View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by College of William & Mary: W&M Publish

WILLIAM & MARY
CHARTERED 1693

W&M ScholarWorks

Reports

3-2001

Food Habits of Large Striped Bass in the Lower Chesapeake Bay and its Tributaries March 1997 - May 1998

Herbert M. Austin
Virginia Institute of Marine Science

John F. Walter
Virginia Institute of Marine Science

Follow this and additional works at: https://scholarworks.wm.edu/reports

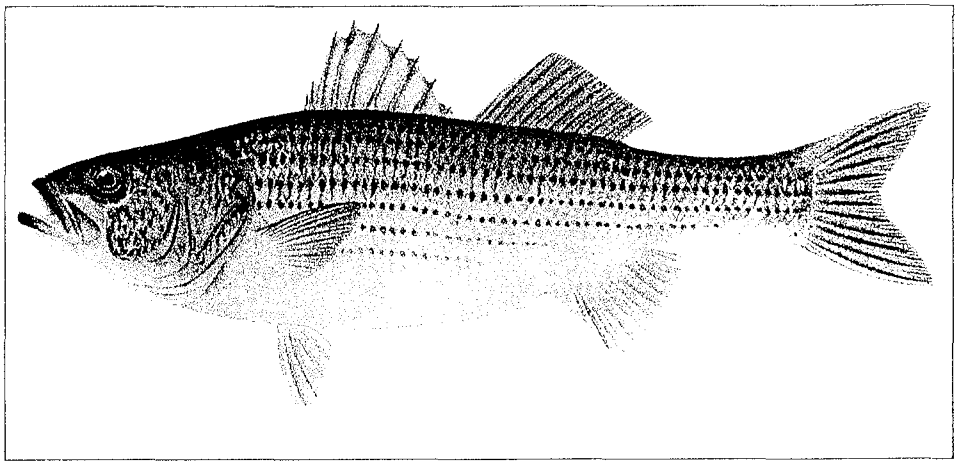
Part of the Aquaculture and Fisheries Commons

Recommended Citation

Austin, H. M., & Walter, J. F. (2001) Food Habits of Large Striped Bass in the Lower Chesapeake Bay and its Tributaries March 1997 - May 1998. Virginia Marine Resource Report No. 2001-7. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5JB2J

This Report is brought to you for free and open access by W&M ScholarWorks. It has been accepted for inclusion in Reports by an authorized administrator of W&M ScholarWorks. For more information, please contact scholarworks@wm.edu.

Food Habits of Large Striped Bass in the Lower Chesapeake Bay and its Tributaries March 1997 - May 1998



Herbert M. Austin
John F. Walter

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

A final report submitted to the
Marine Recreational Fisheries Advisory Board
and
Commercial Fisheries Advisory Board,
Virginia Marine Resources Commission

Funded by Contract Number RF-97-08 and CF-97-08

Food Habits of Large Striped Bass in the Lower Chesapeake Bay and its Tributaries

Herbert M. Austin
John F. Walter

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

A Final Report Submitted to the
Marine Recreational Fisheries Advisory Board
and
Commercial Fisheries Advisory Board,
Virginia Marine Resources Commission

Funded by Contract Number RF-97-08 and CF-97-08

Revised March 2001

Virginia Marine Resource Report No. 2001-7

This document was published by the
Virginia Sea Grant Marine Advisory Program
Virginia Institute of Marine Science
School of Marine Science
College of William & Mary
Gloucester Point, Virginia 23062

Executive Summary

Striped bass, *Morone saxatilis*, are dominant seasonal predators in Chesapeake Bay and support a large recreational and commercial fishery. This document presents the results of a yearlong (1997-1998) food habits study of large (> 450mm or 18 inches) striped bass in lower Chesapeake Bay and adjacent ocean waters. These fish comprise the coastal migratory stock and are found in greatest abundance in Chesapeake Bay during the spring and fall. Fish were obtained from a variety of commercial, recreational and fishery-independent sources and were captured by gill, fyke and pound nets as well as recreational hook and line, otter trawl and electroshocking gear.

From March of 1997 to May of 1998, stomach contents of 1,988 striped bass were examined. The frequency of occurrence, numerical abundance and weight of prey items in the stomachs were combined into an index of relative importance (IRI). This compound index identifies important food items in the diet of striped bass. Overall, menhaden, *Brevoortia tyrannus* were the dominant prey, not only in IRI but also by weight and frequency of occurrence. Menhaden became an increasingly important forage species as striped bass size increased. Anchovies were second in overall importance and first in numerical abundance. Seasonally, and at different locations, gizzard shad, spot and herring were next in importance in the diet. Blue crabs appeared infrequently in the stomachs sampled and contributed little to the overall weight of stomach contents. Other invertebrates were of lesser importance.

Two measures of stomach fullness were employed, a stomach fullness index which measures the relative fullness of the stomach, and the percent frequency of empty stomachs. The highest percentage of empty stomachs was found during the spring months of March and April and also during the summer months of August and September. The highest percentage of full stomachs and the greatest stomach fullness values were found during the fall months of October and November. Gear type, season and location partially determined the fullness of the stomachs and the percentage of empty stomachs but no single variable accounted solely for the observed differences in stomach fullness.

Table of Contents

List of Tables

List of Figures

List of Figures, continued

Introduction

The striped bass, *Morone saxatilis*, is one of the most important commercial and recreational fishes along the Atlantic coast of North America. Annual commercial landings of striped bass along the East Coast in the early 1960's and 1970's ranged from 8 million to 15 million pounds (Boreman and Austin 1984). Recreational harvests approached these levels and may have exceeded the economic value of the commercial fishery (Norton et al 1984). Though landings dropped during the mid 1970's – 80's due to declines in abundance and harvest limits, the economic impact remained significant as coast-wide estimates of the 1993 commercial fishery (6.6 million pounds) range from $53 – $ 270 million (Southwick and Teisl 1995). In Chesapeake Bay, long a center of abundance and the major juvenile producer on the East Coast (Berggren and Lieberman 1977), few fishes rival the striped bass in economic value or desirability as a recreational and commercial target species.

Beginning in the 1970's Chesapeake Bay striped bass stocks underwent a severe decline. 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 1997). The rapid decline in abundance and reproduction prompted the 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.

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-year classes in the 1980's rose to ten age classes in the mid 1990's (Shaefer and Hornick 1994). 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). There are currently more fish and more fish of a larger size in the Chesapeake system than at any time in the past 50 to 100 years. While the recent indices of spawning stock biomass and juvenile production bode well for the future, these stock increases have prompted concerns about the abundance of critical forage species, the predatory impact of striped bass upon these species and linkages of widespread disease infections to starvation in striped bass.

Ecologically, striped bass are upper-level predators, capable of foraging on a wide variety of prey organisms. As upper-level predators they feed upon prey in lower levels of the food chain such as filter-feeding menhaden and anchovies as well as other carnivores including spot and white perch. Though striped bass feed at the higher levels of the food chain, they are critically dependent upon the production of lower trophic levels. It is the production at these lower levels that determines food availability to larger predators and ultimately the carrying capacity of the system. The dramatic recovery of the Chesapeake Bay striped bass stock, and its shift to a population dominated by large fish presents a major change in the top-level predator structure from that of the 1960's and 70's. Increased numbers of large striped bass require more forage and place an increasing demand upon prey in lower trophic levels, many of which themselves weather a significant harvest.

This potential shift in trophic structure and stability motivated us to secure support for this study to determine the food habits of large, adult striped bass in Chesapeake Bay. Little data exist on the food requirements of these large fish or on their predatory impact given recent increases in abundance. As this study was drawing to a close, concerns of food limitation and subsequent linkages to *Mycobacteriosis* disease infections surfaced, increasing the importance of this study. Unlike previous studies of the food habits of striped bass in Chesapeake Bay (Hollis 1952, Hartman and Brandt 1995) and those conducted in similar estuarine systems (Trent and Hassler 1966, Schaefer 1970, Manooch 1973) this study focuses on large, adult striped bass ranging 450 – 1200 mm (18 – 48 inches) total length. These fish form the basis of the commercial and recreational fisheries as well as the spawning stock and include some resident fish (non-migratory) but mostly coastal migratory fish in Virginia. Striped bass exhibit an anadromous migration pattern whereby they ascend rivers to spawn during the spring and then descend to coastal and estuarine waters following spawning. Juveniles reside in the estuary until they reach sexual maturity between the ages of 2 and 5. At age 5, 89% of females and 75% of males leave the estuary and become coastal migrants, migrating northward up the Atlantic coast in the late spring and returning southward in the fall and winter (ASMFC 1990, Kohlenstein 1981). The objective of this study was to determine important prey items in the diet of large striped bass with respect to the location, season or method of capture and size of fish in Chesapeake Bay.

An additional objective of the study was to examine the predator-prey dynamics between striped bass and two prey species of special concern, Atlantic menhaden and the blue crab. The blue crab, *Callinectes sapidus,* has been reported by numerous authors as a consistent, although minor, component of the diet of the striped bass (Hollis 1952, Schaefer 1970, Manooch 1973). Recently, though, VIMS researchers and VMRC management staff have received anecdotal reports of striped bass "gorging" on blue crabs in the Chesapeake Bay. There has been nothing quantitative to substantiate or refute this assertion. Bigelow and Schroeder (1953) reported that the striped bass will gorge themselves and that "...When bass are gorging on any one particular prey it is common knowledge among fishermen that they are likely to ignore food of other sorts for the time being." While there have been some attempts to examine this issue by correlating indices of juvenile blue crab and bass abundance, (Mosca et al 1996) there have been no direct measurements of the significance of crabs in the diet of striped bass, or the potential impact of striped bass predation on crab stocks.

The Atlantic menhaden, *Brevoortia tyrannus*, has been consistently cited in most striped bass feeding literature as an integral part of the diet (Merriman 1941, Hollis 1952, Bigelow and Schroeder 1953, Manooch 1973, Hartman and Brandt 1995). The more recent studies (Manooch 1973 and Hartman and Brandt 1995) have shown that, at the southern end of the range, the Chesapeake Bay and Albermarle-Pamlico Sound area, the menhaden is the single most important prey species by frequency of occurrence, weight/ volume and also in nutritional value. In response to these concerns we investigated the predator-prey interactions between blue crabs and menhaden in more detail through analysis of the size and number of each prey consumed, the location and timing of predation and the relationship between stomach fullness and prey occurrences.

Materials and Methods

Collection of Fish

One thousand nine hundred and eighty-eight (1,988) striped bass were collected from March 1997 to May of 1998 from various localities in Chesapeake Bay, its tributaries and adjacent waters of the Atlantic Ocean (Tables 1 and 2). Figure 1 depicts the sampling area extending from the mouth of Chesapeake Bay northward into Maryland waters as far as Annapolis. These fish were collected with commercial hook and line, gill nets, fyke nets, pound nets, recreational hook and line and scientific electroshocking and trawling gear (Table 3). A majority of the spring-caught samples came from VIMS Anadromous fishes monitoring projects in the spawning reaches of the Rappahannock, York and James River systems (Olney 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. The spatial and temporal distribution of fish samples correspond with the peak harvesting seasons and the seasonal patterns of migration and abundance of striped bass in Chesapeake Bay. The fish ranged in total length from 157 to 1255 mm (6.2 to 49.8 inches, mean 24.2 inches) and from 0.40 to 18.71 kg in weight (0.9 to 41.2 pounds, mean 8.0 pounds) (Fig. 2).

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 the 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 found to be 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 1995).

Often only an excised stomach or filleted carcass was available thus for some fish reliable data on length and weight were not obtained. Many of the 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.

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. The empty stomach was weighed to obtain the weight of the stomach contents. The contents were then sorted and recognizable prey items were 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. For invertebrates total length or either carapace width or length was recorded. Unidentifiable mush was quantified by weight in the stomach contents but did not allow for identification.

Partially digested prey items were identified by coloration of the peritoneum, hard parts (scales, otoliths, spines, rays and distinguishing bones), and other digestion-resistant 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). Vertebrae number and precaudal to caudal vertebral counts aided in the species identification of whole vertebrae (Martin and Drewry 1978). Invertebrates were identified through microscopic examination. Prey too digested for identification to species was identified to the lowest possible taxon; either genus, family or class.

Analyses

Frequency of occurrence, number of striped bass ingesting each prey, numerical counts, and weights and number of items of each prey category were obtained. Numerical abundance provides information on the feeding behavior of the predator (Macdonald and Green 1983), weight measures the nutritional value of the prey class to the predator (Macdonald and Green 1983) and frequency of occurrence represents population-wide food habits (Cailliet 1977). Compound indices incorporate several of these measures and provide a convenient estimate of the overall contribution to the diet. An index of relative importance (IRI) was computed for individual prey items to estimate their overall contribution by number, weight and frequency to the diet (Pinkas et al, 1971, Rudershausen 1994). The index of relative importance for a particular prey category *i* (IRI_i) is expressed as:

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

where %N is the percent by number, %W is the percent by weight, and %FO is the percent frequency of occurrence. IRI values were calculated as percent IRI values (Cortes 1997).

In calculating IRI values some stomach content categories were excluded as they were not deemed to be 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 natural prey. Unidentified fish bones were labeled as unknown fish if the whole fish was present. Scales were not counted in the IRI 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.

