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Final Report

DEVELOPMENT OF A SAMPLING EXPERT SYSTEM:"FISHMAP"

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Executive Summary

This research program consisted of three major component areas: (I) development of experimental design, (II) calibration of the trawl design, and (III) development of the foundation for stock assessment analysis. The products which have resulted from the program are indicated below:

I. EXPERIMENTAL DESIGN

I.1 Experimental Design

The study was successful in identifying spatial and temporal distribution characteristics of the several key species, and the relationships between given species catches and environmental and physical factors which are thought to influence species abundance by areas within the mainstem of the Chesapeake Bay and tributaries.

We developed an efficient sampling program which provides the necessary levels of system stratification for cost effective application to provide minimum effort for the maximum resolution of species-specific abundance estimations. The proposed sampling program, the Fishmap system, is adaptive in that it provides the flexibility to have the design accommodate real-time changes in species density and environmental vagary.

A workshop was conducted to discuss the statistical analyses of trawling data. Participation at the workshop included leading members of the Chesapeake Bay Stock Assessment Committee (CBSAC) from the institutions Chesapeake Biological Laboratory (CBL), Virginia Institute of Marine Science (VIMS), Maryland Department of Natural Resources (MDNR), National Oceanic and Atmospheric Administration (NOAA) and Pennsylvania State University (PSU). The workshop defined the levels of cooperative baywide trawling efforts required among the groups, and efficient statistical estimation schemes to be implemented for future baywide program analysis. The group's recommendations were: (i) to provide baywide stock assessments, (ii) to develop a strategy to integrate all Chesapeake Bay trawling programs, (iii) to enhance the quality of data collection and the processes of data transfer, and (iv) facilitate model identification.

I.2 Analysis and Review of Available Trawl Survey Information.

The historical trawl data was organized and reduced to a computer interactive database. The information is organized by species and area. The data was standardized to facilitate statistical analysis.

Our analysis focused on sources of variability and trends in abundance in the historical data. The inter-annual variability in observed catches exhibited a strong spatial relationship, which may have been forced by physical conditions, primarily functional changes in salinity and temperature. A concurrent study of fish community structure suggested that there have been no major changes in system biomass over the range of data examined; however, intra-annually there appears to be a significant shift in species diversity through the summer-fall period.

Analyses of the 1989 trawl data suggest that certain species are found in close association within specific areas and times. The implication for multispecies sampling is that single species sampling plans may be effective for multispecies assessment.

I.3 Compilation of Data Base.

The archived historical trawl survey database has been implemented in a microcomputer database. The statistical database is available in a user-friendly front-end processor microcomputer environment.

I.4 Development of the Sampling System FISHMAP.

The operational FISHMAP expert system utilizes an intelligent front-end processor computing environment to integrate seven major functional components which facilitates the efficient identification of optimal trawl sampling procedures; (1) data acquisition, (2) spatiotemporal species size-class specific strategic information, (3) tactical models comprised of three submodels, (i) stratification, (ii) sample size and effort allocation, and (iii) sample site selection, (4) operations research-based optimal vessel routing to trawl sites, (5) field sampling decision rules, (6) population estimation and efficient resampling, and (7) system simulation.

The FISHMAP system has been designed specifically to provide a framework for identifying efficient stratified sampling procedures by; (1) providing a strategy to determine the number and real-time dimensions of sampling strata, (2) providing strategies to efficiently allocate trawling effort among sampling strata, (3) provide methodologies to access data during the shipboard sampling process, and use this data to make real-time modification to the sampling process, and (4) provide a strategy to determine what types or classes of data should be sampled.

From the data acquisition facilitated by the FISHMAP system, the user is provided the ability to evaluate potential environmental, anthropogenic, and fishing influences on stock abundance and thus makes determinations and takes steps to invoke the appropriate management actions relative to the magnitude of the factors involved.

II. TRAWL CALIBRATION

II.1 Trawl Calibration.

This study was involved in determining the most efficient complex of factors that optimizes trawling activity for a given species. Statistical information based on six principal variables was developed: (1) net configuration, (2) vessel operation, (3) depth of trawl operation, (4) trawl distance, (5) spatial orientation, and (6) temporal designation for single species targets.

Only one year of data was available for the trawl calibration study. However, we focused on a blanket design that would accommodate the multispecies fishery environment. The impetus was to allow estimation of the relative and absolute abundances on certain single species stocks complexed within a multispecies environment. Relative abundances in time and space for certain single species stocks have been made. Additionally, estimates of standardized effort and the catch accumulated by area have been calculated.

The 1989 sampling regime has provided baseline estimation of relative abundance for key species in both the mainstem of the Chesaepake Bay and river systems which facilitates comparisons. The trawl calibration efforts when combined with the relative abundance information will provide indices of absolute abundance which can, at the minimum, be incorporated into a fishery-independent production model analysis for the important finfish stocks in the Maryland portion of the Chesapeake Bay and tributaries.

II.2 Estimation of Population Vital Rates for Stock Assessments.

Species specific population vital rates have been estimated from the data collected during the 1989 trawl survey. Attempts are being made to parameterize the system specific population dynamics simulation model to determine optimal policy. The 1989 data was analyzed to determine sources of variability on species composition and abundance. Catch was statistically evaluated with respect to various environmental parameters. For certain species there was a size-specific differential distribution with respect to time and space within river systems.

Length frequencies were plotted by month and area for the seven dominant species. Modal analysis was conducted to determine underlying age structure of the trawl catch. In addition, length frequency data was analyzed for growth, mortality, and apparent recruitment indices by species group. Estimates of growth using length frequency analysis suggested an underestimation of the apparent growth rate presumably due to size selective mortality. Age data acquired from hard part (scale) analysis also suggested an underestimate of size at age with increasing age.

Age analysis was conducted specifically on white perch and spot. The impetus of these studies was development of a baywide sampling and analysis protocol for age determination for all species.

III. FOUNDATION FOR STOCK ASSESSMENT ANALYSIS

III.1 Foundation for Stock Assessment.

We conducted research into the optimal data collection and interpretation methodologies requisite for the effective management of key species. A general conceptual and robust interactive data requirements model were completed for key species.

An integrated interactive stock assessment software library for microcomputers with an accompanying manual has been developed.

Final Report

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1.0 INTRODUCTION

This report describes the activities and accomplishments of the research program, Development of a Sampling Expert System: FISHMAP (F-171- 89-008). The objective of the program was the development of an adaptive fishery-independent trawl sampling system, FISHMAP, which provides fishery managers with a tool for estimating precise measures of population abundance and dynamics indices, as well as procedures to assist in the collection of trawl data in a cost-effective manner. The program consisted of three major components; 1) experimental design, 2) trawl calibration, and 3) foundation for stock assessment analysis. In these three components, seven projects were conducted including 1) experimental design, 2) analysis and review of available trawl survey information, 3) compilation of a data base, 4) development of a prototype FISHMAP system, 5) trawl calibration, 6) provide information on spatiotemporal distribution, availability, gear selectivity, life history, and population dynamics based on 1988-1989 trawl generated data, and 7) foundation for stock assessment analysis. The program started December 19, 1988 and ended December 18, 1989. It should be noted that certain aspects of the research program differed from the original proposal. Originally sampling was to be limited to areas in the vicinity of Solomons, MD, similar to those visted in 1988, in an effort to gather additional information on sources of trawling variability. However at the urging of Maryland's Department of Natural Resources, the breadth of sampling was increased and a baywide survey initiated in March 1989.

The formulation of effective fishery resource management strategies relies on precise measures of population abundance and dynamics indices, and an understanding of the functional relationships between these indices and fishing parameters. While information obtained through analysis of commercial fisheries data does allow some estimation of population parameters (population abundance and dynamics indices), inferences concerning the status of stocks are difficult to make using only commercial statistics. These data are biased both by the spatial distribution of the fishing effort and the selectivity of the fishing gear. Analysis of these data require the invocation of a number of assumptions which may lead to conclusions that are inconsistent with observed facts. As a result of these problems, fishery independent sampling procedures, particularly bottom trawl surveys, are generally used to estimate population parameters. Trawl survey objectives are generally concerned with 1) the estimation of indices of abundance per unit area, 2) the collection of large numbers of fish to estimate population dynamics indices, or 3) a combination of objectives 1 and 2. Because fish tend to be heterogeneously distributed, stratified random sampling procedures are generally used to collect punctional data (Clark, 1981; Halliday and Koeller, 1981; Pitt et al., 1981).

A series of trawl surveys provides fishery resource managers with a record of population changes over time and is used in the formulation of management strategies. But for many surveys, indices of both abundance and population dynamics are not very precise. Management strategies formulated using these indices can be ineffective due to this low precision. The focus of this research is the development of an adaptive fishery-independent trawl sampling system which provides fishery managers with a tool for estimating precise measures of population abundance and dynamics indices, as well as procedures to assist in the collection of trawl data in the most cost-effective manner. The system, FISHMAP, is a fisheries resource mapping and sampling system targeted to eventually involve Chesapeake waters of both Maryland and Virginia and to have general applicability in other areas. This is not to say that contemporary sampling procedures are inadequate, but rather limited in the amounts of data they provide to formulate effective management decisions.

The problem with many contemporary trawl surveys lies with their inability to detect differences in population parameters between years and locations. Estimates of abundance are highly variable despite the invocation of variance-reducing stratification procedures during sampling. For example, the Northeast Fisheries Center of the National Marine Fisheries Service has been engaged since 1963 in an intensive multispecies bottom trawl survey program off the northeast coast of the U.S.A. An autumn survey was initiated in 1963, a spring survey was initiated in 1968, and summer and winter surveys have also been conducted but on an intermittent basis. The surveys were designed to monitor trends in abundance and distribution, to determine population age/size composition, and to provide ecological data required to understand interrelationships between the environment and fishery resources of the Atlantic Shelf from western Nova Scotia to Jacksonville, Florida. The program uses a stratified random sampling design, with stratum boundaries based on depth, latitude, and historic fishing patterns (see Survey Working Group, Northeast Fisheries Center (1988) for a detailed description of sampling procedures). Despite these stratification measures to reduce variance, time series of abundance for many of the species contain high variances making it difficult to detect differences between consecutive years. For example, annual mean abundance and 95% confidence intervals for Atlantic cod collected during the autumn survey in the Gulf of Maine from 1963 to 1985 indicate that differences between individual years are difficult to detect due to high within year variability (Survey Working Group, NMFS, 1988). The time series of mean abundance and 95% confidence intervals for yellowtail flounder collected during the autumn survey in the southern New England area shows similar results (Figure 2). Differences in mean abundance between years cannot be detected except in those years when a "collapse" in the population occurs.

In an effort to reduce the high variability associated with annual estimates of abundance, an alternative approach for estimating mean and variance has been proposed. Pennington (1983, 1986) has suggested using the delta-distribution discussed in Aitchison and Brown (1957) for modeling the distribution of catches from fish and plankton surveys. The statistical advantage of using the delta-distribution is that the estimator of the mean for this distribution is more efficient then the ordinary sample mean estimators currently used to estimate abundance within the strata of the study areas. However, the efficiency calculations of

Pennington are based on large-sample approximations of the variance of the delta-distribution estimator mean, and may not be very efficient in small sample situations that are more the rule for trawl surveys (Smith, 1988). When delta-distribution estimators for stratified mean abundance and variance are applied to the data on Atlantic cod and yellowtail flounder collected in the NEFC's autumn survey, and 95% confidence intervals calculated, high within year variability still exists making it difficult to detect differences in abundance between years (see Survey Working Group, NMFS, 1988).

The reason for the high variability and ultimate lack of trend detectability between years in both estimation procedures (ordinary linear estimates and delta-distribution estimators) is thought to result from a combination of incorrectly specified strata and inappropriate allocation of sampling effort to each stratum (Gavaris and Smith, 1987). If information on the spatiotemporal distribution of fishery resources, as well as expected catch rates from the survey were known before the survey, a more efficient stratification and effort allocation scheme could be made, thus increasing the precision of abundance estimators (Francis, 1984).

If a mechanism was available to easily access the historical trawl data, prior information on catch rates and sources of trawling variability could be used to effectively set stratum boundaries and effort allocations, resulting in more efficient estimates. This goes beyond simply assuming an invariant skewed distribution of catch data for all life-stages, over all spatial and temporal scales, and a single invariant stratification scheme (e.g. depth) for all life-stage and species combinations. This inferred similarity in behavior among all life-stage and species combinations, imposed through a single stratification scheme, is highly unlikely. Each life-stage and species combination has a preferred or tolerated range of environmental and physical conditions, not necessarily overlapping. Physical and environmental variables which have been identified as being related to local variability of fish abundance could be incorporated as covariates into a statistical model of catch per tow and these relationships used to formulate a more efficient stratification scheme. The precision of estimates generated using this stratification scheme would be greater due to the inclusion of factors effecting variability in the sampling process. This precision is maximized when these factors are observed in real-time. Other factors such as variations in the performance of the trawl gear also need to be considered, and can be used to define temporal aspects of the sampling process. The identification of factors affecting variability, and their incorporation into a real-time sampling scheme, is complex due to the many permutations and combinations of ways these factors interact. Therefore, what is required is a codified approach which allows for the identification of factors affecting catch and a mechanism for incorporating these relationships into a real-time sampling process. This research addresses this need and is expected to contribute to improved decision-making in Chesapeake Bay fishery resource management through the development of the FISHMAP system. The implementation of the FISHMAP system will insure that decision makers receive precise estimates of abundance and population dynamics indices for specific segments of the population in order to evaluate the effects of the environment, anthropogenic activity, species introduction/interaction, and fishing, and to trigger appropriate management activities regarding these effects.

2.0 MATERIALS AND METHODS

Because data from both the 1988 and 1989 trawling surveys are discussed in subsequent chapters, the sampling plans for both years are described. Since the 1988 sampling plan was previously described only a brief description is included. For further detail regarding the 1988 sampling plan see Rothschild, et.al. (1989).

Collection Vessel and Gear

A total of 666 trawls were fished in 1989, aboard Chesapeake Biological Laboratory's research vessels ORION and AQUARIUS. The trawl used is the same gear used in 1988.

Sample Extent, Effort, and Selection

During 1988, sampling was bimonthly and restricted to the Patuxent River and adjacent Chesapeake Bay transects in the vicinity of Solomons, Maryland. The objective of the 1988 sampling was two-fold. Sampling during the early part of the year, January through May, was for gear testing. Three otter trawls were tested, two shrimp otter trawls and a high-rise otter trawl, and the most efficient trawl in terms of numbers and size classes caught, as well as operation aspects, identified. Results suggested that the high-rise otter trawl was the most efficient (Rothschild et al., 1989). Sampling during the latter half of 1988, June through December, was conducted to identify preliminary sources of trawl variability and spatiotemporal distributions of fish and shellfish. During this phase, trawling was standardized at a distance of 0.5 nm using the high-rise otter trawl with 30-foot sweep.

In 1989, monthly sampling was conducted using the 30-foot high-rise bottom trawl. Trawling distance was standardized at 0.5 nm. During January and February, sampling was restricted to the same area sampled in the latter half of 1988, the Patuxent River and adjacent Chesapeake Bay transects. The objective was to gather additional data on sources of variability. At the urging of Maryland's Department of Natural Resources, the breadth of sampling was increased and a baywide survey initiated in March 1989. Sampling areas comprise the mainstem of the Chesapeake Bay from the Virginia/Maryland state line to the Chesapeake and Delaware Canal in water depths greater than 15 feet, as well as the Patuxent and Choptank Rivers.

During each monthly cruise approximately 71 stations are sampled. Except in November and December when the number of sample sites dropped to 10 and 25, respectively, as a result of weather. Of the 71 stations, 13 stations occur at fixed locations. Eight fixed stations occur in the mainstem of the Chesapeake Bay and 5 stations occur at fixed locations in each of the two tributaries. Replicate trawls were taken at the river stations, one with and one against the current. Replicates were not taken at the mainstem sampling stations due to time constraints. Because of time constraints, sampling frequency within each of the tributaries alternated between months. The location of fixed-site locations visited during 1989 are shown in Figure 2.1. The 53 stations remaining are located in the mainstem and their placement randomly chosen according to stratified random sampling procedures, with strata being defined by depth. Maryland's portion of the mainstem

Chesapeake Bay was divided into depth strata of 0-30 feet, 31-60 feet and greater than 61 feet. These depth strata were then broken down into east and west components relative to the main channel. Percent surface area of each depth stratum, relative to Maryland's portion of the Chesapeake Bay was calculated and the 53 stations proportionally allocated between the strata. Within each strata a one minute by one minute grid was developed and station numbers assigned to each grid node. A random number generator was used to randomly choose station numbers which represented sampling stations for the next trawl cruise. An example of monthly sampling sites is presented in Figure 2.2.

Data collected during each haul includes species specific information such as total number caught, total biomass, total length (for up to 60 individuals), sex, and scales for age analysis. A subsample of fish (key-species only) from each trawl were brought back to the laboratory for analysis of population dynamics parameters. In addition, measurements of the physicochemical parameters water depth, tide, salinity, water temperature, and dissolved oxygen are also recorded. Salinity, temperature, and dissolved oxygen is monitored after each trawl using a Seacat Profiler, model SBE 19, conductivity, temperature, and depth recorder (CTD).

Laboratory Procedures

All fish brought back to the laboratory were weighted, measured for total length, the sex determined, and scales removed. Samples not identifiable in the field were also brought back to the laboratory and identified.

Data Management

All trawl survey data collected in 1989 was entered into the Quattro spreadsheet program (Borland International, 1989) following each sampling period. The format used is compatible with the database management system dBase IV (Aston-tate, 1989), which is used in the FISHMAP system. All Quattro files have been converted to dBase files.

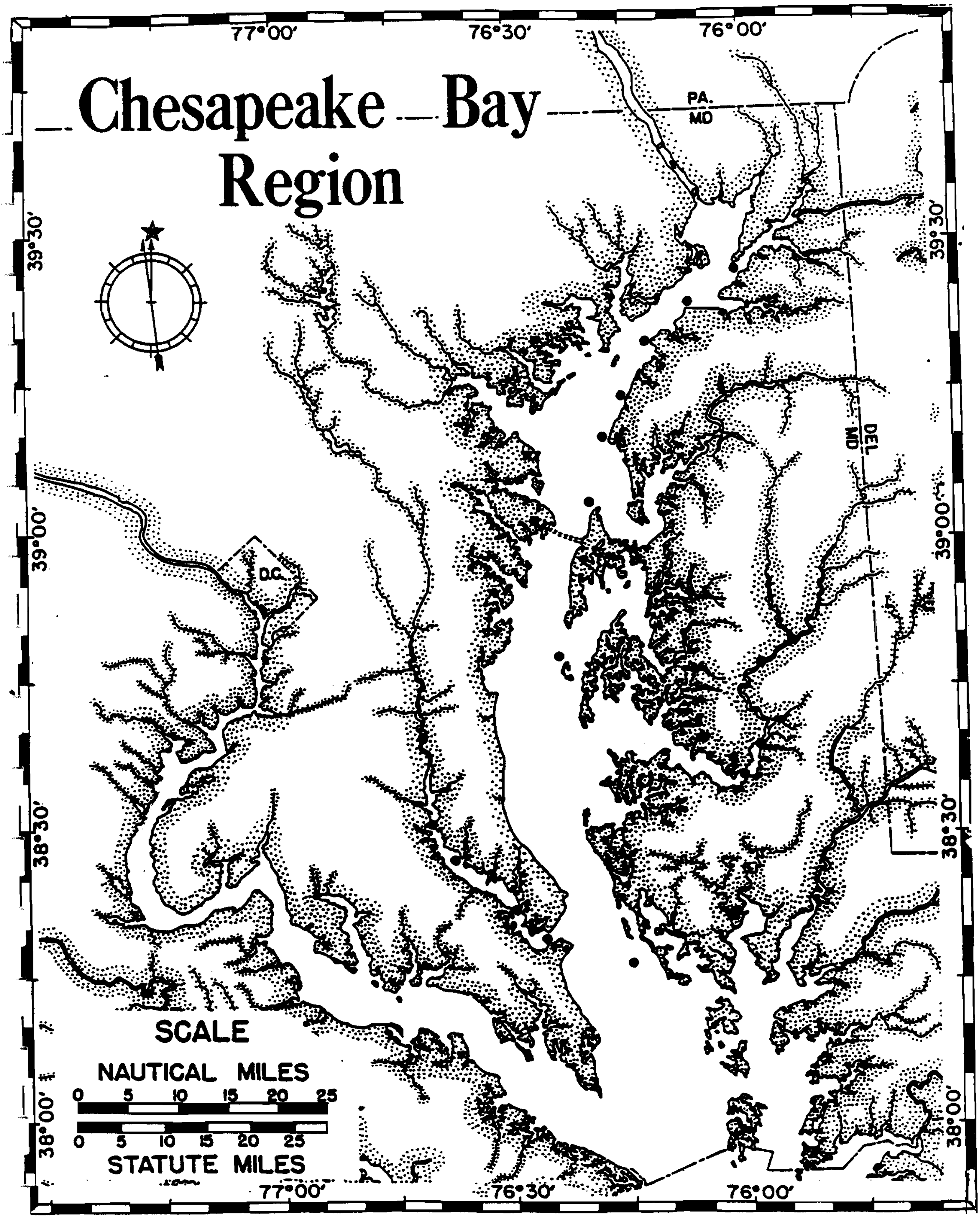
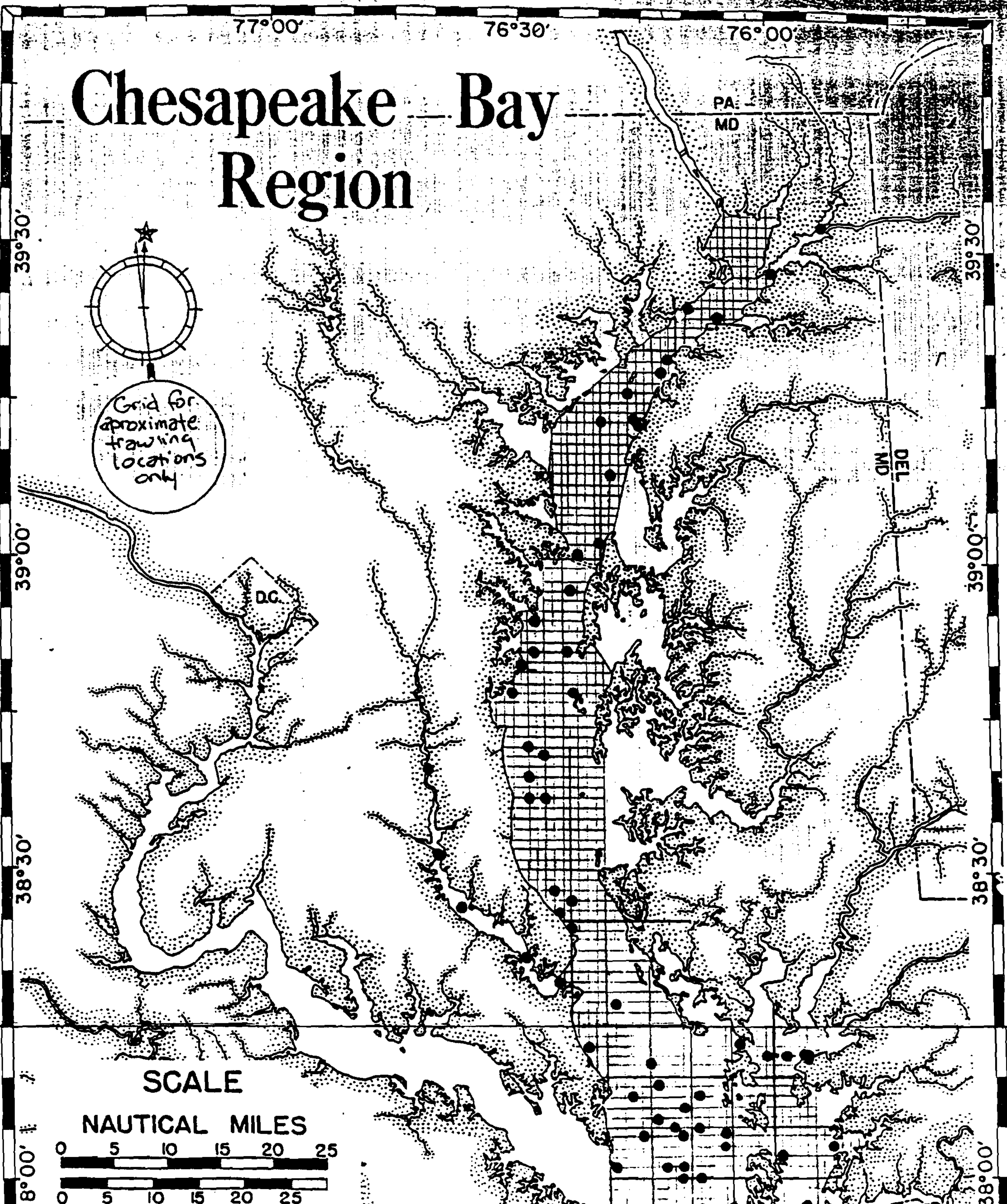


Figure 2.1. Location of fixed stations sampled in 1989.


Chesapeake Bay
Region
77°00'
76°30'
76°00'
PA
MD
39°30'
39°00'
38°30'
38°00'
Grid for aproximate trawling locations only
D.C.
MD
DEL
SCALE
NAUTICAL MILES
0 5 10 15 20 25
0 5 10 15 20 25
STATUTE MILES

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3.0 FISH SPECIES COMPOSITION AND ABUNDANCE

Of the 60 fish species collected during 1989 (Table CA), 5 species accounted for almost 90% of the annual mean catch-per-unit-effort (CPUE=catch per 0.5 nautical mile (nm)) of all species combined. These five species, in order of abundance, were hogchocker (Trinectes maculatus), spot (Leiostomus xanthurus), white perch (Morone americana), channel catfish (Ictalurus punctatus), and bay anchovy (Anchoa mitchilli) (Table CB). With the exception of the bay anchovy, which was most abundant during the fall, these species were most abundant during the late fall and winter months as were the total species CPUE values; however, late fall and winter data were not included in the annual mean figures (Table B) since areal coverage of sampling during these months (January, February, November, and December) was limited.

Tables CC through CG are complete monthly listings of CPUE values for each species caught, by region, during 1989. Data from 1988, which include collections from the mainstem Chesapeake Bay adjacent to the Patuxent River and from the Patuxent River are given as a comparative data source in Tables CH and CJ. The baywide distribution (exclusive of the Patuxent and Choptank Rivers) of all species combined is depicted by monthly CPUE contour plots in Figures A through K. Figure L shows Chesapeake Bay reference locations for the contour plots. Annual mean abundance values were consistent between regions, but peak abundance periods differed, as did dominant species

(Table J). Spot was the dominant species in the mainstem Chesapeake Bay south of the Bay Bridge and Tangier Sound regions, while hogchokers were dominant and white perch and catfish were particularly abundant in the Patuxent and Choptank Rivers and in the Chesapeake Bay north of the Bay Bridge. Above the Bay Bridge, monthly CPUE values were highest in July when spot were most abundant in this area, and in October, when hogchokers, white perch, and channel catfish were present in high numbers. In mainstem Chesapeake Bay south of the Bay Bridge, peak community abundance occurred during January when large numbers of spot were collected east of the Patuxent River. These catches accounted for almost 83% of all spot caught over the entire study period and almost 60% of the annual mean CPUE for all fish species combined in the mainstem below the Bay Bridge. In Tangier Sound, June and July were the peak abundance periods, with collections dominated by spot. Patuxent River CPUE values were highest in the September and November samples when hogchokers, white perch, channel catfish, and spot (September only) were particularly abundant. With the exception of the June sampling period, Choptank River CPUE values did not greatly differ between months.

The percentage contribution to the total catch (all species combined) of the predominant five species and one taxon (Ictalurus spp.) by season and by region are given in Figure M. The area above the Bay Bridge is clearly river-like, demonstrated by seasonal patterns, percentage of total catch figures, and species compositions remarkably similar to those of the two river systems. Hogchokers, white perch, and catfish comprised 96% of the total catch above the Bay Bridge during the spring, 49% during the summer, and 74% during the fall. In the Choptank and Patuxent Rivers, respectively, this collection of species comprised 98% and 94% of the total spring catch, 49% and 23% during the summer, and 80% and 88% in the fall. During the summer, spot (and bay anchovy in the Patuxent River) replaced white perch, hogchokers, and catfish as the dominant species. Spot and bay anchovy dominated the total catch data from both the mainstem below the Bay Bridge and the Tangier Sound area. Spot were particularly dominant during the summer and fall periods, while the bay anchovy was the predominant species during the spring.

During 1988 (Table CH) mainstem collections were restricted to areas adjacent to the Patuxent River and as such are not directly comparable with 1989 data. Data from the Patuxent River, however, indicate a high degree of year-to-year variability regarding dominance and abundance. During 1988, spot was the most abundant species collected from the Patuxent, but was ranked fourth during 1989. Spot mean annual CPUE was five times greater in 1988 than in 1989, but CPUE values for almost every other species collected were greater in 1989 than in 1988.

A complete set of environmental factor data, by region, month, on contour plots, and by river mile is given in Appendix A.

INDIVIDUAL SPECIES

Spot, *Leiostomus xanthurus*.

Spot is a widely distributed member of the drum family (Sciaenidae). This species occurs in the western Atlantic from the Gulf of Maine south to the east coast of Florida, and in the Gulf of Mexico. It occurs throughout the Maryland portion of the Chesapeake Bay, including all tributaries south of the Bay Bridge.

Spot inhabit marine, estuarine, and brackish waters and are most commonly found associated with mud bottoms and, to a lesser extent, sand bottoms. Spot spawn in offshore shelf areas in relatively deep water during the late fall and winter months. In moderate winters, juvenile spot may overwinter in deep trenches in the mainstem of Chesapeake Bay, while during more severe winters they migrate to coastal North Carolina.

During the 1989 study, spot was the second most abundant species collected baywide and occurred in the third highest number of samples (Table S1). Spot was the dominant species in two regions, the mainstem of the Chesapeake Bay below the Bay Bridge and Tangier Sound, and was the second most abundant species in the mainstem of the Chesapeake Bay above the Bay Bridge. On an annual baywide basis, spot peak abundance occurred during January. However, with the exception of the mainstem below the Bay Bridge, regional spot abundance peaks occurred during the summer. This difference in peak abundance timing was caused by the large numbers of spot collected during the winter in the mainstem below the Bay Bridge.

Spot Distribution

The baywide distribution (exclusive of the Patuxent and Choptank rivers) of spot by month is depicted in CPUE contour plots in Figures S1 through S7. Only April through October data are given here as FISHMAP did not randomly sample baywide before April or after October. During April, small numbers of spot were collected in three mainstem locations: approximately 16 km south of the Bay bridge, near the mouth of the Patuxent River, and east of the Potomac River. During May, large numbers of spot were collected in the Tangier Sound area while a small number remained in the locations where they were collected in April. During June, July, and August, spot abundance continued to be high in Tangier Sound, with large catches of spot also taken off the mouth of the Choptank River, and, during July and August, north in the Bay to the mouth of the Chester River. During September, spot were most abundant in three areas: north of the Bay Bridge near the Chester River, mid-bay centered in areas near the Choptank River, and in Tangier Sound. By October, most spot were found in the mainstem near the mouth of the Potomac River.

It appears that non-overwintering spot enter the Maryland portion of the Chesapeake Bay during May and June, funnel through Tangier Sound, and move progressively northward until July or August. They then move back down the Bay and by October are found just north of the Maryland-Virginia line. Some segment of the spot population may remain in the Maryland portion of the Chesapeake Bay during winter periods.

Spot Abundance (AVG-CPUE)

With the exception of January, when the sampling effort was limited to areas in and near the Patuxent River and in the Choptank River, spot were most abundant during the mid- to late-summer months (Figure S8). Spot AVG-CPUE values were generally greatest above the Bay Bridge and in Tangier Sound. However, the highest AVG-CPUE values were recorded during January near the mouth of the Patuxent River.

Spot AVG-CPUE and 95% confidence interval, by river mile, is given in Figures S9-S10 and S11-S13 for the Patuxent River for 1989 and 1988, respectively, and in Figures S14 and S15 for the Choptank River (1989 only). 1989 Spot AVG-CPUE values in the Patuxent River were greatest during September and in the Choptank River during August. During January and February 1989, the few spot collected in the Patuxent River were located near the mouth of the river. Spot were not collected again until July 1989, when they were most abundant near Long Point (river mile 18) and in September 1989 were evenly distributed from the mouth of the Patuxent to the Deep Landing area (river mile 25). The distributional pattern and abundance of spot was quite different during 1988. Spot were collected in relatively large numbers from the Patuxent River from May through November, 1988. During this period, data (Figures S11-S13) indicate a general upriver movement of spot, as peak abundance locations shifted from downriver stations in May and June (river miles 6 to 10), to midriver locations during the July-November period (river miles 14-18).

Spot were not collected in the Choptank River until April, 1989

(AVG-CPUE = 0.4) and in June were most abundant near the mouth of the Choptank River. By August, and continuing into October, spot were most abundant a few miles above the Cambridge Bridge (river mile 17).

Spot Mean Length and Size Class Distribution.

Monthly mean, minimum, and maximum lengths are given in Table S2, by region. From May through October, mean length data were similar among the regions. The minimum-maximum length data indicate, however, that spot population structure differed somewhat between regions. These differences are evident in Figures S16-S20, which give size class percentage frequency data for spot by month and by region. Spot size class distribution above the Bay Bridge (Figure S16) was dominated by 0+ year class individuals with few 1+ year class spot collected. Centered at 110 mm in June, the 0+ cohort is readily followed over time. After August, however, little growth is apparent with the cohort centered at 155 mm from August through October. There was another 0+ group collected in the region above the Bay Bridge during August and September. This cohort was, on the average, about 95 mm smaller than the other and appears to be offspring from the end of the spot spawning season.

In the mainstem below the Bay Bridge (Figure S17), large numbers of 1+ year class spot were collected during January and February. This group averaged about 100 mm during this period, but can only be followed through May. Whether these fish left this region or moved into depths too shallow to sample is not known. During May, 0+ year class spot were first collected and this cohort may be readily followed through October (only 3 fish were collected in December). This group averaged about 95 mm in June and, by August, about 155 mm. Little growth was apparent after August. As in the area above the Bay Bridge, another 0+ cohort was collected beginning in August. This cohort was 90 to 95 mm smaller, on the average, than the earlier 0+ group.

In Tangier Sound (Figure S18) 0+ and 1+ year class spot were collected during May, June, and July with a progressive domination of 0+ individuals. Centered at 50 mm in May, 0+ year class spot can be followed over time through October (when this cohort averaged about 135 mm). Little growth was apparent after August as in the mainstem regions, but the October average length of spot in Tangier Sound was about 20 mm less than those spot collected in mainstem samples. Unlike the mainstem regions, only one 0+ cohort was collected.

Spot were collected from the Choptank River only during June, August, and October (Figure S19). Choptank River spot populations were dominated by 0+ year class individuals with a few 1+ and 2+ year class fish taken during June. Mean length data and apparent growth characteristics were similar to those described for mainstem 0+ spot.

In the Patuxent River (Figure S20), a small number of 1+ year class spot were collected during January and February, similar in size to those found in the mainstem below the Bay Bridge during this period. The spot collected during July and through November, however, appeared to be 0+ year class fish and the earlier 1+ group was not apparent in samples taken after February.

Spot Abundance and Environmental Conditions.

A preliminary description of the relationship between spot abundance and depth, temperature, salinity, and dissolved oxygen follows. Two sets of AVG-CPUE vs. environmental data are discussed, one consisting of regional data with all time periods combined, and the second consisting of June and July data with all regions combined. A complete set of plots, by month and by region, is given in Appendix B.

CPUE vs. Environmental Plots by Region, all months combined.

This data presentation gives general regional trends of spot abundance with respect to environmental conditions (depth, temperature, salinity, dissolved oxygen). However, these relationships do not include temporal considerations.

Mainstem Above the Bay Bridge.

In this region, spot were most abundant within the following ranges of values (Figures S21 and S22):

Depth:	15-25 feet
Temperature:	24-28^{o}C
Salinity:	2.5-7.0 ppt
Dissolved Oxygen:	> 2.0 ppm

Mainstem Below the Bay Bridge.

In this region, spot were most abundant within the following ranges of values (Figures S23 and S24):

Depth:	15-125 feet, time dependent
Temperature:	15-28^{o}C, with the exception of winter

collections when temperatures were at or near 5°C

Salinity: 7.0-15.0 ppt, 22.0-23.0 ppt

Dissolved Oxygen: > 1.5 ppm

Tangier Sound.

In this region, spot were most abundant within the following ranges of values (Figures S25 and S26):

Depth: 15-45 feet

Temperature: 24.5-28.0°C

Salinity: 10.0-16.0 ppt

Dissolved Oxygen: > 4.0 ppm

AVG-CPUE vs. Environmental Plots by Month (June and July), all regions combined.

With the exception of winter catches, spot AVG-CPUE values in regions outside the tributaries were greatest during June and July (Figure S8). These months are highlighted here in Figures S27-S30 as plots of spot AVG-CPUE vs. depth, temperature, salinity, and dissolved oxygen. During these months, spot were most abundant within the following ranges of values:

Depth: 15-45 feet

Temperature: Not important

Salinity: 7.0-15.0 ppt, location dependent

Dissolved Oxygen: > 1.5 ppm

White perch, *Morone americana*.

White perch is a widely distributed member of the temperate bass family (Percichthyidae). Its natural range is from Nova Scotia along the Atlantic Coast to South Carolina, and it has been introduced into freshwater ponds and lakes in New England as well as Lake Erie and Lake Ontario. It occurs throughout the Chesapeake Bay and its tributaries.

White perch primarily inhabit fresh and brackish waters but on occasion have been found in high salinity areas. While commonly found near underwater structures (piers, brush, vegetation), they apparently prefer areas with mud, sand, or clay bottom types with little or no cover (rubble, shell, etc.)

This species appears to prefer depths of 4.6 to 9.1 m during summer daylight hours and 0.9 to 1.2 m during summer nighttime periods. During the winter, white perch are generally found in depths of 12.2 to 18.3 m although they have been taken from areas as deep as 42.1 m.

During the present study, white perch was the third most abundant species collected baywide and occurred in the fourth greatest number of samples. White perch was the second most abundant species in the two river systems, third most abundant in the mainstem above the Bay Bridge, but was not particularly abundant in either the mainstem below the Bay Bridge or in Tangier Sound (Table W1). Peak abundance periods were generally during the fall and winter with the exception of a high July catch above the Bay Bridge.

White Perch Distribution

The baywide distribution (exclusive of the Patuxent and Choptank

Rivers) of white perch by month is depicted by CPUE contour plots in Figures W1-W8. Readily apparent from these plots is the restricted nature of the distribution of white perch in mainstem Chesapeake Bay. This species is essentially found only in the river-like mainstem area above the Bay Bridge.

White Perch Abundance (AVG-CPUE)

Numerical AVG-CPUE white perch data are shown in Figure W9 by month and by region. As was previously mentioned, white perch rarely occurred in mainstem samples taken below the Bay Bridge or in Tangier Sound. The seasonal pattern of white perch abundance was similar between the area above the Bay Bridge and the Patuxent and Choptank Rivers. High winter AVG-CPUE values were followed by declines through the summer (excepting the July period above the Bay Bridge), with extremely high AVG-CPUE values found during the fall. In general, white perch AVG-CPUE values were higher in the two river systems than in the area above the Bay Bridge.

White perch AVG-CPUE and 95% confidence interval, by river mile, in the Patuxent River for 1989 and 1988 is given in Figures W10-W13 and W14-W16, respectively. In the Patuxent River, white perch were rarely found below river mile 18 (Long Point) until November, 1989. During January and February 1989, peak white perch abundance occurred at river mile 18 and from March through September 6-10 miles above Long Point. During November 1989, white perch were concentrated near Battle Creek (river mile 14). The highest 1989 AVG-CPUE values were recorded during September.

During 1988, Patuxent River white perch AVG-CPUE values were much lower than those recorded for 1989, and although white perch were, as in 1989, rarely collected below river mile 18, peak abundance was, in general, located at river mile 18. It should be noted, however, that during July through October 1988, the uppermost stations were at or below river mile 20.

In the Choptank River (Figures W17-W20), white perch were never collected below river mile 17 (Goose Point). During January, peak white perch AVG-CPUE values were at river mile 42 (Denton), while during February, white perch peak AVG-CPUE values were found at river miles 17 and 26 (Lloyds Landing). From April through October, the highest AVG-CPUE values for white perch were recorded at river mile 17. In December, peak AVG-CPUE occurred at river mile 26, with large numbers also taken at river mile 37 (Fowling Creek). Choptank River white perch AVG-CPUE values were particularly high during the winter and fall.

White Perch Mean Length and Size Class Distribution

White perch mean, minimum, and maximum lengths are shown in Table W2 by region and by month. The main difference among the three regions with resident white perch populations was the greater number of small white perch found in the Patuxent River. This is indicated by the size class frequency data depicted in Figures W21-W25.

Few 0+ year class white perch were collected in the area above the Bay Bridge with most found during September (Figure W21). The one-year-old individuals collected in March were taken only sporadically through June. From April through October, older fish, 2+ and greater, dominated upper bay collections.

Similarly, few 0+ year class perch were taken from the Choptank River (Figure W24) and these were collected primarily in October and December. As in the upper Bay, older fish dominated the population.

0+ year class white perch were relatively more abundant in the Patuxent River than in either the upper Bay or the Choptank River. These young-of-the-year were collected from July through November. During January through May, older fish dominated the population.

White Perch Abundance and Environmental Conditions

A preliminary description of white perch CPUE related to depth, temperature, salinity, and dissolved oxygen is presented here. For the purpose of this report, data combined over all sample periods and for three regions are discussed. Monthly CPUE vs. environmental condition plots for all regions are given in Appendix C.

Patuxent River

Depth. White perch were collected from depths ranging from 12 to 40 feet (Figure WP26). With one exception, the largest catches were taken in depths ranging from 15-30 feet. In this data set, there was no apparent seasonal trend with respect to white perch abundance and depth, although from historical data and from a recent winter survey (1990) (Homer et al., 1990) it is known that white perch seek deep areas during the winter.

Temperature. The largest collections of white perch occurred in two bands of temperature, 2.5-12.0^{o}C and 26.0-28.0^{o}C (Figure WP27).

This apparent distribution is tempered, however, by the distribution of samples over temperature as hauls were made in temperatures of 13.0-25.0°C. As with depth, it is known that white perch concentrate in relatively small areas during the winter, a behavior reflected in the extremely high winter CPUE values from previous and ongoing studies.

Salinity. As with temperature, white perch catches, highest CPUE values and in general, ocurred in two salinity bands, 0.0-3.0 ppt and 12.0-15.0 ppt (Figure WP28). Note, however, that few samples were taken between 4.0 and 11.0 ppt.

Dissolved oxygen. No white perch were collected from locations where dissolved oxygen was less than 4.0 ppm (Figure WP29). Most of the largest catches occurred above 6.0 ppm.

Preliminary results of the 1990 winter survey indicate that sampling for white perch should occur during January and February in depths greater than 25 feet, temperatures of 2.0-5.0°C, and salinities of 5 ppt or less.

Choptank River

Depth. In the Choptank River, white perch were collected from depths ranging from 10 to 35 feet with the largest catches in the 15-21 foot range (Figure WP30).

Temperature. The range of sampled temperatures was too limited to discern a pattern (Figure WP31), but as previously mentioned, white perch concentrate during the winter months.

Salinity. White perch catches plotted against salinity gave no apparent pattern for the Choptank River (Figure WP32).

Dissolved oxygen. White perch were not collected in the Choptank River from locations where dissolved oxygen was less than 3.0 ppm (Figure WP33). Most white perch caught were taken from areas of 6.0 ppm or greater.

Future sampling in the Choptank River would follow that outlined for the Patuxent River.

Mainstem Above the Bay Bridge

Depth. White perch were caught above the Bay Bridge in depths ranging from 10 to 50 feet with the highest CPUE values generally associated with the 10-30 foot range (Figure WP34).

Temperature. In this region, no strong pattern between white perch abundance and temperature was evident, although perch were most abundant at temperatures of 12.0-16.0°C and at 27.0-28.0°C (Figure WP35).

Salinity. White perch were rarely collected from locations where salinity exceeded 9.0 ppt, with no strong pattern of white perch abundance over the salinity range of 0.0 to 9.0 ppt (Figure WP36).

Dissolved oxygen. White perch occurred in only one sample in areas of less than 5.5 ppm dissolved oxygen, with the largest collections occurring in areas with greater than 7.0 ppm (Figure WP37).

Future sampling for white perch in the mainstem of the Chesapeake Bay would be limited to areas above the Bay Bridge during winter months, similar to that proposed for the Patuxent and Choptank Rivers.

Striped bass, *Morone saxatilis*.

The striped bass is the largest member of the temperate bass family (Percichthyidae) and ranges along the western Atlantic coast from the St. Lawrence River south to the St. Johns River in Florida. They have also been reported in Gulf of Mexico tributaries in western Florida, Alabama, Mississippi, and Louisiana. Striped bass have been successfully introduced into the lower Sacramento River, California and now are found along the Pacific coast from British Columbia south to Ensenada, Mexico. This species has also been successfully introduced into numerous reservoirs, lakes, and rivers throughout the United States and also into locations in several European and Asian countries.

Juvenile striped bass appear to prefer shallow water over sand or gravel bottoms during summer and fall periods, but during the winter 0+ year class bass are found primarily in deep holes or trenches greater than 8 m. Striped bass adults are found in a variety of inshore habitats, sandy beaches, rocky shorelines, shallow water, deep trenches, bays, and rivers.

During the present study, striped bass was the 10th most abundant species baywide and occurred in the fifth greatest number of samples. Striped bass AVG-CPUE ranked fifth among all species in the Patuxent River, seventh above the Bay Bridge, and eighth in the Choptank River (Table SB1). This species was most abundant during the fall above the

Bay Bridge and during the winter in the two river systems.

Striped Bass Distribution

The baywide distribution (exclusive of the two river systems) of striped bass by month is depicted by CPUE contour plots in Figures SB1-SB8. As with white perch, striped bass were rarely collected in areas below the Bay Bridge.

Striped Bass Abundance (AVG-CPUE)

Numerical AVG-CPUE striped bass data are given in Figure SB9 by month and by region. Bass were rarely taken in the mainstem below the Bay Bridge or in Tangier Sound. Striped bass were most abundant during the winter, particularly in the Patuxent River. During the summer and early fall periods, bass were most abundant in the area above the Bay Bridge.

Striped bass AVG-CPUE and 95% confidence interval, by river mile, in the Patuxent River is given in Figures SB10-SB13 and SB14-SB17, for 1989 and 1988 respectively. Peak striped bass abundance in the Patuxent River during January and February 1989 was located near Long Point (river mile 18). During March 1989 bass peak AVG-CPUE occurred again at Long Point but were also relatively high near Hellen Creek (river mile 6). During May, July, and September 1989, few striped bass were collected, while in November peak abundance occurred at downriver stations, particularly near Hellen Creek.

During 1988, striped bass were generally less abundant than in 1989, and their distribution more restricted than in 1989. However, with the exception of November, peak abundance locations were similar between 1988 and 1989.

In the Choptank River (Figures SB18-SB20), striped bass were rarely collected below river mile 17 (Goose Point) and were, with the exception of October, most abundant at river mile 26 (Lloyds Landing). During October, most bass were collected at river mile 17.

Striped Bass Mean Length and Size Class Distribution

Monthly mean, minimum, and maximum lengths of striped bass are presented in Table SB2. These two sets of values differed substantially among regions, with generally greater mean lengths found in the two river systems than in the upper Bay.

Size class percent frequency plots of striped bass populations by month and by region are given in Figures SB21-SB25. In the area above the Bay Bridge (Figure SB21), 1988 year-class striped bass dominated collections from March through July, while 1989 young-of-the-year, initially collected during August, were dominant or co-dominant from August through October. Few striped bass were collected from either the mainstem below the Bay Bridge (Figure SB22) or from Tangier Sound (Figure SB23). Those fish caught below the Bay Bridge were generally larger than those collected above the Bay Bridge. Choptank River collections (Figure SB24) were dominated by large individuals (>2 years old) during the winter months. During April, the few bass caught were mostly 1+ year olds, while in August and October, collections were dominated by 0+ year class fish. During the winter, Patuxent River collections (Figures SB25) were dominated by 1988 and older year class striped bass. Few fish were taken in May and July and later collections were mixtures of young-of-the-year, 1+ and older striped bass.

Striped bass Abundance and Environmental Conditions

The abundance of striped bass as related to depth, temperature, salinity, and dissolved oxygen is summarized in this section for three regions and for all months combined. Monthly plots of striped bass versus environmental conditions for all regions are given in Appendix D.

Discussion is limited to the 1989 FISHMAP effort. Future sample strategies for striped bass, particularly juveniles, will be developed from a combination of this data set and the winter survey previously mentioned.

Patuxent River

Depth. Striped bass were collected in depths ranging from 10 to 70 feet (Figure SB26). Although data are limited, the largest CPUEs were associated with a depth range of 20 to 42 feet.

Temperature. Most of the striped bass collected in the Patuxent River during 1989 were taken in temperatures of 5.0°C or less (Figure SB27).

Salinity. Striped bass were primarily caught in a narrow range of salinity, 12.0-15.0 ppt (Figure SB28). A few were caught at less than 5.0 ppt and at 17.0 ppt.

Dissolved oxygen. With one exception, striped bass were not collected from locations with dissolved oxygen values of less than 6.0

ppm (Figure SB29).

Choptank River

Depth. In the Choptank River, striped bass were caught in depths ranging from 10 to 35 feet, with the highest CPUE values associated with depths of 21 feet or less (Figure SB30).

Temperature. Striped bass Choptank River CPUE values did not appear related to temperature, although samples were not taken over a temperature continuum (Figure SB31).

Salinity. The highest striped bass CPUEs were associated with a salinity range of 3.0 to 9.0 ppt (Figure SB32). Overall, striped bass were collected in salinities ranging from 0.0 to 11.0 ppt.

Dissolved oxygen. While a few striped bass were taken at locations with dissolved oxygen levels of less than 6.0 ppm, most were collected in areas with 6.0 ppm or greater (Figure SB33).

Mainstem Above the Bay Bridge

Depth. Striped bass were collected in the area above the Bay Bridge from a depth range of 10 to 50 feet, with the highest CPUEs associated with depths in the range of 15 to 26 feet (Figure SB34).

Temperature. The greatest abundance of striped bass in this region occurred at temperatures of 16.0-17.0°C and 25.0-28.0°C, although this species occurred in samples with a temperature range of 7.5 to 28.0°C (Figure SB35).

Salinity. Striped bass were collected in salinities ranging from 0.0 to 12.0 ppt with no strong abundance to salinity relationship over this range (Figure SB36).

Dissolved oxygen. A few striped bass were collected in areas with less than 4.0 ppm dissolved oxygen, but the majority were taken from locations of greater than 5.8 ppm (Figures SB37).

Weakfish, *Cynoscion regalis*.

The weakfish is a moderate-sized member of the drum family (Sciaenidae). They are found along the western Atlantic coast from Massachusetts Bay south to southern Florida, although occasionally reported from Nova Scotia and the west coast of Florida.

Juvenile weakfish prefer soft, muddy bottoms in low salinity areas during the summer, migrating to higher salinity areas during the fall. They leave estuaries during the early winter and overwinter in offshore areas off the coasts of Virginia and North Carolina.

During the present study, weakfish was the sixth most abundant species baywide and occurred in the seventh greatest number of samples. Weakfish ranked third in AVG-CPUE value among species collected in Tangier Sound where it was most abundant (Table WF1), particularly during the early fall.

Weakfish Distribution

The baywide distribution (exclusive of the Patuxent and Choptank Rivers) of weakfish by month is depicted by CPUE contour plots in Figures WF1-WF5. From June through August, weakfish were concentrated in the lower Bay regions, primarily in Tangier Sound. In September, while still concentrated in Tangier Sound, a few were also collected above the Bay Bridge. During October, weakfish were found near the mouth of the Patuxent River in the mainstem and south along the Eastern Shore including Tangier Sound.

Weakfish Abundance (AVG-CPUE)

Numerical AVG-CPUE weakfish data are given in Figure WF6 by month and by region. Weakfish were not particularly abundant before July and were always most abundant in Tangier Sound. A relatively large concentration was found in the Patuxent River during September.

The September 1989 Patuxent River weakfish AVG-CPUE by river mile data (Figure WF7) show two peaks occurring, one near Hellen Creek (river mile 6) and another larger peak near Deep Landing (river mile 25).

In 1988, although overall weakfish abundance was less than in 1989, this species was present in Patuxent River collections from July through November (WF8 and WF9). During the period of July through September, weakfish were generally most abundant in the lower portion of the river, although they were collected as far upriver as river mile 14. During October and November 1988, weakfish were collected from the mouth of the Patuxent upriver to mile 18, with peak abundances at river mile 18 during October and river mile 2 during November. During 1988, few samples were taken above river mile 20. Since large collections of weakfish were taken at river mile 25 during September 1989, the less extensive sampling program in 1988 may have contributed to the observed year-to-year difference in weakfish abundance.

In the Choptank River (Figure WF10), small numbers of weakfish were collected during August and October at river mile 17.

Weakfish Mean Length and Size Class Distribution

Weakfish mean, minimum, and maximum lengths are given in Table WF2 by month and by region. Mean lengths and size range data indicated similar weakfish population structures in the mainstem below the Bay Bridge and in Tangier Sound, and similar structures in the upper Bay and the two river systems.

Size class percent frequency distributions of weakfish are given in Figures WF11-WF15.

In the mainstem above the Bay Bridge, weakfish were collected only during August and September and appeared to be a mixture of 0+ and 1+ year class fish. Few weakfish were found in the Choptank River, but a large number of 0+ year class individuals were collected in the Patuxent River during September. In the mainstem below the Bay Bridge, 0+ fish dominated collections during August and October, and were co-dominant with larger individuals in September. June and July period collections in Tangier Sound were dominated by large (>200 mm) weakfish, but by September and through October, 0+ year class individuals, initially caught during July, dominated the collections.

Weakfish Abundance and Environmental Parameters.

Data from Tangier Sound are the focus of this section in which relationships between weakfish abundance and depth, temperature, salinity, and dissolved oxygen are briefly described. Plots of these parameters vs. weakfish abundance in the mainstem regions and in the two river systems are given in Appendix E.

Weakfish CPUE vs. Depth.

Weakfish abundance during the period June-October, 1989, is given in Figures WF16-WF18, by depth. With the exception of October, weakfish abundance was greatest in depths between 20 and 50 feet, with most of the larger collections found in 20-30 feet of water. During October, weakfish were most abundant at a depth of 55 feet.

Weakfish CPUE vs. Temperature.

During any month, Tangier Sound water temperatures were relatively constant among sample sites and no pattern of weakfish abundance and temperature was discernable (Figures WF19-WF21).

Weakfish CPUE vs. Salinity.

Weakfish CPUE vs. salinity plots are given in Figures WF22-WF24 for the period June-October, 1989. Although the range of salinity values in Tangier Sound was somewhat limited, weakfish were generally most abundant in the 11-15 ppt range.

Weakfish CPUE vs. Dissolved Oxygen.

With one exception, weakfish were most abundant in areas where dissolved oxygen levels were at least 4.0 ppm (WF25-27). During July, the largest collection of weakfish occurred at a location where the dissolved oxygen level was recorded at less than 1.0 ppm.

A preliminary sampling schedule, suggested by the data given here, is presented below:

Location:	Tangier Sound
Time Period:	July and September
Depth:	20-30 feet

Temperature: Not Important

Salinity: 11.0-15.0 ppt

Dissolved Oxygen: > 4.0 ppm

Summer flounder, Paralichthys dentatus.

The summer flounder, a member of the left-eye flounder family (Bothidae), ranges along the western Atlantic Coast from Nova Scotia to Florida and is also found in the northern Gulf of Mexico. In the Maryland portion of the Chesapeake Bay, this species occurs from the Bay Bridge south throughout the mainstem and Tangier Sound.

Juvenile summer flounder move into brackish or estuarine waters shortly after metamorphosis while adults migrate during the winter from nearshore areas to coastal waters. Summer flounder are found primarily over sand and hard bottom types, but may also be located in grass beds, over mud bottoms, or near submerged structures.

During the present study, summer flounder was the eighth most abundant species collected baywide and occurred in the tenth greatest number of samples (Table SF1). By CPUE, summer flounder ranked fifth and ninth among species collected from Tangier Sound and the mainstem below the Bay Bridge, respectively. This species was rarely encountered elsewhere. In all regions, summer flounder were most abundant during the summer.

Summer Flounder Distribution

The baywide distribution (exclusive of the two sampled river systems) of summer flounder by month is depicted by CPUE contour plots in Figures SF1-SF4 by CPUE contour plots. During July and August, summer flounder were caught only in the southernmost portion of the study area and in Tangier Sound where they were most abundant. By September, summer flounder distribution included the area south of the Patuxent River with Tangier Sound still the area of highest concentration. During October, most summer flounder were taken in the mainstem below the Bay Bridge, east of the Patuxent River.

Summer Flounder Abundance (AVG-CPUE).

Summer flounder abundance, as AVG-CPUE, by region and by time period is given in Figure SF5. This species was most abundant during July, August, and September and, with the exception of October, most abundant in Tangier Sound. In October, AVG-CPUE was highest in the mainstem below the Bay Bridge.

Summer flounder abundance by river mile in the Patuxent River is given in Figure SF6 for 1989 and in Figures SF7 and SF8 for 1988. Summer flounder were collected only once during 1989, in September, and most individuals were located in the lower stretch of the Patuxent River. During 1988, summer flounder were taken in the Patuxent during May and from July through October, although this species was never particularly abundant. In general, peak abundances occurred at the lower river stations.

