FINAL REPORT

Chesapeake Bay
Trophic Interactions Laboratory Services
(CTILS)

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TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

SUMMARY OF WORK

Stomach samples or whole fish were obtained from a network of up to eight participating fisheries surveys in the Chesapeake Bay area. Field supplies and sample transport were provided by CTILS. Whole fish were processed for length, weight, and sex determination. Stomachs were removed and analyzed in the laboratory and prey types determined. In support of ecosystem-based fisheries management, estimates of location-specific diet composition were produced for each species. Comparisons of dietary habits of each species among a range of habitats in the Bay and throughout various time frames were made.

INTRODUCTION

Identification of problem

Fisheries researchers and managers in the Chesapeake Bay region are developing multispecies management plans for commercially, recreationally, and ecologically important species. Both the Chesapeake 2000 (C2K) agreement and the recently completed regional Fisheries Ecosystem Plan (FEP) commit the states of Maryland and Virginia to incorporating an adaptive, ecosystem-based approach to fisheries management strategies.

A principal requirement of ecosystem-based fisheries assessment models such as Ecopath with Ecosim (EwE) is well-quantified estimates of predator-prey relationships or trophic interactions (Latour et al., 2003; Christensen, 2006). Trophic interactions among populations are typically elucidated through the analysis of stomach contents. These diet analyses can generate biomass values for specific predators and prey species and can be used to more realistically estimate gains and losses to fish populations (Latour et al., 2003). It must be recognized, however, that trophic interactions vary according to temporal and spatial scales. Therefore, to adequately characterize these interactions within an ecosystem, an extensive database of fish diet composition information is needed.

Specific questions regarding the predator-prey interactions among economically and ecologically important fish species have arisen as a result of this ecosystem-based approach. For example, striped bass (*Morone saxatilis*) are known predators of Atlantic menhaden (*Brevoortia tyrannus*) (Manooch, 1973; Hartman and Brandt, 1995; Griffin, 2001; Uphoff, 2003; and Walter and Austin, 2003) but the extent to which these interactions impact each of the populations is unknown. Furthermore, striped bass prey heavily upon a multitude of other species as well, depending on the foraging habitat. Thus, to provide the most synoptic overview of the trophic ecology of this species, predator-prey interactions in specific habitats should be considered.

Given that the proliferation of submerged aquatic vegetation (SAV) habitat in the Chesapeake Bay is a high priority in restoration efforts and that these habitats provide a nursery area for both fish and invertebrates, trophic dynamics that develop in this newly established habitat should be monitored. There is already evidence that in Chesapeake Bay seagrass beds juvenile blue crabs (*Callinectes sapidus*) comprise the vast majority of the striped bass diet, and significant quantities of soft-shell clams (*Mya arenaria*) have been found in the diet of Atlantic croaker (*Micropogonias undulatus*).

Potential for competition with native species for food and decimation of native species by predation are some of the most dangerous risks when introducing a fish species into a non-native habitat (United States Geological Survey, 2005). Thus, non-indigenous species should be considered when assessing trophic interactions. In Virginia, blue catfish (*Ictalurus furcatus*) are considered a non-indigenous aquatic species introduced from the Mississippi River drainage to control the exotic Asian clam (*Corbicula fluminea*) population and to enhance recreational fishing (Jenkins and Burkhead, 1994; United States Geological Survey, 2005). At present, the species is proliferating in Virginia. Blue catfish was the fifth most abundant species caught (excluding bay anchovy and hogchoker) by the VIMS Juvenile Trawl Survey from July 2004 to June 2005 (Montane and Lowery, 2005).

Because estuaries are temporally dynamic as well as spatially variable, it is also important to consider monthly or seasonal shifts in fish diets. Adequate temporal coverage ensures a broader, more accurate understanding of the trophic dynamics among species within an ecosystem. For example, a monthly diet analysis would be appropriate for a species which inhabits the Chesapeake Bay in large numbers year-round such as Atlantic croaker, while a year to year comparison would be a more reasonable analysis for fish populations that display an influx in population to the Bay only during some parts of the year such as striped bass, weakfish (*Cynoscion regalis*), and summer flounder (*Paralichthys dentatus*).