A stomach fullness index (SFI) was calculated to determine the relative fullness of stomachs in different seasons, locations and gear types. The SFI standardizes the weight of ingested food as a percentage of the total fish weight. It was calculated according to Hureau (1969):

$$SFI = (\text{weight of stomach contents} / \text{weight of fish}) \times 100$$

SFI values were only calculated for fish with stomach contents present. For many fish only lengths were available so weights were calculated using a length-weight regression given in USFWS (1997).

Striped bass were analyzed by separating them by location, season, method of capture and size of fish. Fish were partitioned into five size classes based on total length; 200-400, 401-600, 601-800, 801-1,000 and > 1000 mm (7.9-15.7", 15.8-23.6", 23.7-31.5", 31.5-39.4" and > 39.4"). Four season categories were used with March through May-caught fish placed in spring, June through September in summer, October and November in fall and December through January in winter. The fish were also placed into one of five locations based upon the place of capture, when known. The five locations include upper rivers, lower rivers, upper Chesapeake Bay, middle Chesapeake Bay and lower Chesapeake Bay and adjacent coastal waters (Fig. 1). The upper rivers are defined as locations above river mile 20 on the James, York, Rappahannock and Potomac rivers. Lower rivers locations are from river mile 0 to mile 20 on the same rivers. Upper Chesapeake Bay includes Maryland waters and the upper Virginia part of the Bay (from 37°45' north and above). Middle Chesapeake Bay includes all open waters of the Bay from 37°10' north to 37°45' north. Lower Chesapeake Bay includes all bay and nearshore ocean waters south of 37°10' north.

Results

Overall Feeding Habits

Of the 1988 striped bass from Chesapeake Bay and adjacent coastal waters (Fig. 1) that were examined, 1044 (52.5%) contained ingested items and 988 (47.4%) were empty. Often food that was not part of the natural diet such as chum and bait was the only item present and was excluded from further analysis of the prey items. A total of 699 bass with naturally occurring food items present were included in the stomach contents analysis. Tables 1-3 depict the spatial, temporal and capture method distribution of striped bass observed and the percent of full and empty stomachs. Thirty-nine different species of fish and eighteen species of invertebrates were observed (Table 4). Menhaden was the most important prey item accounting for 43% of the weight of all prey items and occurring in 25% of the stomachs (Table 5). The %IRI for menhaden was 54%, more than all other prey items combined. Anchovies, both bay anchovy, *Anchoa mitchilli*, and striped anchovy, *Anchoa hepsetus*, were combined and were numerically the most abundant at 26.4% of all prey items. Anchovies had the second highest %IRI value at 14.8. Other species in order of %IRI were gizzard shad, *Dorosoma cepedianum*, and threadfin shad, *Dorosoma petenese*, with a combined %IRI of 10; and spot, *Leiostomus xanthurus*, with an IRI of 9.2. The anadromous herrings, blueback herring, *Alosa aestivalis* and alewive, *Alosa psuedoharengus,* had a combined %IRI value of 2.4 and blue crabs, *Callinectes sapidus*, had %IRI values of 2.1.

All other prey categories (n = 42) had %IRI values less than 2 and appeared relatively unimportant in the diet of the striped bass examined. The large number of categories demonstrates the opportunistic feeding of striped bass. Mysid shrimp, *Neomysis americana*, were numerically abundant but not by 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 higher by weight but due to low frequency of occurrence or low number had similarly low %IRI values. The prey category of unknown fish had high numerical abundance and fairly high frequency of occurrence as 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 the categories of unknown clupeid and unknown sciaenid contained backbones which only allowed identification to family and thus encompass several species of prey.

Feeding Habits by Season

There is a distinct shift in the feeding habits of striped bass across seasons. Fig. 3a-d and Tables 6a-d show the indices of relative importance for all species for each season. During the spring months gizzard shad dominated the diet with a %IRI value of 34. Anchovy was second in abundance and anadromous herrings and white perch also were important (Fig. 3a). Unknown clupeids, though not shown on Figure 3a, had a high %IRI value and probably comprised herring or gizzard shad too digested to identify to species. In the summer months of June through September, menhaden dominated the diets and herring and gizzard shad declined in importance (Fig. 3b). Blue crab (6.0%)

and white perch (5.0%) were of minor importance during this period although summer was when the blue crab made its largest contribution. Though the sample size for summer fish (n = 36) is small this trend continued into the fall (October and November) as menhaden again remained the top food item (Fig. 3c). Spot increased in importance and blue crab and anchovy remained moderately important (Fig. 3c). The greatest diversity of food items occurred in fall with forty-one different species of prey items (Table 6c). The winter months of December, January and February again had menhaden and anchovy as dominant food items with American eel, *Anguilla rostrata*, and spot of minor importance (Fig. 3d).

Feeding Habits by Location

The spatial distribution of prey items indicates a shift in feeding habits similar to that observed across seasons (Table 7a-e, Fig. 4a-e). Striped bass fed primarily on gizzard shad, anchovies, herring and white perch in the upper river areas (Fig. 4a). In these areas menhaden was fifth in importance. At the more saline lower rivers areas (Fig. 4b), menhaden again became the dominant food item along with anchovy, gizzard shad and blue crab. In these lower rivers, blue crab made their largest contribution to the diet (12%). In the open waters of the upper-bay in Maryland waters and the upper part of the Bay in Virginia (Fig. 4c), menhaden and anchovy were also dominant food items. Blue crab, American eel and spot were of minor importance. In the middle portion of the Virginia Bay waters menhaden and spot were dominant prey items (Fig. 4d). Here croaker, flounder and anchovy were of moderate importance. In the lower Bay and Bay mouth menhaden remained the dominant forage with spot, anchovy, flounder and croaker of lesser importance (Fig. 4e).

Feeding Habits by Size of Striped Bass

Figures 5a-e and Table 8a-e show differences in the feeding habits of fish by size. While no clear ontogenetic shift in diet appeared to exist, smaller prey items such as anchovy were more important in fish of smaller sizes. Anchovy was the most numerous prey item in fish of the 200-400 mm (8-16") and the 400-600 mm (16-24") size range (Fig. 5a and 5b). For fish in the 400-600 mm size range anchovy had the highest IRI value of 35.3 (Table 8b). Menhaden were second in importance. Invertebrates, including blue crabs, mysid shrimp, mantis shrimp and polychaetes had low IRI values and appeared to be of little importance in fish of these size ranges. As fish increased in size, menhaden increased in importance, having IRI values greater than all other prey categories combined for fish between 600 and 1200 mm (24-48") (Fig. 5c-e and Tables 8c-e). Spot, gizzard shad and American eel appeared next in importance in these upper size ranges and other prey categories were of very little importance. As will be discussed in more detail, larger bass preyed on larger menhaden, and as bass exceeded 750 mm (30") few blue crabs were encountered.

Stomach Fullness Analysis

Overall, 1044 of 1988 (52.5%) fish had stomach contents. When fish from spawning areas were excluded from analysis, the percentage of stomachs with food present rose to 72.2%. Monthly changes in both stomach fullness index and the percentage of full stomachs indicated seasonal variation in feeding intensity (Fig. 15, Table 2, 9). Stomach fullness values were highest in June and in October and November and lowest in March-April and in August and September. Percentages of full stomachs correlated significantly with these results ($r=0.29$, $p<0.038$, $df = 14$) as June had the highest percentage of full stomachs (88.1%) and March, April, August and September the lowest.

Stomach fullness indices differed between locations though these differences generally were attributable to the decline in feeding intensity during the spring spawning migration (Table 9). The low SFI values for fish captured in the upper bay (1.43) were from fish caught in August and September, when fullness values were already low. When the percentage of full stomachs were shown by location, only 237 of the 870 fish (27.2%) from upriver spawning locations were full (Table 1). The highest percentage of full stomachs was found in the lower rivers (80.3%) and lower Bay (76.1%) though there was generally little variation between locations in the percentage of full stomachs. The percentages of full stomachs and the stomach fullness values must be taken with some reservation as both are influenced by capture methodology and seasonal variation in feeding intensity.

As not all gear types were equally represented across time and location this makes gear comparisons of stomach fullness difficult (Table 3). It does appear that fish taken in pound nets and gill nets in the spring had low percentages of full stomachs while those taken from similar gear in different locations in the fall had higher percentages of full stomachs (Table 3). Over 90% of fish captured in pound nets in the fall had full stomachs. These fish also had the highest stomach fullness index (5.04) indicative of net feeding (Table 11). The only other fish that approached these percentages of full stomachs were from fish captured by chumming (86.8%), casting (83.3%) and trawling (81.8%).

Analysis of Blue Crabs and Menhaden

Blue crabs were found in the stomachs of 66 striped bass, or 9.4 % of those with stomach contents. The average crab that was consumed measured 41 mm (1.6"), and ranged from 11 mm to 150 mm (Figure 6). A total of only 10 crabs over 50 mm were taken and all crabs above 65 mm (2.6") were soft crabs or broken shells. Smaller crabs (<25-30 mm, 1") were most common during March through May, and again in October. Crabs were most common in the diet (IRI%=12) of fish from the lower reaches of the James, York and Rappahannock Rivers and in the Maryland section of the Bay, and least abundant in the lower and middle Bay in Virginia and in upper reaches of the rivers. Most fish contained only one crab (N = 45), and only four had consumed more than four crabs, two of which (532 and 565 mm) had consumed 16 (Fig. 7). Whenever more than four crabs were consumed they were small juveniles (<25 mm, 1") from the lower rivers usually in October. Striped bass 450-600 mm (18-24") consumed the most crabs, and as bass size increased above 750 mm (30") the frequency of ingested crabs decreased.

There was no statistical relationship between the stomach fullness index (SFI) and the size of striped bass when crabs were part of the diet (Fig. 8). The fullness indices however, were only over 1.0 when fish were 500 to 725 mm (20-28.5"). No fish over 750 mm (30") that contained crabs had an index of more than 0.75. The SFI was, with one exception, always over 1.0 when the crabs were larger than 50 mm (2"). When the crabs were less than 50 mm the SFI ranged from <0.10 to just over 0.50.

Bass that had blue crabs in their stomachs generally had nothing else (N = 27), or had other benthic invertebrates (e.g. mantis shrimp, *Squilla*) or spot (N = 17). In only a few cases did stomachs with blue crabs also contain pelagic fish (N = 8) such as anchovies or menhaden. The rest were unidentified contents.

One hundred seventy-seven (177) striped bass ranging in size from 337 – 1117 mm (13 – 44 inches) had consumed menhaden, not considered to be chum. This represents 8.6 % of the total striped bass examined, and 25.3% of those with stomach contents. Most of the time (Fig. 9) only one menhaden was present. There was a relation between the size of the prey and the number of prey in a stomach (Fig. 10). Prey with a backbone length of 75-125 mm (3-5") were most common as multiple prey with up to 8-10 prey/bass. Prey over 150 mm (6") were never more frequent than 4/bass; and once over 200 mm (8") they were only encountered as single prey. Small menhaden were found during all months, although they were most common from October to December; and larger prey (> 150 mm) were normally only encountered after September. Considered in combination, menhaden was the dominant prey, particularly in the middle and lower reaches of the Bay during the fall months October to December (Fig. 11 and 12).

Manooch (1973) examined the relation between the relative length of forage fishes taken by striped bass in the Albemarle Sound, NC and the length of the bass. He found large striped bass are capable of ingesting fish up to 60% of their body length. We found that although a striped bass may be capable of ingesting menhaden 40-55% their own body length, it was rare that the menhaden forage exceeded 25% of the bass length. (Fig. 13). There was, however, a statistically significant relation between the total length of the bass and the vertebral length of the menhaden ($p = .0001$, R-Sq = 43.6%) (Fig. 14). A similar relation was found for striped bass TL and menhaden TL. Generally, only bass over 1000 mm (39") consumed menhaden over 300 mm (12").

There was no relationship between striped bass size and the stomach fullness index (SFI) when menhaden were consumed. Generally the index averaged 2.39 and ranged from 0.11 to 11.20 (SD = 2.6). There was also no relationship between the index and the size of the menhaden. Conversely the SFI was higher than the average when crabs were the primary component (Avg. Crab SFI = 0.74).

Discussion

At all locations, over all seasons, and throughout the size range of adult striped bass, schooling pelagic fishes dominated diets in Chesapeake Bay. In particular, clupeoid fishes (menhaden, gizzard shad) and the closely-related anchovies exceeded all other prey species in frequency of occurrence, number and biomass. Among other fishes, only spot rivaled the clupeiods in overall importance. Clupeids and anchovies are very abundant year round in all waters of the Chesapeake Bay from freshwater tributaries to near-shore ocean waters. Similarly, their schooling tendencies, silvery bodies, soft fin rays and high energy content may make them desirable prey. Cummins and Wuycheck (1971) determined that clupeid fishes contained 6360 calories per gram of dry body weight while most other fish averaged 5086 cal/g of dry weight. Decapod crustaceans (crabs and shrimp), on the other hand, contained only 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 switch to abundant small sunfish, small bass or invertebrate prey. It is likely that the overall abundance and schooling tendencies of clupeiod prey account for their importance in the diet of striped bass in Chesapeake Bay.