Few summer flounder were collected from the Choptank River and only during one sampling period, October 1989, and from one location, river mile 17 (SF9).

Summer Flounder Mean Length and Size Class Distribution.

Mean, minimum, and maximum summer flounder lengths by region and month are presented in Table SF2. No regional differences were readily apparent from these values. Size class frequency data (Figures SF10-SF13) showed similar patterns in the two regions where summer flounder were most abundant, Tangier Sound and the mainstem below the Bay Bridge. Most individuals collected were 1+ year class fish.

Summer Flounder Abundance and Environmental Parameters.

As with weakfish, data from Tangier Sound are the focus of this section. Summer flounder AVG-CPUE vs. depth, temperature, salinity, and dissolved oxygen are given in Appendix F for the mainstem above and below the Bay Bridge.

Summer Flounder AVG-CPUE vs. Depth.

With the exception of October, when this species was most abundant in 55 feet of water, summer flounder were generally most abundant in depths of 12-30 feet, with most of the largest collections in depths of less than 20 feet (Figure SF14).

Summer Flounder AVG-CPUE vs. Temperature.

Figure SF15 gives summer flounder AVG-CPUE vs. water temperature plots but, as with weakfish, the range of recorded temperatures was too limited to imply a pattern.

Summer Flounder AVG-CPUE vs. Salinity.

Summer flounder appeared to concentrate in a rather limited salinity range, 14.5-15.5 ppt, with few individuals collected outside this range (Figure SF16).

Summer Flounder AVG-CPUE vs. Dissolved Oxygen.

Summer flounder AVG-CPUE vs. dissolved oxygen plots are given in Figure SF17 for the period July through October, 1989. Few flounder were collected in areas with less than 5.0 ppm and the highest AVG-CPUE values were generally found in areas with dissolved oxygen values in excess of 7.0 ppm.

Based on data given here, the following is a preliminary sampling schedule for this species:

Location:	Tangier Sound
Time Period:	July and August
Depth:	15-25 feet
Temperature:	Not important
Salinity:	14.0-16.0 ppt
Dissolved Oxygen:	> 7.0 ppm

Atlantic croaker, *Micropogonias undulatus*.

The Atlantic croaker is a widely distributed member of the drum family (Sciaenidae). It occurs along the western Atlantic coast from Cape Cod south to Florida, and in the Gulf of Mexico to Campeche Bank. In Maryland, Atlantic croaker are found throughout the Chesapeake Bay and tributaries from the Patapsco River southward.

Atlantic croaker inhabit marine, estuarine, and brackish waters and are most abundant on mixed mud and sand bottoms but also have been taken from areas with mud, sand, mud and shell, sponge, and coral bottom types. Spawning takes place from August through December in offshore locations over a wide range of depths. Juvenile croaker often overwinter in the upper reaches of tidal estuaries, while older fish leave the Bay during the early fall.

During the present study, Atlantic croaker was the eighth most abundant species collected baywide and occurred in the eleventh highest number of samples (Table AC1). In the mainstem below the Bay Bridge, croaker was the second most abundant species and ranked sixth in the mainstem above the Bay Bridge and seventh in Tangier Sound. Baywide and below the Bay bridge, croaker were most abundant during February and December, while they were most abundant during October in the upper Bay and in Tangier Sound.

Atlantic Croaker Distribution

Baywide distribution (exclusive of the Patuxent and Choptank Rivers) of Atlantic croaker by month is depicted by CPUE contour plots in Figures AC1 through AC4. Few croaker were collected during May and June, but in July larger numbers were collected with their distribution restricted to the upper Bay and Tangier Sound. During August and September, Atlantic croaker abundance levels were again low, but relatively large numbers of croaker were collected during October in the mainstem from just north of the Bay Bridge south to Eastern Bay.

Atlantic Croaker Abundance (AVG-CPUE)

Atlantic croaker abundance (AVG-CPUE) by region and month is shown in Figure AC5. Croaker were most abundant during January and

February in the mainstem below the Bay Bridge, and during October, when croaker were relatively abundant in the upper Bay and the mainstem below the Bay Bridge.

Atlantic croaker were never particularly abundant in either of the two river systems, nor were they abundant in the Patuxent River during 1988.

Atlantic Croaker Mean Length and Size Class Distribution

Mean, minimum, and maximum lengths of Atlantic croaker by region and by month are given in Table AC2. The mean length data indicate that most of the croaker collected were young-of-the-year. Croaker collected during January and February were individuals just reaching the end of their first year.

Size class frequency distributions of Atlantic croaker populations by region and time period are given in Figures AC6 through AC8. Whenever large catches of croaker were taken, most of the fish collected were 0+ year class individuals. This occurred during October in the area above the Bay Bridge and in Tangier Sound, and during January, February, October, and December in the mainstem below the Bay Bridge.

Hogchoker, *Trinectes maculatus*.

This small member of the sole family (Soleidae) ranges in the Atlantic from Maine to Venezuela and is found in the northern Gulf of Mexico. In Maryland, hogchokers are found throughout the Chesapeake Bay and its tributaries from Havre De Grace south.

Hogchokers inhabit relatively shallow water over mud, sand, or silt bottoms and are found in salinities ranging from 0 to 50 ppt. Generally, hogchokers occur in shallow areas during the summer and overwinter in deeper areas. Spawning takes place from May through September in the lower regions of tributaries with hogchoker larvae migrating into low salinity waters.

During the present study, hogchokers were the most abundant species collected on a baywide basis, and occurred in the greatest number of collections (Table H1). This species ranked first by AVG-CPUE in the mainstem above the Bay Bridge and in the Patuxent and Choptank Rivers. Hogchokers ranked third in Tangier Sound and sixth in the mainstem below the Bay Bridge. Baywide, hogchokers were most abundant during April, May, and October with the timing of regional peaks quite variable (Table H1).

Hogchoker Distribution

Baywide distribution (exclusive of the Patuxent and Choptank Rivers) of hogchokers by month is depicted by CPUE contour plots in Figures H1-H8. During March, April, and May, hogchoker distribution in the mainstem of the Bay was restricted to areas above the Bay Bridge. From June through September, hogchokers were abundant and regularly collected in both the upper Bay and Tangier Sound. June and July were the only time periods when hogchokers were collected in mainstem areas other than the upper Bay or Tangier Sound. By October, hogchoker distribution was again restricted in the mainstem to areas above the Bay Bridge.

Hogchoker Abundance (AVG-CPUE)

Hogchoker abundance (AVG-CPUE) by region and by time period is shown in Figure H9. Hogchokers were overall most abundant during the spring and fall periods, and most abundant in the river systems and the region above the Bay Bridge.

Hogchoker AVG-CPUE and 95% confidence interval, by river mile, for the Patuxent River, is given in Figures H10-H13 and Figures H14-H17 for 1989 and 1988, respectively. In general, during 1989, hogchokers were more abundant in the upper portions (Deep Landing (river mile 25) and above) of the Patuxent study area than in the lower reaches. Exceptions to this were in July and November 1989 when peak hogchoker abundance occurred at Long Point (river mile 18).

During 1988, hogchokers were generally less abundant than in 1989 and data indicated several year-to-year differences in their spatial distribution. From February through May, 1988 hogchoker distribution was similar to that of 1989, although peak abundance occurred somewhat downriver from 1989 peaks during several time periods. During June 1988, peak hogchoker abundance occurred at river mile 6 and from July through September at river mile 14, again slightly downriver from 1989 peaks. During October and November 1988, hogchokers were most abundant at river mile 18, as found during 1989. Some of the year-to-year differences may have been related to differences in extent of sample locations between 1988 and 1989.

Hogchoker abundance in the Choptank River (Figures H18-H21) was generally greatest at and above river mile 26 (Lloyds Landing).

During June and August, however, peak hogchoker abundance occurred in the mouth of the Choptank River (June) and at river mile 17 (Goose Point).

Hogchoker Mean Length and Size Class Distribution

Mean and minimum and maximum length data of hogchokers by region and by month are shown in Table H2. Mean lengths were similar between regions and over time with about 100 mm total length appearing to be the standard.

Size class frequency distributions of hogchokers by regions and time period are given in Figures H22-H26. Few 0+ year class hogchokers were collected with older fish (1+, 2+, 3+ year classes) dominating the trawl collections. Population structure was similar among regions, although Tangier Sound mean lengths were consistently somewhat greater than those in the other regions.

Table CA . Species list from all 1989 FISHMAP trawls. Families are in phyletic sequence, with species of each family alphabetized to generic and specific names.[1]

	Family	
	Dasyatidae	
Southern Stingray		*Dasyatis americana* Hildebrand and Schroeder
Bluntnose Stingray		*Dasyatis sayi* (Lesueur)
	Anguillidae	
American eel		*Anguilla rostrata* (Lesueur)
	Congridae	
Conger eel		*Conger oceanicus* (Mitchill)
	Clupeidae	
Blueback Herring		*Alosa aestivalis* (Mitchill)
Alewife		*Alosa pseudoharengus* (Wilson)
American Shad		*Alosa sapidissima* (Wilson)
Atlantic Menhaden		*Brevoortia tyrannus* (Latrobe)
Atlantic Herring		*Clupea harengus harengus* Linnaeus
Gizzard Shad		*Dorosoma cepedianum* (Lesueur)
	Engraulidae	
Striped Anchovy		*Anchoa hepsetus* (Linnaeus)
Bay Anchovy		*Anchoa mitchilli* (Valenciennes)
	Synodontidae	
Inshore Lizardfish		*Synodus foetens* (Linnaeus)
	Cyprinidae	
Goldfish		*Carassius auratus* (Linnaeus)
Carp		*Cyprinus carpio* Linnaeus
Eastern Silvery Minnow		*Hybognathus regius* Girard
Golden Shiner		*Notemigonus crysoleucas* (Mitchill)
	Catostomidae	
Quillback		*Carpiodes cyprinus* (Lesueur)
White Sucker		*Catostomus commersoni* (Lacepede)
Silver Redhorse		*Moxostoma anisurum* (Rafinesque)
Shorthead(Northern) Redhorse		*Moxostoma macrolepidotum* (Lesueur)
	Ictaluridae	
White Catfish		*Ictalurus catus* (Linnaeus)
Yellow Bullhead		*Ictalurus natalis* (Lesueur)
Brown Bullhead		*Ictalurus nebulosus* (Lesueur)
Channel Catfish		*Ictalurus punctatus* (Rafinesque)
	Batrachoididae	
Oyster Toadfish		*Opsanus tau* (Linnaeus)

Table CA . (cont.)

	Gobiesocidae	
Skilletfish		_Gobiesox strumosus_ Cope
	Gadidae	
Spotted Hake		_Urophycis regia_ (Walbaum)
	Ophidiidae	
Striped Cusk-Eel		_Ophidion marginatum_ (DeKay)
	Atherinidae	
Rough Siverside		_Membras martinica_ (Valenciennes)
Atlantic Silverside		_Menidia menidia_ (Linnaeus)
	Syngnathidae	
Northern Pipefish		_Syngnathus fuscus_ Storer
	Percichthyidae	
White Perch		_Morone americana_ (Gmelin)
Striped Bass		_Morone saxatilis_ (Walbaum)
	Serranidae	
Black Sea Bass		_Centropristis striata_ (Linnaeus)
	Centrarchidae	
Pumpkinseed		_Lepomis gibbosus_ (Linnaeus)
Bluegill		_Lepomis macrochirus_ Rafinesque
Black Crappie		_Pomoxis nigromaculatus_ (Lesueur)
	Percidae	
Tessellated Darter		_Etheostoma olmstedi_ Storer
Yellow Perch		_Perca flavescens_ (Mitchill)
	Pomatomidae	
Bluefish		_Pomatomus saltatrix_ (Linnaeus)
	Sparidae	
Scup		_Stenotomus chrysops_ (Linnaeus)
	Sciaenidae	
Silver Perch		_Bairdiella chrysoura_ (Lacepede)
Spotted Seatrout		_Cynoscion nebulosus_ (Cuvier)
Weakfish		_Cynoscion regalis_ (Bloch and Schneider)
Spot		_Leiostomus xanthurus_ Lacepede
Northern Kingfish		_Menticirrhus saxatilis_ (Bloch and Schneider)
Atlantic Croaker		_Micropogonias undulatus_ (Linnaeus)

Table CA . (cont.)

Common name	Family	Scientific name
	Blenniidae	
Striped Blenny		Chasmodes bosquianus (Lacepede)
Feather Blenny		Hypsoblennius hentzi (Lesueur)
	Gobiidae	
Naked Goby		Gobiosoma bosci (Lacepede)
	Scombridae	
Spanish Mackerel		Scomberomorus maculatus (Mitchill)
	Stromateidae	
Harvestfish		Peprilus alepidotus (Linnaeus)
Butterfish		Peprilus triacanthus (Peck)
	Triglidae	
Northern Searobin		Prionotus carolinus (Linnaeus)
	Bothidae	
Fringed Flounder		Etropus crossotus Jordan and Gilbert
Summer Flounder		Paralichthys dentatus (Linnaeus)
Windowpane		Scophthalmus aquosus (Mitchill)
	Pleuronectidae	
Winter Flounder		Pseudopleuronectes americanus (Walbaum)
	Soleidae	
Hogchoker		Trinectes maculatus (Bloch and Schneider)
	Cynoglossidae	
Blackcheek Tonguefish		Symphurus plagiusa (Linnaeus)
	Tetradontidae	
Northern Puffer		Sphoeroides maculatus (Bloch and Schneider)

1. From American Fisheries Society, Committee on Names of Fishes (C.R. Robins, Chmn.) 1980. A list of common and scientific names of fishes from the United States and Canada. 4th ed. Am. Fish. Soc. Spec. Publ. No. 12. Bethesda, Md. 174 p.

Table CB . Abundance of dominant species collected from all locations as numerical CPUE by month. Annual mean includes only March -October data. Total fish includes species not listed.

	MONTH												
	1. JAN	1. FEB	2. MAR	2. APR	MAY	JUN	JUL	AUG	SEP	OCT	3. NOV	4. DEC	ANNUAL MEAN
SAMPLE SIZE	33	32	82	75	71	68	68	65	70	68	10	25	
SPECIES													
HOGCHOKER	3	29	19	147	145	39	62	27	68	144	844	1	81
SPOT	874	59	0	1	2	118	253	83	106	51	1*	1*	77
WHITE PERCH	99	100	41	53	8	19	34	19	122	101	246	6	50
CHANNEL CATFISH	33	51	51	27	30	10	34	10	31	41	236	0	29
BAY ANCHOVY	10	14	3	14	19	27	25	20	69	50	1*	9	28
WEAKFISH	0	0	0	1*	1*	1	8	5	36	10	0	0	8
WHITE CATFISH	6	86	1	13	1	1	1*	6	1	6	7	0	4
ATLANTIC CROAKER	18	69	1*	0	1*	1*	3	1	1	19	2	56	3
SUMMER FLOUNDER	0	0	1*	1*	1*	1*	7	6	4	2	0	1*	3
BROWN BULLHEAD	37	4	1*	8	1*	1	1*	1*	1*	1	0	0	2
STRIPED BASS	13	39	2	1	1*	1	1	3	2	5	12	1	2
ATLANTIC MENHADEN	1	50	2	1*	1	1	4	1*	1	2	2	3	1
AMERICAN EEL	1*	1*	1*	1*	2	1	3	1*	1*	1	2	0	1
TOTAL FISH	1111	512	124	268	213	225	447	185	456	442	1379	122	295
BLUE CRAB	1*	1*	1*	1	6	14	29	10	18	7	3	1*	11

* = less than one
1. Mid-bay mainstem and Patuxent and Choptank Rivers only
2. Does not include Tangier Sound
3. Patuxent River only
4. Mainstem south of Bay Bridge and Tangier Sound only

Table CC . Abundance of fish species collected above Bay Bridge as numerical CPUE by month.

	MONTH								
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	ANNUAL MEAN
SAMPLE SIZE	12	33	13	12	8	18	11	11	
SPECIES									
HOGCHOKER	56	114	336	84	123	14	10	336	134
SPOT	0	1*	0	2	481	43	87	37	81
WHITE PERCH	24	87	23	53	115	32	21	199	69
CHANNEL CATFISH	17	22	59	31	118	9	27	133	52
BAY ANCHOVY	3	21	1	5	1	49	15	27	15
ATLANTIC CROAKER	0	0	1*	1	5	1*	1	45	7
STRIPED BASS	1	1	1*	2	4	7	6	13	4
AMERICAN EEL	1*	1*	6	4	9	1*	1*	3	3
WEAKFISH	0	0	0	0	0	2	10	1*	2
CARP	1*	1*	1*	1	1	1*	1*	1	1
ATLANTIC MENHADEN	0	1	1	2	1*	1*	1*	3	1
WHITE CATFISH	0	2	1*	1*	1	1*	1*	2	1
ALEWIFE	0	1*	0	0	1*	0	1	4	1
OYSTER TOADFISH	1*	1*	1	1*	4	0	1*	0	1
BROWN BULLHEAD	0	1*	1*	3	1	1*	0	0	1
BLUE HERRING	0	2	0	0	0	0	0	0	1*
BLUEFISH	0	0	0	1*	1	1*	1*	1*	1*
YELLOW PERCH	0	1*	0	1*	0	0	0	1*	1*
AMERICAN SHAD	1*	1	0	0	0	0	0	0	1*
SPOTTED HAKE	1*	1*	1*	1*	0	0	0	0	1*
SILVERY MINNOW	0	0	0	0	1	0	0	0	1*
SUMMER FLOUNDER	0	0	0	0	1*	0	1*	0	1*
NAKED GOBY	0	0	1*	0	0	0	0	1*	1*
NORTHERN PIPEFISH	1*	0	0	0	1*	0	0	0	1*
SKILLETFISH	1*	1*	0	0	0	0	0	0	1*
GIZZARD SHAD	0	1*	0	1*	0	0	0	0	1*
BLACK CRAPPIE	0	0	0	0	0	0	0	1*	1*
SPANISH MACKEREL	0	0	0	0	0	0	0	1*	1*
BLUEGILL	0	0	1*	0	0	0	0	0	1*
BUTTERFISH	0	1*	0	0	0	0	0	0	1*
TOTAL FISH	103	253	428	189	865	156	178	815	373
BLUE CRAB	0	1	5	4	11	6	9	8	5

* = less than one

Table CD . Abundance of fish species collected in the mainstem below the Bay Bridge as numerical CPUE by month.

	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	DEC	ANN. MEAN
SAMPLE SIZE	16	14	60	32	38	37	37	32	39	42	20	
SPECIES												
SPOT	2618	176	0	1*	2	68	104	44	63	92	1*	288
ATLANTIC CROAKER	53	206	1	0	0	1*	1	2	1	23	111	36
BAY ANCHOVY	28	40	4	18	14	41	6	23	101	44	18	31
ATLANTIC MENHADEN	4	151	6	0	1*	2	1*	1*	1*	1*	6	16
BLUE HERRING	1	3	1*	1*	1*	1*	0	1*	0	0	78	8
HOGCHOKER	1	1	1*	0	1	7	21	1	1	1	1	3
WEAKFISH	0	0	0	1*	1*	1*	1*	5	4	10	0	2
ALEWIFE	2	3	1	1*	0	0	0	0	0	0	0	2
AMERICAN SHAD	1	14	1*	0	0	0	0	1*	0	0	0	1
SUMMER FLOUNDER	0	0	1*	1*	1*	1*	2	3	4	4	1*	1
HARVESTFISH	0	0	0	0	0	0	1*	2	5	3	0	1
BUTTERFISH	1*	0	0	2	1*	1*	1*	3	1	2	0	1
ATLANTIC SILVERSIDE	0	0	0	0	0	0	0	0	0	0	8	1
INSHORE LIZARDFISH	0	0	0	0	0	0	3	1	1	1*	0	1
OYSTER TOADFISH	1*	1*	0	1*	1*	1	3	0	1*	1*	0	1*
STRIPED ANCHOVY	0	0	0	0	0	0	0	4	1	0	0	1*
STRIPED BASS	1	2	1*	1*	0	1*	1*	0	0	1*	1	1*
WINTER FLOUNDER	0	1*	1*	0	0	2	1	0	0	0	0	1*
WHITE PERCH	0	0	0	0	0	2	1*	0	0	1*	1	1*
SPOTTED HAKE	0	1*	1*	1*	1*	1	0	0	0	0	0	1*
GIZZARD SHAD	1*	1	0	0	0	0	0	0	0	0	1*	1*
BLUEFISH	0	0	0	0	0	1*	1*	1*	1*	1*	0	1*
CHANNEL CATFISH	0	0	0	0	0	1	1*	0	0	0	0	1*
AMERICAN EEL	0	0	0	0	1*	1*	0	0	0	0	0	1*
ROUGH SILVERSIDES	0	1*	0	0	0	0	0	0	0	0	0	1*
BLACK SEABASS	0	0	0	0	1*	1*	1*	0	0	0	0	1*
NAKED GOBY	0	0	0	0	0	1*	0	0	0	0	0	1*
NORTHERN PIPEFISH	1*	0	0	0	0	1*	0	0	0	0	0	1*
BLACKCHEEK TONGUEFISH	0	1*	0	0	1*	0	0	0	0	0	1*	1*
SCUP	0	0	0	0	0	0	0	0	1*	0	0	1*
FRINGED FLOUNDER	0	0	0	0	0	0	0	0	0	1*	0	1*
CONGOR EEL	0	0	1*	0	0	1*	0	0	1*	1*	0	1*
CARP	0	0	0	0	0	1*	0	0	0	0	0	1*
NORTHERN SEAROBIN	0	0	1*	1*	1*	0	0	0	0	0	0	1*
BROWN BULLHEAD	0	0	0	0	0	0	1*	0	0	0	0	1*
SILVER PERCH	0	0	0	0	0	0	0	0	0	0	1*	1*
SOUTHERN STINGRAY	0	0	0	0	0	1*	0	0	0	0	0	1*
SPANISH MACKEREL	0	0	0	0	0	0	0	0	0	1*	0	1*
FEATHER BLENNY	0	0	0	0	0	0	0	0	0	1*	0	1*
TOTAL FISH	2711	600	17	25	23	133	146	90	185	182	227	394
BLUE CRAB	1*	1*	0	1*	1	6	12	4	6	6	1*	4

* = less than 1.

Table CE . Abundance of fish species in Tangier Sound as numerical CPUE by month.

	MAY	JUN	JUL	AUG	SEP	OCT	DEC	ANNUAL MEAN
SAMPLE SIZE	9	13	8	5	6	5	5	
SPECIES								
SPOT	7	322	383	97	124	72	0	144
BAY ANCHOVY	47	62	9	5	116	32	0	39
HOGCHOKER	11	33	93	18	5	1	1*	23
WEAKFISH	1	2	33	10	83	29	0	23
SUMMER FLOUNDER	1*	1*	26	22	12	3	0	9
HARVESTFISH	0	0	0	5	32	0	0	5
WHITE PERCH	0	0	0	0	0	6	10	2
ATLANTIC CROAKER	0	0	6	0	0	8	1	2
OYSTER TOADFISH	1	5	5	1*	2	1	1*	2
INSHORE LIZARDFISH	0	0	2	2	2	1*	0	1
ATLANTIC MENHADEN	1	1*	2	1*	1*	2	0	1
STRIPED BASS	0	0	0	0	0	1	1	1*
BLUE HERRING	0	0	0	0	0	0	2	1*
STRIPED ANCHOVY	0	0	0	1*	1	0	0	1*
BLACK SEABASS	0	0	1	0	0	0	0	1*
NORTHERN PUFFER	0	0	1	0	0	0	0	1*
WINDOWPANE	0	0	1	1*	1*	0	0	1*
BLUEFISH	0	0	1	0	1*	1*	0	1*
BUTTERFISH	1*	0	1	0	0	1*	0	1*
SOUTHERN STINGRAY	0	1*	1*	1	0	0	0	1*
WHITE CATFISH	1*	1*	0	0	0	1	0	1*
PORGY	0	0	1	0	1*	0	0	1*
NORTHERN SEAROBIN	0	0	1	0	0	0	0	1*
CONGER EEL	0	0	1	0	0	0	0	1*
AMERICAN EEL	0	1*	1*	0	0	0	0	1*
SILVER PERCH	0	1*	0	0	1*	0	0	1*
ATLANTIC SILVERSIDE	0	0	0	0	0	0	1*	1*
SPOTTED HAKE	1*	1*	0	0	0	0	0	1*
NAKED GOBY	0	1*	0	0	1*	0	0	1*
GIZZARD SHAD	0	0	0	0	0	1*	0	1*
FEATHER BLENNY	0	0	0	0	0	1*	0	1*
STRIPED KILLIFISH	0	0	0	0	0	0	1*	1*
ALEWIFE	0	0	0	0	0	0	1*	1*
SKILLETFISH	0	0	0	0	0	1*	0	1*
NORTHERN KINGFISH	0	0	0	0	0	1*	0	1*
BLUNTNOSE RAY	0	1*	0	0	0	0	0	1*
AMERICAN SHAD	0	1*	0	0	0	0	0	1*
TOTAL FISH	70	429	568	162	380	160	17	255
BLUE CRAB	14	40	81	12	11	7	1*	24

* = less than 1.

Table CF . Abundance of fish species in the Patuxent River as numerical CPUE by month.

	MONTH							
	JAN	FEB	MAR	MAY	JULY	SEP	NOV	ANNUAL MEAN
SAMPLE SIZE	11	10	10	11	15	14	10	
SPECIES								
HOGCHOKER	1	76	0	230	11	254	844	202
WHITE PERCH	159	139	100	10	21	468	246	163
CHANNEL CATFISH	14	115	135	62	17	97	236	97
SPOT	3	1	0	0	42	150	1*	28
STRIPED BASS	30	114	5	1*	1*	1	12	23
BAY ANCHOVY	1	1*	3	13	85	44	1*	21
WHITE CATFISH	8	30	3	3	0	2	7	8
WEAKFISH	0	0	0	0	1*	48	0	7
ALEWIFE	4	2	2	0	16	1*	3	4
YELLOW PERCH	1*	0	0	0	0	0	20	3
ATLANTIC MENHADEN	1*	1*	1*	1	10	2	2	2
AMERICAN EEL	0	1*	1	3	1	1*	2	1
OYSTER TOADFISH	0	0	0	1	1	4	1	1
GIZZARD SHAD	2	2	0	1*	0	0	1	1
BROWN BULLHEAD	0	3	1*	1	0	1*	0	1
ATLANTIC CROAKER	0	1*	0	1*	1*	1*	2	1*
SPOTTED HAKE	0	0	0	3	0	0	0	1*
BLUE HERRING	0	1*	0	0	1*	2	0	1*
SUMMER FLOUNDER	0	0	0	0	0	2	0	1*
HARVESTFISH	0	0	0	0	0	1	0	1*
INSHORE LIZARDFISH	0	0	0	0	1*	1*	0	1*
BLUEFISH	0	0	0	0	1*	1*	0	1*
ATLANTIC HERRING	1*	1*	1*	0	0	0	0	1*
GOLDEN SHINER	1*	0	0	0	0	0	1*	1*
ATLANTIC SILVERSIDE	1*	0	0	0	0	0	0	1*
CARP	0	1*	0	0	0	0	0	1*
SILVERY MINNOW	0	0	0	0	0	0	1*	1*
CHAIN PICKEREL	0	0	0	0	0	0	1*	1*
WHITE SUCKER	0	0	0	1*	0	0	0	1*
SKILLETFISH	1*	0	0	0	0	0	0	1*
BLACK SEABASS	0	0	0	0	0	1*	0	1*
SILVER PERCH	0	0	0	0	0	1*	0	1*
TOTAL FISH	225	486	251	329	208	1079	1379	565
BLUE CRAB	1	1*	1	5	10	46	3	9

* = less than 1.

Table CG . Abundance of fish species in Choptank River as numerical CPUE by month.

	MONTH						
	JAN	FEB	APR	JUN	AUG	OCT	ANNUAL MEAN
SAMPLE SIZE	6	8	10	6	10	10	
SPECIES							
HOGCHOKER	8	9	326	30	76	239	115
WHITE PERCH	137	162	71	20	42	197	105
WHITE CATFISH	11	228	36	3	22	19	53
CHANNEL CATFISH	85	39	59	8	31	31	42
SPOT	0	0	1*	78	147	2	38
BROWN BULLHEAD	111	8	24	1	1	2	25
BAY ANCHOVY	0	1*	2	1	2	98	17
STRIPED BASS	9	1	2	0	3	7	4
SILVERY MINNOW	21	0	0	0	0	1*	4
OYSTER TOADFISH	0	0	4	2	5	1*	2
GIZZARD SHAD	8	1	0	1*	0	0	1
ALEWIFE	0	1*	1*	0	1*	5	1
ATLANTIC MENHADEN	0	0	0	1*	1	3	1
AMERICAN EEL	1*	0	1*	1	1*	2	1*
WEAKFISH	0	0	0	0	1	1	1*
YELLOW PERCH	2	0	0	0	0	0	1*
ATLANTIC CROAKER	0	0	0	1*	1*	1	1*
WINTER FLOUNDER	0	0	0	1	0	0	1*
CARP	0	1*	1	1*	0	0	1*
GOLDEN SHINER	1	0	0	0	0	0	1*
TESSELATED DARTER	1	0	0	0	0	0	1*
PUMPKINSEED	1	0	0	0	0	0	1*
BLUEGILL	1*	0	0	0	0	0	1*
WHITE SUCKER	1*	0	0	0	0	0	1*
SILVER REDHORSE	1*	0	0	0	0	0	1*
YELLOW BULLHEAD	0	0	0	0	0	1*	1*
BLUEFISH	0	0	0	1*	1*	0	1*
GOLDFISH	1*	0	0	0	0	0	1*
SUMMER FLOUNDER	0	0	0	0	0	1*	1*
TOTAL FISH	398	450	526	147	333	609	411
BLUE CRAB	0	0	3	4	18	5	5

* = less than 1.

TABLE CH. Abundance of fish species collected in the mainstem below the Bay bridge as numerical CPUE by month in 1988.

	MONTH												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN. MEAN
SAMPLE SIZE	7	0	34	33	111	43	28	33	21	24	9	10	
SPECIES													
SPOT	0	0	0	1‡	4	442	352	376	245	175	1473	452	320
BAY ANCHOVY	1‡	0	1‡	4	0	69	13	404	81	13	8	1	54
WEAKFISH	0	0	0	0	1	1	0	28	35	5	2	13	8
HARVESTFISH	0	0	0	0	0	0	1‡	2	58	1	0	1‡	6
ATL. CROAKER	1‡	0	0	0	0	1‡	0	1‡	0	0	1	30	3
HOGCHOKER	0	0	1	0	2	6	2	2	6	1‡	1‡	6	2
BLUE. HERRING	0	0	4	0	1‡	0	3	0	0	0	1‡	1	1
ATL. MENHADEN	1	0	11	0	3	2	1‡	1‡	1‡	1‡	1‡	2	1
S. FLOUNDER	0	0	1‡	1‡	1‡	1‡	1	2	1	1	1	0	1
ALEWIFE	1	0	0	1‡	1‡	0	0	0	0	0	0	1	1‡
SP. HAKE	0	0	2	0	3	1‡	0	0	0	0	0	0	1‡
ATL. SILVERSIDES	0	0	0	0	0	0	0	0	0	0	0	1	1‡
W. FLOUNDER	0	0	1‡	0	1‡	1	1‡	1‡	0	0	0	0	1‡
STRIPED BASS	1‡	0	0	1‡	1‡	0	0	0	0	0	0	1	1‡
BUTTERFISH	0	0	0	1‡	1‡	1	1‡	0	1‡	0	0	1‡	1‡
STR. ANCHOVY	0	0	0	0	0	0	0	1	1‡	1‡	0	0	1‡
N. SEAROBIN	0	0	0	1‡	1‡	0	0	1‡	0	1‡	0	1‡	1‡
N. PIPEFISH	0	0	0	0	0	0	0	1‡	0	0	0	0	1‡
SP. MACKEREL	0	0	0	0	0	0	0	1‡	1‡	0	0	0	1‡
ST. MULLET	0	0	0	0	0	0	0	0	0	0	0	1‡	1‡
OYS. TOADFISH	0	0	0	0	1‡	0	1‡	1‡	1‡	1‡	0	0	1‡
SP. SEATROUT	0	0	0	0	0	0	0	0	0	1‡	0	1‡	1‡
BLCHK. TONGUEFISH	0	0	1‡	0	0	1‡	0	0	1‡	0	0	1‡	1‡
GIZ. SHAD	0	0	0	0	0	0	0	0	0	0	1‡	1‡	1‡
WHITE PERCH	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
ATL. STURGEON	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
ATL. MACKEREL	0	0	1‡	0	0	0	0	0	0	0	0	0	1‡
CUSK EEL	0	0	0	0	0	0	1‡	1‡	0	0	0	0	1‡
WINDOWPANE	0	0	0	0	0	0	0	0	0	1‡	0	0	1‡
AM. EEL	0	0	1‡	1‡	1‡	0	0	0	0	0	0	0	1‡
SKILLETFISH	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
WH. CATFISH	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
NAKED GOBY	0	0	0	0	1‡	1‡	0	0	0	0	0	0	1‡
BL. SEA BASS	0	0	0	1‡	0	0	0	1‡	1‡	0	0	1‡	1‡
INSH. LIZARDFISH	0	0	0	0	0	0	1‡	1‡	1‡	1‡	1‡	0	1‡
ATL. HERRING	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
BLUEFISH	0	0	0	0	1‡	0	1‡	0	1‡	0	0	0	1‡
FEATHER BLENNY	0	0	0	0	1‡	0	0	0	0	0	0	0	1‡
TOTAL FISH	2	0	18	4	13	522	371	815	426	195	1485	508	396
BLUE CRAB	1‡	0	1‡	2	4	10	8	21	0	7	2	0	5

‡=LESS THAN ONE

TABLE CI. Abundance of fish species collected in the Patuxent River as numerical CPUE by month in 1988.

	MONTH												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN. MEAN
SAMPLE SIZE	13	17	19	18	11	11	28	20	27	32	23	20	
SPECIES													
SPOT	0	0	0	0	21	120	471	318	145	292	329	1*	141
HOGCHOKER	3	4	5	125	157	5	15	20	9	32	17	22	35
WHITE PERCH	17	78	1	55	53	0	8	7	15	36	28	71	31
CH. CATFISH	0	0	1*	0	13	0	0	0	0	1*	1*	216	19
BAY ANCHOVY	0	0	0	0	23	8	9	65	11	10	3	0	11
STRIPED BASS	17	28	29	2	11	0	4	1	1*	2	1	12	9
WH. CATFISH	0	0	4	10	13	0	1*	0	0	0	1*	15	4
WEAKFISH	0	0	0	0	0	1	1	16	13	9	1	0	3
ATL. MENHADEN	1*	1*	0	0	9	7	1	1*	0	2	2	1*	2
OYS. TOADFISH	0	0	0	1*	1*	1*	2	2	1	2	1	1*	1
HARVESTFISH	0	0	0	0	0	0	0	1*	7	2	0	0	1
ATL. CROAKER	1*	0	0	0	0	1*	1*	1*	0	0	6	1*	1
SP. HAKE	0	0	0	0	1*	0	0	0	0	0	0	0	1*
HICKORY SHAD	0	1*	0	0	0	0	0	0	0	0	0	0	1*
BLCHK. TONGUEFISH	0	0	0	0	0	0	0	0	0	0	0	1*	1*
N. PIPEFISH	0	0	0	0	0	0	0	1*	0	0	0	0	1*
N. SEAROBIN	0	0	0	0	0	0	0	0	0	1*	0	0	1*
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0	1*	1*
INSH. LIZARDFISH	0	0	0	0	0	0	0	1*	1*	1*	0	0	1*
SP. MACKEREL	0	0	0	0	0	0	0	1*	1*	0	0	0	1*
NAKED GOBY	0	0	0	0	0	1*	1*	1*	0	0	0	1*	1*
BLUEFISH	0	0	0	0	0	0	1*	0	1*	1*	0	0	1*
BRN. BULLHEAD	0	0	0	0	0	0	0	0	0	0	0	1*	1*
FEATHER BLENNY	0	0	0	0	0	1*	0	0	0	0	0	0	1*
STR. ANCHOVY	0	0	0	0	0	0	0	1*	0	1*	0	0	1*
BL. SEA BASS	0	0	0	0	0	0	0	0	1*	1*	0	0	1*
SKILLETFISH	0	0	0	0	0	0	0	0	0	0	0	1*	1*
S. STINGRAY	0	0	0	0	0	0	0	0	1*	0	0	0	1*
CARP	0	0	0	0	0	0	0	0	0	0	0	1*	1*
ALEWIFE	1*	1*	0	1*	0	0	0	0	0	0	1*	0	1*
ATL. SILVERSIDES	1*	0	0	0	0	0	0	0	0	0	0	1	1*
GIZ. SHAD	1	1*	0	0	1*	0	0	0	0	0	1*	2	1*
BUTTERFISH	0	0	0	0	1*	1	0	0	0	0	1*	1*	1*
S. FLOUNDER	0	0	0	0	1*	1*	1	2	1	1	0	0	1*
AM. EEL	0	1*	1*	2	1	0	0	1*	0	0	1*	1*	1*
BLUE. HERRING	1*	1*	1	1*	1	0	0	0	0	0	0	0	1*
W. FLOUNDER	0	0	0	0	0	1*	2	1*	0	0	0	1*	1*
TOTAL FISH	38	110	40	194	302	142	514	431	202	388	388	339	258
BLUE CRAB	1*	1*	1	2	5	19	43	33	45	29	7	1	15

*=LESS THAN ONE

Table CJ. Summary of fish community structure and abundance characteristics.

	REGION				
	Above Bay Bridge	Below Bay Bridge	Tangier Sound	Patuxent River	Choptank River
Periods of peak abundance	Jul.,Oct.	Jan.	Jun.,Jul.	Sep.,Nov.	Feb.,Apr.,Oct.
Dominant species (at least 10% of total)	Hogchoker Spot White perch Ch. catfish	Spot	Spot Bay anchovy Hogchoker Weakfish	Hogchoker White perch Ch. catfish	Hogchoker White perch White catfish Ch. catfish
Total number of species	30	40	37	33	28
Annual mean CPUE	373	394	255	565	411
Range of monthly CPUE values:					
Low	103	17	17	208	147
High	865	2711	568	1379	609

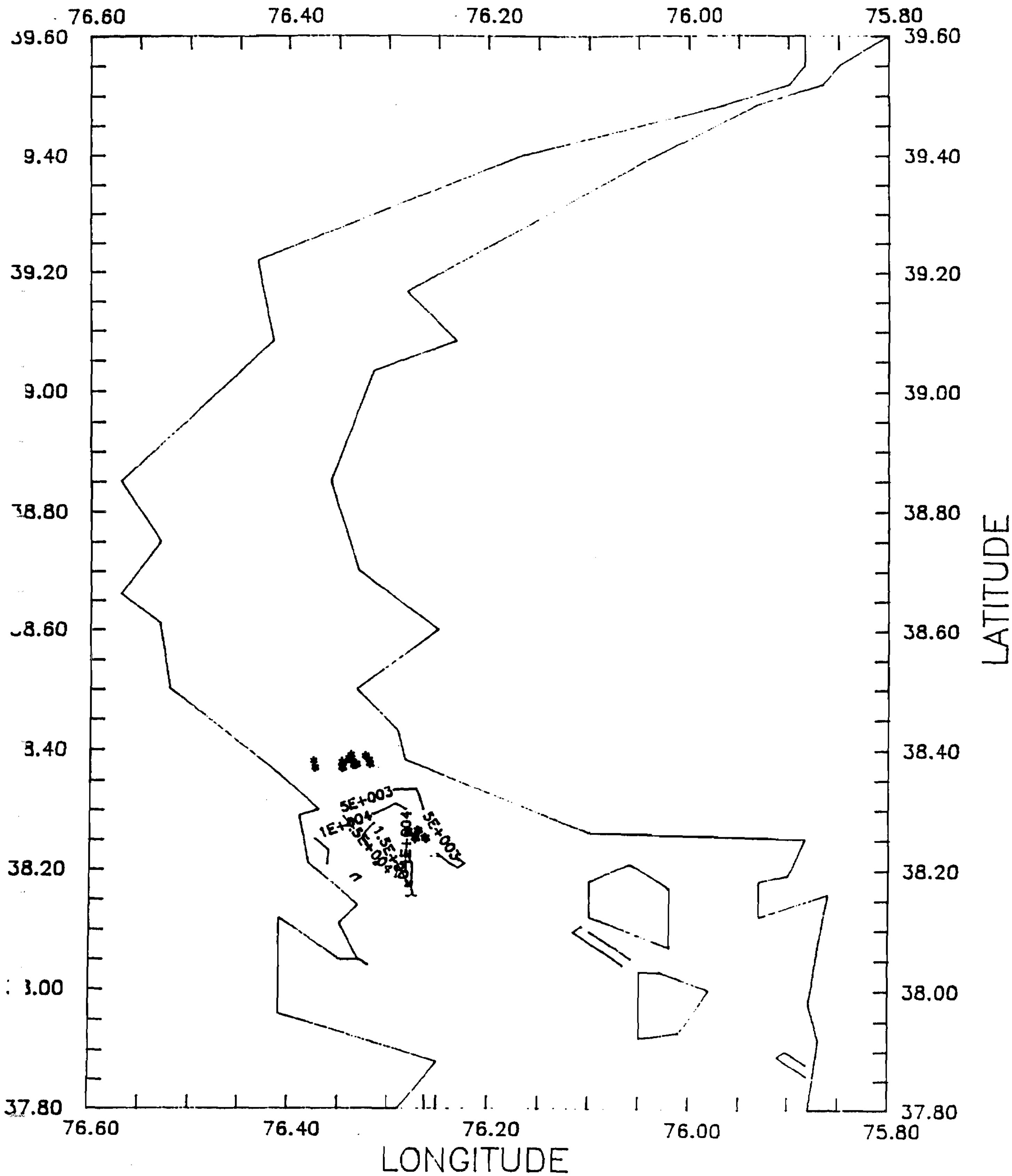


Fig. A. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JAN [illegible]

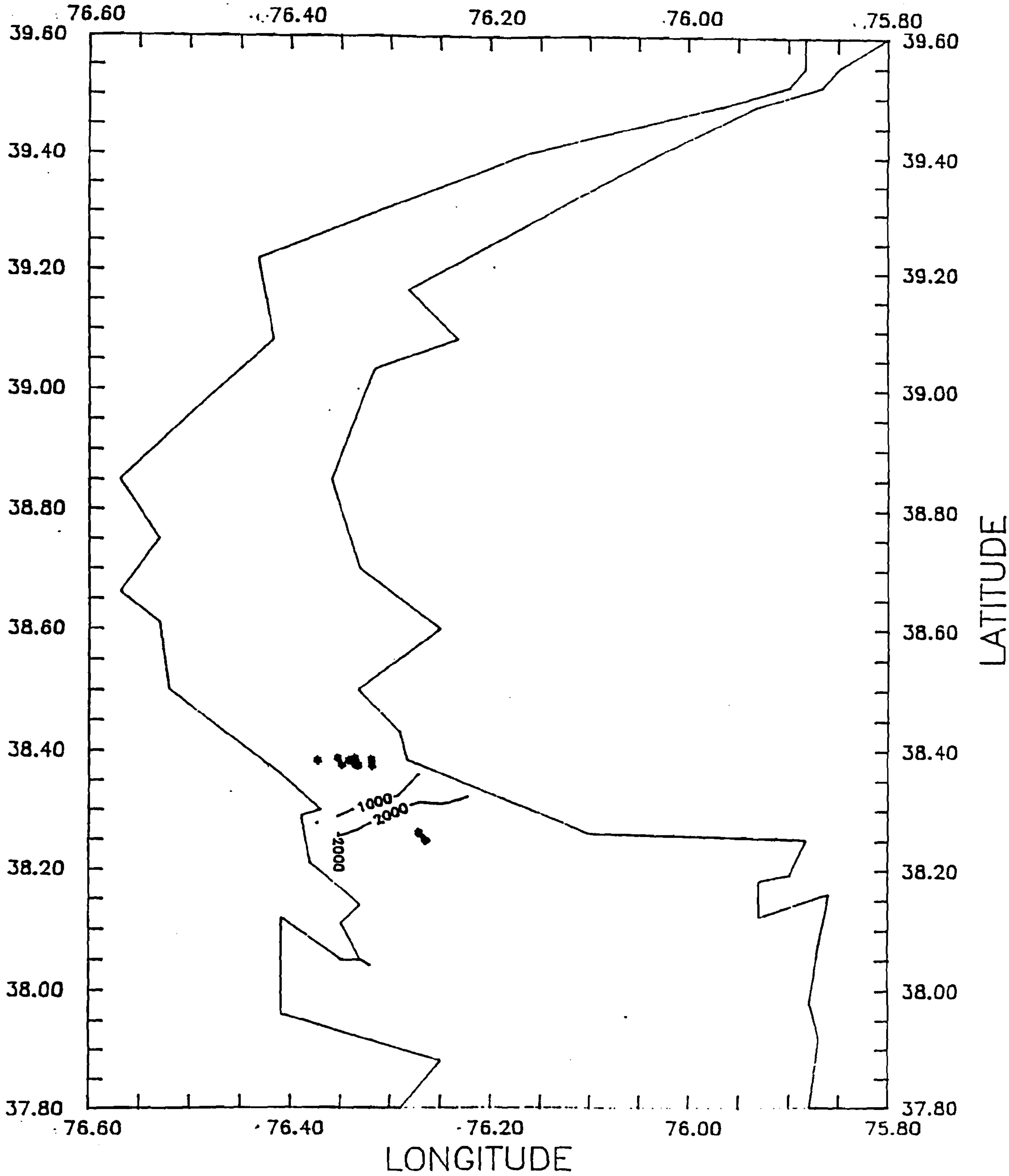


Fig. 8. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY FEB 1987

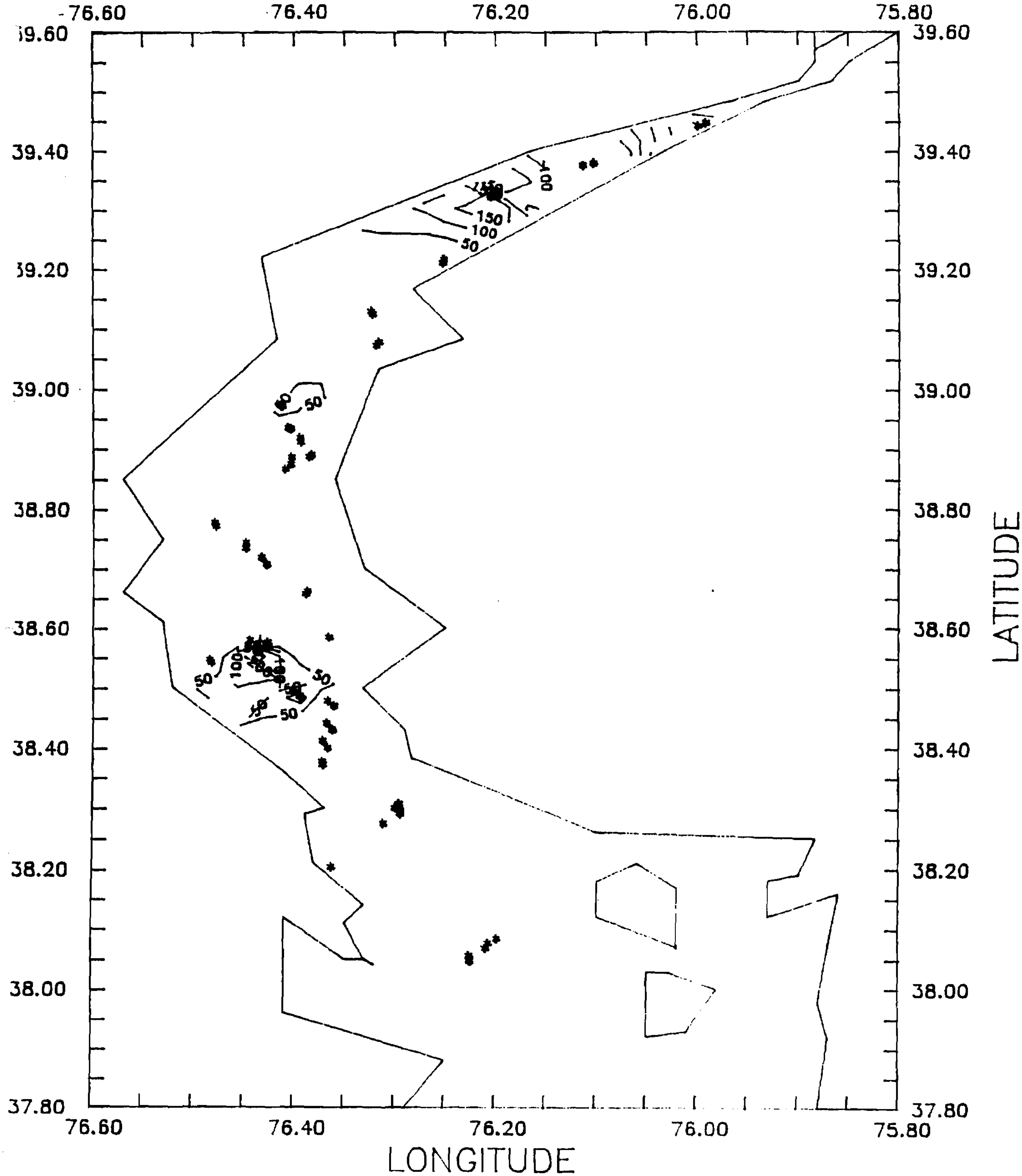


Fig. C.A1. SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAR [illegible]

