ANNUAL REPORT

Striped Bass Research, Virginia

Estimation of Juvenile Striped Bass Relative Abundance
1989 Sampling Season

Prepared by

James A. Colvocoresses

Virginia Institute of Marine Science
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

Submitted to
Virginia Marine Resources Commission
United States Fish and Wildlife Service
Virginia Council on the Environment

1990

TABLE OF CONTENTS

PREFACE

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile striped bass seine survey during the years from 1967 through 1973 and from 1980 through the present, with the primary objective of monitoring the relative annual recruitment success of juvenile striped bass in the spawning and nursery areas of Lower Chesapeake Bay. The survey was funded during it's initial period by the U.S. Fish and Wildlife Service and then 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 made jointly through the Sportfish Restoration Program (Wallop-Breaux Act), administered through the U. S. Fish and Wildlife Service and the Virginia Marine Resources Commission, and through the Virginia Chesapeake Bay Initiatives, administered through the Virginia Council on the Environment. This report summarizes the results of the 1989 sampling period and compares these results with the previous work.

Specific objectives planned for the 1989 program were to:

1. Measure the relative abundance of the 1989 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.

LIST OF TABLES

LIST OF FIGURES

SUMMARY

1. A total of 1,981 young-of-the-year striped bass were collected in 180 seine hauls at index stations during the 1989 survey, for an adjusted average of 11.23 fish per haul, a value second only to 1987's record index in the 17 years sampled. Juvenile production in 1989 in the Virginia portion of Chesapeake Bay should be regarded as exceptionally high.

2. A record juvenile index was recorded in the Pamunkey River and the York drainage as whole in 1989, but the high average was largely attributable to a small number of extremely high catches. A very high index in the James system, on the other hand, was based upon a very broad and relatively much more even distribution of juveniles. The index in the Rappahannock River was considerably lower than during the previous two years but still well above the historical average.

3. Relationships between juvenile striped bass catch rates and environmental parameters in 1989 were essentially the same as those noted previously. There have been no obvious environmental conditions, either on the nursery grounds or during the spawning season, that can be related to the good recruitment success seen in the Virginia tributaries during the past few years, and the most likely factor for the increase would appear to be the protection from fishing pressure of the parental stock.

4. Most of the newly added auxiliary stations produced juvenile striped bass during the 1989 sampling, and the addition of the sites provided a much clearer picture of juvenile striped bass distribution than was afforded by the previous sampling scheme.

5. The Virginia and Maryland juvenile striped bass seine surveys could provide a basis for the calculation of a baywide recruitment index for the Chesapeake stock, but investigations as to appropriate weighting factors for the various nursery areas will be required.

INTRODUCTION

The status of the Atlantic Coast striped bass (*Morone saxatilis*) stocks continues to be an item of intense regional concern despite careful management of this highly prized commercial and recreational resource in recent years. Significant declines in the commercial landings and other population estimators (scientific survey data) during the decade after 1973 (Boreman and Austin 1985) resulted in severe restrictions on the harvest of the species, including total and indefinite moratoria on the taking or possession of striped bass in many jurisdictions, being put in place during the last half of the past decade. Although there is recent evidence that at least some stocks of the Atlantic Coast striped bass population may be recovering, in all likelihood extensive fishing restrictions will continue to remain in place for the forseeable future, as the current management plan calls for very limited and closely monitored "transitional" fisheries. A central focus of management efforts is the restoration of the Chesapeake Bay stock, which has historically contributed a large portion of the fish taken in the coastwide fishery.

Estimates of juvenile abundance are presently widely utilized as the most reliable early estimator of future striped bass year class strength and are a key element of recently developed models of recruitment and reproductive capacity of striped bass stocks. Goodyear (1985) reported a strong relationship between reported landings and prior Maryland Department of Natural Resources beach seine survey indices of young-of-the-year abundance and concluded that such indices provided a useful measure of recruitment. Subsequently, the Maryland juvenile index has been used as an estimate of recruitment in the development of an egg deposition model (Boreman and Goodyear 1984). Simulations run with elaborations of this model to evaluate potential effects of various fishery management strategies have received strong attention by the Interstate Fisheries Management Program bodies during the formulation of recent management measures, particularly in reference as to which regulatory scenarios would or will most expeditiously satisfy Amendments 3 and 4 to the Atlantic States Marine Fisheries Commission's Interstate Fishery Management Plan for the Striped Bass. Amendment 3, put in effect by the Commission in July of 1985, included the stipulation:

> "That the states reduce fishing mortality on the 1982 year class females, and females of all subsequent year classes, by 95% until the females of these year classes have an opportunity to reproduce at least once. This objective is intended to apply to the fishery until the 3-year running average of Maryland young-of-year index attains 8.0."

This target value was indeed achieved as of the completion of the 1989 Maryland juvenile survey, thereby triggering the implementation of Amendment 4 (passed in October of 1989), which outlines procedures and requirements under which the various jurisdictions are allowed to initiate limited and closely monitored relaxations of the restrictions on striped bass fishing. Among the monitoring requirements is the stipulation that monitoring of juvenile abundance will be conducted in all major nursery areas, which of course includes the Virginia portion of Chesapeake Bay.

The present report summarizes the results of the 1989 Virginia juvenile striped bass seining program and compares these results to those obtained in previous years under the present program (1980-1988) and during an earlier but similar program (1967-1973). The major goal of this project is to monitor the relative abundance of zero-age-class striped bass in the three major Virginia river systems (James, York and Rappahannock) while concurrently attempting to identify significant variables which contribute to their interannual fluctuations. The methodology used in this program is identical to that used in the Maryland survey, and the combined results of the two surveys provide a relatively comprehensive picture of annual striped bass recruitment success of the Chesapeake Bay stock.

METHODS

Field sampling was conducted during five approximately bi-weekly sampling periods from mid-July through September of 1989. During each sampling period beach seine hauls were conducted at eighteen historically sampled sites (index stations) and 22 newly added locations (auxiliary stations) along the shores of the James, York and Rappahannock river systems (Fig. 1). This is the most intensive sampling program for this survey to date, and was made possible through additional state funding for the survey. Addition of the auxiliary sites was made in order to provide better geographic coverage and, once a sufficient time series of data is developed, create larger within-river-system sample sizes so that trends in juvenile abundance can be meaningfully monitored on a system by system basis.

One seine haul was made at each auxiliary station, and two replicate hauls made at each index station during each sampling round. Collections were made by deploying a 100′ (30.5m) long, 4′ (1.22m) deep, 1/4" (0.64cm) bar mesh minnow seine perpendicular to the shoreline (either until the net was fully extended or a depth of approximately four feet was encountered) and then leaving the onshore brail in a fixed position while pulling the offshore end downcurrent and back to the shore, resulting in the sweeping of a quarter circle quadrant. In the case of index stations, all fish taken during the first tow were removed from the net and held in water-filled buckets until after the second tow. All fish collected were identified and counted, and all striped bass and all individuals or a subsample 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 Surveyor II water quality instrument. Sampling time, tidal stage and weather conditions were recorded at the time of each haul. When two hauls were made, the first sample was processed in the period between the two hauls and an intervening period of 30 minutes was allowed between hauls. 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 will be 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 (Sokal and Rohlf 1981) prior to analyses. Subsequently computed mean values were retransformed (i.e. the geometric mean), but because the geometric means of such a strongly skewed distribution are much smaller than the arithmetic means, for comparative purposes (particularly with respect to the results of the Maryland survey, wherein arithmetic means are reported) the geometric means have been scaled up to the arithmetic means by multiplication by the ratio of the overall arithmetic to geometric means as of the 1984 survey (2.28).

Mean catch rates are contrasted by comparing 95% confidence intervals as estimated by ± two standard errors (square root of the variance divided by n) of the mean. 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 1989 year class of juvenile striped bass from the James, York and Rappahannock river systems.

A total of 1,981 young-of-the-year striped bass was collected from 180 seine hauls during the 1989 index station sampling (the second highest total in the 17 years sampled), and an additional 342 age 0 striped bass were collected at the auxiliary sites (Table 1). The adjusted overall mean catch per seine haul (CPUE) for the index stations was 11.23, which was not significantly lower than the record index recorded in 1987 (15.75), and was also significantly higher than all other years sampled except the previous year (Table 2, Fig. 2). This value is over two and a half times the overall average index of 4.44 and more than twice the annual average of 4.69. As was the case the prior two years, the distribution of catches indicated that the high index value was due to the presence of a strong year class and not sampling artifact. Young-of-the-year striped bass were taken in 90% of the tows made at the index stations, as contrasted to a pre-1987 average of about 60% and a previous high of 71%.

Similarly to 1988 (Colvocoresses 1989), but in contrast to most other years sampled, when the highest catch rate was seen during the initial sampling period and then followed by a steadily decreasing catch rate in succeeding rounds, during 1989 the lowest catch rate was observed during the middle of the sampling season (Table 3). If the low value during the third round is disregarded a decline in catch rates through the season is evident, but variability was high and the confidence intervals for all 1989 sampling periods overlapped.

The 1989 catch rate in the James drainage as a whole was three times the historical average, with the catch rate in the James River proper being over three and a half times the average and that in the Chickahominy River over twice as high (Table 4). The 1989 James Drainage index (15.4) was second in magnitude only to the record value (18.8) established during 1987 (Fig. 3). Highest catches in 1989 were encountered in the center of the sampling area (stations C1 and J46; Fig. 4), with the center of abundance appearing to be at the former station during the first two sampling rounds and then shifting upstream to the latter during the third round. During the last two sampling rounds the highest catch rates continued to occur in the center of the study area but distribution was much more even across sampling sites. Although the largest catches were generally seen at the historical index stations, young-of-the-year striped bass were taken at least once at each of the newly added auxiliary stations, and in fact 23 of 30 hauls made either upriver or downriver of the historical sampling area produced young striped bass.

The 1989 index for the York Drainage established a new high of 9.3 fish/haul as result of the Pamunkey River achieving a value almost twice as high as any seen previously while the Mattaponi registered it's third consecutive year of very high values (Fig. 3, Table 4). The new high value in the Pamunkey (14.5) was three and a half times higher than the overall average for this river, and while the confidence values for the 1989 Mattaponi index slightly overlapped those of the historical average, the mean was almost twice as high with the net result that the index for both rivers combined exceeded the historical average by a factor of 2.4. Catch rates in the Pamunkey were extremely erratic in 1989 both with respect to stations and sampling rounds, with a few extremely large catches being primarily responsible for the high averages observed. During the first round catches were moderate and centered in the upper half of the sampling area (Fig. 5). In the second sampling round a very large concentration of juveniles was encountered at station P36, a newly added auxiliary station immediately below the historical sampling area. Catches in the third round were relatively low and fairly even across all but the uppermost and lowermost stations. During the forth round an extremely large concentration of fish was again encountered at the middle index station, P45, while during the final round the greatest abundance was recorded at the most upstream index station, P50.

