a re-opened commercial fishery for shad on other recreationally important species, especially striped bass.

## Background

Herring and shad have supported recreational and commercial fisheries along the east coast of the United States and within the Chesapeake Bay since colonial times. They also play a vital ecological role. Juvenile *Alosa* are an important prey species for striped bass and other recreational species while they remain on their freshwater and upper estuarine nursery grounds. In the autumn they move to coastal waters where they are subjected to predation by many types of marine piscivores until they return to their native streams to spawn for the first time at ages 3 to 7 (Maki *et al.*, in review).

Attempts to manage and conserve Virginia's stocks of American shad date to colonial times. Before Virginia was settled, native Americans caught American shad in large quantities using a seine made of bushes (Walburg and Nichols 1967). Shad were so plentiful that they could be speared with pointed sticks as they swam on the flats (VCF 1875). The early settlers used haul seines, and utilized shad as a major food supply (Walburg and Nichols 1967). By 1740, shad were less abundant, presumably due to fishing and obstructions that prevented the fish from reaching their spawning grounds. Concerned colonists passed laws requiring the removal of dams or the building of fish passages, and prohibiting hedges and other obstructions (VCF 1875). In 1771, the Virginia Assembly passed a law requiring that a gap for fish passage be built in dams adhering to specific dimensions, and that it be kept open from February 10 to the last day of May. However, due to the approaching conflict of the Revolutionary War, the law was never enforced (VCF 1875).

The shad fishery of Chesapeake Bay became important about 1869, and developed greatly in the ensuing years. Fishing gear used included haul seines, pound nets, and staked gill nets (Walburg and Nichols 1967). Catches reached a low in 1878, and the U.S. Fish Commission and Virginia Commission of Fisheries instituted an artificial hatching program in 1875. By 1879 the fishery began to improve, and the increase in catches led biologists to believe that the shad fishery was largely dependent upon artificial propagation. However, by the early 1900's the decline in shad harvests resumed despite improved hatching methods and increased numbers of fry released (Mansueti and Kolb 1953).

Today, many American shad stocks along the eastern seaboard of the United States are in low abundance (Figure 1) and there is evidence of recent and persistent stock declines of American shad in three of 12 systems, based on a recently completed stock assessment (ASMFC 1999). Two of these are Virginia stocks in the Rappahannock and York rivers. Large catches no longer occur as they did at the turn of the century. Commercial American shad landings in Virginia decreased from 11.5 million pounds in 1897 to less than a million pounds in 1982 (Fig. 1). Over-fishing, dam construction, pollution, and loss of natural spawning grounds are a few of the factors that may be related to this decline. Historically, the majority of American shad were captured within the rivers. Beginning in 1984, the largest proportion of American shad taken in Virginia's fishery was captured offshore. The overall impact of this shift in the fishery on egg production and annual recruitment of Virginia stocks is unknown. Genetic studies of the catch composition of Virginia and Maryland's coastal landings have suggested that the intercept fishery claims a highly variable proportion of Virginia's riverine stocks (Brown and Epifanio 1994). American shad were pursued by recreational fishermen in Virginia in the past, but the extent and success of this activity is not easily assessed.

In spring 1994, the Virginia Department of Game and Inland Fisheries (VDGIF) and the US Fish and Wildlife Service (USFWS) began a hatchery-restocking effort in the James and Pamunkey rivers. Native adult shad are used as brood stock, eggs are stripped and fertilized in the field, and larvae are reared in the VDGIF hatchery at Stephenville, Virginia, and the USFWS hatchery at Harrison Lake, Virginia. Prior to release, the larvae are immersed in an oxytetracycline (OTC) solution that marks otoliths with a distinctive epifluorescent ring. The success of this ongoing program is not well understood. Annual monitoring of the abundance of juvenile *Alosa* (American shad, hickory shad, blueback herring and alewife) has been conducted annually on the Pamunkey River system since 1979. Since 1995, juveniles bearing the OTC mark have been collected. The data show that hatchery-released shad constituted 0.1-8 % of the total catch of juveniles during the 4-y period (1995-1999).

Prior to 1991, there were no restrictions on the American shad commercial fishery in Virginia rivers and the Chesapeake Bay. A limited season (4 February - 30 April) was established for 1991 by the Virginia Marine Resources Commission (VMRC), and kept in place in 1992. In 1993, a further limitation to the season was established (15 March - 15 April 1993). However, due to bad weather conditions, the season was extended through 30 April. A complete moratorium was established in 1994. The current regulation states that:

“On and after 1 January 1994 it shall be unlawful for any person to catch and retain possession of American shad from the Chesapeake Bay or its tidal tributaries.” (VMRC Regulation 450-01-0069).

In 1997 and 1998, during a series of public hearings, commercial fishing interests asked that the in-river ban on shad fishing be lifted. This proposal was opposed by the VMRC staff, the Virginia Institute of Marine Science, and various other public and private agencies. The Commission decided to leave the ban in place but also decried the lack of information necessary to assess the recovery of Virginia stocks of American shad. The current monitoring project began in the spring of 1998 in response to the VMRC's request for information.

## Current Information

There is mandatory reporting of offshore catches to the VMRC. These data can be accessed through the VMRC website (<http://www.state.va.us/mrc/homepage.htm>). Annual monitoring of the abundance of juvenile *Alosa* (American shad, hickory shad, blueback herring and alewife) is conducted on the York River system with a pushnet developed in the late 1970s (Kriete and Loesch, 1980). Because of the negative phototropic behavior of juvenile *Alosa* (Loesch *et al.*, 1982; Dixon, 1996), the pushnet is used at night to determine catch-per-unit-of-effort. The data record extends back to 1979 but sampling was not conducted during 1987-1990. Pushnet sampling resumed in 1991 and survey methods were changed to include more stations and more cruises during each year. Thus, the most recent results (1990-1999) are not comparable to the older results (1979-1986). These data can be accessed through the VIMS website (<http://www.fisheries.vims.edu/research.htm>). Three manuscripts summarizing various aspects of the reproductive biology of American shad and the VIMS stock assessment program are in review in peer-reviewed journals (Maki *et al.*, Olney and Hoenig, and Olney *et al.*).

## Objectives

The 1999 objectives were the same as for 1998: (1) to establish time series of relative abundance indices of adult American shad during the spawning runs in the James, York and Rappahannock rivers; (2) to relate contemporary indices of abundance of American shad to historical log-book data collected during the period 1980-1992; (3) to assess the relative contribution of hatchery-reared and released cohorts of American shad to adult stocks; (4) to relate recruitment indices (young-of-the-year index of abundance) of American shad based on pushnet surveys in the York River system to relative year-class strength of spawning adults; and (5) to determine the amount of bycatch of other species in the staked gill nets.

## Methods

In 1998, we developed a fishery-independent monitoring protocol that was as similar as possible to traditional shad fishing methods in the middle reaches of Virginia's rivers. When the in-river fishing moratorium was imposed in 1994, commercial fishermen who held permits for existing stands of staked gill nets (SGNs) were allowed to retain priority rights for the locations of those stands in the various rivers. VIMS has records of the historic fishing locations, and one of these locations on each river (the James, York and Rappahannock) was used to monitor catch rates by SGN's in 1998 and 1999. Three commercial fishermen were contracted to prepare and set SGN poles, hang nets, replace or repair poles or nets, and set nets for each sampling event during the monitoring period. Two of these commercial fishermen (Mr. Raymond Kellum and Mr. Mark Brown) were authors of the historical logbooks on the James and York rivers. However, authors of historic logbooks on the Rappahannock River were either retired or not available. Thus, we chose a commercial fisherman (Mr. Jamie Sanders) with previous experience in SGN fishing but who had not participated in the shad fishery on the Rappahannock River in the 1980's. Scientists accompanied commercial fishermen during each sampling trip, and returned the catch to the laboratory.



One SGN, 900 ft (approximately 273 m) in length, was set on each river (Figures 2-4). Locations of the sets were as follows: lower James River near the James River Bridge at river mile 10 (36° 50.0' N, 76° 28.8' W); middle York River near Clay Bank at river mile 14 (37° 20.8' N, 76° 37.7' W); and middle Rappahannock River near the Rappahannock River bridge (at Tappahannock) at river mile 36 (37° 55.9' N, 76° 50.4' W). Historical catch-rate data on the York and James rivers were derived from nets constructed of 4 7/8" stretched-mesh monofilament netting, while historic data from the Rappahannock River were based on larger mesh sizes (nets constructed of 5" stretched-mesh). To insure that 1998 and 1999 catch rates were comparable to logbook records, nets on the York and James rivers were constructed of 4 7/8" (12.4 cm) stretched-mesh monofilament netting, while nets on the Rappahannock River were constructed of 5" (12.7 cm) netting. Panel lengths were consistent with historical records (30 ft each on the James and York rivers; 48 ft each on the Rappahannock River). Each week, nets were fished on two succeeding days (two 24-h sets) and then hung in a non-fishing position until the next sampling episode. Occasionally, high winds prevented the regularly scheduled sampling on Sunday and Monday, and sampling was either postponed or canceled. We monitored catch rates from 24 February 1999 to 5 May 1999 on the James and the Rappahannock rivers; and from 24 February 1999 to 10 May 1999 on the York River. Surface water temperature was recorded at each sampling event.

Individual American shad collected from the monitoring sites were measured and weighed on a Limnoterra FMB IV electronic fish measuring board interfaced with a Mettler PM 30000-K electronic balance. The board recorded measurements (fork length, total length and body depth) to the nearest mm, received weight input from the balance, and allowed manual input of additional data (such as field data and comments) or subsample designations (such as gonadal tissue and otoliths) into a data file for subsequent analysis. All gonads were examined macroscopically; in randomly selected individuals, subsamples of gonad tissue were taken for histological determination of maturity stage. Catches of all other species were recorded on log sheets by observers on each river. By-catch taken in randomly selected panels of the SGN were returned to the laboratory for length and weight determination. The remaining by-catch was released if alive or returned to the laboratory if dead. For striped bass (*Morone saxatilis*), separate records were kept of the number of live and dead fish in the nets.

Sagittal otoliths were removed from samples of adult American shad, placed in numbered tissue culture trays, and stored for subsequent aging. Whole otoliths were cleaned by immersing in a 10% bleach and hydrogen peroxide bath. After immersion, the cleaning solution was drawn off by pipette, and otoliths were rinsed with distilled water. Otoliths were examined under a dissecting microscope at 40x with reflected light under immersion oil, and aged by one individual (J. Goins, VIMS). An otolith annulus was considered to be one opaque zone and its successive hyaline zone. One otolith taken from every fish on the James River and a randomly selected subsample of 50 fish taken on the York River were scanned for hatchery marks using epifluorescent microscopy. To do this, otoliths were mounted on slides and ground and polished by hand using wet laboratory-grade sandpaper. Personnel from the VDGIF (D. Hopler) assisted in this evaluation.

Scales were removed from a mid-lateral area on the left side posterior to the pectoral-fin base of each fish. Scales were cleaned with a dilute bleach solution, mounted and pressed on

acetate sheets, and read on a microfilm projector using the methods of Cating (1953). We compared the two ageing methods (otoliths versus scales) with tests of symmetry (Hoenig *et al.* 1995, Evans and Hoenig 1998).

Catch-at-age data were used to determine relative year-class strengths of American shad in the York River. These data can be compared to predictions of year-class strength based on analysis of historical trends in the juvenile index of abundance of American shad in the York River system. Annual surveys of juvenile abundance of alosines are conducted on the York River system with a pushnet developed in the late 1970's (Kriete and Loesch 1980). Because of the negative phototropic behavior of juvenile *Alosa*, the pushnet is deployed at night (Dixon, Goins and Olney 1997). Because the interpretation of indices of abundance is not always straightforward (Hoenig 1995), several measures of year class strength were computed.

Catch data from each river was summarized in terms of a standardized catch rate (the area under the curve of catch rate versus time of year). These catch rates were compared to summaries of historical logbook data to provide a measure of the relative size of the current shad runs.

## Results

### *Catches of American shad by staked gill nets in 1999*

Fishing days, numbers of American shad captured, and catch rates (males and females) are reported in Tables 1-6 and Figures 5 and 6. A total of 629 American shad (54 males:575 females) were captured. The total weight of the sample was 859.0 kg (1,889.9 lbs). The 1999 catch was lower than that in 1998 when a total of 1,224 fish was captured and the total weight was 1,674.9 kg (Olney and Hoenig 2000). Catches in 1999 were low on the Rappahannock River (103 total fish, 13 males and 90 females), higher on the James River (193 total fish, 21 males and 172 females) and highest on the York River (333 total fish, 20 males and 313 females). On the James River, catches of females peaked on 21 March through 4 April 1999 when catch rates exceeded 0.04 fish/m or 0.06 kg/m. On the York River, catches of females peaked between 17 March and 4 April 1999 when catch rates exceeded 0.08 fish/m or 0.11 kg/m. Catches of females on the Rappahannock River peaked between 22 March and 5 April 1999 when catch rates exceeded 0.04 fish/m or 0.05 kg/m. Catches of males were low throughout the period on all rivers. The highest recorded daily catch occurred on 17 March 1999 when 41 female American shad (57.3 kg or 126.1 lbs) were taken in the York River (Table 3).