While increased survival in the early life history stages may ultimately improve the year-class strength of a fish population (Boynton et al., 1981), consideration of young-of-the year (YOY) and juvenile fish diets is also important. Diet analyses of fishes captured by smaller-scale surveys such as the seine surveys which operate in specific niche environments and usually target young-of-the-year fishes provide insight into the trophic dynamics of the early life history of fishes and their environment. For example, bluefish (*Pomatomus saltatrix*) are considered an important recreational species in the Chesapeake Bay vicinity, and are voracious piscivores not only as adults (Richards, 1976; Buckel et al., 1999; Harding and Mann, 2001; Juanes et al., 2001) but also as young-of-the-year (Buckel and Conover 1997). Atlantic needlefish (*Strongylura marina*) are also considered piscivores (Murdy et al., 1997). Given the apex predator status of these species and the need to quantify trophic interactions between fish populations, monitoring of their diets is important.

Introduction of research

A database of fish diet information continues to be developed at the Virginia Institute of Marine Science. The Chesapeake Bay Trophic Interactions Laboratory Services (CTILS) program was established in 2003 and developed with three years of state-specific grants through the Virginia Marine Resources Commission's (VMRC) Recreational Fishing Advisory Board (RFAB).

The CTILS program provides a service to various fisheries monitoring surveys in the Chesapeake Bay region in return for supplying samples for fish trophic ecology research. Not only is value added to each of these surveys by enhancing their functions as collaborative entities, but they also receive feedback reports containing a complete and thorough analysis of the trophic interactions which occur in their respective study locations. In addition to the collaborative efforts between CTILS and surveys within VIMS, participation by other agencies includes those from Maryland and North Carolina. Also involved are two surveys from Maryland Department of Natural Resources (MDNR), as well as a large-scale cooperative winter trawling operation which partners the United States Fish and Wildlife Service (USFWS) with North Carolina Division of Marine Fisheries (NCDMF), Atlantic States Marine Fisheries Commission (ASMFC), East Carolina University (ECU), MDNR, and the National Marine Fisheries Service (NMFS).

The Chesapeake Bay Trophic Interactions Laboratory Service was designed partially in response to the Fisheries Ecosystem Plan (FEP) developed by the Chesapeake Fisheries Ecosystem Plan Technical Advisory Panel. The Plan calls for development of ecosystem-based fisheries models, and while those models are being generated by scientists working together from a suite of institutions (including University of British Columbia Fisheries Centre, NOAA/Chesapeake Research Consortium, Interstate Commission on the Potomac River Basin, University of Maryland Chesapeake Biological Laboratory, NOAA Chesapeake Bay Office/Cooperative Oxford Laboratory, Virginia Institute of Marine Science, and Maryland Department of Natural Resources), programs such as CTILS are concurrently generating the data required for the models.

Project objectives

The overall goal of this project was to provide fisheries researchers and managers with the integrated trophic interactions database that can be used to support the development of ecosystem-based fisheries stock assessment models. To meet that goal the following objectives were established:

- Continue development of a cooperative network of researchers in the Chesapeake Bay region to collect fish stomach samples and associated environmental data.

- Construct a thorough fish diet composition database encompassing an array of species, locations/habitats, seasons, and age-classes throughout the Chesapeake Bay region.

Specifically, the CTILS program intended to provide biomass values for a subsample of predator (consumer) species and biomass and fractional values of the prey consumed. This diet data will be associated with the survey catch data, a basic requirement of traditional fisheries models.

Because much of our effort was focused on collecting samples encompassing a wide range of temporal and spatial coverage, our extensive database also facilitated numerous secondary objectives. The CTILS website (www.fisheries.vims.edu/ctils) was updated regularly with new diet information, a photo journal of identified prey items, and an interactive map depicting the geographic coverage of samples processed. Additionally, as specific questions arise regarding the trophic ecology of a particular species, time period, and/or geographic location, we will develop a systematic approach for data analysis and to demonstrate results and conclusions quickly and efficiently. Finally, we intend to follow up these analyses by publishing results in peer reviewed scientific journals.

METHODS

The Chesapeake Bay Trophic Interactions Laboratory Services program relied on pre-existing fish monitoring and assessment operations to acquire samples for processing. These surveys not only provided the samples needed to create the rich database proposed by the CTILS program, but also added value to their own operations by enhancing their function as collaborative entities. To ensure that our database reflected adequate temporal and spatial scales, samples and associated environmental data were acquired from this client network of research projects across the bay (Figure1) and near-coastal region (Figure 2).

