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# Diet Composition and Feeding Habits of Large Striped Bass, Morone saxatilis, in Chesapeake Bay

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## ABSTRACT

Large striped bass, *Morone saxatilis*, form a dominant component of the higher trophic level in Chesapeake Bay. These fish peak in abundance seasonally in the spring during their spawning migrations and in the fall when they return to feed and overwinter within the Bay. In recent years, populations of striped bass have increased dramatically, raising concerns about their predatory impact and their forage requirements. In response to these concerns and the need for recent studies, this study characterizes the feeding habits of large striped bass in Chesapeake Bay during the years 1997 and 1998.

Striped bass consumed a wide variety of prey species with 52 different species of vertebrates and invertebrates found in the stomachs. Only a few species, however, notably clupeoid and sciaenid fishes, dominated the diet across all seasons, locations and size ranges of striped bass examined. Of these species, menhaden, *Brevoortia tyrannus* was the dominant prey species in most areas with gizzard shad, *Dorosoma cepedianum*, replacing menhaden in importance in lower salinity waters. Spot, *Leiostomus xanthurus,* and other sciaenid fishes and anadromous herrings, *Alosa sp.*, also constituted large percentages of the diet. Anchovies, *Anchoa sp.*, were important only for smaller striped bass. Invertebrates were relatively unimportant in the diet with only blue crabs, *Callinectes sapidus*, consumed in high numbers and only by smaller striped bass in the summer.

Low indices of stomach fullness and high percentages of empty stomachs indicated decreases in feeding intensity on the springtime spawning grounds and again in the late summer. These declines in feeding appear to be natural cycles associated with spawning and bioenergetic constraints rather than indications of widespread food limitation as suitable prey appeared to be present at those times. Collection methodology influenced the interpretation of the diet composition and feeding behavior, though the lack of controlled comparisons prevented definitive statements of how collection methodology affected the results.

Overall, large striped bass appear to be primarily piscivorous and concentrate their feeding on schooling young-of-the-year fishes. Locally, the diet reflects the most abundant schooling fishes within the environment. This study indicates that trophic bottom-up or top-down control processes involving striped bass and their prey would likely occur at discrete temporal and spatial scales and only with certain sizes of predator and prey. Multispecies management of both predator and prey should consider these spatial, temporal and size-specific interactions

Diet composition and feeding habits of large striped bass, *Morone saxatilis,* in Chesapeake Bay

## INTRODUCTION

The striped bass, *Morone saxatilis*, is a relatively large member of the temperate bass family, Moronidae (Nelson, 1994). Striped bass range from the St. Lawrence River, Canada, to the St. Johns River, Florida, with disjunct populations in the Gulf of Mexico and introduced populations on the Pacific coast of North America and in many freshwater lakes (Murdy et al. 1996). Striped bass are anadromous, migratory fish that spawn in freshwater but may be found in marine, estuarine, riverine and lacustrine environments.

Along the Atlantic coast of North America the striped bass is one of the most important commercial and recreational fishes. Annual commercial landings along the East Coast in the early 1960's and 1970's ranged from 8 million to 15 million pounds. Recreational harvests approached these levels and may have exceeded the economic value of the commercial fishery (Norton et al 1984). Landings dropped during the mid 1970's – 80's and remained low into the 1990's due to declines in abundance and harvest limits. Nevertheless, the economic impact of striped bass catches remained significant as coast-wide estimates of the value of the 1993 commercial fishery (6.6 million pounds) ranged from $53 – $ 270 million (Southwick and Teisl 1995).

Throughout their range, striped bass are important predatory components of the ecosystem (Hartman and Brandt 1995a). At various life history stages striped bass directly utilize all but the lowest trophic levels. Larval striped bass feed upon zooplankton and may be highly selective for the copepod, *Eurytemora affinis* (Limburg et al 1997, Setzler, 1980). Juvenile striped bass reside in the tidal freshwater to mesohaline reaches of rivers where they feed primarily on invertebrates including insect larvae, mysids and cladocerans (Boynton et al 1981, Markle and Grant 1970, Rudershausen 1994). As they mature between ages II and V, striped bass become increasingly piscivorous (Manooch 1973, Rulifson and McKenna 1987), though particular feeding habits appear determined by the habitat utilized and composition of the prey community.

In Canadian waters (Rulifson and McKenna 1987), Long Island surf in the summer (Schaefer 1970) and San Francisco Bay (Johnson and Calhoun 1952) adult fish fed primarily upon crustaceans. In North Carolina waters, adults fed predominantly upon menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*) and blueback herring (*Alosa aestivalis*) (Manooch 1973). Similarly, in two published studies of adult striped bass feeding in Chesapeake Bay, fish fed mainly on anchovies and menhaden (Hollis 1952, Hartman and Brandt 1995a). In the freshwater Lake Texoma, landlocked striped bass exhibited a high preference for clupeid prey to the point that, during declines in clupeid abundance, they starved rather than shifting to more abundant centrarchid prey (Mathews et al 1988). Few other studies have examined feeding selectivity of adult fish other than observing a preference for soft-rayed rather than spiny-rayed fishes (Manooch 1973).

Historically, Chesapeake Bay has produced the largest recreational and commercial fishery on the East Coast of North America and is the spawning area and juvenile nursery for much of the coastal population (Berggren and Lieberman 1977, Kohlenstein 1981). Striped bass reside completely within the Chesapeake Bay estuary as juveniles. Upon reaching maturity between ages III and VI, a large percentage of females leave the estuary and enter coastal waters, migrating as far north as Canada (Austin 1980). Males mature earlier between ages II and III and a larger percentage reside within the estuary throughout their lives, though larger males do migrate into coastal waters. Females generally attain larger sizes and live longer. Both sexes peak in abundance in Chesapeake Bay in the spring during their spawning migration and again in the fall when coastal migrants return to feed and overwinter in the Bay and nearshore coastal waters. Commercial landings reflect the bi-modal distribution of adult striped bass in Chesapeake Bay (Fig. 1)

Beginning in the 1970's, Chesapeake Bay striped bass stocks underwent a severe decline due to overfishing and possibly other causes including habitat degradation, pollution or predation (Funderburk et al, eds 1991). Commercial landings fell from 15 million pounds in 1973 to 3.5 million pounds in 1983. Juvenile production declined and remained poor in all Chesapeake tributaries (Austin et al 1998). The rapid decline in abundance and reproduction prompted adoption of the Atlantic States Marine Fisheries Commission (ASMFC) interstate fisheries management plan in 1982. As stocks continued to decline, more stringent amendments to the ASMFC plan were adopted and, by 1985, culminated in a series of strict harvest limits and harvest moratoria in several states. Intensive juvenile stocking was also implemented to augment natural reproduction.

Through the late 1980's and into the early 1990's, adult stock levels and Bay-wide juvenile production rose dramatically (Austin et al 1992). Years 1993 and 1996 witnessed record year classes of juvenile recruitment (Austin et al 1998). Fishery-independent spawning stock monitoring showed that spawning stocks previously composed of only four-age classes in the 1980's rose to ten age classes in the mid 1990's (Shaefer and Hornick 1994). Spawning stock biomass has increased with these changes in age composition (Fig. 2a, NOAA/NMFS data). Adult abundance estimates indicate that the population has returned to historical levels and that large, older fish (610 mm or 24" and above, age 8 and older) comprise more than 50% of the spawning population (ASMFC 1995). Virtual population analysis indicates that striped bass population numbers have increased nearly an order of magnitude from the early 1980's (Fig. 2b, NOAA/NMFS). While the recent indices of spawning stock biomass and juvenile production bode well for the future of striped bass, they reflect a large-scale increase in numbers of an upper-trophic level predator in the Chesapeake ecosystem.

Increased numbers of striped bass require more forage and place an increasing demand upon prey in lower trophic levels such as blue crabs, *Callinectes sapidus*, and menhaden which, themselves, weather a significant harvest and may fluctuate greatly in annual abundance. VIMS and Maryland DNR Atlantic menhaden and bay anchovy seine and trawl survey indices of juvenile abundance show high interannual variations and possible declines throughout the 1980's and into the 1990's (VIMS juvenile finfish trawl survey data). Mesozooplankton abundance in the mainstream Bay has declined and has shifted in spatial and temporal distribution (Buchanan and Uphoff 1998). Submerged aquatic vegetation, an important, shallow-water benthic habitat type has been reduced to a fraction of its former extent (Orth et al 1998). Similarly the extent of oyster reefs, once the dominant hard-bottom structure in Chesapeake Bay, has declined due to disease and overfishing of the oyster population. The latter changes have altered the multi-dimensional structure of benthic habitats and may have altered predator and prey resource utilization patterns. In addition, widespread prevalence of *Mycobacterium spp.* infections (Vogelbein et al 1999) and observations of very "skinny " striped bass have fueled a belief that the fish are starving either as a result of disease or a decrease in forage food (Buchanan and Uphoff 1998).

Traditional trophic studies in Chesapeake Bay and other similar estuarine systems have focused on bottom-up controls of production through nutrient limitation, light or other environmental factors that affect primary productivity and detrital input (Fisher et al 1992). These systems receive high nutrient and detrital inputs that drive primary and secondary production through bottom-up controls (Nybakken 1993). In contrast, primary production in oligotrophic systems is often regulated by grazing (top-down control). Observational evidence of changes in the distribution and composition of phytoplankton and mesozooplankton suggest that bottom-up factors may be influencing upper trophic levels by decreasing the biomass of important secondary consumers which are, in turn, food for predators such as striped bass (Buchanan and Uphoff 1998).

The increase in the numbers of striped bass also presents the possibility that they may influence the Chesapeake system through top-down control (Mosca et al 1996). In relatively simple lake ecosystems, top-down control by larger piscivores can dramatically alter the structure and function of lower trophic levels through cascading trophic interactions (Carpenter et al 1985). In these systems increased piscivore predation can lower planktivore biomass, thus increasing herbivore grazer biomass and decreasing phytoplankton density and chlorophyll concentrations. Management strategies to limit primary productivity (biomanipulation) or to decrease numbers of overpopulated forage fishes utilize these predator-prey relationships (Shapiro and Wright 1984).

Determining how a top-level predator such as the striped bass might affect an ecosystem (top-down control) or how changes in lower trophic levels might affect that predator (bottom-up control) initially depends upon descriptive food habits studies. Diet studies indicate the direction and provide an estimate of the magnitude of energy flow in a system. Studies that have documented top-down and bottom-up control phenomena depend upon initial descriptions of feeding relationships (Rudstam et al 1994, Stewart et al 1981). Control processes between striped bass and their prey are likely to occur at specific spatial locations and temporal periods given the strong seasonality of the region, the migratory habits of most species and the seasonal nature of trophic dynamics. Diet studies can indicate where and when predatory-prey interactions occur and with what sizes or ages of predator and prey. Descriptive food habits studies also provide the necessary preliminary data to construct testable hypotheses and theoretical models of energy flow and consumption (Baird and Ulanowicz 1989, Hartman and Brandt 1995b).

Despite their importance in Chesapeake Bay, comparatively little has been published on the regional feeding habits of striped bass. Several studies have focused on feeding habits of larval and juvenile fish (Limburg et al 1997, Markle and Grant 1970, Setzler et al 1980). Two studies (Hollis 1952) conducted in 1937 and (Hartman and Brandt 1995a), represent the most widely cited accounts of feeding habits of adult striped bass in Chesapeake Bay. These studies included few of the larger coastal migrants and sampled few fish in Virginia waters of Chesapeake Bay. No study has focused on the feeding habits of larger, adult fish ranging 450 – 1200 millimeters in total length. These fish comprise the bulk of the spawning stock and commercial fishery and include some resident fish (non-migratory) but mostly coastal migratory fish. These, now abundant, larger fish may also compete directly for species also harvested by man.

Sampling diets of large, mobile predators such as striped bass pose many logistical and methodological difficulties (Cortes 1997). Large migratory predators range over considerable distances and may be absent during some seasons or at some locations thus complicating the assessment of diet changes based solely on seasonal or geographic differences. Capture regulations and market conditions as well as abundance determine the availability fish. Thus, sampling tends to be non-random, sporadic and fishery-dependent. Additionally, there are political and ethical considerations involved with killing a large animal solely for the purpose of stomach content analysis. Some researchers have advocated non-lethal methods to obtain stomach contents, though the practicability of such methods is limited to situations where the researcher has captured the live animal and can provide for its care while stomach contents are flushed (Giles 1980). Additional methodological considerations such as time of day, gear type, and sample processing may affect the obtainable results (Hayward et al 1989, Hodgson and Cochran 1988). Some of these factors can be controlled; others represent unavoidable sources of potential bias that can only be acknowledged and their potential effects discussed. These difficulties often complicate statistical analyses and introduce confounding effects in food habits studies.

Cortes (1997) and others (Ferry and Cailliet 1996, Marshall and Elliot 1997) recognize these methodological and analytical difficulties and provide suggestions for improving diet studies. Cortes (1997) outlines several recommendations below:

1) standardization of indices of food importance in a percent index of relative importance (%IRI)

2) reporting of precision and determination of sample size sufficiency

3) consideration of the influence of sampling gear type, experimental design and statistical analysis on the results

Other authors echo these sentiments, advocating precision estimates and graphical techniques for diet studies (Costello 1990, Tokeshi 1991). Gelsleichter et al. (1998) and Ferry and Calliet (1996) incorporated cumulative prey curves to assess precision of diet sampling.

Recent changes in the population structure of striped bass coupled with potential changes in the structure and function of the bay ecosystem have brought the diet of striped bass to the forefront of management concerns. In response to concerns about trophic changes, Chesapeake Bay researchers have initiated collaborative efforts to analyze trends in the status of Bay ecosystem indicators (Buchanan and Uphoff 1998). Questions concerning the predatory impact of striped bass, the relative importance of various prey species and availability of forage prompted the Virginia Marine Resources Commission Recreational Fishing Advisory Board (VMRC-RFAB) to fund a study in 1997 of the feeding habits of striped bass in Chesapeake Bay (Austin and Walter 1998).

The purpose of this thesis is to analyze the results of this study (Austin and Walter 1998) from the perspective of what prey species are important in the diet, what sizes of prey are important, and what biologically important trends and patterns in feeding can be observed. The specific objectives of this analysis are as follows:

To assess the precision of diet characterization through the use of cumulative prey curves and to compare the effects of different capture methodology where possible.

To depict prey which are most important to striped bass by constructing indices of relative importance.

To assess trends and patterns in the diet of striped bass over various seasons, locations and fish sizes.

To assess trends in feeding behavior as measured by stomach fullness and the number of empty/full stomachs.

Under the limitations imposed by the sampling methodology and the availability of striped bass, I examine the data for trends and patterns in feeding based on size of fish, location, season and methodological considerations such as gear type. This thesis provides qualitative data to managers on the feeding habits and potential predatory impact of striped bass. Though the inherently descriptive nature of a food habits study limits formal hypothesis testing, this study represents a first step in determining which factors are responsible for observed patterns of predatory-prey interaction and feeding behavior and provides a basis for future hypothesis generation and experimentation.

# METHODS AND MATERIALS

## Collection of fish

Two thousand and two (2002) striped bass were collected from March 1997 to May of 1998 from various localities in Chesapeake Bay, its Virginia tributaries and the Chesapeake Bay mouth. Figure 3 depicts the sampling area and the distribution of samples plotted as weighted circles. Spatial coverage extends from the mouth of Chesapeake Bay northward into Maryland waters as far as Annapolis and corresponds to Chesapeake Bay Program sampling strata (EPA, Chesapeake Bay Program). Fish were collected with commercial hook and line, gill nets, fyke nets, pound nets, recreational hook and line and scientific electroshocking and trawling gear. A majority of spring-caught samples came from VIMS Anadromous fishes monitoring projects in the middle and upper reaches of the Rappahannock, York and James river systems (Sadler et al 1997). These fish were captured in anchored gill nets, staked gill nets, pound nets and fyke nets. The bulk of the fall-caught fish came from commercial pound and gill nets and recreational hook and line.

When whole fish were obtained, fork length (+/- 1.0 mm), total length (+/- 1.0 mm), sex and weight (+/- 0.001 kg wet weight) were recorded along with location, date and method of capture. Stomachs were then removed by cutting the alimentary canal anterior to the stomach and posterior to the pylorus. Stomachs were then labeled and preserved by freezing. Freezing was an effective method of preservation due to the often large volumes of stomach contents and has been used successfully in other food habits studies (Hartman and Brandt 1995a, Steimle and Figley 1996, Stillwell and Kohler 1981)

For some fish only an excised stomach or filleted carcass was available thus reliable data on length and weight were not obtained. Many recreational hook and line samples were excised stomachs obtained from volunteer fisherman and a large number of commercial samples were from filleted carcasses obtained at cutting houses.

For each fish salinity and temperature data were obtained from the nearest Chesapeake Bay program monitoring station or VIMS trawl survey station.

## Laboratory Procedures

Stomachs were thawed in the laboratory for processing. Full stomachs were weighed (+ /- 0.001 or 0.1 g) and then the contents emptied. Weight of the empty stomach was then subtracted from the total weight to obtain the weight of the stomach contents. Contents were then sorted and recognizable prey items identified to the lowest possible taxa (often species and usually family), weighed (+/- 0.001 or 0.1 g) and counted. Each individual item was measured (0.5 mm) using calipers. Total length or backbone length of fish was taken unless the state of digestion did not allow a length measurement. Total length and either carapace width or length of invertebrates was recorded. Unidentifiable matter was quantified by weight in the stomach contents but could not be enumerated.

Partially digested prey items were identified by analyses of hard parts (scales, otoliths, spines, rays and distinguishing bones), peritoneum coloration and digestionresistant parts such as the digestive structures. Menhaden, in particular, could be distinguished from gizzard shad, *Dorosoma cepedianum*, and other fishes of the shad and herring family (Clupeidae), by the shape of the gizzard (Manooch 1973). Sciaenids could be readily identified on the basis of their distinctive otolith shapes. Vertebral number and precaudal to caudal vertebral counts aided in species identification using whole vertebrae (Martin and Drewry 1978). Invertebrates were identified through microscopic examination (Gosner 1971). Prey too digested for accurate identification to species was identified to the lowest possible taxon; either genus, family or class. For certain species backbone lengths were converted to total lengths for prey length-frequency plots. Backbone length-total length regressions are given in Appendix A.

Data analysis

Striped bass were analyzed by separating them by length of fish, salinity regime, season, location and method of capture. Striped bass feeding habits have been observed to differ ontogenetically so fish were partitioned into four size classes based on total length (150-450, 451-600, 601-800, 801-1300 mm).

In Chesapeake Bay estuary, salinity (Wagner 1998), and temperature determine distribution of plants and animals (Jenkins and Munroe 1994). Thus I assumed that trends in feeding habits would occur over similar gradients. The salinity distribution of prey provides a more general partitioning of prey along a natural gradient. I placed fish into one of three salinity regimes based on the Venice estuarine classification system (Anonymous 1959). The three salinity zones include tidal freshwater-oligohaline (0-5 ppt), mesohaline (5-18 ppt) and polyhaline (18-30 ppt). I also partitioned fish into four season categories based on actual temperature breaks in the 1997-1998 VIMS pier temperatures (Fig. 4a-b) rather than calender seasons. As actual biological seasons governing fish behavior (spawning, feeding, migrations) vary from year to year with water temperature and environmental conditions, these temperature breaks more accurately reflect seasonal changes. Fish caught from March 1 through May 31 were placed in spring, June 1- September 30 in summer, October 1 through November 30 in fall and December 1 through February 28 in winter.

For spatial analysis of feeding habits, each fish was placed into one of four locations based upon Chesapeake Bay program monitoring segments (Fig. 3) (EPA, Chesapeake Bay Program). Location one is in the tidal freshwater and oligohaline reaches of the James, York, Rappahannock and Potomac rivers. This location corresponds to tidal freshwater (TF) and estuarine transition zone (OH) monitoring segments in these rivers. Location two is the lower reaches of rivers and corresponds to mesohaline waters (MH). Location three is the upper bay corresponding to Chesapeake Bay Program segments four, five, six and seven comprising mesohaline to polyhaline open-bay waters (MH-PH). Location four is the polyhaline waters of the lower Bay, Bay mouth and adjacent ocean waters in Bay Program segment eight (PH).

Capture methodology has been shown to affect interpretation of diet composition (Hodgson and Cochran 1988). Thus, gear type was recorded and fish were partitioned accordingly into five categories. Pound-net and fyke-net caught fish were placed in the first category; gillnet in category two; hook and line, three; trawl, four; and electroshock in category five.

Cumulative prey curves were constructed for each fish size class, location and season to assess the precision of the diet sampling. Following Ferry and Cailliet (1996) and Gelsleichter et al. (1998), the order stomachs were analyzed was randomized five times and the mean number of new species was plotted against number of stomachs examined. The asymptotic stabilization of the curve can indicate that a sufficient number of stomachs were analyzed to represent the diet composition within each category, assuming each stomach is independent of all others. Standard deviations were calculated to provide a measure of the variation around the asymptotic region of the curve (Ferry and Cailliet 1996). Non-independence of samples compromises this method of analysis. Fish stomachs obtained from the same pound net, gill net or school may not be truly independent and thus may lead to a false stabilization of the curve and an underestimate of the variety of prey consumed. Conversely, lack of an asymptote indicates that insufficient sample sizes were obtained to adequately characterize diets at that location, season or for that size of fish. Nevertheless, the lack of random sampling and the schooling nature of the species make cumulative prey curves the best available means of assessing sampling precision though they can give a false indication of sample-size sufficiency.

To assess diet composition, I obtained frequency of occurrence, number of striped bass ingesting each prey, numerical counts and weights of each prey category. Each method of diet quantification addresses different questions. Number of prey provides information on predatory impact in terms of number of prey taken.

Numerical abundance (%N) is the number of prey category *i* ($n_i$) divided by the total number of all prey over all prey categories, *k*:

$$\%N = [\Sigma n_i / \sum_{i=1}^{k} n_i] \times 100$$

The total number of prey taken provides information on the feeding behavior of the predator (Macdonald and Green 1983) and on the impact upon the prey population. Percent weight (%W) is the weight of all prey category *i* ($w_i$) divided by the total weight of all prey categories, *k*:

$$\%W = [\Sigma w_i / \sum_{i=1}^{k} w_i] \times 100$$

Percent weight measures the nutritional value of the prey class to the predator as weight approximates calorific content (Macdonald and Green 1983). Frequency of occurrence (%FO) is the number of stomachs in which each prey species *i* occurs ($FO_i$) divided by the total number of stomachs (N):

$$\%FO = [\Sigma FO_i / N] \times 100$$

The percent frequency of occurrence measures how often a prey species is consumed by the predator.

Determining the importance of various prey species to a predator is an inherently subjective exercise (Hyslop 1980) and even more so the impact of a predator on its prey. Several methods of quantification may be used to assess dietary importance, however each has biases that vary according to prey type. When food items vary greatly in size and number any single quantitative measure may over- or underestimate the importance of certain prey types. Ranking prey numerically may overestimate the importance of small numerous prey items. Similarly ranking prey based upon weight contribution overestimates rare, bulky items and biases against small, frequently encountered prey. A commonly accepted protocol in diet studies is to incorporate several measures into a compound index, with the rationale that a combination of different measures appears to cancel out biases in individual components (Bigg and Perez 1985).

The most widely used compound measure is the index of relative importance (IRI) which combines the percent by number, percent by weight and frequency of occurrence to estimate the overall contribution of a prey type to the diet (Pinkas et al, 1971, Rudershausen 1994). The IRI for a particular prey category *i* ($IRI_i$) is expressed as:

$$IRI_i = (\%N + \%W)\%FO,$$

where %N is the percent by number, %W is the percent by weight, and %FO is the percent frequency of occurrence.

Percent IRI values express the importance of an individual prey item relative to all other prey items.

These values were calculated for each prey category ($i$) according to standardized methods proposed by Cortes (1997):

$$\%IRI_i = 100\ IRI_i / \sum_{i=1}^{k} IRI_i$$

In calculating IRI values some stomach content categories were excluded as they were deemed to be non-naturally occurring prey items. Chum, often finely ground menhaden, and bait, whole and cut spot with hooks or hook marks and cut menhaden were not considered as a natural prey category. Unidentified fish bones were labeled as unknown fish if the whole fish was present. Scales were not counted as many appeared to be taken in incidentally and not as part of a whole fish. Trash, plant material and other detritus were also excluded from the IRI.

Several prey species were combined in the analysis for practical reasons though, wherever possible, all reasonable attempts to preserve species integrity were made. Anchovies, both *A. mitchilli* and *A. hepsetus,* were treated as one species because it was impossible to identify a partially digested backbone to species. For the same reason, *D. cepedianum* and *D. petenense* were treated as the same species despite ecological differences between the two.

To analyze broader trends in striped bass feeding, prey categories were further pooled according to intuitive pooling procedures whereby ecologically, morphologically or taxonomically similar prey categories were combined (Crow 1981). This facilitated generalizations regarding striped bass feeding behavior and choice of prey. Prey species were combined into six categories; clupeids, sciaenids, engraulids, other fishes, blue crabs and other invertebrates.

Stomach fullness analysis

The intensity of feeding was measured by the stomach fullness index (SFI) and the percentage of full stomachs. The SFI standardizes the weight of ingested food as a percentage of total fish weight. It was calculated according to Hureau (1969):

SFI = (weight of stomach contents / weight of fish) x 100

SFI values were calculated for all fish regardless of the presence or absence of stomach contents. For many fish only lengths were available so weights were calculated using a length-weight regression calculated from the length and weights of the combined sample of fish. For all fish the reconstructed weight was used to generate a SFI to avoid introducing biases associated with individual fish such as spawning activity or poor condition.

Stomach fullness index values must be interpreted along with the percentage of full stomachs to make meaningful inferences concerning fish feeding intensity (Cortes 1997). Both measures, however, only reflect food consumed within the past several hours. Neither are accurate measures of long-term starvation or food deprivation, though they can indicate short-term decreases in feeding intensity or food availability.

Stomach fullness values were not normally distributed and had heterogenous variances. Numerous data transformations (square root, log, arcsine) failed to achieve normality or homogeneity of variance so nonparametric analysis of variance was performed with the Kruskal-Wallis test (Zar 1996). The Kruskal-Wallis test statistic was calculated as:

$$H = [12 / N (N + 1)] \sum_{i=1}^{k} R_i^2/n_i - 3(N + 1)$$

where $n_i$ is the number of observations in group $i$, N = the total number of observations in all $k$ groups and $R_i$ is the sum of the ranks of $n_i$ observations in group $i$. Critical values of H are approximated by the chi-square distribution with $k - 1$ degrees of freedom. Corrections for H for tied ranks were employed using the correction factor, C:

$$C = 1 - \sum t / N^3 - N$$

where:

$$\sum t = \sum_{i=1}^{m} (t_i^3 - t_i)$$

and $t_i$ is the number of ties in the $i$th group of ties and $m$ is the number of groups of tied ranks.

The correction factor C provides a corrected value of H, $H_c$ as follows:

$$H_c = H / C$$

To test for differences between groups of fish, a posteriori nonparametric multiple comparisions were performed using a test proposed by Dunn (1964) found in Zar (1996). Dunn's test is similar to a non-parametric Tukey-type multiple comparison test but allows for unequal numbers of data in each of *k* groups. Dunn's procedure calculates a standard error:

$$SE = \left[(N (N + 1)/ 12) (1/ n_A + 1/ n_B)\right]^{-0.5}$$

for a test statistic

$$Q = \bar{R}_B - R_A / SE$$

where R indicates a mean rank ($\bar{R}_A = R_A/n_A$) for each group obtained from the Kruskal-Wallis test. Values for Q are then compared with critical values given in Zar, Appendix Table B. 15 (1996). In all tests a significance level of 0.05 was chosen.

<u>Methodological considerations</u>

When possible, gear types were compared to evaluate methodological effects. Comparisons were possible when two gear types were used in close spatial and temporal proximity. Fish from the spawning grounds were collected by VIMS anadromous fishes monitoring survey from commercial pound nets and experimental multiple-mesh gillnets from within two river miles of each other (Sadler et al 1998). This temporally and spatially similar sampling provided a robust comparison of the effects of capture methodology on diet composition and stomach fullness.

Gear type effects on feeding intensity were assessed by comparing stomach fullness by nonparametric Mann-Whitney rank testing (Zar 1996). The Mann-Whitney test statistic (U) was calculated as

$$U = n_1 n_2 + n_1(n_1 + 1)/2 - R_1$$

where $n_1$ and $n_2$ are the number of observations in each sample and $a_1$ is the sum of the ranks of the observations in the first sample. A two-tailed hypothesis was used and U' was calculated as

$$U' = n_1 n_2 - U$$

The larger of U and U' was compared with a critical value of U found in Zar Appendix table B. 11. (1996). Gear effects on diet were examined through plots of diet composition and comparisons of length-frequency plots for various prey species.

# RESULTS

Between March 1997 and May 1998, stomach contents of 2002 striped bass from Chesapeake Bay, its tributaries and adjacent coastal waters were examined. Spatial and temporal distribution of fish samples corresponded with peak harvesting seasons and the seasonal patterns of migration and abundance of larger striped bass in the Virginia portion of Chesapeake Bay (Figs. 1a and b). Fish were sampled from all months except July, when no recreational or commercial samples could be obtained. The majority of fish came from the spring (47.6%) and the fall (33.4%) when larger striped bass are most abundant in Chesapeake Bay. Smaller percentages of fish were collected during summer (14.3%) and winter (4.6%) due to low availability. Fish ranged were 157 to 1255 mm total length (mean 617.3 mm, SD 170.2) (Figure 5) and 0.40 to 18.71 kg in weight (mean 3.65 kg SD 3.2). Length frequency plots by season, location and salinity illustrate the size ranges of fish sampled in each area and time (Figs. 6-8). For each area and time, fish of similar sizes were obtained except in summer, when no fish > 900 mm total length were collected and in the spring and winter when no fish below the legal size limit of 456 mm (18 inches) were obtained.

Figure 3 depicts the spatial distribution of striped bass samples. Large numbers of fish were obtained from the upriver spawning grounds in tidal freshwater reaches of the Rappahannock and James rivers. Fewer samples were obtained from the upper York and Potomac rivers. Most samples from open waters of Chesapeake Bay were obtained by recreational fishermen and are plotted as weighted circles within the Chesapeake Bay program strata where they occurred. Though each circle is plotted in a single position the samples were widely distributed throughout the segments. Fish captured in the middle and lower reaches of the tributaries came mainly from fixed commercial pound and gill nets and they have a narrower spatial distribution. Due to the migratory nature of the large striped bass, fish were not obtained in all locations at all seasons.

Of the 2002 striped bass examined, 943 (47.1%) contained stomach contents and 1059 (52.8%) had empty stomachs. Often food that was not part of the natural diet (chum or bait) was the only item present and was excluded from further analysis. Trash and detritus consisting of varied items such as cigarette butts, leaves, feathers, stones and plastic were recorded but not included in the analysis of diet composition. Pieces of aged bivalve mollusk shells were found but no evidence of actual feeding on living bivalves was observed. A total of 720 bass with naturally occurring, recognizable food items present were included in the stomach contents analysis. Thirty-four different species of fish and 18 species of invertebrates were observed (Table 1).

The cumulative prey curve for all stomachs combined (Fig. 9) reached a well-defined asymptote indicating that the sample size was sufficient to describe the diet. The majority of prey species (40 / 47) were encountered after examining only 250 stomachs; further sampling resulted in the addition of only very rare single prey items.

The cumulative prey curve for the spring (Fig. 10a ) reached an asymptote. The samples of stomachs from fall, spring and winter fish (Figs. 10b, 10c, 10d) did not reach asymptotes. The cumulative prey curve for the fall did not reach an asymptote after over 300 stomachs indicating that new prey species continued to accumulate as more samples were added. Cumulative prey curves for summer and winter (Figs. 10b and 10d) likely did not reach asymptotes due to low sample sizes and summer and winter feeding habits of striped bass may not have been adequately sampled. The dominant prey items, by number, weight and frequency of occurrence were, however, obtained in the first 20 stomachs in both the summer and the spring and within 50 stomachs in the fall. With increased numbers of stomachs, relatively rare and likely insignificant prey species continued to accumulate, preventing the cumulative prey curves from reaching a clear asymptote. Often these additional prey species were rare occurrences of a single prey item.

Within each length class above 450 mm, the cumulative prey curves approached asymptotes (Figs. 11). The cumulative prey curve for the smallest length class, 150-450 mm TL, did not reach a clear asymptote, indicating that further samples were needed to characterize the diet adequately (Fig. 11).

Diet composition

Menhaden were the dominant prey by weight and frequency of occurrence accounting for 43% of the weight of all prey items and occurring in 24.8% of the stomachs (Table 2, Fig. 12). The % IRI for menhaden was 54.8, more than all other prey items combined. The % IRI values listed in the figures do not correspond exactly to the table values as minor prey species were removed from the figures to facilitate graphical representation. Anchovies, both bay anchovy, *Anchoa mitchilli*, and striped anchovy, *Anchoa hepsetus*, were combined and were numerically the most abundant at 26.5% of all prey items. Anchovies had the second highest % IRI value at 15.0. Other species in order of decreasing %IRI were gizzard shad, *Dorosoma cepedianum*, and threadfin shad, *Dorosoma petenense*, with a combined % IRI of 7.7; and spot, *Leiostomus xanthurus*, with an IRI of 9.6. Blue crabs, *Callinectes sapidus*, had %IRI values of 3.6 and anadromous herrings, both blueback herring, *Alosa aestivalis,* and alewife, *Alosa psuedoharengus,* had a combined %IRI value of 1.6.

All other prey categories had %IRI values < 2 and appeared relatively unimportant in the overall diet of the striped bass examined. The large number of categories demonstrated the opportunistic feeding of striped bass. Mysid shrimp, *Neomysis americana*, were numerically abundant in the stomachs but contributed very little weight and thus had a very low IRI value. White perch, *Morone americana*, croaker, *Micropogonius undulatus*, summer flounder, *Paralichthys dentatus*, and weakfish, *Cynoscion regalis*, were high by weight but due to low frequency of occurrence or low number had low %IRI values. The prey category of unknown fish had high numerical abundance and fairly high frequency of occurrence. This was due to the fact that this prey category included several species of fishes. This category had relatively low percent by weight because each item was usually only a very well-digested backbone devoid of distinguishing characters. Similarly prey categories consisting of unknown clupeids and unknown sciaenids contained backbones of several species but could not be identified beyond the family.