In the Mattaponi, the highest catch rates observed in 1989 in each sampling round occurred at either of two stations, M33 or M41 (Fig. 6). During the first round large catches, amounting to almost half of the young-of-the-year striped bass taken in the Mattaponi during the entire sampling season, were taken at M41 (Table 1). This station also produced the most juveniles during the third sampling round, although similar catches were taken at station M33, which produced the highest catches during all other sampling rounds. Very few juvenile striped bass were encountered at the stations above M41 or at M37, a newly added auxiliary station located between the two most productive sites. Station Y28, another newly added auxiliary station at the confluence of the Pamunkey and Mattaponi Rivers, in fact proved to be more productive in 1989 for juvenile striped bass than either of the upper two index stations in the Mattaponi. The two lower stations added in the York mainstem failed to produce striped bass during 1989 sampling efforts.

The 1989 index in the Rappahannock River, as in the other two river systems, exceeded the historical average by a factor of more than two (Table 4) despite being considerably lower than that seen the previous two years (Fig. 3). Catch rates showed an approximately normal (but slightly skewed) distribution during all sampling periods (Fig. 7), with the center of abundance occurring at the two upriver index stations (R50 and R55). The two newly added auxiliary stations downstream of the historical sampling area (R12 and R21) failed to produce any juvenile striped bass, while the sampling sites added above the index stations all produced young-of-the-year striped bass at least once, although the station immediately above the historical stations (R60) was the the only one to show significant numbers.

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

Collection information and pertinent environmental variables recorded at the time of each collection are given in Appendix Table 1 and Tables 5 and 6. Other than lower than normal salinities at the downstream sampling sites (particularly in the James River), no particularly exceptional conditions were encountered and all five sampling rounds were completed at the index stations without interruption under nominal conditions. During the third sampling the uppermost auxiliary stations in the Rappahannock were not sampled due to a vessel breakdown. In the final round, station M37 could not be sampled due to abnormally high tides and station R41 was aborted due to high winds.

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

Distribution of catch rates with respect to salinity in the 1989 survey showed the same pattern as has been evident during most other years and for the data set as a whole, i.e. a definitive trend towards higher catches at lower salinities (Table 7), and in fact this trend was more pronounced than usual. This is in sharp contrast to the situation during the record year of 1987, when catch rates were essentially the same between 5 and 10 ppt. as below that range (Colvocoresses 1988). Past data have indicated that an expansion of the nursery zone into waters of higher salinity occurs during years of high abundance, but the results from the two most recent years have shown high indices which were largely attributable to elevated catches in the normal low salinity nursery zone, with no evidence of expansion of the nursery area into waters of moderate salinity. The 1988 results indicated that expansion of the nursery areas into more saline waters in years of high abundance may be mediated in years of below average salinities, and the 1989 results certainly substantiate this hypothesis. Average salinity for the index stations was lower during 1989 than in any previous year (Table 8), a reflection of very heavy late spring and early summer runoff, particularly in the James River.

Catch rates with respect to water temperature in 1989 adhered to the pattern seen in most previous years, i.e. catch rates were lower in the cooler waters sampled (Table 9). This relationship is largely a result of the fact that there is a coincident downward progression of both catch rates and temperature as the survey season progresses, at least after the second sampling round. While this pattern was not strictly followed in terms of catch rates in 1989, both the highest catch rates and warmest water temperatures were encountered during the first two sampling rounds.

Data on pH, dissolved oxygen concentrations and secchi disc visibility depth readings were recorded with the seine collections for the first time in 1989, so there is no prior basis for comparison. With the exception of the upper Mattaponi river and a few readings from the upper Pamunkey, the pH values recorded equaled or exceeded 6.5 (Appendix Table 1) and therefore should have been easily tolerated by juvenile striped bass (Buckler et al. 1987). Dissolved oxygen concentrations always exceeded 5 ppm outside of the York system, and should likewise have had little or no effect on juvenile striped bass distributions. Low dissolved oxygen values (near 3 ppm) were recorded from the Pamunkey and Mattaponi rivers during the first sampling round and from the Mattaponi during the second. Secchi depth readings were generally low (<0.5 m) except for the upper York system and lower Rappahannock. The low catch rates observed in the upper Mattaponi may well be related to the depressed pH values, but the lower dissolved oxygen values did not appear to be adversely effecting juvenile distribution, as the extremely large catch taken at station M41 during the first sampling round was associated with a low dissolved oxygen reading. Although increased water clarity can be expected to contribute to increased detection of the sampling gear and hence greater gear avoidance and escapement, and most high secchi disc readings were observed at stations which yielded few or no juveniles, inferring a direct relationship is not possible since these areas also exhibited either low pH values or high salinities. All of these parameters, as well as those previously discussed and undoubtedly others which are not currently measured, probably exert complex and interrelated effects on juvenile striped bass distribution, catchability and survival, and several more years of data will be required before even preliminary meaningful assessments of the effects of the newly measured parameters can be attempted.

DISCUSSION AND CONCLUSIONS

The striped bass juvenile index recorded in the Virginia Chesapeake Bay nursery areas in 1989 continued a trend of high values in recent years, with the three highest index values recorded having been observed in the most recent three years. Although natural variability cannot be completely ruled out as a potential cause for this trend, in the absence of any other readily evident factors it seems evident that the stringent conservation measures being applied to the Chesapeake Bay striped bass population is the most likely explanation for the very high juvenile recruitment success experienced on the Virginia spawning grounds in recent years. No obviously exceptional environmental conditions have been encountered either within the nursery areas or reported from the spawning grounds that have shown any consistency within the past few years. Of even greater significance is the fact that while the high juvenile recruitment seen in the Virginia tributaries the previous two years did not appear to be part of an overall resurgence of the Chesapeake Bay stock, as the recruitment index in the upper Chesapeake Bay tributaries remained near historic lows, during the 1989 sampling season near-record juvenile abundances were recorded during the Maryland seine survey as well, and the 1989 year class may well prove to be one of largest ever produced in Chesapeake Bay.

Regardless of the cause, the continued high rate of reproductive success seen in the Virginia tributaries in the past three years coupled with the very high Maryland waters production in 1989 is a very strong indication that the Chesapeake Bay stock is undergoing at least some level of recovery, and the possibility that general environmental conditions on the spawning/nursery grounds have deteriorated to the point where striped bass juvenile production is severely inhibited by water quality conditions can be largely dispelled. This does not preclude the fact that localized water quality conditions in some parts of Chesapeake Bay may be still be detrimental or even prohibitive to striped bass reproduction, nor does it necessarily imply that environmental conditions have improved on the spawning and nursery grounds in recent years. Since the most parsimonious explanation for the recent high rates of juvenile production is that they are a consequence of the dramatic reduction in fishing mortality to the parental stock afforded by the highly protective regulations in place in recent years, the strong positive effect exerted by reduced fishing mortality could well mask even negative population effects caused by other sources of mortality or inhibiting factors to reproductive success.

Potential relative contributions of the various Chesapeake Bay subsystems to the overall reproductive success of the Bay as a whole is poorly understood and appears to vary greatly from year to year (Heimbuch et al. 1983, Colvocoresses and Austin 1987). Recent juvenile production in the Virginia tributaries as evidenced by beach seine catch rates appears to be very high relative to the historical average within Virginia, but these catch rates are only moderately higher than the historical average in the Upper Bay and Maryland tributaries. Although the standardization of seining methodologies between the Virginia and Maryland juvenile striped bass surveys offers the opportunity for making such direct comparisons between survey results and also potentially allows for the calculation of a baywide juvenile abundance index, it must be kept in mind that these juvenile index values are only highly relative measures of striped bass recruitment. In no case should proportionality be assumed between index values and actual juvenile abundances, which will not only depend on the size of the nursery/spawning ground available within the system but also the degree to which it can be utilized (also probably variable between years).

The revised Interstate Striped Bass Management Plan (ASMFC 1989), which has been activated for 1990 by the attainment of the trigger level in the Maryland juvenile index in 1989, calls for the development of baywide and coastwide juvenile indicies as key elements for monitoring and evaluating the effects of relaxed fishing restrictions under the provisons of Amendment 4. An optimal Chesapeake Bay juvenile striped bass index will need to incorporate appropriate weighting factors for each of the major spawning/nursery areas. This applies not only for any future fusion of the present Maryland and Virginia indices, but should also be considered within each state's survey. Present contributions of each state's tributaries to the overall index are according to sampling effort, which is only loosely tied to potential production (i.e. size of system). Past efforts at determining more sophisticated weightings have included the application of factors based on historical commercial catch contributions and factors based on the relative areas of the assumed juvenile habitat in each system (Heimbuch et al. 1983). Present use of the first approach is virtually prohibited by the recent fishery having either been subjected to severe and annually and jurisdictionally varying restrictions on the fishery or complete closures. Optimal application of the second approach will require a more thorough knowledge of the extent of available juvenile habitat and relative usage than is presently available. Nevertheless, in view of the fact that there is little intra-annual coherence between the juvenile indices for the various subsystems (Colvocoresses and Austin 1987), it is obvious that this is an area which will require considerable future investigation, particularly in view of the very different patterns of recruitment success seen in recent years as compared to the past.

The increased sampling effort initiated during the present year, particularly the large increase in areal coverage provided by the newly added auxiliary stations, will provide a much sounder basis for evaluating the extent and utilization of juvenile habitat in these systems. Although the highest catch rates and centers of abundance were observed in the areas bracketed by the historical index stations, juveniles were encountered at all newly added stations upriver of the index areas and over half of those added below these reaches. The James River showed an extremely large nursery area in 1989, with juveniles being taken at all stations at least once and having been encountered regularly over a 50 mile stretch of the river. Whether this nursery zone expansion was a result of dispersion due to competitive effects as result of high abundance or a reflection of displacement or dispersion related to the high runoff and greater areal extent of low salinity waters or both will not be determinable until more data from the expanded sampling program becomes available. It is interesting to note that while record high catch rates were seen in the York system, particularly the Pamunkey River, distribution of juveniles was much more restricted and more erratic than in the James system, with little indication of an expanded nursery zone. The high catch rates in the York stemmed largely from single extremely high catches being encountered during each sampling round at one of a relatively small number of stations in or near the normal primary nursery area, suggesting that a few very dense congregations of juveniles were moving about within a fairly restricted stretch of this system. Why the type of dispersion seen in the James in 1989 or in other systems in previous years did not occur is unclear. The shoreline in the York nursery areas is generally morphologically very dissimilar to that in the other two systems, with much narrower and muddier intertidal zones and more severe current regimes. The newly collected data on pH and dissolved oxygen concentrations suggests that the water chemistry in the York tributaries may be considerably different as well. To what extent these factors effect juvenile striped bass distribution, and possibly availability to the sampling gear, will be a focus of future investigations.