The predominance of fish found in the diet of adult striped bass attests to their piscivorous nature, an observation corroborated by numerous other studies which found fish to be the major component of the diet. (Manooch 1973, Hollis 1952). While invertebrates are most important in the diet of juvenile and sub-adult bass (< age 2) (Markle and Grant 1970, Hartman and Brandt 1995) they did not appear important to the larger fish we sampled. This study focused on fish in larger size ranges than previous studies so it is possible that the shift away from benthic crustaceans to schooling fish may be ontogenetic. Blue crabs were consistently encountered in the samples but in low numbers and weight, resulting in low relative importance. Juvenile (25-30 mm, 1") blue crabs may be seasonally important in certain areas such as grass beds and shallow waters of the lower rivers, particularly for mid-sized bass 450-600 mm (18-24"), though these areas were not well sampled by conventional harvesting gear and probably are not primary foraging areas for larger-sized (>750 mm, 30") striped bass. Based upon the results of this single-year study, the low numbers of blue crabs found in stomachs does not warrant concern that the bass are adversely impacting the crab stock, though more directed studies of striped bass predation in specific habitats may be necessary. In addition it does not appear that blue crabs contribute significantly to diet the large striped bass diet based upon their frequency of occurrence and biomass.

Other invertebrates (mantis shrimp, penaeid shrimp, grass shrimp and mysids) were commonly found but also contributed little by weight or number to the diet. Both Manooch (1973) and Hollis (1952) found fish to be major items in the diet, though Shaeffer (1970), sampling in the Long Island surf, noted a summer predominance of invertebrate prey. It should also be noted that the blue crab was neither common in Long Island during the 1960's or early 1970's, nor is it ever common in the surf. Striped bass were not sampled in surf zone environments for this study and geographic differences or interannual fluctuations in abundance may account for the variability observed between this and other studies.

Hartman and Margraf (1995) and Gardinier and Hoff (1982) observed an ontogenetic shift from invertebrate to vertebrate prey in the diet of striped bass. They reported that striped bass less than 200 millimeters total length fed mainly upon invertebrates and shifted to fish as they grew larger. This study sampled size ranges larger than 200 mm and found no shift from invertebrate to vertebrate prey. In the size range of fish we sampled (157 to 1255 millimeters, most 450-800 mm) most fish had become predominately piscivorous. There is a shift in the relative importance of smaller schooling fishes (spot and anchovies) in smaller bass (<600 mm) to larger schooling fish (menhaden, gizzard shad) in larger striped bass. This shift appears simply to be larger fish choosing larger prey, though the prey remains a pelagic schooling-type fish. For menhaden this trend is evident in the significant relationship between striped bass total length and vertebral length of ingested menhaden. Other studies which sampled fish in smaller size ranges (200-600mm) found anchovies also to be dominant food items (Manooch 1973, Hartman and Margraf 1995) for fish of those sizes.

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 spring dominance of gizzard shad, herring and white perch corresponds to the 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 herring are anadromous migrants. Trent and Hassler (1966) found that migrating striped bass in the Roanoke River, NC also fed upon anadromous herrings and gizzard shad. Spring-caught fish from the lower more saline sections of the rivers consumed anchovies, blue crabs and menhaden; prey more abundant in these areas. Hollis (1952) also observed that anchovy, menhaden and anadromous herrings were the predominant food items in the lower rivers during the spring.

During the late spring and summer most large striped bass migrate out of the Bay and rivers and up the Atlantic Coast (Kohlenstein 1981). Smaller resident and juvenile striped bass remain and these fish were not generally sampled in this study. The few summer stomach samples from the middle and upper region of Chesapeake Bay indicate that menhaden were the predominant food item. This contrasts with the findings of Hollis (1952) who observed anchovy to be the dominant food item in summer-caught fish.

Large striped bass return to the Bay in mid-fall and winter and 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 summer fishes (e.g. spot and croaker) are leaving the Bay thus making them easy prey for returning striped bass. Late summer and fall also are the periods of the greatest fish 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 that were not found in other months. These included penaeid shrimp, majorras, white mullet, inshore lizard fish and Atlantic needlefish. Menhaden, anchovies, spot, blue crabs and gizzard shad remained the most important prey species during the fall months.

During the winter months of December, January and February, menhaden, spot and anchovies were forage. Striped bass in the 450-600 mm size range have the overall greatest diversity in the diet, and the largest fish, >1000 the least diversity.

The low SFI values and the low numbers of full stomachs observed in this study indicate that striped bass apparently 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 higher than the percentages of full stomachs found in March and April on the spawning grounds in this study. During the spring spawning migration there is an abundance of both resident fish (gizzard shad) and anadromous herrings and white perch in the upper reaches of the rivers. Prey supply is high but apparently striped bass are not feeding as actively as at other times. Most striped bass were in a prespawning or spawning condition which may explain the low feeding intensity. While striped bass decrease feeding intensity during the 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.

Striped bass appear to resume feeding heavily after spawning and some were observed to migrate further upstream above their own spawning grounds where they fed on spawning river herring. Most striped bass, however, rapidly leave the rivers and migrate into coastal waters. The increase in the percentages of full stomachs and in stomach fullness values for May and June indicate a resumption of high feeding activity.

The reduction in feeding observed in August and September suggests that some external factor might lead to decreased consumption. The fish caught in August and September were smaller Bay-resident fish (450-600 mm, 18-24 inches) captured during the Maryland recreational striped bass season. At this time, water temperatures are high and striped bass may be thermally stressed and spatially confined by areas of low dissolved oxygen to certain thermal niches and feeding areas (Coutant and Benson, 1990). 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-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). The 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.

The middle and lower Bay and the lower rivers had high percentages of full stomachs and fairly high stomach fullness values. Only the upper bay fish had low fullness values and low percentages of full stomachs. These fish were captured during the August-September period of low feeding intensity and it is likely that the fact that season rather than the location had more effect on the feeding intensity. The upper rivers, likewise, had low SFI values and low percentages of full stomachs but fish were only obtained from these areas in the spring during the spawning period.

When stomach fullness was examined by gear type we found that pound nets in the spring, gill nets and fyke nets had low percentages of full stomachs. Most methods of hook and line fishing and trawling had higher percentages of full stomachs. The stomach fullness index values support these findings but indicate a distinct shift among seasons and locations. When plotted by gear and season, stomach fullness indices were lowest for spring pound and gill nets and highest for fall pound and gill nets. This indicates that fish may feed actively in pound nets in the fall and may not feed actively in the nets in the spring likely because of the high abundance of forage fish in the nets in the fall. This "net feeding" behavior complicates stomach content analysis and appears to be dependent upon the season or location of capture. 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 and stomach fullness alone. 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. This may result in an upward bias in stomach fullness for passive gears.

Conclusions

1. Large, >800 mm (31") striped bass fed on large 200-300 mm (8-12") menhaden in the Bay during fall, and adult gizzard shad, white perch and alosines up-river during the spring spawning season.

2. Mid-size bass, 400-800 mm (16-31") fed on a diversity of invertebrates and forage fish; and when resident in the Bay through the summer, primarily on smaller menhaden, anchovy and spot.

3. Blue crab was not an important dietary component for larger striped bass during 1997. When consumed, they were generally taken in lower rivers by mid-sized striped bass. Most crabs were 25-30 mm (1").

4. Menhaden was the single most important forage species in the Chesapeake Bay, particularly for bass 400-600 mm (16-24") and over 800 mm.

5. Striped bass fed while on the spawning ground though feeding intensity was greatly reduced. Feeding intensity also was reduced in the late summer.

Acknowledgements

We would like to acknowledge the Virginia Recreational Fishing Advisory Board and the Virginia Commercial Advisory Board for funding project number RF-97-08 and CF-97-08. We would also like to thank the many recreational fishermen, charter captains and cutting houses who provided fish for the project. In particular we would like to acknowledge Captains Choice Seafood, C. W. O'Biers Seafood and Monarch foods for allowing us access to fish, Captains Jim Brincefield, Danny Crabbe, Herb Gordon, Walter Harrow, Joe Schwartz, and Steve and Mark Wray for providing us with fish samples and the many recreational fishermen and women of the Peninsula Saltwater Sportfishing Association, the Tidewater Anglers Club and the Virginia Beach Anglers club. Without the participation of these recreational and commercial fisherman this project could not have been completed. We would also like to thank the Anadromous fishes research staff under the direction of Dr. John Olney and the juvenile finfish trawl survey of the Virginia Institute of Marine Science for providing specimens.

References Cited

ASMFC 1993. 1993 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for striped bass, *In* 1993 Annual review of interstate fishery management plans, ASMFC Spec. Rpt No. 60, (Christian, R.T., *Editor*), 128 pp.

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.

Austin, H. M., Colvocoresses, J. A., and T. C. Mosca, III. 1992. Develop a Chesapeake Bay-wide young-of-the-year striped bass index. Final Rpt. to Ches. Bay Stock Assess. Comm., 52 pp + Appendix.

Austin, H. M., A. D. Estes, and D. M. Seaver. 1998. Estimation of juvenile striped bass relaltive abundance in the Virginia portion of Chesapeake Bay, Ann. Prog. Rpt. USF&WS PRP F87R4. 30 pp.

Berggren, T. J. and J. T. Lieberman. 1977. Relative contribution of Hudson, Chesapeake and Roanoke striped bass, *Morone saxatilis*, stocks to the Atlantic Coast fishery. U. S. Fishery Bulletin. 76: 335-342.

Bigelow and Schroeder. 1953. <u>Fishes of the Gulf of Maine</u>, Bull. Fish & Wildlife Serv., Vol. 53, 569 pp.

Brandt, S. B., and J. Kirsch. 1993. Spatially explicit models of Striped Bass growth potential in Chesapeake Bay. Trans. Am. Fish. Soc. 122:845-869.

Cailliet. G. M. 1977. Several approaches to the feeding ecology of fishes. p 1-13. – In C. Simenstad and S. Lipovsky (eds.) 1st Pacific Northwest Technical Workshop Fish Food Habits studies. Gutshop 1976.

Cortes, E. 1995. A critical review of methods of studying fish feeding based on analysis of stomach contents: an application to elasmobranch fishes. Can. J. Fish Aquat. Sci. 54: 726-738.

Coutant, C. C. and D. L. Benson. 1990. Summer habitat suitability for striped bass in Chesapeake Bay: reflections on a population decline. Trans. Am. Fish. Soc. 119:757-778.

Cummins, K. W. and J. C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Internationale Vereinigung for Theoretische und Angewandte Limnologie. Mitteilung No. 18.

Gardinier, M., and T. Hoff. 1982. Diet of striped bass in the Hudson River Estuary. New York Fish and Game Journal. 29:152-165.

Hartman, K. and S. Brandt. 1995. Trophic resource partitioning, diets and growth of sympatric estuarine predators. Transactions American Fish Soc. 124:520-537.

Hartman, K. and S. Brandt. 1995b. Predatory demand and impact of striped bass, bluefish and weakfish in the Chesapeake Bay: applications of bioenergetics models. Can. J. Fish. Aquat. Sci. 52: 1667-1687.

Hollis, E. H. 1952. Variations in the feeding habits of the striped bass, *Roccus saxatilis*, in Chesapeake Bay., Bul. Bingh. Oceanogr. Coll. 14(1):111-131.

Hureau, J. C. 1969. Biologie comparee be quelques poissons anarctiques (Nothotheniidae) Bull. Inst. Oceangr. Monaco 68, 1-44. - in J. Berg. 1979. Discussion of Methods of Investigating the food of fishes with reference to a preliminary study of the prey of Gobiusculus flavescens. Marine Biology 50, 263-273.

Kohlenstein, L. C. 1981. On the proportion of the Chesapeake Bay stock of striped bass that migrates into the coastal fishery. Transactions of the Amerian Fisheries Society. 110:168-179.

Macdonald, J. S. and R. H. Green. 1983. Redundancy of variables used to describe importance of prey species in fish diets. Can. J. Fish Aquat. Sci. 40:635-637.

Manooch, C. S. III. 1973. Food habits of yearling and adult striped bass, *Morone saxatilis*, from Albemarle Sound, North Carolina, Ches.. Sci. 14(2):73-86.

Markle, D. and G. Grant. 1970. The summer food habits of young-of-the-year striped bass in three Virginia rivers. Chesapeake Science. 11:50-54.

Martin, F. D. and G. E. Drewry. 1978. Development of fishes of the Mid-Atlantic Bight. USDOI Biological services program. FWS/OBS-78/12. Volumes I-VI.

Mathews, W., L.G. Hill, D. Edds, J. Hoover, and T.G. Heger. 1988. Trophic ecology of striped bass, *Morone saxatilis*, in a freshwater reservoir (Lake Texoma, USA). J. Fish Biol. 33:273-288.

Merriman, D. 1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic coast. Fish. Bull. U.S. Fish and Wildl. Serv., 50(35):1-77.

Mosca, T. III, P.J. Rudershausen and R. N. Lipcius. 1996. The potential for population regulation in the blue crab by striped bass: Do predator and prey abundances correlate in Chesapeake Bay? Va. J. Sci., 46(4):249-258.

Norton, V., T. Smith and I. Strand. 1984. Stripers: The economic value of the Atlantic Coast commercial and recreational striped bass fisheries. MD Seagrant publications # UM-SG-TS-83-12.

