# ANNUAL PROGRESS REPORT

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

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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$^{o}$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$^{o}$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).

## LITERATURE CITED


ASMFC. 1991. Supplement to the striped bass FMP-Amendment No. 4. ASMFC Fisheries Management Report, Washington, D.C.

Austin, H.M., A.D. Estes and D.M. Seaver. 2003. Estimation of Juvenile Striped Bass Relative Abundance in the Virginia Portion of Chesapeake Bay. Ann. Rep. 2001. Virginia Institute of Marine Science, Gloucester Pt. Virginia. 33 p.

Austin, H.M., J.A. Colvocoresses and T.A. Mosca III. 1993. Develop a Chesapeake Bay-wide Young-of -the-Year striped bass index. Final Report, CBSAC Coop. Agree. No. NA16FUO393-01, 59p + 2 app.

Colvocoresses, J.A. and H.M. Austin. 1987. Development of an index of juvenile striped bass abundance for the Chesapeake Bay System: I. An evaluation of present measures and recommendations for future studies. Va. Inst. Mar. Sci. Spec. Sci. Rep. No. 120. 108p.

Colvocoresses, J. A. 1984. Striped bass research, Virginia. Part I: Juvenile striped bass seining program. Ann. Rep. 1987-88. Virginia Institute of Marine Science, Gloucester Point, Virginia. 64 p.

ESBS. 1993. Emergency Striped Bass Research Study, Report for 1991. Prepared by the U.S.F&W.S., ASMFC, and the NMFS/NOAA. 35 p.

Palmer, W. C. 1965. Meteorological drought. U.S. Dept. of Commerce, Office of Climatology, U.S. Weather Bur., Washington, D.C., Research paper No.45, 58pp.

Rago, P., D. Stephan, and H. Austin. 1996. ASMFC Special Report No. 48. Report of the Juvenile Indices Abundance Workshop, January 1992, Kent Island, MD. 83p.

Sokal, R.R. and F.J Rohlf. 1981. Biometry. W.H. Freeman and Co., San Francisco, CA. 851 p.

Wood, R. J. 2000. Synoptic scale climatic forcing of multispecies recruitment patterns in Chesapeake Bay /by Robert J. Wood, Dissertation, College of William and Mary, School of Marine Science, Gloucester Point, VA.

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 1n (x+1) * 2.28, the ratio of overall arithmetic and geometric means through 1984).

| **Year** | Total | Mean 1n (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.

| Drainage River | 2003 Total Fish | 2003 Adjust. Mean | 2003 C.I. (2 ± SE) | 2003 N (sites) | All Years Combined Total Fish | All Years Combined Adjust. Mean | All Years Combined C.I. (± 2 SE) | All Years Combined 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 ($^{o}$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 |