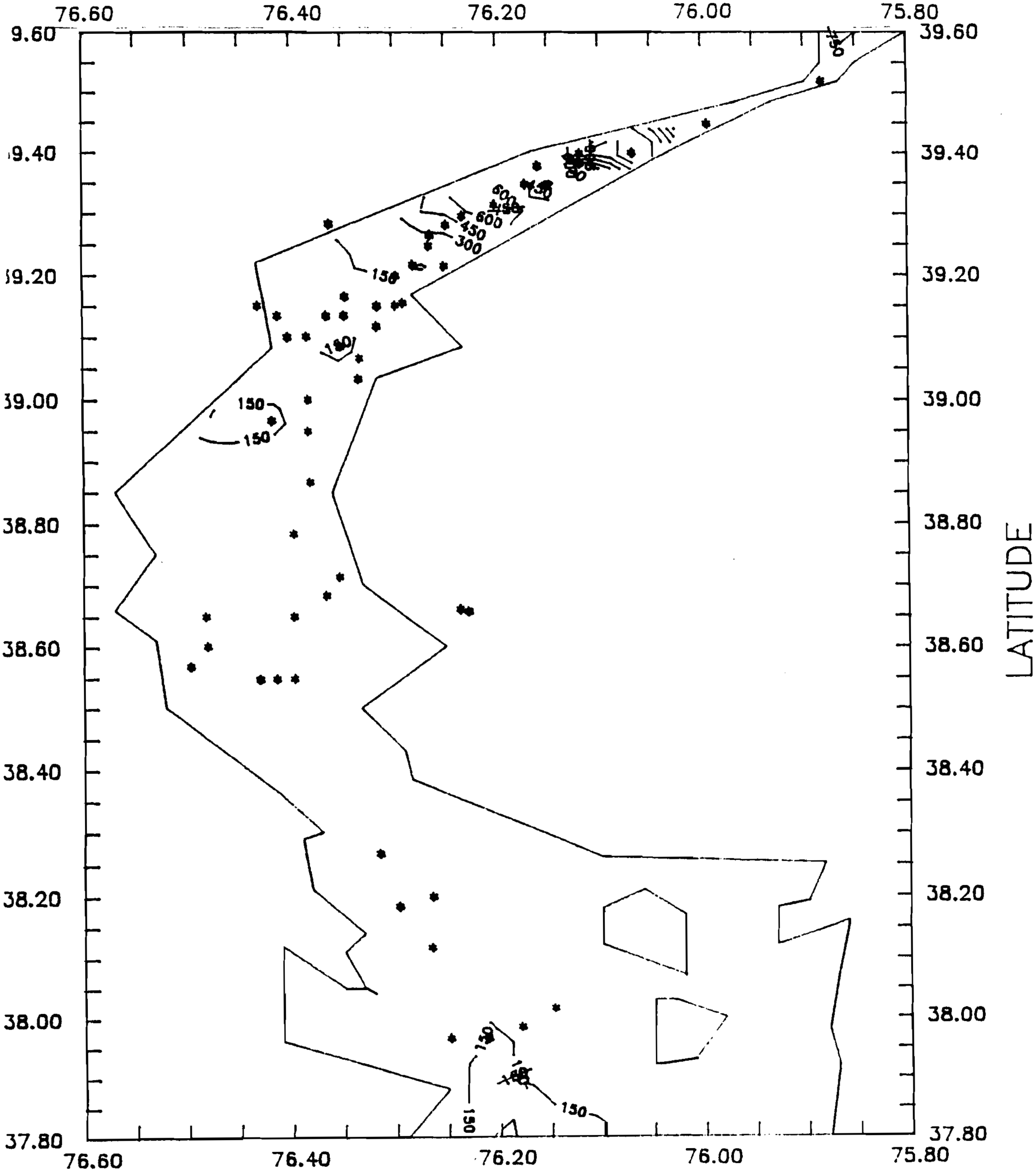


Fig. D. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY APR 1989

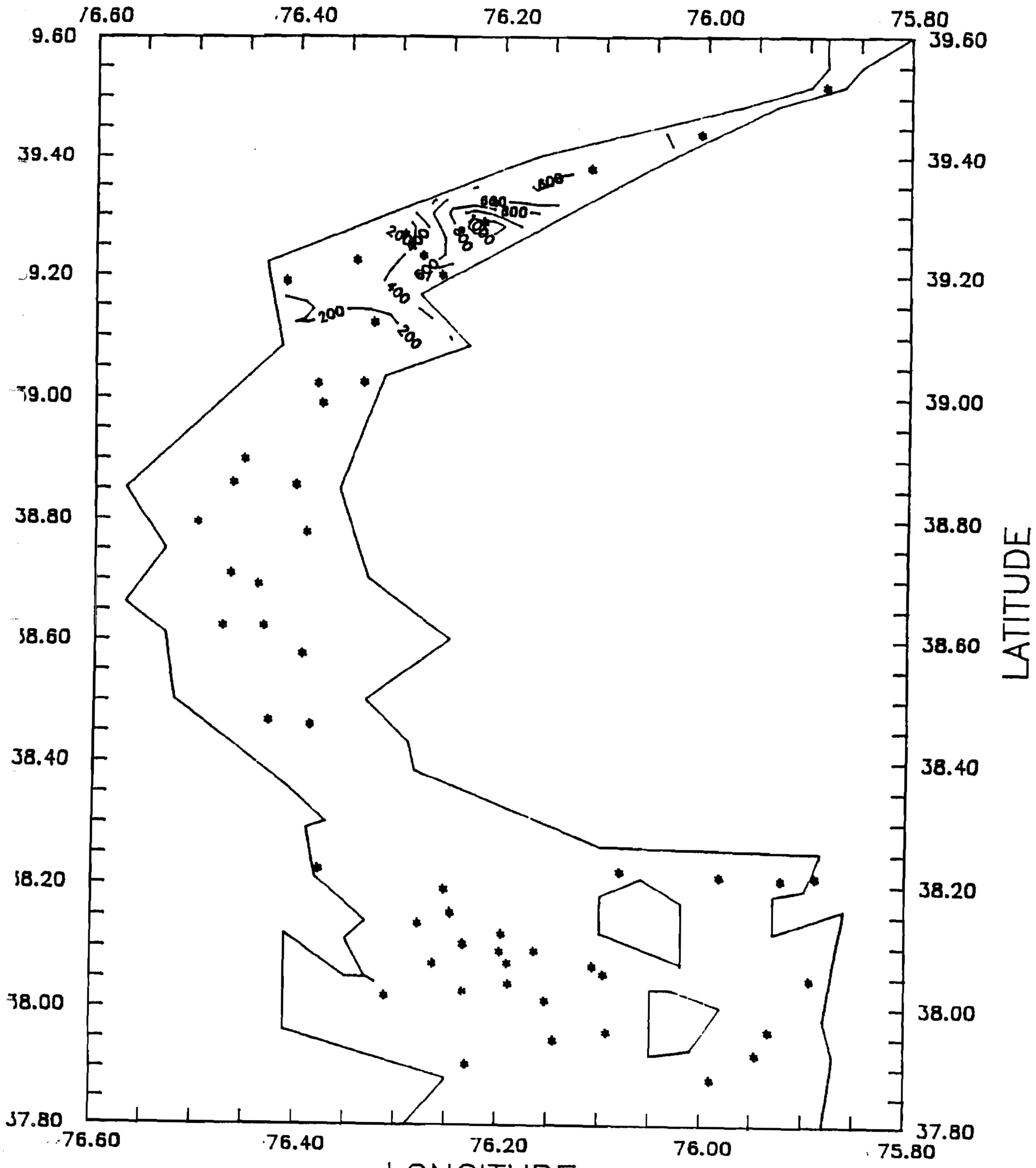


Fig. E. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAY 1989

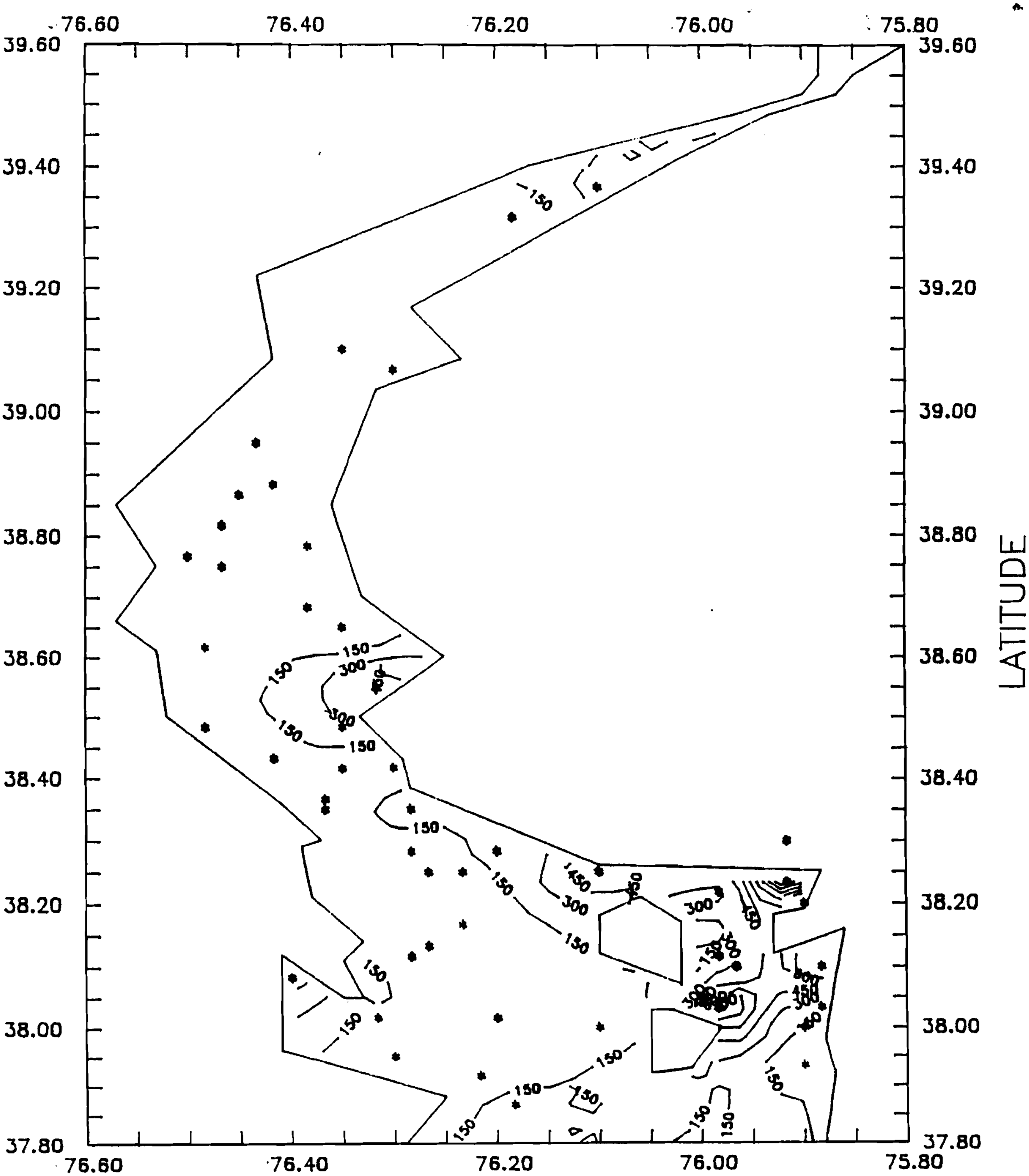


Fig. F. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JUN 1989

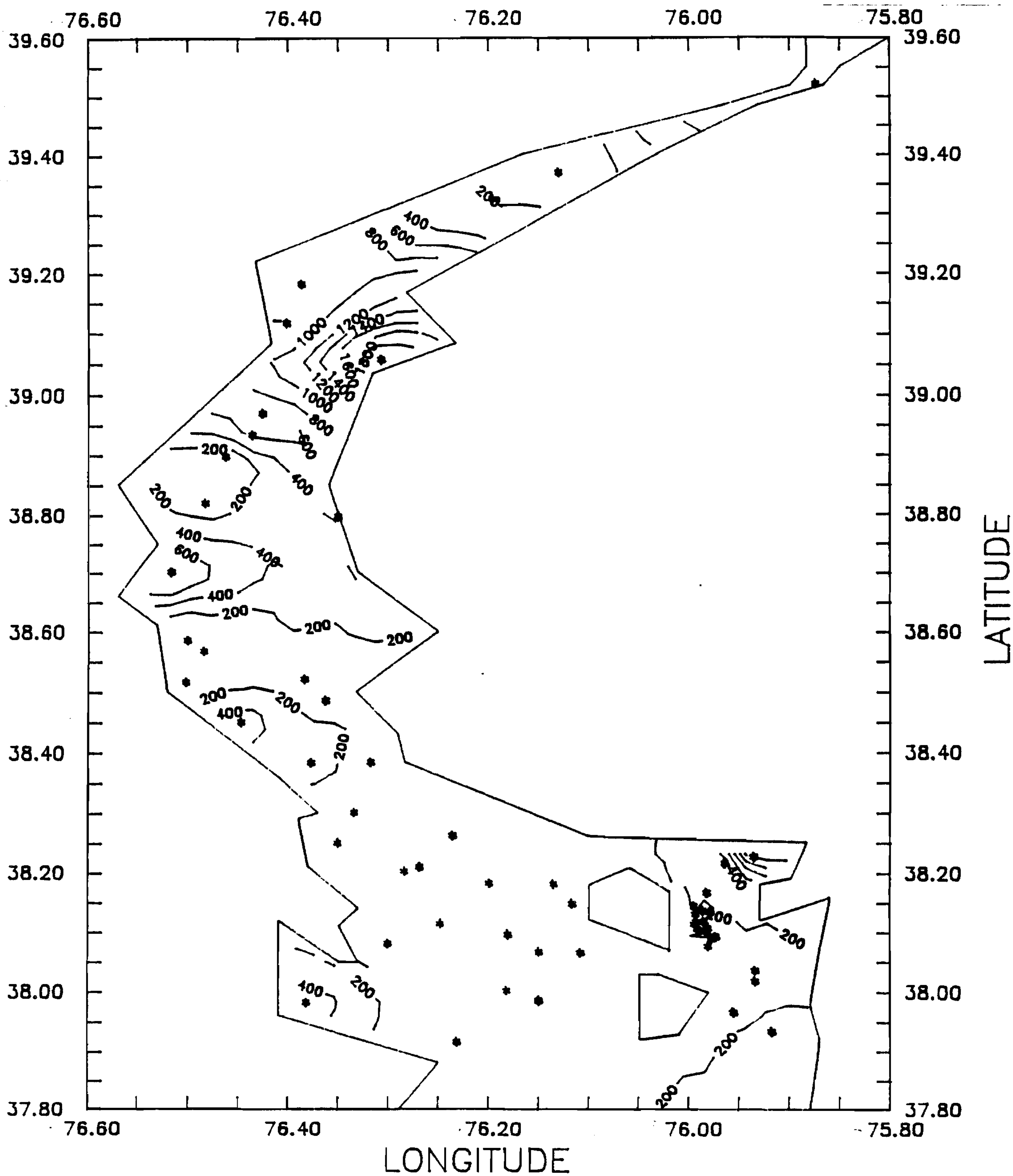


Fig. 6. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JUL 1989

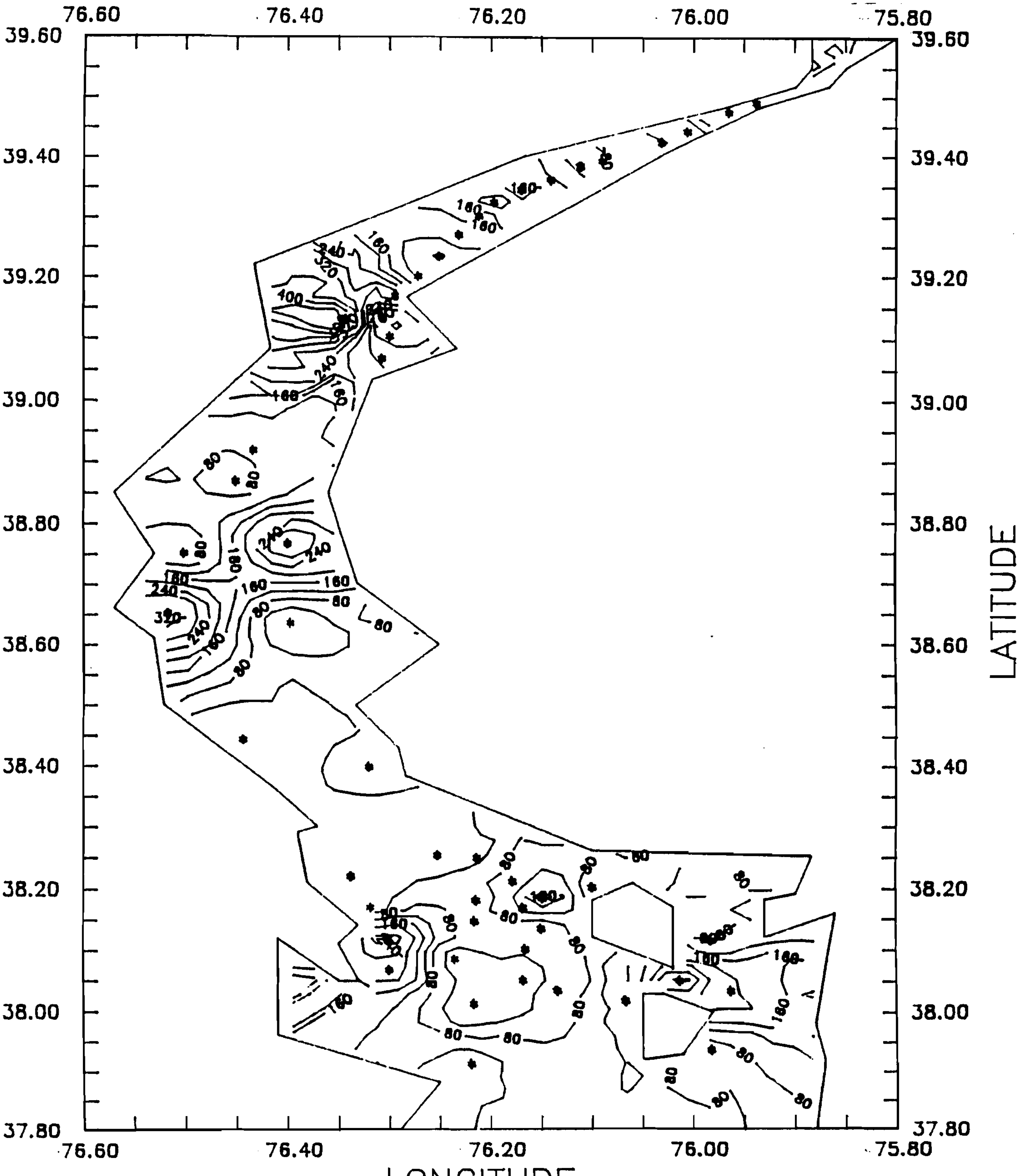


Fig. H. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY AUG 1989

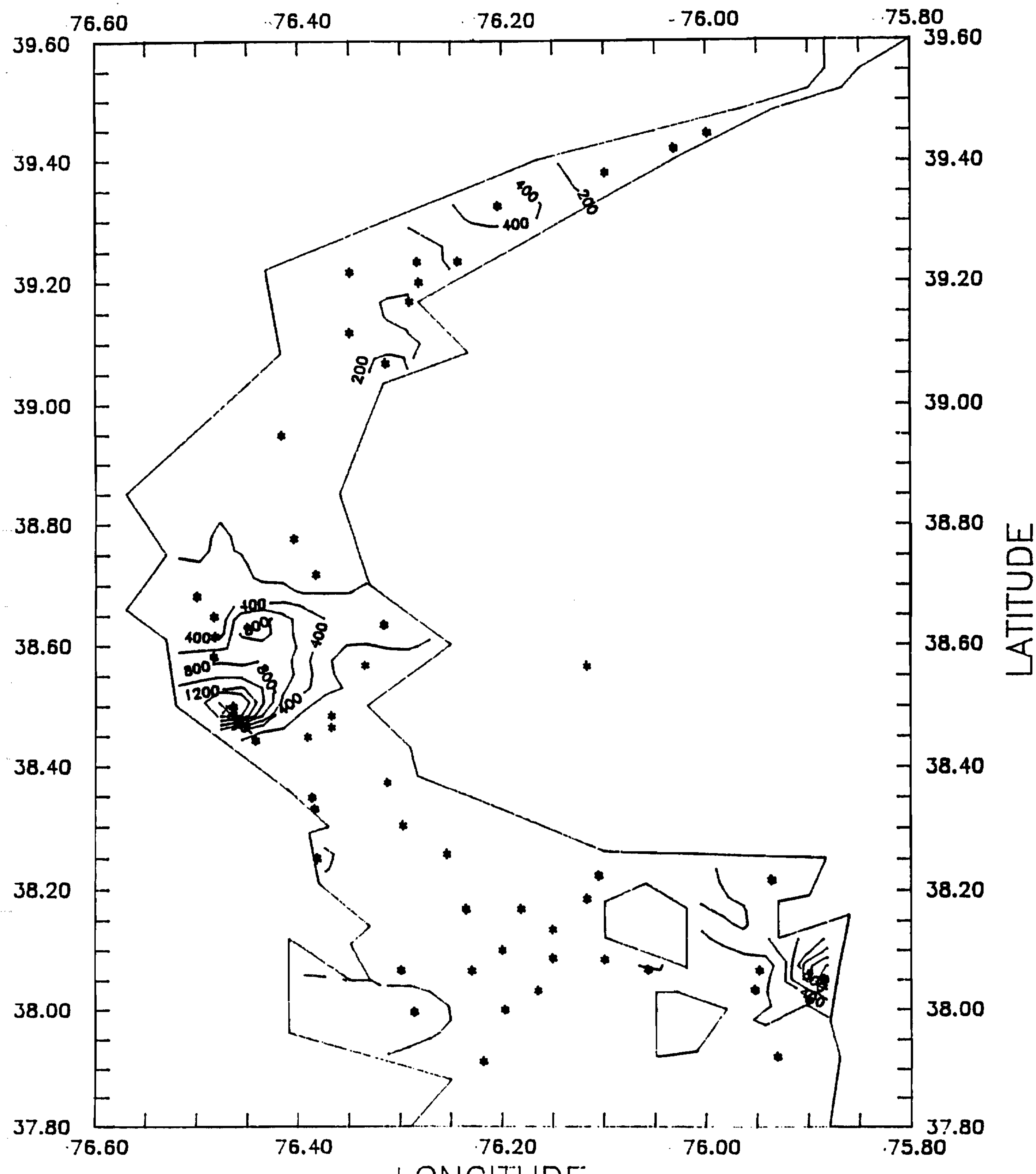


Fig. I. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY SEP 1989

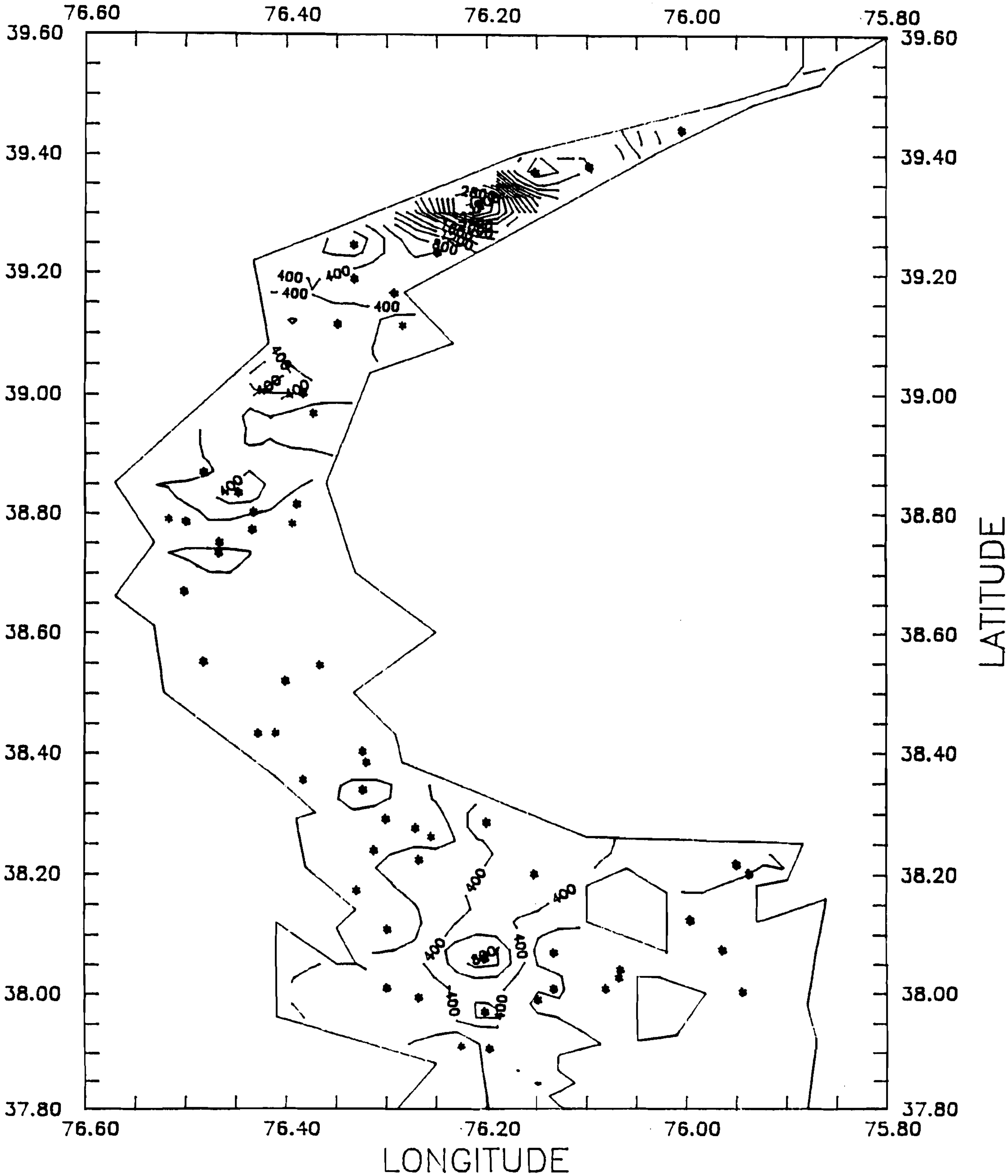


Fig. J. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY OCT 1989

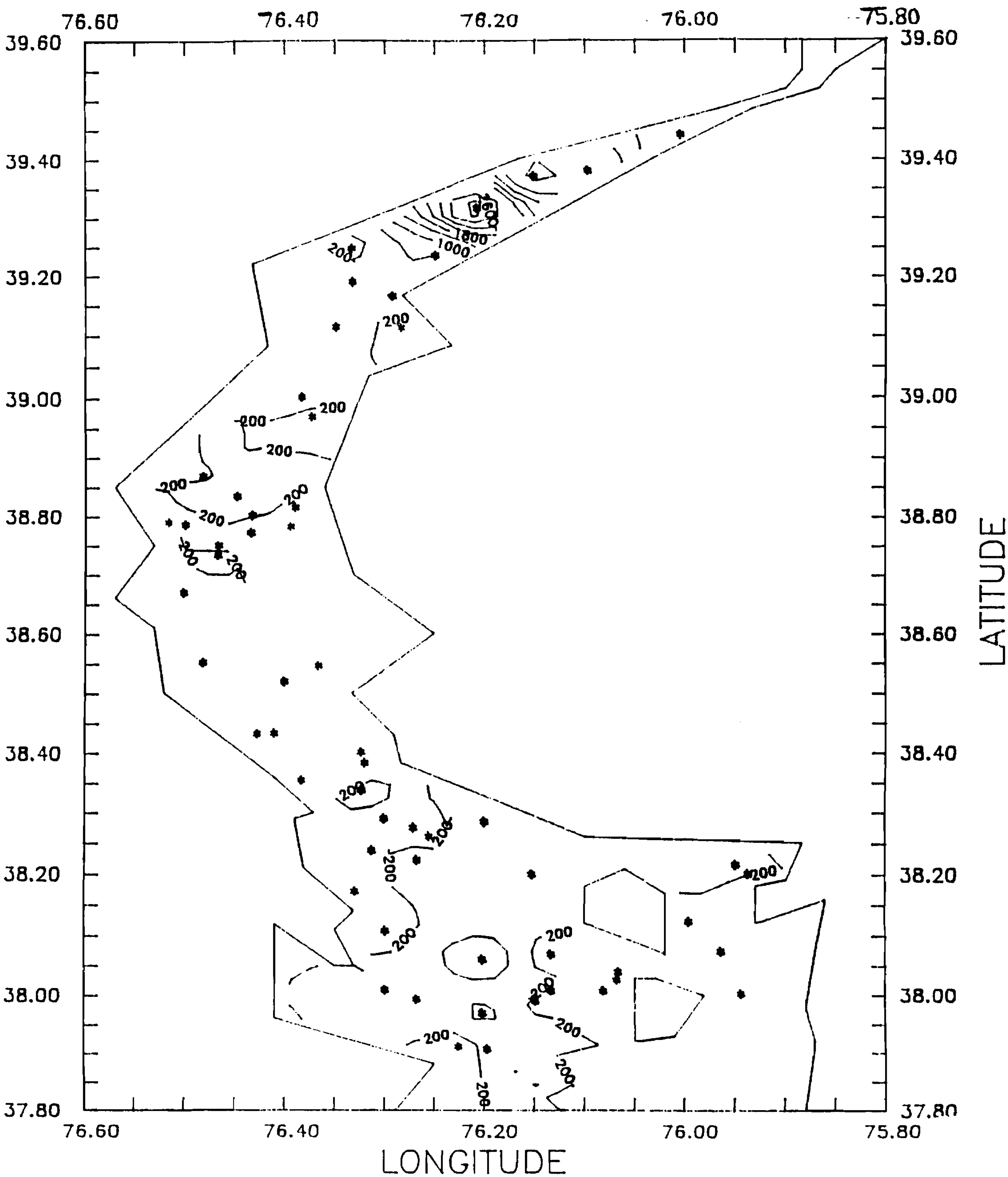


Fig. K. ALL SPECIES CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY OCT 1989

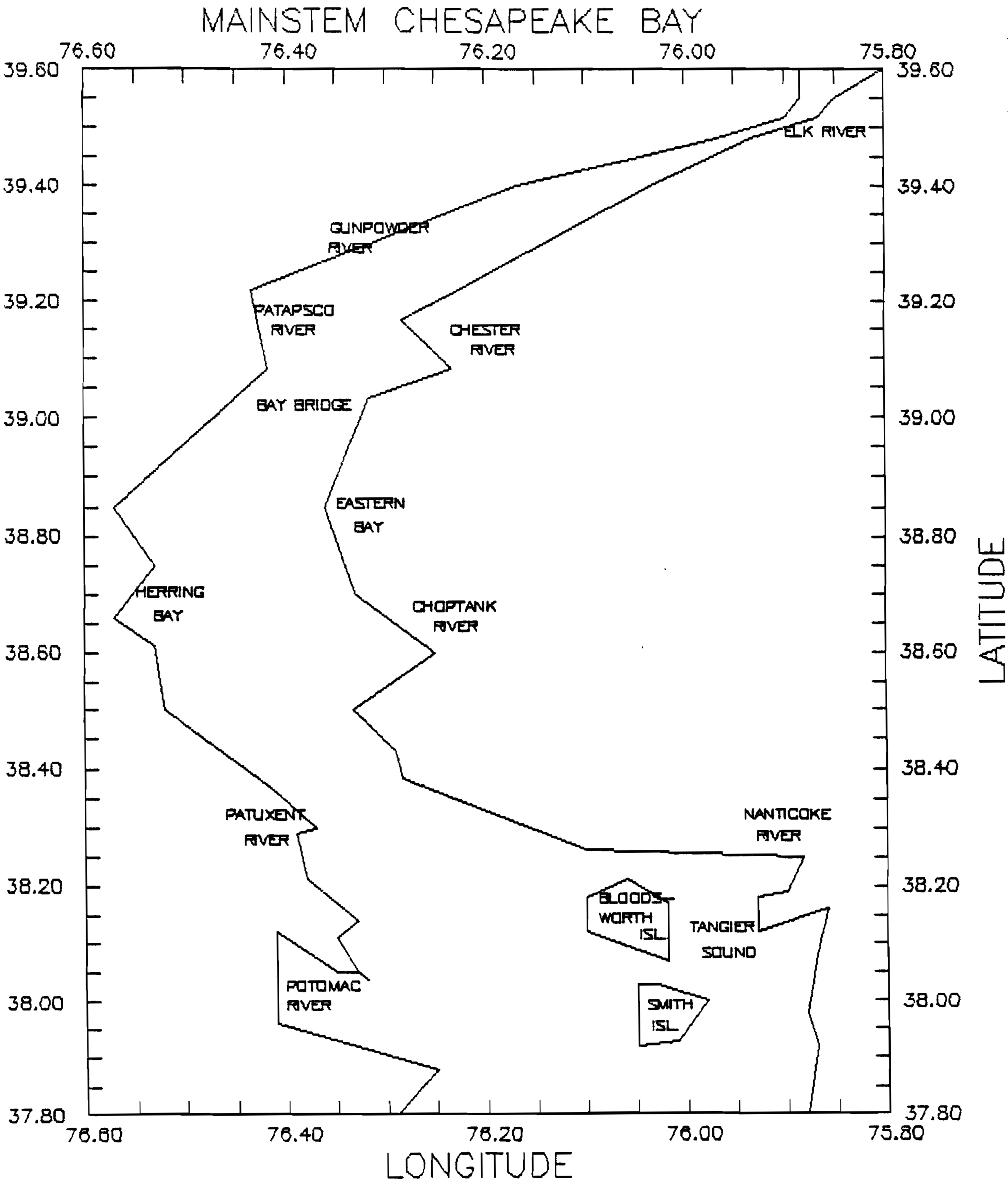


Fig. L. Reference labels of the mainstem of the Chesapeake Bay for CPUE contour plots.

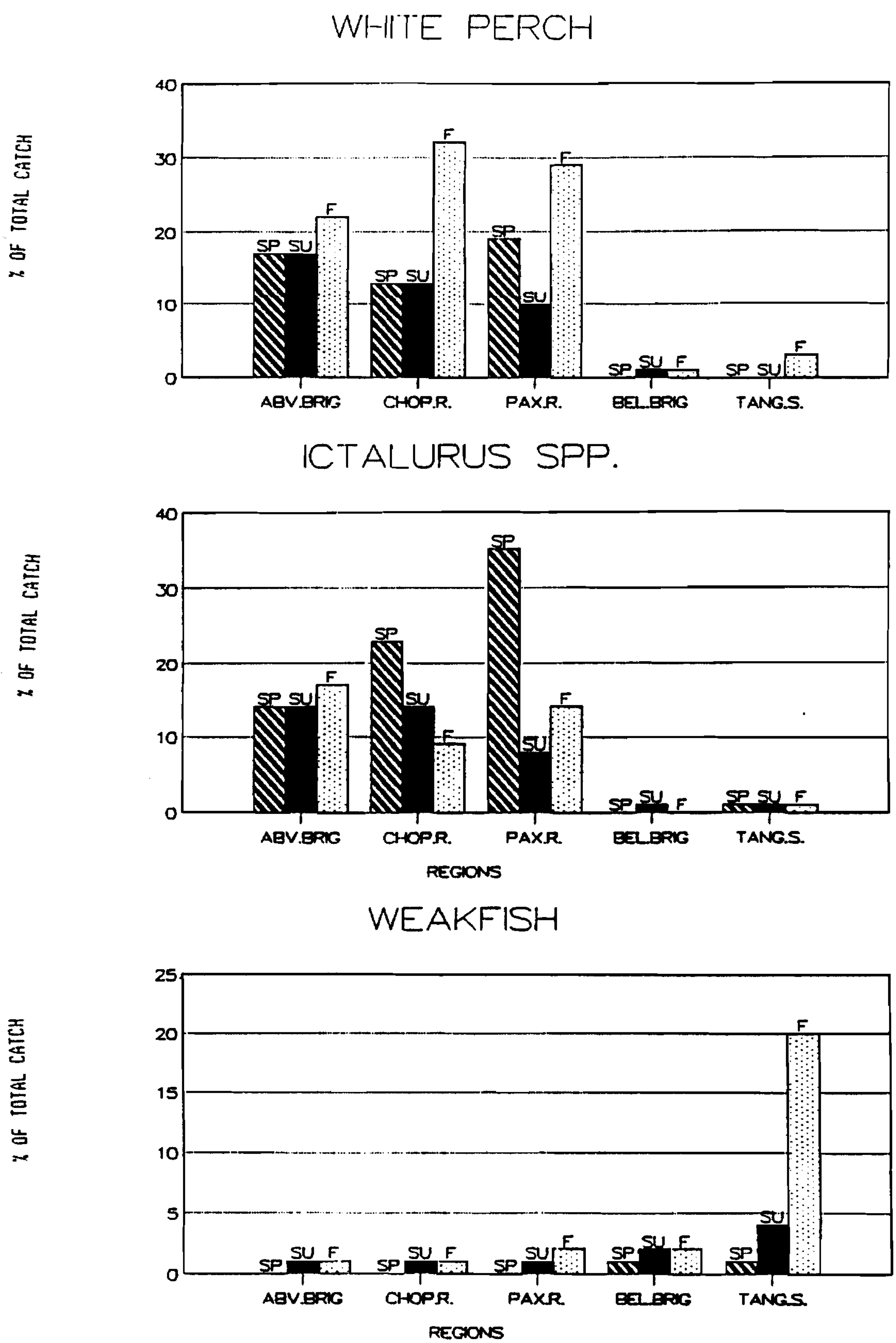


FIG. 11. Percent contribution to the total catch of white perch, catfish and weakfish by season and by region. Seasons are represented as SP=spring, SU=summer, and F=fall. Locations are represented as above Bay Bridge=ABV. BRIG., Choptank River=CHOP.R., Patuxent River=PAX.R., below Bay Bridge=BEL.BRIG. and Tangier Sound=TANG. S.

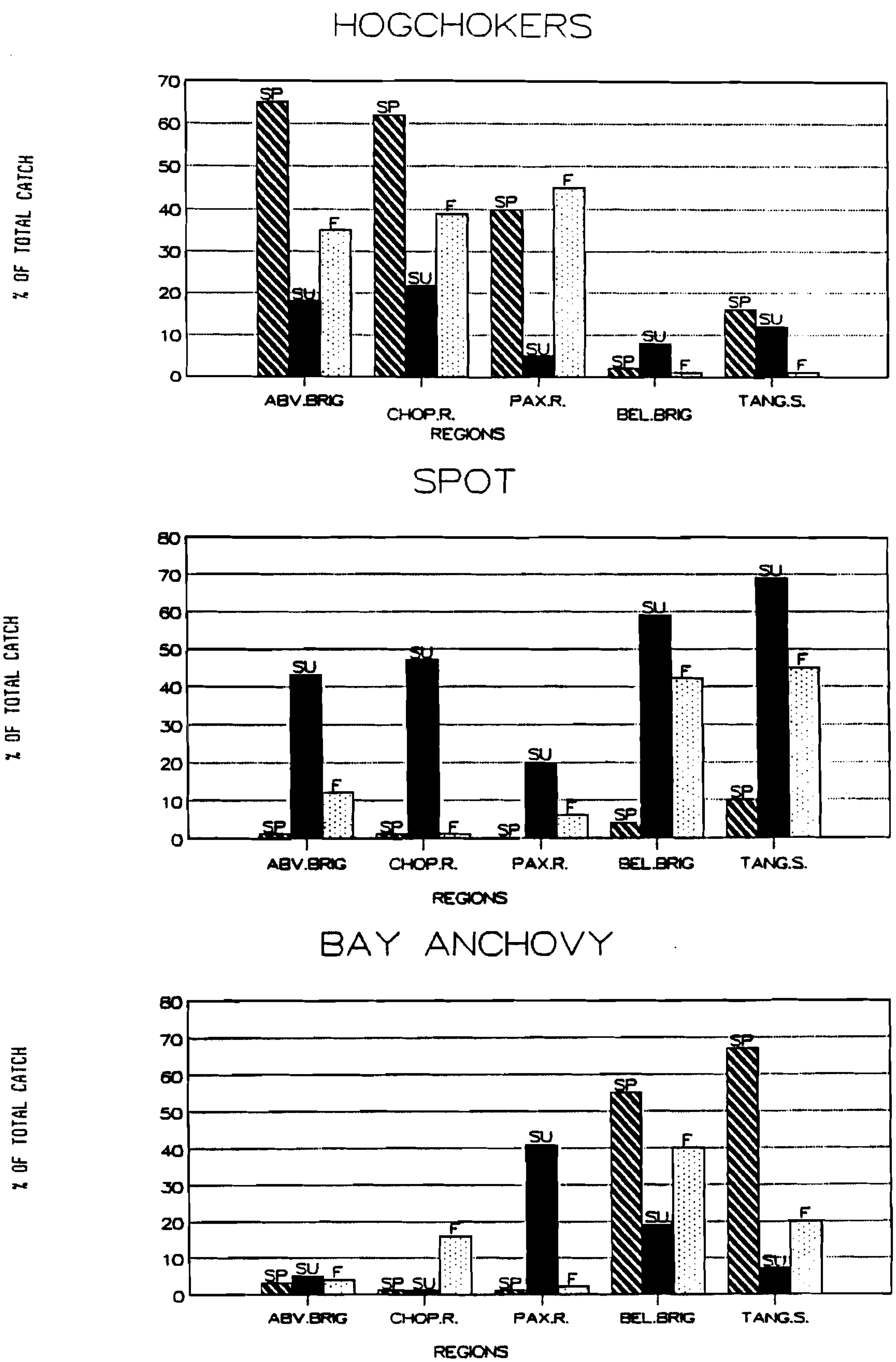


Fig. M(cont). Percent contribution to the total catch of hogchokers, spot, and bay anchovies by season and by region.

Table S1. Summary of abundance of spot by region and time period.

	Location					
	Bay-wide	Above Bay Bridge	Below Bay Bridge	Tangier Sound	Patuxent River	Choptank River
Annual Mean CPUE	77	81	288	144	28	38
Rank by CPUE	2	2	1	1	4	5
Percent Frequency in Collection	49	34	46	95	46	24
Period of Peak Abundance	January	July	January	June-July	September	August

TABLE S2. Monthly mean, minimum, maximum lengths of Spot by region.

SPOT		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ABOVE BAY	N=						25	284	391	455	221		
BRIDGE	MEAN LTH.						99	144	143	137	157		
	RANGE						58-122	92-183	46-207	32-197	114-188		
BELOW BAY	N=	683	471		13	24	330	780	789	945	1143		3
BRIDGE	MEAN LTH.	102	106		150	163	95	144	146	150	152		152
	RANGE	26-196	36-225		125-210	23-220	43-227	70-254	31-256	32-252	27-206		142-166
TANGIER	N=					63	444	420	221	231	165		
SOUND	MEAN LTH.					148	118	134	128	140	138		
	RANGE					25-217	53-245	84-258	13-157	115-241	105-202		
CHOPTANK	N=						79		135		17		
RIVER	MEAN LTH.						110		139		145		
	RANGE						70-242		90-178		122-170		
PATUXENT	N=	30	7					283		432		2	
RIVER	MEAN LTH.	92	111					135		146		135	
	RANGE	70-111	89-132					87-197		70-195		127-142	

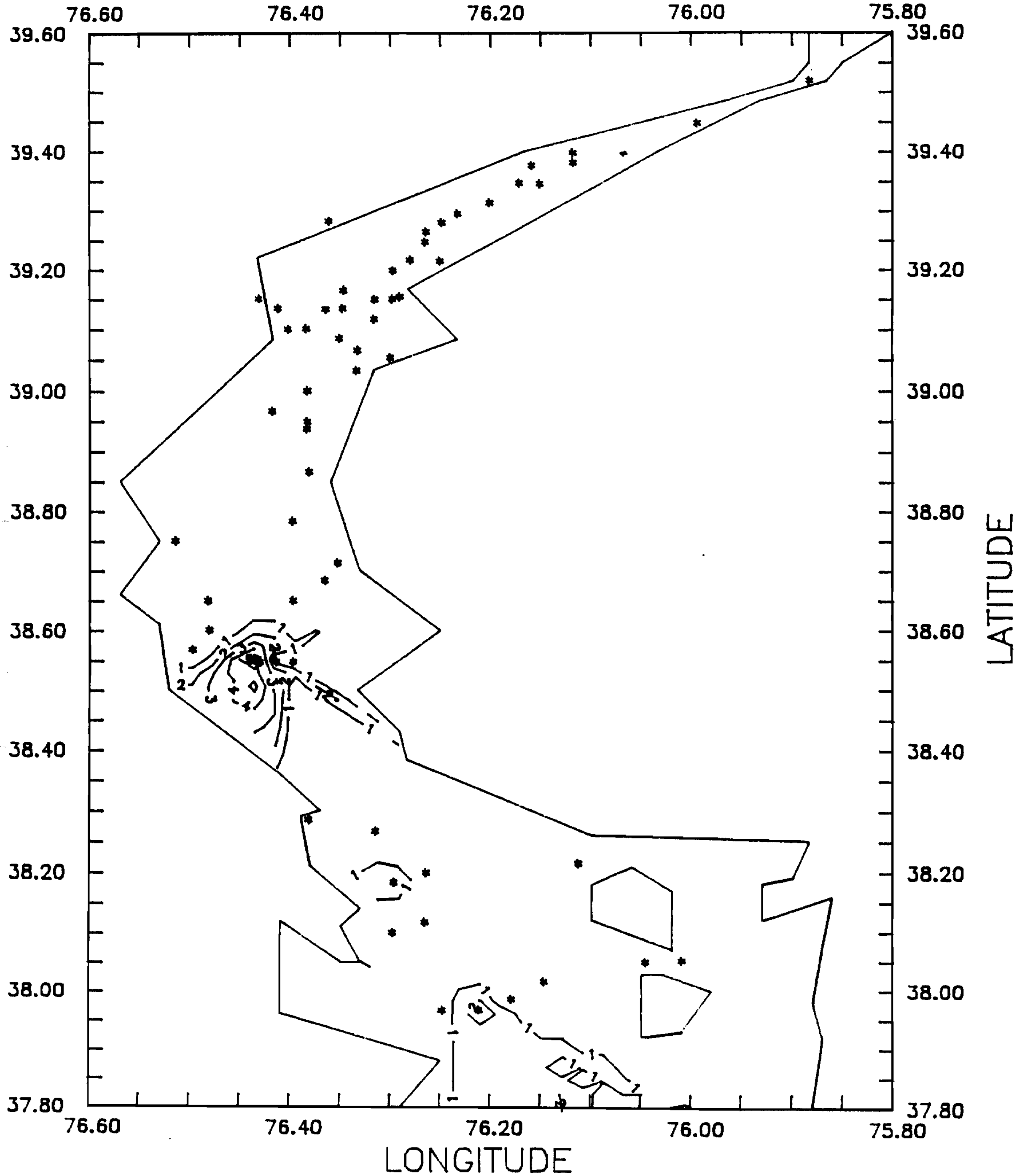


FIG. S1. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY APRIL 1989

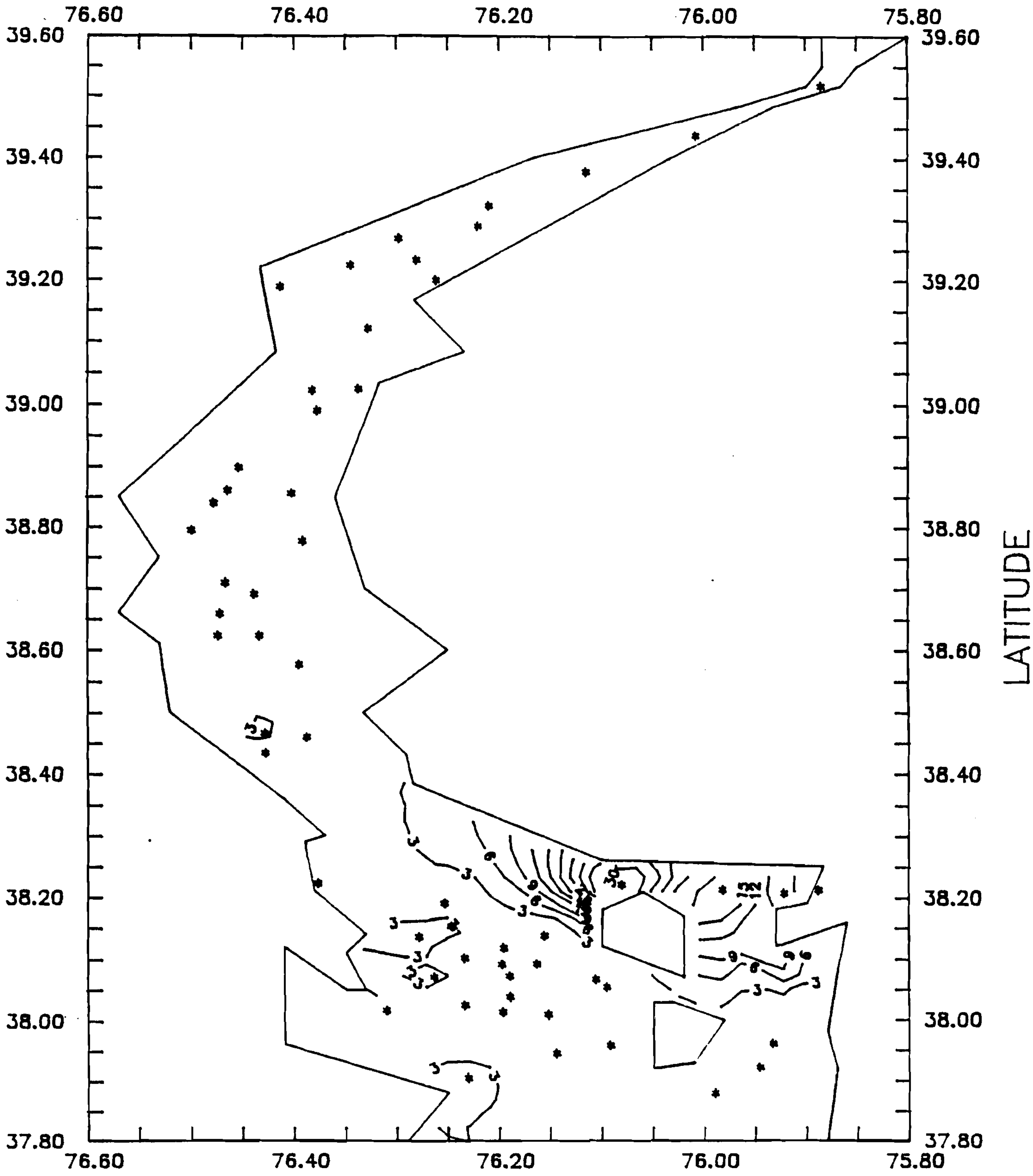


FIG. S2. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAY 1989

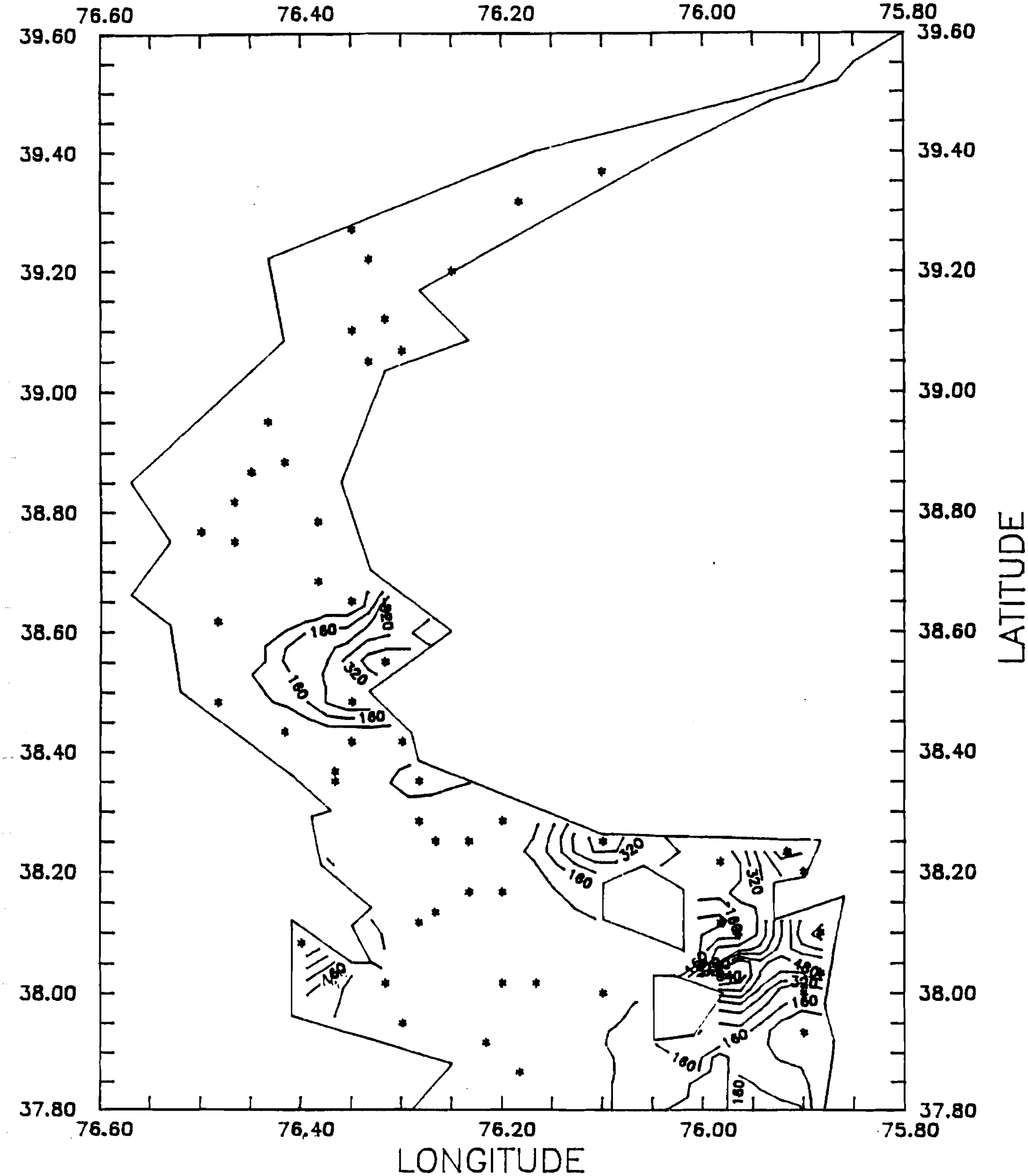


FIG. S3. SPOT CPUE CONTOURS
MAINSTEM CHESAPFAKE BAY JUNE 1989

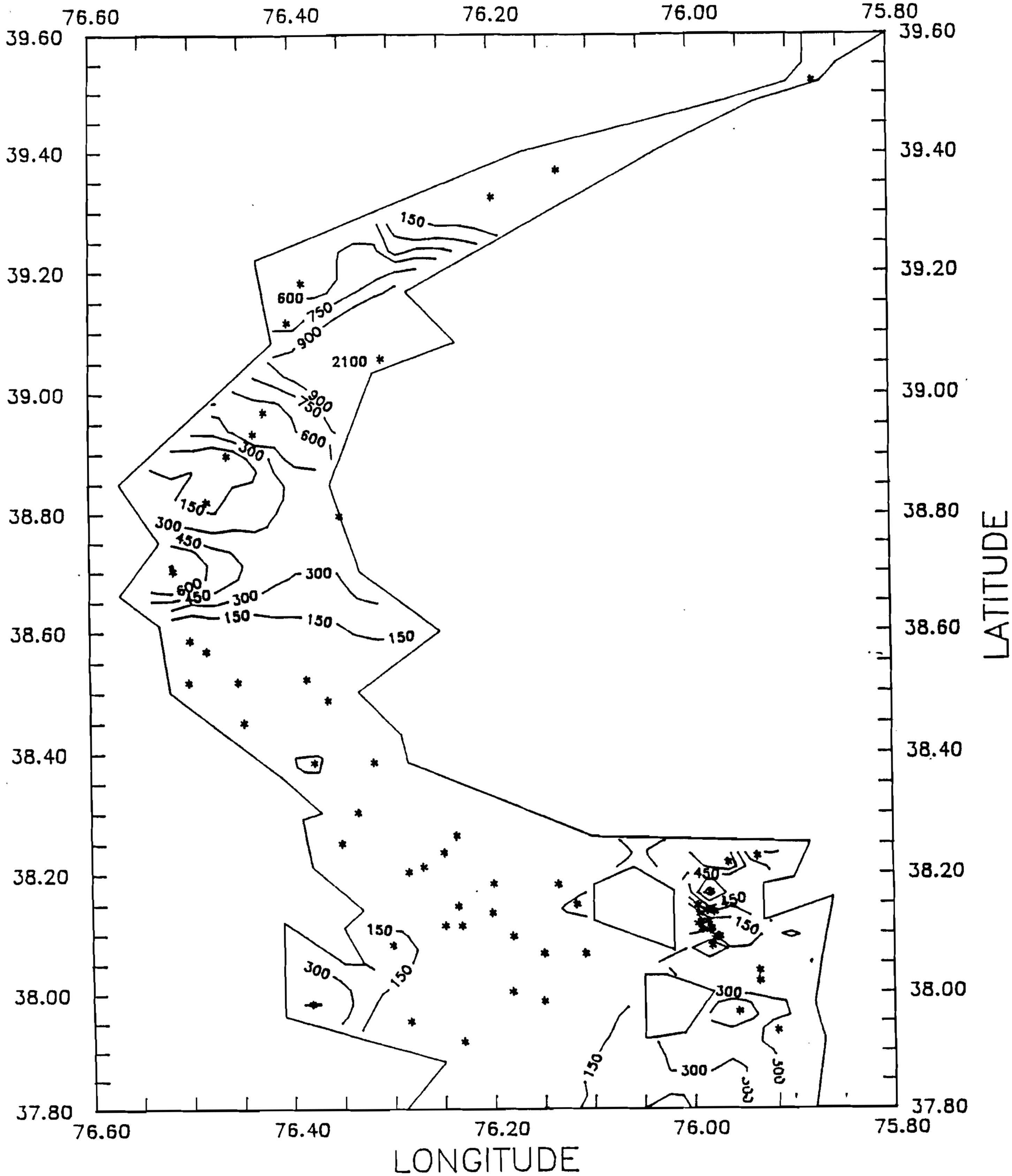


FIG. S4. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JULY 1989

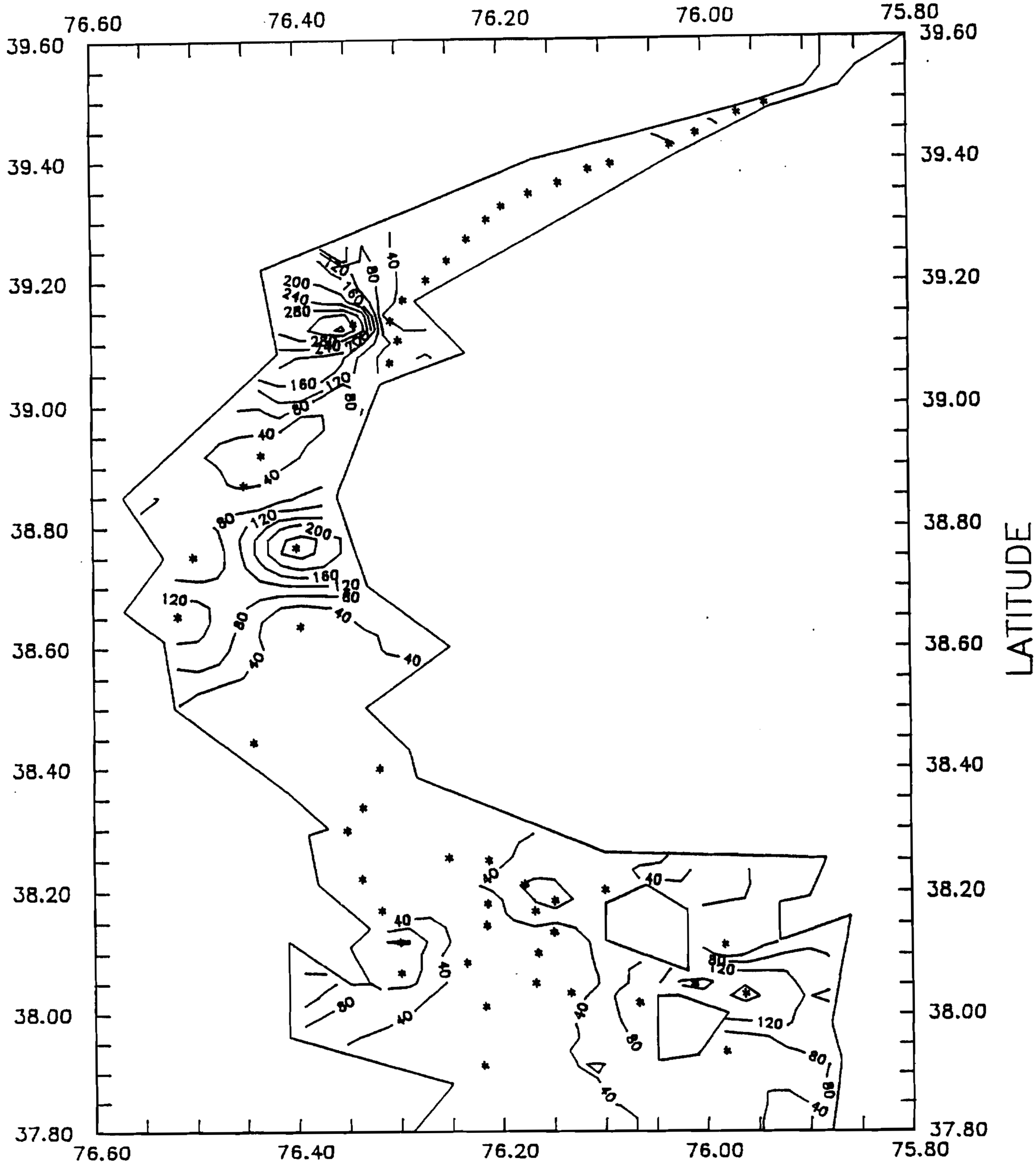


FIG. S5. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY AUGUST 1989

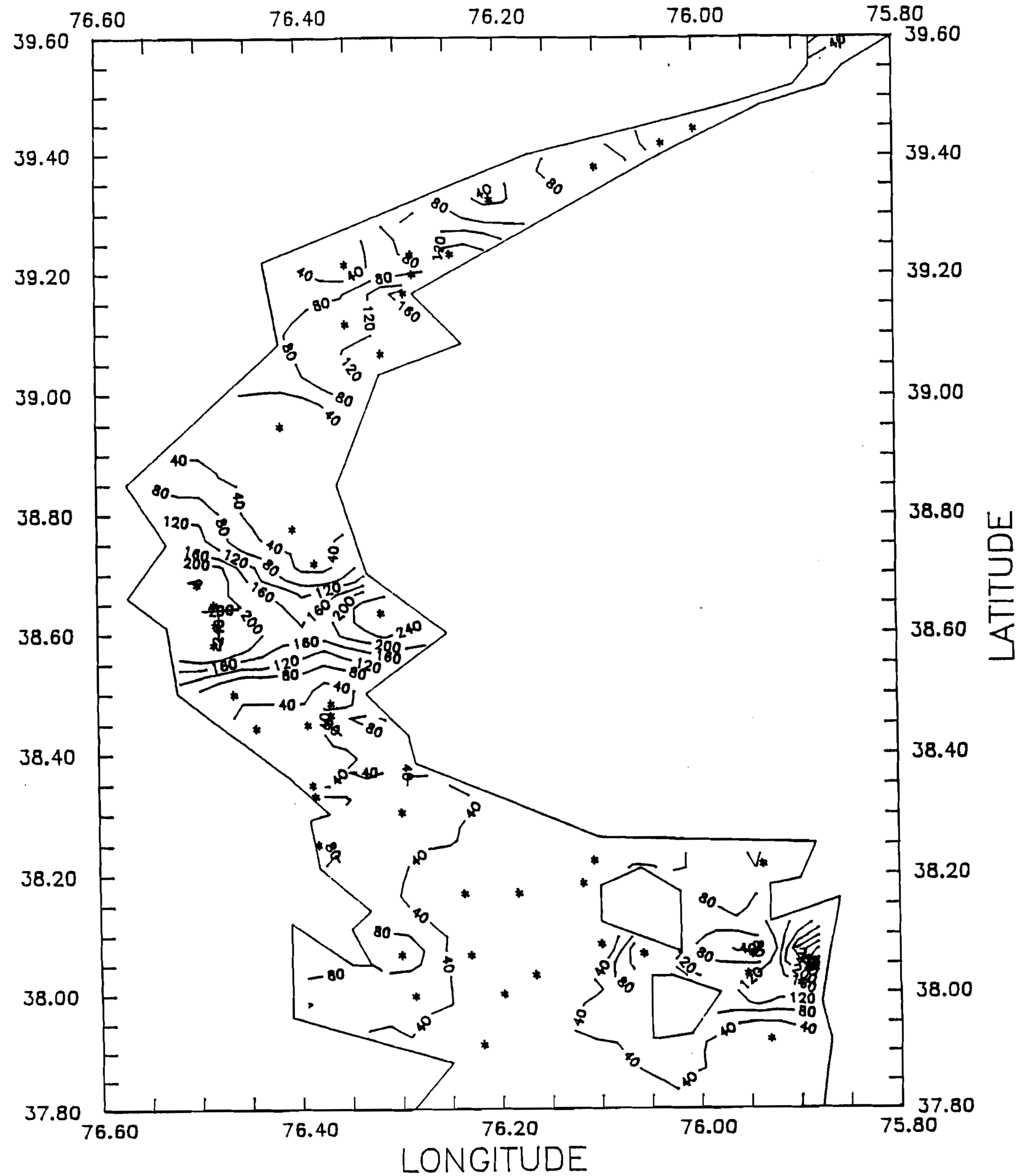


FIG. S6. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY SEPTEMBER 1989

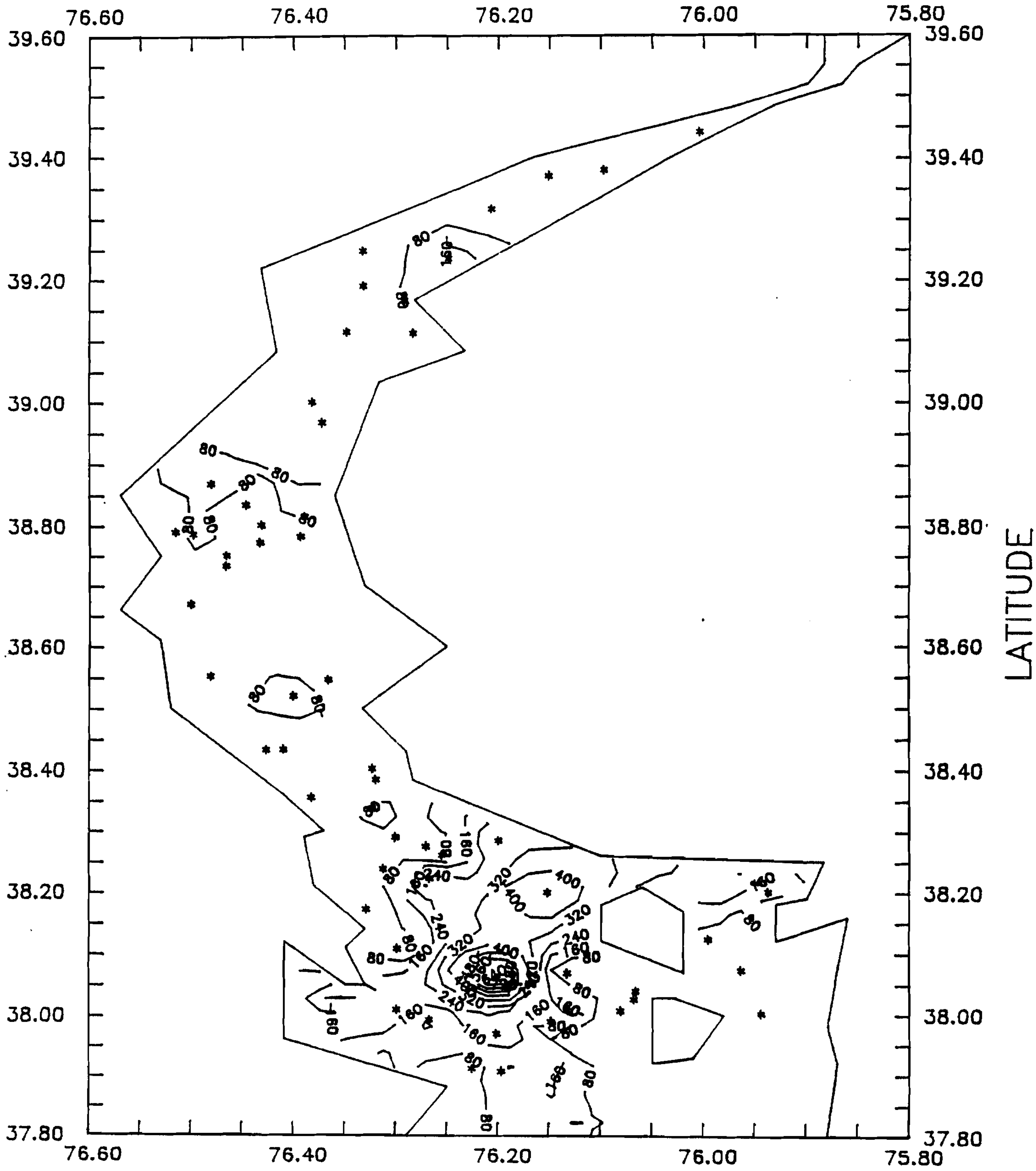


FIG. S7. SPOT CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY OCTOBER 1989