Loesch, J. Olney, J. E., R.E. Harris, Jr. J. S. Davis, P. W. Sadler, B. G. Darouse, J. D. Goins and J. C. Owens.1997. Evaluation of striped bass stocks in Virginia: tagging and monitoring studies. Annual Report 1996/1997. F-77-R-10. Virginia Institute of Marine Science.

Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna and bonita in California waters. Fish. Bull. Calif. 152: 1-105.

Rudershausen, P. 1994. Food, feeding and length-weight relationships of young-of-the-year striped bass, *Morone saxatilis*, and young of the year white perch, *Morone americana*. A thesis to SMS/VIMS, College of William and Mary, 118 pages.

Schaefer. R. 1970. Feeding habits of striped bass from the surf waters of Long Island. N.Y. Fish and Game J., 17(1):1-17.

Shaefer, R. K. and H. T. Hornick. 1994. Striped bass spawning stock assessment in Maryland waters. In: USDOC and USDOI. 1994. Striped bass study annual workshop abstracts, 1994. Washington, DC.

Southwick, R. and M. Tiesl. 1995. Economic impact study for the Atlantic States Marine Fisheries Commission striped bass fishery management plan. ASMFC, Washington, D. C. 25 p.

Stevens, 1969. (Comments on page 295, Session IV discussion). In: Predator-prey systems in fisheries management (H. Clepper, ed.). Washington, DC: Sport Fishing Institute.

Trent, L. and W. Hassler. 1966. Feeding habits of adult striped bass, *Roccus saxatilis*, in relation to stages of sexual maturity. Chesapeake Science. 7:189-192.

Wahl, D. H. and R. A. Stein. 1988. Selective predation by three esocids: the role of prey behavior and morphology. Tran. Am. Fish. Soc. 117:142-151.

USFWS. 1997. Investigation of striped bass in Chesapeake Bay, 1995-1996. Federal Aid project, F-42-R-9. Maryland Fisheries Service, MdDNR.

Table 1. Geographic distribution of striped bass stomach samples.

Location	Number full	Total	Percent Full
Upper rivers	237	870	27.2%
Lower rivers	236	294	80.3%
Upper Bay	242	382	63.4%
Middle Bay	44	60	73.3%
Lower Bay	191	251	76.1%
Unknown	94	131	71.8%
All locations	**1044**	**1988**	**52.5%**

Table 2. Temporal distribution of striped bass stomach samples.

Month	Number full	Total Number	Percent full
Mar-97	30	219	13.7%
Apr-97	142	486	29.2 %
May-97	20	23	87.0%
Jun-97	126	143	88.1%
Aug-97	6	38	15.8%
Sep-97	30	91	33.0%
Oct-97	320	426	75.1%
Nov-97	173	230	75.2%
Dec-97	58	70	82.9%
Jan-98	7	9	77.8%
Feb-98	9	14	64.3%
Mar-98	63	115	54.8%
Apr-98	36	80	45.0%
May-98	13	31	41.9%
Unknown	11	13	84.6%
Totals	**1044**	**1988**	**52.5%**

Table 3. Striped bass stomach sample distribution by gear type.

Gear type	Number full	Total	Percent full
Pound net (all seasons)	250	523	47.8%
Spring pound net	174	440	39.5%
Fall Pound nets	76	83	91.6%
Gill net (all seasons)	148	366	40.4%
Spring gill nets	132	328	40.2%
Fall gill nets	15	29	51.7%
Fyke net	53	128	41.4%
Hook and line, unknown	133	199	66.8%
Hook and line, chumming	197	227	86.8%
Hook and line, trolling	138	270	51.5%
Hook and line, casting	40	48	83.3%
Trawl	9	11	81.8%
Electroshock	10	17	58.8%
Commercial gear, unknown	107	141	75.9%
Unknown gear	56	79	70.9%

Table 4. List of common and scientific names of prey species.

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 majorra	*Eucinostomus argenteus*
Silver perch	*Bairdiella chrysura*
Shiner species	*Notropis spp.*
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*
Invertebrates	
Eastern oyster	*Crassostrea virginica*
Blue crab	*Callinectes sapidus*
Other blue crab species	Genus *Callinectes*
Bay opossum shrimp	*Neomysis americana*
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 Polychaete
Redbeard sponge	*Microciona prolifera*
Ornate worm	*Amphitrite ornata*
Rock crab	*Cancer irroratus*
Sand shrimp	*Crangon septemspinosa*
Snail	Class Gastropoda
White shrimp	*Peneaus setiferus*

Table 5. Stomach contents of striped bass, *Morone saxatilis*, from Chesapeake Bay, 1997-1998 (n = 901; total number of stomachs with contents). Index of relative importance (IRI) is calculated with only those items deemed of natural food value (n = 699)

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	177	25.32	465	18.24	20384.81	42.22	54.38
Alosa sp.	37	5.29	66	2.59	4965.83	10.29	2.42
Dorosoma sp.	86	12.30	225	8.82	6791.45	14.07	10.00
Clupeidae	46	6.58	58	2.27	236.17	0.49	0.65
Moronidae							
Morone saxatilis	3	0.43	3	0.12	446.66	0.93	0.02
Morone americana	53	7.58	68	2.67	1767.28	3.66	1.70
Sciaenidae							
Leiostomus xanthurus	108	15.45	214	8.39	4070.41	8.43	9.23
Bairdiella chrysura	14	2.00	19	0.75	214.41	0.44	0.08
Cynoscion regalis	17	2.43	22	0.86	1094.16	2.27	0.27
Micropogon undulatus	20	2.86	20	0.78	2084.78	4.32	0.52
Unknown scieanid	16	2.29	28	1.10	117.53	0.24	0.11
Engraulidae							
Anchoa spp.	107	15.31	672	26.35	436.56	0.90	14.82
Other fish							
Paralichthys dentatus	18	2.58	32	1.25	2278.65	4.72	0.55
All silversides	17	2.43	48	1.88	73.78	0.15	0.18
Anguilla rostrata	11	1.57	22	0.86	591.29	1.22	0.12
Symphurus plagiusa	9	1.29	39	1.53	117.57	0.24	0.08
Peprilus triacanthus	8	1.14	16	0.63	476.61	0.99	0.07
Urophycis regia	4	0.57	27	1.06	420.31	0.87	0.04
Notropis sp.	6	0.86	6	0.24	15.54	0.03	0.01
Trinectes maculatus	5	0.72	6	0.24	31.41	0.07	0.01
Pomatomus saltatrix	3	0.43	3	0.12	184.21	0.38	0.01
Eucinostomus argenteus	3	0.43	3	0.12	39.92	0.08	0.00
Gobiosoma bosci	2	0.29	6	0.24	1.42	0.00	0.00
Synodus foetens	2	0.29	2	0.08	68.54	0.14	0.00
Strongylura marina	1	0.14	3	0.12	67.96	0.14	0.00
Scopthalmus aquosus	2	0.29	2	0.08	22.08	0.05	0.00
Mugil curema	1	0.14	1	0.04	36.08	0.07	0.00
Opisthonema oglinum	1	0.14	1	0.04	11.89	0.02	0.00
Sphoeroides maculatus	1	0.14	1	0.04	4.80	0.01	0.00
Hypsoblennius hentzi	1	0.14	1	0.04	4.15	0.01	0.00
Fundulus heteroclitus	1	0.14	1	0.04	3.39	0.01	0.00
Unidentified fish remains	76	10.87	112	4.39	312.30	0.65	1.95
Class Crustacea							
Callinectes sapidus	66	9.44	132	5.18	498.83	1.03	2.08
Neomysis americana	15	2.15	110	4.31	12.58	0.03	0.33
Squilla empusa	23	3.29	39	1.53	213.67	0.44	0.23
Ovalipes ocellatus	15	2.15	17	0.67	106.75	0.22	0.07
Lironeca ovalis	10	1.43	10	0.39	0.85	0.00	0.02
Callinectes sp.	4	0.57	7	0.27	28.83	0.06	0.01

Peneaus setiferus	5	0.72	5	0.20	12.99	0.03	0.01
Crangon septimspinosa	5	0.72	11	0.43	3.71	0.01	0.01
Paleomonetes pugio	4	0.57	9	0.35	2.24	0.00	0.01
Olencira praegustator	1	0.14	1	0.04	0.00	0.00	0.00
Cancer irroratus	1	0.14	1	0.04	7.73	0.02	0.00
Upogebia affinis	1	0.14	1	0.04	0.59	0.00	0.00
Xanthid crabs	1	0.14	1	0.04	3.52	0.01	0.00
Class Bivalvia							
Mytilus edulis	*	*	2	*	*	*	**
Crossostrea virginica	*	*	2	*	*	*	**
Class Gastropoda							
All gastropods	1	0.14	1	0.04	0.39	0.00	0.00
Class Polychaeta							
All polychaetes	8	1.14	8	0.31	11.37	0.02	0.01
Class Hydrozoa							
All hydroids	4	0.57	4	0.16	0.00	0.00	0.00
Phylum porifera							
All sponges	1	0.14	1	0.04	2.29	0.01	0.00
Miscellaneous items							
Chum (ground menhaden)	*	*	159	*	*	*	**
Bait (cut menhaden, 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 6a. Number, weight, frequency of occurrence and %IRI for spring. N = 263

Prey item	number	% number	weight	% weight	frequency	% frequency	%IRI
gizzard shad	121	13.34	5627.99	42.34	70	26.62	33.80
anchovy	395	43.55	318.61	2.40	51	19.39	27.94
unknown clupeid	47	5.18	221.89	1.67	38	14.45	9.51
herring	61	6.73	4595.45	34.57	34	12.93	8.02
white perch	42	4.63	1272.55	9.57	34	12.93	7.61
unknown fish	39	4.30	121.54	0.91	30	11.41	5.96
blue crab	26	2.87	109.85	0.83	20	7.60	2.65
menhaden	31	3.42	414.38	3.12	19	7.22	2.47
mysid shrimp	87	9.59	10.20	0.08	11	4.18	1.31
cyprinid	6	0.66	15.54	0.12	6	2.28	0.23
polychaete	5	0.55	0.25	0.00	5	1.90	0.16
spot	9	0.99	113.98	0.86	4	1.52	0.12
croaker	3	0.33	174.48	1.31	3	1.14	0.06
flounder	3	0.33	7.51	0.06	3	1.14	0.06
spotted hake	25	2.76	232.19	1.75	2	0.76	0.06
mantis shrimp	2	0.22	17.09	0.13	2	0.76	0.03
american eel	1	0.11	22.64	0.17	1	0.38	0.01
butter fish	1	0.11	12.72	0.10	1	0.38	0.01
hogchoker	1	0.11	3.68	0.03	1	0.38	0.01
unknown sciaenid	1	0.11	0.41	0.00	1	0.38	0.01
fish gill isopod	1	0.11	0.02	0.00	1	0.38	0.01

Table 6b. Number, weight, frequency of occurrence and %IRI for summer. N = 36

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	25	29.07	2014.28	78.97	14	38.89	88.68
blue crab	15	17.44	227.04	8.90	7	19.44	5.67
white perch	12	13.95	236.00	9.25	8	22.22	5.30
anchovy	23	26.74	6.01	0.24	4	11.11	0.19
herring	1	1.16	39.25	1.54	1	2.78	0.09
spot	1	1.16	24.74	0.97	1	2.78	0.05
unknown fish	3	3.49	1.92	0.08	2	5.56	0.01
silversides	1	1.16	1.43	0.06	1	2.78	0.00
fish gill isopod	4	4.65	0.17	0.01	4	11.11	0.00
sand shrimp	1	1.16	0.10	0.00	1	2.78	0.00

