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September 2, 2005

Virginia Department of Environmental Quality
Attention: Ms. Ellie Irons, Environmental Impact
Review Program Manager
629 East Main Street
Richmond, VA 23219

Dear Ms. Irons:

The Board of Directors of the Lake Anna Civic Association (LACA) passed the enclosed resolution at its regular business meeting on September 1, 2005. The resolution is in response to the early site permit application by Dominion Resources to add additional nuclear reactors at their North Anna power plant.

This resolution addresses the concerns of the Lake Anna Civic Association relative to the proposed additional reactors, which we believe must be addressed prior to any approval of an early site permit.

Request you include the concerns addressed in the attached resolution in your comments back to the Nuclear Regulatory Commission from the Commonwealth of Virginia.

If you have any questions, please feel free to contact me at the address reflected above. You can also contact me at my home phone, (540) 854-5753 or via email at bhayden37@yahoo.com.

Thank you for your assistance with this matter.

Sincerely,

William S. Hayden
President

Cc:
U.S. Nuclear Regulatory Commission (Mr. Jack Cushing)

Enclosure

RESOLUTION OF THE LACA BOARD OF DIRECTORS
September 1, 2005

WHEREAS, Dominion Power has requested an early site permit to build two additional nuclear reactors at the North Anna power plant, and

WHEREAS, Dominion proposes to cool the first of the two new reactors using water from Lake Anna in a similar manner as used for the two existing reactors, and

WHEREAS, the operation of this third reactor could increase the flow of lake water through the plant by as much as 60 percent, and

WHEREAS, the increased temperature and greatly increased flow of the water exiting the plant could have serious adverse effects on Lake Anna, both the waste heat treatment facility and the main lake, and

WHEREAS, these adverse effects could include raising the water temperature in some locations at some times to the point that it would be dangerous for humans and animals to be in the water, and

WHEREAS, these adverse effects could include raising the water temperature generally on the waste heat treatment facility and on parts of the lake, making it unsuitable for popular recreational activities during the time of the year when those activities are most popular, and

WHEREAS, these adverse effects could include permanent changes in water levels in parts of Lake Anna that may result in damage to docks, seawalls, and other waterside facilities, and

WHEREAS, these adverse effects could include other problems stemming from the increased water flow, and

WHEREAS, Mr. Harry Ruth, a member of the Lake Anna Civic Association, has undertaken to get regulatory limits placed on Dominion's permits to expand the North Anna nuclear power plant, including sending a letter on August 17, 2005, to the Virginia Department of Environmental Quality.

NOW THEREFOR BE IT RESOLVED that the Board of Directors of the Lake Anna Civic Association

1. Agrees that increased water temperatures could make parts of Lake Anna dangerous for humans and animals at certain times and make parts of Lake Anna unusable for popular recreational activities at times when these activities are most popular.
2. Agrees that permanent changes in water levels on all or part of Lake Anna could cause substantial damage to waterside facilities and cost property owners millions of dollars.
3. Believes that the other possible effects of increased water flows through the plant (e.g., increased erosion, turbulence) should be thoroughly investigated.
4. Believes that our concerns would be satisfied by appropriate regulatory limits regarding lake water temperatures, levels, and possibly flows through the plant being placed on Dominion's permits for expanding the North Anna nuclear power plant. These limits should provide that the plant's expansion should not be allowed to increase water temperatures (and should never exceed 104 degrees under any circumstances) or to significantly and/or permanently change current overall water levels.

BE IT FURTHER RESOLVED THE LACA BOARD OF DIRECTORS DIRECTS THE PRESIDENT TO FORTHWITH NOTIFY THE LACA MEMBERSHIP, THE VIRGINIA DEQ, AS WELL AS ADDITIONAL ADDRESSEES THAT ARE YET TO BE DETERMINED, OF THIS RESOLUTION.

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Transactions of the American Fisheries Society
Article: pp. 31–61 | PDF (644K)

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Transactions of the American Fisheries Society 1985;114:31–61

Striped Bass, Temperature, and Dissolved Oxygen: A Speculative Hypothesis for Environmental Risk

CHARLES C. COUTANT

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Abstract.—Striped bass Morone saxatilis has a paradoxical record of distribution and abundance, including population declines in coastal waters and variable success of freshwater introductions. This record is analyzed for consistency with a hypothesis that striped bass are "squeezed" between their thermal and dissolved oxygen preferences or requirements. A commonality among diverse field and laboratory observations supports an inherent thermal niche for the species that changes to lower temperatures as fish age. This shift can cause local conditions, especially warm surface strata and deoxygenated deep water, to be incompatible with the success of large fish. Crowding due to temperature preferences alone or coupled with avoidance of low oxygen concentrations can lead to pathology and overfishing, which may contribute to population declines. Through a mixture of evidence and conjecture, the thermal niche-dissolved oxygen hypothesis is proposed as a unified perspective of the habitat requirements of the species that can aid in its study and management.

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Transactions of the American Fisheries Society 1981;110:226–238

Growth Dynamics of Juvenile Striped Bass as Functions of Temperature and Ration

DAVID K. COX and CHARLES C. COUTANT

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Abstract.—Growth dynamics of juvenile striped bass Morone saxatilis were determined at constant temperatures (12-34.5 C), at fluctuating temperatures (± 4 C around means of 18, 24, and 30 C), and at ration levels of 100, 60, 30, and 0% of satiation at each temperature regime. At constant temperatures, both maximum growth for 100% ration and minimum maintenance ration occurred near 24 C; zero growth occurred at 33.5 C. Reduced ration lowered growth rates and shifted the point of zero growth to lower temperatures, but it did not significantly shift the temperature of optimum growth. The greatest bioenergetic efficiency in fluctuating temperature regimes was in the range 14-22 C (mean, 18 C).

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North American Journal of Fisheries Management 2001;21:34–45

Reservoir Striped Bass Movements and Site Fidelity in Relation to Seasonal Patterns in Habitat Quality

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Abstract.—Adult striped bass *Morone saxatilis* perform best when water temperatures are below 26°C and dissolved oxygen levels are above 2 mg/L and will begin to exhibit stress responses at higher temperatures or lower oxygen levels. In southern U.S. reservoirs, summer conditions may result in a reduction of suitable habitat for adult striped bass and therefore influence population dynamics and distribution. We tracked 51 adult striped bass that had been implanted with individually coded sonic transmitters for 2 years in Lake Gaston, Virginia–North Carolina, to determine the impact of habitat availability on seasonal trends in movement and distribution. Monthly movement rates of individual fish averaged 7,340 m (SE = 544 m) over the course of the study, and no significant differences in movement rates were detected among seasons or between sexes. Striped bass were relocated throughout the reservoir in all seasons despite evidence of spatial variability in the availability of suitable habitat during the summer months. Individual striped bass tended to occupy specific reservoir areas in all seasons and years of the study, with the exception of spring spawning runs. Home ranges of individual fish were not clearly related to the availability of summer habitat refuges but tended to be located in large, downlake basins or near the tailrace of an upstream dam. Fidelity of striped bass to limited areas within the reservoir suggests that spatially explicit management strategies are appropriate for reservoir populations of striped bass.

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Transactions of the American Fisheries Society 1993;122:636–641

NOTES: Vitellolipid and Vitelloprotein Profiles of Environmentally Stressed and Nonstressed Populations of Striped Bass

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Abstract.—Striped bass *Morone saxatilis* were collected from Lake Anna, a thermally enriched Virginia reservoir, and Smith Mountain Lake, an ambient-temperature Virginia reservoir, and their ovaries were compared for differences in vitellolipid and vitelloprotein. Habitat analyses indicated summer temperatures and dissolved oxygen concentrations were stressful to striped bass in Lake Anna and nonstressful to striped bass in Smith Mountain Lake. Summer ovary weights, condition factors, and body lengths and weights were significantly lower for Lake Anna striped bass than for Smith Mountain Lake fish. Total vitellolipid and total vitelloprotein concentrations did not differ significantly between the two samples, but concentrations of vitellotriglyceride and other esters and of certain component vitelloproteins were significantly greater in ovaries of Smith Mountain Lake striped bass. These data indicate bioenergetic stresses in Lake Anna did not significantly affect the quantity of vitellolipids and vitelloproteins sequestered by Lake Anna striped bass, but did significantly affect vitellolipid and vitelloprotein composition.

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ANNUAL PROGRESS REPORT

Estimation of Juvenile Striped Bass Relative Abundance in the Virginia portion of Chesapeake Bay

January 2003 - December 2003

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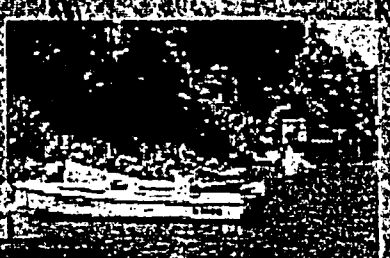

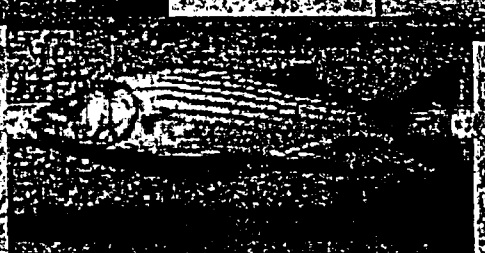

U.S. Fish and Wildlife Service
Sportfish Restoration Project F87R15

Submitted to
Virginia Marine Resources Commission
April 2004

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ACKNOWLEDGEMENTS

We are deeply indebted to the many landowners on the tributaries of Chesapeake Bay that have graciously allowed us to conduct sampling on their property. We thank the Mariners Museum, Jamestown 4-H Camp, Powhatan Resorts, and the United States Army at Fort Eustis for their permission to sample. We would also like to thank the many students and staff who assisted in the field sampling and data compilation of this report.

