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Estimation of Relative Abundance of Recreationally Important Finfish in the Virginia Portion of Chesapeake Bay: Annual Progress Report 1993-1994

Patrick J. Geer
Virginia Institute of Marine Science

Herb M. Austin
Virginia Institute of Marine Science

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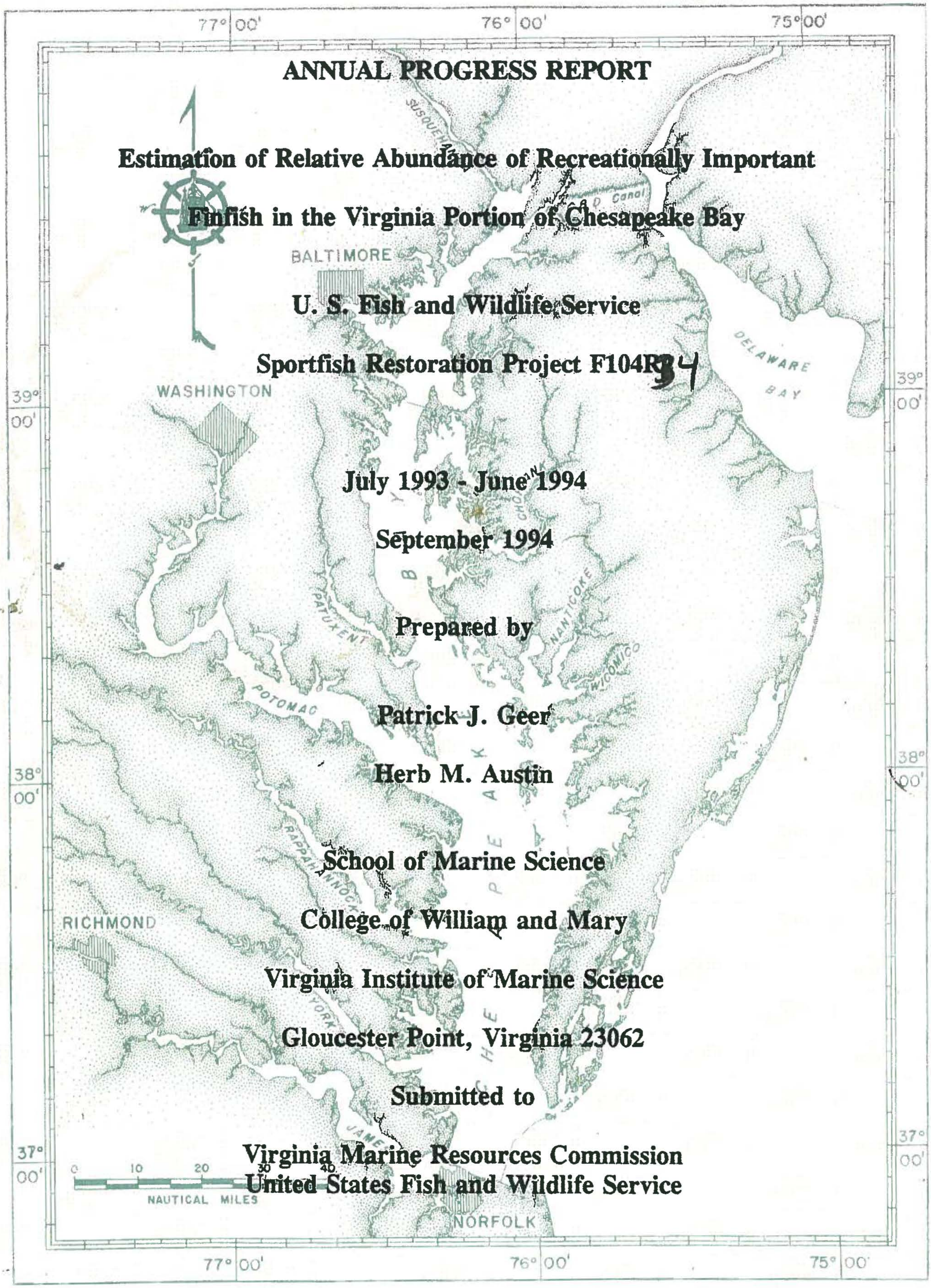

ANNUAL PROGRESS REPORT

Estimation of Relative Abundance of Recreationally Important Finfish in the Virginia Portion of Chesapeake Bay

U. S. Fish and Wildlife Service

Sportfish Restoration Project F104R34

July 1993 - June 1994

September 1994

Prepared by

Patrick J. Geer

Herb M. Austin

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

Submitted to

Virginia Marine Resources Commission
United States Fish and Wildlife Service

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SUMMARY

Project Objectives

1 & 2: Provisional annual indices of juvenile abundance have been generated from trawl survey data for six species of key recreational importance in the Virginia portion of Chesapeake Bay (spot, croaker, weakfish, summer flounder, black sea bass and striped bass) and two species of secondary importance (scup and white perch) for the period 1988-1993. No species has shown a continuous trend during the six year period. Spot has shown the largest decline from a high geometric mean catch per trawl of 68 (1988) to a low (1992) of 2, recovering to 9.7 in 1993. Atlantic croaker continued to decline reaching levels comparable to the survey low experienced in the early 1980's. The weakfish have remained relatively stable in recent years. Striped bass indices continued to recover reaching levels near equal to the very successful 1987 year class (1987: 3.6, 1993: 3.3) Both scup and y-o-y white perch showed substantial increase in 1993, while the age 1+ component of white perch reached a six year low. Of most concern is the recruitment failure of y-o-y summer flounder which continued to decline below levels seen in 1988 (1993: 0.5) Black sea bass decreased to near record lows for the 1992 year class (0.2). However, preliminary results for the 1993 year class indicate a moderate recovery to 1.0.

3: Analysis of vessel comparisons indicates little if any difference for the species of importance, with only marginal significance ($P < 0.1$) for other species of interest. Gear comparisons between different door types had little effect on the fishing power of the net in regards to the total catch. However, limited catches of y-o-y specimens warrants further sampling at times when juveniles are more abundant. Size selectivity does not seem to be a factor concerning the different door types. Comparisons have continued on historic gear configurations, providing a first preliminary glimpse at conversions to the present gear. Preliminary results between the present gear and that used prior to 1972 (30ft, unlined, no tickler chain), indicate some degree of size selectivity. Noticely absent from the unlined net were bay anchovies which comprised 85% of catches (in total numbers) for the lined gear. Extensive callibrations studies are continuing in the Fall of 1994, with this and other historical gears. When completed, the generated regression formulae will allow for estimates of juvenile abundance for the past forty years, regardless of gear type.

4: Analysis and summary of data continues to be routinely produced and available in the form of an annual data summary report. These summaries allow for detailed comparisons and contrasts of annual results with previous surveys. This annual series will continue, with efforts now underway to examine the earlier years of the survey in a similar fashion. To date, two such reports have been distributed (1986 and 1987), with a modified version for the years 1955 to 1970 presently being prepared.

Other VIMS data sets are being examined for inclusion into the historical trawl survey data base. These data will compliment existing data by filling gaps in the knowledge of specific regions and times (specifically the main-stem Chesapeake Bay).

INTRODUCTION

Measures of juvenile abundance are presently in wide use as a key element in the management of the Atlantic States' coastal fishery resources. Estimates of the relative interannual abundance of early juveniles (age-0) generated from scientific survey programs have been found to provide a reliable and early estimator of future year class strength (Goodyear 1985, Lipcius and Van Engel 1990). After a review of previously available indices of juvenile abundance for important fishery resource species in the Chesapeake Bay, the Chesapeake Bay Stock Assessment Committee (CBSAC), a federal/state committee sponsored and funded by the National Oceanic and Atmospheric Administration (NOAA), recommended that " a unified, consistent trawl program should be one of the primary monitoring tools for finfish and crab stock assessment." (Chesapeake Bay Program Stock Assessment Plan, Chesapeake Executive Council 1988). In order to facilitate the implementation of such a program, CBSAC directly supported pilot studies directed at developing a comprehensive trawl survey for Chesapeake Bay. In the Virginia portion of the bay the primary focus of this support was the initiation in 1988 of a monthly trawl survey of the main-stem portion of the lower Bay. This survey served to compliment and greatly expand the on-going state funded monthly trawl surveys of the major Virginia tributaries (James, York and Rappahannock rivers) which have been conducted by the Virginia Institute of Marine Science (VIMS) since 1955, as part of a long-term effort to monitor and assess the condition of fishery stocks in the lower Chesapeake Bay and its tributaries. The primary intent of the present project is to assure that this expanded, main stem Chesapeake Bay and tributaries, sampling effort be continued on a long-term basis as well.

The expanded sampling program is a particularly vital component to insure that data will be of sufficient geographic resolution for the generation of annual relative estimates of recruitment success of recreationally important finfish species of Chesapeake Bay. An analysis of the Virginia portion of the National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistics Survey (MRFSS) (VMRC 1985), showed Virginia marine recreational catches were dominated by six species (spot, croaker, weakfish, black sea bass, summer flounder, and bluefish) constituting over 85% of the total estimated catch by both numbers caught and weight landed. All of these species use the lower Chesapeake Bay and its tributaries as major nursery areas, with all but bluefish highly vulnerable to bottom trawls. In addition to the five key species cited above, past survey results indicate other species of recreational interest, including scup, white perch, striped bass, white and channel catfish, kingfish, and others, are taken with sufficient regularity during trawling operations as to provide data sets suitable for the generation of useful indices of juvenile abundance.

The project also seeks to facilitate the further development of a comprehensive trawl survey program through gear evaluations and comparison studies which will serve to unify current trawling efforts and maximize continuity with historical data sets. Although the primary focus of the project is the generation of annual indices of juvenile (young-of-year) abundance of recreationally and ecologically important marine and estuarine finfish, survey results can also be used to address other aspects of the population biology of these species, such as habitat utilization, early growth and survival, and climate and pollutant interactions.

The development of juvenile indices requires considerable continuous time series of data in order to determine the proper area-time sequences best used in index calculations. Since results from the expanded pilot survey span only six full years of data, the calculation of abundance indices possible at present can only be performed on a preliminary and tentative basis. In view of the fact that even very short term trends in juvenile abundance may be of importance for the five key species identified earlier, during the first project segment (Colvocoresses and Geer 1991), provisional annual juvenile abundance indices were calculated. In the fourth year of the expanded survey (second project segment), a provisional index was developed for a sixth species, scup (Colvocoresses et al. 1992). In last year's report (third project segment) indices were developed for two more species; striped bass and white perch. Both species are captured in significant numbers in the upper tributaries during colder months, with the white perch being taken across several year classes and striped bass across at least three. As a result, both y-o-y and age 1+ indices have been created for these species. Preliminary results for five additional species (white and channel catfish, silver perch, northern puffer, and tautog), will briefly be discussed, but currently these results are still considered developmental. Calculations of indices for other species will be deferred until a conceptual basis for their calculation can be generated.

The provisional nature of the reported values is emphasized by the fact that all of the abundance indices for the initial five species reported during previous segments have undergone minor modifications since their first publication.

The present report continues an attempt to relate the juvenile indices developed here with the longer time series based on the traditional tributary sampling. In some cases this appears to provide a historical context in which to place recent project results, while in others it only emphasizes the need for the expanded sampling program. Overall summaries for data collected in the 1988 main-stem bay sampling (Chittenden 1989) and for both the bay and river sampling in 1988 (Land et al. 1994), 1989 (Geer et al. 1990), 1990 to 1992 (Bonzek et al. 1991, 1992, 1993) and 1993 (Geer et al. 1994) have been previously prepared and distributed.

METHODS

Field Sampling

All collections were made with a lined 30' (9.14m) semi-balloon otter trawl (38.1mm stretched mesh, 6.35mm cod liner) and towed along the bottom for a period of five minutes during daylight hours at approximately 2.0 knots. No effort was made to consistently trawl with or against the tidal flow since wind was often a more important factor. However, tows were made parallel to isobaths at constant depth. Catches were sorted to species, enumerated and individual lengths recorded. Relevant hydrographic and atmospheric parameters were recorded with each collection, including depth, salinity, temperature and dissolved oxygen. Details of sampling protocols, gear specifications and specific collection information have been summarized in the reports for previous segments and the data report series cited above.

Sampling has been performed monthly using a random stratified sampling design in the main-stem bay and a fixed transect design in the tributaries. Exceptions include the winter months (January through March), when very few fish are present in the main-stem waters and only a single winter cruise in the main-stem bay has been conducted since 1991. Preliminary analysis of the six years of expanded data suggests no significant difference in important species during this period (Geer, unpublished). Stratification in the main-stem bay is based on depth and latitudinal zones (Fig . 1). Trawling sites within strata are selected randomly from the

National Ocean Service's Chesapeake Bay bathymetric grid, a data base containing depth records measured or calculated at 15 cartographic second intervals. Two to four trawling sites are randomly selected for each strata each month, the number chosen varying seasonally according to observed changes in distribution, with sampling intensity being highest in the most heavily utilized strata. The number of potential sites and approximate areas of each strata, which are subsequently used as weighing factors in the calculation of abundance indices, are given in Table 1. Latitudinal strata were slightly different, and overall coverage greater during the first year's (1988) sampling, but for the purpose of juvenile index calculation 1988 data were post-stratified into, and restricted to, those strata which have been continually sampled (1-12).

Sampling in the tributaries is conducted at fixed sites in the river channels spaced at approximately 5 mile intervals from the river mouths to approximately the fresh water interface in each system. These stations have been sampled on a monthly basis almost continuously since 1980 with the present sampling gear, and were previously used in monthly surveys using an unlined 30' trawl beginning in the mid-1950's (York R.) or early-1960's (James and Rappahannock) through 1972. During 1973-79 semi-annual random stratified sampling was performed by the Ichthyology Department while the Crustaceology Department continued the fixed tributary stations on a limited monthly basis, (May - November). This sampling effort has been supported by VIMS internal funds until budget cuts in mid 1980's. Since the data collected in the tributaries are highly relevant to juvenile abundance estimates they will be reported here as well. Areal weightings for the tributaries were assigned by dividing each river into two approximately equal length "strata" and assuming that the stations in each strata are representative of the channel areas in those reaches (Table 2). In general the channels were arbitrarily considered to be those areas greater than 12 ft. deep (Table 1). The exception was the lower Rappahannock, where the fixed stations were assigned only to depths greater than 30' feet. The lower Rappahannock is generally deeper than the other two tributaries and is hydrographically quite dissimilar. A shallow sill at the river's mouth greatly reduces deep circulation, which results in severe anoxic conditions in the lower reaches of this river during the warmer months. No sampling was performed in the tributaries in December 1987, or April of 1988.

It would be preferable that the main-stem and tributaries be monitored using the same sampling design, and the random stratified design offers numerous advantages over the fixed station design. Although a random stratified sampling scheme has been conceptually developed for the tributaries, before it can replace the fixed station surveys comparability of results must be established in order to assure continuity with the historical data set. To that end, during the first project segment, a pilot random stratified survey design in one of the Virginia tributaries (the York system, for logistical reasons) was initiated and is being conducted in a parallel manner with the fixed transect survey. Gear and sampling protocol are identical. The parallel survey was conducted throughout the second, third and fourth segments. The data collected during the first three years of parallel sampling (June 1991-May 1994) are presently being evaluated as to the need for further parallel sampling and as to whether the fixed-transect sampling can be incorporated into a stratified design. Preliminary analysis indicates a good correlation between the deep water strata of the random stratified design with those stations of the fixed transect (Bonzek, per. com.).

Gear Comparisons

Supplementary sampling and analysis were continued this segment on the various gears used throughout the history of the program. Analyses of the vessel changes were completed this segment. In August 1990 a new, dedicated trawling vessel, the R/V *Fish Hawk* was purchased and the former sampling platform, the R/V *Captain John Smith* was subsequently taken out of service. Side-by-side comparisons between the vessels were performed during the August 1990 tributary survey resulting in 21 paired tows for analysis.

Because the *Fish Hawk* is a much more compact vessel with limited deck space, it was decided that for safety reasons the large wooden trawl doors (54"x 24" otter boards) used previously should be replaced with smaller but more hydrodynamically efficient metal china-v doors. For continuity of the annual data base, this change was delayed until January 1991. A series of comparison tows between the different doors were performed during the first and second segments (April 1991 to June 1992). As with all gear calibrations studies, at each selected location, each gear was towed twice, once in an upstream and then a downstream direction, to negate any affects of tide and current. These four tows represented a set with a total of fifteen sets being completed during the two segments (60 tows). Differences in gear configuration during the April 1991 comparisons, (unrelated to the doors), forced the removal of the first 12 samples for purposes of analysis. This reduced the total number of samples to 48. Most comparison work was performed in the lower York River for both logistic reasons and the fact catches are typically clean of debris and usually provided a good representation of many key species. Unfortunately, results indicate relatively few juveniles of target species were captured during these original studies. Since few target species use the months of April to June for the temporal component of their indices, additional door comparisons have been planned for the Fall of 1994. The period from August to November seems better suited for such studies since most target species' juveniles are at or near peak abundances. An additional drawback is the lack of samples for two key species, striped bass and white perch. Further work will be necessary in areas and times of striped bass and white perch abundance if these gear changes indicate significant statistical differences for other key species.

Gear comparisons performed during the past segment include the historical gear used from 1955 to 1972. A similar 30' net without a tickler chain or liner was used during this period. To date there have been 50 paired tows between this gear and the present gear, during the summer, fall, and winter months. Efforts will continued with this gear since it comprises a bulk of the historical sampling (Table 3 and Figure 2). In particular, in regards to the various trawling durations (7.5 or 15 minutes depending on location). Other gears used during the history of the program are also being evaluated and are in various stages of completion.

All gear calibration studies were compared statistically using a paired t-test after ln(x + 1) transformation of individual catches. Differences between that of the older gear configuration to that now used were obtained and back transformed to the geometric mean difference.

Juvenile Index Computations

Measuring the abundance of migratory species (including key target species in this project) presents special difficulties, particularly if the timing and duration of migration is not constant from year to year. Juvenile fishes which use estuarine nursery areas are especially vulnerable to the vagaries of climate, as many rely upon climatically dependent wind driven and tidal circulation patterns for semi-passive transport into the estuaries as larvae and early juveniles, and later key their outward migration from the nursery areas on such annually variable environmental cues as temperature changes. Ideally the abundance of a juvenile finfish population should be measured at that point when it is most fully recruited to the nursery area being monitored. However, in practicality this can only be accomplished if the time of maximal abundance and size of recruitment to the gear can be predicted (and surveys timed accordingly), or surveys can be conducted on such an intense periodicity over the season of potential maximal abundance as to be certain of reasonable temporal coincidence. Neither of these two approaches is logistically possible. For each species the period of recruitable maximal abundance and the scope of the area being surveyed has proved to be variable between years. When this is coupled with the multi-species monitoring objectives, temporally intense surveys in the face of finite resources are precluded. As further knowledge of the interannual variability of recruitment patterns of the target species in Chesapeake Bay is accumulated, it may be possible to adjust survey timing in order to maximize the usefulness of the data collected. However, until a sufficient body of information is available upon which to base such decisions, the survey will have to be conducted on a regular periodicity and juvenile indices constructed as best possible from these data.

In the previous and present reports the following approach was used for juvenile index calculation. Trawl catches of target species were separated into young-of-year and older components by applying a cutoff value to the length frequency information collected with each catch. Cutoff values vary among months for each species and were based on modal analyses of historical composite monthly length frequency data and reviews of ageing studies for each species (Colvocoresses and Geer 1991). In the later part of the biological year, when early spawned, rapidly growing individuals of the most recent year class may overtake late spawned and slowly growing individuals of the previous year class, cutoff values are selected so as to preserve the correct numeric proportionality between year classes despite the misclassification of individuals (Table 4). The extent of the zone of overlapping lengths and the proportion within that range attributable to each year class is estimated based on the shapes of each modal curve during the months prior to overlap occurring. A length value is then selected from within that range which will result in the appropriate proportional separation. Although this process involves considerable subjectivity and ignores possible interannual variability in average growth rates, there is little likelihood that any significant error will be introduced, as only a very small fraction of the total number of young-of-the-year individuals fall within the zone of overlap and most of the data used to construct juvenile indices is drawn from months when no overlap at all is present.

After partitioning out non-young-of-the-year individuals, monthly catch rates of the target species are map-plotted and strata-specific abundances and occurrence rates calculated. Numbers of individuals caught are logrithmetically transformed ($\ln(n+1)$) prior to abundance calculations, as this transformation has repeatedly been shown to best normalize collection data for contagiously distributed organisms such as fishes (Taylor 1953) and has been verified as the best suited transformation for Chesapeake Bay trawl collections (Chittenden 1991). Resultant average catch rates (and the 95% confidence intervals as estimated by $\pm$ 2 standard errors) are then back-transformed to the geometric means. Plots and data matrices are then examined for the area-time combinations which appear to provide the best basis for juvenile index calculations. Criteria applied during the selection process include identification of maximal abundance levels, uniformity of distribution, minimization of overall variance and avoidance of periods which indicated distribution patterns suggesting migration was occurring. Although identification of areas most suitable for index calculations (primary nursery zones) is generally clear, selection of appropriate time windows has proven a more complex issue. Surveys are timed on regular period intervals which might or might not coincide with periods of maximal recruitment to the nursery areas. Using very limited portion of the overall data set would decrease sample sizes, increasing both confidence intervals, and the risk of sampling artifacts influencing results. As a result, the use of a single (maximal) month's survey results was deemed inappropriate. Conversely, a conscious effort is made not to incorporate any longer temporal series of data into index calculations than is necessary in order to capture the period of maximal juvenile utilization of the nursery area. It is believed indices calculated over longer time periods run the risk of confounding temporal persistence on the nursery area with maximal occupation levels. Using this approach it has been possible to identify three or four month periods which consistently capture the months of highest abundance for the species thus far examined (Table 4).

After area-time combinations are selected, annual juvenile indices are calculated as the weighted geometric mean catch per tow. Strata-specific means and variances are calculated and then combined, weighing by stratum areas according to the formulae supplied by Cochran (1977). The fixed tributary stations are post-stratified as mentioned earlier (Table 2). Since stratum areas are quite variable, use of a weighted mean will provide an index that more closely mirrors actual population sizes than will a simple mean.

RESULTS

Gear and Vessel Comparisons

Comparisons between vessels were only reported for the total catch in the previous segment (Geer et al. 1994). These catch data have now been analyzed extensively in regards to total catch, the index aged component, and length frequency information. These further analyses support earlier findings indicating minimal differences associated with the change in vessels. There were no significant differences for total catch of target species presented here (Table 5). However, there were minor differences in catch rates for several other species of related interest, as well as the index aged component of some species, summer flounder and silver perch for example (Table 6). Length data collected during these vessel comparisons were evaluated for homoscedasticity of variance. Results seemed conflicting for several abundant species. In cases where the number of length samples were high for both vessels, the test inevitably found the variances to be heterogeneous even though the means were quite similar. The large N's made the test overly sensitive, providing results that, although statistically valid, proved of little use in any decision making process. As a result a different approach was applied for abundant species where small samples (N = 50) were randomly selected from each data set. The analysis was performed on this small subset and the process repeated several thousand times. The results provided a percent of simulations where the variances were either homogeneous or heterogeneous (Louis Rugulo per. com.) These data show the percent of homogeneous variances to be no less than 50% for any target species.

These new results and large variability involved in such sampling, indicate little if any difference in lengths for key species due to the vessel change. For the y-o-y of target species where differences were found, relatively few samples (8 for summer flounder and 14 for silver perch) captured these species of a possible 42 samples collected. These limited collections make results for these -y-o-y target species inconclusive. The major effects of a vessel are the engine horsepower and propeller wash. Since these samples were collected in relatively deep water (< 10m), the latter is of little circumstance. There were no differences in tow distance between vessels (mean difference = 13.6 m), indicating engine horsepower also had little effect. Results for the total catch of a species (regardless of age) indicates no difference between vessels. The differences found for their juvenile component is probably a result of the variability involved with such sampling.

The results involving the different type trawl doors were reevaluated using similar methods as described above. At each location, the upriver and downriver samples for a gear were added prior to analysis. It was believed this would lower variability at a site but in turn also halved the number of samples. Unfortunately variability was not always lowered, and power was effected by the smaller sample size. Since the up and downriver tows are independent (beginning tow direction is randomly selected at each location and gear), future analyses should be performed without summing the two tows for each gear and location prior to calculations. Then comparisons between the methods can be made and results reported accordingly. This additive method seemed much more sensitive to that previously used in last year's segment, as significant differences in total catch rates were found for spot and Atlantic croaker, and for nearly all species of juvenile specimens (Tables 7 and 8). Although summer flounder were captured in all 24 paired samples(22 for y-o-y), most other y-o-y specimens were collected in less than half of all trawls. Atlantic croaker indicates a significant difference at the

0.01 level. However, the average length of these individuals was 177mm, indicating they are or near the process of laying down the first annuli. The period these samples were collected, April to May 1991, and June 1992, seems inappropriate for evaluating juvenile catch rates since many of the juvenile indices are generated from late summer and fall months when abundances are consistently high. In addition, most juveniles collected were relatively large (< 150mm), lengths associated with the end of the first year. Further sampling will be necessary in the fall months to better evaluate the fishing power effects on juvenile fishes.