LITERATURE CITED

Boreman, J. and H. M. Austin. 1985. Production and harvest of anadromous striped bass stocks along the Atlantic Coast. Trans. Amer. Fish. Soc. 114(1): 3-7.

Boreman, J. and C. P. Goodyear. 1984. Effects of fishing on the reproductive capacity of striped bass in Chesapeake Bay, Maryland. Woods Hole Lab. Ref. Doc. No. 84-29.

Buckler, D. R., P. M. Mehrle, L. Cleveland and F. J. Dwyer. 1987. Influence of pH on the toxicity of aluminum and other inorganic contaminants to East Coast striped bass. Water, Air and Soil Pollution 35:97-106.

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

Colvocoresses, J. A. 1988. Striped bass research, Virginia. Part I: Juvenile striped bass seining program. Annu. Rep. 1987-88. Virginia Institute of Marine Science, Gloucester Point, Virginia. 43 p.

Colvocoresses, J. A. 1989. Striped bass research, Virginia. Estimation of juvenile striped bass relative abundance. Ann. Rep., 1988. Virginia Institute of Marine Science, Gloucester Point, VA. 36 p.

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. 108 p.

Goodyear, C. P. 1985. Relationship between reported commercial landings and abundance of young striped bass in Chesapeake Bay, Maryland. Trans. Amer. Fish. Soc. 114(1): 92-96.

Heimbuch, D. G., P. W. Jones and B. J. Rothschild. 1983. An analysis of Maryland's juvenile striped bass index of abundance. UMCEES Ref. No. 83-51 CBL.

Sokal, R. R. and F. J. Rohlf. 1981. Biometry. W. H. Freeman and Co., San Francisco, CA. 859 pp.

Table 1. Catch per seine haul of young-of-the-year striped bass during the 1989 survey. Two hauls were made per sampling round at each of the historical index stations.

Drainage

JAMES

Station Round	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	TOT.
1	2	11	10/16	18/19	51/13	10/ 9	31/ 7	1	7/ 3	6	1	7	0	222
2	1	1	12/ 6	4/ 4	52/26	16/ 5	10/ 1	2	2/ 3	0	4	0	3	152
3	1	5	20/ 8	7/ 4	16/ 8	11/ 9	73/24	9	13/ 2	1	2	0	2	215
4	3	3	1/ 1	1/ 3	6/ 2	7/ 8	4/ 5	0	4/ 2	1	1	0	3	55
5	2	0	6/ 6	1/ 0	6/ 4	4/ 1	7/ 9	2	9/ 8	1	1	0	1	68
														712

YORK

Station Round	Y15	Y21	Y28	P36	P42		P45	P50	P55	P61	TOT.
1	0	0	2	6	24/ 1		45/11	5/16	14	0	108
2	0	0	0	129	8/ 1		19/ 4	4/ 0	3	0	164
3	0	0	7	10	4/ 3		20/ 5	3/ 4	5	0	61
4	0	0	1	11	4/ 2		243/ 8	17/ 5	5	1	294
5	0	0	2	22	1/ 1		4/ 2	77/14	5	0	134

Station Round	M33	M37	M41	M44	M47	M52	TOT.
1	6/ 4	0	103/46	0/ 2	1/ 2	1	165
2	25/ 5	0	8/ 4	2/ 1	3/ 2	0	50
3	14/ 2	2	9/11	2/ 0	0/ 1	0	41
4	10/ 3	2	2/ 1	1/ 0	1/ 0	0	20
5	36/ 2	ns	1/ 4	0/ 0	1/ 1	0	45
							1082

RAPPAHANNOCK

Station Round	R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76	TOT.
1	0	ns	2/ 2	3/ 0	2	16/11	6/ 5	74/43	5	0	0	2	171
2	0	0	3/ 2	0/ 1	5	17/14	3/ 0	23/16	8	0	0	0	92
3	0	0	1/ 0	1/ 1	5	10/ 2	14/ 9	56/ 6	ns	ns	ns	ns	105
4	0	0	0/ 0	0/ 0	2	15/ 5	17/12	17/ 0	3	1	0	0	72
5	0	0	1/ 0	3/ 0	ns	7/15	8/10	33/ 8	0	2	1	1	89
													529
													2323

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 the overall arithmetic and geometric means thru 1984).

Year	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N
1967	219	1.11	0.993	4.61	2.97-6.77	53
1968	218	0.96	0.906	3.70	2.50-5.19	66
1969	219	0.82	0.908	2.91	1.94-4.11	77
1970	469	1.34	1.115	6.42	4.47-8.93	77
1971	185	0.81	0.847	2.83	1.95-3.90	80
1972	103	0.42	0.588	1.19	0.83-1.59	116
1973	139	0.53	0.790	1.59	0.98-2.32	84
1980	229	0.75	0.901	2.54	1.70-3.56	89
1981	165	0.52	0.691	1.57	1.10-2.09	116
1982	324	0.78	0.968	2.71	1.86-3.75	106
1983	300	0.93	0.832	3.48	2.60-4.51	102
1984	464*	1.07	1.009	4.36	3.18-5.80	106
1985	322	0.72	0.859	2.41	1.78-3.14	142
1986	672	1.13	1.038	4.75	3.63-6.08	144
1987	2192	2.07	1.228	15.75	12.4-19.9	144
1988	1349	1.47	1.127	7.64	6.11-9.45	180
1989	1981	1.78	1.119	11.23	9.15-13.7	180
Overall	9550	1.08	1.078	4.44	4.11-4.78	1862
Unweighted Annual Mean				4.69		17

* adjusted figure (see 1984 report)

Table 3. Catch of young-of-the-year striped bass per seine haul in the primary nursery area summarized by sampling period and month.

Month	1989 Total	1989 Mean ln(x+1)	1989 Std. Dev.	1989 Adjust. Mean	1989 C.I. (± 2 SE)	1989 N	All Years Combined Total	All Years Combined Mean ln(x+1)	All Years Combined Std. Dev.	All Years Combined Adjust. Mean	All Years Combined C.I. (± 2 SE)	All Years Combined N
July (1st)	606	2.25	1.159	11.66	7.14-18.4	36	3771	1.31	1.138	6.13	5.36-6.98	560
2nd	302	1.75	1.001	9.49	5.30-16.0	36						
August (3rd)	373	1.88	1.057	5.22	3.14-8.11	36	3527	1.16	1.074	4.97	4.39-5.60	657
4th	404	1.41	1.169	6.88	4.17-10.7	36						
Sept. (5th)	296	1.60	1.080	6.23	3.77-9.68	36	2252	0.81	0.967	2.83	2.46-3.24	645
Overall	1981	1.78	1.119	11.23	9.15-13.7	180	9550	1.08	1.078	4.44	4.11-4.78	1862

Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area summarized by drainage and river.

Drainage River	1989 Total	1989 Mean ln(x+1)	1989 Std. Dev.	1989 Adjust. Mean	1989 C.I. (± 2 SE)	1989 N	All Years Combined Total	All Years Combined Mean ln(x+1)	All Years Combined Std. Dev.	All Years Combined Adjust. Mean	All Years Combined C.I. (± 2 SE)	All Years Combined N
James	635	2.05	0.877	15.40	11.8-19.9	60	3491	1.18	1.136	5.17	4.51-5.88	611
James	371	1.92	0.886	13.24	9.45-18.3	40	1723	0.97	1.053	3.72	3.13-4.38	413
Chickahom.	264	2.31	0.821	20.66	13.6-30.8	20	1768	1.63	1.173	9.39	7.60-11.5	198
York	854	1.62	1.184	9.29	6.44-13.1	70	2615	0.98	0.921	3.81	3.40-4.26	682
Pamunkey	538	2.00	1.171	14.50	8.66-23.5	30	1359	1.04	1.001	4.17	3.45-4.99	286
Mattaponi	316	1.35	1.128	6.48	3.85-10.2	40	1256	0.94	0.856	3.56	3.08-4.09	396
Rappahannock	492	1.67	1.241	9.87	6.27-15.0	50	3444	1.09	1.176	4.48	3.84-5.18	569
Overall	1981	1.78	1.119	11.23	9.15-13.7	180	9550	1.08	1.078	4.44	4.11-4.78	1862

Table 5. Salinity (parts per thousand) recorded at 1989 seine survey stations.

Drainage

JAMES

Station / Round	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	MEAN
1	7.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
2	14.9	2.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
3	10.7	3.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
4	15.9	5.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
5	13.1	0.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
														0.9

YORK

Station / Round	Y15	Y21	Y28	P36	P42	P45	P50	P55	P61	MEAN
1	12.7	7.8	3.4	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2	14.0	10.5	7.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
3	13.7	10.8	7.8	1.8	0.0	0.0	0.0	0.0	0.0	1.6
4	16.4	13.7	9.8	3.0	0.0	0.0	0.0	0.0	0.0	2.1
5	17.0	13.1	9.6	2.7	0.0	0.0	0.0	0.0	0.0	2.0
										1.7

Station / Round	M33	M37	M41	M44	M47	M52	MEAN
1	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.0	(included above)
3	0.9	0.0	0.0	0.0	0.0	0.0	
4	1.6	0.3	0.0	0.0	0.0	0.0	
5	0.0	ns	0.0	0.0	0.0	0.0	

RAPPAHANNOCK

Station / Round	R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76	MEAN
1	12.1	ns	8.1	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
2	11.8	10.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
3	11.6	10.8	8.4	3.1	1.0	0.0	0.0	0.0	ns	ns	ns	ns	3.6
4	14.4	12.6	8.9	3.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
5	13.7	11.5	8.3	1.6	ns	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
													2.8
													1.8

Table 6. Water temperature (°C) recorded at 1989 seine survey stations.