The duration of the 1999 spawning run (defined as the number of days between the first and last observation of a catch rate that equals or exceeds 0.01 female kg/m) was estimated to be 66 days on the James River (28 February - 4 May), 65 days on the York River (1 March - 4 May) and 42 days on the Rappahannock River (9 March - 19 April).

### *Biological characteristics of the American shad in 1999*

Age, length (mm TL) and weight (g) of American shad in staked gill nets are summarized in Tables 7-8 and frequency distributions of total length are depicted in Figure 7. Males and females ranged in size from 390-540 mm TL and 410-610 mm TL, respectively. Overall, the 1993 and 1994 year classes of female American shad were the most abundant on all three rivers. Males were infrequently collected and no age class dominated. On the James River, five age classes were represented (1991-1995) and the sample was dominated by age-5 females (58.6% of the total that were aged). On the York River, seven age classes were represented (1990-1996) and the sample was dominated by age-5 females (51.4% of the total that were aged). On the Rappahannock River, five age classes were taken (1991-1995) and catches were dominated by age-6 females (45.0% of the aged sample).

Spawning histories of female American shad collected in the York River in 1998 and 1999 are presented in Tables 9 and 10. In both years, females ranged in age from 3 to 9 years with 0 (virgin) to 4 spawning marks. Based on these samples, 40.2% of all females (171 virgins in a sample of 286) had a least one prior spawn in 1998. In 1999, 67.3% of all females (82 virgins in a sample of 251) had a least one prior spawn.

Age-specific catch rates of American shad are reported in Tables 11-12 and depicted in Figure 8. Since males were infrequently collected, mortality was not calculated. Total instantaneous mortality ( $Z$ ) was estimated using simple linear regression analysis of the natural log of age-specific catch on the descending limb of the catch curve. Estimates of  $Z$  for females for each stock were: James, 1.17 ( $r^2=0.98$ ); York, 1.04 ( $r^2=0.96$ ); and Rappahannock, 1.89 ( $r^2=0.98$ ).

### *Comparison of age estimation using otoliths and scales, 1998 and 1999*

Estimates of age determined by scales and otoliths in samples collected in 1998 and 1999 were compared using a  $\chi^2$  test of symmetry (Hoenig *et al.* 1995). Hoenig *et al.* (1995) applied the method to a similar sample of alewife (*Alosa pseudoharengus*) from Lake Huron and found that otolith and scale methods were not interchangeable in alewives since older ages did not occur in scale samples. In our samples of American shad from the York River, scale and otolith methods were in agreement 41% of the time (125 of 305 comparisons) in 1998 samples, and 45% of the time (82 of 182 comparisons) in 1999 samples. The hypothesis that disagreements between the two methods were randomly distributed on either side of the diagonal in a contingency table (Tables 13 and 14) were rejected in each year (1998,  $p=0.017$ ; 1999,  $p=0.028$ ). We concluded that the two methods of determining age are not interchangeable, and that further work to validate and compare the methods was required.

### *Evaluation of hatchery origin of American shad in 1999*

Otoliths from 227 adult American shad taken in the James and York rivers were scanned for hatchery marks. The proportion of the staked gill net catch in 1999 with hatchery marks was 4.5% (8 out of 177 fish that were 5 to 7 years old on the basis of examination of scales) from the

James River, and 2.0% (one 6-year old fish out of 50 fish) from the York River. One specimen from the James River had a juvenile feed mark, the origin of which was determined to be the Patuxent River. The biological attributes of these specimens are presented in Table 15.

Otoliths of juvenile American shad collected during pushnet cruises in 1998 and 1999 on the Pamunkey River were scanned for hatchery marks. The proportion of the 1998 catch with hatchery marks was 1.5 % (6 of 413 fish). The proportion of the 1999 catch with hatchery marks was 6.0 % (3 of 50 fish).

#### *Juvenile abundance of American shad*

Tables 16 and 17 report several indexes of juvenile abundance of American shad and associated estimated standard deviations. Values of areas under the catch curve reported in Table 15 are updated from the previous report (Olney and Hoenig 2000). The calculation now includes the actual number of days between cruises. Traditionally, the juvenile index in Virginia has been reported as maximum geometric mean catch rate (Figure 9). This index is defined as the maximal geometric mean catch (the maximal mean CPUE) in a sampling period (i.e., during any one week of sampling) that exceeds the mean CPUE in all other periods (i.e., over a series of weekly cruises). The maximal geometric mean catch was below the time-series average on the Mattaponi River (average, 32.2; 1999 value, 11.8), and well below average on the Pamunkey River (average 6.9; 1999 value 1.7).

Cruise-specific catch rates of juvenile American shad, reported as mean catch rates over all stations sampled each week, were used to estimate the annual geometric mean catch (and the standard deviation) for each river, the area under the catch curve for each river annually, and the combined area under the catch curve of both rivers annually (Table 17). The time series of the combined area under the catch curve for both rivers depicts average or better-than-average production of juveniles in the York River system in 1994, 1996, 1997 and 1998 relative to the other years in the record (dating back to 1979), while index values were low in 1991, 1992, 1995 and 1999.

#### *By-catch of striped bass and other species in 1999*

Daily numbers and seasonal totals of striped bass and other species captured in staked gill nets are reported in Tables 18-20 and Figure 10. Twenty-four species of by-catch were captured. The most commonly encountered by-catch species were: menhaden (*Brevoortia tyrannus*), gizzard shad (*Dorosoma cepedianum*), striped bass (*Morone saxatilis*), white catfish (*Ictalurus catus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), white perch (*Morone americana*), hickory shad (*Alosa mediocris*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*) and summer flounder (*Paralichthys dentatus*). Almost 4,000 striped bass were captured by the gear (York River, 584; James, 2,528; Rappahannock, 800). Ratios of the total number (both sexes) of American shad to the total number of striped bass taken on each river were: James, 1:13.9; York, 1:1.8; Rappahannock, 1:7.8. We counted and released live striped bass that were captured. The proportions of dead striped bass on each river were: James River, 27.1%; York River, 38.4%; and the Rappahannock River, 36.1%.

### *Seasonal catch indexes, 1980-1992 and 1998-1999*

A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for the years 1998, 1999 and for each year of the historical record of staked net catches on each river (Tables 21-23 and Figures 11-14). On the York River, the seasonal catch index in 1999 (4.85) was well below the 1998 value (13.47) but higher than the historical time-series average (3.96). On the James River, the 1999 value was equivalent to the 1998 value (2.60) and was well below the historical times-series average (8.88). In both 1998 and 1999, the James River catch index was similar to those obtained by the fishery in the years immediately preceding the moratorium. The catch index on the Rappahannock River in 1999 was slightly lower (1.30) than the value obtained in 1998 (1.46) and below the historical time-series average (1.76).

### **Discussion**

The staked gill net monitoring program continues to be useful for assessment of the current status of stocks of American shad in Virginia. It is the only method available to determine the size of the spawning runs relative to what was obtained in the decade prior to the moratorium. The program also provides information for validating the juvenile index of abundance and for determining the amount of bycatch in the commercial fishery that can be expected if the in-river fishing ban is lifted.

Relative to 1998 results, catch rates of American shad were unchanged on the James and Rappahannock rivers in 1999. On the James River, the catch rate remains as low as was observed at the time the moratorium was imposed, suggesting that there has been no substantial recovery of this stock and that the outlook is poor. On the Rappahannock River, recent catch rates are comparable to the entire historic record and are difficult to interpret. A sharp decline in catches on the York River 1999 confirms that there is considerable annual variability in run strength. Until the predictive value of the juvenile abundance index is validated or some other method of forecasting is developed, we believe that high catch rates on the York River should be observed for several successive years before concluding abundance is now higher than at the time the moratorium was imposed.

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Table 1. Dates of capture, number, total weight (g) and catch rates (numbers per m; kg per m) of female American shad taken in staked gill net monitoring on the James River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	1	0.004	1,387.80	0.005
2/25/99	1	0.004	1,218.50	0.004
2/28/99	3	0.011	4,097.00	0.015
3/1/99	3	0.011	3,759.60	0.014
3/9/99	5	0.018	8,031.50	0.029
3/10/99	3	0.011	5,445.10	0.020
3/14/99	4	0.015	5,064.50	0.018
3/17/99	3	0.011	3,802.90	0.014
3/21/99	19	0.069	25,352.10	0.092
3/22/99	12	0.044	16,833.80	0.061
3/29/99	36	0.131	50,105.10	0.183
3/30/99	22	0.080	30,168.60	0.110
4/4/99	17	0.062	24,904.00	0.091
4/5/99	22	0.080	32,432.60	0.118
4/11/99	6	0.022	7,626.60	0.028
4/12/99	2	0.007	2,685.40	0.010
4/18/99	4	0.015	4,784.40	0.017
4/19/99	3	0.011	3,867.00	0.014
4/25/99	2	0.007	3,001.80	0.011
4/26/99	2	0.007	2,457.40	0.009
5/4/99	2	0.007	3,193.40	0.012
5/5/99	0	0.000	0.00	0.000
Total	172		240,219.10	



Table 2. Dates of capture, number, total weight and catch rates (numbers per m; kg per m) of male American shad taken in staked gill net monitoring on the James River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	0			
2/25/99	0			
2/28/99	2	0.007	2,193.80	0.008
3/1/99	0			
3/9/99	0			
3/10/99	0			
3/14/99	0			
3/17/99	2	0.007	2,574.00	0.009
3/21/99	4	0.014	5,050.50	0.018
3/22/99	3	0.011	2,832.30	0.010
3/29/99	3	0.011	3,432.10	0.013
3/30/99	5	0.018	6,363.40	0.023
4/4/99	1	0.004	1,057.30	0.004
4/5/99	1	0.004	1,461.70	0.005
4/11/99	0			
4/12/99	0			
4/18/99	0			
4/19/99	0			
4/25/99	0			
4/26/99	0			
5/4/99	0			
5/5/99	0			
Total	21		24,965.10	

Table 3. Dates of capture, number, total weight (g) and catch rates (numbers per m; kg per m) of female American shad taken in staked gill net monitoring on the York River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	0			
2/28/99	0			
3/1/99	2	0.007	2,669.10	0.010
3/9/99	5	0.018	6,352.70	0.023
3/10/99	1	0.004	1,503.80	0.005
3/14/99	9	0.033	12,296.90	0.045
3/17/99	41	0.149	57,283.50	0.209
3/21/99	29	0.106	42,625.10	0.155
3/22/99	42	0.153	57,567.00	0.210
3/29/99	29	0.106	39,807.50	0.145
3/30/99	38	0.139	52,274.80	0.191
4/4/99	22	0.080	31,135.00	0.113
4/5/99	14	0.051	19,502.60	0.071
4/11/99	15	0.055	20,906.60	0.076
4/12/99	5	0.018	6,801.80	0.025
4/18/99	19	0.069	25,668.10	0.094
4/19/99	9	0.033	12,194.60	0.044
4/25/99	18	0.066	24,642.50	0.090
4/26/99	8	0.029	10,564.10	0.039
5/3/99	2	0.007	2,390.50	0.009
5/4/99	4	0.015	4,981.90	0.018
5/9/99	0			
5/10/99	1	0.004	1,281.10	0.005
Total	313		432,449.20	

Table 4. Dates of capture, number, total weight and catch rates (numbers per m; kg per m) of male American shad taken in staked gill net monitoring on the York River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	0			
2/28/99	2	0.007	1,890.00	0.007
3/1/99	1	0.004	1,098.00	0.004
3/9/99	0			
3/10/99	1	0.004	1,772.40	0.006
3/14/99	2	0.007	2,555.60	0.009
3/17/99	6	0.022	5,695.50	0.021
3/21/99	3	0.011	4,112.80	0.015
3/22/99	3	0.011	3,413.40	0.012
3/29/99	0			
3/30/99	2	0.007	2,289.70	0.008
4/4/99	0			
4/5/99	0			
4/11/99	0			
4/12/99	0			
4/18/99	0			
4/19/99	0			
4/25/99	0			
4/26/99	0			
5/3/99	0			
5/4/99	0			
5/9/99	0			
5/10/99	0			
Total	20		22,827.40	

Table 5. Dates of capture, number, total weight (g) and catch rates (numbers per m; kg per m) of female American shad taken in staked gill net monitoring on the Rappahannock River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	2	0.007	2,236.20	0.008
2/25/99	0	0.000	0.00	0.000
2/28/99	0	0.000	0.00	0.000
3/1/99	1	0.004	1,269.70	0.005
3/9/99	3	0.011	4,119.10	0.015
3/17/99	9	0.032	11,951.20	0.043
3/18/99	3	0.011	4,422.60	0.016
3/21/99	5	0.018	6,236.80	0.022
3/22/99	11	0.040	15,199.40	0.055
3/29/99	10	0.036	13,506.90	0.049
3/30/99	11	0.040	14,618.10	0.053
4/5/99	11	0.040	15,387.60	0.055
4/6/99	6	0.022	8,353.60	0.030
4/11/99	3	0.011	4,178.10	0.015
4/12/99	6	0.022	8,538.40	0.031
4/18/99	4	0.014	5,837.70	0.021
4/19/99	5	0.018	7,543.20	0.027
4/25/99	0	0.000	0.00	0.000
4/26/99	0	0.000	0.00	0.000
5/4/99	0	0.000	0.00	0.000
5/5/99	0	0.000	0.00	0.000
Total	90		123,398.60	

Table 6. Dates of capture, number, total weight and catch rates (numbers per m; kg per m) of male American shad taken in staked gill net monitoring on the Rappahannock River, spring 1999.