Historical gear evaluations during this past segment include the 30' unlined net with 30' bridle and no tickler chain used between 1955 and 1972 (Table 3). Between October 1992 and September 1993, 80 samples were collected in the lower York River and Mobjack Bay. In February 1994, 20 samples were collected at upriver sites on the York River to evaluate the effects on such species as striped bass, white perch, gizzard shad, and catfish species. Analyses and sampling are still be conducted, but as would be expected, the unlined gear on average caught slightly larger fish than the lined gear. Noticeable absent form the unlined gear were anchovy species which were number one in abundance for the lined gear (Tables 9a and 9b). Work is continuing on these comparisons and further investigation might be necessary to examine different tow durations (15 and 7.5 minutes) used for the unlined gear, versus five minutes typically used for the present gear. Preparations are underway for a detailed summary of all comparisons in a VIMS scientific report which will be available in the near future.

Juvenile Index Calculations

Spot (*Leiostomus xanthurus*) - This has typically been the most abundant, widely, and consistently distributed of the recreational finfish species taken (Appendix Figs. 1 a-b). Young-of-the-year usually first recruit into the survey area during April, so for the purposes of year class index calculation this month was taken as the beginning of the biological year. Slight modifications were made during the second project segment (1991-1992) to the length-based cutoff values used to separate the nominal young-of-the-year and older fractions of the total catches. This results in index values that are slightly different from those reported in the first segment report. In addition, these data sets are constantly being scrutinized for accuracy, resulting in slight changes in values from segment to segment (usually as a result of increasing or decreasing the samples used in index calculations). For example, values for 1992 have been modified slightly for spot, as well as croaker, weakfish, and summer flounder due to a single observation in September. This observation was incorrectly coded as a fish collection, when in reality it was collected as part of the VIMS Crustaceology Departments routine sampling.

The 1993 y-o-y index recovered slightly from the extremely small catches in 1992, reaching levels similar to that of 1991 (Table 10). Monthly catch rates have shown a bimodal pattern of abundance three of the six years of the expanded survey. The remaining years, 1990, 1992, and 1993, have a single peak in September (Fig. 3). The period July through October captures both peaks during the three years when catch rates dipped during September as well as the unimodal peak seen in that month the remaining three years, and has therefore been chosen to this point as the temporal window for index calculation. Since during this period spot were strongly distributed throughout the survey area, all strata have been included in the calculations.

The weighted geometric mean catch per tow for juvenile spot has recovered slightly from the 15 year low experienced in 1992 (9.7 in 1993, 2.0 in 1992) (Table 10, Fig. 4), with the last three years of poor recruitment having discrete confidence intervals from the previous three years, as well as with 1992.

Atlantic Croaker (*Micropogonias undulatus*) - This species, like the spot, displays high levels of abundance in the trawl catches but presents much more complex patterns of recruitment and distribution. This species spawns on a much more protracted basis than the other species considered here and small early juveniles (<30mm) have been found to be present in the catches on a year around basis (Norcross 1983; Colvocoresses and Geer 1991; Colvocoresses et al. 1992; Geer et al. 1994). During the first three years of the expanded survey and throughout most of the earlier surveys, peak recruitment of early juveniles clearly took place during the fall months. For the purposes of separating size cohorts on an annual basis, September was chosen as the most appropriate month to designate as the first month of 'new' recruitment. The months of October through December were the three months of highest juvenile abundance during the first three years and the vast majority of juveniles captured were taken during this season. A completely anomalous pattern observed in 1991, when highest abundance occurred during June (Fig. 3). Length frequency data suggested these spring peaks were the result of returning individuals from the previous year class and not a new cohort of early juveniles. Recent ageing studies supports this theory, indicating these spring recruits are in the process of laying down an annulus and therefore should be considered age-1 individuals (Barbieri 1993). The 1993 data again shows similar high values of older juveniles for June and July. Interestingly, numbers of small juveniles were higher in January to March than for any index month. This follows a successful month of recruitment in December of 1992, possibly due to mild temperatures during the period.

After six years of the expanded survey, the recruitment patterns of croaker continue to show a large variability. In some years (1988 - 1990), the spatial component shows high utilization in the tributaries while 1991 and 1992 indicated a more even distribution between the tributaries and the main-stem bay with exception of November 1992. The 1993 data seems to support the tributary based index (Appendix Figs. 2 a & b). The protracted nature of Atlantic croaker will warrant additional investigation if such phenomena continue. Therefore, until further investigation reveals a clear understanding of the spatial and temporal utilization of age-0 individuals, the tributary strata and the months October through December will be maintained for index calculations.

The anomalous data notwithstanding, survey results clearly indicate a much stronger year class of croaker in 1989 than during the three years prior (1985 was a large year class) or four years following. The calculated index for 1989 (65, Table 10 and Fig. 4) was four to seven times that seen in other years, when results were similar and statistically indistinguishable.

Weakfish (*Cynoscion regalis*) - This species, while considerably less abundant than the other two sciaenid species discussed above, is still one of the dominant species of the trawl collections. Occasionally juveniles first occur as early as late June, the beginning of its biological year, but most recruitment takes place in July, August and September. As during the previous five years, July young-of-the-year weakfish were found primarily in the tributaries. However, by August and for the ensuing summer and fall months they had dispersed into the main-stem bay as well (Appendix Figs. 3 a & b). The three months of highest juvenile abundances were observed during the same three month period during all six years, August-October (Fig. 5). Index calculations were therefore based on data from all strata collected during these months.

The weakfish juvenile index for 1993 remained relatively stable compared to the 1992 year class (6.11 in 1993, 6.93 in 1992) . The 1988 and 1989 values were similar (9 and 12, respectively, Table 10 and Fig. 4) and had broadly overlapping confidence intervals, as did the two lower 1990 (5) and 1991 (4) values. These 1993 results show overlap with all years but 1989 of the expanded survey.

Summer Flounder (*Paralichthys dentatus*) - This species is generally a regularly occurring component of the trawl catches. Small juveniles may first appear as early as late March, which for the current purposes is used as the beginning of the biological year; but in most years are not taken in appreciable numbers until June (Appendix Figs. 4 a & b). As in the previous five years, young-of-the-year summer flounder abundance continued to increase steadily throughout the summer and early fall towards a late fall peak (November in this case) and then show clear evidence of emigration during December (Fig. 5). As was the case with weakfish, a single three month period, September to November, encompassed the months of greatest abundance for all years sampled but 1992, when August had slightly higher values than October. During this period juvenile flounder are broadly distributed across the main-stem bay and are commonly taken in the lower rivers, but only rarely appear in catches in the upper tributaries. Index calculations therefore include all bay strata and the lower river strata.

The 1993 juvenile index for summer flounder reached historical low values (0.530), declining significantly to values similar to those seen in 1988 (0.533). This 1993 value is significantly different from all years except 1988 (Table 9), suggesting a need for concern when compared to the historical tributary index (Fig. 4), and subsequent adult recruitment. These data were communicated to the Mid-Atlantic Fisheries Management Council (MAFMC) and VMRC in March 1994 (Austin 1994).

Black Sea Bass (*Centropristis striata*) - Like summer flounder, black sea bass are seldom taken in large numbers but still regularly occur in the catches. Small juveniles first appear in low numbers in August, which is used as the initial month for year class separation. When present, young-of-the-year sea bass occur throughout the bay strata but do not penetrate into most tributaries on a regular basis except the lower James River. This pattern held in 1993 (Appendix Figs. 5 a & b). Index calculations are based on all bay and the lower James strata. Choice of the appropriate time period for index calculation is less obvious though, as young-of-the-year black sea bass appear to use Chesapeake Bay as a nursery area in a more complicated manner. Although some early y-o-y appear in the bay during the summer and fall, a much larger number enter the estuary during the following spring (Fig. 6). During some years there is virtually no recruitment to the Chesapeake Bay by early juveniles spawned the same calendar year. Since abundances are higher and distribution much more consistent during the late spring and early summer of the following year, juvenile index calculations have been based on the months of May through July. This period normally encompasses the three months of highest abundance for all years except 1992. Mild winter (1992-1993) temperatures resulting in warmer spring waters allowed April abundances to be slightly higher than May 1993. However, the general window of maximal utilization was clearly the same. Since this index is calculated from the middle portion of the calendar year but the very end of the biological year, the resultant index is for the year class spawned the previous calendar year, i.e. the 1988 index is for the 1987 year class. It is conceivable that an earlier, fall based "pre-index" could also be generated, but because of the very low abundances and erratic distribution seen in the fall no confidence can be placed in such an index until a relationship can demonstrated with the much more statistically robust following summer index. Fall abundances were much lower in 1988 than 1989 with an intermediate value in 1990. The same pattern was seen for these year classes the following spring and summer, but several more years of data will be required to determine if a consistent relationship exists.

The annual juvenile indices for black sea bass have shown no pattern (Fig. 5) during the last few years, ranging from 0.2 (1992 year class) to 2.4 (1989 year class). Preliminary results from the 1994 sampling season(1993 year class) indicate an increase from the low experienced the previous year (1.04 for the 1993 year class, 0.2 in 1992) (Table 10).

Scup (*Stenotomus chrysops*) - The scup is a primarily marine, summer-spawning species and appears to use the Chesapeake Bay in much the same way as black sea bass; i.e. there is minimal usage of the estuary as a nursery area by early y-o-y but a very significant use by older juveniles during their second summer (age 1). Y-o-y scup (25-40mm FL) occasionally appear in the catches in June, but rapidly disappear after that if they appear at all. Older scup first appear in the catches in May, and by June there are clearly three distinct size classes present which can easily be assigned as the age-0, age-1 and age-2+ year classes based on previous ageing studies (Morse 1978). Since the age-0 component is annually variable and not persistent, and the largest size class is only taken in very small numbers, index calculations are performed on age-1 individuals. This component clearly remains present in the bay and available to the gear for the remainder of the summer and early fall. Thus, while the data collected are obviously not amenable to the construction of a true young-of-the-year juvenile index, it is suitable for assessing juvenile scup abundance as they enter their second year. Distributional data for 1993 (Appendix Figs. 6 a-b) supports previous findings that the early age-1 nursery area is largely restricted to the two lower main-stem segments although some large catches were associated with the upper bay. Catch rates for age-1 scup peaked in July during four of the six years sampled (1989-1991, 1993) and essentially showed a July-August dome during the other two years (1988 and 1992)(Fig. 6). With the exception of 1988, when age-1 scup were not taken until July, there were also sizable numbers of late juveniles taken during June and September. These months were therefore chosen as the temporal basis for the index calculation.

No trend is evident in the age-1 index to this point due in part to the short time series. The high value (4.9) recorded for the 1989 year class is marginally different from the 1990 year class index (1.9) with only slightly overlapping confidence intervals for the 1987 year class (Table 10, Fig. 7). The present year class of 1992 (3.36) recovered considerably from the low abundance experienced for the 1991 year class.

White Perch (*Morone americana*) - The semi-anadromous white perch is taken in large numbers but in different spatial and temporal frames than the species previously mentioned. Spawning occurs in the upper tributaries from March to July with a peak occurring from late

April to early May. A few early y-o-y first appear in the size range $\leq$ 35 mm in May, the initial month for year class separation. Previous segments of this program found several year classes are captured in high enough abundance for evaluation (Geer et al. 1994). Since white perch populations from various tributaries can exhibit significantly different growth rates (Bowen, 1987; Setzler-Hamilton, 1991), and those separations are not clear at this point, for purposes of this analysis all specimens were categorized as either age-0 or age-1+. Examination of distributional data (Appendix Figures 7 a-b, 8 a-b), reveals neither year class of white perch are found in the main-stem bay, with the highest abundances found in upper portions of each tributary. As a result, index calculations are confined to the upper stratum of each tributary. The month of peak abundance for age-1+ individuals ranged from December to February, with complimenting months of abundance from November to March (Figure 8). The temporal component of November to February for age 1+, and December to February for y-o-y is disturbed only by periodic abundance shown in March for age 1+ individuals, and November and March for y-o-y specimens. With the exception of December 1989, January has consistently had the highest catch rates for age 0 fish during this period. Since the index is calculated from the end of the biological year and across calendar years, values are for the previous year class, i.e. the 1989 and 1990 data form the 1989 index.

The juvenile indices for white perch have been on the decline in recent years but have recovered to above average values in 1993, 17.9 (Fig. 7, Table 10). The resulting confidence intervals are significantly different from all recent years except 1987, the last year of relatively high abundance.

The age-1+ indices have complimented that of the Y-O-Y indices. A peak in the 1987 and 1989 age-0 fish were slightly evident in the 1988 and 1990 age-1+ populations. Catch rates continued to decline reaching 15.0 in 1993 (Figure 7, Table 10). Although abundance is on the decline, values of age-1+ have typically been nearly ten times higher than the y-o-y counterparts. This pattern ended in 1993, with the juvenile index being greater than the age 1+ counterpart for the first time in recent history.

Striped Bass -(*Morone saxatilis*) - The striped bass, like the white perch, is an anadromous species using the upper tributaries for spawning and nursery grounds. Spawning in the Chesapeake Bay region takes place from early to mid-April through the end of May, primarily in tidal freshwater areas just above the salt intrusion. Young-of-the-year striped bass first appear in the samples in May in the size class less than 50 mm although index calculations are developed on older individuals (November). There appears to be a minor peak that occurs immediately following spawning from June to July consisting mainly of individuals less than 75mm. This small peak is quickly followed by a period of minimal catches which continues through November (Figure 9). The peak and following trough can possibly be due to the migration of the fish beyond the sampling area.

A second, stronger, and more consistent period of abundance occurs in December and continues through to February the following calendar year. This period is better fitted for abundance estimates because sampling is routinely performed further upriver during these months. For this reason, December to February has been chosen for the temporal period for y-o-y calculations. As in white perch, only the upper river strata were used in calculations, (Appendix Figures - 9 a-b).

The young of year index of striped bass had shown a downward trend from its historical high of 3.6 in 1987 to 1991, (1.0) increasing steadily the past two years to 3.3 in 1993 (Fig. 7). However, with the exception of the large 1987 and 1993 year classes, there appears to be no significant difference in the weighted geometric means from the lowest value in 1991, (1.02), to the highest in 1992. These overlapping confidence intervals seem larger than some of the other species examined, possibly due to the limited number of annual samples involved in calculations. The 1987 year class would seem an anomaly in the data. However, other measures of striped bass year class strength indicate and support 1987 to be one of the strongest on record, (Colvocoresses et al. 1993; Austin 1993).

Ancillary Species

There are several species which have been examined for inclusion in this report, each at varying levels of completeness, and so are still considered strictly provisional (Fig. 10). The white and the channel catfish, *Ictalurus catus* and *I. punctatus,* are typical of many of the upriver species captured in the trawls. Many more age 1+ specimens are captured than the y-o-y component (exceptions include 1989 for channel catfish). The temporal component is January to April for both species in the upper river strata. The survey typically catches both species from 30mm up to 500mm. The biology of these species would suggest the calculated age 1+ component to be comprised of several year classes.

The northern puffer *Sphoeroides maculatus*, is typically taken only in the main-stem bay, in relatively low numbers. The peak abundance is found in all reaches of the bay during the months of July to October, in the size ranges below 85, 120, 130, and 135mm respectively for each month. The species has experienced continued decline during most of the expanded survey, recovering slightly in 1993 (Fig. 10).

All strata are used for the spatial component of the silver perch, *Bairdiella chrysoura.* interestingly, the York River is where they are most prevalent. Individuals of length less than 160 mm for the months September to November are used in calculating the index. Values have been near constant for the expanded survey, but large catches on the York River in 1990 made the tributary index 5 times greater than the combined index. It appears this species was much more abundant during past surveys (VIMS historical Trawl Survey Database, Chris Bonzek per. com.). Preliminary examinations indicate some gears to be much more effective in capturing the species than others used throughout the survey. This has been substantiated with the recent calibration studies where the unlined net had higher catch rates than its lined counterpart.

Tautog, *Tautoga onitis*, is a highly prized recreational species caught by anglers near submerged structures. The species is an incidental catch on the survey, since trawling avoids the areas of known submerged obstructions. A limited number have been caught over the forty year survey (206), usually in association with a coral or sponge reefs. Although the numbers are extremely low, an index (all year classes) was created to provide the Atlantic States Marine Fisheries Commission (ASMFC) some type of fisheries independent data in Virginia for part of a tautog management plan. The data are obviously too scarce to draw any conclusions, however, it may provide some insight, and possibly support other states' data collections for the species. The strata information indicates the species was captured only 53 times over the course of the survey (1955-1993), but 16 of those appeared in the lower James River. There appears to be two distinct periods of abundance, April/May, and October/November. Although it goes against the premise of selecting a single period of peak abundance, both periods were used in the calculations. Results seem to show an approximate 10 year cycle, occurring in 1970, 1980, and again in 1990-91 (Fig. 10). Due to the extremely small amount of data involved in these calculations, these results can only be used to support other findings, and should by no means be used independently for management decisions.

The indices for these five species are in various stages of development. Values can be more concrete with literature searches on the spawning, reproduction, growth rates, and migrational patterns of silver perch and northern puffer. The catfish species should be confirmed with freshwater biologists, to insure that sampling is indeed capturing these species in comparable levels to that found further upriver. The survey quite possibly is on the fringe of the catfish preferred habitat, and thus the numbers shown here are not a true measure of availability. These species, as well as the eight mentioned throughout this text, indicate this forty year multi-species survey and the associated data base invaluable for the finfish species of Virginia.

DISCUSSION

Gear and Vessel Calibration Studies

Although the Virginia Institute of Marine Science has been conducting a trawl survey dating back to 1955, changes in both gear and sampling protocol limit the "usuable" data at this time to the years since 1979. A major portion of the collections from 1973-1978 involved semi-annual random stratified surveys. Although sampling was quite intense, it was generally concentrated within a short period, drastically effecting the ability to detect temporal changes.

In addition, a smaller size net was used for much of this period, making comparisons with the 30' nets difficult. This introduces serious doubts concerning its usefulness in the present abundance time series. Recently discovered data from the VIMS Crustaceology Department however revealed fish catches were routinely recorded during its monthly fixed station survey covering this same period. Unfortunately, quite often only total numbers of each species were recorded. Never-the-less, length frequencies have been generated based on known proportions from previous years (1955-1972) and similar gear types, as well as direct comparison with the semi-annual surveys conducted during that time (Chris Bonzek, personal com.). Y-O-Y cutoffs have been applied and juvenile indices generated using these reliable length frequency proportions. This has provided a contiguous 40-year data base for the fixed station transects of the major Virginia tributaries, with the only difference related to sampling gear. During the initial segment objectives were established to investigate these different gears and how they relate to the present gears and sampling protocol. However, the vessel replacement and subsequent door change force the postponement of historical gear comparisons in favor of those of a more immediate concern.

The results presented here indicate little if any difference between vessels relative to abundance, with any minor differences in lengths probably a result of high variability associated with such sampling. Although the sample size was small, (N = 21), the lack of any clear pattern provides confidence that the vessel change had little impact on survey results. The original 48 samples taken for door comparisons seem to have found little difference in total catch rates between the two gear types. The absence of large numbers of juveniles during this sampling period (April to June) have forced re-evaluation of these data to provide accurate results for y-o-y stocks. With this in mind, continued sampling has begun in the Fall of 1994, the period of peak juvenile abundance for many key species. Presently, comparisons are also being performed with similar sized gear used during the history of the program. A 30' net without a cod-end liner nor tickler chain (VIMS Gearcode 010)(Table 3) has been paired with the present gear in over 100 collections between October 1992 and the present. In recent months calibration studies with the gear used by the Crustaceology Department (unlined with tickler chain, VIMS Gearcode 043, Years 1973 - 1978) (Table 3), have begun. To date only eight pairs of tows have been conduct, not enough for any analysis at this point. Calibration studies will continue throughout the Fall of 1994 to evaluate most if not all the sampling gears historically used by the program.

Preliminary calibration results between two earlier gears and that now used seem quite promising. When significant differences were found in the paired t-test analyses, regressions were applied resulting in conversions to the gear presently used in sampling. For two representative species of interest, spot and summer flounder, significant differences between the present gear (VIMS Gearcode 108) and previous gears 010 (unlined, no tickler chain) and gear 070 (wooden otter board doors) provided the following regression formulae;

Y-O-Y Summer Flounder:

$$\mathrm{Ln}(\mathrm{Catch}_{108}) = \mathrm{Ln}(\mathrm{Catch}_{070}) * 0.819 + 0.645 \quad r^2 = 0.7545$$

$$\mathrm{Ln}(\mathrm{Catch}_{108}) = \mathrm{Ln}(\mathrm{Catch}_{010}) * 0.924 - 0.050 \quad r^2 = 0.8530$$

Y-O-Y Spot:

$$\mathrm{Ln}(\mathrm{Catch}_{108}) = \mathrm{Ln}(\mathrm{Catch}_{070}) * 0.411 + 0.269 \quad r^2 = 0.2151$$

$$\mathrm{Ln}(\mathrm{Catch}_{108}) = \mathrm{Ln}(\mathrm{Catch}_{010}) * 0.955 + 0.051 \quad r^2 = 0.9030$$

The small r^2 value for spot with the door comparisons adds support for additional sampling since juveniles were only captured in two thirds of the paired trawls, while summer flounder were captured in 22 of 24 pairs.

Although these conversions are extremely provisional, and will undoubtedly undergo changes with additional sampling, they allow for a first attempt at relating historic sampling to that now being performed. With the ultimate goal of these calibration studies to provide a continuous estimate of juvenile abundance for the entire 40 year history of the program, a first attempt was made at using these conversions on older data. Figure 11 shows this first attempt for y-o-y spot and summer flounder. Data used for these estimates were only the fixed mid-channel stations since they provided the most constant data set. The program can be separated into four major stanzas: (1) Gear 010 was used exclusively from 1955 to 1970, sharing sampling with a variety of gears, (including gear 043) in the early 1970's; (2) the intense semi-annual surveys of the 1970's are of little use until some method of relating them to monthly levels of abundance can be derived. Therefore gear 043 which was used exclusively at the fixed tributary stations will initially be used for this stanza; (3) From 1979 to 1991 the net was identical to that now used with the exception of the wooden otter boards versus the (4) china-v doors. No conversion is yet available for gear 043. These plots are just a first attempt at relating the various sampling gears to some common factor, and thusly should not be considered but for casual observations. However, with continued sampling and analysis, it is hoped most if not all of the forty year data set (over 20,000 trawls), will be available to provide a more accurate, precise, estimate of juvenile abundance.

Juvenile Indices

The annual juvenile abundance indices presented here should still be regarded as provisional. Six years of expanded data (main-stem bay and tributaries) have undoubtedly not captured all the interannual variability in nursery area utilization, as is clearly suggested in the croaker data set. A larger data set may well suggest different area-time combinations for juvenile index calculations than those used here. Likewise, it will take a considerably longer period of data collection in order to place the present results in a proper population trend context. It may be advantageous to develop a variable time/abundance window for certain species to capture fluctuations in period of abundance and spatial distributions. The historical VIMS tributary data do provide some basis for comparison, but comparison of these data to those reported here clearly shows that the degree to which this information will augment current survey results can be expected to significantly vary between species (Figs. 4 and 7). Agreement of the expanded and tributary-only time series for croaker, striped bass, and white perch are of course coherent since the same data set was used for both, but the agreement of the other four species ranges greatly.

In terms of general trends the tributary and complete data sets for spot produced similar results for the six years sampled, but it is evident that there is considerable interannual variability in the relative utilization of main-stem and tributary waters as nursery areas. During 1990 - 1993 the tributary and combined indices were essentially identical, indicating a very uniform distribution of juveniles (Fig. 4). But during 1989 abundances were clearly higher in the tributaries with 1988 having opposite results. Within this possible limitation, comparison of recent results to the longer time series suggests that the downward trend in spot juvenile recruitment in Chesapeake Bay over the past six years has spanned a range of values comparable to that seen over the past 15 years; i.e. 1988 was probably a year of very successful recruitment by these standards, but 1992 recruitment was at historic lows. This decline in recruitment is possibly caused by variations in wind direction and timing during spawning and larval transport (Bodolus 1994).

The initial 1989 year class of croaker was obviously much stronger than those immediately preceding or following it (at least on the Chesapeake Bay nursery grounds), and it also appeared to have been a strong year class on a historical basis based on the tributary results (Figure 4). A large segment-percentage of the juvenile croaker population may reside in the main-stem bay and considering its much larger area, warrant consideration in index calculations. The use of the bay as a nursery area for late age-0's also raises interesting questions as to alternative ways of calculating a juvenile index for croaker. Since abundances of 1990 year class individuals were higher during the summer of 1991 than during early recruitment in the fall of 1990, it is evident that the summer immigrants must have included (or even been entirely composed of) juveniles which had initially recruited to different nursery areas (possibly Delaware Bay, probably Pamlico Sound). Y-O-Y which recruit to one estuary as early juveniles out-migrate the following fall to over-winter elsewhere may return to a different estuary the next spring. This is supported by the fact the large 1989 year class showed little evidence of returning during 1990 sampling. This might warrant examining other temporal or spatial components in the future. Since the number of small juvenile croaker retained in the Chesapeake system is a factor of temperature (in warm years croaker remain in the system while in cold years migration or death occurs), it might be advantageous, from a management view point, to examine recruits the following spring just prior to entering the fishery. If this species continues to show inconsistent patterns, it may be necessary to explore other temporal and spatial components. Although, due to its extreme density-independent environment forced recruitment (Norcross 1983), it may not be possible to achieve a time-stationary recruitment window.

The lack of agreement between the tributary and combined indices for weakfish (Figure 4) clearly supports the need for the expanded sampling program. Juvenile weakfish densities are consistently several times higher in the tributaries than in the main-stem, but the degree of relative utilization can vary dramatically between years. Tributary catch rates peaked in 1990 when overall catch rates dropped, as there was a much lower utilization of the main-stem than during the prior two years. Since the combined index should be much more representative of actual population levels, there is little reason to believe that the tributary only series provides a meaningful measure of overall reproductive success in Chesapeake Bay. Further investigation is necessary, possibly with North Carolina trawl data of Pamlico Sound, to validate these findings.