Drainage														
JAMES														
Station	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	MEAN
Round														
1	27.7	29.8	30.1	30.1	32.1	29.8	31.0	26.2	26.1	26.9	26.4	26.9	25.8	28.8
2	27.7	25.5	26.5	26.5	29.2	27.7	29.3	29.0	26.4	27.9	28.7	27.3	28.2	27.6
3	28.8	29.0	26.5	26.5	28.0	27.8	28.9	29.2	25.6	26.1	27.1	26.2	26.1	27.3
4	24.9	26.1	24.5	24.5	24.8	25.0	26.8	26.2	25.6	26.6	27.9	27.5	28.3	25.8
5	21.4	19.5	24.4	24.4	25.0	24.5	26.3	24.8	25.1	25.7	23.8	22.2	21.8	24.1
														26.7
YORK														
Station	Y15	Y21	Y28	P36	P42		P45	P50	P55	P61				
Round														
1	31.1	30.8	27.7	27.5	27.6		27.6	27.3	28.8	28.0				28.7
2	25.8	25.7	25.1	27.6	28.1		28.9	29.2	29.0	27.8				28.4
3	27.2	27.6	27.0	26.9	27.1		27.5	27.4	28.4	27.2				27.2
4	23.2	23.9	23.6	24.7	25.1		25.8	25.1	25.8	25.2				25.2
5	25.4	24.9	24.7	24.9	25.3		25.1	24.6	24.8	23.8				24.8
														26.9
Station				M33	M37	M41	M44	M47	M52					
Round														
1				28.9	28.7	27.8	29.1	30.9	31.1					
2				28.7	28.8	29.0	29.1	29.8	29.0					(included above)
3				26.5	26.5	26.5	26.8	55.6	28.2					
4				25.0	24.9	25.0	25.1	27.1	26.1					
5				25.0	ns	24.8	24.3	24.4	25.0					
RAPPAHANNOCK														
Station	R12	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
Round														
1	26.7	ns	29.1	30.8		29.0	28.8	26.5	27.4	26.6	28.7	26.9	26.2	28.1
2	31.4	29.5	26.2	27.6		28.5	29.4	27.2	27.0	26.8	27.8	25.3	23.3	27.5
3	27.4	26.6	27.7	25.5		25.7	26.3	26.1	26.7	ns	ns	ns	ns	26.5
4	23.9	23.4	22.0	22.9		23.8	23.6	26.8	27.6	27.1	26.6	27.6	27.7	25.1
5	25.3	25.9	21.8	21.9		ns	26.9	26.1	26.6	26.4	26.6	26.8	26.4	25.3
														26.5
														26.7

Table 7. Catch of young-of-the-year striped bass per seine haul in the primary nursery area summarized by salinity.

	1989						All Years Combined					
Salinity (ppt.)	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N
0-4.9	1943	1.84	1.109	12.05	9.80-14.7	168	8691	1.17	1.092	5.07	4.68-5.49	1541
5-9.9	38	0.95	0.949	3.61	1.13-7.90	12	752	0.77	0.962	2.65	2.04-3.34	216
10-14.9							81	0.40	0.623	1.12	0.68-1.62	81
15-19.9							2	0.11	0.260	0.26	-0.09-0.65	13
Overall	1981	1.78	1.119	11.23	9.15-13.7	180	9526	1.08	1.078	4.45	4.12-4.80	1851

Table 8. Average salinity (ppt.) by year at stations occupied in the primary nursery area.

Year	Mean Salinity
1967	2.20
1968	2.30
1969	1.94
1970	3.87
1971	2.47
1972	1.32
1973	2.41
1980	3.47
1981	4.28
1982	1.82
1983	3.04
1984	0.86
1985	2.52
1986	2.58
1987	2.36
1988	2.08
1989	0.74
Overall	2.27

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

	1989						All Years Combined					
Temp. (deg. C)	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N
15-19.9							79	0.87	0.913	3.15	1.57-5.39	28
20-24.9	154	1.03	1.043	4.08	2.07-7.03	30	820	0.70	0.867	2.33	1.91-2.78	335
25-29.9	1693	1.92	1.066	13.28	10.7-16.4	140	5433	1.14	1.049	4.82	4.38-5.30	1065
30-34.9	134	2.05	1.251	15.51	5.78-37.0	10	3105	1.40	1.248	6.93	5.80-8.22	362
Overall	1981	1.78	1.119	11.23	9.15-13.7	180	9437	1.10	1.082	4.59	4.25-4.96	1790

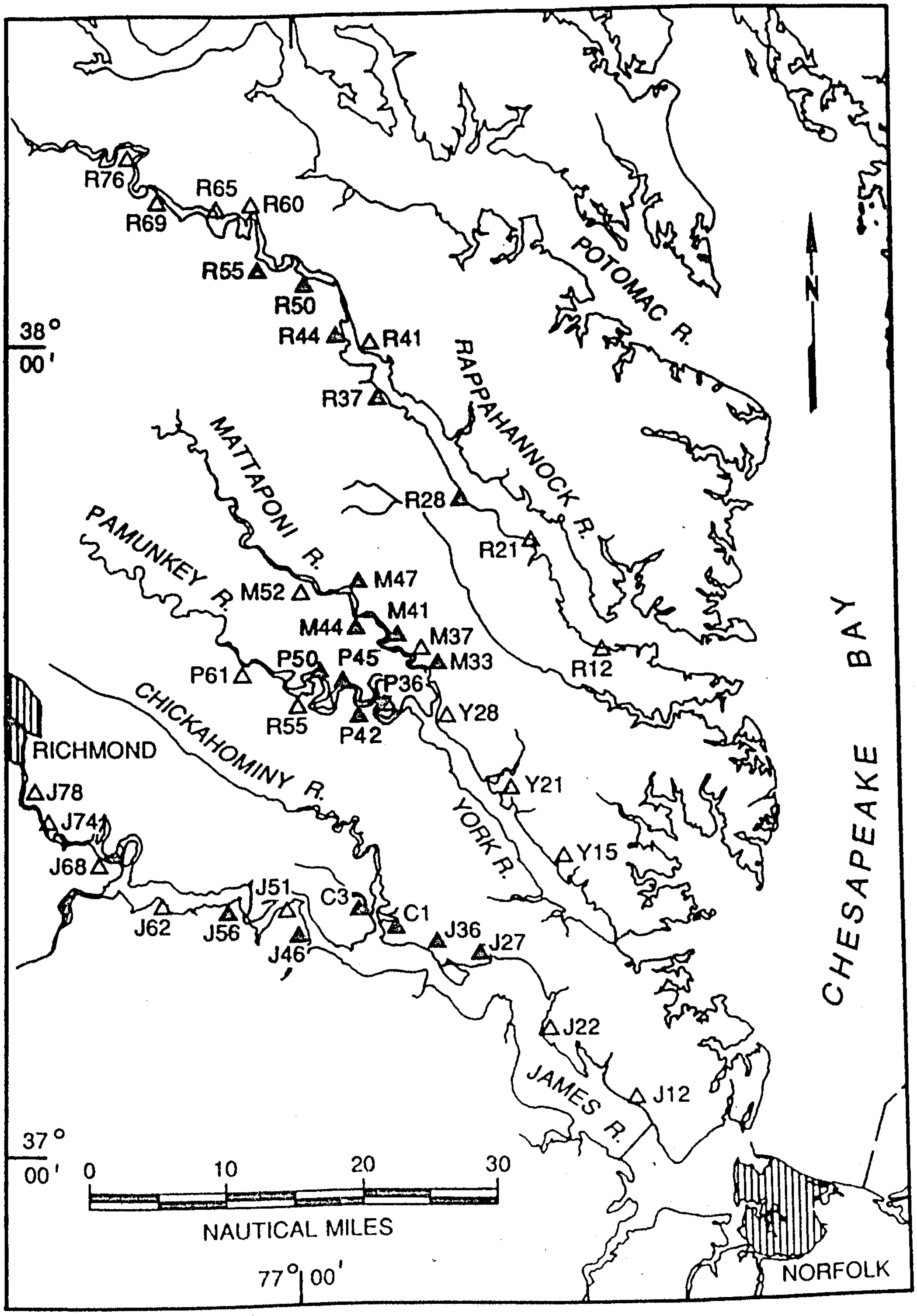

Figure 1. 1989 juvenile striped bass seine survey sampling locations. Numeric portion of station designations indicate river mile from mouth. Solid triangles are index stations, open ones auxiliary stations.