Funding was provided by a grant from the United Stated Fish and Wildlife Service (Sportfish Restoration Project F87R15) through the Virginia Marine Resources Commission to the Virginia Institute of Marine Science.

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PREFACE

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile striped bass seine survey from 1967 through 1973 and from 1980 through the present. The primary objective has been the monitoring of the relative annual recruitment success of juvenile striped bass in the spawning and nursery areas of Lower Chesapeake Bay. Initially (1967-1973), the survey was funded by the U.S. Fish and Wildlife Service and when reinstated in 1980 with funding from the National Marine Fisheries Service under the Emergency Striped Bass Study program. Commencing with the 1988 annual survey, support of the program has been jointly made through the Sportfish Restoration Program (Wallop-Breaux Act), administered through the U.S. Fish and Wildlife Service and the Virginia Marine Resources Commission. This report summarizes the results of the 2003 sampling period and compares these results with the previous work.

Specific objectives for the 2003 program were to:

1. Measure the relative abundance of the 2003 year class of striped bass from the James, York and Rappahannock river systems.
2. Quantify environmental conditions at the time of collection.
3. Examine relationships between juvenile striped bass abundance and measured or proxy environmental and biological data.

INTRODUCTION

The estimation of juvenile striped bass abundance in Virginia waters, funded by the U.S. Fish and Wildlife Service, is part of a coast-wide sampling program of striped bass recruitment conducted from New England to North Carolina under the coordination of the Atlantic States Marine Fisheries Commission (ASMFC). Virginia's efforts started in 1967 with funding from the Commercial Fisheries Development Act of 1965 (PL88-309) and continued until 1973 when the program was terminated. It was re-instituted in 1980 with Emergency Striped Bass Study funds (PL 96-118, 16 U.S.C. 767g, the "Chafee Amendment"), and since 1989 has been funded by the Wallop-Breaux expansion of the Sportfish Restoration and Enhancement Act of 1988 (PL 100-448 known as the Dingle-Johnson Act).

The Atlantic Coast Striped Bass Interstate Fisheries Management Plan was developed by ASMFC in 1981, then adopted by the Virginia Marine Resources Commission (VMRC) in March 1982 (Regulation 450-01-0034). Amendment VI (adopted in February, 2003) to the plan requires "producing states" (e.g. Virginia, Maryland, Delaware and New York) to develop and support monitoring programs of recruitment levels. This became a mandate when Congress passed the Atlantic Striped Bass Conservation Act in 1984 (reauthorization 1991, PL102-130). To remain in compliance with the Act, each state must adhere to all provisions in the interstate FMP (ESBS 1993). Virginia has done this through December 2003.

Originally, the Virginia program used a 6' x 100' (2m x 30.5m) x 0.25" (6.4mm) mesh bag seine, but after comparison tows with Maryland gear, 4' x 100' x 0.25" mesh (1.2m x 30.5m x 6.4mm)

showed virtually no statistical differences in catch, Virginia adopted the "Maryland seine" (Colvocoresses 1984). The original purpose of the gear comparison study was to standardize methods thereby allowing a Bay-wide examination of recruitment success (Colvocoresses and Austin 1987). This was never realized however, for various differences in data handling (MD: arithmetic index, VA: geometric index) and state politics. A Bay-wide index using a weighted (by river spawning area) geometric mean was finally developed in 1993 (Austin, Colvocoresses and Mosca 1993).

METHODS

Field sampling was conducted during five approximately biweekly sampling periods from July through mid-September of 2003. During each sampling period the seine was hauled at eighteen historically sampled sites (index stations) and twenty-two auxiliary stations along the shores of the James, York and Rappahannock systems (Fig. 1). Addition of the auxiliary sites in 1989 was made to provide better geographic coverage and create larger within-river-system sample sizes so that trends in juvenile abundance can be meaningfully monitored on a system-by-system basis, particularly as the stock size increases and the nursery ground expands.

Duplicate hauls were made at each index station during each round and a single haul was made at each auxiliary station. Collections were made by deploying a 100' (30.5m) long, 4' (1.22m) deep, 1/4" (0.64cm) mesh minnow seine perpendicular to the shoreline (either until the net was fully extended or a depth of approximately four feet was encountered), pulling the offshore end down-

current and back to the shore. In the case of index stations, all fish taken during the first tow were removed from the net, measured, and held in water-filled buckets until after the second tow, then released unharmed. All fish collected were identified and counted, and all striped bass and all individuals or a sub-sample of at least 25 individuals of other species measured to the nearest mm fork length (or total length if appropriate). Salinity, water temperature, pH and dissolved oxygen concentrations were measured after the first haul using a Hydrolab Reporter® water quality sampler. Sampling time, tidal stage and weather conditions were recorded at the time of each haul. When two hauls were made, an intervening period of 30 minutes was allowed between hauls and the first sample was processed during this interlude. All fishes captured, excepting those preserved for life history studies, were returned to the water at the conclusion of sampling.

In the present report, comparisons with prior years are made on the basis of the 'primary nursery' standardized data set (Colvocoresses 1984), i.e. only the data collected from the months and areas covered during all surveys will be included in the analyses. Data from the auxiliary stations will not be included since there is no direct basis for comparison. Since the frequency distribution of catch size of these collections is extremely skewed and approximates a negative binomial distribution (Colvocoresses 1984), a logarithmic transformation (ln(x+1)) was applied in order to normalize the data prior to analyses (Sokal and Rohlf 1981). Subsequently computed mean values were retransformed (i.e. the geometric mean) and scaled up arithmetically to allow comparison with Maryland data.

Mean catch rates are contrasted by comparing 95% confidence intervals. Reference to "significant" differences between means in this context will be restricted to cases of non-overlap by

these confidence intervals. Because the standard errors are calculated using the transformed (logarithmic) values, confidence intervals on the retransformed and adjusted scale are non-symmetrical.

RESULTS

Objective 1: Measure the relative abundance of the 2003 year class of juvenile striped bass from the James, York and Rappahannock river systems.

A total of 3406 young-of-the-year striped bass were collected from 180 seine hauls during the 2003 index station sampling and an additional 873 age 0 striped bass were collected in 102 hauls at the auxiliary sites (Table 1, Fig. 1). The adjusted overall mean catch per seine haul (CPUE) for the index stations was 22.89, the second highest index in Virginia (Table 2, Fig. 2) since the implementation of stringent harvest regulations in 1985. This value was significantly higher than the overall average index of 7.03 (non overlap of confidence intervals) and was significantly higher than the 2002 value (3.98). The 2003 index was only slightly lower than the record index of 1996 (23.00). There were 353 fewer yoy striped bass captured in 2003 (versus 1996) but the geometric means were very close due to the distribution of catch. Indices for all individual rivers and river systems were significantly higher than their overall average.

The 2003 catch in the James drainage was 34.71, significantly higher than the overall average of 9.12 and this index was the second highest on record (Table 3, Fig. 3). Juvenile striped bass were widely distributed throughout the James system in 2003 and consistent catches were made at nearly

all of the sampling sites. (Table 1, Fig. 4). Greatest catches were located in and around the mouth of the Chickahominy River near the center of the defined nursery area. Downriver catches are probably attributable to the depressed salinities and increased yearclass strength in 2003. The large catch at J12 in round one is a phenomenon that occurs mainly when a large yearclass is present. These fish are presumably spawned early in the season and move into the lower portion of the river to avoid competition.

The main-stem James catch rate (27.34) was three times higher than its overall average of 8.01. The Chickahominy catch rate (55.41) increased significantly in 2003 and was nearly five times higher than its overall average of 11.78 (Table 1; Fig. 4). J36 was the highest producing index site in the James River. J56, the uppermost index site situated just upriver of J51 rarely produces large catches and 2003 was no exception though catches were made during all site visits. C1 catches were the highest in the James system and C3, while catches there were smaller, was the third highest producing site.

The 2003 index in the York drainage (17.47) was the highest index recorded and was three times higher than the historical average (5.46)(Table 3, Fig. 3). The index in the Pamunkey (24.10) and the Mattaponi (13.61) were both well above their respective overall averages (Pamunkey = 6.43, Mattaponi = 4.82). The Pamunkey index is the highest on record for that river and the Mattaponi is the second highest. These indices were a dramatic reversal of a two-year downward progression in index values in each river that culminated with record and near record lows in 2002.