Date	Number	Catch Rate (count/m)	Total weight (g)	Catch Rate (kg/m)
2/24/99	0			
2/25/99	0			
2/28/99	0			
3/1/99	2	0.007	2,535.20	0.009
3/9/99	2	0.007	2,353.60	0.008
3/17/99	1	0.004	1,390.80	0.005
3/18/99	0			
3/21/99	4	0.014	4,715.30	0.017
3/22/99	2	0.007	2,325.00	0.008
3/29/99	0			
3/30/99	1	0.004	1,221.50	0.004
4/5/99	0			
4/6/99	0			
4/11/99	0			
4/12/99	0			
4/18/99	1	0.004	639.00	0.002
4/19/99	0			
4/25/99	0			
4/26/99	0			
5/4/99	0			
5/5/99	0			
Total	13		15,180.40	

Table 7. Mean total length (mm) and mean weight (g) of female American shad captured in gill nets in the James, York and Rappahannock rivers, spring 1999. Abbreviations are: NA, not aged; Rapp, Rappahannock River; SD, standard deviation. Age estimates are based on examination of scales following Cating (1953).

River	Year Class	Number	Mean length	SD	Mean Weight	SD
James	NA	39	506.5	23.5	1,387.0	205.0
	1995	10	487.3	23.8	1,283.7	170.5
	1994	78	502.1	21.5	1,345.7	186.3
	1993	37	517.5	23.5	1,478.8	245.7
	1992	6	550.0	13.3	1,661.7	249.1
	1991	2	543.0	24.0	1,818.7	300.0
York	NA	62	507.4	27.1	1,411.1	244.0
	1996	2	450.0	25.5	1,043.6	278.9
	1995	21	485.2	17.8	1,271.8	147.5
	1994	129	491.7	21.1	1,328.5	174.6
	1993	76	508.9	22.3	1,414.4	182.0
	1992	14	539.1	27.0	1,497.8	271.1
	1991	8	556.3	24.2	1,747.3	370.2
	1990	1	610.0		2,348.3	
Rapp.						
	NA	9	504.6	31.5	1,469.2	209.9
	1995	5	465.4	19.0	1,090.2	51.2
	1994	29	492.7	18.9	1,304.5	133.5
	1993	36	511.8	18.1	1,446.0	169.1
	1992	9	511.2	11.1	1,390.1	140.1
	1991	1			1,338.8	

Table 8. Mean total length (mm) and mean weight (g) of male American shad captured in gill nets in the James, York and Rappahannock rivers, spring 1999. Abbreviations are: NA, not aged; Rapp, Rappahannock River; SD, standard deviation. Age estimates are based on examination of scales following Cating (1953).

River	Year Class	Number	Mean length	SD	Mean Weight	SD
James						
	NA	8	491.6	45.2	1,153.7	283.7
	1994	5	500.8	21.6	1,296.9	120.3
	1993	7	489.6	11.6	1,149.7	96.0
	1992	1	486.0		1,203.8	
York						
	NA	6	481.2	32.7	1,172.1	141.7
	1996	2	385.5	14.8	587.5	86.4
	1995	1	446.0		1,002.9	
	1994	5	472.4	33.6	1,118.0	246.0
	1993	3	515.3	68.7	1,302.1	408.5
	1992	3	514.7	9.9	1,373.6	125.7
Rapp.						
	NA	2	485.0	36.8	1,239.8	213.5
	1995	1	438.0		977.6	
	1993	9	480.0	29.4	1,162.1	222.4
	1992	1	497.0		1,264.5	

Table 9. Spawning histories of American shad collected in the York River, Virginia, 1998. Table entries are numbers of fish (N=251). Ages are based on scale analysis. Numbers in bold are virgins in the year class.

Age at Maturity

Year Class	Age at Capture	3	4	5	6	7
1995	3	1				
1994	4	1	<b>73</b>			
1993	5	6	40	<b>83</b>		
1992	6	2	10	27	14	
1991	7	0	8	9	1	0
1990	8	0	2	7	0	0
1989	9	0	0	1	1	0

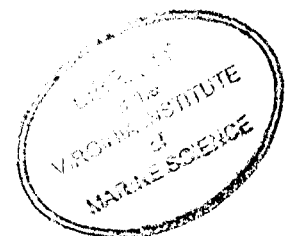




Table 10. Spawning histories of American shad collected in the York River, Virginia, 1999. Table entries are numbers of fish (N=251). Ages are based on scale analysis. Numbers in bold are virgins in year class.

Year Class	Age at Capture	Age at Maturity				
		3	4	5	6	7
1996	3	2				
1995	4	8	<b>13</b>			
1994	5	7	72	<b>51</b>		
1993	6	2	33	26	<b>14</b>	
1992	7	0	7	5	0	<b>2</b>
1991	8	0	5	3	0	0
1990	9	0	0	1	0	0

Table 11. Number, total weight and seasonal catch rates (total number per season per m; total weight per season per m) by year class of female American shad in the James, York and Rappahannock rivers captured in staked gill nets, spring, 1999. Age estimates are based on examination of scales following Cating (1953). Abbreviations are: NA, not aged; Rapp, Rappahannock River.

River	Year Class	Number	Total Weight (kg)	Total effort (days)	Catch Rate (numbers per m)	Catch Rate (kg per m)
James	1995	10	12.8	22.0	0.00166	0.00213
	1994	78	105.0	22	0.0129	0.0174
	1993	37	54.7	22	0.0061	0.0091
	1992	6	10.0	22	0.0010	0.0017
	1991	2	3.6	22	0.0003	0.0006
	NA	39	54.1	22	0.0065	0.0090
York	1996	2	2.1	23	0.0003	0.0003
	1995	21	26.7	23	0.0033	0.0042
	1994	129	171.4	23	0.0205	0.0272
	1993	76	107.5	23	0.0121	0.0170
	1992	14	21.0	23	0.0022	0.0033
	1991	8	14.0	23	0.0013	0.0022
	1990	1	2.3	23	0.0002	0.0004
	NA	62	87.5	23	0.0098	0.0139
Rapp.	1995	5	5.5	21	0.0009	0.0009
	1994	29	37.8	21	0.0050	0.0065
	1993	36	52.1	21	0.0062	0.0089
	1992	9	12.5	21	0.0015	0.0021
	1991	1	1.3	21	0.0002	0.0002
	NA	9	13.2	21	0.0015	0.0023
Total		574	795.1			

Table 12. Number, total weight and seasonal catch rates (total number per season per m; total weight per season per m) by year class of male American shad in the James, York and Rappahannock rivers captured in staked gill nets, spring, 1999. Age estimates are based on examination of scales following Cating (1953). Abbreviations are: NA, not aged; Rapp, Rappahannock River.

River	Year Class	Number	Total Weight (kg)	Total effort (days)	Catch Rate (numbers per m)	Catch Rate (kg per m)
James	1994	5	6.5	22	0.0008	0.0011
	1993	7	8.0	22	0.0012	0.0013
	1992	1	1.2	22	0.0002	0.0002
	NA	8	9.2	22	0.0013	0.0015
York	1996	2	1.2	23	0.0003	0.0002
	1995	1	1.0	23	0.0002	0.0002
	1994	5	5.6	230	0.0009	
	1993	3	3.9	23	0.0005	0.0006
	1992	3	4.1	23	0.0005	0.0007
	NA	6	7.0	23	0.0010	0.0011
Rapp.	1995	1	1.0	0	0.0002	0.0002
	1993	9	10.5	21	0.0015	0.0018
	1992	1	1.3	21	0.0002	0.0002
	NA	2	2.5	21	0.0003	0.0004
Total		54	63.0			

Table 13. Ages of female American shad captured in staked gill nets in the York River as determined by otoliths and scales, 1998. Bold numbers are where the two methods agree. Numbers with the same superscript are compared in a test of symmetry (Hoenig *et al.* 1995).

Otolith Age

Scale Age	3	4	5	6	7	8	9
3	<b>0</b>	1 <sup>(1)</sup>	0 <sup>(6)</sup>	0 <sup>(10)</sup>			
4	2 <sup>(1)</sup>	<b>34</b>	33 <sup>(2)</sup>	4 <sup>(7)</sup>	0 <sup>(11)</sup>		
5	3 <sup>(6)</sup>	40 <sup>(2)</sup>	<b>78</b>	19 <sup>(3)</sup>	2 <sup>(8)</sup>	0 <sup>(12)</sup>	
6	1 <sup>(10)</sup>	9 <sup>(7)</sup>	30 <sup>(3)</sup>	<b>10</b>	6 <sup>(4)</sup>	1 <sup>(9)</sup>	1 <sup>(13)</sup>
7		3 <sup>(11)</sup>	9 <sup>(8)</sup>	6 <sup>(4)</sup>	<b>3</b>		
8			6 <sup>(12)</sup>	3 <sup>(9)</sup>		<b>0</b>	0 <sup>(5)</sup>
9				0 <sup>(13)</sup>		1 <sup>(5)</sup>	<b>0</b>

Table 14. Ages of female American shad captured in staked gill nets in the York River as determined by otoliths and scales, 1999. Bold numbers are where the two methods agree. Numbers with the same superscript are compared in a test of symmetry (Hoenig *et al.* 1995).

Otolith Age

Scale Age	4	5	6	7	8
4	<b>0</b>	8 <sup>(1)</sup>	3 <sup>(4)</sup>		
5	20 <sup>(1)</sup>	<b>55</b>	30 <sup>(2)</sup>	6 <sup>(5)</sup>	0 <sup>(7)</sup>
6	5 <sup>(4)</sup>	20 <sup>(2)</sup>	<b>26</b>	3 <sup>(3)</sup>	2 <sup>(6)</sup>
7		2 <sup>(5)</sup>	0 <sup>(3)</sup>	<b>1</b>	
8		1 <sup>(7)</sup>	0 <sup>(6)</sup>		<b>0</b>

Table 15. Biological attributes (age, sex, maturity stage, fork length, total length, and total weight) of American shad with hatchery marks taken in staked gill net monitoring on the James and York rivers in 1999. Age estimates are based on presumptive annuli observed in whole otoliths and estimates based on scales following Cating (1953). One specimen (designated by the asterisk) had a feed tag attributable to the Patuxent River.

James River						
Specimen number	Otolith Age	Scale Age	Sex	Fork Length (mm)	Total Length (mm)	Total Weight (g)
1637*	5	7	male	428	486	1,203.80
1730	5	5	female	443	494	1,260.00
1233	4	6	female	438	502	1,267.20
1353	5	5	female	434	494	1,142.40
1558	5	6	female	450	509	1,482.30
1570	5	5	female	434	492	1,314.60
1774	4	NA	female	479	499	1,227.90
1973	7	NA	female	448	511	1,237.00
York River						
2059	6	6	female	502	564	1453.6

Table 16.

Summary of maximum geometric mean catch rate (numbers of juveniles per standard tow) for juvenile blueback herring, alewife, and American shad in the Pamunkey and Mattaponi rivers: 1979-1999.

River	Year	Blueback herring	Alewife	American shad
		Maximum CPUE	Maximum CPUE	Maximum CPUE
Pamunkey	1979	49.1	3.5	32.0
	1980	50.2	2.9	3.5
	1981	6.1	2.7	3.3
	1982	177.2	11.6	1.9
	1983	59.4	1.9	3.6
	1984	25.0	0.9	1.0
	1985	61.2	5.9	10.1
	1986	33.3	3.7	4.4
	1987	80.1	2.9	0.4
	1988	*	*	*
	1989	*	*	*
	1990	*	*	*
	1991	7.5	1.2	6.3
	1992	0.1	0.0	0.1
	1993	2.3	0.1	0.7
	1994	59.3	3.9	9.5
	1995	5.9	0.1	2.2
	1996	66.1	4.4	31.5
	1997	39.7	0.5	8.2
	1998	29.7	0.8	3.5
	1999	1.2	0.21	1.7
Mattaponi	1979	24.4	2.9	24.3
	1980	3.8	1.3	18.5

River	Year	Blueback herring	Alewife	American shad
		Maximum CPUE	Maximum CPUE	Maximum CPUE
	1981	9.0	5.0	13.5
	1982	92.3	18.3	9.3
	1983	17.1	3.2	7.3
	1984	93.4	19.0	22.6
	1985	127.2	13.6	26.0
	1986	15.5	7.1	26.1
	1987	14.6	0.8	7.3
	1988	*	*	*
	1989	*	*	*
	1990	*	*	*
	1991	4.6	0.3	7.0
	1992	0.2	0.0	1.5
	1993	5.1	0.2	30.3
	1994	38.8	12.8	51.5
	1995	0.4	0.1	6.4
	1996	63.6	22.4	144.2
	1997	27.4	6.6	95.4
	1998	68.1	6.8	77.3
	1999	42.1	2.7	11.8

\* No sampling was conducted in 1988 and 1989, and only partial sampling was conducted in 1990.