Figure 13 indicates a distinct shift in the feeding habits of striped bass across seasons. Tables 3-6 show calculated values for indices of relative importance for all species for each season. During spring (March 1 to May 30, gizzard shad dominated the diet with a %IRI value of almost 40. Anchovies were second in importance followed by anadromous herrings and white perch (Fig. 13a). Unknown clupeids had a high %IRI value but were most likely herring or gizzard shad too digested to identify to species. No American shad, *Alosa sapidissima* or hickory shad, *Alosa aestivalis* were found in the stomachs. In the summer months (June 1 -September 31), menhaden and blue crabs dominated the diets and herring and gizzard shad declined in importance (Fig. 13b). Blue crabs were abundant in the diet mostly in the early summer (June). Bay anchovy and white perch were of minor relative importance during this period.

In the fall, (October 1 to November 30), menhaden dominated the diet by number, weight, frequency of occurrence and had a percent IRI of 71% (Fig. 13c). Spot, as well as other sciaenids, increased in importance and blue crab and anchovy remained moderately important. The greatest diversity of food items occurred in fall with forty-four different species of prey items observed (Table 1). Many prey species represented single occurrences of rare prey, though tonguefish, *Symphurus plagiusa*, butterfish, *Peprilus triacanthus*, mantis shrimp, *Squilla empusa* and lady crab, O*valipes ocellatus*, occurred in fairly high numbers in the fall. In winter (December, January and February), menhaden and anchovy were again dominant prey and American eel, *Anguilla rostrata*, and spot contributed minor amounts to the diet (Fig. 13d).

The spatial and salinity distributions of prey items show a shift in feeding habits similar to that observed across seasons (Figs. 14a-d, 15a-c, Tables 7-13). Plots of diet composition by location generally mirror those of salinity zones and to avoid repetition they are not discussed further. In tidal freshwater and oligohaline reaches of the James, York and Rappahannock river systems (0-5 ppt), striped bass fed primarily on gizzard shad, anchovies, herring and white perch (Figs 14a, 15a). Diet composition was similar for upriver reaches of each river system. In mesohaline (5-18 ppt) lower rivers areas

(Figs. 14b) and middle and upper Chesapeake Bay (Fig. 15b) menhaden again became the dominant food item along with blue crabs. Bay anchovy generally was third in importance. Gizzard shad, spot and mysid shrimp were of minor importance. In polyhaline waters of the open Chesapeake Bay and Bay mouth, menhaden again was the dominant prey by number, weight and frequency of occurrence (Figs. 14d, 15c). Spot was second in relative importance and anchovies third. Diet composition of striped bass in lower Chesapeake Bay waters (Fig. 14d) closely resembled that of those taken in the polyhaline salinity zone (Fig. 15c). Tables 6-8 show the numerical values for the indices of relative importance.

Figure 16(a-d) show differences in feeding habits of fish by size class (Tables 14-17). The greatest difference in the diet was the prevalence of anchovies and blue crabs in smaller size classes. Upon reaching 600 mm TL, striped bass consumed almost exclusively fish, primarily clupeids and sciaenids. Anchovies were the dominant prey in fish 150-450 mm TL (Figs. 16a). As striped bass increased in size, menhaden became increasingly important in the diet, approaching 66-70% of the total IRI for the largest fish. For fish 451-600 mm TL, menhaden were nearly equal in importance to anchovy (33.3% IRI to 35.1%); however menhaden contributed far more to the weight of stomach contents. For fish in all size ranges examined invertebrates were relatively unimportant. Mysid shrimp were numerically abundant in fish 451-600 mm TL though their very low weight made them relatively unimportant (1% IRI). Blue crabs were of minor importance (4.5% and 6.5% of the diet) in fish of intermediate size ranges; in the largest size range (801 mm to 1300 mm) a total of only four blue crabs were found and blue crabs had an IRI value of less than 0.1%. For fish above 450 mm, gizzard shad and spot were generally the next most important prey items ranging in relative importance from between 2% and 13% of the diet. White perch and croaker were minor components of the diet. In fish of the largest size range, river herring and summer flounder contributed a minor amount to the diet (6.5% and 4.3% of IRI, respectively).

Pooled prey categories

When prey categories were pooled according to ecological or morphological affinity, the pooled diet composition appeared fairly homogenous across seasons (Figs. 17-19). Clupeid fishes dominated both spring and winter diets comprising > 60% of the total IRI. Anchovies and other fish were next in importance during spring and winter. Only in summer and fall when blue crabs increased to nearly 40% of the total IRI were diets noticeably different among similarly-sized fish. During this time clupeids remained the majority of the diet, while anchovies greatly declined in importance. In the fall clupeid fishes again comprised the largest category in the diets, however sciaenid fishes (croaker, spot, silver perch and weakfish) increased to almost 30 % of the total IRI. In general clupeoid fishes (shads, herrings and anchovies) dominated the diet during all seasons. Sciaenids were temporally important in the fall and blue crabs in the summer. All other fish combined represented only 6 - 16 % of the total IRI across all seasons.

When plotted across salinity zones three fairly distinct feeding modes appear (Fig. 18). In tidal freshwaters (0-5 ppt), anadromous and resident clupeids dominated the diet. Other fish, represented mainly by white perch, were next in importance and anchovies ranked third. Very few invertebrates appeared in the diets of striped bass from these areas. In the mesohaline waters of Chesapeake Bay (5-18 ppt), estuarine-dependent clupeid fishes remained the dominant prey category, though the diet of fish taken here broadened to include blue crabs, anchovies and to a lesser extent sciaenids, other fish and and mysid shrimp. In polyhaline waters of the Bay, clupeids remained important in the diets, but declined in relative importance as sciaenids and other fishes comprised a larger percentage of the diet. The category of other fish included a diverse assemblage of fishes such as summer flounder, butterfish, tonguefish and hogchokers not found in high numbers in the diet of striped bass taken in lower salinity areas. Blue crabs, *C. sapidus*, were rarely encountered in the diet in high salinity waters. Other invertebrates, mantis shrimp, *Squilla empusa*, lady crabs, *Ovalipes ocellatus,* and other portunid crabs *Callinectes spp.* comprised a very small percentage of the diet of striped bass taken from these high salinity waters.

Clupeid fishes increased in importance with striped bass size in plots of pooled prey categories (Fig. 19). Anchovies were important dietary items for the two smaller size classes but declined in importance as fish size increased. Sciaenids contributed approximately 20% of the diet for fish > 451 mm TL. Blue crabs and other invertebrates were only of minor importance for fish in intermediate size ranges (451-800 mm).

Examination of prey length frequencies (Figs 20a-d and 21a-d) indicated that for most prey a single cohort or size class predominated in the diets. For spot, all fish except one were < 200 mm TL and likely young-of-the-year (YOY) fish according to age-length estimates used by the VIMS trawl survey to determine YOY recruitment (VIMS juvenile finfish trawl survey data). Similarly, menhaden, gizzard shad, blue crab and anchovy length-frequencies were dominated by YOY fish. Of blue crabs above 65 mm carapace width, all were either newly molted soft crabs or were present in stomachs as broken pieces, indicating that rarely were large hard blue crabs ingested whole. Only for the river herrings and white perch did striped bass consume predominantly older year classes of spawning adults.

Significant relationships between striped bass total length and prey total length were found for both gizzard shad ($p < 0.01$, $R^2 = 0.63$) and menhaden ($p < 0.01$, $R^2 = 0.30$) (Figs 22a, 22d). Regressions were fitted by least-squares linear regression of the untransformed values. No significant relationships were found for white perch, spot, anchovy or blue crabs (Figs 22b, 22c, 22e, 22f).

Stomach fullness analysis

Two measures were used to evaluate stomach fullness; the stomach fullness index (SFI) and the percentage of empty stomachs. The SFI indicates the amount of food present in the stomach of an individual fish as a percentage of the total weight and. Overall 941 out of 2002 (47.0%) fish had stomach contents. When fish from spawning areas were excluded from analysis the percentage of full stomachs rose to 62.3%.

The stomach fullness index differed significantly between seasons (Fig. 23a, Table 18, Kruskal-Wallis nonparametric rank test, $H = 334.95$, $DF = 3$, $p < 0.00$). Subsequent multiple comparisions indicated that stomach fullness values in spring were lower in other seasons (Dunn's nonparametric multiple comparison test). The range of stomach fullness values differed between summer and fall and winter (Fig. 23a), however no significant differences were observed in the SFI. In the figure bar widths are proportional to the square root of the sample sizes. The spring season also had the lowest percentage of full stomachs (28.2%, Table 19). The percentage of full stomachs increased in the summer and fall, peaking at 79.6% in the winter. When partitioned further by individual month (Fig. 23b, the stomach fullness values were highest in June and the fall months of October, November and December and lowest in the months of April, May, August and September. The percentages of full stomachs corroborated these results, as June had the highest percentage of full stomachs (88.1%) and March, April, August and September the lowest (Table 20).

When examined by location, the upper rivers had significantly lower SFI values than other areas (Fig. 24a, Table 21, Kruskal-Wallis nonparametric rank test, $H = 487.09$, $DF = 5$, $p < 0.00$). Multiple comparisons of stomach fullness values indicated that the lower rivers also differed significantly from the middle rivers, the lower Bay and the upper Bay (Dunn's nonparametric multiple comparison test). Likewise when partitioned by salinity, fish in tidal freshwater had significantly lower SFI values than other salinity zones (Fig. 24b, Table 23, Kruskal-Wallis nonparametric rank test, $H = 424.35$, $DF = 2$, $p < 0.00$). Multiple comparisons indicated that fish in each salinity zone differed in stomach fullness with those in polyhaline waters having the highest SFI. The percentages of full stomachs also reflected these variations as the lowest percentage of full stomachs was found in the upper river-tidal freshwater areas. The percentage of full stomachs increased with increasing salinity and proximity to the Bay mouth and varied between 59 and 77% for all locations other than the upper rivers (Tables 22, 24).

Stomach fullness differed by size class of striped bass (Fig. 25a, Table 25, Kruskal-Wallis nonparametric rank test, $H = 99.20$, $DF = 4$, $p < 0.00$) with the smallest size class (150-450 mm TL) exhibiting the lowest SFI values (Dunn's nonparametric multiple comparison test). Similarly, these fish in the smallest size class exhibited the lowest percentage of full stomachs (Table 26). Fish in this smallest size class were captured only in upstream rivers during the spawning period, a time when stomach fullness values for all size classes were low. Stomach fullness values for the other size classes included representative samples from all seasons and locations and showed less variation though SFI values differed significantly between fish 601-800mm TL and 450-600 mm TL.

Stomach fullness values of striped bass also varied significantly by gear type (Fig. 25b, Table 27, Kruskal-Wallis nonparametric rank test, $H = 381.40$, $DF = 6$, $p < 0.00$). Multiple comparisons indicated that fish taken in pound nets in the spring, gill nets and fyke nets (the latter two were also primarily sampled in the spring) had lower SFI values than either fish taken in pound nets in the fall or by hook and line. As sample sizes for trawl-caught fish (6) and electroshocked fish (22), were very small the standard errors are high and provide little power to detect differences in SFI between fish taken by these gear and other gears. Other significant differences in SFI were found between fish caught in pound nets and by hook and line in the fall and between fish caught in pound nets and gill nets in the spring, though these differences are discussed in the gear type comparison. The percentages of full stomachs (Table 28) generally reflect the variation in stomach fullness with spring pound nets, gillnets and fyke nets having the lowest percentages among those examined.

Gear type comparison

The close spatial and temporal proximity of fish captured on the springtime spawning grounds in multiple-mesh gill nets and in pound nets provided a robust comparison of the effects of gear type on diet composition and stomach fullness. The multiple-mesh paneled gill nets ranged in mesh size from 3" to 10" and thus captured a size range of fish comparable to the pound nets. Comparison of length-frequencies of pound net and gill net striped bass indicated that, with the exception of several small (<450 mm) and one very large (1255 mm) fish from pound nets, the two gear types captured similarly-sized fish (Fig. 26a) and thus similar sized striped bass were compared. Diets of pound net and gill net-caught fish on the springtime spawning grounds did not differ in species composition, however they did differ greatly in the relative importance of various species (Fig. 26a-b). Gizzard shad dominated the diet of fish captured in gill nets, accounting for 88.9 % of the total IRI and a majority of the weight, number and frequency of occurrence. White perch, river herrings and anchovies contributed minor components to the diet of fish taken in gill nets. Several species shared importance in the diet composition of fish captured from pound nets. River herrings (*Alosa psuedoharengus* and *Alosa aestivalis*) comprised 42 % of the index of relative importance, gizzard shad, bay anchovy and white perch comprised 20%, 17% and 14% of the total IRI, respectively. The stomach fullness did not differ between spring pound nets and gill nets (Fig. 28a, Table 29, Mann-Whitney nonparametric rank test, $p > 0.05$). The percentages of full stomachs also did not differ between spring pound nets (28.15%) and gill nets (26.48%).

Comparision of the size frequency of prey in the stomachs indicated that striped bass from the two gear types consumed similarly-sized prey (Figs. 29a-c). Examination of stomachs from striped bass from pound nets only accounted for one very large (>450 mm) gizzard shad and one large (>300 mm) white perch. With these exceptions, the size distributions of gizzard shad and white perch were similar for each gear. The small number of river herring captured in gill nets provided few comparisons, though fish from the largest size classes (>275 mm) were consumed in both pound nets and gill nets.

Diet composition and stomach fullness of fish captured during the fall in pound nets and by hook and line fish were also compared (Figs 26c-d). Menhaden dominated the diet composition of fish captured in pound nets, with spot, blue crab and gizzard shad contributing minor amounts to the diet. Numerous species shared importance in the diet of fish captured by hook and though bay anchovy, menhaden, spot and blue crab were the most important. A total of 31 different species were observed in the stomachs of hook and line fish while only nine species were observed in pound net fish, though the greater number of samples might partially account for this difference. The length-frequency distribution of hook and line-caught fish extended into larger size ranges than pound net-caught fish; thus these fish may also have consumed larger prey (Figure 27b).

Comparison of the stomach fullness values for the two gear types indicated that the SFI for fish taken by hook and line was significantly higher than that of fish taken in pound nets (Table 30, Mann-Whitney nonparametric rank test, $p < 0.05$). Box-and-whisker plots (Figure 28b) indicated that the SFI values for the fall pound nets displayed a greater range and higher third quartiles than the hook and line samples. Nevertheless, median SFI values for hook and line fish were higher than for pound net fish and the percentage of full stomachs for hook and line caught fish (89.6%) was double that for pound net fish (44.6%).

The size frequencies of menhaden and spot found in fish captured by hook and line differed from those in pound nets (Figures 30a, b). Larger menhaden and spot were found in hook and line fish though this gear also captured larger striped bass. The modal size of menhaden is similar for both gears and corresponds to 170-200 mm total length menhaden reaching the end of their first year of life in the fall. For spot YOY fish also dominated the diet.

# DISCUSSION

At all locations, over all seasons and throughout the size range of adult striped bass in Chesapeake Bay, schooling pelagic fishes dominated the diet. In particular, clupeids (menhaden, gizzard shad, and river herrings) and similar clupeid-like schooling fishes (anchovies) exceeded all other prey species in frequency of occurrence, number and weight. Other fish (spot, white perch, summer flounder) were locally or seasonally important in the diets but did not rival clupeids or anchovies in importance. Clupeids and anchovies are highly abundant in all waters of Chesapeake Bay from freshwater tributaries to near-shore ocean waters. Similarly, their schooling tendencies, soft rays and high energy content may make them desirable prey (Wahl and Stein 1988). Cummins and Wuycheck (1971) determined that clupeids contained 6360 calories per gram of dry body weight, while combined values for other fish averaged 5086 cal/g of dry weight and decapod crustaceans (crabs and shrimp) only contained 3944 cal/g of dry weight. Wahl and Stein (1988) indicate that piscivorous predators choose gizzard shad over spiny-rayed sunfishes in experimental situations and hypothesize that gizzard shad are more vulnerable to predation. Mathews et al (1988) and Stevens (1969) observed that striped bass in freshwater impoundments fed almost exclusively upon gizzard shad and starved rather than switched to abundant small sunfish, small bass or invertebrate prey. Overall abundance, availability or the potentially high nutritional profitability of clupied fishes may account for the importance of clupeid and clupeid-like prey in the diet of striped bass in Chesapeake Bay.

The predominance of fish in adult striped bass diets attest to the piscivorous nature of striped bass, an observation corroborated by numerous other studies which found fish to be the major component of the diet (Manooch 1973, Hollis 1952). Hartman and Brandt (1995a) and Gardinier and Hoff (1982) observed an ontogenetic shift from invertebrate to vertebrate prey in the diet of smaller striped bass. Striped bass less than 200 millimeters total length fed mainly upon invertebrates and shifted to fish as they grew larger. The present study sampled size ranges larger than 200 mm and found no shift from invertebrate to vertebrate prey. In the size range of fish sampled (157 to 1255 mm TL), most fish were predominately piscivorous. There is a shift in the relative importance of smaller schooling fishes (anchovies) in smaller bass to larger schooling fishes (menhaden, gizzard shad) in larger striped bass. Other studies that sampled smaller fish (200-600mm) found anchovies also to be dominant food items (Manooch 1973, Hartman and Brandt 1995a). This shift at large sizes of striped bass appears simply to be larger fish choosing larger prey, though the prey remains a pelagic schooling fish. This trend is evident in significant relationships between striped bass total length and total length of ingested menhaden and gizzard shad. For other prey, no significant relationships existed mainly because a very narrow size range of prey was ingested over the size range of striped bass examined. Manooch (1973) also found a significant relationship between striped bass total length and total length of consumed fishes.

Several invertebrates (blue crabs, mantis shrimp, penaied shrimp, grass shrimp and mysids) were commonly found but generally contributed little by weight or number to the diet. Of these, only blue crabs were important in the diet and then only during the summer in the mesohaline reaches of the estuary. At this time, mainly smaller, resident striped bass are found in the Bay and thus are most likely to consume blue crabs. At other times of the year and in fish larger than 600 mm, blue crabs were very rarely found and were likely not important components of the diet. Soft-bodied invertebrates were possibly under-represented in the diet due to digestion, though, given the dominance of vertebrate prey in the diet of fish examined in this study and previous studies, it is unlikely that soft-bodied prey represent important dietary items for larger striped bass.

It is likely that, within small-scale habitats such as oyster reefs and SAV beds, locally abundant prey may dominate the diet and increase temporarily in importance. This study did not examine feeding habits on local scales such as within a specific habitat type, but rather focused on broad spatial and temporal trends in diet. Recent studies that focused on striped bass diets on oyster reefs (Harding and Mann 1999) and on seagrass beds (Orth et al 1999) found large numbers of structure-dwelling prey (blennies, gobies and blue crabs). These studies indicate that, on short time and spatial scales, locally abundant prey are consumed and that small-scale habitat differences can affect diet composition. These habitat types, grass beds and oyster reefs, were once dominant bottom-structures in Chesapeake Bay, though they have declined to a fraction of their former extent. Historically, they may have played a greater role in the foraging ecology of striped bass, though, at present, their diminished spatial extent may shift the primary foraging areas to the pelagic zone where anchovies and menhaden are abundant. Without estimates of habitat-specific usage patterns by striped bass, however, it is impossible to estimate either the effects of habitat type or the potential predatory impact striped bass might have in these areas.

The seasonal and spatial differences in the diet of striped bass correspond to the behavioral and seasonal migration patterns of the bass and reflect changes in the community composition at the location and time of capture. The major seasonal shift is the spring-time feeding on gizzard shad, herring and white perch which corresponds to spawning migrations of striped bass and their prey in the freshwater tributaries. Most of the spring samples came from upper river sites where gizzard shad are year-round residents and white perch and herrings are anadromous migrants. During the spring both predator and prey are abundant in these up-river areas. Trent and Hassler (1966) found that migrating striped bass in the Roanoke River, NC also fed upon anadromous herrrings and gizzard shad. Spring-time fish from the lower more saline sections of the rivers consumed anchovies, blue crabs and menhaden; prey more abundant in these areas. Hollis (1952) observed that anchovy, menhaden and anadromous herrings were the predominant food items in the lower rivers during the spring. The low SFI values and the low numbers of full stomachs observed in this study indicate that striped bass decrease feeding intensity during spawning. Trent and Hassler (1966) found that fish fed during the pre and post-spawn period but not during the actual spawning time period. Overall they found that 43% of the fish sampled had food in the stomachs during the spring spawning migration. This number is similar to the percentages of full stomachs found in March and April in this study though it is lower than for other time periods. While striped bass decrease feeding intensity during their spawning period, the large numbers of fish and the relatively small area of the tidal freshwater rivers make the predator-prey interaction between herrings, white perch, gizzard shad and striped bass potentially significant.

During late spring and summer, large striped bass migrate out of Chesapeake Bay and move north along the Atlantic Coast. Smaller resident and juvenile striped bass remain and these fish were not well sampled in this study. The few summer stomach samples from the middle and upper Chesapeake Bay mesohaline waters indicate that menhaden and blue crabs were the predominant prey species taken at this time. This large increase in the importance of blue crabs in the diet in the summer likely was the result of increased sampling in the upper and middle Chesapeake Bay and the smaller size range of fish sampled. The lack of anchovies in the diet contrasts the findings of Hollis (1952) who observed anchovies to be the dominant food of summer-caught fish. Hartman and Brandt (1995a) also observed more anchovies in the diet during July and August in age-3 and older striped bass. The scarcity of anchovies in the diet, the high percentages of empty stomachs and the low stomach fullness values may indicate that striped bass in upper Chesapeake Bay in the summer are food-limited. These conclusions must be interpreted as preliminary given the small sample sizes, the limited spatial distribution and potential biases associated with capture methodology. Nevertheless, these decreases in feeding and the changes in diet composition warrant further investigation of possible summer food limitation in resident striped bass.

Large striped bass return to the bay in the fall and winter and then feed upon menhaden, spot and to a lesser extent on blue crabs and anchovies. At this time most fish were taken from open waters in the upper, middle and lower reaches of the Bay. In the lower bay during fall, large numbers of transient young-of-the-year (YOY) marine fishes (spot, croaker, flounder, weakfish and silver perch) congregate at the Bay mouth prior to fall migration out of the Bay, thus making them accessible prey for returning striped bass. Late summer and fall also are periods of highest fish species diversity in the Bay as warm-water species combine with temperate species and estuarine residents to provide a diverse forage base. The striped bass diet reflects this prey diversity as many species were taken then that were not found in other months. These included peneid shrimp, mojarras, white mullet, inshore lizard fish and Atlantic needlefish. At this time, striped bass feeding intensity is high as evidenced by high SFI values and high percentages of full stomachs. The fall period is the time of fastest growth rate potential (Brandt and Kirsch 1993) and is also the time when a large amount of consumed energy is used for gonadal maturation. Similar to white perch, striped bass exhibit a biphasic gonadal cycle where gonado-somatic index (GSI) values peak in the fall during vitellogenesis and spermatogenesis and then in the spring during spawning (Jackson and Sullivan 1995). The fall period thus is critical for both growth and the accumulation and storage of energy for spawning the following spring.

During December, January and February, menhaden, spot and anchovies were found in the diet indicating their availability to striped bass during these winter months. Stomach fullness values and the percentage of full stomachs remained high even during the coldest recorded temperatures (4.5$^{O}$C) indicating that striped bass actively fed during the winter. Dovel (1968) observed that striped bass consumed large quantities of over-wintering YOY croaker. Despite the abundance of YOY croaker in VIMS trawl survey samples none were found in stomachs of striped bass during winter, though the limited sample sizes and the lack of an asymptotic prey curve indicated that this time period may warrant further sampling.

Size-frequency distributions of prey indicate that striped bass fed primarily upon age 0 or YOY prey. YOY menhaden, spot, gizzard shad, anchovies and blue crabs dominated the diet; only for gizzard shad, river herrings and menhaden were age classes above age 0 important in the diet. Consumption of primarily YOY prey indicates that predatory control by striped bass would likely occur during the first year of life for all prey species. Once prey reach their second year of life, if biologically attainable, the predatory impact by striped bass may be minimal as their prey have either outgrown vulnerable size ranges or the younger age classes present more desirable targets. The importance of YOY prey in the diet also indicates that striped bass might be affected by inter-annual variation in recruitment. If these variations do affect striped bass the impact will not have a temporal lag but will occur in the same year. The effects will also be most pronounced on certain age classes that rely upon specific prey. For example, striped bass 451-600 mm TL might be affected by fluctuations in anchovies or YOY menhaden. Conversely, larger striped bass, because of their consumption of multiple year classes of both menhaden and other prey species, may be relatively immune to fluctuations in a single year class of a single species. The size frequency-dependence of predator-prey interactions observed in this study have rarely been considered in multispecies management, yet they are vital to understanding and ultimately managing ecosystems.

Cumulative prey curves provide a measure of a posteriori sample sufficiency, though they are not without limitations. While the asymptotic cumulative prey curves suggest that an adequate number of stomachs have been sampled to represent a given population of predators, they represent only a partial measure of precision in diet sampling. Cumulative prey curves assume independence of sampling units (fish stomachs) if they are to provide an estimate of the precision of diet characterization. Non-independence and non-randomness of samples can greatly affect these curves and can lead to errors where one assumes that the sample sizes are adequate when they are not. For instance, a large number of fish from one time or location may come from a single fixed location and may be feeding on a narrow range of prey. Individual fish cannot be viewed as purely independent units as the diet composition of one affects the composition of another. In cases of schooling species, this interdependence is problematic and leads to decreased actual sample sizes. In such a case the cumulative prey curves rapidly stabilize after a few samples and adding more stomachs results in no more new prey species, though the actual fish population may not have been well-sampled. The non-random nature of sampling and the contagious distribution of a schooling species such as striped bass require that these estimates of sampling precision be interpreted as preliminary.

Nevertheless, in cases where the curve fails to reach a well-defined asymptote it definitively indicates that additional samples must be taken; adding more stomachs results in more new species added to the diet. In this study the lack of an asymptotic curve for smaller striped bass (<450 mm) indicates that these fish were not adequately sampled and indeed they were not intended study subjects.

Rarely are measures of precision employed in food habits studies (Ferry and Cailliet 1996). When utilized, prey curves lend rigor to observations regarding feeding habits and can indicate when more samples need to be taken. These techniques may be of greatest utility in the design of future studies as they can indicate how many samples need to be taken to characterize the diet. For this purpose it is much more instructive to include all stomachs, whether empty or full to create the prey curve. Since the researcher cannot collect full stomachs but must collect the actual fish, regardless of stomach contents, the inclusion of empty stomachs provides a more accurate measure of the number of fish that need to be taken to characterize the diet. High numbers of empty stomachs thus require large sample sizes to characterize the diet. In these instances a researcher must weigh the costs of sampling against the benefits of the information (Ferry and Cailliet 1996).

Variation in stomach fullness and the percent of full stomachs was examined for indications of changes in feeding intensity related to environmental or biological factors. Both measures have been used to indicate short-term changes in fish feeding activity such as diel feeding chronology (Cortes 1997, Jenkins and Green 1977) and spawning behavior (Trent and Hassler 1966). Both measures reflect recent (depending upon digestion times) feeding activity and are not ideally suited to examining longer-term changes in feeding behavior related to food limitation, disease or adverse environmental conditions. Decreases in either measure can suggest, but never equivocally state, that reductions in feeding activity, whether due to fish behavior or food availability, have occurred. Fish that may be starved may have recently fed and thus the fullness index would not reflect this condition and would, in fact, be inflated by the diminished physical condition of the fish. Nevertheless, the stomach fullness index and the percentage of full stomachs provide a proxy for behavioral or environmental conditions that might affect food consumption. Given observed fluctuations in the populations of Chesapeake Bay forage fishes, the increase in striped bass population size and growing concerns about food limitation, such a preliminary examination is warranted (Buchanan and Uphoff 1999).

Both the percentage of full stomachs and the stomach fullness indices appeared generally to correlate, indicating that both function to measure similar changes in feeding behavior. In a few cases, notably pound nets in the fall, plots of stomach fullness (Fig.

25f and Fig. 28b) appeared to indicate that feeding intensity was high or higher than in other gears. Statistical testing failed to indicate this and, in fact, indicated that SFI values for these pound net fish were less than that for hook and line fish. Box-and-whisker plots for stomach fullness indicate that the range of values for pound net fish was much greater than for hook and line caught fish, though median values were lower. This greater range of SFI values for pound net-caught fish indicates that, for some fish, SFI values were extremely high in comparison to other gear types, while for most fish the values were low. This indicates that the effects of pound net confinement may cause many fish not to feed or may remove them from their food source while the few fish that do feed within the pound nets feed heavily. Specific gear type comparisons provide a more rigorous comparison of the effects of gear type and will be discussed later.

Though significant differences in stomach fullness were observed between groups of fish, care must be taken not to extrapolate these differences to larger populations than they represent. Though a group of fish might have come from a certain section of a river they may not represent all fish in that river. Rather, the measures of feeding intensity may only reflect local conditions possibly influenced by capture methodology or other factors. For example, the high SFI values for the month of June came primarily from fish captured from a single location during a recreational fishing tournament when fish were full of chum (ground menhaden). Thus, values for June should not be considered representative of naturally-feeding fish. The SFI values for the late summer (August and September) also come from fish captured by recreational gear and often by chumming but these values are very low. Given the observed effects of chumming in the June samples this is surprising and suggests other factors may be affecting feeding behavior.

These fish will be discussed later. Without random and representative sampling, though, it is impossible to assess how well a single sample approximates the larger population. Thus, the differences in stomach fullness values are meant to suggest factors that might affect feeding intensity rather than to show causality. Further controlled experimentation would be necessary to empirically determine the effects of each factor on the feeding behavior of striped bass.

The spring period of low SFI values and high percentages of empty stomachs likely was the result of a reduction in feeding on the upriver spawning grounds. Similar decreases in feeding activity have been noted for striped bass in other river systems (Trent and Hassler 1966). It is likely that this represents a natural reduction in feeding intensity and not a decrease due to limited food availability. Gizzard shad, anadromous herrings and white perch are abundant on the striped bass spawning areas, though these prey are all fairly large and there may be little food available for smaller striped bass. Regardless, the residence time of an individual fish on the spawning grounds is short (around 1 week for females and at most 1 month for males) based on ultrasonic telemetry (Hocutt et al 1990). Striped bass appear to resume feeding heavily after spawning and some appear to migrate further upstream where they feed on spawning river herring. Other fish rapidly leave the rivers and migrate into coastal waters, again likely feeding on migrating herrings.

The general increase in feeding intensity with proximity to the Bay mouth and increasing salinity reflects the migratory habits of both striped bass and their prey. Striped bass feed heavily upon returning to Chesapeake Bay in the fall at which time their prey have assembled in large schools to leave the Bay for coastal wintering grounds. The lower Chesapeake Bay provides an interception point where striped bass and their prey converge and thus feeding activity is high.

The dramatic reduction in feeding observed in the months of August and September suggests that some external factor might lead to decreased consumption. At this time water temperatures are high and striped bass may be thermally stressed and spatially confined by areas of low dissolved oxygen (Coutant and Benson 1990). This combination of unfavorably high temperatures and low dissolved oxygen has been hypothesized to restrict striped bass feeding areas to certain thermal niches. Bioenergetic modeling has shown that striped bass, unlike bluefish, fail to approach maximum levels of consumption during this time period (Hartman and Brandt 1995b). In bioenergetic simulations, striped bass growth rate potential was lowest in August, at a time when habitat conditions were poorest and mean growth rate was negative (Brandt and Kirsch 1993). Given the abundance of juvenile fishes in Chesapeake Bay during summer, it is likely that physiological constraints rather than food limitation play a greater role in limiting food consumption during this time period.

Stomach fullness index values and percentages of full stomachs increased in October, November and December. At this time, water temperatures cooled to 15-21°C, the summer thermocline disappeared and the well-mixed waters contained higher dissolved oxygen concentrations. In bioenergetic simulations striped bass growth potential and prey density peaked in October (Brandt and Kirsch 1993). This combination of favorable physiological conditions (lower temperatures and higher dissolved oxygen) and high prey abundance likely explains the observed increases in stomach fullness index and percentage of full stomachs in the examined striped bass.

Collection methodology can affect the results of feeding habits studies by altering diet composition, food consumption and feeding behavior (Hayward et al 1989, Hodgson and Cochran 1988). As striped bass were collected from a variety of commercial, recreational and scientific collection methods it was desirable to examine sources of bias or variation associated with specific gears. To compare gear types, I needed spatially and temporally similar samples collected from different gear types. Given the fishery-dependent nature of the sampling, few such opportunities existed to compare gear types, though two comparisons, one between spring-time pound nets and gill nets and another between fall pound nets and fall hook and line, were possible

Striped bass captured in spring pound nets and gill nets differed in diet composition. Depth might account for this difference as pound nets were placed in deeper water than gill nets. It is likely that gizzard shad were more abundant in shallow water and thus contributed more to the diet of gill net fish. The large numbers of river herring found in pound net fish also suggest that "net feeding" might be a factor allowing striped bass to capture these larger cluepeids, however, similarly-sized river herring dominated the diet of striped bass captured by electrofishing in the upper tidal freshwater zone. This indicates that striped bass can, under natural circumstances, capture river herrings. It does not eliminate pound net bias caused by the aggregation of fish within the pound net but it does indicate that river herring can be an important component of the diet independent of the pound nets. Similarly, the greater numbers of white perch found in pound nets fish suggest that either depth or aggregation within the net might account for the difference. The absence of invertebrate prey in the upriver tidal freshwater precludes any statement of gear effects upon vertebrate or invertebrate contribution to the diet.

The comparison of pound nets and gill net diets allowed for examination of the length-frequencies of ingested prey. Pound nets might, by confining and aggregating prey, allow predators to feed on larger prey sizes than they could capture in open environments. With the exception of one large white perch and one large gizzard shad the size-frequencies of ingested prey overlapped. Thus, it appeared that confinement of prey did not result in larger ingested prey.

Pound nets might, by aggregating prey, allow fish to feed at higher than normal levels. This "net feeding" behavior complicates stomach content analysis when multiple gear types are used and may result in biases. When spring pound nets and gill nets were compared, neither the percentage of full stomachs nor the mean stomach fullness index differed, indicating that, at this time and location, gear type effects on feeding intensity were minimal.

Fall pound net and hook and line fish from the lower rivers and middle Bay differed in diet composition. The broader range of prey in hook and line fish likely reflects the wider spatial and temporal distribution of these samples. Pound net fish were captured from a few fixed pound nets on several occasions. The major difference appeared to be the dominance of menhaden and the absence of anchovies in pound nets. The diet of hook and line fish appeared balanced between anchovies, menhaden, spot and several other species. Hook and line fish consumed larger size ranges of both menhaden and spot, though the greater size range of striped bass and the lack of precise spatial and temporal proximity may account for this difference. It appeared that pound nets resulted in higher levels of menhaden, possibly due to confinement. Pound nets do not appear to greatly bias against invertebrates as blue crabs were similar in importance in both gears.