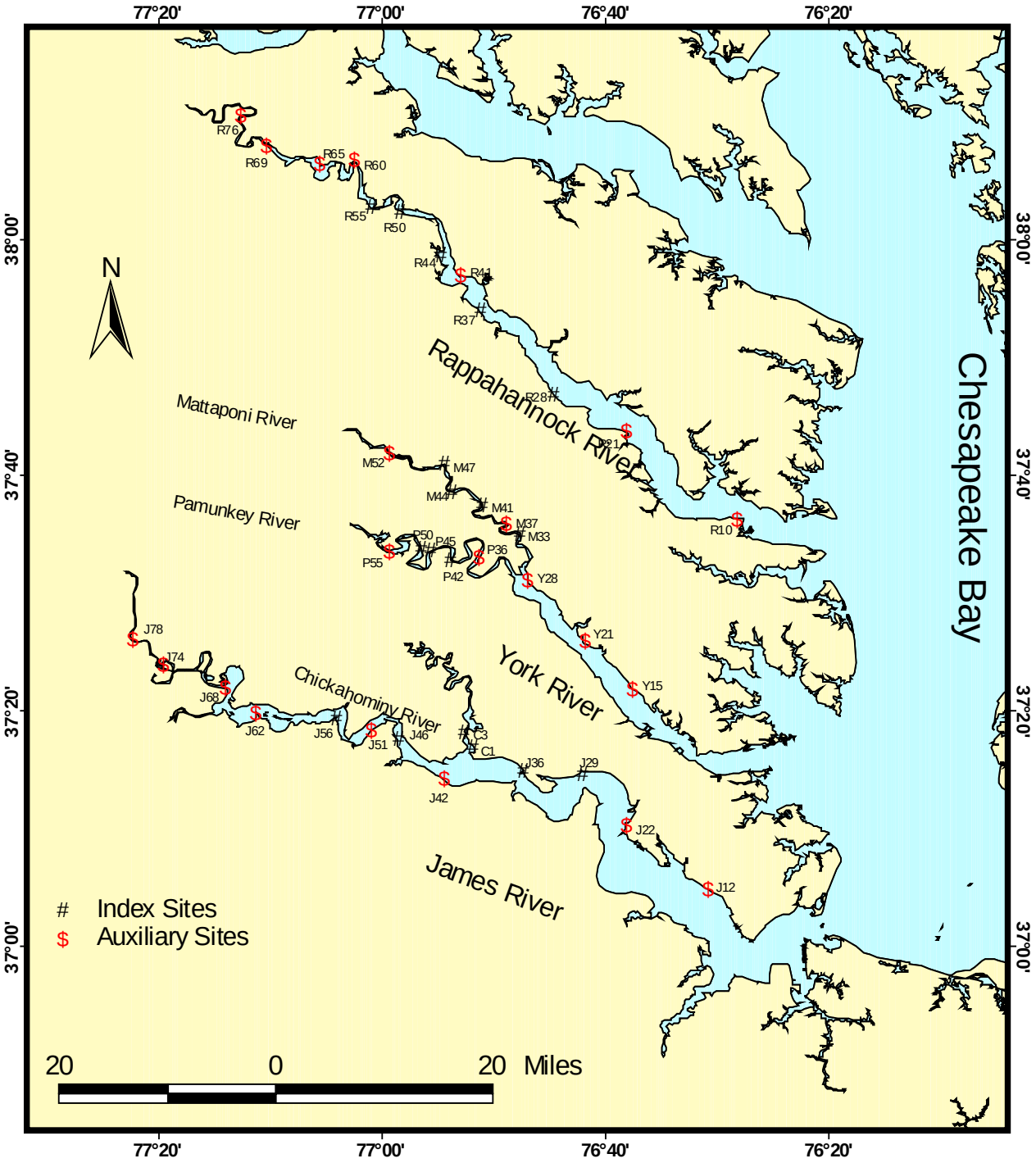


Figure 1. Juvenile striped bass survey stations. Numeric portion of station designations indicate river mile from the mouth.