Even though the present flounder and sea bass indices are primarily based on the main-stem data (where abundances are clearly higher), and there is little reason to believe that the tributary abundances will necessarily reflect overall abundances, for the six years sampled there is reasonably good coherence (Figure 4), particularly for summer flounder. These two species may occupy lower riverine nursery areas in a much more proportional manner to their overall abundance. If this proves to hold true the tributary data can provide a historical context for the upward trend in summer flounder seen from 1988 to 1991, and the ensuing demise in 1992 and 1993. Black sea bass recruitment to the Chesapeake nursery areas would appear to have been near a historical high as well for the 1989 year class and about average the other five years. The tributary based values of 1991 are a historical high, with the combined index simply near the median for the six years studied. This provides strength for the inclusion of the tributaries in an overall index, refuting previous results that questioned the usefulness of the rivers based on 1987 findings (Colvocoresses and Geer 1991).

The juvenile index of white perch has been on the decline in recent years but increased dramatically in 1993 (Fig. 7). Although the age 1+ specimens have remained at relatively constant levels in relation to the Y-O-Y counterparts, this can probably be due to the fact sampling is over several year classes. Piavis (1993) suggests a strong year-class is necessary only every several years (10 to 14) to support the Maryland fishery. Environmental factors effecting growth can vary from river to river resulting in different size distributions with age for each system. Future efforts might attempt to examine the length at age relationship for each system to determine if index calculation methods need to be modified. The absence of Y-O-Y indices for the years 1979 to 1983 can be explained by the fact that sampling during that period was routinely performed from May through November, and only up to mile 35 on each river. Presently the survey samples at the fringe of the juveniles habitat, with presumably higher concentrations located above river mile 40 and in the shallower waters of the tributaries. Increasing winter sampling further upriver or beyond the channels would vastly enhance the precision and accuracy of the estimates. Supporting these findings for the y-o-y data are the results from the VIMS summer seine survey, ($r=0.94$, $P < 0.0001$) (Geer et al. 1994; Mosca et al. in press)

The 1993 striped bass Y-O-Y index reached near historic highs in 1993, but has still not matched that of 1987. Unfortunately, since sampling was routinely performed only during the months of May to November, there are no supporting data for the 1979 to 1982 year classes (Fig. 7). Also of concern is the lack of data from December 1987. This month could have supported the contention that 1987 was the largest year class on record. Without it there might be questions to its validity. The VIMS beach seine survey supports 1987 as a very successful year class (Colvocoresses et al, 1993; Austin 1993). Correlation between the beach seine and trawl surveys is fairly good for the years 1983 to 1992 at the $P < 0.001$ level (Geer et al. 1994). Very large year class of both striped bass and white perch were observed on the summer seine survey (Austin et al. 1994) and continue to be highly correlated to data presented here. As mentioned previously, large confidence intervals for striped bass can possibly be attributed to the small number of trawls upon which the index is based, averaging 34 the past six years. As with white perch, extending the survey further upriver or beyond the channel depths during the winter months when these anadromous species are abundant, would probably aid in developing a more precise and accurate measure of abundance. In addition, replicate trawls could be performed at index stations to better provide information for a particular area of the tributary. Like many other species routinely found in the upper tributary, several year classes of striped bass are caught in large enough quantities for index consideration. Future efforts will be directed at producing indices for other year classes similar to that of age 1+ white perch.

The extreme rarity of scup in the tributary collections precludes a similar exercise for that species.

The juvenile indices presented here must be kept in a geographic context. This is evidenced by their absence during the winter months, as the first six species discussed here are highly migratory and only use the Bay nursery grounds during the summer months. Chesapeake Bay does constitutes a major nursery area for all of them (with the possible exception of black sea bass and scup) but is certainly only one of several along the Atlantic seaboard for these stocks. With the exception of weakfish and the anadromous species, all of the juveniles recruited to the Chesapeake Bay nursery areas are the result of spawning activities which take place outside of the Bay. Early juveniles of the three sciaenid species are thought to be estuarine dependent, but black sea bass young of year also utilize nearshore continental shelf waters (Musick and Mercer 1977) and juvenile summer flounder also frequent shallow, high salinity coastal lagoons (Wyanski 1989). Scup do not appear in the bay in appreciable numbers until they are a year old. Conceivably, Chesapeake Bay nursery zone abundances may well be reflective of overall reproductive success, but this will only be able to be verified through comparisons with recruitment in other nursery areas. Assessment of annual recruitment success for coastal Atlantic finfish populations as a whole will require multi-state monitoring efforts, as may complete validation of area-specific juvenile indices.

Efforts have continued to scrutinize historical data for its accuracy. One of the best methods found to evaluate these older data sets have been the data summary series. These summaries will continue as new data becomes available, and on older data as time and funding permits. Additional data base interests involve the examination of other VIMS data sets for inclusion into the trawl survey data base. Over the years, many programs have used similar gears and protocols as the trawl survey, (example, the Crustaceology Department 1973-1978). These data are examined and if deemed useful and accurate, incorporated into historical data sets. Presently, data is being examined from a summer flounder project (1986-1990). This program used identical gear and protocol as the trawl survey of the time, conducting monthly sampling transects across the bay mouth, the historic transect from the bay mouth to the York River, as well as sampling along the Eastern Shore, Virginia. This information will provide an additional two years of data for the main-stem bay (1986 and 1987) and compliment historical bay transects (1955 - 72).

A random stratified sampling approach, if coupled with knowledge of gear efficiencies and physical sampling frames, can be used to provide absolute population estimates as well as relative indices of abundance. Unfortunately, 40 years of sampling the same locations, (as it has been performed on the tributary survey) provides an excellent reference to historical fish stocks. If these fixed locations can be incorporated into a random stratified design, and still meet the assumptions of that design, then there will be a reference point to the past, with a sampling design to meet future research and management goals. Hopefully the pilot random survey being conducted in the York system will provide the basis for incorporating the fixed tributary stations into a random sampling design, but additional resources may have to be identified in order to establish the random stratified design in all three tributaries.

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Table 1. Numbers of potential trawl sites and approximate areas of sampling strata.

Area	Stratum	Name	No. of Points	Sq. Naut. Miles
Bottom Bay	ST01	Bottom WS, 12-30'	1740	112.33
	ST02	Bottom ES, 12-30'	863	55.72
	ST03	Bo. Plain, 30-42'	910	58.75
	ST04	Bottom Deep, >42'	386	24.92
			3899	251.72
Lower Bay	ST05	Lower WS, 12-30'	1027	66.30
	ST06	Lower ES, 12-30'	398	25.69
	ST07	Lo. Plain, 30-42'	1756	113.37
	ST08	Lower Deep, >42'	684	44.16
			3865	249.52
Upper Bay	ST09	Upper WS, 12-30'	768	49.58
	ST10	Upper ES, 12-30'	632	40.80
	ST11	Up. Plain, 30-42'	2197	141.84
	ST12	Upper Deep, >42'	844	54.49
			4441	286.71
James River	JA01	Lower James, >12'	687	44.35
	JA02	Upper James, >12'	364	23.50
			1051	67.85
York River	YK01	Lower York, >12'	372	24.02
	YK02	Upper York, >12'	184	11.88
			556	35.90
Rappahannock River	RA01	Lower Rapp., >30'	283	18.27
	RA02	Upper Rapp., >12'	190	12.26
			473	30.53

Table 2. Assignment of fixed tributary stations to potential random strata.

River	Lower	Upper
James	J01, J05, J13, J17	J24, J27, J35, J40
York	Y02, Y05, Y10, Y15	Y20, Y25, Y30, Y35, Y40
Rappahannock	R02, R10, R15, R20	R25, R30, R35, R40

Table 3. Summary of samples collected, 1955 - 1993.

KEY

System:	CL	Lower Chesapeake Bay (Virginia Portion)
	JA	James River
	MB	Mobjack Bay
	PO	Potomac River
	RA	Rappahannock River
	YK	York River
	OT includes:	Atlantic Ocean (AT) - 1971, 78-79
		Piankatank (PK) - 1970-71
Vessel:	BR	W.K. Brooks
	FH	Fish Hawk
	JS	Captain John Smith
	LA	Langley
	PA	Pathfinder
	RE	Restless
	VL	Virginia Lee
	OT includes:	Aquarius (AQ) - 1978
		Investigator (IN) - 1970
		Judith Ann (JA) - 1981
		Langley II (LN) - 1985
		Sally Jean (SJ) - 1981
		Outboard Skiff (SK) - 1970-71
		Three Daughters (TD) - 1978
Gear Code:	010	Unlined, no tickler chain, 30' bridle, 48"x22" otter board doors
	033	Lined, no tickler chain, 30' bridle, 48"x22" doors
	043	Unlined, tickler chain, 30' bridle, 54"x24" doors
30' Gears	068	Lined, tickler chain, 30' bridle, 54"x24" otter board doors
	070	Lined, tickler chain, 60' bridle, 54"x24" doors
	108	Lined, tickler chain, 60' bridle, metal china-v doors
	OT includes 3	configurations of 16 foot nets.
		Gearcode 035: Lined, no tickler chain. Main Gear used
		Gearcode 009: Unlined, no tickler chain. 19 samples in 1972.
		Gearcode 067: Lined, w/ tickler chain. 60 samples in 1982-83.

Tow Type: OT is tow duration in minutes for those not listed.
DIS is distance rather than duration. Always 0.25 nautical miles.

All Codes found on table are in Wojcik and Van Engel, 1988a and b. Appendices A - C.

Table 3. Sample Collection Summary of the VIMS Trawl Survey, 1955-1993.

Codes are on attached Key.

YEAR	TOTAL	MONTH												SYSTEM							VESSEL								GEAR CODE							STTYPE		TOW TYPE					
		1	2	3	4	5	6	7	8	9	10	11	12	CL	JA	MB	PO	RA	YK	OT	BR	FH	JS	LA	PA	RE	VL	OT	10	33	43	68	70	108	OT	F	R	5	7.5	10	15	OT	DIS
1955	31	0	3	1	3	1	5	14	1	3	0	0	0	6	0	0	0	0	25	0	0	0	0	0	0	0	31	0	31	0	0	0	0	0	0	31	0	0	12	0	17	2	0
1956	135	0	0	0	16	17	0	17	20	17	16	16	16	43	0	0	0	0	92	0	0	0	0	0	0	0	135	0	135	0	0	0	0	0	0	135	0	0	6	1	127	1	0
1957	142	12	16	16	0	12	0	5	16	17	16	16	16	47	0	0	0	0	95	0	0	0	0	0	86	0	56	0	142	0	0	0	0	0	0	142	0	0	44	0	98	0	0
1958	192	16	16	13	16	19	16	15	17	16	16	16	16	55	0	0	0	0	137	0	0	0	0	0	192	0	0	0	192	0	0	0	0	0	0	192	0	0	58	0	134	0	0
1959	117	0	0	0	14	3	16	19	16	16	16	17	0	32	0	0	0	0	85	0	0	0	0	0	117	0	0	0	117	0	0	0	0	0	0	117	0	0	34	0	83	0	0
1960	57	0	0	0	0	16	14	14	13	0	0	0	0	19	0	0	0	0	38	0	0	0	0	0	57	0	0	0	57	0	0	0	0	0	0	57	0	0	10	3	44	0	0
1961	81	6	0	0	4	10	12	8	8	7	8	10	8	15	0	0	0	0	66	0	0	0	0	0	81	0	0	0	81	0	0	0	0	0	0	81	0	0	26	0	55	0	0
1962	83	8	8	8	5	8	8	8	8	5	3	7	7	18	0	0	0	0	65	0	0	0	0	10	73	0	0	0	83	0	0	0	0	0	0	83	0	0	29	0	54	0	0
1963	98	6	8	9	9	7	7	9	9	9	9	9	7	19	0	0	0	0	79	0	0	0	0	23	75	0	0	0	98	0	0	0	0	0	0	98	0	0	37	0	61	0	0
1964	168	23	9	9	8	10	22	18	15	14	15	10	15	25	48	0	0	0	95	0	0	0	0	58	110	0	0	0	168	0	0	0	0	0	0	168	0	1	36	4	127	0	0
1965	188	22	13	17	14	14	14	14	19	14	15	11	21	1	71	0	0	23	93	0	0	0	0	43	145	0	0	0	188	0	0	0	0	0	0	188	0	0	38	1	144	5	0
1966	213	14	21	25	16	17	17	17	23	13	18	15	17	22	70	0	0	8	113	0	0	0	0	183	30	0	0	0	213	0	0	0	0	0	0	213	0	0	51	0	162	0	0
1967	259	14	17	32	17	17	24	23	23	23	23	23	23	23	68	0	18	43	107	0	0	0	0	8	251	0	0	0	259	0	0	0	0	0	0	259	0	0	58	3	192	6	0
1968	261	14	15	16	23	23	23	21	31	23	23	23	26	23	70	0	0	65	103	0	0	0	0	4	257	0	0	0	258	3	0	0	0	0	0	261	0	10	66	2	179	4	0
1969	286	23	23	24	24	24	24	24	24	24	24	24	24	23	72	0	0	83	108	0	0	0	0	0	286	0	0	0	286	0	0	0	0	0	0	286	0	1	86	4	189	6	0
1970	358	17	24	23	24	24	24	51	24	51	23	51	22	23	70	60	0	80	104	21	14	0	0	0	298	0	0	46	304	0	0	0	0	0	54	358	0	3	173	3	176	3	0
1971	772	51	18	51	47	61	63	103	82	74	74	74	74	24	80	126	0	96	417	29	154	0	0	42	334	234	0	8	348	0	24	0	0	0	400	540	232	408	172	1	189	2	0
1972	842	73	73	73	56	56	74	71	85	35	112	80	54	14	86	111	0	87	544	0	73	0	0	139	199	431	0	0	251	0	87	0	0	0	504	497	345	656	96	0	89	1	0
1973	863	54	53	11	56	80	202	91	83	105	105	23	0	88	67	45	0	80	583	0	126	0	0	64	240	433	0	0	0	122	171	0	0	0	570	296	567	743	0	119	0	1	0
1974	748	156	137	75	0	27	26	166	62	55	26	18	0	138	147	0	73	174	216	0	0	0	0	568	105	75	0	0	0	498	175	0	0	0	75	478	270	256	0	37	0	2	453
1975	787	194	128	16	0	18	18	349	18	18	10	18	0	162	148	0	60	194	223	0	174	0	0	453	160	0	0	0	0	535	118	0	0	0	134	118	669	463	0	0	0	2	322
1976	1141	184	141	23	40	40	40	525	40	40	36	32	0	174	340	0	60	318	249	0	210	0	6	491	262	172	0	0	0	426	308	0	0	0	407	308	833	816	0	0	0	0	325
1977	858	0	0	182	0	16	18	493	71	26	26	26	0	113	243	0	8	274	220	0	172	0	0	266	138	282	0	0	0	240	164	0	0	0	454	164	694	753	0	0	0	0	105
1978	1130	94	214	79	0	26	90	396	66	26	26	26	87	171	366	0	78	220	285	10	22	0	96	521	153	179	0	159	0	583	181	0	0	0	366	181	949	551	0	0	16	2	561
1979	813	282	70	124	0	36	42	49	46	37	44	44	39	60	270	0	63	159	260	1	0	0	43	371	336	63	0	0	2	461	0	287	0	0	63	288	525	488	0	0	0	2	323
1980	561	28	48	46	18	50	51	50	50	58	52	52	58	129	146	0	0	115	171	0	0	0	368	0	193	0	0	0	0	140	0	0	421	0	0	363	198	559	0	0	0	2	0
1981	489	43	33	53	17	51	47	52	25	39	42	38	49	52	148	0	18	97	174	0	0	0	341	0	17	0	0	131	1	0	0	0	488	0	0	296	193	483	0	0	0	6	0
1982	587	11	67	80	54	54	40	40	46	51	48	48	48	43	186	0	37	140	181	0	0	0	587	0	0	0	0	0	0	0	0	0	544	0	43	371	216	584	0	0	0	3	0
1983	482	32	54	14	15	40	39	39	38	38	65	50	58	0	162	0	19	118	183	0	0	0	482	0	0	0	0	0	0	0	0	0	465	0	17	367	115	478	0	0	0	4	0
1984	475	19	13	38	45	50	49	47	46	37	49	49	33	0	212	0	21	95	147	0	0	0	475	0	0	0	0	0	0	0	0	0	475	0	0	475	0	470	0	0	0	5	0
1985	310	36	26	26	26	35	12	38	39	27	45	0	0	0	111	0	17	67	115	0	0	0	273	0	0	0	0	37	0	0	0	0	310	0	0	310	0	308	0	0	0	2	0
1986	374	22	24	25	24	37	35	37	37	37	37	36	23	0	135	0	0	117	122	0	0	0	374	0	0	0	0	0	0	0	0	0	374	0	0	374	0	374	0	0	0	0	0
1987	334	23	24	23	24	36	37	33	34	32	34	34	0	0	108	0	0	108	118	0	0	0	334	0	0	0	0	0	0	0	0	0	334	0	0	334	0	334	0	0	0	0	0
1988	889	69	69	62	48	82	82	82	82	82	82	80	69	576	97	0	0	105	111	0	0	0	889	0	0	0	0	0	0	0	0	0	889	0	0	313	576	889	0	0	0	0	0
1989	840	61	61	61	66	76	76	76	76	76	76	76	59	479	108	0	0	124	129	0	0	0	840	0	0	0	0	0	0	0	0	0	840	0	0	361	479	840	0	0	0	0	0
1990	827	61	61	61	61	76	76	77	75	76	69	76	58	473	108	0	0	119	127	0	0	279	548	0	0	0	0	0	0	0	0	0	827	0	0	354	473	827	0	0	0	0	0
1991	768	61	25	61	61	73	73	72	70	73	73	73	53	411	108	0	0	120	129	0	0	768	0	0	0	0	0	0	0	0	0	0	0	768	0	357	411	767	0	0	0	1	0
1992	765	58	25	58	58	73	73	73	73	71	73	73	57	404	110	0	0	124	127	0	0	765	0	0	0	0	0	0	0	0	0	0	0	765	0	361	404	762	0	0	0	3	0
1993	735	25	58	25	56	73	73	73	73	73	73	73	60	370	110	0	0	126	129	0	0	735	0	0	0	0	0	0	0	0	0	0	0	735	0	365	370	735	0	0	0	0	0

Table 4. Spatial, temporal and length criteria used to calculate juvenile indices.

Species	Strata Included	Months Included
Spot	Bay 1-12, J1-2, Y1-2, R1-2	July-October
Atlantic Croaker	J1-2, Y1-2, R1-2	October-December
Weakfish	Bay 1-12, J1-2, Y1-2, R1-2	August-October
Summer Flounder	Bay 1-12, J1, Y1, R1	September-November
Black Sea Bass	Bay 1-12, J1	May-July
Scup	Bay 1-8	June-September
White Perch Age 1+	J2, Y2, R2	November-February (Year + 1)
White Perch Age 0	J2, Y2, R2	December-February (Year + 1)
Striped Bass	J2, Y2, R2	December-February (Year + 1)

Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Spot	≤200	≤200	≤200	≤75	≤100	≤135	≤160	≤180	≤200	≤200	≤200	≤200
Atlantic Croaker	≤100	≤100	≤100	≤110	≤135	≤160	≤180	≤220	≤50	≤80	≤100	≤100
Weakfish	≤200	≤200	≤200	≤225	≤240	≤90	≤120	≤150	≤180	≤200	≤200	≤200
Summer Flounder	≤290	≤290	≤60	≤100	≤140	≤170	≤200	≤225	≤250	≤275	≤290	≤290
Black Sea Bass	≤110	≤110	≤110	≤110	≤110	≤150	≤175	≤70	≤85	≤100	≤105	≤110
Scup	90-170	90-170	90-170	90-170	35-90	40-100	50-125	60-145	75-160	85-170	90-170	90-170
White Perch Age 1+	>85	>85	>85	>95	>35	>65	>73	>80	>85	>85	>85	>85
White Perch Age 0	≤85	≤85	≤85	≤95	≤35	≤65	≤73	≤80	≤85	≤85	≤85	≤85
Striped Bass	≤200	≤200	≤200	≤200	≤50	≤80	≤100	≤120	≤135	≤150	≤175	≤190

Table 5. Paired t-test statistics for total catch of important and abundant species for vessel comparisons between *R/V Captain John Smith* and *Fish Hawk.* Differences represent *Capt. J. Smith* values minus *Fish Hawk* values.

SPECIES	GEOMETRIC MEAN DIFFERENCE	95% C.I.'s (+/-)	t	PROBABILITY	SPECIES[1] OCCUR. (N)
Scup	0.13	0.21	1.30	0.2068	4
Black Sea Bass	0.02	0.22	0.19	0.8482	4
Summer Flounder	0.08	0.18	0.97	0.3439	9
Atlantic Croaker	0.39	0.50	1.64	0.1176	16
Weakfish	0.26	1.55	0.49	0.6305	34
Harvestfish	0.05	0.35	0.32	0.7511	26
Kingfish Sp.	0.10	0.41	0.95	0.3530	27
Striped Bass	0.07	0.10	1.45	0.1623	2
White Perch	0.01	0.14	0.18	0.8611	9
Spot	0.16	0.61	0.63	0.5349	35
White Catfish	-0.09	0.22	-0.89	0.3855	8
Channel Catfish	0.003	0.14	0.04	0.9683	6
Northern Puffer	-0.01	0.03	-1.00	0.3293	2
American Eel	-0.10	0.38	-0.66	0.5166	12
Atlantic Spadefish	-0.09	0.44	-0.52	0.6061	14
Bay Anchovy	1.98	1.00	3.15	0.0051	28
Hogchoker	-0.10	0.78	-0.37	0.7155	33
BlackcheekTonguefish	0.29	0.62	1.06	0.3016	18
Oyster Toadfish	0.27	0.38	1.49	0.1519	22
Silver Perch	0.62	0.63	1.96	0.0635	14

1: Species occurrence is the number of samples the species was present. Both vessels summed collected 42 samples, or 21 paired trawls when replicate tows were combined.

Table 6. Paired t-test statistics for index aged specimens of important and abundant species for vessel comparisons between *R/V Captain John Smith* and *Fish Hawk*. Differences represent *Capt. J. Smith* values minus *Fish Hawk* values.

SPECIES	GEOMETRIC MEAN DIFFERENCE	95% C.I.'s (+/-)	t	PROBABILITY	SPECIES[1] OCCUR. (N)
Scup	0.19	0.28	1.41	0.1742	3
Black Sea Bass	0.05	0.11	1.00	0.3293	1
Summer Flounder	0.18	0.17	2.06	0.0530	8
Atlantic Croaker	0.26	0.43	1.30	0.2067	16
Weakfish	0.32	1.64	0.57	0.5768	33
Harvestfish	0.05	0.35	0.32	0.7511	26
Kingfish Sp.	-0.32	0.57	-1.68	0.1087	21
Striped Bass	0.00	0.00	.	.	0
White Perch	0.00	0.00	.	.	0
Spot	0.11	0.58	0.46	0.6502	35
White Catfish	0.00	0.00	.	.	0
Channel Catfish	0.00	0.00	.	.	0
Northern Puffer	-0.01	0.03	1.00	0.3293	2
American Eel	0.00	0.00	.	.	0
Atlantic Spadefish	0.00	0.00	.	.	0
Bay Anchovy	1.57	1.00	2.73	0.0130	25
Hogchoker	0.40	0.67	1.32	0.2008	4
BlackcheekTonguefish	0.16	0.31	1.12	0.2778	8
Oyster Toadfish	0.00	0.00	.	.	0
Silver Perch	0.61	0.63	1.97	0.0634	14

[1] Species occurrence is the number of samples the species was present. Both vessels summed collected 42 samples, or 21 paired trawls when replicate tows were combined.

Table 7. Paired t-test statistics for total catch of important and abundant species for door comparisons, otter boards (VIMS Gearcode 070) and the metal china-v doors (VIMS Gearcode 108). Differences represent Gear 070 values minus Gear 108 values.

SPECIES	GEOMETRIC MEAN DIFFERENCE	95% C.I.'s (+/-)	t	PROBABILITY	SPECIES[1] OCCUR. (N)
Scup	0.00	0.00	.	.	0
Black Sea Bass	-0.17	0.25	-1.66	0.1112	10
Summer Flounder	-0.11	0.32	-0.79	0.4360	24
Atlantic Croaker	0.61	0.37	3.02	0.0061	13
Weakfish	0.24	0.38	1.35	0.1911	12
Striped Bass	0.00	0.00	.	.	0
White Perch	0.00	0.00	.	.	0
Spot	1.03	0.51	3.43	0.0023	19
White Catfish	0.00	0.00	.	.	0
Channel Catfish	0.00	0.00	.	.	0
Northern Puffer	0.08	0.34	0.52	0.6060	5
Bay Anchovy	2.38	0.94	3.69	0.0012	23
Hogchoker	-0.24	0.51	-1.30	0.2057	17
Oyster Toadfish	-0.10	0.35	-0.74	0.4685	12
Silver Perch	0.72	0.48	2.76	0.0111	10

1: Species occurrence is the number paired trawls the species was present. Both vessels summed collected 48 samples, or 24 paired trawls.

Table 8. Paired t-test statistics for index aged specimens of important and abundant species for door comparisons; otter boards (VIMS Gearcode 070) and the metal china-v doors (VIMS Gearcode 108). Differences represent Gear 070 values minus Gear 108 values.