The higher stomach fullness values and lower percentage of full stomachs for pound nets when compared with hook and line fish suggest that some pound net fish may feed more heavily in the nets but others might not feed at all. Differences in prey availability in the nets, differences in size of the predator and or differences in prey capture ability might contribute to these differential effects on feeding intensity. The higher percentage of full stomachs in hook and line caught fish might also be due to bias on the part of the collector to save fish with stomach contents, though fisherman were told explicitly to save all fish stomachs from a particular trip.

Originally, pound net fish were to be excluded from the analysis because of net feeding behavior but it does not appear that a clear relationship exists between gear type, stomach fullness and diet composition. Fish may feed actively in pound nets under certain conditions and may feed very little under other conditions or at other locations. Each gear type (hook and line, gill net, fyke net, electroshock and trawl) has certain known and unknown biases. Hayward et al (1989) found that gillnetted fish had higher median food amounts than trawled fish indicating that passive gear (gill nets) may sample actively foraging fish. Thus, fish from all gear types were included in the analysis to provide comparisons where possible and to avoid arbitrarily removing data from consideration. When pound nets were removed from the analysis and the index of relative importance recalculated, menhaden declined but still remained the most important prey item. Spot and other species increased in importance, though the overall rank order and relative importance remained unchanged. Without rigorous, spatially and temporally explicit pair-wise comparisons of gear types it is impossible to conclusively determine gear effects on diet composition or feeding behavior.

Overall, while striped bass consumed a wide variety of prey species, the pooling of prey categories demonstrates that only a few species, notably clupeids and sciaenids, dominated the diet across all seasons, salinity ranges and across the larger sizes of fish sampled (451-1300 mm). Anchovies represented a major component of the diet for smaller fish in mesohaline reaches of the estuary but for fish above 451 mm throughout Chesapeake Bay, clupeid and sciaenid fishes dominated the diet. The diet reflects the species composition of the Chesapeake estuary where species diversity is low but abundance of certain species is high. Most prey species are migratory and vary spatially and temporally in abundance. This study found the following general conclusions:

1. Clupeoid fishes dominated the diet of large striped bass in Chesapeake Bay.
2. Sciaenid fishes were second in importance with spot the most frequently encountered sciaenid.
3. Migrations of striped bass appear coordinated with the abundance of various prey species.
4. Invertebrates were relatively unimportant; blue crabs were only consumed in high numbers by smaller striped bass in the summer.
5. Capture methodology appears to affect diet composition and feeding intensity, though effects vary with location and season and do not affect the overall ranking of individual prey importance.

6. Primarily YOY fishes and invertebrates comprise the diet of all size classes of striped bass.
7. Reductions in feeding intensity were noted during the spring spawning period and also in late summer.

Future studies of striped bass feeding must incorporate the seasonal, spatial and methodological variability in diet composition. Future studies must also examine habitat-specific usage patterns by striped bass and determine diet composition at discrete spatial and temporal scales. With some estimates of the habitat types utilized by an individual striped bass over the course of its life and the diet composition at each of these habitats coupled with information on growth, it is possible to determine the amount of food consumed to support observed growth. Along with population size estimates, these data can then be used to determine the predatory impact of striped bass on certain prey species or the numbers of prey necessary to support a given population size of striped bass. This study provides a necessary first step towards such an integrated goal.

Table 1. List of common and scientific names of prey species found in striped bass stomachs in Chesapeake Bay, March 1997- May 1998.

| Common Name | Scientific name or group |
|---|---|
| Vertebrates | |
| Alewife | *Alosa pseudoharengus* |
| American eel | *Anguilla rostrata* |
| Atlantic croaker | *Micropogon undulatus* |
| Atlantic menhaden | *Brevoortia tyrannus* |
| Atlantic needlefish | *Strongylura marina* |
| Atlantic silverside | *Menidia menidia* |
| Atlantic thread herring | *Opisthonema oglinum* |
| Bay anchovy | *Anchoa mitchilli* |
| Blackcheek tonguefish | *Symphurus plagiusa* |
| Blueback herring | *Alosa aestivalis* |
| Bluefish | *Pomatomus saltatrix* |
| Butterfish | *Peprilus triacanthus* |
| Feather blenny | *Hypsoblennius hentzi* |
| Gizzard shad | *Dorosoma cepedianum* |
| Hogchoker | *Trinectes maculatus* |
| Inshore lizardfish | *Synodus foetens* |
| Mummichog | *Fundulus heteroclitus* |
| Naked goby | *Gobiosoma bosci* |
| Northern Puffer | *Sphoeroides maculatus* |
| Rough silverside | *Membras martinica* |
| Spotfin mojarra | *Eucinostomus argenteus* |
| Silver perch | *Bairdiella chrysoura.* |
| Spotted hake | *Urophycis regia* |
| Spot | *Leiostomus xanthurus* |
| Spottail shiner | *Notropis hudsonius* |
| Striped anchovy | *Anchoa hepsetus* |
| Striped bass | *Morone saxatilis* |
| Summer flounder | *Paralichthys dentatus* |
| Threadfin shad | *Dorosoma petenense* |
| Weakfish | *Cynoscion regalis* |
| White mullet | *Mugil curema* |
| White perch | *Morone americana* |
| Windowpane | *Scopthalmus aquosus* |

Table 1, continued. List of common and scientific names of prey species.

| Common Name | Scientific name or group |
|---|---|
| Invertebrates | |
| Other portunids | *Callinectes spp.* |
| Bay opossum shrimp | *Neomysis americana* |
| Eastern oyster | *Crassostrea virginica* |
| Blue crab | *Callinectes sapidus* |
| Fish-gill isopod | *Lironeca ovalis* |
| Fish-mouth isopod | *Olencira praegustator* |
| Flat-browed mud shrimp | *Upogebia affinis* |
| Grass shrimp | *Paleomonetes pugio* |
| Lady crab | *Ovalipes ocellatus* |
| Mantis shrimp | *Squilla empusa* |
| Mud crab | Family Xanthidae |
| Mussel | *Mytilis edulis* |
| Polycheates | Class Polychaeta |
| Redbeard sponge | *Microciona prolifera* |
| Rock crab | *Cancer irroratus* |
| Sand shrimp | *Crangon septemspinosa* |
| Snail | Class Gastropoda |
| White shrimp | *Peneaus setiferus* |

Table 2. Stomach contents of striped bass, *Morone saxatilis*, from Chesapeake Bay, 1997-1998 (n = 943, total number of stomachs with contents). Index of relative importance (IRI) is calculated with only those items deemed of natural food value (n=720).

| Prey | Number of stomachs in which item occurred | % frequency of occurrence | Number of items | % by number | Weight in grams | % by mass | % IRI |
|---|---|---|---|---|---|---|---|
| **Class Osteichthyes** | | | | | | | |
| Clupeidae | | | | | | | |
| *Brevoortia tyrannus* | 179 | 24.86 | 446 | 16.98 | 20589.7 | 41.89 | 54.86 |
| *Alosa sp.* | 25 | 3.47 | 67 | 2.55 | 4971.98 | 10.12 | 1.65 |
| *Dorosoma sp.* | 66 | 9.17 | 226 | 8.6 | 6803.35 | 13.84 | 7.71 |
| Unknown clupeid | 46 | 6.39 | 57 | 2.17 | 307.62 | 0.63 | 0.67 |
| Moronidae | | | | | | | |
| *Morone saxatilis* | 3 | 0.41 | 3 | 0.11 | 446.66 | 0.91 | 0.02 |
| *Morone americana* | 55 | 7.64 | 70 | 2.66 | 1768.76 | 3.6 | 1.79 |
| Sciaenidae | | | | | | | |
| *Leiostomus xanthurus* | 108 | 15 | 227 | 8.64 | 4160.93 | 8.47 | 9.62 |
| *Bairdiella chrysura* | 16 | 2.22 | 22 | 0.84 | 270.66 | 0.55 | 0.12 |
| *Cynoscion regalis* | 19 | 2.64 | 24 | 0.91 | 1109.88 | 2.26 | 0.31 |
| *Micropogon undulatus* | 23 | 3.19 | 24 | 0.91 | 2463.96 | 5.01 | 0.71 |
| Unknown scieanid | 20 | 2.78 | 32 | 1.22 | 80.54 | 0.16 | 0.14 |
| Engraulidae | | | | | | | |
| *Anchoa spp.* | 108 | 15 | 678 | 25.81 | 440.49 | 0.89 | 15.02 |
| Other fish | | | | | | | |
| *Paralichthys dentatus* | 18 | 2.5 | 32 | 1.22 | 2278.65 | 4.64 | 0.55 |
| *Membras martinica* | 1 | 0.14 | 15 | 0.57 | 26.17 | 0.05 | 0.003 |
| *Menidia menidia* | 16 | 2.22 | 32 | 1.22 | 45.94 | 0.09 | 0.11 |
| *Anguilla rostrata* | 11 | 1.53 | 22 | 0.84 | 591.29 | 1.21 | 0.17 |
| *Symphurus plagiusa* | 10 | 1.39 | 41 | 1.56 | 127.12 | 0.26 | 0.09 |
| *Peprilus triacanthus* | 8 | 1.11 | 16 | 0.61 | 476.61 | 0.97 | 0.07 |
| *Urophycis regia* | 3 | 0.42 | 26 | 0.98 | 399.99 | 0.81 | 0.03 |
| *Notropis sp.* | 6 | 0.83 | 9 | 0.34 | 15.54 | 0.03 | 0.01 |
| *Trinectes maculatus* | 6 | 0.83 | 7 | 0.27 | 39.08 | 0.08 | 0.01 |
| *Pomatomus saltatrix* | 3 | 0.42 | 3 | 0.11 | 184.21 | 0.37 | 0.007 |
| *Eucinostomus argenteus* | 3 | 0.42 | 3 | 0.11 | 39.92 | 0.08 | 0.003 |
| *Gobiosoma bosci* | 2 | 0.28 | 6 | 0.23 | 1.52 | 0 | 0.002 |
| *Synodus foetens* | 2 | 0.28 | 2 | 0.08 | 68.54 | 0.14 | 0.002 |
| *Strongylura marina* | 1 | 0.14 | 3 | 0.11 | 67.96 | 0.14 | 0.001 |
| *Scopthalmus aquosus* | 1 | 0.14 | 1 | 0.04 | 14.42 | 0.03 | 0 |
| *Mugil curema* | 1 | 0.14 | 1 | 0.04 | 36.08 | 0.07 | 0 |
| *Opisthonema oglinum* | 1 | | | | | | |
| *Sphoeroides maculatus* | 1 | 0.14 | 1 | 0.04 | 4.8 | 0.01 | 0 |
| *Hypsoblennius hentzi* | 1 | 0.14 | 1 | 0.04 | 4.15 | 0.01 | 0 |
| *Fundulus heteroclitus* | 1 | 0.14 | 1 | 0.04 | 3.39 | 0.01 | 0 |
| Unidentified fish remains | 86 | 11.94 | 110 | 4.19 | 172.88 | 0.35 | 2.03 |

Table 2, Continued.

| Prey | Number of stomachs in which item occurred | % frequency of occurrence | Number of items | % by number | Weight in grams | % by mass | % IRI |
|---|---|---|---|---|---|---|---|
| **Class Crustacea** | | | | | | | |
| *Callinectes sapidus* | 790 | 10.97 | 192 | 7.31 | 727.89 | 1.48 | 3.62 |
| *Neomysis americana* | 15 | 2.08 | 110 | 4.19 | 12.58 | 0.03 | 0.33 |
| *Squilla empusa* | 25 | 3.47 | 41 | 1.56 | 216.42 | 0.44 | 0.26 |
| *Ovalipes ocellatus* | 15 | 2.08 | 17 | 0.65 | 106.75 | 0.22 | 0.07 |
| *Lironeca ovalis* | 10 | 1.39 | 10 | 0.38 | 0.85 | 0 | 0.02 |
| *Callinectes sp.* | 4 | 0.56 | 7 | 0.27 | 28.83 | 0.06 | 0.007 |
| *Peneaus setiferus* | 5 | 0.69 | 5 | 0.19 | 12.99 | 0.03 | 0.006 |
| *Crangon septimspinosa* | 5 | 0.69 | 11 | 0.42 | 3.71 | 0.008 | 0.01 |
| *Paleomonetes pugio* | 4 | 0.56 | 9 | 0.34 | 2.237 | 0.004 | 0.007 |
| *Olencira praegustator* | 1 | 0.14 | 1 | 0.04 | 1 | 0.002 | 0 |
| *Cancer irroratus* | 1 | 0.14 | 1 | 0.04 | 7.725 | 0.016 | 0 |
| *Upogebia affinis* | 1 | 0.14 | 1 | 0.04 | 0.592 | 0.001 | 0 |
| Xanthid crabs | 1 | 0.14 | 1 | 0.04 | 3.52 | 0.007 | 0 |
| **Class Bivalvia** | | | | | | | |
| *Mytilus edulis* | * | * | 2 | * | * | * | ** |
| *Crossostrea virginica* | * | * | 2 | * | * | * | ** |
| **Class Gastropoda** | | | | | | | |
| All gastropods | 1 | 0.14 | 1 | 0.04 | 0.39 | 0 | 0 |
| **Class Polychaeta** | | | | | | | |
| All polychaetes | 8 | 1.11 | 8 | 0.31 | 11.37 | 0.02 | 0.01 |
| **Class Hydrozoa** | | | | | | | |
| All hydroids | 4 | 0.57 | 4 | 0.16 | 0 | 0 | 0 |
| **Phylum porifera** | | | | | | | |
| All sponges | 1 | 0.14 | 1 | 0.04 | 2.29 | 0.01 | 0 |
| Miscellaneous items | | | | | | | |
| Chum | * | * | 159 | * | * | * | ** |
| Bait (cut spot, etc.) | * | * | 28 | * | * | * | ** |
| Plant material | * | * | 11 | * | * | * | ** |
| Woody material | * | * | 6 | * | * | * | ** |
| Plastic trash | * | * | 1 | * | * | * | ** |
| Cigarette butts | 3 | * | 2 | * | * | * | ** |
| Stones, gravel | * | * | 2 | * | * | * | ** |
| Feathers | * | * | 2 | * | * | * | ** |
| Totals | | | 2765 | | 48278.29 | | |

* not quantified and not included in IRI calculations

** not included in IRI calculations

**Table 3:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the spring. N= 260.

| Species | number | % number | weight (grams) | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| gizzard shad | 121 | 14.60 | 5628.00 | 42.97 | 51 | 19.62 | 1129.25 | 39.91 |
| bay anchovy | 342 | 41.25 | 300.54 | 2.29 | 47 | 18.08 | 787.24 | 27.82 |
| river herring | 66 | 7.96 | 4932.73 | 37.67 | 25 | 9.62 | 438.72 | 15.50 |
| whiteperch | 44 | 5.31 | 1272.55 | 9.72 | 36 | 13.85 | 208.03 | 7.35 |
| unknown clupeid | 44 | 5.31 | 289.47 | 2.21 | 36 | 13.85 | 104.09 | 3.68 |
| unknown fish | 44 | 5.31 | 44.47 | 0.34 | 35 | 13.46 | 76.02 | 2.69 |
| mysid shrimp | 87 | 10.49 | 10.20 | 0.08 | 11 | 4.23 | 44.73 | 1.58 |
| blue crab | 26 | 3.14 | 109.07 | 0.83 | 20 | 7.69 | 30.53 | 1.08 |
| spotted hake | 25 | 3.02 | 232.20 | 1.77 | 2 | 0.77 | 3.68 | 0.13 |
| spottail shiner | 9 | 1.09 | 15.54 | 0.12 | 6 | 2.31 | 2.78 | 0.10 |
| croaker | 3 | 0.36 | 174.48 | 1.33 | 3 | 1.15 | 1.95 | 0.07 |
| polychaete | 5 | 0.60 | 8.90 | 0.07 | 5 | 1.92 | 1.29 | 0.05 |
| summer flounder | 3 | 0.36 | 7.51 | 0.06 | 3 | 1.15 | 0.48 | 0.02 |
| atlantic silverside | 2 | 0.24 | 18.14 | 0.14 | 2 | 0.77 | 0.29 | 0.01 |
| mantis shrimp | 2 | 0.24 | 17.10 | 0.13 | 2 | 0.77 | 0.29 | 0.01 |
| spot | 2 | 0.24 | 9.08 | 0.07 | 1 | 0.38 | 0.12 | 0.00 |
| american eel | 1 | 0.12 | 22.64 | 0.17 | 1 | 0.38 | 0.11 | 0.00 |
| hogchoker | 1 | 0.12 | 3.68 | 0.03 | 1 | 0.38 | 0.06 | 0.00 |
| lironeca ovalis | 1 | 0.12 | 0.02 | 0.00 | 1 | 0.38 | 0.05 | 0.00 |
| unknown sciaenid | 1 | 0.12 | 0.00 | 0.00 | 1 | 0.38 | 0.05 | 0.00 |

**Table 4:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the summer. N= 55.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| atlantic silverside | 27 | 17.31 | 2232.34 | 67.26 | 16 | 29.09 | 2460.21 | 50.08 |
| blue crab | 70 | 44.87 | 450.02 | 13.56 | 19 | 34.55 | 2018.53 | 41.09 |
| whiteperch | 12 | 7.69 | 237.48 | 7.16 | 8 | 14.55 | 215.97 | 4.40 |
| bay anchovy | 23 | 14.74 | 6.01 | 0.18 | 4 | 7.27 | 108.54 | 2.21 |
| croaker | 3 | 1.92 | 322.41 | 9.71 | 3 | 5.45 | 63.48 | 1.29 |
| lironeca ovalis | 4 | 2.56 | 0.17 | 0.00 | 4 | 7.27 | 18.68 | 0.38 |
| mysid shrimp | 10 | 6.41 | 1.43 | 0.04 | 1 | 1.82 | 11.73 | 0.24 |
| unknown fish | 3 | 1.92 | 0.70 | 0.02 | 2 | 3.64 | 7.07 | 0.14 |
| river herring | 1 | 0.64 | 39.25 | 1.18 | 1 | 1.82 | 3.32 | 0.07 |
| spot | 1 | 0.64 | 24.74 | 0.75 | 1 | 1.82 | 2.52 | 0.05 |
| menhaden | 1 | 0.64 | 4.23 | 0.13 | 1 | 1.82 | 1.40 | 0.03 |
| sand shrimp | 1 | 0.64 | 0.10 | 0.00 | 1 | 1.82 | 1.17 | 0.02 |

**Table 5:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the fall. N= 336.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 356 | 26.99 | 13449.84 | 52.09 | 127 | 37.80 | 2989.00 | 68.18 |
| spot | 210 | 15.92 | 3600.37 | 13.94 | 98 | 29.17 | 871.06 | 19.87 |
| bay anchovy | 156 | 11.83 | 59.13 | 0.23 | 41 | 12.20 | 147.11 | 3.36 |
| blue crab | 92 | 6.97 | 161.93 | 0.63 | 39 | 11.61 | 88.24 | 2.01 |
| gizzard shad | 97 | 7.35 | 1063.87 | 4.12 | 14 | 4.17 | 47.81 | 1.09 |
| unknown fish | 46 | 3.49 | 117.73 | 0.46 | 37 | 11.01 | 43.42 | 0.99 |
| summer flounder | 26 | 1.97 | 2248.67 | 8.71 | 13 | 3.87 | 41.32 | 0.94 |
| croaker | 16 | 1.21 | 1811.20 | 7.01 | 15 | 4.46 | 36.73 | 0.84 |
| weakfish | 22 | 1.67 | 881.24 | 3.41 | 17 | 5.06 | 25.71 | 0.59 |
| mantis shrimp | 39 | 2.96 | 199.33 | 0.77 | 23 | 6.85 | 25.52 | 0.58 |
| unknown sciaenid | 30 | 2.27 | 80.31 | 0.31 | 18 | 5.36 | 13.85 | 0.32 |
| silver perch | 21 | 1.59 | 216.60 | 0.84 | 15 | 4.46 | 10.85 | 0.25 |
| atlantic silverside | 29 | 2.20 | 40.58 | 0.16 | 14 | 4.17 | 9.82 | 0.22 |
| butterfish | 16 | 1.21 | 476.61 | 1.85 | 8 | 2.38 | 7.28 | 0.17 |
| tonguefish | 36 | 2.73 | 64.08 | 0.25 | 8 | 2.38 | 7.09 | 0.16 |
| lady crab | 16 | 1.21 | 106.75 | 0.41 | 14 | 4.17 | 6.78 | 0.15 |
| unknown clupeid | 11 | 0.83 | 17.02 | 0.07 | 8 | 2.38 | 2.14 | 0.05 |
| striped bass | 3 | 0.23 | 446.66 | 1.73 | 3 | 0.89 | 1.75 | 0.04 |
| white perch | 7 | 0.53 | 111.40 | 0.43 | 5 | 1.49 | 1.43 | 0.03 |
| mysid shrimp | 13 | 0.99 | 0.96 | 0.00 | 3 | 0.89 | 0.88 | 0.02 |
| grass shrimp | 9 | 0.68 | 2.24 | 0.01 | 4 | 1.19 | 0.82 | 0.02 |
| blue crab, others | 7 | 0.53 | 28.83 | 0.11 | 4 | 1.19 | 0.76 | 0.02 |
| peneid shrimp | 5 | 0.38 | 13.00 | 0.05 | 5 | 1.49 | 0.64 | 0.01 |
| hogchoker | 5 | 0.38 | 30.14 | 0.12 | 4 | 1.19 | 0.59 | 0.01 |
| lironeca ovalis | 5 | 0.38 | 0.66 | 0.00 | 5 | 1.49 | 0.57 | 0.01 |
| rough silverside | 15 | 1.14 | 26.17 | 0.10 | 1 | 0.30 | 0.37 | 0.01 |
| mojarra | 3 | 0.23 | 39.92 | 0.15 | 3 | 0.89 | 0.34 | 0.01 |
| bluefish | 2 | 0.15 | 101.03 | 0.39 | 2 | 0.60 | 0.32 | 0.01 |
| lizardfish | 2 | 0.15 | 68.54 | 0.27 | 2 | 0.60 | 0.25 | 0.01 |
| american eel | 2 | 0.15 | 62.79 | 0.24 | 2 | 0.60 | 0.24 | 0.01 |
| spotted hake | 1 | 0.08 | 167.80 | 0.65 | 1 | 0.30 | 0.22 | 0.00 |
| hydroid | 3 | 0.23 | 0.00 | 0.00 | 3 | 0.89 | 0.20 | 0.00 |
| sand shrimp | 4 | 0.30 | 1.29 | 0.01 | 2 | 0.60 | 0.18 | 0.00 |
| needlefish | 3 | 0.23 | 67.96 | 0.26 | 1 | 0.30 | 0.15 | 0.00 |
| polychaete | 2 | 0.15 | 0.35 | 0.00 | 2 | 0.60 | 0.09 | 0.00 |
| mullet | 1 | 0.08 | 36.08 | 0.14 | 1 | 0.30 | 0.06 | 0.00 |
| northern puffer | 1 | 0.08 | 4.80 | 0.02 | 1 | 0.30 | 0.03 | 0.00 |
| feather blenny | 1 | 0.08 | 4.15 | 0.02 | 1 | 0.30 | 0.03 | 0.00 |
| mudcrab | 1 | 0.08 | 3.52 | 0.01 | 1 | 0.30 | 0.03 | 0.00 |
| mummichog | 1 | 0.08 | 3.39 | 0.01 | 1 | 0.30 | 0.03 | 0.00 |
| bryozoan | 1 | 0.08 | 2.29 | 0.01 | 1 | 0.30 | 0.03 | 0.00 |
| menhaden isopod | 1 | 0.08 | 1.00 | 0.00 | 1 | 0.30 | 0.02 | 0.00 |
| mudshrimp | 1 | 0.08 | 0.59 | 0.00 | 1 | 0.30 | 0.02 | 0.00 |
| naked goby | 1 | 0.08 | 0.10 | 0.00 | 1 | 0.30 | 0.02 | 0.00 |

**Table 6:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the winter. N= 70.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 61 | 19.12 | 4889.38 | 70.77 | 34 | 48.57 | 4366.11 | 72.89 |
| bay anchovy | 157 | 49.22 | 74.82 | 1.08 | 16 | 22.86 | 1149.70 | 19.19 |
| american eel | 19 | 5.96 | 505.86 | 7.32 | 8 | 11.43 | 151.75 | 2.53 |
| spot | 14 | 4.39 | 526.75 | 7.62 | 8 | 11.43 | 137.29 | 2.29 |
| unknown fish | 17 | 5.33 | 9.98 | 0.14 | 12 | 17.14 | 93.83 | 1.57 |
| white perch | 7 | 2.19 | 147.33 | 2.13 | 6 | 8.57 | 37.09 | 0.62 |
| weakfish | 2 | 0.63 | 228.64 | 3.31 | 2 | 2.86 | 11.25 | 0.19 |
| croaker | 2 | 0.63 | 155.87 | 2.26 | 2 | 2.86 | 8.24 | 0.14 |
| tonguefish | 5 | 1.57 | 63.03 | 0.91 | 2 | 2.86 | 7.08 | 0.12 |
| gizzard shad | 8 | 2.51 | 111.48 | 1.61 | 1 | 1.43 | 5.89 | 0.10 |
| sand shrimp | 6 | 1.88 | 2.31 | 0.03 | 2 | 2.86 | 5.47 | 0.09 |
| summer flounder | 3 | 0.94 | 22.47 | 0.33 | 2 | 2.86 | 3.62 | 0.06 |
| naked goby | 5 | 1.57 | 1.42 | 0.02 | 1 | 1.43 | 2.27 | 0.04 |
| bluefish | 1 | 0.31 | 83.18 | 1.20 | 1 | 1.43 | 2.17 | 0.04 |
| unknown clupeid | 2 | 0.63 | 1.13 | 0.02 | 2 | 2.86 | 1.84 | 0.03 |
| silver perch | 1 | 0.31 | 54.06 | 0.78 | 1 | 1.43 | 1.57 | 0.03 |
| atlantic silverside | 2 | 0.63 | 1.13 | 0.02 | 1 | 1.43 | 0.92 | 0.02 |
| windowpane | 1 | 0.31 | 14.42 | 0.21 | 1 | 1.43 | 0.75 | 0.01 |
| cancer crab | 1 | 0.31 | 7.73 | 0.11 | 1 | 1.43 | 0.61 | 0.01 |
| hogchoker | 1 | 0.31 | 5.26 | 0.08 | 1 | 1.43 | 0.56 | 0.01 |
| polychaete | 1 | 0.31 | 2.12 | 0.03 | 1 | 1.43 | 0.49 | 0.01 |
| gastropod | 1 | 0.31 | 0.39 | 0.01 | 1 | 1.43 | 0.46 | 0.01 |
| unknown sciaenid | 1 | 0.31 | 0.23 | 0.00 | 1 | 1.43 | 0.45 | 0.01 |
| lady crab | 1 | 0.31 | 0.00 | 0.00 | 1 | 1.43 | 0.45 | 0.01 |

**Table 7:** Number, weight, frequency of occurrence and index of relative importance for striped bass in tidal freshwater (0-5 ppt). N= 190.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| american eel | 1 | 0.16 | 22.64 | 0.18 | 1 | 0.43 | 0.15 | 0.00 |
| bay anchovy | 269 | 42.70 | 244.28 | 1.91 | 35 | 15.15 | 675.84 | 20.82 |
| blue crab | 10 | 1.59 | 8.30 | 0.06 | 8 | 3.46 | 5.72 | 0.18 |
| croaker | 2 | 0.32 | 85.84 | 0.67 | 2 | 0.87 | 0.86 | 0.03 |
| gizzard shad | 128 | 20.32 | 5733.91 | 44.76 | 51 | 22.08 | 1436.80 | 44.26 |
| menhaden | 1 | 0.16 | 11.74 | 0.09 | 1 | 0.43 | 0.11 | 0.00 |
| atlantic silverside | 0 | 0.00 | 0.00 | 0.00 | 0 | 0.00 | 0.00 | 0.00 |
| spottail shiner | 9 | 1.43 | 15.54 | 0.12 | 6 | 2.60 | 4.03 | 0.12 |
| mysid shrimp | 4 | 0.63 | 0.05 | 0.00 | 2 | 0.87 | 0.55 | 0.02 |
| polychaete | 2 | 0.32 | 1.31 | 0.01 | 2 | 0.87 | 0.28 | 0.01 |
| river herring | 66 | 10.48 | 4932.73 | 38.51 | 25 | 10.82 | 530.12 | 16.33 |
| silver perch | 0 | 0.00 | 0.00 | 0.00 | 0 | 0.00 | 0.00 | 0.00 |
| spot | 0 | 0.00 | 0.00 | 0.00 | 0 | 0.00 | 0.00 | 0.00 |
| unknown clupeid | 43 | 6.83 | 289.35 | 2.26 | 35 | 15.15 | 137.64 | 4.24 |
| unknown fish | 43 | 6.83 | 44.42 | 0.35 | 34 | 14.72 | 105.56 | 3.25 |
| unknown sciaenid | 1 | 0.16 | 0.00 | 0.00 | 1 | 0.43 | 0.07 | 0.00 |
| weakfish | 0 | 0.00 | 0.00 | 0.00 | 0 | 0.00 | 0.00 | 0.00 |
| white perch | 51 | 8.10 | 1419.88 | 11.08 | 42 | 18.18 | 348.72 | 10.74 |

**Table 8:** Number, weight, frequency of occurrence and index of relative importance for striped bass in mesohaline waters (5-18 ppt). N= 214.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 129 | 15.12 | 5260.16 | 56.16 | 49 | 25.79 | 1838.26 | 50.10 |
| blue crab | 164 | 19.23 | 691.03 | 7.38 | 61 | 32.11 | 854.11 | 23.28 |
| bay anchovy | 220 | 25.79 | 151.83 | 1.62 | 36 | 18.95 | 519.39 | 14.16 |
| sand shrimp | 95 | 11.14 | 870.71 | 9.30 | 17 | 8.95 | 182.82 | 4.98 |
| spot | 46 | 5.39 | 791.62 | 8.45 | 23 | 12.11 | 167.58 | 4.57 |
| mysid shrimp | 93 | 10.90 | 11.58 | 0.12 | 10 | 5.26 | 58.03 | 1.58 |
| unknown fish | 14 | 1.64 | 2.79 | 0.03 | 13 | 6.84 | 11.43 | 0.31 |
| croaker | 4 | 0.47 | 411.05 | 4.39 | 4 | 2.11 | 10.23 | 0.28 |
| spotted hake | 25 | 2.93 | 232.20 | 2.48 | 2 | 1.05 | 5.69 | 0.16 |
| striped bass | 2 | 0.23 | 427.20 | 4.56 | 2 | 1.05 | 5.05 | 0.14 |
| whiteperch | 5 | 0.59 | 87.63 | 0.94 | 5 | 2.63 | 4.00 | 0.11 |
| weakfish | 2 | 0.23 | 268.70 | 2.87 | 2 | 1.05 | 3.27 | 0.09 |
| lironeca ovalis | 7 | 0.82 | 0.52 | 0.01 | 7 | 3.68 | 3.04 | 0.08 |
| rough silverside | 15 | 1.76 | 26.17 | 0.28 | 1 | 0.53 | 1.07 | 0.03 |
| unknown sciaenid | 6 | 0.70 | 15.89 | 0.17 | 2 | 1.05 | 0.92 | 0.03 |
| atlantic silverside | 7 | 0.82 | 2.85 | 0.03 | 2 | 1.05 | 0.90 | 0.02 |
| polychaete | 3 | 0.35 | 7.59 | 0.08 | 3 | 1.58 | 0.68 | 0.02 |
| summer flounder | 3 | 0.35 | 7.51 | 0.08 | 3 | 1.58 | 0.68 | 0.02 |
| silver perch | 3 | 0.35 | 24.60 | 0.26 | 2 | 1.05 | 0.65 | 0.02 |
| mantis shrimp | 2 | 0.23 | 17.10 | 0.18 | 2 | 1.05 | 0.44 | 0.01 |
| bluefish | 1 | 0.12 | 47.35 | 0.51 | 1 | 0.53 | 0.33 | 0.01 |
| unknown clupeid | 2 | 0.23 | 2.64 | 0.03 | 2 | 1.05 | 0.28 | 0.01 |
| hogchoker | 1 | 0.12 | 3.68 | 0.04 | 1 | 0.53 | 0.08 | 0.00 |
| mudcrab | 1 | 0.12 | 3.52 | 0.04 | 1 | 0.53 | 0.08 | 0.00 |
| menhaden isopod | 1 | 0.12 | 1.00 | 0.01 | 1 | 0.53 | 0.07 | 0.00 |
| gizzard shad | 1 | 0.12 | 0.10 | 0.00 | 1 | 0.53 | 0.06 | 0.00 |
| hydroid | 1 | 0.12 | 0.00 | 0.00 | 1 | 0.53 | 0.06 | 0.00 |