All sites in the mainstem York River are auxiliary sites. Striped bass were captured at all of these

sites in 2003 which is a distinct reversal of catches in 2002 when no striped bass were captured (Table 1; Fig. 5). This is mainly attributable to depressed salinities and large yearclass strength. Striped bass were captured during all visits to Y28 but only during three visits to Y15. Severe thunderstorms prevented sampling at Y21 during rounds two, three and five but striped bass were captured during successful sampling visits. Catches on the Mattaponi River were highest at M33, the most down-river site. M41 and M44 had moderate catches during early rounds but catches dropped off in later rounds. In the Pamunkey River, highest catches were at P50, the uppermost index station (Fig. 6). Catches at P45, the middle index site were the second highest. P36, the downriver auxiliary site, had good catches during all rounds but since only one seine haul is made, catch per haul numbers may be unduly elevated.

The 2003 index in the Rappahannock River was 19.98, more than double the historic average of 7.12 and four times the 2002 index of 4.96 (Table 3). Highest catches were at the three uppermost index sites (R44, R50 and R55) with R55 being the most productive site (Table 1, Fig. 7). Catch at these three sites accounted for 79 percent of the total catch for the river in 2003. Juvenile striped bass were distributed throughout the entire length of the sampling area but were concentrated in the upper half of the defined nursery area.

Because the number and precise timing of sampling rounds has varied throughout the history of the sampling program, results by sampling period cannot be directly compared. However, temporal usage of the nursery area can be evaluated by comparing round by round results with historical monthly averages. Generally, catch rates are highest during July and early August and taper off in the later rounds of August and September as fish disperse to deeper water and grow large enough to

effectively avoid capture. In 2003 this overall pattern was observed (Table 4) however total catches during the first four rounds fluctuated somewhat. There was a 12% rise in catch from round one to round two and then a 24% decline from round two to three. The largest decline (34%) occurred between rounds four and five (late August to early September).

Forty-seven young-of-the-year striped bass were captured at the former Bluefish Seine Survey sites in the lower James River, Chesapeake Bay and seaside Eastern Shore. In June, eleven were captured at Willoughby Spit in the lower James, one at Seashore State Park on the western side of lower Chesapeake Bay and twenty-one at Bloxom. Bloxom is located on the Bay side of the Eastern Shore in Pocomoke Sound and these fish probably came from a nearby nursery area. In July, six fish were captured at Bloxom and one fish at Wachapreague on the seaside of the Eastern Shore. In August, seven fish were captured at Bloxom.

These catches are in contrast to the one striped bass captured in 2002 and the disparity is likely a result of the difference in yearclass size. In years of high abundance, fish tend to disperse downriver/bay more readily, probably in response to increased competition for food and space in the upriver nursery areas.

Objective 2: Quantify environmental conditions at the time of collection.

Collection information and pertinent environmental variables recorded at the time of each collection in 2003 are given in Tables 5 through 8. Generally, direct round by round comparisons of environmental and water quality parameters are difficult because of local site conditions and

variations, so they must be examined on a broader scale.

Generally, salinities were substantially lower in 2003 than in 2002 (Table 5) (Austin et al, 2003). Salinities at all index sites were lower than those recorded in 2002 when higher salinities were being recorded due to two years of ongoing drought conditions. The drought conditions dissipated during the fall of 2002. The Palmer Drought Index (Palmer, 1965) and data from the National Climate Data Center indicated that conditions in 2003 in Virginia were wet through March and became very wet in April. In May, conditions became extremely wet and remained so throughout the sampling season.

Overall, water temperatures were slightly below normal in 2003 (Table 6). The normal pattern of higher temperature in the early rounds and temperature slowly declining during the later rounds was not as well defined in 2003 as in other years, probably due to the increased occurrence of rainfall events. Water temperatures by round varied somewhat from 2002 readings since there were frequent weather events that affected water temperatures during the 2003 sampling season. Water temperature readings in these estuaries are not only affected by the long term weather patterns of summer but significant variations from day to day and river to river can be caused by time of sampling (morning versus afternoon, etc) and local events such as thunderstorms. We sample the shallow shoreline areas that are easily affected by such events and these effects on site-specific striped bass abundances are not easily assessed.

Dissolved oxygen levels were generally within the norms expected during this sampling period (Table 7). Slightly depressed levels were recorded at the lowermost sites in the Mattaponi River in late August and catches did drop at those times but catches dropped at all Mattaponi sites during that

round (Table 1; Fig. 5).

The pH levels during the 2003 sampling were near normal for most areas (Table 8). Generally the James and Rappahannock systems have pH values that are slightly basic. The Pamunkey River is near neutral pH and the Mattaponi River has pH values that are slightly acidic. In rounds three through five, pH values in the Mattaponi were slightly acidic, presumably due to the increased runoff from rains. The Pamunkey River also had several sites with acidic pH readings during rounds four and five.

All index sites were completed without interruption. Some auxiliary sites were not sampled due to severe electrical storms in the area at the time and the subsequent loss of available sampling beach due to rising tide levels.

Objective 3: Examine relationships between juvenile striped bass abundance and measured or proxy environmental and biological data.

Overall distribution of catch rates with respect to salinity in 2003 followed the normally observed pattern of higher catches at lower salinities within the primary nursery area (Table 9). Since no index site had a salinity reading greater than 7.4ppt and only one site had a reading above the lower salinity range (0.0-4.9), this trend was especially evident due to the low salinities. There were catches made at auxiliary sites where higher salinity readings were found, but their numbers were small as a general rule. Only the lowest index sites in the major rivers had salinity readings that surpassed 9.9ppt. Table 10 shows the relationship of juvenile striped bass catches with respect to historical and

2003 salinity gradients within each river system. Table 10 clearly shows that the defined salinity regimes were displaced downriver considerable distances. Overall, catches were highest in the areas of lowest salinities (0-4.9ppt) for both the long term and 2003 but the percentage of catch was higher in 2003 (99% in 2003 vs 93% overall (Table 9)).

Catch rates with respect to water temperature in 2003 clearly adhered to the pattern seen historically, i.e. catch rates varied directly with water temperature at the time of collection (Table 11). Most fish are captured in the 25-30°C range which is the normal water temperature range during our sampling. Even though temperatures in 2003 were less than normal, most sampling still occurred in 25-30°C water. As noted in previous reports, this relationship is considered to be largely the result of a coincident downward progression of both catch rates and temperature as the survey season progresses (at least after the second sampling round) rather than any causative effect of water temperature on juvenile distribution. The growth and subsequent gear escapement or movement of fish into deeper waters usually play a larger role in this trend. Generally, catches within the sampling season are not governed by water temperatures and the overall relationship between catch and water temperature within the sampling season is probably coincidental.

Data on pH, dissolved oxygen concentrations and Secchi disc visibility depth readings have been recorded with the seine collections since the expansion of the sampling program in 1989. Dissolved oxygen concentrations generally exceeded 5mg/l outside of the York system, and have little or no effect on juvenile striped bass distributions. pH values during our sampling are generally near neutral to slightly basic outside of the Mattaponi River and like dissolved oxygen appear to have little effect. Secchi disc readings are a relative measure of turbidity which can affect catches in two

ways: when turbidity is extremely high fish are more vulnerable to our gear and when it is low (e.g. greater clarity) net avoidance becomes a potential problem. We saw no high turbidity episodes in 2003 and though secchi readings are not presented herein, the data are collected, stored, and are available upon request.

Data and indices for other species captured during the juvenile striped bass abundance survey can be accessed on the web at http://www.fisheries.vims.edu/seinedata/.

DISCUSSION AND CONCLUSIONS

The striped bass juvenile index recorded in the Virginia Chesapeake Bay nursery areas in 2003 was three times higher (significant) than the historical average (Table 2) and almost six times higher than the 2002 index (Austin et al., 2003). It was the second highest index recorded since 1985 after stringent harvest regulations of the ASMFC Interstate Fisheries Management Plan were implemented in 1982. Indices for all rivers were above historical averages. The York index was the highest recorded for that system while the James was the second highest and the Rappahannock was the third highest.

The spring and summer of 2003 had moderate to extreme rainfall and very wet conditions were present throughout the entire Chesapeake Bay watershed through September. Salinities were depressed and the freshwater interface in each river was displaced downstream. As a result, the nursery areas were extended downstream and favorable conditions plus a large yearclass increased

catches at downriver auxiliary sites in 2003.

The strong recruitment of juvenile striped bass in 2003 was likely a result of the cool, wet conditions that produced favorable river flow for survival and subsequent growth during the spring spawning and summer nursery seasons. The environment resulting from these flow/temperature conditions was more conducive to successful recruitment in the Virginia portion of Chesapeake Bay. Wood (2000) found that weather in March affects springtime temperatures and rainfall (thus river flow) and can affect the recruitment success of anadromous fishes. With the persistence of the winter Ohio Valley High climate pattern, cold and fresh conditions extend into March and as a result the suitable anadromous fish nursery areas are extended both spatially and temporally benefiting recruitment. When March is dominated by the Azores-Bermuda High, warm and dry conditions are present in spring which is not as conducive to anadromous fish recruitment success.

Striped bass recruitment success in the Virginia portion of Chesapeake Bay remains variable between years and between the different nursery areas within years. These fluctuations had been bracketing a much higher average with the exception of 1999 and 2002 when weak recruitment occurred. Conditions were quite conducive for recruitment of young striped bass in 2003 and an exceptionally strong yearclass survived.