Table 6c. Number, weight, frequency of occurrence and %IRI for fall. N = 313

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	349	29.13	13284.94	53.48	123	39.30	71.28
spot	183	15.28	3142.18	12.65	92	29.39	18.02
blue crab	89	7.43	151.52	0.61	37	11.82	2.09
anchovy	97	8.10	3.12	0.01	36	11.50	2.05
unknown fish	53	4.42	179.60	0.72	32	10.22	1.16
gizzard shad	89	7.43	989.37	3.98	13	4.15	1.04
flounder	25	2.09	2120.16	8.53	12	3.83	0.89
croaker	15	1.25	1754.43	7.06	15	4.79	0.87
mantis shrimp	36	3.01	182.05	0.73	21	6.71	0.55
weakfish	19	1.59	852.26	3.43	14	4.47	0.49
silversides	45	3.76	68.41	0.28	15	4.79	0.42
unknown sciaenid	26	2.17	116.89	0.47	14	4.47	0.26
silver perch	17	1.42	149.45	0.60	12	3.83	0.17
butterfish	15	1.25	463.88	1.87	7	2.24	0.15
tonguefish	34	2.84	54.50	0.22	7	2.24	0.15
lady crab	14	1.17	86.08	0.35	12	3.83	0.13
striped bass	3	0.25	446.66	1.80	3	0.96	0.04
unknown clupeid	9	0.75	13.37	0.05	6	1.92	0.03
white perch	6	0.50	109.56	0.44	4	1.28	0.03
mysid shrimp	13	1.09	0.96	0.00	3	0.96	0.02
grass shrimp	9	0.75	2.23	0.01	4	1.28	0.02
blue crab species	7	0.58	28.83	0.12	4	1.28	0.02
spotted hake	2	0.17	188.11	0.76	3	0.96	0.02
white shrimp	5	0.42	12.99	0.05	5	1.60	0.02
fish gill isopod	5	0.42	0.66	0.00	5	1.60	0.01
hogchoker	4	0.33	22.47	0.09	3	0.96	0.01
majorra	3	0.25	39.92	0.16	3	0.96	0.01
bluefish	2	0.17	101.03	0.41	2	0.64	0.01
lizard fish	2	0.17	68.54	0.28	2	0.64	0.01
american eel	2	0.17	62.79	0.25	2	0.64	0.01
sand shrimp	4	0.33	1.29	0.01	2	0.64	0.00
atlantic needlefish	3	0.25	67.96	0.27	1	0.32	0.00
polychaete	2	0.17	0.35	0.00	2	0.64	0.00
white mullet	1	0.08	36.08	0.15	1	0.32	0.00
atlantic thread herring	1	0.08	11.89	0.05	1	0.32	0.00
windowpane	1	0.08	7.66	0.03	1	0.32	0.00
northern puffer	1	0.08	4.80	0.02	1	0.32	0.00
feather blenny	1	0.08	4.15	0.02	1	0.32	0.00
mud crab	1	0.08	3.52	0.01	1	0.32	0.00
mummichog	1	0.08	3.39	0.01	1	0.32	0.00
bryozoan	1	0.08	2.29	0.01	1	0.32	0.00
mud shrimp	1	0.08	0.59	0.00	1	0.32	0.00
fish mouth isopod	1	0.08	0.00	0.00	1	0.32	0.00
naked goby	1	0.08	0.00	0.00	1	0.32	0.00

Table 6d. Number, weight, frequency of occurrence and %IRI for winter. N = 72

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	61	18.65	4889.38	68.67	34	47.22	72.41
anchovy	157	48.01	74.82	1.05	16	22.22	19.15
american eel	19	5.81	505.86	7.10	8	11.11	2.52
spot	14	4.28	526.75	7.40	8	11.11	2.28
unknown fish	16	4.89	8.89	0.12	11	15.28	1.35
white perch	8	2.45	149.18	2.09	7	9.72	0.78
gizzard shad	15	4.59	174.09	2.44	3	4.17	0.51
flounder	4	1.22	150.98	2.12	3	4.17	0.24
weakfish	2	0.61	228.64	3.21	2	2.78	0.19
croaker	2	0.61	155.88	2.19	2	2.78	0.14
tonguefish	5	1.53	63.06	0.89	2	2.78	0.12
sand shrimp	6	1.83	2.31	0.03	2	2.78	0.09
lady crab	2	0.61	19.65	0.28	2	2.78	0.04
naked goby	5	1.53	1.42	0.02	1	1.39	0.04
bluefish	1	0.31	83.18	1.17	1	1.39	0.04
unknown clupeid	2	0.61	1.13	0.02	2	2.78	0.03
silver perch	1	0.31	54.06	0.76	1	1.39	0.03
windowpane	1	0.31	14.42	0.20	1	1.39	0.01
cancer crab	1	0.31	7.73	0.11	1	1.39	0.01
hogchoker	1	0.31	5.26	0.07	1	1.39	0.01
polychaete	1	0.31	2.12	0.03	1	1.39	0.01
silversides	1	0.31	1.13	0.02	1	1.39	0.01
snail	1	0.31	0.39	0.01	1	1.39	0.01
unknown sciaenid	1	0.31	0.23	0.00	1	1.39	0.01

Table 7a. Number, weight, frequency of occurrence and %IRI for upper rivers. N = 215

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
gizzard shad	172	30.99	4056.78	35.09	67	14.41	56.9
anchovy	130	23.42	119.46	1.03	19	10.89	15.9
herring	61	10.99	4595.45	39.75	34	5.11	15.5
white perch	52	9.37	1442.55	12.48	42	4.36	5.7
unknown clupeid	45	8.11	270.62	2.34	36	3.77	2.3
menhaden	33	5.95	898.88	7.78	5	2.77	2.35
unknown fish	36	6.49	41.87	0.36	28	3.02	1.23
blue crab	10	1.80	9.08	0.08	8	0.84	0.09
cyprinid	6	1.08	15.54	0.13	5	0.50	0.04
mysid shrimp	4	0.72	0.05	0.00	2	0.34	0.01
croaker	2	0.36	85.84	0.74	2	0.17	0.01
polychaete	2	0.36	1.31	0.01	2	0.17	0.00
american eel	1	0.18	22.64	0.20	1	0.08	0.00
spot	1	0.18	0.00	0.00	1	0.08	0.00

Table 7b. Number, weight, frequency of occurrence and %IRI for lower rivers. N = 113

Lower Rivers n= 113	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	73	11.34	1453.99	39.56	26	23.01	33.43
anchovy	207	32.14	178.14	4.85	27	23.89	25.23
gizzard shad	16	2.48	451.58	12.29	34	30.09	12.69
blue crab	67	10.40	163.72	4.45	32	28.32	12.01
spot	39	6.06	440.12	11.97	20	17.70	9.11
mysid shrimp	83	12.89	10.15	0.28	9	7.96	2.99
unknown fish	23	3.57	88.12	2.40	10	8.85	1.51
spotted hake	25	3.88	232.20	6.32	2	1.77	0.52
silversides	24	3.73	32.13	0.87	4	3.54	0.46
mantis shrimp	13	2.02	88.14	2.40	4	3.54	0.45
croaker	2	0.31	217.96	5.93	2	1.77	0.32
white perch	4	0.62	88.73	2.41	3	2.65	0.23
flounder	5	0.78	29.57	0.80	4	3.54	0.16
unknown sciaenid	8	1.24	17.91	0.49	3	2.65	0.13
sand shrimp	9	1.40	3.57	0.10	3	2.65	0.11
silver perch	5	0.78	26.05	0.71	3	2.65	0.11
american eel	2	0.31	62.79	1.71	2	1.77	0.10
tonguefish	11	1.71	10.94	0.30	2	1.77	0.10
polychaete	4	0.62	9.71	0.26	4	3.54	0.09
hogchoker	4	0.62	19.88	0.54	3	2.65	0.09
grass shrimp	7	1.09	1.82	0.05	2	1.77	0.06
white mullet	1	0.16	36.08	0.98	1	0.88	0.03
naked goby	5	0.78	1.42	0.04	1	0.88	0.02
unknown clupeid	2	0.31	0.34	0.01	2	1.77	0.02
fish gill isopod	2	0.31	0.21	0.01	2	1.77	0.02
feather blenny	1	0.16	4.15	0.11	1	0.88	0.01
mummichog	1	0.16	3.39	0.09	1	0.88	0.01
white shrimp	1	0.16	2.82	0.08	1	0.88	0.01

Table 7c. Number, weight, frequency of occurrence and %IRI for upper Bay. N = 69

Upper Bay	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	32	18.50	4207.26	77.57	19	27.54	59.53
anchovy	78	45.09	24.73	0.46	19	27.54	28.22
blue crab	20	11.56	268.88	4.96	12	17.39	6.46
american eel	16	9.25	416.33	7.68	6	8.70	3.31
spot	4	2.31	425.53	7.85	3	4.35	0.99
fish gill isopod	6	3.47	0.38	0.01	6	8.70	0.68
unknown fish	4	2.31	2.60	0.05	4	5.80	0.31
white perch	3	1.73	18.48	0.34	3	4.35	0.20
silversides	3	1.73	1.22	0.02	2	2.90	0.11
bluefish	1	0.58	47.35	0.87	1	1.45	0.05
mantis shrimp	1	0.58	4.46	0.08	1	1.45	0.02
mud crab	1	0.58	3.52	0.06	1	1.45	0.02
mysid shrimp	1	0.58	1.43	0.03	1	1.45	0.02
unknown clupeid	1	0.58	0.79	0.01	1	1.45	0.02
mud shrimp	1	0.58	0.59	0.01	1	1.45	0.02
sand shrimp	1	0.58	0.10	0.00	1	1.45	0.02

Table 7d. Number, weight, frequency of occurrence and %IRI for middle Bay. N = 86

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	66	23.24	2479.44	42.54	31	36.05	52.03
spot	65	22.89	1229.88	21.10	33	38.37	37.04
croaker	4	1.41	773.13	13.27	4	4.65	1.50
flounder	7	2.46	503.09	8.63	5	5.81	1.42
anchovy	17	5.99	9.20	0.16	8	9.30	1.25
tonguefish	23	8.10	43.56	0.75	5	5.81	1.13
mantis shrimp	13	4.58	80.44	1.38	7	8.14	1.06
unknown fish	12	4.23	10.13	0.17	8	9.30	0.90
weakfish	7	2.46	177.13	3.04	6	6.98	0.84
silversides	13	4.58	18.20	0.31	6	6.98	0.75
silver perch	7	2.46	128.75	2.21	5	5.81	0.60
mysid shrimp	13	4.58	0.96	0.02	3	3.49	0.35
blue crab	7	2.46	9.14	0.16	4	4.65	0.27
spotted hake	2	0.70	188.14	3.23	2	2.33	0.20
unknown sciaenid	5	1.76	14.77	0.25	3	3.49	0.15
unknown clup	5	1.76	5.17	0.09	3	3.49	0.14
majorra	3	1.06	39.92	0.69	3	3.49	0.13
butterfish	3	1.06	78.01	1.34	1	1.16	0.06
white shrimp	2	0.70	9.55	0.16	2	2.33	0.04
grass shrimp	2	0.70	0.42	0.01	2	2.33	0.04
polychaete	2	0.70	0.35	0.01	2	2.33	0.04
atlantic thread herring	1	0.35	11.89	0.20	1	1.16	0.01
rock crab	1	0.35	7.73	0.13	1	1.16	0.01
hogchoker	1	0.35	6.27	0.11	1	1.16	0.01
sponge	1	0.35	2.29	0.04	1	1.16	0.01
snail	1	0.35	0.39	0.01	1	1.16	0.01
naked goby	1	0.35	0.00	0.00	1	1.16	0.01

Table 7e. Number, weight, frequency of occurrence and %IRI for lower Bay. N = 133

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	146	21.10	4663.61	43.07	45	33.83	50.06
spot	180	26.01	1315.49	12.15	39	29.32	25.80
anchovy	180	26.01	83.79	0.77	27	20.30	12.54
flounder	20	2.89	1745.99	16.12	9	6.77	2.97
unknown fish	33	4.77	167.32	1.55	23	17.29	2.52
croaker	12	1.73	1007.85	9.31	12	9.02	2.30
weakfish	12	1.73	635.07	5.86	8	6.02	1.05
lady crab	16	2.31	105.73	0.98	14	10.53	0.80
butterfish	12	1.73	385.88	3.56	6	4.51	0.55
unknown sciaenid	14	2.02	84.43	0.78	9	6.77	0.44
mantis shrimp	11	1.59	26.08	0.24	11	8.27	0.35
silversides	8	1.16	22.23	0.21	5	3.76	0.12
silver perch	6	0.87	48.72	0.45	5	3.76	0.11
blue crab species	7	1.01	28.83	0.27	4	3.01	0.09
gizzard shad	9	1.30	42.73	0.39	2	1.50	0.06
spotted hake	2	0.29	136.86	1.26	2	1.50	0.05
tonguefish	5	0.72	63.06	0.58	2	1.50	0.05
american eel	3	0.43	89.53	0.83	2	1.50	0.04
lizard fish	2	0.29	68.54	0.63	2	1.50	0.03
a. needle fish	3	0.43	67.96	0.63	1	0.75	0.02
windowpane	2	0.29	22.08	0.20	2	1.50	0.02
white shrimp	2	0.29	0.64	0.01	2	1.50	0.01
fish gill isopod	2	0.29	0.26	0.00	2	1.50	0.01
unknown clupeid	2	0.29	5.37	0.05	1	0.75	0.01
hogchoker	1	0.14	5.26	0.05	1	0.75	0.00
northern puffer	1	0.14	4.80	0.04	1	0.75	0.00
sand shrimp	1	0.14	0.04	0.00	1	0.75	0.00

Table 8a. Number, weight, frequency of occurrence and %IRI for fish 200-400 mm. N = 12

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	4	13.79	89.29	56.62	2	16.67	34.58
spot	5	17.24	55.49	35.19	2	16.67	25.75
anchovy	12	41.38	8.38	5.32	2	16.67	22.93
cyprinid	2	6.90	3.69	2.34	2	16.67	4.54
unknown fish	4	13.79	0.72	0.46	3	25.00	10.50
unknown clupeid	1	3.45	0.12	0.08	1	8.33	0.87
polychaete	1	3.45	0.00	0.00	1	8.33	0.85

Table 8b. Number, weight, frequency of occurrence and %IRI for 400-600 mm. N = 351