**Table 9:** Number, weight, frequency of occurrence and index of relative importance for striped bass polyhaline waters (18-30 ppt). N= 263.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 234 | 22.20 | 10915.22 | 50.48 | 91 | 34.60 | 2514.89 | 61.69 |
| spot | 160 | 15.18 | 2876.52 | 13.30 | 76 | 28.90 | 823.11 | 20.19 |
| bay anchovy | 223 | 21.16 | 107.38 | 0.50 | 41 | 15.59 | 337.57 | 8.28 |
| unknown fish | 51 | 4.84 | 125.77 | 0.58 | 37 | 14.07 | 76.26 | 1.87 |
| summer flounder | 29 | 2.75 | 2271.14 | 10.50 | 15 | 5.70 | 75.60 | 1.85 |
| croaker | 17 | 1.61 | 1708.27 | 7.90 | 16 | 6.08 | 57.88 | 1.42 |
| mantis shrimp | 37 | 3.51 | 184.81 | 0.85 | 22 | 8.37 | 36.51 | 0.90 |
| weakfish | 21 | 1.99 | 827.92 | 3.83 | 16 | 6.08 | 35.42 | 0.87 |
| american eel | 21 | 1.99 | 568.65 | 2.63 | 10 | 3.80 | 17.58 | 0.43 |
| tonguefish | 41 | 3.89 | 127.12 | 0.59 | 10 | 3.80 | 17.03 | 0.42 |
| unknown sciaenid | 24 | 2.28 | 64.23 | 0.30 | 16 | 6.08 | 15.66 | 0.38 |
| silver perch | 18 | 1.71 | 230.16 | 1.06 | 13 | 4.94 | 13.70 | 0.34 |
| atlantic silverside | 25 | 2.37 | 43.09 | 0.20 | 14 | 5.32 | 13.69 | 0.34 |
| lady crab | 16 | 1.52 | 105.73 | 0.49 | 14 | 5.32 | 10.68 | 0.26 |
| butterfish | 15 | 1.42 | 463.88 | 2.15 | 7 | 2.66 | 9.50 | 0.23 |
| gizzard shad | 18 | 1.71 | 314.27 | 1.45 | 5 | 1.90 | 6.01 | 0.15 |
| unknown clupeid | 9 | 0.85 | 11.55 | 0.05 | 6 | 2.28 | 2.07 | 0.05 |
| blue crab | 9 | 0.85 | 11.64 | 0.05 | 5 | 1.90 | 1.73 | 0.04 |
| sand shrimp | 10 | 0.95 | 3.61 | 0.02 | 4 | 1.52 | 1.47 | 0.04 |
| mysid shrimp | 13 | 1.23 | 0.96 | 0.00 | 3 | 1.14 | 1.41 | 0.03 |
| hogchoker | 6 | 0.57 | 35.40 | 0.16 | 5 | 1.90 | 1.39 | 0.03 |
| grass shrimp | 9 | 0.85 | 2.24 | 0.01 | 4 | 1.52 | 1.31 | 0.03 |
| blue crab, others | 7 | 0.66 | 28.83 | 0.13 | 4 | 1.52 | 1.21 | 0.03 |
| peneid shrimp | 5 | 0.47 | 13.00 | 0.06 | 5 | 1.90 | 1.02 | 0.02 |
| bluefish | 2 | 0.19 | 136.86 | 0.63 | 2 | 0.76 | 0.63 | 0.02 |
| mojarra | 3 | 0.28 | 39.92 | 0.18 | 3 | 1.14 | 0.54 | 0.01 |
| naked goby | 6 | 0.57 | 1.52 | 0.01 | 2 | 0.76 | 0.44 | 0.01 |
| lizardfish | 2 | 0.19 | 68.54 | 0.32 | 2 | 0.76 | 0.39 | 0.01 |
| polychaete | 3 | 0.28 | 2.47 | 0.01 | 3 | 1.14 | 0.34 | 0.01 |
| spotted hake | 1 | 0.09 | 167.80 | 0.78 | 1 | 0.38 | 0.33 | 0.01 |
| lironeca ovalis | 3 | 0.28 | 0.33 | 0.00 | 3 | 1.14 | 0.33 | 0.01 |
| whiteperch | 3 | 0.28 | 21.42 | 0.10 | 2 | 0.76 | 0.29 | 0.01 |
| needlefish | 3 | 0.28 | 67.96 | 0.31 | 1 | 0.38 | 0.23 | 0.01 |
| mullet | 1 | 0.09 | 36.08 | 0.17 | 1 | 0.38 | 0.10 | 0.00 |
| windowpane | 1 | 0.09 | 14.42 | 0.07 | 1 | 0.38 | 0.06 | 0.00 |
| cancer crab | 1 | 0.09 | 7.73 | 0.04 | 1 | 0.38 | 0.05 | 0.00 |
| northern puffer | 1 | 0.09 | 4.80 | 0.02 | 1 | 0.38 | 0.04 | 0.00 |
| feather blenny | 1 | 0.09 | 4.15 | 0.02 | 1 | 0.38 | 0.04 | 0.00 |
| mummichog | 1 | 0.09 | 3.39 | 0.02 | 1 | 0.38 | 0.04 | 0.00 |
| bryozoan | 1 | 0.09 | 2.29 | 0.01 | 1 | 0.38 | 0.04 | 0.00 |
| mudshrimp | 1 | 0.09 | 0.59 | 0.00 | 1 | 0.38 | 0.04 | 0.00 |
| gastropod | 1 | 0.09 | 0.39 | 0.00 | 1 | 0.38 | 0.04 | 0.00 |
| hydroid | 1 | 0.09 | 0.00 | 0.00 | 1 | 0.38 | 0.04 | 0.00 |

**Table 10:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the middle and upper rivers. N = 21

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| gizzard shad | 175 | 32.59 | 6253.33 | 47.63 | 49 | 22.79 | 5073.95 | 50.11 |
| white perch | 52 | 9.68 | 1421.72 | 10.83 | 43 | 20.00 | 1256.59 | 12.41 |
| unknown clupeid | 43 | 8.01 | 213.46 | 1.63 | 35 | 16.28 | 726.47 | 7.18 |
| unknown fish | 41 | 7.64 | 43.19 | 0.33 | 33 | 15.35 | 634.35 | 6.27 |
| river herring | 66 | 12.29 | 4932.73 | 37.57 | 25 | 11.63 | 1204.34 | 11.89 |
| bay anchovy | 130 | 24.21 | 118.46 | 0.90 | 19 | 8.84 | 1156.81 | 11.43 |
| blue crab | 10 | 1.86 | 8.30 | 0.06 | 8 | 3.72 | 37.44 | 0.37 |
| spottail shiner | 9 | 1.68 | 15.54 | 0.12 | 6 | 2.79 | 25.45 | 0.25 |
| croaker | 2 | 0.37 | 85.84 | 0.65 | 2 | 0.93 | 2.47 | 0.02 |
| mysid shrimp | 4 | 0.74 | 0.05 | 0.00 | 2 | 0.93 | 3.72 | 0.04 |
| polychaete | 2 | 0.37 | 1.31 | 0.01 | 2 | 0.93 | 1.87 | 0.02 |
| menhaden | 1 | 0.19 | 11.74 | 0.09 | 1 | 0.47 | 0.51 | 0.01 |
| unknown sciaenid | 1 | 0.19 | 0.00 | 0.00 | 1 | 0.47 | 0.47 | 0.00 |
| american eel | 1 | 0.19 | 22.64 | 0.17 | 1 | 0.47 | 0.55 | 0.01 |

**Table 11:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the lower rivers. N = 151.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 130 | 16.77 | 4994.17 | 59.75 | 49 | 32.45 | 6157.44 | 40.39 |
| bay anchovy | 213 | 27.48 | 182.27 | 2.18 | 29 | 19.21 | 4132.61 | 27.11 |
| blue crab | 94 | 12.13 | 198.83 | 2.38 | 39 | 25.83 | 2489.25 | 16.33 |
| spot | 54 | 6.97 | 740.48 | 8.86 | 29 | 19.21 | 1207.23 | 7.92 |
| mysid shrimp | 83 | 10.71 | 10.15 | 0.12 | 9 | 5.96 | 495.43 | 3.25 |
| gizzard shad | 34 | 4.39 | 451.58 | 5.40 | 13 | 8.61 | 339.23 | 2.23 |
| unknown fish | 15 | 1.94 | 10.13 | 0.12 | 12 | 7.95 | 120.17 | 0.79 |
| mantis shrimp | 14 | 1.81 | 98.57 | 1.18 | 5 | 3.31 | 50.26 | 0.33 |
| spotted hake | 25 | 3.23 | 232.20 | 2.78 | 2 | 1.32 | 36.79 | 0.24 |
| atlantic silverside | 10 | 1.29 | 7.50 | 0.09 | 5 | 3.31 | 33.41 | 0.22 |
| sand shrimp | 9 | 1.16 | 3.57 | 0.04 | 3 | 1.99 | 17.97 | 0.12 |
| polychaete | 5 | 0.65 | 10.04 | 0.12 | 5 | 3.31 | 16.95 | 0.11 |
| unknown sciaenid | 8 | 1.03 | 17.91 | 0.21 | 3 | 1.99 | 16.32 | 0.11 |
| grass shrimp | 8 | 1.03 | 2.10 | 0.03 | 3 | 1.99 | 15.94 | 0.10 |
| tonguefish | 11 | 1.42 | 10.94 | 0.13 | 2 | 1.32 | 14.74 | 0.10 |
| summer flounder | 5 | 0.65 | 29.57 | 0.35 | 4 | 2.65 | 14.18 | 0.09 |
| silver perch | 5 | 0.65 | 26.05 | 0.31 | 3 | 1.99 | 10.55 | 0.07 |
| rough silverside | 15 | 1.94 | 26.17 | 0.31 | 1 | 0.66 | 10.14 | 0.07 |
| whiteperch | 4 | 0.52 | 88.73 | 1.06 | 3 | 1.99 | 10.06 | 0.07 |
| striped bass | 2 | 0.26 | 427.20 | 5.11 | 2 | 1.32 | 9.42 | 0.06 |
| hogchoker | 4 | 0.52 | 19.88 | 0.24 | 3 | 1.99 | 8.42 | 0.06 |
| unknown clupeid | 3 | 0.39 | 78.74 | 0.94 | 3 | 1.99 | 7.83 | 0.05 |
| weakfish | 2 | 0.26 | 268.70 | 3.21 | 2 | 1.32 | 6.91 | 0.05 |
| croaker | 2 | 0.26 | 217.96 | 2.61 | 2 | 1.32 | 6.10 | 0.04 |
| american eel | 2 | 0.26 | 62.79 | 0.75 | 2 | 1.32 | 3.64 | 0.02 |
| naked goby | 5 | 0.65 | 1.42 | 0.02 | 1 | 0.66 | 3.32 | 0.02 |
| lironeca ovalis | 2 | 0.26 | 0.21 | 0.00 | 2 | 1.32 | 2.65 | 0.02 |
| butterfish | 3 | 0.39 | 78.01 | 0.93 | 1 | 0.66 | 2.60 | 0.02 |
| mullet | 1 | 0.13 | 36.08 | 0.43 | 1 | 0.66 | 0.95 | 0.01 |
| mojarra | 1 | 0.13 | 12.87 | 0.15 | 1 | 0.66 | 0.76 | 0.01 |
| feather blenny | 1 | 0.13 | 4.15 | 0.05 | 1 | 0.66 | 0.70 | 0.00 |
| mummichog | 1 | 0.13 | 3.39 | 0.04 | 1 | 0.66 | 0.69 | 0.00 |
| peneid shrimp | 1 | 0.13 | 2.82 | 0.03 | 1 | 0.66 | 0.68 | 0.00 |
| bryozoan | 1 | 0.13 | 2.29 | 0.03 | 1 | 0.66 | 0.68 | 0.00 |
| menhaden isopod | 1 | 0.13 | 1.00 | 0.01 | 1 | 0.66 | 0.67 | 0.00 |
| hydroid | 1 | 0.13 | 0.00 | 0.00 | 1 | 0.66 | 0.66 | 0.00 |

**Table 12:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the middle and upper Chesapeake Bay. N = 114.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 50 | 16.08 | 4929.16 | 67.48 | 30 | 26.32 | 2198.84 | 57.15 |
| blue crab | 78 | 25.08 | 502.27 | 6.88 | 26 | 22.81 | 728.83 | 18.94 |
| bay anchovy | 94 | 30.23 | 33.61 | 0.46 | 26 | 22.81 | 699.84 | 18.19 |
| american eel | 16 | 5.14 | 416.33 | 5.70 | 6 | 5.26 | 57.07 | 1.48 |
| spot | 8 | 2.57 | 527.15 | 7.22 | 6 | 5.26 | 51.52 | 1.34 |
| croaker | 4 | 1.29 | 595.81 | 8.16 | 4 | 3.51 | 33.13 | 0.86 |
| mysid shrimp | 23 | 7.40 | 2.39 | 0.03 | 4 | 3.51 | 26.06 | 0.68 |
| unknown fish | 7 | 2.25 | 2.93 | 0.04 | 7 | 6.14 | 14.07 | 0.37 |
| atlantic silverside | 9 | 2.89 | 11.93 | 0.16 | 4 | 3.51 | 10.73 | 0.28 |
| lironeca ovalis | 6 | 1.93 | 0.38 | 0.01 | 6 | 5.26 | 10.18 | 0.26 |
| weakfish | 3 | 0.96 | 94.02 | 1.29 | 3 | 2.63 | 5.93 | 0.15 |
| white perch | 3 | 0.96 | 18.48 | 0.25 | 3 | 2.63 | 3.20 | 0.08 |
| mantis shrimp | 3 | 0.96 | 12.67 | 0.17 | 3 | 2.63 | 2.99 | 0.08 |
| summer flounder | 1 | 0.32 | 185.25 | 2.54 | 1 | 0.88 | 2.51 | 0.07 |
| bluefish | 1 | 0.32 | 47.35 | 0.65 | 1 | 0.88 | 0.85 | 0.02 |
| mud crab | 1 | 0.32 | 3.52 | 0.05 | 1 | 0.88 | 0.32 | 0.01 |
| unknown clupeid | 1 | 0.32 | 0.79 | 0.01 | 1 | 0.88 | 0.29 | 0.01 |
| mud shrimp | 1 | 0.32 | 0.59 | 0.01 | 1 | 0.88 | 0.29 | 0.01 |
| sand shrimp | 1 | 0.32 | 0.10 | 0.00 | 1 | 0.88 | 0.28 | 0.01 |
| polychaete | 1 | 0.32 | 0.02 | 0.00 | 1 | 0.88 | 0.28 | 0.01 |

**Table 13:** Number, weight, frequency of occurrence and index of relative importance for striped bass in the lower Chesapeake Bay. N = 187.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 184 | 23.06 | 6377.64 | 43.07 | 62 | 0.33 | 2128.79 | 63.67 |
| spot | 144 | 18.05 | 2400.51 | 16.21 | 64 | 0.34 | 827.11 | 24.74 |
| summer flounder | 26 | 3.26 | 2063.83 | 13.94 | 13 | 0.07 | 144.44 | 4.32 |
| croaker | 15 | 1.88 | 1305.55 | 8.82 | 14 | 0.07 | 98.40 | 2.94 |
| weakfish | 18 | 2.26 | 733.90 | 4.96 | 13 | 0.07 | 51.36 | 1.54 |
| unknown fish | 43 | 5.39 | 115.51 | 0.78 | 31 | 0.17 | 19.28 | 0.58 |
| silver perch | 16 | 2.01 | 228.71 | 1.54 | 12 | 0.06 | 14.78 | 0.44 |
| bay anchovy | 182 | 22.81 | 84.11 | 0.57 | 28 | 0.15 | 12.68 | 0.38 |
| butterfish | 12 | 1.50 | 385.88 | 2.61 | 6 | 0.03 | 12.46 | 0.37 |
| lady crab | 16 | 2.01 | 105.73 | 0.71 | 14 | 0.07 | 7.97 | 0.24 |
| mantis shrimp | 22 | 2.76 | 90.66 | 0.61 | 16 | 0.09 | 7.81 | 0.23 |
| unknown sciaenid | 22 | 2.76 | 62.21 | 0.42 | 15 | 0.08 | 5.02 | 0.15 |
| tonguefish | 30 | 3.76 | 116.17 | 0.78 | 8 | 0.04 | 5.00 | 0.15 |
| bluefish | 2 | 0.25 | 136.86 | 0.92 | 2 | 0.01 | 1.47 | 0.04 |
| atlantic silverside | 13 | 1.63 | 26.51 | 0.18 | 7 | 0.04 | 1.00 | 0.03 |
| american eel | 3 | 0.38 | 89.53 | 0.60 | 2 | 0.01 | 0.96 | 0.03 |
| spotted hake | 1 | 0.13 | 167.80 | 1.13 | 1 | 0.01 | 0.90 | 0.03 |
| gizzard shad | 10 | 1.25 | 54.62 | 0.37 | 3 | 0.02 | 0.88 | 0.03 |
| lizardfish | 2 | 0.25 | 68.54 | 0.46 | 2 | 0.01 | 0.74 | 0.02 |
| blue crab, others | 7 | 0.88 | 28.83 | 0.19 | 4 | 0.02 | 0.62 | 0.02 |
| needlefish | 3 | 0.38 | 67.96 | 0.46 | 1 | 0.01 | 0.37 | 0.01 |
| hogchoker | 3 | 0.38 | 19.20 | 0.13 | 3 | 0.02 | 0.31 | 0.01 |
| mojarra | 2 | 0.25 | 27.05 | 0.18 | 2 | 0.01 | 0.29 | 0.01 |
| unknown clupeid | 7 | 0.88 | 10.54 | 0.07 | 4 | 0.02 | 0.23 | 0.01 |
| peneid shrimp | 4 | 0.50 | 10.18 | 0.07 | 4 | 0.02 | 0.22 | 0.01 |
| white perch | 1 | 0.13 | 14.42 | 0.10 | 1 | 0.01 | 0.08 | 0.00 |
| cancer crab | 1 | 0.13 | 7.73 | 0.05 | 1 | 0.01 | 0.04 | 0.00 |
| northern puffer | 1 | 0.13 | 4.80 | 0.03 | 1 | 0.01 | 0.03 | 0.00 |
| blue crab | 1 | 0.13 | 1.57 | 0.01 | 1 | 0.01 | 0.01 | 0.00 |
| lironeca ovalis | 2 | 0.25 | 0.26 | 0.00 | 2 | 0.01 | 0.00 | 0.00 |
| gastropod | 1 | 0.13 | 0.39 | 0.00 | 1 | 0.01 | 0.00 | 0.00 |
| grass shrimp | 1 | 0.13 | 0.14 | 0.00 | 1 | 0.01 | 0.00 | 0.00 |
| naked goby | 1 | 0.13 | 0.10 | 0.00 | 1 | 0.01 | 0.00 | 0.00 |
| sand shrimp | 1 | 0.13 | 0.04 | 0.00 | 1 | 0.01 | 0.00 | 0.00 |
| hydroid | 1 | 0.13 | 0.00 | 0.00 | 1 | 0.01 | 0.00 | 0.00 |

**Table 14:** Number, weight, frequency of occurrence and index of relative importance for striped bass 150-450 mm total length. N= 37.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| bay anchovy | 46 | 56.10 | 36.02 | 29.65 | 10 | 27.03 | 2317.62 | 58.33 |
| unknown fish | 16 | 19.51 | 16.65 | 13.71 | 10 | 27.03 | 897.84 | 22.60 |
| gizzard shad | 5 | 6.10 | 42.98 | 35.38 | 5 | 13.51 | 560.53 | 14.11 |
| spottail shiner | 4 | 4.88 | 7.09 | 5.83 | 3 | 8.11 | 86.84 | 2.19 |
| whiteperch | 2 | 2.44 | 3.05 | 2.51 | 2 | 5.41 | 26.75 | 0.67 |
| unknown clupeid | 2 | 2.44 | 1.31 | 1.08 | 2 | 5.41 | 19.03 | 0.48 |
| polychaete | 2 | 2.44 | 1.31 | 1.08 | 2 | 5.41 | 19.01 | 0.48 |
| menhaden | 1 | 1.22 | 6.88 | 5.66 | 1 | 2.70 | 18.60 | 0.47 |
| spot | 1 | 1.22 | 4.45 | 3.66 | 1 | 2.70 | 13.19 | 0.33 |
| blue crab | 2 | 2.44 | 1.74 | 1.43 | 1 | 2.70 | 10.46 | 0.26 |
| unknown sciaenid | 1 | 1.22 | 0.00 | 0.00 | 1 | 2.70 | 3.30 | 0.08 |

**Table 15:** Number, weight, frequency of occurrence and index of relative importance for striped bass 451-600 mm total length. N= 329.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| bay anchovy | 551 | 37.59 | 315.35 | 3.12 | 82 | 24.92 | 1014.58 | 35.06 |
| menhaden | 158 | 10.78 | 3905.20 | 38.66 | 64 | 19.45 | 961.64 | 33.23 |
| spot | 113 | 7.71 | 1583.11 | 15.67 | 50 | 15.20 | 355.30 | 12.28 |
| gizzard shad | 121 | 8.25 | 1215.79 | 12.03 | 33 | 10.03 | 203.50 | 7.03 |
| blue crab | 98 | 6.68 | 265.50 | 2.63 | 46 | 13.98 | 130.21 | 4.50 |
| white perch | 36 | 2.46 | 1067.44 | 10.57 | 27 | 8.21 | 106.87 | 3.69 |
| unknown fish | 48 | 3.27 | 42.69 | 0.42 | 38 | 11.55 | 42.70 | 1.48 |
| mysid shrimp | 106 | 7.23 | 12.53 | 0.12 | 13 | 3.95 | 29.06 | 1.00 |
| unknown clupeid | 17 | 1.16 | 113.52 | 1.12 | 14 | 4.26 | 9.72 | 0.34 |
| tonguefish | 36 | 2.46 | 50.67 | 0.50 | 8 | 2.43 | 7.19 | 0.25 |
| atlantic silverside | 24 | 1.64 | 24.34 | 0.24 | 10 | 3.04 | 5.71 | 0.20 |
| unknown sciaenid | 17 | 1.16 | 23.54 | 0.23 | 10 | 3.04 | 4.23 | 0.15 |
| mantis shrimp | 13 | 0.89 | 83.24 | 0.82 | 8 | 2.43 | 4.16 | 0.14 |
| river herring | 4 | 0.27 | 337.15 | 3.34 | 3 | 0.91 | 3.29 | 0.11 |
| weakfish | 5 | 0.34 | 128.52 | 1.27 | 5 | 1.52 | 2.45 | 0.08 |
| spotted hake | 25 | 1.71 | 232.20 | 2.30 | 2 | 0.61 | 2.43 | 0.08 |
| silver perch | 8 | 0.55 | 79.15 | 0.78 | 5 | 1.52 | 2.02 | 0.07 |
| lironeca ovalis | 9 | 0.61 | 0.66 | 0.01 | 9 | 2.74 | 1.70 | 0.06 |
| sand shrimp | 10 | 0.68 | 3.67 | 0.04 | 4 | 1.22 | 0.87 | 0.03 |
| croaker | 2 | 0.14 | 115.62 | 1.14 | 2 | 0.61 | 0.78 | 0.03 |
| grass shrimp | 9 | 0.61 | 2.24 | 0.02 | 4 | 1.22 | 0.77 | 0.03 |
| butterfish | 4 | 0.27 | 88.73 | 0.88 | 2 | 0.61 | 0.70 | 0.02 |
| polychaete | 5 | 0.34 | 9.73 | 0.10 | 5 | 1.52 | 0.66 | 0.02 |
| striped bass | 1 | 0.07 | 205.00 | 2.03 | 1 | 0.30 | 0.64 | 0.02 |
| mojarra | 3 | 0.20 | 39.92 | 0.40 | 3 | 0.91 | 0.55 | 0.02 |
| rough silverside | 15 | 1.02 | 26.17 | 0.26 | 1 | 0.30 | 0.39 | 0.01 |
| naked goby | 6 | 0.41 | 1.52 | 0.02 | 2 | 0.61 | 0.26 | 0.01 |
| summer flounder | 3 | 0.20 | 7.51 | 0.07 | 3 | 0.91 | 0.25 | 0.01 |
| peneid shrimp | 3 | 0.20 | 6.08 | 0.06 | 3 | 0.91 | 0.24 | 0.01 |
| lady crab | 3 | 0.20 | 1.77 | 0.02 | 3 | 0.91 | 0.20 | 0.01 |
| spottail shiner | 4 | 0.27 | 3.35 | 0.03 | 2 | 0.61 | 0.19 | 0.01 |
| bluefish | 1 | 0.07 | 47.35 | 0.47 | 1 | 0.30 | 0.16 | 0.01 |

**Table 16:** Number, weight, frequency of occurrence and index of relative importance for striped bass 601-800 mm total length. N= 180.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 165 | 30.61 | 7809.36 | 51.83 | 56 | 31.11 | 2564.75 | 70.58 |
| spot | 70 | 12.99 | 1478.64 | 9.81 | 36 | 20.00 | 456.00 | 12.55 |
| blue crab | 79 | 14.66 | 439.80 | 2.92 | 24 | 13.33 | 234.34 | 6.45 |
| gizzard shad | 43 | 7.98 | 1036.13 | 6.88 | 9 | 5.00 | 74.27 | 2.04 |
| unknown fish | 25 | 4.64 | 81.44 | 0.54 | 23 | 12.78 | 66.17 | 1.82 |
| river herring | 22 | 4.08 | 1366.41 | 9.07 | 9 | 5.00 | 65.75 | 1.81 |
| croaker | 10 | 1.86 | 1119.11 | 7.43 | 10 | 5.56 | 51.57 | 1.42 |
| white perch | 16 | 2.97 | 352.93 | 2.34 | 11 | 6.11 | 32.45 | 0.89 |
| unknown clupeid | 15 | 2.78 | 53.32 | 0.35 | 11 | 6.11 | 19.17 | 0.53 |
| bay anchovy | 18 | 3.34 | 12.32 | 0.08 | 6 | 3.33 | 11.40 | 0.31 |
| weakfish | 7 | 1.30 | 398.47 | 2.64 | 5 | 2.78 | 10.95 | 0.30 |
| silver perch | 9 | 1.67 | 155.50 | 1.03 | 7 | 3.89 | 10.51 | 0.29 |
| mantis shrimp | 10 | 1.86 | 27.68 | 0.18 | 9 | 5.00 | 10.19 | 0.28 |
| lady crab | 9 | 1.67 | 56.01 | 0.37 | 7 | 3.89 | 7.94 | 0.22 |
| butterfish | 8 | 1.48 | 297.15 | 1.97 | 4 | 2.22 | 7.68 | 0.21 |
| unknown sciaenid | 8 | 1.48 | 41.44 | 0.28 | 4 | 2.22 | 3.91 | 0.11 |
| striped bass | 2 | 0.37 | 241.66 | 1.60 | 2 | 1.11 | 2.19 | 0.06 |
| blue crab, others | 5 | 0.93 | 14.30 | 0.09 | 2 | 1.11 | 1.14 | 0.03 |
| mysid shrimp | 4 | 0.74 | 0.05 | 0.00 | 2 | 1.11 | 0.82 | 0.02 |
| hogchoker | 2 | 0.37 | 6.96 | 0.05 | 2 | 1.11 | 0.46 | 0.01 |
| peneid shrimp | 2 | 0.37 | 6.92 | 0.05 | 2 | 1.11 | 0.46 | 0.01 |
| atlantic silverside | 2 | 0.37 | 1.13 | 0.01 | 2 | 1.11 | 0.42 | 0.01 |
| summer flounder | 1 | 0.19 | 34.93 | 0.23 | 1 | 0.56 | 0.23 | 0.01 |
| american eel | 1 | 0.19 | 22.64 | 0.15 | 1 | 0.56 | 0.19 | 0.01 |
| lizardfish | 1 | 0.19 | 8.41 | 0.06 | 1 | 0.56 | 0.13 | 0.00 |
| spottail shiner | 1 | 0.19 | 5.10 | 0.03 | 1 | 0.56 | 0.12 | 0.00 |
| polychaete | 1 | 0.19 | 0.33 | 0.00 | 1 | 0.56 | 0.10 | 0.00 |
| lironeca ovalis | 1 | 0.19 | 0.19 | 0.00 | 1 | 0.56 | 0.10 | 0.00 |
| sand shrimp | 1 | 0.19 | 0.04 | 0.00 | 1 | 0.56 | 0.10 | 0.00 |
| hydroid | 1 | 0.19 | 0.00 | 0.00 | 1 | 0.56 | 0.10 | 0.00 |

**Table 17:** Number, weight, frequency of occurrence and index of relative importance for striped bass 801-1300 mm total length. N= 152.

| species | number | % number | weight | % weight | frequency | %frequency | IRI | %IRI |
|---|---|---|---|---|---|---|---|---|
| menhaden | 111 | 28 | 8302.17 | 37.42 | 51 | 33.55 | 2196.15 | 66.76 |
| gizzard shad | 47 | 11.9 | 4443.95 | 20.03 | 18 | 11.84 | 377.77 | 11.48 |
| river herring | 41 | 10.4 | 3268.42 | 14.73 | 13 | 8.55 | 214.56 | 6.52 |
| summer flounder | 26 | 6.57 | 2214.14 | 9.98 | 13 | 8.55 | 141.51 | 4.30 |
| spot | 22 | 5.56 | 752.24 | 3.39 | 12 | 7.89 | 70.63 | 2.15 |
| unknown clupeid | 20 | 5.05 | 135.60 | 0.61 | 16 | 10.53 | 59.60 | 1.81 |
| white perch | 14 | 3.54 | 324.47 | 1.46 | 14 | 9.21 | 46.03 | 1.40 |
| unknown fish | 19 | 4.8 | 27.70 | 0.12 | 14 | 9.21 | 45.34 | 1.38 |
| croaker | 10 | 2.53 | 964.91 | 4.35 | 9 | 5.92 | 40.71 | 1.24 |
| american eel | 19 | 4.8 | 505.86 | 2.28 | 8 | 5.26 | 37.25 | 1.13 |
| weakfish | 8 | 2.02 | 519.23 | 2.34 | 6 | 3.95 | 17.21 | 0.52 |
| bay anchovy | 13 | 3.28 | 8.59 | 0.04 | 7 | 4.61 | 15.30 | 0.46 |
| mantis shrimp | 12 | 3.03 | 63.34 | 0.29 | 6 | 3.95 | 13.09 | 0.40 |
| blue crab | 4 | 1.01 | 5.83 | 0.03 | 4 | 2.63 | 2.73 | 0.08 |
| lady crab | 3 | 0.76 | 45.90 | 0.21 | 3 | 1.97 | 1.90 | 0.06 |
| silver perch | 3 | 0.76 | 34.56 | 0.16 | 3 | 1.97 | 1.80 | 0.05 |
| unknown sciaenid | 3 | 0.76 | 12.74 | 0.06 | 3 | 1.97 | 1.61 | 0.05 |
| bluefish | 2 | 0.51 | 136.86 | 0.62 | 2 | 1.32 | 1.48 | 0.04 |
| tonguefish | 4 | 1.01 | 60.92 | 0.27 | 1 | 0.66 | 0.85 | 0.03 |
| blue crab, others | 2 | 0.51 | 14.53 | 0.07 | 2 | 1.32 | 0.75 | 0.02 |
| hogchoker | 2 | 0.51 | 12.92 | 0.06 | 2 | 1.32 | 0.74 | 0.02 |
| needlefish | 3 | 0.76 | 67.96 | 0.31 | 1 | 0.66 | 0.70 | 0.02 |
| spotted hake | 1 | 0.25 | 167.80 | 0.76 | 1 | 0.66 | 0.66 | 0.02 |
| lizardfish | 1 | 0.25 | 60.13 | 0.27 | 1 | 0.66 | 0.34 | 0.01 |
| windowpane | 1 | 0.25 | 14.42 | 0.06 | 1 | 0.66 | 0.21 | 0.01 |
| cancer crab | 1 | 0.25 | 7.73 | 0.03 | 1 | 0.66 | 0.19 | 0.01 |
| northern puffer | 1 | 0.25 | 4.80 | 0.02 | 1 | 0.66 | 0.18 | 0.01 |
| feather blenny | 1 | 0.25 | 4.15 | 0.02 | 1 | 0.66 | 0.18 | 0.01 |
| atlantic silverside | 1 | 0.25 | 2.13 | 0.01 | 1 | 0.66 | 0.17 | 0.01 |
| gastropod | 1 | 0.25 | 0.39 | 0.00 | 1 | 0.66 | 0.17 | 0.01 |

**Table 18:** Kruskal-Wallis nonparametric rank test of stomach fullness by season with Dunn's multiple comparisions. Median values are untransformed stomach fullness values. The Kruskal-Wallis test statistic (H) is corrected for tied ranks.

Kruskal-Wallis nonparametric rank test

| Season | N | Median | Average Rank |
|---|---|---|---|
| 1. Spring | 934 | 0 | 696.7 |
| 2. Summer | 172 | 0.15 | 1132.6 |
| 3. Fall | 634 | 0.225 | 1129.7 |
| 4. Winter | 92 | 0.431 | 1274 |
| overall | 1832 | | 916.5 |

H = 368.61 DF = 3 p = 0.000* adjusted for ties

| Multiple comparisons (Dunn's) | SE | Difference ($R_b$-$R_a$) | q | $q_{(0.05,4)}$ | conclusion |
|---|---|---|---|---|---|
| 1v4 | 57.804 | 577.3 | 9.987 | 2.639 | significant* |
| 1v2 | 43.892 | 435.9 | 9.931 | 2.639 | significant* |
| 1v3 | 27.221 | 433 | 15.906 | 2.639 | significant* |
| 3v4 | 59.017 | 144.3 | 2.445 | 2.639 | not significant |
| 3v2 | 45.479 | 2.9 | 0.063 | 2.639 | not significant |
| 2v4 | 68.328 | 141.4 | 2.069 | 2.639 | not significant |

* significant at $p < 0.05$

**Table 19:** Percentages of full and empty stomachs by season.

| season | number full | total | % full |
|---|---|---|---|
| Spring | 303 | 954 | 28.15 |
| Summer | 158 | 287 | 55.05 |
| Fall | 408 | 668 | 61.08 |
| Winter | 74 | 93 | 79.57 |

**Table 20:** Percentages of full and empty stomachs by month.

| month | number full | total | % full |
|---|---|---|---|
| Jan | 7 | 9 | 77.78 |
| Feb | 9 | 14 | 64.29 |
| Mar | 92 | 334 | 27.54 |
| Apr | 177 | 565 | 31.33 |
| May | 33 | 54 | 61.11 |
| June | 126 | 143 | 88.11 |
| Aug | 4 | 38 | 10.53 |
| Sept | 28 | 106 | 26.42 |
| Oct | 224 | 425 | 52.71 |
| Nov | 173 | 230 | 75.22 |
| Dec | 58 | 70 | 82.86 |

**Table 21:** Kruskal-Wallis nonparametric rank test of stomach fullness by location with Dunn's multiple comparisions. Median values are untransformed stomach fullness values. The Kruskal-Wallis test statistic (H) is corrected for tied ranks.

Kruskal-Wallis nonparametric rank test

| Locations | Number | Median | Average Rank |
|---|---|---|---|
| 1. Upper river | 850 | 0 | 600.8 |
| 2. Middle river | 31 | 0.965 | 1331.7 |
| 3. Lower river | 254 | 0.147 | 950.4 |
| 4. Upper Bay | 271 | 0.178 | 1125.1 |
| 5. Middle Bay | 59 | 0.265 | 1134.4 |
| 6. Lower Bay | 240 | 0.575 | 1205 |
| overall | 1705 | | 853.0 |

H = 531.62 DF = 5 p = 0.000* adjusted for ties

| Dunn's multiple comparisons | SE | Difference ($R_b$-$R_a$) | q | $q_{(0.05,6)}$ | conclusion |
|---|---|---|---|---|---|
| 1v2 | 90.02 | 730.9 | 8.119307 | 2.936 | significant* |
| 1v6 | 35.988 | 604.2 | 16.78893 | 2.936 | significant* |
| 1v5 | 66.28 | 533.6 | 8.050694 | 2.936 | significant* |
| 1v4 | 34.3455 | 524.3 | 15.26547 | 2.936 | significant* |
| 1v3 | 30.08 | 349.6 | 11.62234 | 2.936 | significant* |
| 3v2 | 93.66683 | 381.3 | 4.070812 | 2.936 | significant* |
| 3v6 | 44.32024 | 254.6 | 5.744554 | 2.936 | significant* |
| 3v5 | 71.15254 | 184 | 2.585994 | 2.936 | not significant |
| 3v4 | 42.99 | 174.7 | 4.063736 | 2.936 | significant* |
| 4v2 | 93.35 | 206.6 | 2.213176 | 2.936 | not significant |
| 4v6 | 43.55 | 79.9 | 1.834673 | 2.936 | not significant |
| 4v5 | 70.73061 | 9.3 | 0.131485 | 2.936 | not significant |
| 5v2 | 109.2133 | 197.3 | 1.806557 | 2.936 | not significant |
| 5v6 | 71.54265 | 70.6 | 0.986824 | 2.936 | not significant |
| 6v2 | 93.96352 | 126.7 | 1.348396 | 2.936 | not significant |

* significant at $p < 0.05$

**Table 22:** Percentages of full and empty stomachs by location.

| location | number full | total | % full |
|---|---|---|---|
| Upper rivers | 236 | 870 | 27.13 |
| Middle rivers | 24 | 31 | 77.42 |
| Lower rivers | 157 | 263 | 59.70 |
| Upper bay | 234 | 382 | 61.26 |
| Middle bay | 44 | 60 | 73.33 |
| Lower bay | 191 | 251 | 76.10 |

**Table 23:** Kruskal-Wallis nonparametric rank test of stomach fullness by salinity class with Dunn's multiple comparisions. Median values are untransformed stomach fullness values. The Kruskal-Wallis test statistic (H) is corrected for tied ranks.

