U. S. Army Corps of Engineers
New York District

Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York: Reformulation Study

West of Shinnecock Inlet Multispecies Sampling

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EXECUTIVE SUMMARY

This report presents the study design, methodologies, and results of a 12-month marine environmental survey of an offshore site to be used as a borrow area. Sand will be removed from the borrow area in order to replenish the beaches west of Shinnecock Inlet. The borrow area site is located approximately 1.5 miles offshore, to the east of Shinnecock Inlet in the Atlantic Ocean and covers an area approximately 20,000 by 7,000 feet along the contours of 30 to 60 feet. Although this area near Shinnecock Inlet is a prime fishing region, it has not been extensively studied, and limited biological data is available. This program serves to fill that data gap by intensively characterizing the benthic invertebrates and fisheries resources in the offshore environment of Shinnecock Inlet. Sampling was conducted monthly from April 1999 to April 2000. Major portions of the program included a collection of demersal finfish, shellfish, squid and other macroinvertebrates. Additional elements of the program included data collection on fishes, water quality, sediment grain size and composition.

The following are major elements of the study design and results:

- Sampling was conducted along the 30, 40, 50, and 60-foot depth contours.
- Fisheries trawls and benthic grabs were sampled both within the borrow area and at control stations east and west outside the borrow area.
- 192 bottom trawls were collected between April 1999 and April 2000.
- 43,446 finfish were collected. Dominant species were butterfish, scup, bay anchovy, little skate, spotted hake, and winter skate.
- BRAT analyses of stomach contents, as well as age and growth determinations, were performed on the following seven species: black sea bass, bluefish, weakfish, scup, striped bass, summer flounder and winter flounder.
- 35 benthic macroinvertebrate samples were collected during both July and November 1999.
- 41,871 benthic macroinvertebrates were collected. Dominant species were sand dollar and longfin squid.
- Sediment was analyzed for grain size and composition.
- Water quality parameters collected at each station included; temperature, salinity, conductivity, dissolved oxygen, pH and light transmission.

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I. INTRODUCTION

The U.S. Army Corps of Engineers (USACE) New York District is proposing to undertake a beach nourishment project in the area immediately west of Shinnecock Inlet. Initial construction would involve dredging approximately 800,000 cy of material from a location roughly 1.5 miles offshore, east of Shinnecock Inlet, covering an area of 20,000 by 7,000 feet (approximately 3,200 acres). Two renourishment operations (approximately 400,000 cy each) are scheduled for this borrow area. The dredge disturbance area for initial construction is approximately 2,000 by 2,500 feet (115 acres), and for each renourishment operation, approximately 1,500 by 1,300 feet (45 acres). The total estimated area for initial construction and two renourishment operations is approximately 205 of the 3,200 acres within the entire identified borrow area (Figure 1).

This report presents the results of the 12-month study on finfish and macroinvertebrates in the west of Shinnecock Inlet borrow area. The present study is being conducted in response to a request from the New York State Department of Environmental Conservation (NYSDEC), and other Federal and State agencies, for additional baseline data on demersal finfish, shellfish, squid, and other macroinvertebrates present within the west of Shinnecock borrow area. Using the Benthic Resource Analysis Technique (BRAT) sampling protocols, the existing macroinvertebrate resources were identified and analyzed to determine their utilization by demersal species that frequent the borrow area. Data presented in this report will be utilized to establish baseline biological conditions and to enable preparation of an impact analysis of the effects of sand dredging.

II. METHODOLOGY

A. Ecological Studies

1. Fisheries – Demersal Trawl Survey

To determine species composition and abundance of the demersal fish community, bottom trawls were conducted offshore at the Shinnecock borrow area (SH) (Figure 1). Finfish and macroinvertebrates were collected by towing a 30-foot otter-trawl with a ½ inch mesh cod end (Figure 2) from an ocean-going research vessel along the 30, 40, 50, and 60-foot contour lines. The net was towed along each transect at a speed of 2 to 3 knots for a distance of 0.25 nautical miles. Sampling was performed once each month except January 2000, when ice conditions prevented operations. Every effort was made to sample during the first week of every month. This was not always feasible, however, due to weather conditions. A total of 16 transects were sampled within and adjacent to the borrow area (Figure 1). Eight transects were sampled within the borrow area along each depth contour and designated as follows: T-30B, T-30C, T-40B, T-40C, T-50B, T-50C, T-60B, T-60C. Eight reference transects were sampled adjacent to and outside of the borrow area along each depth contour and designated as follows: T-30A, T-30D, T-40A, T-40D, T-50A, T-50D, T-60A, T-60D. The reference transects were trawled outside the borrow area and served as comparison sites on the east and west sides of the proposed borrow area. Two Global Positioning System units (GPS) were used for navigation: Garmin 45XL and Garmin 185. These two units were interfaced with a Garmin GBR-21in order to produce greater position accuracy.

Bottom time for each trawl haul was 8-10 minutes. Trawl contents were processed on board the vessel. The catch was separated by species and identified to the lowest practical taxa. All species were weighed and enumerated. When large numbers of species were encountered (i.e. in excess of 1,000 individuals) random subsamples were taken. For each trawl, lengths were measured for 30 individuals per finfish species, as well as for squid. Total weight by species was recorded for up to 30 individuals. Fish abundance was measured as the number of fishes occurring within a trawl area. Species diversity is a measurement of the number of different species. CPUE was calculated as the number of fish collected per trawl. A student's t-test and correlation coefficient were used to look for spatial differences in the data. Statistics were calculated using the computer software program Statistica ©.

2. Benthic Resource Assessment Technique (BRAT)

BRAT analyses were performed each month on the following target species: winter flounder, weakfish, summer flounder, striped bass, black sea bass, scup and bluefish. Age and growth was determined for all BRAT species. Stomach contents were analyzed for all species except bluefish. Tautog was to be included in this assessment, however, none were collected. Specimens were identified, measured and weighed as per protocol for demersal trawls.

a) Stomach Contents

Stomachs were removed from the target species on board the ship and placed in formaldehyde for preservation. When large numbers of species were collected, a maximum of 30 stomachs per species per sampling event were analyzed. In the laboratory, stomach samples were opened and rinsed over a 63μm mesh screen. Rinsed samples were transferred to labeled petri dishes. Samples were identified to species or lowest practical identification level with the aid of a stereomicroscope. Identified samples were counted and weighed separately by taxonomic group. Samples that contained more than 100 amphipods were split either in half or quarter. Wet weights were measured for each species type.

b) Age and Growth

To conduct age analyses, otoliths and scales were removed from six of the seven target finfish species. No aging was performed on bluefish since all specimens collected were young-of-the-year. When large numbers of species were collected, a maximum of 30 individuals per species per cruise were analyzed. Scales were removed from all species except winter flounder, in which case otoliths were taken. Age was determined by counting annual scale and otolith growth increments. A length at age regression was computed to calculate annual growth rates.

3. Mid-Water Finfish Trawl Survey

The pelagic finfish community was sampled along the same 16 transects as the demersal trawls. A mid-water beam trawl was deployed with an appropriate cable length to achieve a mid-water depth stratum. The net was towed at a speed of 2 to 3 knots for a distance of 0.25 nautical miles along each transect. The coordinates of the beginning and end position were recorded using the vessel's Differential GPS. Each of the 16 trawls were towed parallel to the shoreline along the designated contour line for approximately 10 minutes at a constant vessel speed. Net contents were examined for pelagic finfish and by-catch organisms.

4. Benthic Macroinvertebrate Grab Survey

To characterize sediment samples and benthic macroinvertebrate composition, grab samples were collected from 35 locations (Figure 1). Thirty stations were located within the borrow area and six were randomly selected outside and east of the borrow area. Locations for the 29 stations within the borrow area were provided by the USACE from their 1996-98 studies for the Shinnecock borrow area. A Garmin 185 GPS was used for station location. Samples were collected at each location during both July and November 1999. A modified Ted Young benthic grab (sample area = $0.025m^2$) was used to collect all samples (Figure 2).

Macrofaunal samples were retained after being sieved on board through a 0.5 mm mesh screen and preserved with 10% formalin in the field. In the laboratory, all macroinvertebrates were inventoried, stained with Rose Bengal and stored in 70% isopropanol until processing. Subsequently, samples were sorted and identified to the lowest practical identification level. Oligochaetes, chironomids, nemerteans, and anthozoans were left as high taxonomic groupings due to the difficulty associated with their identification or the small size and scarcity of specimens. Each sample was weighed for wet weight biomass (standing stock biomass in grams per m^2) for the major taxonomic groups identified.

B. Physical Studies

1. Water Quality

a) Fisheries-Demersal Trawl Surveys

Water quality measurements were collected at the beginning and end of each trawl. Surface and bottom readings of temperature, dissolved oxygen, salinity and conductivity were taken using a Yellow Springs Instruments (YSI) Model R85-10 meter. The pH was recorded using an Oakton Waterproof pH tester. Bottom water samples were collected with a Van Dorn water bottle. Light transmission through the water column was measured using a Secchi disc.

b) Benthic Macroinvertebrate Grab Survey

Water quality analyses were conducted at half of the benthic grab station locations. Environmental parameters were measured using the same YSI meter and pH tester as in the fisheries survey. Water quality data was collected from the bottom using a Van Dorn water bottle. The same parameters were recorded as in the fisheries survey.

The frequency of water quality sampling at the benthic grab stations was designed to coincide with water quality sampling at the fisheries trawl stations. This was done in order to obtain the most useful data and eliminate redundancy in sampling due to the fact that each benthic station was approximately one-tenth of a mile apart.

2. Sediment Analysis

In conjunction with the benthic grab samples, a grab sample was taken for grain size and composition. Sediment samples were collected at each of the 35 benthic grab stations during both July and November. These samples were placed in jars and sent to a laboratory for analysis. Sediment grain size was determined using sieve analysis. Sediment was classified by percentage, as gravel, sand, clay or silt.

III. RESULTS

A. Ecological Studies

1. Fisheries – Demersal Trawl Survey

a) Finfish

Abundance and Diversity

Trawl samples were collected monthly from April 1999 through April 2000, with the exception of January when no samples were obtained due to ice conditions. A total of 192 samples, 12 at each of the 16 stations, were collected. A total of 58 finfish species (Table 1) were collected comprising 43,446 individuals (Table 2). Table 2 presents a summary of the trawl catch by taxa, monthly total, total catch and percent composition. Note that in all tables finfish were listed to species level, with the exception of *Urophycis* sp. and *Prionotus* sp.which were identified to genus and Gadidae at the family level. Incidental to the finfish collections, 22 species of macroinvertebrates were collected (Table 3).

Figure 3 shows the total number of fishes and species collected during each month. Total fish abundance peaked during the summer months of August and September, with values averaging 10 to 20 times greater than other times of the year. Species diversity exhibits a similar trend to abundance, with peak values occurring during summer and fall months. The dominant species collected was butterfish. The 13,759 individuals collected represent one third (~32 %) of the total catch. The next most abundant species was scup, representing twenty percent of the total catch. The third through sixth ranked fish species, by abundance, were bay anchovy, little skate, spotted hake and winter skate, respectively. These along with windowpane, red hake, striped searobin and silver hake comprised nearly ninety-five percent of the total catch (Table 2). A ranking of species by year and season is listed in Table 4. Of the ten most abundant species for the year, five species (butterfish, scup, bay anchovy, winter skate and windowpane), also ranked in the ten most abundant for each season. Figure 4 shows the yearly abundance for the 15 most abundant species. Butterfish abundances far exceeded all other species, primarily due to extremely high landings in August. Scup was the second most abundant species with landings approximately double the next three most abundant species (bay anchovy, little skate and spotted hake). Winter skate ranked sixth most abundant, while all other species had total numbers of less than one thousand for the year.

Finfish species diversity by month is presented in Figure 5. Species diversity was greatest from August through October, when approximately 30 species were collected. This is nearly three times the number of species collected during February, the month with the lowest value. During February, only 11 species were collected. March and July also had low species diversity with only 17-18 species collected, respectively. Little skate, smallmouth flounder, spotted hake, windowpane and winter skate were collected during all months sampled. Note that some species were collected during only one month of the year; Atlantic torpedo (June), conger eel (July), American eel (April 2000), smooth puffer (October), smooth trunkfish (November), white hake (April 1999) and Atlantic sturgeon (June). The Shinnecock borrow area may be a breeding ground for Atlantic sturgeon however, only one was collected throughout the survey program.

<u>Weight and Catch per Unit Effort (CPUE)</u>

The monthly total weight for all species collected is shown in Figure 6. Monthly total weights approximated 200 kilograms on average, with a peak weight in April 2000 of 323 kg and a low in February of 47 kg. Table 5 displays the monthly weights for each species collected and their percent composition of the total weight. The five dominant species by weight were little skate, winter skate, windowpane, summer flounder and winter flounder. Combined they comprise over ninety percent of the total weight. The five most abundant species by weight are shown in Figure 7. Little skate dominated the catch in weight every month of the year with a total weight of 1,208 kg. This is more than twice the catch of winter skate (541 kg) and approximately ten times more than the weight of windowpane (168 kg), summer flounder (112 kg) and winter flounder (69 kg).

Table 6 summarizes the total and mean monthly catch-per-unit-effort (CPUE) for the demersal fish species. Total catch rates peaked during August with a CPUE of 1,084. The next highest CPUE was recorded in September (602). CPUE was lowest in February with a value of 14. Species with the highest overall CPUE values were butterfish (860), scup (592), bay anchovy (306), little skate (283), and spotted hake (250). Mean values for CPUE showed similar trends to total values. Monthly CPUE values for each station are shown in Table 7. CPUE values for each station ranged from a high of 4,544 at station T60D to a low of 1,187 at station T30B. There appears to be a trend in the catches with higher CPUE values at stations along the 50 and 60 ft. contours compared to the 30 and 40 ft. contours. This will be discussed later in the report.

Commercially Important Finfish Species

The five trawl species generally considered to be of greatest commercial value are butterfish, scup, summer flounder, winter flounder and bluefish. Length frequency distributions are shown for these five species in Figure 8. Sample sizes are indicated by 'n' in Figure 8. Sample sizes represent only those fish that were measured. A subsample of the total number collected were measured (refer to the methods section). Fish lengths ranged from 14 to 630 millimeters. Mean fish lengths for each species were: butterfish (67 mm), scup (79 mm), bluefish (109 mm), winter flounder (272 mm) and summer flounder (384 mm). Butterfish, scup and bluefish were the smallest; lengths ranged from 14 to 308 mm, with one bluefish at 440 mm. Summer flounder and winter flounder had the largest lengths ranging from 106 to 630 mm. All distributions show a single mode, indicating one cohort. It is possible to interpret the scup length distribution as bimodal, with one mode occurring from 0 to 150 mm and a second from 170 to 300 mm. However, only 67 fish out of a total 1,187 occur in the second mode.

Figure 9 presents an annual weight summary for the five commercially important species. Overall, summer flounder had the greatest total weight of 112.3 kilograms. The weight of summer flounder landed is nearly twice the weight of winter flounder (68.9 kg), five times greater than scup (21.5 kg), 15 times greater than butterfish (7.4 kg) and 40 times greater than bluefish (2.8 kg). A monthly comparison of weight estimates indicates that winter flounder weight was highest during spring/winter, while summer flounder weight was greater during fall and summer (Figure 10). The weights of scup, butterfish and bluefish are minimal compared to winter and summer flounders. Table 8 summarizes the monthly weight of these five species as a mean weight (g) per fish. Summer flounder consistently had a higher average weight each month than all other species. The maximum average weight for summer flounder occurred in July 1999

(1,733 g/fish) and April 2000 (1,625 g/fish), indicating when the largest summer flounder were collected. These average weights are 2-5 times higher than at other times of the year. Scup had a much lower average weight during the fall than in spring and summer. This could indicate a new cohort entering the fishery and is further discussed in the age and growth section of this report. In months that fish were collected, August recorded the lowest overall average weights.

Spatial Analysis

Spatial analysis of the data was performed to determine if there were trends in an east-west direction and/or along depth contours. The monthly mean number of fishes and species was plotted against depth in Figure 11. In general, there appears to be a slightly increasing trend in fish abundance with depth (r^2=0.56). A positive relationship is shown for an increasing number of species along deeper contours, although the correlation is not strong (r^2=0.44). Transects A, B, C, and D were combined for each depth contour and the average number of fishes and species were calculated (Figure 12). Similarly to Figure 11, there appears to be a slightly increasing trend in both the abundance of fishes and the number of species with increasing depth. Correlation coefficient values (r^2) for mean numbers of fishes and species are 0.69 and 0.98, respectively. This analysis indicates that the number of fishes and the number of different species is higher along the 50 and 60 ft. contours than the 30 and 40 ft. contours.

A similar analysis was conducted to examine trends in an east-west direction and possible influences of the Shinnecock inlet. In this case, the more easterly transects are farthest from the inlet. Figure 13 shows the mean number of fishes and species plotted for each transect from west to east. There is a slightly increasing trend in the number of fishes toward the eastern transects, r^2=0.63. However, the same does not occur for species diversity. The mean number of species fluctuates randomly in a west-to-east direction, r^2=0.06. Averages were calculated for each transect and the results are shown in Figure 14. Similarly to Figure 14, the abundance of fishes increases slightly from west to east, while the number of species shows no correlation. Values of r^2 for mean number of fishes and species are 0.46 and 0.02, respectively. These results indicate an increasing number of fishes toward the east, away from the inlet. However, the diversity of species does not exhibit any trend in transects located east of the inlet.

A general analysis of the data shows that finfish abundance was highest at station T60D (4792 fishes) and lowest at station T30B (1,278 fishes) (Figure 15). Species diversity was highest at two stations, T60C and T50D (mean number of species=11) (Figure 16). Station T30B had the lowest mean number of species (7). Station T30B is also where the least number of fishes were collected.

b) Macroinvertebrates

Abundance and Diversity

Macroinvertebrates collected in the otter trawls were sorted and counted prior to being returned to the water. As a commercially important, free-swimming species, longfin squid lengths and weights were recorded. Longfin squid egg masses were recorded as either present or absent. Table 9 presents a summary of the trawl catch by taxa, monthly total, total catch and percent composition. A total of 41,871 invertebrates were collected in the trawls, representing 22 species, including squid egg masses. Table 3 lists both the common and scientific names for all macroinvertebrate species collected.

The numerically dominant species collected was the sand dollar. The 22,157 sand dollars collected represented 53 percent of the total catch. The second most abundant species was the longfin squid, comprising 25 percent of the catch. The next most abundant seven species (New England dog whelk, northern moonsnail, lady crab, sand shrimp, rock crab, longwrist hermit crab and boreal red shrimp) constituted merely 1 to 5 percent of the catch. The remaining species were less than 1 percent of the catch. Figure 17 shows the percent composition of the dominant invertebrate species. Sand dollar and longfin squid represent over 75 percent of the total catch.

Figure 18 shows the total monthly catch of macroinvertebrates in the trawls. The greatest number of invertebrates (8,954 organisms) was collected during August. This number is nearly twice the amount collected in the next highest month (November = 5,505). The least number of invertebrates were collected during May 1999 and April 2000 (754 and 709, respectively). Interestingly, in April 1999 there were 3,051 invertebrates collected, 4 times higher than the catch in April 2000. Sand dollars dominated the catch in nearly all months. During August, longfin squid was the dominant species. In March, the New England dog whelk was most abundant. Total abundances for each species are plotted in Figure 19.

Spatial Analysis

Spatial analysis of invertebrate data was performed to observe trends along depth contours and in a west-to-east direction. Figure 20 shows the total number of macroinvertebrates plotted against depth. The data suggests a strong correlation for increasing numbers of macroinvertebrates with increasing depth, r^2=0.74. Figure 20 shows an increase in organisms at stations along the 50 and 60 ft. contours. Therefore, a t-test was performed to see if the difference in macroinvertebrate abundances at the 50 and 60 ft. contours were significantly different from abundances at the 30 and 40 ft. contours. The test proved highly significant, with a T-value of 5.732 and a P-value of 0.00005. The number of macroinvertebrates was plotted along transects to look for differences from west-to-east (Figure 21). The data was highly variable with an r^2 of 0.08; there appears to be no correlation.

Longfin Squid

A length frequency distribution for longfin squid is shown in Figure 22. Mean mantle lengths ranged from 5 to 250 mm. Nearly all of the squid collected were less than 100 mm in length and most ranged from 5 through 40 mm. The small sizes indicate the presence of a newly hatched year class. Longfin squid monthly weight and length are plotted in Figure 23. The average length of squid was highest in April and steadily decreased through summer and fall. During the winter months average length increased. During October, the largest weight of squid was caught (5,460 g). The second greatest weight of squid was collected in July (4,370 g). During February and March no squid were collected in the trawls, and only one squid was collected in April 2000.

To observe spatial trends in longfin squid biomass, the mean monthly weight was plotted for each station. Figure 24 shows weight plotted along depth contours (A) and along transects (B). The weight of squid collected appears to steadily increase with increasing depth (r^2=0.91). A t-test was performed to look for differences between the 30-40 foot contours and the 50-60 foot contours. The results of the t-test indicate a highly significant difference between the two areas; T-value=7.39, P value=3 x 10^{-6}. The graph representing weight along transects heading in a west-to-east direction shows no relationship, r^2=0.08.

Because this area is considered to be an important spawning ground for squid, egg masses were also counted at each site. The only time egg masses were collected was during August. A total of eight squid egg masses were collected at stations along the 50 and 60-foot contours. Additionally, five shortfin squid were collected along the 50 and 60-foot contours in December.

Atlantic Surfclam

Although they were not collected in significant numbers, Atlantic surfclams were caught each month (except August and April 2000) along transect A at the 30 and 40 foot depth contours. Additionally, surfclams were collected at station T30A all months except August, March and April 2000. This is significant because the Atlantic surfclam is an important commercial species and the consistency of their presence at this station and along this transect is noteworthy. It is important to note, however, that samples were collected with a bottom trawl which is not the appropriate gear for collecting clams.

2. Benthic Resources Assessment Technique (BRAT)

a. Stomach Content Analysis

Stomach contents were examined for the following six species of finfish: black sea bass, scup, striped bass, summer flounder, weakfish and winter flounder. Length frequency distributions for these six species are shown in Figure 25. Sample sizes are denoted by 'n' in Figure 25. A subsample of the total number of fishes were analyzed for stomach contents (refer to methods section). Black sea bass were the smallest in size, while winter flounder, summer flounder and striped bass were the largest. Relatively few striped bass and weakfish were collected throughout the year, approximately 30 for each species. Organisms collected from fish stomachs were identified to species level and grouped by phylum (Table 10). Table 10 also shows the total number of guts examined for prey contents and the actual number of empty versus full stomachs.

Total weight of prey in fish stomachs is shown in Figure 26. Arthropods were found in the stomachs of all six species. Arthropods were the primary component of weight in all species stomachs except summer flounder, where vertebrates dominated the composition of prey items. It is important to note that most arthropods have a hard, chitinous exoskeleton while some echinoderms have a calcareous test (e.g. sand dollars); both of which contribute to most of their weight. Therefore, it is important to consider this factor when analyzing weight data. Annelids were found in all species stomachs except striped bass. Winter and summer flounder stomachs contained the greatest diversity of prey organisms.

A monthly analysis of prey as a percent of total weight is plotted in Figure 27. Prey was found in fish stomachs most frequently from April through October for all species except striped bass. Striped bass catches were low, only one was caught in October (empty stomach) and 28 in April 2000. Winter flounder was the only species collected in February and March. It was the only species taken with prey in its guts during those months. Prey in the stomachs of black sea bass, scup, winter flounder and striped bass was dominated by arthropods for all but two months. The primary prey item in weakfish and summer flounder stomachs was vertebrates for all but one month. Stomach contents were examined on a species by species basis for the entire year combined (Figure 28). Arthropoda was the dominant taxon in the guts for all species except summer flounder. Vertebrata comprised the greatest percentage of weight in summer flounder stomachs and nearly half the weight in weakfish.

Prey was analyzed as a percent of the frequency with which it occurs in the fish stomach (i.e. the number of stomachs a prey item is either present or absent). In this type of analysis, the weight of the organism is not a factor. Figure 29 shows the percent frequency of occurrence for the six fish species sampled in this study. Arthropods occurred in most stomachs for black sea bass, scup, winter flounder, striped bass and weakfish. Vertebrates were in the greatest percentage of summer flounder stomachs. Analysis of percent frequency on a monthly basis is illustrated in Figure 30. Again, arthropods were the dominant taxon each month for all species except summer flounder where vertebrates dominated. All species (with the exception of striped bass) had a high percentage of vertebrates in their stomachs each month. The occurrence of annelids was sporadic. When annelids were present, however, they appeared in high numbers. The dominant arthropod noted was the amphipod *Gammarus*. The sandlance (*Ammodytes* sp.), was the dominant vertebrate noted. Siphons of the Atlantic surfclam, *Spisula solidissima*, were the most abundant mollusc.

Due to the difficulty in ascertaining where fishes from this study actually forage, it can only be tentatively concluded that they feed within the sampled area. This result is plausible since the prey organisms found in the guts are those commonly found in this region of the field. However, there is uncertainty regarding the distances fishes will travel to feed. It is likely that these species will experience separate prey fields dependent on different forage areas. Many of the species collected in this study will migrate to connected bay areas to feed. For example, flounders had the most diverse array of organisms in their stomachs. This could be attributed to the fact that they are experiencing a different prey field, by migrating to a protected bay area. It is unclear if the difference in their diet was due to selection or availability.

b. Age and Growth

Of the six species analyzed, scales and otoliths were collected from more than 400 fishes. Figure 31 shows the age frequency distribution for black sea bass, scup, winter flounder, weakfish, summer flounder and striped bass. Tautog and bluefish were also part of the study, however, no tautog were collected and all bluefish were young-of-the-year. Therefore, tautog and bluefish were excluded from the analyses. Of the six species analyzed, summer flounder was the only species with fishes older than 4 years. Sixty-six percent of the fishes collected were less than 3 years old while eighty-three percent were younger than 4 years; all were less than 7 years old. A monthly analysis of age distribution is shown in Figure 32. Weakfish was the only species that was consistently collected in the age 0 group. Throughout the year, black sea bass, scup and striped bass were primarily in the age 0-1 class except during spring and fall when older fishes were collected. Summer flounder ages primarily varied from 3 to 4 throughout the year, except in February and March when only age 0 fishes were collected. Winter flounder ages were close to 2 years for most of the year except during summer when age 0-1 class fishes were collected.

Table 11 shows the number of fishes for each age class and the range of their total lengths. Summer flounder and striped bass had the largest mean total length per age class. Black sea bass were the smallest for each age class. Figure 33 is a plot of total length versus age. A regression equation has been calculated to give yearly growth rates. Growth rates for each species are as follows: Black sea bass = 96 mm/yr, scup = 63 mm/yr, winter flounder = 60 mm/yr, weakfish = 48 mm/yr, summer flounder = 58 mm/yr and striped bass = 139 mm/yr. Weakfish has the lowest growth rate (48 mm/yr), while striped bass has the highest (139 mm/yr).

The growth rate for striped bass, however, could be skewed due to the small sample size and two large fishes collected. On average, our calculations show that the fishes collected during this survey grew at a rate between 48 and 96 mm/yr. However, species-specific growth rates within and between years vary significantly. Generally, most fishes will have highest growth rates during their first year. As the fish ages, growth will stabilize to a constant rate.

The age of the fishes collected along the depth contours and transects are shown in Figure 34. In general, there does not appear to be a trend in either a west-to-east direction or along depth. Summer flounder and winter flounder were the oldest (2-4 years average) and were collected at all depths and transects. Scup were also collected along all depths and transects with ages between 0 and 2 years. Young weakfish were consistently caught along transect A and at the 30-40 ft. contours. Black sea bass and striped bass were generally less than 2 years old and had variable ages along depths and transects.

3. Mid-Water Finfish Trawl Survey

During the single sampling effort conducted in June, no finfish were caught at any of the 16 designated sampling stations. On several occasions, a small number of jellyfish were found in the cod end of the trawl.

4. Benthic Macroinvertebrate Grab Survey

Abundance, Diversity and Biomass

A total of 5,848 benthic organisms were collected in the grabs during July (approximately 167 per grab) and 1,373 during November (approximately 39 per grab) (Table 12). Species were classified into six major taxonomic groups; Rhynchocoela, Aschelminthes, Annelida, Mollusca, Arthropoda and Echinodermata. As expected, abundance of organisms was much greater in July than November (more than 4 times higher). The most abundant species noted during July and November was the worm *Polygordius triestinus*. During July and November, *P. triestinus* accounted for 77% and 26% of the total abundance, respectively. The next most abundant species taken in July were the amphipod *Protohaustorius wigleyi* (6%), an unidentified nematode (4%), and the sand dollar *Echinarachnius parma* (4%). In November, *P. wigleyi* was second most abundant (14%), followed by *E. parma* (13%) and the amphipod, *Gammarus annulatus* (12%). Similar species compositions dominated during both seasons.

Table 13 shows a list of the dominant taxa (i.e. ≥ 1% of total abundance) collected during both the July and November grab surveys. During both survey efforts (summer and fall) *P. triestinus* exceeded all other species in abundance. In general, July had fewer dominant species, however, the abundance of these species was much greater than in November. Biomass estimates for the major taxonomic groups are listed in Table 14. Biomass was dominated by echinoderms due to test weight. Molluscs contributed over 30% to the total biomass in July. In November, arthropods were second most dominant contributing over 14% to total biomass. The weight of rhynchocoels and nematodes was too small to be detected (i.e., less than 0.01 g).

<u>Comparison to Grain Size Data</u>

Sediment samples were collected for grain size and composition analyses (discussed in the following section). In general, sediment samples consisted of approximately 95% quartz sand. During November, two stations, SH-04 and SH-30, had less sand than the other sites. SH-04 and SH-30 consisted of ~ 77% sand and ~20% clay/silt. Benthic macroinvertebrate abundances were compared at these stations versus other sites. Table 15 shows the percent each taxonomic group contributed to total benthic abundance at stations 4, 30 and all combined. Although data is displayed as a percent contribution, it is important to note that abundances of organisms at stations 4 and 30 were generally low. A t-test comparing stations 4 and 30 to all stations combined indicates that there was no significant difference between the stations for both November and July. Figure 35 graphically displays the same information. Archiannelids appear to have a slightly higher abundance during November at station 4, however, they are generally a dominant taxon.