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
anchovy	580	38.13	339.05	3.34	89	25.36	35.29
menhaden	164	10.78	4016.07	39.59	66	18.80	31.79
spot	107	7.03	1557.53	15.35	49	13.96	10.49
gizzard shad	125	8.22	1246.88	12.29	46	13.11	9.02
white perch	43	2.83	1254.98	12.37	30	8.55	4.36
blue crab	99	6.51	267.24	2.63	47	13.39	4.11
unknown fish	71	4.67	170.40	1.68	45	12.82	2.73
mysid shrimp	106	6.97	12.53	0.12	13	3.70	0.88
silversides	39	2.56	50.50	0.50	11	3.13	0.32
unknown clupeid	17	1.12	36.31	0.36	14	3.99	0.20
tonguefish	34	2.24	41.09	0.41	7	1.99	0.18
mantis shrimp	12	0.79	80.49	0.79	7	1.99	0.11
unknown sciaenid	14	0.92	23.39	0.23	7	1.99	0.08
spotted hake	25	1.64	232.19	2.29	2	0.57	0.08
weakfish	4	0.26	122.03	1.20	4	1.14	0.06
fish gill isopod	9	0.59	0.66	0.01	9	2.56	0.05
silver perch	6	0.39	48.22	0.48	4	1.14	0.03
polychaete	6	0.39	11.04	0.11	6	1.71	0.03
sand shrimp	10	0.66	3.67	0.04	4	1.14	0.03
croaker	2	0.13	115.62	1.14	2	0.57	0.02
grass shrimp	9	0.59	2.24	0.02	4	1.14	0.02
herring	4	0.26	33.14	0.33	4	1.14	0.02
butterfish	4	0.26	88.73	0.87	2	0.57	0.02
striper	1	0.07	205.00	2.02	1	0.28	0.02
majorra	3	0.20	39.92	0.39	3	0.85	0.02
naked goby	6	0.39	1.42	0.01	2	0.57	0.01
flounder	3	0.20	7.52	0.07	3	0.85	0.01
cyprinid	3	0.20	6.75	0.07	3	0.85	0.01
white shrimp	3	0.20	6.08	0.06	3	0.85	0.01
lady crab	3	0.20	1.77	0.02	3	0.85	0.01
bluefish	1	0.07	47.35	0.47	1	0.28	0.01
white mullet	1	0.07	36.08	0.36	1	0.28	0.00
american eel	1	0.07	15.98	0.16	1	0.28	0.00
thread herring	1	0.07	11.89	0.12	1	0.28	0.00
hogchoker	1	0.07	3.68	0.04	1	0.28	0.00
mummichog	1	0.07	3.39	0.03	1	0.28	0.00
bryozoan	1	0.07	2.29	0.02	1	0.28	0.00
mud shrimp	1	0.07	0.59	0.01	1	0.28	0.00
fish mouth isopod	1	0.07	0.00	0.00	1	0.28	0.00

Table 8c. Number, weight, frequency of occurrence and %IRI for 600-800 mm. N = 155

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	183	38.77	7954.10	36.13	56	25.01	75.15
spot	60	12.71	1367.27	23.23	36	8.20	11.82
gizzard shad	44	9.32	1060.37	9.68	15	6.01	4.58
unknown fish	20	4.24	28.87	10.97	17	2.73	1.67
blue crab	24	5.08	211.82	7.10	11	3.28	1.60
herring	18	3.81	1035.21	8.39	13	2.46	1.20
unknown clupeid	15	3.18	53.32	7.10	11	2.05	0.84
anchovy	17	3.60	12.32	3.87	6	2.32	0.70
white perch	11	2.33	166.96	6.45	10	1.50	0.53
mantis shrimp	10	2.12	27.68	5.81	9	1.37	0.43
lady crab	9	1.91	56.01	4.52	7	1.23	0.32
silver perch	8	1.69	135.19	3.87	6	1.09	0.24
croaker	7	1.48	798.69	4.52	7	0.96	0.23
butterfish	8	1.69	297.15	2.58	4	1.09	0.19
unknown scieanid	7	1.48	21.80	1.94	3	0.96	0.13
weakfish	6	1.27	389.24	2.58	4	0.82	0.13
blue crab species	5	1.06	14.30	1.29	2	0.68	0.06
mysid shrimp	4	0.85	0.05	1.29	2	0.55	0.05
silversides	3	0.64	2.79	1.29	2	0.41	0.03
striper	2	0.42	241.66	1.29	2	0.27	0.02
hogchoker	2	0.42	6.96	1.29	2	0.27	0.02
white shrimp	2	0.42	6.92	1.29	2	0.27	0.02
flounder	1	0.21	34.93	0.65	1	0.14	0.00
american eel	1	0.21	22.64	0.65	1	0.14	0.00
spotted hake	1	0.21	20.31	0.65	1	0.14	0.00
lizard fish	1	0.21	8.41	0.65	1	0.14	0.00
cyprinid	1	0.21	5.10	0.65	1	0.14	0.00
polychaete	1	0.21	0.33	0.65	1	0.14	0.00
fish gill isopod	1	0.21	0.19	0.65	1	0.14	0.00

Table 8d. Number, weight, frequency of occurrence and %IRI for 800-1000 mm. N = 106

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	77	26.64	4596.93	30.05	30	28.30	50.39
gizzard shad	37	12.80	3597.37	23.51	19	17.92	20.44
herring	31	10.73	2983.10	19.50	13	12.26	11.64
flounder	18	6.23	1477.42	9.66	10	9.43	4.71
unknown clupeid	18	6.23	139.81	0.91	14	13.21	2.96
spot	18	6.23	445.63	2.91	10	9.43	2.71
white perch	11	3.81	239.06	1.56	11	10.38	1.75
croaker	7	2.42	481.82	3.15	7	6.60	1.16
anchovy	13	4.50	8.59	0.06	7	6.60	0.94
weakfish	7	2.42	486.06	3.18	5	4.72	0.83
mantis shrimp	12	4.15	63.34	0.41	6	5.66	0.81
unknown fish	9	3.11	18.30	0.12	6	5.66	0.57
unknown scieanid	4	1.38	69.51	0.45	4	3.77	0.22
blue crab	4	1.38	5.83	0.04	4	3.77	0.17
lady crab	3	1.04	45.90	0.30	3	2.83	0.12
silver perch	3	1.04	34.56	0.23	3	2.83	0.11
bluefish	2	0.69	136.86	0.89	2	1.89	0.09
american eel	2	0.69	119.27	0.78	2	1.89	0.09
tonguefish	4	1.38	60.95	0.40	1	0.94	0.05
windowpane	2	0.69	22.08	0.14	2	1.89	0.05
blue crab species	2	0.69	14.53	0.09	2	1.89	0.05
atlantic needlefish	3	1.04	67.96	0.44	1	0.94	0.04
spotted hake	1	0.35	167.80	1.10	1	0.94	0.04
hogchoker	1	0.35	5.26	0.03	1	0.94	0.01
northern puffer	1	0.35	4.80	0.03	1	0.94	0.01
feather blenny	1	0.35	4.15	0.03	1	0.94	0.01
silversides	1	0.35	2.13	0.01	1	0.94	0.01

Table 8e. Number, weight, frequency of occurrence and %IRI for 1000^{+} mm. N = 39

Prey items	number	% number	weight	% weight	frequency	% frequency	%IRI
menhaden	30	32.26	3611.07	53.75	19	48.72	71.47
american eel	17	18.28	386.59	5.75	6	15.38	10.69
gizzard shad	9	9.68	822.34	12.24	4	10.26	4.01
herring	7	7.53	231.46	3.45	4	10.26	3.38
unknown fish	6	6.45	7.23	0.11	4	10.26	3.07
flounder	8	8.60	736.73	10.97	3	7.69	2.55
spot	5	5.38	306.62	4.56	3	7.69	1.84
unknown clupeid	4	4.30	2.96	0.04	3	7.69	1.61
croaker	2	2.15	426.31	6.35	2	5.13	0.61
white perch	1	1.08	85.42	1.27	1	2.56	0.15
lizard fish	1	1.08	60.13	0.90	1	2.56	0.15
weakfish	1	1.08	33.16	0.49	1	2.56	0.15
cancer crab	1	1.08	7.73	0.11	1	2.56	0.15
snail	1	1.08	0.39	0.01	1	2.56	0.15

Table 9. Stomach fullness index for each location.

Location	Number	Mean	Standard Deviation
Upper River	234	1.29	2.12
Lower River	173	2.53	3.19
Upper Bay	145	1.43	1.70
Middle Bay	43	1.47	1.72
Lower Bay	180	2.30	3.02
unknown	47	3.70	3.63

Table 10. Stomach fullness index by month.

Month	Number	Mean	Standard Deviation
March 1997	29	1.51	2.78
April 1997	141	1.22	1.98
May 1997	20	1.46	1.84
June 1997	31	3.91	3.26
August 1997	6	0.81	1.03
September 1997	28	0.75	0.88
October 1997	216	2.39	2.96
November 1997	161	2.74	3.35
December 1997	57	1.51	1.63
January 1998	7	1.19	1.03
February 1998	9	1.65	2.00
March 1998	62	1.23	1.64
April 1998	36	1.19	2.56
May 1998	13	0.93	1.62
unknown	6	1.28	1.11

Table 11. Stomach fullness index by gear type.

Gear	Number	Mean	Standard Deviation
Spring pound nets	117	1.24	2.15
Fall Pound nets	26	5.04	3.65
Spring gill nets	110	1.17	1.69
Fall gill nets	15	3.95	2.51
Fyke net	21	2.44	3.08
Hook and line, unknown	93	2.38	3.45
Hook and line, chumming	79	1.74	1.92
Hook and line, trolling	131	1.47	2.04
Hook and line, casting	37	1.82	2.25
Trawl	9	1.42	1.56
Electroshock	10	1.52	2.08
Commercial gear, unknown	77	4.69	4.49

Figure 1. Map of striped bass collections in Chesapeake Bay.

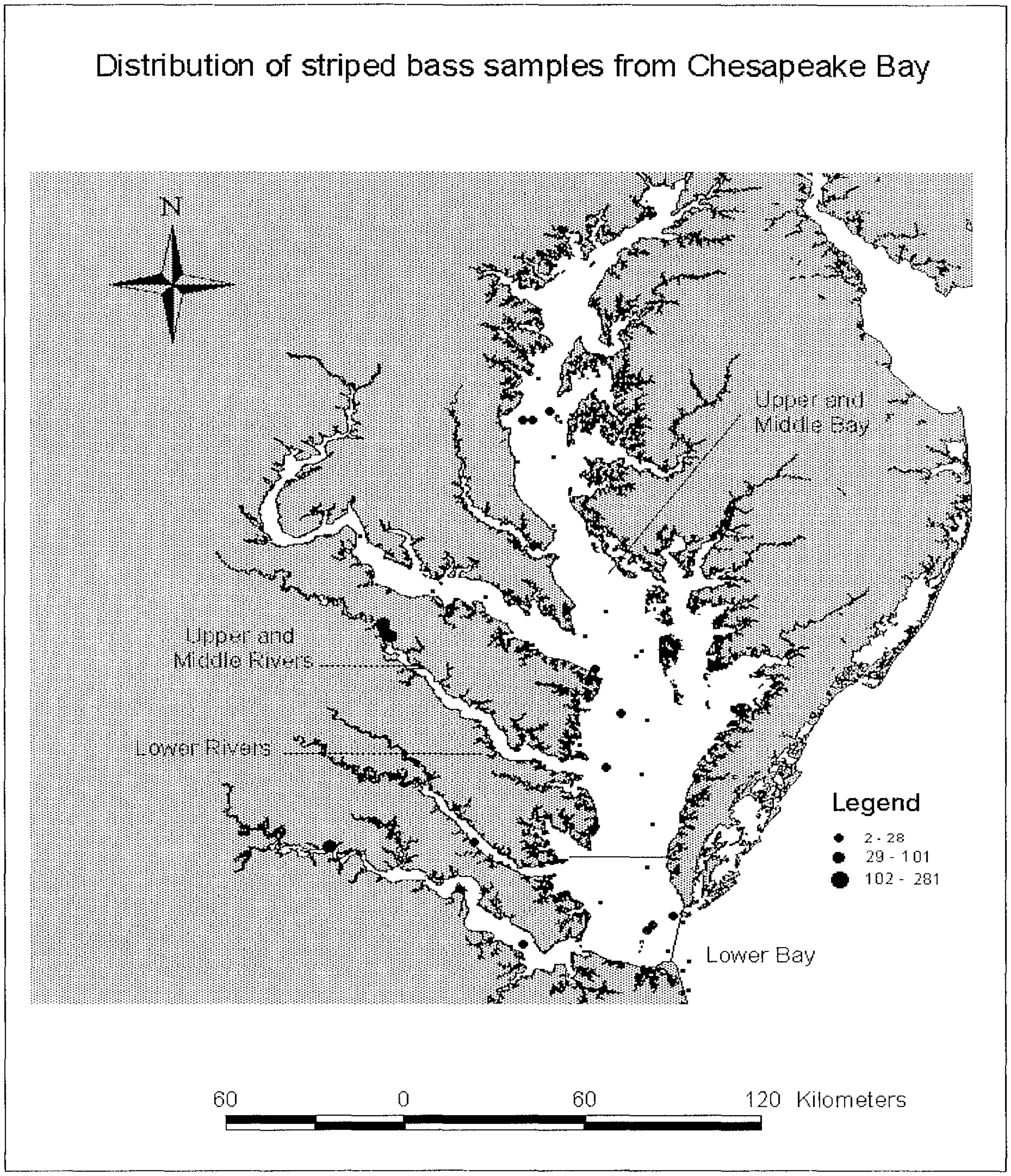


Figure 2. Length frequency distribution of striped bass.