The strong yearclasses in 1998, 2000, 2001 and 2003 should adequately overcome any weak yearclasses that may have resulted from the low 1999 and 2002 recruitment. Continued monitoring of recruitment success will be an important factor in determining management strategies to protect the spawning stock of Chesapeake Bay striped bass.

The addition of auxiliary stations in 1989 has provided better areal coverage of the nursery areas. These additional areas of coverage have revealed that in years of high or low river flow there may be a shift in the traditional nursery areas up or down-river plus in years of high abundance the nursery area generally expands both up and down river. Figures 4-7 represent average catch per haul at all sites and past analyses have demonstrated that catches are consistently higher in the first haul of any given set of seine hauls. Since only one haul is made at the auxiliary sites, the figures may over-emphasize the relative contribution of the auxiliary sites. They are included only to demonstrate the spatial distribution of the yearclass. They are important in that they allow us to see a shift in distribution that could be affecting catches at the index sites. Reducing hauls at index sites to one per site and including some of the auxiliary sites in the index and deleting others may lead to a more precise estimate of relative year-class strength but it will undoubtedly elevate the recalculated indices (Rago et al, 1996).

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Table 1. Catch of young-of-the-year striped bass per seine haul during the 2003 survey. Two hauls were made per sampling round at each of the historical index stations (bold).

Drainage																
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78	TOT.
	Round															
	1	85	3	2/3	20/12	8	39/20	3/14	51/17	19	8/6	31	0	0	0	341
	2	3	18	10/26	22/36	7	97/44	59/30	13/13	22	10/0	4	13	6	3	436
	3	7	15	24/11	30/35	14	40/28	16/31	1/2	0	3/3	45	4	0	8	317
	4	1	5	7/9	63/40	1	125/55	17/5	9/16	20	12/12	6	5	3	10	421
	5	0	12	16/20	54/46	19	37/33	10/3	14/15	11	25/2	4	0	2	0	323
																1838
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55						
	1	0	ns	15	43	26/9		59/13	39/27	3						234
	2	10	ns	10	21	1/9		38/18	43/26	2						178
	3	8	36	4	47	6/8		21/12	55/40	2						239
	4	1	11	1	13	0/0		3/2	2/17	2						52
	5	0	ns	10	20	4/3		12/2	24/33	ns						108
	Station				M33	M37	M41	M44	M47	M52						
	1				52/27	10	27/31	5/16	5/10	4						187
	2				3/4	10	4/7	28/14	2/3	1						76
	3				88/15	7	24/17	5/6	1/3	0						166
	4				46/6	0	10/3	2/3	1/0	1						72
	5				3/1	1	0/1	4/2	1/3	0						16
																1328
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76		
	1	ns	ns	0/0	2/3		8	21/15	22/36	77/77	7	8	3	0		279
	2	0	15	8/4	3/8		18	60/56	59/19	63/50	2	9	20	7		401
	3	1	ns	8/3	3/4		ns	36/16	41/8	17/12	8	6	15	8		186
	4	0	1	7/7	2/2		6	4/13	12/12	83/25	1	4	3	1		183
	5	0	0	1/0	0/0		4	1/7	3/6	28/3	1	1	4	5		64
																1113
																4279

ns = no sample taken

Table 2. Catch of young-of-the-year striped bass per seine haul in the primary nursery area summarized by year (adjusted mean = retransformed mean of ln (x+1) * 2.28, the ratio of overall arithmetic and geometric means through 1984).

Year	Total	Mean ln (x+1)	Std. Dev.	Adjust Mean	C.I. (± 2 SE)	N
1967	209	1.07	0.977	4.40	2.82-6.45	53
1968	208	0.93	0.900	3.50	2.35-4.94	66
1969	207	0.78	0.890	2.71	1.80-3.84	77
1970	461	1.31	1.121	6.17	4.27-8.63	78
1971	178	0.76	0.857	2.61	1.76-3.64	81
1972	96	0.39	0.575	1.07	0.73-1.45	119
1973	139	0.53	0.790	1.59	0.98-2.32	87
1980	228	0.74	0.900	2.52	1.68-3.53	89
1981	165	0.52	0.691	1.57	1.10-2.09	116
1982	323	0.78	0.967	2.71	1.85-3.74	106
1983	296	0.91	0.833	3.40	2.53-4.42	102
1984	597	1.09	1.059	4.47	3.22-6.02	106
1985	322	0.72	0.859	2.41	1.78-3.14	142
1986	669	1.12	1.036	4.74	3.62-6.06	144
1987	2191	2.07	1.228	15.74	12.4-19.8	144
1988	1348	1.47	1.127	7.64	6.10-9.45	180
1989	1978	1.78	1.119	11.23	9.15-13.7	180
1990	1249	1.44	1.096	7.34	5.89-9.05	180
1991	667	0.97	0.951	3.76	2.96-4.68	180
1992	1769	1.44	1.247	7.32	5.69-9.28	180
1993	2323	2.19	0.975	18.12	15.4-21.3	180
1994	1510	1.72	1.034	10.48	8.66-12.6	180
1995	926	1.22	1.045	5.45	4.33-6.75	180
1996	3759	2.41	1.227	23.00	18.8-28.1	180
1997	1484	1.63	1.097	9.35	7.59-11.4	180
1998	2084	1.92	1.139	13.25	10.8-16.1	180
1999	442	0.80	0.862	2.80	2.19-3.50	180
2000	2741	2.09	1.240	16.18	13.06-19.92	180
2001	2624	1.98	1.271	14.17	11.33-17.60	180
2002	813	1.01	1.085	3.98	3.05-5.08	180
2003	3406	2.40	1.18	22.89	18.84-27.71	180
Overall	35414	1.41	1.20	7.03	6.70-7.38	4389

Table 3. Catch of young-of-the-year striped bass per seine haul in primary nursery area in 2003 summarized by drainage and river.

	2003				All Years Combined			
Drainage River	Total Fish	Adjust. Mean	C.I. (2 ± SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)
James	1424	34.71	26.26-45.68	60	14200	9.12	8.42-9.87	1458
James	718	27.34	19.53-37.96	40	8072	8.01	7.26-8.82	980
Chickahom.	706	55.41	35.47-85.88	20	6128	11.78	10.24-13.50	478
York	1035	17.47	12.70-23.76	70	10134	5.46	5.06-5.89	1662
Pamunkey	552	24.10	14.87-38.30	30	5261	6.43	5.69-7.23	706
Mattaponi	483	13.61	8.93-20.25	40	4873	4.82	4.37-5.30	956
Rappahannock	947	19.98	13.16-29.80	50	11080	7.12	6.47-7.81	1269
Overall	3406	22.89	18.84-27.71	180	35414	7.03	6.70-7.38	4389

Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2003 summarized by sampling period and month.

	2003				All Years Combined			
Month	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)
July (1st)	794	30.52	20.31-45.33	36	10437	10.22	9.24-11.30	926
(2nd)	890	33.08	21.96-49.29	36	8713	8.04	7.24-8.90	937
Aug. (3rd)	673	26.92	18.70-38.38	36	6383	6.41	5.79-7.09	929
(4th)	632	18.02	11.20-28.30	36	5834	6.36	5.67-7.11	793
Sept. (5th)	417	12.40	7.50-19.75	36	3842	5.56	4.92-6.26	667

Table 5. Salinity (parts per thousand) recorded at 2003 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage															
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
	Round														
	1	6.5	1.0	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	.01	0.1	0.1	0.1
	2	9.0	3.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	3	10.5	3.2	1.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
	4	12.5	5.4	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
	5	1.8	5.2	1.8	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	12.2	ns	3.3	0.1	0.1		0.1	0.1	0.0					
	2	13.7	ns	5.7	0.3	0.1		0.1	0.1	0.1					
	3	11.7	8.2	6.2	0.3	0.1		0.1	0.1	0.1					
	4	12.6	9.1	3.9	0.1	0.1		0.1	0.1	0.1					
	5	13.5	ns	8.6	0.8	0.2		0.1	0.1	ns					
	Station				M33	M37	M41	M44	M47	M52					
	1				0.1	0.1	0.0	0.0	0.0	0.0					
	2				0.3	0.1	0.1	0.0	0.0	0.0					
	3				0.1	0.1	0.1	0.0	0.0	0.0					
	4				0.2	0.1	0.1	0.1	0.1	0.0					
	5				2.8	0.7	0.2	0.1	0.1	0.0					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	ns	ns	5.6	2.1		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
	2	11.2	9.2	6.1	1.5		0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
	3	10.6	ns	6.0	2.6		ns	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	4	12.4	9.9	6.6	1.3		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	5	12.0	10.5	7.4	3.1		1.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	