<u>Atlantic Surfclam</u>

The commercially important Atlantic surfclam, *Spisula solidissima*, was present in the Shinnecock borrow area. Abundances of the surfclam were low. Only 25 surfclams were collected in July (0.4% of total abundance) and 22 in November (1.6% of total abundance). No adult surfclams were collected in any of the samples. Surfclams were collected throughout the borrow area. They did not appear to be concentrated at specific sample locations.

B. <u>Physical Studies</u>

1. Water Quality

a) Trawl Surveys

A survey of water quality parameters was conducted at the beginning and end of each trawl during the study. Water quality parameters measured in conjunction with ecological sampling included temperature, dissolved oxygen (DO), pH, conductivity, and light transmission (measured with a Secchi disk). Table 16 presents mean monthly readings for demersal and mid-water fisheries trawls and benthic grab surveys. Demersal fish trawl readings cover the entire one-year period. The mid-water fish trawl survey was conducted during June only. Surface and bottom readings were recorded for all parameters measured, except light transmission.

Mean values of surface and bottom waters recorded during the mid-water trawl were not significantly different. Mean surface water temperature was 16.9°C and 16.2°C on the bottom. Salinity measurements averaged 31.5 ppt. throughout the water column. Mean dissolved oxygen was 8.40 mg/l (bottom) and 8.60 mg/l (surface). Mean light transmission was 3.9 meters. Mean conductivity was 40.72 mS/cm on the surface and 40.60 mS/cm on the bottom. Mean surface and bottom pH was 8.6.

Surface and bottom values for all environmental parameters recorded during the demersal trawls were similar (Figure 36). Temperature increased steadily from spring through summer and began decreasing in the fall to a low in February. Mean temperatures varied from a bottom low of 3.5°C (February) to a surface high of 21.1°C (September). Salinity remained fairly constant throughout the year (28.9-33.1 ppt) except in May when it dropped to a mean low of 28.9 ppt at the surface and 29.1 ppt on the bottom. Mean dissolved oxygen values ranged from a surface high of 10.18 mg/l in February to a low bottom value of 5.42 mg/l in November. Light transmission ranged from a low of 2.1 meters (April 00) to a high of 5.9 meters (April 99). Conductivity ranged from a mean high surface value of 45.83 mS/cm in September to a low bottom value of 30.27 mS/cm (February). Mean pH was constant throughout the year (~8).

Spatial Analysis

A spatial analysis on the data was performed to look for differences between transects and along depth contours. A t-test was performed on all variables to determine if there was a difference between surface and bottom water values. Surface and bottom water values were similar for all water quality parameters except temperature and dissolved oxygen. Therefore, a mean was calculated for those parameters proven to have similar surface and bottom values (i.e. salinity, conductivity and pH). Temperature and dissolved oxygen for surface and bottom waters were analyzed separately. Figure 37 shows the mean values for water quality parameters along depth contours. No trend in the data is apparent. The light transmission at station T40D appears to spike, however, it is unclear as to why this occurred. Figure 38 shows the water quality readings in a west-to-east direction. All variables remain consistent, except for the Secchi disk light transmission readings that fluctuate randomly. Generally, the water variables appear to be uniform in this borrow area.

b) Benthic Grab Surveys

A survey of water quality was conducted during July and November as part of the benthic grab survey. Water quality was measured at every other set of sample stations due to the proximity of each station. Water quality parameters were measured at the bottom of the water column during this effort. Mean values for water quality parameters are reported in Table 16.

Water temperatures for July and November were 16.8°C and 12.5°C, respectively. Salinity, conductivity, dissolved oxygen and pH were not significantly different for the two seasons.

2. Sediment Analysis

Sediment samples were classified by percent as gravel, sand, clay and silt. Results from the July and November analyses are presented in Table17. Seventy samples were analyzed (35 from July and 35 from November). With the exception of three samples, all had greater than 90% sand, with most containing 95% sand or more. The mean percentage of sand in the July samples was 97% and for November, 96%. The three stations with less than 90% quartz based sand were: SH-04 (77%), SH-30 (77%) and SH-34 (89%). Animal composition at these stations was compared to other stations to assess differences. No differences between stations were noted. In general, the Shinnecock borrow area appears to have similar sediment composition for during July and November. Samples were primarily composed of sand with some clay and silt at every station. The presence of gravel was minimal; approximately half of the stations had no gravel. As mentioned previously, stations with a lower percentage of sand were analyzed for species abundances; no significant difference was found in species abundance at these stations.

IV. COMPARISON TO OTHER STUDIES

A. Fisheries

During 1995 and 1996 the U.S. Army Corps of Engineers New York District conducted fisheries studies for potential borrow areas offshore of New Jersey employing similar gear types as utilized in the present program. The data was reported for spring and fall seasons. For comparison, the New Jersey data is presented in Figure 39. Herring was the dominant species in the New Jersey program, comprising approximately half of the catch. Hake, winter flounder, American sand lance and windowpane contributed the next highest percentages. In the present study, butterfish was the dominant species. However, few butterfish were found in the New Jersey study in 1995 and none in 1996. Figure 40 shows a similar representation for the top species in this survey. Clearly, butterfish, scup and bay anchovy dominate overall catches. Although they appear in the USACE survey in 1995, butterfish and scup either do not occur in 1996 or occur in such small numbers that they are lumped into the 'other' category. Spring and fall catches off the Atlantic coast of Long Island (this study) were dominated by skates, hakes, scup, windowpane, bay anchovy, and striped searobin.

In general, the fisheries community structure for the two areas is comparable in that similar species were found. Species abundance, however, varies greatly. Species diversity appeared similar for the two studies with approximately 40 species found in both studies. Results from the New Jersey study established seasonal and yearly trends in species composition and diversity. A similar observation was made in this study, where an obvious seasonal difference was noted.

B. Benthic Invertebrates

During June and November of 1998, B. Vittor and Associates Inc. performed a benthic macroinvertebrate assessment of the Shinnecock borrow area. Species composition was similar to the findings of this study with polychaetes dominating the catch. This study found *Polygordius triestinus* was the dominant species during both July and November. Vittor and Assoc. found *P. triestinus* dominated in October and *Scolelepis squamata* in June. Vittor and Assoc. (1998) also found their highest abundance occurred in October (5,875 organisms compared to 1,773 in June). During this study, the opposite seasonal trend occurred where a total of 5,848 organisms were collected in July, versus 1,373 in November.

Additional studies conducted by Cerrato (1983) and RMC Environmental (1996) did not report the presence of *P. triestinus*. This is most likely due to the size of the sieve used in the analysis. Currently, EEA uses a 0.5 mm mesh sieve while earlier programs used a 1.0 mm sieve. Cerrato's study found amphipods to be the dominant organism during both the spring and fall followed by polychaetes and bivalves.

V. CONCLUSIONS

A. Fisheries

Temporal and spatial analyses of the data demonstrate a strong seasonal link in community assemblages. Additionally, a possible trend is apparent along depth contours. Seasonally, abundance and species diversity peaked during the summer and fall primarily in August and September. Butterfish was the dominant species collected over the entire year, constituting one third of the total catch. This is primarily due to an extremely large catch in August, as butterfish were not collected during all months. Winter and little skates dominated the monthly catches, however, their total abundances did not exceed butterfish for the whole year. Other species of relative importance in abundance were: scup, bay anchovy, little skate, spotted hake and winter skate. These species along with windowpane, red hake, striped searobin, and silver hake constitute approximately 95% of the total catch.

Total weights of all finfish species combined peaked in April 2000 and was at a low in February. Weight was dominated by little skate, winter skate, summer flounder, and winter flounder. Combined they account for over ninety percent of the total weight. On a monthly basis, little skate always had the highest weight.

Due to their commercial importance, five finfish species were analyzed separately:

butterfish, bluefish, scup, winter flounder, and summer flounder. Length frequency analyses determined that each species was likely from one cohort. By weight, winter flounder and summer flounder dominated catches of the five aforementioned species. Winter flounder contributed most to weight during the spring and winter, while summer flounder contributed most during summer and fall. Monthly weight estimates were dominated by summer flounder for all months. All species exhibited low weights in August.

CPUE values peaked in August and September, while lowest values occured in February. CPUE was highest for the following species: butterfish, scup, bay anchovy, little skate, and spotted hake. Monthly CPUE values were highest for little skate. Additionally, CPUE values were highest along the 50 and 60 ft. contours. Fish abundance and species diversity also tended to increase as the station depth increased. Fish abundance was highest at station T60D and lowest at T30B. Species diversity was highest at stations T60C and T50D. Species diversity was lowest at station T30B.

BRAT analysis was performed on the following six commercially important species: black sea bass, scup, striped bass, summer flounder, weakfish and winter flounder. The amphipod, *Gammarus* sp., was the dominant prey taxon in most fish stomachs. Fish remains were the dominant prey items in summer flounder stomachs. Winter and summer flounder stomachs contained the greatest diversity of organisms.

Finfish community composition is similar to the study conducted by the USACE New York District off of the New Jersey coast between Asbury Park and Manasquan Inlet. Temporal and spatial differences in fisheries composition have been noted..

B. Benthic Invertebrates

The results of the July/November sampling effort indicate that the offshore zone of the Shinnecock borrow area supports infaunal assemblages typical of a high energy environment. These results are reasonably consistent with earlier programs given the inherent variability of biological organisms over time and distance. Benthic macroinvertebrates were dominated by the sand dollar, constituting 53% of the total catch. The second most abundant species was the longfin squid, comprising 25% of the total catch. Other abundant species include: New England dog whelk, northern moonsnail, lady crab, sand shrimp, rock crab, longwrist hermit crab, and boreal red shrimp. Catches of benthic macroinvertebrates peaked in August. The least number of invertebrates were collected in May 99 and April 00. Similar to the finfish data, there appears to be a positive correlation between species abundance and depth.

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TABLE 1
LIST OF FISH SPECIES COLLECTED IN BOTTOM TRAWLS
APRIL 1999 THROUGH APRIL 2000

COMMON NAME	SCIENTIFIC NAME
ALEWIFE	*Alosa pseudoharengus*
AMERICAN EEL	*Anguilla rostrata*
AMERICAN SHAD	*Alosa sapidissima*
ATLANTIC COD	*Gadus morhua*
ATLANTIC HERRING	*Clupea harengus*
ATLANTIC MACKEREL	*Scomber scombrus*
ATLANTIC MENHADEN	*Brevoortia tyrannus*
ATLANTIC MOONFISH	*Selene setapinnis*
ATLANTIC SILVERSIDE	*Menidia menidia*
ATLANTIC STURGEON	*Acipenser oxyrhynchus*
ATLANTIC TORPEDO	*Torpedo nobiliana*
BAY ANCHOVY	*Anchoa mitchilli*
BIGEYE	*Priacanthus arenatus*
BLACK SEA BASS	*Centropristis striata*
BLUEBACK HERRING	*Alosa aestivalis*
BLUEFISH	*Pomatomus saltatrix*
BLUESPOTTED CORNETFISH	*Fistularia tabacaria*
BUTTERFISH	*Peprilus triacanthus*
CLEARNOSE SKATE	*Raja eglanteria*
CONGER EEL	*Conger oceanicus*
CUNNER	*Tautogolabrus adspersus*
FAWN CUSK-EEL	*Lepophidium profundorum*
FLYING GURNARD	*Dactylopterus volitans*
FOURSPOT FLOUNDER	*Paralichthys oblongus*
GOOSEFISH	*Lophius americanus*
HICKORY SHAD	*Alosa mediocris*
INQUILINE SNAILFISH	*Liparis inquilinus*
INSHORE LIZARDFISH	*Synodus foetens*
LITTLE SKATE	*Raja erinacea*
LONGHORN SCULPIN	*Myoxocephalus octodecemspinosus*
NORTHERN KINGFISH	*Menticirrhus saxatilis*
NORTHERN PIPEFISH	*Syngnathus fuscus*
NORTHERN PUFFER	*Sphoeroides maculatus*
SEA RAVEN	*Hemitripterus americanus*
NORTHERN SEAROBIN	*Prionotus carolinus*
OCEAN POUT	*Macrozoarces americanus*
PLANEHEAD FILEFISH	*Monacanthus hispidus*
POLLOCK	*Pollachius virens*
RED HAKE	*Urophycis chuss*
ROUGH SCAD	*Trachurus lathami*
ROUND SCAD	*Decapterus punctatus*
SCUP	*Stenotomus chrysops*
SEAHORSE	*Hippocampus erectus*
SILVER HAKE	*Merluccius bilinearis*
SMALLMOUTH FLOUNDER	*Etropus microstomus*
SMOOTH DOGFISH	*Mustelus canis*
SMOOTH PUFFER	*Lagocephalus laevigatus*
SMOOTH TRUNKFISH	*Lactophrys triqueter*
SPOTTED HAKE	*Urophycis regia*
STRIPED ANCHOVY	*Anchoa hepsetus*
STRIPED BASS	*Morone saxatilis*
STRIPED SEAROBIN	*Prionotus evolans*
SUMMER FLOUNDER	*Paralichthys dentatus*
WEAKFISH	*Cynoscion regalis*
WHITE HAKE	*Urophycis tenuis*
WINDOWPANE	*Scophthalmus aquosus*
WINTER FLOUNDER	*Pseudopleuronectes americanus*
WINTER SKATE	*Raja ocellata*

Source: Robins, C.R. and G.C. Ray. 1986. Peterson Field Guides: A Field Guide to Atlantic Coast Fishes: North America.

TABLE 2

SUMMARY OF TRAWL CATCH DATA-FISHERIES

MONTHLY TOTALS, TOTAL NUMBER, PERCENT COMPOSITION

	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	FEB.	MARCH	APRIL	TOTAL CAUGHT	PERCENT OF TOTAL
BUTTERFISH	0	68	294	39	11,422	1,760	173	3	0	0	0	0	13,759	31.67
SCUP	2	26	127	285	5,061	3,777	190	1	0	0	0	1	9,470	21.80
BAY ANCHOVY	0	72	43	5	4	3,278	584	544	369	0	0	0	4,899	11.28
LITTLE SKATE	530	362	284	361	53	214	255	254	225	56	765	1,398	4,757	10.95
SPOTTED HAKE	48	5	25	29	1	1	5	1,466	2,084	4	153	172	3,993	9.19
WINTER SKATE	71	169	66	35	13	44	61	65	71	11	413	733	1,752	4.03
WINDOWPANE	48	24	39	29	35	104	182	146	89	1	20	33	750	1.73
RED HAKE	13	0	0	0	0	1	0	104	202	0	67	275	662	1.52
STRIPED SEAROBIN	0	15	10	21	467	46	70	10	0	0	0	0	639	1.47
SILVER HAKE	40	0	1	6	6	7	28	143	249	0	0	8	488	1.12
BLUEFISH	0	0	0	0	14	228	4	0	0	0	0	0	246	0.57
WINTER FLOUNDER	80	46	0	2	0	0	2	4	27	28	18	20	227	0.52
NORTHERN SEAROBIN	32	5	24	31	81	19	14	6	0	0	1	12	225	0.52
SMALLMOUTH FLOUNDER	31	14	7	18	22	5	10	8	11	2	14	34	176	0.41
SUMMER FLOUNDER	24	19	14	9	28	24	24	20	6	0	0	3	171	0.39
NORTHERN PUFFER	0	0	0	0	10	74	50	7	0	0	0	0	141	0.32
ATLANTIC HERRING	1	23	2	95	0	0	0	0	2	0	5	2	130	0.30
STRIPED ANCHOVY	0	0	0	0	0	1	0	0	0	109	0	0	110	0.25
ATLANTIC MOONFISH	0	0	0	0	62	2	16	22	0	0	0	0	102	0.23
NORTHERN KINGFISH	0	1	0	0	0	5	46	37	9	0	0	0	98	0.23
NORTHERN PIPEFISH	0	0	0	0	1	0	0	18	0	1	33	17	70	0.16
BLACK SEA BASS	16	2	2	5	0	1	10	0	0	0	0	32	68	0.16
ALEWIFE	0	3	0	0	0	0	0	0	12	0	2	49	66	0.15
UROPHYCIS SP.	4	32	5	2	0	0	8	0	0	0	0	4	55	0.13
WEAKFISH	0	0	0	0	1	14	13	11	15	0	0	0	54	0.12
SEAHORSE	0	0	0	0	1	1	10	36	0	0	1	5	54	0.12
ATLANTIC MENHADEN	0	0	0	0	25	5	0	0	13	5	0	5	53	0.12
ROUND SCAD	0	0	0	0	23	2	27	0	0	0	0	0	52	0.12
STRIPED BASS	0	0	0	0	0	0	1	0	0	0	0	28	29	0.07
ATLANTIC COD	12	4	0	0	1	0	0	0	0	0	0	0	17	0.04
CLEARNOSE SKATE	0	0	5	0	2	5	0	0	0	0	1	1	14	0.03
INSHORE LIZARDFISH	0	0	0	0	5	2	6	0	0	0	0	0	13	0.03
ATLANTIC SILVERSIDE	0	0	0	0	0	0	0	0	0	0	9	2	11	0.03
FOURSPOT FLOUNDER	1	1	0	1	2	0	1	0	0	0	0	3	9	0.02
BLUESPOTTED CORNETFISH	0	0	0	0	1	6	1	0	0	0	0	0	8	0.02
ATLANTIC MACKEREL	3	0	0	0	0	0	0	0	4	0	0	0	7	0.02
OCEAN POUT	6	0	0	0	0	0	0	0	1	0	0	0	7	0.02
SMOOTH DOGFISH	0	1	3	0	1	1	0	0	0	0	0	0	6	0.01

TABLE 2 (continued)

SUMMARY OF TRAWL CATCH DATA-FISHERIES

MONTHLY TOTALS, TOTAL NUMBER, PERCENT COMPOSITION

	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	FEB.	MARCH	APRIL	TOTAL CAUGHT	PERCENT OF TOTAL
AMERICAN SHAD	1	0	1	0	0	0	0	0	1	0	3	0	6	0.01
LONGHORN SCULPIN	0	0	0	0	0	0	0	0	4	0	0	1	5	0.01
GOOSEFISH	3	0	1	0	0	0	0	0	0	0	0	0	4	0.01
BIGEYE	0	0	0	0	3	1	0	0	0	0	0	0	4	0.01
PLANEHEAD FILEFISH	0	0	0	0	1	0	3	0	0	0	0	0	4	0.01
SEA RAVEN	0	0	0	0	0	0	0	0	2	0	1	1	4	0.01
GADIDAE	0	0	0	0	0	0	0	0	0	0	0	4	4	0.01
FLYING GURNARD	0	0	0	0	2	1	0	0	0	0	0	0	3	0.01
BLUEBACK HERRING	0	0	1	0	0	0	0	0	0	2	0	0	3	0.01
INQUILINE SNAILFISH	0	0	0	0	0	0	0	0	2	1	0	0	3	0.01
POLLOCK	0	1	0	0	0	0	0	0	0	0	2	0	3	0.01
PRIONOTUS SP.	0	0	0	0	0	0	1	1	0	0	0	0	2	<0.01
CUNNER	0	0	0	0	0	0	0	1	1	0	0	0	2	<0.01
FAWN CUSKEEL	0	0	0	0	0	0	0	0	0	0	0	2	2	<0.01
WHITE HAKE	1	0	0	0	0	0	0	0	0	0	0	0	1	<0.01
ATLANTIC TORPEDO	0	0	1	0	0	0	0	0	0	0	0	0	1	<0.01
ATLANTIC STURGEON	0	0	1	0	0	0	0	0	0	0	0	0	1	<0.01
CONGER EEL	0	0	0	1	0	0	0	0	0	0	0	0	1	<0.01
ROUGH SCAD	0	0	0	0	0	0	1	0	0	0	0	0	1	<0.01
SMOOTH PUFFER	0	0	0	0	0	0	1	0	0	0	0	0	1	<0.01
SMOOTH TRUNKFISH	0	0	0	0	0	0	0	1		0	0	0	1	<0.01
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0	1	1	<0.01
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0	1	1	<0.01
MONTHLY TOTALS	**967**	**893**	**956**	**974**	**17,348**	**9,629**	**1,797**	**2,908**	**3,399**	**220**	**1,508**	**2,847**	**43,446**	

*Note: Finfish listed by common name, with the exception of *Urophycis* sp. and *Prionotus* sp. (genus) and Gadidae (family).

TABLE 3
LIST OF BENTHIC MACROINVERTEBRATE SPECIES COLLECTED IN BOTTOM TRAWLS APRIL 1999 THROUGH APRIL 2000

ACADIAN HERMIT CRAB	*Pagurus acadianus*
LONGGFIN SQUID	*Loligo pealei*
ATLANTIC SURFCLAM	*Spisula solidissima*
BLUE CRAB	*Callinectes sapidus*
BOREAL RED SHRIMP	*Pandalus propinquus*
FLATCLAW HERMIT CRAB	*Pagurus pollicaris*
HORSESHOE CRAB	*Limulus polyphemus*
LADY CRAB	*Ovalipes ocellatus*
LOBED MOONSNAIL	*Neverita duplicata*
LONGWRIST HERMIT CRAB	*Pagurus longicarpus*
NEW ENGLAND DOG WHELK	*Ilyanassa trivittata*
NORTHERN MOONSNAIL	*Euspira heros*
OCTOPUS	*Octopus vulgaris*
ROCK CRAB	*Cancer irroratus*
SAND DOLLAR	*Echinarachnius parma*
SAND SHRIMP	*Crangon septemspinosa*
SEA SCALLOP	*Placopecten magellanicus*
SHORTFIN SQUID	*Illex illecebrosus*
SMOOTH ASTARTE	*Astarte castanea*
SOUTHERN BLUE CLAW CRAB	*Calinectes similis*
SPIDER CRAB	*Libinia emarginata*
STARFISH	*Asterias forbesi*

Source: Weiss, H.M. 1995. Marine Animals of Southern New England and New York: Identification Keys to Common Nearshore and Shallow Water Macrofauna.

TABLE 4
RANK ABUNDANCE OF FISH SPECIES BY YEAR AND SEASON

	Yearly		Spring	Summer	Fall	Winter
BUTTERFISH	1		3	1	9	-
SCUP	2		6	2	8	-
BAY ANCHOVY	3		9	3	2	-
LITTLE SKATE	4		1	4	3	1
SPOTTED HAKE	5		5	15	1	3
WINTER SKATE	6		2	10	7	2
WINDOWPANE	7		8	7	5	8
RED HAKE	8		4	26	6	5
STRIPED SEAROBIN	9		17	5	11	-
SILVER HAKE	10		14	18	4	-
BLUEFISH	11		-	6	27	-
WINTER FLOUNDER	12		7	25	17	6
NORTHERN SEAROBIN	13		11	8	20	14
SMALLMOUTH FLOUNDER	14		10	14	18	9
SUMMER FLOUNDER	15		12	13	13	-
NORTHERN PUFFER	16		-	11	12	-
ATLANTIC HERRING	17		16	9	29	11
STRIPED ANCHOVY	18		-	26	-	4
ATLANTIC MOONFISH	19		-	12	16	-
NORTHERN KINGFISH	20		25	22	10	-
NORTHERN PIPEFISH	21		18	26	21	7
BLACK SEA BASS	22		13	21	24	-
ALEWIFE	23		13	-	23	13
UROPHYCIS SP.	24		15	25	25	-
WEAKFISH	25		-	19	15	-
SEAHORSE	25		21	25	14	14
ATLANTIC MENHADEN	26		21	16	22	11
ROUND SCAD	27		-	17	19	-
STRIPED BASS	28		16	-	30	-
ATLANTIC COD	29		19	26	-	-
CLEARNOSE SKATE	30		20	20	-	14
INSHORE LIZARDFISH	31		-	20	26	-
ATLANTIC SILVERSIDE	32		24	-	-	10
FOURSPOT FLOUNDER	33		21	24	30	-
BLUESPOTTED CORNETFISH	34		-	20	30	-
ATLANTIC MACKEREL	35		23	-	27	-
OCEAN POUT	35		20	-	30	-
SMOOTH DOGFISH	36		22	25	-	-
AMERICAN SHAD	36		24	-	30	12
LONGHORN SCULPIN	37		25	-	27	-
GOOSEFISH	38		22	-	-	-
BIGEYE	38		-	23	-	-
PLANEHEAD FILEFISH	38		-	26	28	-
SEA RAVEN	38		25	-	29	14
GADIDAE	38		22	-	-	-
FLYING GURNARD	39		-	24	-	-
BLUEBACK HERRING	39		25	-	-	13
INQUILINE SNAILFISH	39		-	-	29	14
POLLOCK	39		25	-	-	13
PRIONOTUS SP.	40		-	-	29	-
CUNNER	40		-	-	29	-
FAWN CUSKEEL	40		24	-	-	-
WHITE HAKE	41		25	-	-	-
ATLANTIC TORPEDO	41		25	-	-	-
ATLANTIC STURGEON	41		25	-	-	-
CONGER EEL	41		-	26	-	-
ROUGH SCAD	41		-	-	30	-
SMOOTH PUFFER	41		-	-	30	-
SMOOTH TRUNKFISH	41		-	-	30	-
AMERICAN EEL	41		25	-	-	-
HICKORY SHAD	41		25	-	-	-

TABLE 5
Fisheries Trawl Data
Total Weight (kilograms) By Month For All Species Collected

	April-99	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Feb.	March	April-00	*Species Totals*	*Percent of Total*
Little Skate	118.75	116.90	97.65	88.36	25.81	102.30	94.95	110.58	89.39	31.43	146.90	185.86	1,208.88	52.61
Winter Skate	36.57	93.60	68.33	25.66	5.30	21.71	36.70	42.30	52.00	5.27	55.64	97.90	540.98	23.54
Windowpane	6.65	5.33	7.73	5.75	9.68	25.60	36.63	30.69	24.75	0.01	4.28	10.72	167.82	7.30
Summer Flounder	17.20	8.55	8.45	7.21	15.60	17.14	15.35	15.54	4.10			3.25	112.39	4.89
Winter Flounder	25.46	15.60		0.37			0.56	1.64	7.42	9.55	4.28	4.05	68.92	3.00
Striped Searobin		4.27	1.78	1.18	3.60	4.53	12.07	2.64					30.07	1.31
Scup	0.40	2.00	5.09	7.17	0.19	1.29	4.74	0.35					21.21	0.92
Clearnose Skate			4.95		5.10	6.50					0.30		16.85	0.73
Atlantic Torpedo			15.00										15.00	0.65
Northern Searobin	0.52	0.52	1.05	1.37	4.68	1.75	1.60	0.02				1.74	13.23	0.58
Striped Bass							3.00					9.07	12.07	0.53
Spotted Hake	0.26	0.05	0.08	1.27	0.10	0.20	1.21	2.32	1.95	0.03	1.32	1.29	10.04	0.44
Red Hake	2.55					0.01		1.07	3.60		0.53	2.28	10.03	0.44
Northern Kingfish		0.15				0.16	4.54	4.23	0.91				9.98	0.43
Butterfish		1.16	0.43	0.25	0.66	3.34	1.64						7.48	0.33
Ocean Pout	5.65								0.41				6.06	0.26
Smooth Dogfish		0.29	2.95		0.65	1.80							5.69	0.25
Weakfish					0.03	1.03	1.20	0.41	0.83				3.50	0.15
Alewife		0.16							0.18			2.96	3.30	0.14
Atlantic Sturgeon			3.00										3.00	0.13
Northern Puffer					0.13	1.56	0.95	0.29					2.93	0.13
Bluefish					0.03	2.72	0.07						2.82	0.12
Sea Raven									1.20		0.55	0.80	2.55	0.11
Atlantic Mackerel	1.50								0.97				2.47	0.11
Black Sea Bass	1.00	0.06	0.04	0.10		0.15	0.04					0.83	2.20	0.10
Goosefish	2.13		0.01										2.14	0.09
Silver Hake	0.24		0.01	0.14	0.01	0.03	0.06	0.70	0.78				1.95	0.09
American Shad	1.20		0.45						0.15		0.15		1.95	0.08
Smallmouth Flounder	0.15	0.09	0.10	0.29	0.44	0.08	0.10	0.22	0.12	0.01	0.10	0.00	1.67	0.07
Longhorn Sculpin									1.05			0.37	1.42	0.06
Atlantic Herring	0.20	0.04		0.29					0.10		0.36	0.31	1.29	0.06
Atlantic Moonfish					1.20		0.02	0.02					1.24	0.05
Bay Anchovy		0.26	0.16	0.01	0.01	0.34	0.21	0.08	0.05				1.11	0.05
Fourspot Flounder	0.20	0.08		0.16	0.01		0.01					0.51	0.97	0.04
Atlantic Menhaden					0.04	0.04			0.29	0.13		0.31	0.81	0.04
Inshore Lizardfish					0.02	0.01	0.72						0.75	0.03
Fawn Cusk-eel												0.73	0.73	0.03
Striped Anchovy						0.01				0.57			0.58	0.03
Hickory Shad												0.38	0.38	0.02
Smooth Puffer							0.22						0.22	0.01
Seahorse							0.02	0.11				0.01	0.14	0.01
Northern Pipefish								0.04			0.06	0.04	0.14	0.01
Cunner								0.12					0.12	0.01
Atlantic Silverside											0.10	0.01	0.11	<0.01
Urophycis sp.	0.01	0.05	0.01				0.02					0.01	0.09	<0.01
American Eel												0.10	0.10	<0.01
Planehead Filefish					0.01		0.09						0.09	<0.01
Rough Scad					0.02		0.07						0.08	<0.01
Conger Eel				0.01									0.01	<0.01
Bluespotted Cornetfish					0.01	0.04	0.01						0.06	<0.01
Atlantic Cod	0.02	0.01								0.01			0.03	<0.01
Inquiline Snailfish													0.00	<0.01
Blueback Herring			0.01										0.01	<0.01
White Hake	0.01												0.01	<0.01
Bigeye					0.01								0.01	<0.01
Flying Gurnard					0.01								0.01	<0.01
Pollock		0.01											0.01	<0.01
Prionotus sp.													0.00	<0.01
Smooth Trunkfish													0.00	<0.01
Monthly Totals:	***220.65***	***249.15***	***217.25***	***139.57***	***73.32***	***192.32***	***216.76***	***213.34***	***190.24***	***46.99***	***214.54***	***323.50***	***2,297.63***	

TABLE 6
Summary of Trawl Catch Data
Mean Monthly CPUE by Taxa (Number of Fish per Trawl)