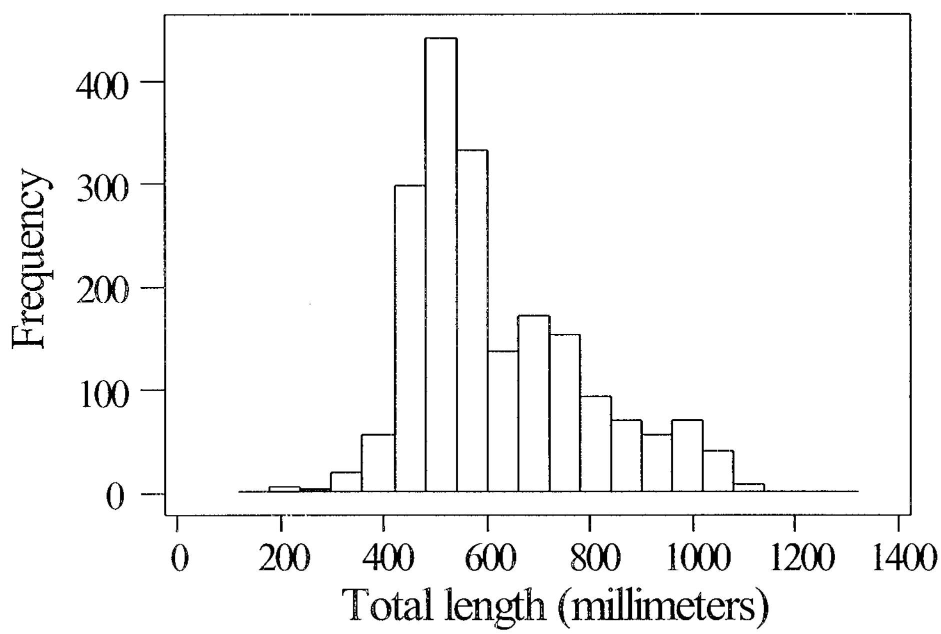


Figure 3a. % IRI for spring
n = 263

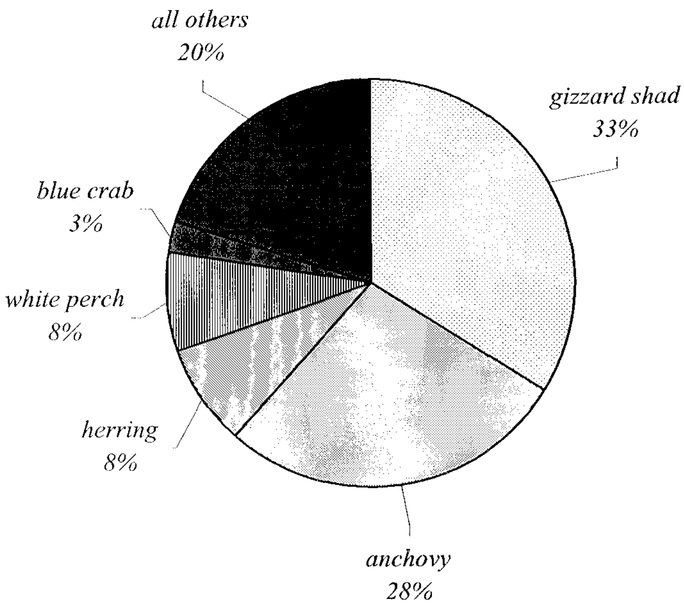


Figure 3b. %IRI for summer
n = 36

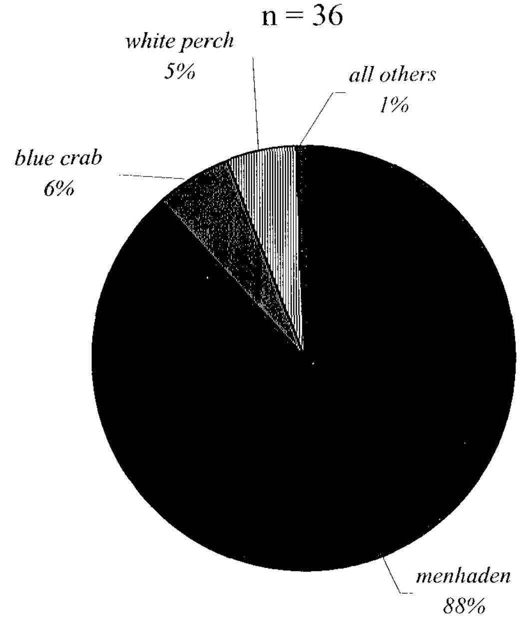


Figure 3c. %IRI for Fall
n = 313

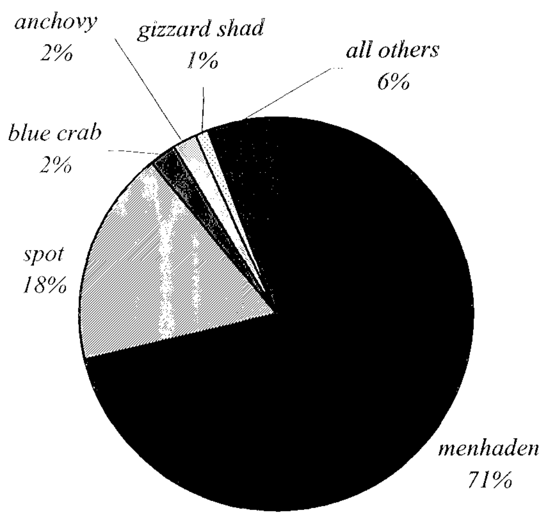


Figure 3d. %IRI for winter
n = 72

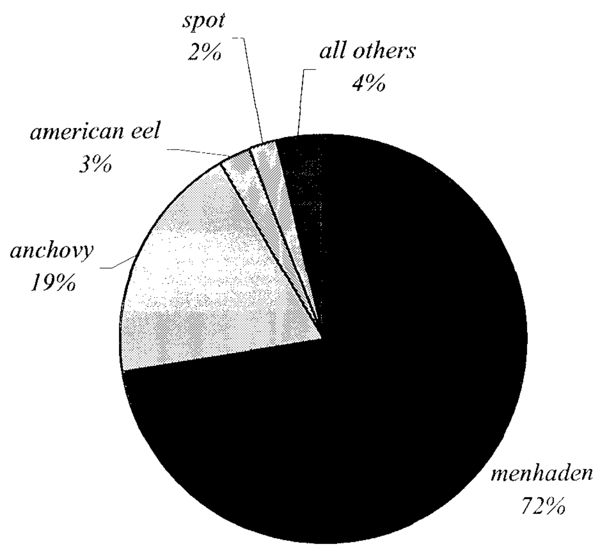


Figure 4a. % IRI for upper rivers, n = 215

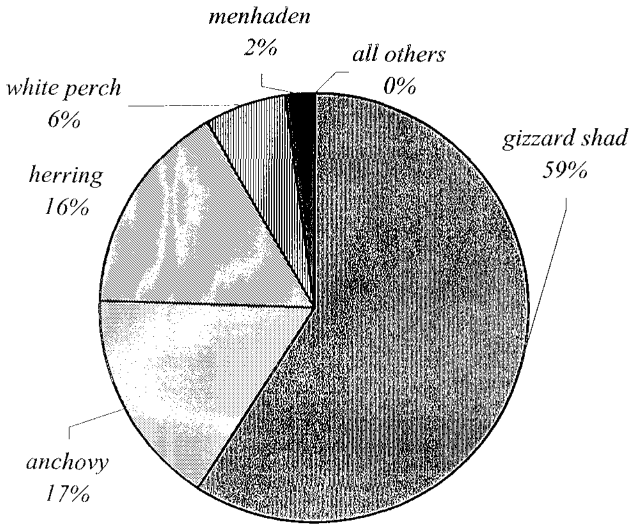


Figure 4b. % IRI for lower rivers, n = 113

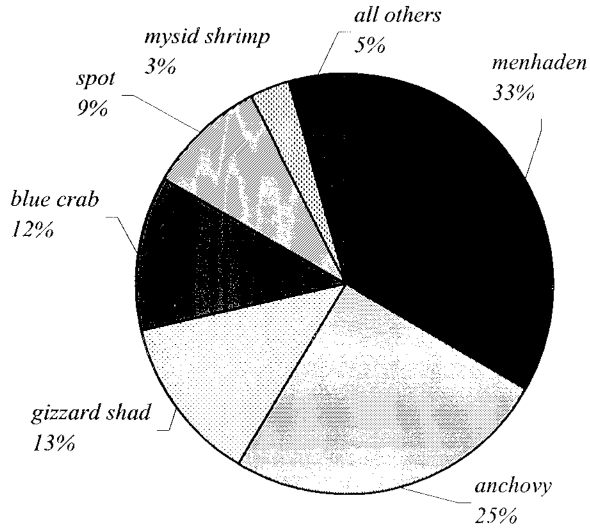


Figure 4c. % IRI for upper bay, n = 69

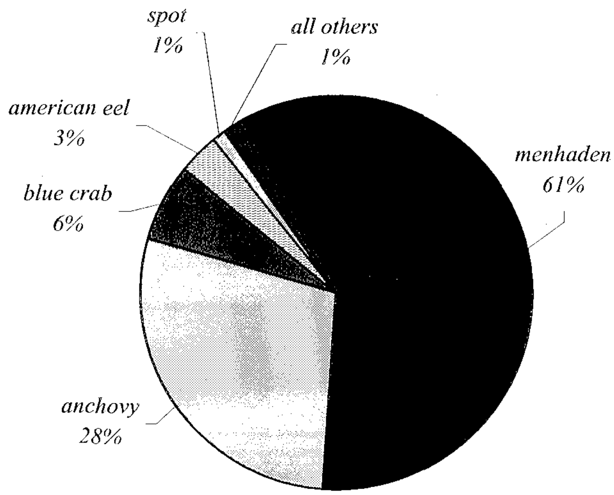


Figure 4d. % IRI for middle bay, n = 86

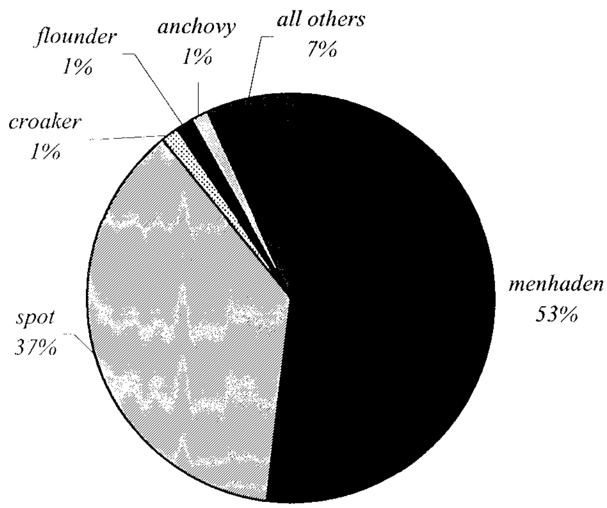


Figure 4e. % IRI for lower bay, n = 133

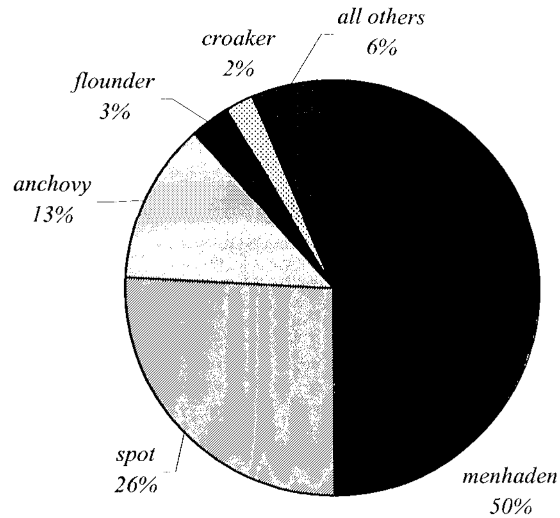


Figure 5a % IRI for fish 200-400 mm
n = 12

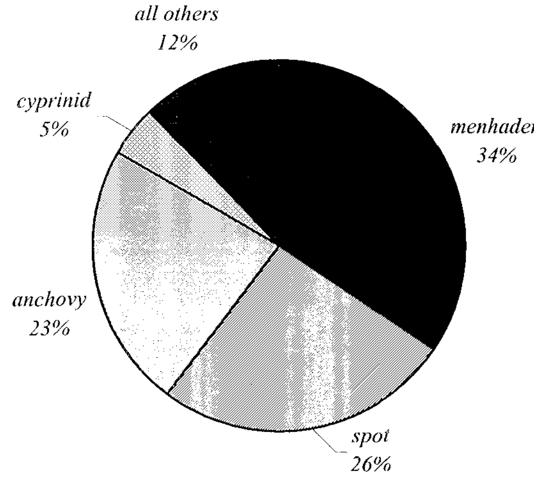


Figure 5b. %IRI for fish 400-600 mm
n = 351

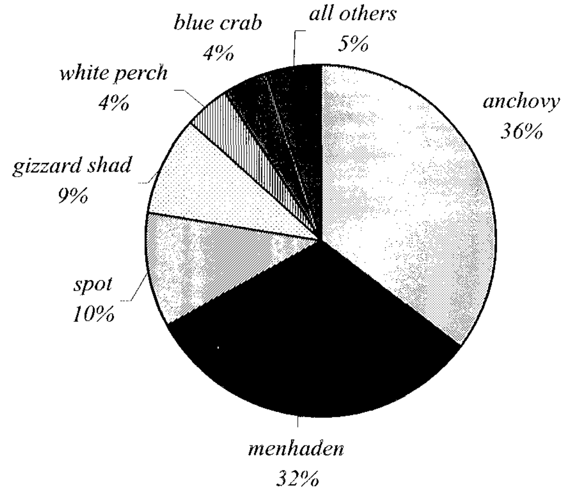


Figure 5c. %IRI for fish 600-800mm
n = 155

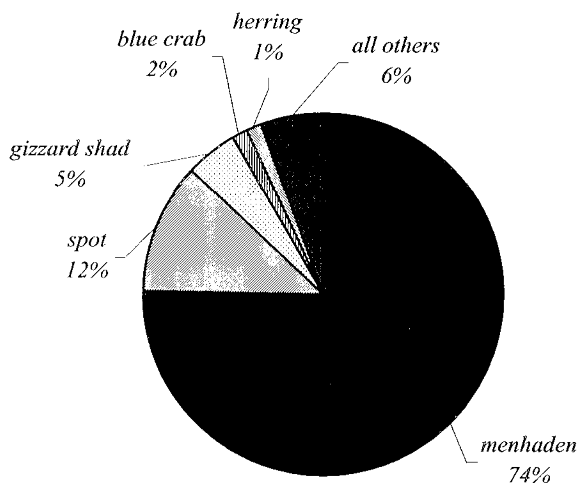


Figure 5d. % IRI for fish 800-1000mm
n = 106