ns = no sample taken

Table 6. Water temperature (°C) recorded at 2003 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage															
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
	Round														
	1	28.5	30.5	26.5	24.8	27.1	25.6	26.1	26.5	26.7	26.8	29.0	28.1	27.6	28.6
	2	27.3	28.5	29.5	27.4	29.1	28.8	28.6	29.7	28.3	28.7	30.8	29.3	29.4	29.6
	3	29.2	27.7	28.9	25.9	27.6	27.5	27.2	27.9	28.5	28.1	28.8	29.5	29.4	29.7
	4	25.1	26.0	29.9	27.6	31.1	29.8	28.9	29.3	27.3	27.8	29.7	27.7	28.3	27.4
	5	27.4	25.2	30.5	26.8	29.5	29.1	29.1	30.8	28.8	28.4	30.3	30.6	31.4	31.6
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	31.8	ns	31.0	30.1	29.5		29.4	29.8	28.7					
	2	26.9	ns	28.5	29.2	29.7		29.7	29.3	29.6					
	3	25.8	27.7	26.1	27.0	27.2		26.8	26.5	25.9					
	4	26.3	27.7	27.6	28.2	28.8		29.1	29.0	29.0					
	5	26.9	ns	27.8	29.9	29.1		29.4	28.3	ns					
	Station				M33	M37	M41	M44	M47	M52					
	1				28.7	28.2	28.4	28.9	29.4	28.7					
	2				28.9	28.6	28.5	29.2	29.5	28.5					
	3				27.3	27.4	27.0	26.9	27.8	27.6					
	4				28.5	28.5	28.4	28.5	29.9	28.5					
	5				28.1	28.2	28.0	28.2	28.1	26.9					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	ns	ns	26.2	26.5		26.8	26.9	27.1	27.9	26.9	28.6	27.0	28.2	
	2	29.2	26.6	29.6	29.7		30.1	29.9	28.5	29.2	28.0	28.5	27.3	26.8	
	3	24.3	ns	25.2	25.3		ns	25.1	29.2	29.5	29.0	28.9	29.1	29.2	
	4	29.6	29.8	27.4	27.8		28.8	29.8	27.8	28.0	27.5	28.3	27.6	28.3	
	5	30.4	30.5	28.4	28.8		29.9	30.10	29.1	29.9	28.9	29.6	29.4	29.1	

ns = no sample taken

Table 7. Dissolved oxygen (milligrams per liter) recorded at 2003 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage														
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
	Round														
	1	7.0	7.5	7.9	7.5	7.4	8.0	7.3	6.2	7.2	7.8	9.5	8.2	7.4	8.9
	2	6.7	7.7	7.5	6.4	8.7	9.5	7.1	7.3	5.7	8.0	10.3	7.9	6.5	7.3
	3	6.8	6.3	6.9	6.2	7.7	6.8	5.0	5.6	6.6	7.0	7.4	6.1	6.1	5.2
	4	7.2	6.6	6.5	6.4	9.4	7.6	6.1	7.3	5.8	6.6	6.2	6.9	6.5	6.9
	5	6.8	7.0	7.9	7.4	7.5	8.7	7.1	7.6	4.8	6.4	8.3	6.3	6.9	6.9
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	8.0	ns	6.9	5.8	5.6		5.7	5.7	6.1					
	2	3.8	ns	7.1	5.7	6.4		6.1	5.7	6.0					
	3	5.3	5.9	5.1	5.1	5.5		5.1	4.9	5.1					
	4	4.5	6.5	5.1	5.1	4.5		4.7	5.1	5.8					
	5	9.7	ns	5.2	5.9	5.4		5.3	5.7	ns					
	Station				M33	M37	M41	M44	M47	M52					
	1				4.4	4.4	4.6	4.1	4.5	5.0					
	2				5.5	5.6	5.5	5.0	5.1	5.4					
	3				4.1	4.5	4.5	4.0	4.7	4.7					
	4				3.9	3.8	3.9	4.6	6.1	4.8					
	5				4.9	4.5	4.5	4.7	6.0	6.5					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	ns	ns	4.8	6.0		9.0	9.5	7.8	7.0	6.9	9.2	7.4	7.8	
	2	7.1	5.3	7.3	8.7		8.9	8.4	8.2	8.9	6.3	8.7	6.5	5.6	
	3	7.3	ns	6.7	5.9		ns	7.5	7.7	8.2	7.3	6.7	6.4	5.7	
	4	6.8	6.5	5.3	6.4		6.3	7.4	6.8	7.2	6.5	7.4	6.0	6.3	
	5	8.2	6.4	5.4	5.9		6.7	7.6	6.3	7.3	7.4	9.0	5.5	7.9	

ns = no sample taken

Table 8. pH recorded at 2003 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage															
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
	Round														
	1	7.9	8.4	8.3	8.1	8.2	8.3	7.9	7.8	7.9	8.2	8.4	8.4	8.7	9.3
	2	9.0	8.0	8.1	7.8	8.5	8.5	7.7	7.9	7.5	7.9	8.4	8.2	7.9	7.8
	3	7.6	7.4	7.7	7.6	8.3	7.8	7.5	7.5	7.6	7.8	7.9	7.5	7.5	7.5
	4	7.6	7.4	7.8	7.7	8.6	8.0	7.6	5.5	7.4	7.5	7.4	7.6	7.7	7.7
	5	7.3	7.5	8.0	7.7	7.9	8.4	7.6	7.8	7.3	7.6	8.2	7.4	7.9	7.6
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	7.7	ns	7.5	7.4	7.4		7.5	7.4	7.5					
	2	6.8	ns	7.4	7.4	7.5		7.4	7.4	7.4					
	3	7.1	7.1	7.0	7.1	7.1		7.1	6.9	7.0					
	4	7.1	7.2	7.0	7.2	7.0		7.0	7.1	6.9					
	5	7.9	ns	6.8	6.9	7.0		7.1	7.1	ns					
	Station				M33	M37	M41	M44	M47	M52					
	1				7.2	7.1	7.0	7.1	7.1	7.1					
	2				7.2	7.2	7.2	7.2	7.2	7.0					
	3				6.8	6.8	6.8	6.8	6.7	6.6					
	4				6.8	6.8	6.7	6.7	6.9	6.5					
	5				6.7	6.8	6.7	6.9	6.9	6.9					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	ns	ns	7.3	7.4		8.2	8.5	7.6	7.6	7.6	8.1	7.7	7.8	
	2	8.0	7.6	7.8	8.3		9.0	9.2	8.7	8.7	7.3	8.6	7.3	7.2	
	3	7.8	ns	7.3	7.3		ns	7.7	8.5	8.6	7.9	7.9	7.4	7.4	
	4	7.9	7.6	7.4	7.8		7.3	8.0	7.4	7.8	7.6	8.3	7.2	7.1	
	5	8.1	7.6	7.3	7.6		7.2	7.9	7.8	8.1	7.9	8.7	7.6	7.7	

ns = no sample taken

Table 9. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2003 summarized by salinity.

	2003				All Years Combined			
Salinity (ppt.)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)
0-4.9	3368	24.69	20.32-29.91	170	32803	8.12	7.71-8.55	3655
5-9.9	38	5.48	1.94-11.96	10	2363	3.99	3.45-4.59	526
10-14.9	0	0	0.0-0.0	0	246	1.59	1.19-2.02	179
15-19.9	0	0	0.0-0.0	0	2	0.11	-0.04-0.28	29
Overall	3406	22.89	18.84-27.71	180	35414	7.03	6.70-7.38	4389

Table 10. Average salinity (parts per thousand) and corresponding striped bass indices recorded at seine survey stations from 1967 to 2003 and in 2003. York system includes Pamunkey and Mattaponi Rivers.

Drainage															
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
	67-03	13.6	7.2	4.4	2.4	2.0	1.3	1.2	0.6	0.3	0.2	0.2	0.1	0.1	0.1
	Index	3.2	13.4	6.7	11.6	13.4	16.2	7.3	16.3	13.8	4.9	6.8	4.2	8.0	4.3
	2003	8.1	3.6	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Index	10.5	20.3	23.2	74.0	17.0	102.0	29.6	24.2	21.2	12.7	25.3	5.4	3.3	5.3
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	67-03	16.3	13.2	10.3	3.8	1.6		0.7	0.4	0.3					
	Index	0.8	1.4	4.5	8.9	3.7		9.3	11.2	5.6					
	2003	12.7	8.7	6.3	0.3	0.1		0.1	0.1	0.1					
	Index	4.3	45.8	14.1	58.7	8.7		25.9	57.0	5.1					
	Station				M33	M37	M41	M44	M47	M52					
	67-03				4.1	2.1	1.1	0.4	0.3	0.1					
	index				6.1	6.8	6.6	3.7	4.0	1.0					
	2003				0.7	0.2	0.1	0.0	0.0	0.0					
	index				26.7	8.1	16.5	14.0	4.9	1.9					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	67-03	13.9	12.8	9.8	5.3		3.2	2.1	1.0	0.6	0.3	0.2	0.1	0.0	
	Index	0.5	1.0	1.9	3.5		4.9	8.7	10.5	38.0	7.7	4.3	3.0	5.2	
	2003	11.6	9.9	6.3	2.1		0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Index	0.4	5.0	5.5	4.8		17.8	33.3	36.1	71.0	6.5	10.8	15.3	6.5	

Table 11. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2003 summarized by water temperature.