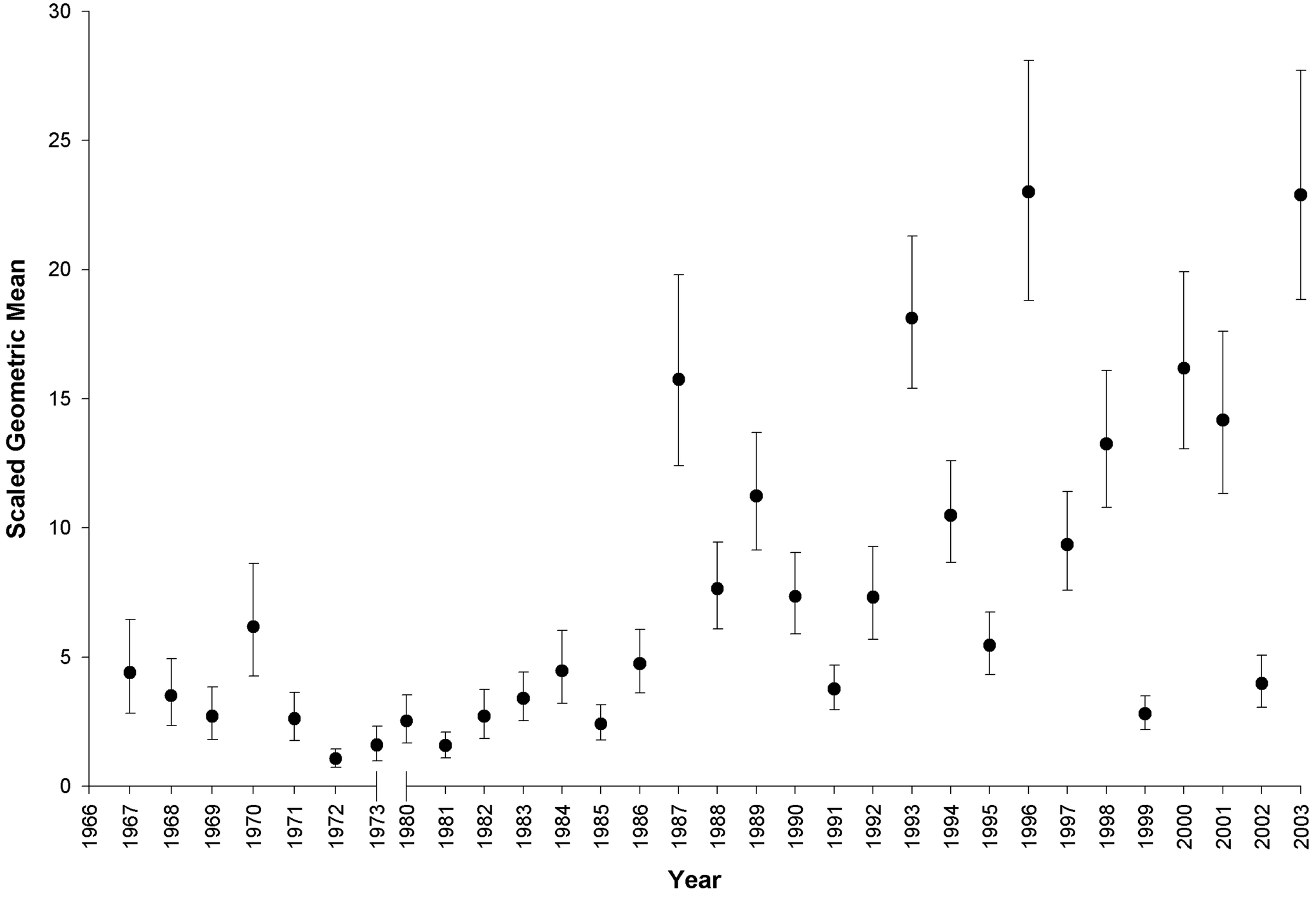


Figure 2. Scaled average catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean.