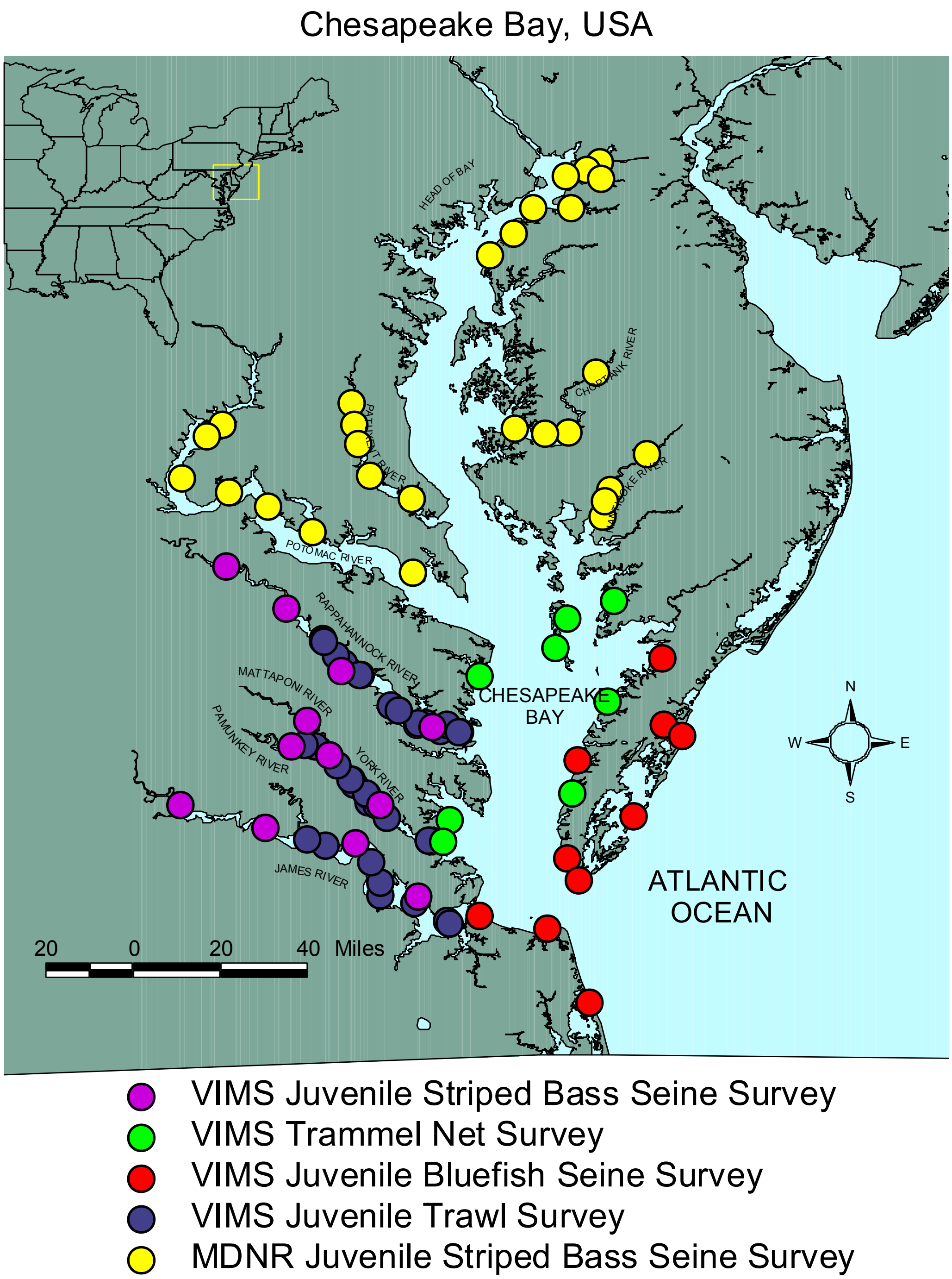


Figure 1. Locations sampled by various surveys participating in the CTILS program 2003-2004. In some cases, exact locations were randomly selected each month and therefore changed throughout the sampling period. The MDNR Adult Striped Bass Creel and Spawning Stock Survey sampled throughout the main stem of the Maryland portion of Chesapeake Bay.