Kruskal-Wallis nonparametric rank test

| Salinity class | N | Median | Average Rank |
|---|---|---|---|
| 1. 0-5 ppt | 881 | 0 | 613.7 |
| 2. 5-18 ppt | 486 | 0.176 | 1044.3 |
| 3. 18-30 ppt | 319 | 0.392 | 1172.2 |
| overall | 1686 | | |

H = 464.06 DF = 2 p = 0.000 adjusted for ties

| Multiple comparisons (Dunn's) | SE | Difference ($R_b$-$R_a$) | q | $q_{(0.05,3)}$ | conclusion |
|---|---|---|---|---|---|
| 1v3 | 31.8 | 558.5 | 17.56 | 2.399 | significant* |
| 1v2 | 27.5 | 430.6 | 16.79 | 2.399 | significant* |
| 2v3 | 35.08 | 127.9 | 3.65 | 2.399 | significant* |

*significant at $p < 0.05$

**Table 24:** Percentages of full and empty stomachs by salinity zone.

| salinity zone | number full | total | % full |
|---|---|---|---|
| tidal freshwater | 255 | 901 | 28.30 |
| mesohaline | 404 | 731 | 55.27 |
| polyhaline | 252 | 335 | 75.22 |

**Table 25:** Kruskal-Wallis nonparametric rank test of stomach fullness by size class with Dunn's multiple comparisions. Median values are untransformed stomach fullness values. The Kruskal-Wallis test statistic (H) is corrected for tied ranks.

Kruskal-Wallis nonparametric rank test

| Length class | N | Median | Average Rank |
|---|---|---|---|
| 1. 150-450 mm | 196 | 0 | 591.5 |
| 2. 450-600 mm | 947 | 0.076 | 913.2 |
| 3. 601-800 mm | 386 | 0.136 | 1037.9 |
| 4. 800-1300 mm | 303 | 0.094 | 982.4 |
| overall | 1832 | | 916.5 |

H = 109.04  DF = 3  p = 0.00  adjusted for ties

| Multiple comparisons (Dunn's) | SE | Difference ($R_b$-$R_a$) | q | $q_{(0.05,4)}$ | conclusion |
|---|---|---|---|---|---|
| 1v3 | 46.39 | 446.4 | 9.62 | 2.639 | significant* |
| 1v4 | 48.49 | 390.9 | 8.06 | 2.639 | significant* |
| 1v2 | 41.51 | 321.7 | 7.75 | 2.639 | significant* |
| 3v2 | 31.94 | 124.7 | 3.90 | 2.639 | significant* |
| 3v4 | 40.60 | 55.5 | 1.37 | 2.639 | not significant |
| 4v2 | 34.91 | 69.2 | 1.98 | 2.639 | not significant |

* significant at $p < 0.05$

**Table 26:** Percentages of full and empty stomachs by size class.

| length class | number full | total | % full |
|---|---|---|---|
| 150-450 | 12 | 56 | 21.43 |
| 451-600 | 446 | 1100 | 40.55 |
| 601-800 | 296 | 495 | 59.80 |
| 801-1300 | 161 | 304 | 52.96 |

**Table 27:** Kruskal-Wallis nonparametric rank test of stomach fullness by gear type with Dunn's multiple comparisions. Median values are untransformed stomach fullness values. The Kruskal-Wallis test statistic (H) is corrected for tied ranks.

Kruskal-Wallis nonparametric rank test

| Gear types | N | Median | Average Rank |
|---|---|---|---|
| 1. Pound spring | 440 | 0 | 599.6 |
| 2. Pound fall | 116 | 0 | 878.7 |
| 3. Gill | 374 | 0 | 734.1 |
| 4. Fyke | 115 | 0 | 544.7 |
| 5. Hook and line | 611 | 0.219 | 1122.9 |
| 6. Trawl | 6 | 0.402 | 953 |
| 7. Electroshock | 22 | 0.293 | 1092.5 |
| overall | 1684 | | 842.5 |

H = 416.06 DF = 6 p = 0.000* adjusted for ties

| Multiple comparisons (Dunn's) | SE | Difference ($R_b$-$R_a$) | q | $Q_{(0.05,7)}$ | conclusion |
|---|---|---|---|---|---|
| 4v5 | 49.428 | 578.2 | 11.697 | 3.038 | significant* |
| 4v7 | 113.156 | 547.8 | 4.841 | 3.038 | significant* |
| 4v6 | 203.633 | 408.3 | 2.005 | 3.038 | not significant |
| 4v2 | 63.989 | 334 | 5.219 | 3.038 | significant* |
| 4v3 | 51.850 | 189.4 | 3.652 | 3.038 | significant* |
| 4v1 | 50.927 | 54.9 | 1.078 | 3.038 | not significant |
| 1v5 | 30.404 | 523.3 | 17.211 | 3.038 | significant* |
| 1v7 | 106.234 | 492.9 | 4.639 | 3.038 | significant* |
| 1v6 | 199.869 | 353.4 | 1.768 | 3.038 | not significant |
| 1v2 | 50.753 | 279.1 | 5.499 | 3.038 | significant* |
| 1v3 | 34.200 | 134.5 | 3.932 | 3.038 | significant* |
| 3v5 | 31.926 | 388.8 | 12.178 | 3.038 | significant* |
| 3v7 | 106.679 | 358.4 | 3.359 | 3.038 | significant* |
| 3v6 | 200.106 | 218.9 | 1.094 | 3.038 | not significant |
| 3v2 | 51.679 | 144.6 | 2.798 | 3.038 | not significant |
| 2v5 | 49.249 | 244.2 | 4.958 | 3.038 | significant* |
| 2v7 | 113.078 | 213.8 | 1.891 | 3.038 | not significant |
| 2v6 | 66.005 | 74.3 | 1.126 | 3.038 | not significant |
| 6v5 | 199.493 | 169.9 | 0.852 | 3.038 | not significant |
| 6v7 | 223.961 | 139.5 | 0.623 | 3.038 | not significant |
| 7v5 | 105.524 | 30.4 | 0.288 | 3.038 | not significant |

* significant at $p < 0.05$

**Table 28:** Percentages of full and empty stomachs by gear type.

| gear | number full | total | % full |
|---|---|---|---|
| Pound spring | 125 | 444 | 28.15 |
| Pound fall | 52 | 121 | 42.98 |
| Gill | 156 | 375 | 41.60 |
| Fyke | 24 | 127 | 18.90 |
| Hook and line | 497 | 749 | 66.36 |
| Trawl | 5 | 6 | 83.33 |
| Electroshock | 19 | 22 | 86.36 |

**Table 29:** Mann-Whitney two-sample rank test of spring pound net and spring gill net stomach fullness indices.

Mann-Whitney Two-sample rank test
Spring pound nets vs spring gill nets

| | number | median | |
|---|---|---|---|
| pound | 440 | 0 | |
| gill | 252 | 0 | |
| p = 0.5969 | | | ns |

**Table 30:** Mann-Whitney two-sample rank test of fall pound net and fall hook and line stomach fullness values.

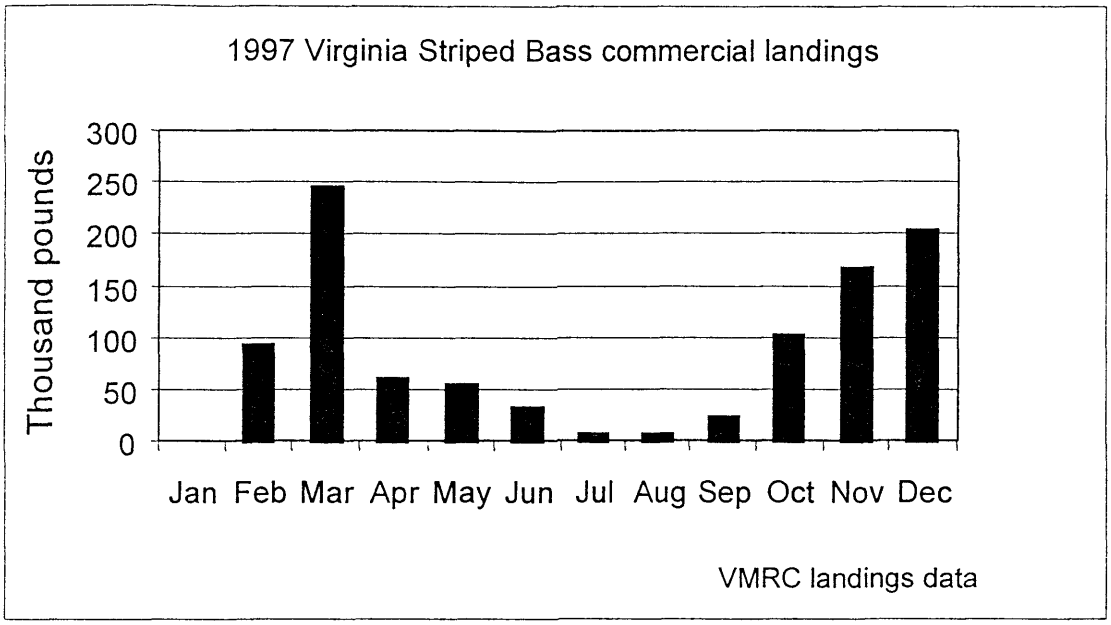
Fall pound nets vs fall hook and line

| | number | median | |
|---|---|---|---|
| pound | 116 | 0 | |
| hook and line | 371 | 0.176 | |
| p = 0.0067 | | | sig |

* significant at $p < 0.05$

**Figure 1a:** 1997 Virginia commercial landings of striped bass (pounds). From Virginia Marine Resources Commission (VMRC) landings data.

**Figure 1b:** 1997-1998 Striped bass stomach samples collected from Chesapeake Bay and its tributaries.


1997 Virginia Striped Bass commercial landings
Thousand pounds
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
VMRC landings data

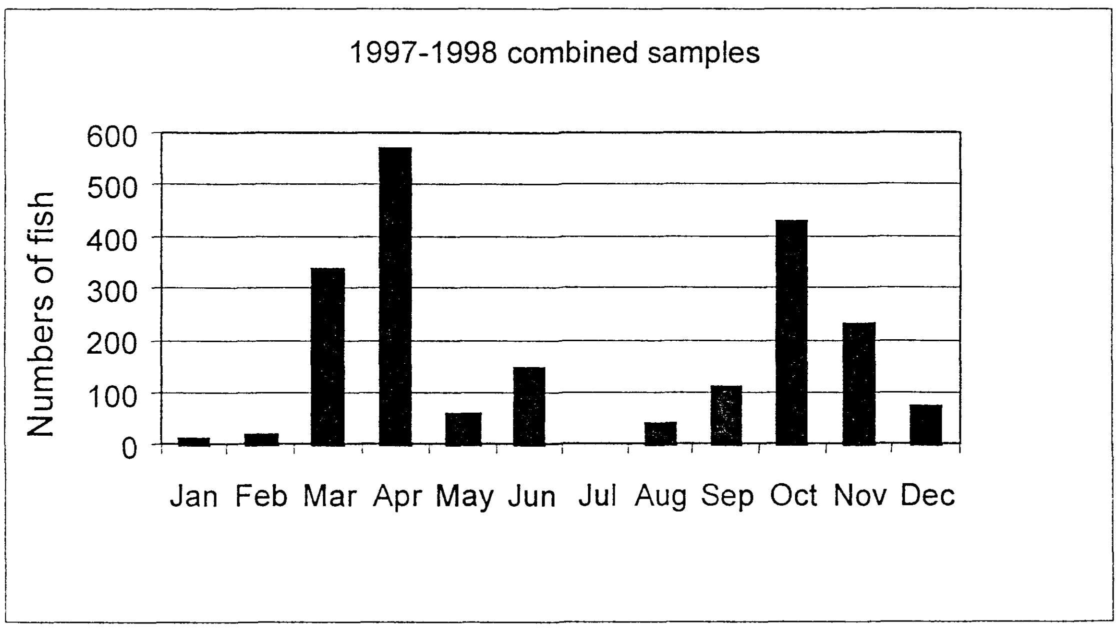
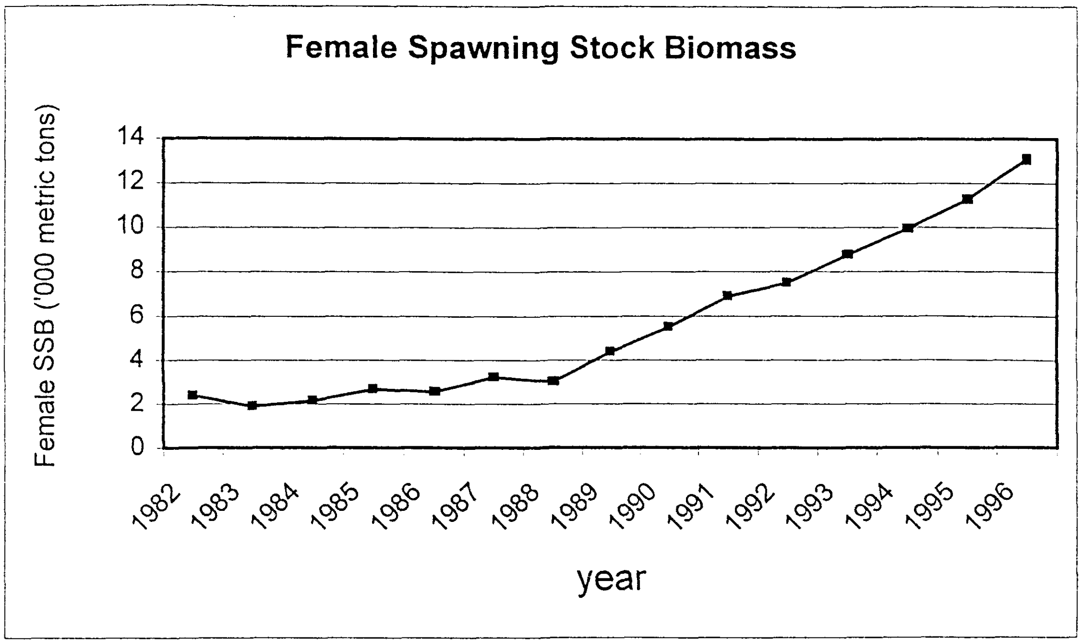

1997-1998 combined samples
Numbers of fish
600
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

**Figure 2a:** Striped bass spawning stock biomass in metric tons of females for the Atlantic Coast, 1982-1997. From NMFS virtual population analysis (NOAA/NMFS 1998).

**Figure 2b:** Atlantic Coast striped bass population size in millions from 1982-1997. From NMFS virtual population analysis (NOAA/NMFS 1998).


Female Spawning Stock Biomass
Female SSB ('000 metric tons)
14
12
10
8
6
4
2
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
year

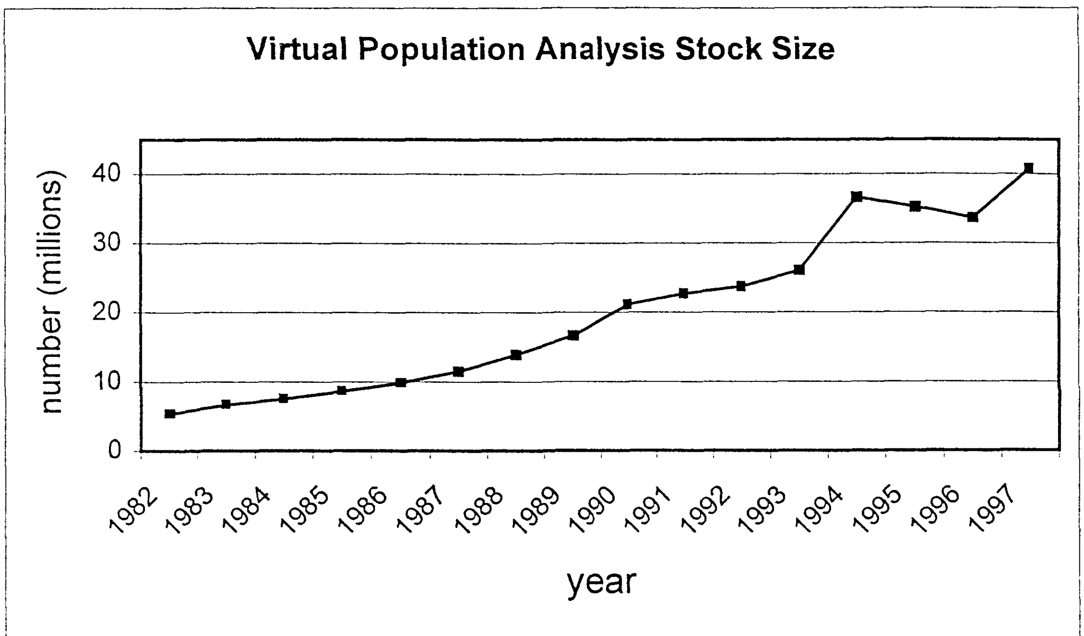

Virtual Population Analysis Stock Size
number (millions)
40
30
20
10
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
year

**Figure 3:** Map of Chesapeake Bay showing spatial distribution of samples for 1997 and 1998. Numbers of samples are depicted by weighted circles.

Distribution of striped bass samples from Chesapeake Bay

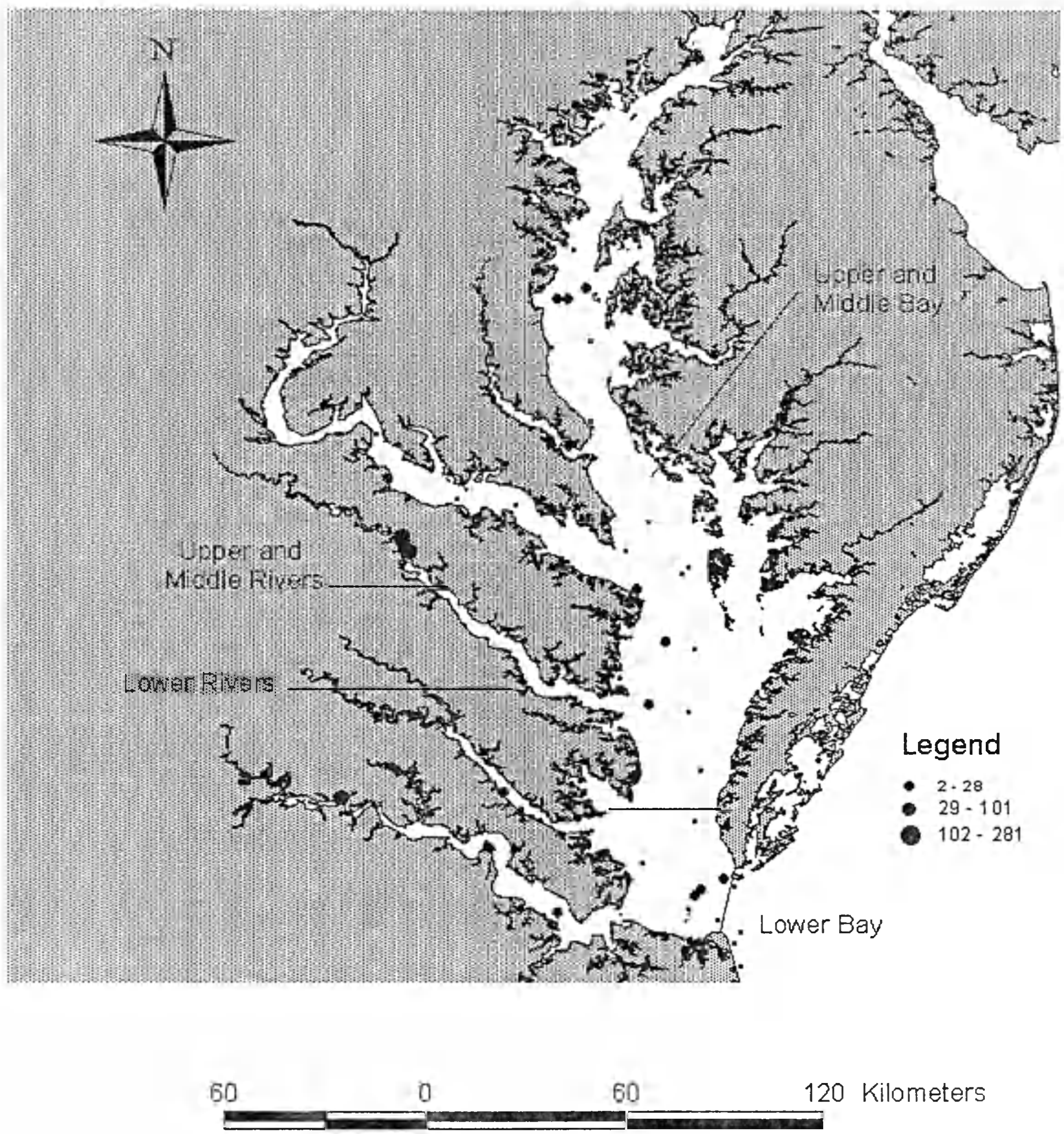
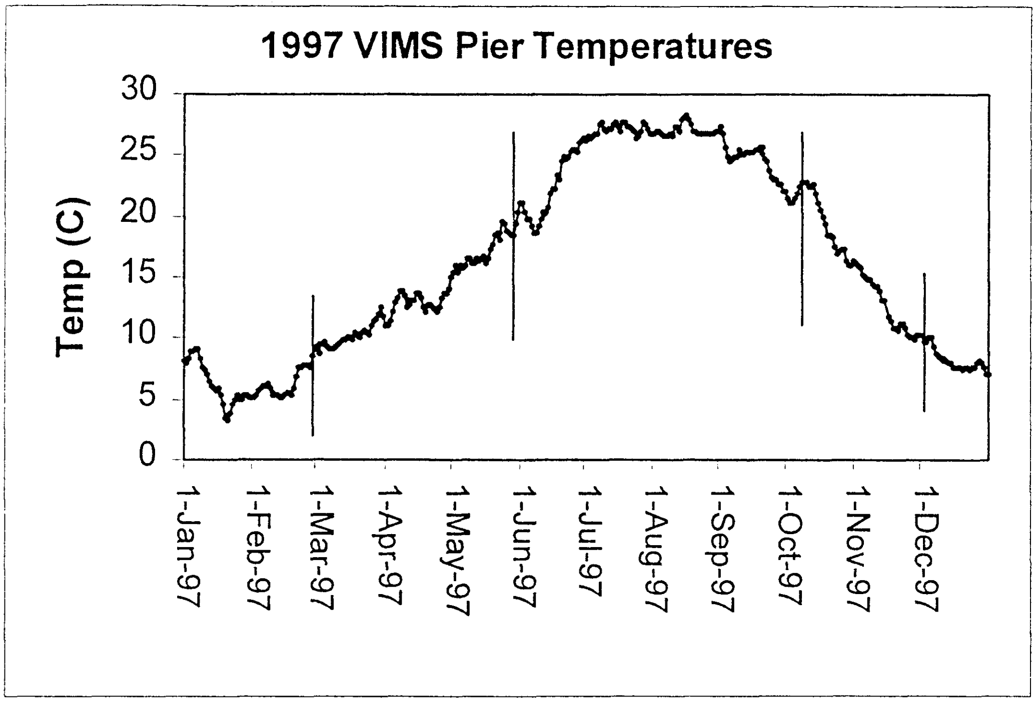
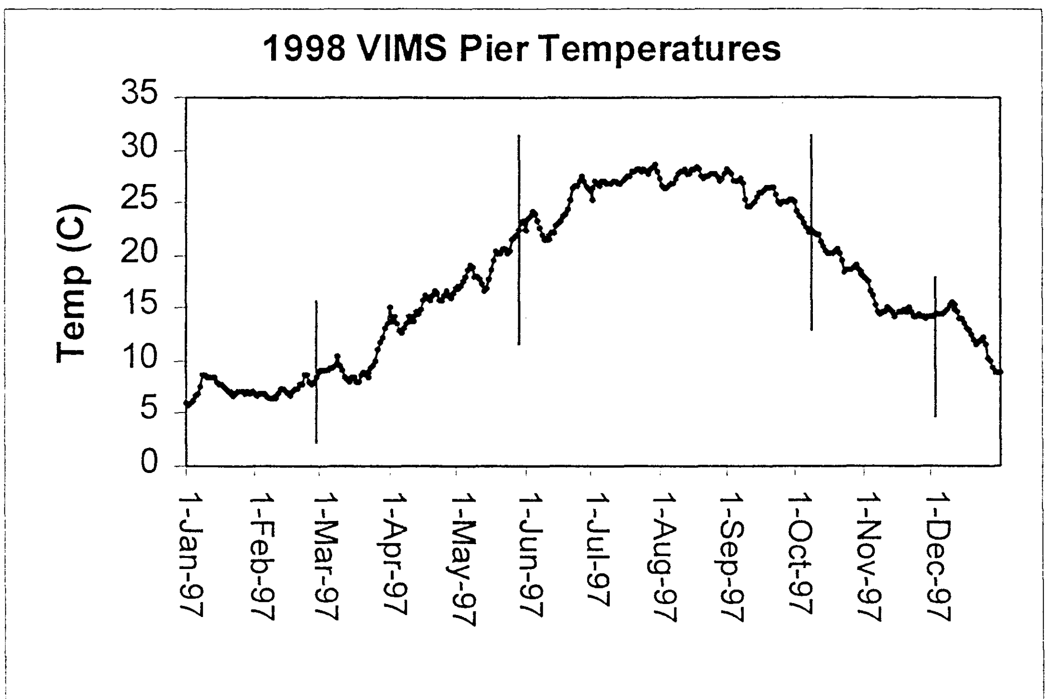


**Figure 4a:** VIMS daily pier temperatures for 1997. Also shown are the seasonal breaks based on temperature changes that were used to partition fish samples. Spring is defined as March 1 to May 31; Summer, June 1-September 30; Fall, October 1 –November 30; and Winter, December 1-February 28. From VIMS online data retrieval (VIMS 1999).

**Figure 4b:** VIMS daily pier temperatures for 1998. From VIMS data request.

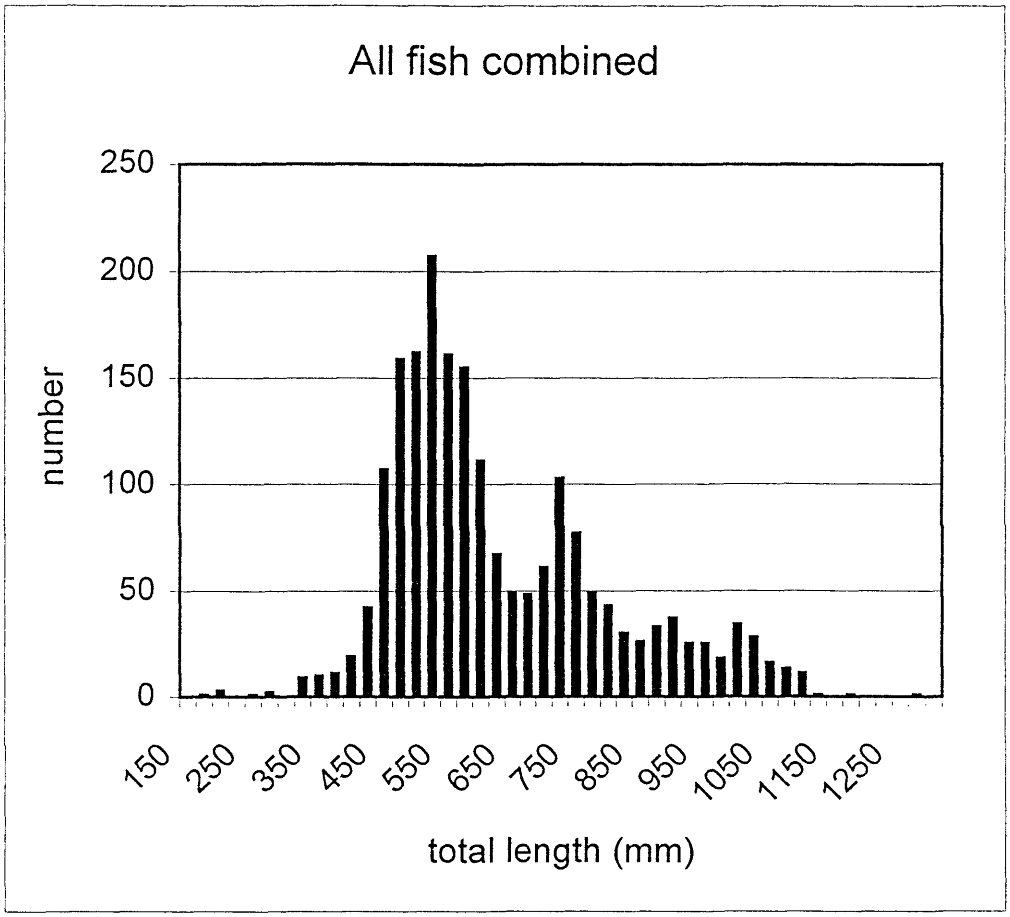


1997 VIMS Pier Temperatures
Temp (C)
30
25
20
15
10
5
0
1-Jan-97
1-Feb-97
1-Mar-97
1-Apr-97
1-May-97
1-Jun-97
1-Jul-97
1-Aug-97
1-Sep-97
1-Oct-97
1-Nov-97
1-Dec-97

1998 VIMS Pier Temperatures
Temp (C)
35
30
25
20
15
10
5
0
1-Jan-97
1-Feb-97
1-Mar-97
1-Apr-97
1-May-97
1-Jun-97
1-Jul-97
1-Aug-97
1-Sep-97
1-Oct-97
1-Nov-97
1-Dec-97

**Figure 5:** Length-frequency plot for striped bass collected in Chesapeake Bay March 1997- May 1998. Lengths are total lengths in millimeters.



All fish combined
250
200
150
100
50
0
number
150
250
350
450
550
650
750
850
950
1050
1150
1250
total length (mm)

**Figure 6a-d:** Length-frequency plots of striped bass for each season. Lengths are total lengths in millimeters.

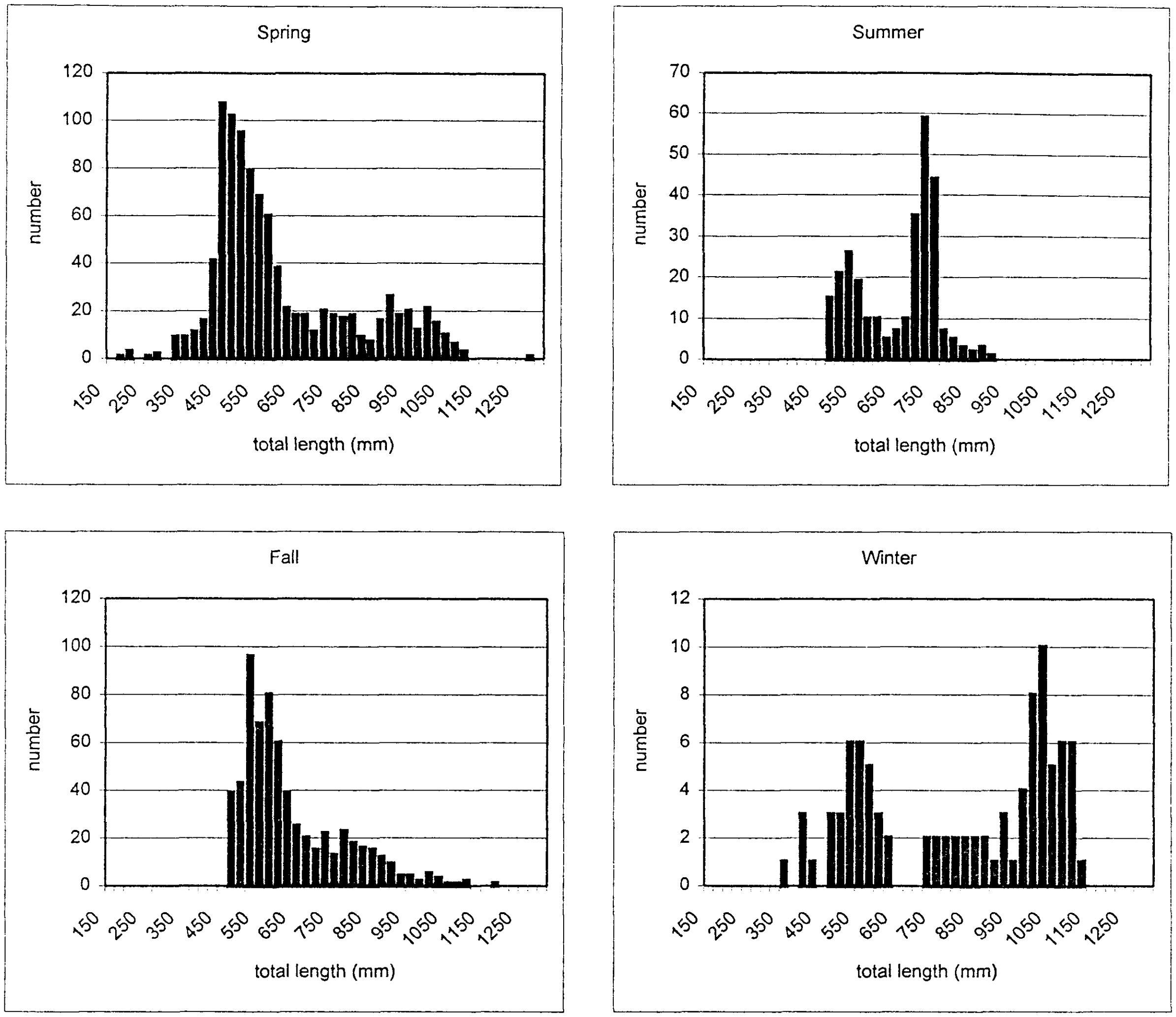
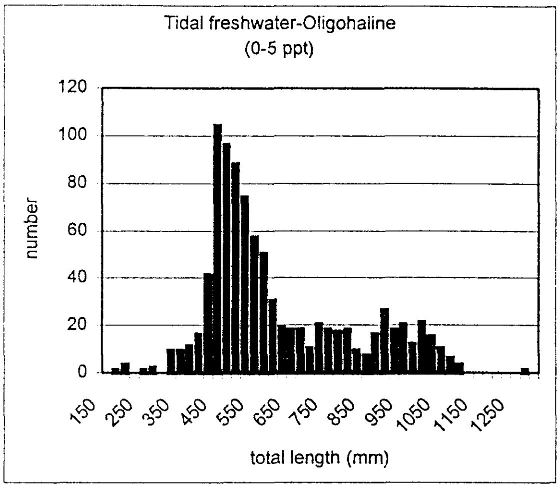
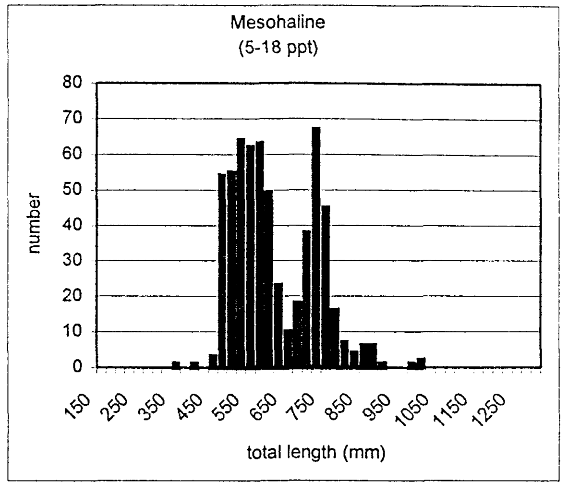

Spring
number
total length (mm)
Summer
number
total length (mm)
Fall
number
total length (mm)
Winter
number
total length (mm)

**Figure 7a-c:** Length-frequency plots of striped bass for each salinity zone. Lengths are total lengths in millimeters.