	April 99	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Feb.	March	April 00	Total CPUE	Mean CPUE
BUTTERFISH		4.25	18.38	2.44	713.88	110.00	10.81	0.19					860	72
SCUP	0.13	1.62	7.94	17.81	316.31	236.06	11.88	0.06				0.06	592	49
BAY ANCHOVY		4.5	2.69	0.31	0.25	204.88	36.50	34.00	23.06				306	26
LITTLE SKATE	33.13	22.63	17.75	22.56	3.31	13.88	15.94		14.63	3.5	47.81	87.38	283	24
SPOTTED HAKE	3.00	0.31	1.56	1.81	0.06	0.06	0.31	91.63	130.25	0.25	9.56	10.75	250	21
WINTER SKATE	4.44	10.56	4.13	2.19	0.81	2.75	3.81	4.06	4.44	0.69	25.81	45.81	110	9
WINDOWPANE	3.00	1.44	2.44	1.81	2.19	6.50	11.38	9.13	5.56	0.06	1.25	2.06	47	4
RED HAKE	0.81	0.06				0.06		6.50	12.63		4.19	17.19	41	3
STRIPED SEAROBIN		0.94	0.63	1.31	29.19	2.88	4.38	0.63					40	3
SILVER HAKE	2.5	0.06	0.06	0.38	0.38	0.43	1.75	8.94	15.56			0.5	31	3
BLUEFISH					0.88	14.25	0.25						15	1
WINTER FLOUNDER	5.00	2.88		0.13			0.13	0.25	1.69	1.75	1.13	1.25	14	1
NORTHERN SEAROBIN	2.00	0.31	1.50	1.94	5.06	1.18	0.88	0.38			0.06	0.75	14	1
SMALLMOUTH FLOUNDER	1.94	0.88	0.44	1.13	1.38	0.31	0.63	0.50	0.69	0.13	0.88	2.13	11	1
SUMMER FLOUNDER	1.5	1.19	0.88	0.56	1.75	1.50	1.50	1.25	0.38			0.19	11	1
NORTHERN PUFFER					0.63	4.62	3.13	0.44					9	1
ATLANTIC HERRING	0.06	1.44	0.13	5.94					0.13		0.31	0.13	8	1
STRIPED ANCHOVY						0.06				6.81			7	1
ATLANTIC MOONFISH					3.88	0.12	1.00	1.38					6	1
NORTHERN KINGFISH		0.06				0.31	2.88	2.31	0.56				6	1
NORTHERN PIPEFISH					0.06			1.13		0.06	2.06	1.06	4	<1
BLACK SEA BASS	1.00	0.13	0.13	0.31		0.06	0.63					2	4	<1
ALEWIFE		0.19							0.75		0.13	3.06	4	<1
UROPHYCIS SP.	0.25	2	0.31	0.13			0.50					0.25	3	<1
WEAKFISH					0.06	0.88	0.81	0.69	0.94				3	<1
SEAHORSE					0.06	0.06	0.63	2.25			0.06	0.31	3	<1
ATLANTIC MENHADEN					1.56	0.31			0.81	0.31		0.31	3	<1
ROUND SCAD					1.44	0.12	1.69						3	<1
STRIPED BASS							0.06					1.75	2	<1
ATLANTIC COD	0.75	0.25			0.06								1	<1
CLEARNOSE SKATE			0.31		0.13	0.31					0.06	0.06	1	<1
INSHORE LIZARDFISH					0.31	0.12	0.34						1	<1
ATLANTIC SILVERSIDE											0.56	0.13	1	<1
FOURSPOT FLOUNDER	0.06	0.06		0.06	0.13		0.06					0.19	1	<1
LONGHORN SCULPIN								0.25	0.25			0.06	1	<1
ATLANTIC MACKEREL	0.19	0.06							0.25				1	<1
BLUESPOTTED CORNETFISH					0.06	0.37	0.06						<1	<1
AMERICAN SHAD	0.06	0.06	0.06					0.06	0.06		0.19		<1	<1
OCEAN POUT	0.38								0.06				<1	<1
SMOOTH DOGFISH		0.06	0.19		0.06	0.06							<1	<1
GOOSEFISH	0.19	0.06	0.06										<1	<1
BIGEYE					0.19	0.06							<1	<1
PLANEHEAD FILEFISH					0.06		0.19						<1	<1
SEA RAVEN									0.13		0.06	0.06	<1	<1
GADIDAE												0.25	<1	<1
FLYING GURNARD					0.13	0.06							<1	<1
POLLOCK		0.06									0.13		<1	<1
BLUEBACK HERRING			0.06							0.13			<1	<1
INQUILINE SNAILFISH									0.13	0.06			<1	<1
FAWN CUSK-EEL												0.13	<1	<1
WHITE HAKE	0.06	0.06											<1	<1
PRIONOTUS SP.							0.06	0.06					<1	<1
CUNNER								0.06	0.06				<1	<1
ATLANTIC TORPEDO			0.06										<1	<1
ATLANTIC STURGEON			0.06										<1	<1
CONGER EEL				0.06									<1	<1
ROUGH SCAD							0.06						<1	<1
SMOOTH PUFFER							0.06						<1	<1
SMOOTH TRUNKFISH								0.06					<1	<1
HICKORY SHAD												0.06	<1	<1
AMERICAN EEL												0.06	<1	<1
TOTAL CPUE ALL TAXA	**60.45**	**56.12**	**59.77**	**60.88**	**1084.27**	**602.26**	**112.31**	**166.21**	**213.02**	**13.75**	**94.25**	**177.94**	2696	
MEAN CPUE ALL TAXA	**2.88**	**2.08**	**2.72**	**3.38**	**37.39**	**20.77**	**3.74**	**6.93**	**9.68**	**1.25**	**5.54**	**6.36**	75	
NUMBER OF TAXA	21	27	22	18	29	29	30	24	22	11	17	28	36	
NUMBER OF SAMPLES	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*	*16*		

TABLE 7
SUMMARY OF FINFISH TRAWL CATCH DATA
MONTHLY CPUE BY STATION
Number Fish per Trawl

	APR. 99	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	FEB.	MAR.	APR. 00	TOTAL CPUE	MEAN CPUE
T-30-A	36	48	28	96	370	301	132	57	312	0	4	82	1,466	122
T-30-B	62	33	16	28	115	466	89	90	256	2	3	27	1,187	99
T-30-C	165	27	24	14	752	590	259	91	109	4	1	50	2,086	174
T-30-D	101	56	95	14	1,083	1,180	101	224	41	8	0	5	2,908	242
T-40-A	42	41	54	94	217	90	325	49	181	14	134	190	1,431	119
T-40-B	33	43	26	106	108	132	243	23	292	27	185	219	1,437	120
T-40-C	88	42	165	94	1,274	365	39	459	312	12	111	187	3,148	262
T-40-D	132	21	33	66	1,192	110	49	299	369	19	111	374	2,775	231
T-50-A	73	97	64	60	192	735	89	39	24	16	69	381	1,839	153
T-50-B	72	18	26	182	1,803	229	53	36	159	4	263	338	3,183	265
T-50-C	12	49	9	35	2,544	530	68	72	59	15	143	64	3,600	300
T-50-D	33	40	10	38	2,173	694	182	159	150	21	295	172	3,967	331
T-60-A	48	188	331	32	142	95	65	111	188	7	33	364	1,604	134
T-60-B	12	71	28	21	1,339	589	24	743	262	26	14	125	3,254	271
T-60-C	34	61	32	17	937	962	36	218	363	29	51	161	2,901	242
T-60-D	20	61	15	51	3,107	472	43	238	322	16	91	108	4,544	379

TABLE 9

SUMMARY OF TRAWL CATCH DATA-MACROINVERTEBRATES

MONTHLY TOTALS, TOTAL NUMBER, PERCENT COMPOSITION

	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	FEB.	MAR.	APRIL	TOTAL CAUGHT	PERCENT OF TOTAL
SAND DOLLAR	2,605	226	2,582	3,413	1,215	2,568	2,362	2,440	2,280	1,688	464	314	22,157	52.92
LONGFIN SQUID	4	45	13	119	6,878	1,216	1,148	1,150	6	0	0	1	10,580	25.27
NEW ENGLAND DOG WHELK	30	112	58	125	38	22	13	197	92	675	532	194	2,088	4.99
NORTHERN MOONSNAIL	254	88	104	153	92	51	91	107	344	294	0	94	1,672	3.99
LADY CRAB	14	35	100	71	393	303	196	122	13	0	0	12	1,259	3.01
SAND SHRIMP	14	88	30	47	6	0	163	486	347	19	23	1	1,224	2.92
ROCK CRAB	30	79	63	13	41	17	49	418	44	34	14	37	839	2.00
LONGWRIST HERMIT CRAB	14	38	26	53	131	50	34	104	34	2	20	19	525	1.25
BOREAL RED SHRIMP	9	7	0	4	0	0	2	414	26	0	0	0	462	1.10
FLATCLAW HERMIT CRAB	2	12	12	49	40	76	40	40	14	5	8	20	318	0.76
ACADIAN HERMIT CRAB	34	15	14	33	12	0	0	1	6	158	32	9	314	0.75
SPIDER CRAB	17	3	2	19	88	12	3	4	2	1	0	3	154	0.37
ATLANTIC SURFCLAM	21	2	3	30	0	6	7	10	2	5	4	0	90	0.21
STARFISH	1	0	2	4	2	2	2	12	43	5	2	0	75	0.18
LOBED MOONSNAIL	0	0	0	1	0	0	0	0	0	0	60	0	61	0.15
HORSESHOE CRAB	2	3	1	2	9	4	4	0	0	2	2	5	34	0.08
SQUID EGG MASS	0	0	0	0	8	0	0	0	0	0	0	0	8	0.02
SHORTFIN SQUID	0	0	0	0	0	0	0	0	5	0	0	0	5	0.01
OCTOPUS	0	0	0	0	1	1	0	0	0	0	0	0	2	<0.01
BLUE CRAB	0	1	0	0	0	0	0	0	0	0	0	0	1	<0.01
SOUTHERN BLUE CLAW CRAB	0	0	0	0	0	0	0	0	1	0	0	0	1	<0.01
SEA SCALLOP	0	0	0	0	0	0	0	0	1	0	0	0	1	<0.01
SMOOTH ASTARTE	0	0	0	0	0	0	0	0	0	0	1	0	1	<0.01
MONTHLY TOTALS	3,051	754	3,010	4,136	8,954	4,328	4,114	5,505	3,260	2,888	1,162	709	41,871	

TABLE 10

Stomach Classification Groups for BRAT Analysis

Phylum	Groups
Vertebrata	Fish
Echinodermata	Echinoidea
Arthropoda	Amphipod, Isopod, Cumacean, Mysid, Stomatopod, Decapod
Mollusca	Bivalvia, Cephalopod
Annelida	Polychaeta
Other Phyla and Unidentifiables	Rhynchocoela, Aschelminthes, Plant Material, Unidentified Remains

Number of Guts Empty vs. Full

	Empty	Full	Total
Black Sea Bass	25	33	58
Summer Flounder	64	76	140
Scup	71	92	163
Striped Bass	2	27	29
Weakfish	8	22	30
Winter Flounder	38	101	139
Total:	*208*	*351*	*559*

TABLE 11
Mean Length for Age Class

	Age	Range TL (mm)	Mean TL (mm)	Number
BLACK SEA BASS	0	66-132	104	25
	1+	148-210	171	3
	2+	256-378	317	2
		(no fish older than 2+)		
SCUP	0	74-202	121	49
	1+	116-264	191	25
	2+	202-350	245	8
	3+	296-296	296	1
		(no fish older than 3+)		
WINTER FLOUNDER	0	55-143	123	7
	1+	116-290	220	19
	2+	178-348	278	53
	3+	290-366	327	30
	4+	352-428	381	5
		(no fish older than 4+)		
WEAKFISH	0	122-230	179	39
	1+	178-270	227	3
		(no fish older than 1+)		
SUMMER FLOUNDER	0	-	-	-
	1+	234-280	257	2
	2+	232-522	308	17
	3+	312-418	363	39
	4+	372-480	419	44
	5+	405-550	473	13
	6+	440-630	554	5
	7	616	616	1
		(no fish older than 7)		
STRIPED BASS	0	-	-	-
	1+	256-322	285	10
	2+	322-414	356	7
	3+	600-670	635	2
		(no fish older than 3+)		

TABLE 12
Total Number of Benthic Invertebrates from Grab Survey

	July	November
Mollusca		
Astarte castanea	0	2
Ensis directus	1	1
Lunatia heros	1	1
Macoma brevifrons	1	0
Nassarius trivittatus	7	3
Natica pusilla	0	1
Nucula atacellana	4	1
Nucula proxima	1	0
Spisula solidissima	25	23
Tellina agilis	41	63
Tellina sp.	3	0
Yoldia limatula	1	0
Unidentified bivalves	4	10
Totals	89	105
Arthropoda		
Acanthohaustorius intermedius	1	0
Acanthohaustorius millsi	53	53
Ampelisca vadorum	0	1
Amphipoda	2	1
Bathyporeia quoddyensis	4	1
Cancer irrorata	7	0
Cancer sp.	16	0
Carcinus maenas	4	0
Chiridotea	2	2
Chiridotea coeca	0	2
Cirolana concharum	30	0
Cirolana polita	2	0
Cirolana sp.	1	0
Crangon septemspinosa	5	2
Cumacea	0	1
Diastylis polita	1	1
Diastylis quadris	0	2
Dissodactylus mellitae	2	15
Edotea triloba	5	5
Gammarus annulatus	4	160
Gammarus lawrencianus	0	12
Gammarus oceanicus	0	5
Gammarus palustris	0	4
Gammarus sp.	4	1
Haustoriidae	1	0
Hippomedan serratus	1	4
Leptocuma minor	3	0
Leptognatha caeca	49	40
Monoculodes intermedius	0	1
Orchomanella pinguis	0	2
Ovalipes ocellatus	21	1
Pagurus longicarpus	2	2
Pagurus sp.	0	1
Paraphoxus epistomus	46	32
Phoxocephalus holbolli	0	9
Pinnixa chaetopterana	1	0
Protohaustorius wigleyi	340	195
Psammonyx nobilis	5	3
Pseudunciola obliqua	0	29
Tanaidacea	14	29
Tanaissus lilgeborgi	0	0
Totals	626	616
Echinodermata		
Echinarachnius parma	216	183
Totals	216	183

	July	November
Rhynchocoela		
Nemertean (unidentified)	6	6
Aschelminthes		
Nematoda (unidentified)	231	2
Annelida		
Polygordius triestinus	4479	356
Aricidea catherinae	0	2
Aricidea jeffreysii	3	0
Aricidea quadrilobata	2	2
Aricidea sp.	8	2
Aricidea suecica	1	0
Asabellides oculata	1	10
Cirratulid sp.	1	0
Cirratulidae	11	0
Drilonereis longa	1	0
Eteone longa	1	0
Eteone sp.	2	0
Exogene sp.	4	0
Glycera sp.	35	6
Goniadella gracillis	17	5
Haploscoloplos rubustus	0	1
Lumbrineris acuta	6	3
Magelona papillicornis	0	18
Magelona rosea	3	2
Nephtys bucera	38	22
Nephtys picta	0	1
Nephtys sp.	8	2
Oligochaeta	2	0
Orbiniidae	7	0
Paraonidae	0	7
Phyllodoce arenae	0	2
Polychaeta	23	4
Scoleoepis squamata	2	0
Sigalionidae	6	4
Spiophanes bombyx	6	5
Syllidae	9	3
Tharyx acutus	3	2
Tharyx sp.	1	2
Totals	201	105

	July	November
Grand Totals	5848	1373

TABLE 13
Percent Composition of Dominant Benthic Organisms

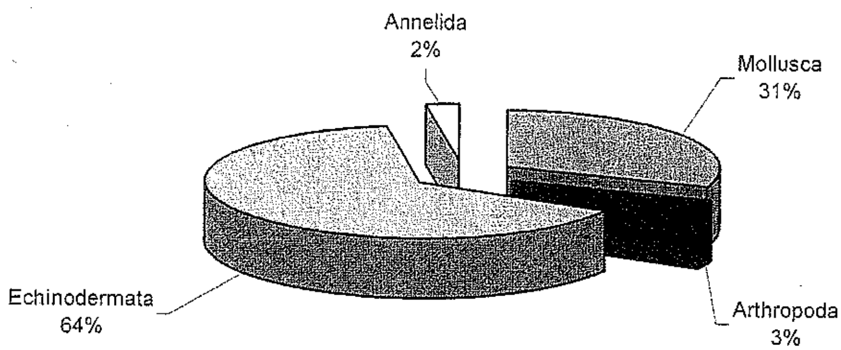
July	Total Number	Percent of Total	Abundance (# organisms per m^2)
Polygordius triestinus	4,479	77	179,160
Protohaustorius wigleyi	340	6	13,600
Nematoda (unidentified)	231	4	9,240
Echinarachnius parma	216	4	8,640
Acanthohaustorius millsi	53	1	2,120
Leptognatha caeca	49	1	1,960
Paraphoxus epistomus	46	1	1,840
Tellina agilis	41	1	1,640
Nephtys bucera	38	1	1,520
Glycera sp.	35	1	1,400
Cirolana concharum	30	1	1,200

November	Total Number	Percent of Total	Abundance (# organisms per m^2)
Polygordius triestinus	355	26	14,200
Protohaustorius wigleyi	191	14	7,640
Echinarachnius parma	175	13	7,000
Gammarus annulatus	157	11	6,280
Tellina agilis	62	5	2,480
Acanthohaustorius millsi	49	4	1,960
Leptognatha caeca	37	3	1,480
Paraphoxus epistomus	32	2	1,280
Pseudunciola obliqua	29	2	1,160
Tanaidacea	29	2	1,160
Spisula solidissima	22	2	880
Nephtys bucera	21	2	840
Magelona papillicornis	18	1	720
Dissodactylus mellitae	15	1	600
Gammarus lawrencianus	12	1	480
Asabellides oculata	10	1	400
Bivalvia (unidentified)	10	1	400
Phoxocephalus holbolli	9	1	360
Paraonidae	7	1	280

TABLE 14
Benthic Grab Weight Estimates

	July (grams)	November (grams)
Echinodermata	66.95	51.36
Mollusca	31.71	3.44
Arthropoda	2.70	14.17
Annelida	2.47	1.85
Rhynchocoela	-	-
Aschelminthes	-	-

<u>July Weight - Percent of Total</u>



<u>November Weight - Percent of Total</u>

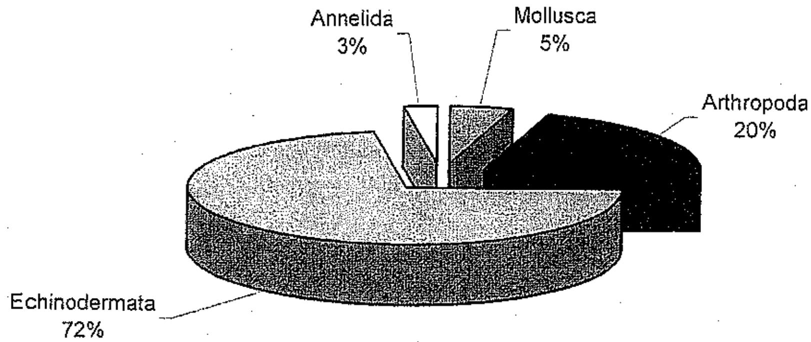


TABLE 15
Percent Abundance of Benthic Organisms at Stations 4 and 30

July

	Station 4	Station 30	All Stations
Annelida	43.5	19.4	80.0
Arthropoda	34.8	12.9	10.7
Aschelminthes	0	0	4.0
Echinodermata	17.4	41.9	3.7
Mollusca	4.3	25.8	1.5
Rhynchocoela	0	0	0.1

November

	Station 4	Station 30	All Stations
Arthropoda	17.6	35.1	44.9
Annelida	82.4	22	33.5
Echinodermata	0	27.0	13.3
Mollusca	0.0	16.2	7.6
Rhynchocoela	0	0	0.4
Aschelminthes	0	0	0.1

TABLE 16
Mean Monthly Water Quality Parameters For All Stations

Demersal Fish Trawls

Surface Mean Values

	Temperature (°c)	Salinity (ppt)	DO (mg/l)	Conductivity	pH	Light Transmission (m)
April	8.5	31.5	9.14	32.90	8.2	5.9
May	13.6	28.9	8.86	34.94	8.5	3.1
June	17.0	30.9	8.70	40.11	8.6	4.2
July	18.2	32.9	6.45	N/A	8.6	3.9
August	20.9	31.9	7.21	44.86	8.4	N/A
September	21.1	32.4	6.66	45.83	6.70	4.4
October	18.2	32.8	6.46	43.50	8.5	3.2
November	15.1	33.0	5.92	40.85	8.6	3.1
December	N/A	N/A	N/A	N/A	N/A	N/A
February	3.3	33.0	10.18	30.27	8.3	3
March	5.3	32.3	9.48	31.38	8.2	3.8
April 00	6.1	32.9	8.72	32.60	8.2	2.1

* N/A-no water quality measurements due to instrument malfunction.

Bottom Mean Values

	Temperature (°c)	Salinity (ppt)	DO (mg/l)	Conductivity	pH
April	7.8	31.8	8.56	32.70	8.3
May	12.5	29.1	9.07	34.22	8.6
June	16.2	31.2	8.51	39.75	8.6
July	15.4	31.0	6.22	N/A	8.6
August	19.4	31.9	6.95	43.59	8.3
September	20.4	32.6	6.31	45.50	6.7
October	18.0	32.8	6.49	43.28	8.5
November	15.0	33.1	5.42	40.83	8.6
December	N/A	N/A	N/A	N/A	N/A
February	3.5	33.1	9.98	30.51	8.3
March	4.6	32.7	9.36	31.1	8.2
April 00	5.8	33.0	8.66	32.5	8.2

Mid-Water Fish Trawls

Surface Mean Values

	Temperature (°c)	Salinity (ppt)	DO (mg/l)	Conductivity	pH	Light Transmission (m)
June	16.9	31.5	8.60	40.72	8.6	3.9

Bottom Mean Values

	Temperature (°c)	Salinity (ppt)	DO (mg/l)	Conductivity	pH
June	16.2	31.5	8.40	40.60	8.6

Benthic Grab Survey

Bottom Mean Values

	Temperature (°c)	Salinity (ppt)	DO (mg/l)	Conductivity	pH	Light Transmission (m)
July	16.8	32.1	8.31	41.34	7.9	6.0
November	12.5	33.2	7.60	38.64	8.8	2.0

TABLE 17
Percent Composition of Sediment Samples

July:

Station	Gravel	Sand	Clay	Silt
SH-01	0.00	97.16	1.81	1.30
SH-02	0.54	97.65	1.31	0.50
SH-03	0.00	98.31	1.54	0.15
SH-04	0.16	98.44	1.33	0.07
SH-05	0.00	98.78	0.18	1.04
SH-06	0.36	97.91	0.75	0.98
SH-07	0.00	99.42	0.47	0.11
SH-08	0.25	98.50	0.01	1.24
SH-09	0.00	96.39	1.34	2.27
SH-10	1.04	94.83	1.65	2.48
SH-11	0.31	97.24	0.08	1.63
SH-12	0.13	98.39	0.01	1.47
SH-13	0.13	98.52	1.34	0.01
SH-14	0.00	97.95	1.07	0.98
SH-15	0.00	97.96	0.87	1.17
SH-16	0.00	99.27	0.01	0.72
SH-17	0.04	96.35	2.94	0.67
SH-18	0.00	94.82	3.24	1.94
SH-19	0.39	94.42	2.68	2.51
SH-20	0.45	96.43	0.63	2.49
SH-21	0.49	93.89	2.66	2.96
SH-22	2.55	92.74	2.41	2.30
SH-23	0.52	95.74	3.03	0.71
SH-24	0.00	96.15	2.25	1.60
SH-25	0.04	99.84	0.00	0.12
SH-26	5.85	92.02	1.10	1.03
SH-27	0.00	99.70	0.11	0.19
SH-28	1.93	93.48	2.68	1.91
SH-29	0.00	95.39	1.69	2.92
SH-30	0.04	97.30	1.14	1.52
SH-31	0.00	97.49	2.15	0.36
SH-32	0.00	97.57	1.52	0.91
SH-33	0.00	97.52	1.09	1.39
SH-34	0.00	88.94	4.41	6.65
SH-35	0.00	96.16	2.50	1.34
Mean	***0.43***	***96.65***	***1.49***	***1.42***

November:

Station	Gravel	Sand	Clay & Silt
SH-01	0.00	96.26	3.74
SH-02	1.81	98.08	0.10
SH-03	1.02	97.75	1.23
SH-04	0.99	77.31	21.70
SH-05	0.00	92.65	7.35
SH-06	0.09	95.94	3.97
SH-07	0.00	90.58	9.42
SH-08	0.00	98.82	1.18
SH-09	0.25	95.87	3.88
SH-10	0.00	98.87	1.13
SH-11	0.00	98.30	1.70
SH-12	3.04	95.07	1.89
SH-13	0.17	99.76	0.07
SH-14	0.00	99.36	0.64
SH-15	0.00	97.83	2.17
SH-16	0.36	98.08	1.57
SH-17	0.00	98.81	1.19
SH-18	0.00	98.81	1.19
SH-19	0.00	99.71	0.28
SH-20	0.08	97.46	2.45
SH-21	0.00	92.21	7.79
SH-22	1.01	96.16	2.83
SH-23	0.26	97.26	2.48
SH-24	0.00	94.37	5.63
SH-25	0.17	98.58	1.25
SH-26	0.00	95.08	4.92
SH-27	0.00	95.26	4.74
SH-28	0.33	98.65	1.02
SH-29	0.17	92.03	7.80
SH-30	3.19	77.22	19.59
SH-31	1.78	97.58	0.63
SH-32	0.00	96.10	3.90
SH-33	0.00	96.76	3.24
SH-34	0.00	91.64	8.35
SH-35	0.00	99.62	0.38
Mean	***0.42***	***95.54***	***4.04***