Table 17. Updated indexes of abundance of juvenile American shad in pushnet surveys on the Mattaponi and Pamunkey rivers, 1979-1999. Geometric means (GM), standard deviations of cruise-specific means (SD) and areas under the catch curve were estimated from cruise-specific catch rates for each year. Data are not available for 1998-1990. Data are revised from a previous report (Olney and Hoenig 2000).

Year	Mattaponi Mean GM	Pamunkey Mean GM	Mattaponi Area under the Catch Curve	Pamunkey Area Under the catch Curve	Combined Area Under the catch Curve
1979	5.1 (8.8)	3.6 (16.5)	1,134.0	1,258.9	2,392.9
1980	5.3 (8.8)	1.2 (2.9)	636.2	228.1	864.3
1981	2.3 (0.6)	0.7 (1.4)	43.6	106.4	150.0
1982	4.3 (3.3)	0.4 (0.7)	342.2	32.0	374.2
1983	3.0 (2.8)	1.5 (1.2)	300.5	105.4	405.9
1984	9.6 (6.6)	0.8 (0.4)	446.2	25.7	471.9
1985	7.2 (4.6)	3.7 (3.5)	410.8	156.5	567.3
1986	10.6 (7.1)	3.1 (0.7)	598.2	112.8	711.0
1987	1.9 (2.5)	0.3 (0.1)	228.9	6.0	234.9
1991	1.2 (2.3)	1.5 (2.1)	93.5	129.0	222.5
1992	0.4 (0.5)	2.3 (<0.1)	37.3	1.9	39.2
1993	14.7 (9.4)	0.2 (0.2)	973.4	12.0	985.4
1994	15.0 (14.6)	2.7 (19.0)	1,055.0	571.0	1,626.0
1995	4.0 (1.8)	1.3 (0.6)	273.2	88.6	361.8
1996	88.3 (28.2)	14.8 (7.2)	6,325.1	1,082.5	7,407.6
1997	29.7 (27.1)	2.3 (2.2)	2,103.4	169.2	2,272.6
1998	26.7 (21.6)	1.1 (1.0)	2,544.2	91.2	2,635.4
1999	2.7 (3.5)	1.0 (0.60)	298.0	79.8	377.8
Mean			<b>991.3</b>	<b>236.5</b>	<b>1,227.8</b>

Table 18. Daily numbers and seasonal totals of striped bass and other species captured by staked gill net in the York River, 1999.

Date	All Striped Bass	Dead Striped Bass	Other Species	Total
2/24/99	12	3	1,930	1,942
2/28/99	61	25	916	977
3/1/99	121	37	791	912
3/9/99	34	12	553	587
3/10/99	8	2	443	451
3/14/99	47	16	1,320	1,367
3/17/99	63	22	1,248	1,311
3/21/99	89	36	169	258
3/22/99	67	31	284	351
3/29/99	15	7	165	180
3/30/99	22	14	171	193
4/4/99	4	1	91	95
4/5/99	6	4	116	122
4/11/99	4	3	503	507
4/12/99	5	0	231	236
4/18/99	2	1	196	198
4/19/99	4	2	195	199
4/25/99	2	2	548	550
4/26/99	5	2	391	396
5/3/99	2	1	97	99
5/4/99	6	1	115	121
5/9/99	2	0	57	59
5/10/99	3	2	126	129
<b>TOTALS</b>	<b>584</b>	<b>224</b>	<b>10,656</b>	<b>11,240</b>

Table 19. Daily numbers and seasonal totals of striped bass and other species captured by staked gill net in the James River, 1999.

Date	All Striped Bass	Dead Striped Bass	Other Species	Total
2/24/99	173	36	35	208
2/25/99	88	14	25	113
2/28/99	482	65	20	502
3/1/99	395	83	41	436
3/9/99	21	0	49	70
3/10/99	28	3	89	117
3/14/99	65	13	64	129
3/17/99	365	59	46	411
3/21/99	254	92	238	492
3/22/99	150	71	180	330
3/29/99	101	44	231	332
3/30/99	103	34	329	432
4/4/99	32	17	168	200
4/5/99	40	21	261	301
4/11/99	15	13	423	438
4/12/99	10	4	205	215
4/18/99	44	26	260	304
4/19/99	27	16	242	269
4/25/99	34	22	343	377
4/26/99	32	15	229	261
5/4/99	47	29	187	234
5/5/99	22	7	60	82
<b>TOTALS</b>	<b>2,528</b>	<b>684</b>	<b>3,725</b>	<b>6,253</b>

Table 20. Daily numbers and seasonal totals of striped bass and other species captured by staked gill net in the Rappahannock River, 1999.

Date	All Striped Bass	Dead Striped Bass	Other Species	Total
2/24/99	25	0	102	127
2/25/99	22	3	78	100
2/28/99	15	1	41	56
3/1/99	51	16	57	108
3/9/99	25	8	133	158
3/17/99	52	5	75	127
3/18/99	86	23	64	150
3/21/99	103	23	162	265
3/22/99	130	38	213	343
3/29/99	35	13	123	158
3/30/99	54	22	114	168
4/5/99	15	9	323	338
4/6/99	17	11	696	713
4/11/99	15	4	687	702
4/12/99	8	5	786	794
4/18/99	13	6	491	504
4/19/99	9	7	395	404
4/25/99	11	8	343	354
4/26/99	31	21	573	604
5/4/99	46	35	330	376
5/5/99	37	31	394	431
<b>TOTALS</b>	<b>800</b>	<b>289</b>	<b>6,180</b>	<b>6,980</b>

Table 21. Summary of historical and recent catch and effort data of American shad by staked gill nets in the Rappahannock River, Virginia. Historical data are taken from the voluntary log books of Mr. M. Delano, Urbanna, Virginia. Catch rates are expressed as female kg/d. Duration of the run was not estimated in 1998 since monitoring began late in the season.

Year	Effort (10 <sup>3</sup> m/yr)	Duration of run (d)	Highest Catch Rate	Mean Catch Rate	Area under the Catch Curve
1980	43.4	35	0.121	0.036	1.79
1981	112.1	57	0.032	0.011	1.89
1982	82.3	51	0.046	0.009	1.68
1983	106.7	59	0.093	0.031	0.59
1984	30.5	48	0.139	0.033	0.60
1985	77.2	60	0.136	0.029	1.83
1986	34.9	43	0.155	0.039	2.18
1987	23.3	37	0.090	0.023	0.97
1988	23.2	53	0.073	0.025	1.25
1989	16.2	44	0.856	0.123	6.19
1990	41.3	55	0.092	0.023	1.31
1991	25.9	54	0.129	0.022	1.13
1992	8.6	51	0.299	0.044	1.44
Average of historical data					1.76
1998	3.82	----	0.053	0.020	1.46
1999	5.73	42	0.055	0.026	1.30

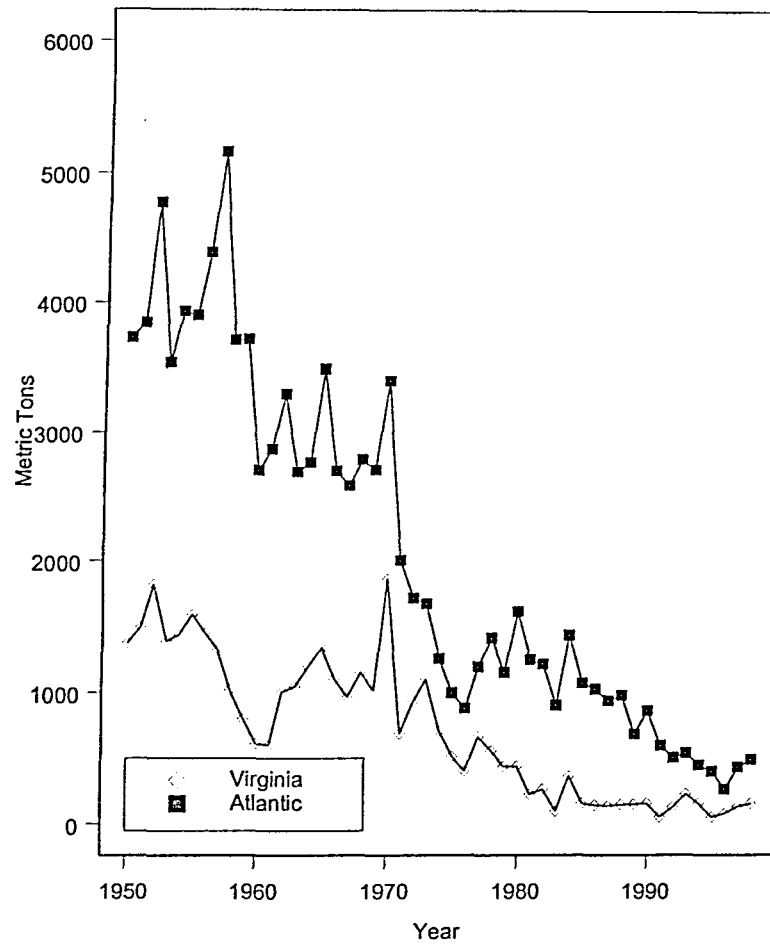
Table 22. Summary of historical and recent catch and effort data of American shad by staked gill nets in the York River, Virginia. Historical data are taken from the voluntary log books of Mr. R. Kellum, Achilles, Virginia. Catch rates are expressed as female kg/d.

Year	Effort (10 <sup>3</sup> m/yr)	Duration of run (d)	Highest Catch Rate	Mean Catch Rate	Area under the Catch Curve
1980	79.4	44	0.556	0.268	10.15
1981	114.7	51	0.259	0.121	4.35
1982	86.4	44	0.326	0.101	5.31
1983	121.3	40	0.212	0.066	3.06
1984	171.4	48	0.548	0.139	8.21
1985	205.4	49	0.227	0.091	4.61
1986	185.2	38	0.145	0.055	2.17
1987	152.9	37	0.088	0.039	1.78
1988	126.2	40	0.134	0.028	1.34
1989	146.3	55	0.397	0.131	4.92
1990	106.9	38	0.951	0.037	1.31
1991	77.8	40	0.111	0.062	2.72
1992	60.8	41	0.079	0.041	1.60
Average of historical data					<b>3.96</b>
1998	5.7	78	1.080	0.190	13.47
1999	6.3	65	0.209	0.075	4.85

Table 23. Summary of historical and recent catch and effort data of American shad by staked gill nets in the James River, Virginia. Historical data are taken from the voluntary log books of the Brown family, Rescue, Virginia. Catch rates are expressed as female kg/d.

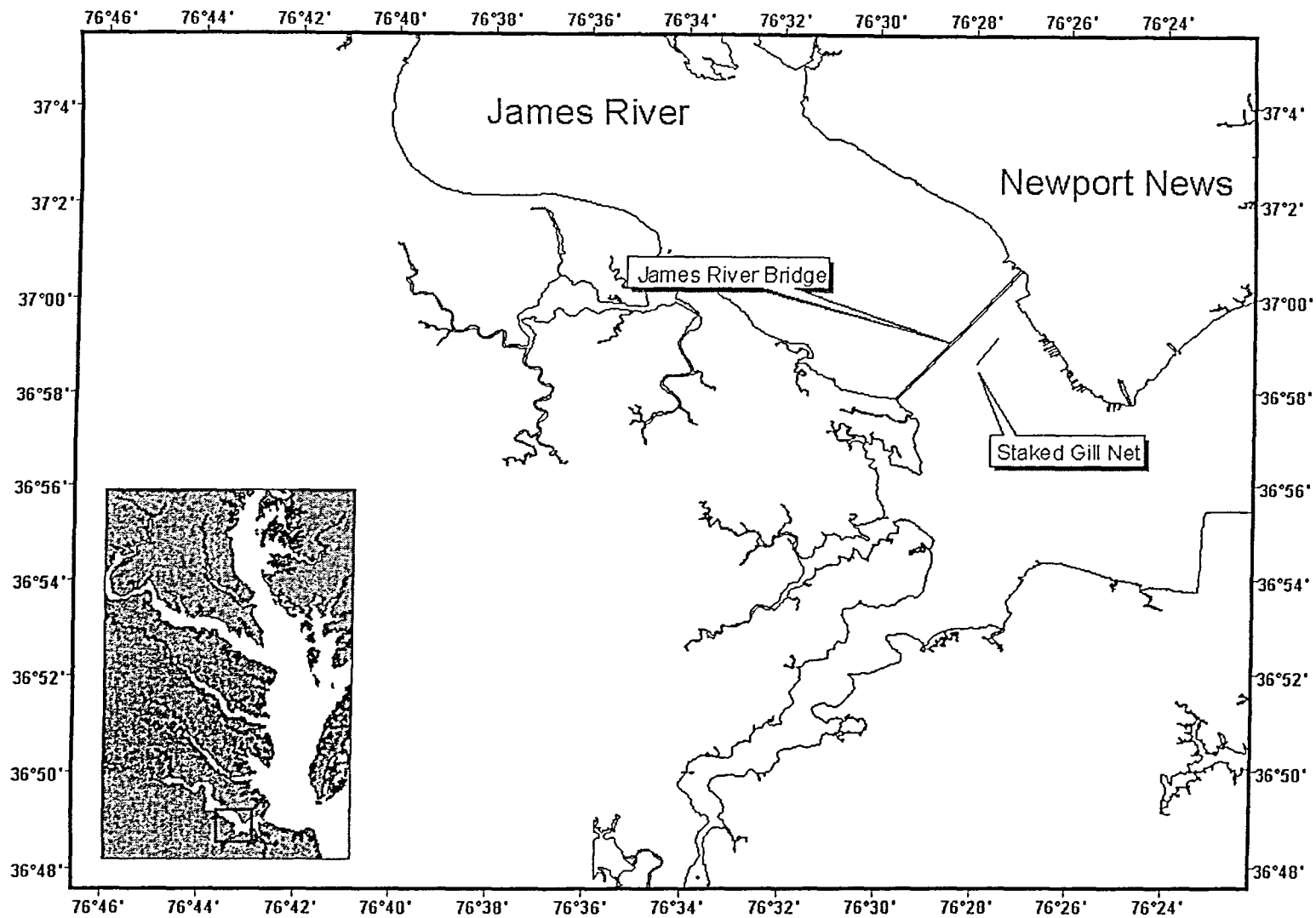
Year	Effort (10 <sup>3</sup> m/yr)	Duration of run (d)	Highest Catch Rate	Mean Catch Rate	Area under the Catch Curve
1980	20.5	41	2.239	0.699	29.20
1981	67.7	41	0.547	0.130	5.20
1982	49.3	35	0.331	0.115	4.20
1983	94.0	57	1.274	0.297	16.50
1984	89.7	50	0.897	0.036	19.30
1985	91.3	45	0.295	0.103	4.90
1986	31.5	26	1.289	0.152	6.10
1987	30.1	30	0.352	0.085	2.70
1988	19.1	20	0.487	0.193	9.30
1989	31.5	30	0.331	0.176	6.40
1990	29.7	25	0.184	0.079	2.10
1991	28.3	40	0.138	0.062	1.90
1992	59.8	50	0.562	0.232	7.70
Average of historical data					<b>8.88</b>
1998	3.8	50	0.198	0.051	2.60
1999	6.0	66	0.183	0.042	2.60