Tidal freshwater-Oligohaline
(0-5 ppt)
number
total length (mm)
0
20
40
60
80
100
120
150
250
350
450
550
650
750
850
950
1050
1150
1250


Mesohaline
(5-18 ppt)
number
total length (mm)
0
10
20
30
40
50
60
70
80
150
250
350
450
550
650
750
850
950
1050
1150
1250

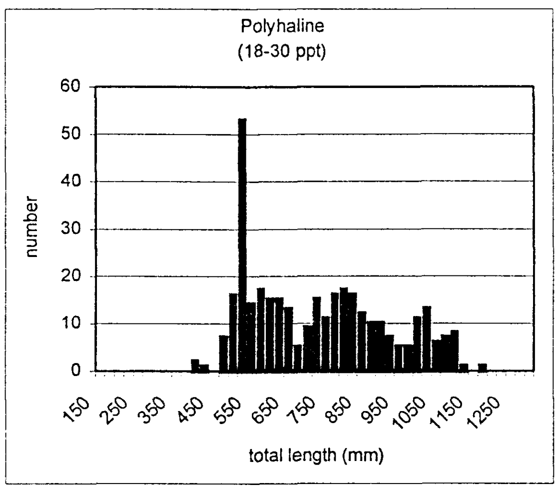
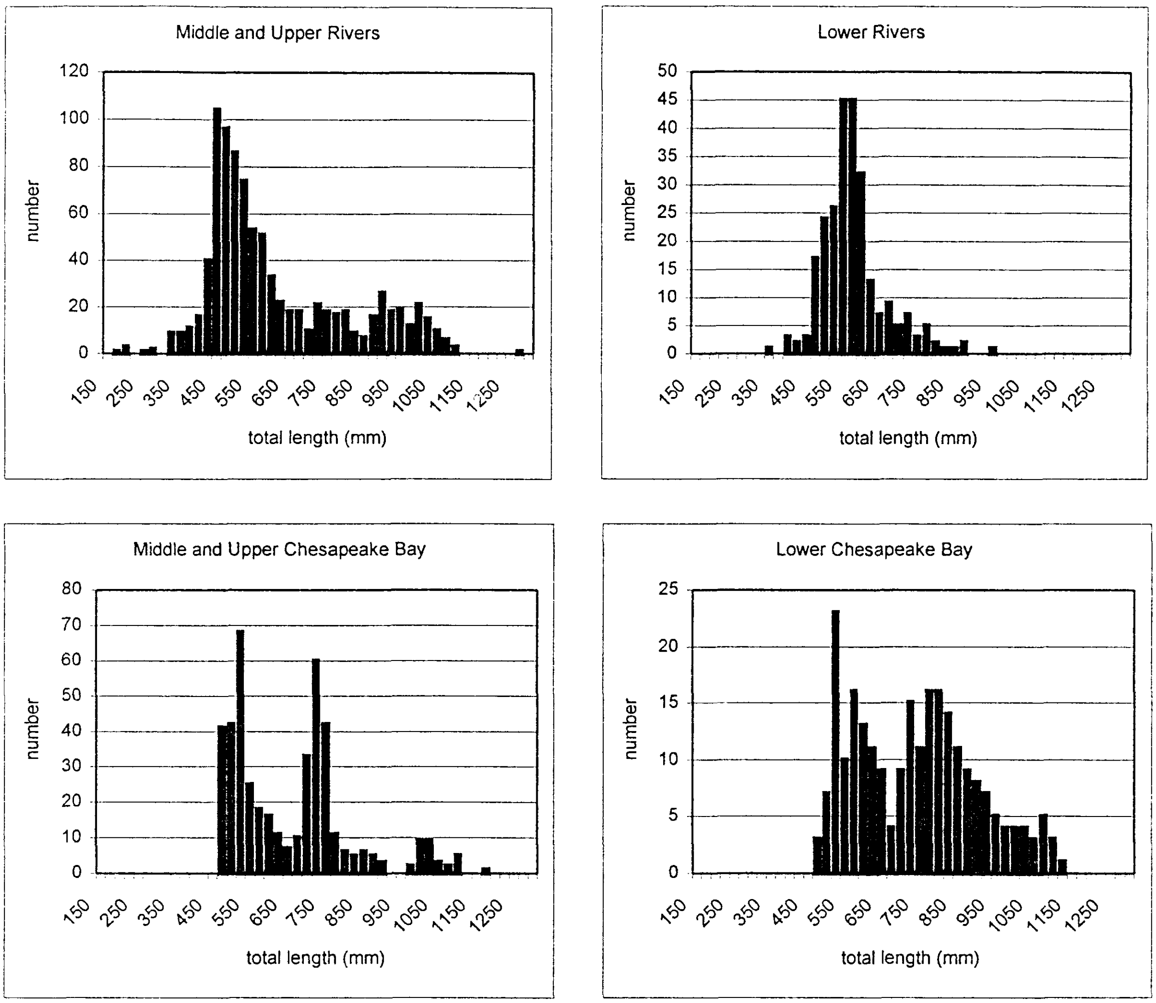

Polyhaline
(18-30 ppt)
number
total length (mm)
0
10
20
30
40
50
60
150
250
350
450
550
650
750
850
950
1050
1150
1250

**Figure 8a-d:** Length-frequency plots for each location. Lengths are total lengths in millimeters.



Middle and Upper Rivers
Lower Rivers
Middle and Upper Chesapeake Bay
Lower Chesapeake Bay
number
total length (mm)

**Figure 9:** Cumulative prey curve for all striped bass stomachs combined.

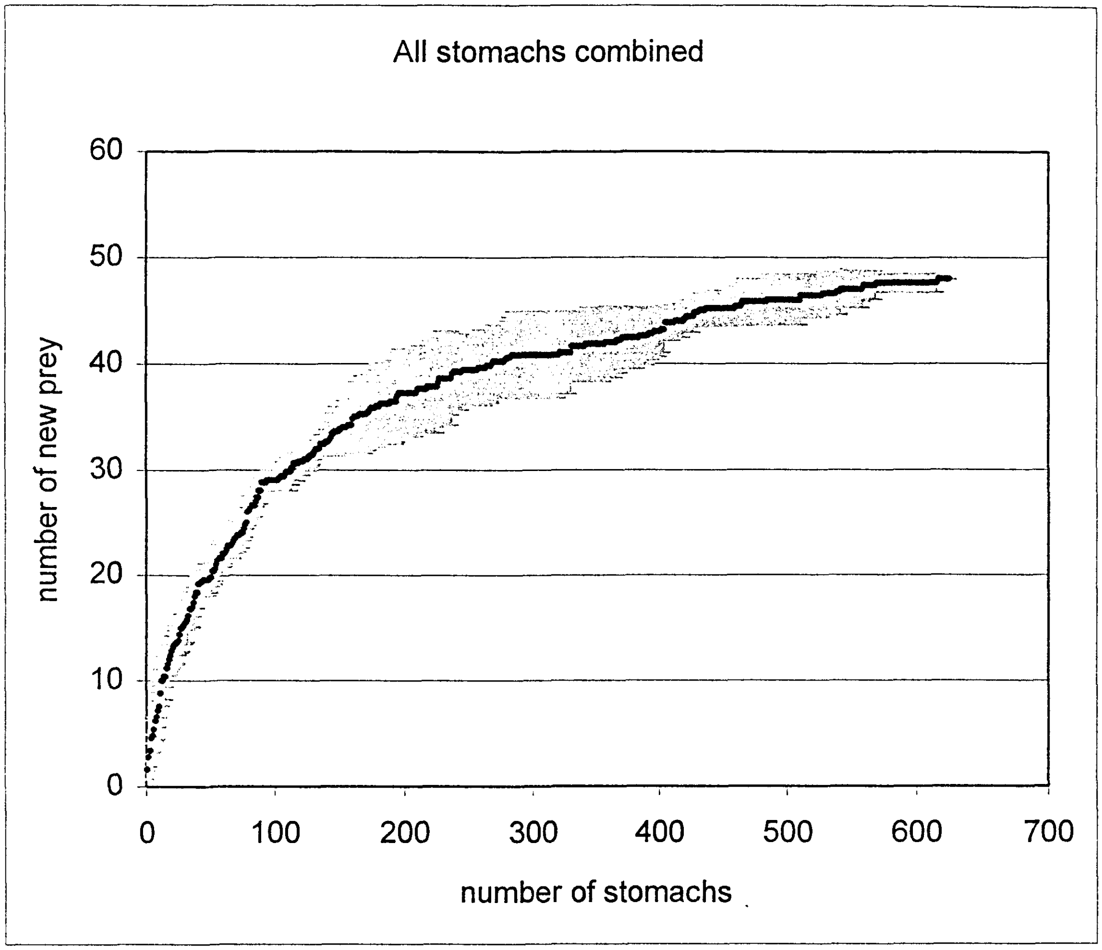
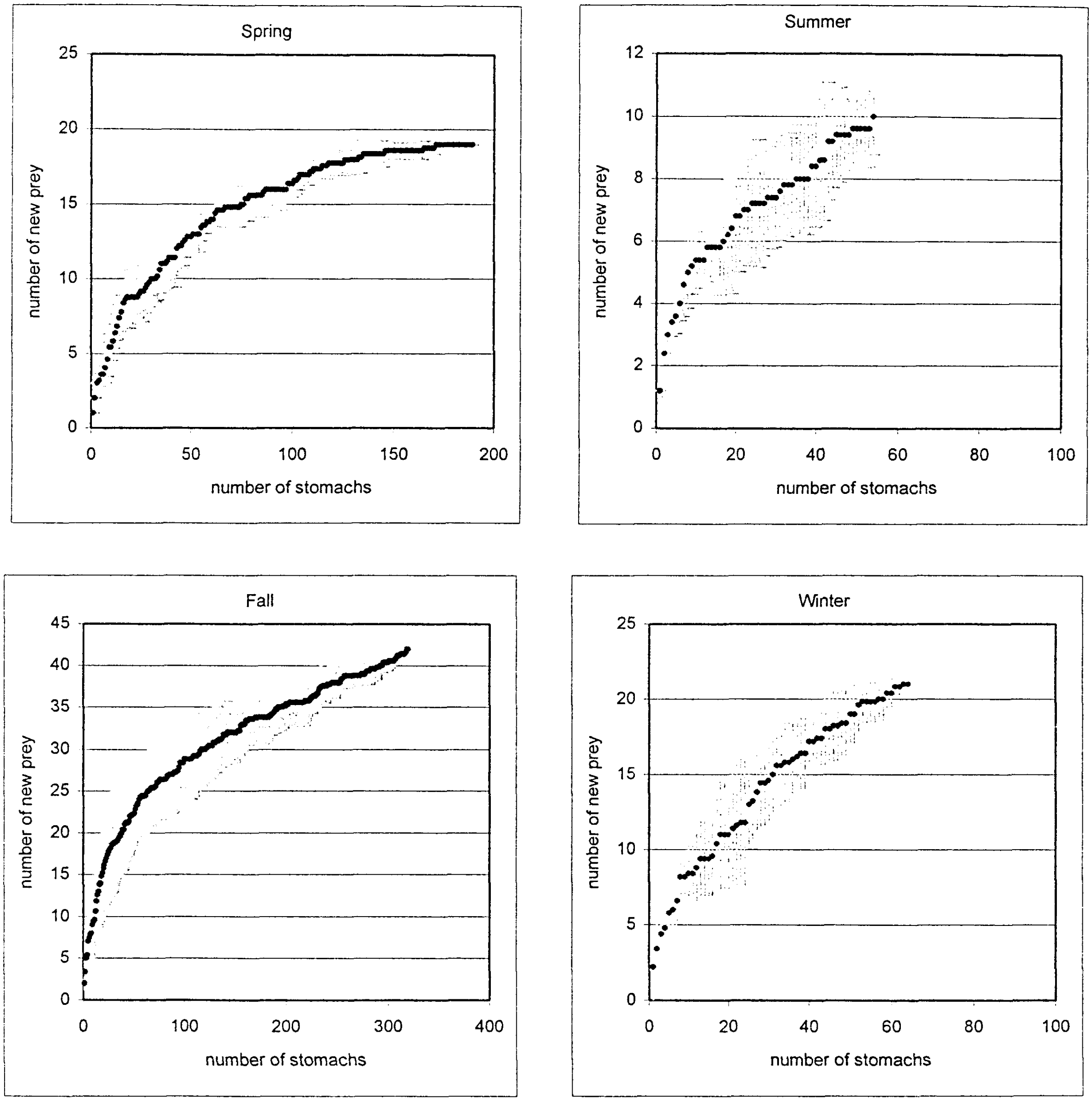

All stomachs combined
60
50
40
30
20
10
0
number of new prey
0
100
200
300
400
500
600
700
number of stomachs

**Figure 10a-d:** Cumulative prey curve for each season.



Spring
number of new prey
number of stomachs
Summer
number of new prey
number of stomachs
Fall
number of new prey
number of stomachs
Winter
number of new prey
number of stomachs

**Figure 11a-d:** Cumulative prey curve for each size class of striped bass.

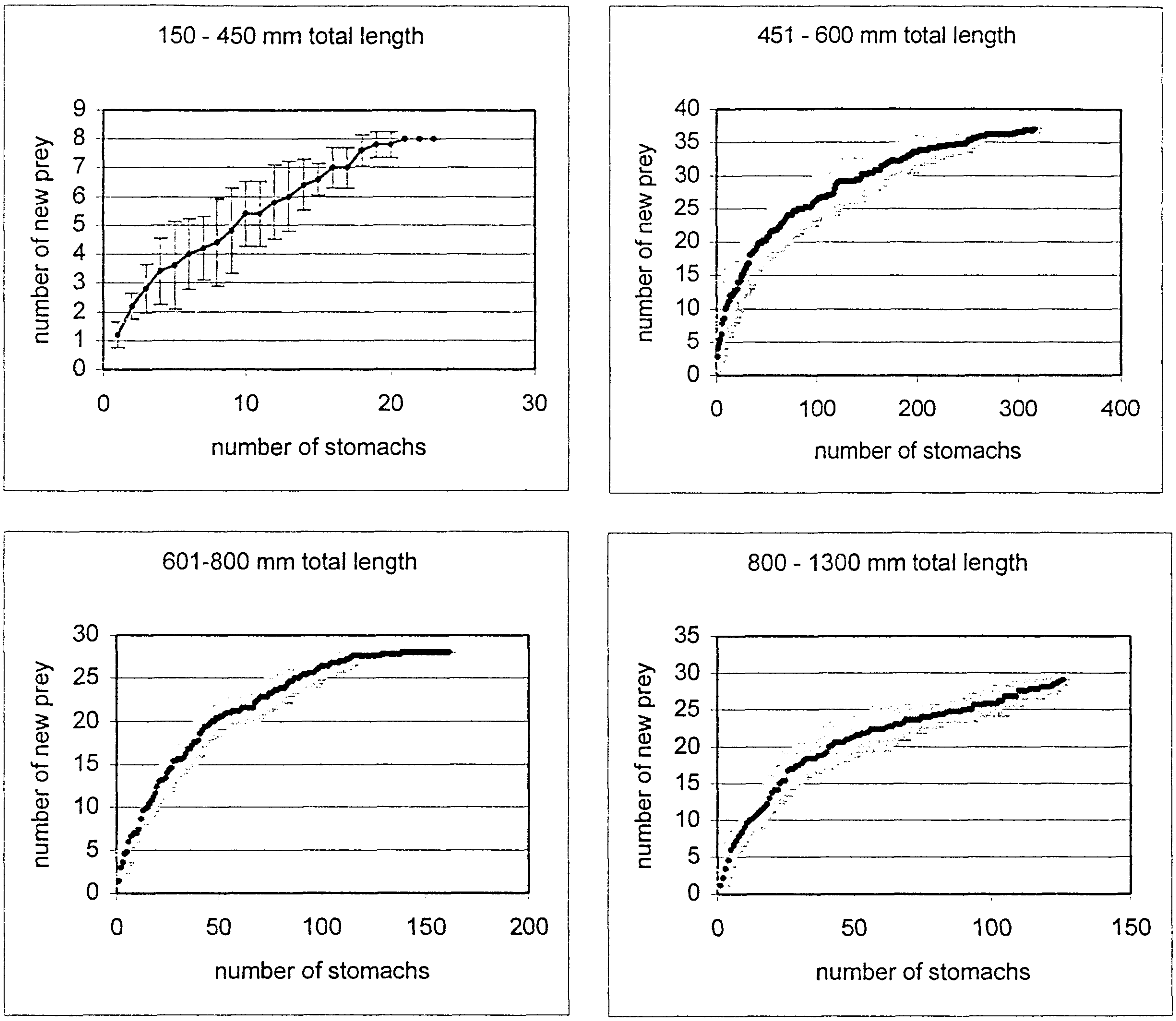

150 - 450 mm total length
number of new prey
number of stomachs
451 - 600 mm total length
number of new prey
number of stomachs
601-800 mm total length
number of new prey
number of stomachs
800 - 1300 mm total length
number of new prey
number of stomachs

**Figure 12:** Plot of the percent index of relative importance (IRI) for all striped bass stomachs with food (n = 720).

## All fish combined

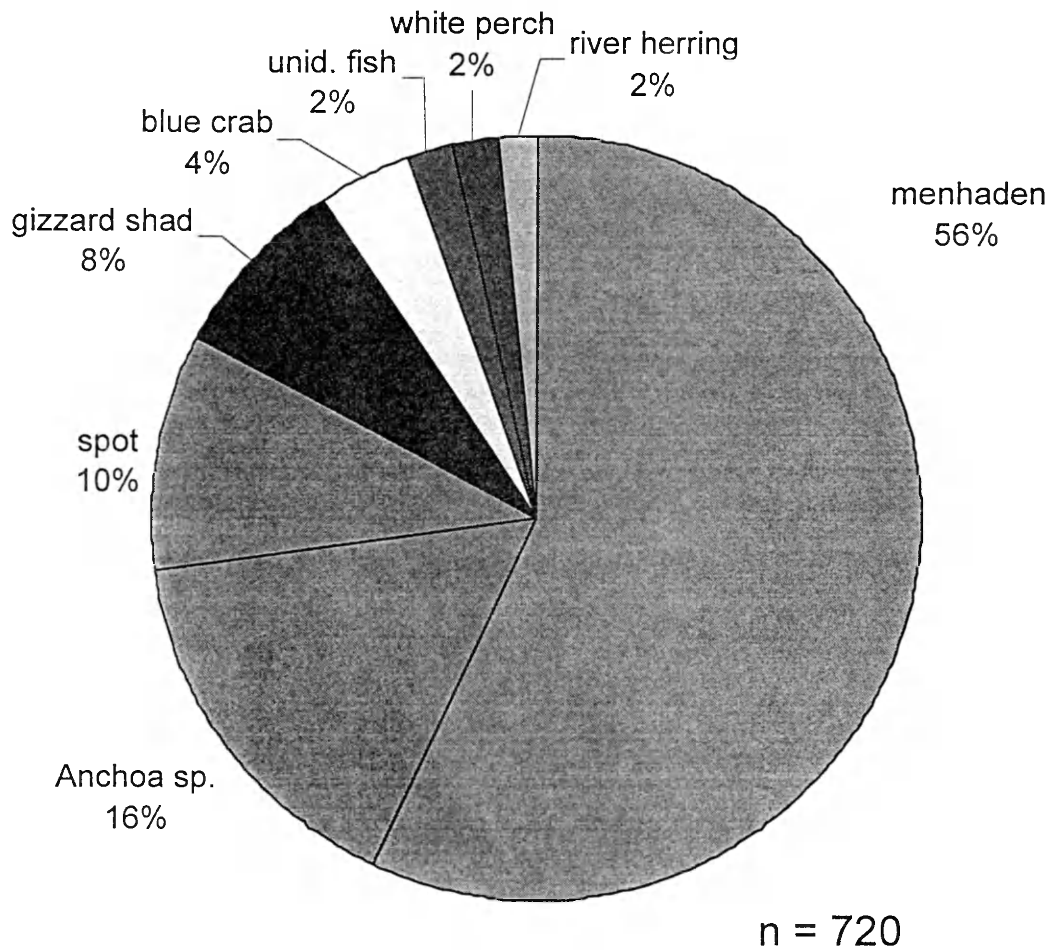
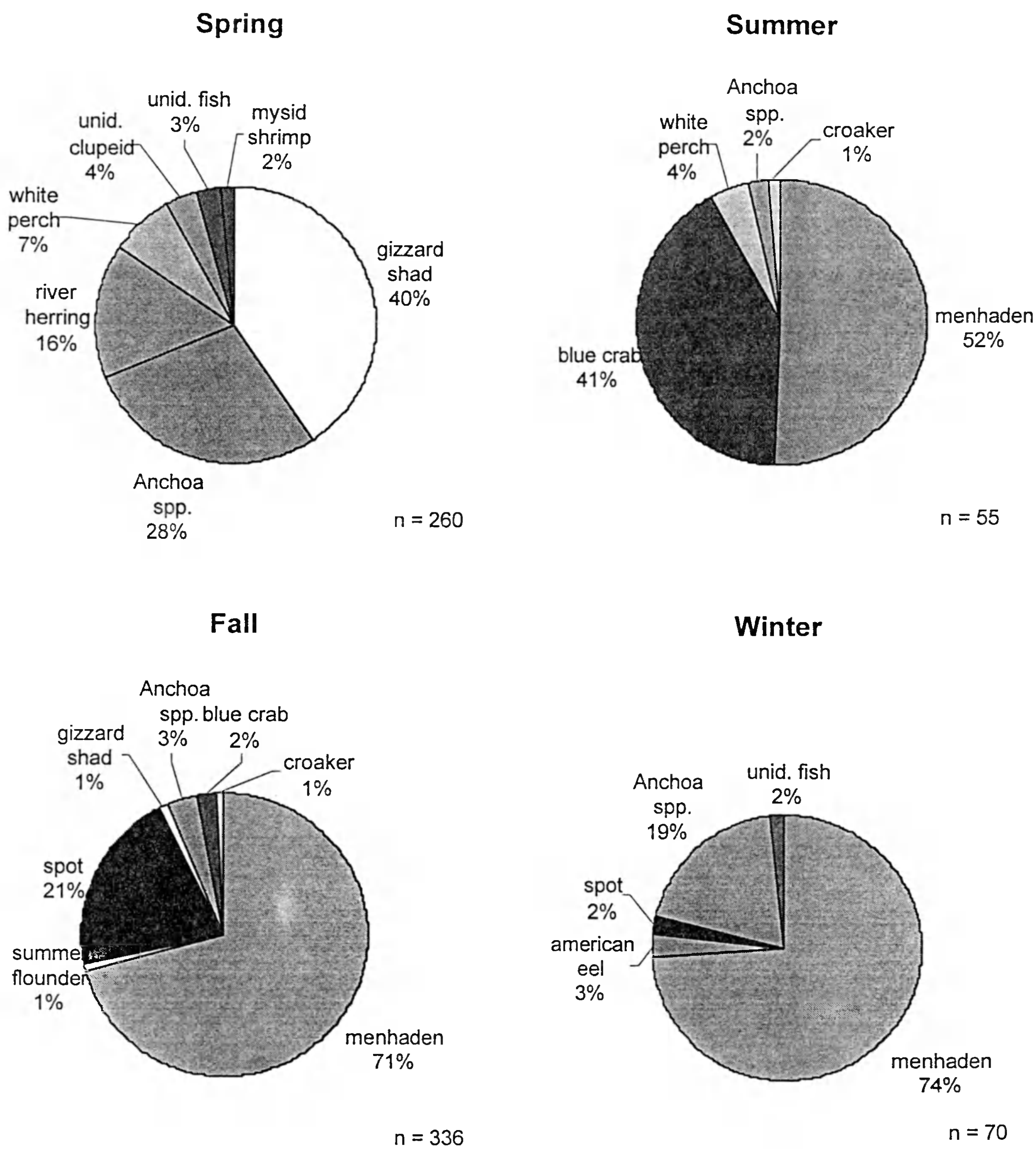


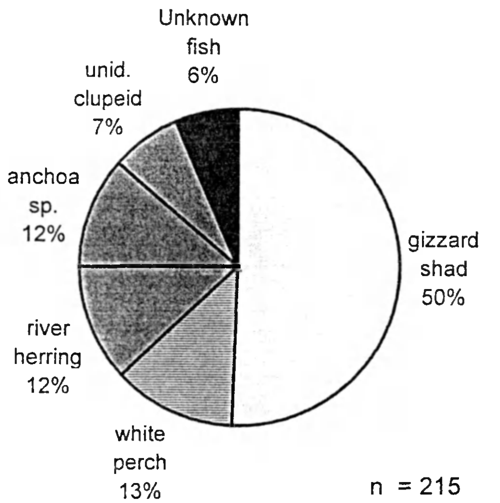
**Figure 13 a-d:** Plot of the percent index of relative importance (IRI) by season.



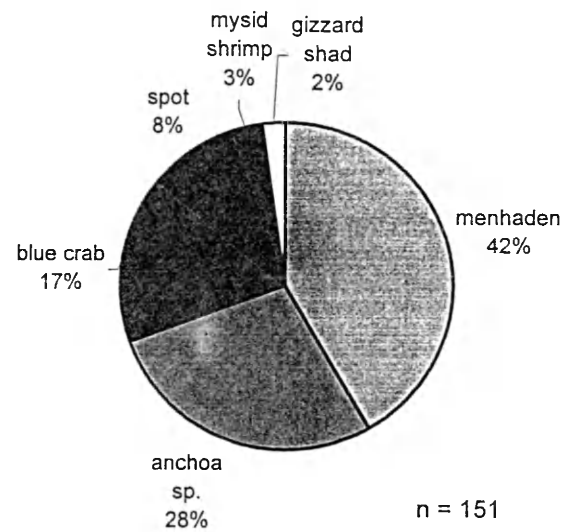
Spring
unid. fish 3%
mysid shrimp 2%
unid. clupeid 4%
white perch 7%
river herring 16%
gizzard shad 40%
Anchoa spp. 28%
n = 260
Summer
Anchoa spp. 2%
white perch 4%
croaker 1%
menhaden 52%
blue crab 41%
n = 55
Fall
Anchoa spp. 3%
blue crab 2%
gizzard shad 1%
croaker 1%
spot 21%
summe
flounder 1%
menhaden 71%
n = 336
Winter
unid. fish 2%
Anchoa spp. 19%
spot 2%
american eel 3%
menhaden 74%
n = 70

**Figures 14 a-d:** Plot of the percent index of relative importance (IRI) by location.

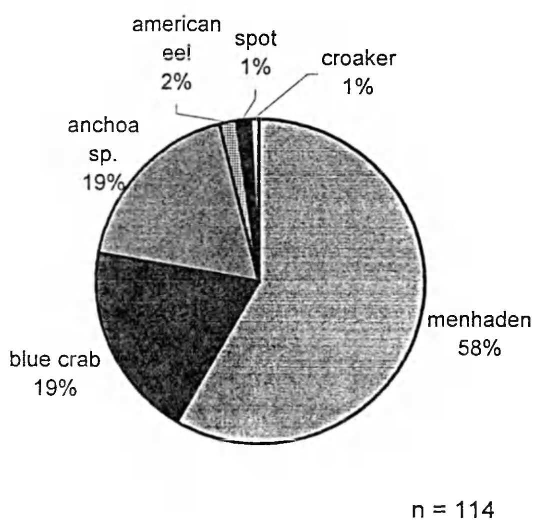
## Middle and Upper Rivers



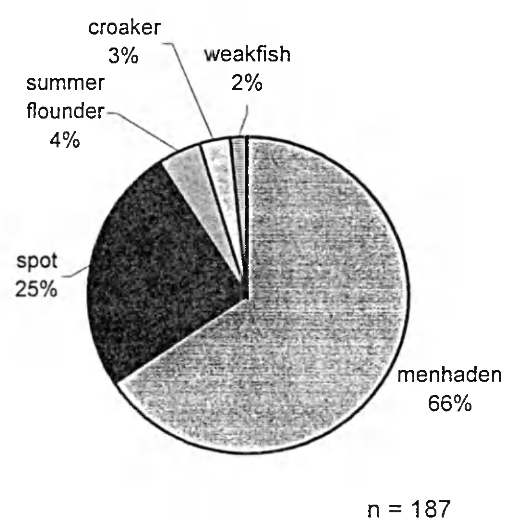

## Lower Rivers




## Middle and Upper Chesapeake Bay

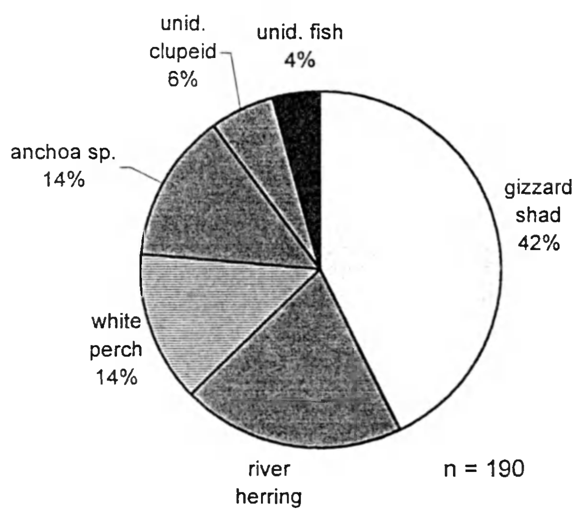



## Lower Chesapeake Bay

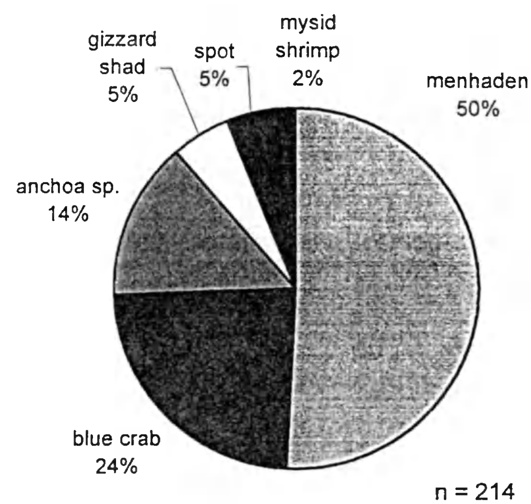


**Figures 15 a-c:** Plot of the percent index of relative importance (IRI) by salinity zone.

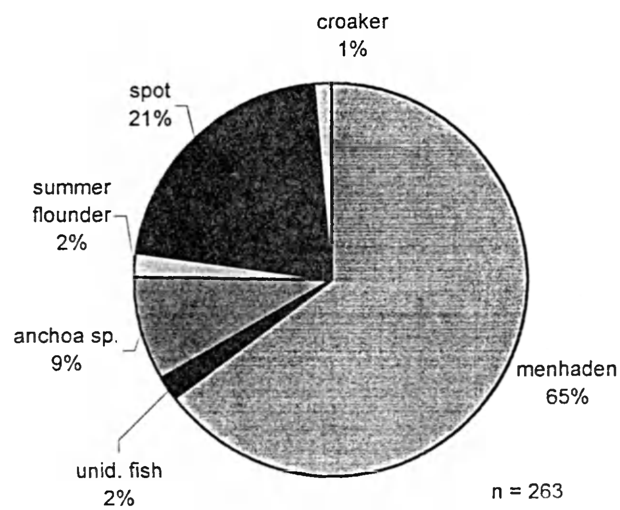
**Tidal freshwater-Oligohaline (0-5 ppt)**