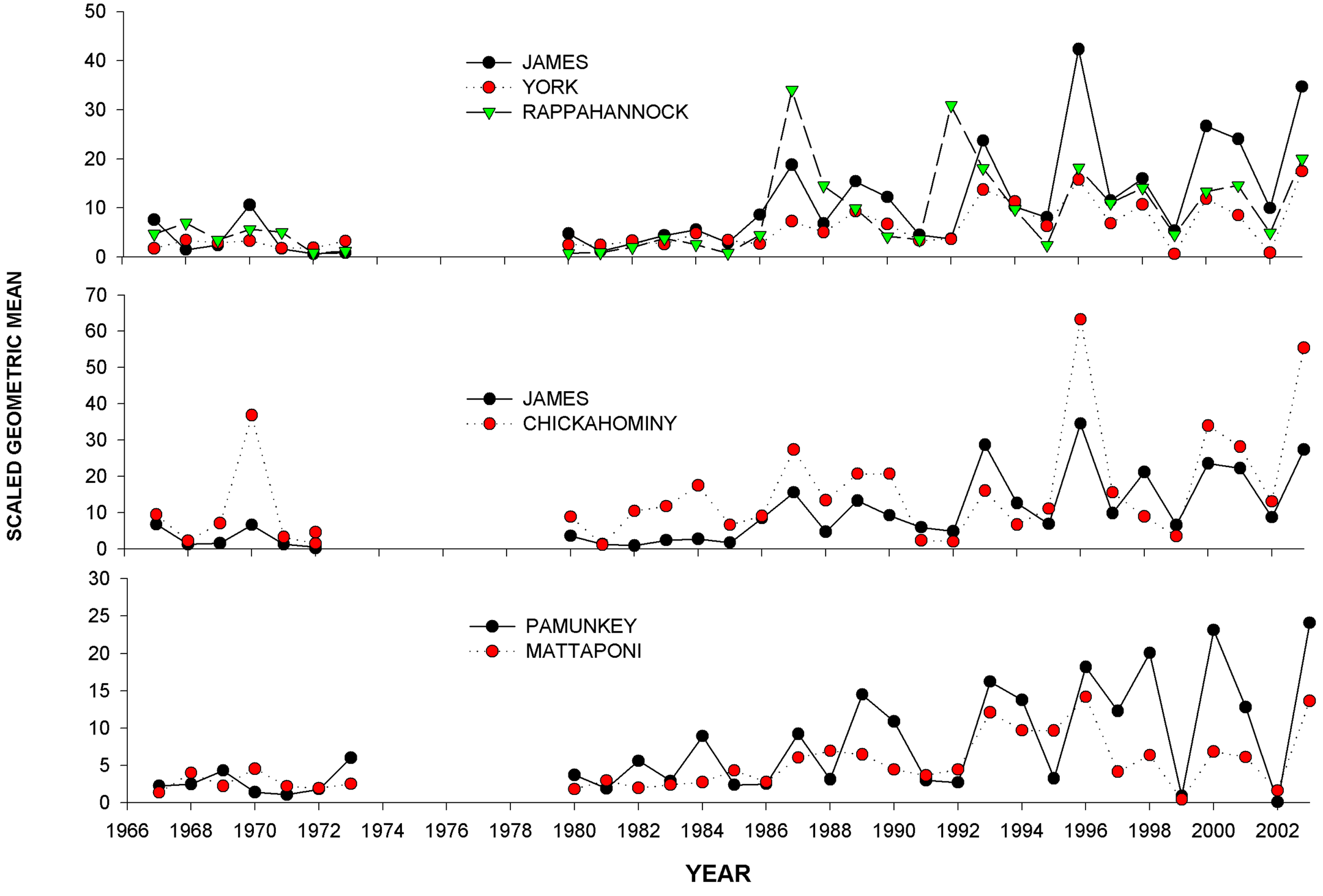


Figure 3. Adjusted average annual catch of young-of-the-year striped bass per seine haul in the primary nursery area by drainage and river.