	2003				All Years Combined			
Temp. (deg. C)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (±2 SE)	N (sites)
15-19.9					79	2.85	1.40-4.86	30
20-24.9	32	35.39	21.04-58.57	2	2186	3.29	2.85-3.76	593
25-29.9	3301	22.81	18.64-27.81	172	27712	8.11	7.66-8.56	3099
30-34.9	73	21.75	9.47-46.87	6	5047	7.95	6.96-9.04	568
Overall	3406	22.89	18.84-27.71	180	35414	7.03	6.70-7.38	4389

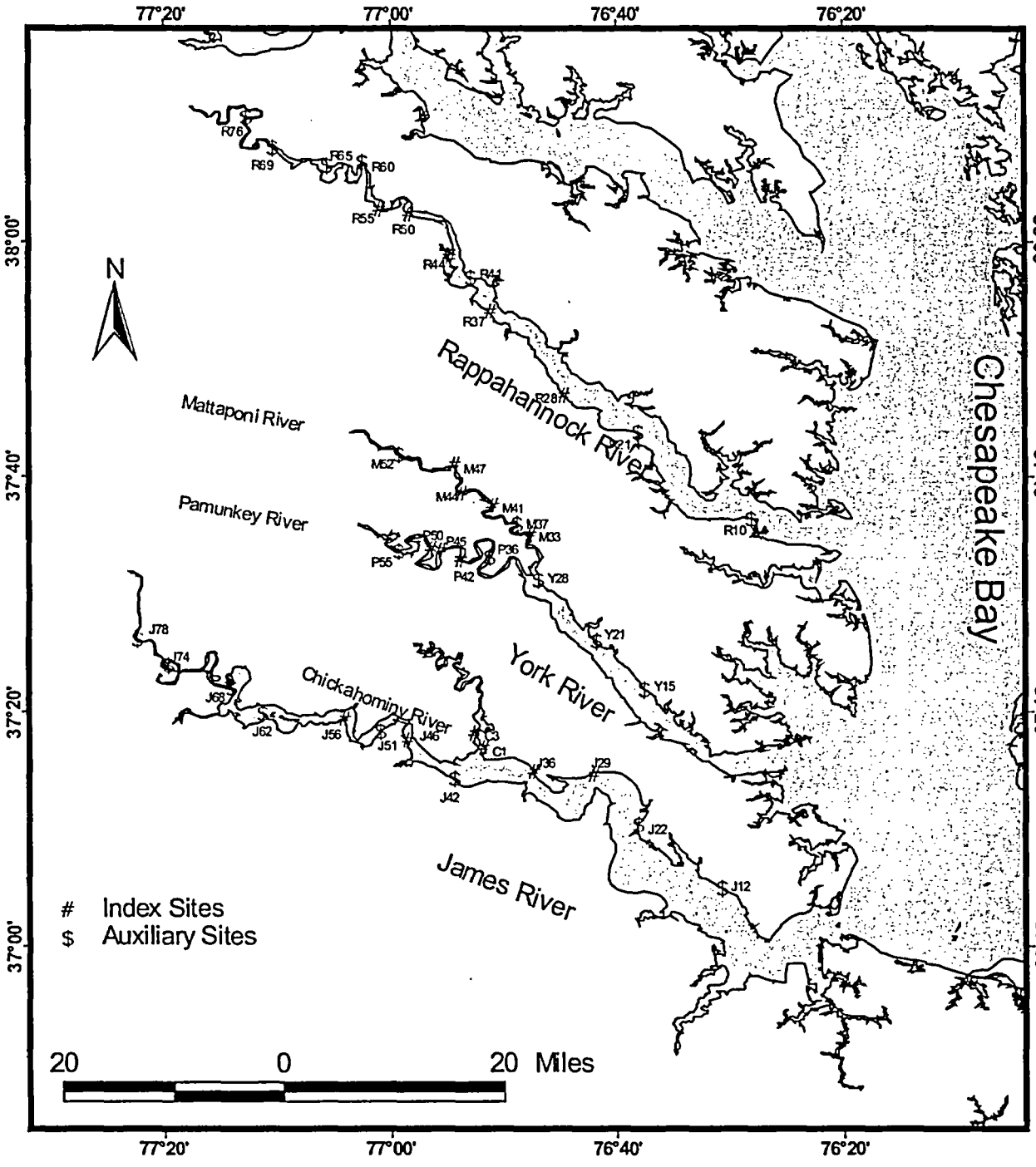

Figure 1. Juvenile striped bass survey stations. Numeric portion of station designations indicate river mile from the mouth.

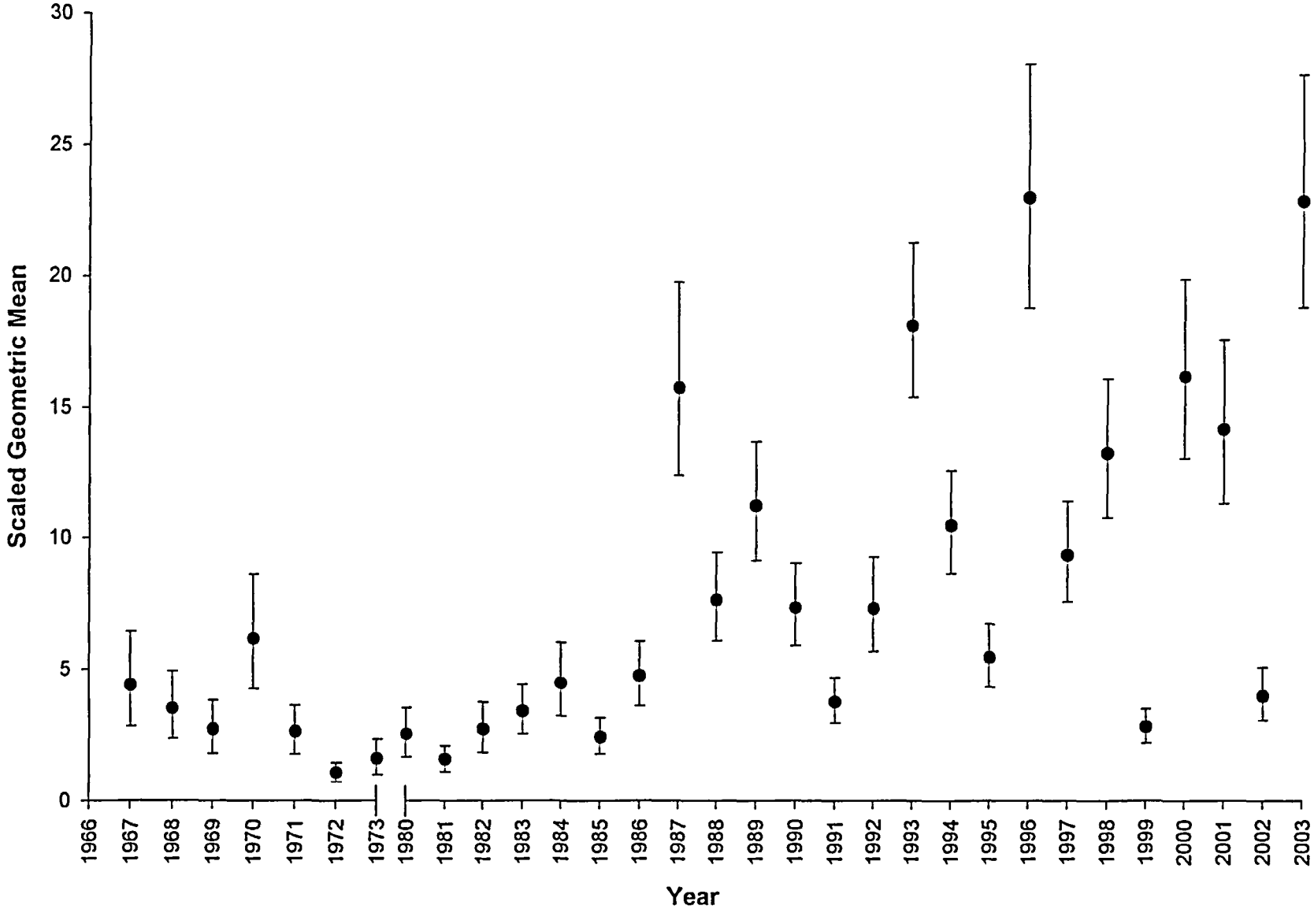

Figure 2. Scaled average catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean.