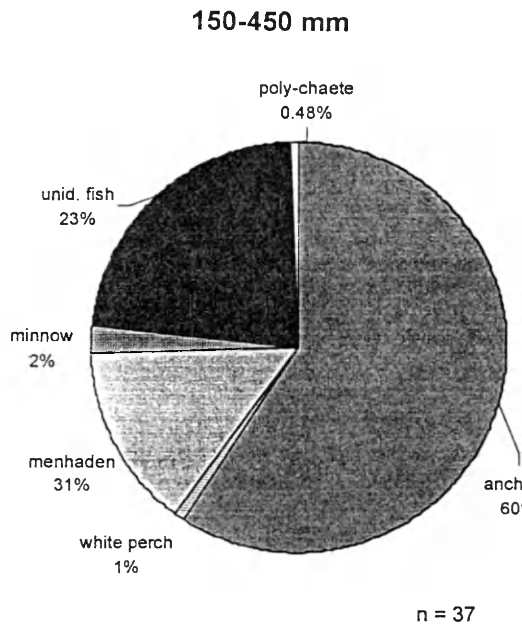

**Mesohaline (5-18 ppt)**

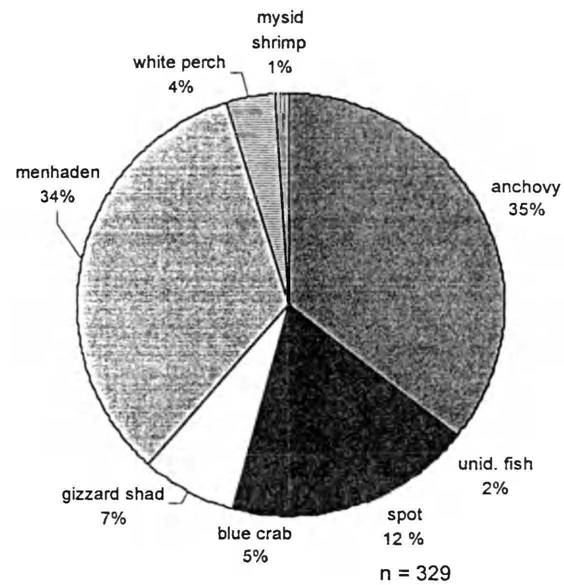


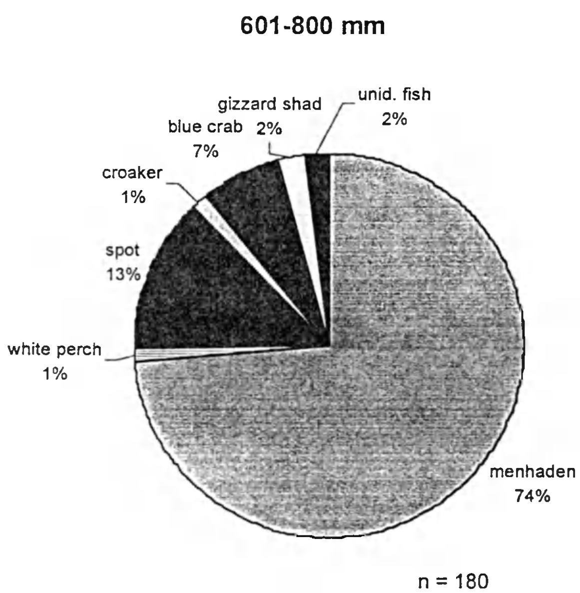

**Polyhaline (18-30 ppt)**



**Figures 16 a-d:** Plot of the percent index of relative importance (IRI) by size class.


150-450 mm
poly-chaete
0.48%
unid. fish
23%
minnow
2%
menhaden
31%
white perch
1%
anchovy
60%
n = 37


451-600 mm
mysid
shrimp
1%
white perch
4%
menhaden
34%
anchovy
35%
unid. fish
2%
spot
12 %
blue crab
5%
gizzard shad
7%
n = 329


601-800 mm
unid. fish
2%
gizzard shad
2%
blue crab
7%
croaker
1%
spot
13%
white perch
1%
menhaden
74%
n = 180

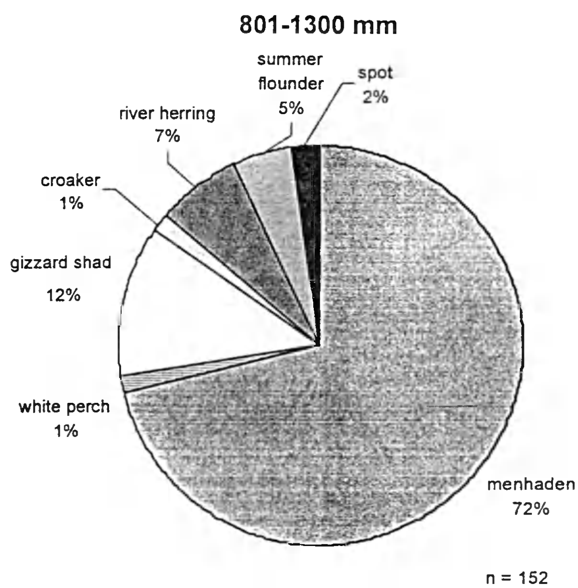
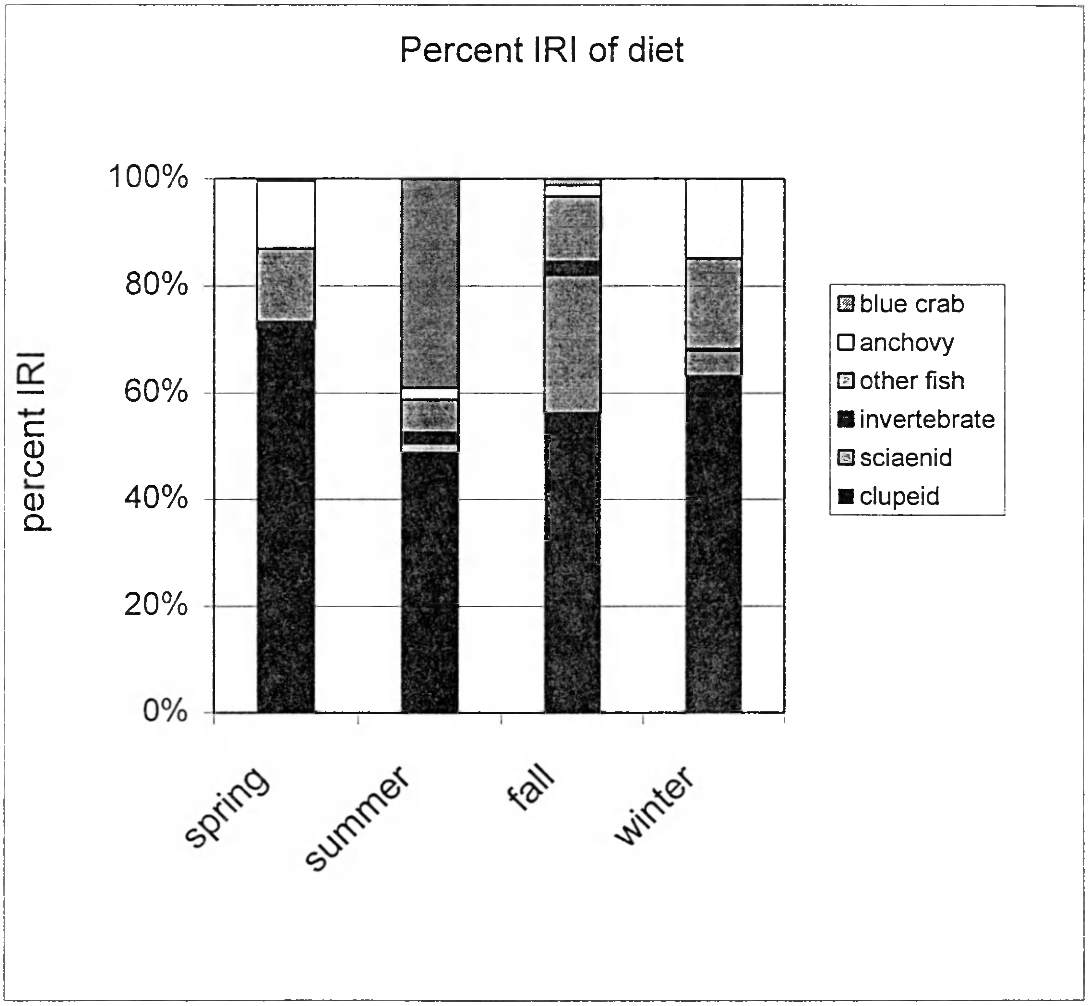

801-1300 mm
summer
flounder
5%
spot
2%
river herring
7%
croaker
1%
gizzard shad
12%
white perch
1%
menhaden
72%
n = 152

**Figure 17:** Percent index of relative importance for combined prey categories by season.



Percent IRI of diet
100%
80%
60%
40%
20%
0%
percent IRI
spring
summer
fall
winter
blue crab
anchovy
other fish
invertebrate
sciaenid
clupeid

**Figure 18:** Percent index of relative importance for combined prey categories by salinity zone.

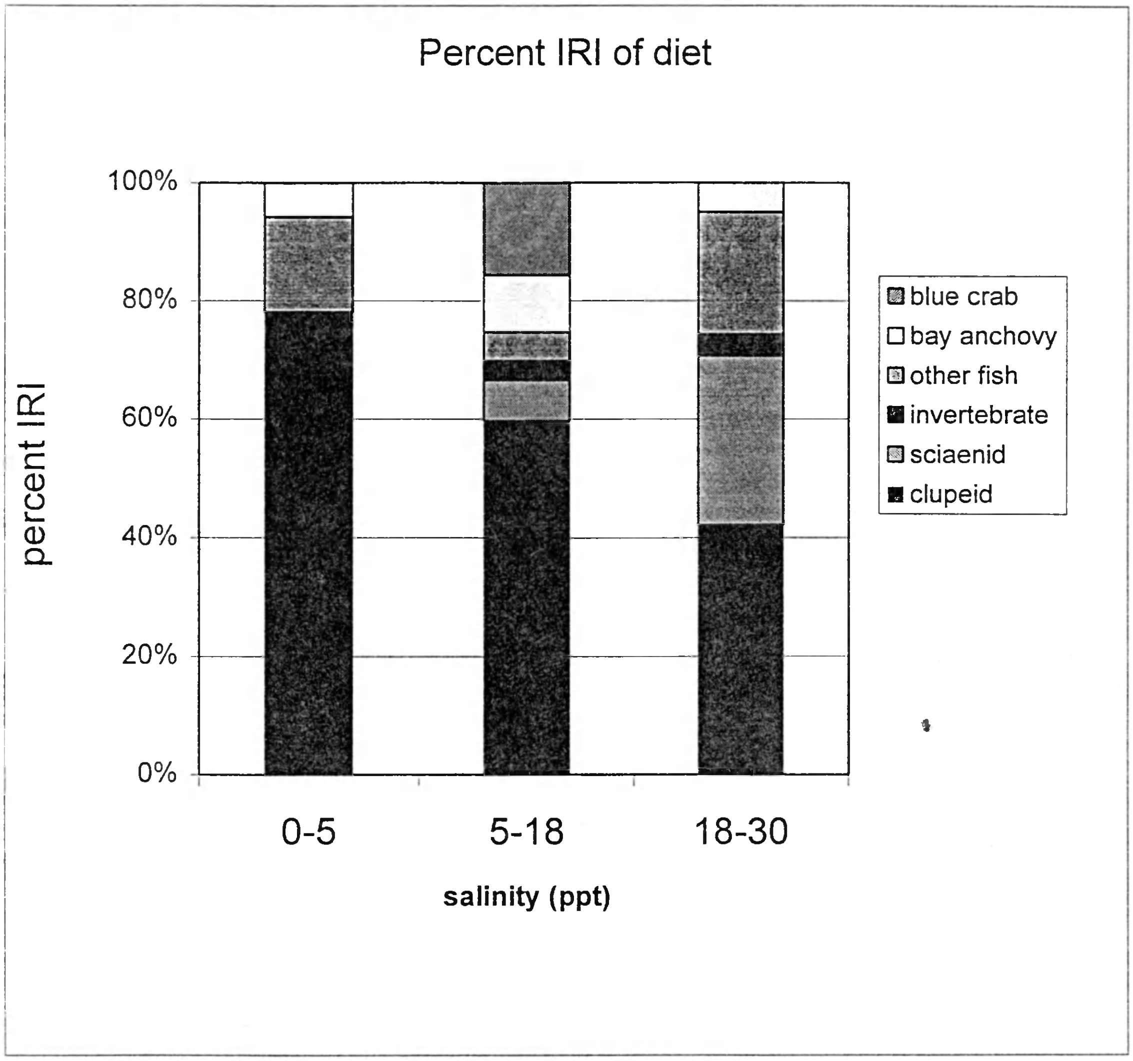
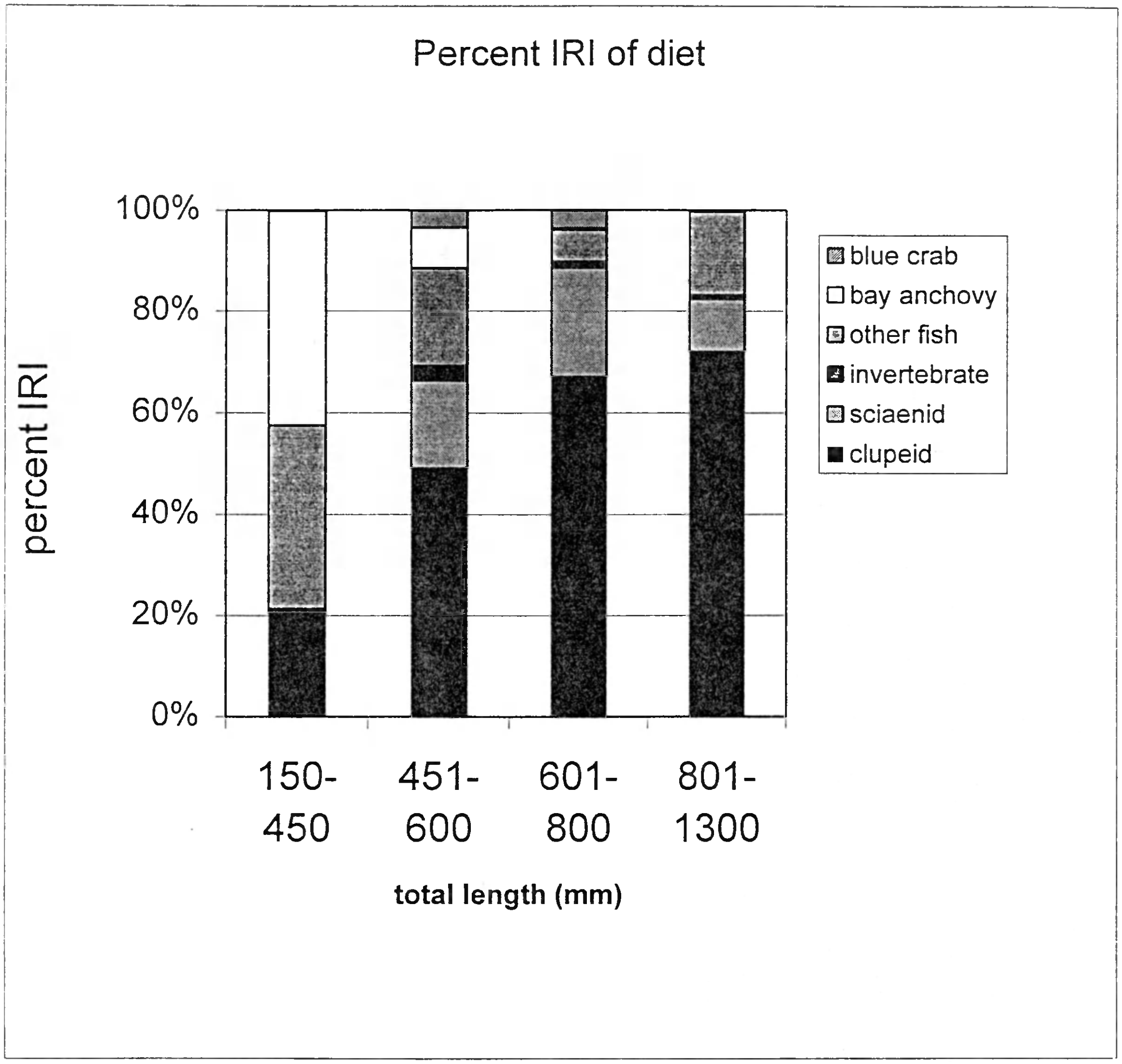

Percent IRI of diet
percent IRI
100%
80%
60%
40%
20%
0%
0-5
5-18
18-30
salinity (ppt)
blue crab
bay anchovy
other fish
invertebrate
sciaenid
clupeid

**Figure 19:** Percent index of relative importance for combined prey categories by length class.



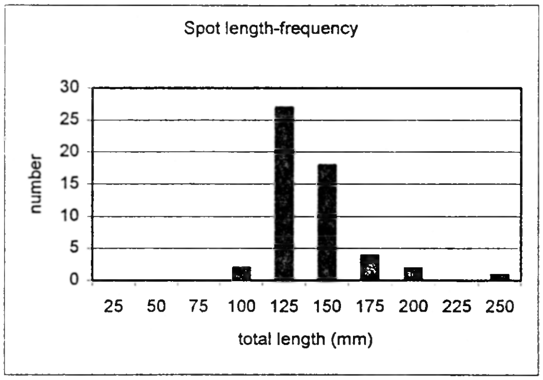
Percent IRI of diet
percent IRI
100%
80%
60%
40%
20%
0%
150-450
451-600
601-800
801-1300
total length (mm)
blue crab
bay anchovy
other fish
invertebrate
sciaenid
clupeid

**Figure 20a:** Ingested spot length-frequency distribution.

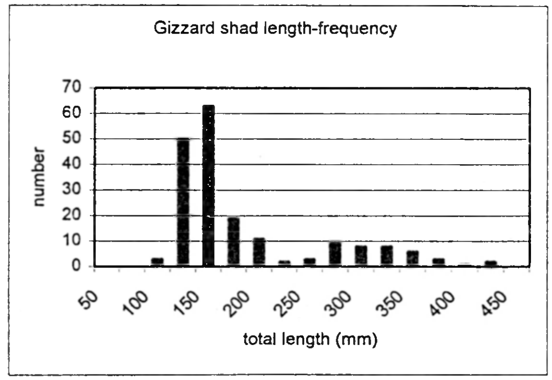
**Figure 20a:** Ingested gizzard shad length-frequency distribution.

**Figure 20a:** Ingested anchovy length-frequency distribution.

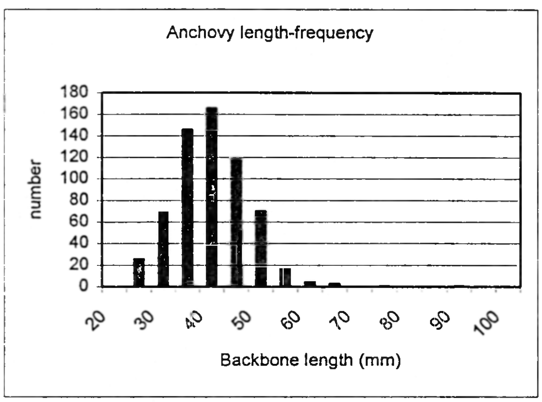
**Figure 20a:** Ingested blue crab length-frequency distribution. Length is carapace width in millimeters. All crabs above 65 mm carapace width were either soft or broken parts.



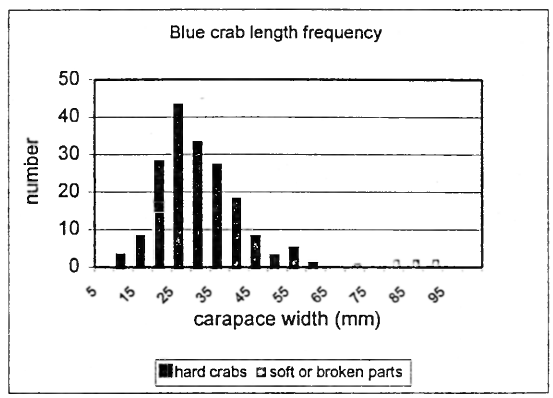
Spot length-frequency
number
30
25
20
15
10
5
0
25 50 75 100 125 150 175 200 225 250
total length (mm)

Gizzard shad length-frequency
number
70
60
50
40
30
20
10
0
50 100 150 200 250 300 350 400 450
total length (mm)

Anchovy length-frequency
number
180
160
140
120
100
80
60
40
20
0
20 30 40 50 60 70 80 90 100
Backbone length (mm)

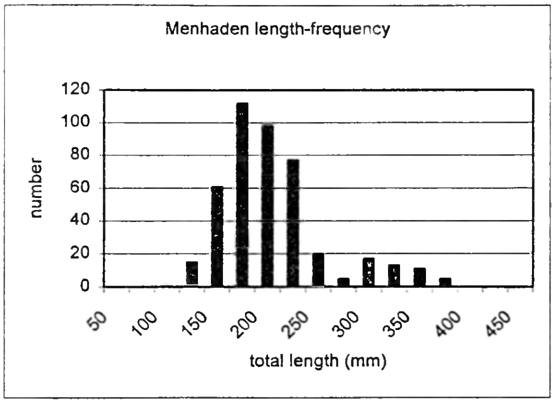
Blue crab length frequency
number
50
40
30
20
10
0
5 15 25 35 45 55 65 75 85 95
carapace width (mm)
hard crabs
soft or broken parts

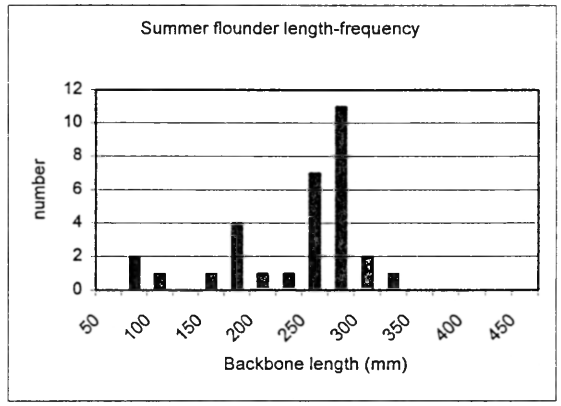
**Figure 21a:** Ingested menhaden length-frequency distribution.

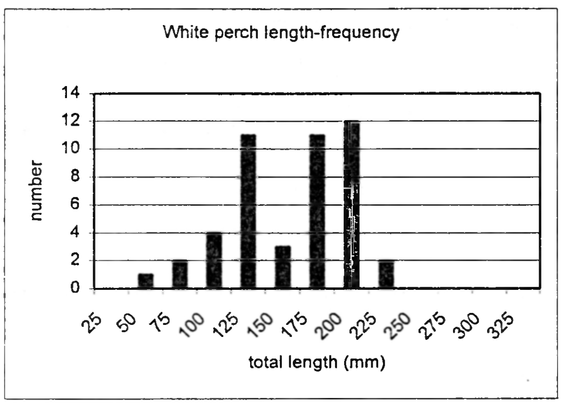
**Figure 21b:** Ingested summer flounder length-frequency distribution.

**Figure 21c:** Ingested white perch length-frequency distribution.

**Figure 21d:** Ingested herring length-frequency distribution. Alewives and blueback herring are separated.


Menhaden length-frequency
120
100
80
60
40
20
0
number
50 100 150 200 250 300 350 400 450
total length (mm)


Summer flounder length-frequency
12
10
8
6
4
2
0
number
50 100 150 200 250 300 350 400 450
Backbone length (mm)


White perch length-frequency
14
12
10
8
6
4
2
0
number
25 50 75 100 125 150 175 200 225 250 275 300 325
total length (mm)

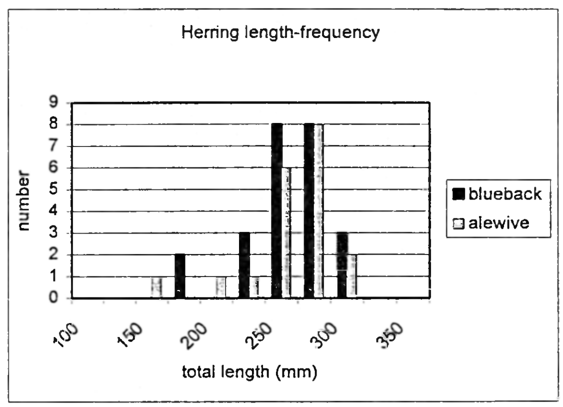

Herring length-frequency
9
8
7
6
5
4
3
2
1
0
number
100 150 200 250 300 350
total length (mm)
blueback
alewive

**Figure 22a:** Least squares linear regression of menhaden total length to striped bass total length, $p < 0.01$, $R^2 = 0.30$.

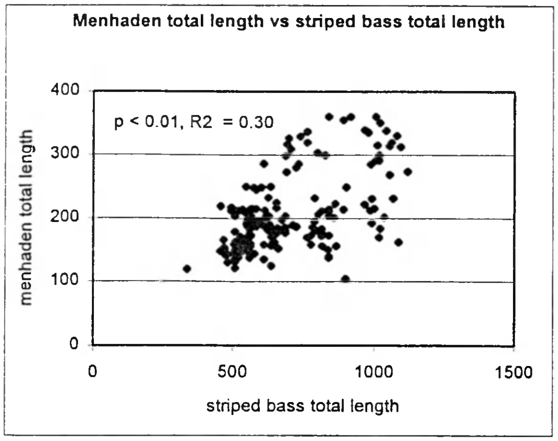
**Figure 22b:** Least squares linear regression of spot total length to striped bass total length, $p = 0.39$.

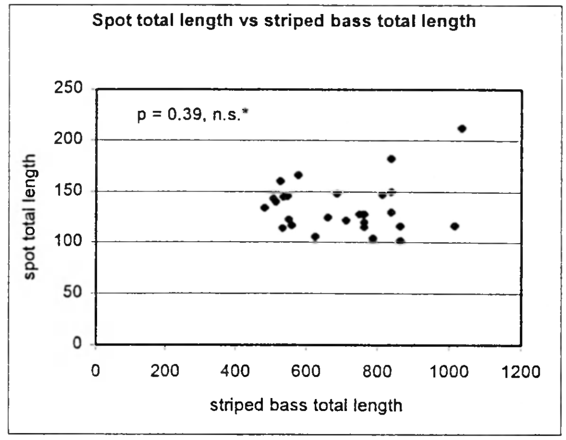
**Figure 22c:** Least squares linear regression of white perch total length to striped bass total length, $p = 0.39$.

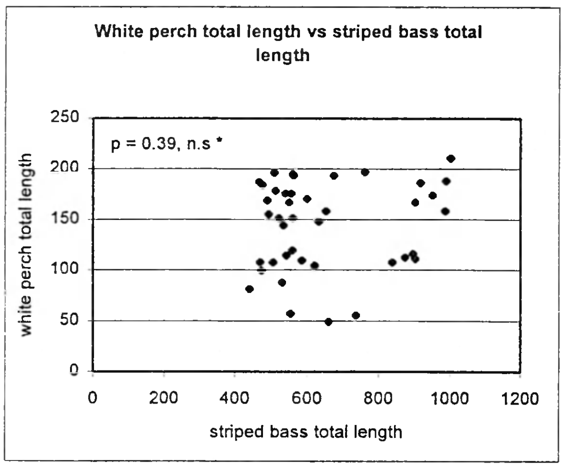
**Figure 22d:** Least squares linear regression of gizzard shad total length to striped bass total length, $p < 0.01$, $R^2 = 0.63$.

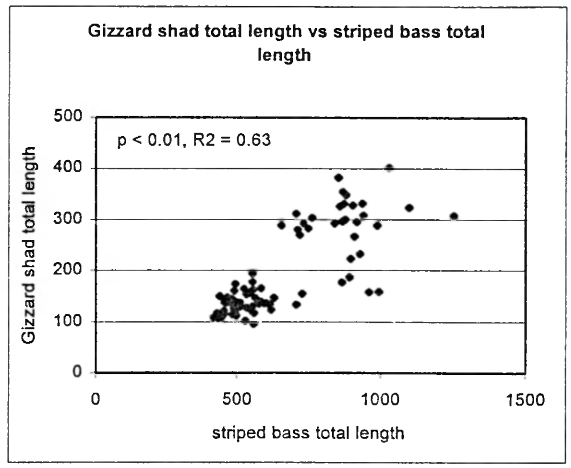
**Figure 22e:** Least squares linear regression of blue crab carapace width to striped bass total length, $p = 0.053$.

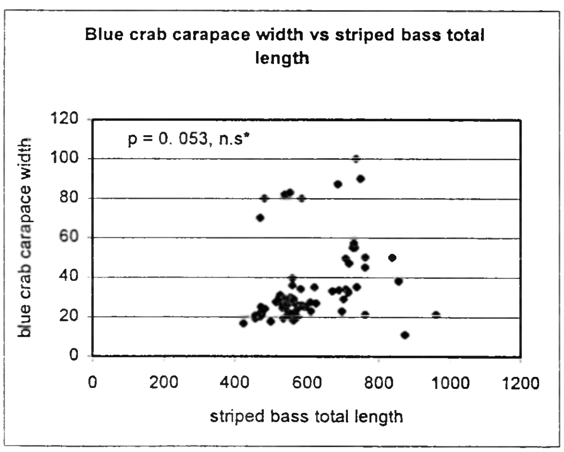
**Figure 22f:** Least squares linear regression of anchovy total length to striped bass total length, $p = 0.21$.


Menhaden total length vs striped bass total length
p < 0.01, R2 = 0.30
menhaden total length
striped bass total length
0
100
200
300
400
0
500
1000
1500


Spot total length vs striped bass total length
p = 0.39, n.s.*
spot total length
striped bass total length
0
50
100
150
200
250
0
200
400
600
800
1000
1200


White perch total length vs striped bass total length
p = 0.39, n.s *
white perch total length
striped bass total length
0
50
100
150
200
250
0
200
400
600
800
1000
1200


Gizzard shad total length vs striped bass total length
p < 0.01, R2 = 0.63
Gizzard shad total length
striped bass total length
0
100
200
300
400
500
0
500
1000
1500


Blue crab carapace width vs striped bass total length
p = 0. 053, n.s*
blue crab carapace width
striped bass total length
0
20
40
60
80
100
120
0
200
400
600
800
1000
1200

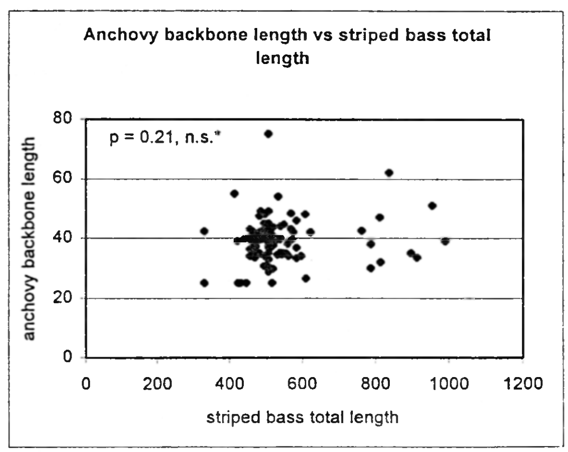
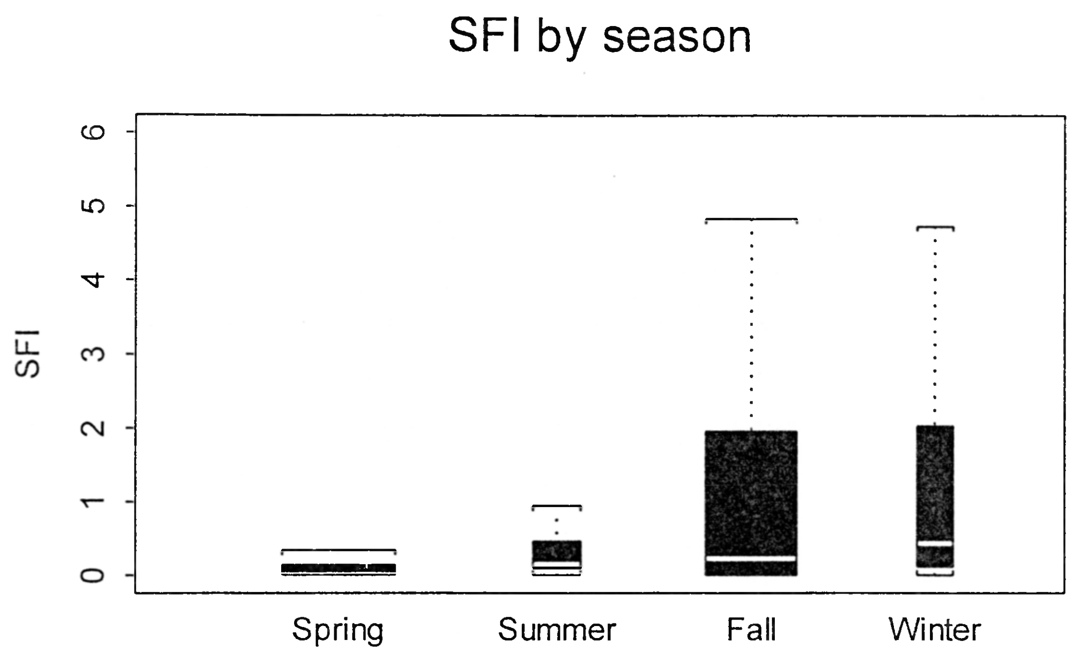

Anchovy backbone length vs striped bass total length
p = 0.21, n.s.*
anchovy backbone length
striped bass total length
0
20
40
60
80
0
200
400
600
800
1000
1200

**Figure 23a:** Box-and-whisker plots of stomach fullness index plotted by season. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars is proportional to the square root of the sample size.

**Figure 23b:** Box-and-whisker plots of stomach fullness index plotted by month. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars does not correspond to sample sizes.