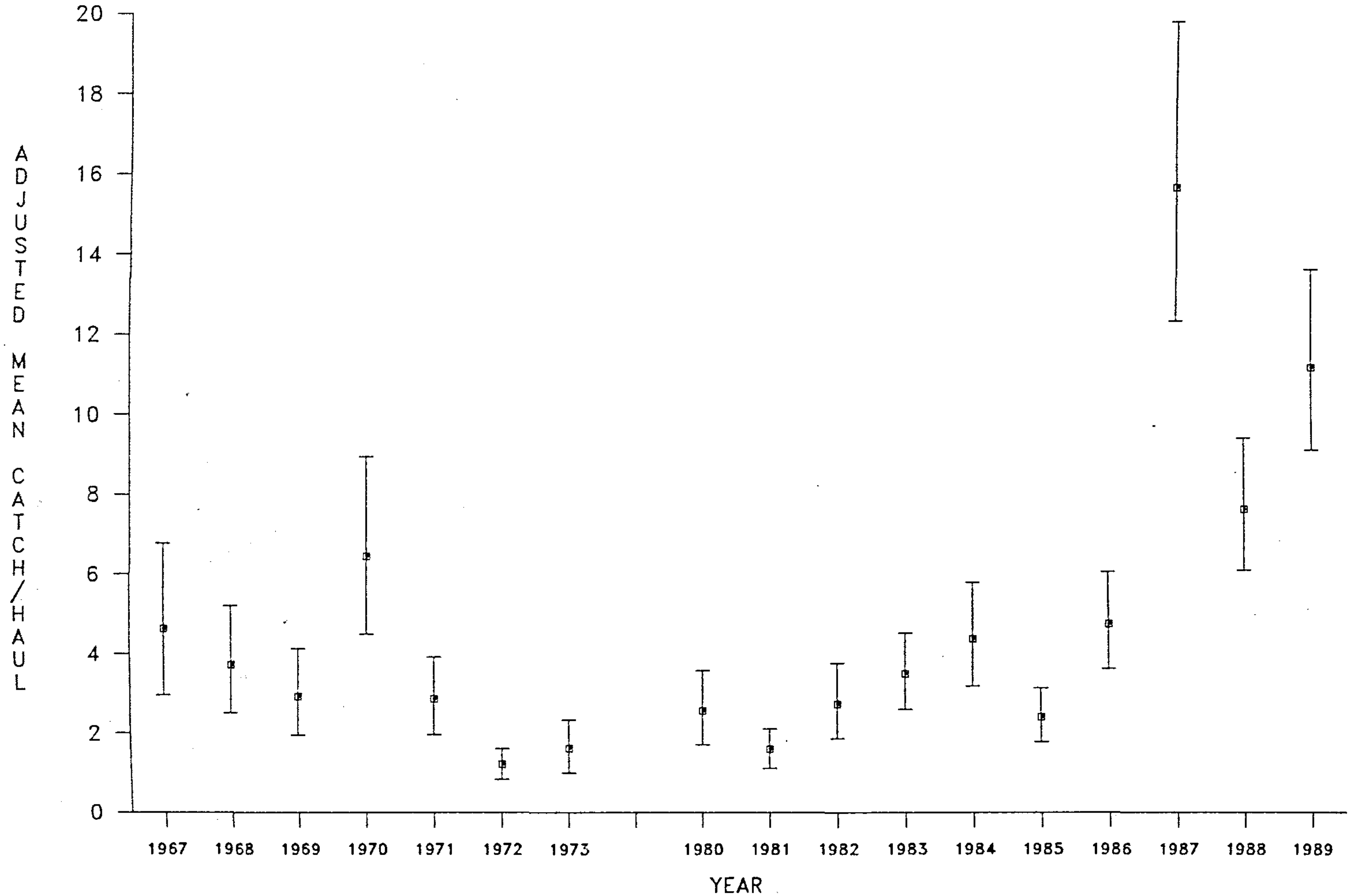

Figure 2. Adjusted average catch per seine haul of young-of-the-year striped bass in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean.

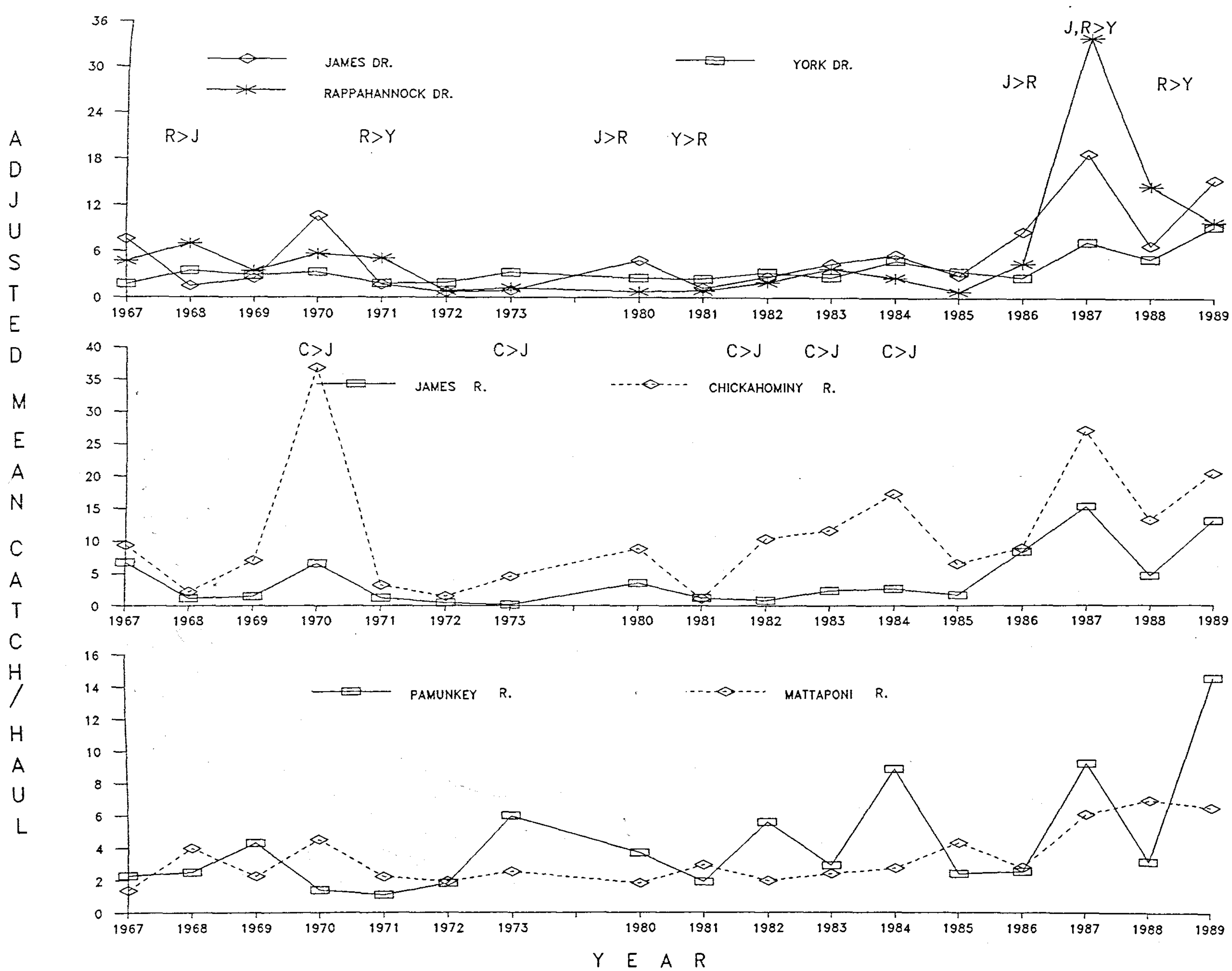

Figure 3. Adjusted average annual catch per seine haul of young-of-the-year striped bass in the primary nursery area by drainage and river.

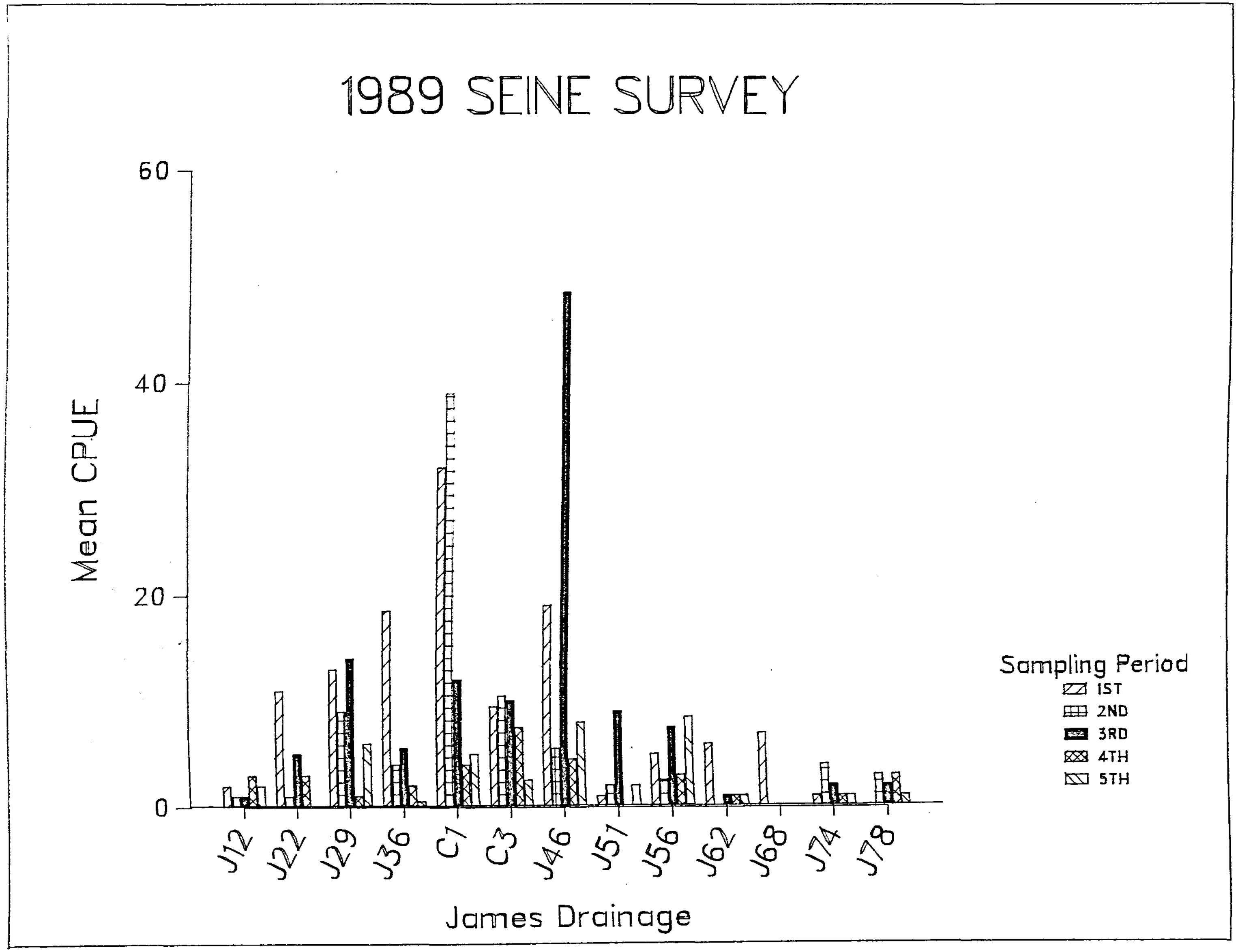

Figure 4. Average catch per seine haul of young-of-the-year striped bass by station in the James River in 1989.