Figure 1
Station Locations for Fisheries Trawls and Benthic Grabs

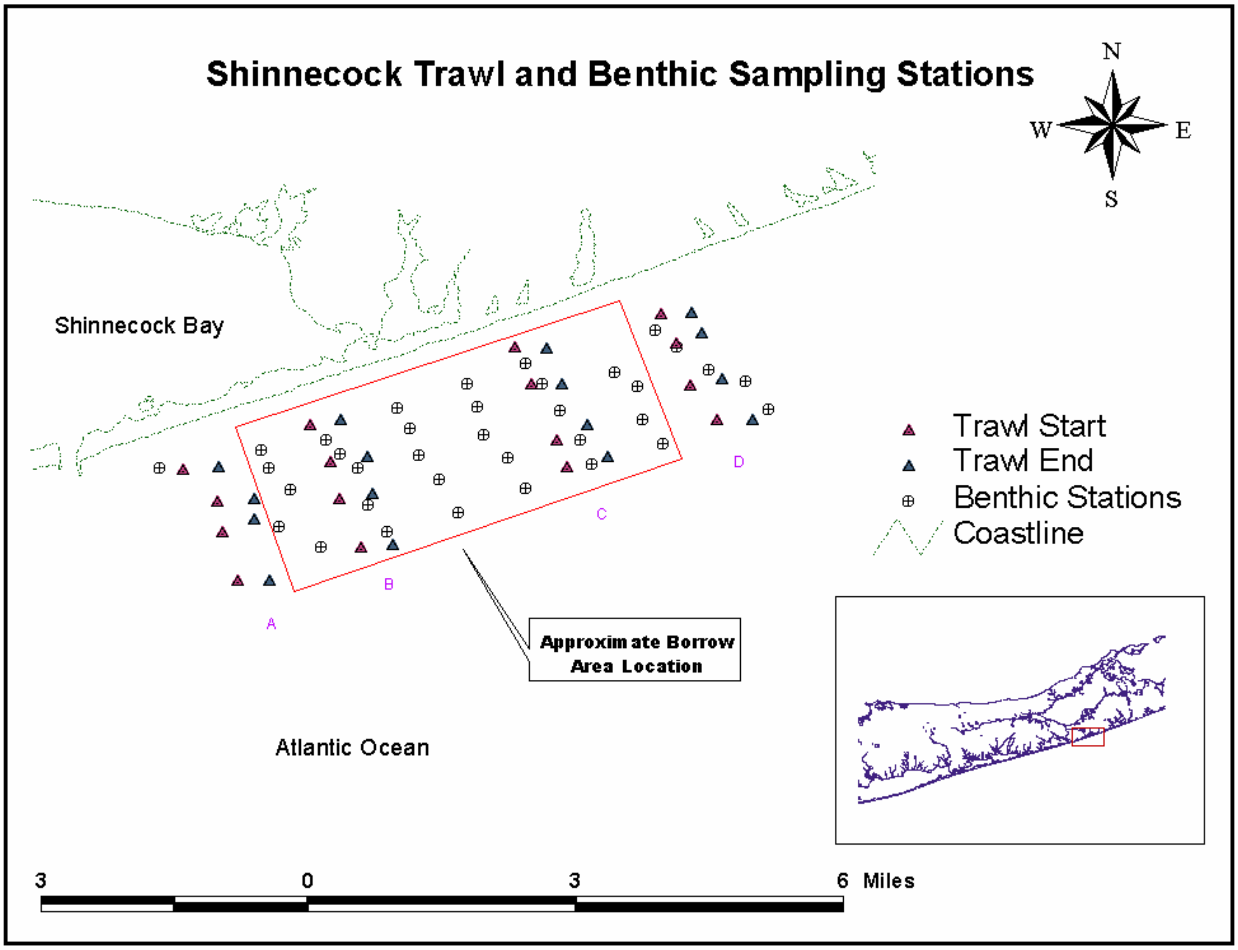


FIGURE 2

Fisheries Otter Trawl

Ted Young Grab

FIGURE 3
TOTAL NUMBER OF FISHES AND SPECIES PER MONTH

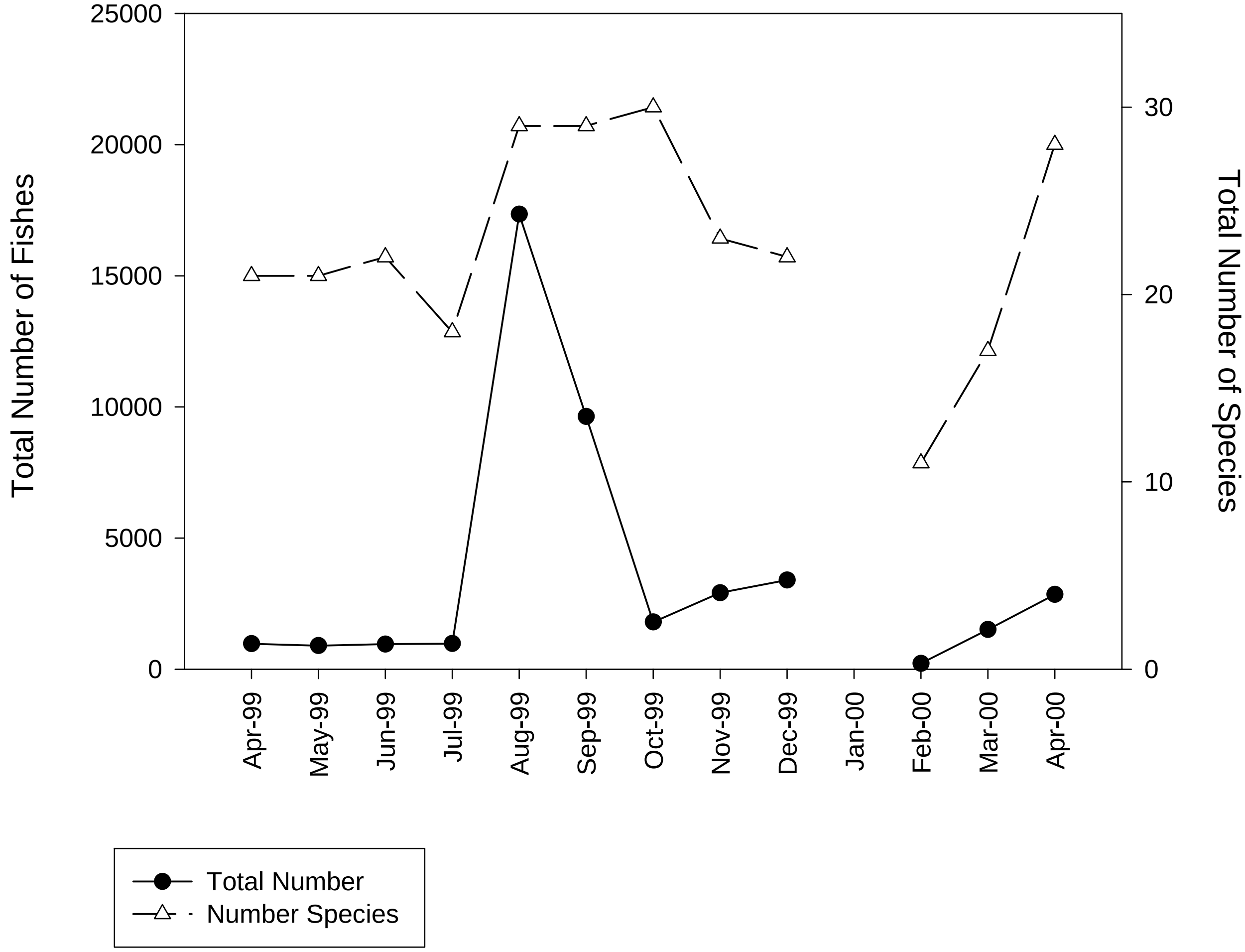


FIGURE 4
Top Species Abundance
April 1999 through April 2000

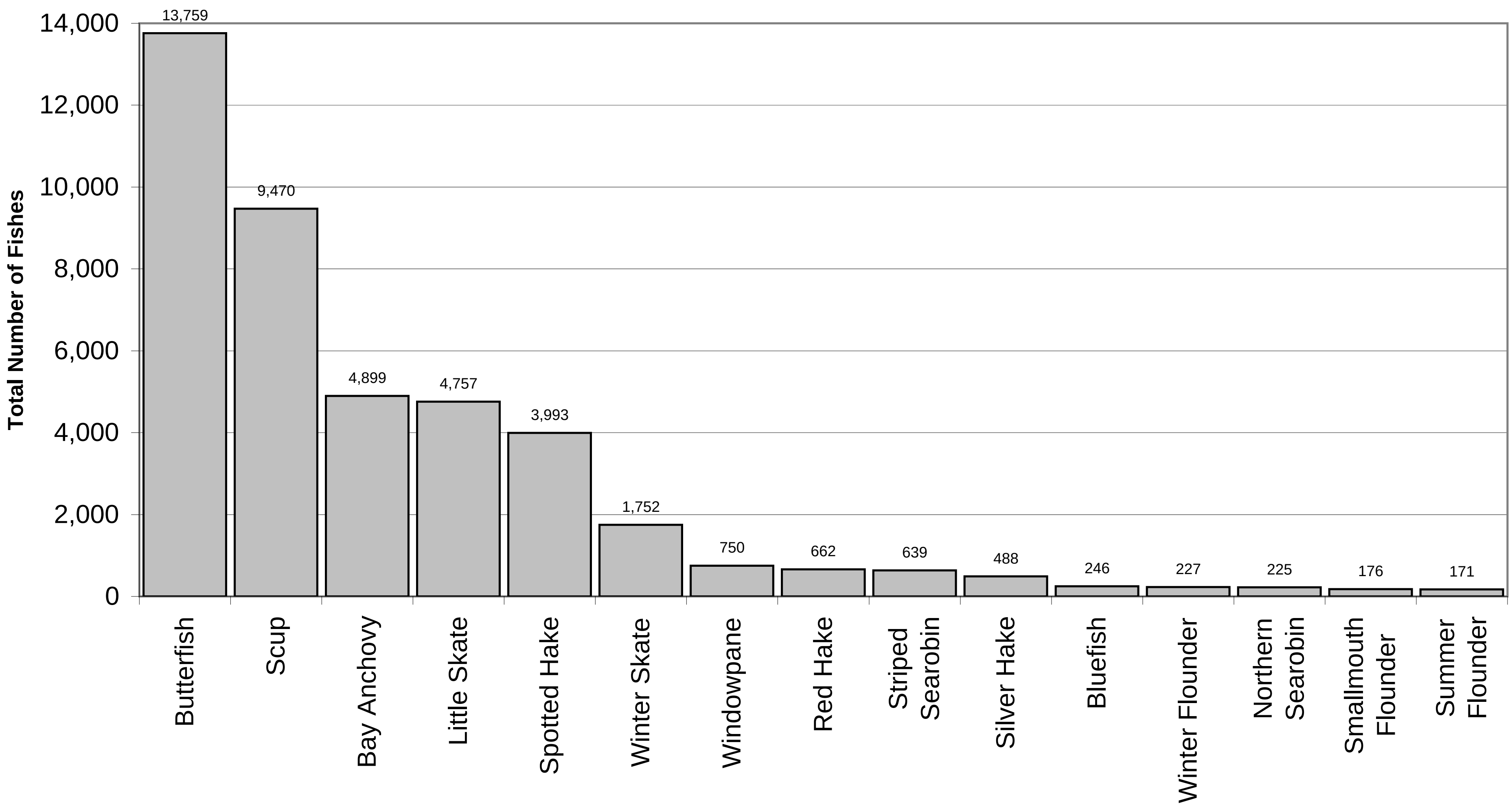


FIGURE 5
Total Number of Species by Month

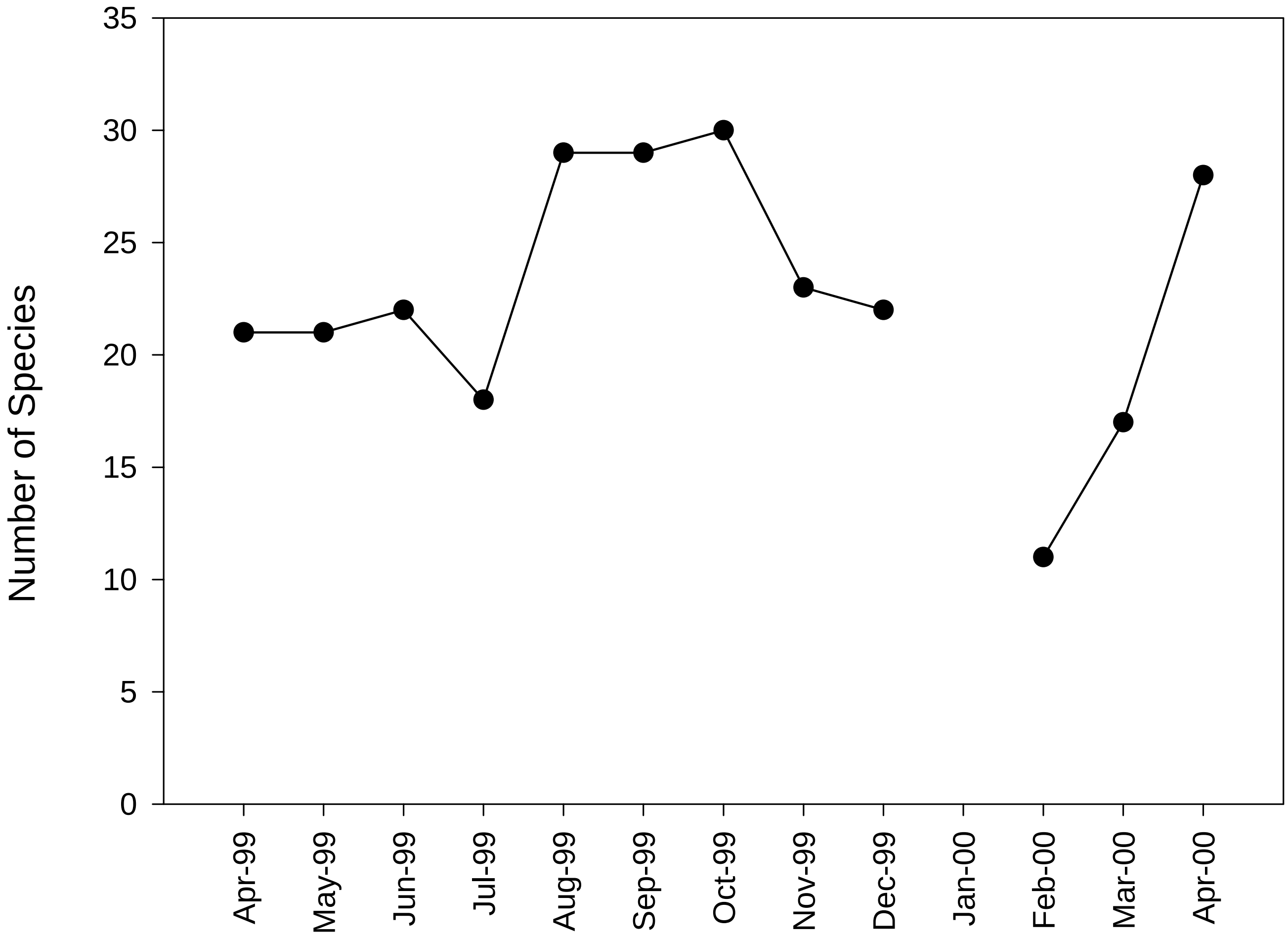


FIGURE 6
Total Weight of All Species Collected by Month

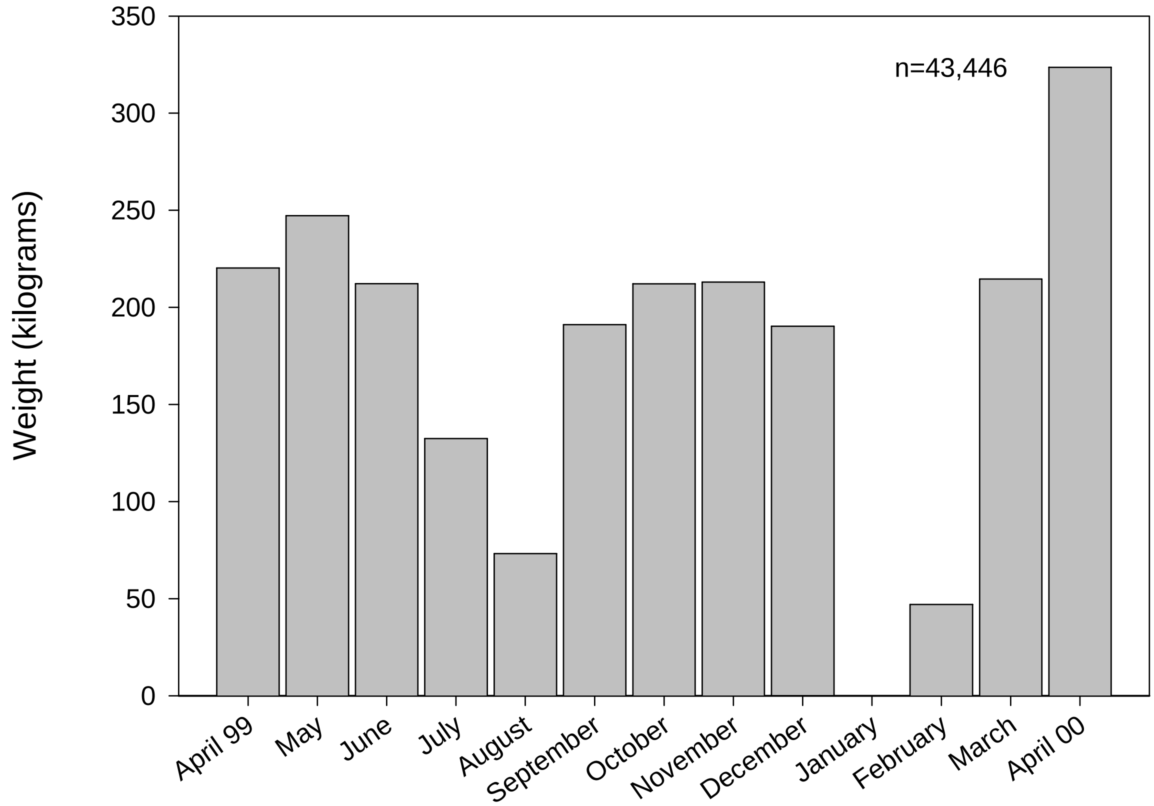
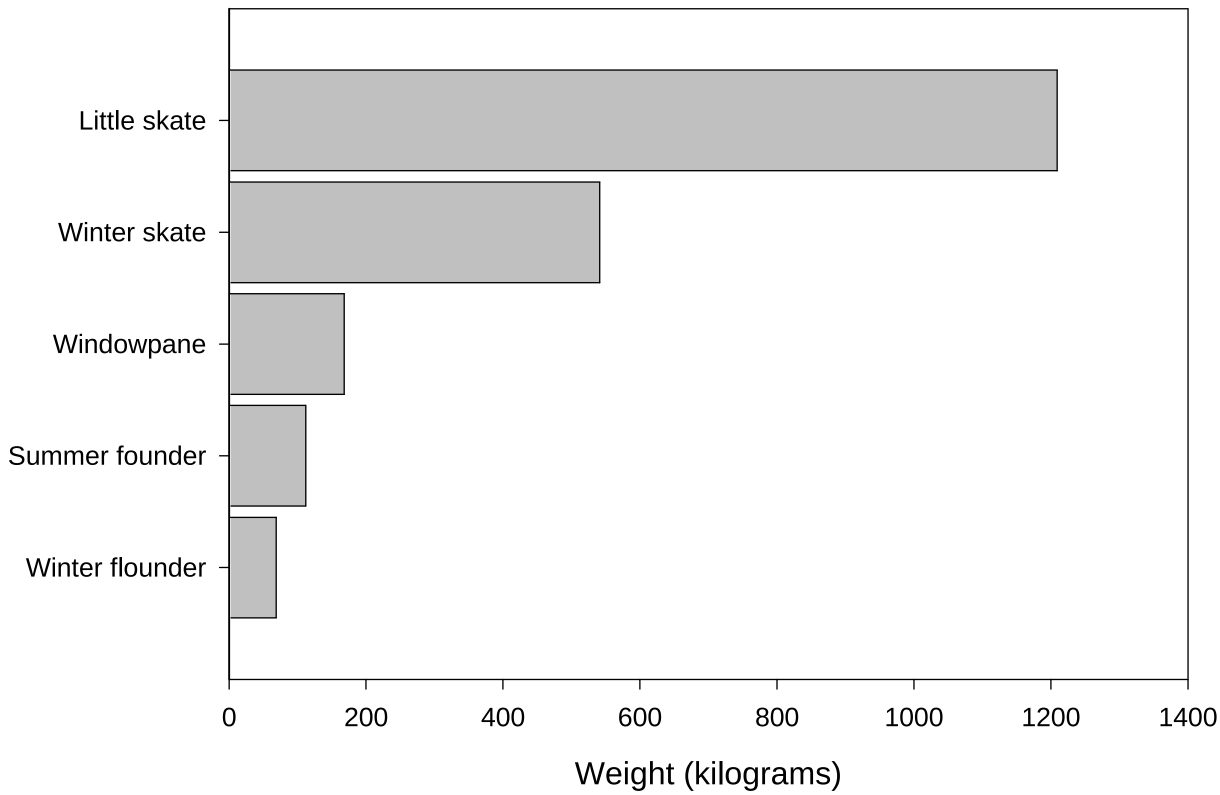


FIGURE 7
Total Weight of the Five Most Abundant Species



Percent of Total Weight

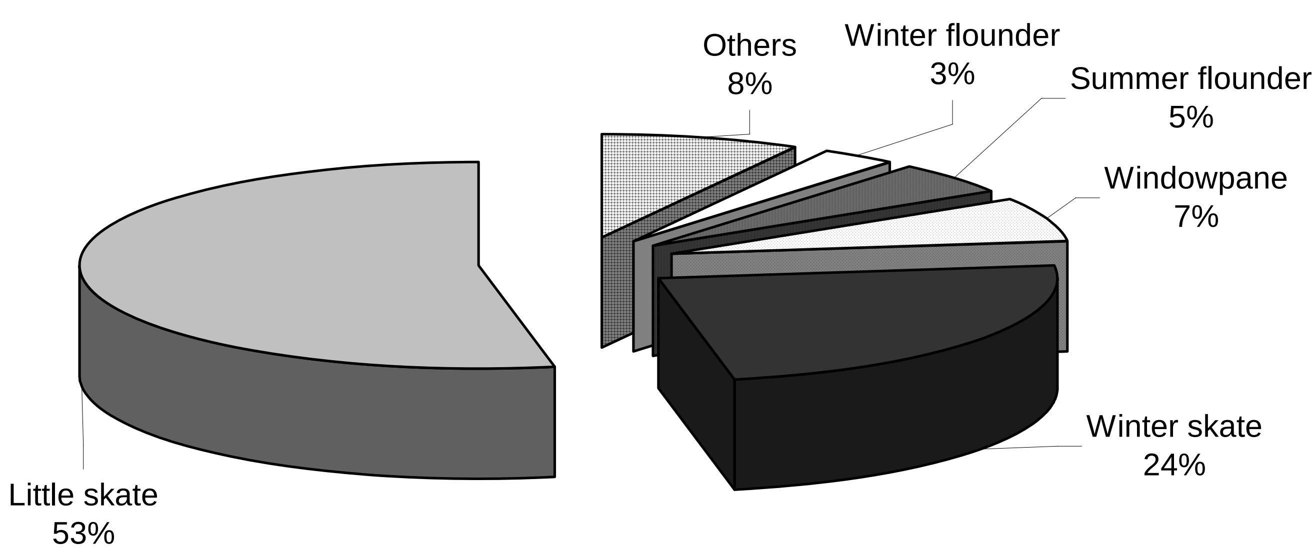


FIGURE 8
Length Frequency Distributions for Commercially Important Species

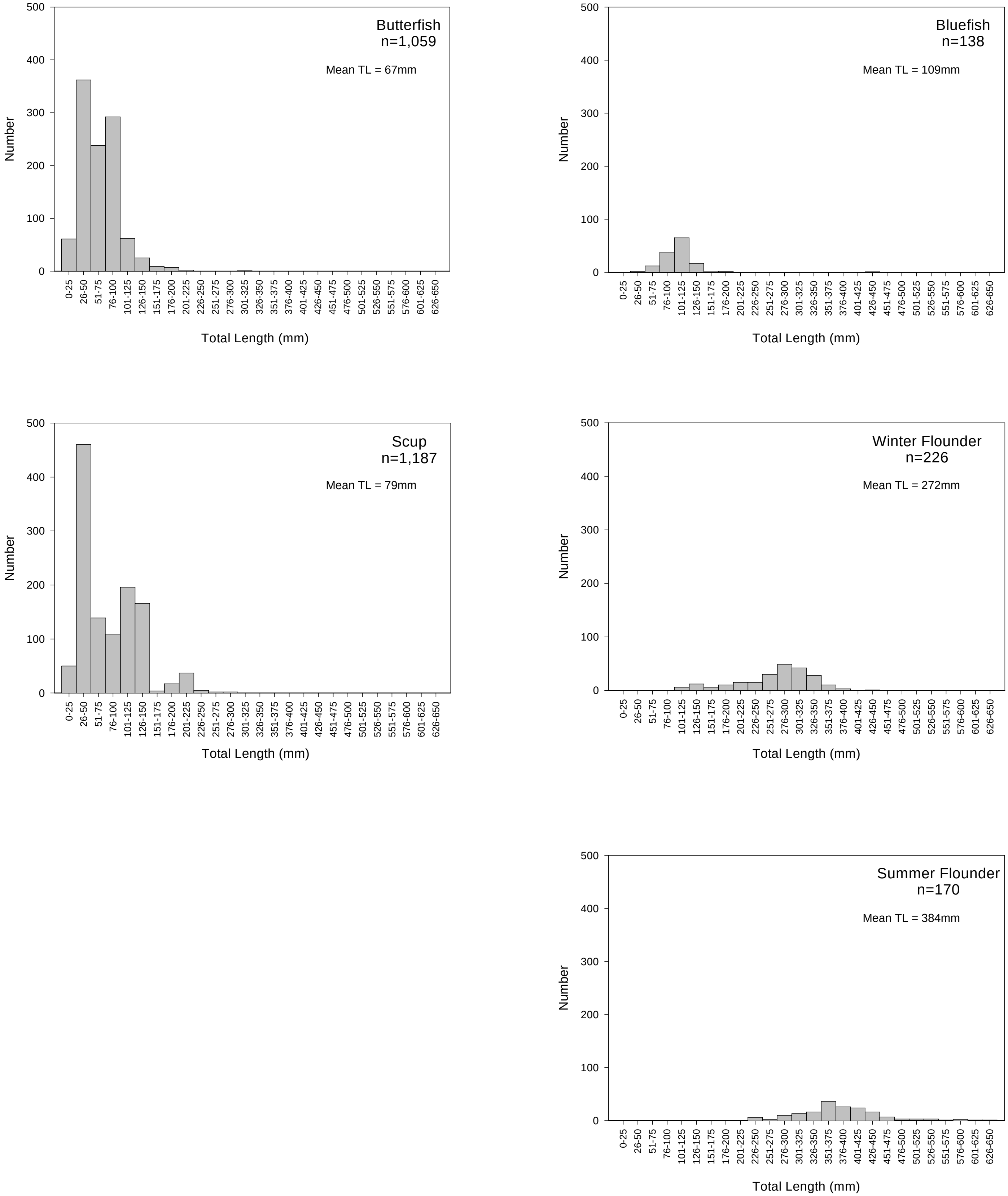


FIGURE 9
Total Annual Weight for Commercially Important Species

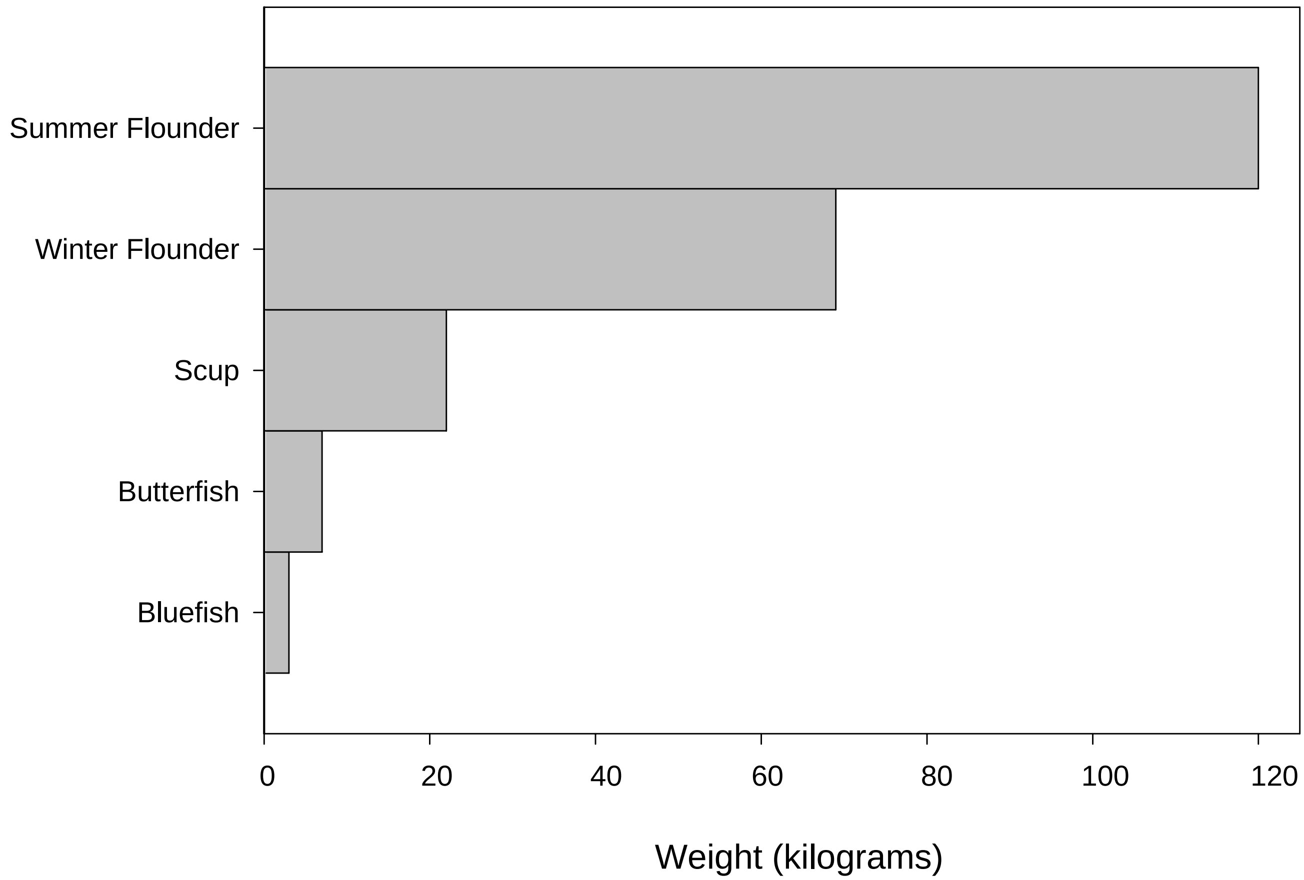


FIGURE 10
Monthly Weight for Commercially Important Species

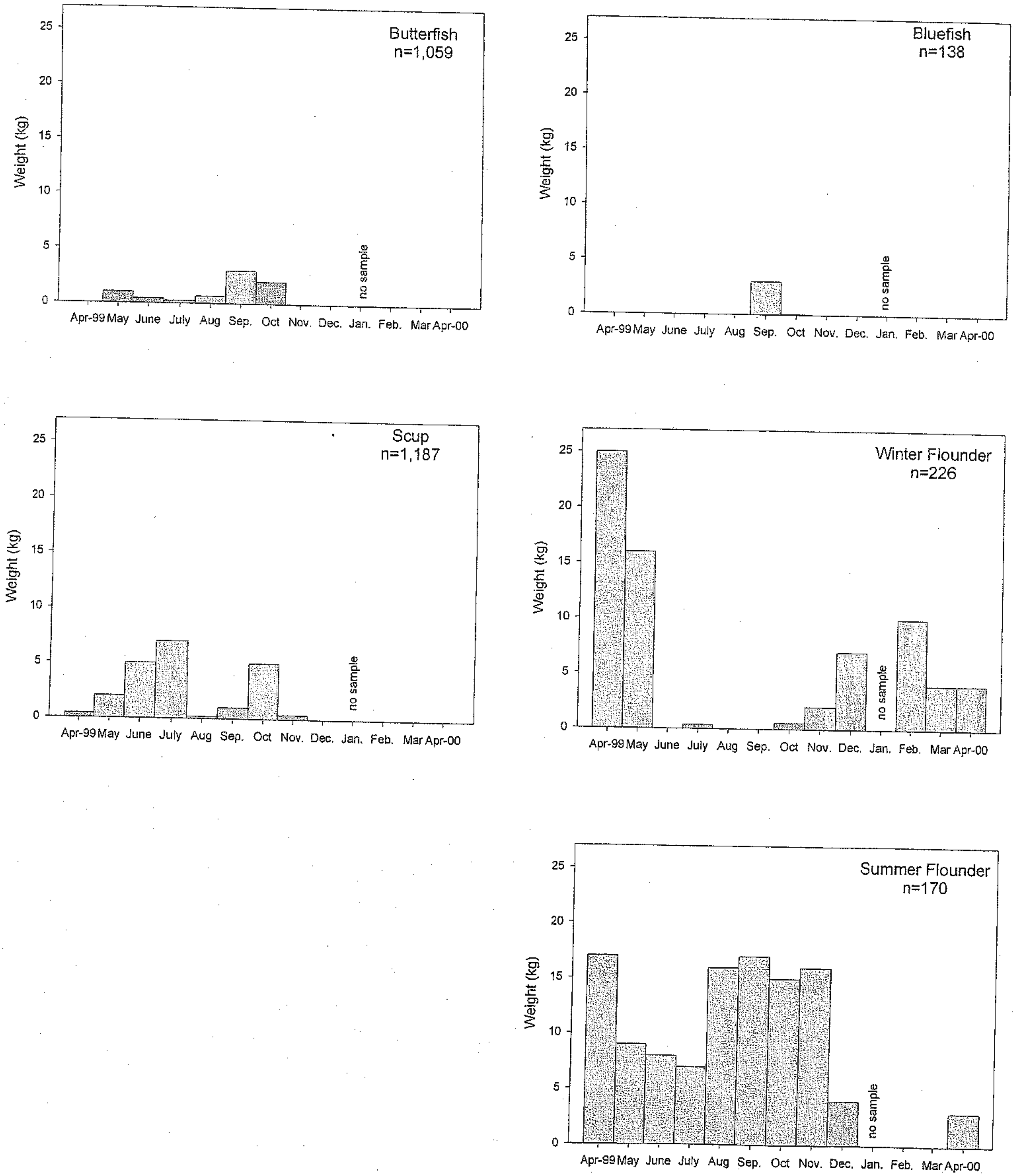
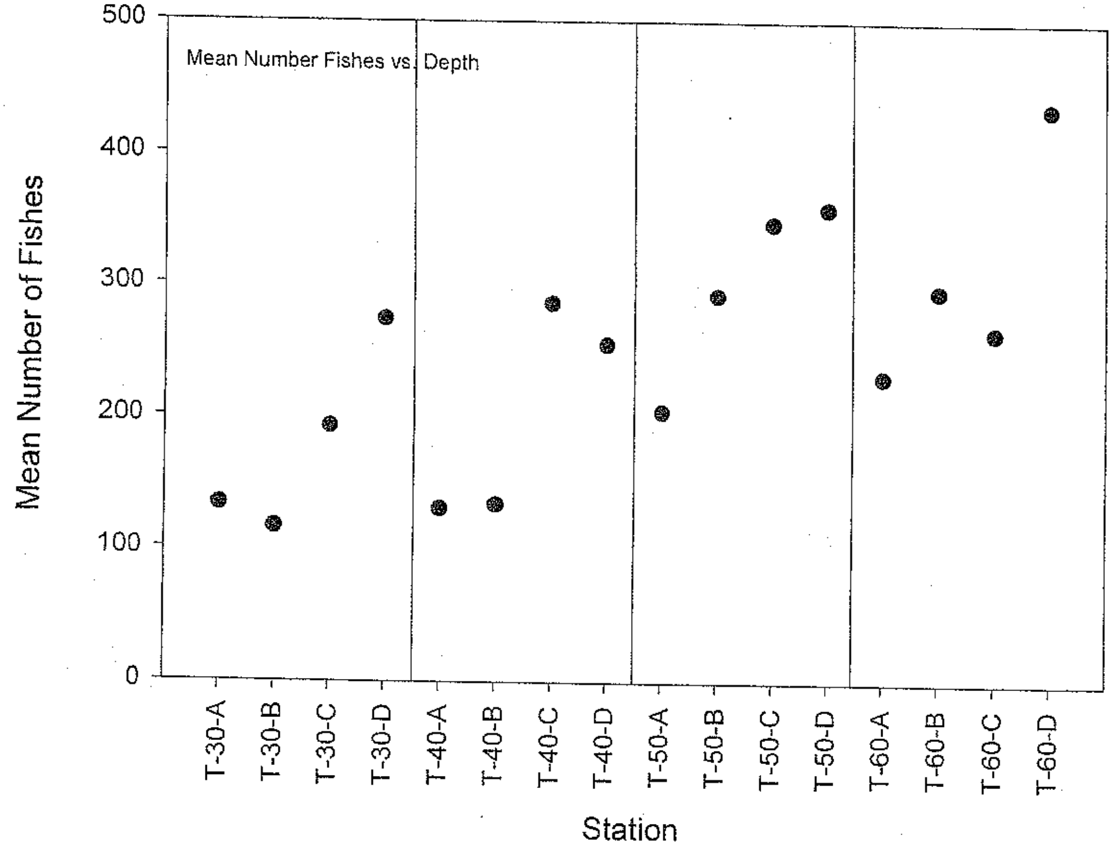