SPECIES	GEOMETRIC MEAN DIFFERENCE	95% C.I.'s (+/-)	t	PROBABILITY	SPECIES[1] OCCUR. (N)
Scup	0.00	0.00	.	.	0
Black Sea Bass	-0.21	0.21	-2.48	0.0208	9
Summer Flounder	-0.24	0.28	-2.26	0.0339	22
Atlantic Croaker	0.72	0.46	2.87	0.0086	13
Weakfish	0.00	0.00	.	.	0
Striped Bass	0.00	0.00	.	.	0
White Perch	0.00	0.00	.	.	0
Spot	0.63	0.41	2.82	0.0097	16
White Catfish	0.00	0.00	.	.	0
Channel Catfish	0.00	0.00	.	.	0
Northern Puffer	0.02	0.25	0.16	0.8711	3
Bay Anchovy	2.37	0.94	3.68	0.0013	23
Hogchoker	-0.49	0.77	-2.37	0.0266	13
Oyster Toadfish	0.00	0.00	.	.	0
Silver Perch	0.63	0.43	2.72	0.0122	10

1: Species occurrence is the number paired trawls the species was present. Both vessels summed collected 48 samples, or 24 paired trawls.

Table 9a. Species composition summary for VIMS Gearcode 010. Collected duri
callibrations studies conducted with the present gear (VIMS Gearcode 108).

Gear - Unlined, no tickler chain, 30' bridle
GearCode - 010
Period - Oct 92, Jun-Sep 93, Feb 94
No. of Trawls Made - 50
No. of Species - 50

Species	Number of Fish	Percent Within River	Cumulative Percent	Catch Per Trawl	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)	Number Index A F
weakfish	3,848	25.5	25.5	76.96	128	1.3	38	352	3622
spot	3,377	22.4	47.8	67.54	134	0.8	71	235	3312
hogchoker	1,812	12.0	59.8	36.24	100	0.7	61	185	27
Atlantic croaker	1,608	10.6	70.5	32.16	174	1.1	22	298	394
bay anchovy	1,221	8.1	78.6	24.42	53	0.4	26	89	897
blackcheek tonguefish	520	3.4	82.0	10.40	132	0.5	38	161	1
silver perch	500	3.3	85.3	10.00	138	1.0	63	221	419
blue crab, juvenile female	438	2.9	88.2	8.76	45	1.1	13	117	.
summer flounder	362	2.4	90.6	7.24	214	2.1	152	418	324
blue crab, male	349	2.3	92.9	6.98	55	1.9	15	212	.
striped bass	238	1.6	94.5	4.76	117	2.3	30	418	233
oyster toadfish	232	1.5	96.0	4.64	221	4.4	55	352	.
white perch	147	1.0	97.0	2.94	148	4.4	63	246	20
harvestfish	65	0.4	97.4	1.30	79	1.2	48	100	65
squid	58	0.4	97.8	1.16	60	4.0	27	82	.
blue crab, adult female	55	0.4	98.2	1.10	137	1.9	102	171	.
southern kingfish	52	0.3	98.5	1.04	144	3.5	92	222	48
inshore lizardfish	42	0.3	98.8	0.84	216	6.4	117	320	.
gizzard shad	23	0.2	99.0	0.46	177	13.2	113	337	19
white shrimp	22	0.1	99.1	0.44	129	3.0	102	168	.
scup	17	0.1	99.2	0.34	157	5.7	116	191	10
northern puffer	14	0.1	99.3	0.28	141	16.2	75	266	6
Atlantic spadefish	13	0.1	99.4	0.26	78	2.4	59	91	.
kingfish sp.	11	0.1	99.5	0.22	84	9.0	37	135	11
striped anchovy	11	0.1	99.5	0.22	72	4.9	53	98	.
brown shrimp	10	0.1	99.6	0.20	128	4.3	116	158	.
black seabass	6	0.0	99.7	0.12	187	9.8	150	220	0
Atlantic thread herring	6	0.0	99.7	0.12	62	2.2	52	68	.
blue runner	6	0.0	99.7	0.12	124	4.1	107	135	.
blueback herring	5	0.0	99.8	0.10	71	2.0	65	77	5
lookdown	4	0.0	99.8	0.08	76	8.5	63	100	.
butterfish	3	0.0	99.8	0.06	115	21.4	75	148	2
Spanish mackerel	3	0.0	99.8	0.06	130	39.5	53	183	.
striped searobin	3	0.0	99.9	0.06	66	12.1	42	81	.
conger eel	3	0.0	99.9	0.06	463	23.1	437	509	.
black drum	2	0.0	99.9	0.04	219	7.0	212	226	.
white catfish	2	0.0	99.9	0.04	177	107.0	70	284	1
spotted seatrout	2	0.0	99.9	0.04	222	28.5	193	250	.
feather blenny	2	0.0	99.9	0.04	65	16.5	48	81	.
pigfish	1	0.0	99.9	0.02	185	.	185	185	.
American eel	1	0.0	99.9	0.02	734	.	734	734	.
windowpane	1	0.0	99.9	0.02	282	.	282	282	.
spotted hake	1	0.0	100.0	0.02	171	.	171	171	1
green goby	1	0.0	100.0	0.02	35	.	35	35	.
naked goby	1	0.0	100.0	0.02	93	.	93	93	.
Atlantic silverside	1	0.0	100.0	0.02	88	.	88	88	1
skilletfish	1	0.0	100.0	0.02	52	.	52	52	.
Atlantic stingray	1	0.0	100.0	0.02	473	.	473	473	.
fringed flounder	1	0.0	100.0	0.02	143	.	143	143	.
spotfin mojarra	1	0.0	100.0	0.02	94	.	94	94	.
All Species Combined	15,103								

able 9b. Species composition summary for VIMS Gearcode 108. Collected during callibrations studies conducted with the historic gear (VIMS Gearcode 010).

ear - Lined,tickler chain,60ft bridle w/ china-v doors
earCode - 108
riod - Oct 92, Jun-Sep 93, Feb 94
o. of Trawls Made - 50
o. of Species - 54

ecies	Number of Fish	Percent Within River	Cumulative Percent	Catch Per Trawl	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)	Number of Index Aged Fish
y anchovy	72,304	84.7	84.7	1446.08	50	0.2	24	83	51477
eakfish	2,960	3.5	88.1	59.20	121	1.4	28	355	2678
ot	2,899	3.4	91.5	57.98	131	0.8	61	230	2855
lantic croaker	2,084	2.4	94.0	41.68	120	2.0	12	261	947
gchoker	1,510	1.8	95.7	30.20	102	0.8	37	186	44
ue crab, juvenile female	729	0.9	96.6	14.58	44	1.0	5	119	.
ue crab, male	649	0.8	97.3	12.98	46	1.3	12	164	.
ackcheek tonguefish	417	0.5	97.8	8.34	131	0.5	68	171	5
iped bass	334	0.4	98.2	6.68	114	1.9	67	392	328
ite perch	276	0.3	98.5	5.52	122	3.3	63	270	112
ver perch	262	0.3	98.9	5.24	140	1.6	49	208	201
ster toadfish	139	0.2	99.0	2.78	210	5.4	55	339	.
mmer flounder	131	0.2	99.2	2.62	236	6.6	162	505	103
ngfish sp.	109	0.1	99.3	2.18	78	2.3	28	194	108
rvestfish	93	0.1	99.4	1.86	79	0.9	60	107	93
iped anchovy	78	0.1	99.5	1.56	80	1.9	50	117	.
ue crab, adult female	66	0.1	99.6	1.32	132	1.9	104	172	.
uthern kingfish	53	0.1	99.6	1.06	129	3.0	79	175	53
shore lizardfish	49	0.1	99.7	0.98	186	6.6	89	293	.
zzard shad	44	0.1	99.7	0.88	180	10.8	97	364	34
uid	28	0.0	99.8	0.56	42	3.1	24	78	.
rthern puffer	22	0.0	99.8	0.44	101	9.0	48	218	16
lantic spadefish	20	0.0	99.8	0.40	85	2.8	63	115	.
ite shrimp	17	0.0	99.8	0.34	132	3.6	110	158	.
e runner	16	0.0	99.9	0.32	121	2.2	104	138	.
eback herring	14	0.0	99.9	0.28	66	1.3	58	73	14
tterfish	11	0.0	99.9	0.22	90	10.1	28	146	9
lantic thread herring	9	0.0	99.9	0.18	55	4.9	46	93	.
up	8	0.0	99.9	0.16	136	4.8	118	157	8
ugh silverside	8	0.0	99.9	0.16	87	2.8	74	97	.
ked goby	7	0.0	99.9	0.14	40	5.1	32	70	.
own shrimp	7	0.0	99.9	0.14	140	7.3	115	176	.
iped searobin	5	0.0	99.9	0.10	110	27.1	47	194	.
a lamprey	5	0.0	100.0	0.10	170	5.7	158	187	.
rthern pipefish	4	0.0	100.0	0.08	111	20.5	85	172	.
lantic silverside	4	0.0	100.0	0.08	85	5.3	73	94	4
nger eel	4	0.0	100.0	0.08	435	6.5	423	452	.
lantic cutlassfish	4	0.0	100.0	0.08	294	17.5	260	325	.
ck seabass	3	0.0	100.0	0.06	171	19.4	132	192	0
anish mackerel	3	0.0	100.0	0.06	115	38.6	38	158	.
fish	3	0.0	100.0	0.06	183	8.5	166	193	.
kdown	3	0.0	100.0	0.06	89	9.1	72	103	.
rthern stargazer	2	0.0	100.0	0.04	52	24.0	28	76	.
efish	1	0.0	100.0	0.02	50	.	50	50	.
lantic menhaden	1	0.0	100.0	0.02	122	.	122	122	1
otted seatrout	1	0.0	100.0	0.02	231	.	231	231	.
nerican eel	1	0.0	100.0	0.02	322	.	322	322	.
ndowpane	1	0.0	100.0	0.02	282	.	282	282	.
otted hake	1	0.0	100.0	0.02	168	.	168	168	1
rthern searobin	1	0.0	100.0	0.02	48	.	48	48	1
mmichog	1	0.0	100.0	0.02	86	.	86	86	.
iped killifish	1	0.0	100.0	0.02	128	.	128	128	.
lantic stingray	1	0.0	100.0	0.02	267	.	267	267	.
y snapper	1	0.0	100.0	0.02	86	.	86	86	.
Species Combined	85,404								

Table 10. Juvenile abundance indices for key recreational species. '*' indicates a revision from last segment.

Species	Year Class	Weighted Geo. Mean CPUE	95% C. I.	N
Spot	1988	67.5	47.0 - 96.7	231
	1989	32.3	25.4 - 41.0	252
	1990	44.6	32.4 - 61.2	248
	1991	16.6	12.6 - 21.7	238
	1992	1.96	1.49 - 2.52	238*
	1993	9.74	7.26 - 13.0	240
Atlantic Croaker	1988	9.0	6.0 - 13.4	65
	1989	64.8	37.9 -110.2	65
	1990	13.1	8.9 - 19.2	60
	1991	9.6	5.9 - 15.3	63
	1992	14.6	8.30 - 25.1	67*
	1993	5.42	3.73 - 7.72	69
Weakfish	1988	8.9	5.9 - 13.1	173
	1989	12.2	8.6 - 17.2	189
	1990	4.8	3.3 - 6.6	184
	1991	3.6	2.6 - 4.7	179
	1992	6.93	4.90 - 9.66	178*
	1993	6.12	4.33 - 8.51	180

cont.

Table 10. (cont.).

Species	Year Class	Weighted Geo. Mean CPUE	95% C. I.	N
Summer Flounder	1988	0.53	0.35 - 0.74	143
	1989	1.22	0.93 - 1.56	162
	1990	2.54	2.07 - 3.09	162
	1991	2.78	2.26 - 3.38	153
	1992	0.91	0.70 - 1.15	153*
	1993	0.53	0.39 - 0.69	153
Black Sea Bass	1987	1.57	1.07 - 2.19	124
	1988	0.83	0.58 - 1.12	138
	1989	2.36	1.70 - 3.17	138
	1990	1.12	0.78 - 1.52	128
	1991	1.29	0.91 - 1.74	129
	1992	0.22	0.14 - 0.32	129
	1993	1.04	0.73 - 1.40	129
Scup	1987	2.07	1.24 - 3.21	92
	1988	3.06	2.05 - 4.41	112
	1989	4.86	3.07 - 7.42	112
	1990	1.90	1.11 - 2.99	103
	1991	0.65	0.41 - 0.93	104
	1992	3.36	2.16 - 5.01	104

cont.

Table 10. (cont.).

Species	Year Class	Weighted Geo. Mean CPUE	95% C. I.	N
White Perch Age 1+	1987	21.9	12.6 - 37.5	36
	1988	35.1	21.6 - 56.7	46
	1989	25.9	15.4 - 43.0	46
	1990	32.0	20.1 - 50.4	45
	1991	29.5	20.4 - 42.5	44
	1992	15.8	9.55 - 25.7	48
	1993	15.0	9.79 - 22.8	50
White Perch Age 0	1987	42.1	25.1 - 70.4	20
	1988	5.29	2.31 - 10.9	35
	1989	13.3	7.23 - 14.9	37
	1990	3.31	1.56 - 6.26	36
	1991	2.30	0.93 - 4.67	36
	1992	1.21	0.48 - 2.31	39
	1993	17.9	11.9 - 26.7	41
Striped Bass	1987	3.62	1.88 - 6.44	20
	1988	1.93	0.96 - 3.36	35
	1989	1.59	0.81 - 2.70	37
	1990	1.14	0.50 - 2.06	36
	1991	1.02	0.52 - 1.68	36
	1992	2.15	1.30 - 3.32	39
	1993	3.30	1.93 - 5.31	41

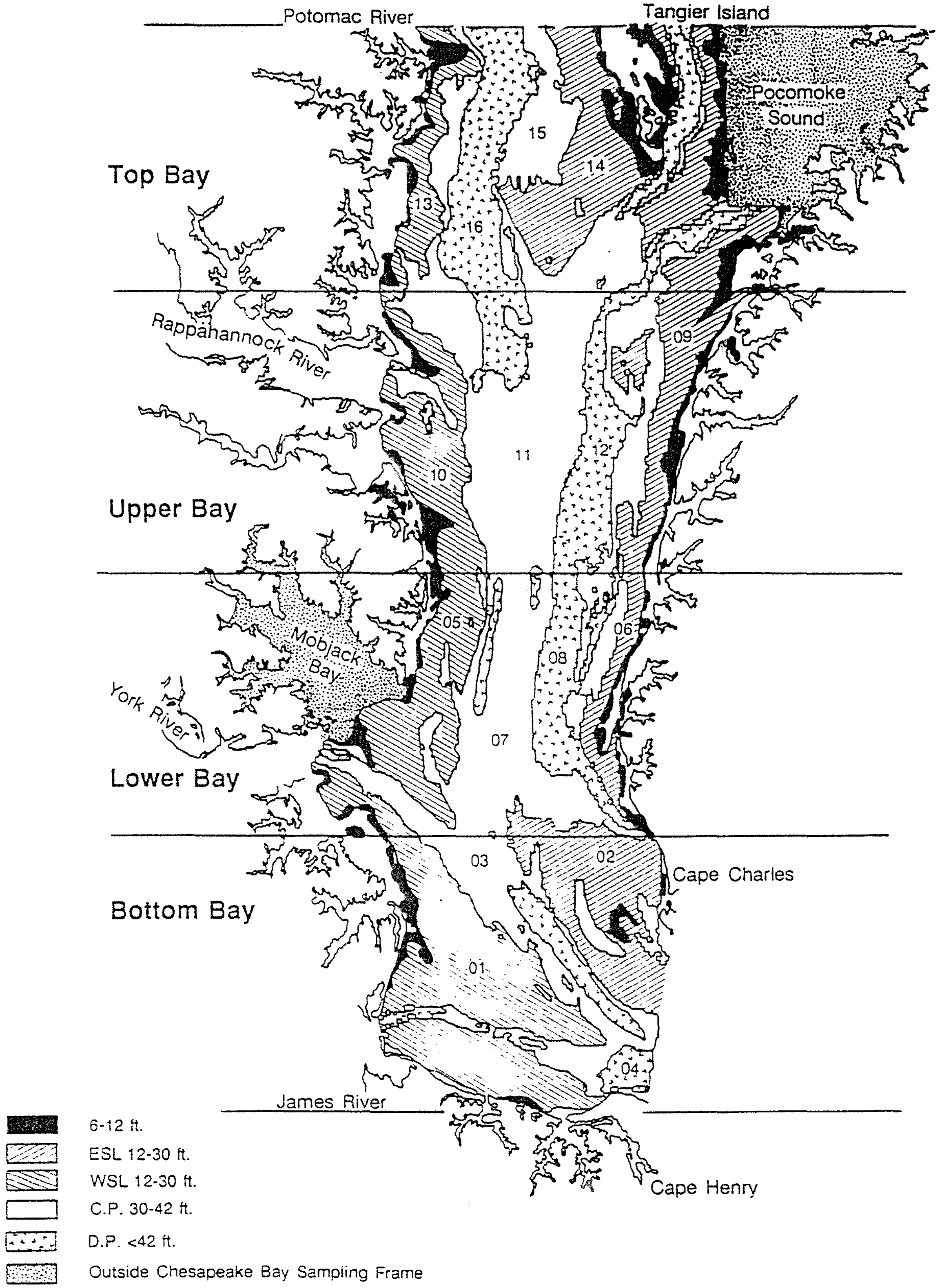


Figure 1. Chesapeake Bay trawl survey strata.

Figure 2. Sampling Changes of the VIMS Trawl Survey, 1955 - 1994. See Table 3 key for full description of gears.

Figure 2.

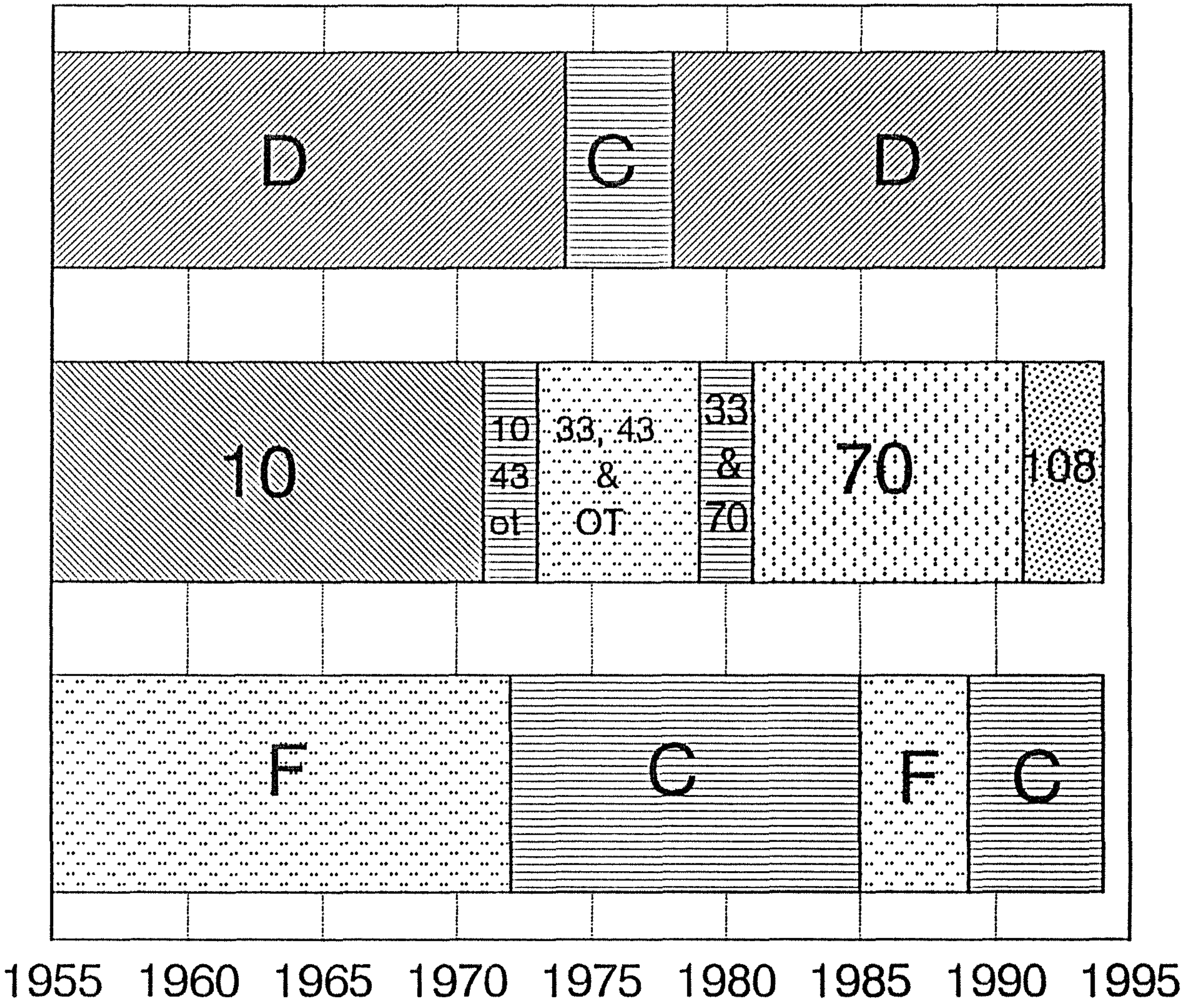
VIMS Juvenile Fish Trawl Survey

Sampling Changes 1955 - 1994

Tow Type
D = Duration
C = Duration and/or Distance

Gear Type
10 = Unlined/No Tickler
33 = Lined/No Tickler
43 = Unlined/Tickler
OT = 16' Nets
70 = Lined/Tickler
108 = Lined/Tickler/China-V

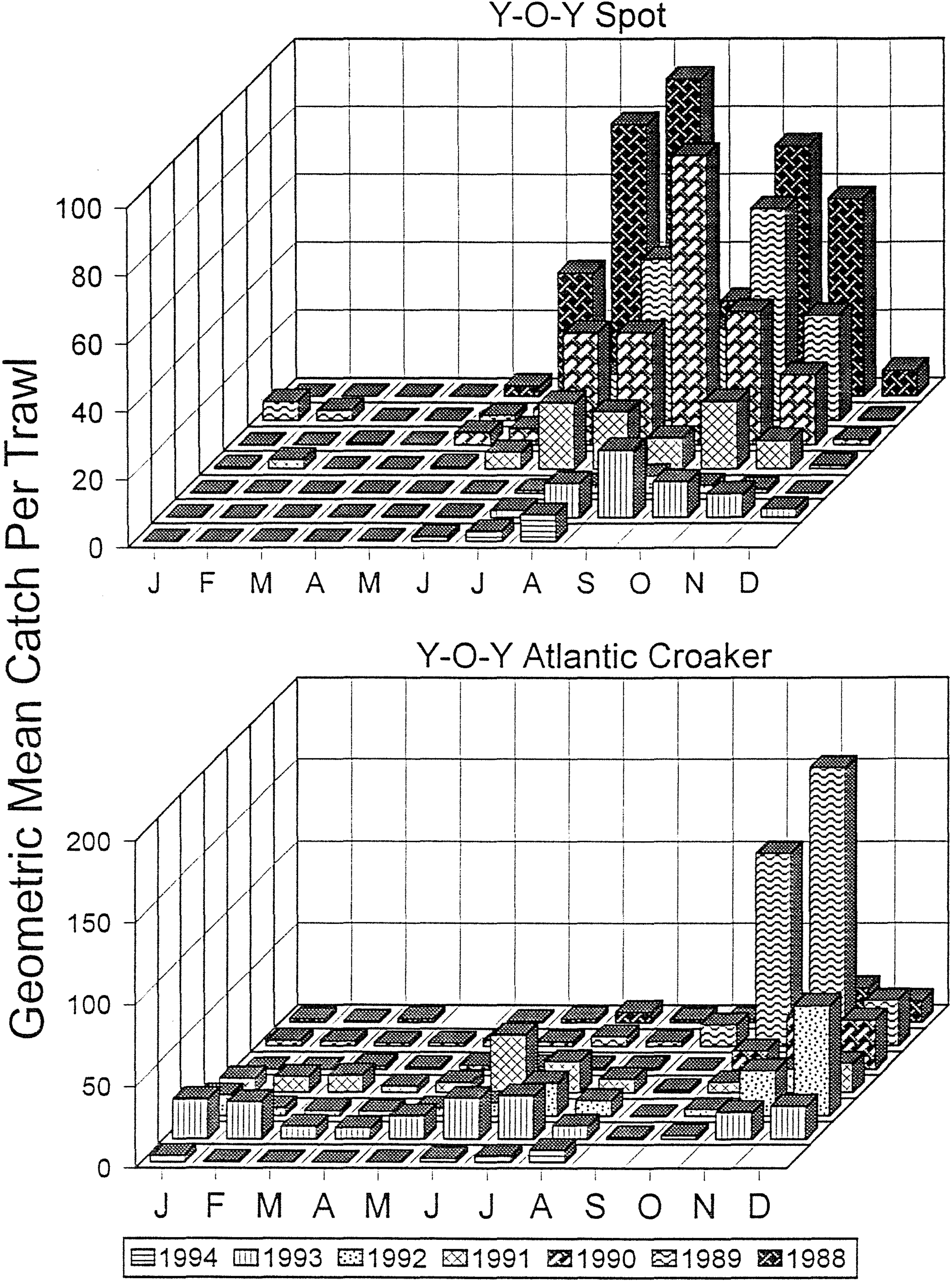
Sampling System
F = Fixed
R = Random
C = Combination



Gear Type is 30 foot otter trawl if not specified.

Figure 3. Geometric mean catch per tow of spot and Atlantic croaker by month on the primary nursery grounds.

Figure 3.