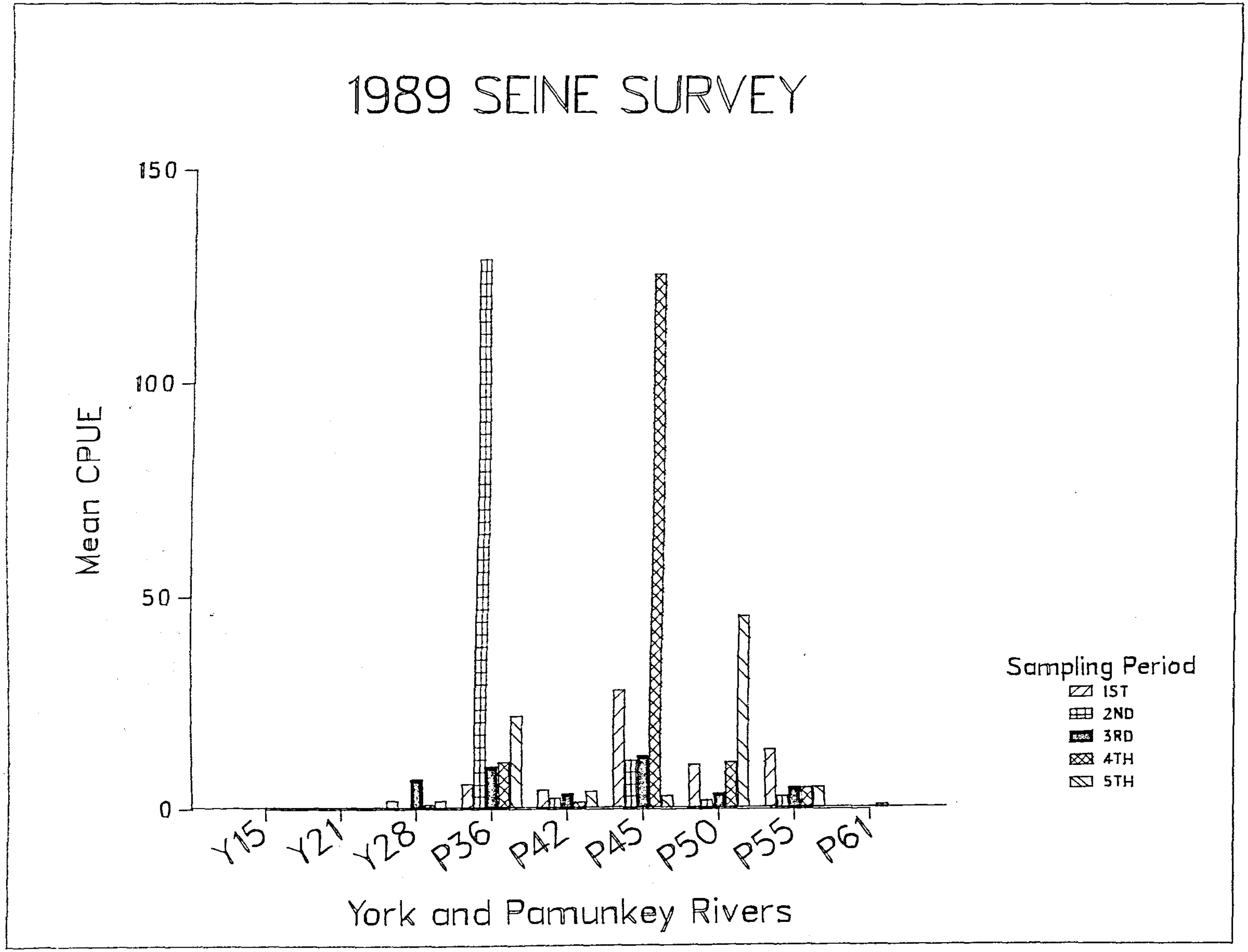

Figure 5. Average catch per seine haul of young-of-the-year striped bass by station in the York and Pamunkey Rivers in 1989.

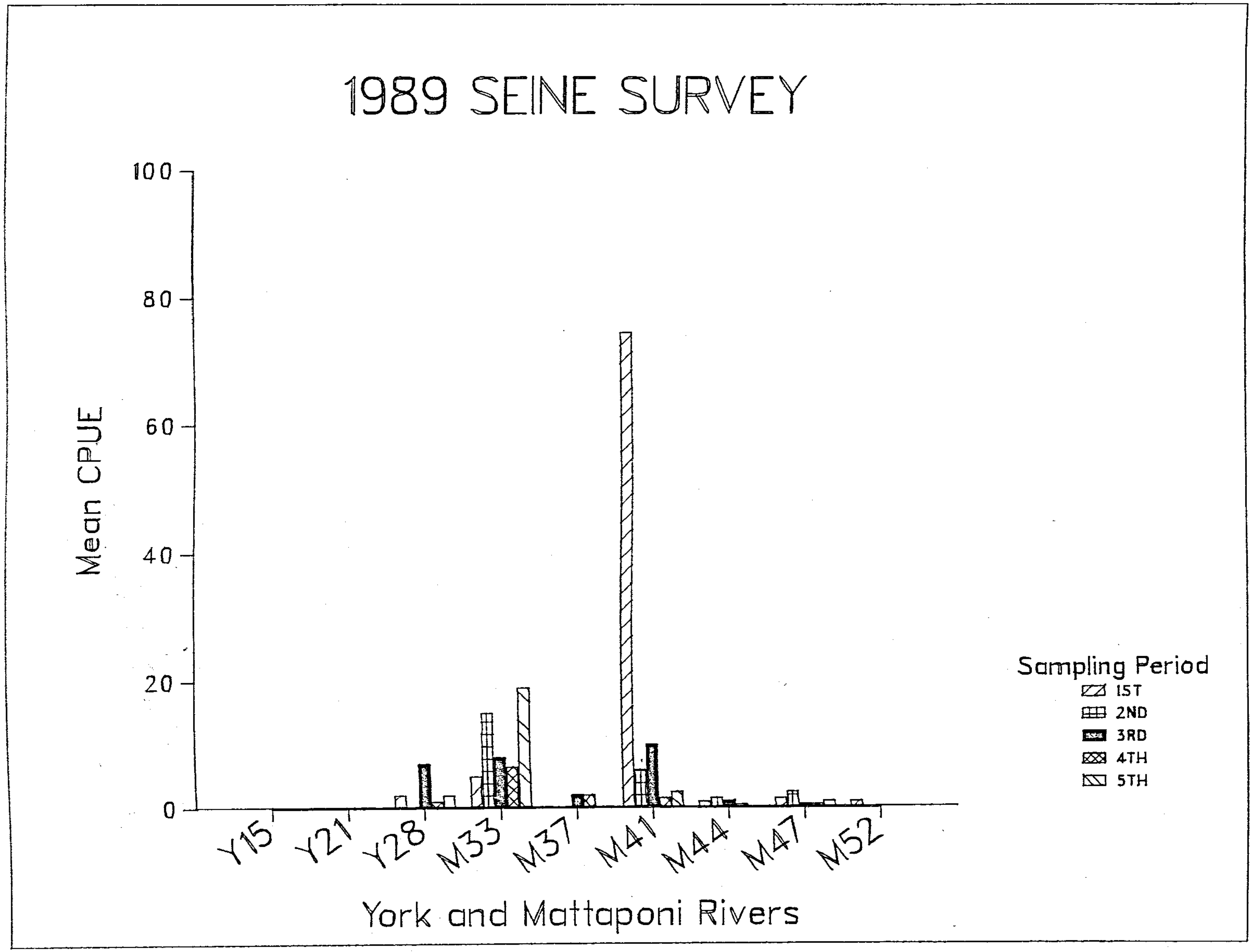

Figure 6. Average catch per seine haul of young-of-the-year striped bass by station in the York and Mattaponi Rivers in 1989.

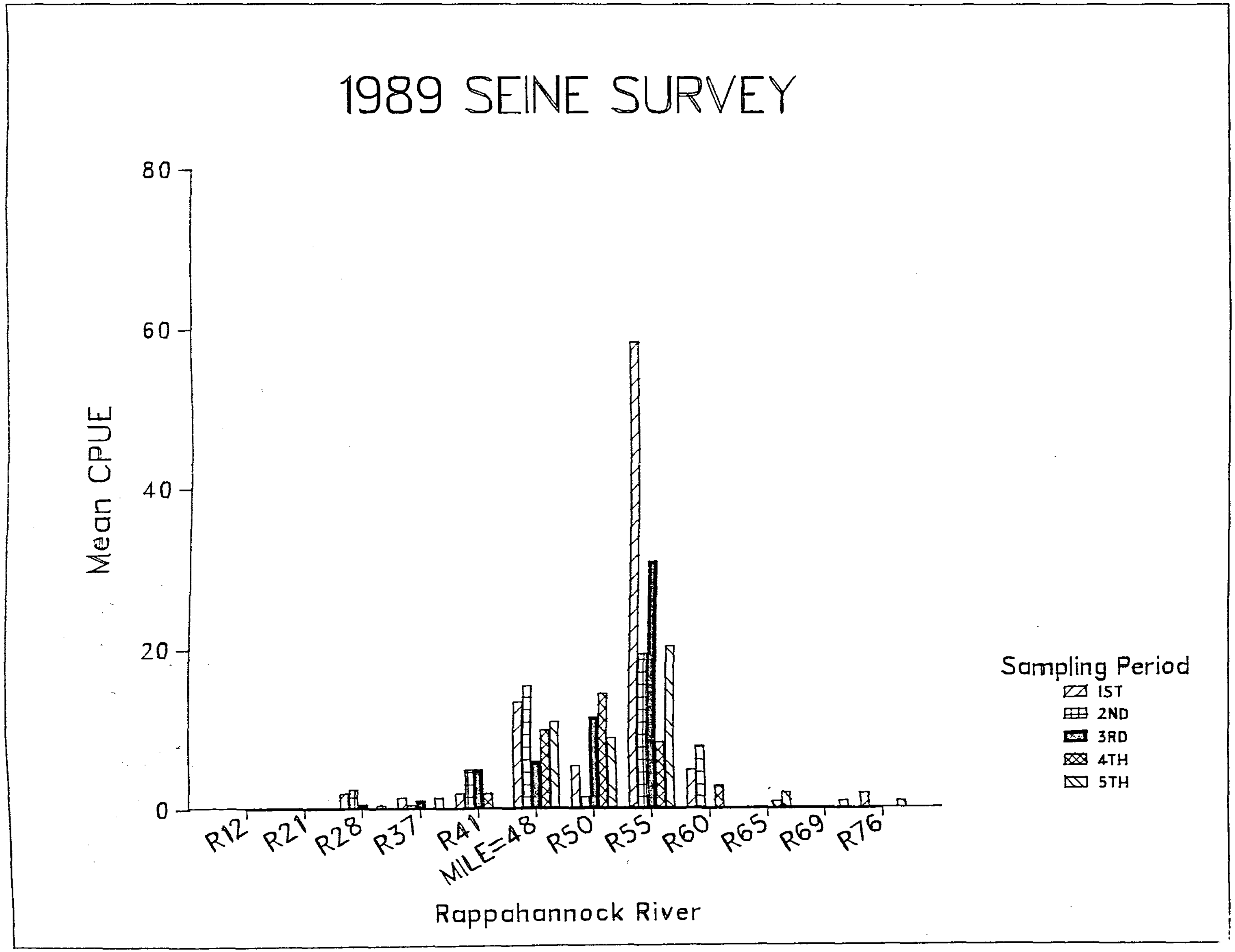

Figure 7. Average catch per seine haul of young-of-the-year striped bass by station in the Rappahannock River in 1989.