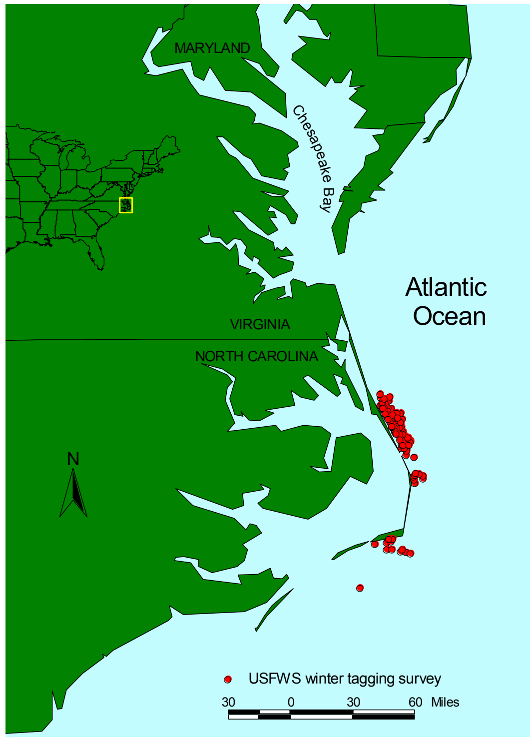


Figure 2. Area sampled by the USFWS Cooperative Winter Tagging Survey, 2005.

Participation by VIMS surveys included that of the Juvenile Fish and Blue Crab Trawl Survey, the Juvenile Striped Bass Seine Survey, the Juvenile Bluefish Seine Survey, the Seagrass Trammel Net Survey, and a crab enhancement study in association with the Trammel Net Survey. Maryland Department of Natural Resources (MDNR) participation included that of the Juvenile Striped Bass Seine Survey, and the Adult Striped Bass Creel and Spawning Stock Survey. Participation by the United States Fish and Wildlife Service (USFWS) near-coastal winter striped bass tagging survey, in cooperation with North Carolina Division of Marine Fisheries (NCDMF), Atlantic States Marine Fisheries Commission (ASMFC), East Carolina University (ECU), MDNR, and the National Marine Fisheries Service (NMFS), was also established.

Initially, CTILS focused on defining the diet composition of a limited number of primarily piscivorous fishes. However, with continued funding, resources and expertise allowed for an expansion of the program to include additional fish species linked by trophic interactions to benthic and plankton communities.

A standardized protocol for the laboratory and analytical services provided by CTILS, which includes methodologies for sample preservation, transportation, and processing, was adhered to. Whole fish were provided to CTILS for processing by the VIMS trawl and seine surveys, and the MDNR seine survey. The fish were measured to the nearest 5 mm and weighed to the nearest 0.1 g. Stomachs were removed and preserved in normalin. The VIMS trammel net survey and crab enhancement study, the MDNR adult creel survey, and the USFWS cooperative tagging survey provided stomach samples, already preserved, along with associated fish length and weight data. All samples were accompanied by environmental data for the study locations.

Preserved stomachs were processed via a standardized laboratory protocol (Hyslop, 1980). The stomachs were removed from the fixative and weighed to the nearest 0.0001 g. The stomach contents were emptied and the stomach weighed again. The prey items were identified to the lowest possible taxon, enumerated, and weighed to the nearest 0.0001 g wet weight. The proportion by weight of each prey type was determined in all analyses. Empty stomachs were eliminated from the analyses.

Diet analyses were presented in regular reports to the participating surveys.

RESULTS AND DISCUSSION

Ultimately, the data generated by CTILS will be incorporated into the Chesapeake Bay Ecopath with Ecosim (EwE) model as well as several multispecies bioenergetics models currently under development by various research groups (Pauly et al., 2000; Latour et al., 2003; Christensen et al., 2006). From these models, management decisions can be based upon a more complete understanding of the population dynamics and interactions of commercially and recreationally exploited fish stocks. All diet and related field data will become a part of a regional library and will be identifiable as to survey and/or investigator. Any publications that result from shared samples will either be joint publications with those who provided samples, or the partners will be given appropriate acknowledgement according to the level of participation. These publications will also formally acknowledge the Virginia Marine Resources Commission Recreational Fishing Advisory Board.

To date, samples for CTILS have been provided by eight different surveys, and 8425 stomachs from 34 species have been processed (Tables 1 and 2).

Table 1. Distribution of samples obtained from the various surveys participating in the CTILS program,2003-2006.