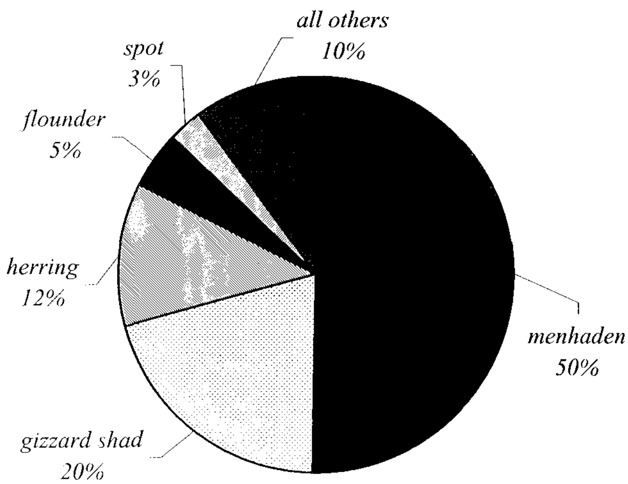


Figure 5e. %IRI for fish 1000+mm
n = 39

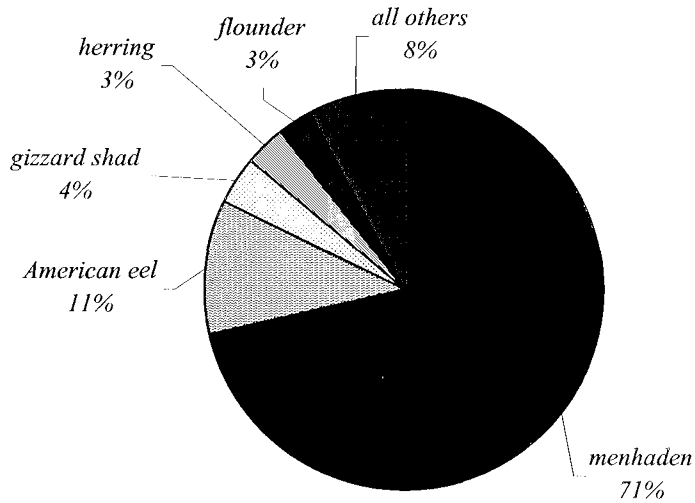


Figure 6

Blue crab length-frequency

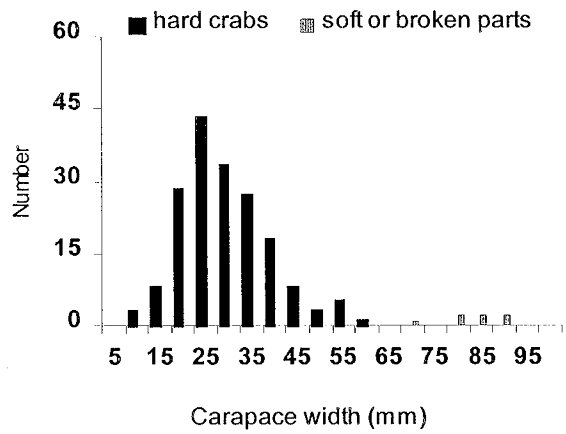


Figure 7

Frequency of Occurrence of Blue Crabs In Striped Bass Stomachs

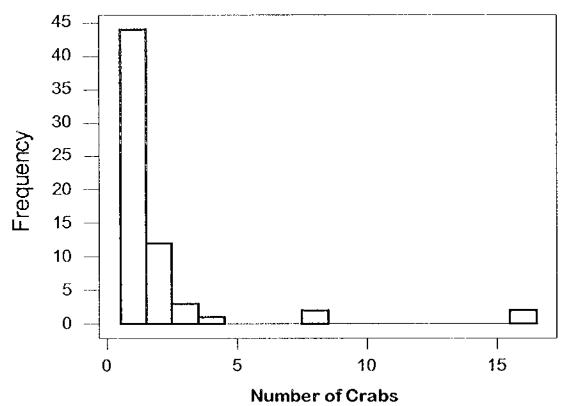


Figure 8

Stomach Fullness Index (SFI) vs Blue Crab Carapace Width

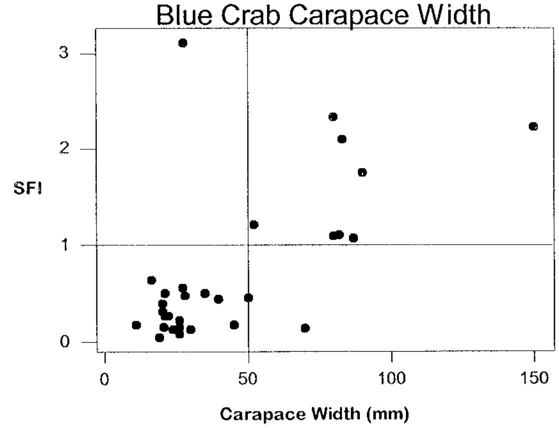


Figure 9

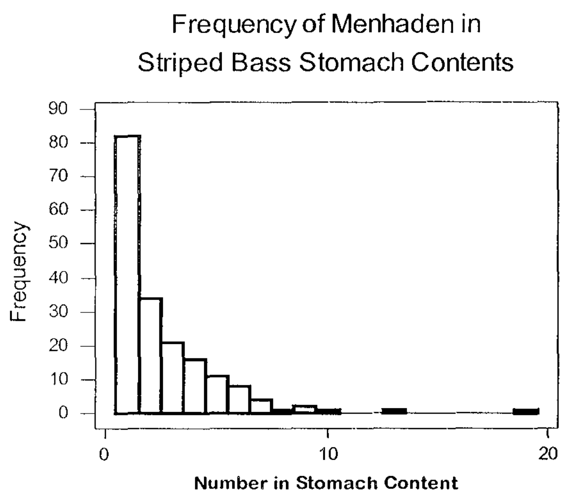


Figure 10

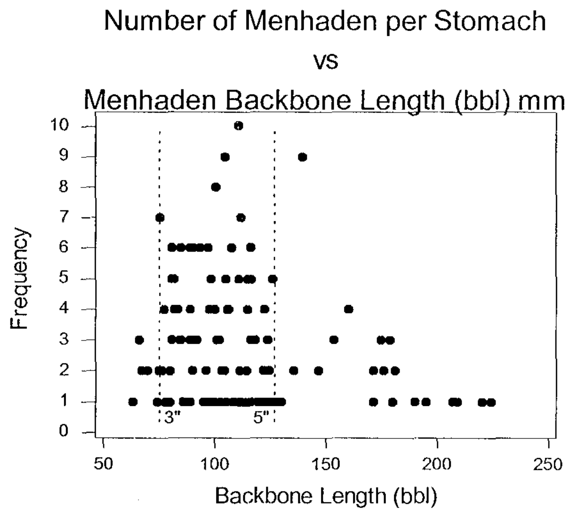


Figure 11

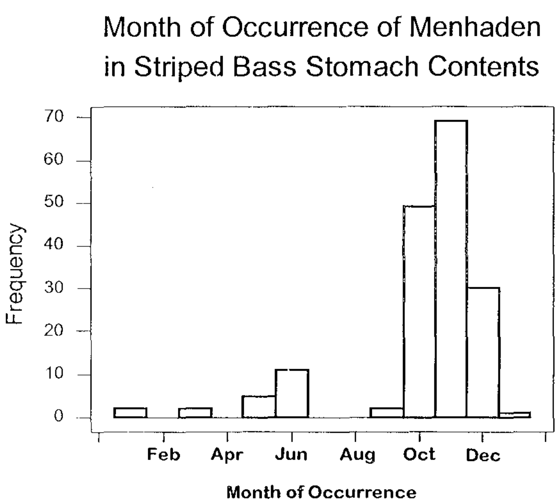


Figure 12

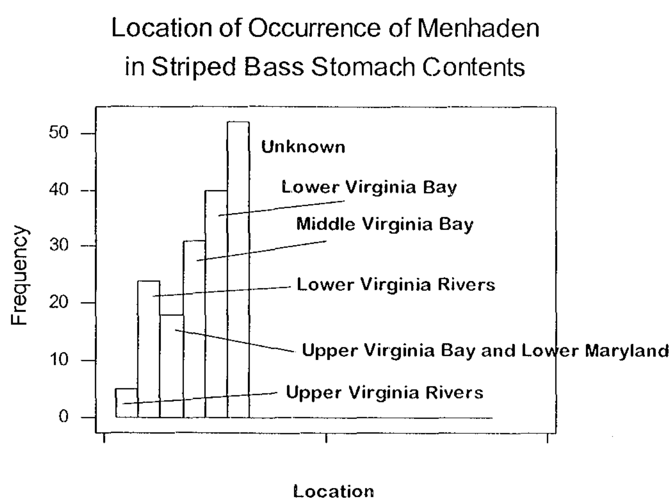


Figure 13

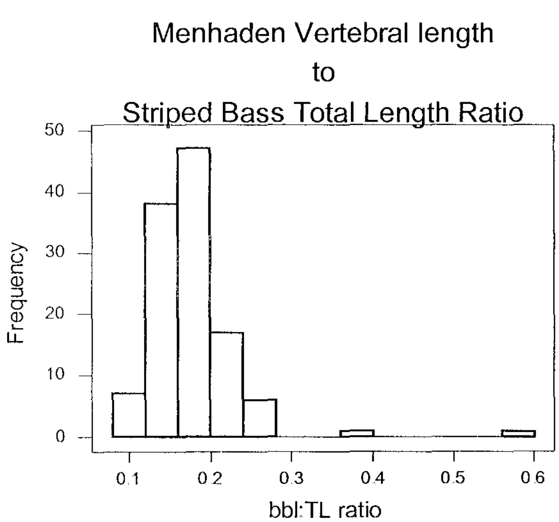


Figure 14

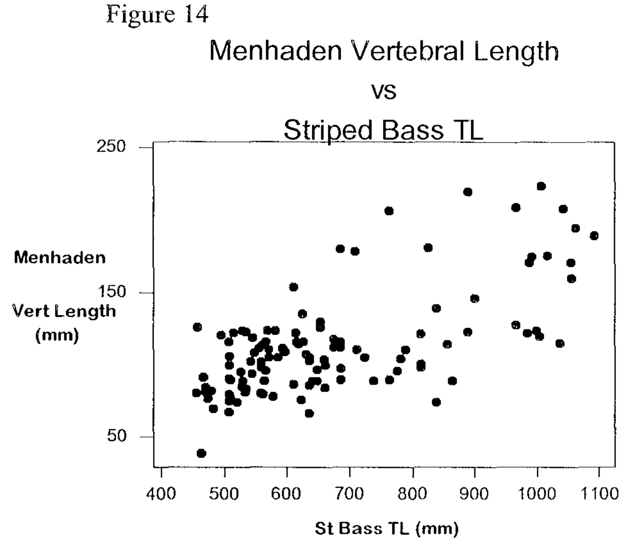


Figure 15. Monthly variation in stomach fullness index values and percentage of full stomachs in striped bass March 1997 – May 1998. Error bars are upper standard deviations. Numbers above the bars represent the percentage of full stomachs. Numbers below months represent the sample sizes used in construction of the stomach fullness indices.