### American Shad Landings

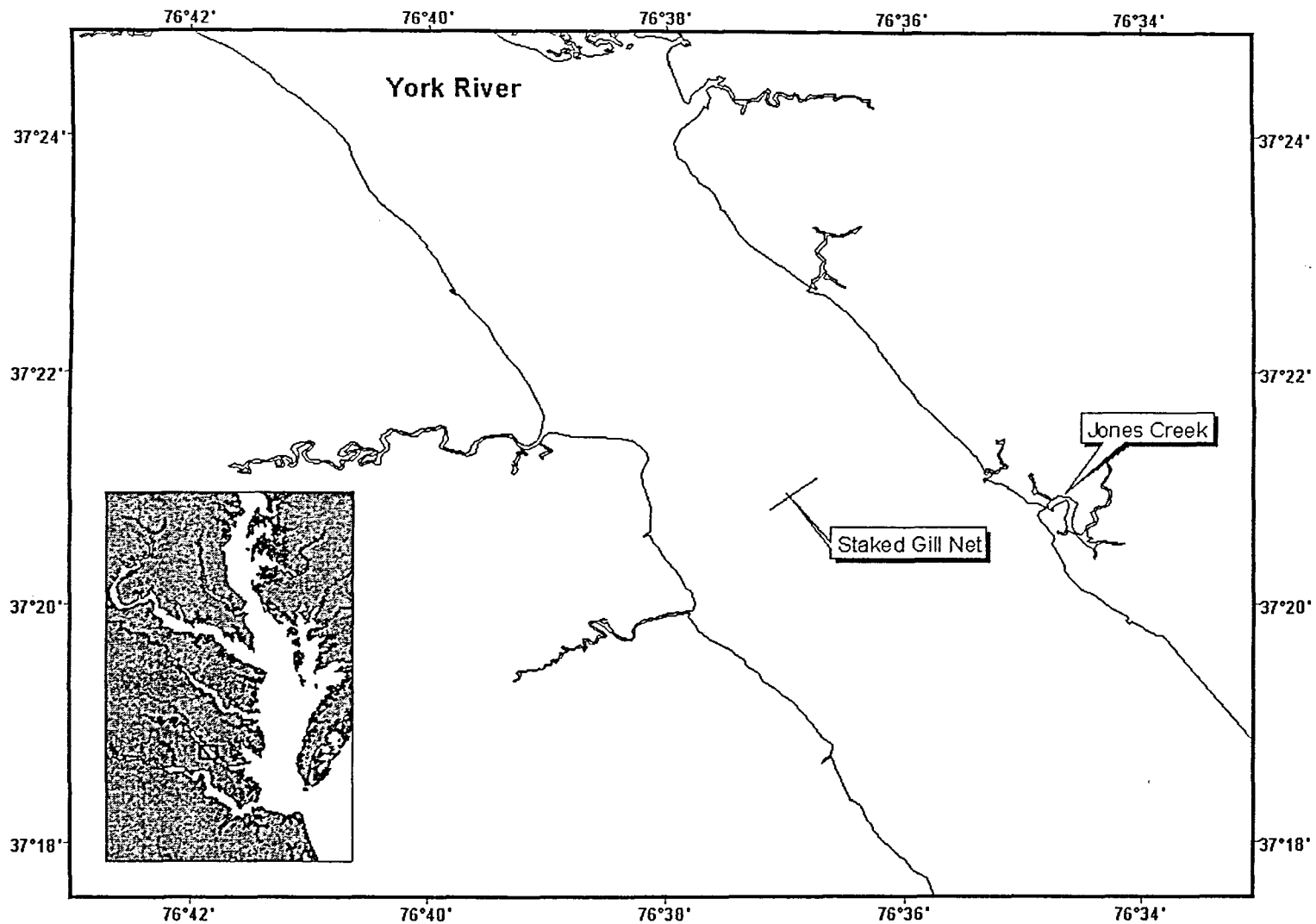


**Figure 1. Commercial landings of American shad along the Atlantic coast and in Virginia since 1950. Data source: National Marine Fisheries Service, Fisheries Statistics and Economics Division.**

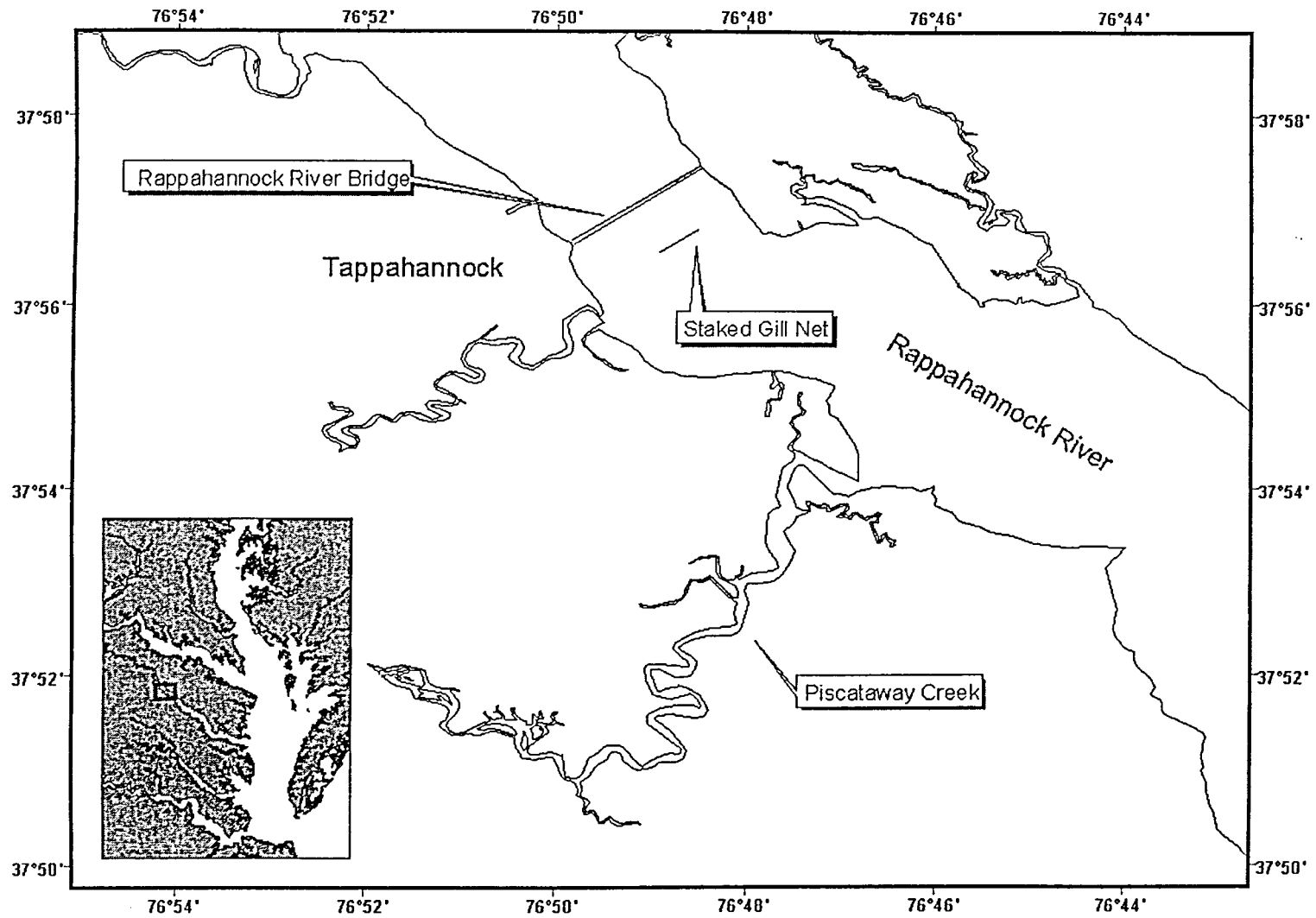




**Figure 2.** Location of the staked gill net fished by Mr. Mark Brown on the James River. The length of the net (273 m) is not to scale.

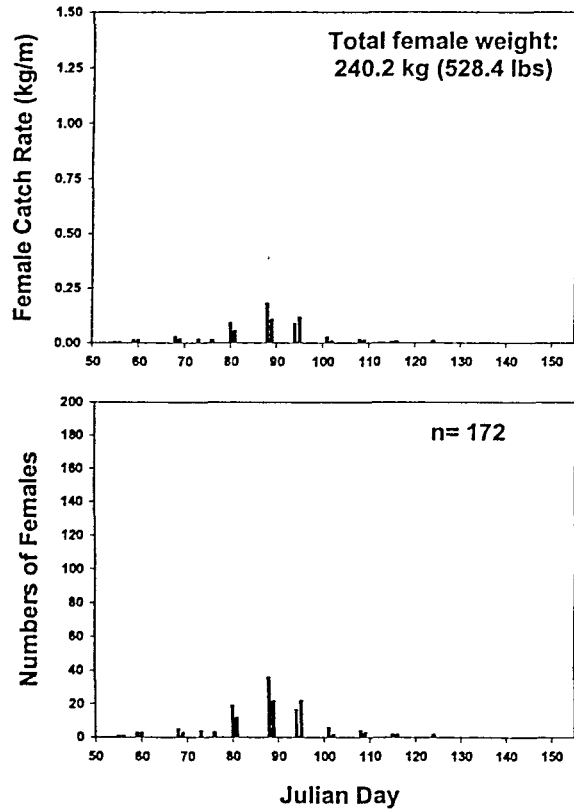


**Figure 3.** Location of the staked gill net fished by Mr. Raymond Kellum on the York River. The length of the net (273 m) is not to scale.

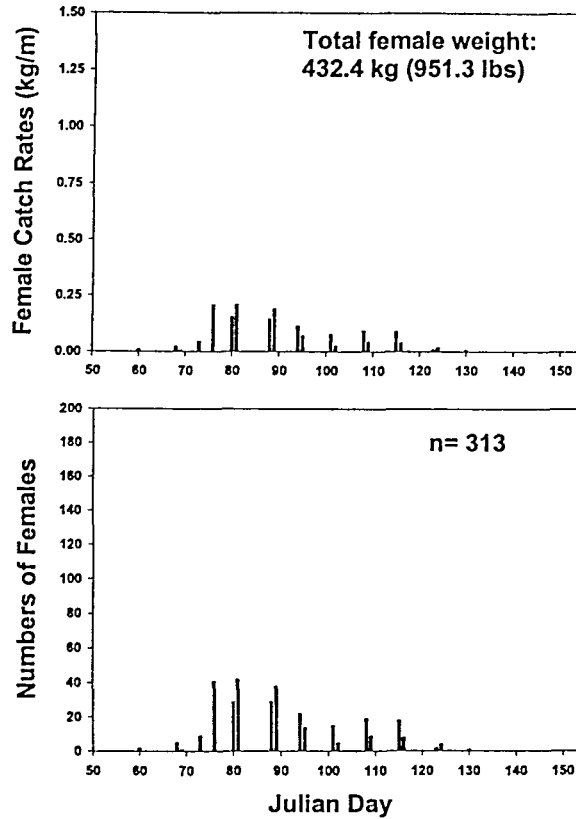


**Figure 4.** Location of the staked gill net fished by Mr. Jamie Sanders on the Rappahannock River. The length of the net (273 m) is not to scale.