Survey	**Habitat sampled**	**Total Stomachs Processed**	**Percent of Total**
VIMS Juvenile Fish and Blue Crab Trawl Survey	Pelagic, Virginia tributaries (James, York, Rappahannock Rivers)	4143	49
VIMS Trammel Net Survey	Seagrass beds, Chesapeake Bay	1400	17
MDNR Juvenile Striped Bass Seine Survey	Littoral, Maryland tributaries (Choptank, Nanticoke, Patuxent, Potomac Rivers and Head of Bay)	594	7
VIMS Juvenile Bluefish Seine Survey	Littoral and surf zone, Virginia Eastern Shore and Southside Chesapeake Bay	608	7
VIMS Juvenile Striped Bass Seine Survey	Littoral, Virginia tributaries (James, York, Rappahannock Rivers)	755	9
MDNR Striped Bass Creel Survey	Pelagic, Maryland Chesapeake Bay main stem	325	4
USFWS Cooperative Winter Tagging Cruise	Nearshore oceanic, Northeast North Carolina	402	5
VIMS Crab Enhancement Study	Littoral, sheltered, York River	198	2
TOTAL		**8425**	**100**

Table 2. Distribution of species collected for diet analysis by the CTILS program, 2003 to 2006.

Species	**Common name**	**Total**	**Percent of Total**
Micropogonias undulatus	Atlantic croaker	2297	27.26
Morone saxatilis	striped bass	2097	24.89
Cynoscion regalis	weakfish	744	8.83
Ictalurus furcatus	blue catfish	691	8.20
Morone americana	white perch	559	6.64
Paralichthys dentatus	summer flounder	548	6.50
Bairdiella chrysoura	silver perch	353	4.19
Leiostomus xanthurus	spot	230	2.73
Menticirrhus spp.	kingfish spp.	220	2.61
Strongylura marina	Atlantic needlefish	203	2.41
Pomatomus saltatrix	bluefish	138	1.64
Others		345	4.09
TOTAL		**8425**	100.00

In addition to providing information for ecosystem-based fisheries models in the future, the CTILS database was used to compare the diets of fish species in multiple contexts, as fish diets change in time and space. Performing simple diet analyses on priority species based on their commercial, recreational, or ecological importance reveals preliminary information on which to build more robust analyses. A comparison of the diets of adult striped bass (*Morone saxatilis*) collected by four surveys operating in different regions of the Chesapeake Bay indicated notable differences as well as similarities (Figure 3). A similar comparison between the diets of juvenile striped bass sampled by three different surveys in the Chesapeake Bay in 2004 was performed (Figure 4).

Comparisons were also made between the diets of predators utilizing the Chesapeake Bay seagrass beds and the James, York, and Rappahannock Rivers. Diets of weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), silver perch (*Bairdiella chrysoura*), and Atlantic croaker were compared (Figures 5-8). The diets of blue catfish (*Ictalurus furcatus*) were also compared between the James, York, and Rappahannock Rivers midwater habitats (Figure 9) and the James and Rappahannock Rivers littoral habitat (Figure 10). The diet of blue catfish was monitored in order to establish any interactions with native species and/or ascertain any impacts on the Asian clam.