Appendix Table 1. Collection information and selected hydrographic parameters for the 1989 Virginia striped bass seine survey.

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
1	19/07/89	R50	0838	ME	7.1	6.5	0.4	LT	PC	4.0	60
			0911	ME						4.0	60
		R55	0951	LE	7.0	7.7	0.4	CLM	CDY	4.0	45
			1021	LE						4.0	45
		R60	1125	ME	7.2	7.2	0.4	LT	PC	4.0	-
		R65	1226	LE	8.6	9.1	0.4	LT	PC	4.0	30
		R69	1322	LE	6.9	5.2	0.4	LT	PC	4.0	45
		R76	1410	LE	6.7	5.1	0.2	LT	PC	4.0	20
	20/07/89	J51	0850	LE	7.2	5.1	0.4	LT	CDY	2.5	90
		J56	0937	LE	7.3	6.2	0.4	MD	CDY	4.0	50
			1007	LE						4.0	50
		J62	1100	LE	7.0	5.4	0.2	LT	PC	2.0	95
		J68	1205	LS	7.3	5.5	0.2	MD	PC	2.5	40
		J74	1305	1F	7.4	5.9	0.3	LT	PC	1.8	30
		J78	1346	1F	7.5	6.5	0.3	LT	PC	4.0	70
	21/07/89	R12	0702	LE	7.9	5.4	1.0	CLM	CL	2.0	100
		R18	0911	LE	7.7	6.8	0.9	LT	PC	1.3	100
		R24	0958	1F	7.8	7.2	1.1	LT	CL	1.0	100
		R28	1010	1F	7.9	7.3	0.4	LT	PC	1.8	100
			1110	1F						1.8	100
		R37	1132	1F	8.4	8.7		LT	PC	2.0	100
			1207	1F						2.0	100
		R41	1240	1F	7.3	6.6	0.2	LT	PC	3.5	100
		R44	1308	MF	7.8		0.2	CLM	PC	3.0	100
			1338	MF						3.0	100
	24/07/89	Y28	0652	LE	6.9	4.3	0.1	LT	HZ	2.5	100
		P36	0750	LE	6.8	4.3	0.1	CLM	HZ	3.5	60
		P42	0852	LE	6.5	4.2	0.4	CLM	HZ	3.5	30
			0922	LE						3.5	30
		P45	0940	LE	6.4	3.7	0.4	CLM	HZ	4.0	15
			1010	LE						4.0	15
		P50	1045	LS	6.3	3.3	0.4	CLM	HZ	4.0	20
			1130	LS						4.0	20
		P55	1225	LS	6.5	2.9	0.3	CLM	HZ	4.0	90
		P61	1325	1F	6.5	3.5	0.5	LT	PC	4.0	10
	25/07/89	M41	0919	LE	6.3	3.5	0.4	CLM	CL	4.0	40
			0949	LE						4.0	40
		M37	1023	LE	6.5	3.5	0.4	CLM	CL	4.0	35
		M33	1050	LE	6.6	3.0	0.4	CLM	CL	4.0	20
			1120	LE						4.0	20
		M44	1235	1F	6.1	3.2	0.7	CLM	CL	4.0	40
			1305	1F						4.0	40

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		M47	1330	1F	6.1	3.7	1.0	CLM	CL	4.0	45
			1400	1F						4.0	45
		M52	1425	MF	6.1	4.5	1.0	CLM	CL	4.0	45
	26/07/89	J12	0746	LE	7.9	5.6	0.3	LT	HZ	1.0	100
		J22	0945	LE	8.7	7.6	0.4	CLM	HZ	2.0	100
		Y21	1100	LE	8.0	10.4	0.2	CLM	CL	2.0	100
		Y15	1200	1F	7.9	11.6	0.4	CLM	CL	2.0	100
		J36	1056	LE	8.0	7.5		CLM	HZ	2.0	100
			1126	LE						2.0	100
		C1	1215	LS	9.1	9.0	0.5	CLM	HZ	1.3	100
			1245	LS						1.3	100
		C3	1320	1F	7.7	6.9	0.2	LT	HZ	4.0	15
			1350	1F						4.0	15
		J46	1420	1F	7.6	6.6	0.2	MD	CL	4.0	50
			1450	1F						4.0	50
		J29	1730	LF	8.9	7.2	0.4	MD	CDY	3.0	100
			1800	LF						3.0	100
2	02/08/89	R50	0758	LE	7.3	7.3	0.3	CLM	PC	4.0	75
			0828	LE						4.0	75
		R55	0850	LE	7.2	7.8	0.4	CLM	PC	4.0	50
			0920	LE						4.0	50
		R60	1040	LE	6.9	6.8	0.4	CLM	PC	4.0	40
		R65	1120	LE	7.3	8.6	0.4	CLM	PC	4.0	60
		R69	1200	LE	6.6	6.2	0.3	CLM	PC	4.0	50
		R76	1300	LS	6.5	5.4	0.2	CLM	CDY	4.0	40
	03/08/89	J56	0804	LE	7.5	7.2	0.4	MD	HZ	4.0	90
			0834	LE						4.0	90
		J62	0915	LE	7.7	6.9	0.3	LT	HZ	2.5	100
		J68	1013	LE	7.0	5.8	0.5	LT	HZ	4.0	80
		J74	1035	LE	7.4	6.2	0.6	LT	HZ	4.0	20
		J78	1130	LE	7.3	5.8	0.4	LT	HZ	4.0	50
	04/08/89	R28	0658	LE	7.5	5.9	1.0	CLM	HZ	2.0	100
			0728	LE						2.0	100
		R37	0820	LE	7.0	6.0	0.3	CLM	HZ	2.0	100
			0850	LE						2.0	100
		R41	0921	LE	6.8	6.3	0.3	CLM	HZ	3.0	100
		R44	0950	LE	7.7	8.0	0.5	LT	HZ	3.0	100
			1020	LE						3.0	100
		R21	1155	MF	7.7	6.0	1.1	LT	HZ	4.0	50
		R12	1325	LF	8.2	8.1	1.0	LT	HZ	4.0	90
	07/08/89	M33	0818	LE	6.5	3.3	0.4	LT	HZ	4.0	20
			0848	LE						4.0	20

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		M37	0920	LE	6.4	3.4	0.5	LT	HZ	4.0	30
		M41	0950	LE	6.2	3.4	1.0	LT	PC	4.0	30
			1020	LE						4.0	30
		M44	1040	LE	6.2	3.8	0.4	MD	CDY	4.0	30
			1110	LE						4.0	30
		M47	1135	FF	6.2	4.5	1.0	MD	CL	4.0	25
			1205	FF						4.0	25
		M52	1245	FF	6.1	5.2	1.0	MD	PC	4.0	70
	08/08/89	Y21	0815	LE	7.4	7.5	0.3	MD	CL	2.5	100
		Y15	0900	LS	7.4	7.7	0.2	MD	CL	2.0	100
		J22	1100	FF	8.2	9.2	0.1	MD	CL	2.5	100
		J12	1221	MF	7.6	7.7	0.3	LT	CL	3.0	100
		P36	1032	LE	6.9	4.4	0.1	MD	CL	4.0	70
		P42	1125	LE	6.7	5.0	0.6	MD	CL	4.0	30
			1155	LE						4.0	30
		P45	1232	LS	6.7	5.3	0.5	MD	CL	4.0	15
			1302	LS						4.0	15
		P50	1325	FF	6.7	6.4	0.5	MD	CL	4.0	40
			1355	FF						4.0	40
		P55	1420	FF	6.9	6.3	0.6	MD	PC	4.0	50
		P61	1456	FF	6.8	5.8	1.1	MD	PC	4.0	20
	09/08/89	J29	0843	LE	7.7	6.8	0.6	LT	PC	2.0	100
			0913	LE						2.0	100
		J36	0943	LE	8.6	8.3	0.6	LT	PC	3.0	100
			1013	LE						3.0	100
		C3	1131	LS	8.0	8.1	0.5	CLM	PC	4.0	20
			1201	LS						4.0	20
		C1	1219	FF	8.9	10.4	0.4	CLM	PC	2.0	100
			1243	FF						2.0	100
		J46	1328	FF	8.5	8.3	0.4	CLM	PC	4.0	60
			1358	FF						4.0	60
		J51	1426	FF	8.8	9.1	0.4	CLM	CDY	4.0	80
3	17/08/89	R50	0825	LE	7.2	7.1	0.4	CLM	HZ	4.0	60
			0855	LE						4.0	60
		R55	0920	LE	7.9	8.3	0.5	CLM	HZ	4.0	40
			0950	LE						4.0	40
	18/08/89	J62	0725	LE	7.6	7.4	0.3	LT	DK	2.5	100
		J56	0825	LE	7.4	8.4	0.3	MD	DK	4.0	90
			0920	LS						4.0	90
		J68	1010	LE	7.4	7.2	0.3	LT	CDY	4.0	90
		J74	1030	LE	7.6	6.7	0.5	CLM	CDY	4.0	20
		J78	1120	LS	7.5	6.6	0.3	LT	CDY	4.0	60
	21/08/89	R37	0851	LE	6.9	5.3	0.1	LT	CDY	2.0	100
			0922	LE						2.0	100