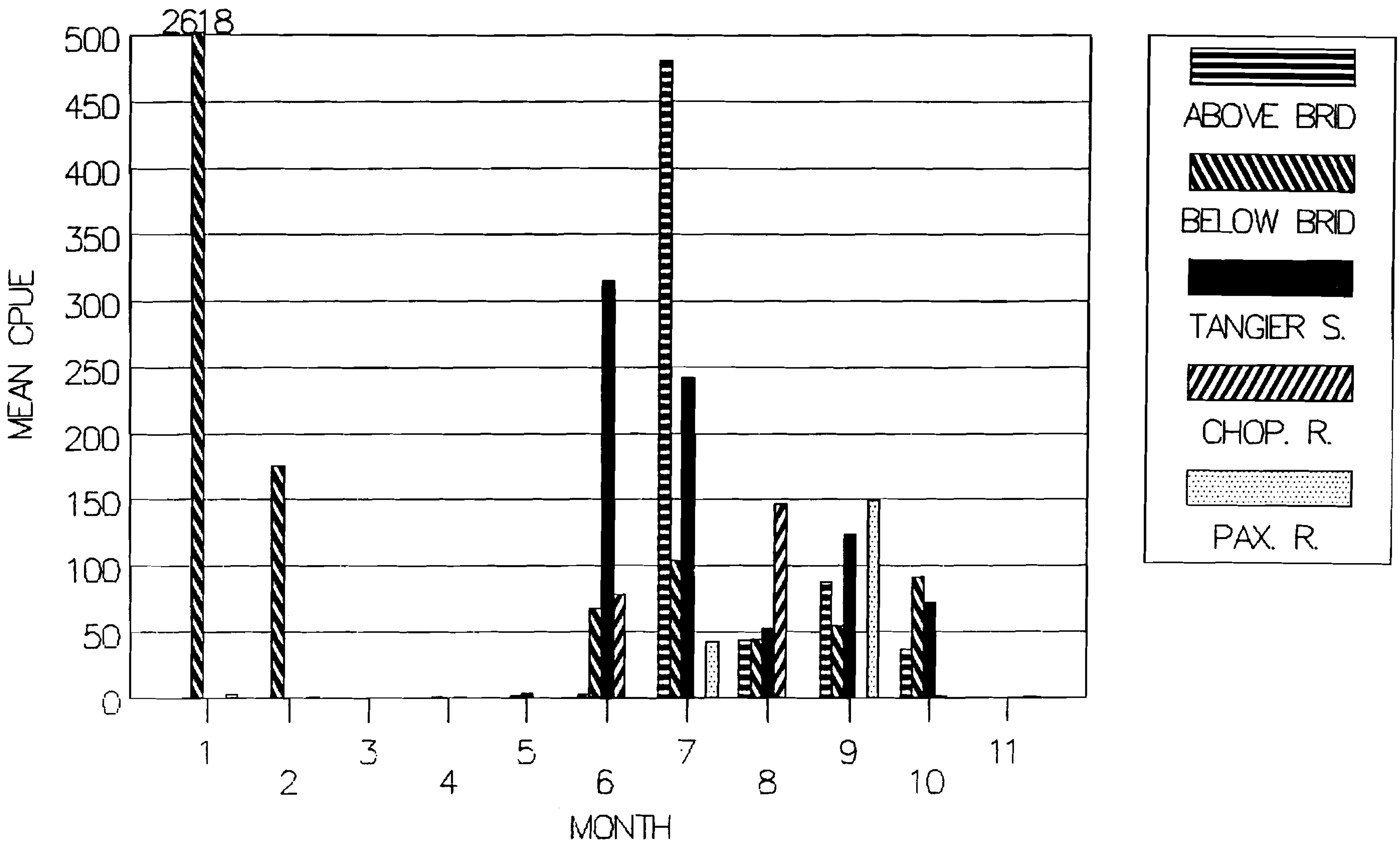
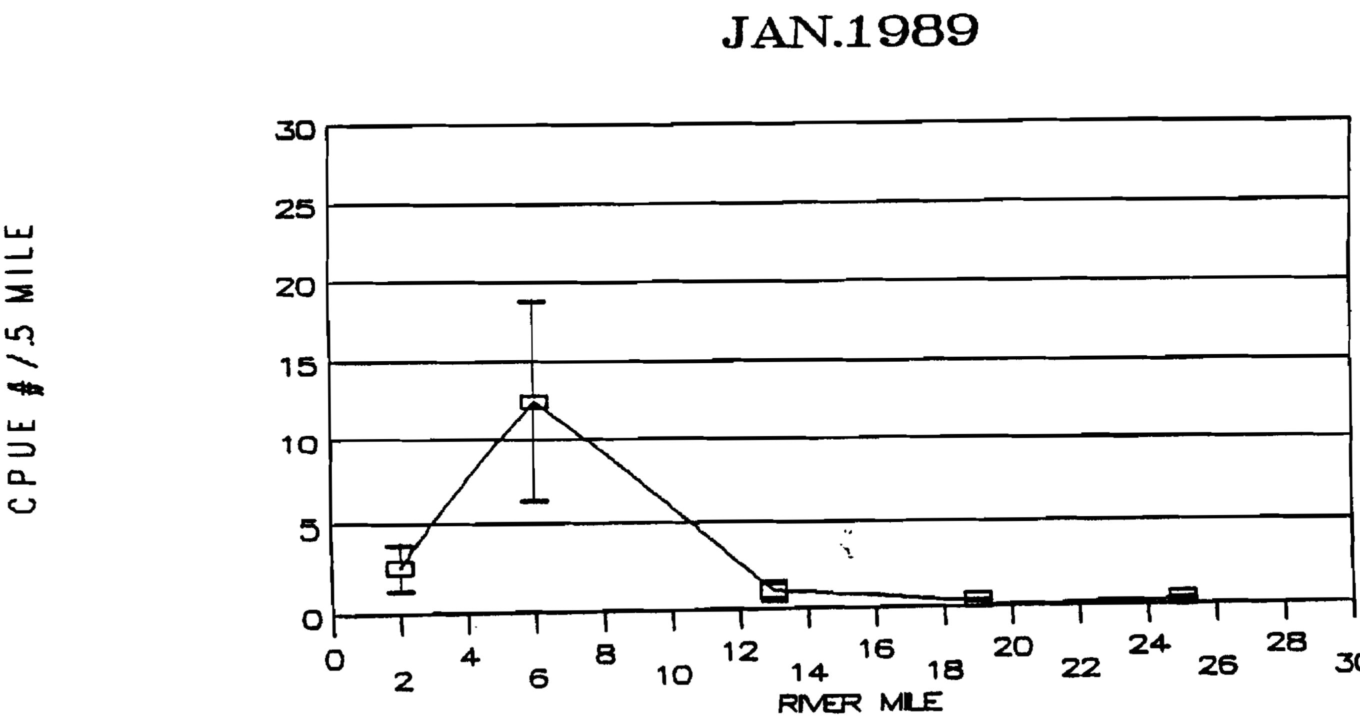


FIG 58. SPOT 1989 CPUE DATA
MONTH VS. MEAN CPUE FOR TOTAL HAULS



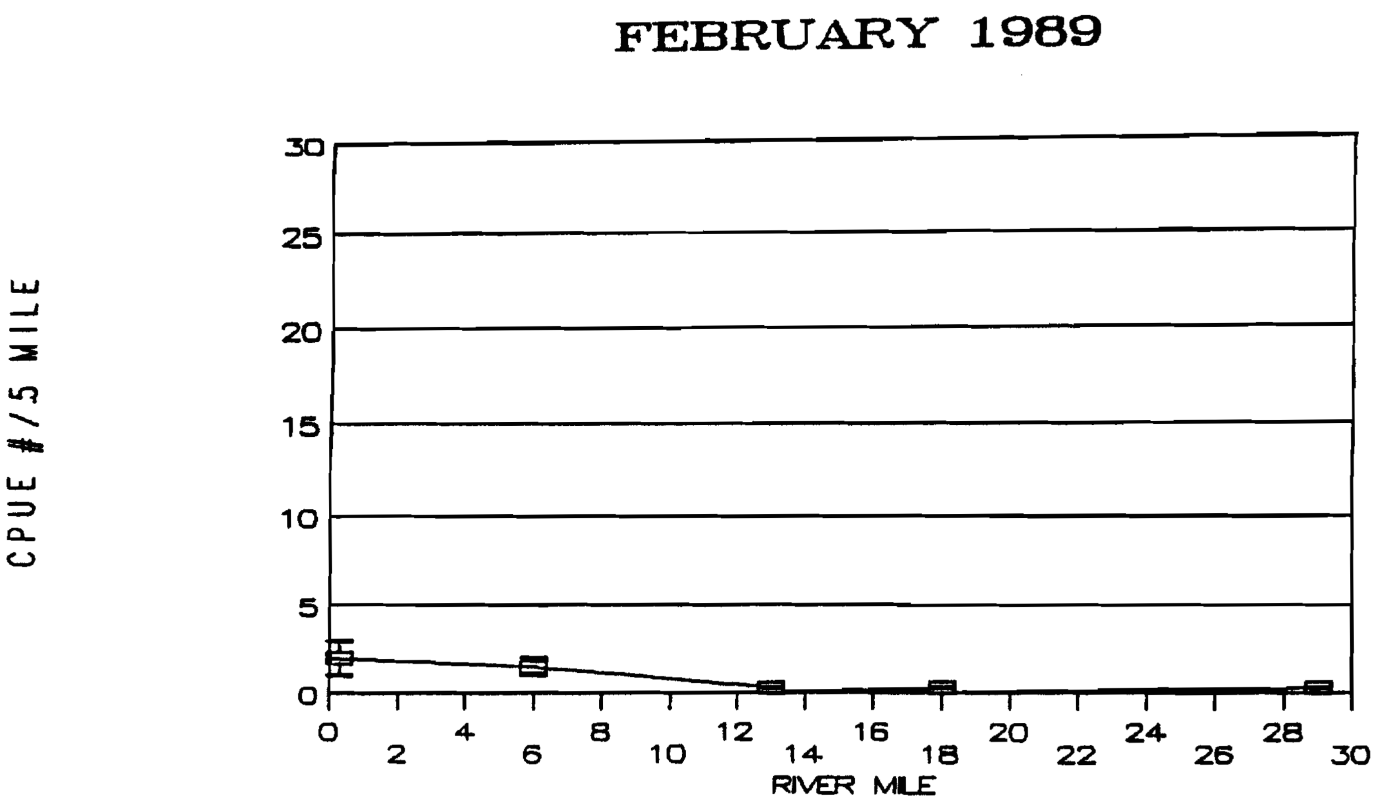
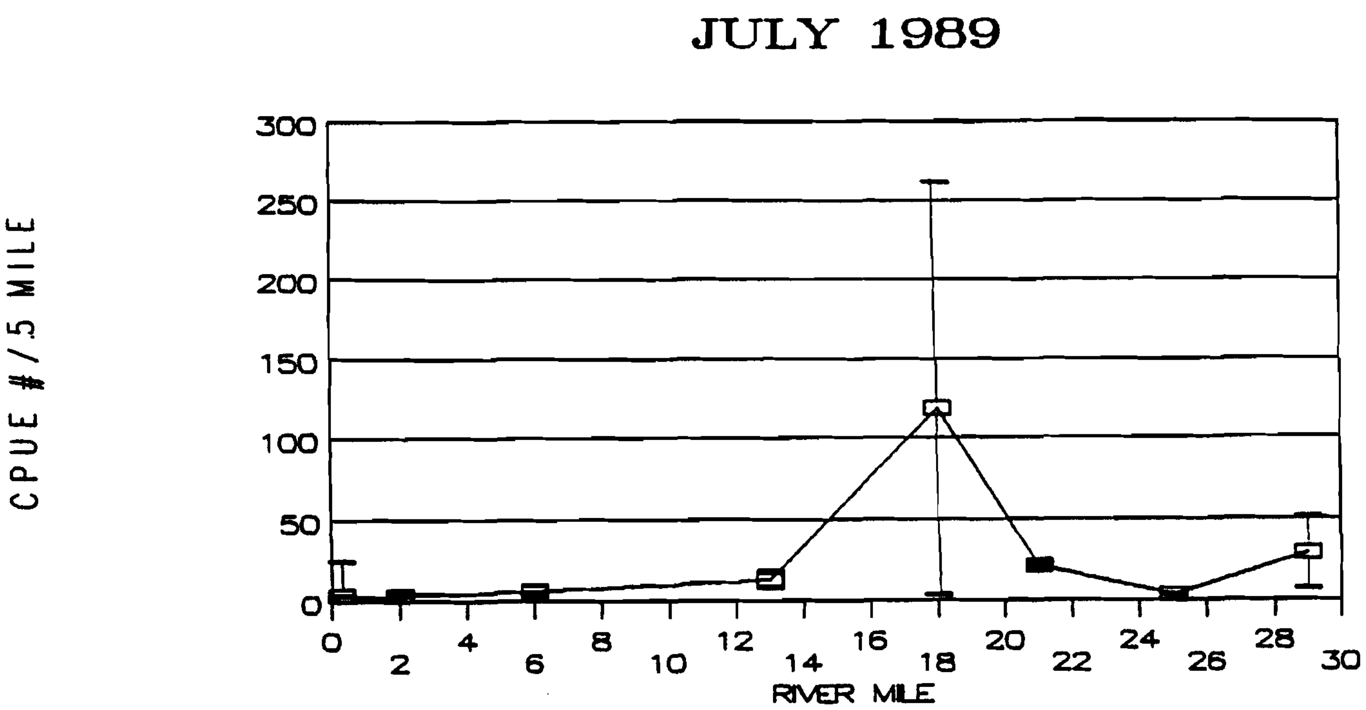


FIG. S9. CPUE BY RIVER MILE FOR SPOT IN THE PATUXENT RIVER, 1989.



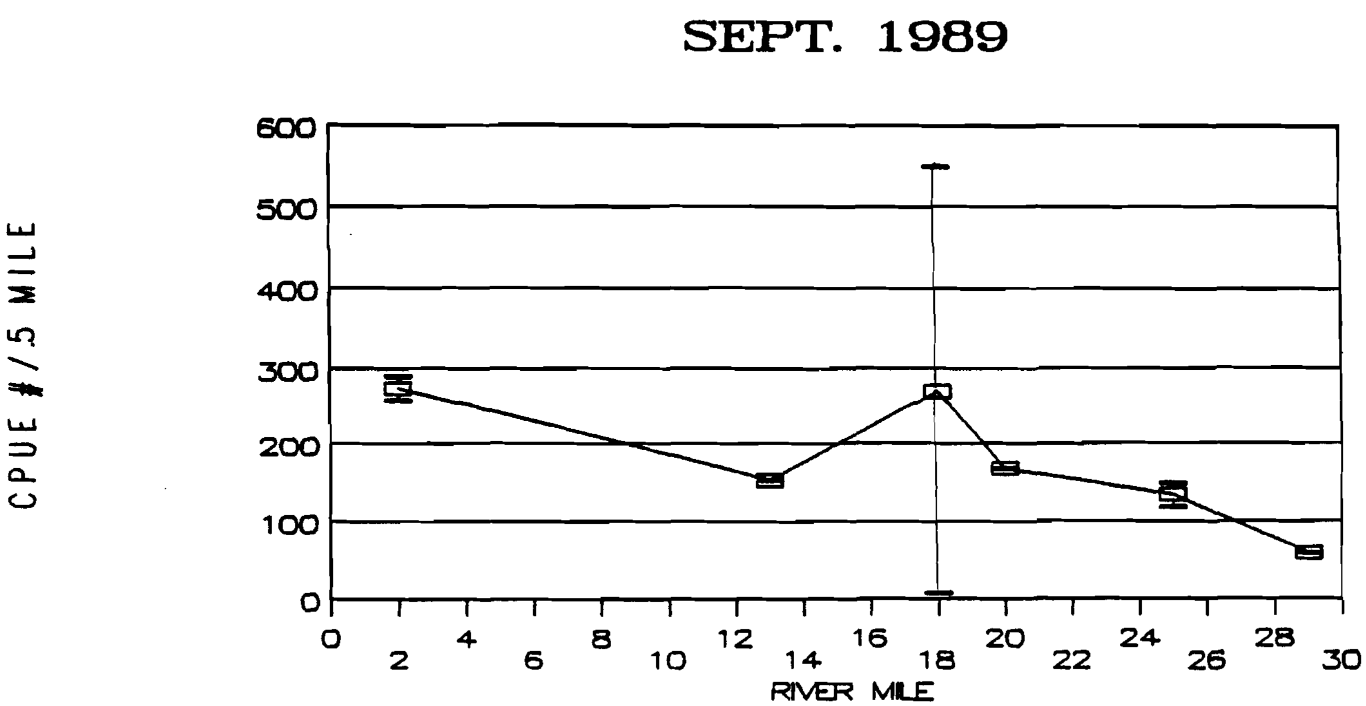


FIG. S10. CPUE BY RIVER MILE FOR SPOT IN THE PATUXENT RIVER, 1989.

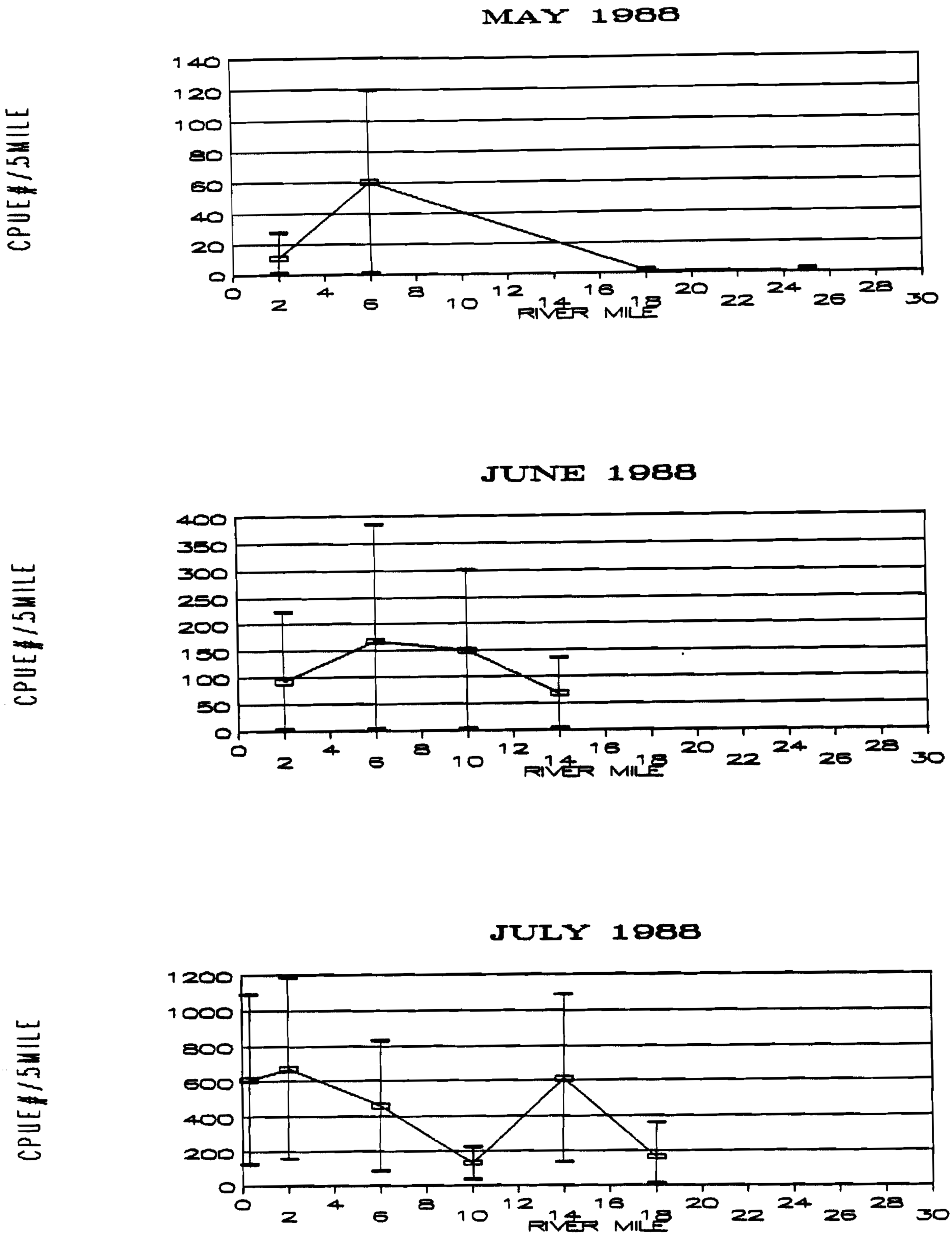


FIG. S11. CPUE BY RIVER MILE FOR SPOT IN THE PATUXENT RIVER, 1988.

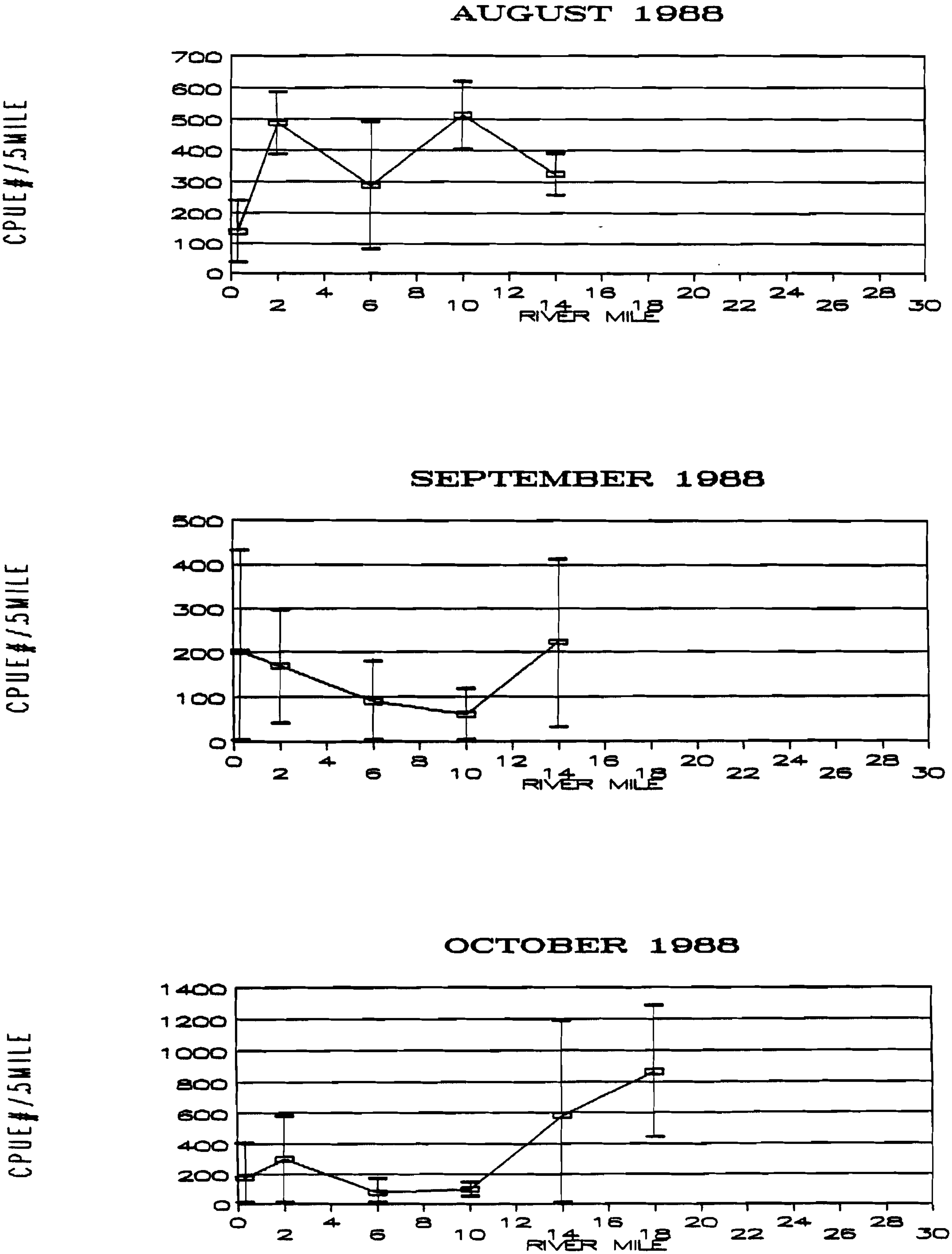
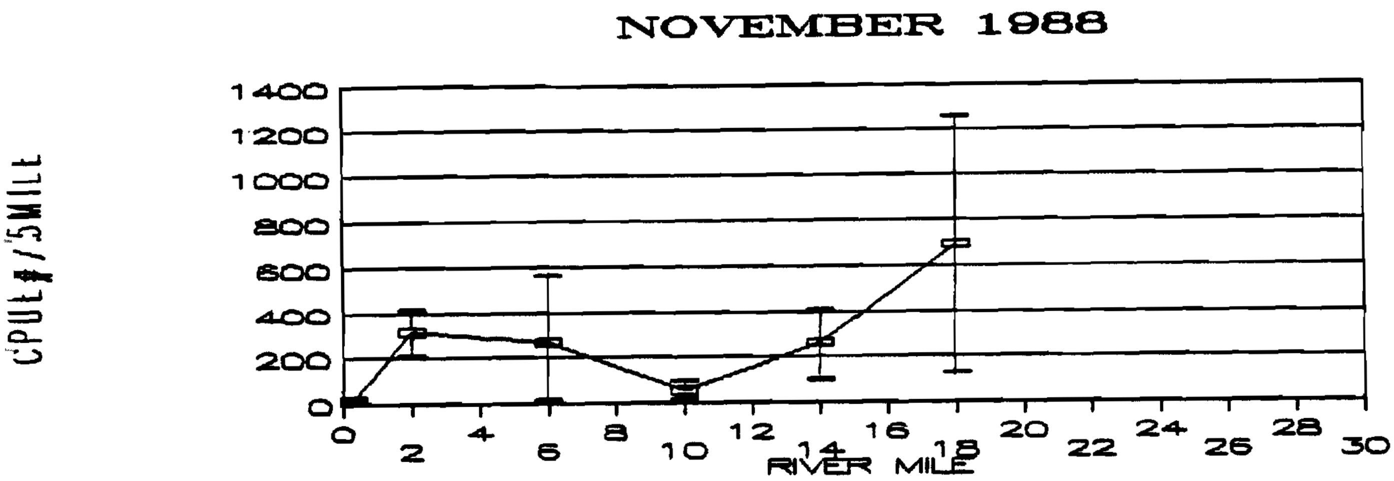


FIG. S12. CPUE BY RIVER MILE FOR SPOT
IN THE PATUXENT RIVER, 1988.



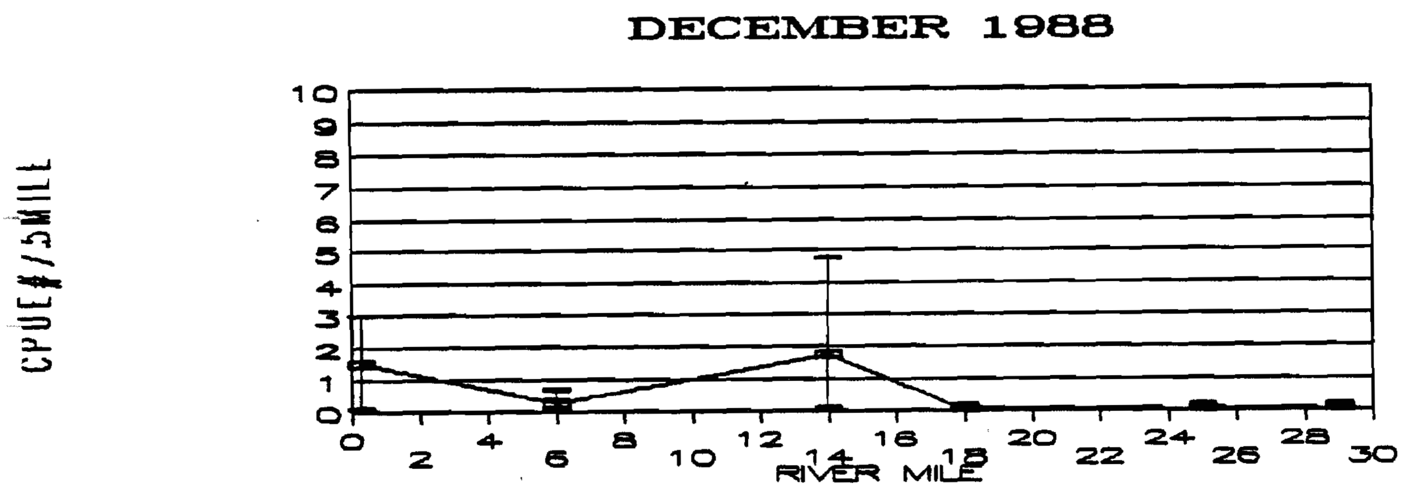
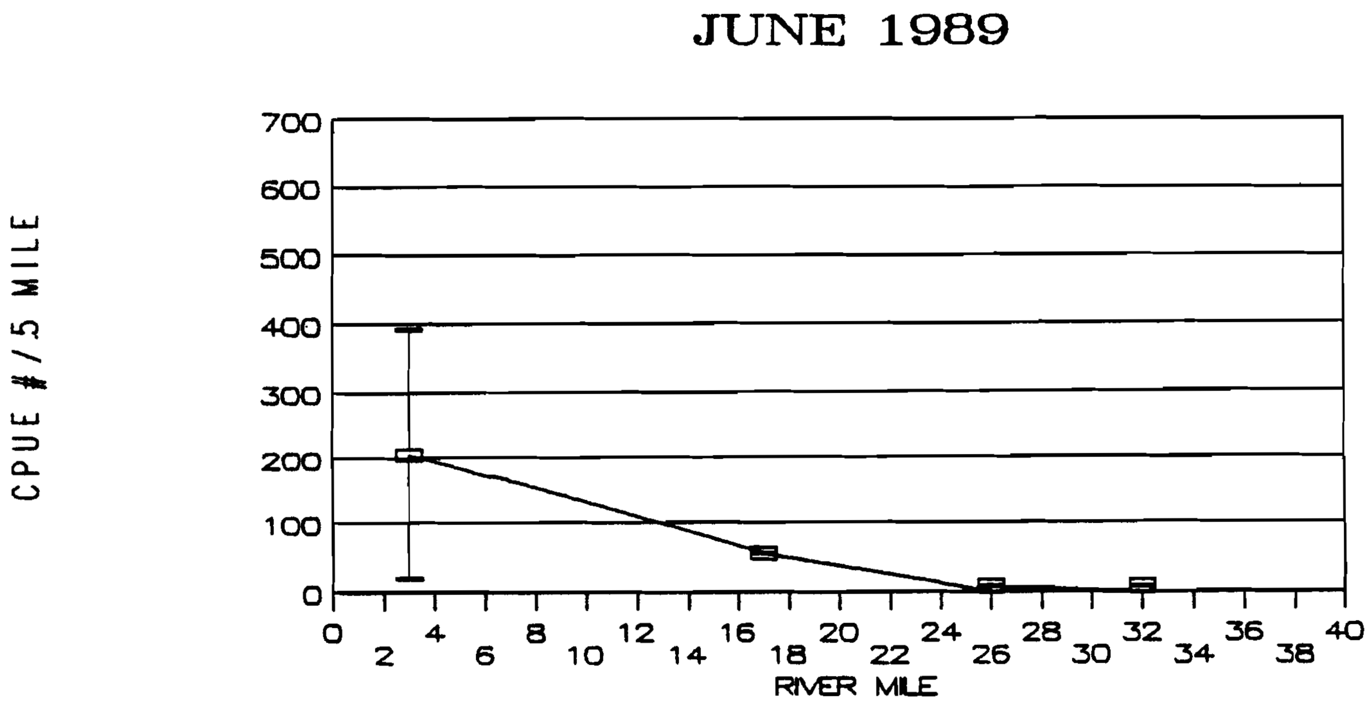


FIG. S13. CPUE BY RIVER MILE FOR SPOT IN THE PATUXENT RIVER, 1988.



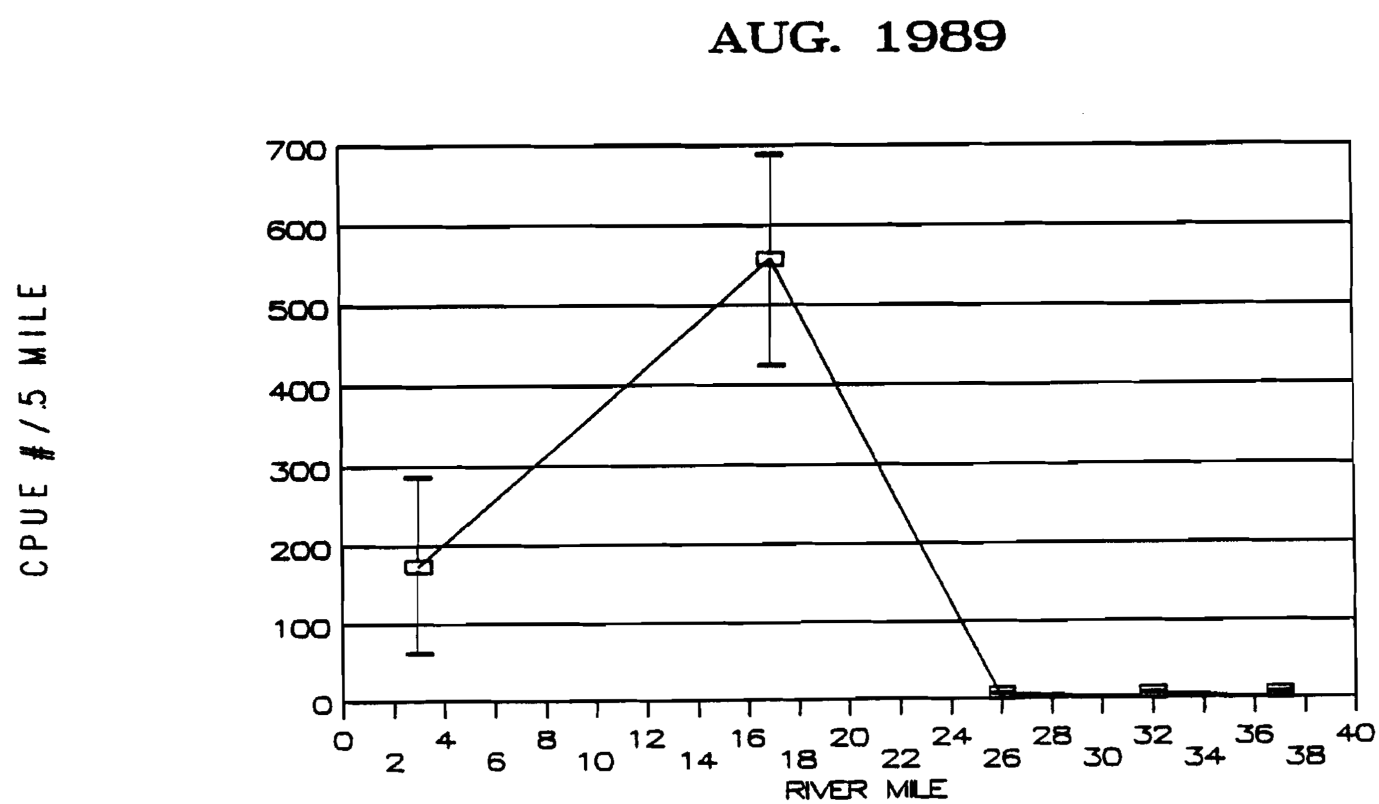


FIG. S14. CPUE BY RIVER MILE FOR SPOT
IN THE CHOPTANK RIVER, 1989.

OCT. 1989

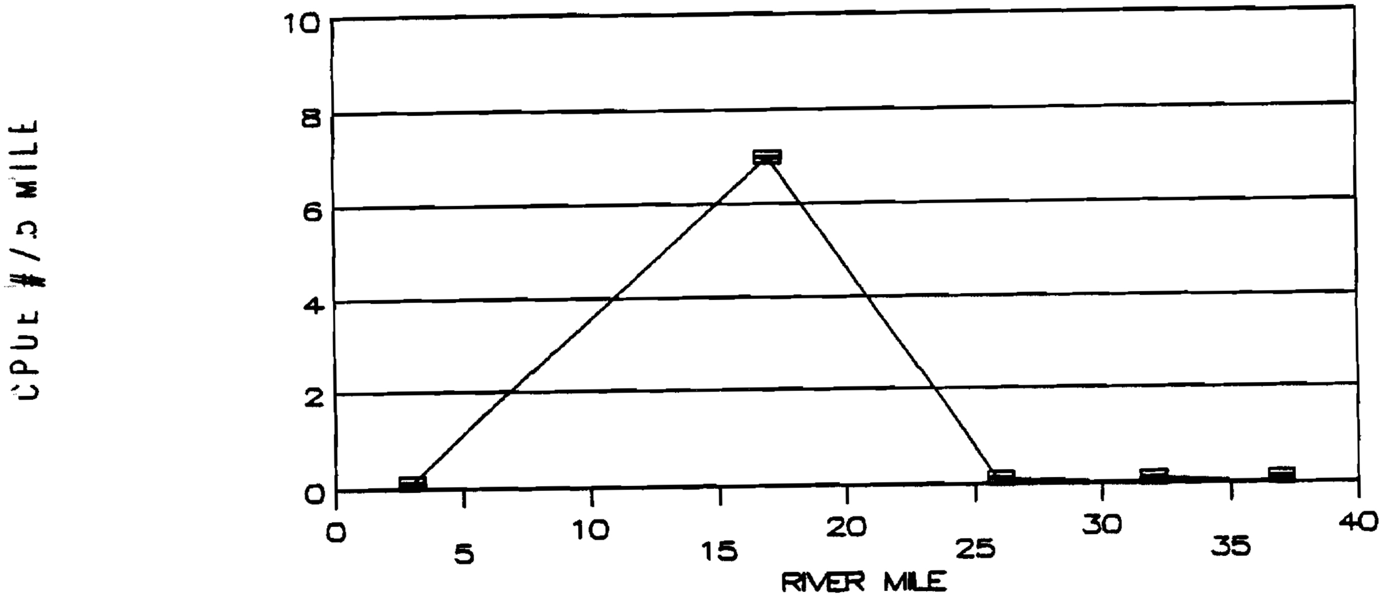


FIG. S15. CPUE BY RIVER MILE FOR SPOT IN THE CHOPTANK RIVER, 1989..

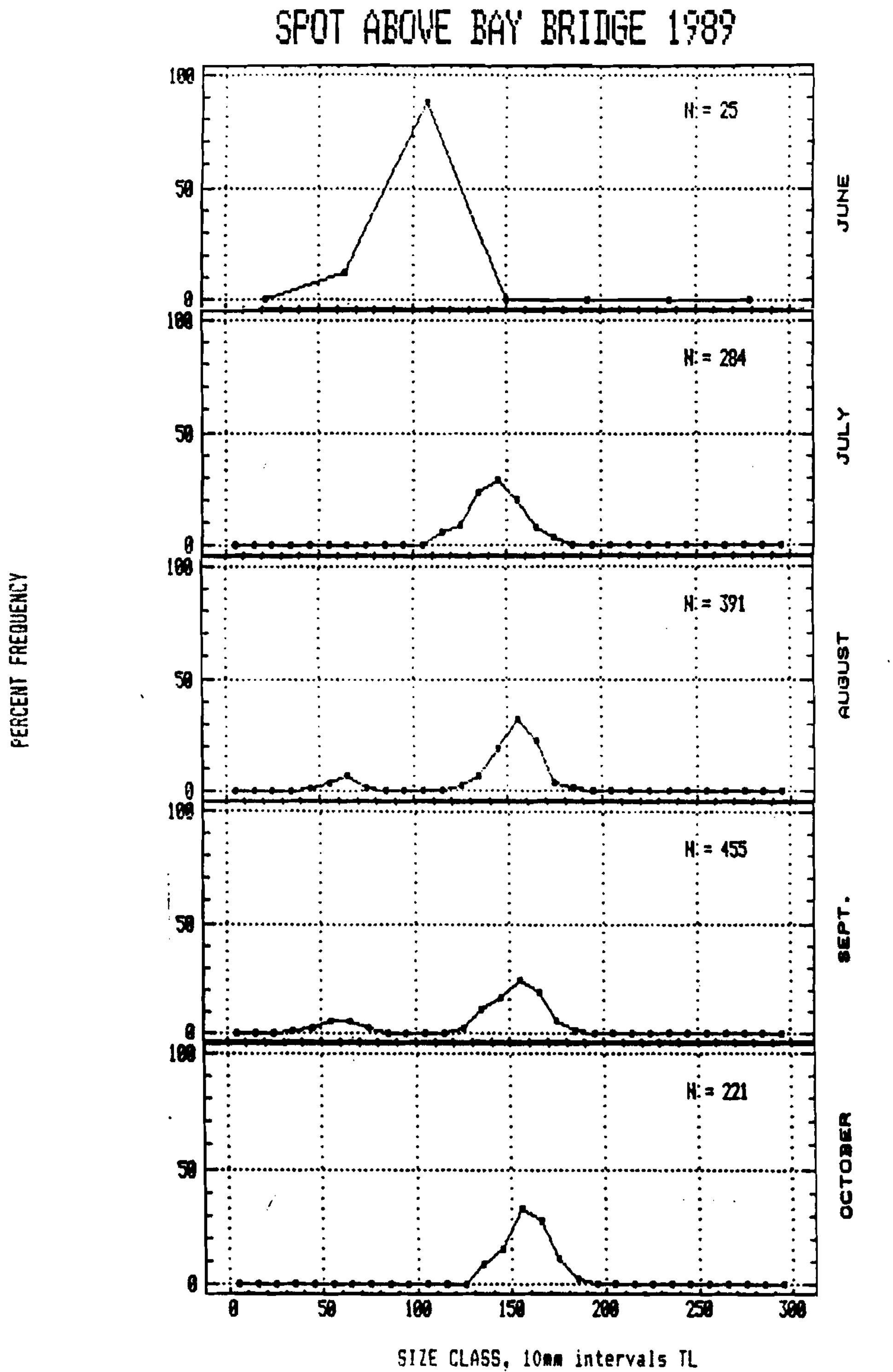


Fig. S16. Percent frequency of lengths of spot in the Above Bay Bridge region, 1989.

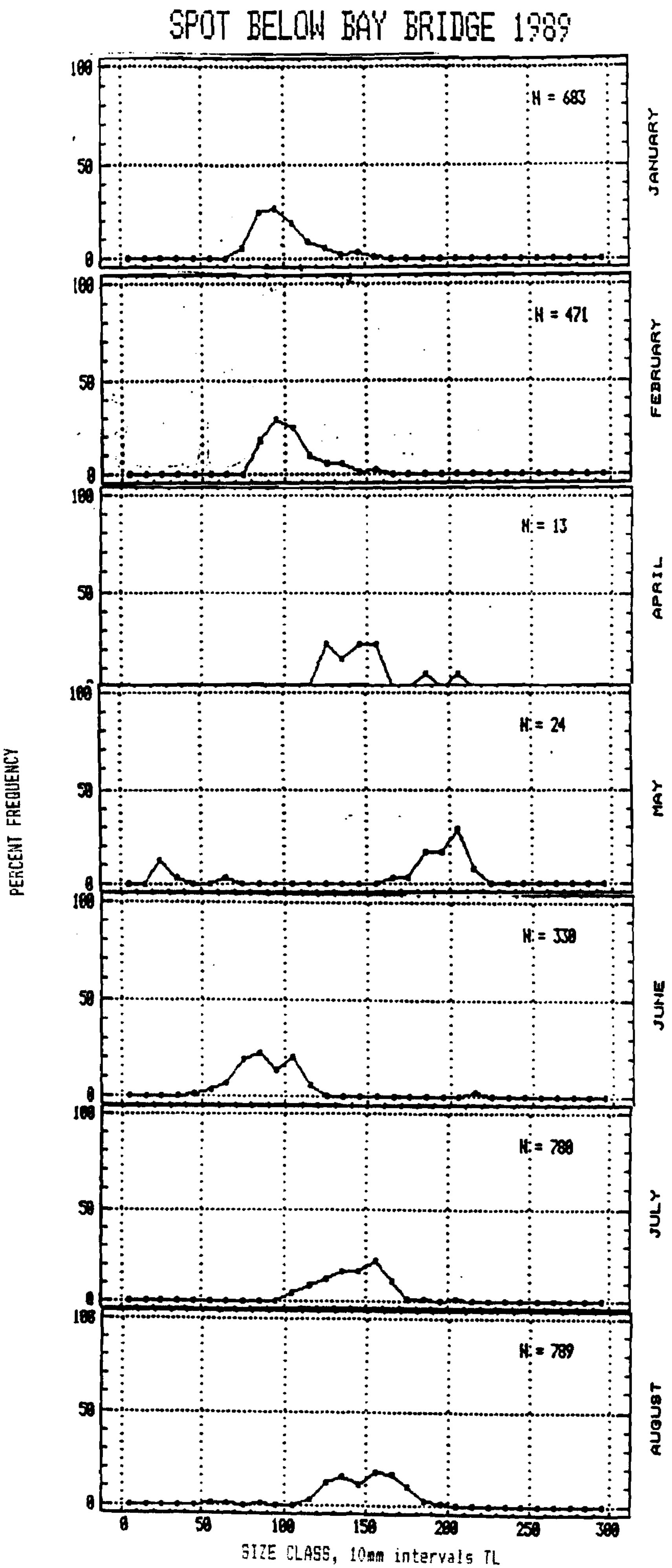


Fig. 617. Percent frequency of lengths of spot in the Below Bay Bridge region, 1989.

SPOT BELOW BAY BRIDGE 1989

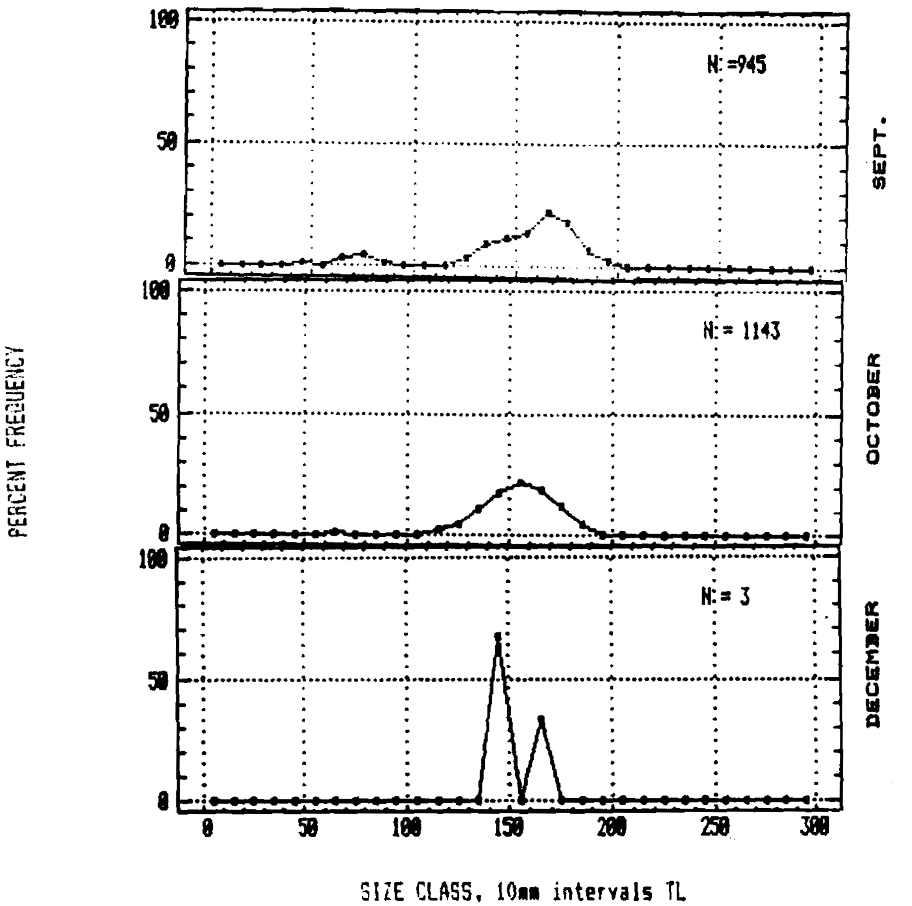


Fig. S17(cont.). Percent frequency of lengths of spot in the Below Bay Bridge region, 1989.

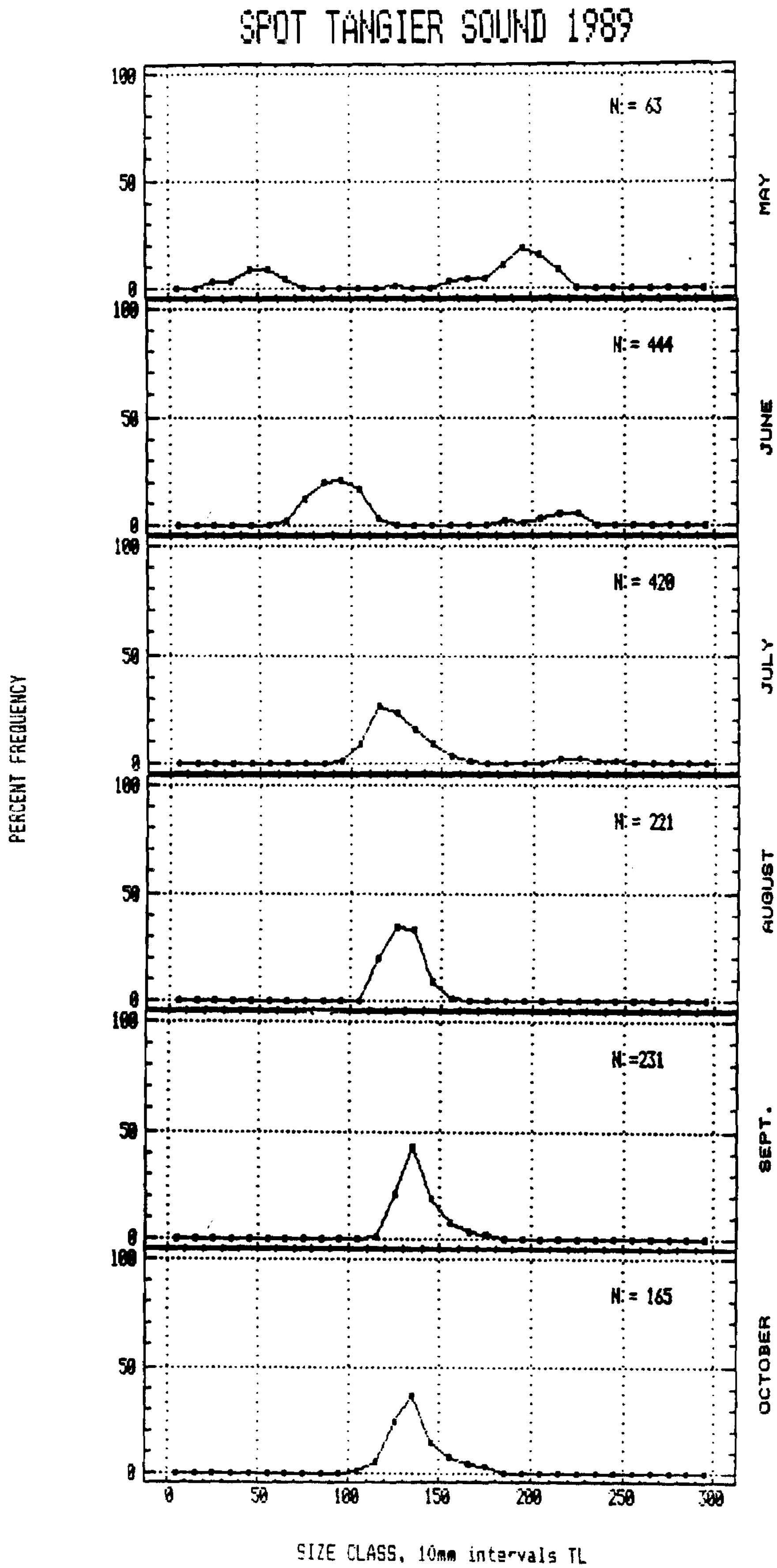


Fig. S18. Percent frequency of lengths of spot in the Tangier Sound region, 1989.