James River American Shad  
Brown Staked Gill Net Catches



York River American Shad  
Kellum Staked Gill Net Catches



Rappahannock River American Shad  
Sanders Staked Gill Net Catches

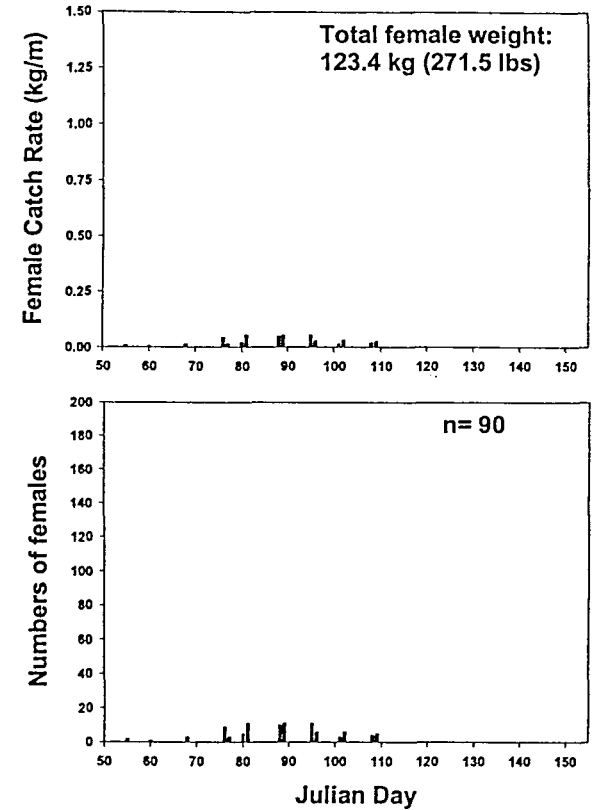
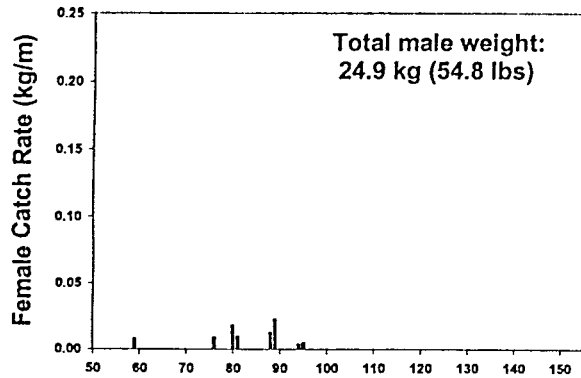
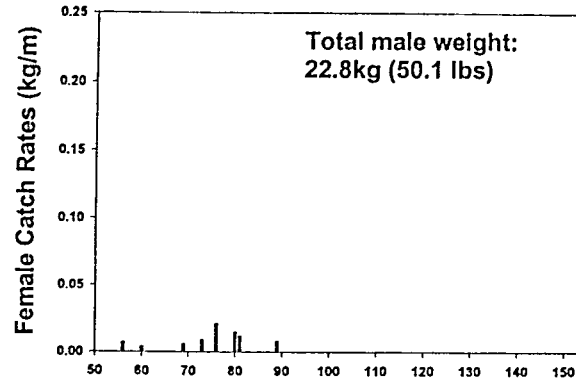


Figure 5. Catch rates and total numbers of female American shad taken by staked gill nets in the James, York and Rappahannock rivers, spring 1999.

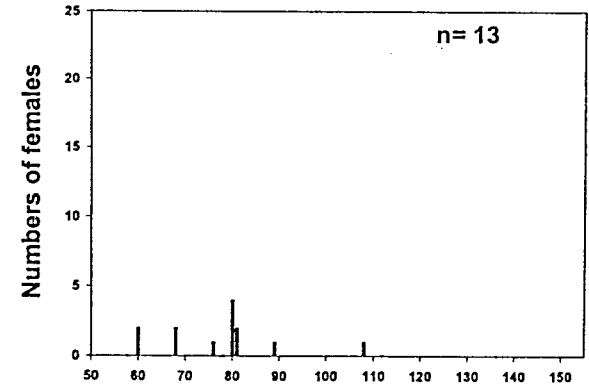
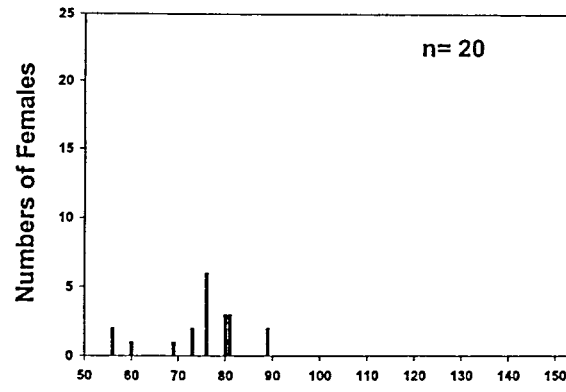
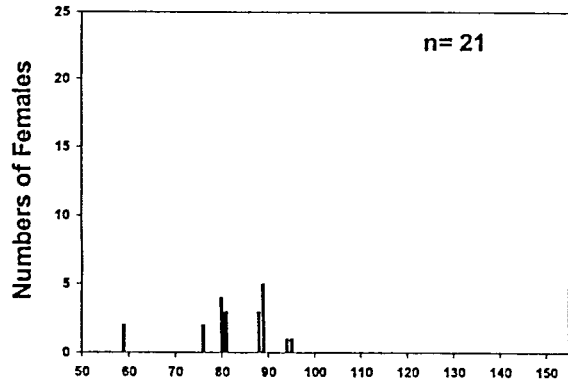
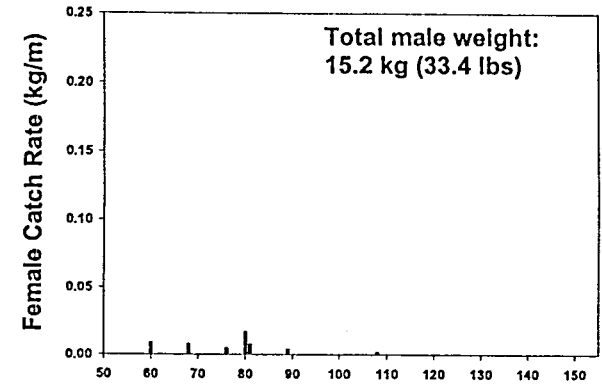
James River American Shad  
Brown Staked Gill Net Catches



York River American Shad  
Kellum Staked Gill Net Catches



Rappahannock River American Shad  
Sanders Staked Gill Net Catches



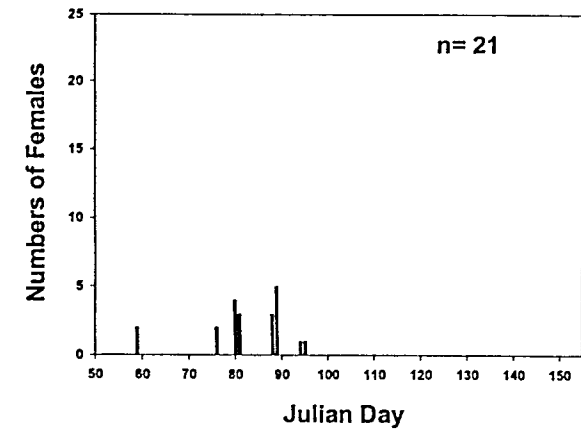
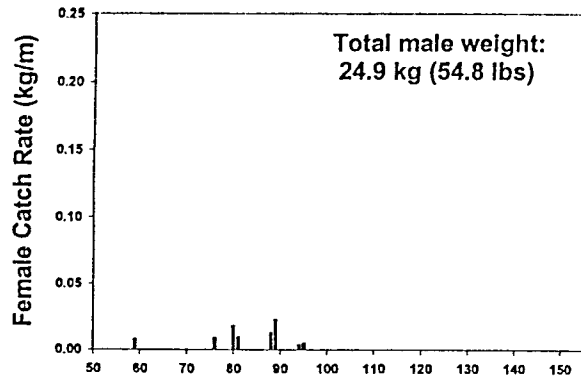
Julian Day

Julian Day

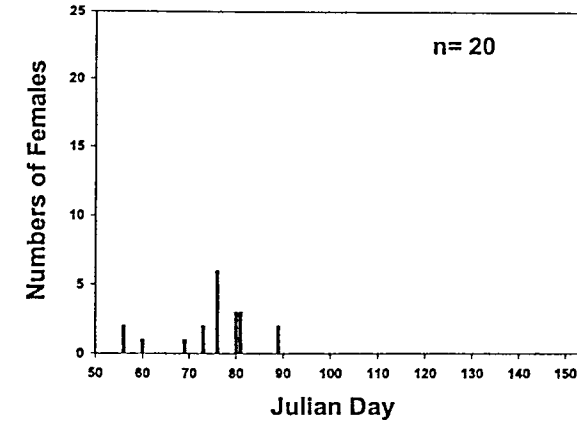
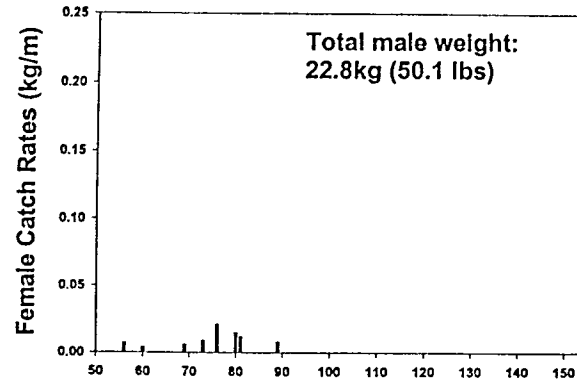
Julian Day

Figure 6. Catch rates and total numbers of male American shad taken by staked gill nets in the James, York and Rappahannock rivers, spring 1999.

James River American Shad  
Brown Staked Gill Net Catches



York River American Shad  
Kellum Staked Gill Net Catches



Rappahannock River American Shad  
Sanders Staked Gill Net Catches

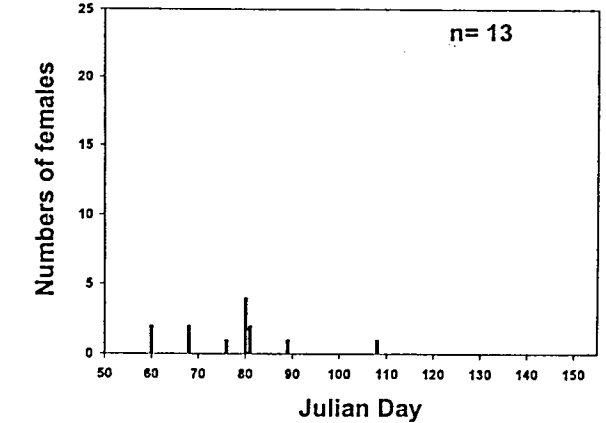
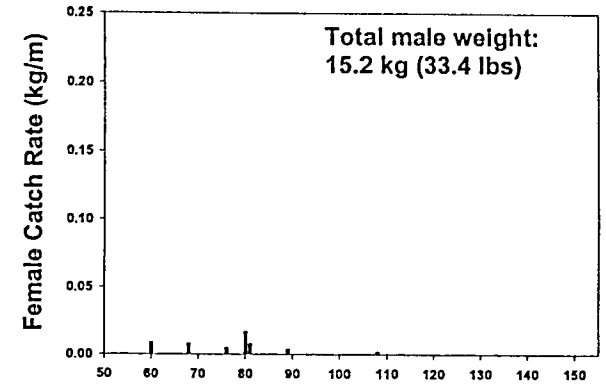
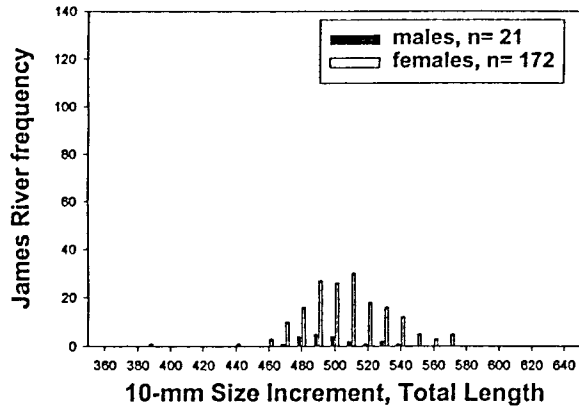
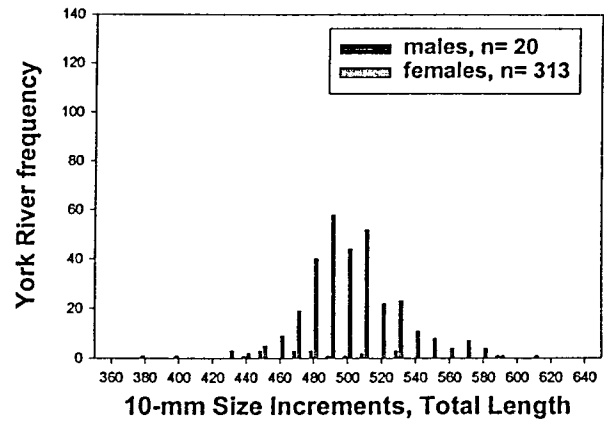


Figure 6. Catch rates and total numbers of male American shad taken by staked gill nets in the James, York and Rappahannock rivers, spring 1999.