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		R41	0951	LE	6.8	6.1	0.2	MD	CDY	3.0	100
		R44	1028	LE	6.8	6.0	0.2	CLM	CDY	2.5	100
			1058							2.0	100
		R28	1240	FF	7.7	7.8	0.3	CLM	CDY	3.0	100
			1310	FF						3.0	100
		R21	1417	MF	7.5	6.2	0.6	LT	CDY	4.0	30
		R12	1631	LF	8.1	8.1	0.7	LT	CDY	3.5	25
	22/08/89	J29	0814	LE	7.8	8.1	1.0	LT	PC	1.0	100
			0844	LE						1.0	100
		J36	0927	LE	7.5	7.6	0.4	LT	PC	2.5	100
			0957	LE						2.5	100
		C1	1033	LE	8.3	8.5	0.5	LT	PC	1.0	100
			1103	LE						1.0	100
		C3	1124	FF	7.3	6.4	0.4	LT	PC	4.0	15
			1154	FF						4.0	15
		J46	1231	FF	7.4	6.5	0.5	LT	CL	4.0	40
			1301	FF						4.0	40
		J51	1330	FF	7.2	6.0	0.5	CLM	PC	3.0	100
	23/08/89	M33	0827	LE	6.5	4.3	0.9	CLM	CL	4.0	30
			0857	LE						4.0	30
		M37	0920	LE	6.5	4.0	0.3	LT	CL	4.0	30
		M41	0945	LE	6.3	4.7	0.8	LT	PC	4.0	35
			1015	LE						4.0	35
		M44	1037	LE	6.3	4.8	1.0	MD	CDY	4.0	50
			1110	LE						4.0	35
		M47	1136	LS	6.4	4.9	0.7	LT	PC	4.0	30
			1206	FF						4.0	30
		M52	1234	LS	6.1	6.1	1.2	MD	PC	4.0	40
	24/08/89	Y15	0758	LE	7.4	5.4	0.8	CLM	HZ	2.0	100
		Y21	0905	LE	7.2	5.8	0.3	LT	HZ	2.5	100
		J12	1130	FF	7.6	7.0	0.3	CLM	CDY	2.5	100
		J22	1230	FF	8.7	9.8	0.3	CLM	CDY	3.5	100
		Y28	0800	LE	7.0	5.5	0.4	CLM	CL	3.5	100
		P36	0835	LE	6.8	4.6	0.4	MD	PC	4.0	40
		P42	0912	LE	6.7	5.2	0.5	LT	PC	4.0	50
			0942	LE						4.0	45
		P45	1126	LE	6.7	6.0	0.4	MD	PC	4.0	20
			1156	LE						4.0	20
		P50	1230	LS	6.6	5.5	0.3	MD	PC	4.0	30
			1300	LS						4.0	30
		P55	1330	LS	6.6	5.4	0.6	MD	PC	3.0	100
		P61	1400	LS	6.6	5.1	0.7	MD	PC	4.0	15
4	01/09/89	R50	0822	LE	7.5	6.7	0.5	MD	CL	4.0	90
			0852	LE						4.0	90

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		R55	0920	LE	8.2	8.0	0.5	MD	CL	4.0	40
			0950	LE						4.0	40
		R60	1025	LE	7.5	6.6	0.3	MD	CL	4.0	40
		R65	1110	LS	8.6	9.1	0.3	MD	CL	4.0	80
		R69	1140	LE	7.9	10.0	0.5	MD	CL	4.0	60
		R76	1228	LS	7.1	6.1	0.5	MD	CL	4.0	50
		J56	0748	LE	7.2	6.9	0.4	LT	CL	4.0	50
			0818	LE						4.0	50
		J62	0851	LE	7.9	8.9	0.4	LT	CL	2.0	100
		J68	0936	LE	7.4	7.1	0.5	LT	CL	4.0	90
		J74	1000	LE	7.6	6.8	0.3	LT	CL	4.0	20
		J78	1045	LE	7.6	6.6	0.8	MD	CL	4.0	30
	05/09/89	R28	0805	LE	7.5	8.5	0.4	MD	CDY	2.5	100
			0835	LE						2.5	100
		R37	0922	LE	6.8	6.4	0.3	MD	PC	2.5	100
			0952	LE						2.5	100
		R41	1022	LE	6.8	7.1	0.5	LT	CDY	3.5	100
		R44	1045	LE	7.5	8.0	0.5	MD	CDY	4.0	100
			1115	LE						4.0	100
		R21	1310	MF	7.7	7.8	0.7	MD	CDY	4.0	30
		R12	1415	LF	8.0	7.6	0.7	LT	CDY	3.0	100
	06/09/89	J29	0810	LE	7.8	7.5	0.5	LT	PC	2.5	100
			0840	LE						2.5	100
		J36	0907	LE	7.5	6.6	0.7	CLM	PC	3.0	100
			0937	LE						3.0	100
		C1	1015	LE	7.9	7.7	0.5	CLM	PC	3.0	100
			1045	FF						3.0	100
		C3	1110	FF	7.5	6.9	0.6	LT	PC	4.0	20
			1140	FF						4.0	20
		J46	1250	FF	7.6	7.8	0.5	LT	CDY	4.0	40
			1300	FF						4.0	40
		J51	1328	FF	7.6	7.7	0.5	LT	PC	4.0	90
	07/09/89	Y15	0801	LE	7.4	5.7	0.6	LT	CL	2.0	100
		Y21	0840	LE	7.3	6.3	0.4	LT	CL	3.0	100
		J12	1030	FF	7.6	7.5	0.6	LT	CL	2.0	100
		J22	1217	MF	7.8	7.8	0.5	LT	CL	3.0	100
		Y28	0810	LE	7.0	5.5	0.4	CLM	CL	3.0	100
		P36	0905	LE	6.8	5.8	0.4	CLM	CL	4.0	40
		P42	0945	LE	6.8	6.0	0.5	LT	CL	4.0	35
			1015	LE						4.0	35
		P45	1035	LE	6.8	6.3	0.6	LT	CL	4.0	30
			1112	LE						4.0	30
		P50	1225	LE	6.8	6.9	0.3	LT	PC	4.0	35
			1255	LE						4.0	35

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		P55	1320	FF	6.8	6.8	0.3	LT	PC	4.0	40
		P61	1350	FF	6.7	5.8	0.3	LT	PC	4.0	20
	08/09/89	M33	0845	ME	7.1		0.4	CLM	CL	4.0	40
			0915	ME						4.0	40
		M37	0935	LE	7.2		0.5	CLM	CL	4.0	50
		M41	1007	LE	6.7		0.8	CLM	CL	4.0	40
			1037	LE						4.0	40
		M44	1122	LE	6.7		0.6	LT	CL	4.0	40
			1152	LE						4.0	40
		M47	1212	FF	6.6		0.9	CLM	CL	4.0	25
			1242	FF						4.0	25
		M52	1308	FF			1.0	CLM	CL	4.0	50
5	15/09/89	R50	0805	LE	6.7	6.7	0.6	CLM	PC	4.0	80
			0835	LE						4.0	80
		R55	0905	LE	7.1	7.1	0.5	CLM	PC	4.0	45
			0935	LE						4.0	45
		R60	1005	LE	6.9	6.5	0.4	CLM	PC	4.0	20
		R65	1042	LE	7.7	8.7	0.4	CLM	PC	4.0	45
		R69	1140	LE	6.8	8.6	0.4	LT	PC	4.0	40
		R76	1222	LE	6.6	5.8	0.4	CLM	PC	4.0	45
	18/09/89	J62	0830	LE	7.5	7.4	0.5	MD	HZ	3.0	100
		J56	0920	LE	7.6	7.6	0.5	MD	HZ	4.0	90
			0950	LE						4.0	90
		J68	1040	LE	7.1	7.4	0.2	MD	CDY	4.0	75
		J74	1145	LE	7.1	7.4	0.1	LT	CDY	4.0	40
		J78	1240	LE	6.9	8.2	0.1	LT	CDY	4.0	60
	19/09/89	R28	0805	LE	7.2	7.7	0.4	ST	CDY	3.0	100
			0835	LE						3.0	100
		R37	0925	LE	6.6	9.0		ST	CDY	3.0	100
			0959	LE						3.0	100
	20/09/89	J29	0807	LE	7.1	8.5	0.3	MD	CDY	2.5	100
			0837	LE						2.5	100
		J36	0911	LE	7.1	9.7	0.6	LT	PC	3.0	100
			0941	LE						3.0	100
		C1	1019	LE	5.5	8.5	0.8	LT	CDY	2.0	100
			1049	LE						2.0	100
		C3	1110	LS	7.1	8.5	0.6	MD	PC	4.0	30
			1140	LS						4.0	30
		J46	1230	FF	6.5	7.5	0.3	MD	PC	4.0	35
			1300	FF						4.0	35
		J51	1330	FF	6.9	7.1	0.2	LT	PC	4.0	60
	21/09/89	Y28	0800	LE	6.9		0.4	LT	CL	3.0	100
		P36	0840	LE	6.7		0.3	LT	CL	4.0	50

Appendix Table 1. (cont.)

Sample Round	Date	Station	Time EST	Tide	pH	D.O. (ppm)	Secchi (m)	Wind	Sky	Max. Depth (ft)	Dist. Ext. (ft)
		P42	0930	LE	6.9	6.9	0.4	LT	CL	4.0	40
			1000	LS						4.0	40
		P45	1030	LE	6.9		0.4	LT	PC	4.0	20
			1100	LE						4.0	20
		P50	1125	LE	6.9		0.4	MD	PC	4.0	30
			1155	LE						4.0	20
		P55	1240	FF	7.0		0.3	MD	PC	4.0	80
		P61	1315	FF			0.7	MD	PC	4.0	15
		Y21	0755	LE	6.9	4.4	0.3	LT	PC	2.5	100
		Y15	0836	LE	7.0	5.8	0.6	CLM	PC	2.5	100
		R12	0953	LE	7.5	5.7	1.0	CLM	PC	2.5	100
		R21	1050	FF	7.2	6.6	0.7	CLM	PC	4.0	100
		R44	1251	FF	7.4	7.8	0.8	LT	PC	3.5	100
			1321	FF						3.5	100
	23/09/89	M41	0925	LE	6.6	5.9	0.9	MD	CDY	4.0	45
			0955	LE						4.0	45
		M33	1020	LE	6.5	5.7	0.4	MD	CDY	4.0	50
			1050	LE						4.0	50
		M44	1130	LE	6.2	5.8	1.0	MD	CL	4.0	50
			1200	LE						4.0	50
		M47	1220	LE	6.1	6.7	0.5	MD	PC	4.0	30
			1250	LE						4.0	30
		M52	1330	LS	6.0	5.2	0.8	MD	CL	4.0	75
	27/09/89	J12	1107	MF	7.5		1.0	LT	CL	4.0	100
		J22	1215	MF	7.4		0.2	ST	CL	4.0	30

Codes:

Tide
- HS - High Slack
- 1E - First Ebb
- ME - Middle Ebb
- LE - Last Ebb
- LS - Low Slack
- 1E - First Flood
- ME - Middle Flood
- LE - Last Flood

Wind
- CLM - Calm
- LT - Light
- MD - Moderate
- ST - Strong

Sky
- CL - Clear
- HZ - Haze
- PC - Partly Cloudy
- CDY - Cloudy