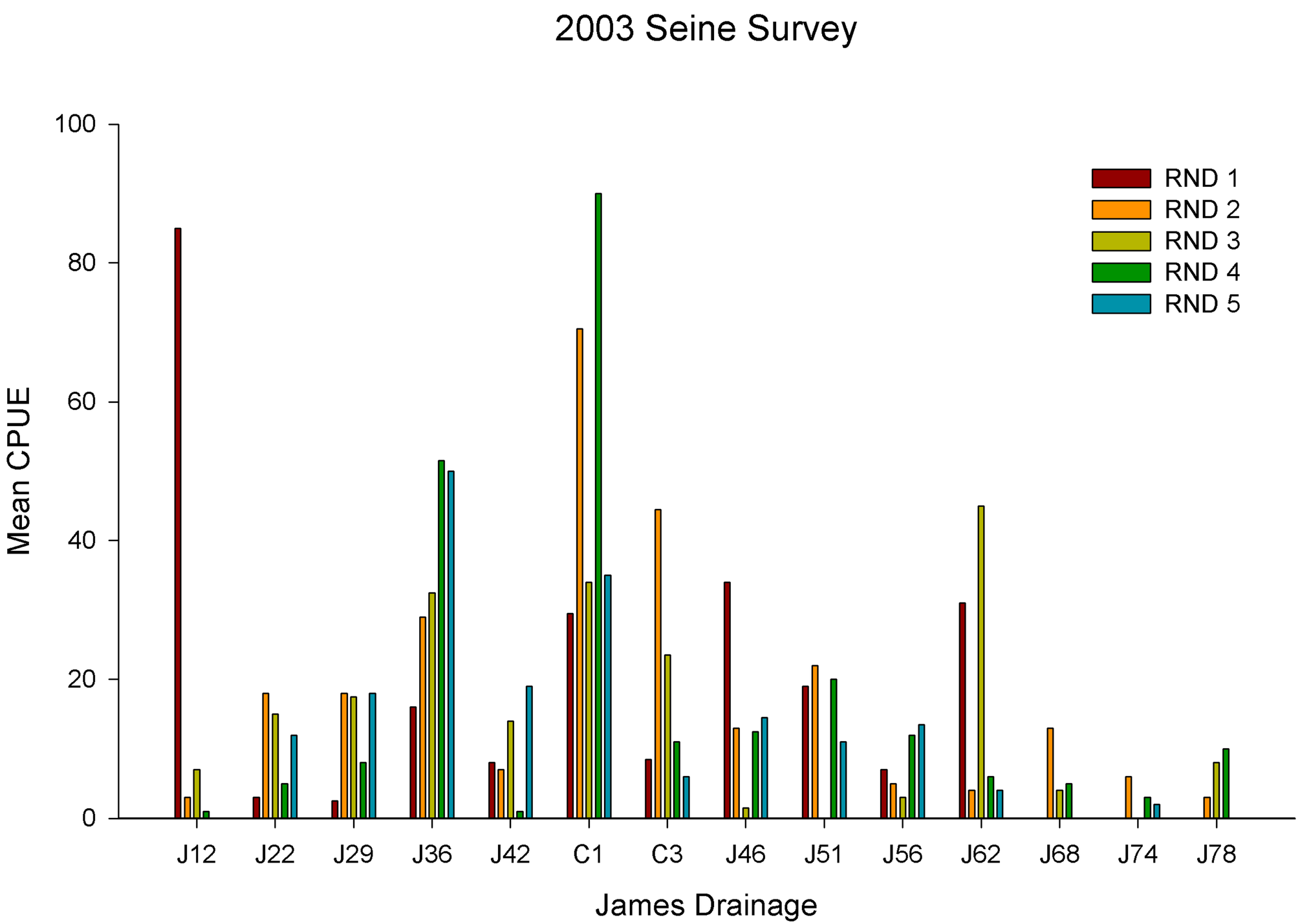


Figure 4. Average catch of young-of-the-year striped bass per seine haul in the James drainage.