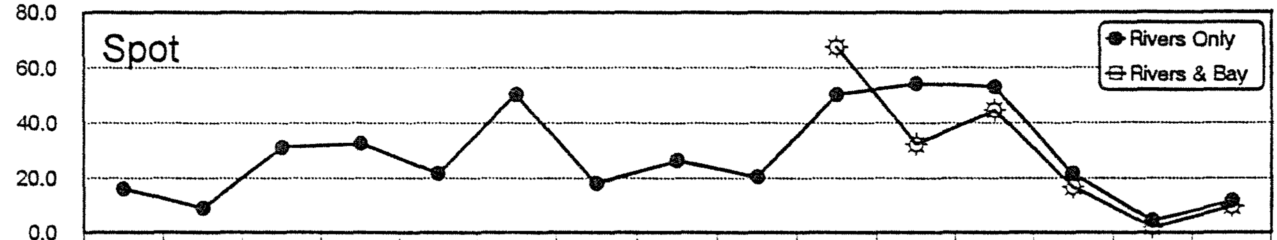
Y-O-Y Spot

Y-O-Y Atlantic Croaker

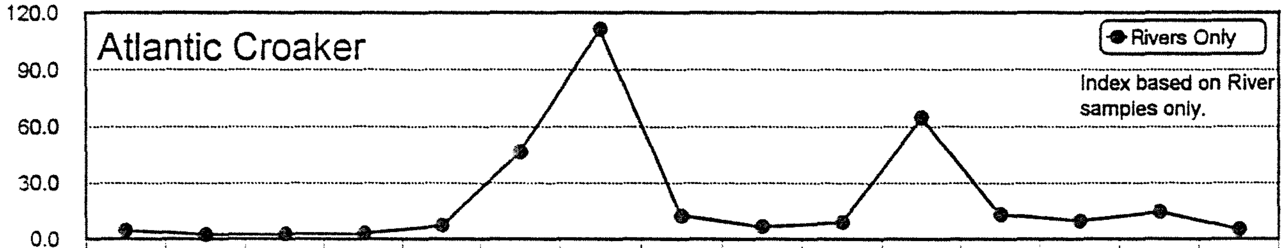
Figure 4. Annual juvenile abundance indices for spot, Atlantic croaker, weakfish, summer flounder, and black sea bass. Indices are calculated for the expanded survey (1988-1994) as well as the historic tributary data (1979-1987).

Figure 4.

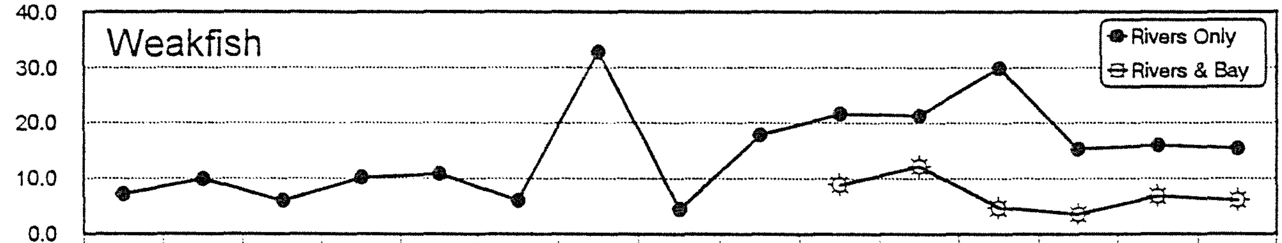
Juvenile Finfish Stock Assessment



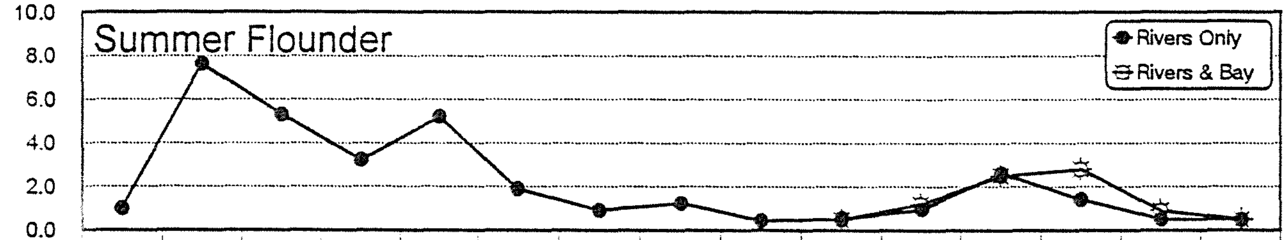
	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only	16.0	8.9	31.1	32.5	21.5	50.3	18.1	26.3	20.4	50.2	54.2	53.0	21.4	4.4	11.8
Rivers & Bay										67.5	32.3	44.6	16.6	2.0	9.7



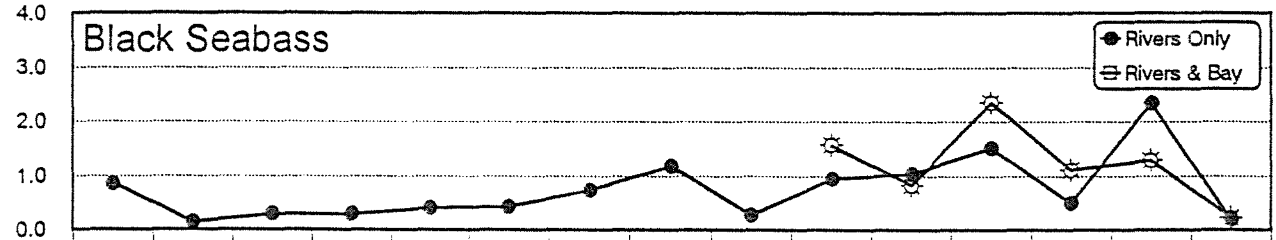
	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only	4.7	2.5	2.9	3.2	7.3	46.4	111.6	12.6	6.5	9.0	64.8	13.1	9.6	14.6	5.4



	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only	7.2	9.9	6.0	10.1	10.8	6.1	32.9	4.6	17.8	21.7	21.3	30.0	15.3	15.9	15.4
Rivers & Bay										8.9	12.2	4.8	3.6	6.9	6.1



	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only	1.0	7.6	5.3	3.2	5.2	1.9	0.9	1.2	0.5	0.5	1.0	2.6	1.4	0.5	0.5
Rivers & Bay										0.5	1.2	2.5	2.8	0.9	0.5



	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
Rivers Only	0.9	0.1	0.3	0.3	0.4	0.4	0.7	1.2	0.3	1.0	1.0	1.5	0.5	2.4	0.2
Rivers & Bay										1.6	0.8	2.4	1.1	1.3	0.2

Figure 5. Geometric mean catch per tow of weakfish and summer flounder by month on the primary nursery grounds.

Figure 5.

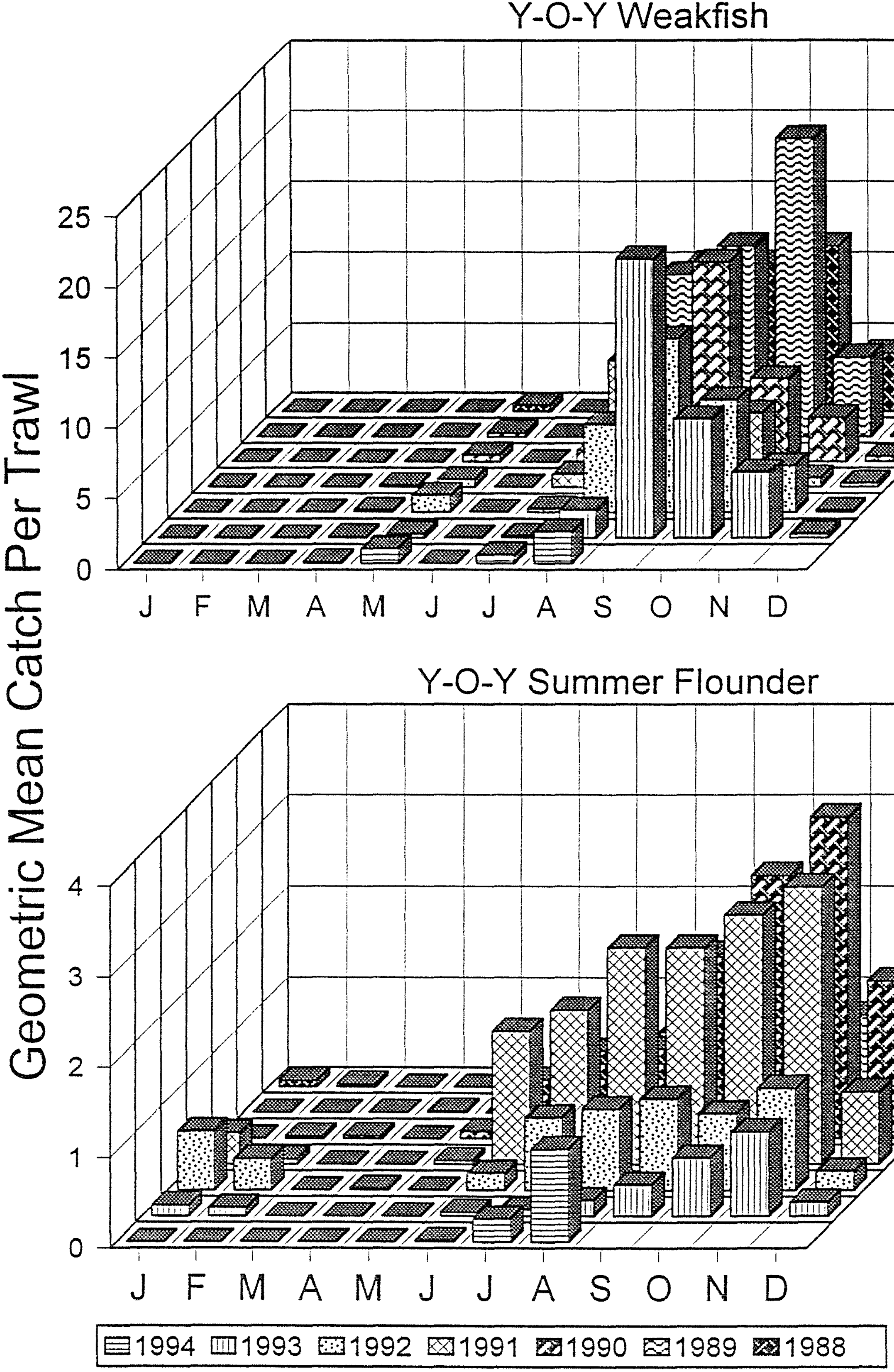

Y-O-Y Weakfish
Geometric Mean Catch Per Trawl
0
5
10
15
20
25
J
F
M
A
M
J
J
A
S
O
N
D
Y-O-Y Summer Flounder
0
1
2
3
4
J
F
M
A
M
J
J
A
S
O
N
D
▤1994 ▥1993 ▩1992 ▦1991 ▨1990 ▧1989 ▩1988

Figure 6. Geometric mean catch per tow of black sea bass and scup by month on the primary nursery grounds.

Figure 6.

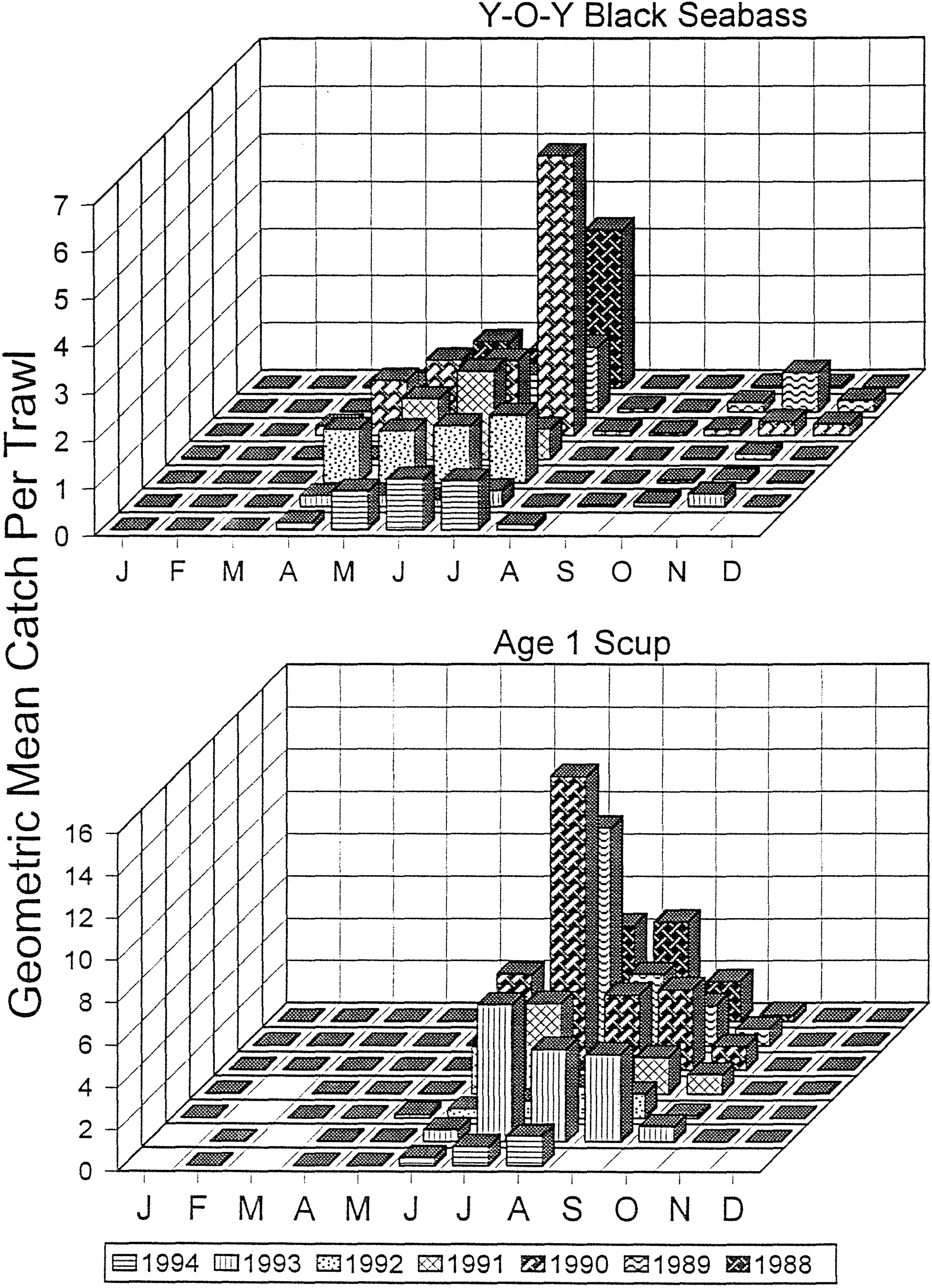
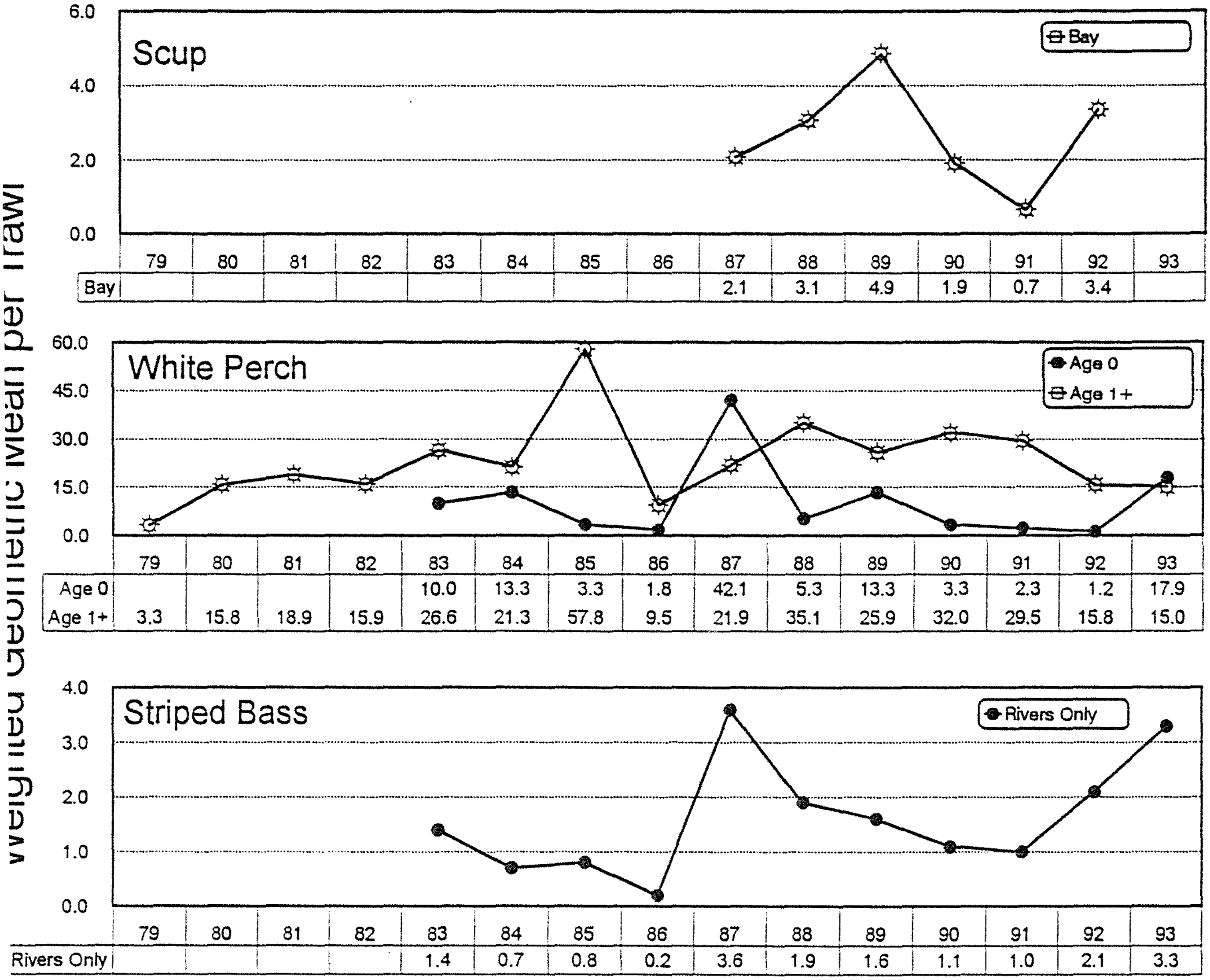

Y-O-Y Black Seabass
Geometric Mean Catch Per Trawl
0
1
2
3
4
5
6
7
J
F
M
A
M
J
J
A
S
O
N
D
Age 1 Scup
0
2
4
6
8
10
12
14
16
J
F
M
A
M
J
J
A
S
O
N
D
▤1994 ▥1993 ▨1992 ▩1991 ▧1990 ▦1989 ▩1988

Figure 7. Annual juvenile abundance indices for scup, white perch (both age 1+ and y-o-y) and striped bass. Indices are calculated for the expanded survey (1988 - 1994) as well as the historic tributary data (1979-1987).

Figure 7. Juvenile Finfish Stock Assessment



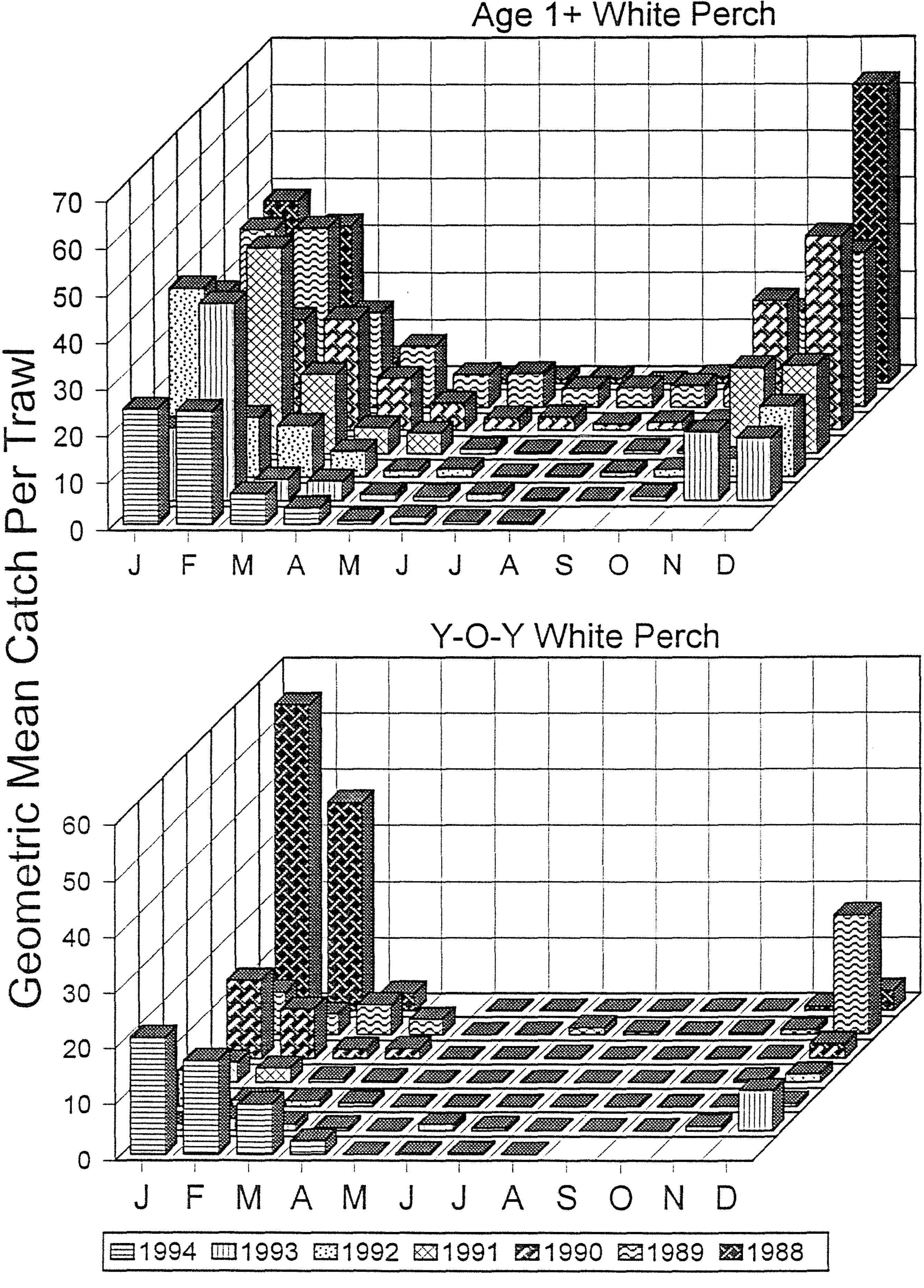
	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Bay									2.1	3.1	4.9	1.9	0.7	3.4	

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Age 0					10.0	13.3	3.3	1.8	42.1	5.3	13.3	3.3	2.3	1.2	17.9
Age 1+	3.3	15.8	18.9	15.9	26.6	21.3	57.8	9.5	21.9	35.1	25.9	32.0	29.5	15.8	15.0

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only					1.4	0.7	0.8	0.2	3.6	1.9	1.6	1.1	1.0	2.1	3.3

Figure 8. Geometric mean catch per tow of age 1+ and y-o-y white perch by month on the primary nursery grounds.

Figure 8.


Age 1+ White Perch

Y-O-Y White Perch

Figure 9. Geometric mean catch per tow of juvenile striped bass by month on the primary nursery grounds.

Figure 9.