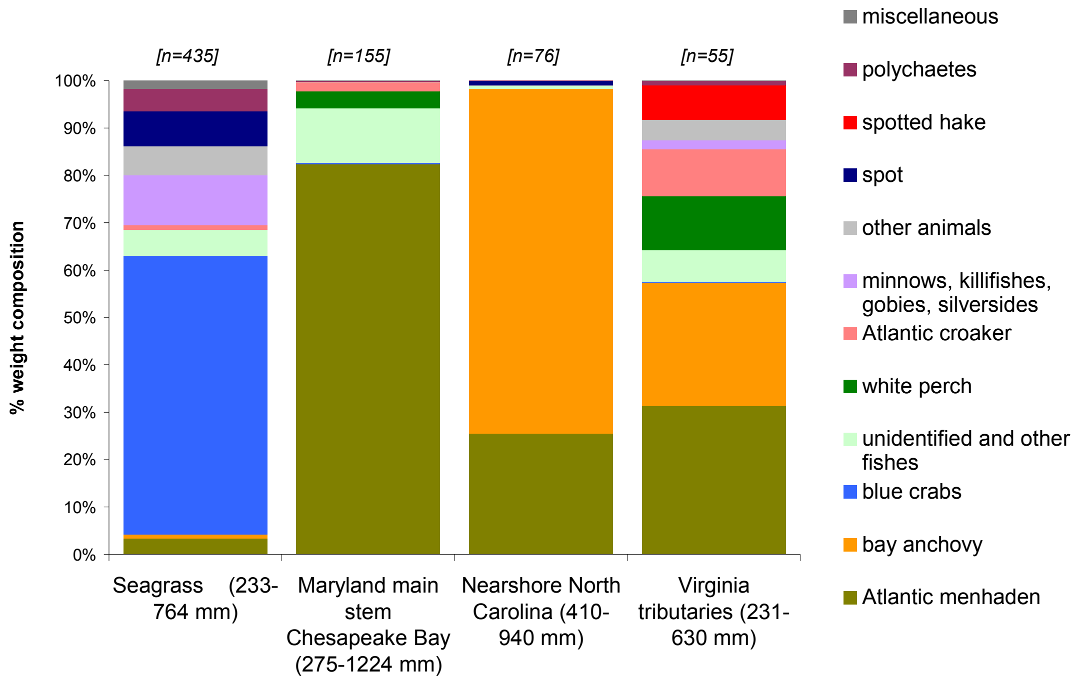
Because substantial numbers of Atlantic croaker (*Micropogonias undulatus*) occur in Chesapeake Bay habitats year-round, a monthly plot of diet data from specimens sampled in the James, York, and Rappahannock Rivers in Virginia was generated (Figure 11).

Young-of-the-year bluefish (*Pomatomus saltatrix*) diet was compared between fish captured at Southside and Eastern Shore locations of Chesapeake Bay (Figure 12). The VIMS Juvenile Bluefish Seine Survey and the Juvenile Striped Bass Seine Survey both captured Atlantic needlefish (*Stronylura marina*), and a diet comparison between fish captured at the Southside and Eastern Shore locations and the Virginia tributaries was made (Figure 13).

Adult and juvenile striped bass foraging habitats

The most distinct difference between the diets of adult striped bass captured in various habitats was between that in the seagrass beds versus the Virginia river tributaries, the Maryland main stem, and the nearshore North Carolina vicinity (Figure3). The primary prey of striped bass in seagrass beds were blue crabs (*Callinectes sapidus*). Atlantic menhaden (*Brevoortia tyrannus*) was the main prey of specimens sampled in the main stem of the Chesapeake Bay in Maryland. Bay anchovies (*Anchoa mitchilli*), followed by Atlantic menhaden, were the most important prey for striped bass collected in nearshore waters of Virginia and North Carolina. Bay anchovy and Atlantic menhaden were equally important, by weight, in the diet of striped bass collected from the Virginia Chesapeake Bay tributaries.

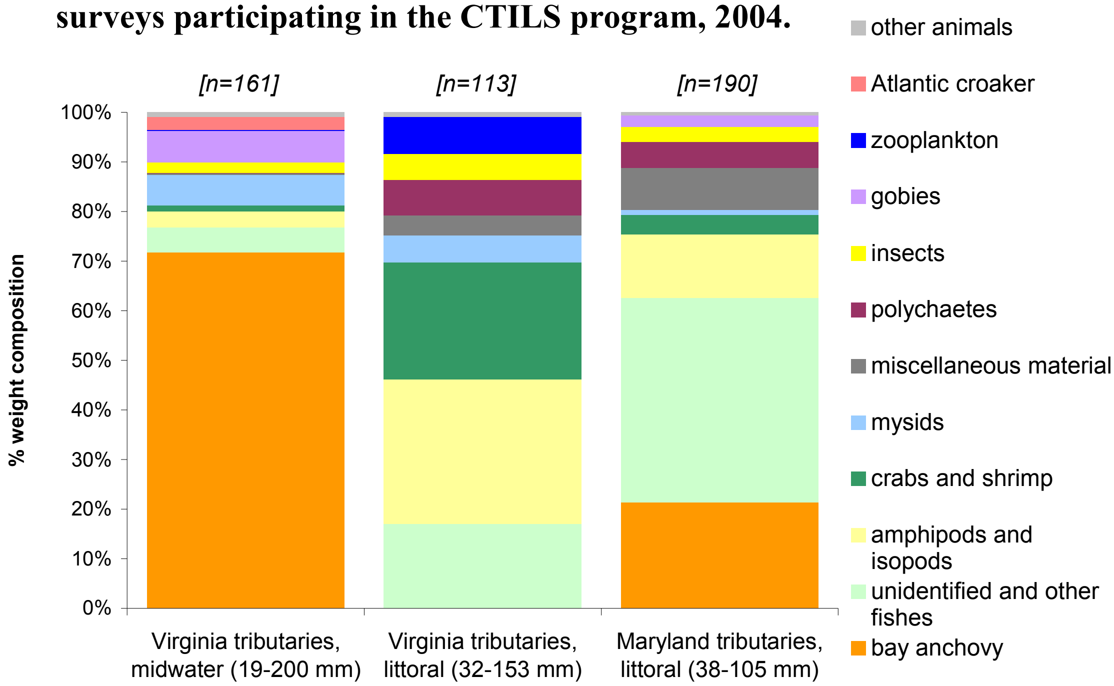
Figure 3. Diet of adult striped bass captured by various surveys participating in the CTILS program, 2003-2006