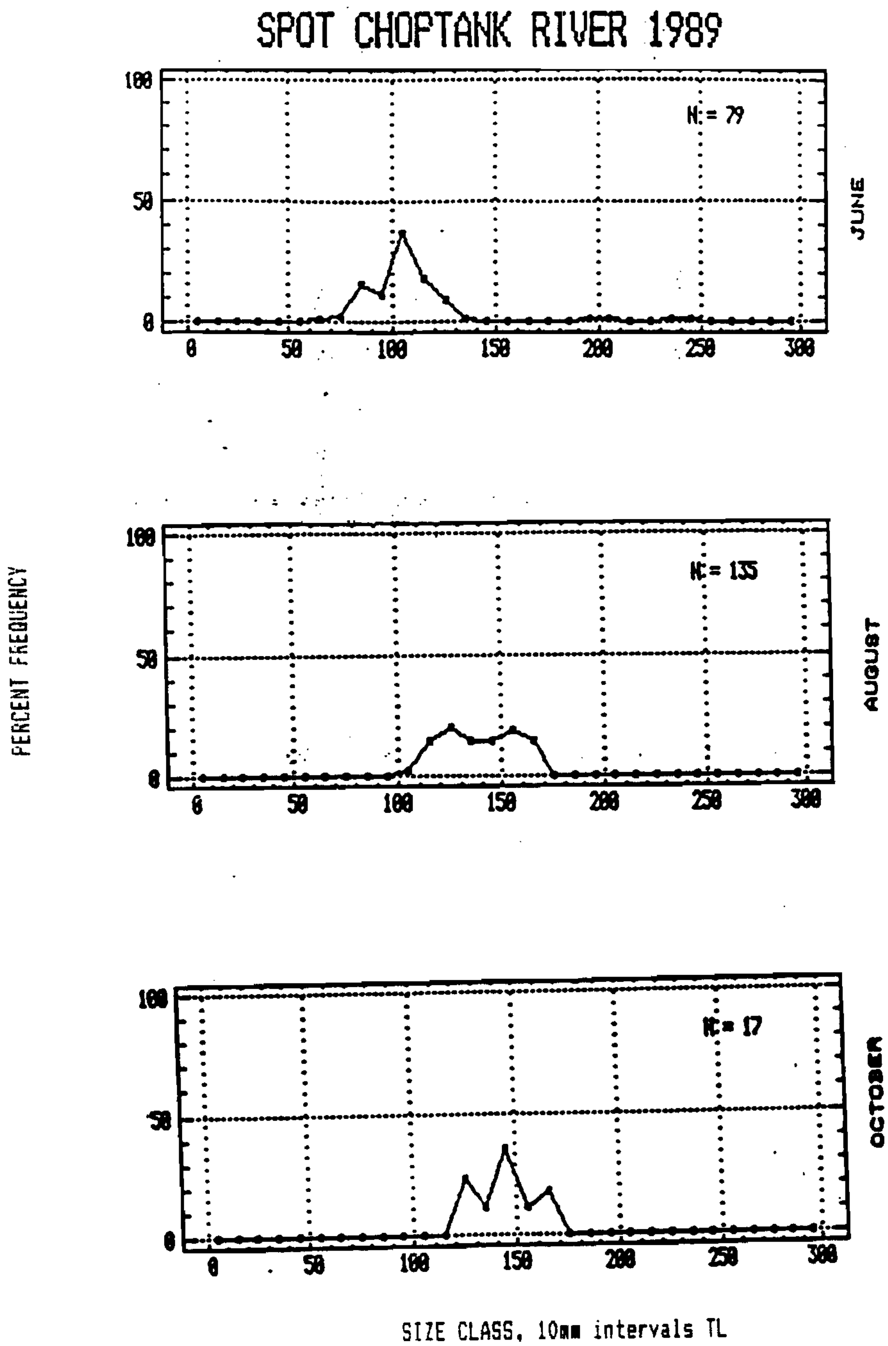


Fig. S19. Percent frequency of lengths of spot in the Choptank River region, 1989.

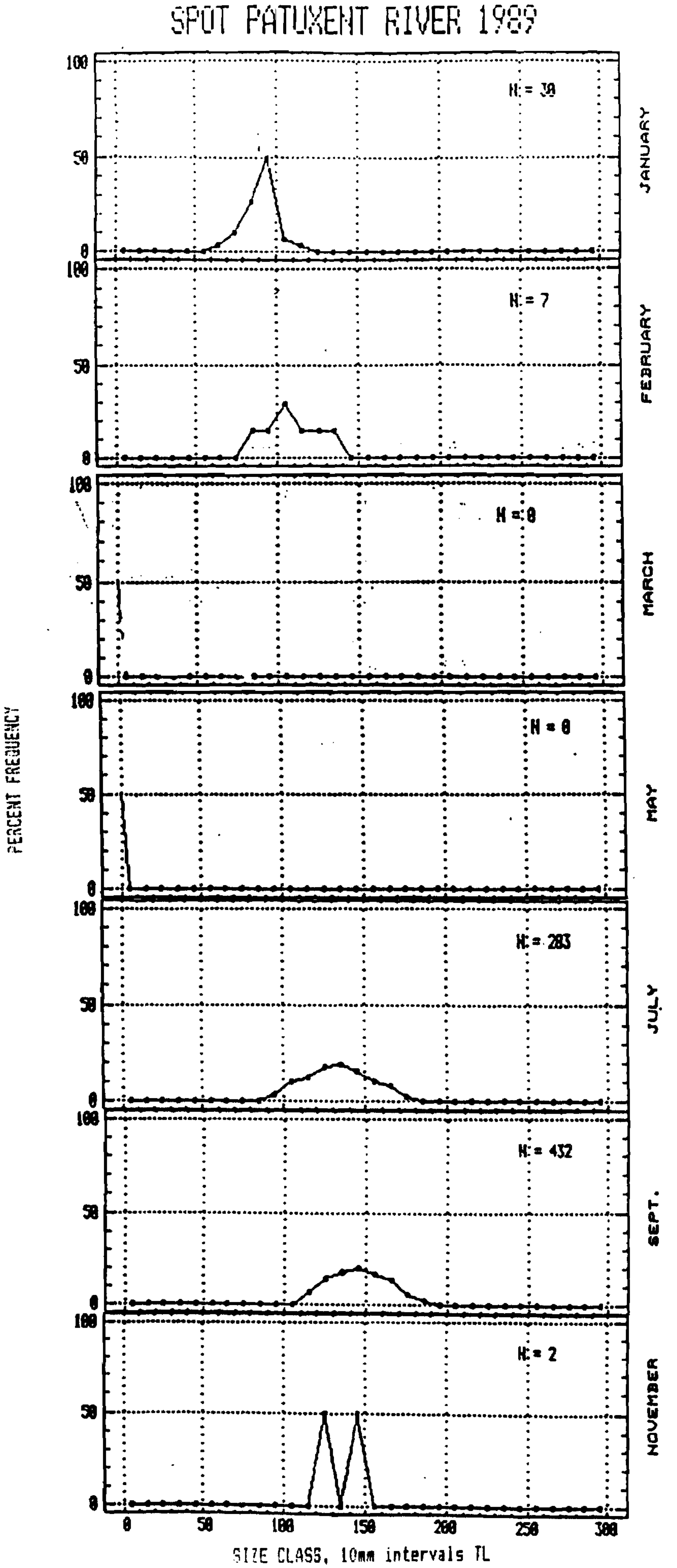


Fig. S20. Percent frequency of lengths of spot in the Patuxent River region, 1989.

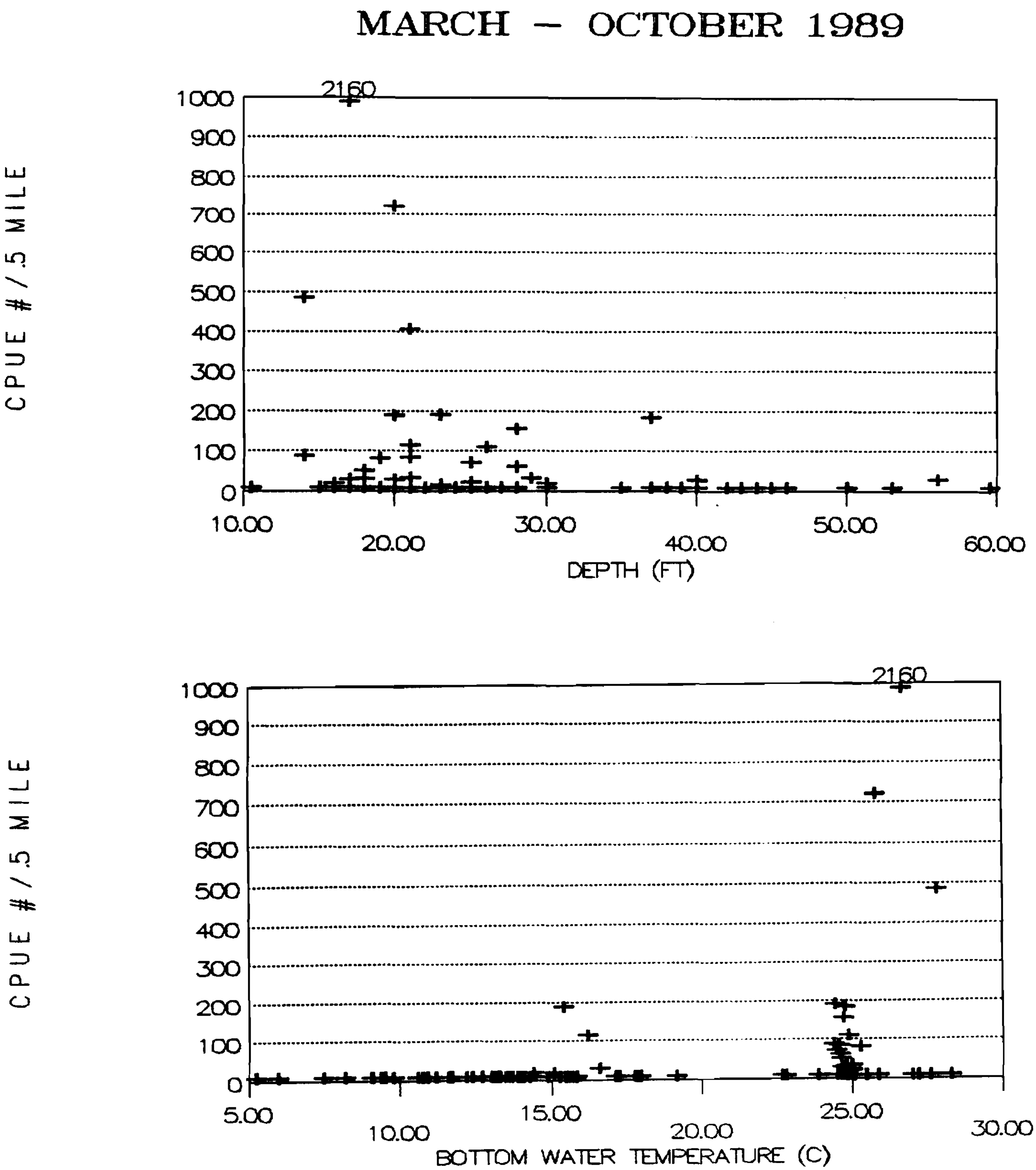
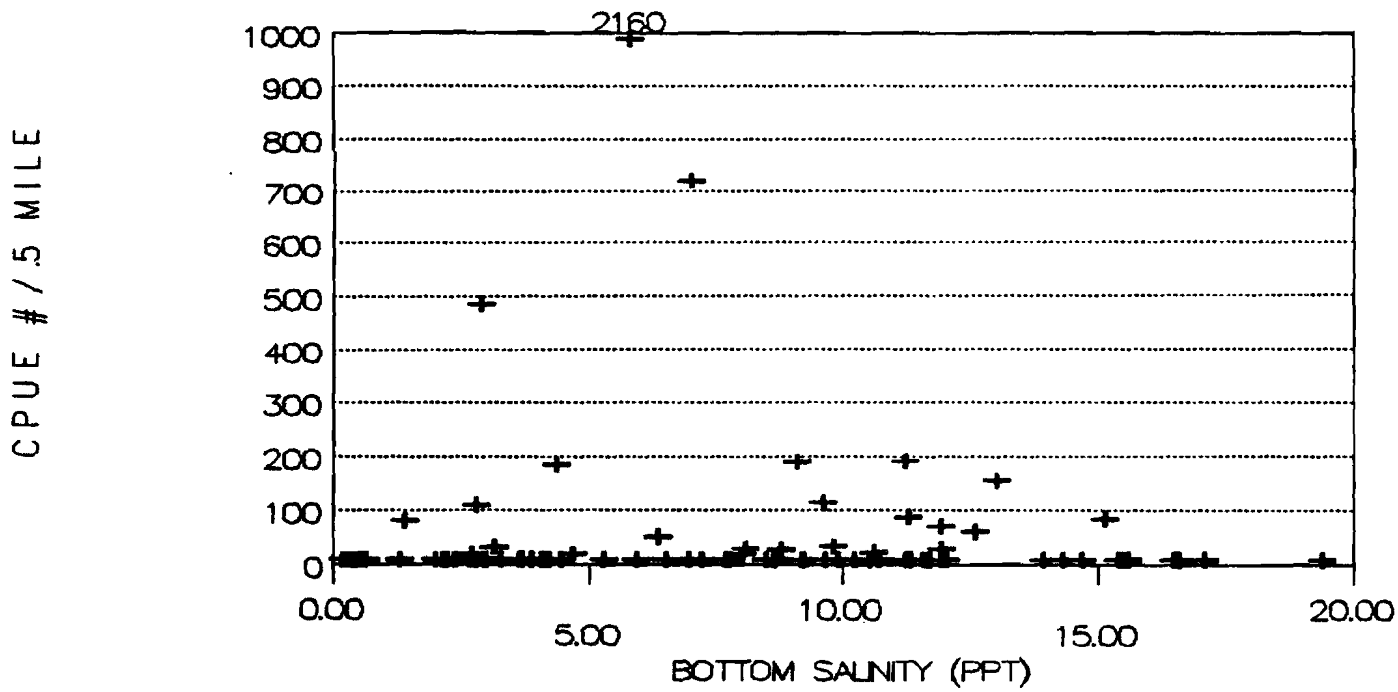


Fig. S21. Spot CPUE by environmental parameters in the Above Bay Bridge region for all months combined, 1989.

MARCH – OCTOBER 1989



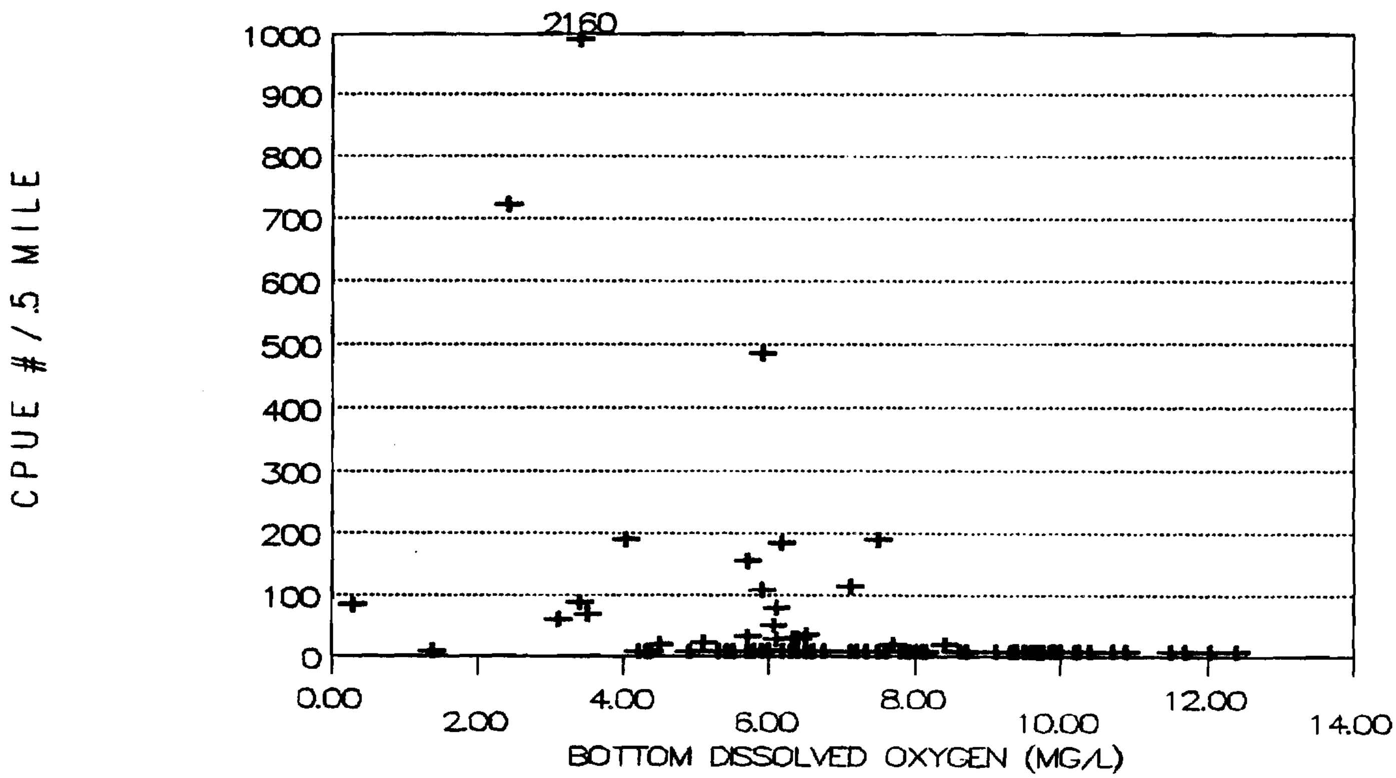
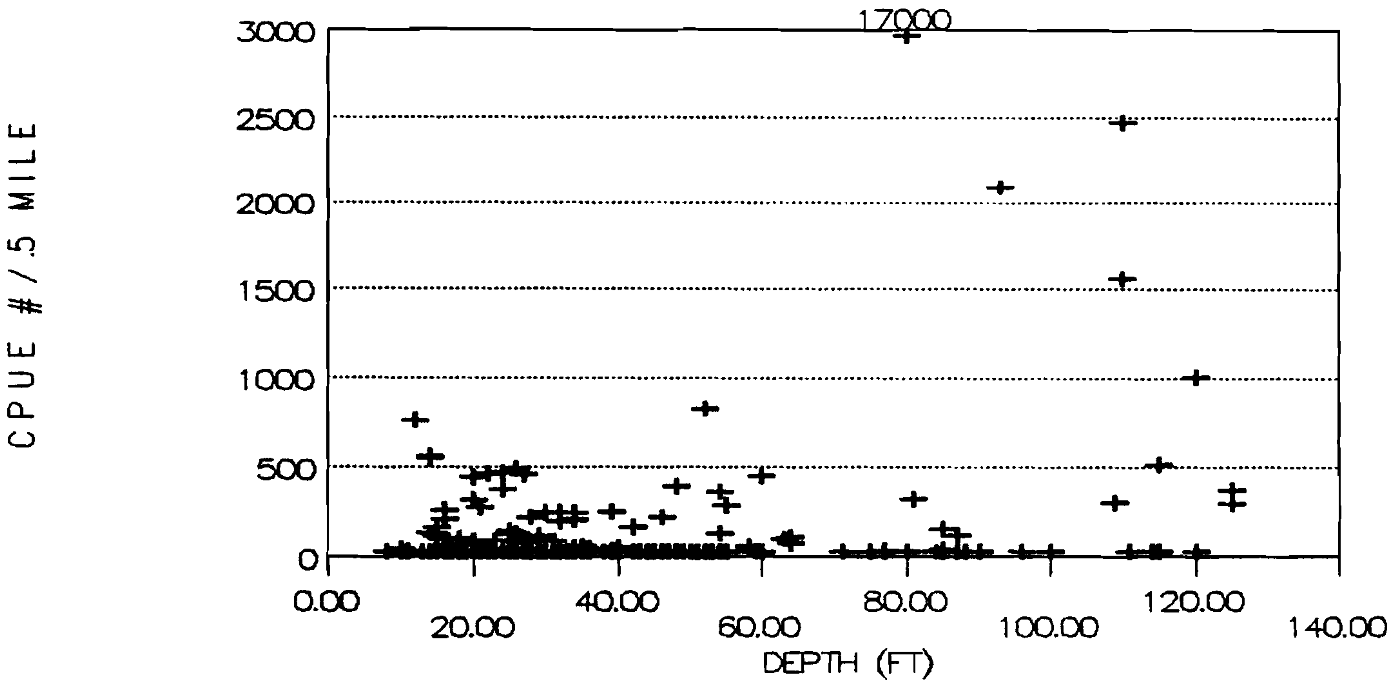


Fig. S22. Spot CPUE by environmental parameters in the Above Bay Bridge region for all months combined, 1989.

JANUARY – OCTOBER 1989



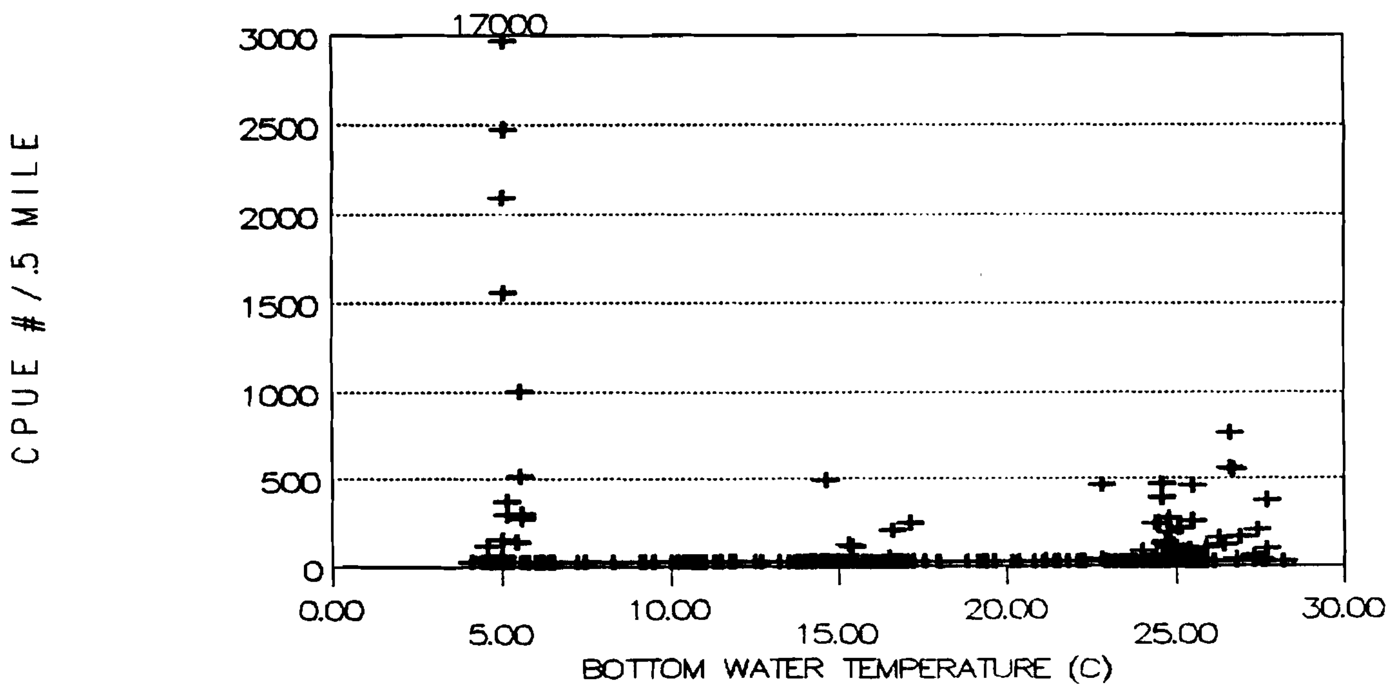
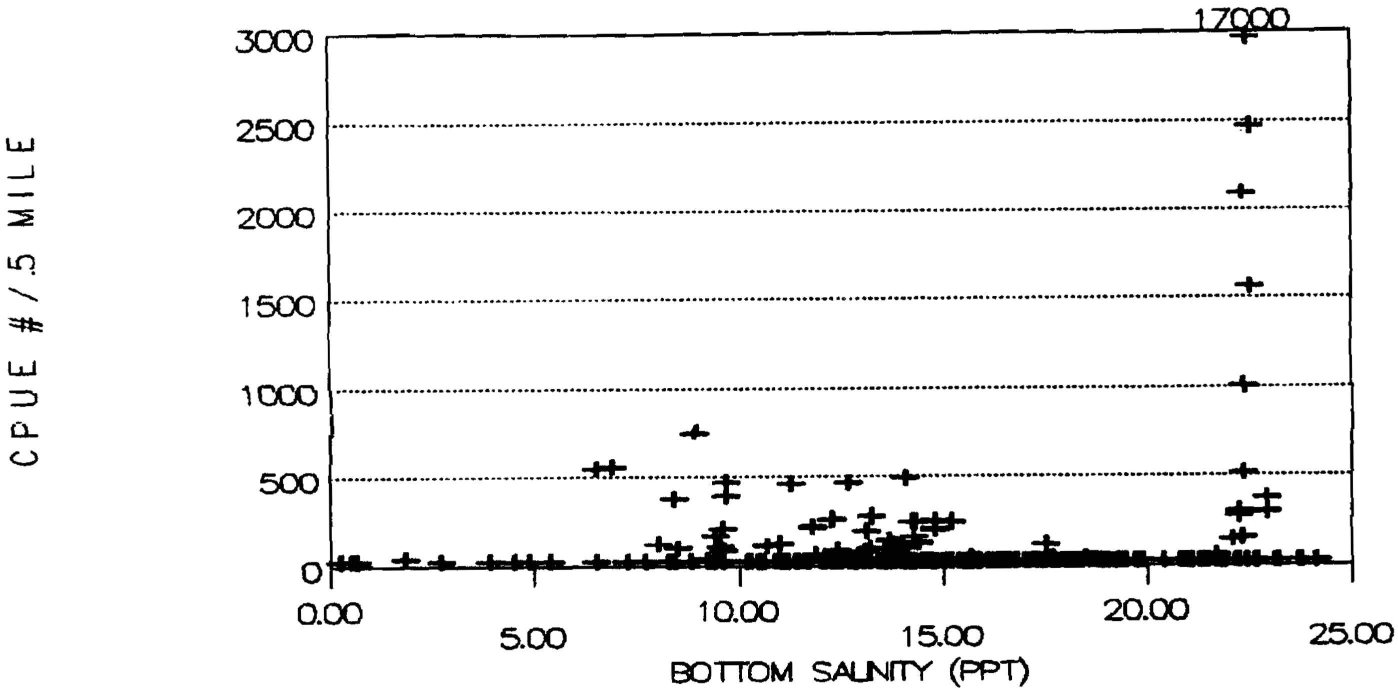


Fig. S23. Spot CPUE by environmental parameters in the Below Bay Bridge region for all months combined, 1989.

JANUARY – OCTOBER 1989



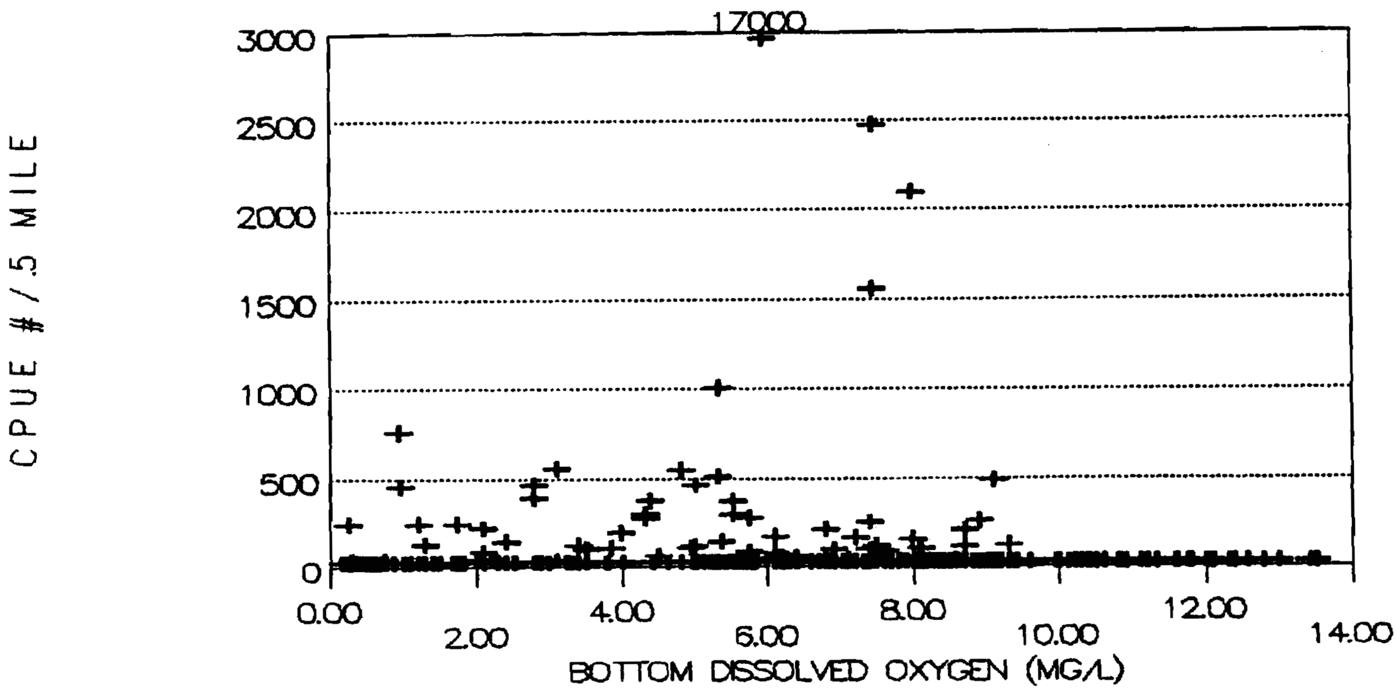


Fig. 524. Spot CPUE by environmental parameters in the Below Bay Bridge region for all months combined, 1989.

APRIL — OCTOBER 1989

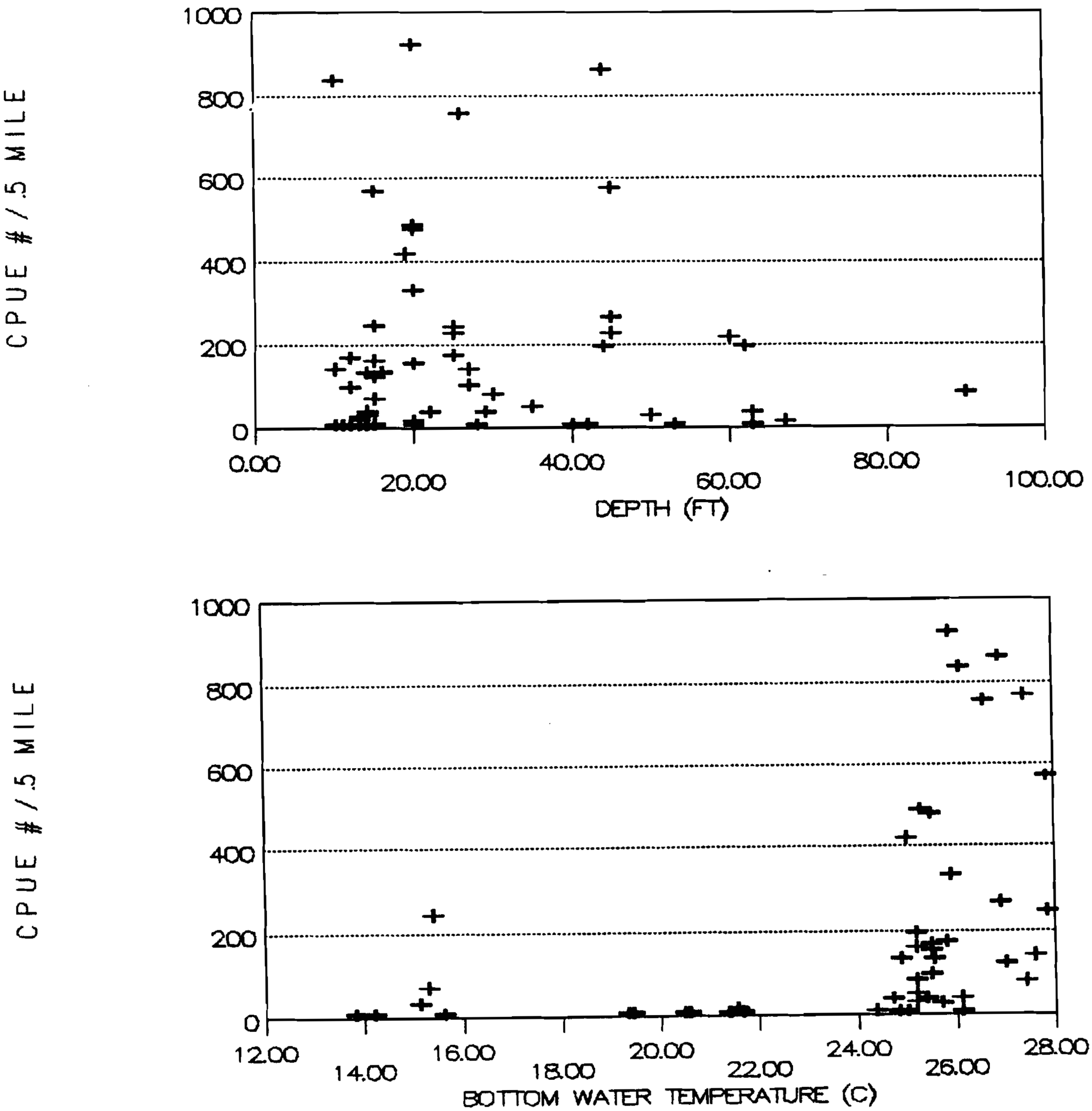
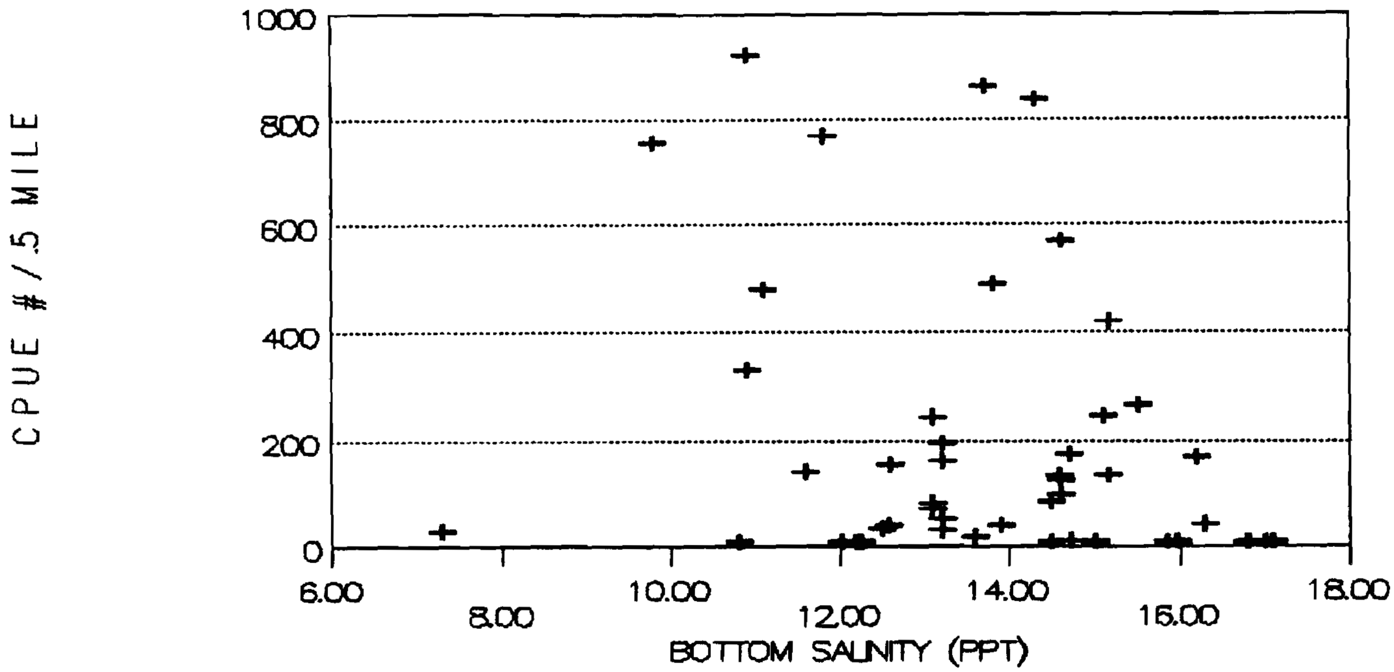


Fig. S25. Spot CPUE by environmental parameters in the Tangier Sound region for all months combined, 1989.

APRIL – OCTOBER 1989



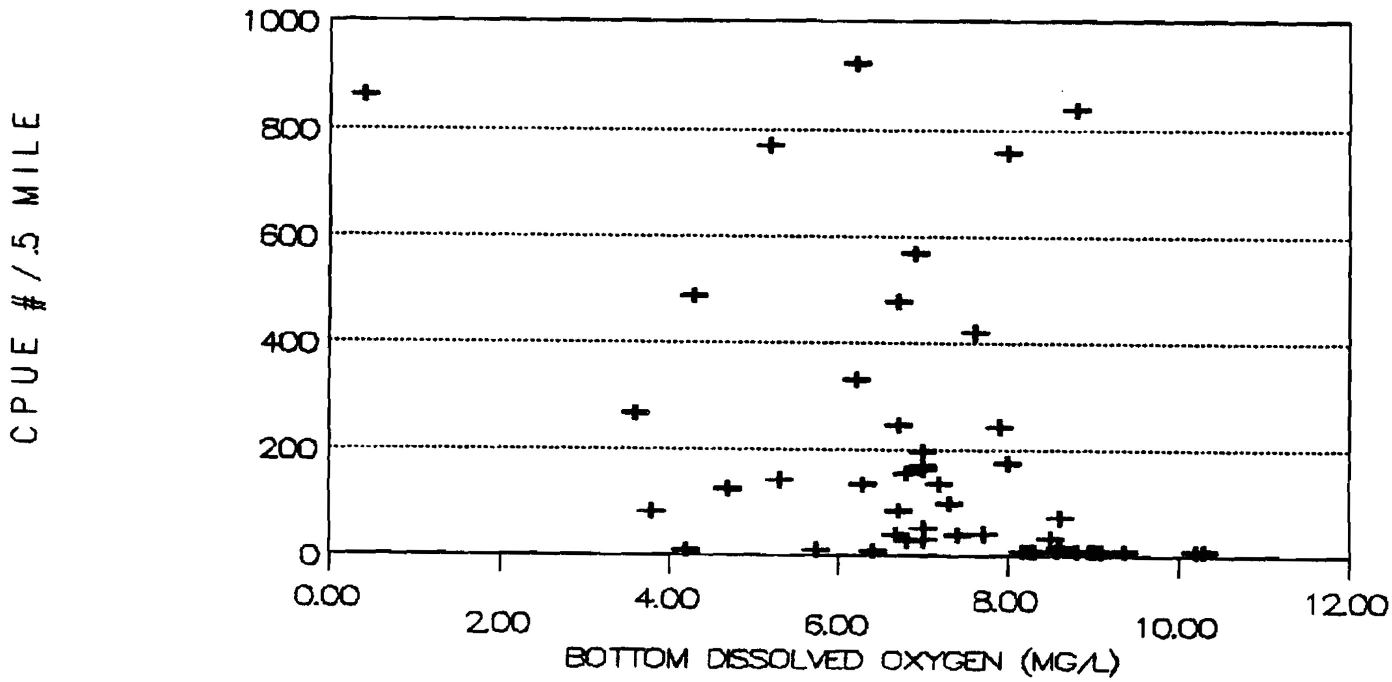
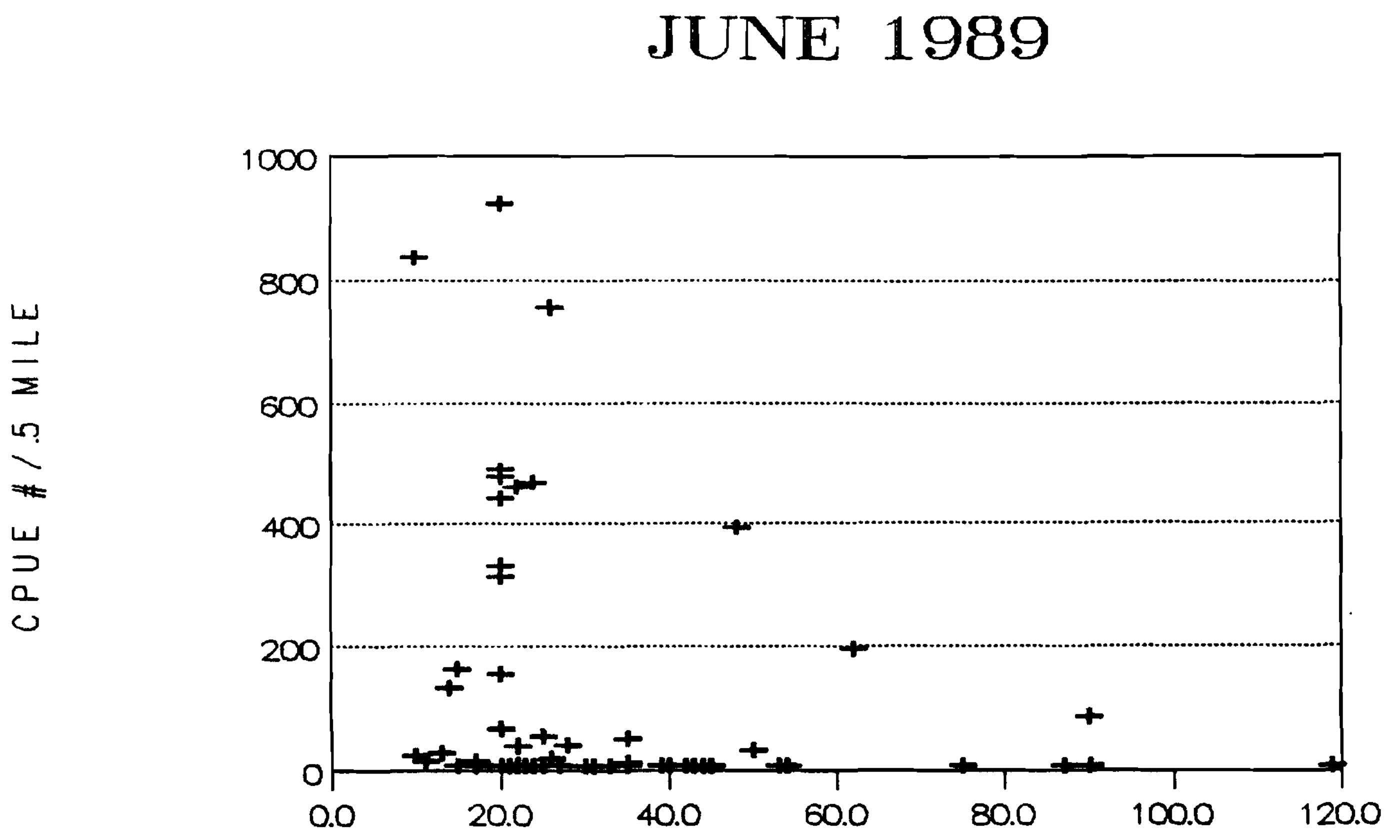


Fig. S26. Spot CPUE by environmental parameters in the Tangier Sound region for all months combined, 1989.



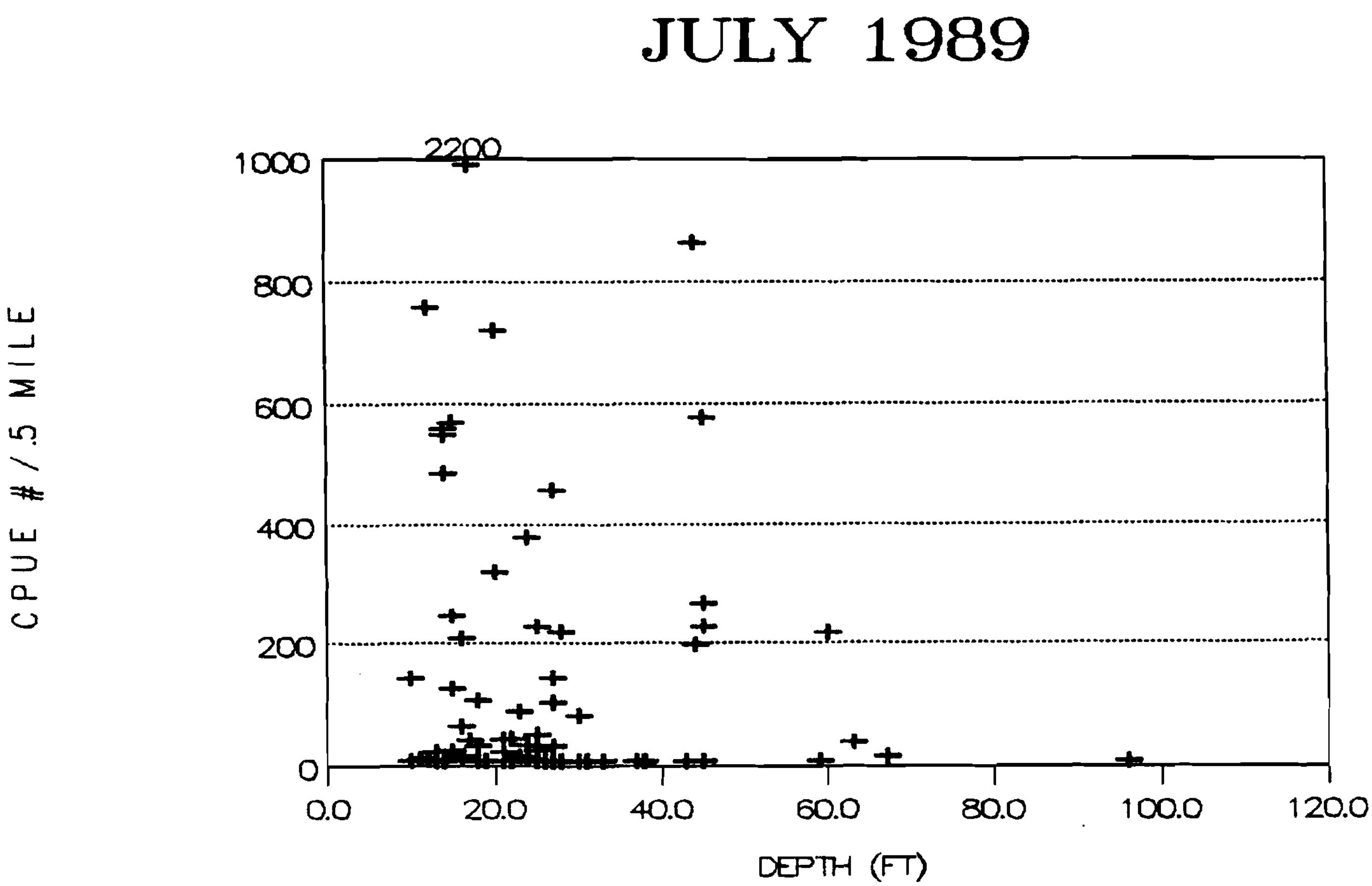
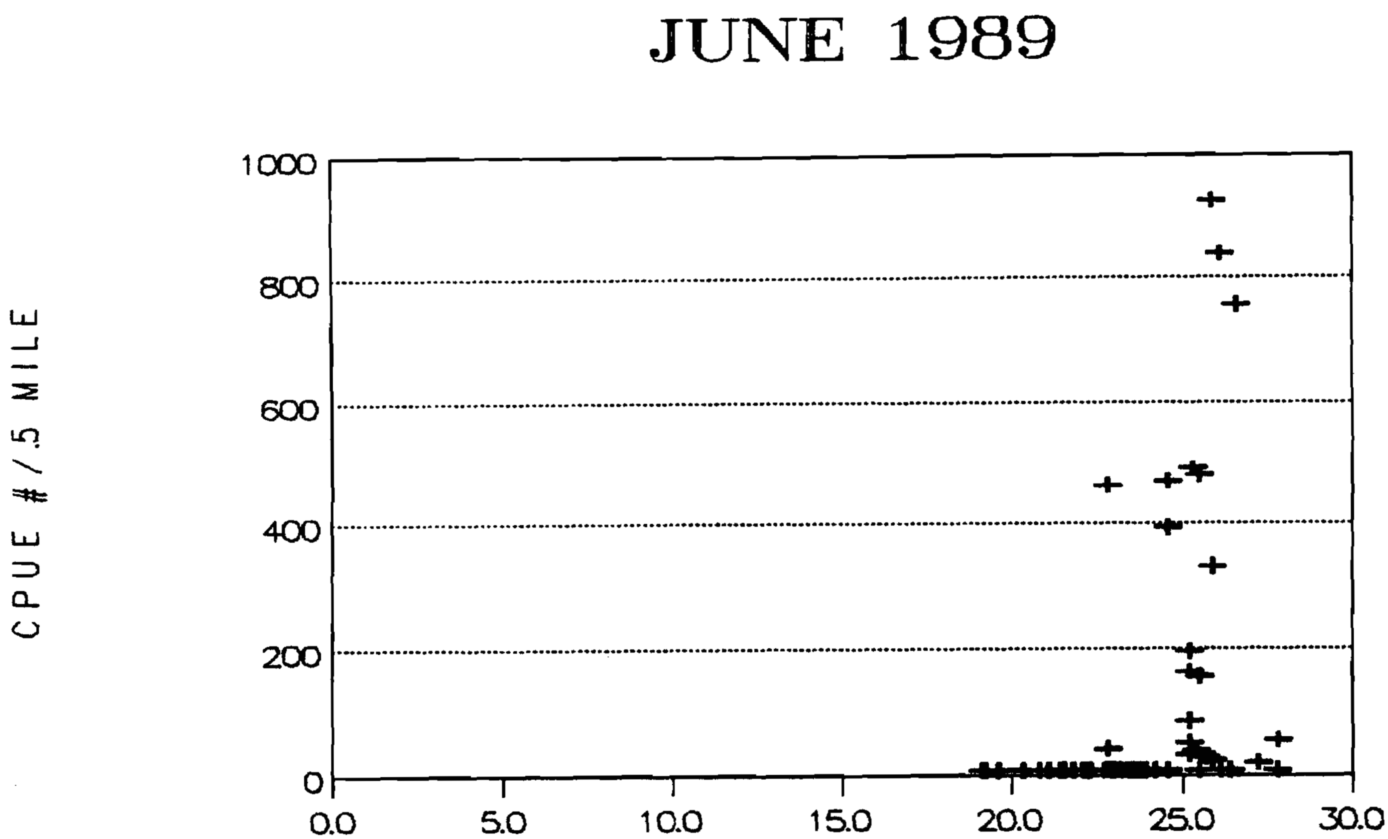


FIG. S27. Spot CPUE by environmental parameters for all regions combined, 1989.



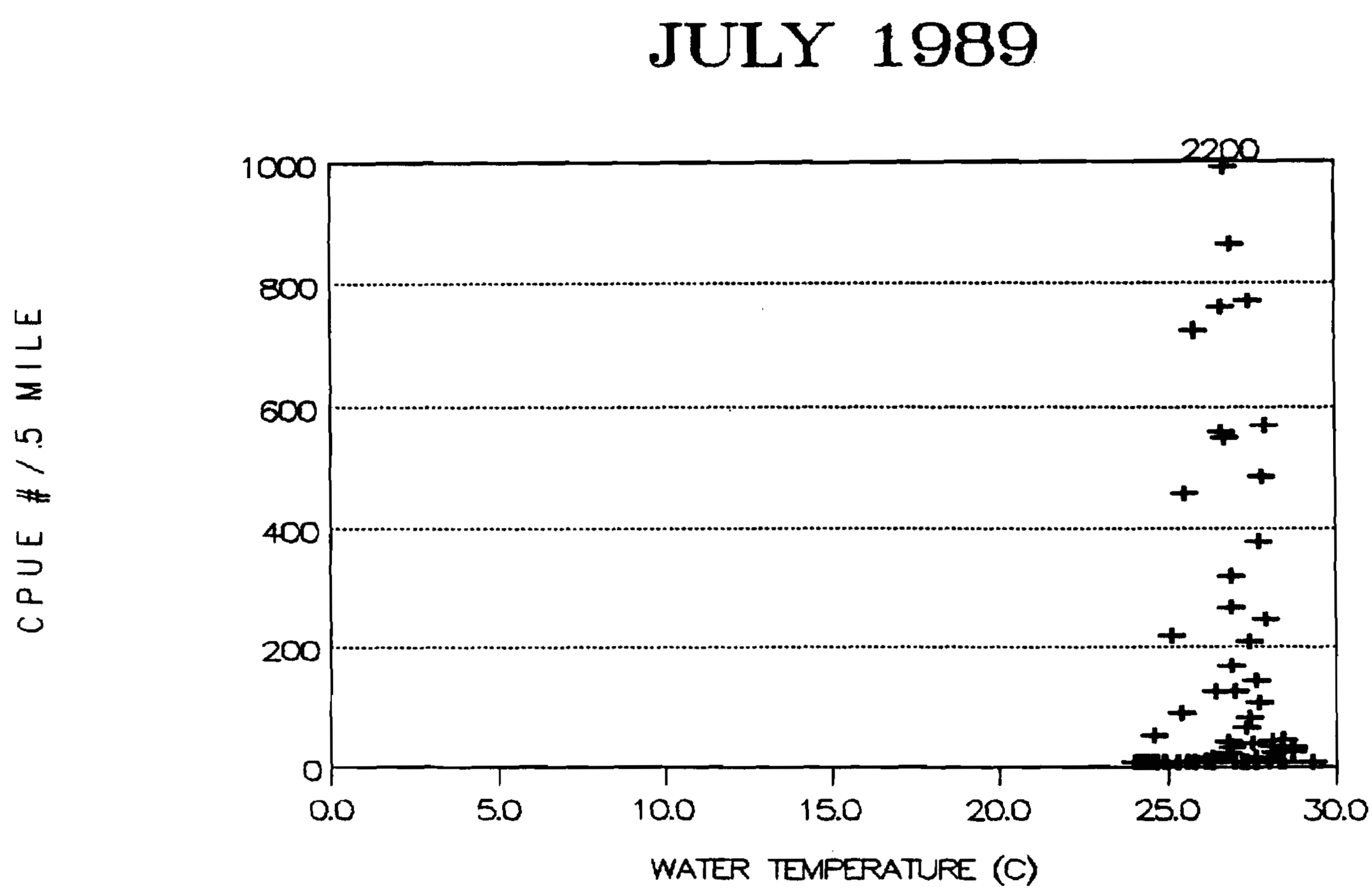
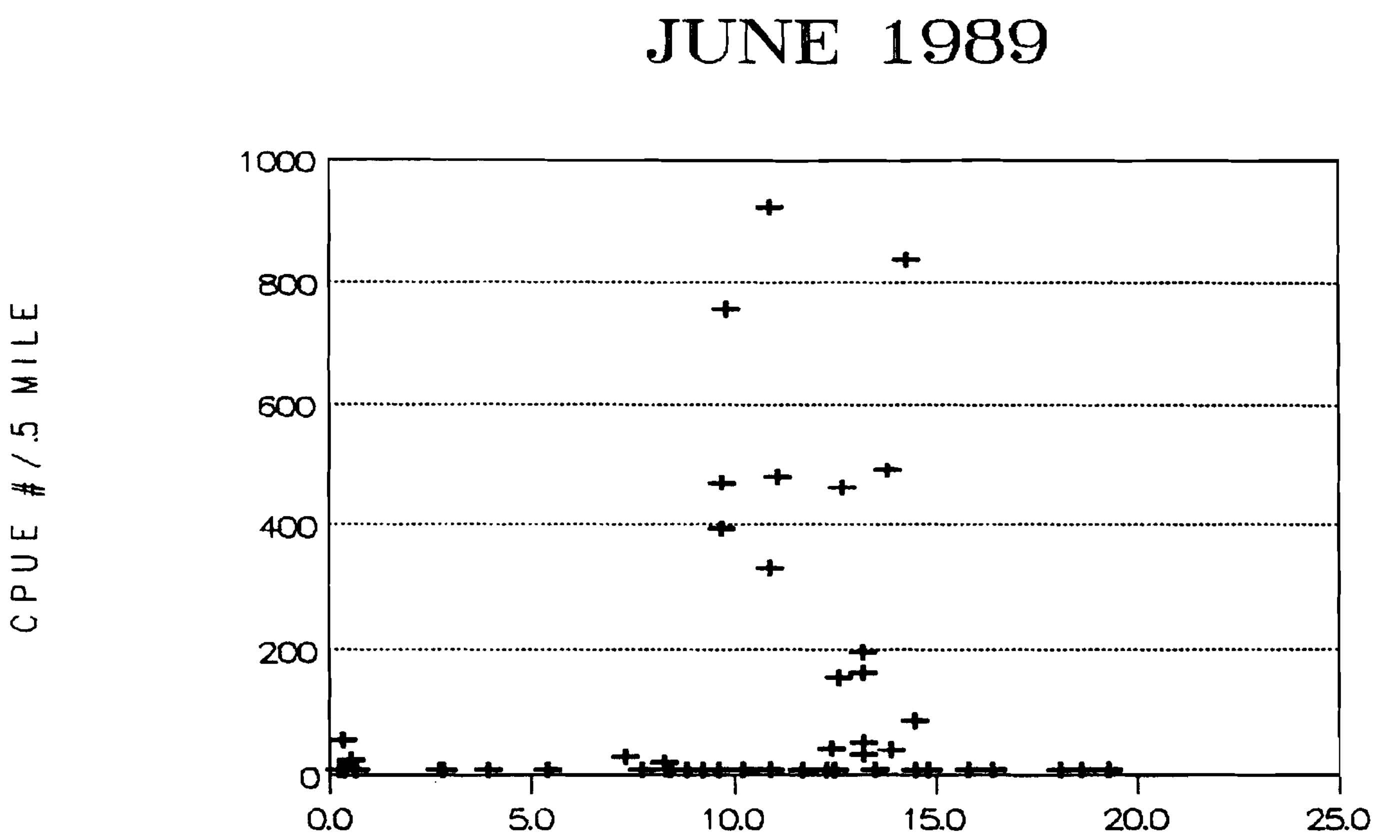


FIG. S28. Spot CPUE by environmental parameters for all regions combined, 1989.