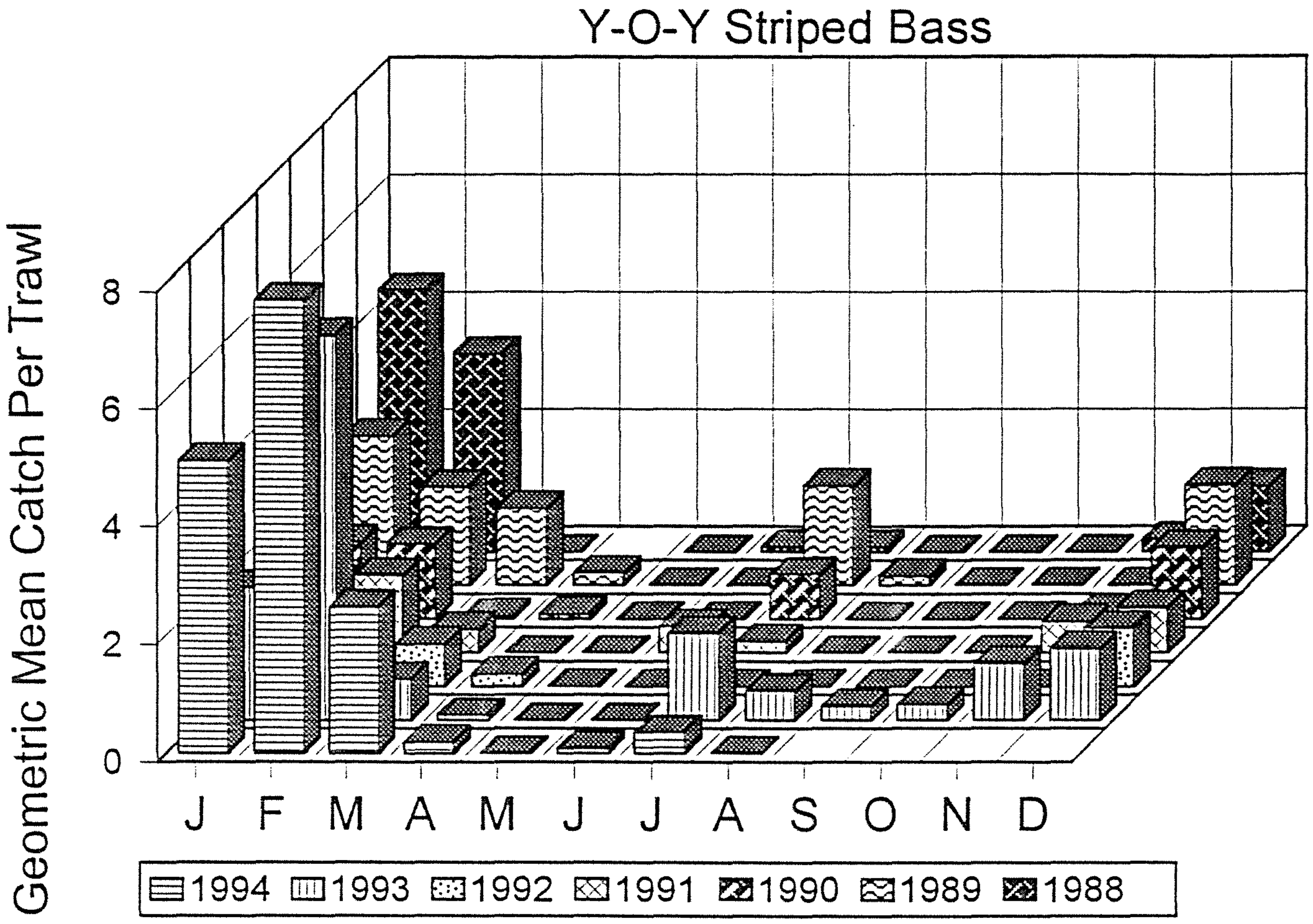
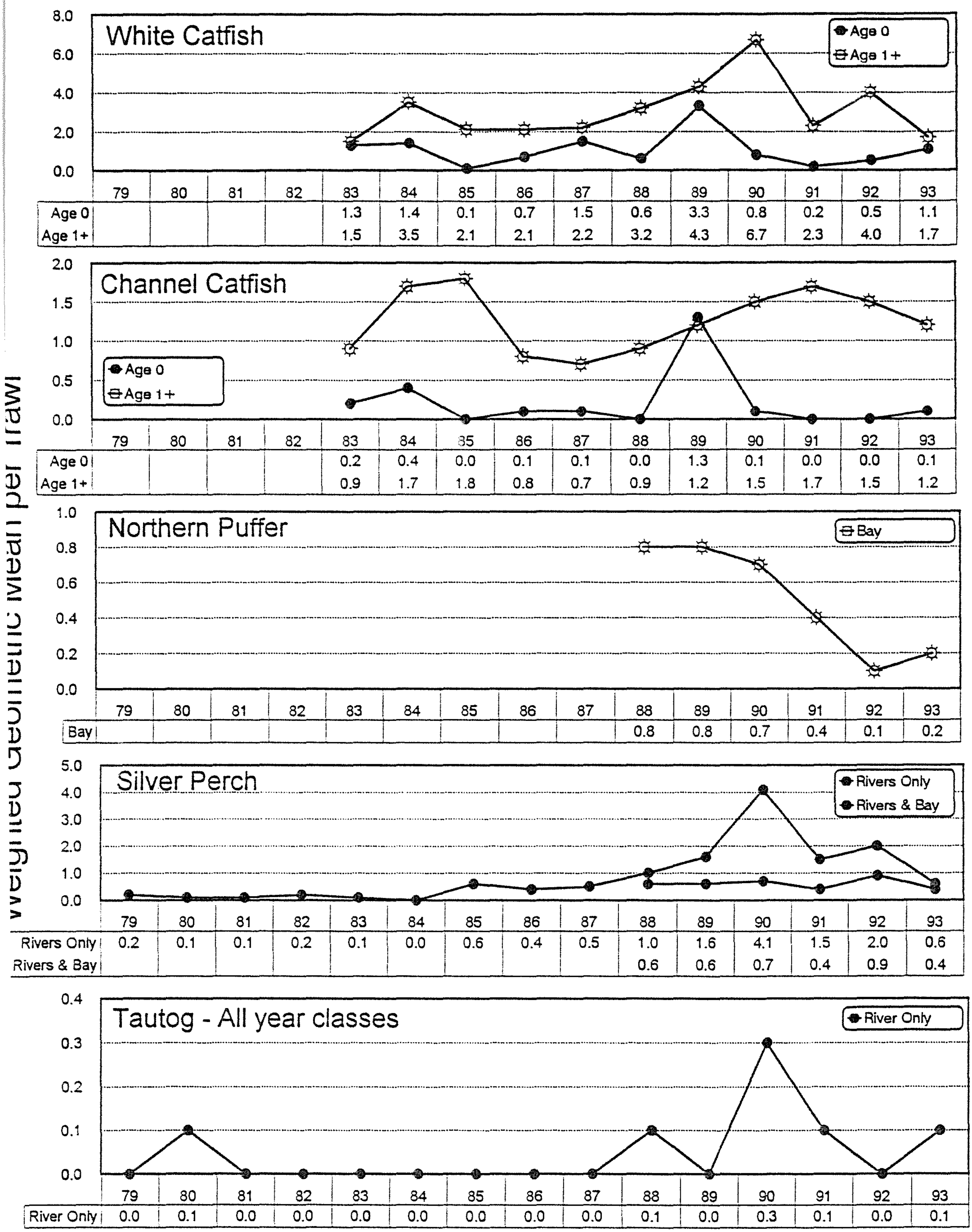

Y-O-Y Striped Bass
Geometric Mean Catch Per Trawl
0
2
4
6
8
J
F
M
A
M
J
J
A
S
O
N
D
1994
1993
1992
1991
1990
1989
1988

Figure 10. Provisional juvenile abundance indices for white and channel catfish, northern puffer, silver perch, and tautog. Indices are calculated for the expanded survey (1988 - 1994) as well as the historic tributary data (1979-1987).

Figure 10. Juvenile Finfish Stock Assessment



White Catfish

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Age 0					1.3	1.4	0.1	0.7	1.5	0.6	3.3	0.8	0.2	0.5	1.1
Age 1+					1.5	3.5	2.1	2.1	2.2	3.2	4.3	6.7	2.3	4.0	1.7

Channel Catfish

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Age 0					0.2	0.4	0.0	0.1	0.1	0.0	1.3	0.1	0.0	0.0	0.1
Age 1+					0.9	1.7	1.8	0.8	0.7	0.9	1.2	1.5	1.7	1.5	1.2

Northern Puffer

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Bay										0.8	0.8	0.7	0.4	0.1	0.2

Silver Perch

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Rivers Only	0.2	0.1	0.1	0.2	0.1	0.0	0.6	0.4	0.5	1.0	1.6	4.1	1.5	2.0	0.6
Rivers & Bay										0.6	0.6	0.7	0.4	0.9	0.4

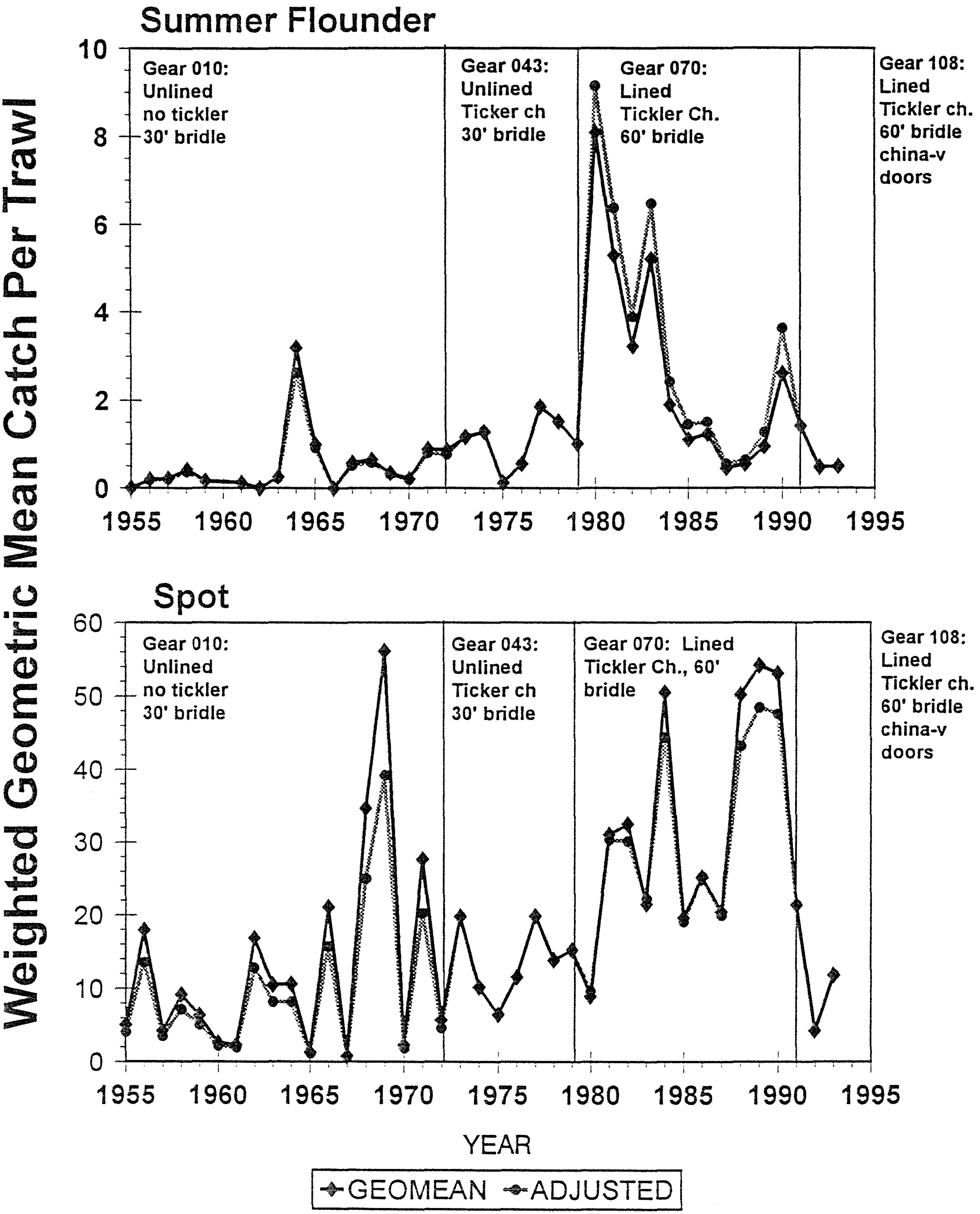
Tautog - All year classes

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
River Only	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0	0.1

Figure 11. Preliminary gear conversions for VIMS juvenile indices of summer flounder and spot, 1955 - 1994.

Figure 11.

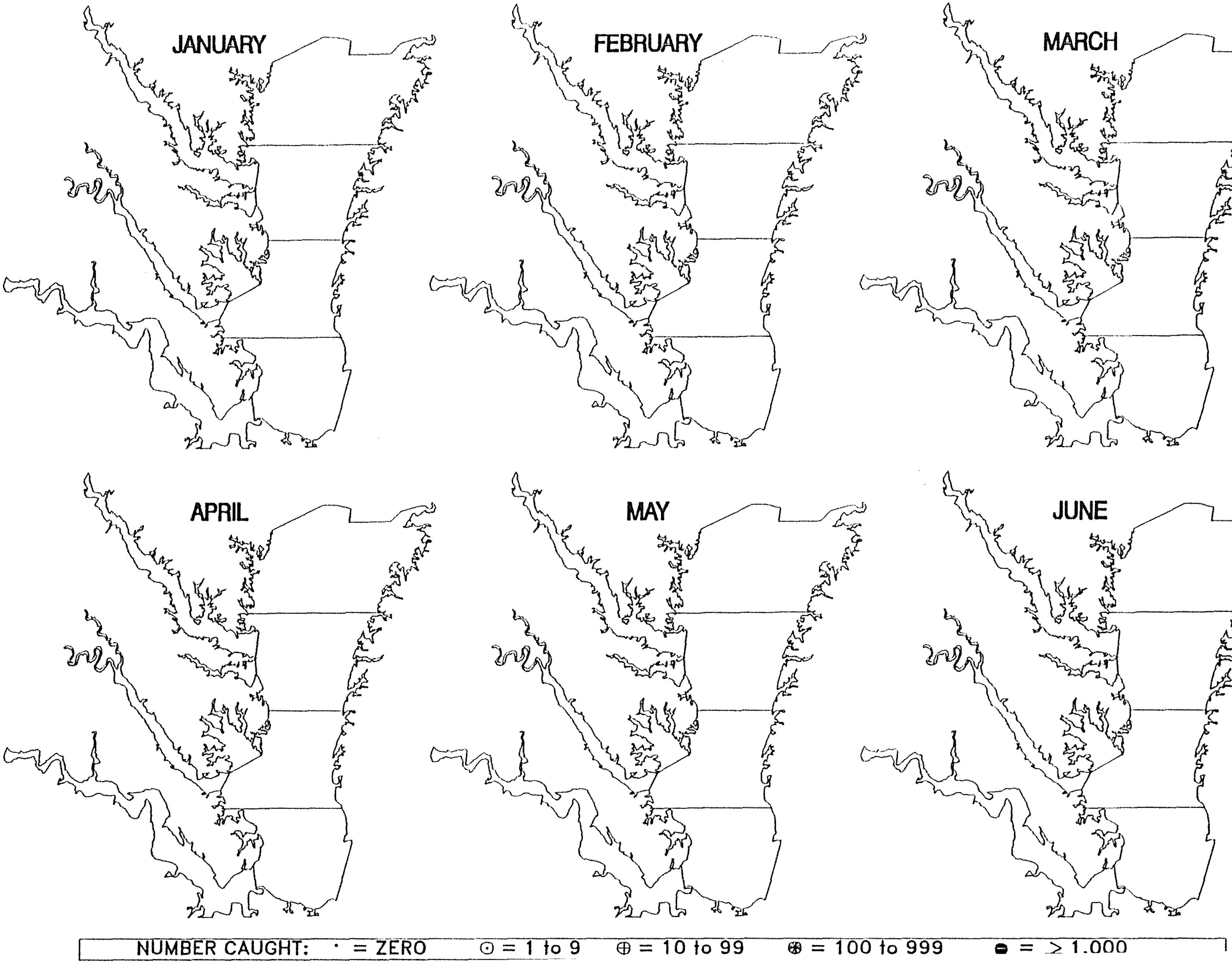
Gear Conversions for VIMS Juvenile Indices



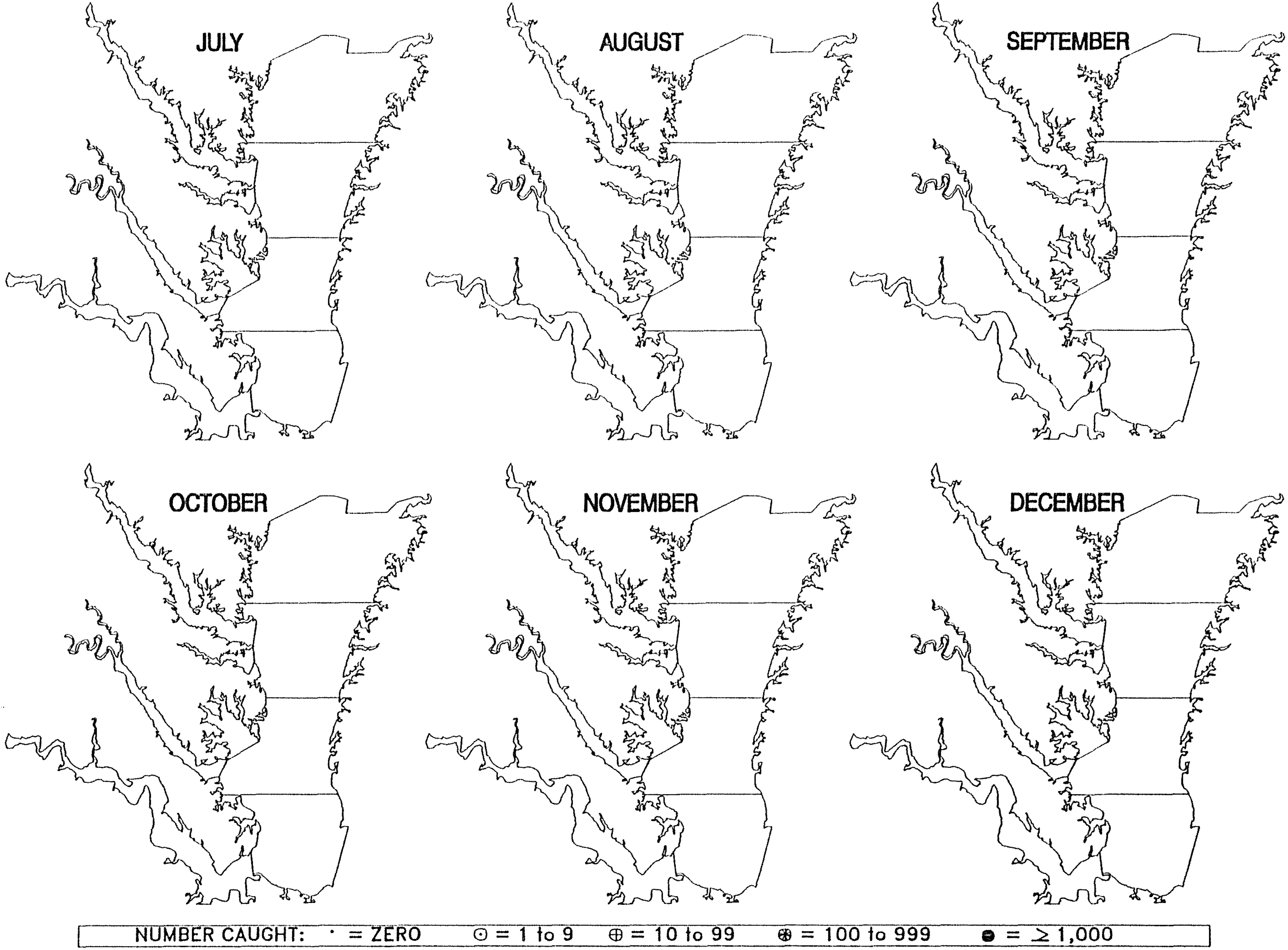
Appendix Figures 1-9. Trawl catches (numbers of individuals) of young-of-the-year of 1, spot; 2, Atlantic croaker; 3, weakfish; 4, summer flounder; 5, black sea bass; 6, early age-1 scup; 7, y-o-y white perch; 8, age 1+ white perch; and 9, striped bass plotted by month for 1993. Plots are arranged chronologically (a, Jan.-June; b, July-Dec).

Appendix Figure 1-a.

Y-O-Y Spot

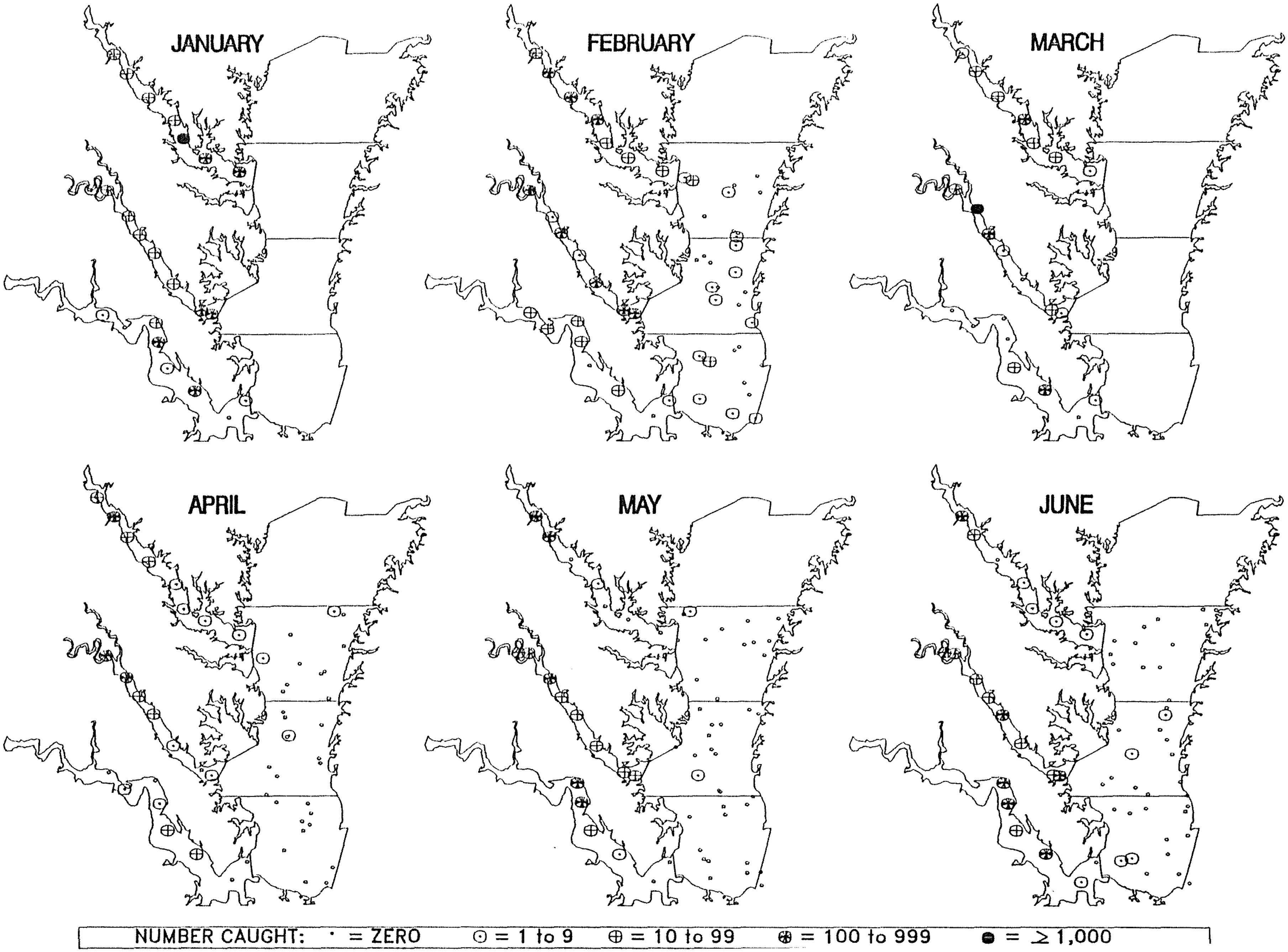


Y – O – Y Spot

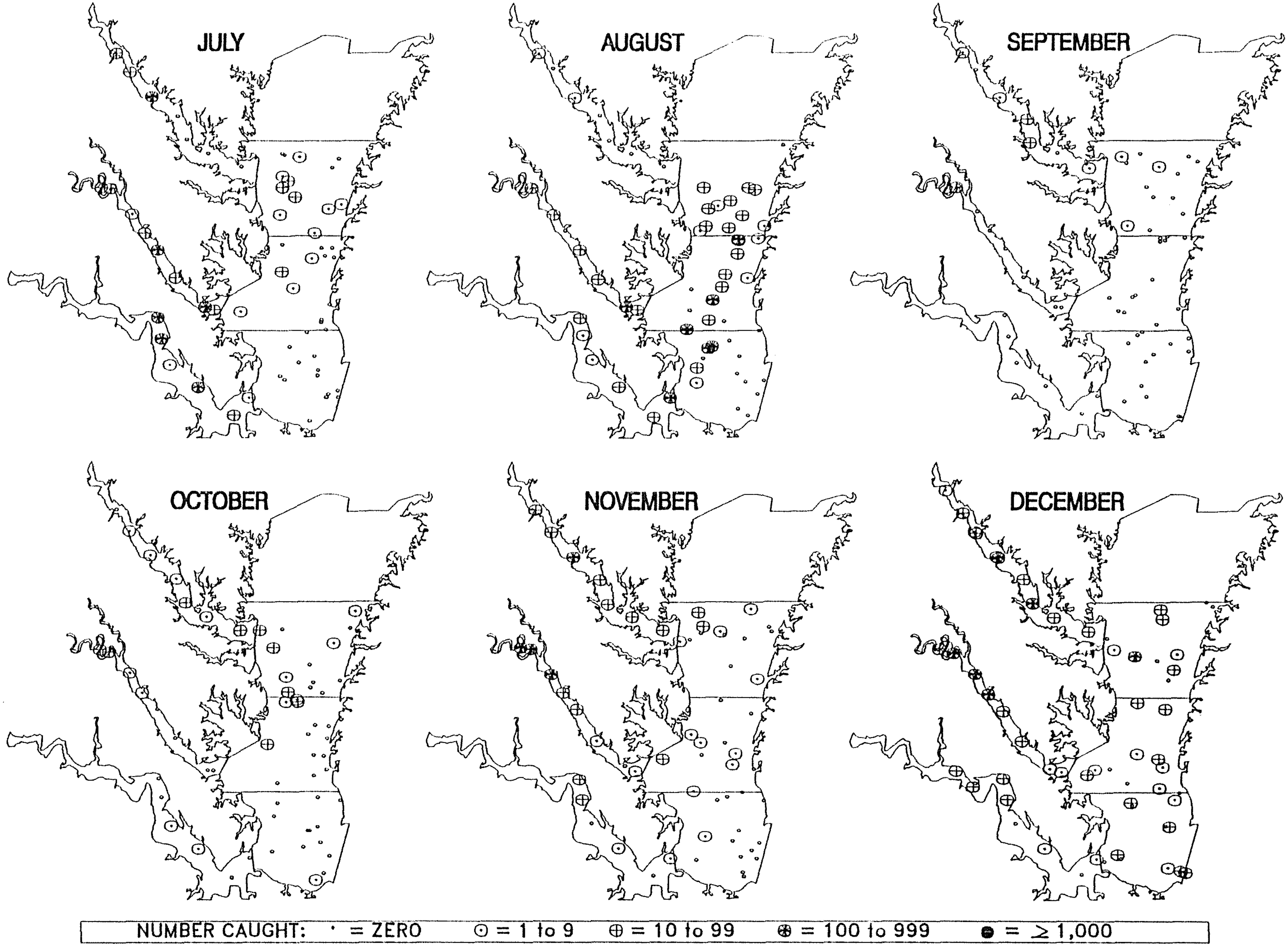

JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
NUMBER CAUGHT: · = ZERO ⊙ = 1 to 9 ⊕ = 10 to 99 ⊛ = 100 to 999 ● = ≥ 1,000

Appendix Figure 2-a.