FIGURE 11
Species Diversity and Abundance vs. Depth



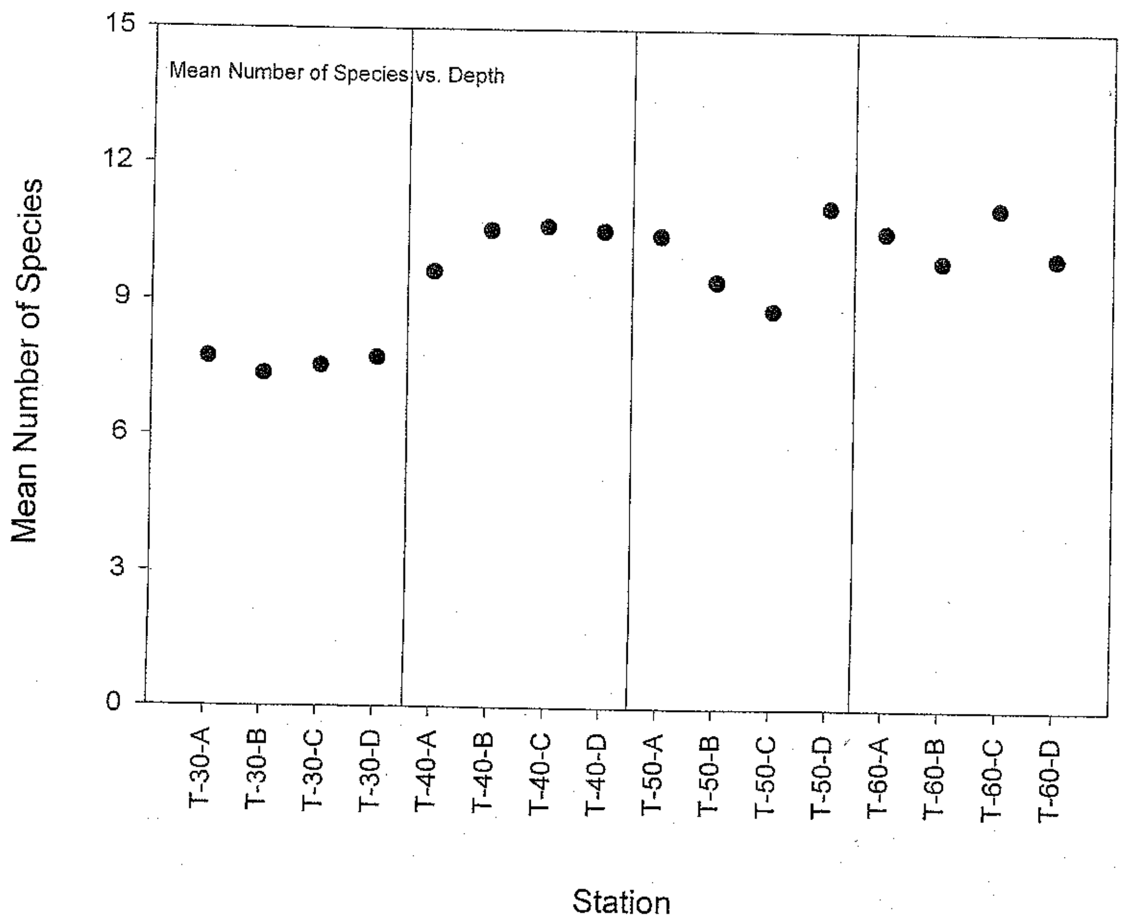
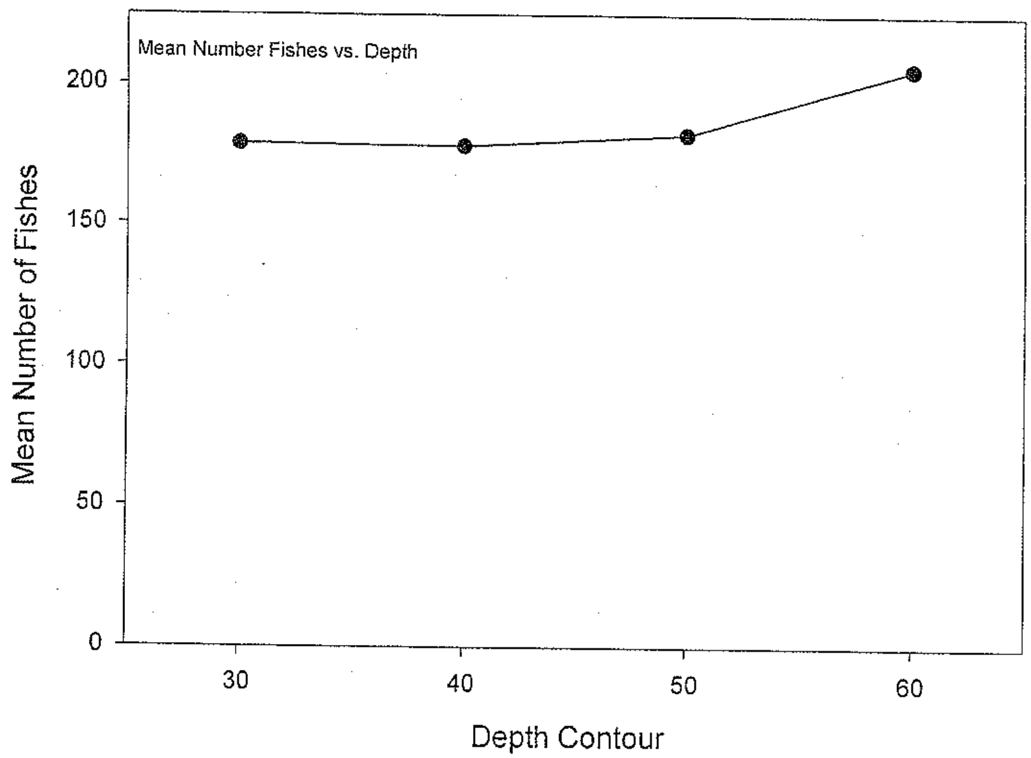


FIGURE 12

Species Diversity and Abundance vs. Depth (averaged for all transects)



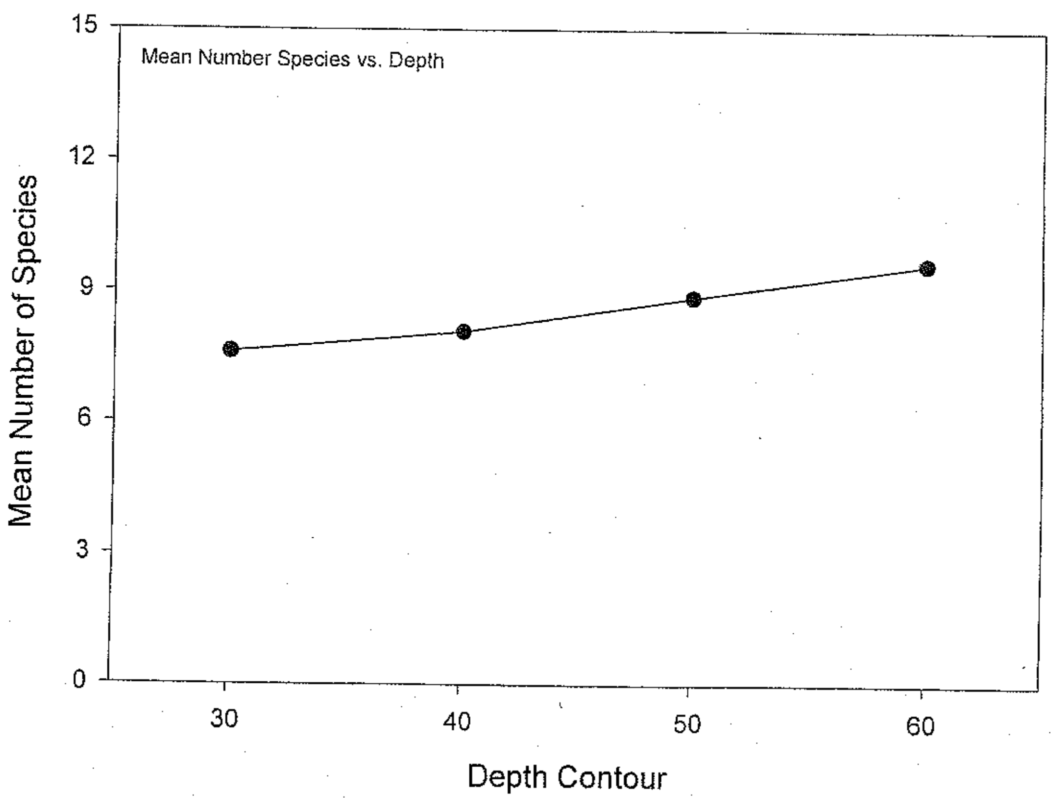
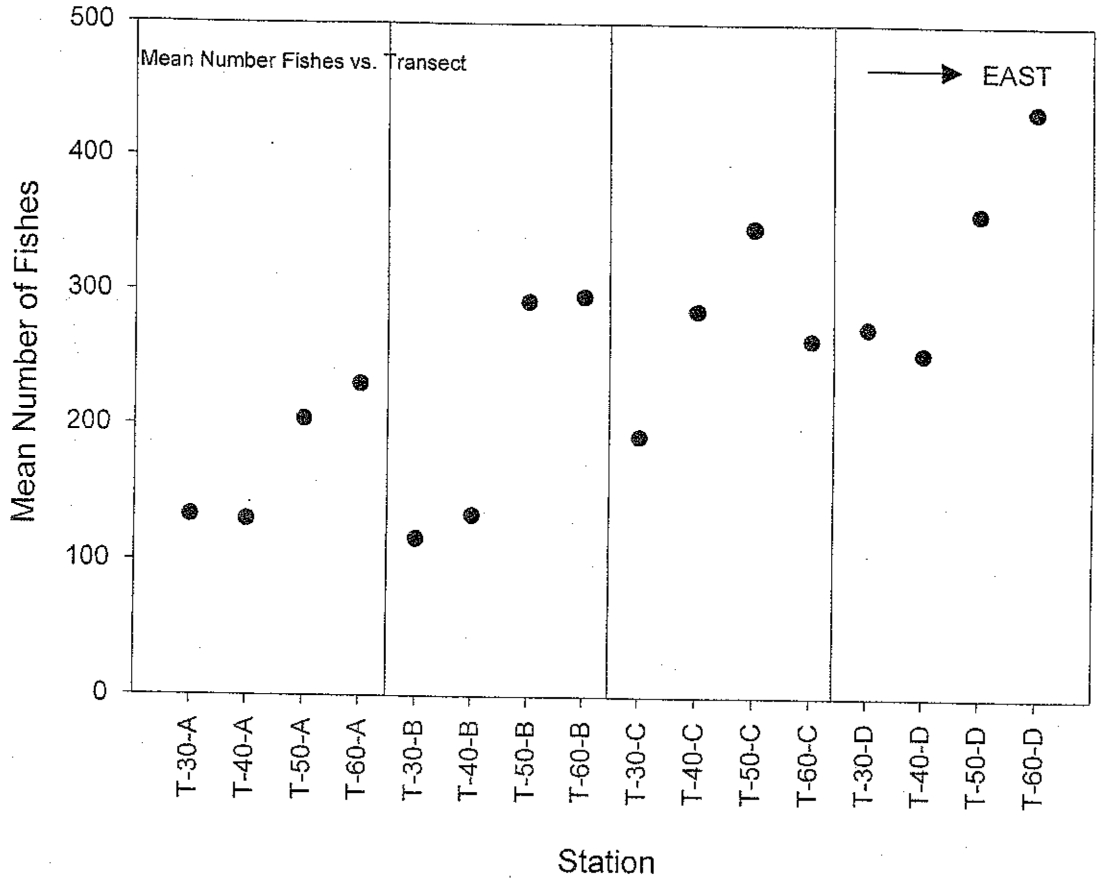


FIGURE 13

Species Diversity and Abundance vs. Transect



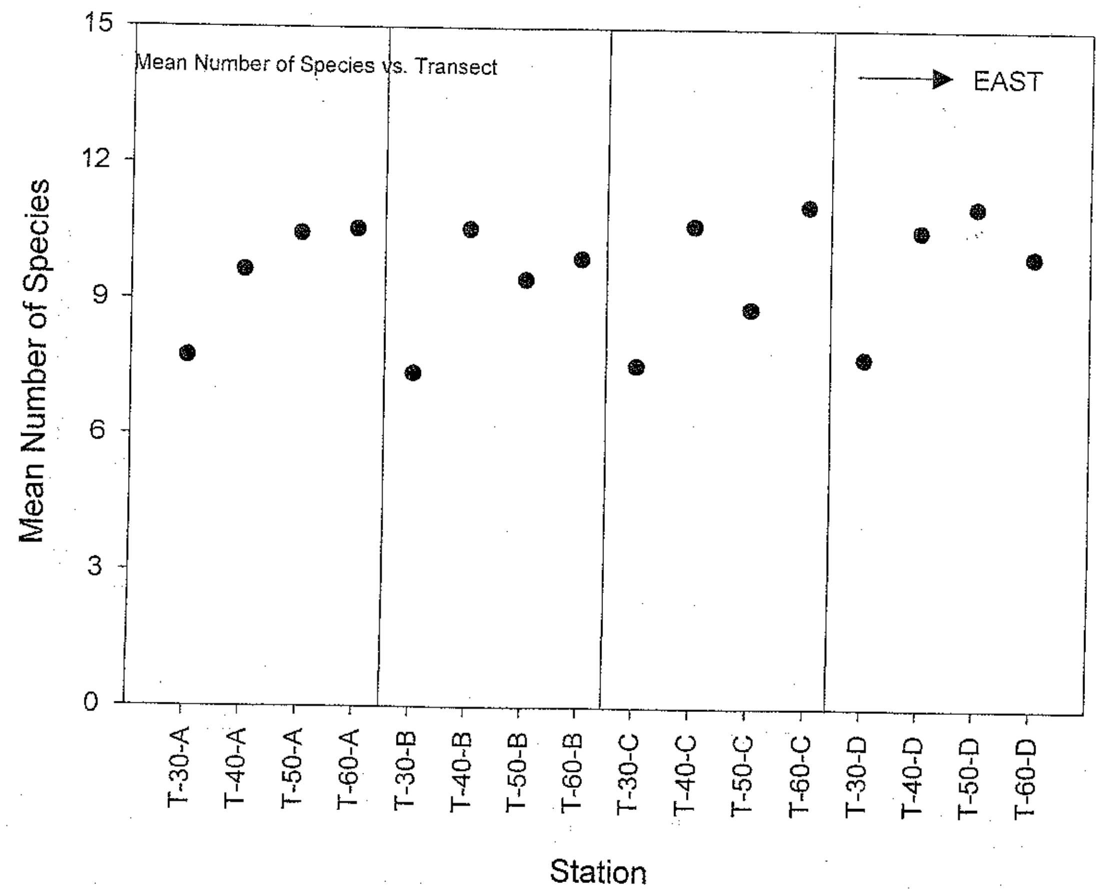
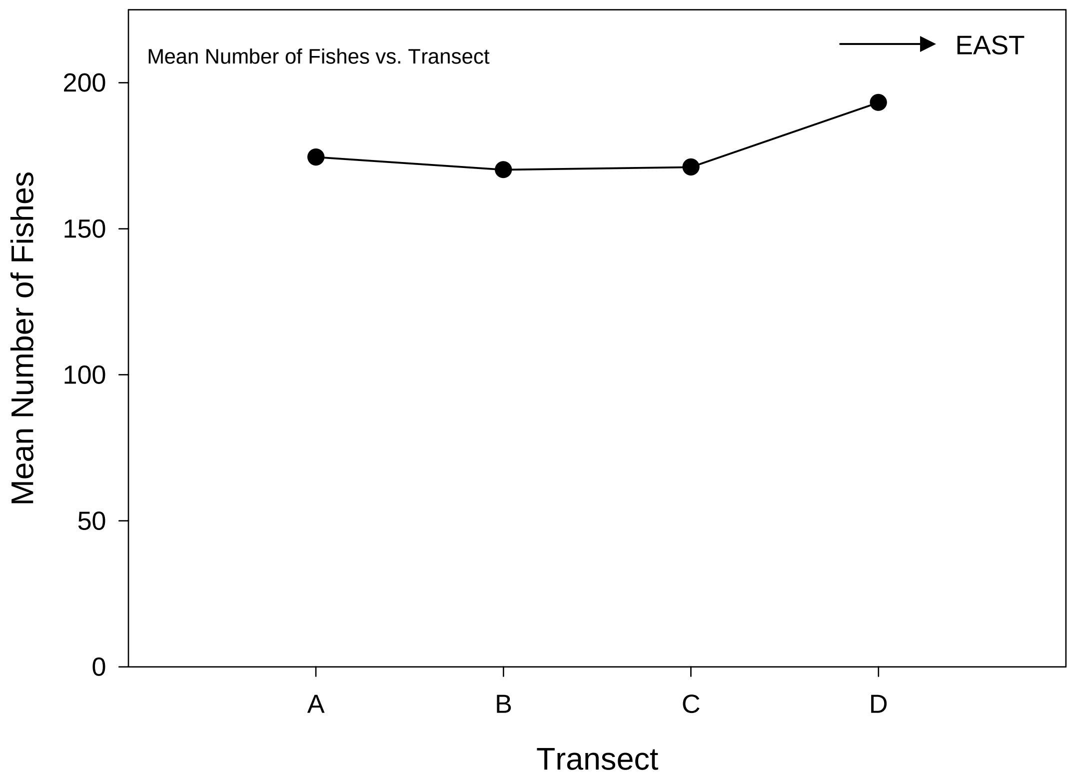


FIGURE 14

Species Diversity and Abundance vs. Transect (averaged for all transects)