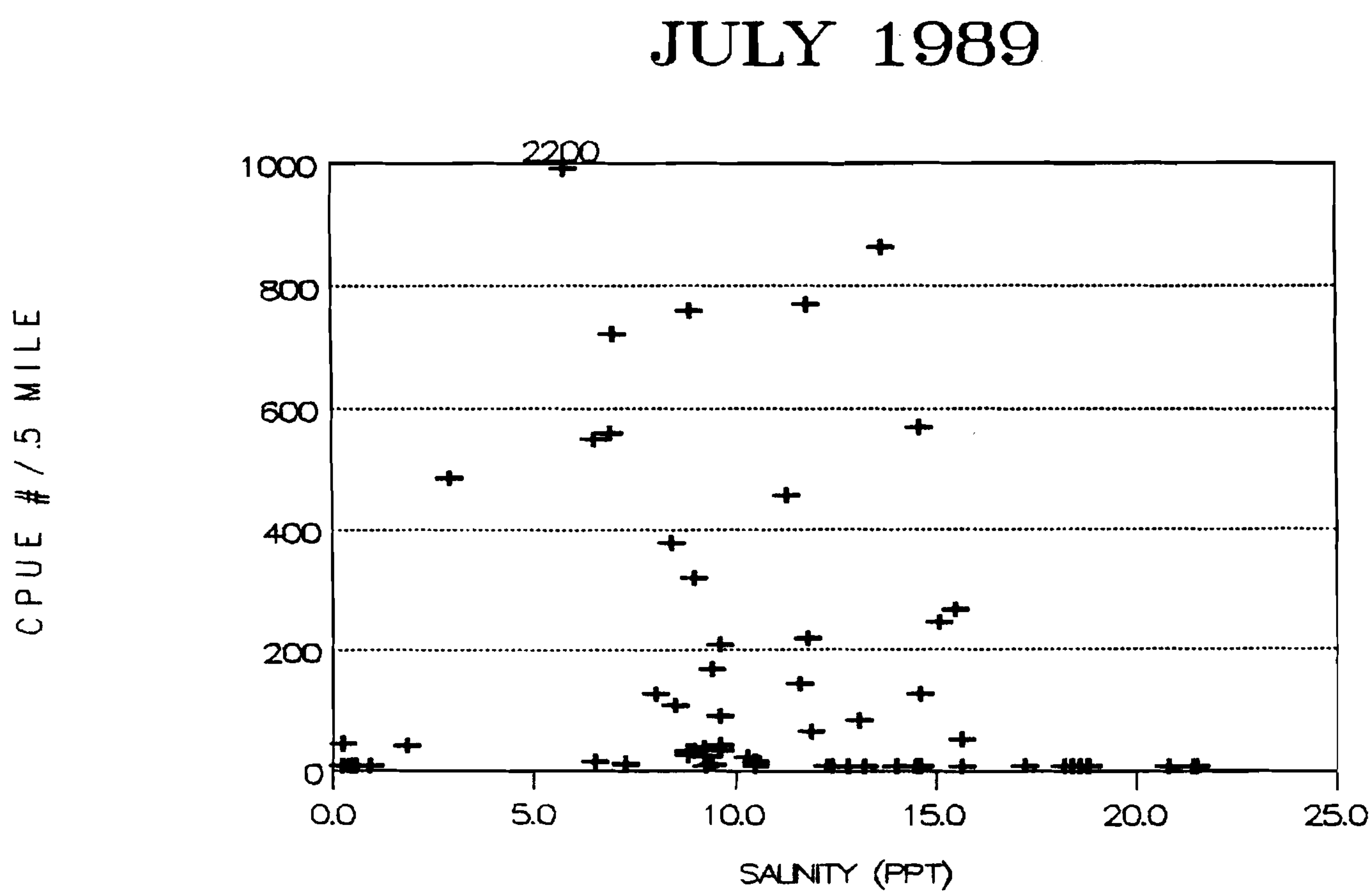
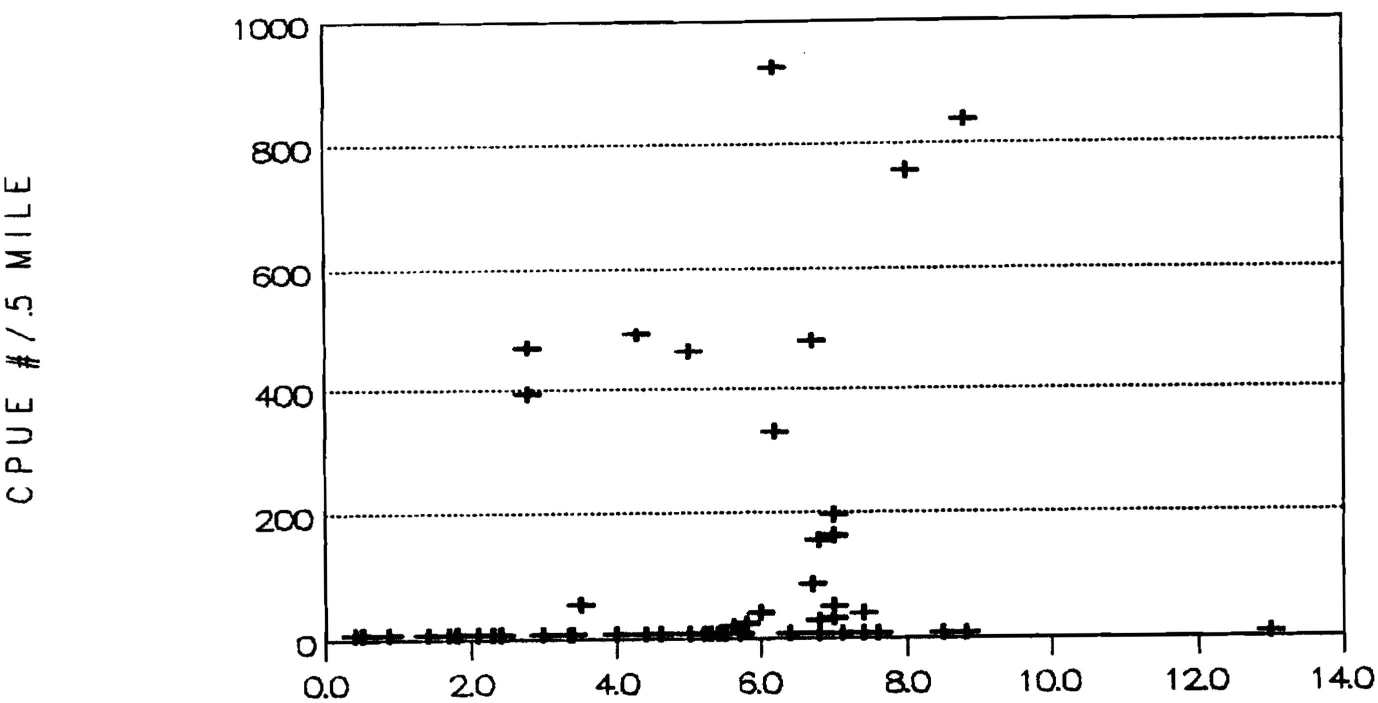


FIG. S29. Spot CPUE by environmental parameters for all regions combined, 1989.

JUNE 1989



JULY 1989

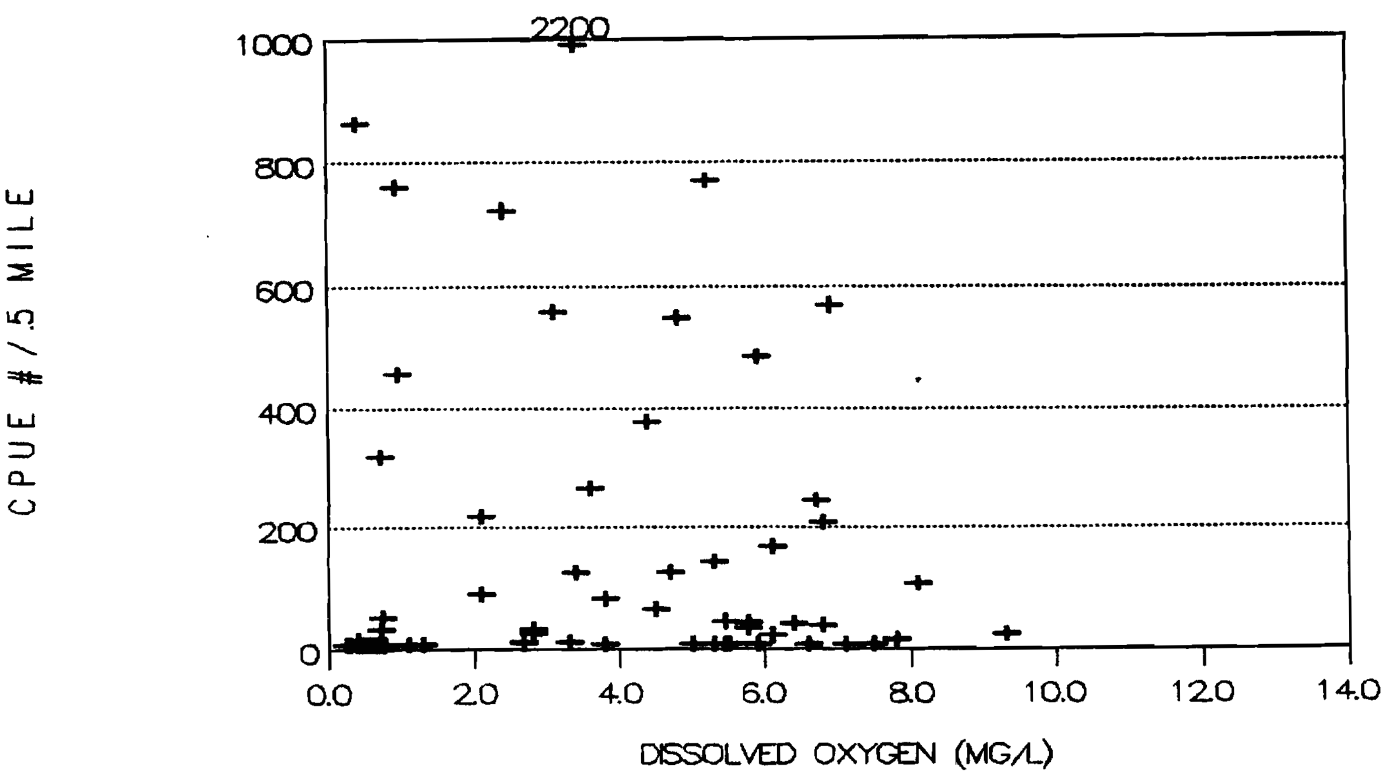


FIG. S30. Spot CPUE by environmental parameters for all regions combined, 1989.

Table W1. Summary of abundance of white perch by region and time period.

	Location					
	Bay-wide	Above Bay Bridge	Below Bay Bridge	Tangier Sound	Patuxent River	Choptank River
Annual Mean CPUE	50	69	1	2	163	105
Rank by CPUE	3	3	19	7	2	2
Percent Frequency in Collection	37	63	1	7	37	76
Period of Peak Abundance	Sept.-Nov., Jan.,Feb.	Jul.,Oct.	-	Oct.,Dec.	September	October

TABLE W2. Monthly mean, minimum, maximum lengths of White Perch by region.

WHITE PERCH		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ABOVE BAY	N=			239	932	247	253	212	344	185	425		
BRIDGE	MEAN LTH.			116	177	151	164	168	176	164	163		
	RANGE			49-251	40-292	55-245	98-253	99-235	60-286	64-257	53-270		
BELOW BAY	N=										4		2
BRIDGE	MEAN LTH.										209		212
	RANGE										113-254		196-228
TANGIER	N=										29		52
SOUND	MEAN LTH.										235		198
	RANGE										203-325		74-294
CHOPTANK	N=	240	294		252		99		245		410		262
RIVER	MEAN LTH.	158	176		175		170		151		155		152
	RANGE	61-318	62-323		75-270		108-228		47-220		47-274		62-283
PATUXENT	N=	240	188	74		50		99		140		305	
RIVER	MEAN LTH.	172	169	188		177		129		99		136	
	RANGE	34-326	91-230	118-278		19-258		41-207		23-253		57-290	

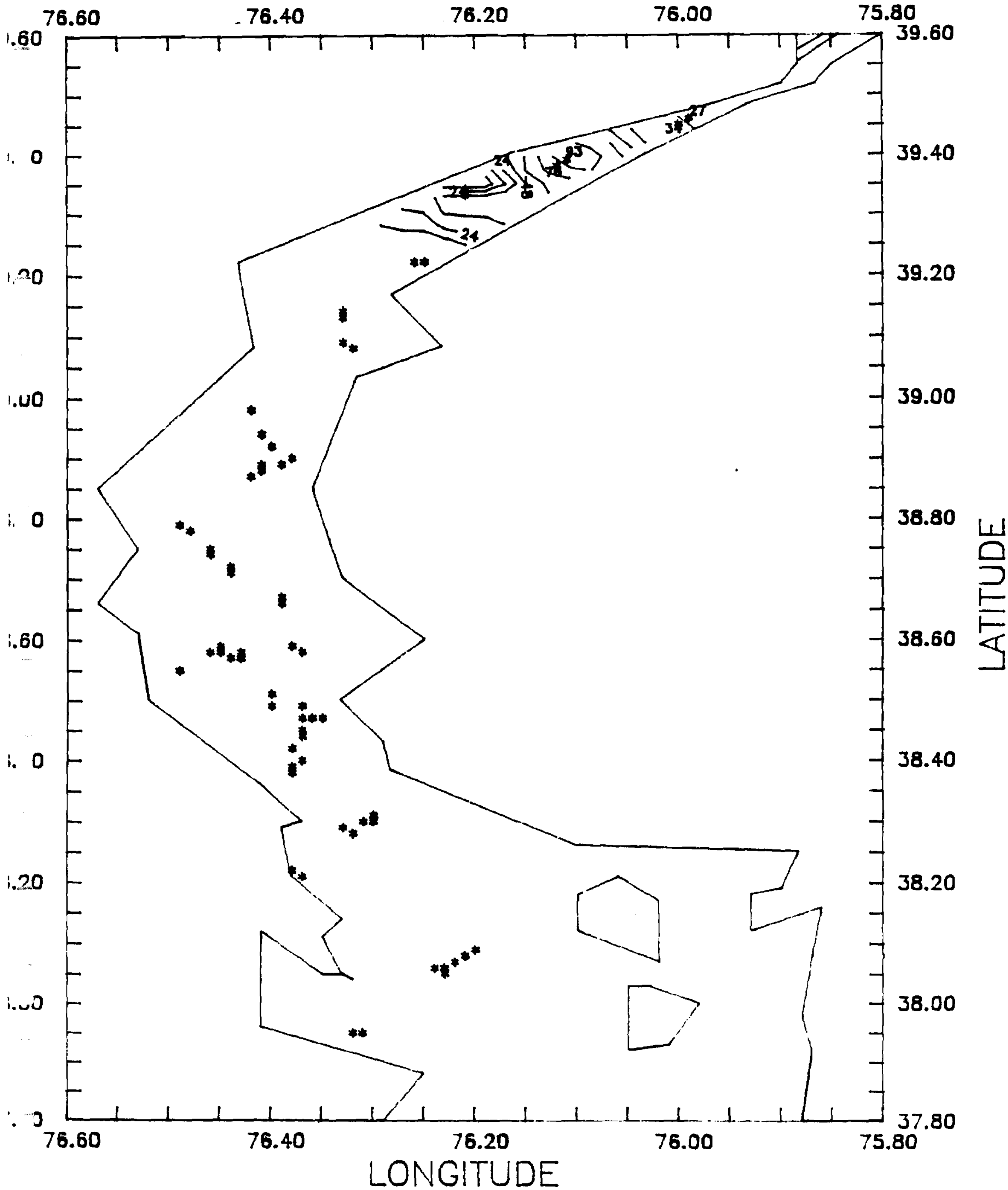


FIG. W1. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAR 1989

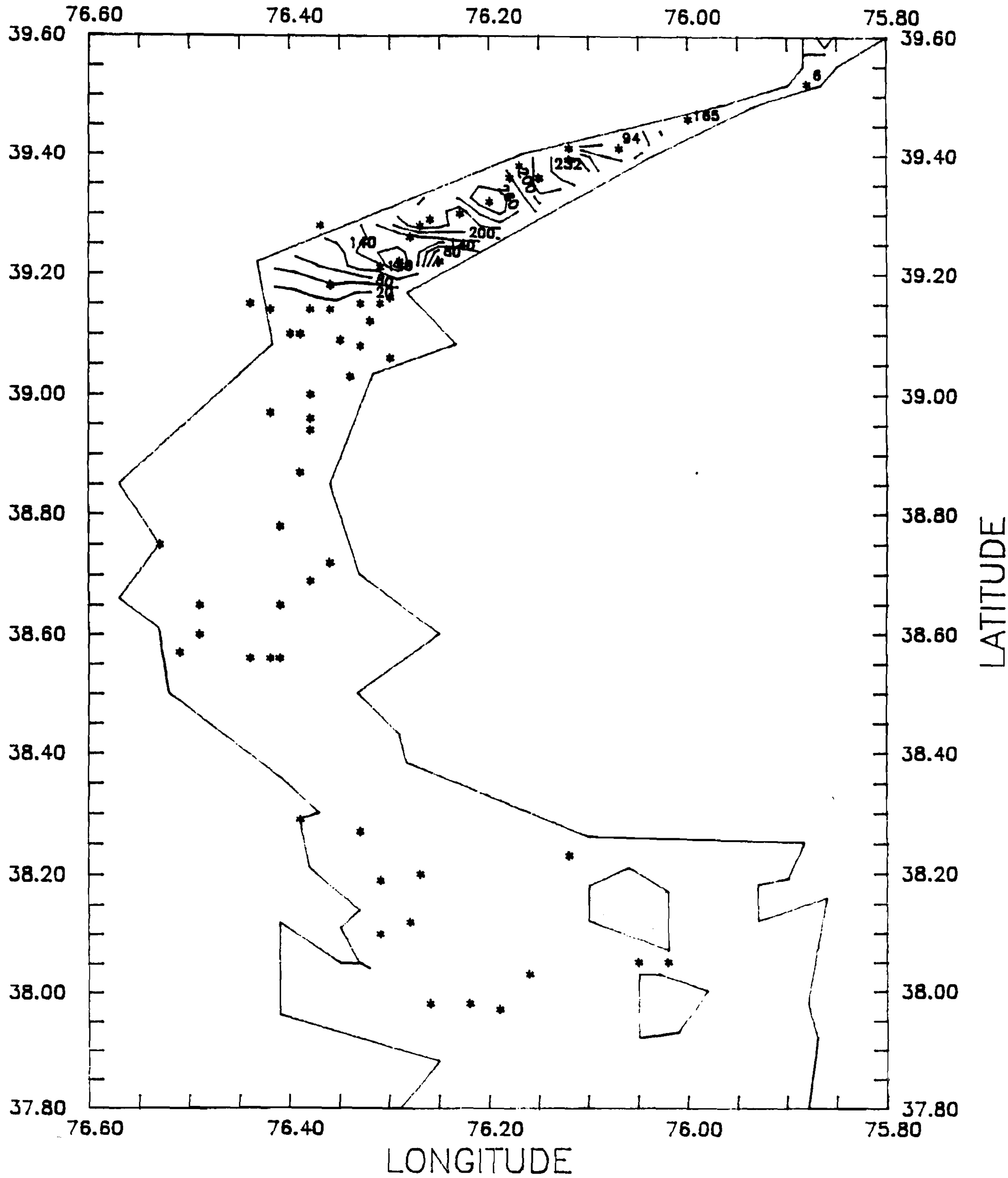


FIG. W2. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY APR 1989

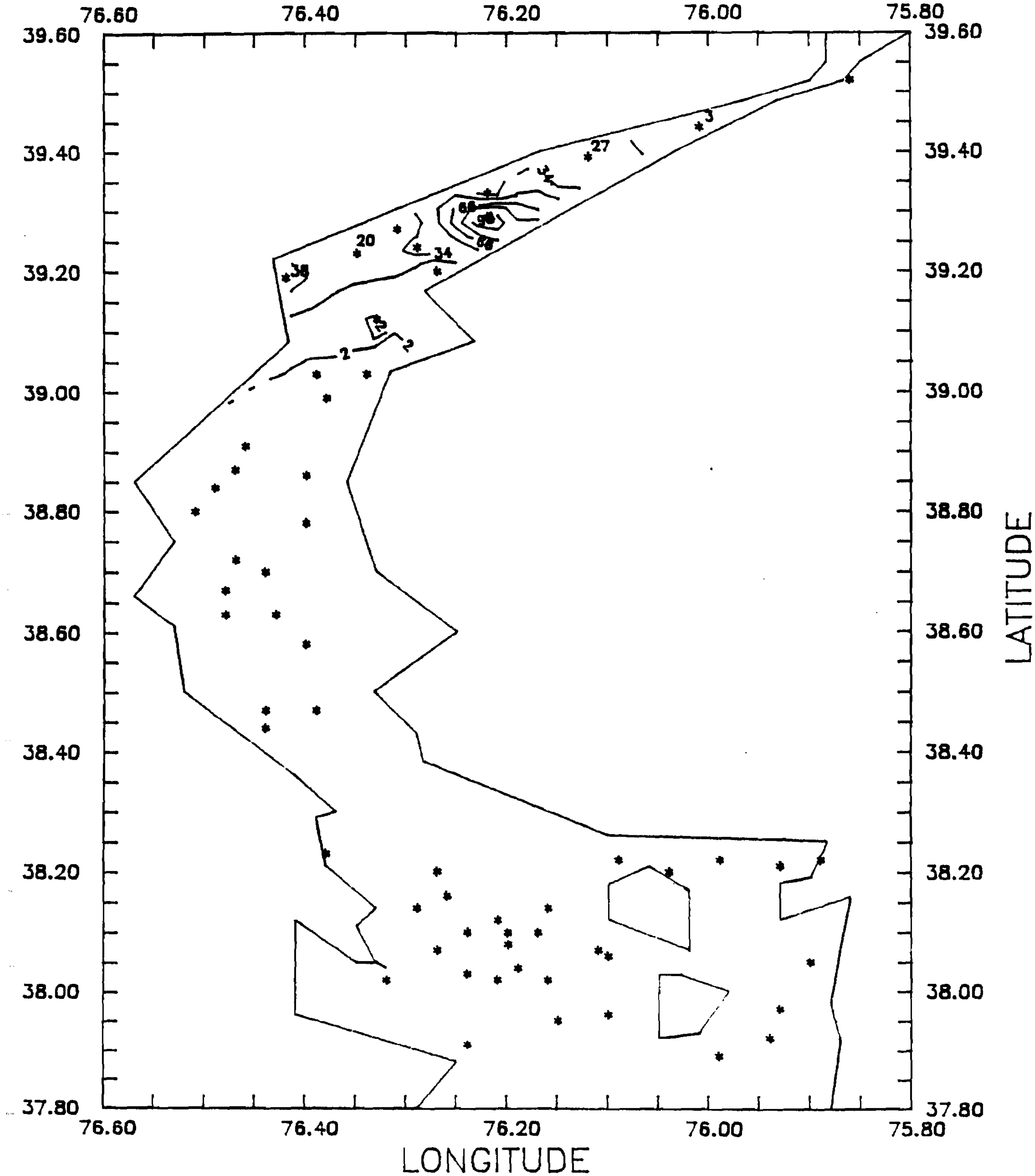


FIG. W3. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAY 1989

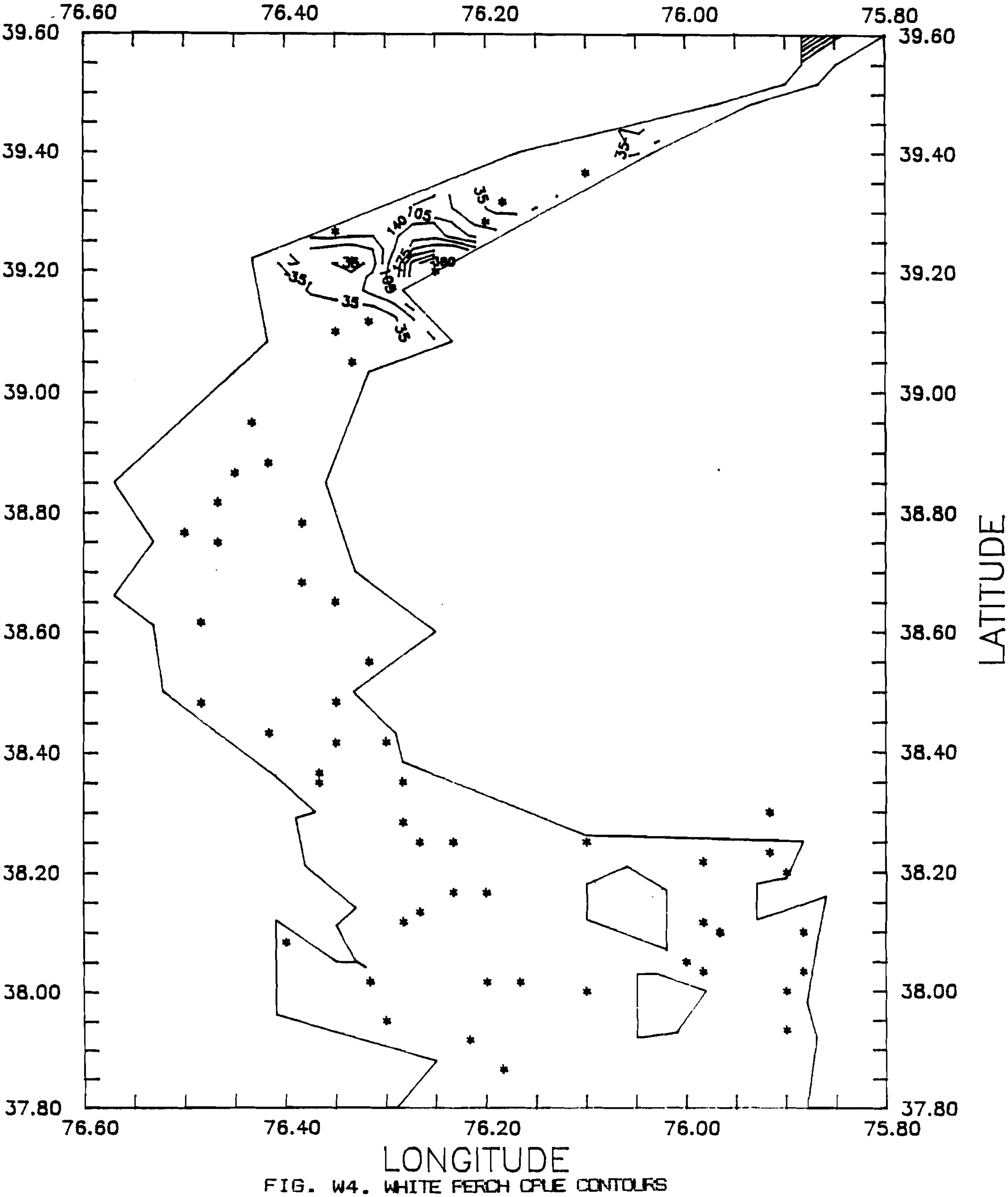


FIG. W4. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JUN 1989

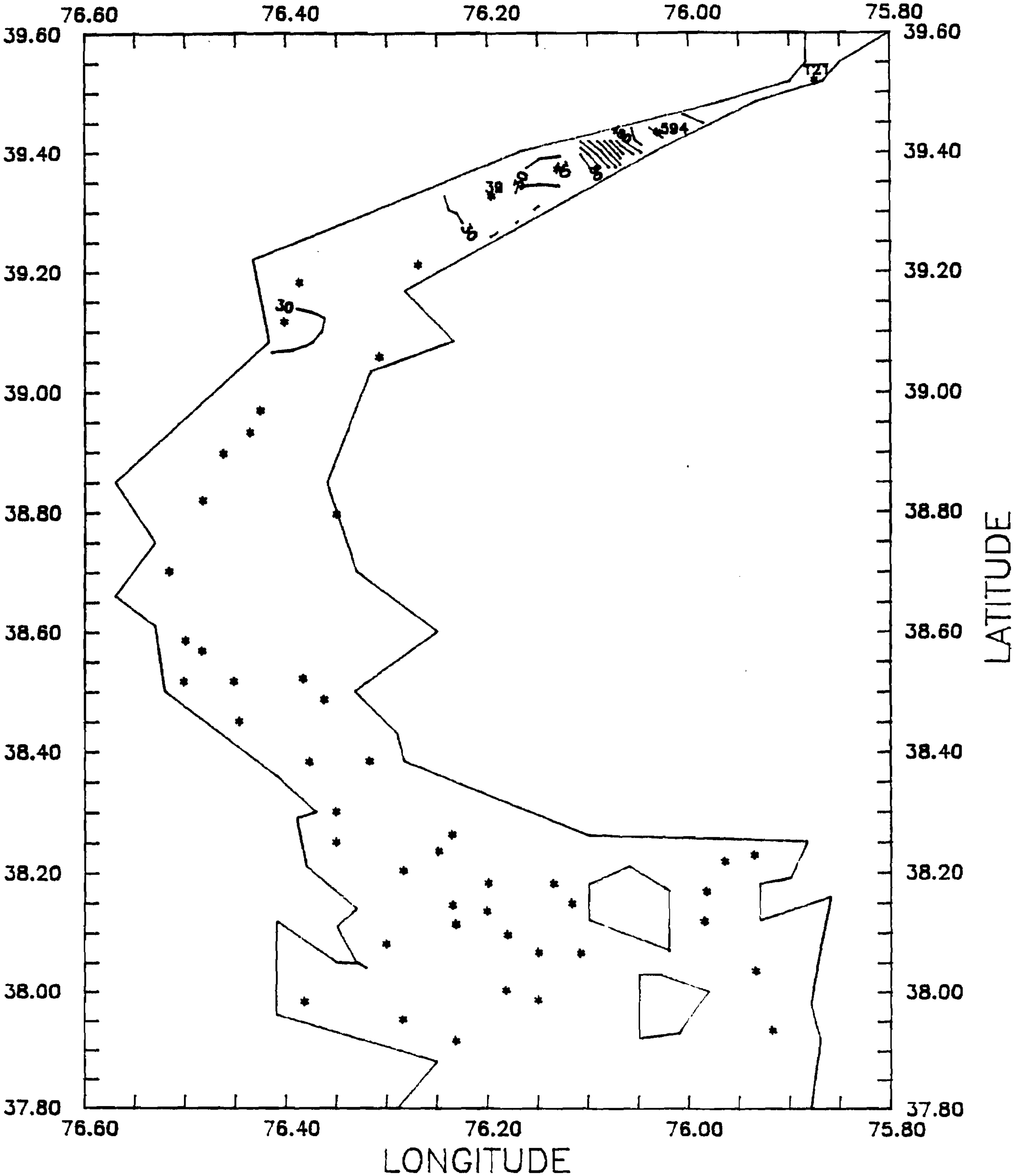


FIG. W5. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY JUL 1989

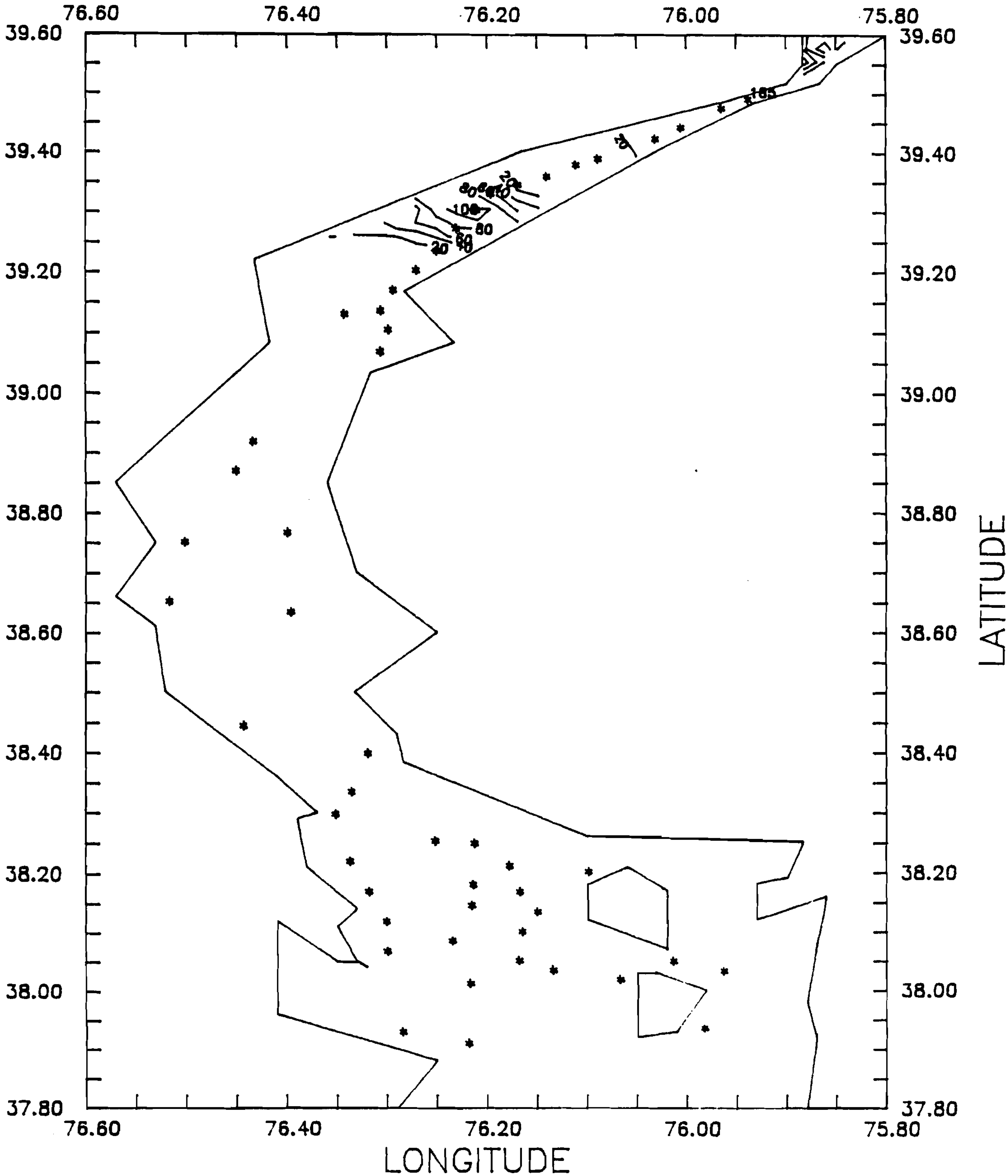


FIG. W6. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY AUG 1989

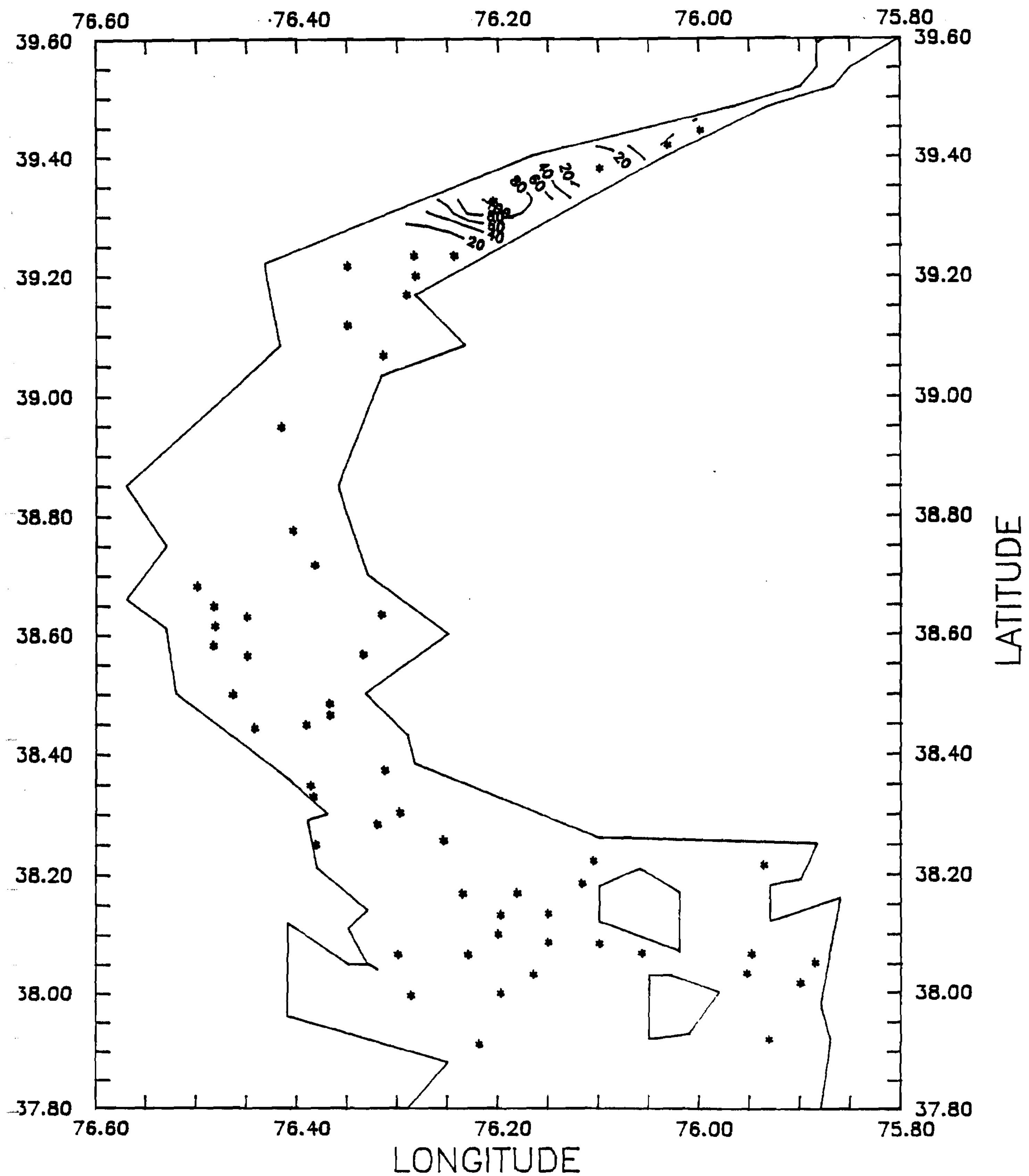


FIG. W7. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY SEP 1989

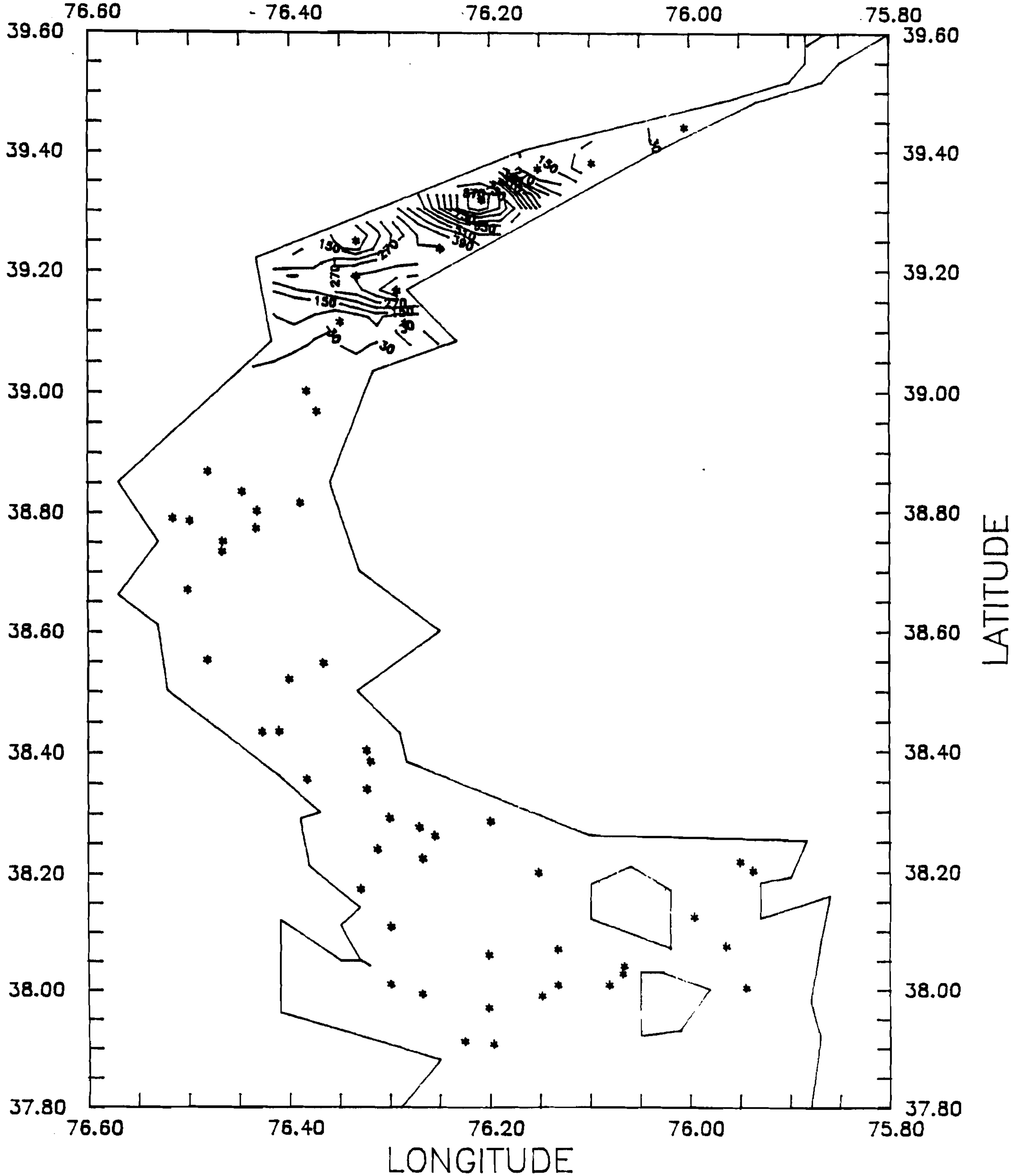


FIG. W8. WHITE PERCH CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY OCT 1989

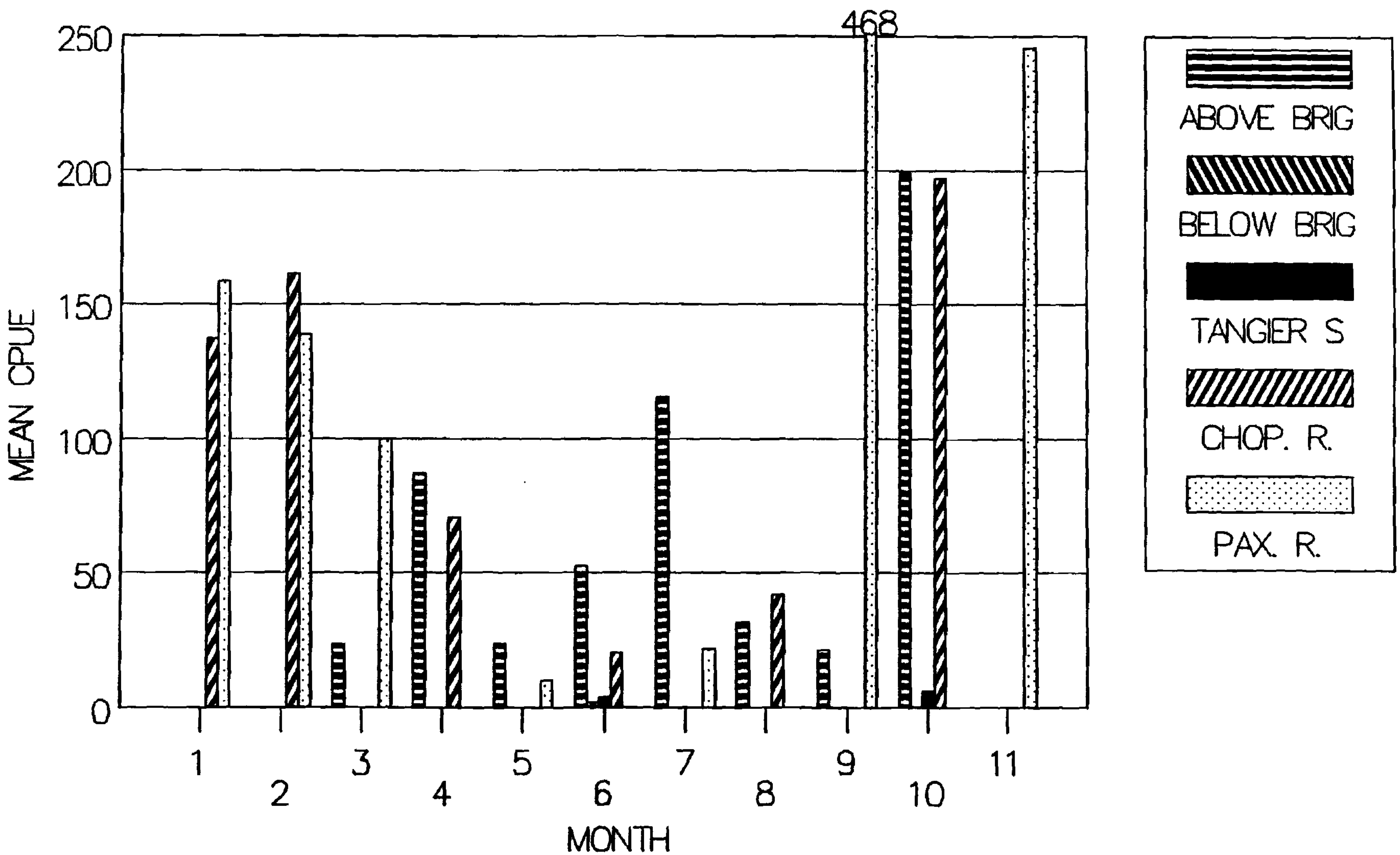
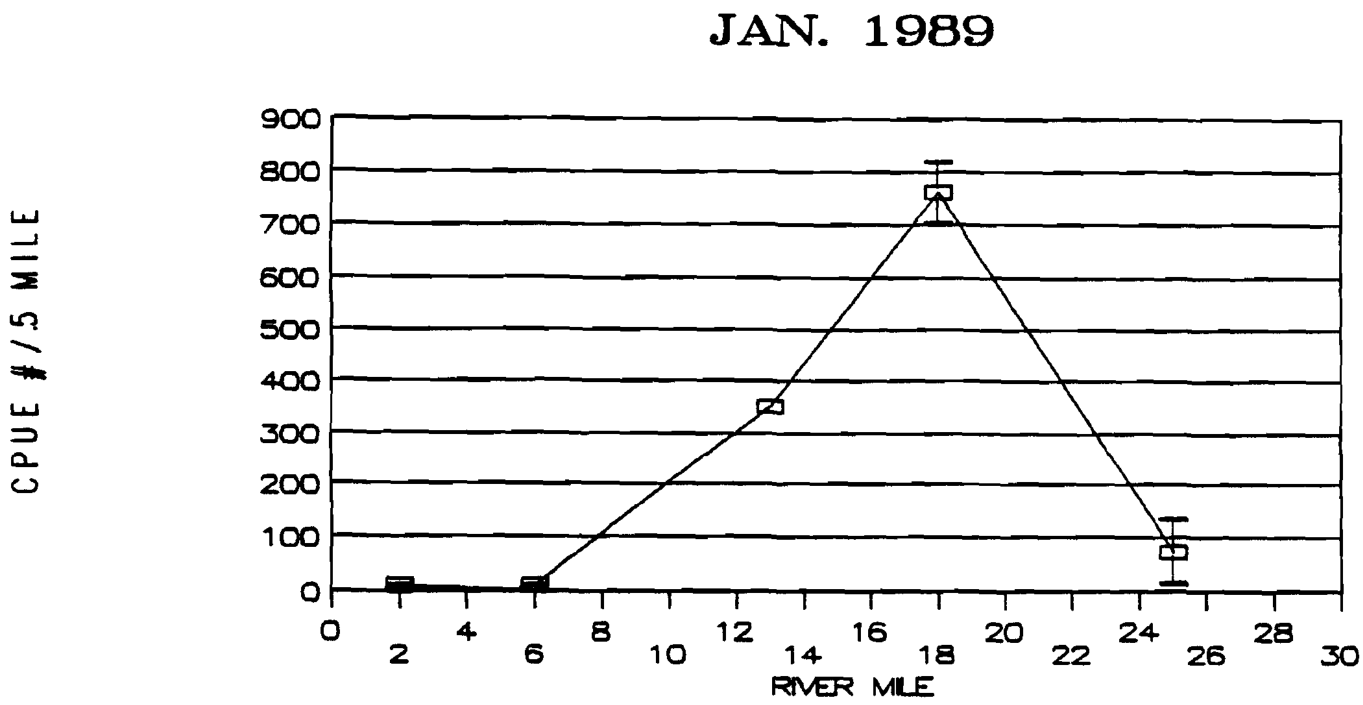


FIG W9. WHITE PERCH 1989 CPUE DATA
MONTH VS. MEAN CPUE FOR TOTAL HAULS



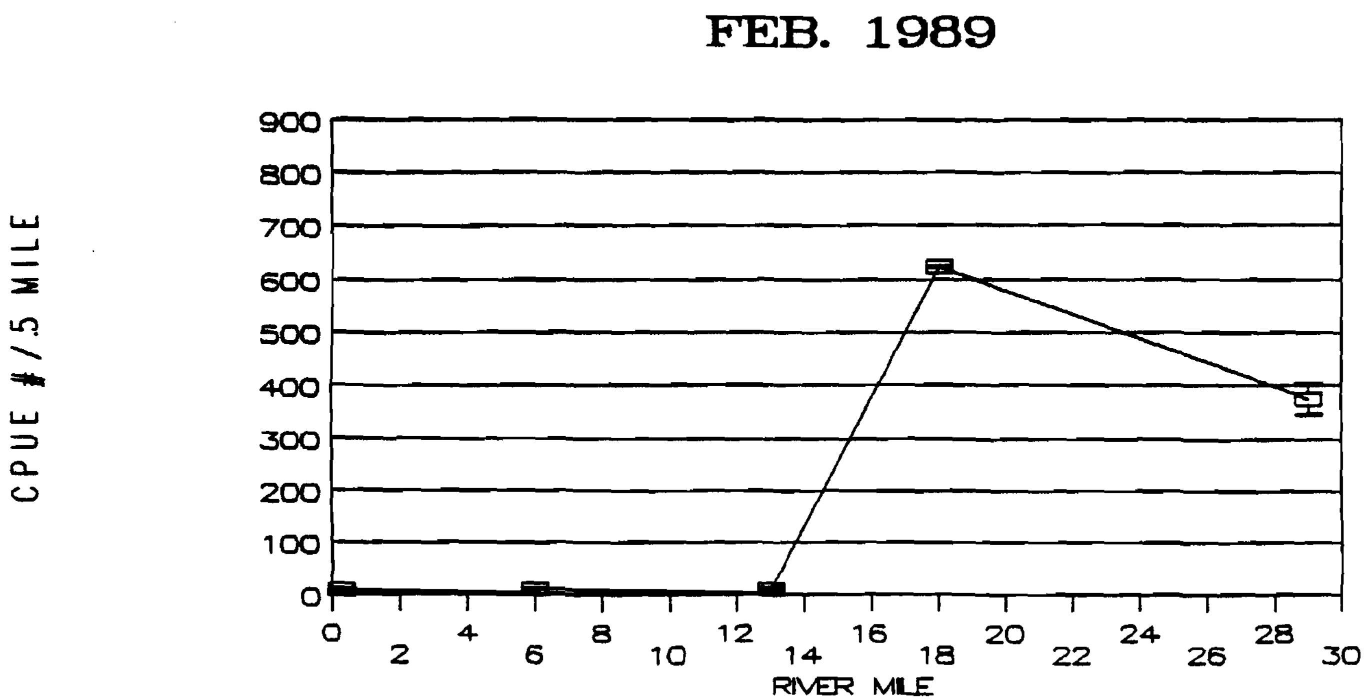
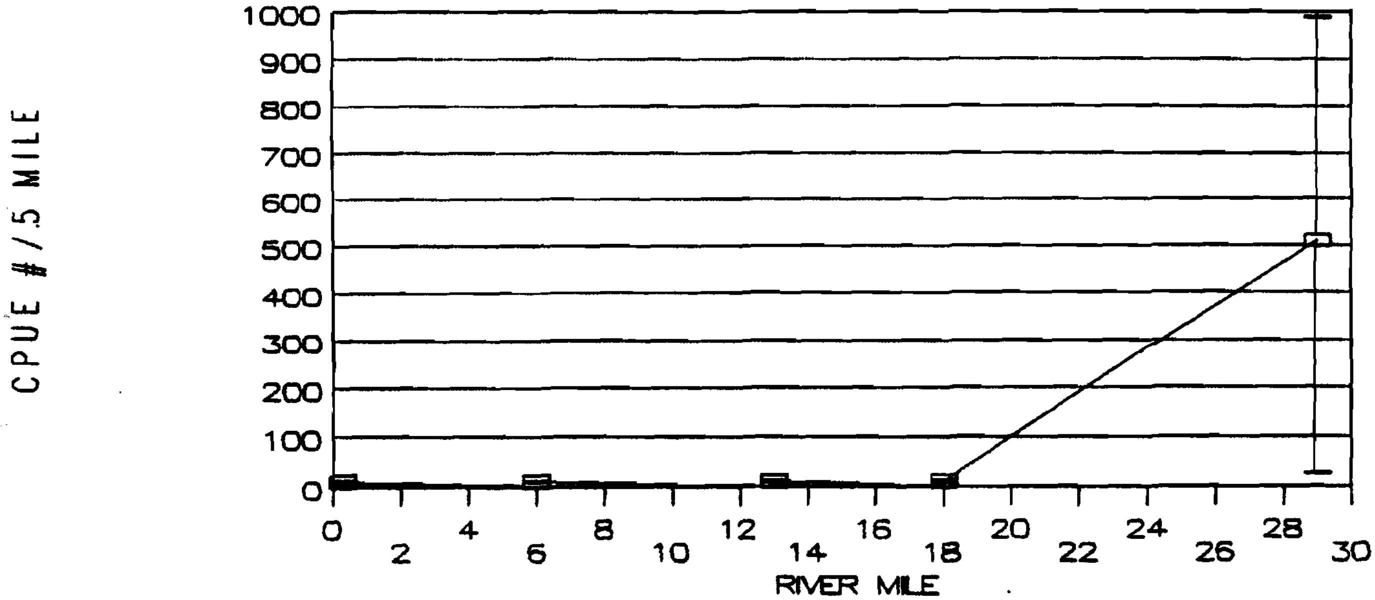


Fig. W10. CPUE by river mile for white perch in the Patuxent River, 1989.

MARCH 1989



MAY 1989

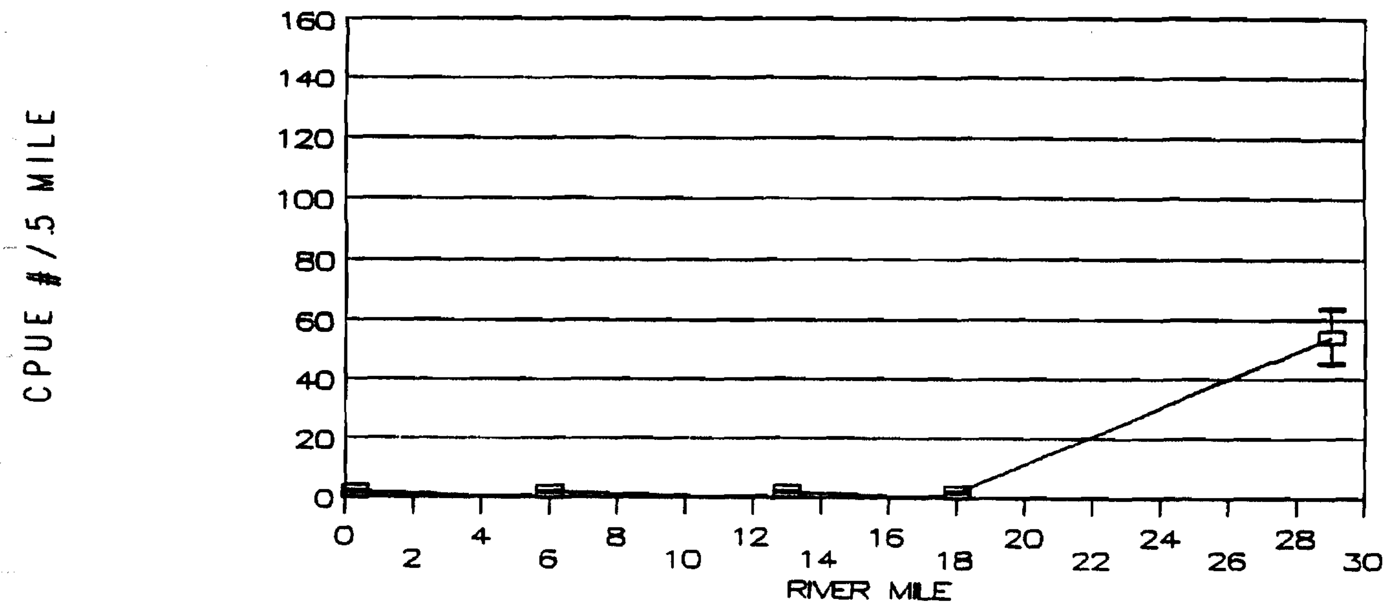


Fig. W11. CPUE by river mile for white perch in the Patuxent River, 1989.