Y–O–Y Atlantic Croaker

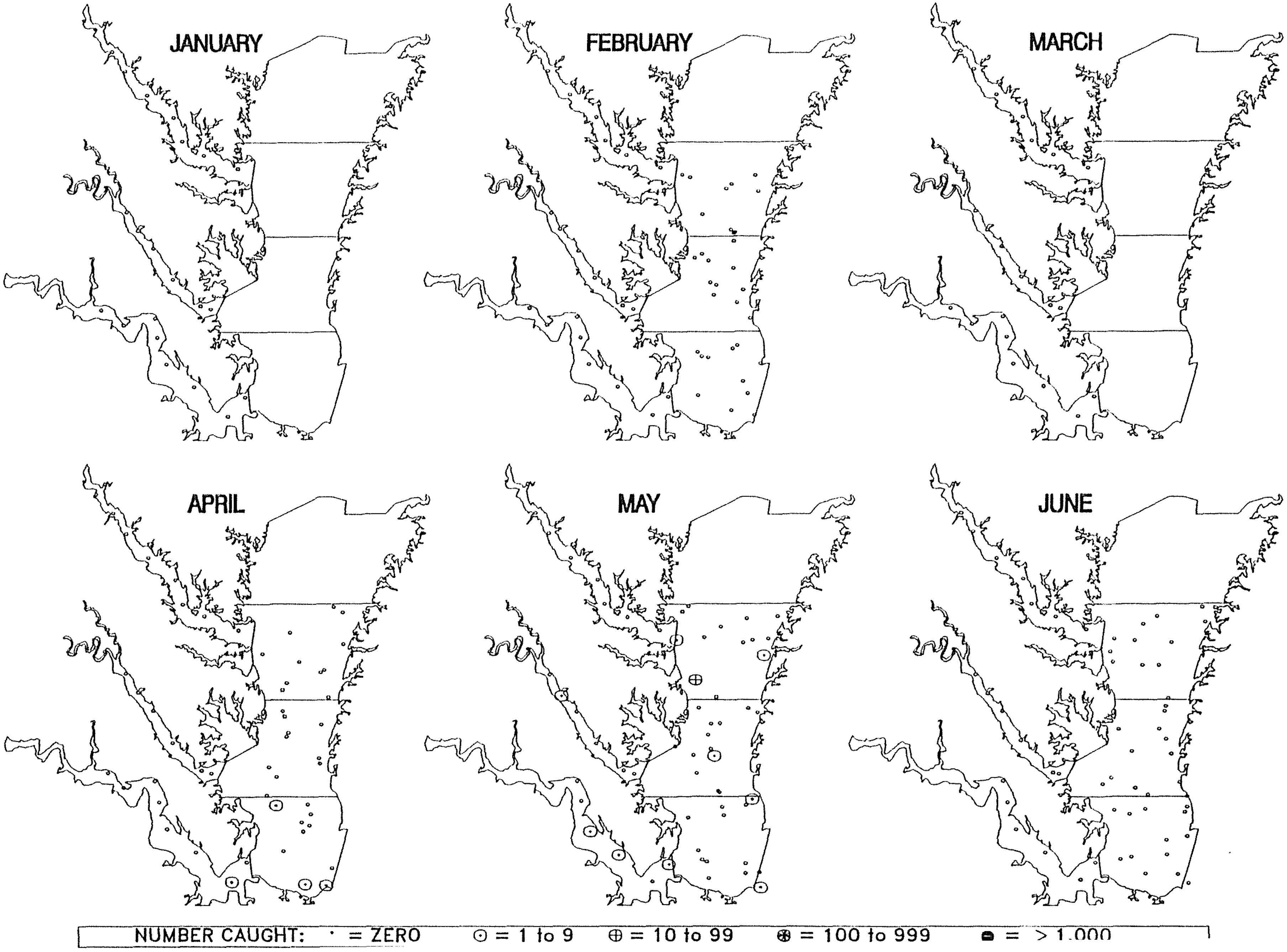


Y–O–Y Atlantic Croaker

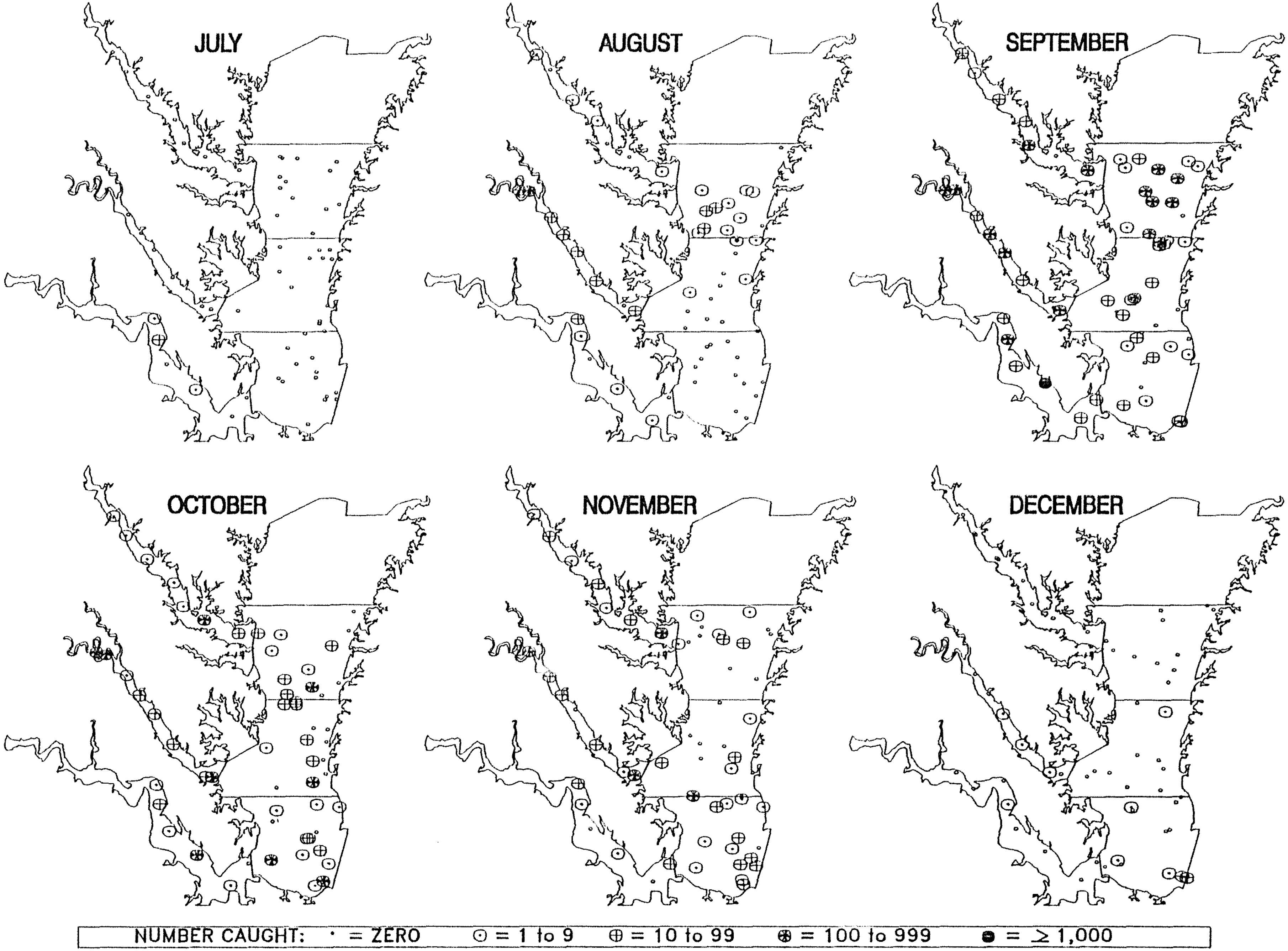


Appendix Figure 3-a.

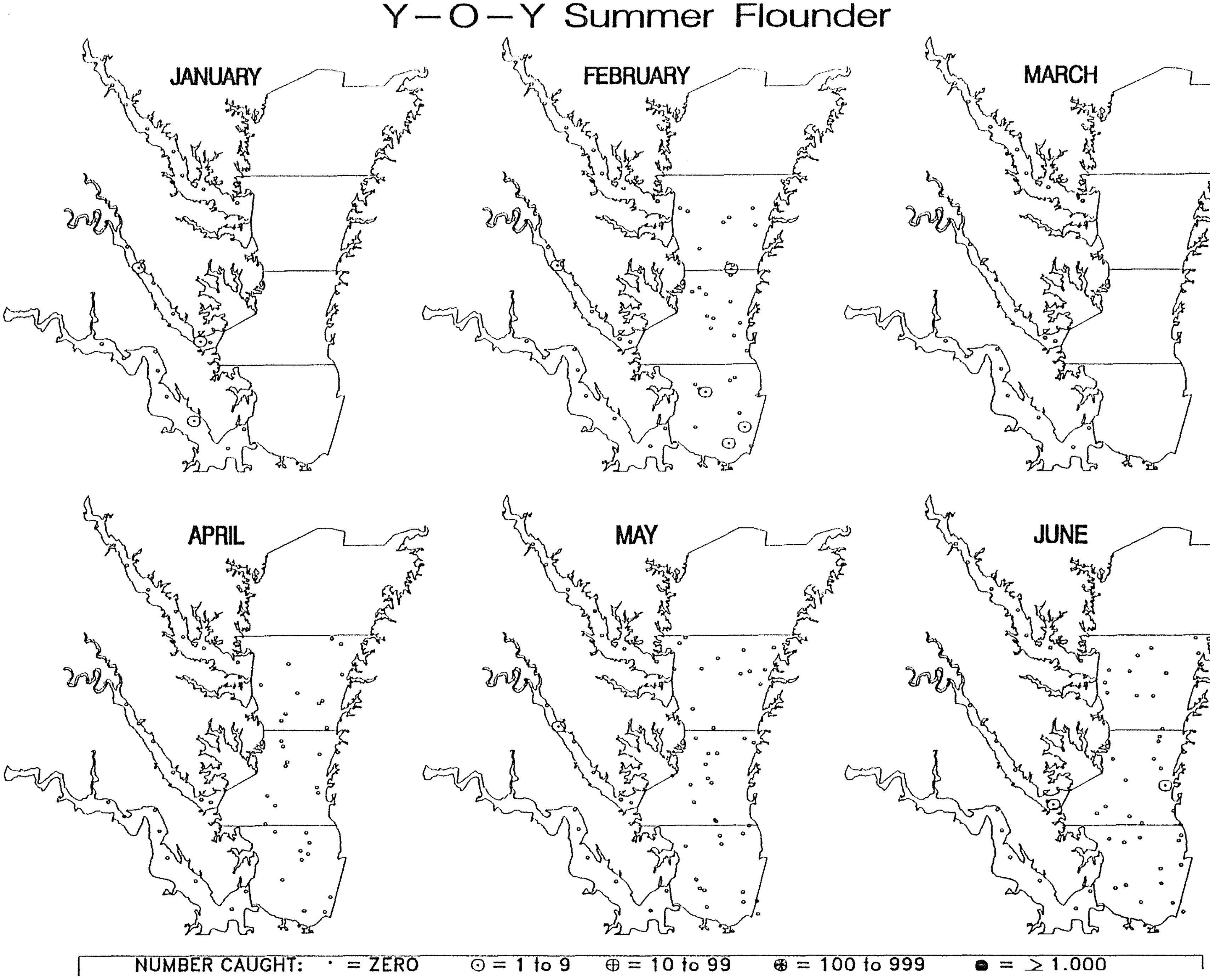
Y–O–Y Weakfish



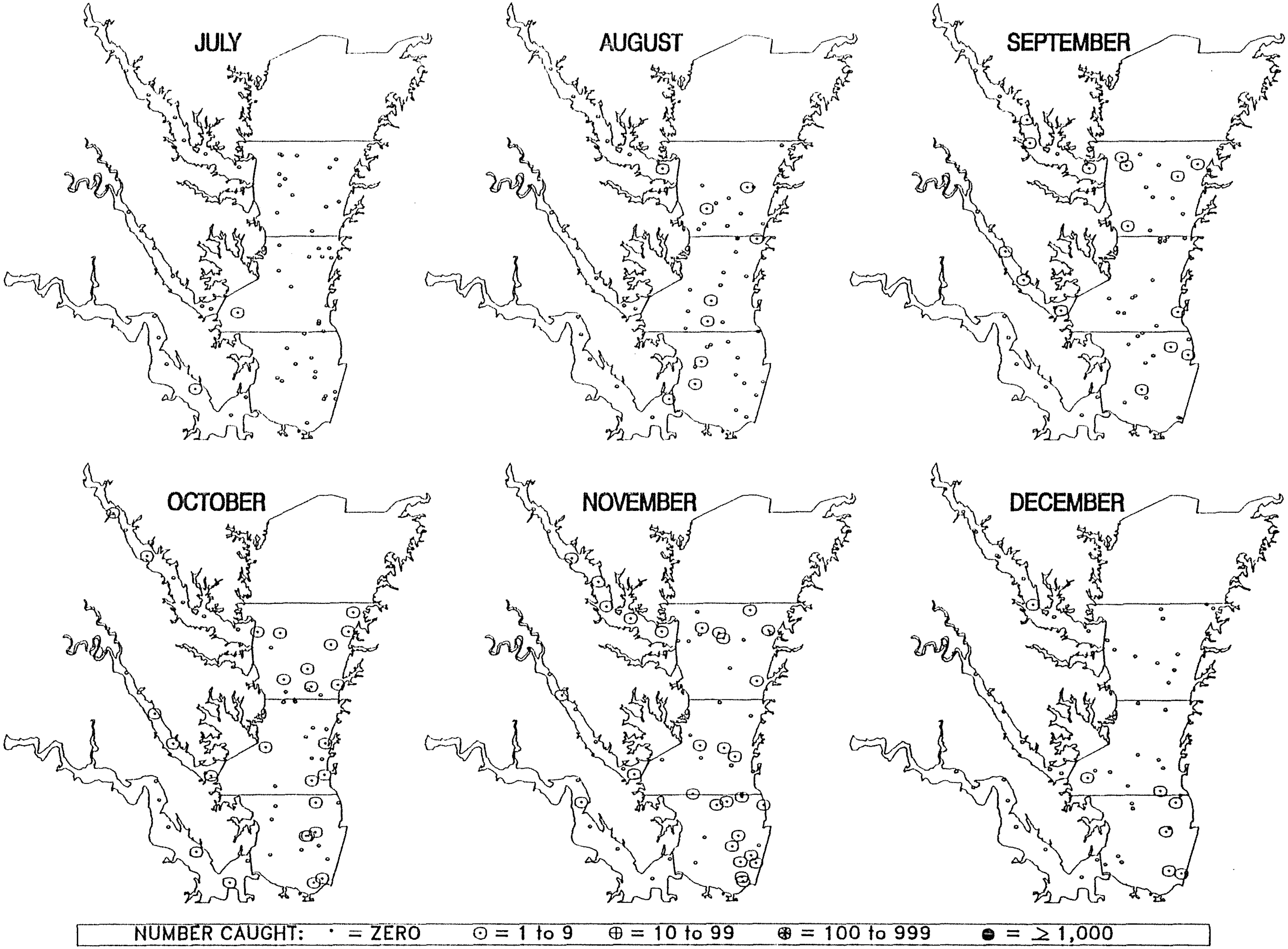
Y — O — Y Weakfish



Appendix Figure 4-a.

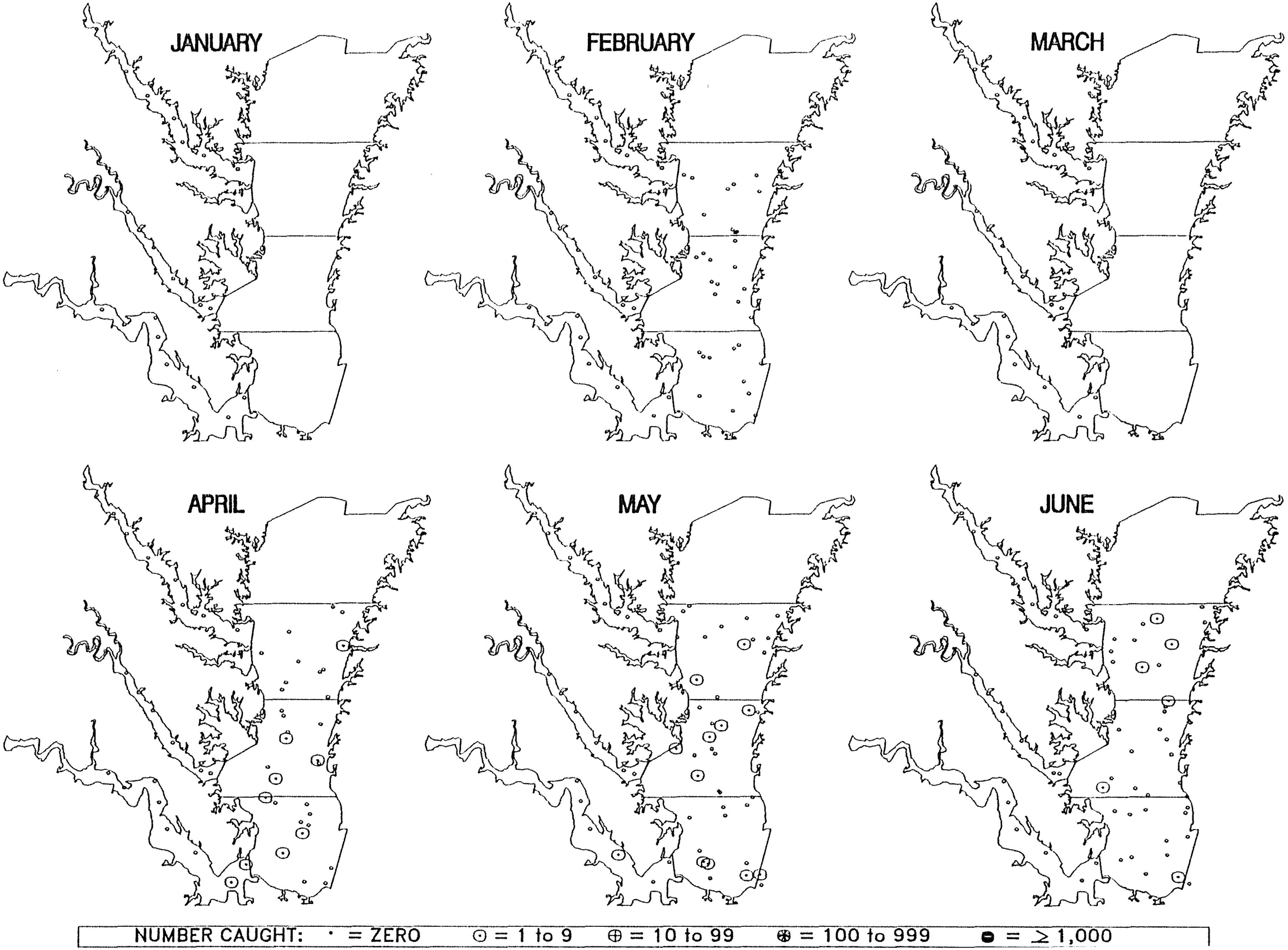


Y – O – Y Summer Flounder

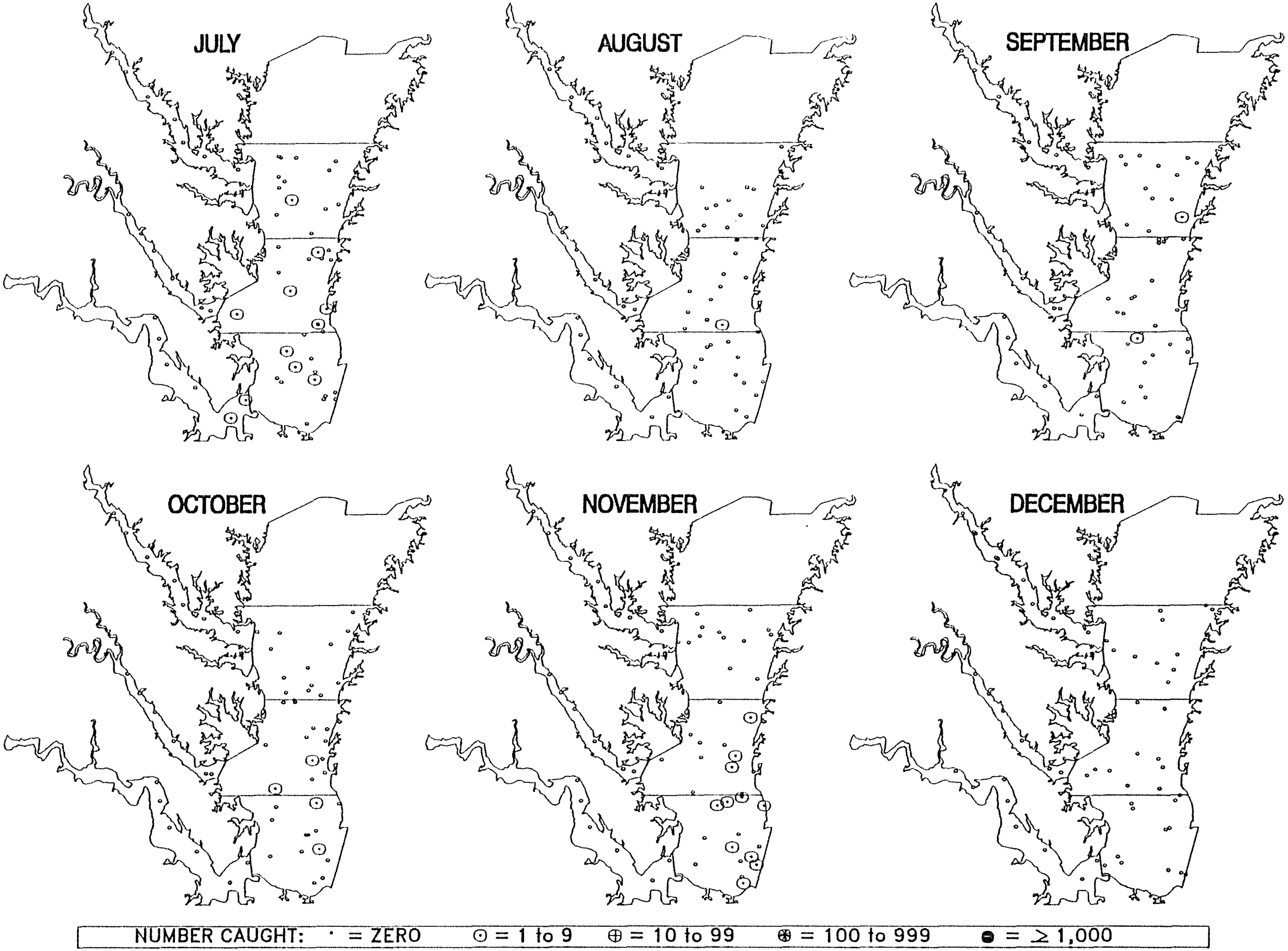


Appendix Figure 5-a.