Furthermore, the diets of striped bass captured in the Virginia tributaries and in the seagrass beds display a greater diversity than the striped bass captured in the Maryland Chesapeake Bay main stem and nearshore North Carolina. This may be due to the relatively higher availability of forage habitat in the specialized niches sampled by the VIMS surveys in comparison to the more barren pelagic habitat sampled by the other two surveys. In addition, the fish sampled in Maryland and North Carolina were larger and likely more capable of preying upon schooling fishes, as opposed to foraging on slower-moving benthic prey.

The most distinct difference in a comparison of juvenile striped bass captured in various habitats was that fishes were the primary prey of fish captured in the midwater region of the Virginia tributaries and the littoral region of the Maryland tributaries, while invertebrates dominated the diet of fish captured in the Virginia tributary littoral habitats (Figure 4). Specifically, bay anchovy made up the vast majority of the diet of juvenile striped bass sampled in the midwater tributary habitats in Virginia. A significant portion of the diet of fish captured in the Maryland littoral tributary habitats was made up of bay anchovy, while two silversides (*Menidia spp.*) and a tessellated darter (*Etheostoma olmstedi*) comprised most of the weight composition indicated by the category "unidentified and other fishes".

Figure 4. Diet of juvenile striped bass captured by various surveys participating in the CTILS program, 2004.