SFI by season
SFI
0
1
2
3
4
5
6
Spring
Summer
Fall
Winter

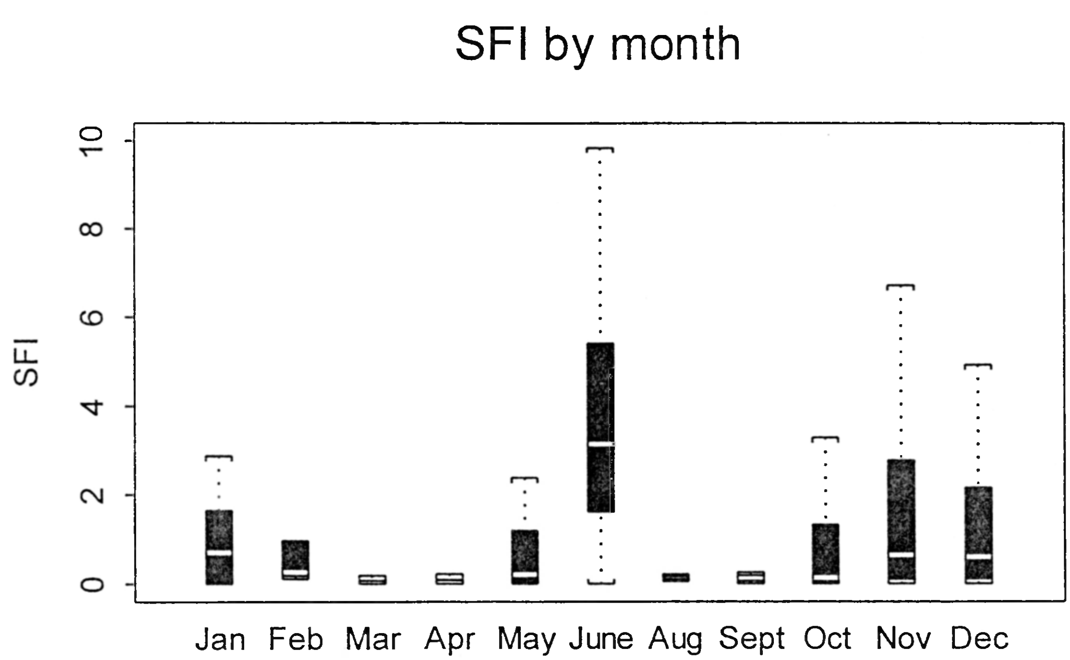
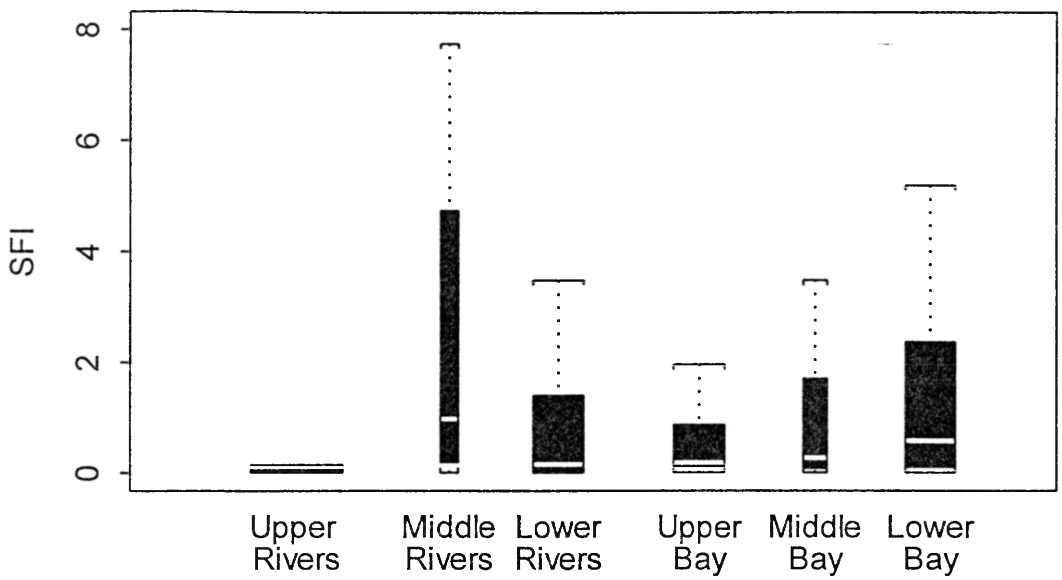

SFI by month
SFI
0
2
4
6
8
10
Jan
Feb
Mar
Apr
May
June
Aug
Sept
Oct
Nov
Dec

**Figure 24a:** Box-and-whisker plots of stomach fullness index plotted by location. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars is proportional to the square root of the sample size.

**Figure 24b:** Box-and-whisker plots of stomach fullness index plotted by salinity class. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars is proportional to the square root of the sample size.

SFI by location




SFI by salinity class

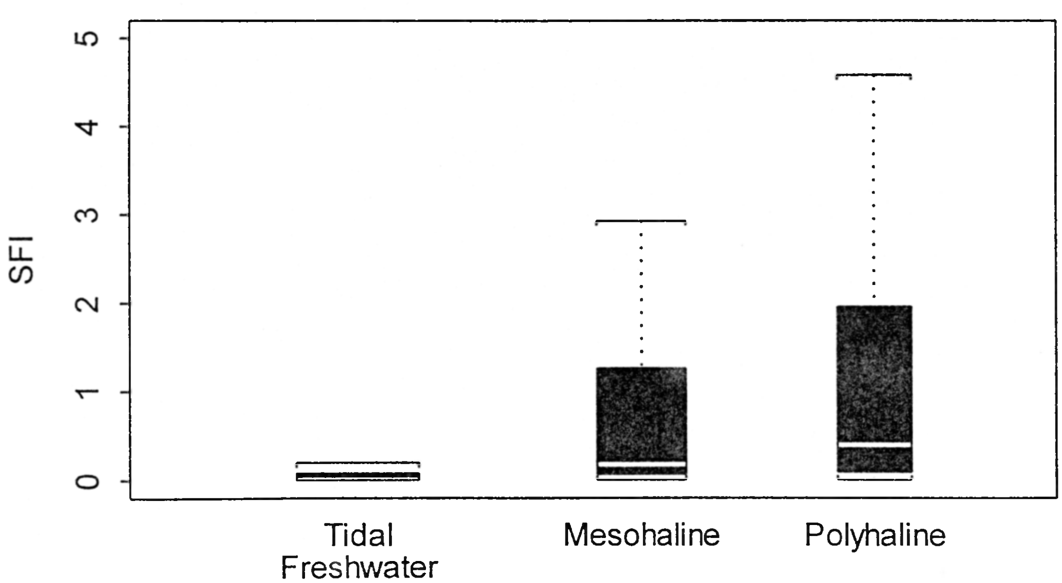
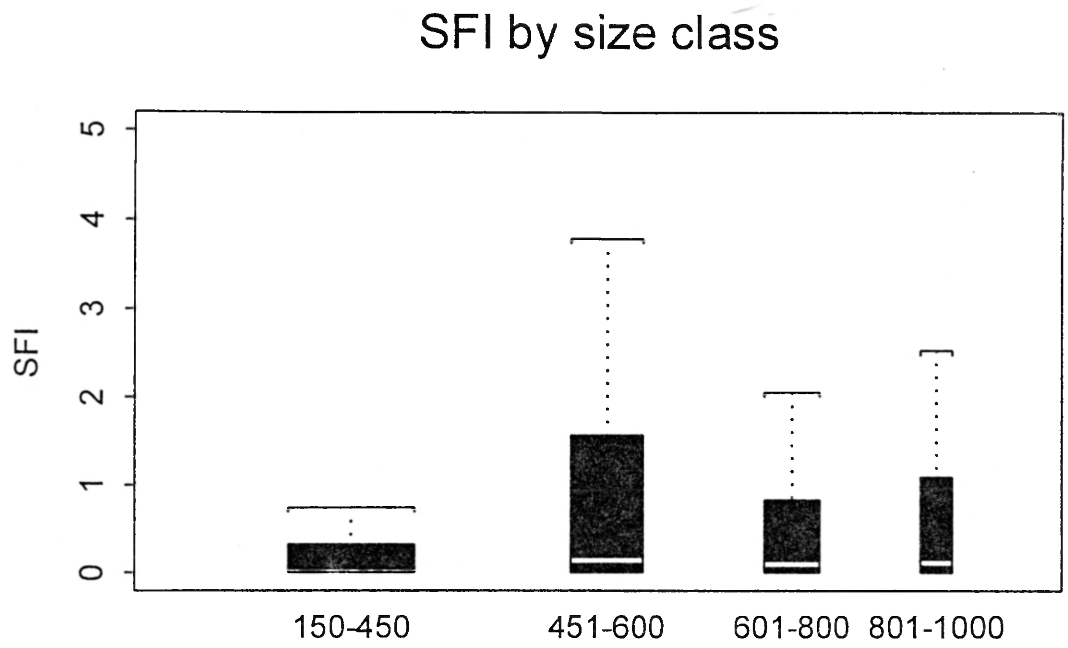
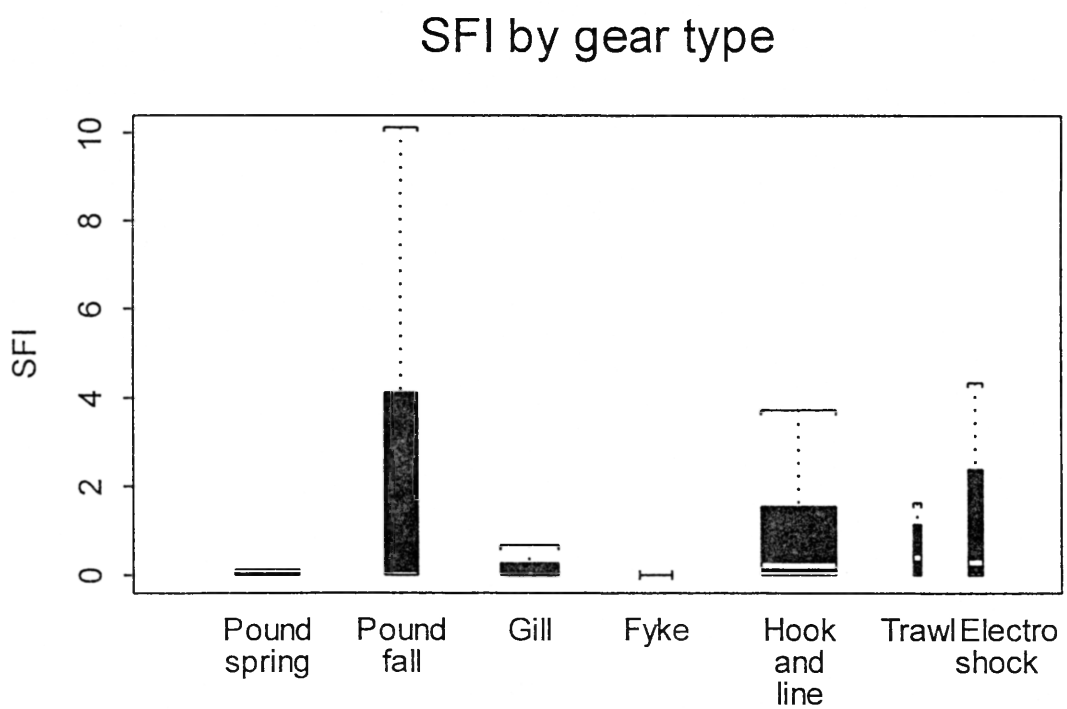


**Figure 25a:** Box-and-whisker plots of stomach fullness index plotted by size class of striped bass. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars is proportional to the square root of the sample size.

**Figure 25b:** Box-and-whisker plots of stomach fullness index plotted by gear type. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines represent the median of the distribution. The width of the bars is proportional to the square root of the sample size.



SFI by size class
SFI
0
1
2
3
4
5
150-450
451-600
601-800
801-1000

SFI by gear type
SFI
0
2
4
6
8
10
Pound spring
Pound fall
Gill
Fyke
Hook and line
Trawl
Electro shock

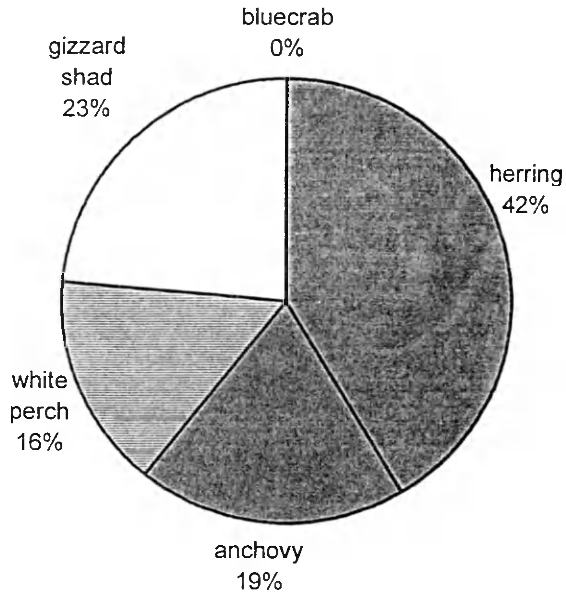
**Figure 26a:** Percent index of relative importance for spring pound nets in tidal freshwater.

**Figure 26b:** Percent index of relative importance for spring gill nets in tidal freshwater.

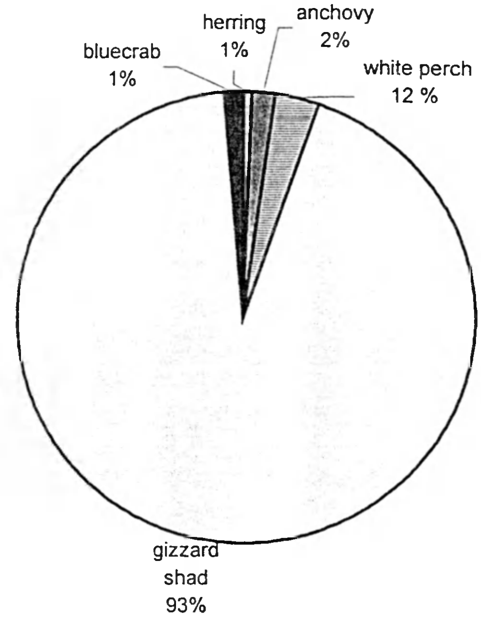
**Figure 26c:** Percent index of relative importance for fall pound nets in the middle Chesapeake Bay and lower rivers.

**Figure 26d:** Percent index of relative importance for fall hook and line in the middle Chesapeake Bay and lower rivers.

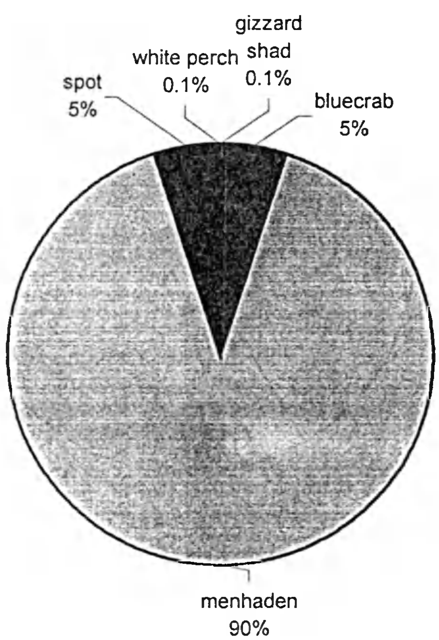
## Pound net, spring




## Gill net, spring




## Pound net, fall




## Hook and line fall

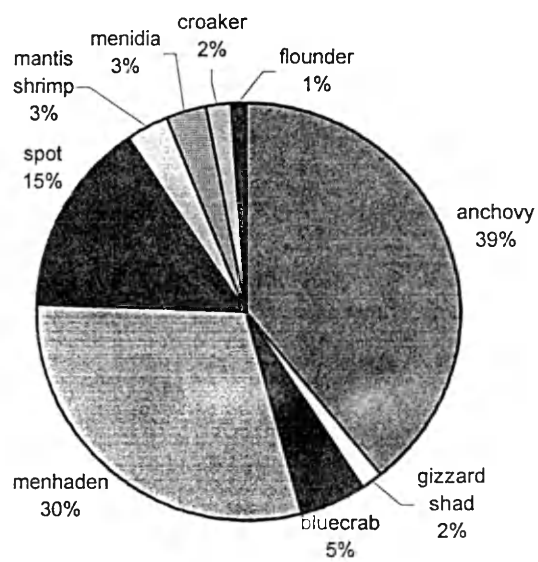
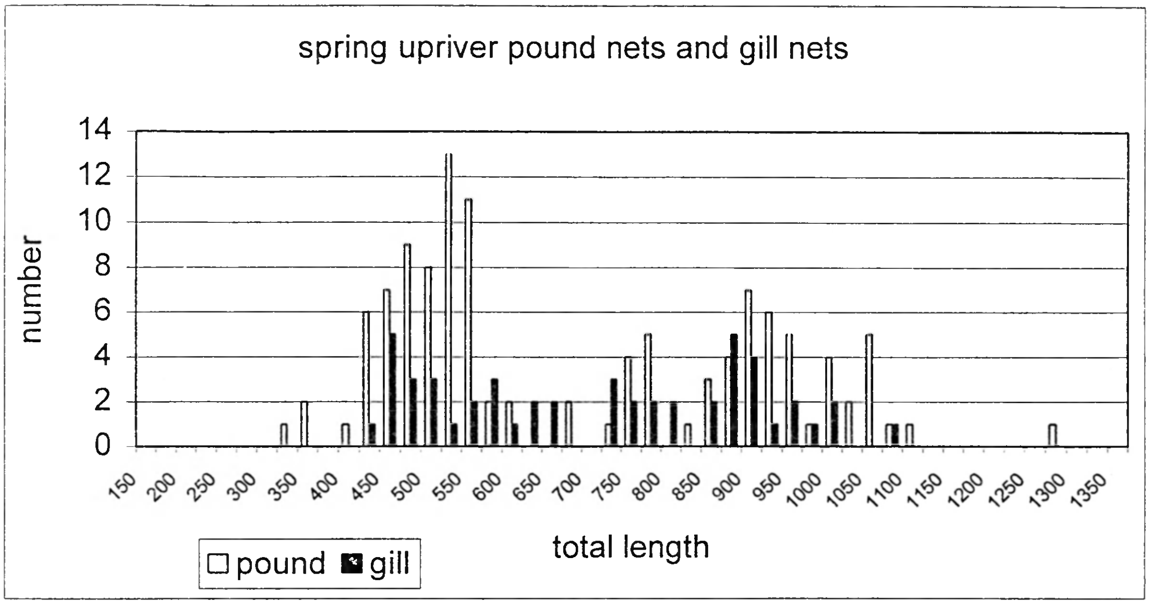


**Figure 27a:** Length-frequency distributions for striped bass from spring gill nets and pound net-caught striped bass. Lengths are total lengths in millimeters.

**Figure 27b:** Length-frequency distributions for striped bass from spring gill nets and pound net-caught striped bass. Lengths are total lengths in millimeters.


spring upriver pound nets and gill nets
14
12
10
8
6
4
2
0
number
150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350
total length
pound
gill

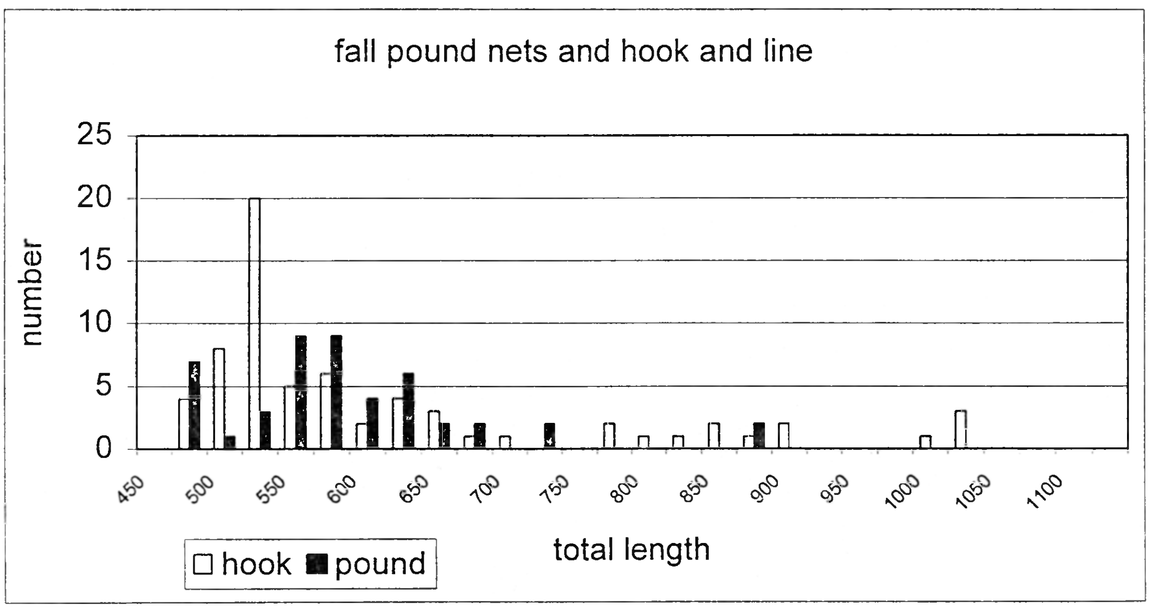
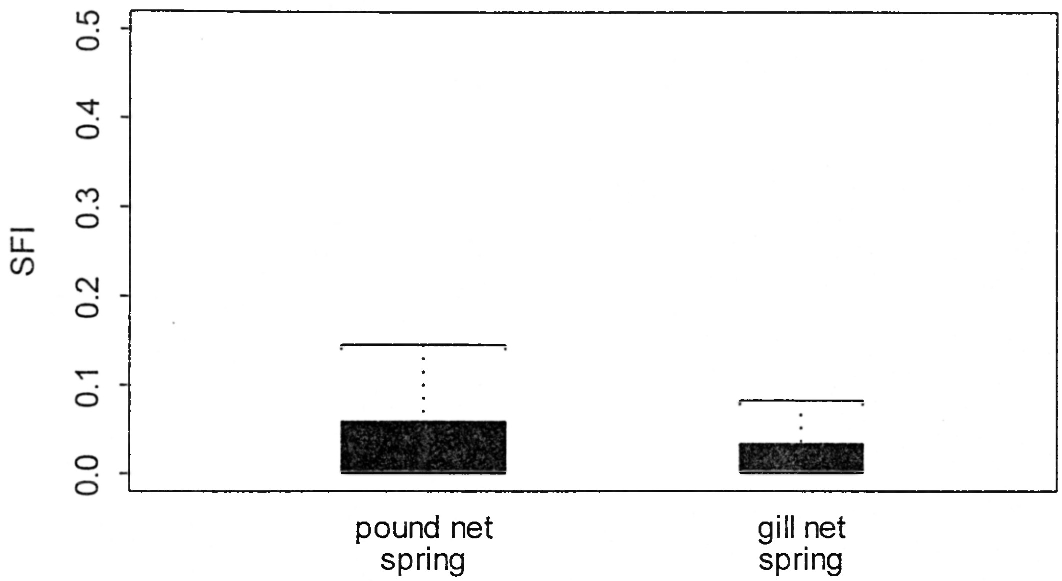

fall pound nets and hook and line
25
20
15
10
5
0
number
450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100
total length
hook
pound

**Figure 28a:** Box-and-whisker plots of stomach fullness index values for striped bass captured in pound nets and gill nets in tidal freshwater in spring. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines indicate the median of the distribution. The width of the bars is proportional to the square root of the sample size.

**Figure 28b:** Box-and-whisker plots of stomach fullness index values for striped bass captured by hook and line and pound net in fall in middle Chesapeake Bay and lower rivers. Dashed lines represent minimum and maximum values, dark boxes represent interquartile range and light lines indicate the median of the distribution. The width of the bars is proportional to the square root of the sample size.

SFI of spring pound nets and gillnets




SFI of fall pound nets and fall hook and line

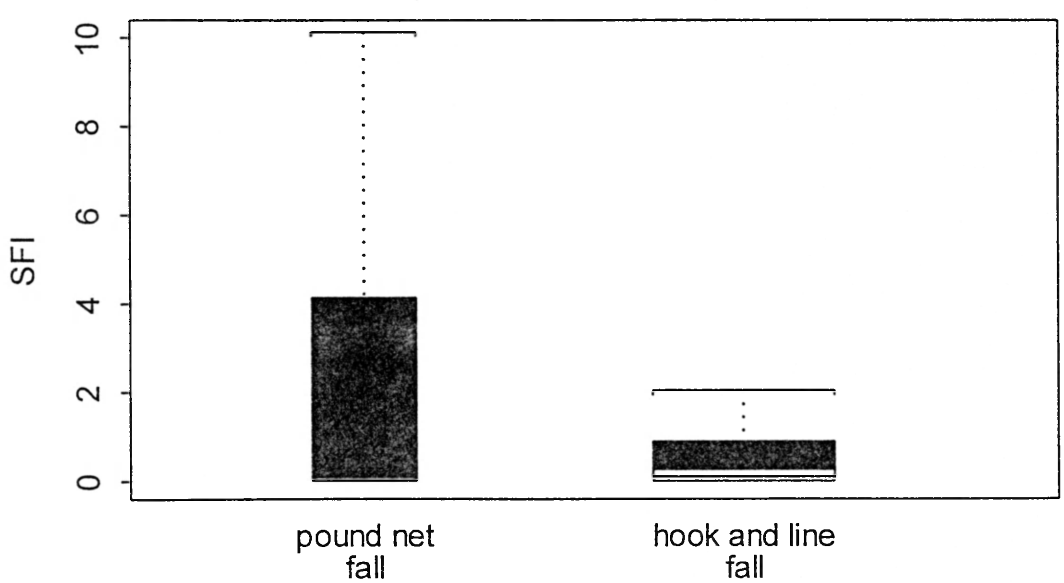
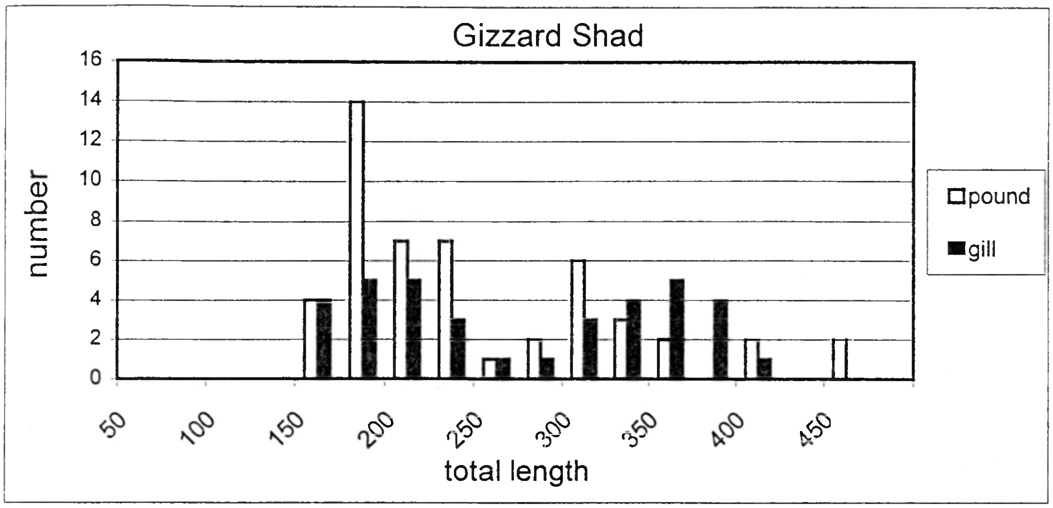
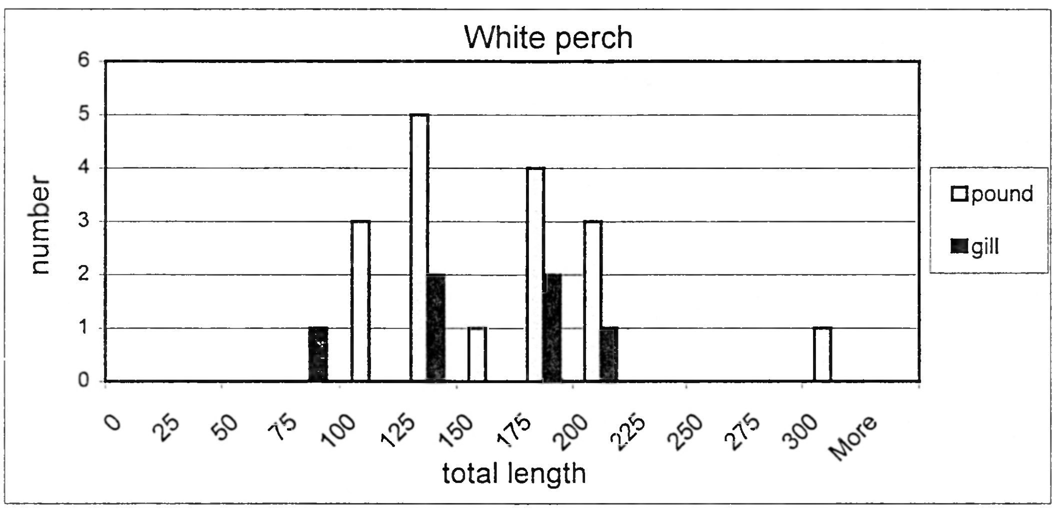


**Figure 29a:** Length-frequency distributions for ingested gizzard shad from spring gill nets and pound net-caught striped bass. Lengths are total lengths in millimeters.

**Figure 29b:** Length-frequency distributions for ingested white perch from spring gill nets and pound net-caught striped bass. Lengths are total lengths in millimeters.

**Figure 29c:** Length-frequency distributions for ingested river herring from spring gill nets and pound net-caught striped bass. Lengths are total lengths in millimeters.


Gizzard Shad
number
16
14
12
10
8
6
4
2
0
50
100
150
200
250
300
350
400
450
total length
pound
gill


White perch
number
6
5
4
3
2
1
0
0
25
50
75
100
125
150
175
200
225
250
275
300
More
total length
pound
gill

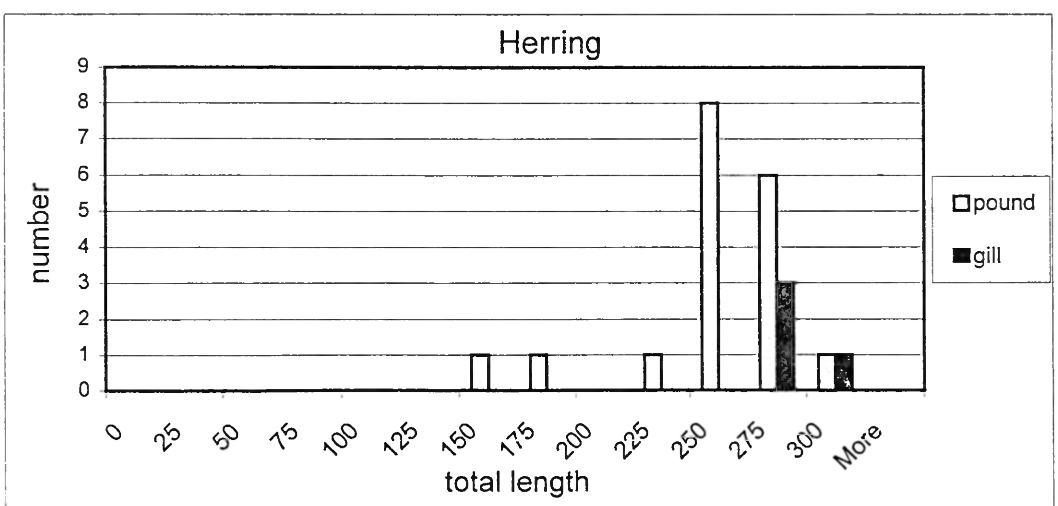
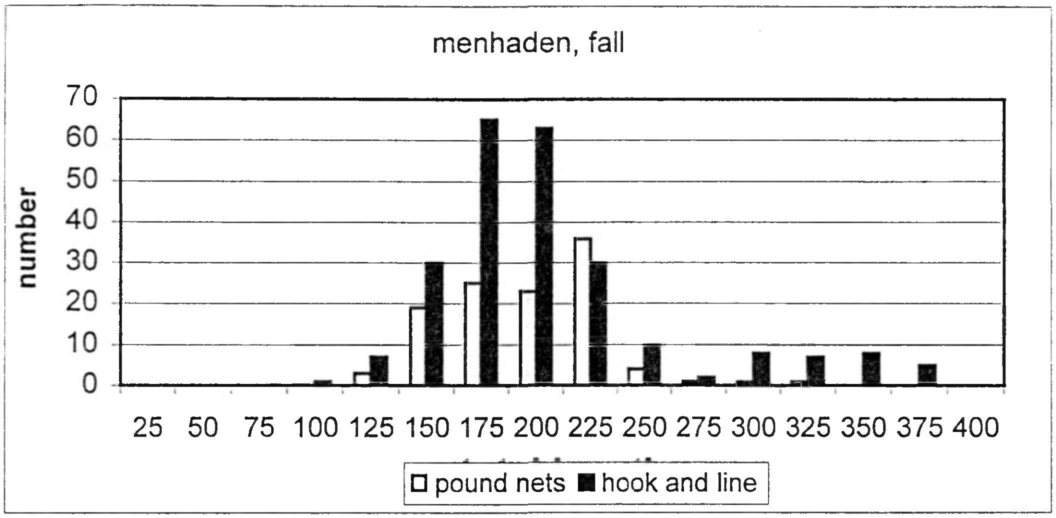
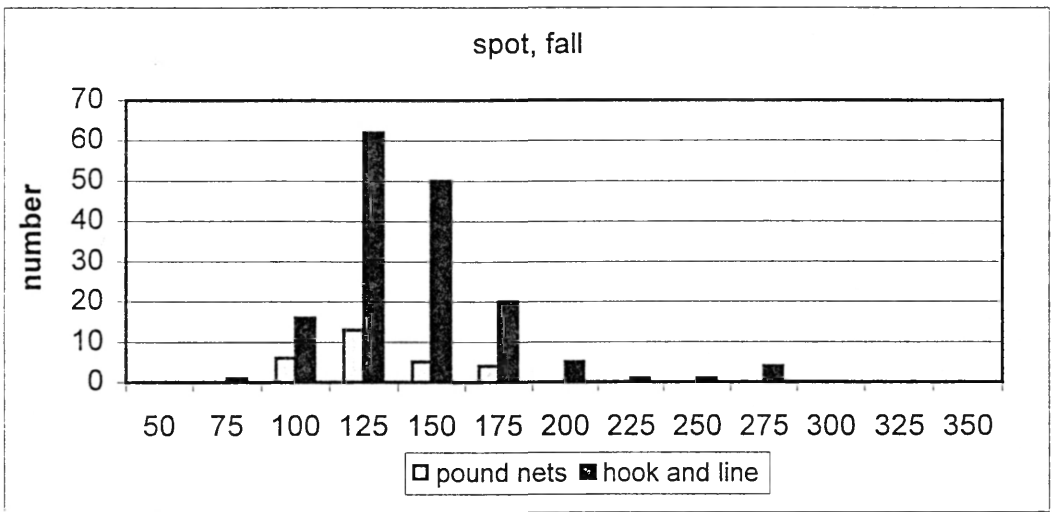

Herring
number
9
8
7
6
5
4
3
2
1
0
0
25
50
75
100
125
150
175
200
225
250
275
300
More
total length
pound
gill

**Figure 30a:** Length-frequency distributions for ingested menhaden from fall hook and line and pound net-caught striped bass. Lengths are total lengths in millimeters.

**Figure 30b:** Length-frequency distributions for ingested spot from fall hook and line and pound net-caught striped bass. Lengths are total lengths in millimeters.


menhaden, fall
70
60
50
40
30
20
10
0
number
25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400
pound nets
hook and line


spot, fall
70
60
50
40
30
20
10
0
number
50 75 100 125 150 175 200 225 250 275 300 325 350
pound nets
hook and line

**Appendix A.** Prey backbone length to total length regressions.

| Prey | Equation | $r^2$ | N |
|---|---|---|---|
| menhaden | $TL = 3.266598 * BBL^{0.869151}$ | 0.98 | 20 |
| gizzard shad | $TL = 1.947059 * BBL^{0.960142}$ | 0.99 | 33 |
| summer flounder | $TL = 1.556205 * BBL^{0.994052}$ | 0.99 | 14 |
| blueback herring | $TL = 3.504504 * BBL^{0.835559}$ | 0.95 | 27 |
| alewive | $TL = 3.360494 * BBL^{0.847415}$ | 0.97 | 22 |

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ASMFC 1995. 1995 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for striped bass. pp 32-44, *In* 1995 Annual review of interstate fishery management plans, ASMFC Spec. Rpt No. 60, (Christian, R.T., *Editor*), 128 pp.

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