Y-O-Y Black Sea Bass

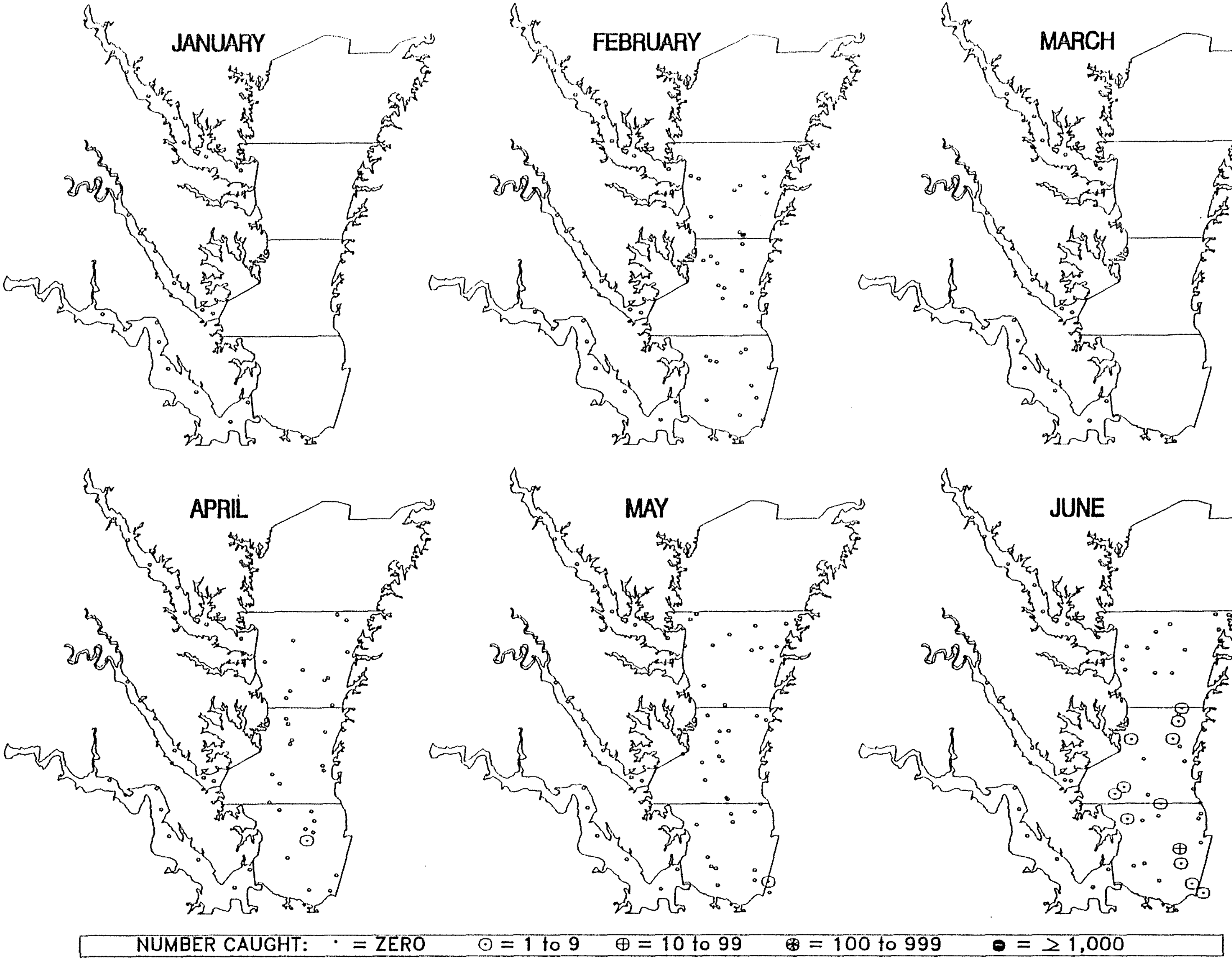


Y–O–Y Black Sea Bass

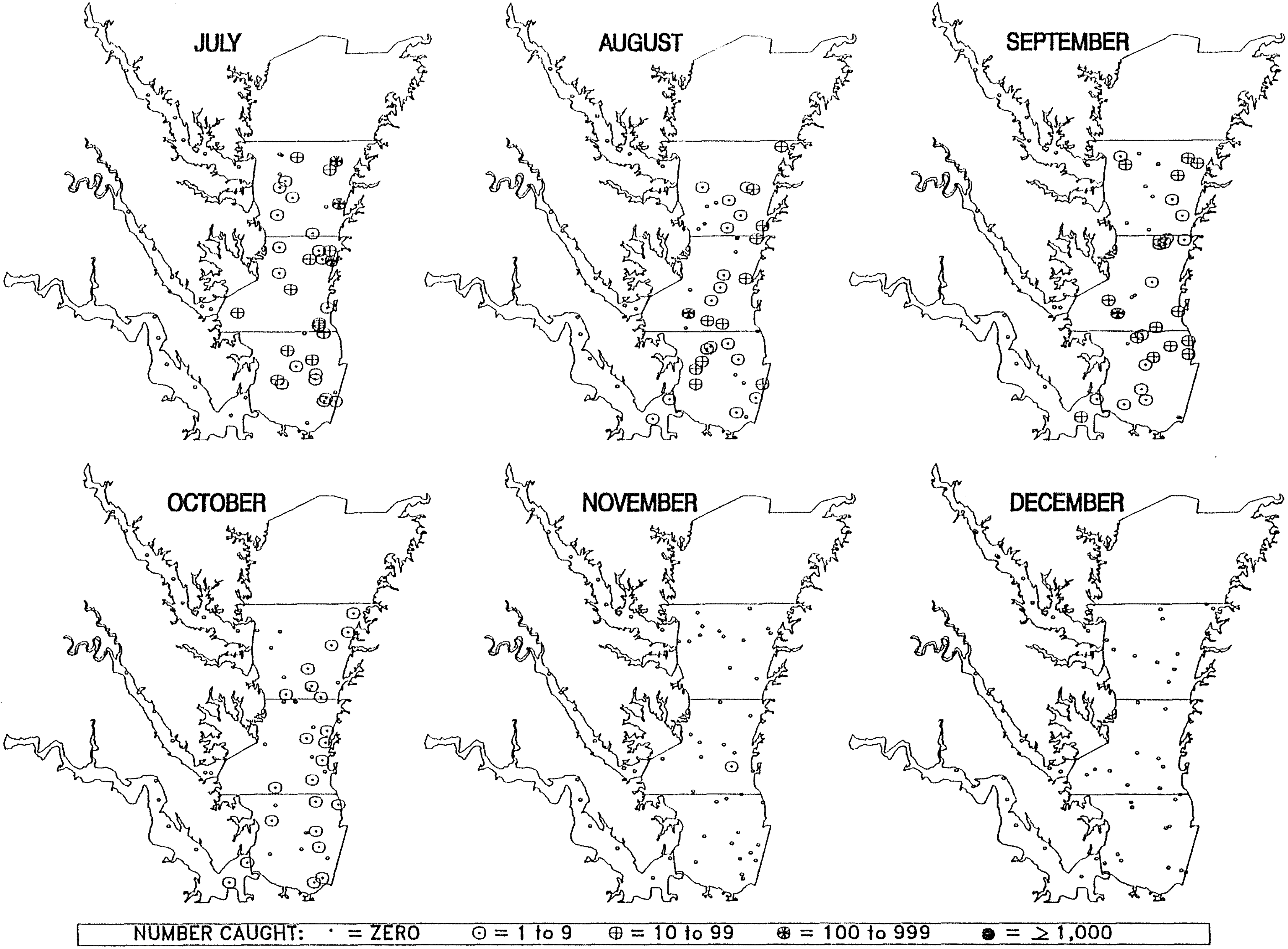


Appendix Figure 6-a.

Age 1 Scup

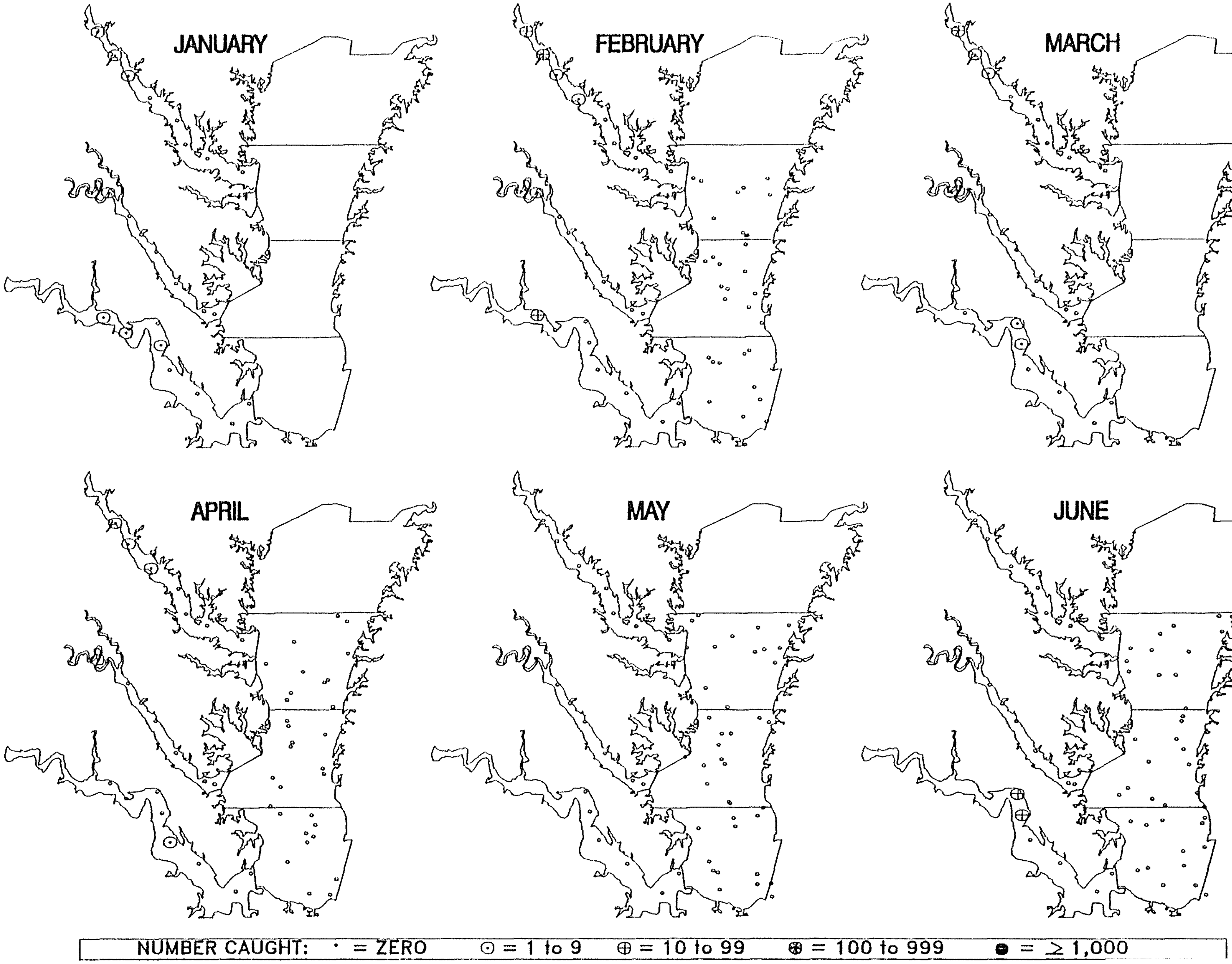


Age 1 Scup

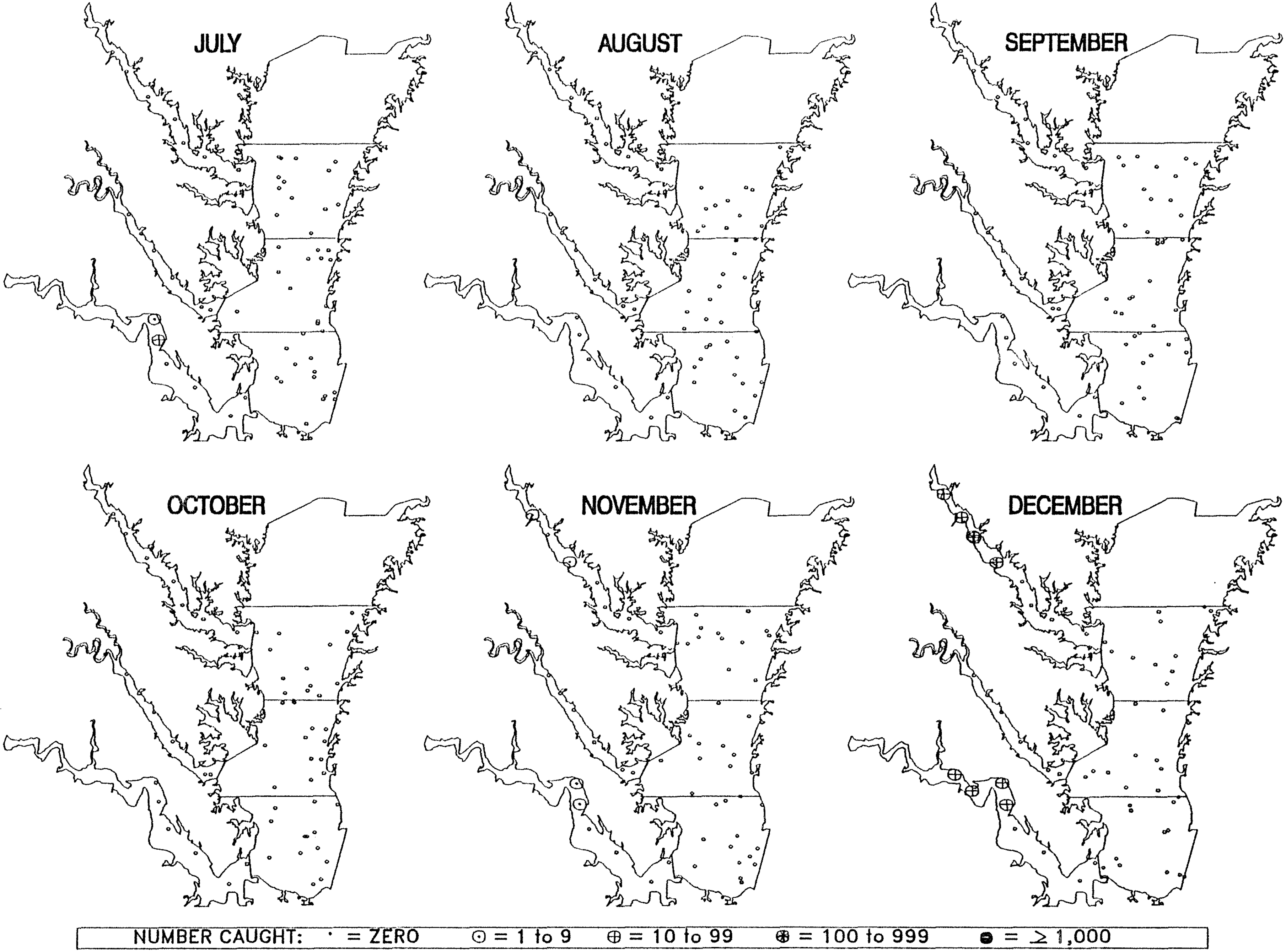

JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
NUMBER CAUGHT: · = ZERO ⊙ = 1 to 9 ⊕ = 10 to 99 ⊛ = 100 to 999 ● = ≥ 1,000

Appendix Figure 7-a.

Y-O-Y White Perch

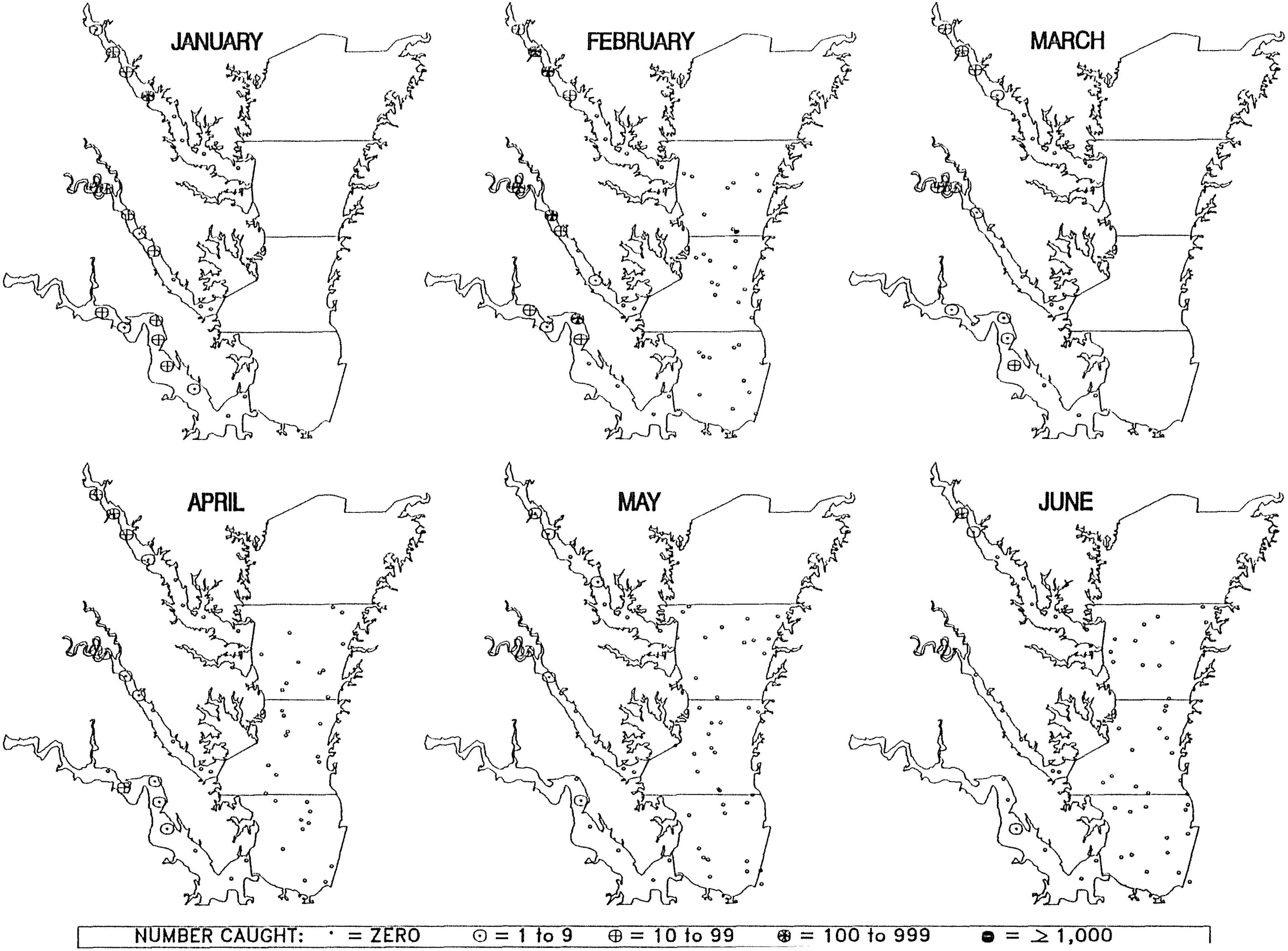


Y – O – Y White Perch

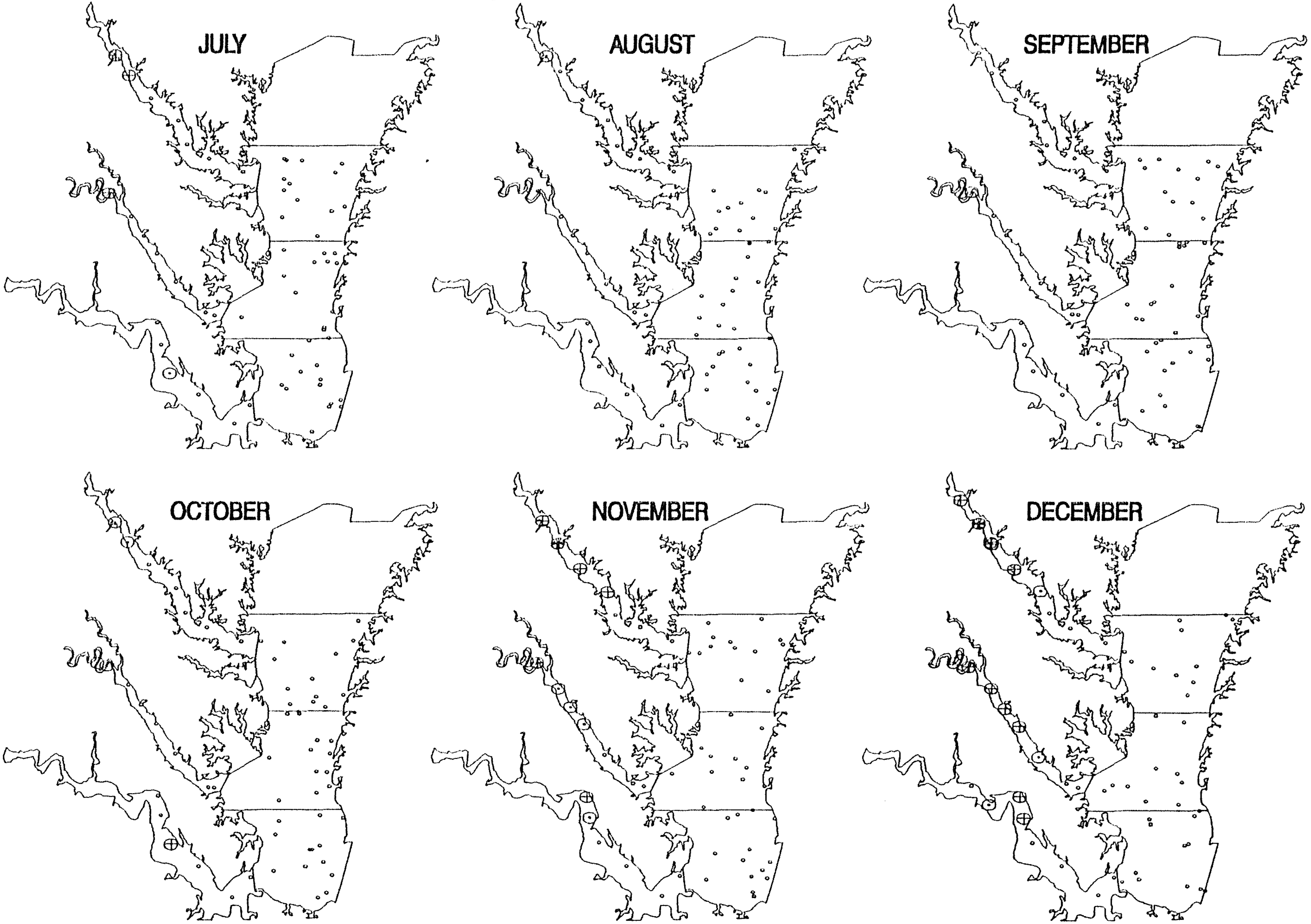


Appendix Figure 8-a.

Age 1+ White Perch



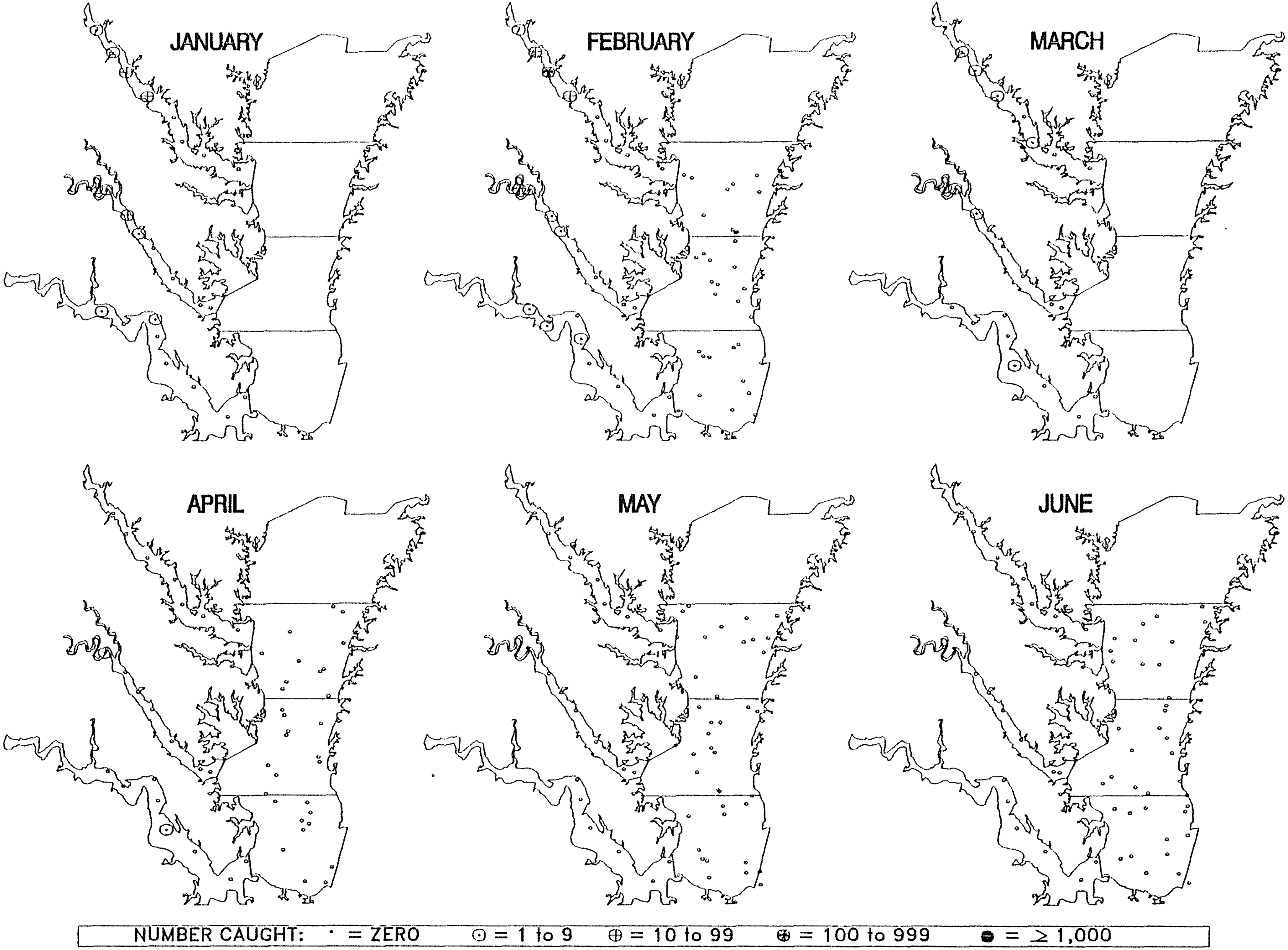
Age 1+ White Perch



NUMBER CAUGHT: · = ZERO ⊙ = 1 to 9 ⊕ = 10 to 99 ⊛ = 100 to 999 ● = ≥ 1,000

Appendix Figure 9-a.

Y–O–Y Striped Bass



Y – O – Y Striped Bass