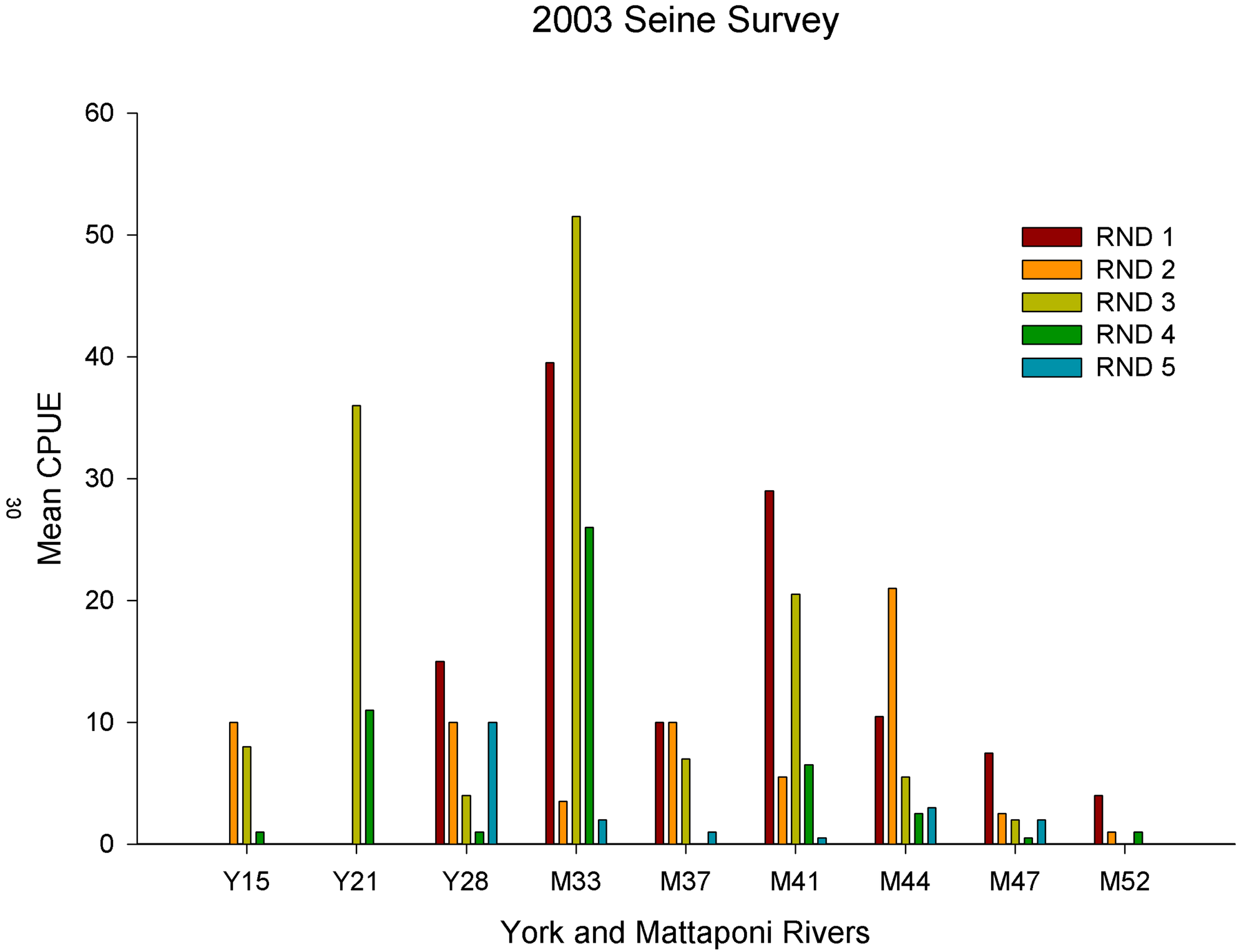


Figure 5. Average catch of young-of-the-year striped bass per seine haul by station in the Mattaponi and York Rivers.

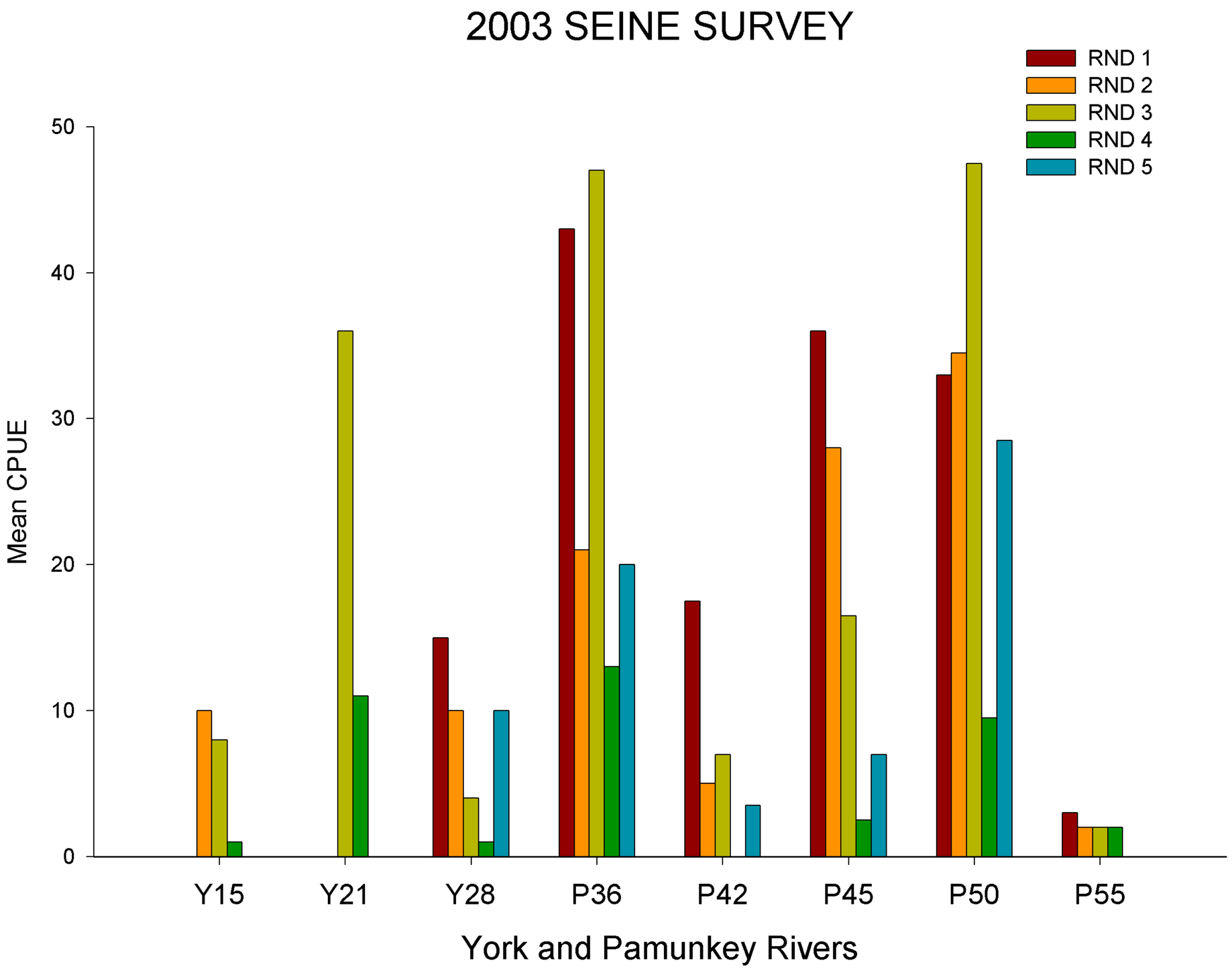


Figure 6. Average catch of young-of-the-year striped bass per seine haul by sation in the Pamunkey and York rivers.