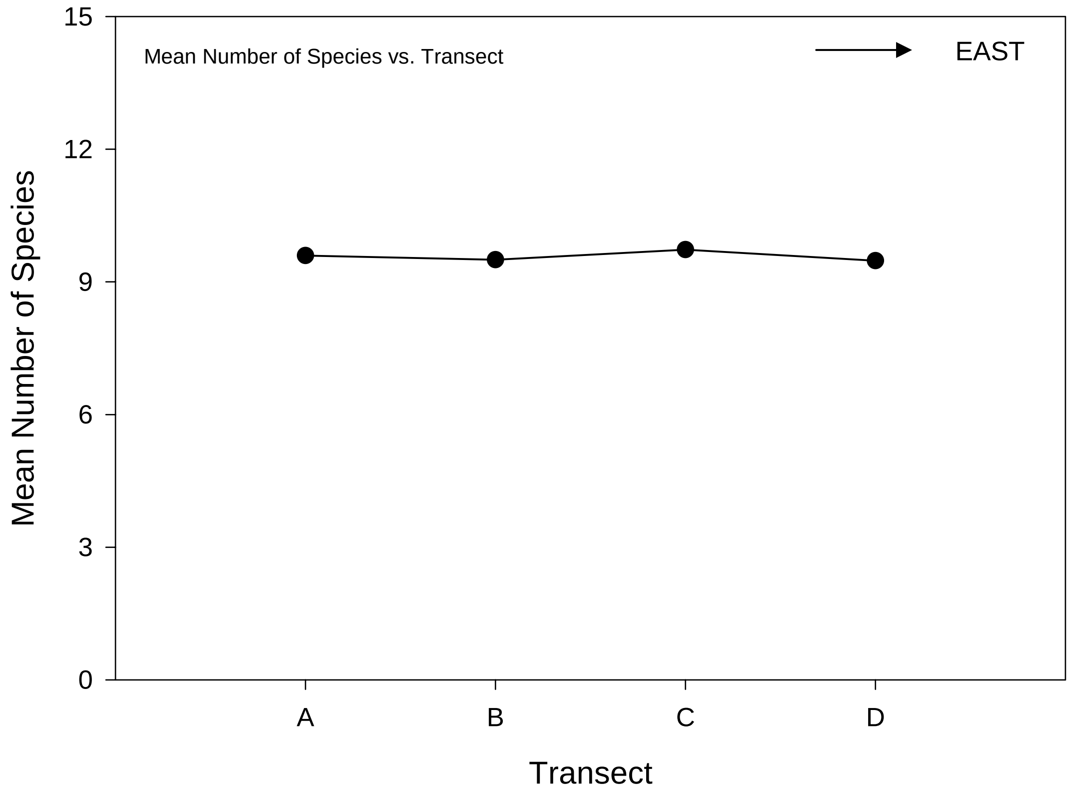


FIGURE 15
Total Finfish Abundance per Station

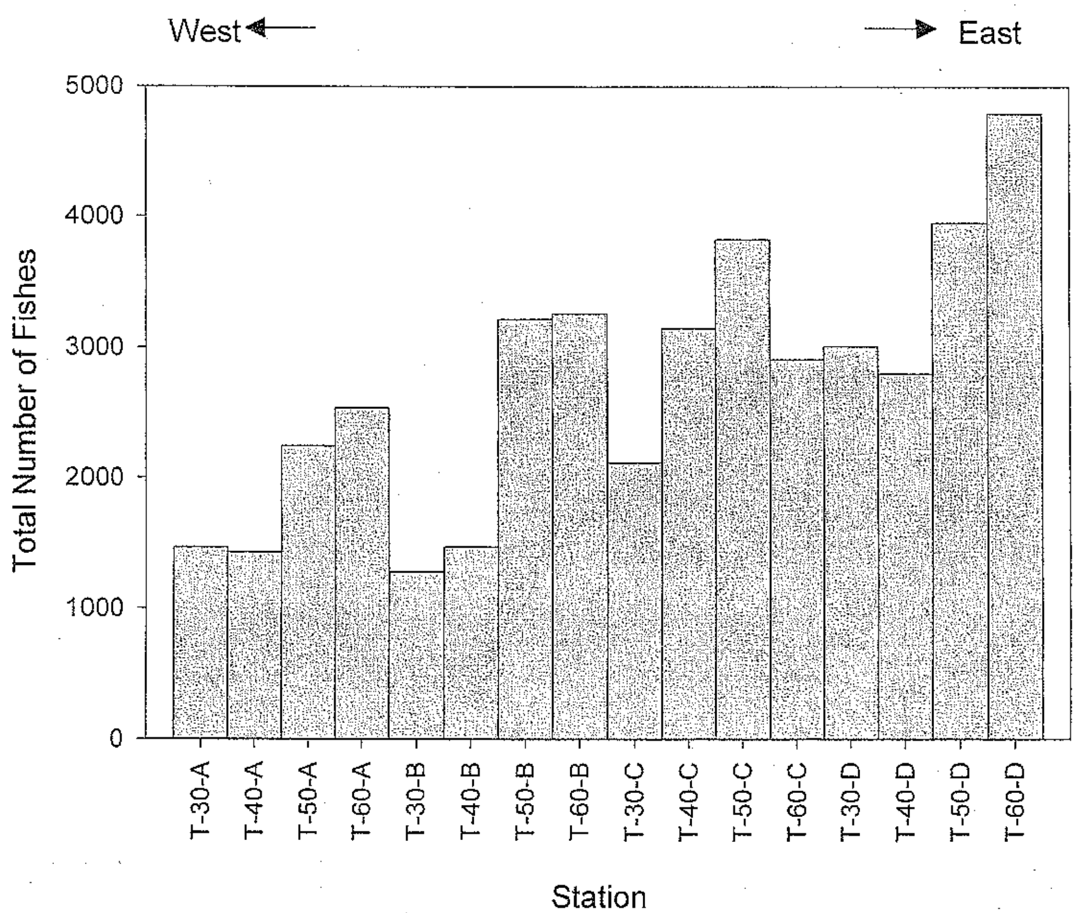


FIGURE 16
Mean Number of Species per Station

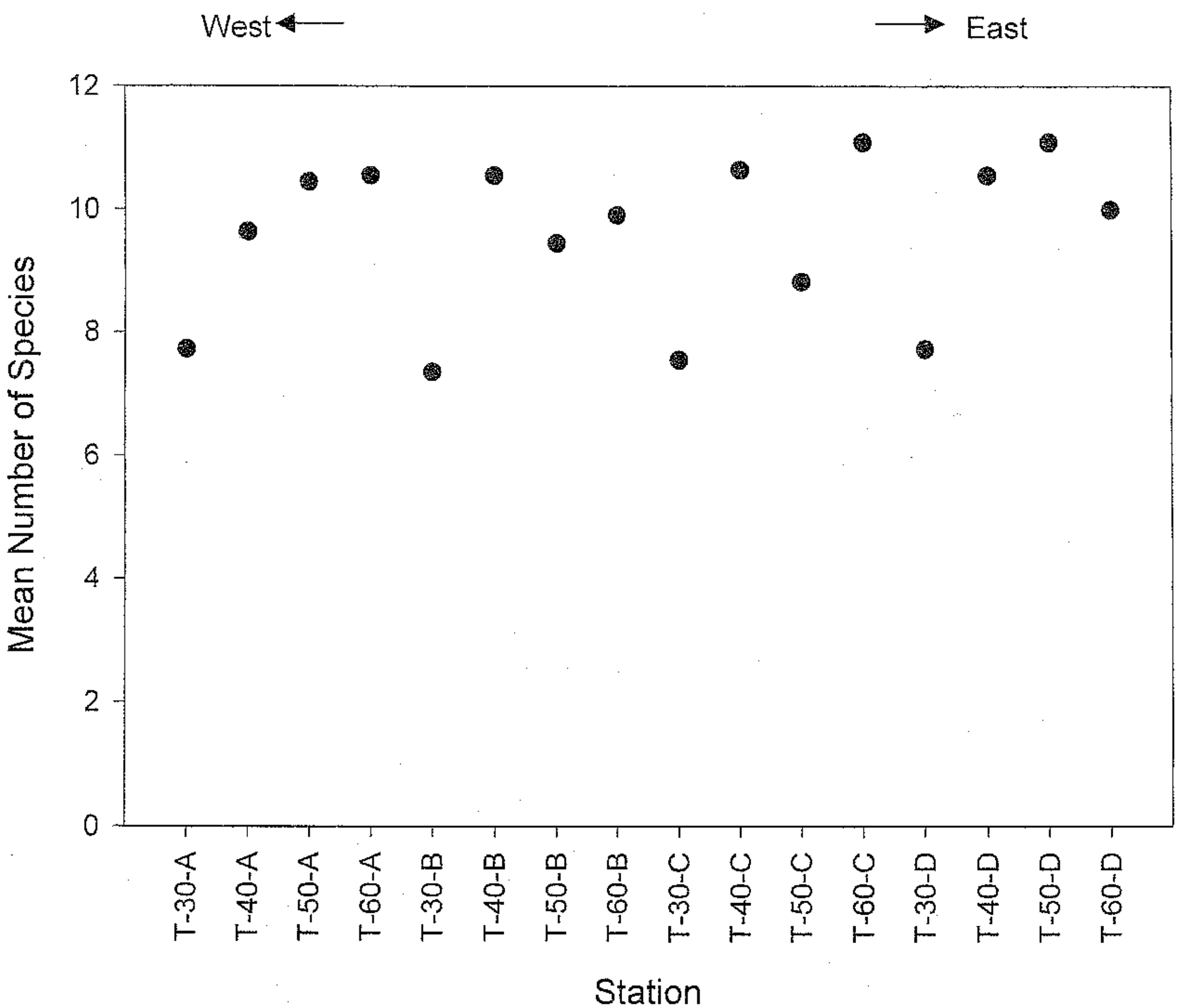


FIGURE 17
Percent Composition of Benthic Macroinvertebrates Collected in Trawls

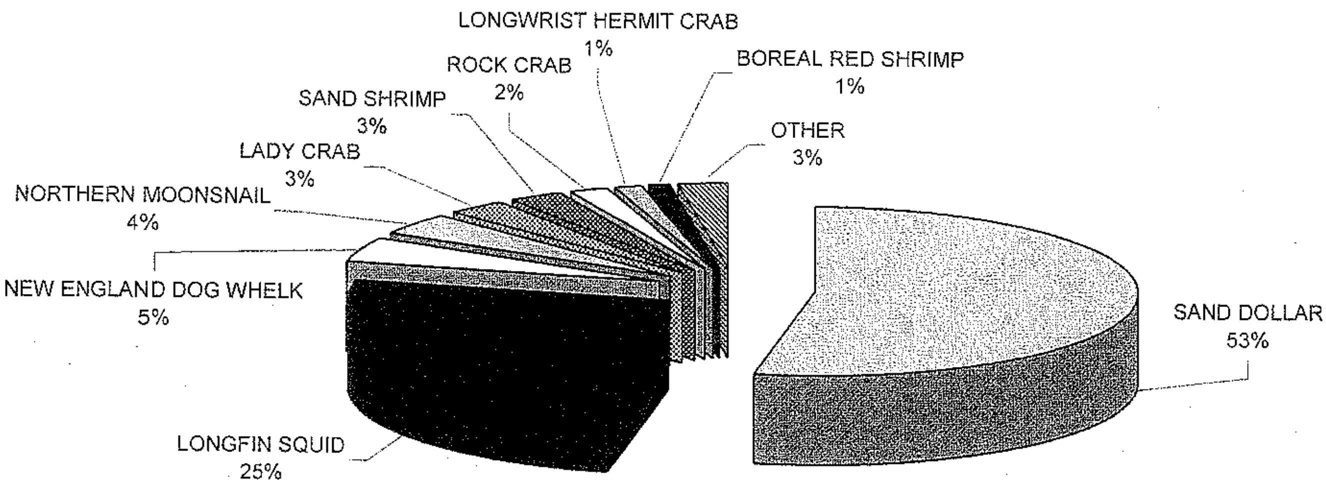


FIGURE 18
Monthly Benthic Macroinvertebrate Totals

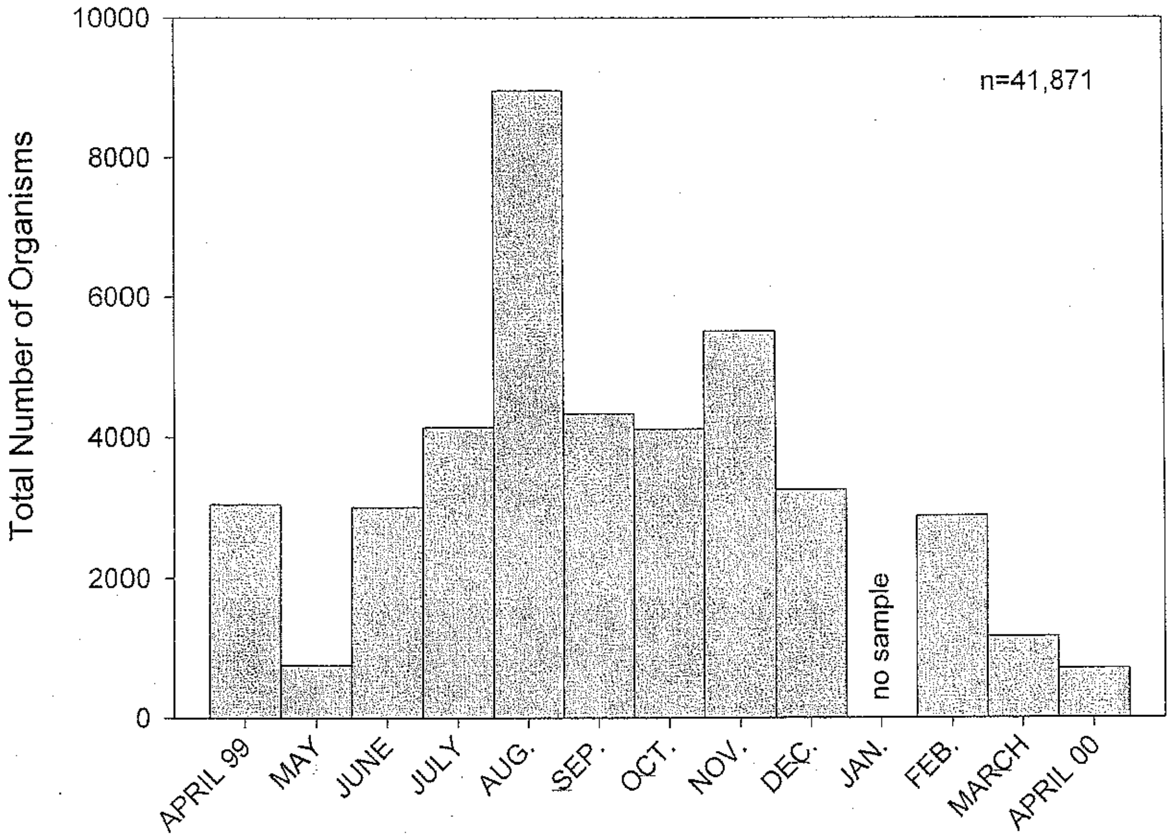


FIGURE 19
Total Number of Invertebrates by Species

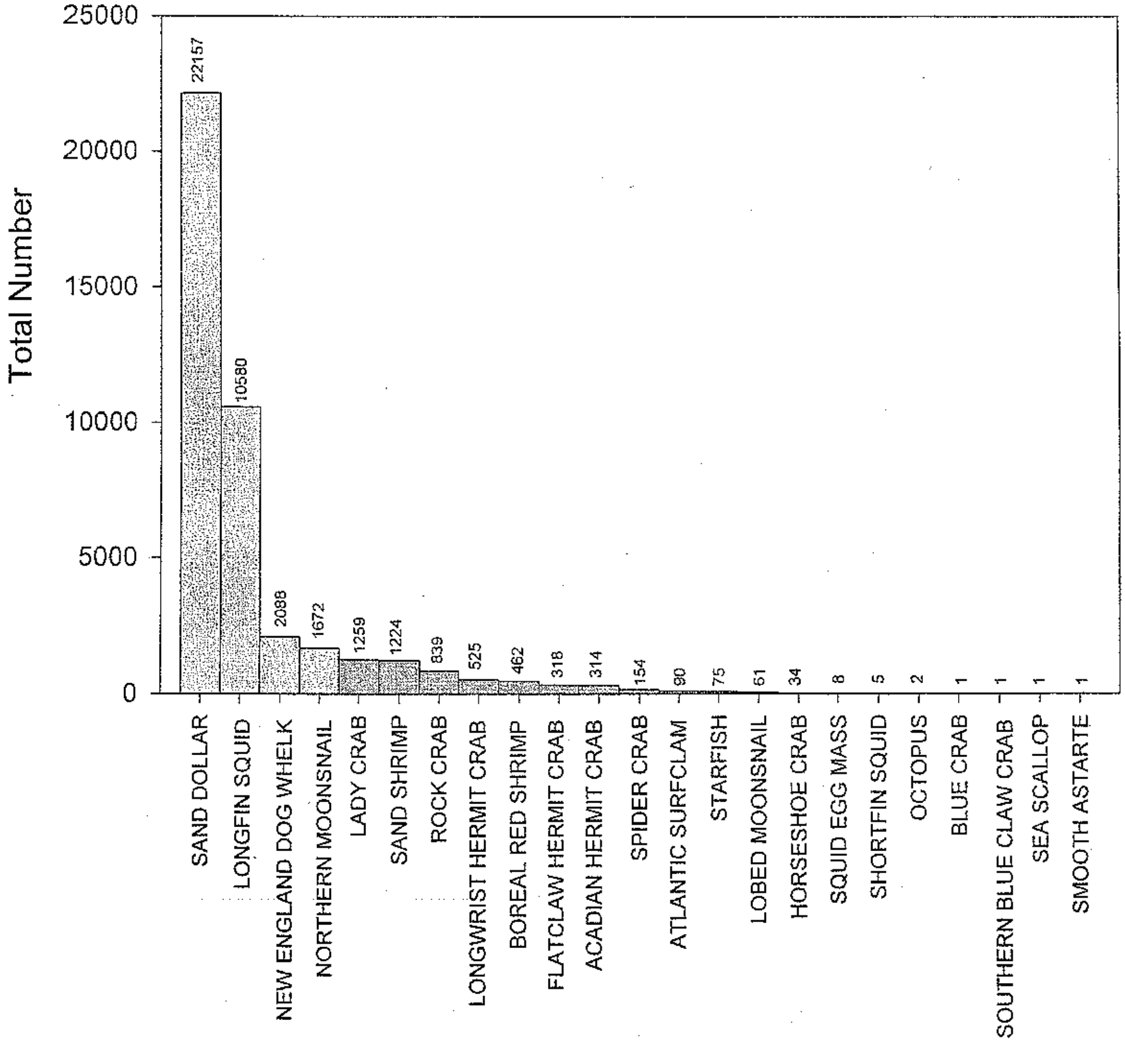


FIGURE 20
Total Number of Benthic Macroinvertebrates vs. Depth

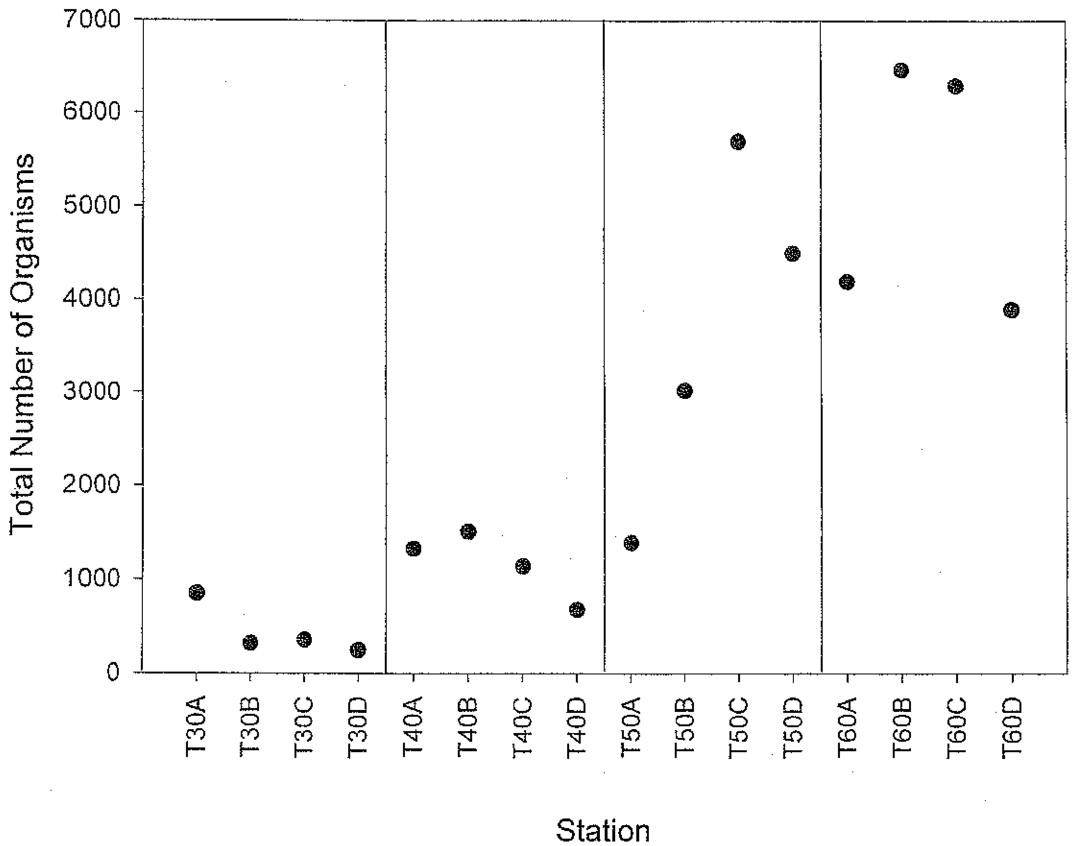


FIGURE 21
Total Number of Benthic Macroinverterbrates vs. Transect

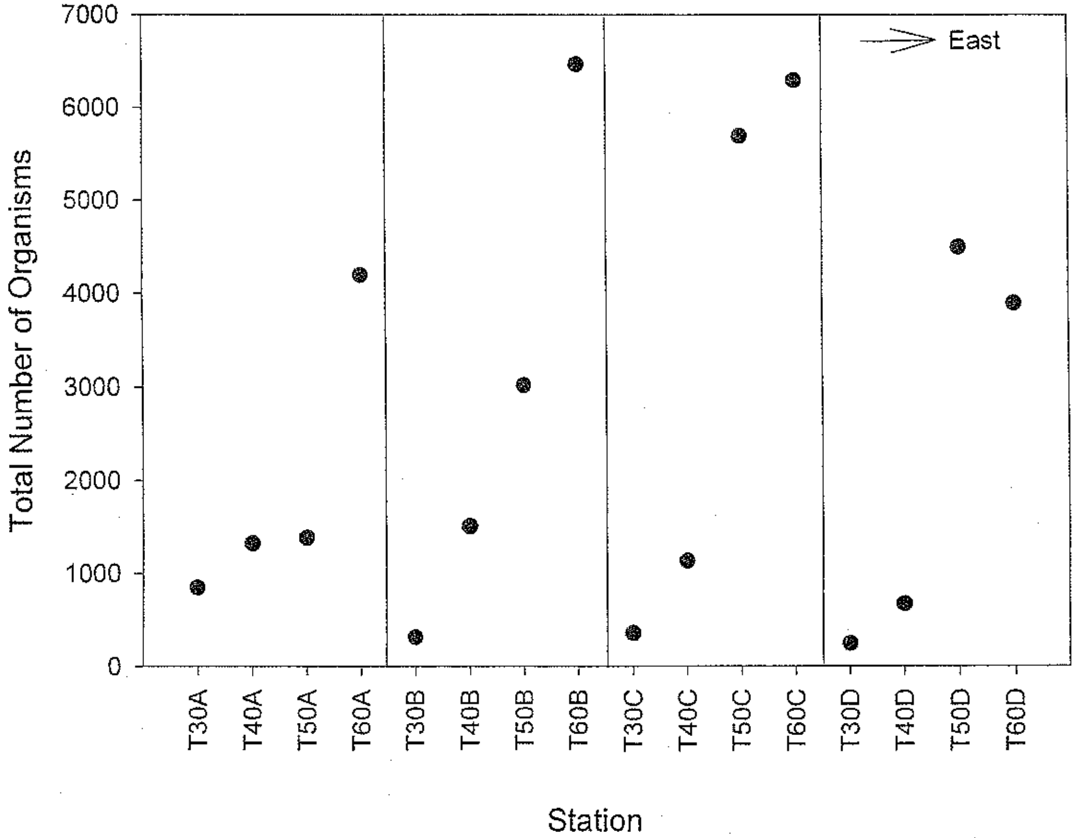


FIGURE 22
Length Frequency Distribution for Longfin Squid

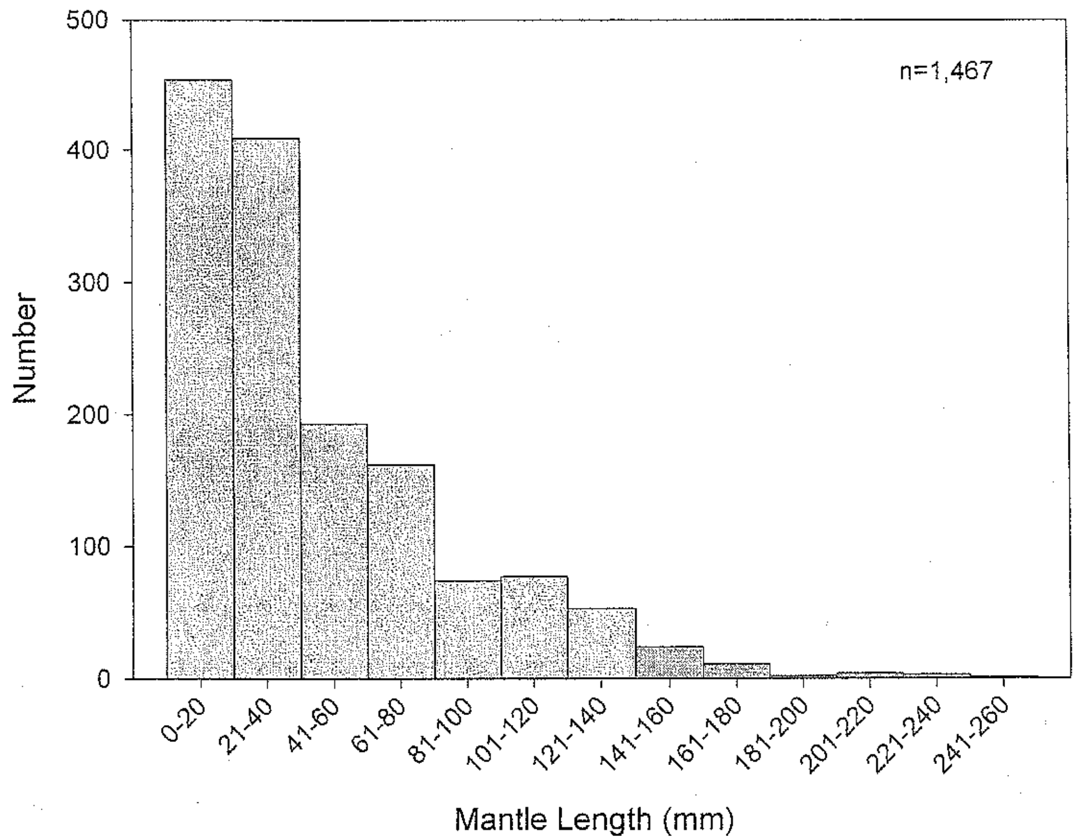
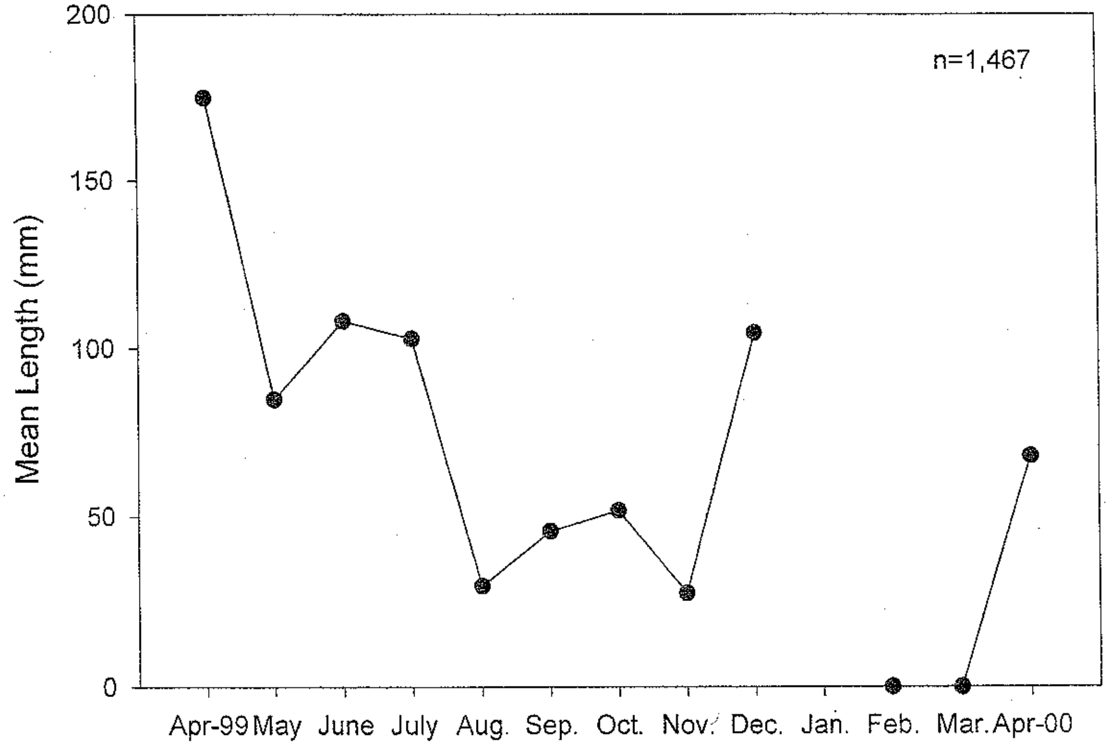
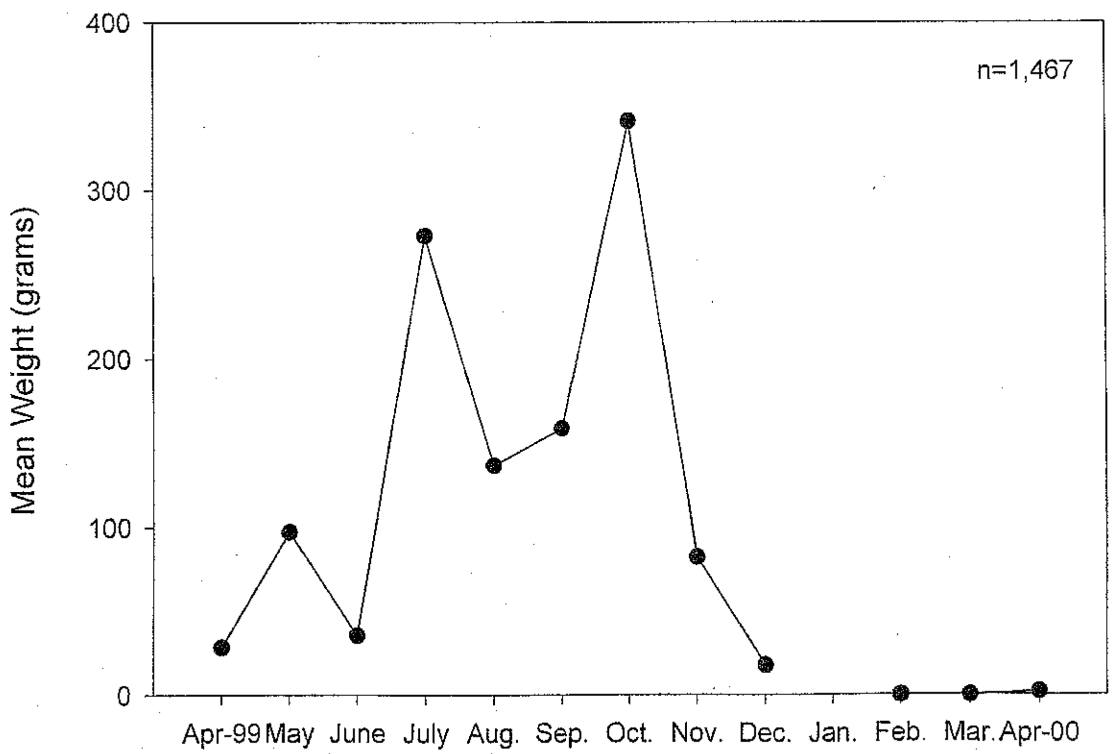