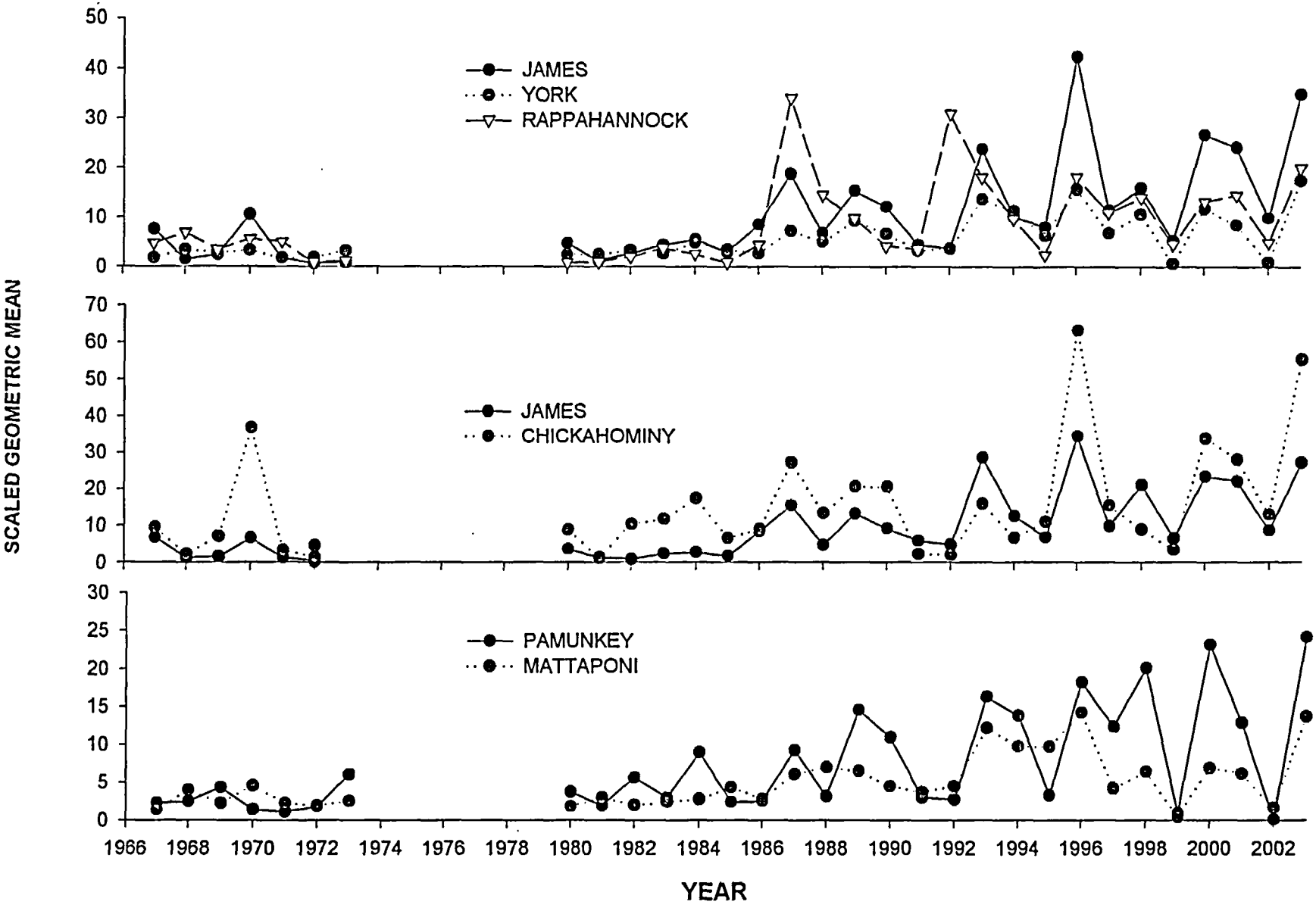

Figure 3. Adjusted average annual catch of young-of-the-year striped bass per seine haul in the primary nursery area by drainage and river.

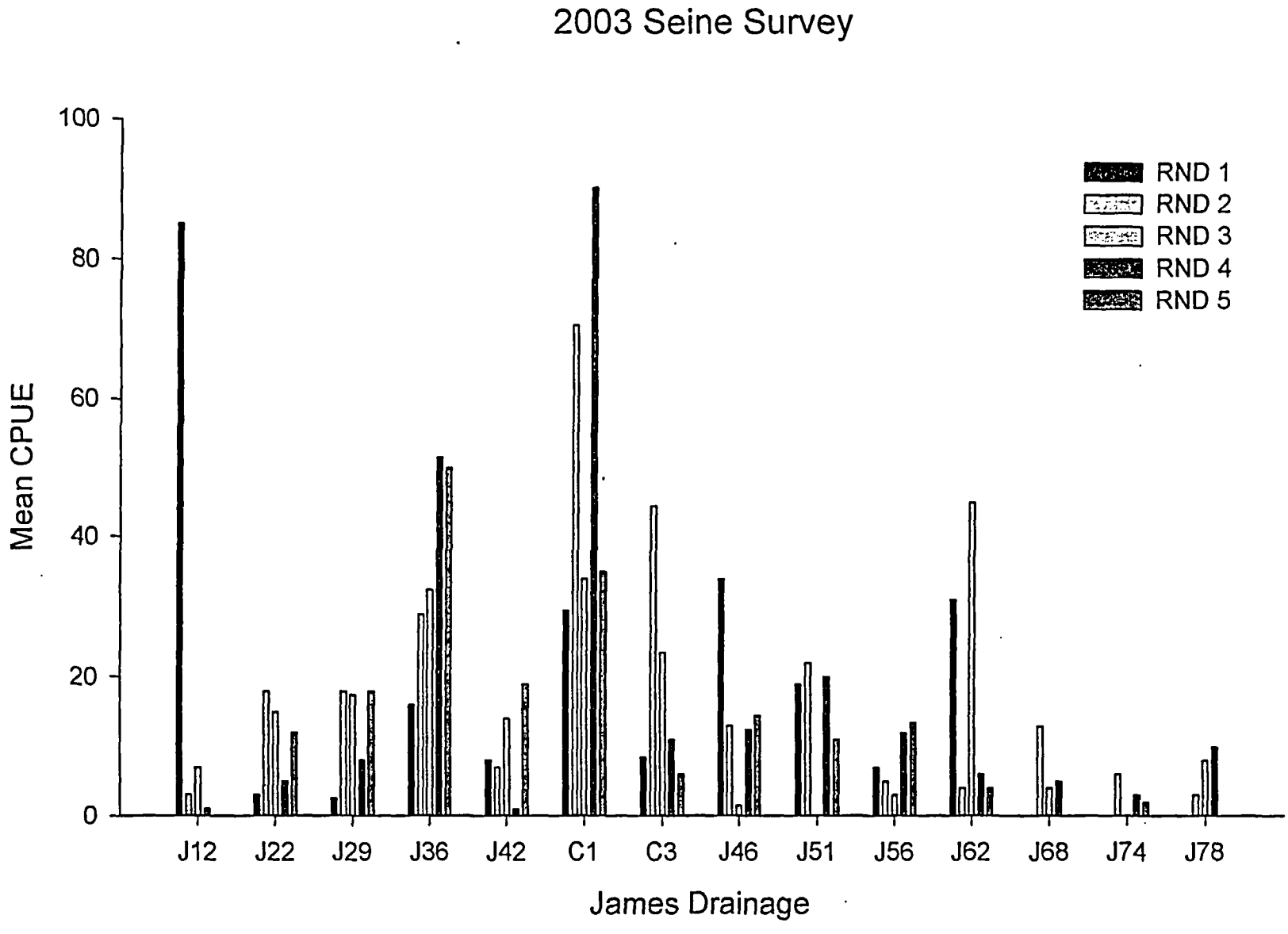

Figure 4. Average catch of young-of-the-year striped bass per seine haul in the James drainage.

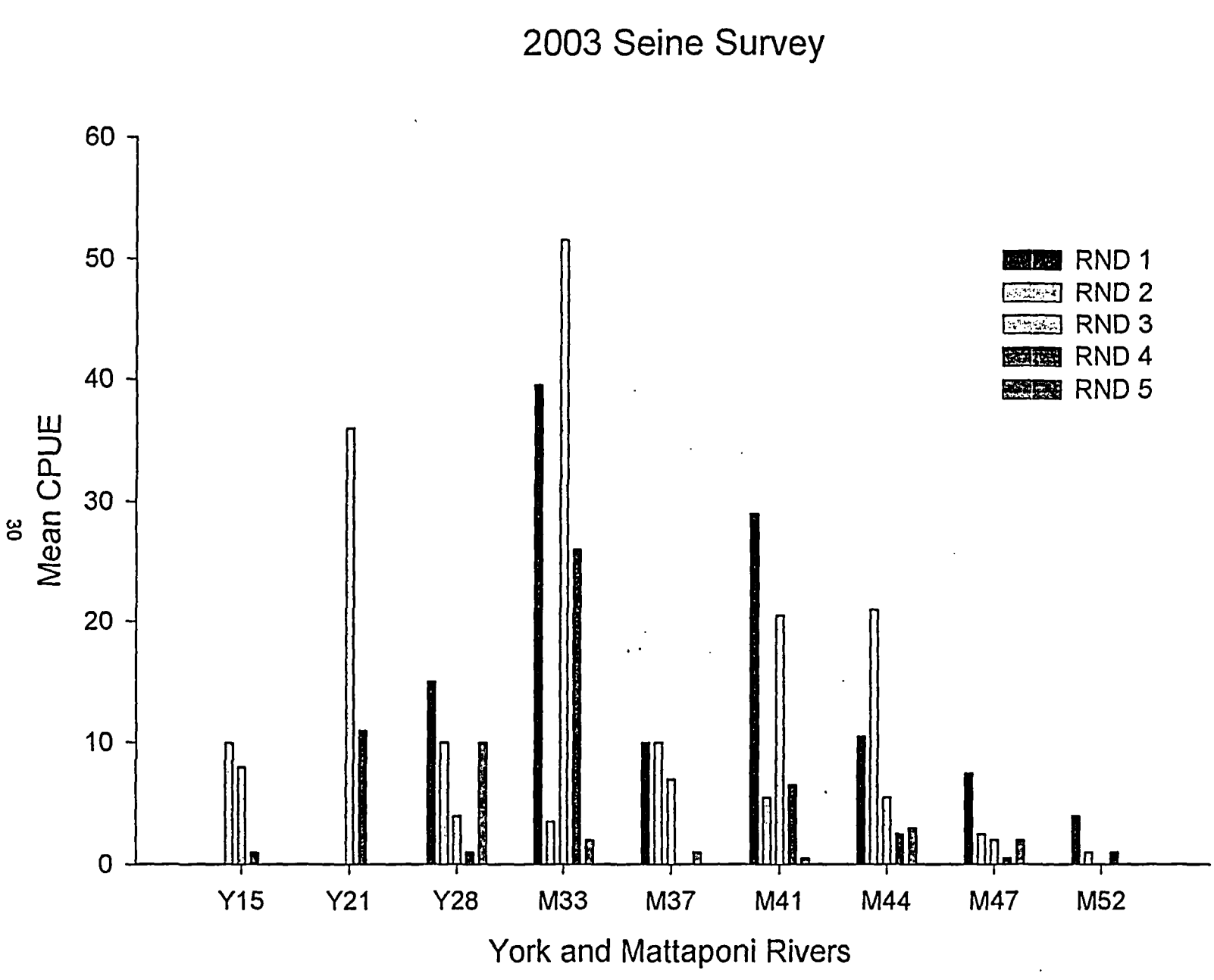

Figure 5. Average catch of young-of-the-year striped bass per seine haul by station in the Mattaponi and York Rivers.