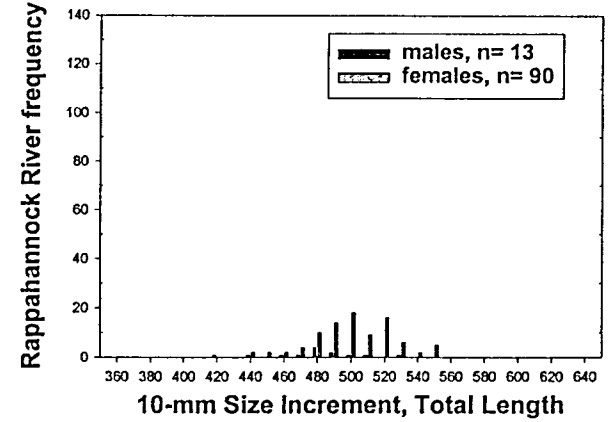
### James River



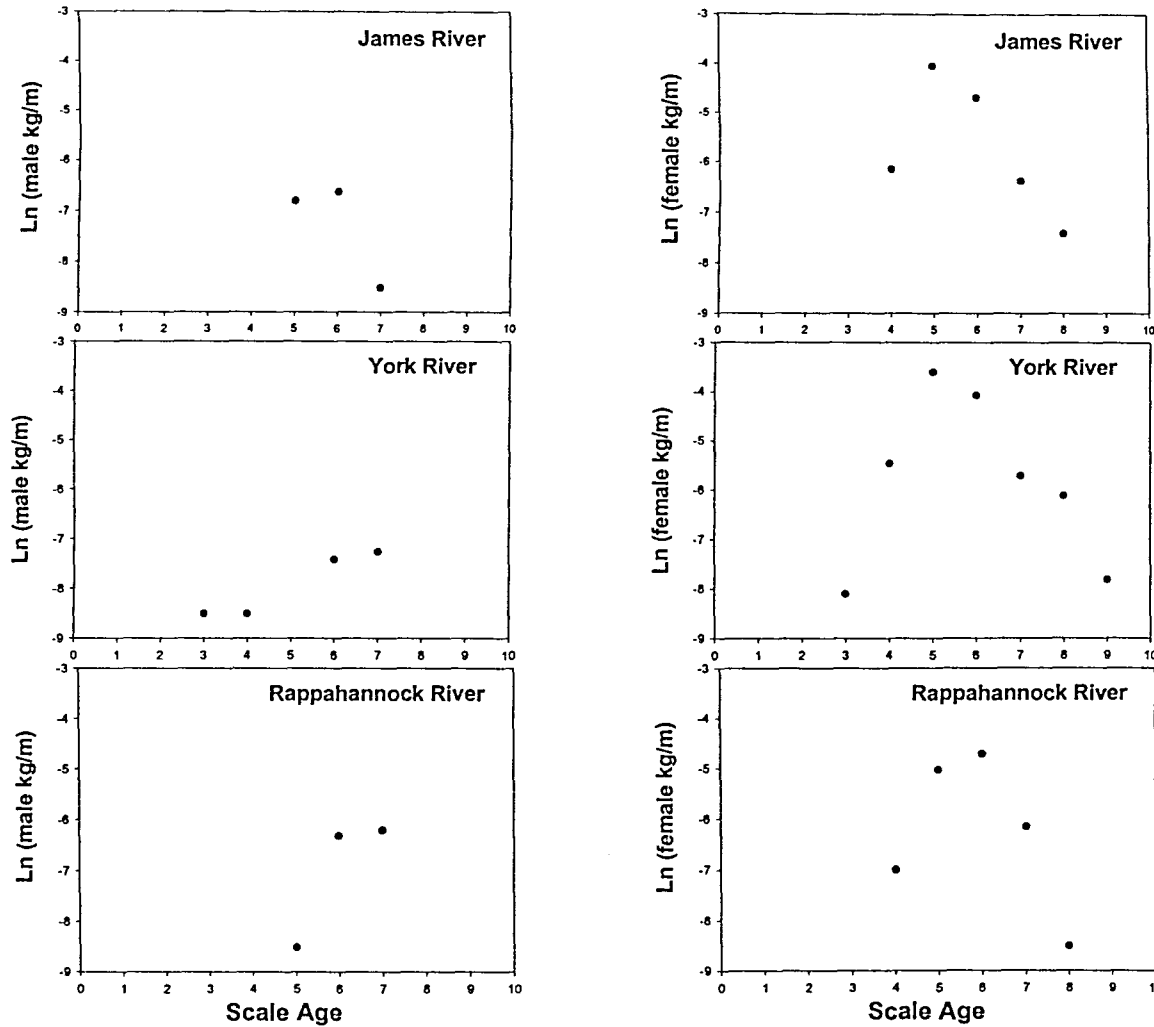
### York River



### Rappahannock River

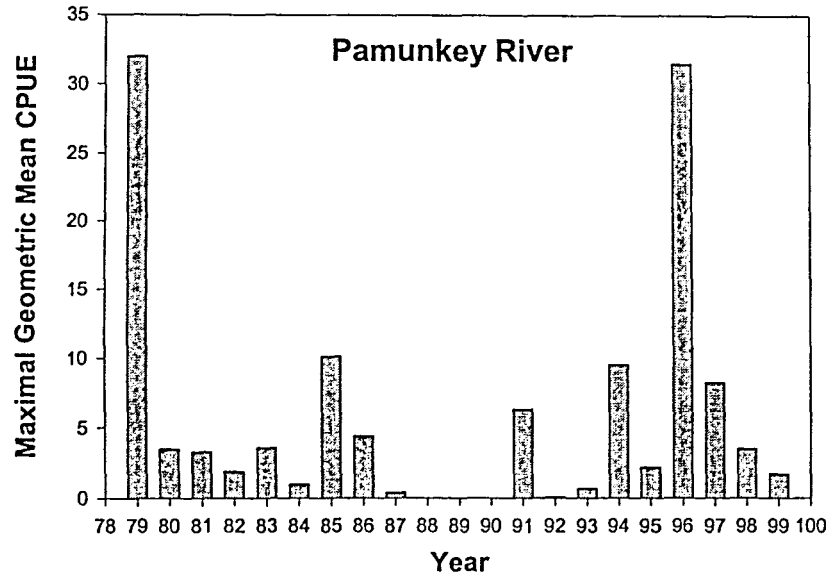
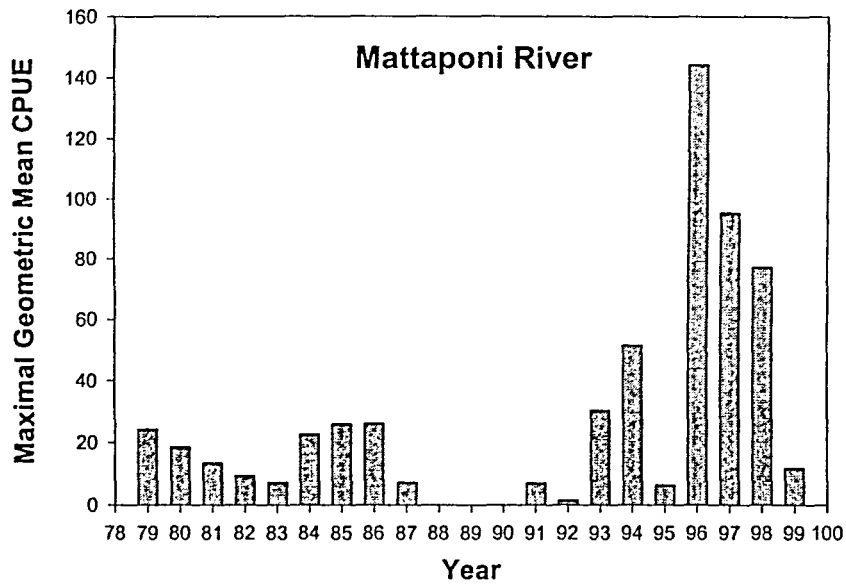


**Figure 7. Total length (mm) frequency distributions for American shad captured in staked gill nets on the James, York and Rappahannock rivers, spring 1999.**



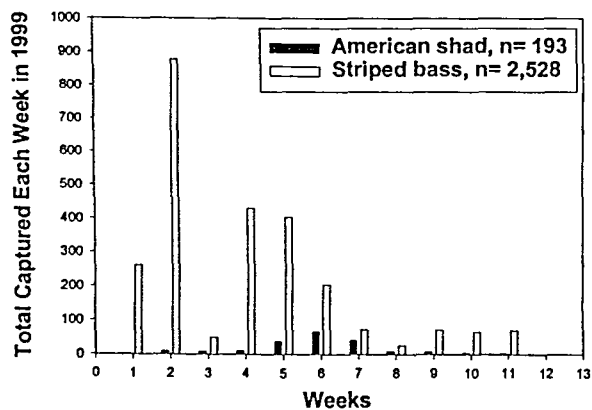
**Figure 8.** Age-specific catch rates (kg/m) of male (left) and female (right) American shad taken by staked gill net in the James, York and Rappahannock rivers, 1999. Ages were estimated from scales.



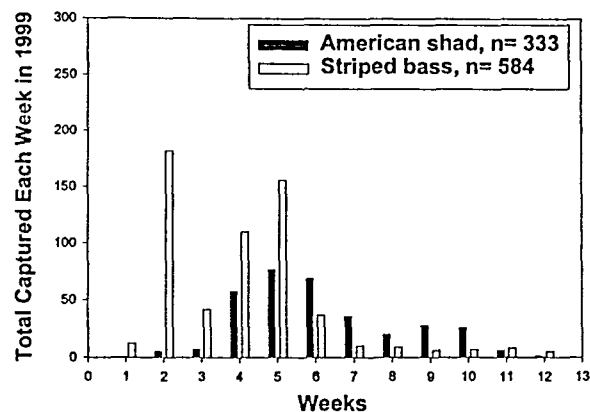


**Figure 9.** The index of juvenile abundance of American shad in the Mattaponi and Pamunkey rivers as estimated by evening pushnet surveys. Each value is the maximum catch rate (expressed as a geometric mean for any weekly cruise) observed in each year. Note the difference in scale on the vertical axis.