FIGURE 23
Monthly Length and Weight Distributions for Longfin Squid

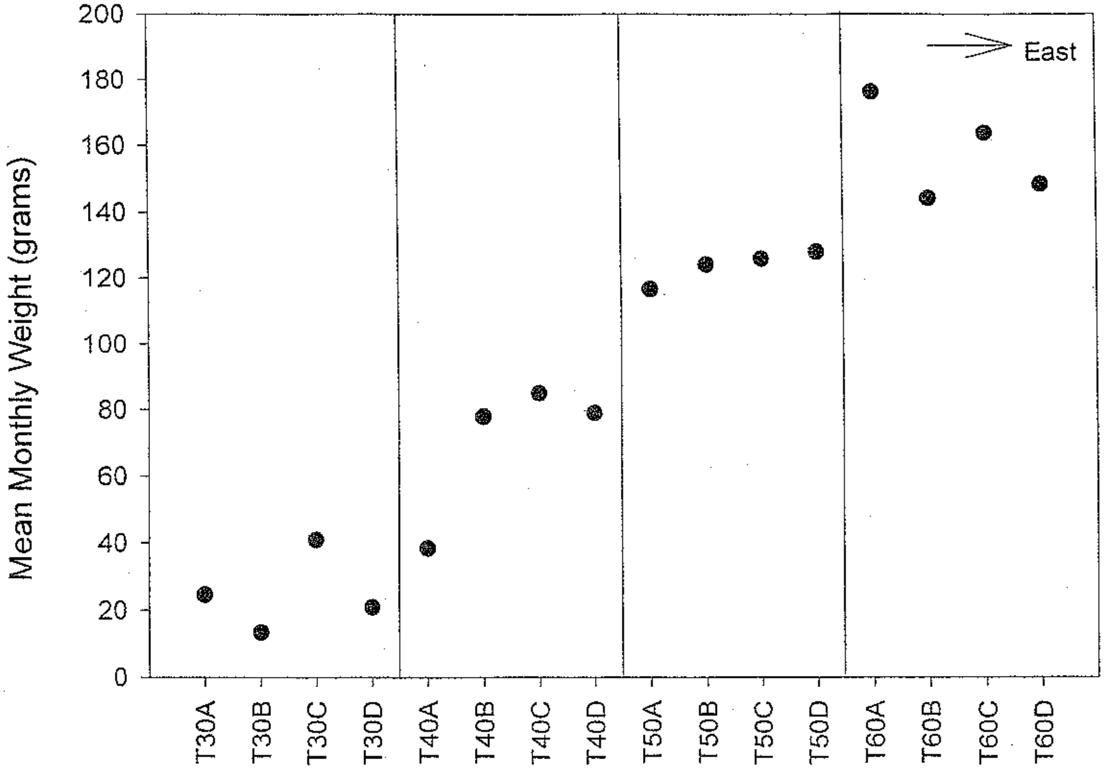


A. Monthly Length Distribution

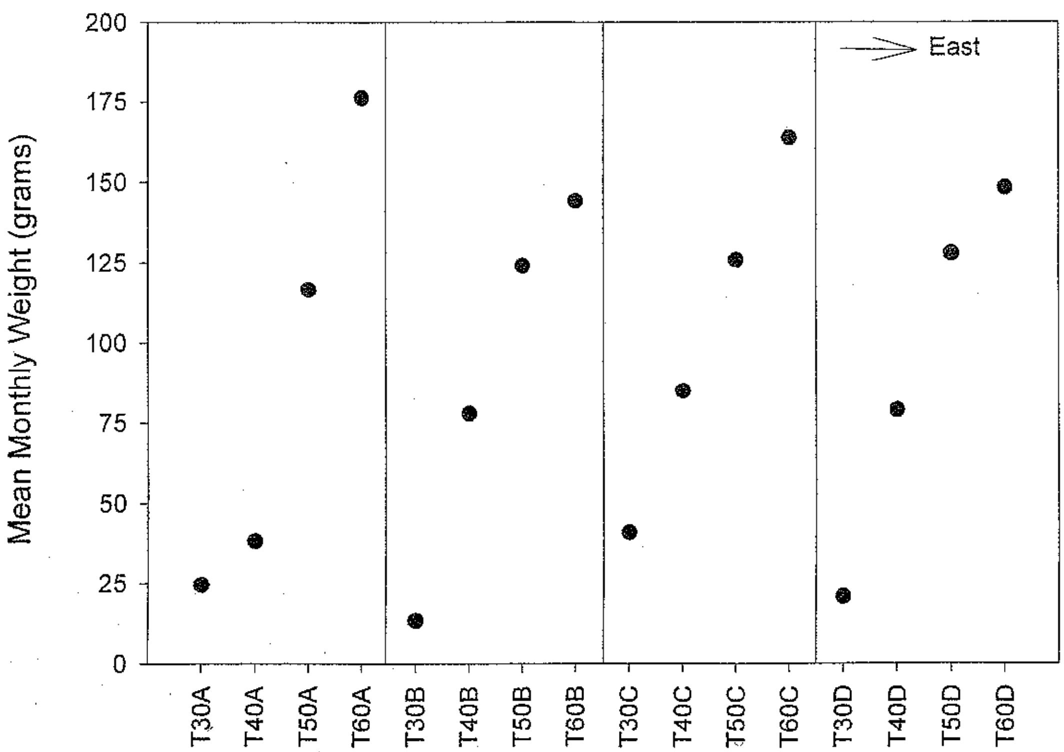


B. Monthly Weight Distribution

FIGURE 24
Longfin Squid Mean Weight per Station



A. Mean weight along depth contours.



B. Mean Weight along transects.

FIGURE 25
BRAT Analysis
Length Frequency Distributions

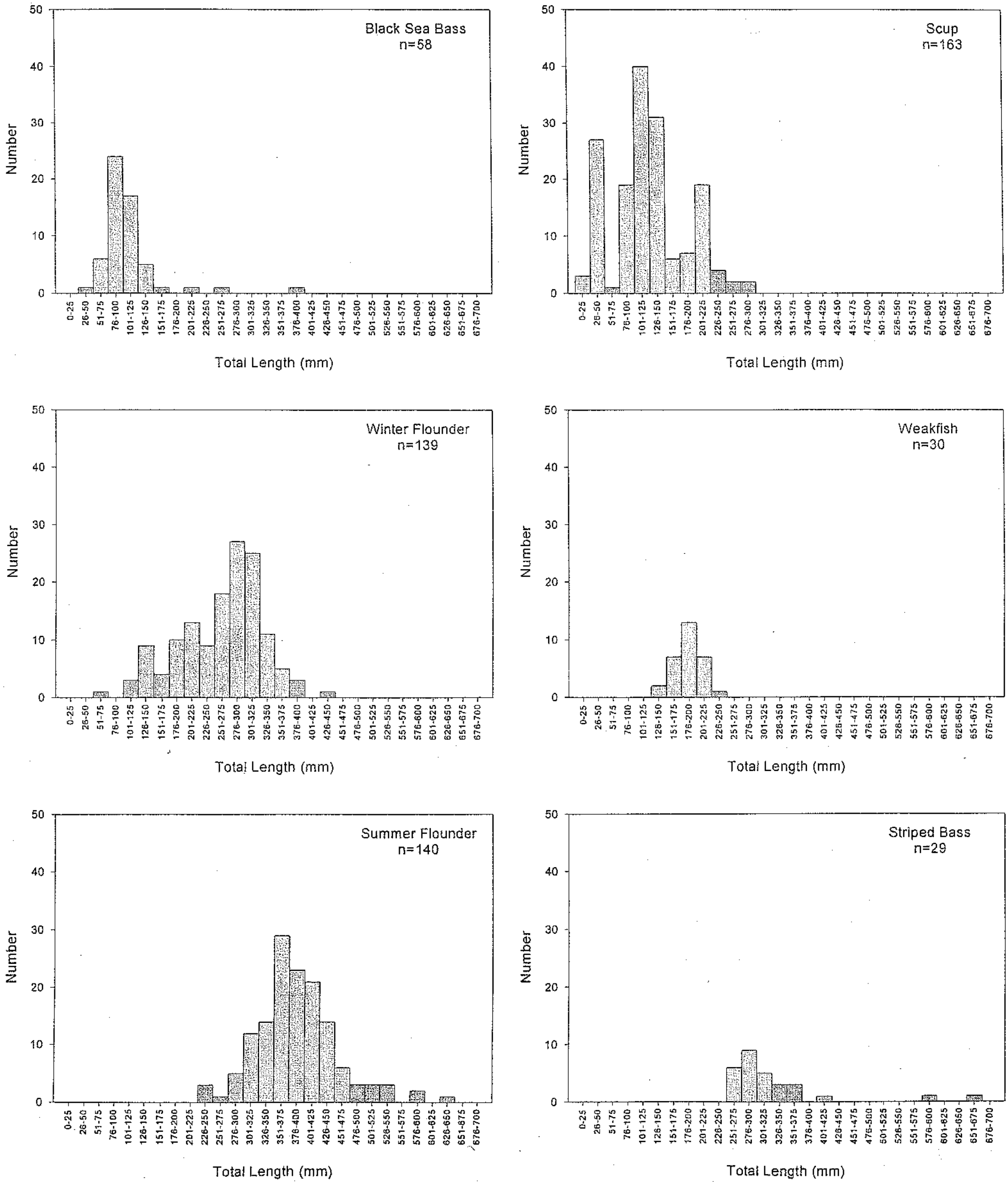


FIGURE 26
BRAT Analysis
Weight of Prey in Fish Stomachs

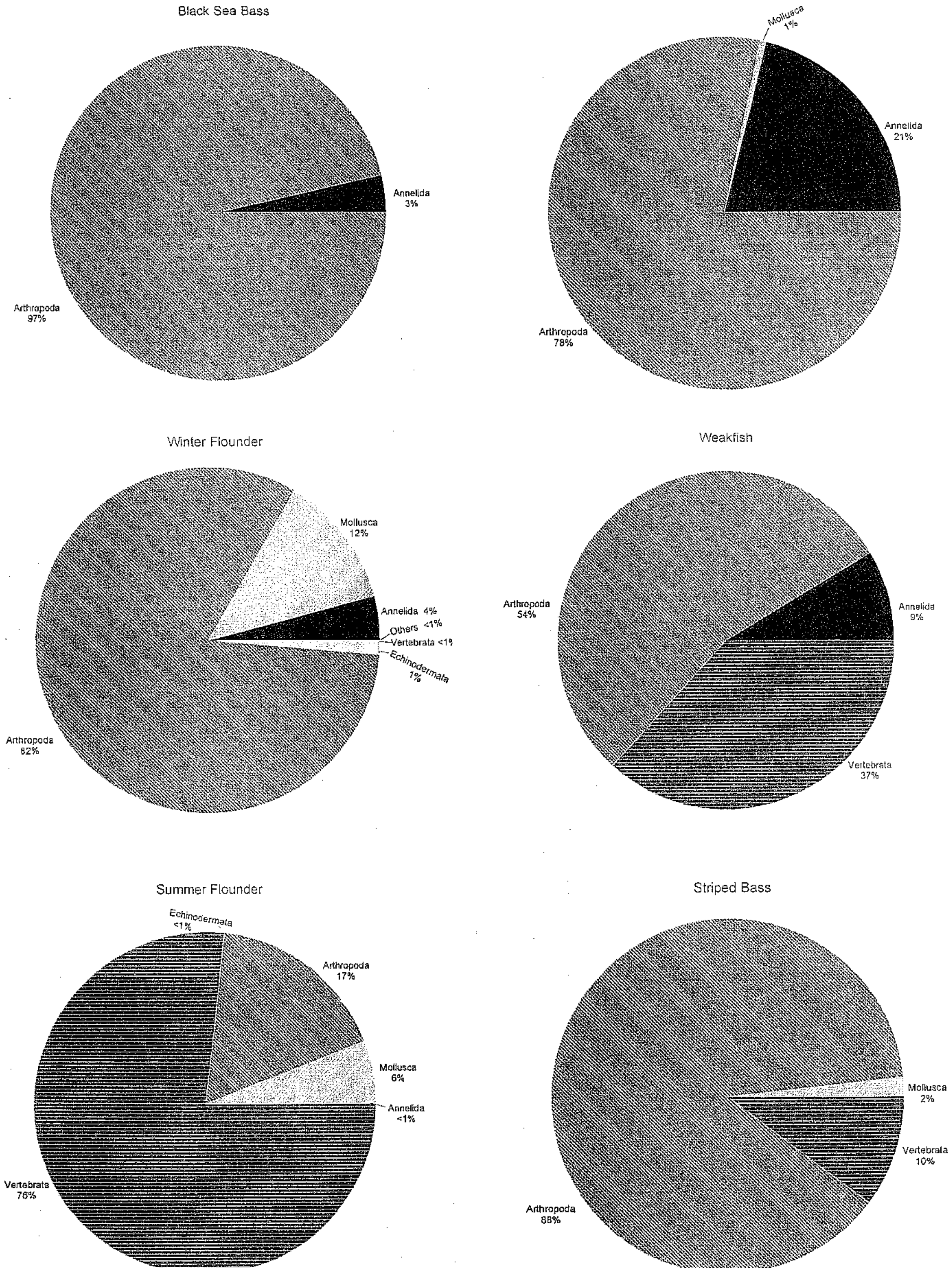


FIGURE 27
BRAT Analysis
Prey as Percent of Total Weight per Month

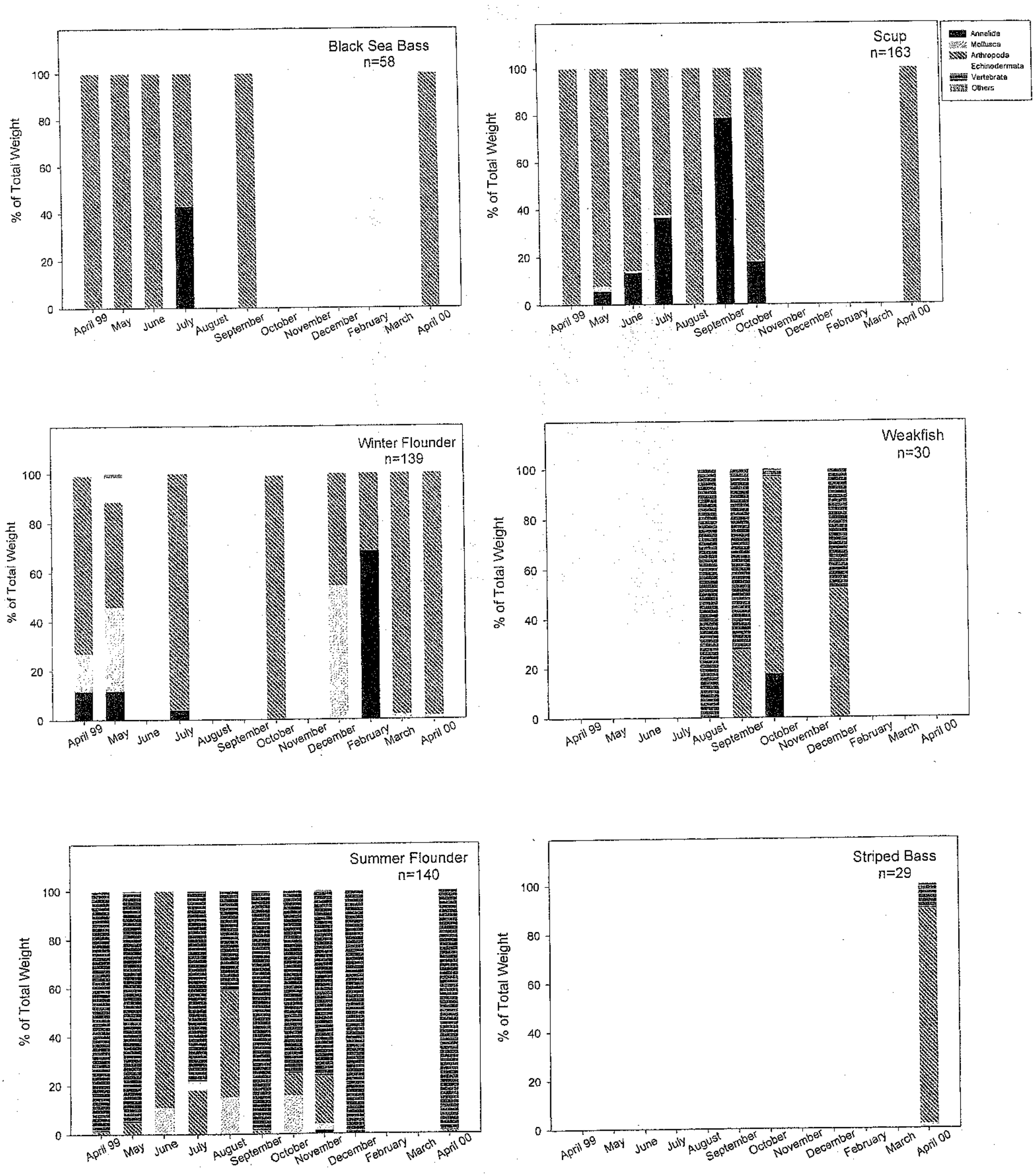


FIGURE 28
BRAT Analysis
Prey as Percent of Total Weight per Species

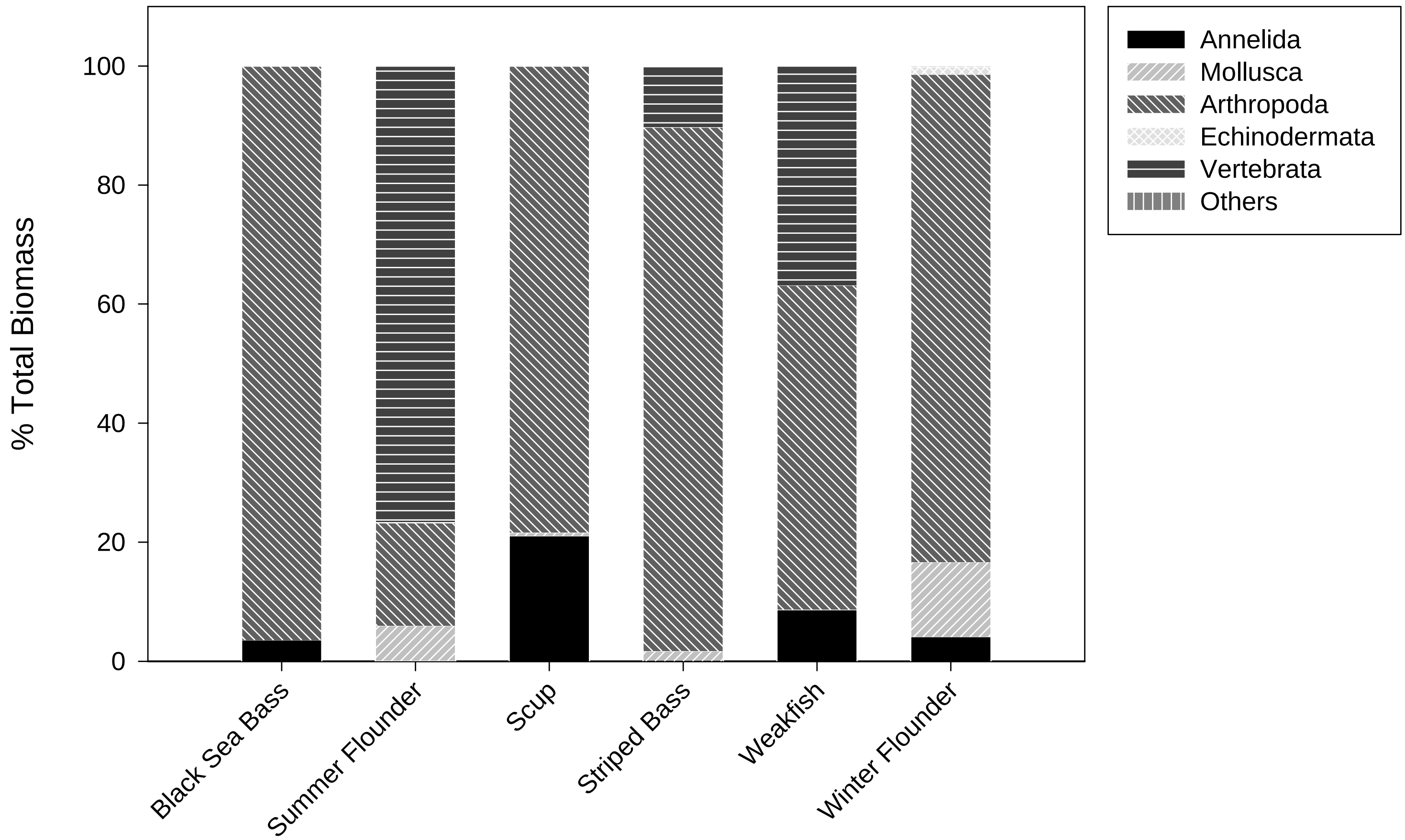


FIGURE 29
BRAT Analysis
Prey as Percent Frequency of Occurrence-Yearly Total

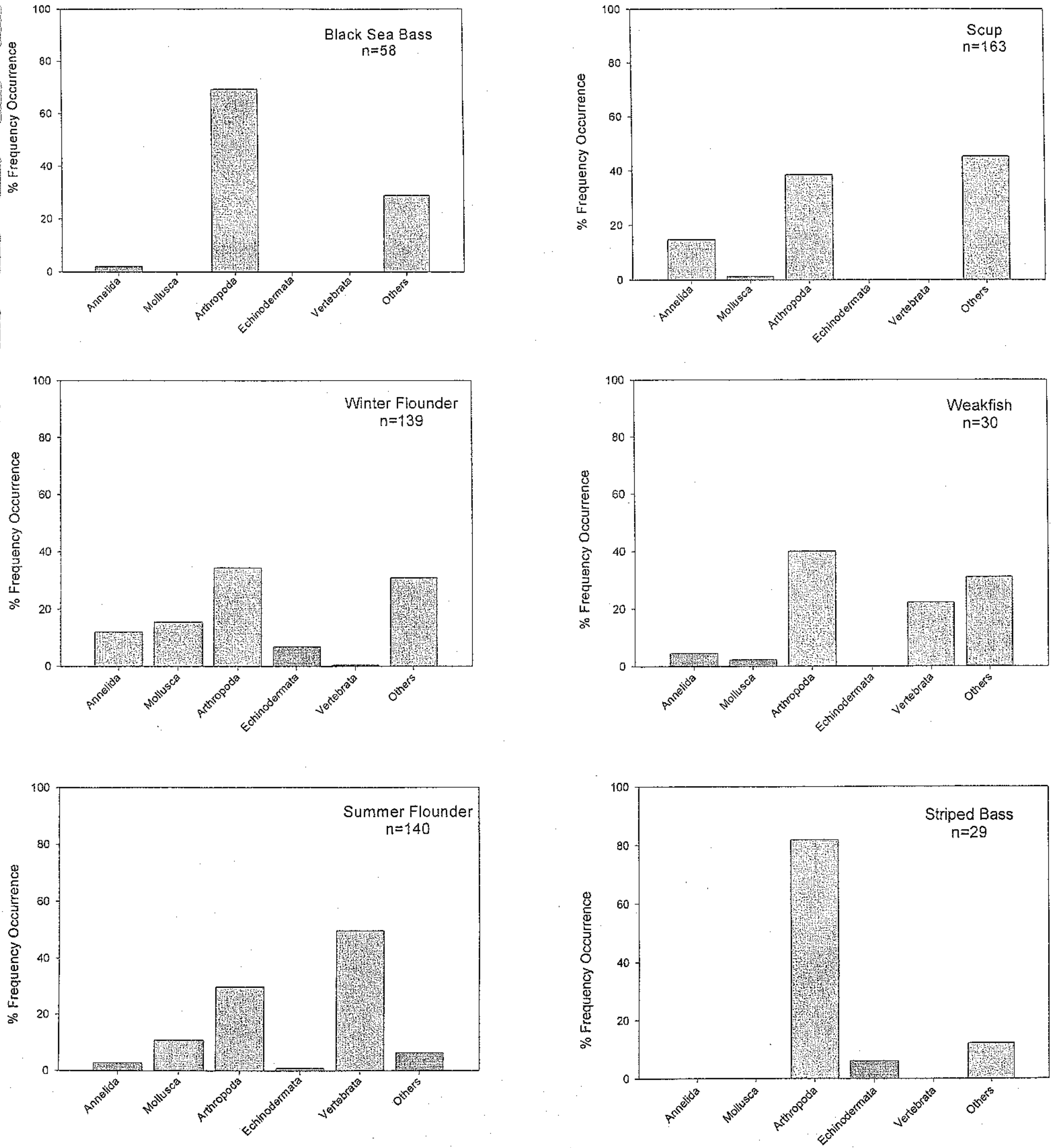


FIGURE 30
BRAT Analysis
Prey as Percent Frequency of Occurrence by Month

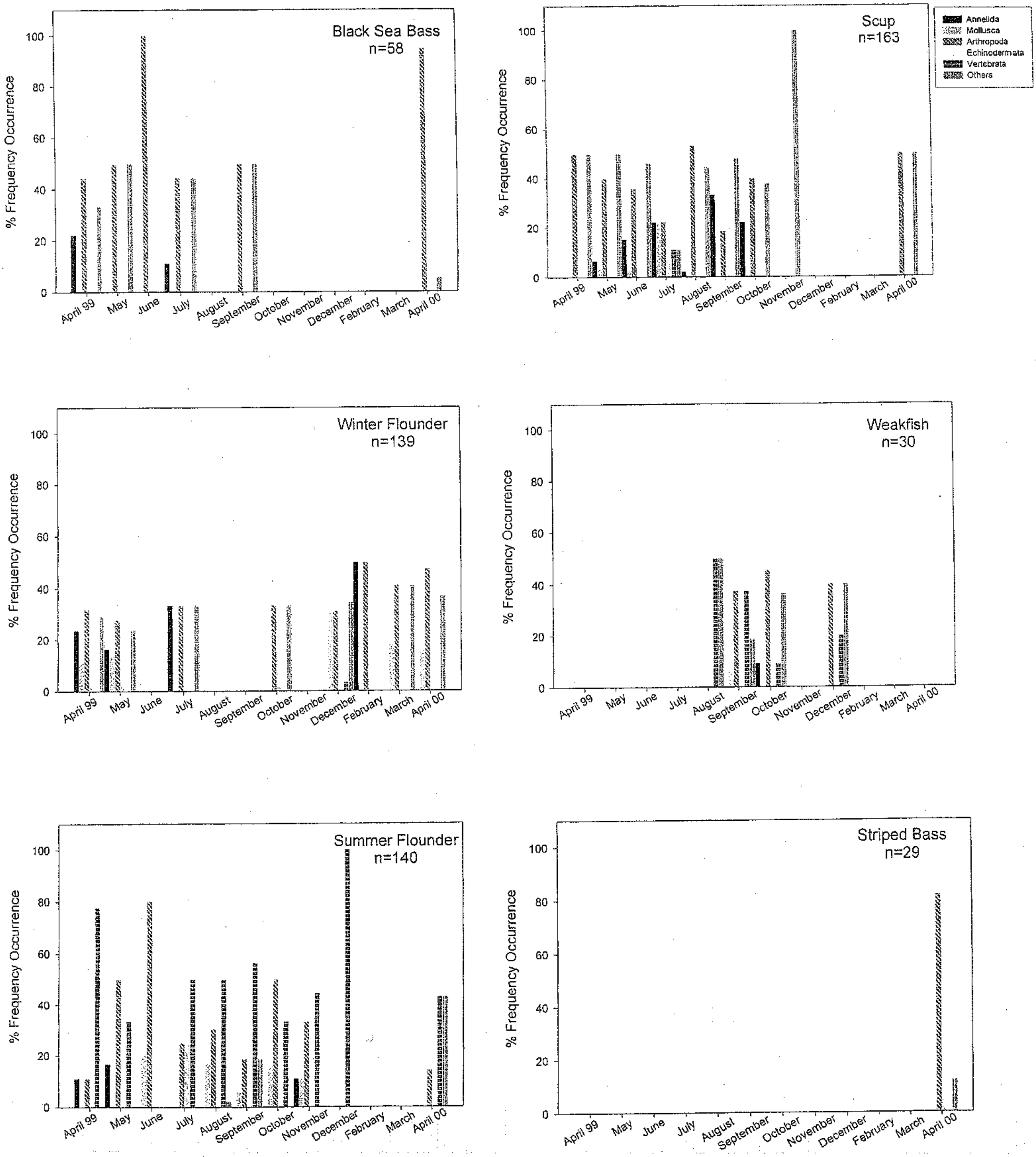


FIGURE 31
Age Frequency Distribution

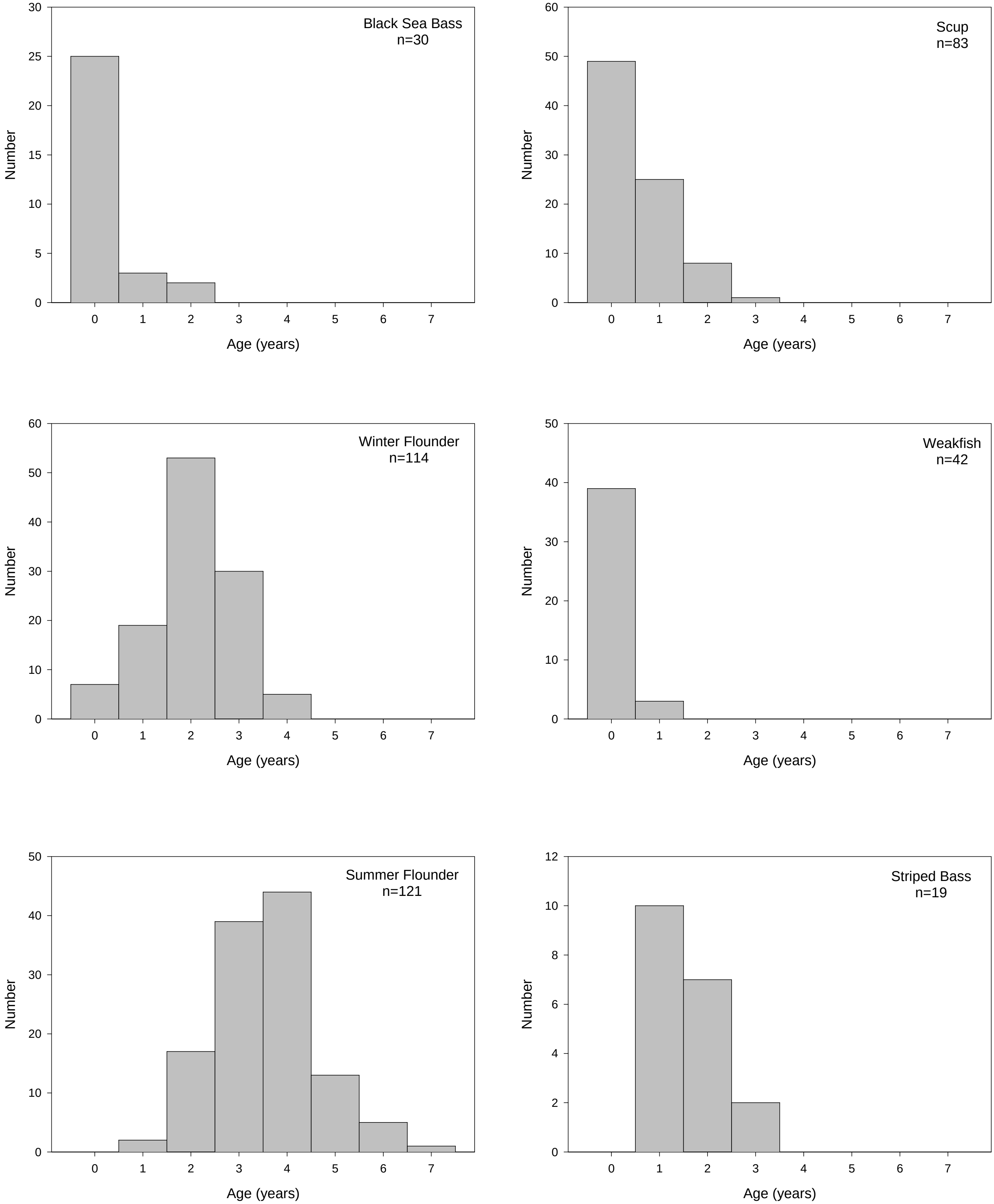
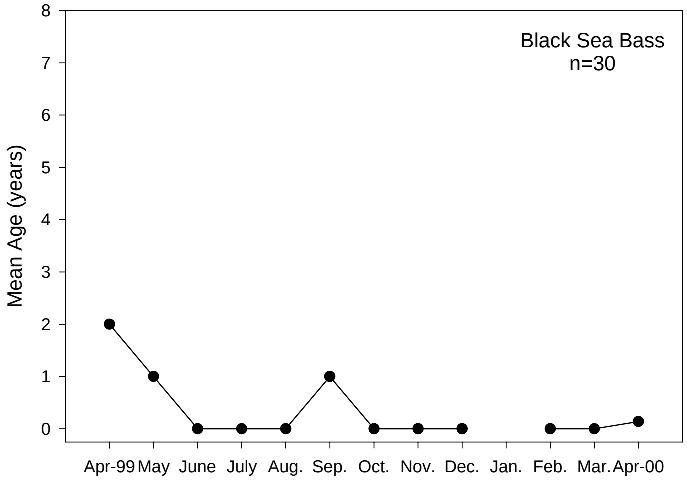
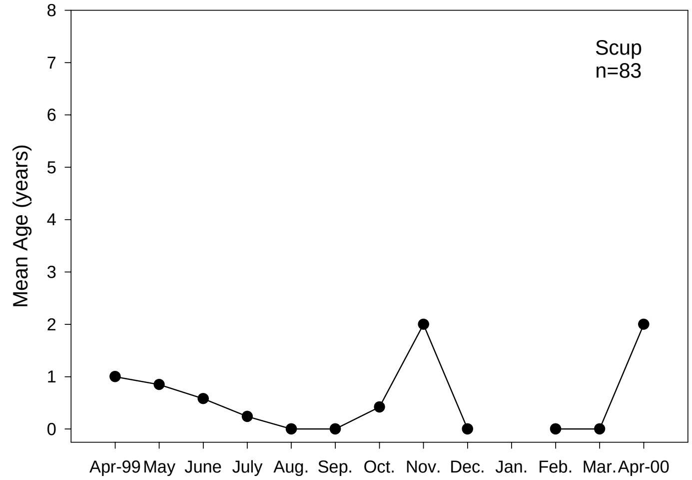
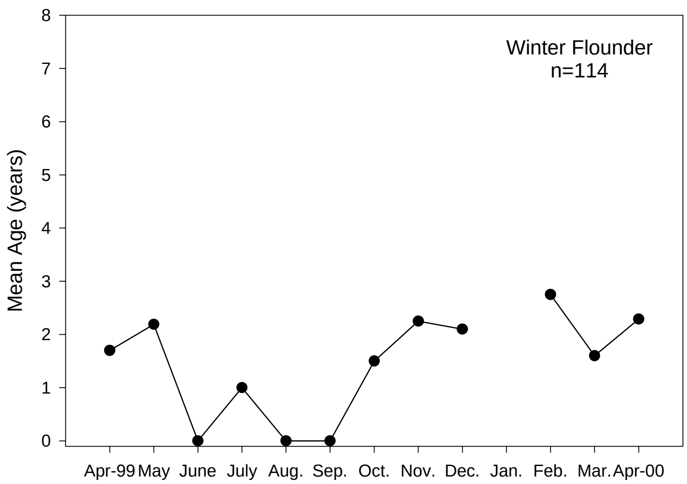
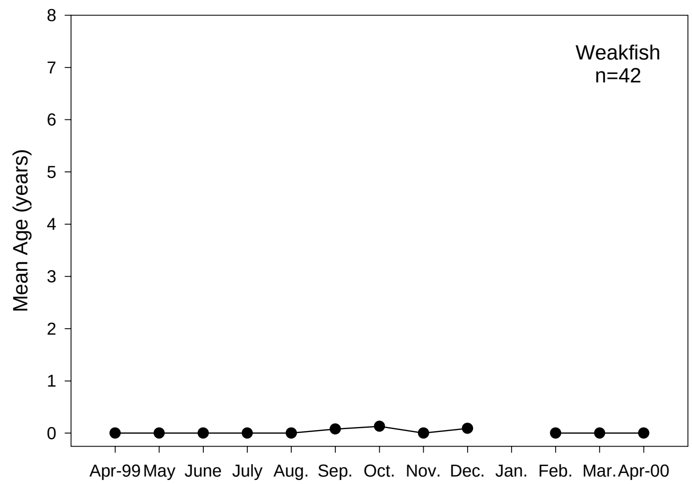