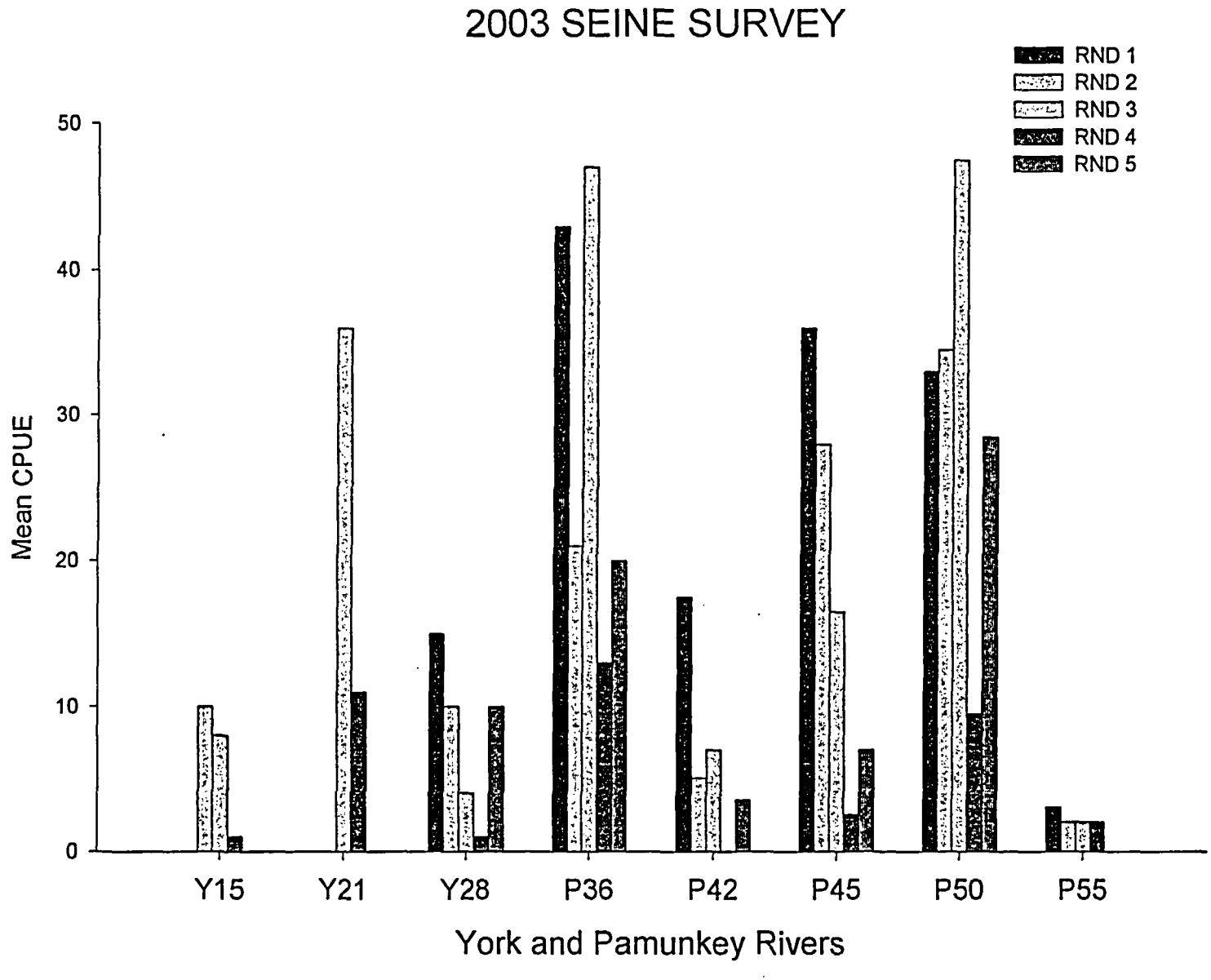

Figure 6. Average catch of young-of-the-year striped bass per seine haul by sation in the Pamunkey and York rivers.

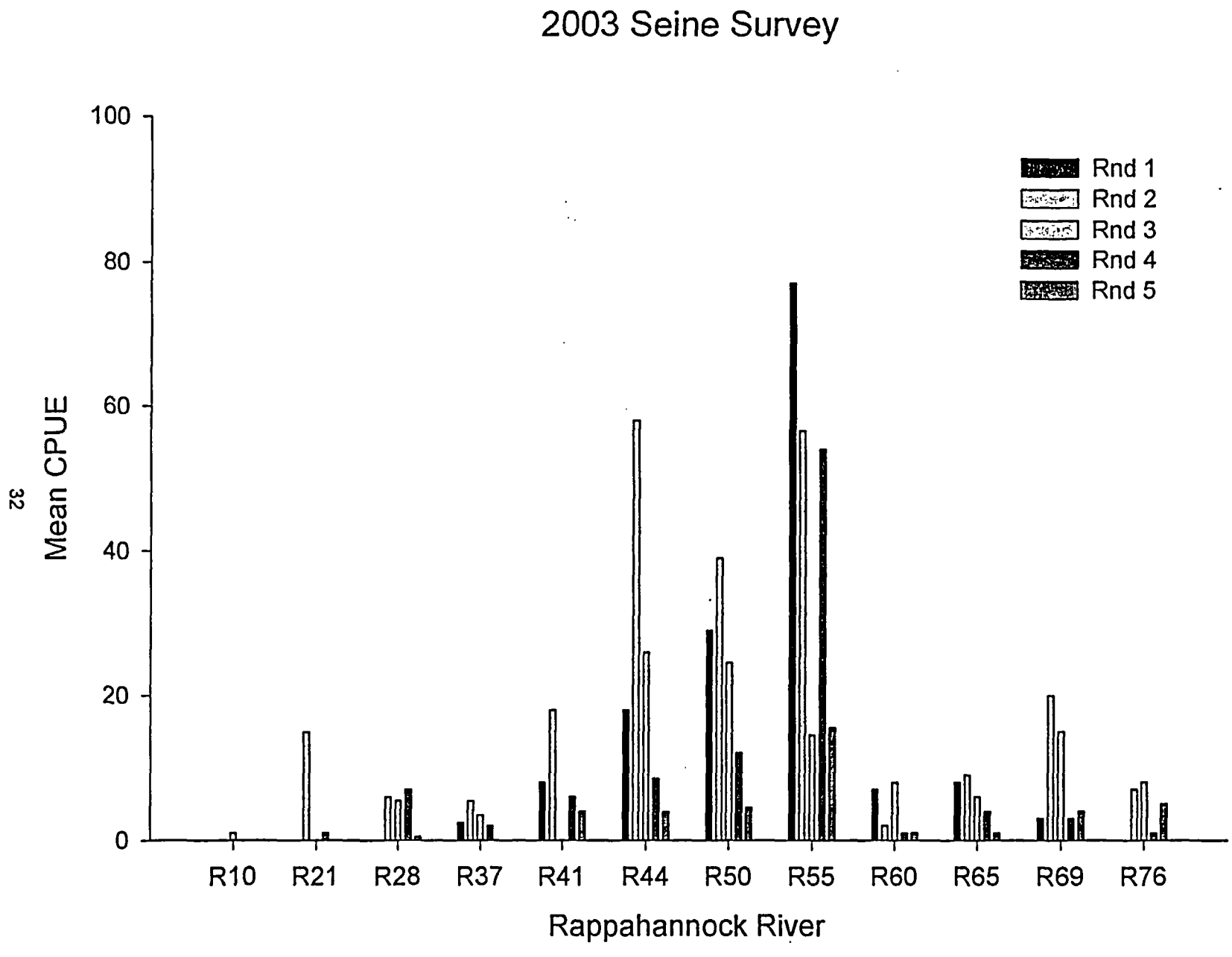

Figure 7. Average catch of young-of-the-year striped bass per seine haul by station in the Rappahannock River.