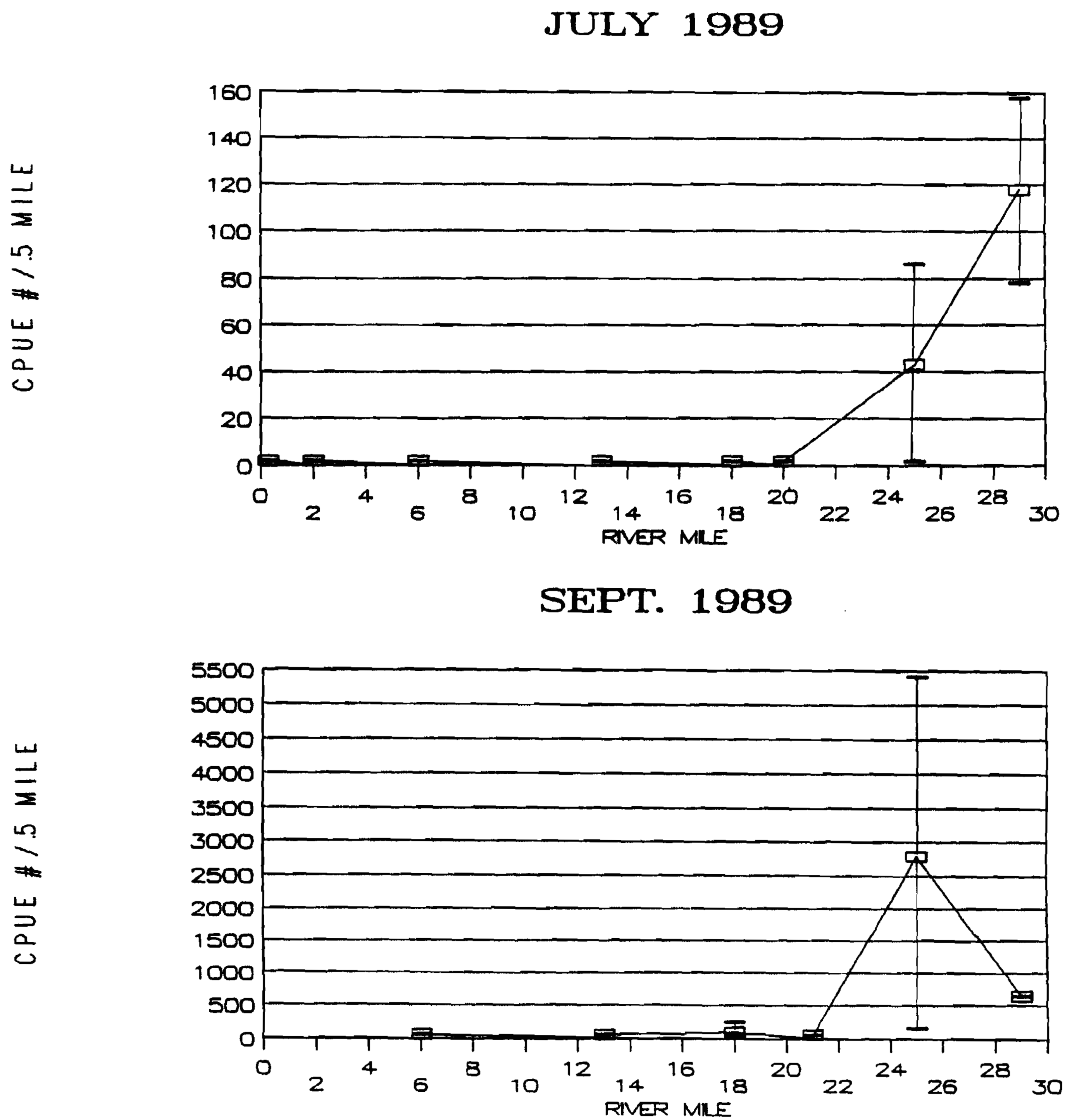


Fig. W12. CPUE by river mile for white perch in the Patuxent River, 1989.

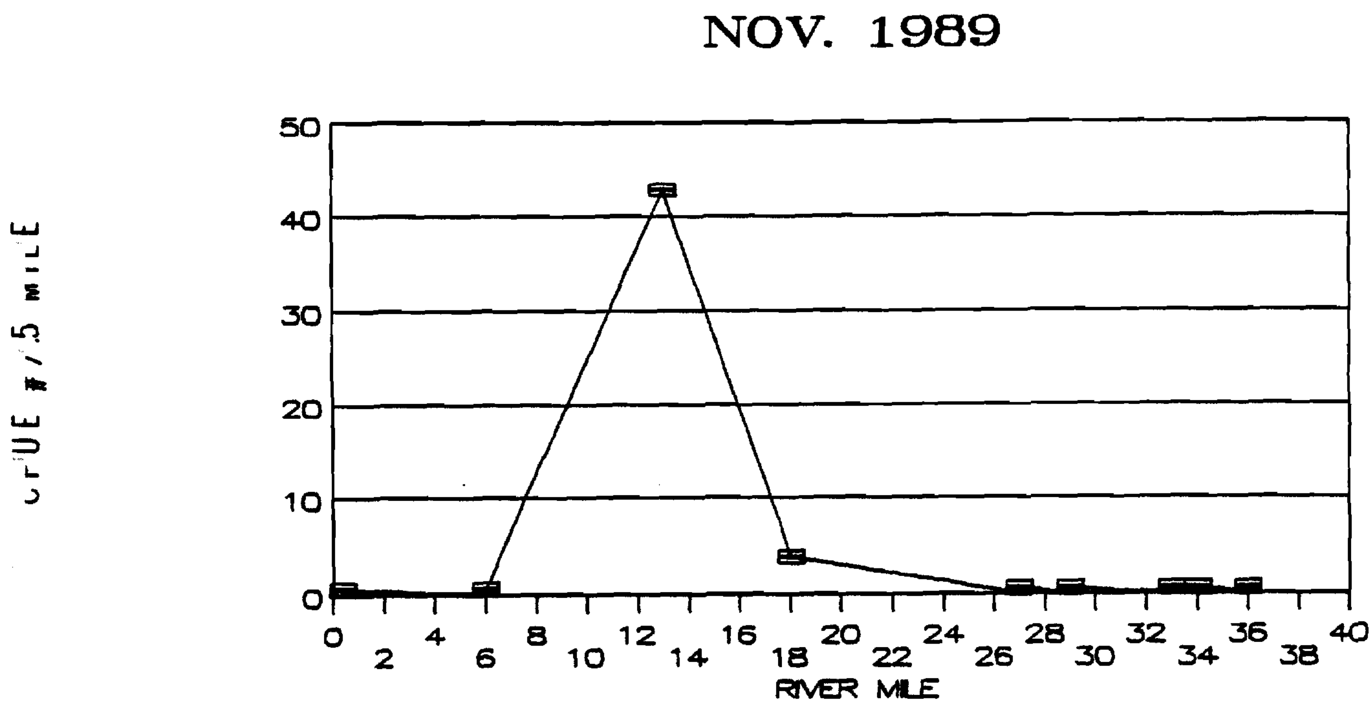
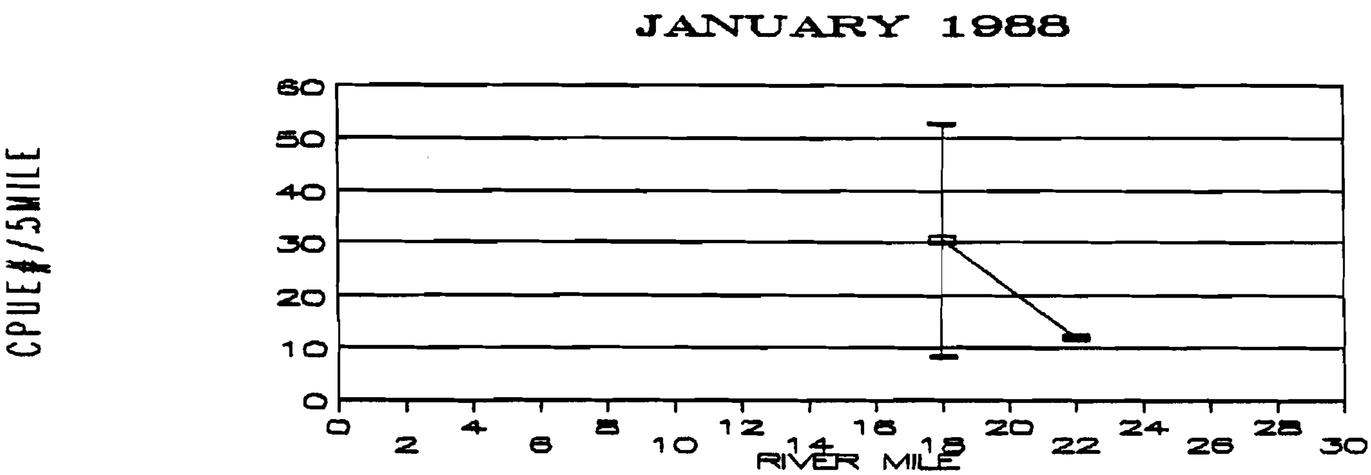
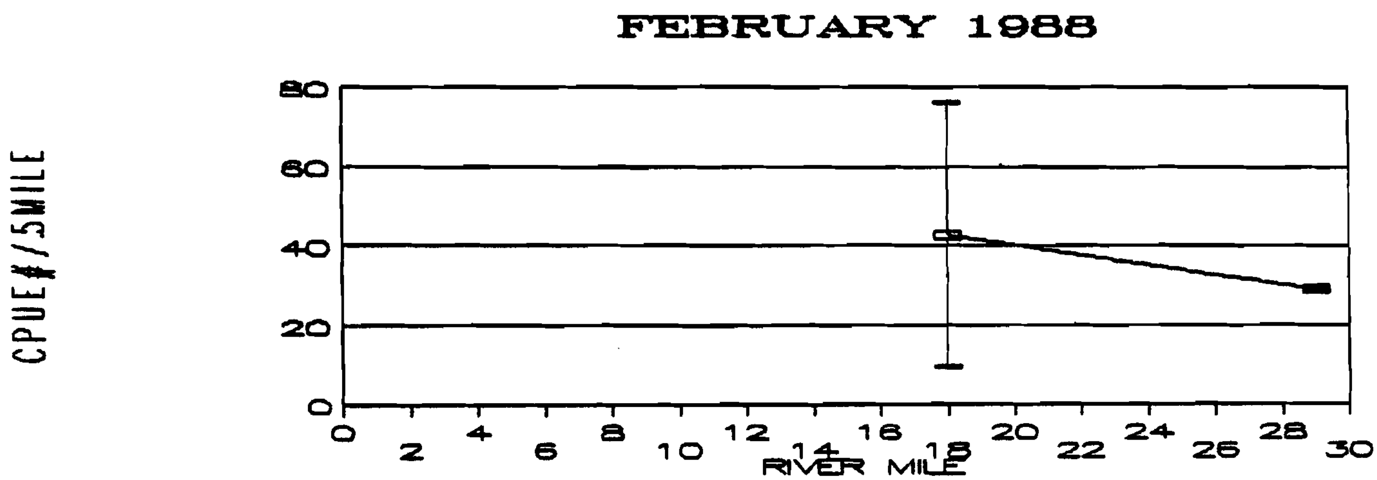


Fig. W13. CPUE by river mile for white perch in the Patuxent River, 1989.





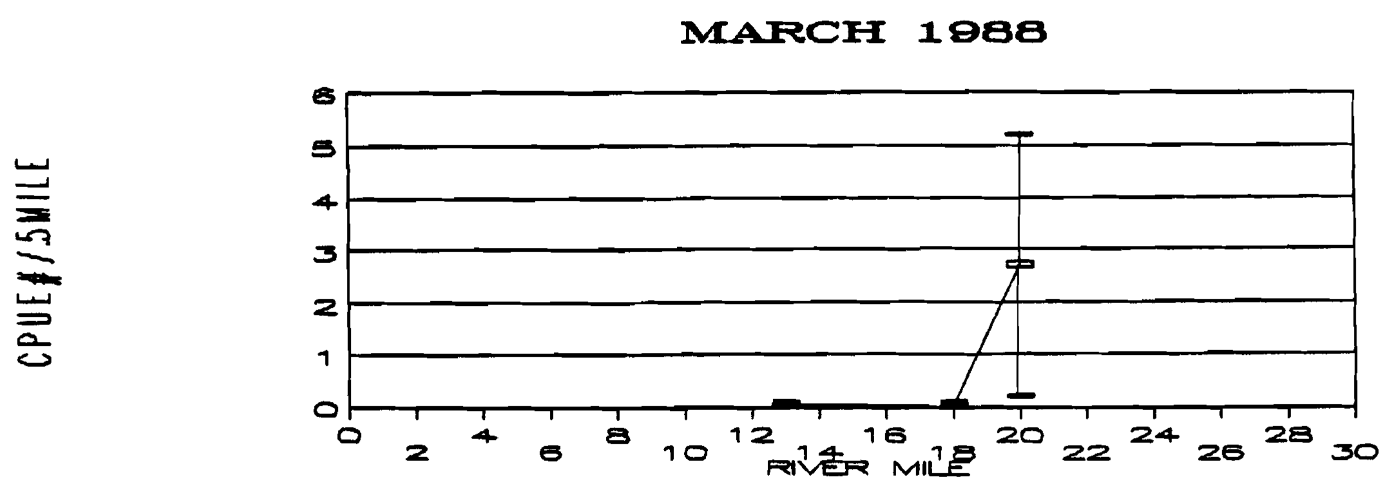


Fig. W14. CPUE by river mile for white perch in the Patuxent River, 1988.

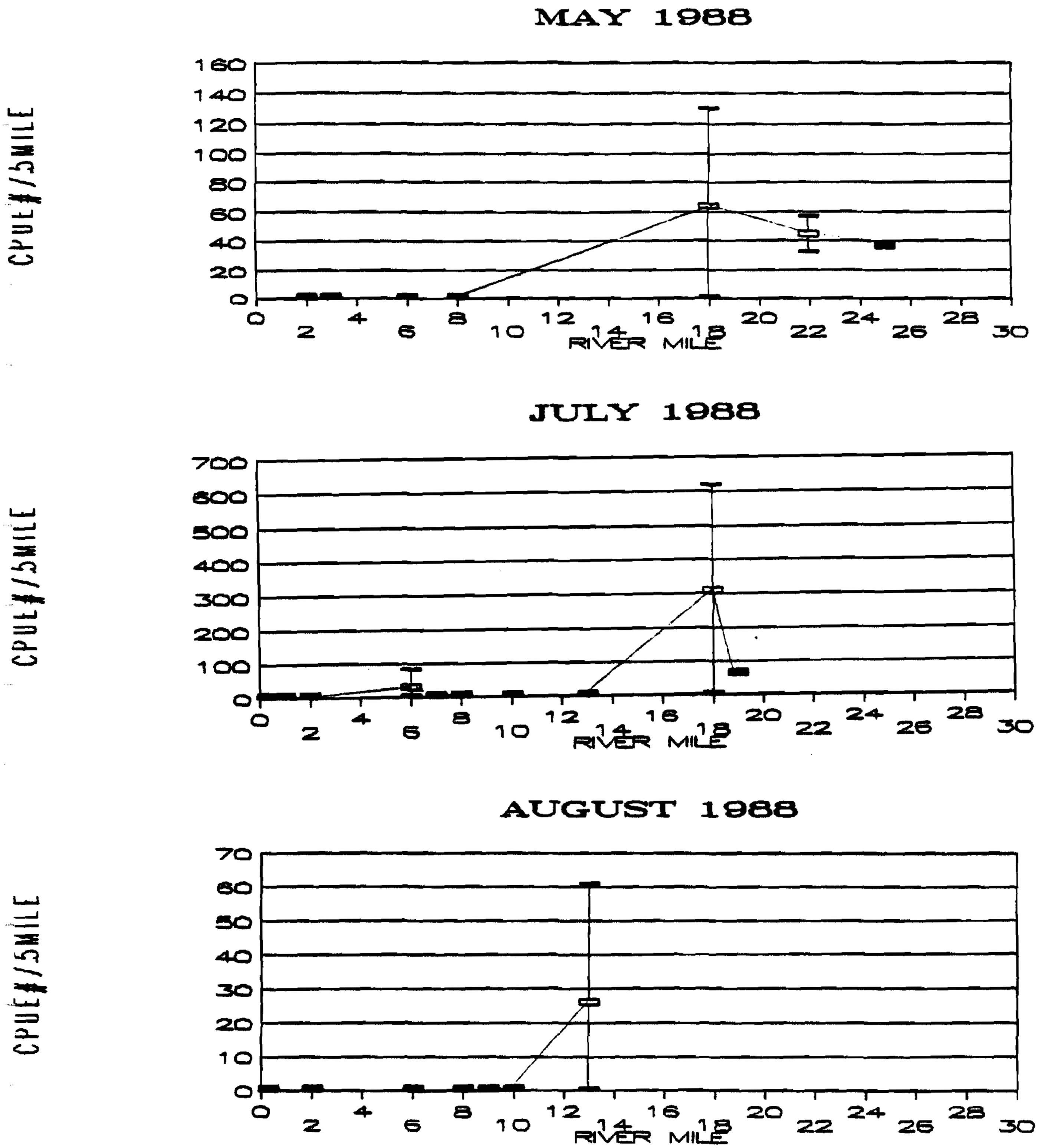


Fig. W15. CPUE by river mile for white perch in the Patuxent River, 1988.

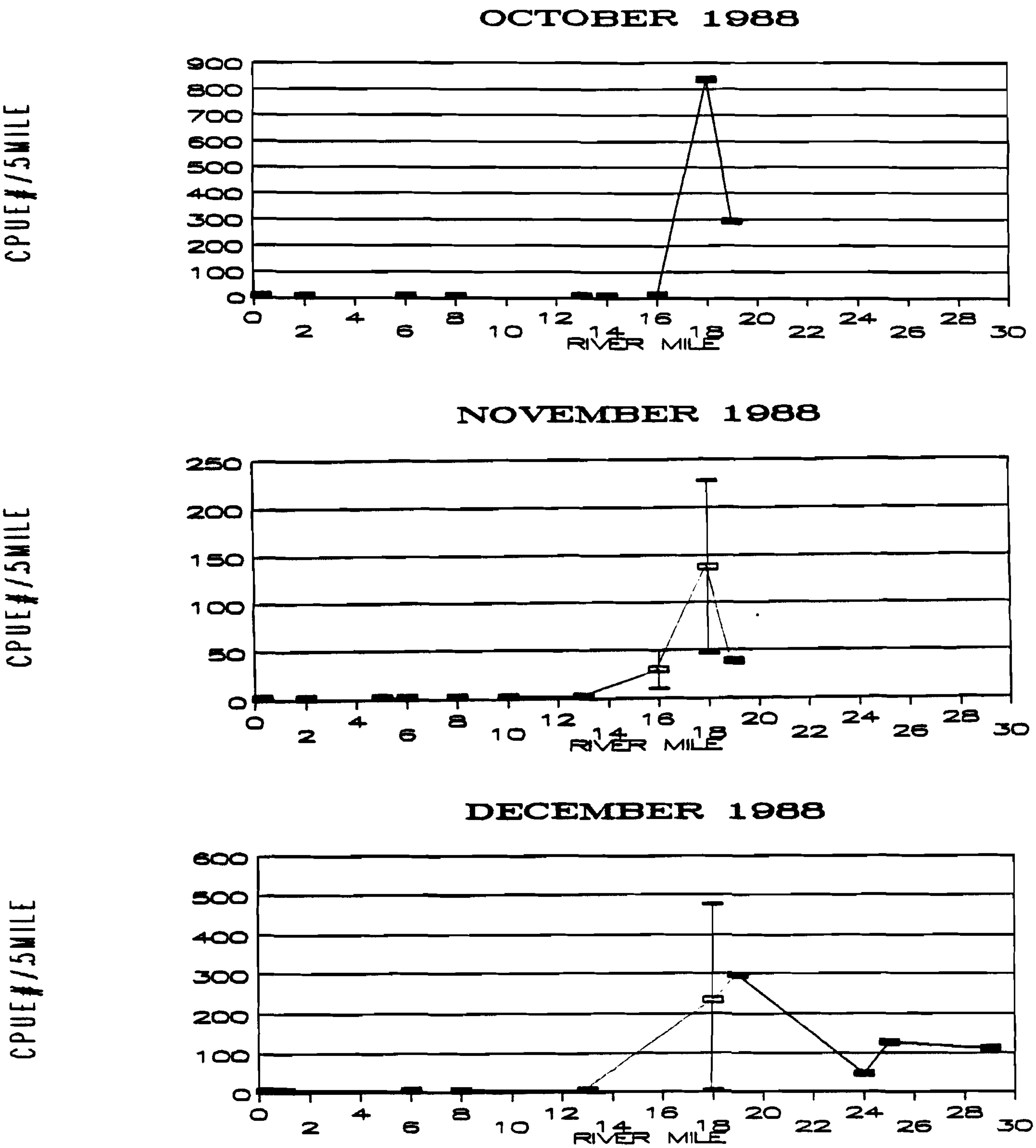
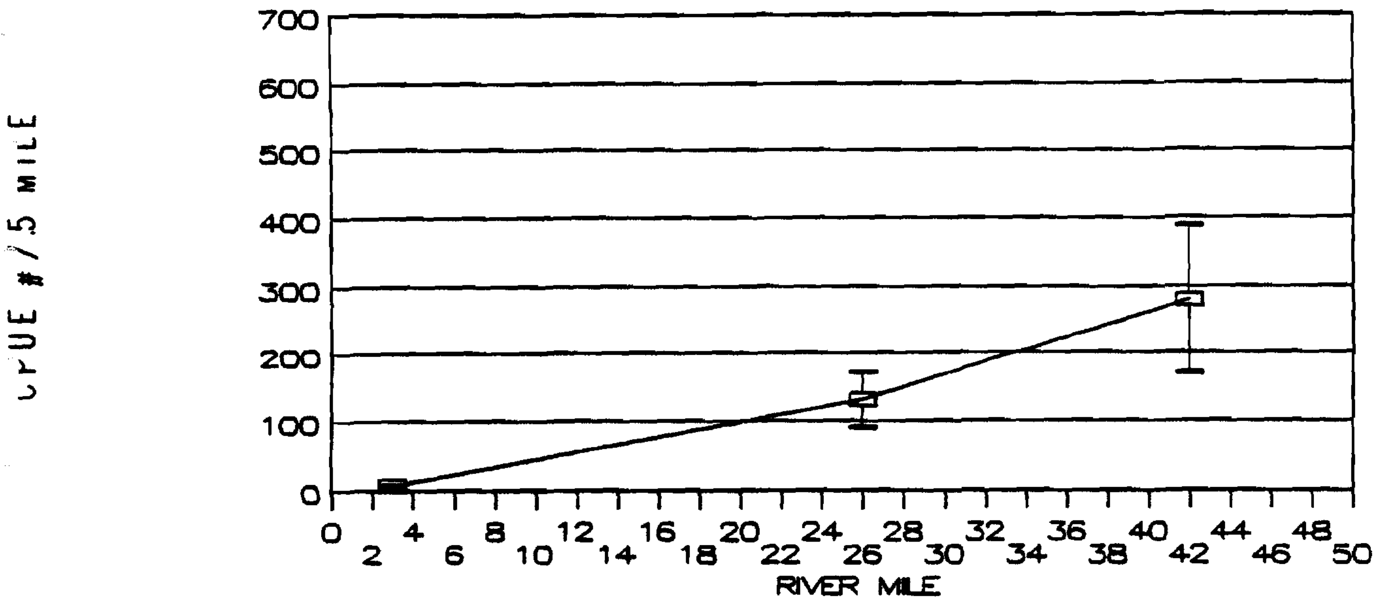


Fig. W16. CPUE by river mile for white perch in the Patuxent River, 1988.

JAN. 1989



FEB. 1989

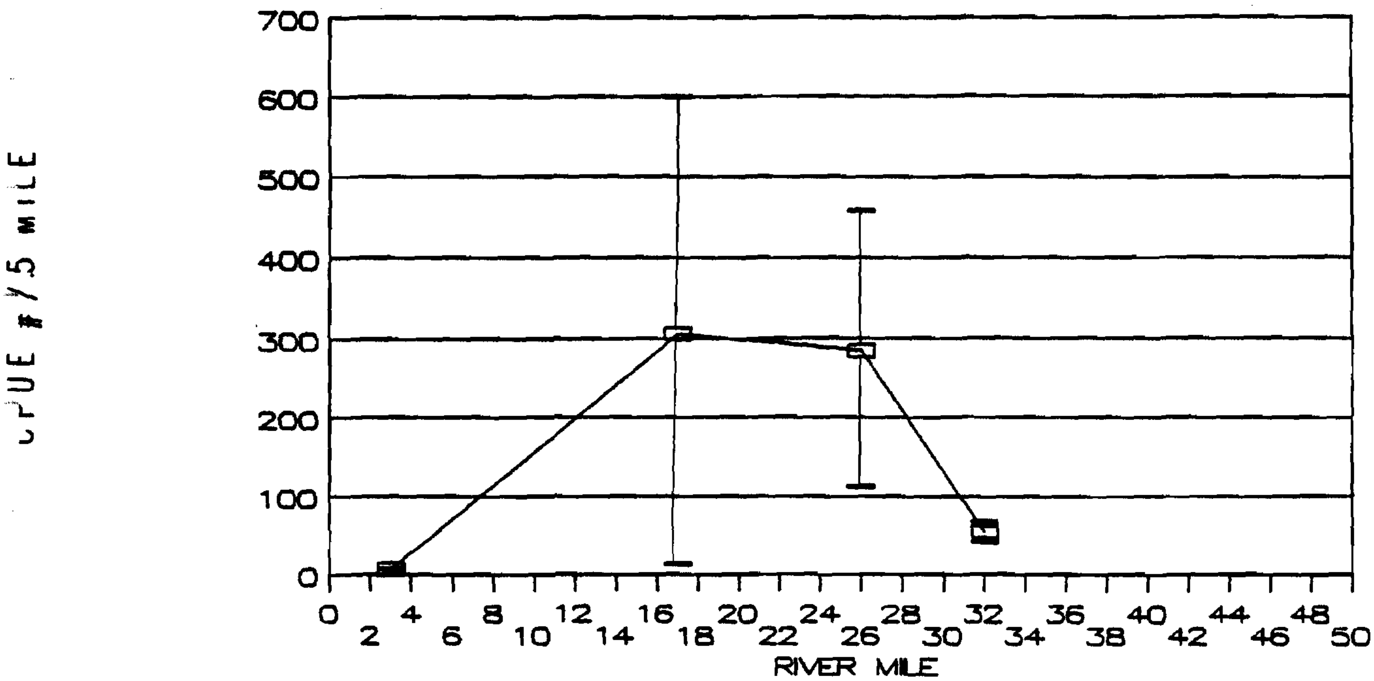
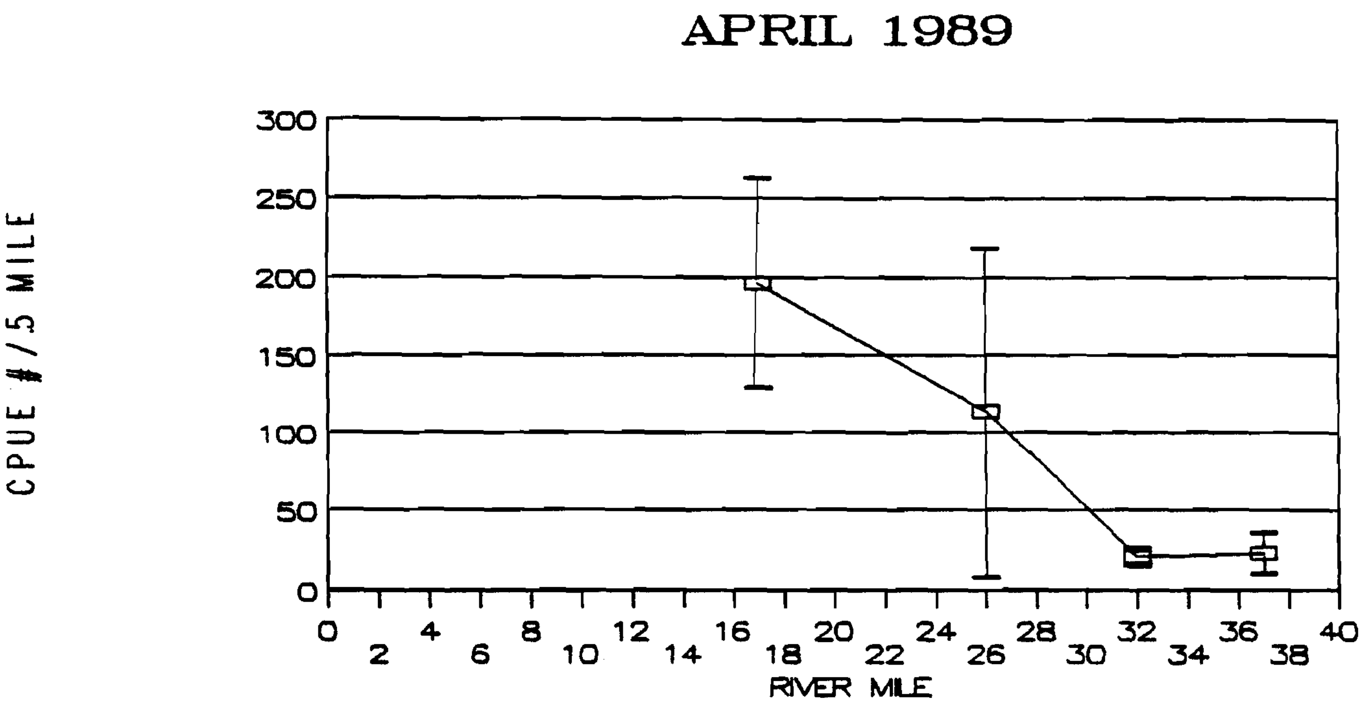


Fig. W17. CPUE by river mile for white perch in the Choptank River, 1989.



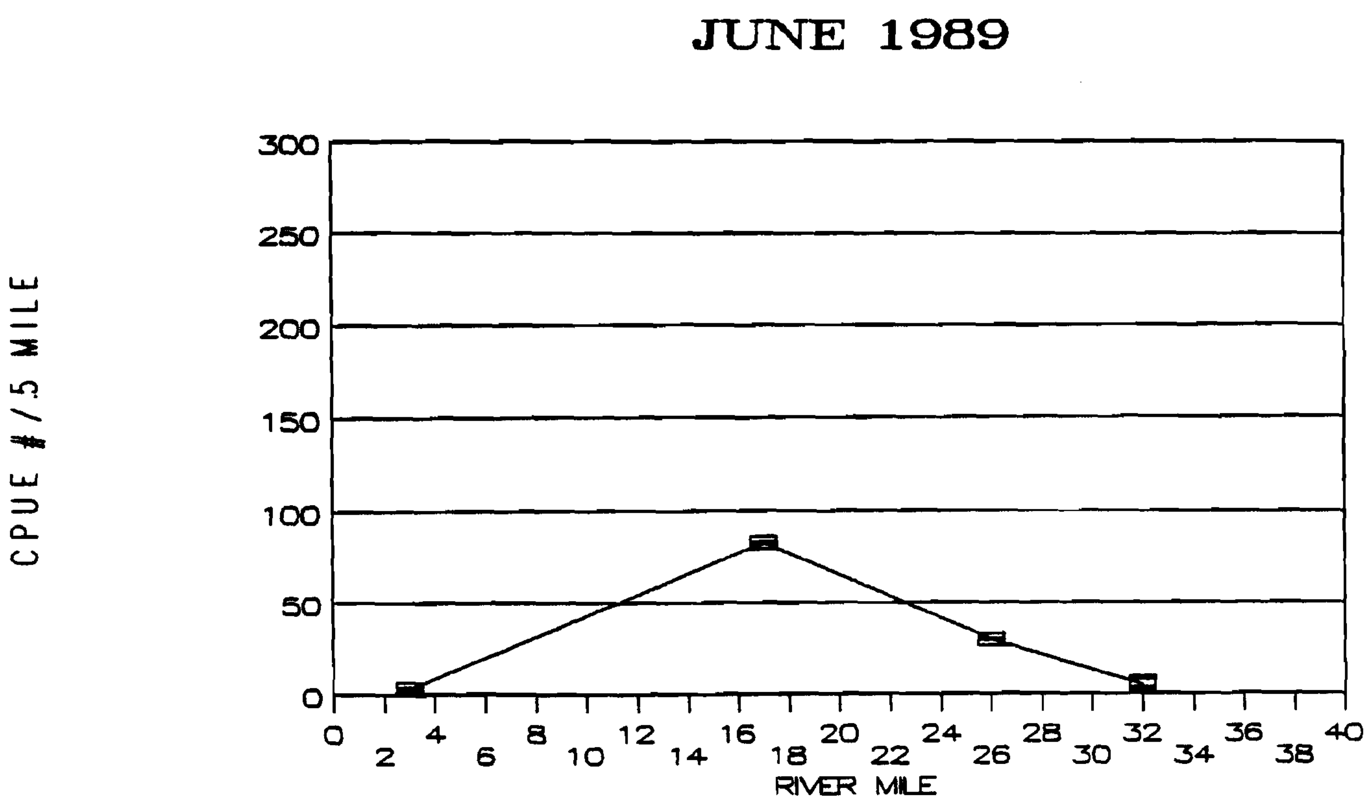
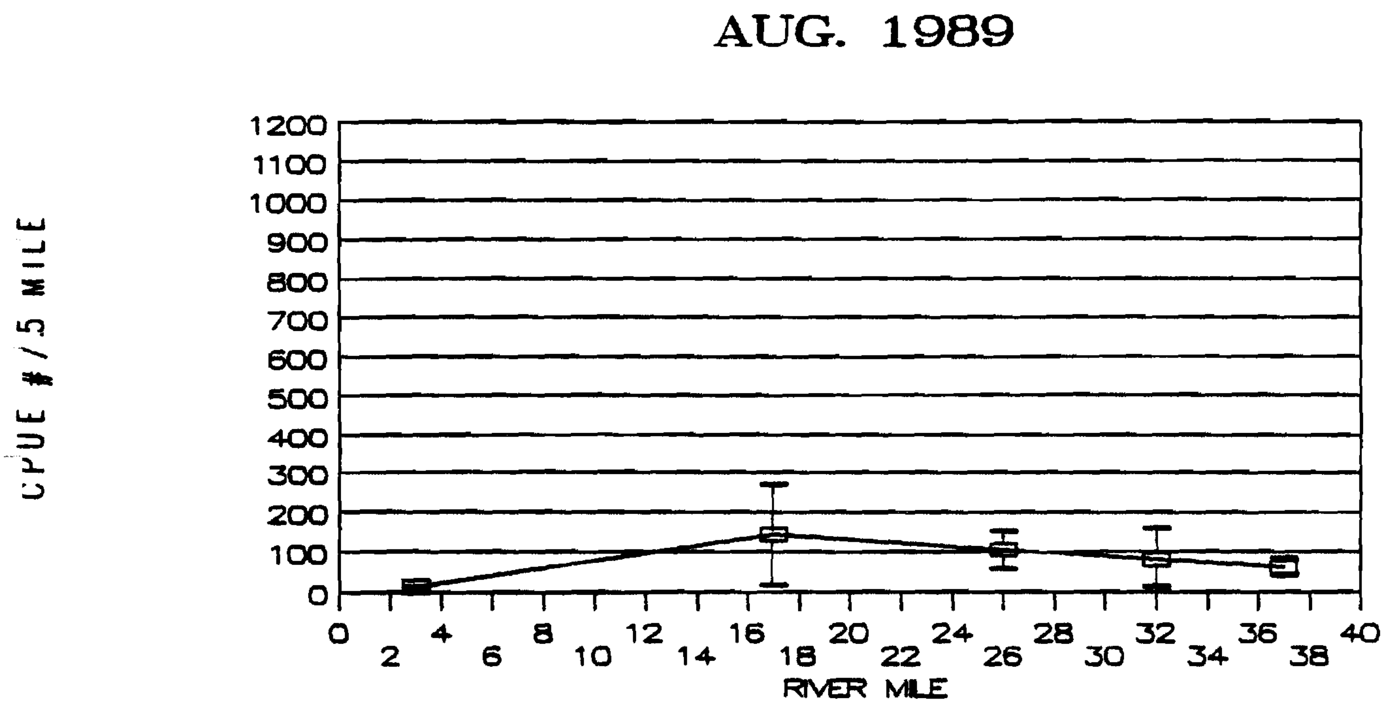


Fig. W18. CPUE by river mile for white perch in the Choptank River, 1989.



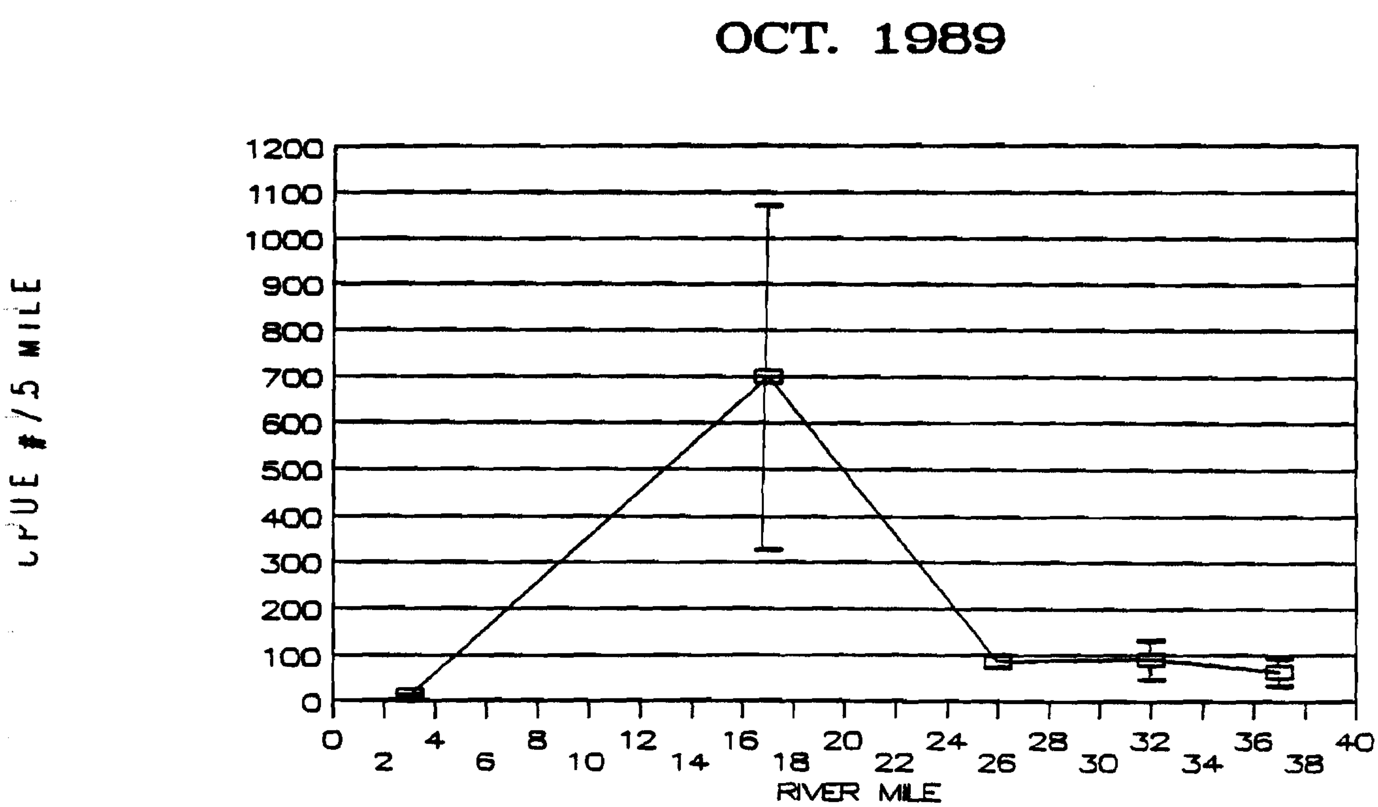


Fig. W19. CPUE by river mile for white perch in the Choptank River, 1989.

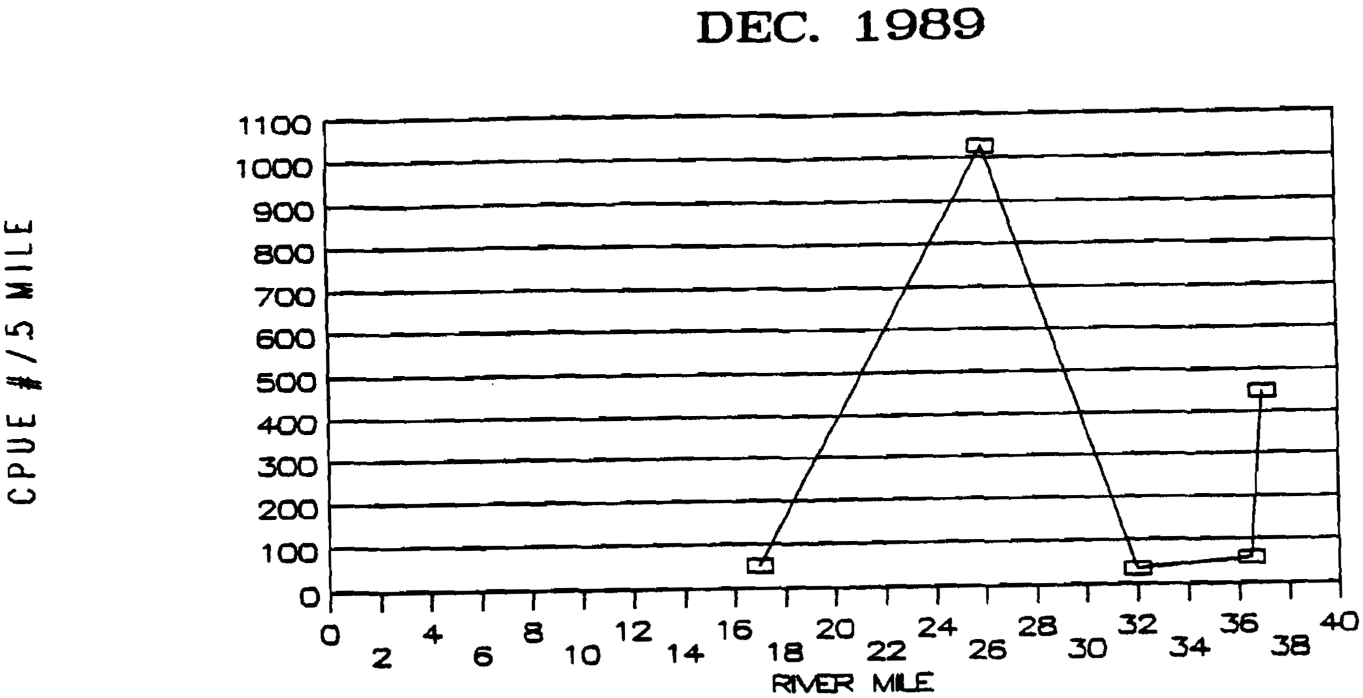


Fig. W20. CPUE by river mile for white perch in the Choptank River, 1989.

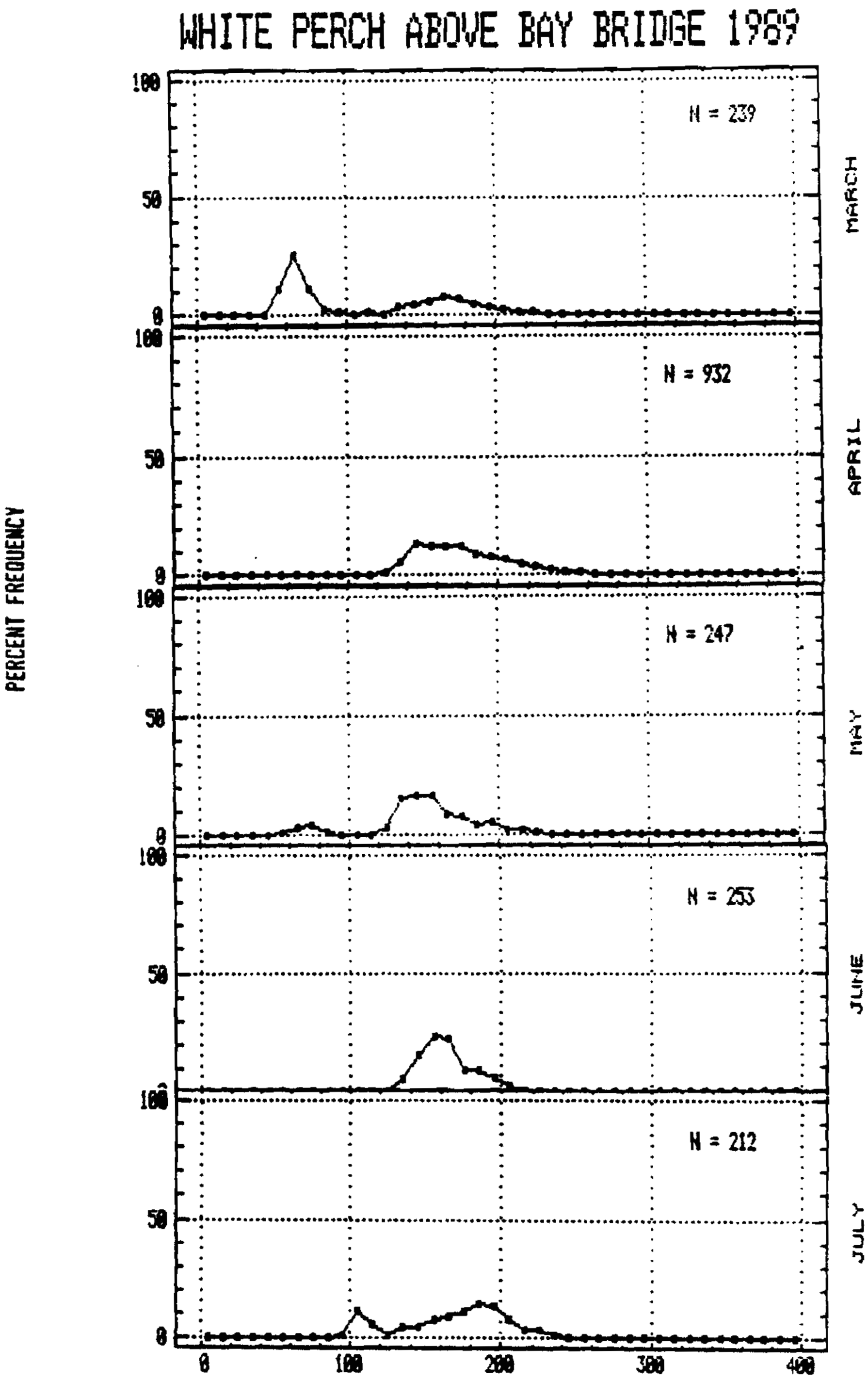


Fig. #21. Percent frequency of lengths of white perch in the Above Bay Bridge region 1989.

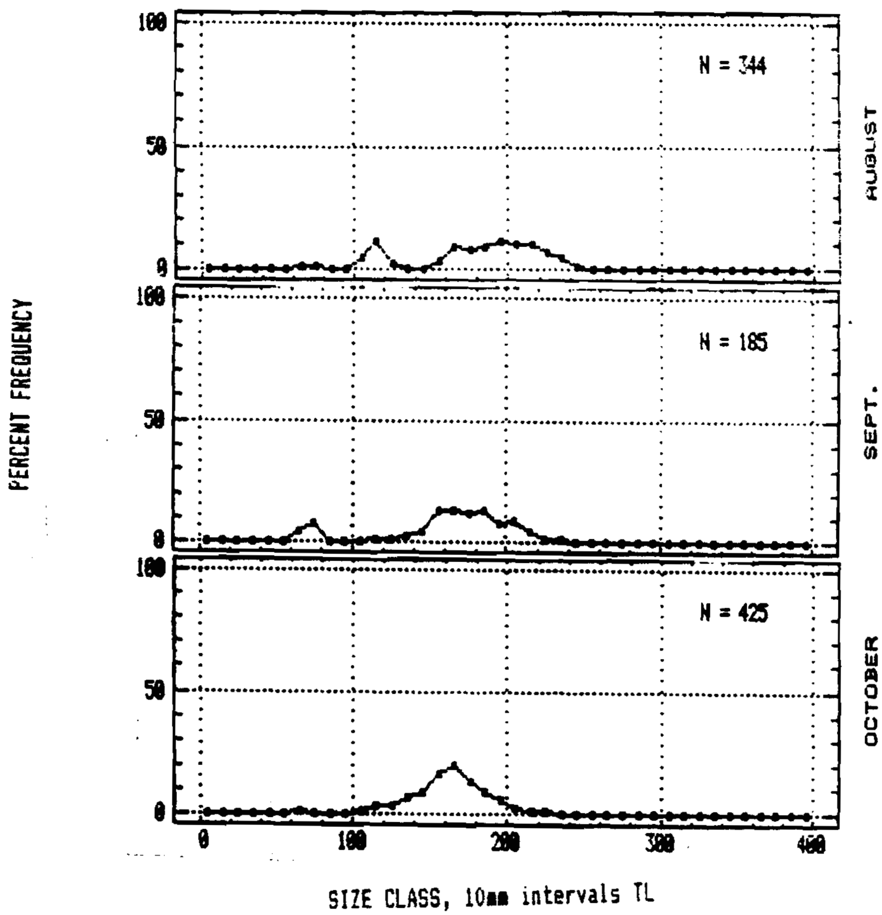


Fig. W21(cont.) Percent frequency of lengths of white perch in the Above Bay Bridge region 1989.

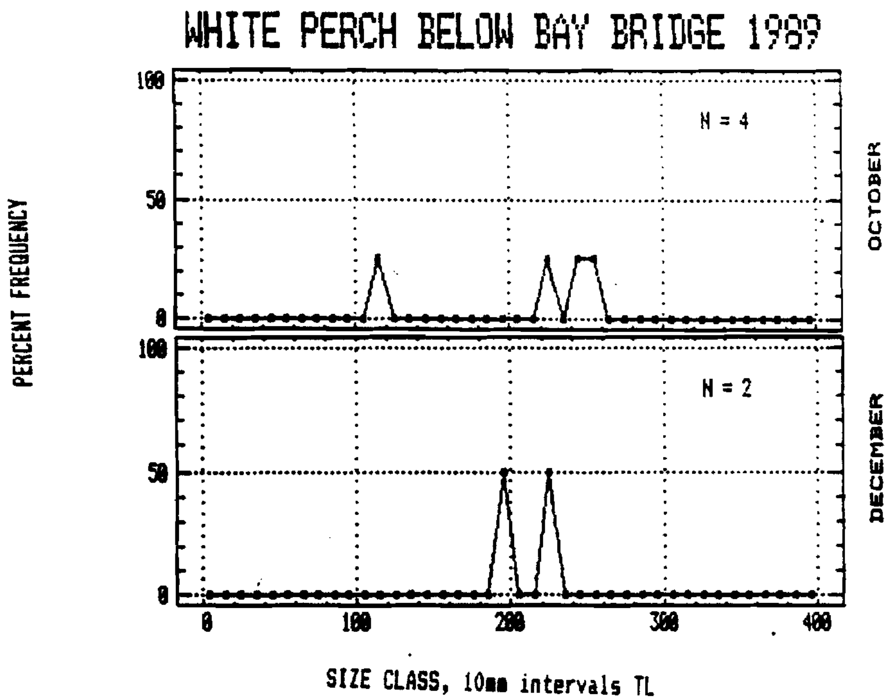


Fig. W22. Percent frequency of lengths of white perch in the Below Bay Bridge region 1989.

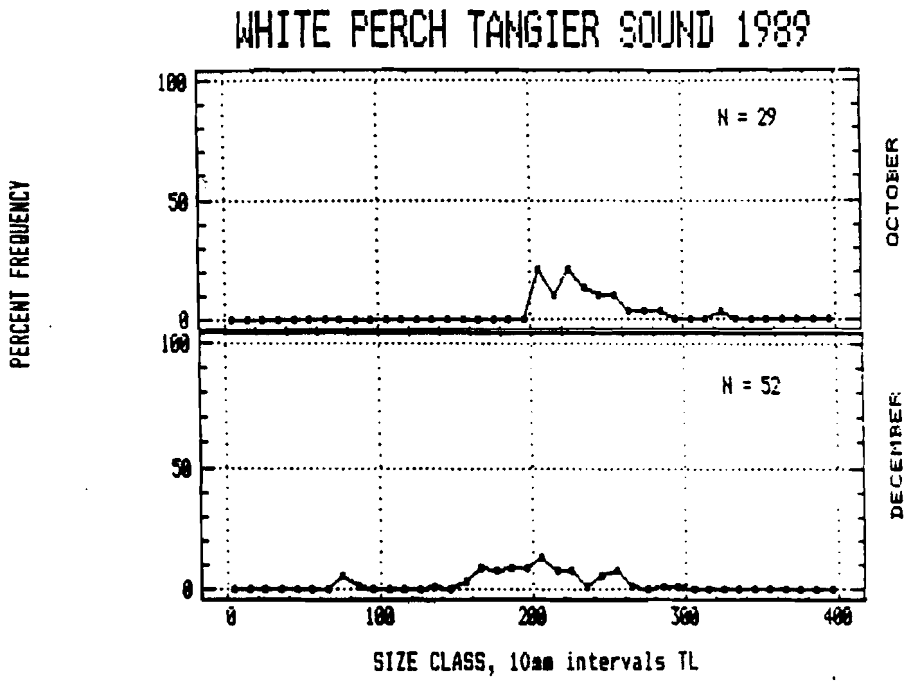


Fig. W23. Percent frequency of lengths of white perch in the Tangier Sound region 1989.

WHITE PERCH CHOPTANK RIVER 1989

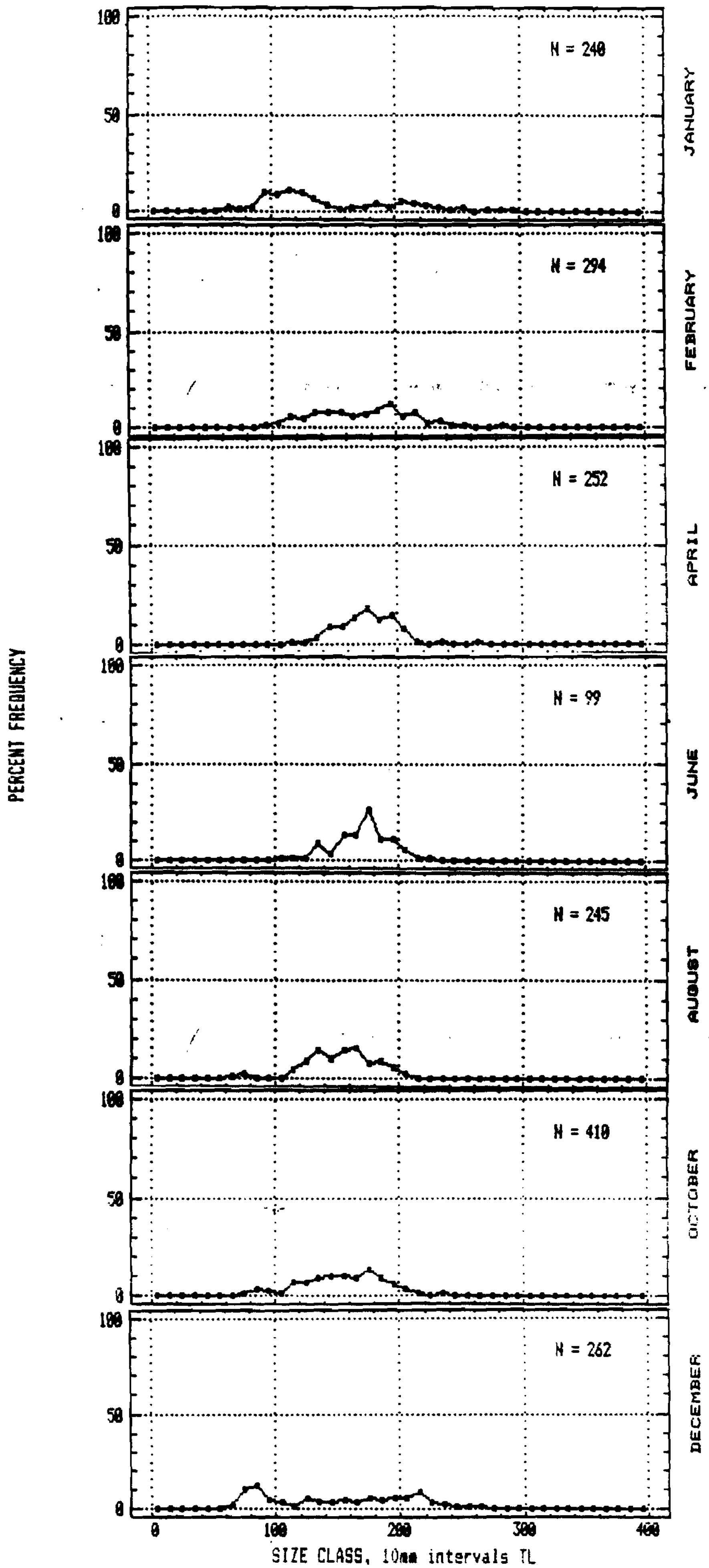


Fig. W24. Percent frequency of lengths of white perch in the Choptank River region 1989.