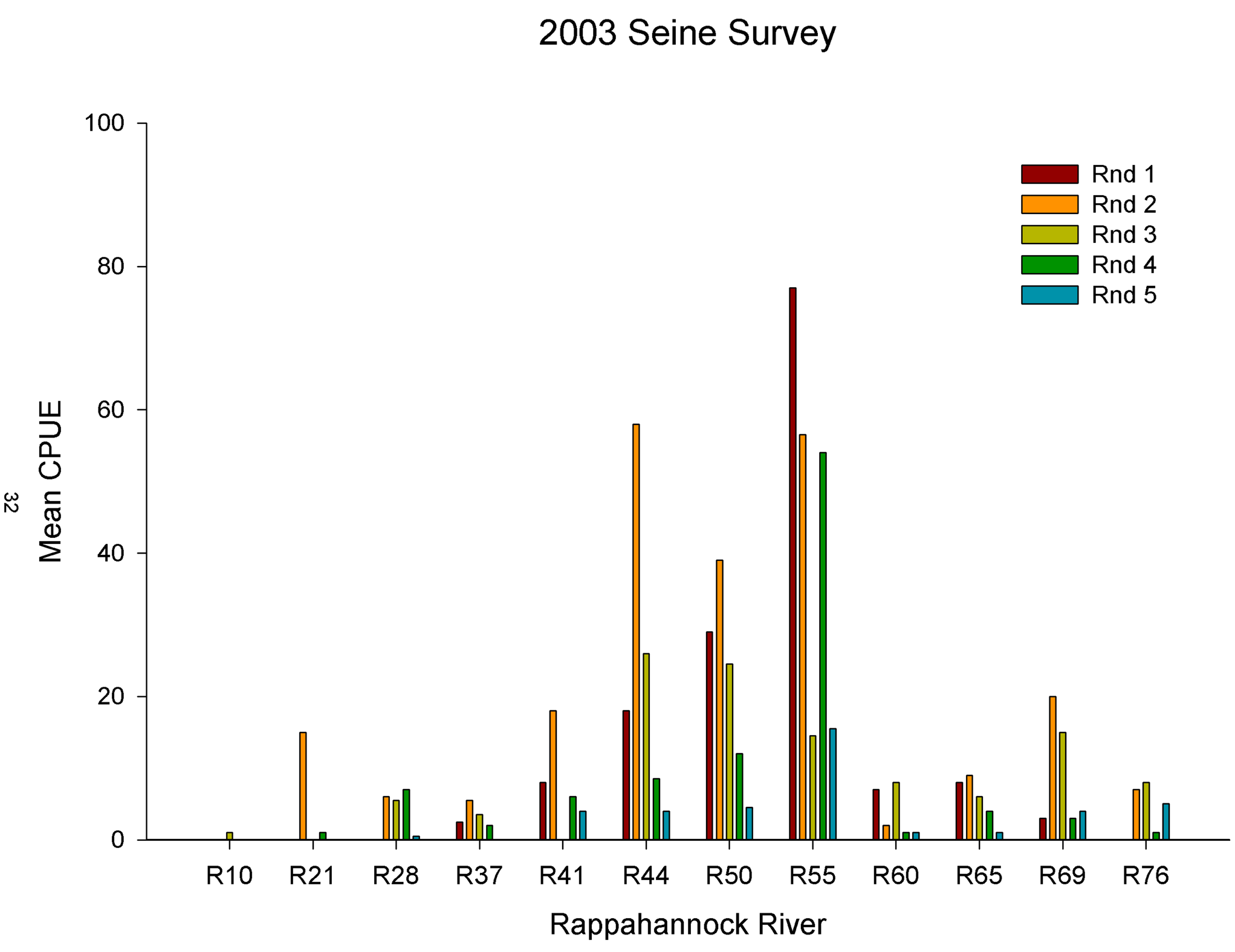




Figure 7. Average catch of young-of-the-year striped bass per seine haul by station in the Rappahannock River.