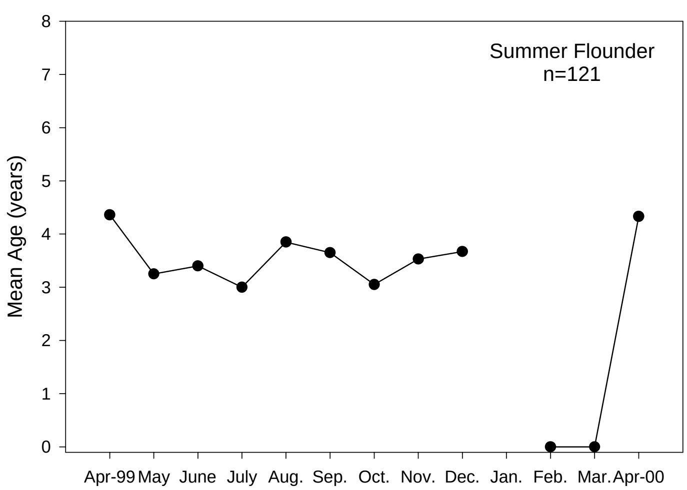
FIGURE 32
Monthly Mean Age Distribution











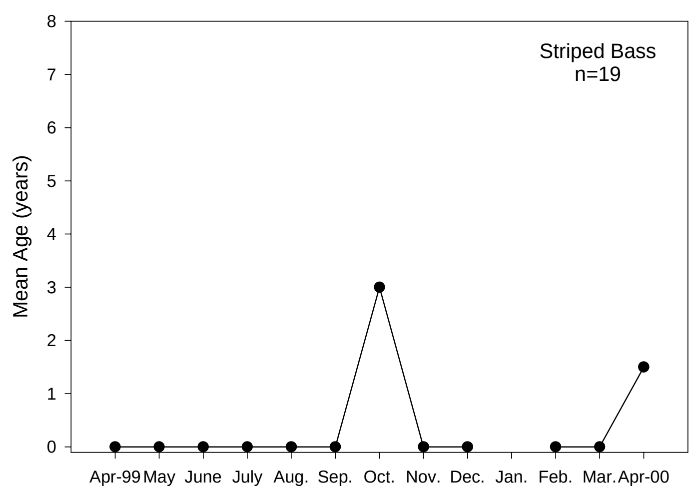


FIGURE 33
Length at Age Distributions

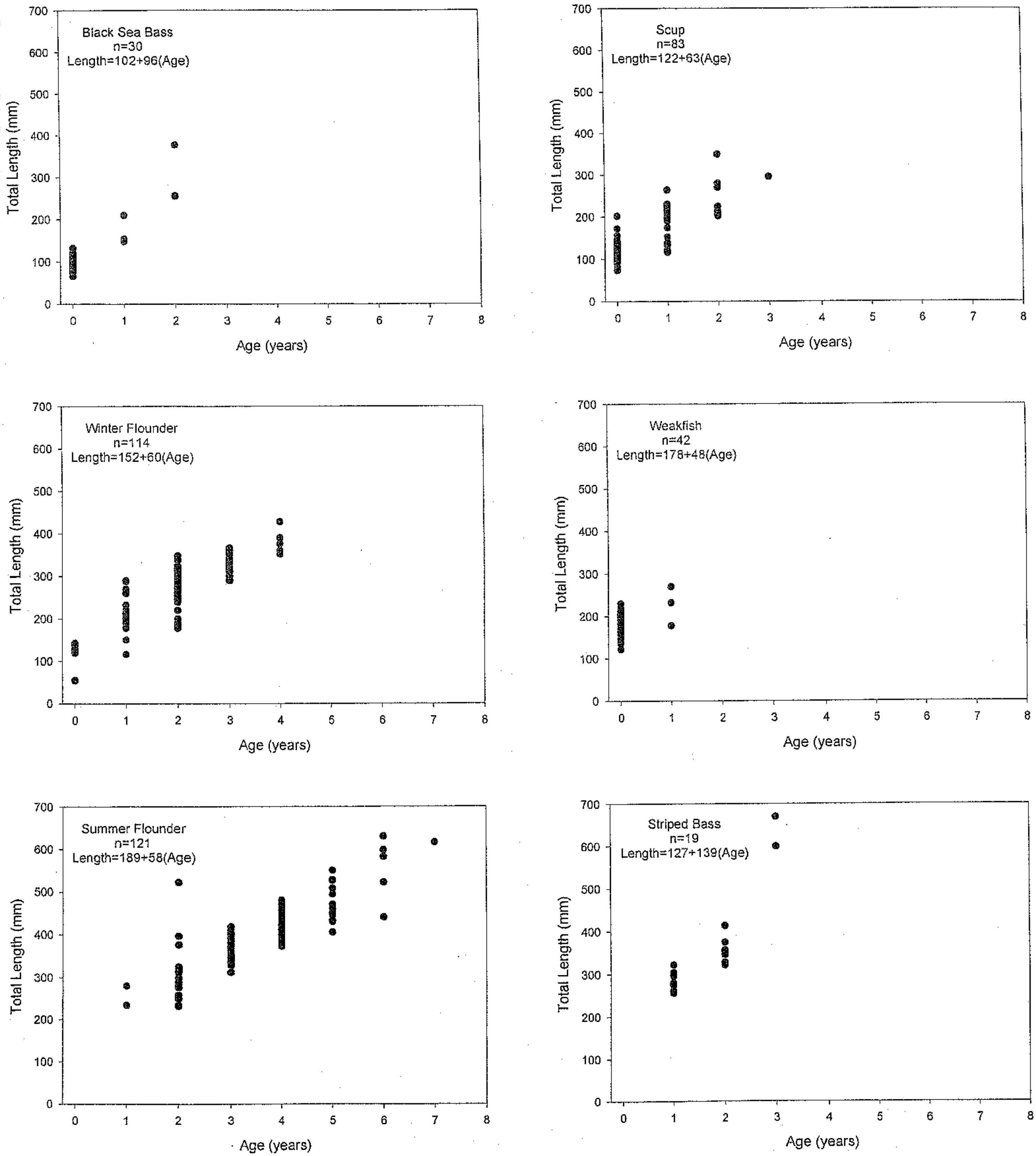


Figure 34
Average Age per Station

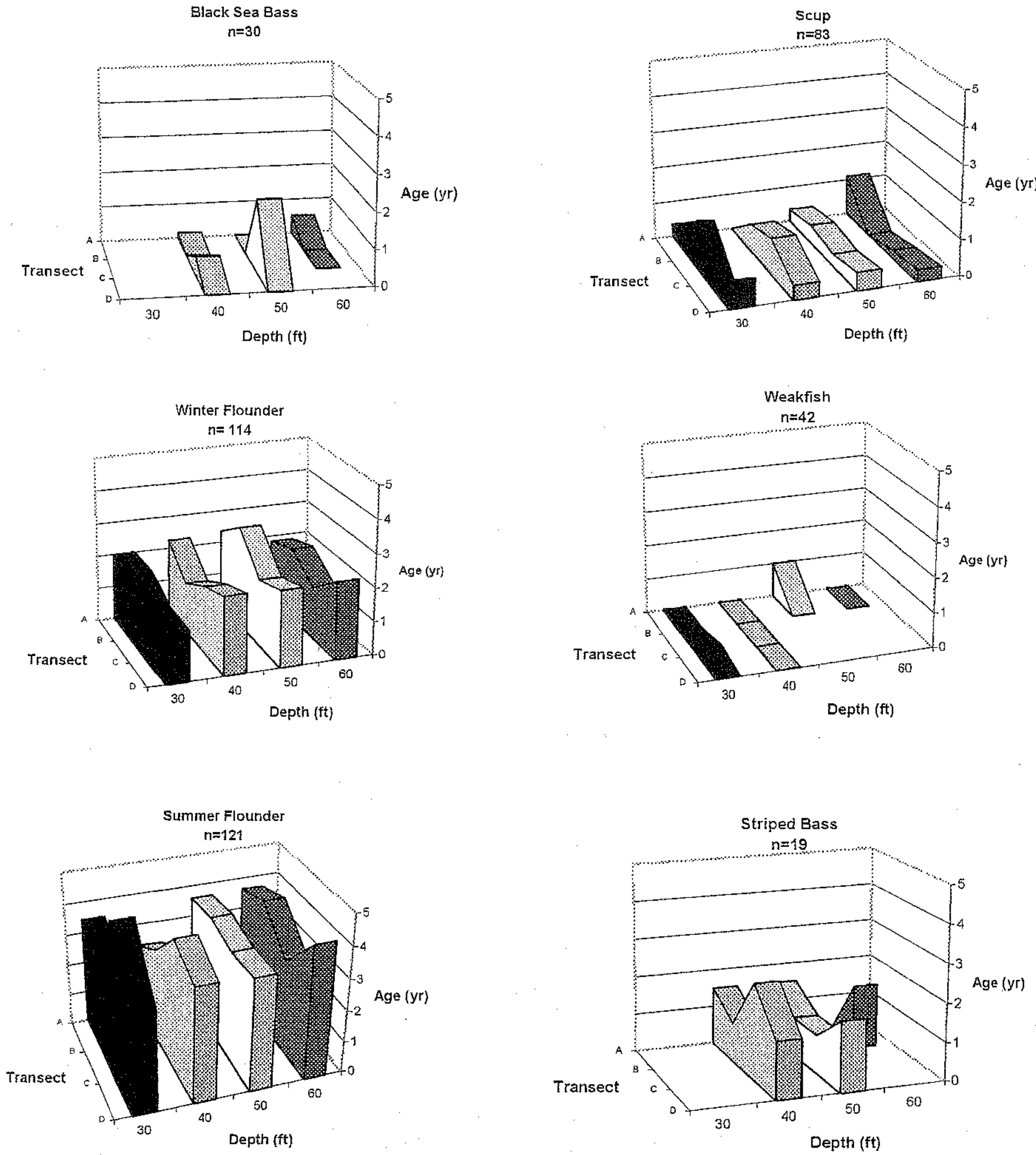


FIGURE 35
Percent Abundance of Benthic Organisms at Stations 4 and 30

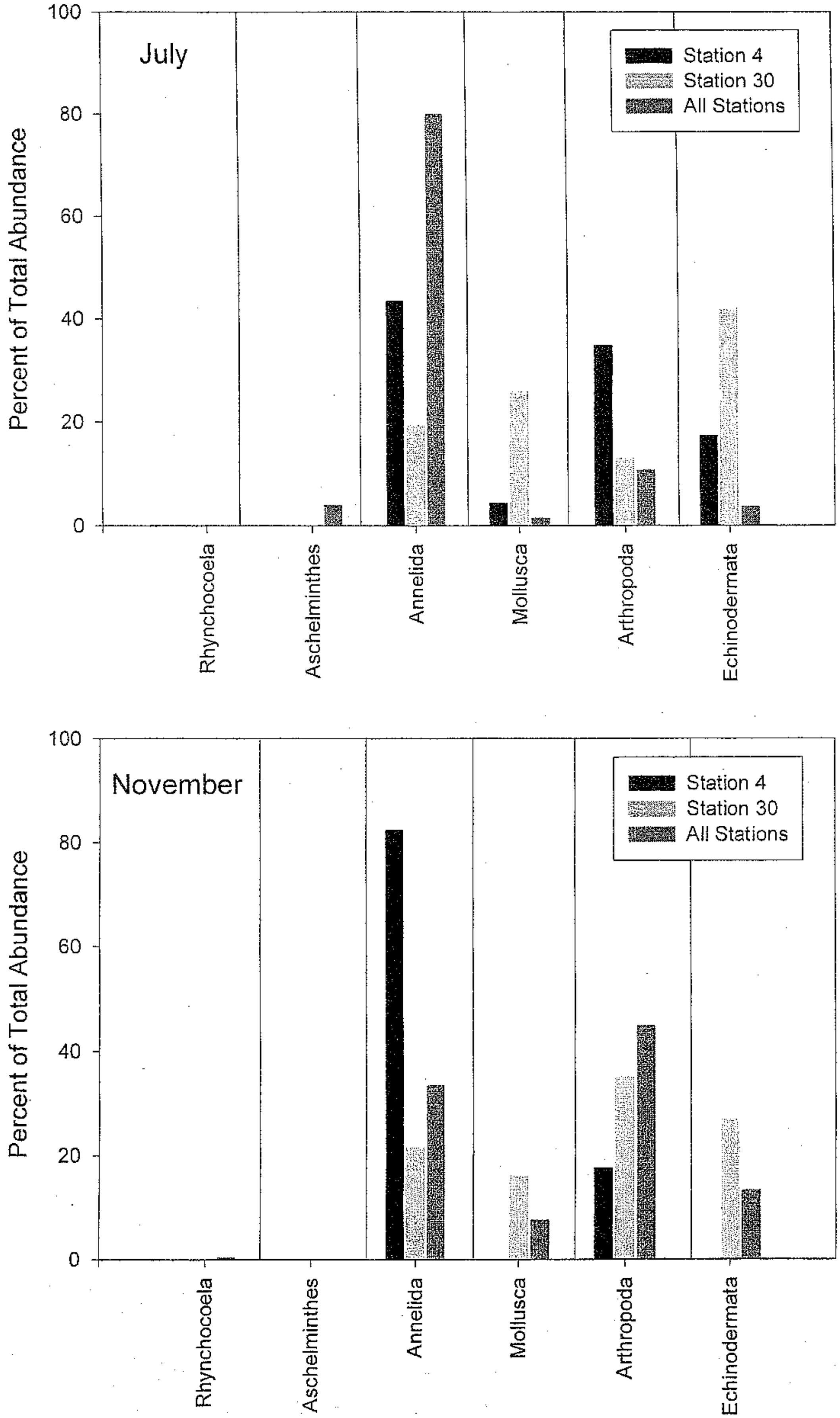


FIGURE 36
Water Quality Parameters for Demersal Trawls
Mean Monthly Values

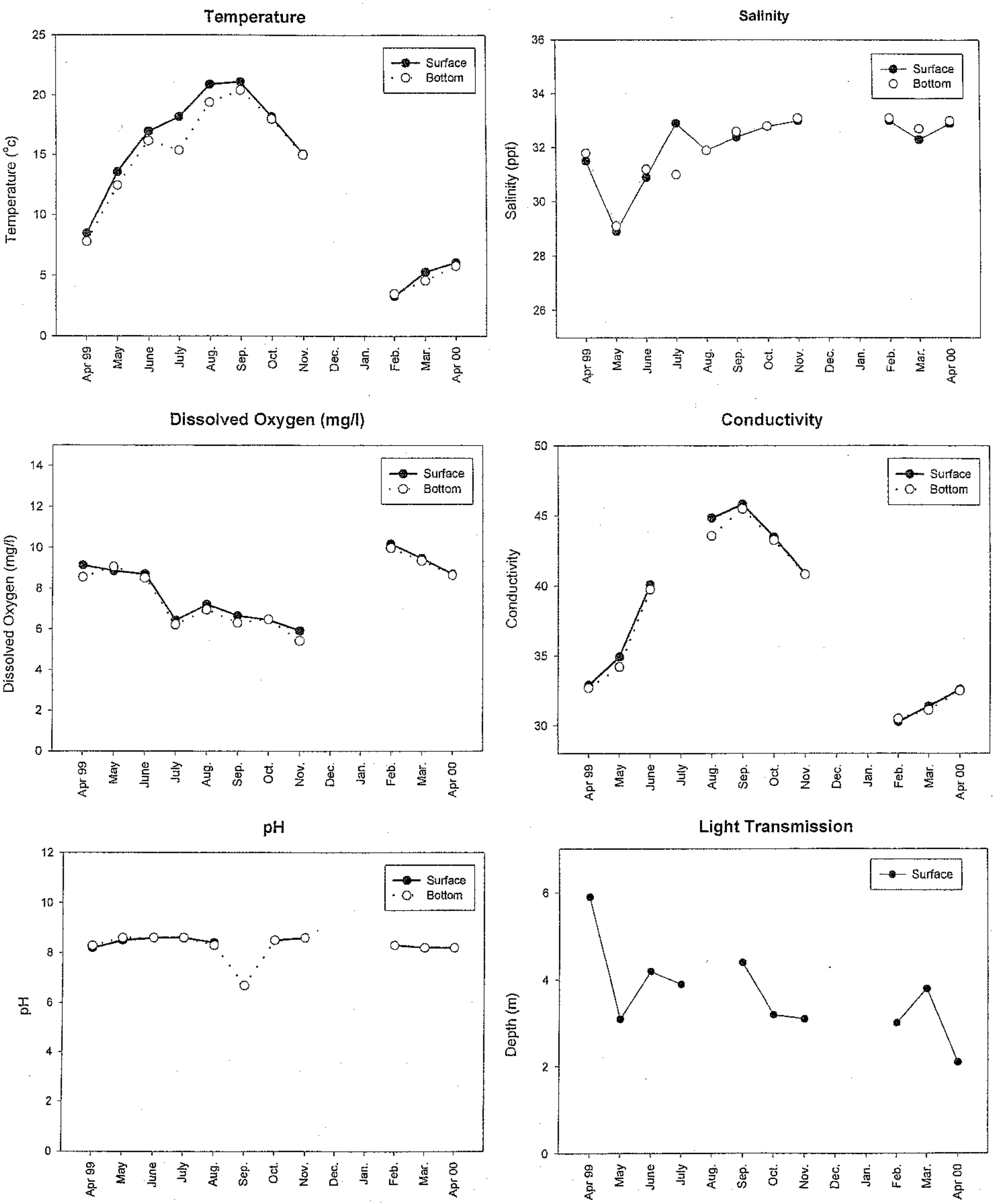


FIGURE 37
Mean Water Quality Values for Depth Contours

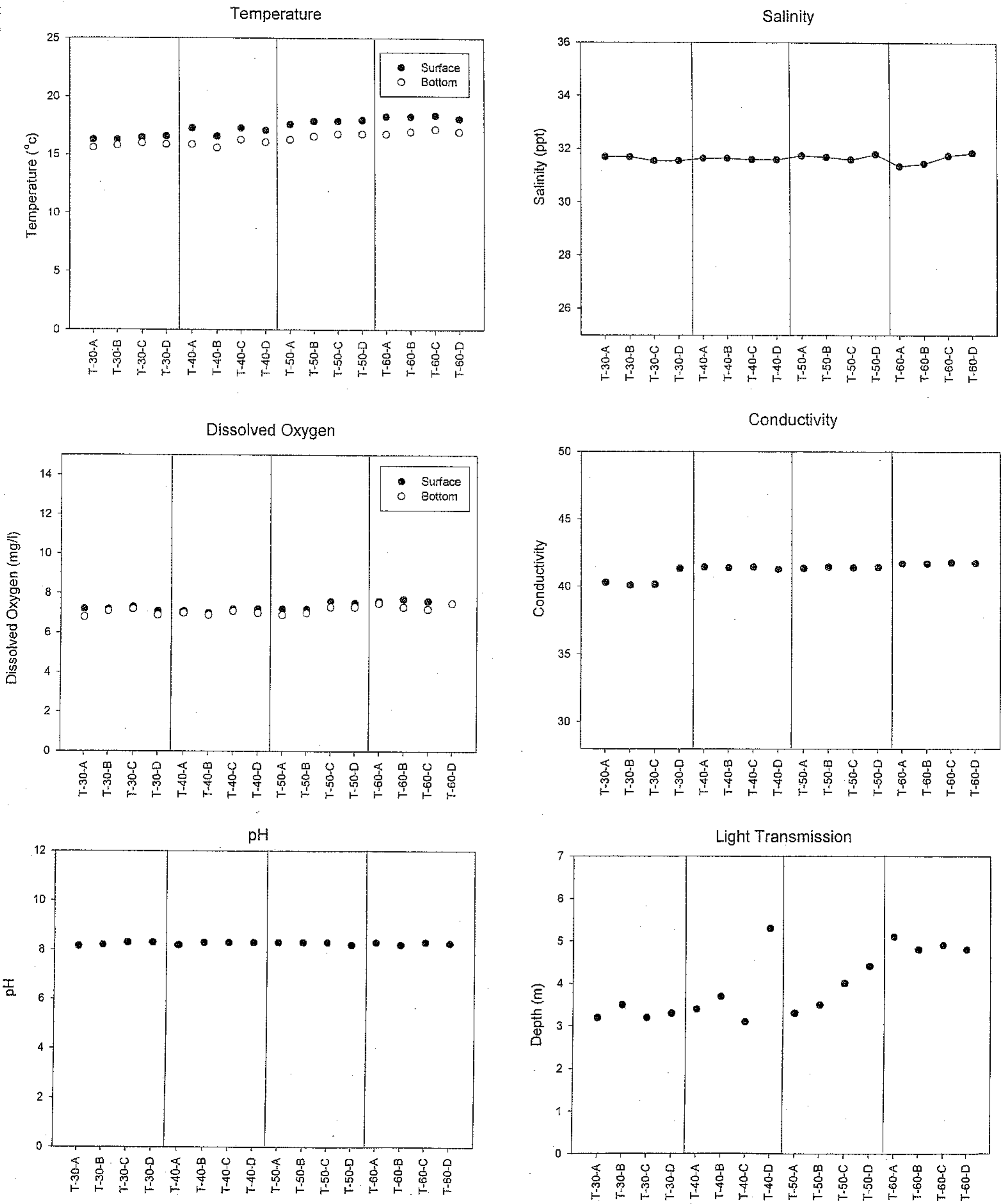


FIGURE 38
Mean Water Quality Values for Station Transects

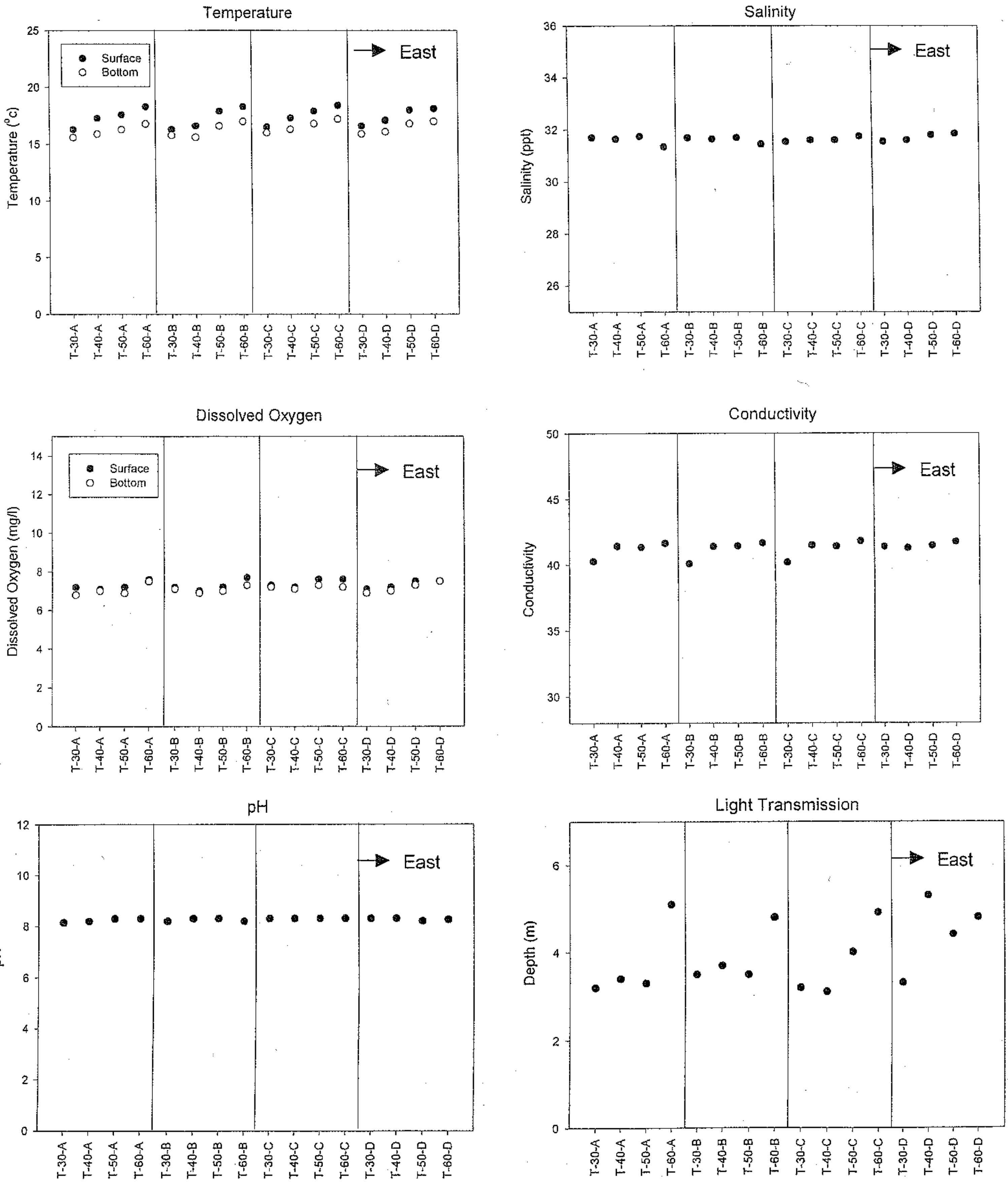
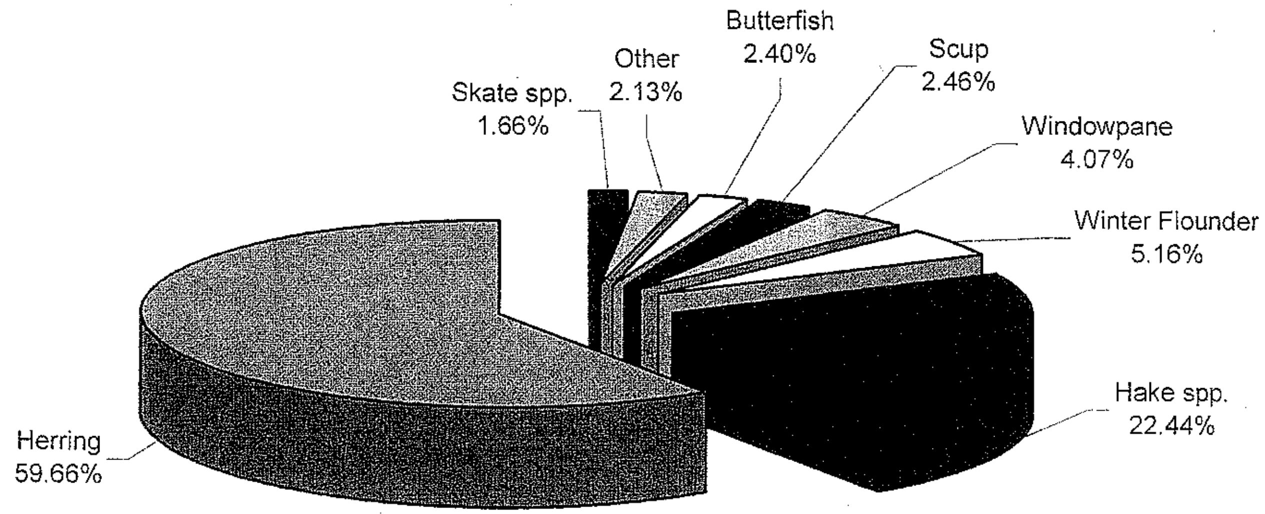
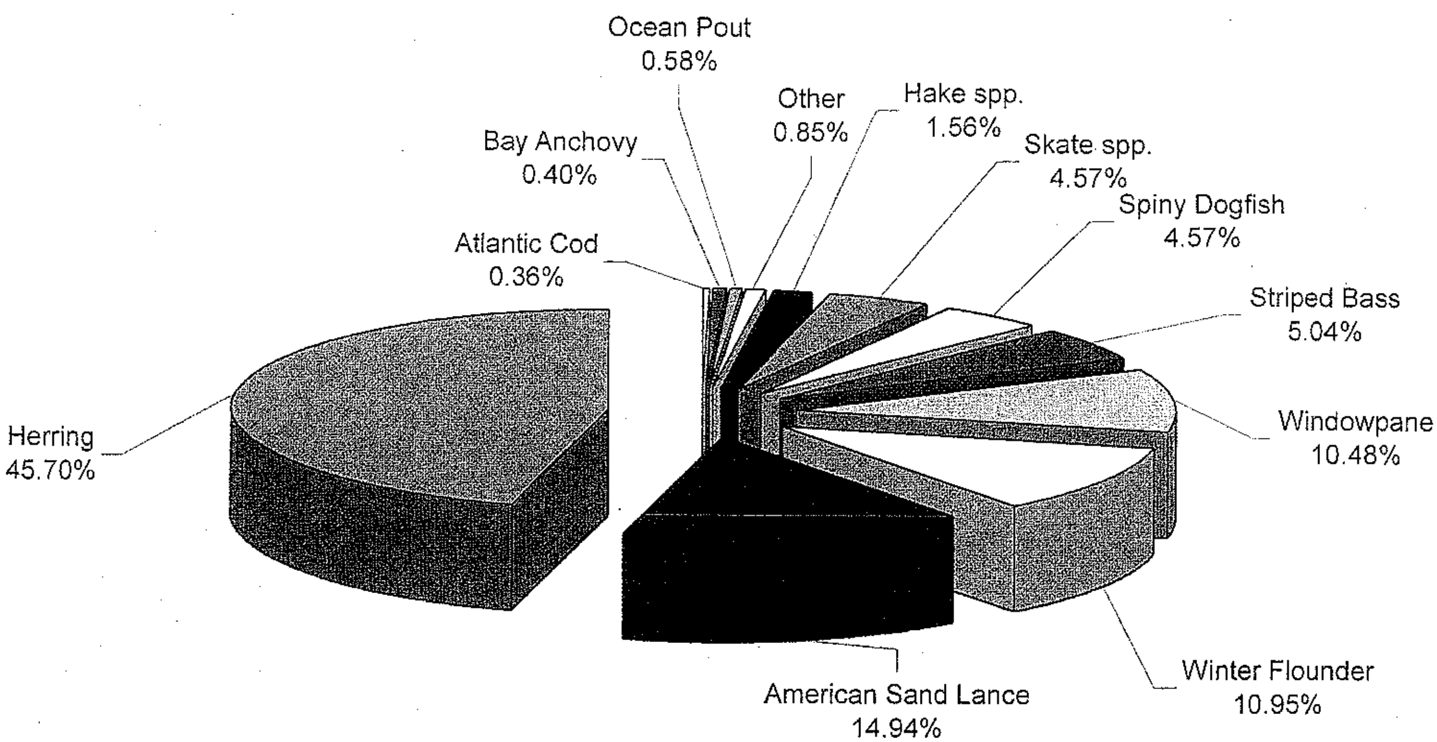


FIGURE 39
USACE Fisheries Trawl Data from the Atlantic Coast of New Jersey-Percent Composition



1995



1996

Source: USACOE 1998 Draft. Waterways Experimental Station, Vicksburg, MS. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury to Manasquan Section Beach Erosion Control Project.

FIGURE 40
Percent Compositon of Yearly Trawl Catches
1999 – 2000 EEA, Inc. Survey