WHITE PERCH PATUXENT RIVER 1989

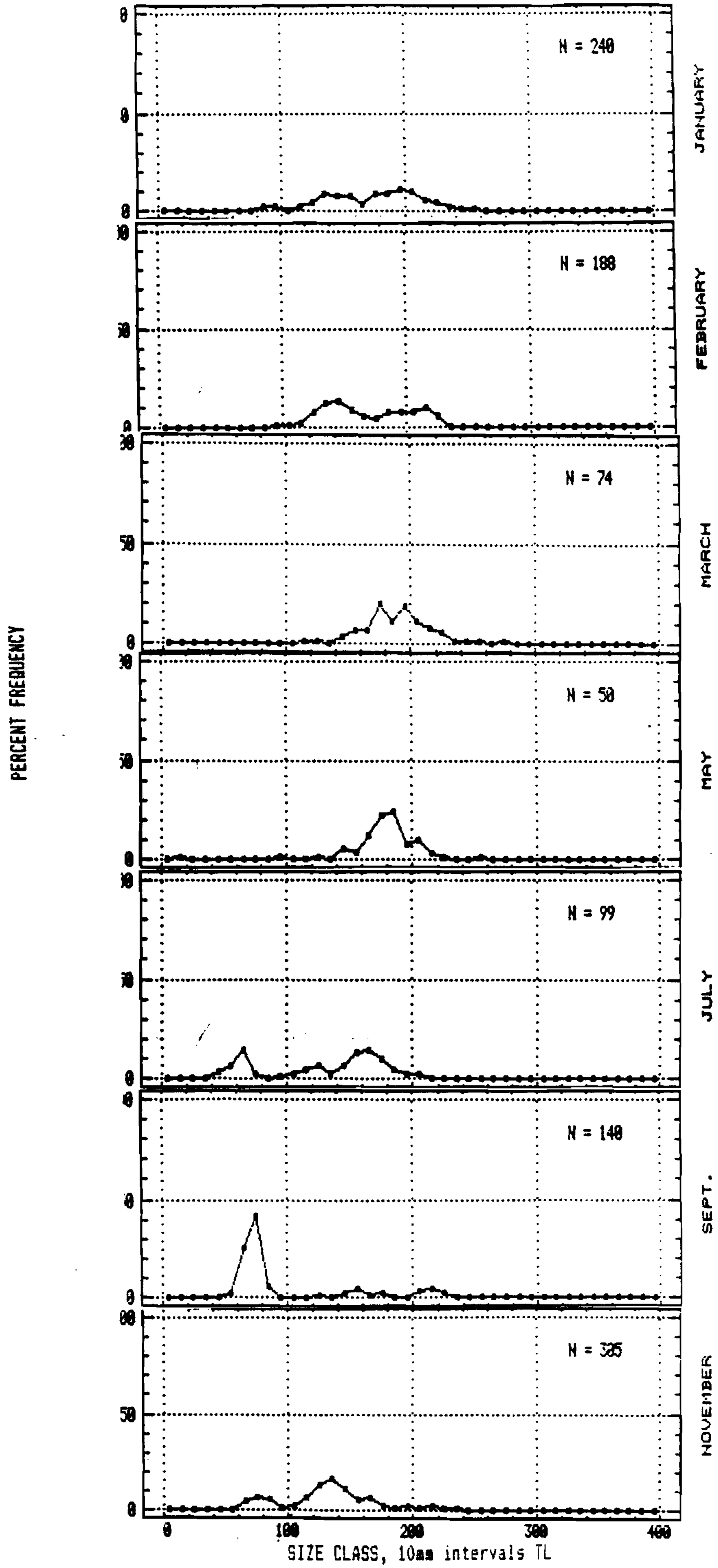


Fig. W25. Percent frequency of lengths of white perch in the Patuxent River region 1989.

WHITE PERCH PATUXENT RIVER

JAN. – DEC. 1989

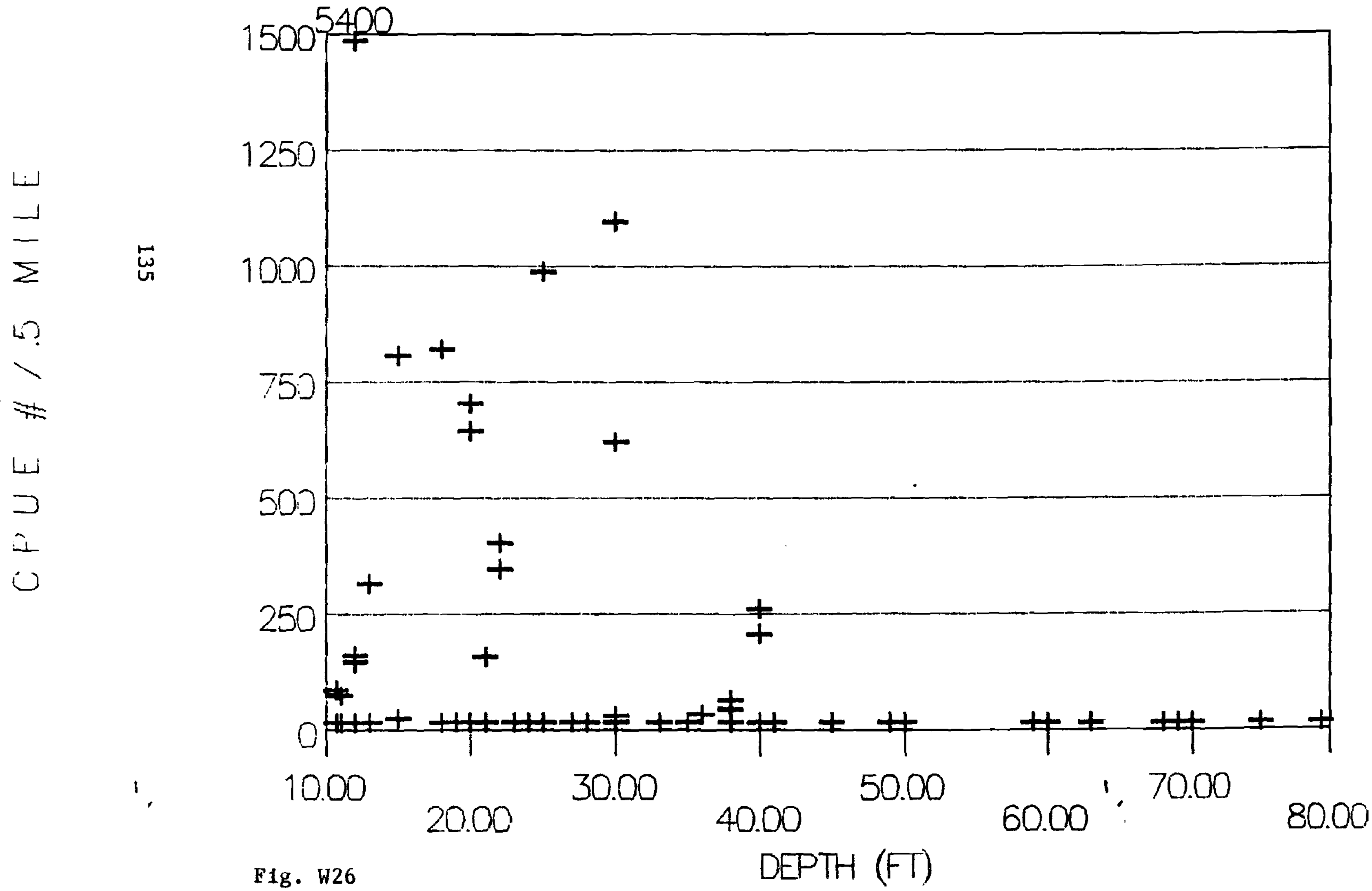


Fig. W26

WHITE PERCH PATUXENT RIVER

JAN. – DEC. 1989

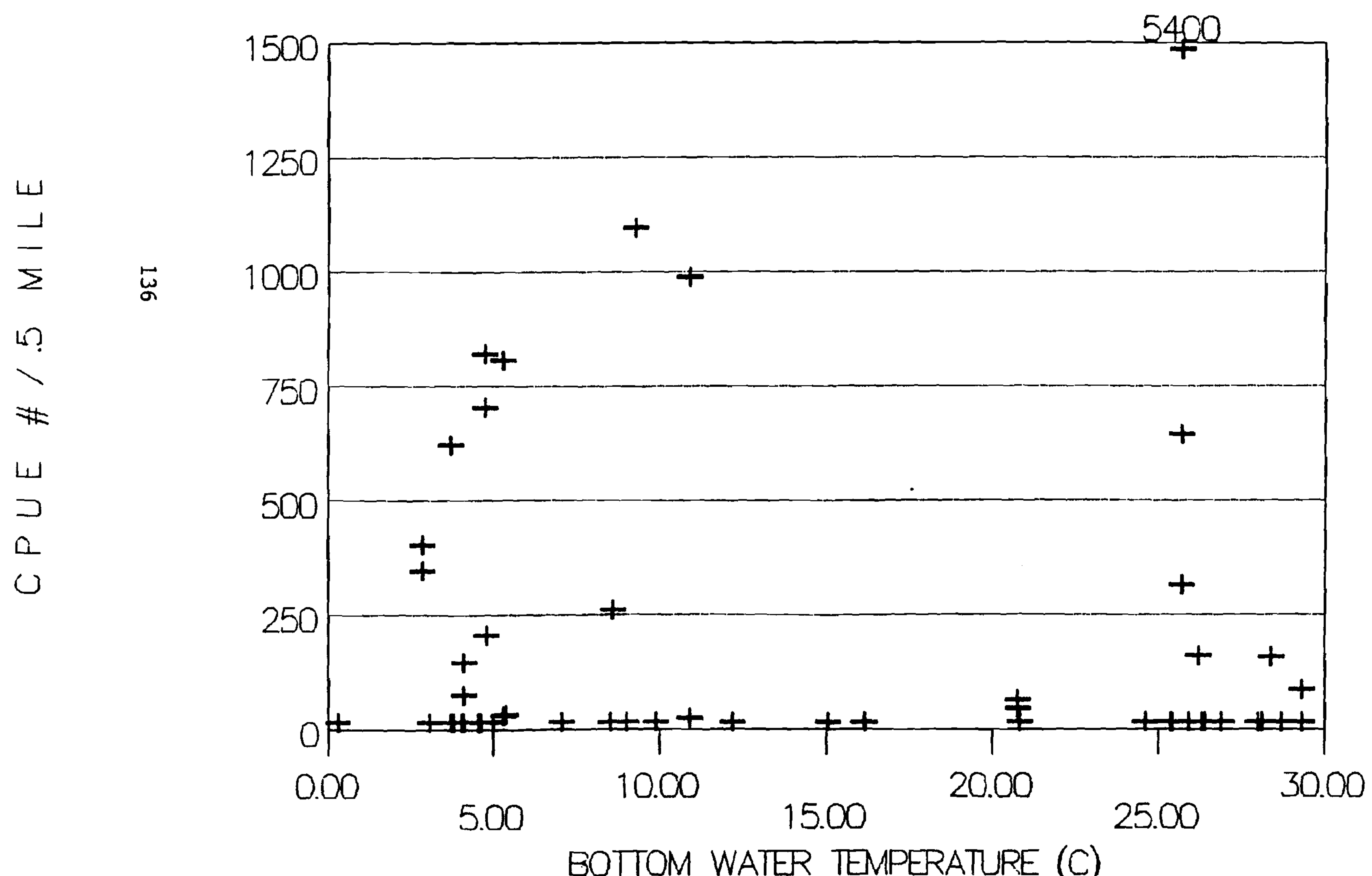


Fig. W27

WHITE PERCH PATUXENT RIVER

JAN. – DEC. 1989

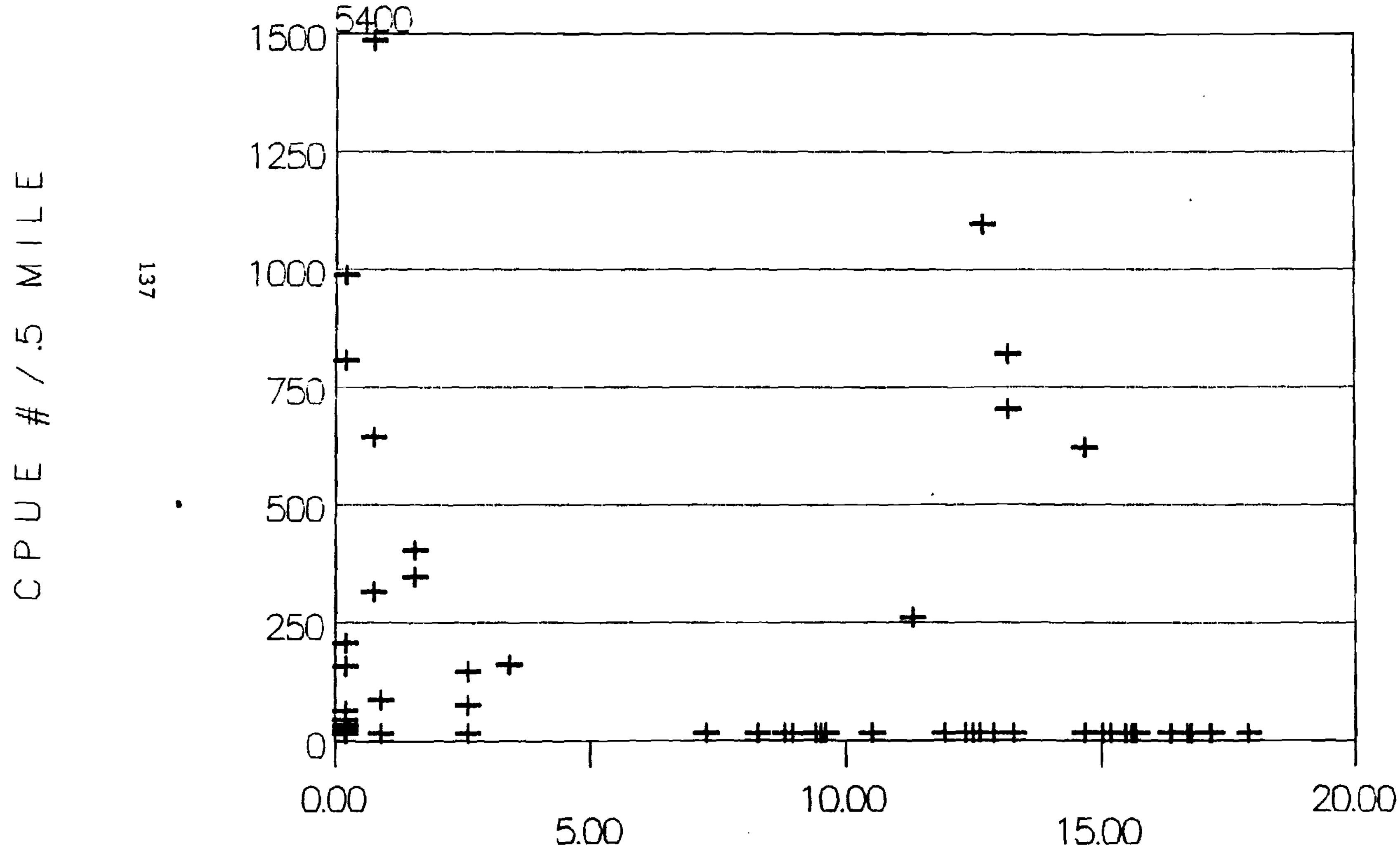


Fig. W28

WHITE PERCH PATUXENT RIVER

JAN. – DEC. 1989

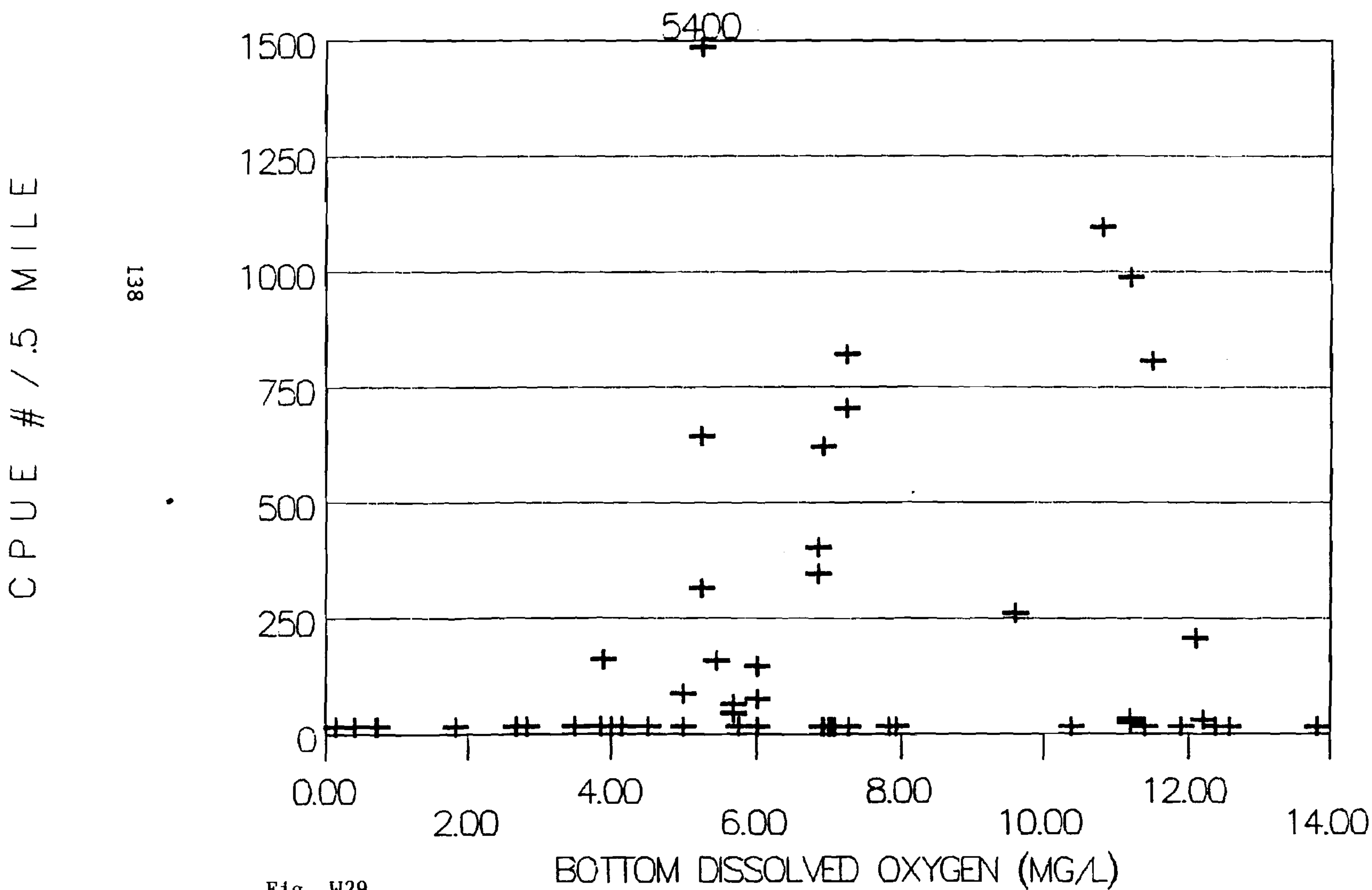


Fig. W29

WHITE PERCH CHOPTANK RIVER

JAN. – DEC. 1989

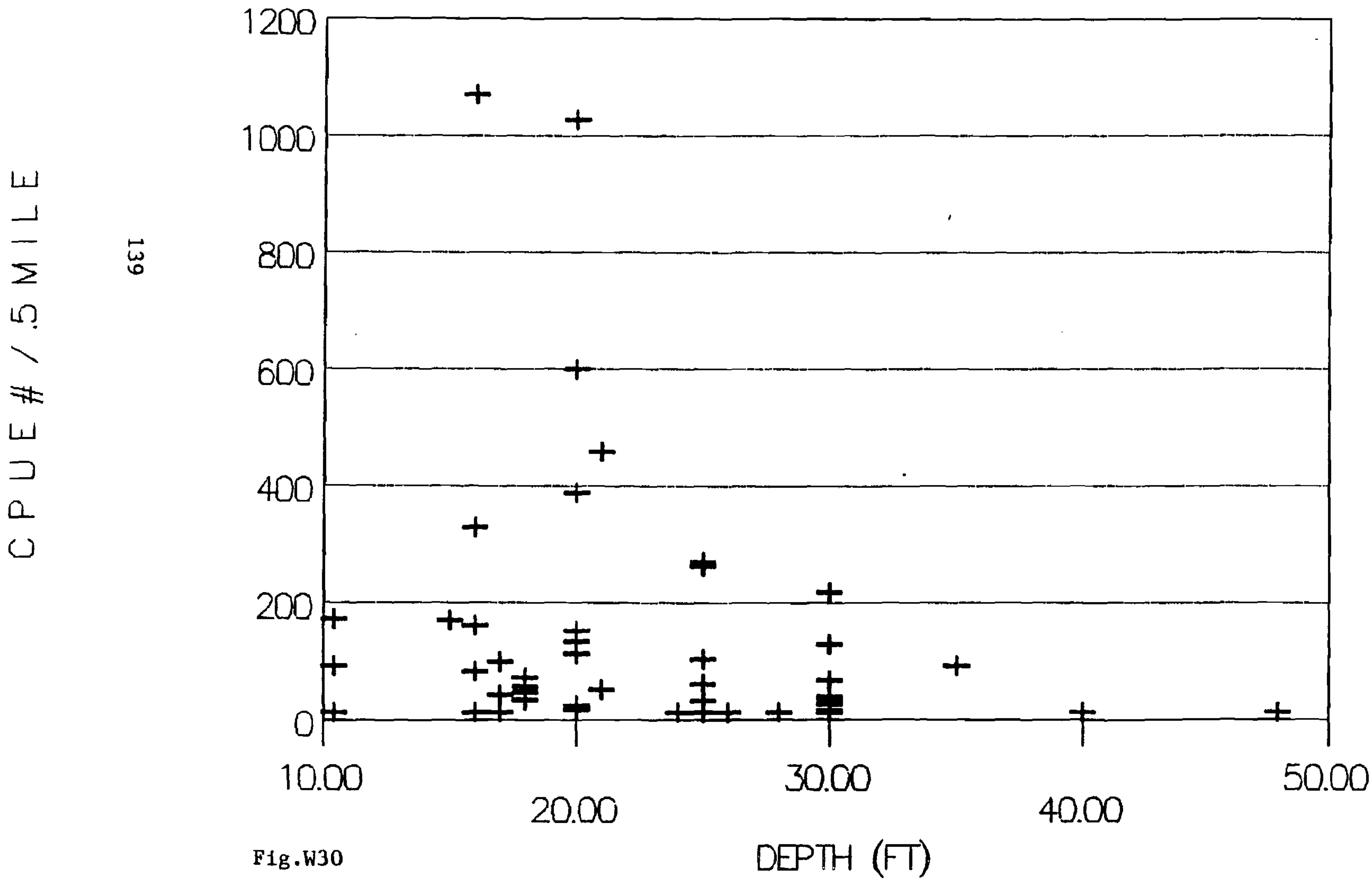


Fig.W30

WHITE PERCH CHOPTANK RIVER

JAN. – DEC. 1989

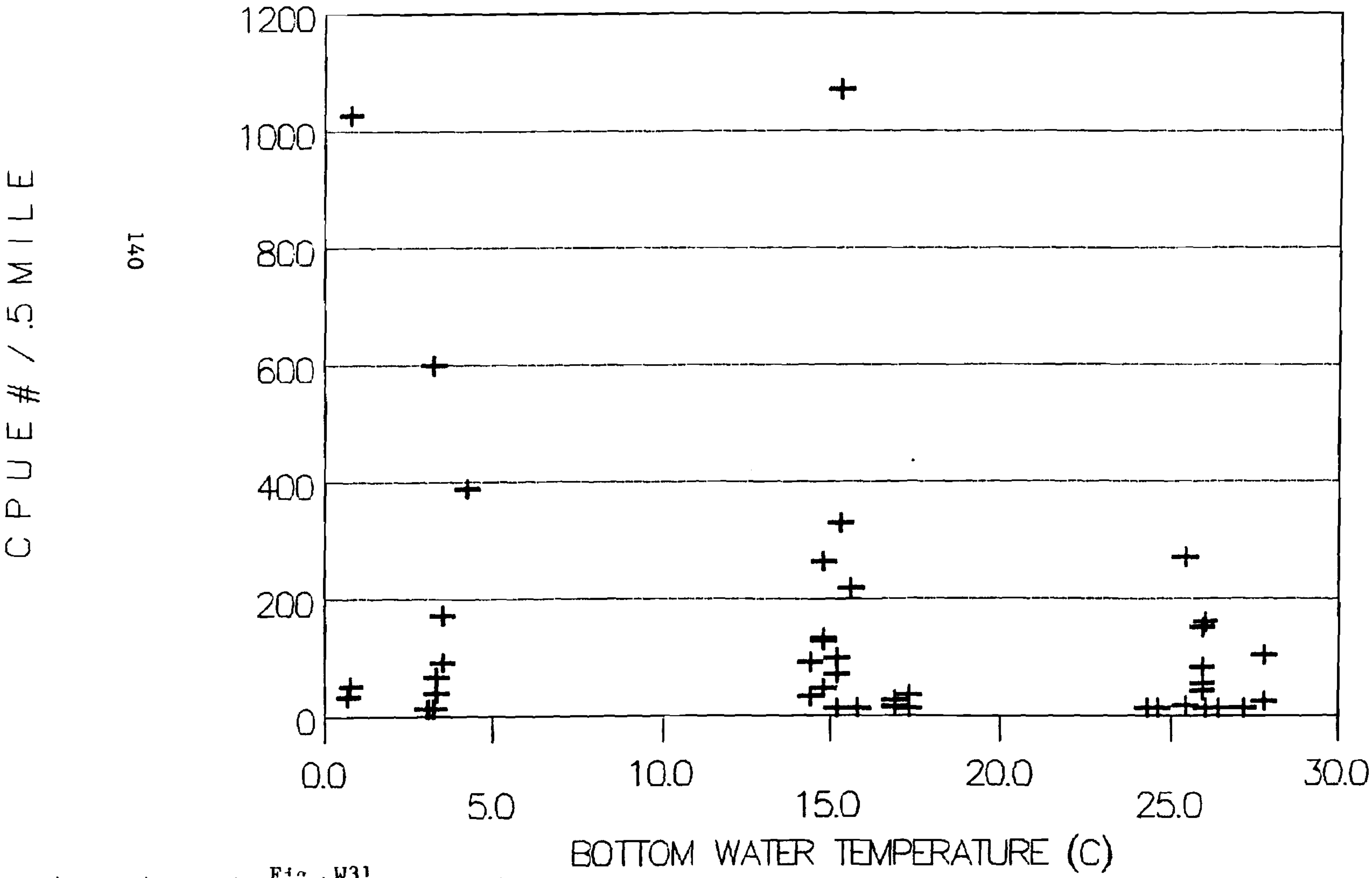


Fig. W31

WHITE PERCH CHOPTANK RIVER

JAN. – DEC. 1989

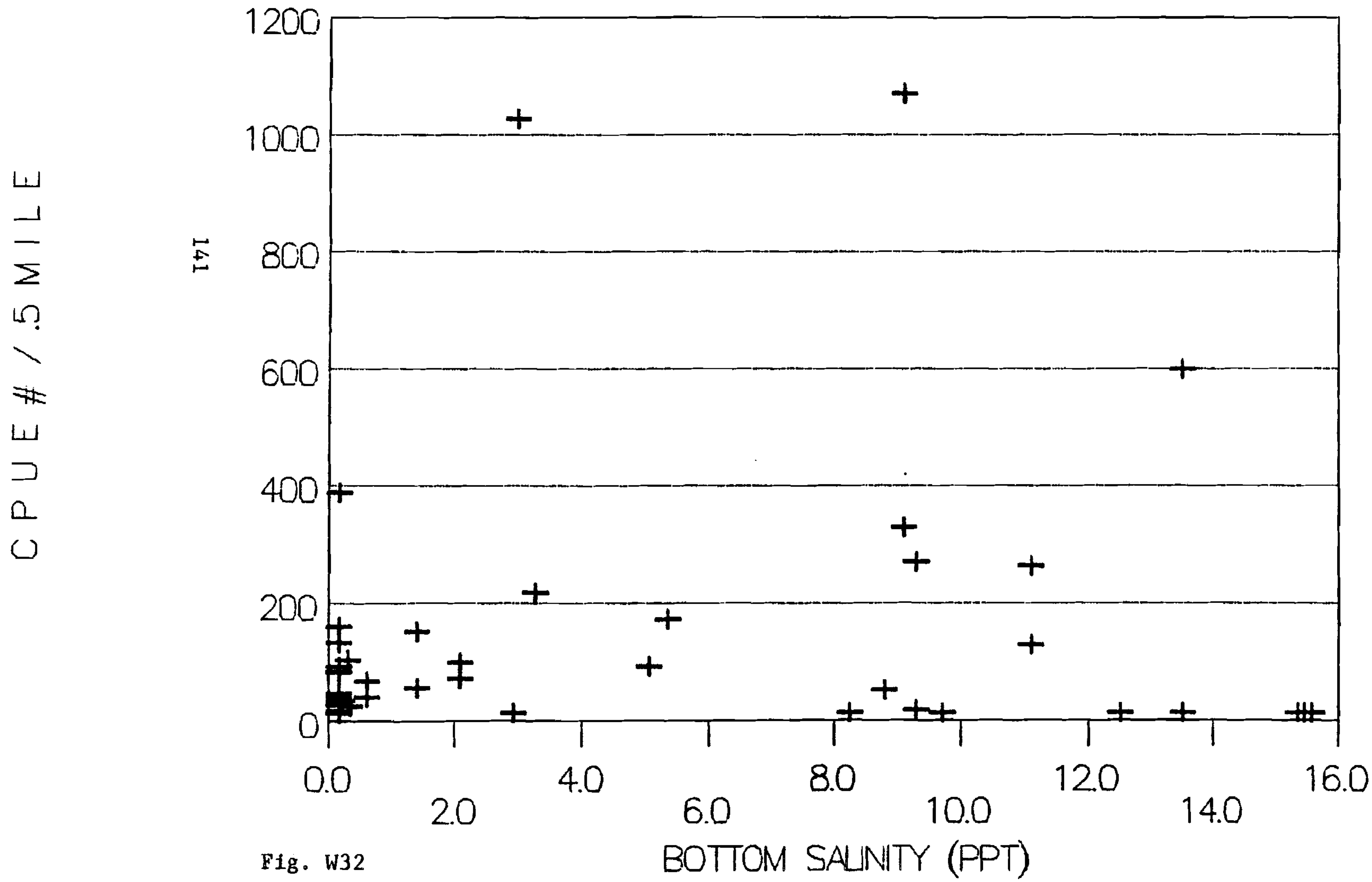


Fig. W32

WHITE PERCH CHOPTANK RIVER

JAN. – DEC. 1989

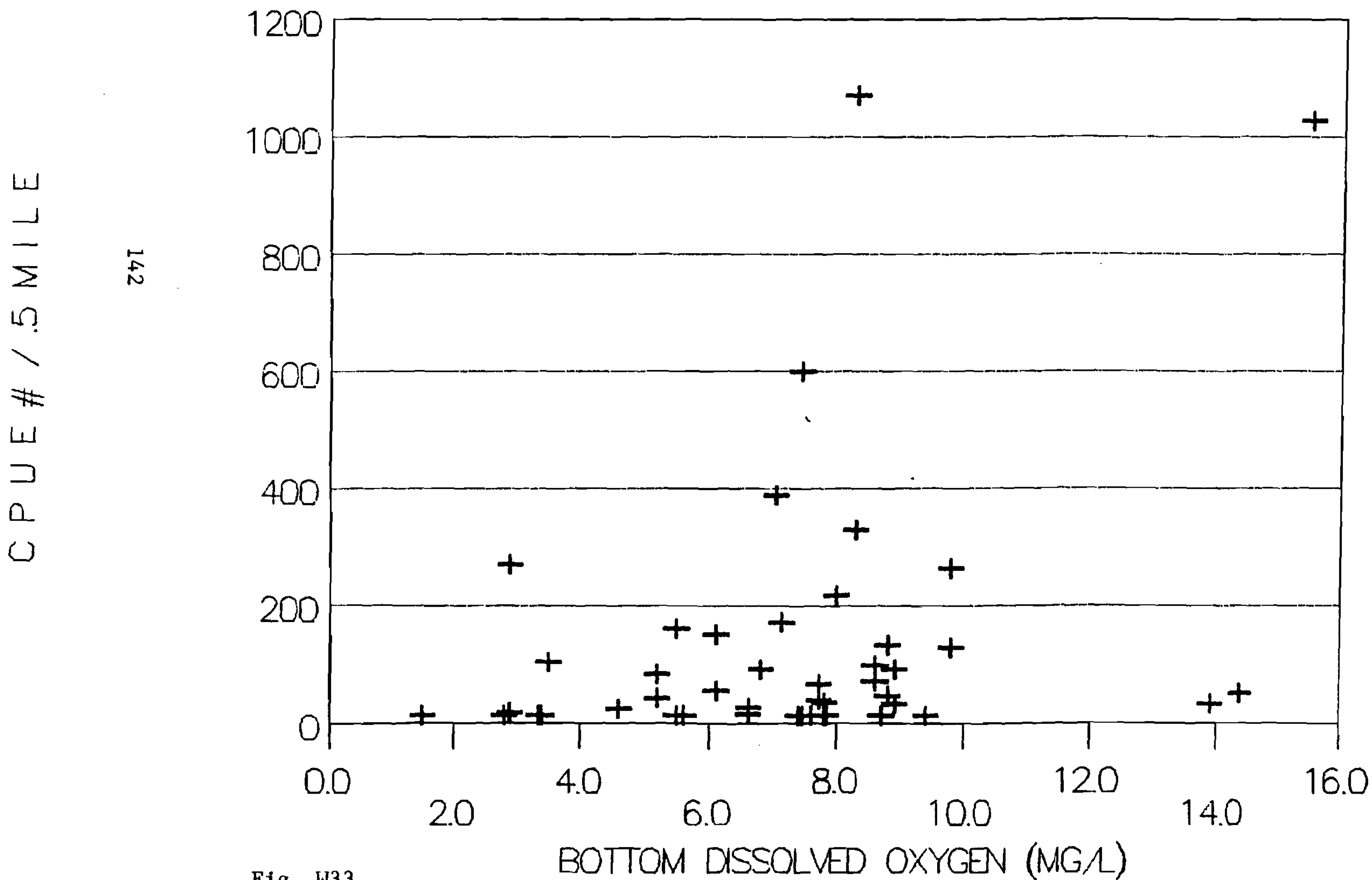


Fig. W33

WHITE PERCH ABOVE BRIDGE

MAR. – OCT. 1989

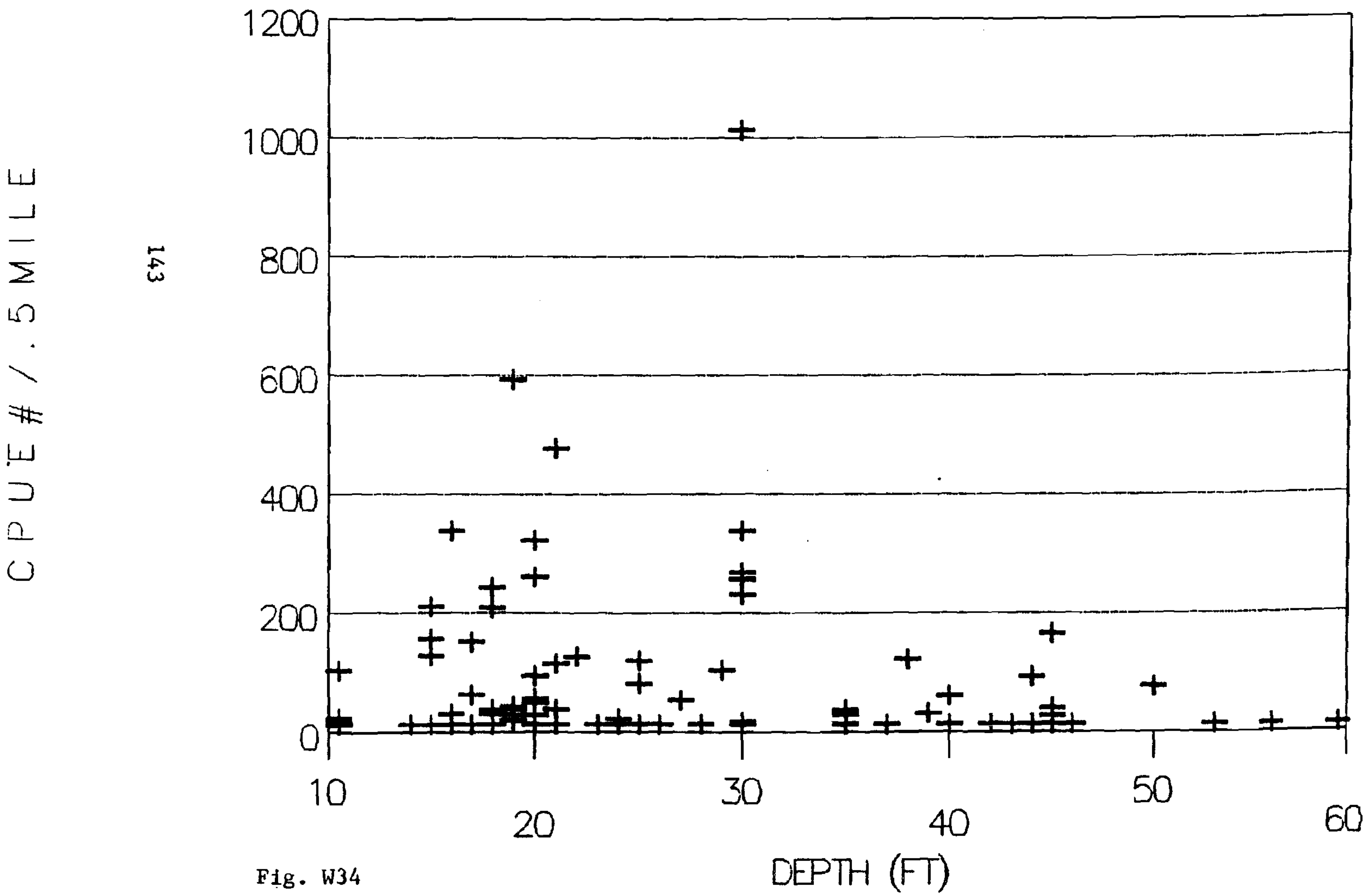


Fig. W34

WHITE PERCH ABOVE BRIDGE

MAR. – OCT. 1989

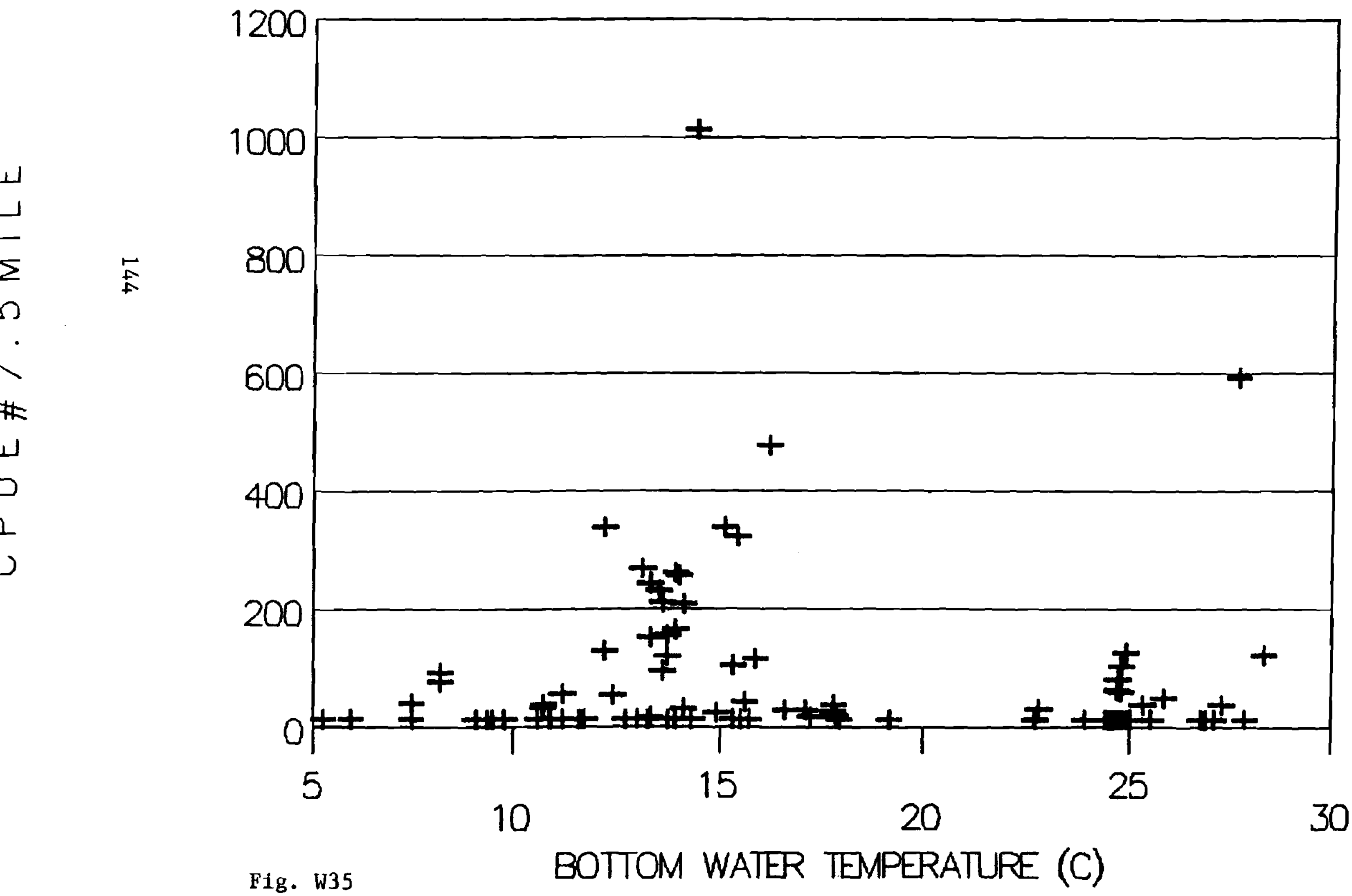


Fig. W35

WHITE PERCH ABOVE BRIDGE

MAR. – OCT. 1989

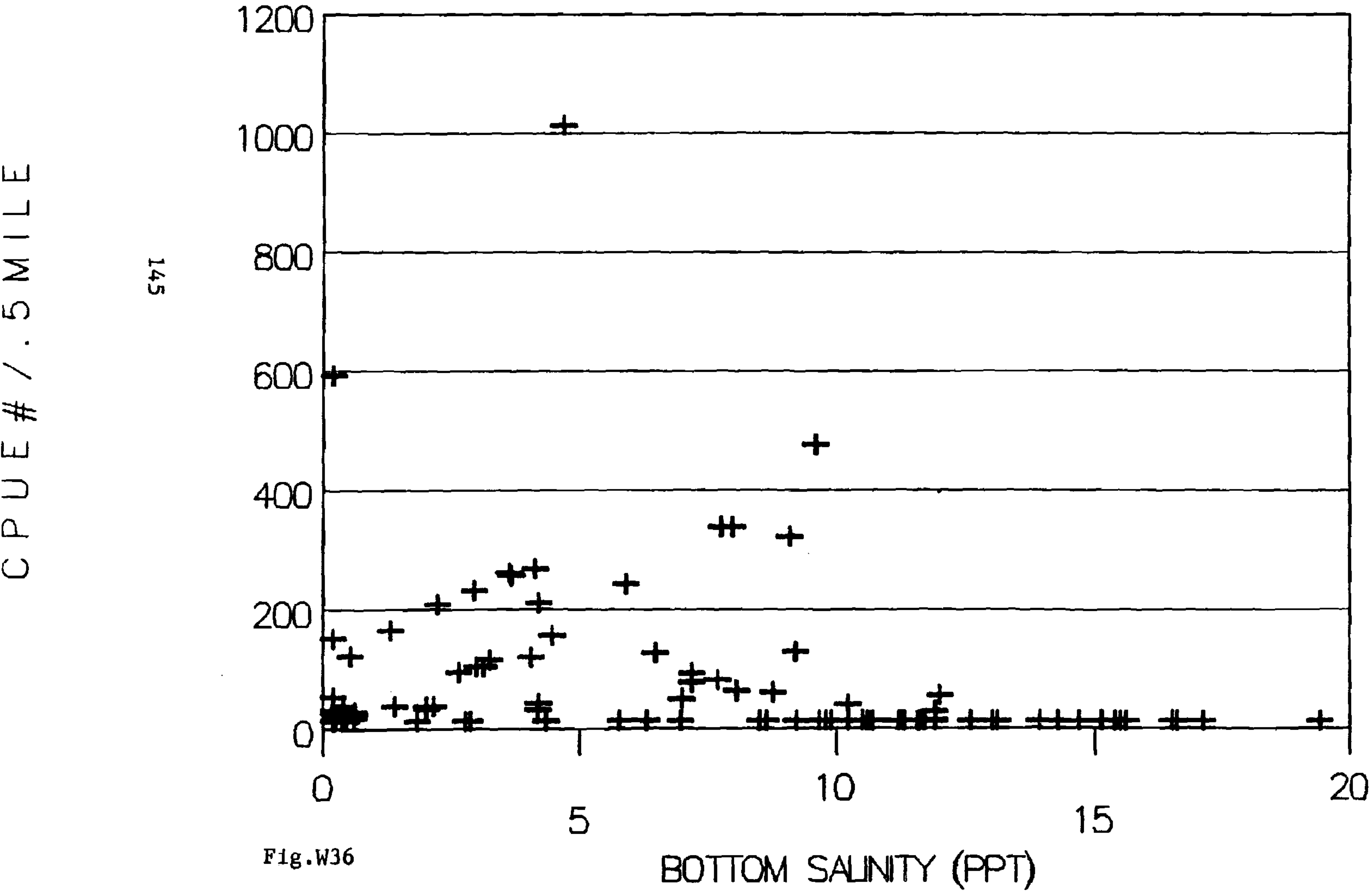


Fig.W36

WHITE PERCH ABOVE BRIDGE

MAR. – OCT. 1989

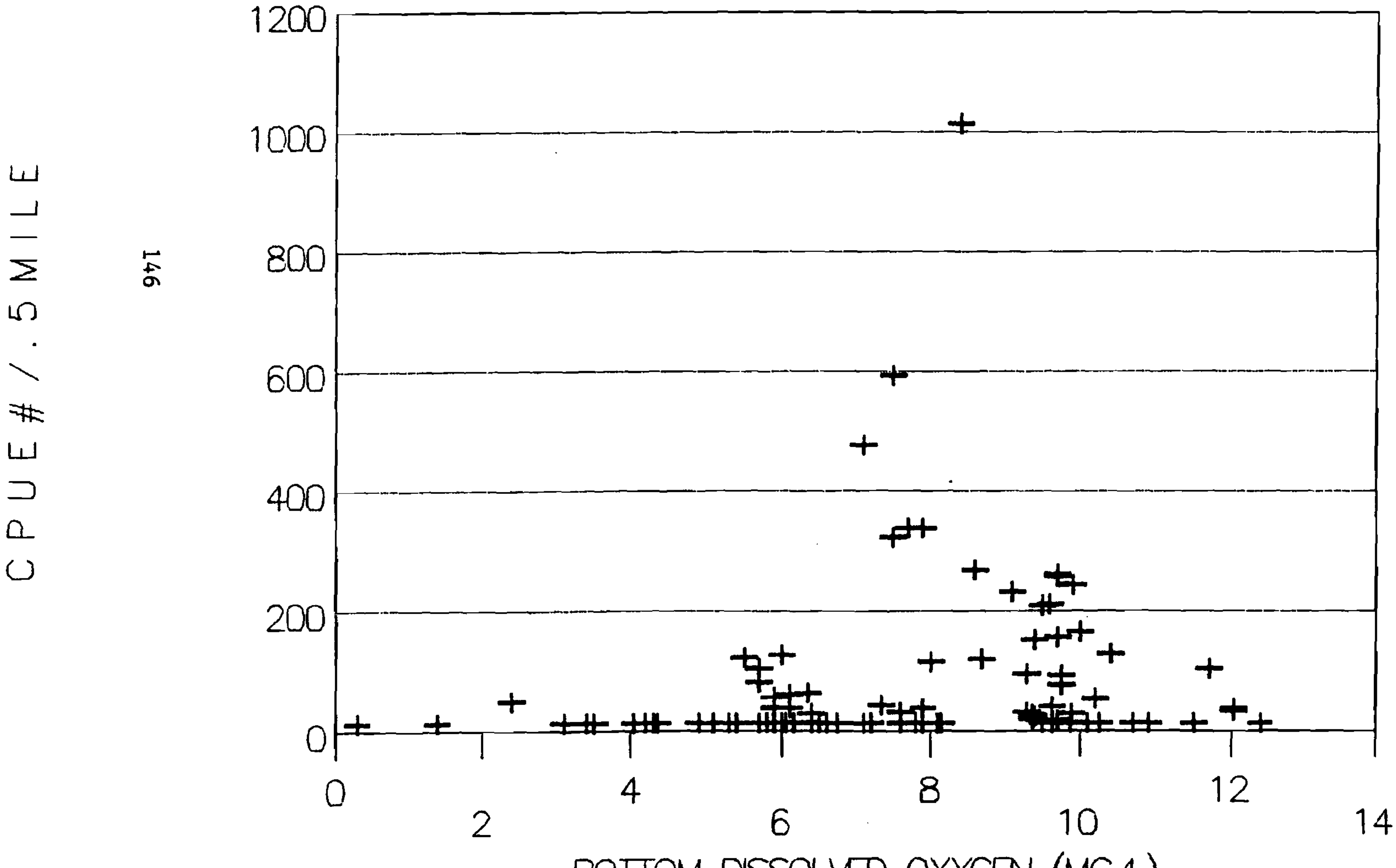


Fig. W37

Table SB1. Summary of abundance of striped bass by region and time period.

	Location					
	Bay-wide	Above Bay Bridge	Below Bay Bridge	Tangier Sound	Patuxent River	Choptank River
Annual Mean CPUE	2	4	<1	<1	23	4
Rank by CPUE	10	7	15	12	5	8
Percent Frequency in Collection	26	44	3	5	38	38
Period of Peak Abundance	Feb.	Oct.	-	-	Feb.	Jan.

TABLE SB2. Monthly mean, minimum, maximum lengths of Stiped Bass by region.

STRIPED BASS		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ABOVE BAY	N=			15		5	27	28	117	62	133		
BRIDGE	MEAN LTH.			152		117	129	158	131	129	167		
	RANGE			79-418		97-144	111-152	115-585	61-310	76-244	74-471		
BELOW BAY	N=	24	22	8				1			7		12
BRIDGE	MEAN LTH.	165	170	194				244			290		312
	RANGE	120-252	60-245	152-325				244-244			257-316		96-435
TANGIER	N=										3		7
SOUND	MEAN LTH.										468		162
	RANGE										345-664		84-359
CHOPTANK	N=	51	27		16		1		21		65		65
RIVER	MEAN LTH.	386	407		186		586		92		139		334
	RANGE	206-659	93-669		104-471		586-586		42-392		79-433		72-559
PATUXENT	N=	334	199	34		2		3		15		113	
RIVER	MEAN LTH.	251	210	202		179		144		266		238	
	RANGE	90-645	108-482	94-321		172-186		77-278		141-406		126-443	

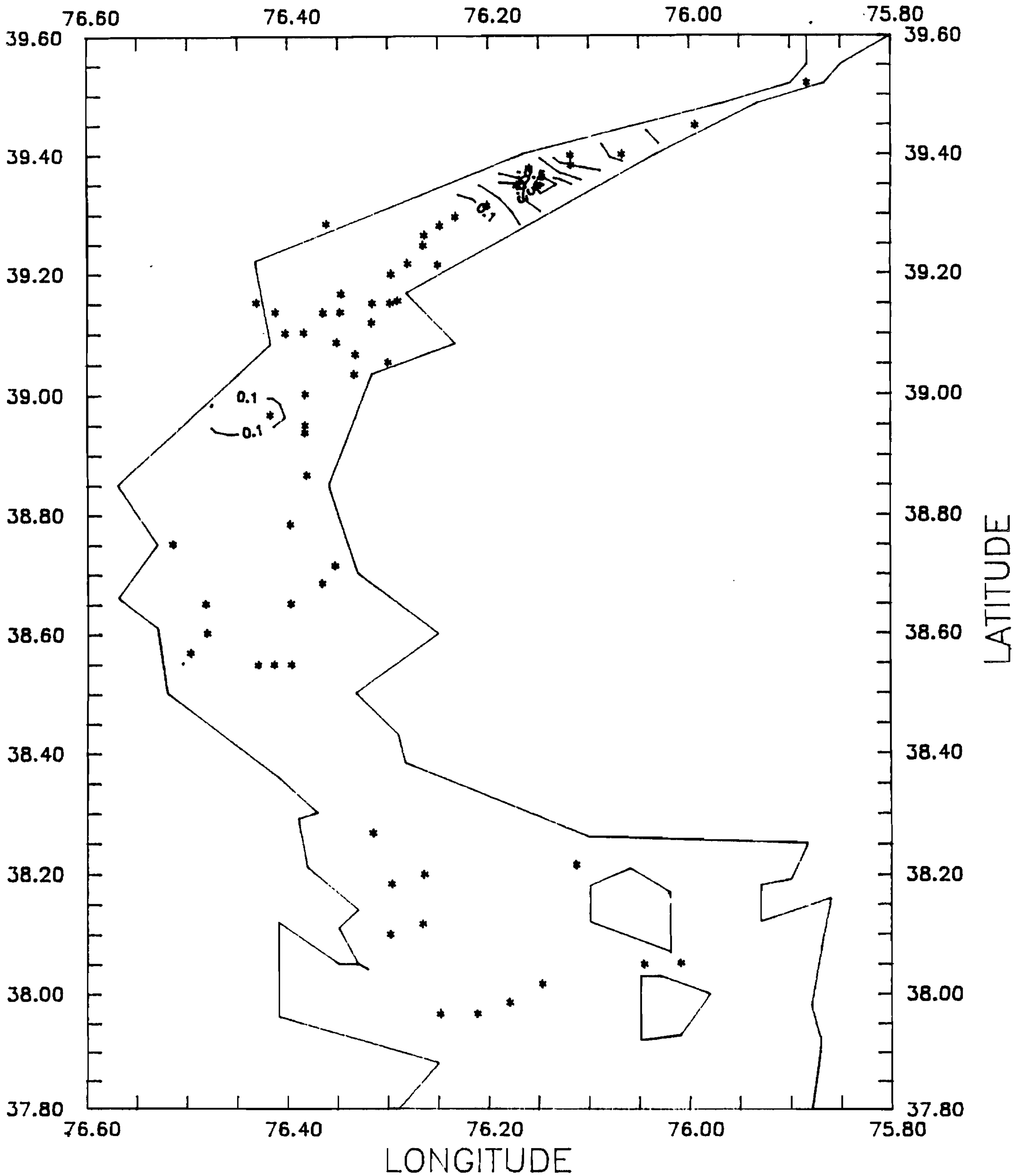


FIG. SB1. STRIPED BASS CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY APR 1989

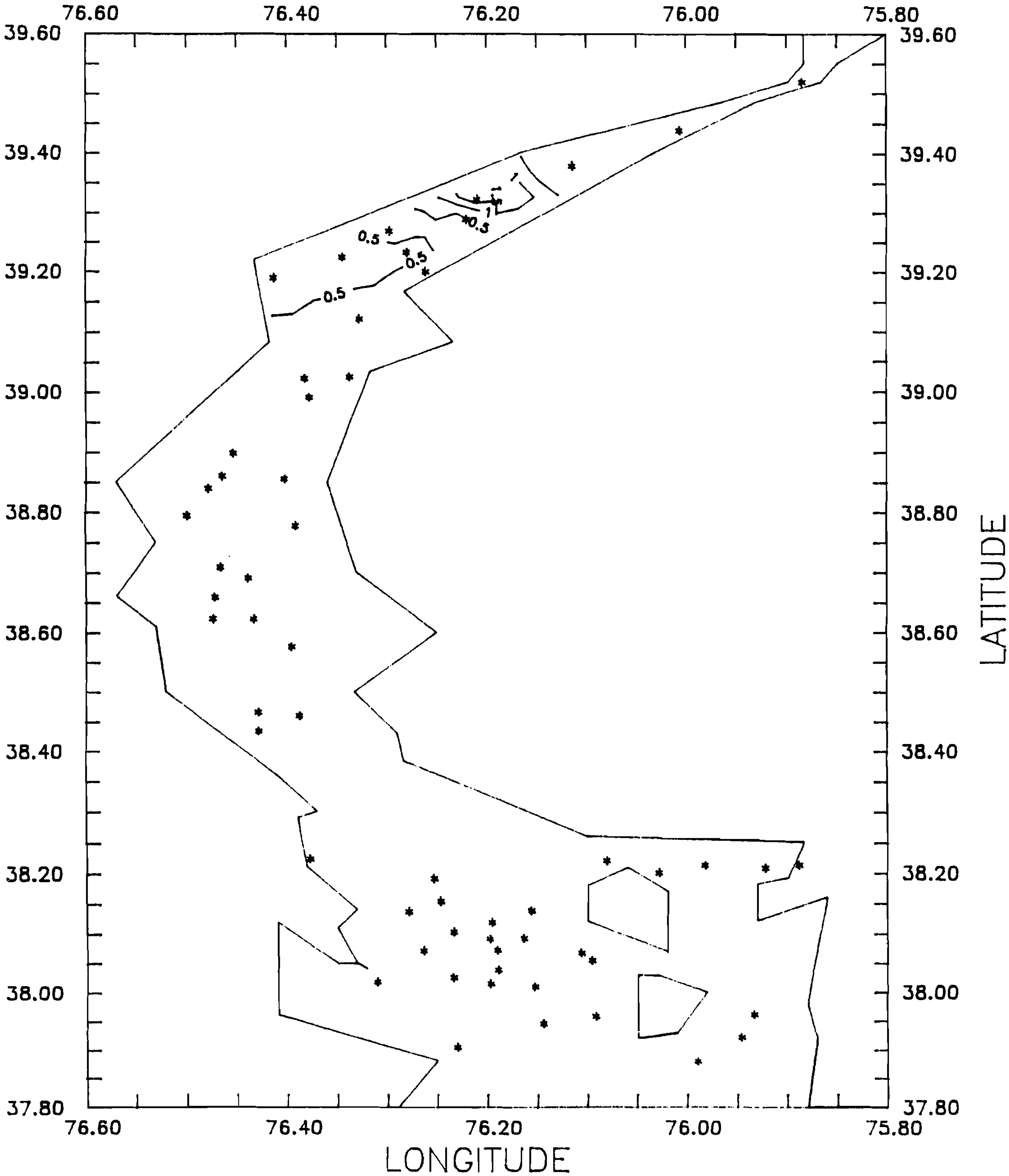


FIG. SB2. STRIPED BASS CPUE CONTOURS
MAINSTEM CHESAPEAKE BAY MAY 1989