## James River



## York River



## Rappahannock River

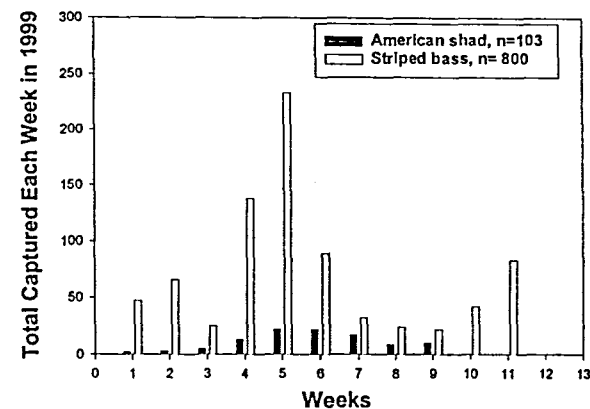
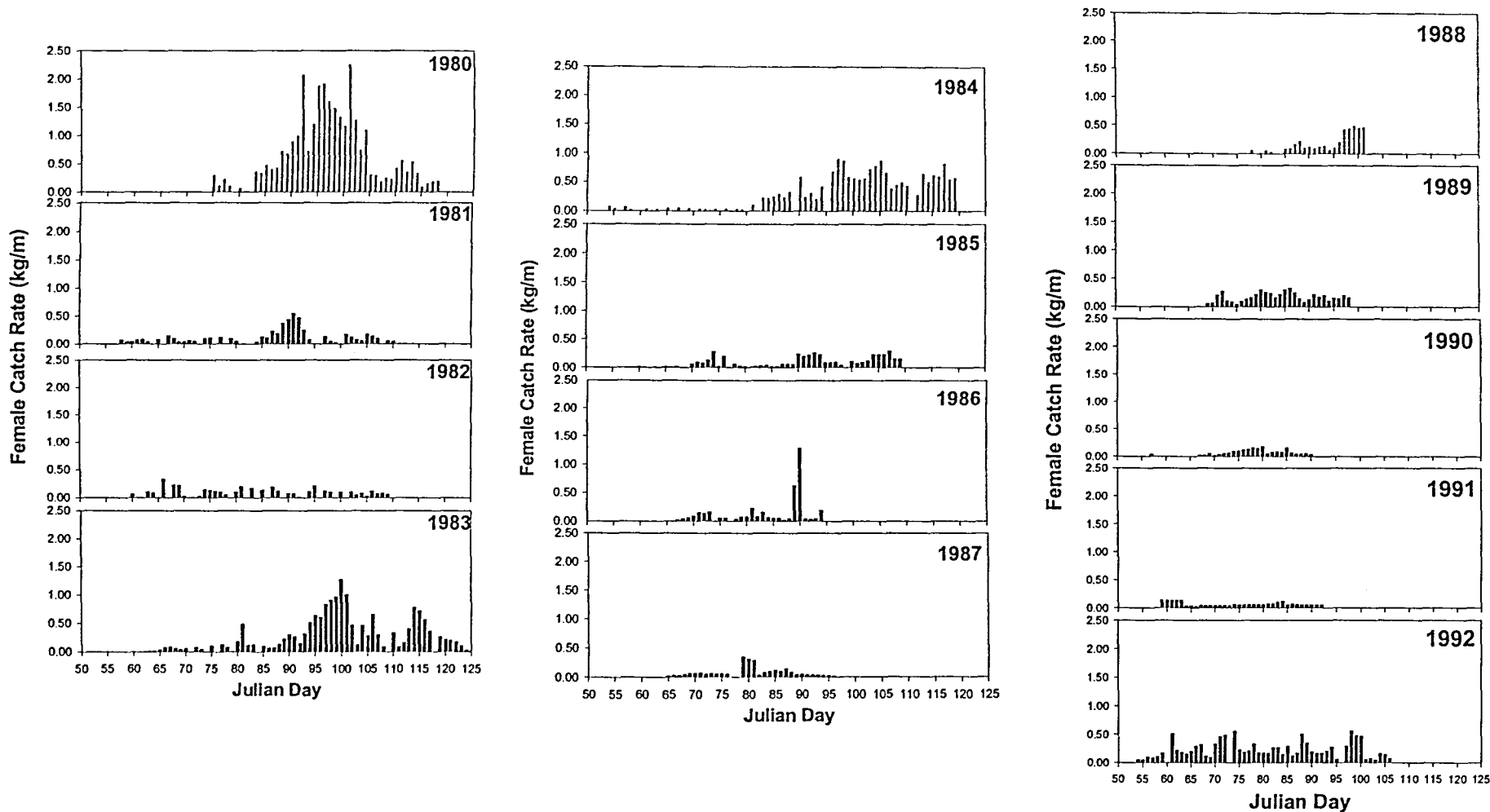
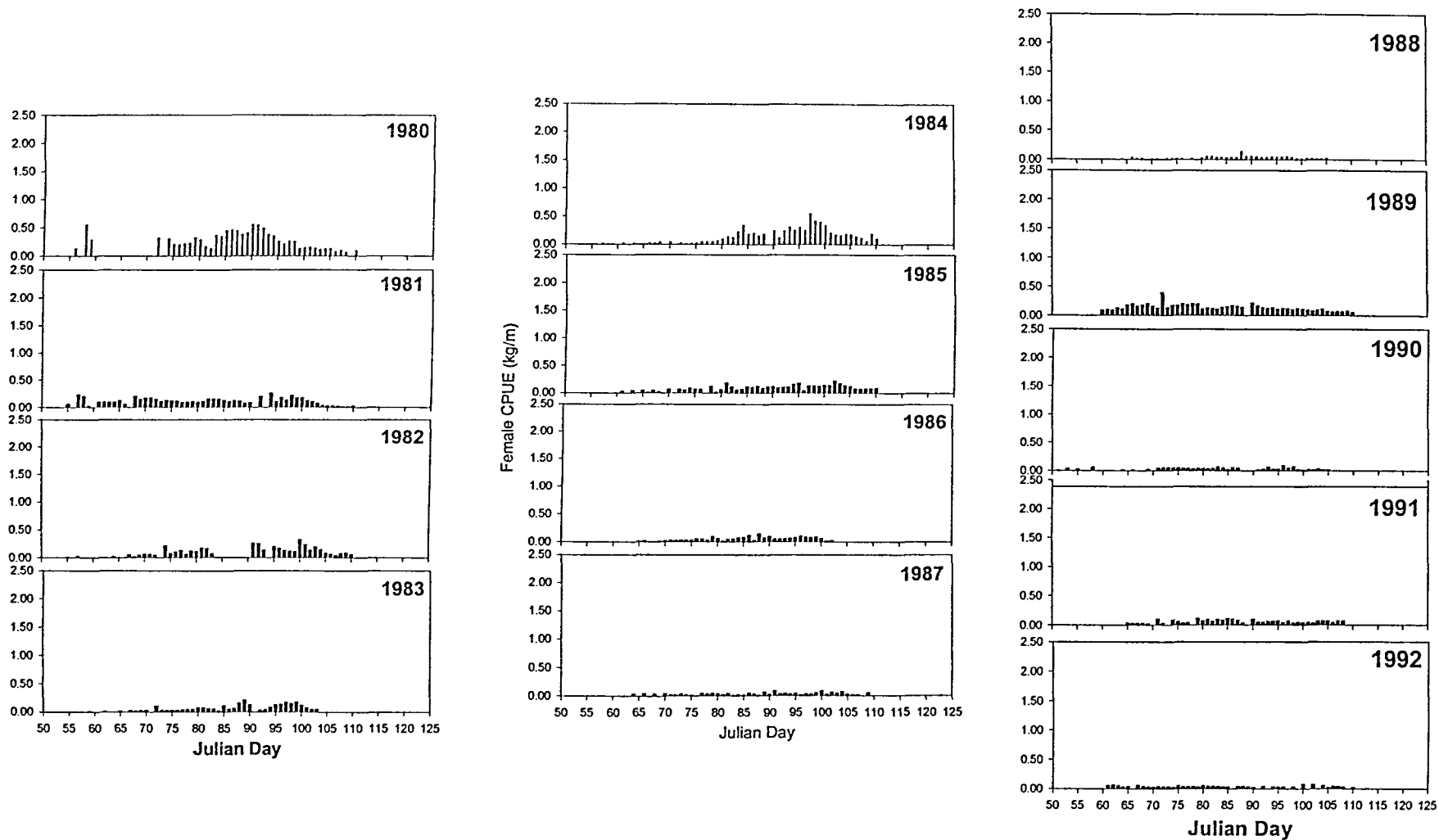


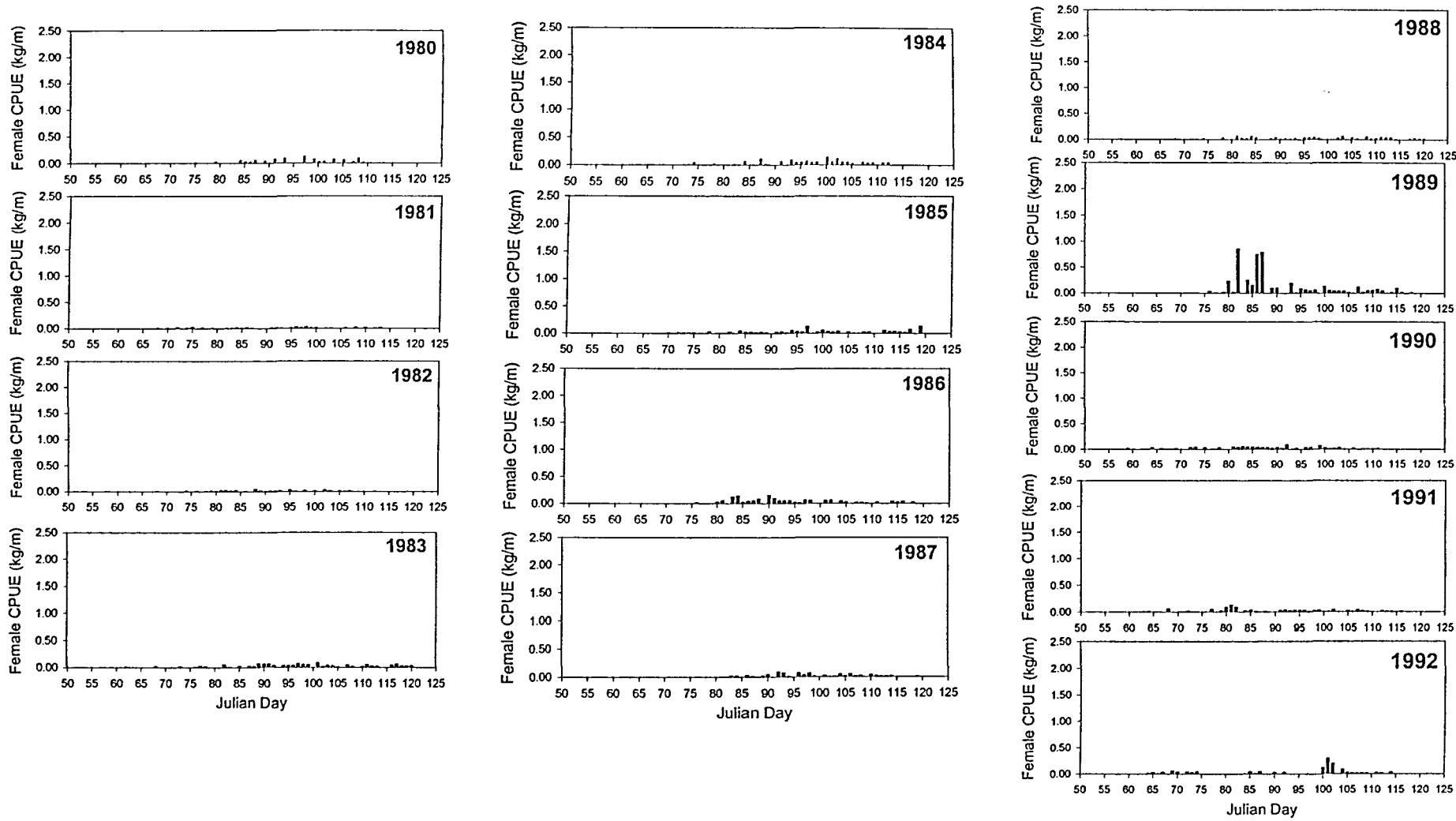
Figure 10. Numbers of American shad and striped bass (both sexes combined) captured in staked gill nets on the James, York and Rappahannock rivers, spring 1999. Note the difference in scale of the vertical axis in the James River panel.



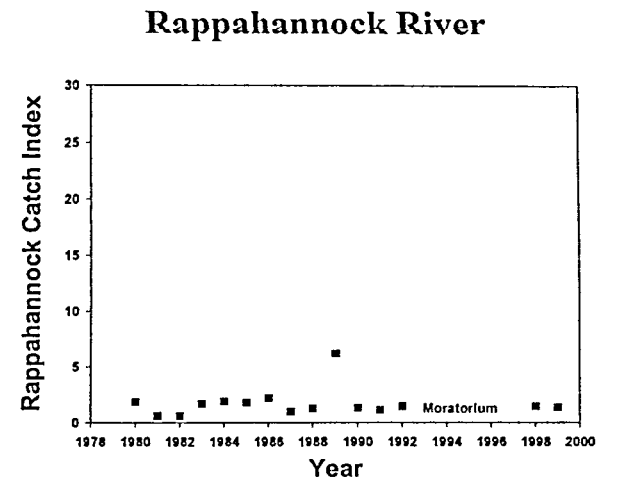
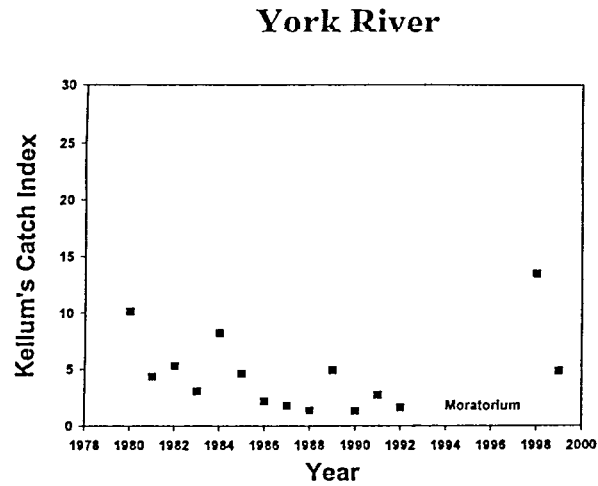
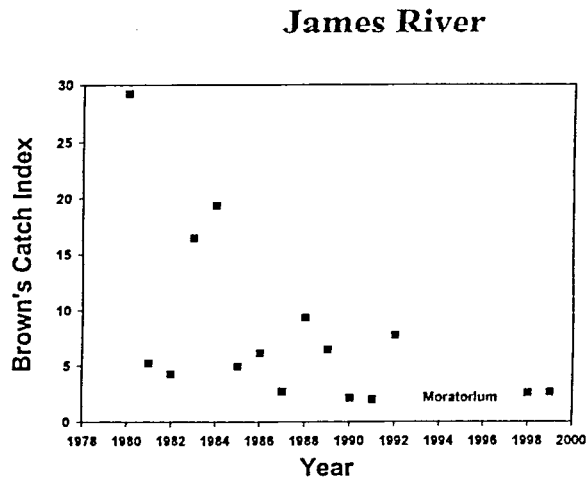
**Figure 11. Historical catch rates of female American shad taken by staked gill nets in the James River (1980-1992) based on voluntary logbooks provided by the Brown family, Rescue, Virginia.**



**Figure 12. Historical catch rates of female American shad taken by staked gill nets in the York River (1980-1992) based on voluntary logbooks provided by Raymond Kellum, Gloucester County, Virginia.**



**Figure 13. Historical catch rates of female American shad taken by staked gill nets in the Rappahannock River (1980-1992) based on voluntary logbooks provided by Marvin Delano, Tappahannock, Virginia.**



**Figure 14. Recent (1998 and 1999) and historic values of the catch index of female American shad on the James, York and Rappahannock rivers.**