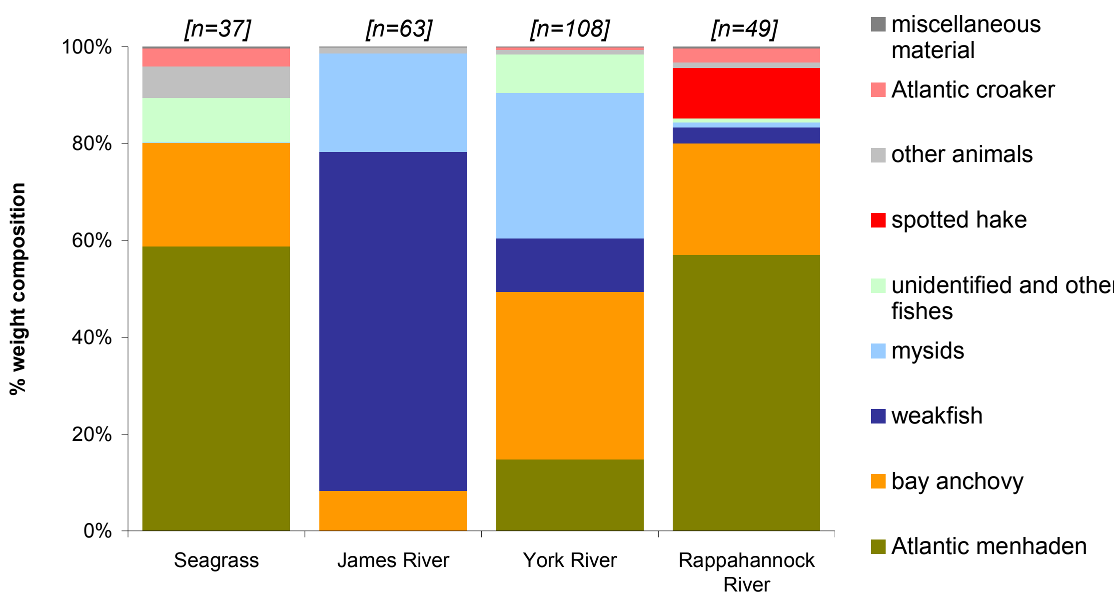


In contrast, the diet of juvenile striped bass in the littoral areas of the Virginia tributaries, was dominated by invertebrates. Amphipods (mostly *Corophium spp.*, *Gammarus spp.*, Haustoriids, and *Leptocheirus plumulosus*) and isopods (mostly *Cyathura polita*) were the dominant prey types, followed by grass shrimp (*Palaemonetes spp.*). Two mosquitofish (*Gambusia affinis*) made up about one-fourth of the weight composition indicated by "unidentified and other fishes". Notably, large numbers of the megalopa stage of blue crabs (*Callinectes spp.*), an important species of commercial and recreational interest in the Chesapeake Bay, were consumed by juvenile striped bass in all three sampling locations.

Virginia vegetated and non-vegetated habitats

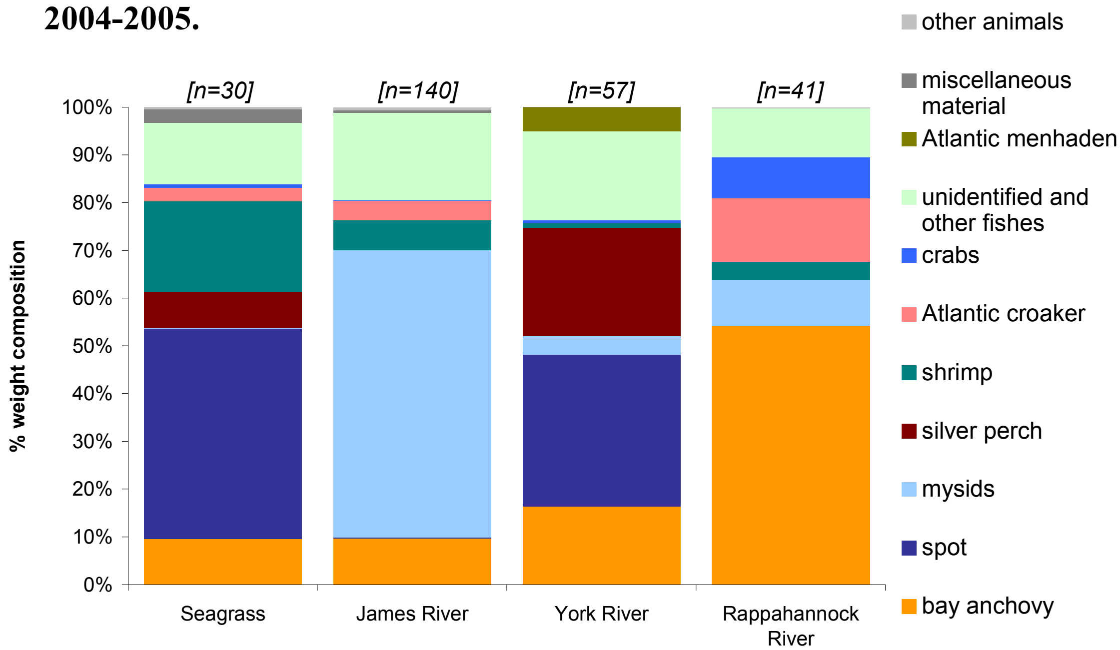
In general, weakfish preyed primarily upon bay anchovy, Atlantic menhaden, and mysids (*Neomysis americana*) in the seagrass and Virginia tributary habitats (Figure 5). Atlantic menhaden was the primary prey by weight in the diet of weakfish captured in the seagrass beds and in the Rappahannock River. However, it is important to note that the number of bay anchovy was 14 times greater than the number of Atlantic menhaden consumed by weakfish in the seagrass beds and 10 times greater than Atlantic menhaden eaten by weakfish in the Rappahannock River. Bay anchovy and mysids dominated the weakfish diet by weight in the York River (bay anchovy also outnumbered Atlantic menhaden in the diet by 8 times). In the James River, weakfish (*Cynoscion regalis*) appear to be the most dominant prey consumed by weakfish; however, the number of bay anchovy eaten was 18 times more than the number of weakfish consumed.

Figure 5. Diet of weakfish captured by the VIMS Trammel Net Survey and the VIMS Juvenile Trawl Survey, 2004-2005.



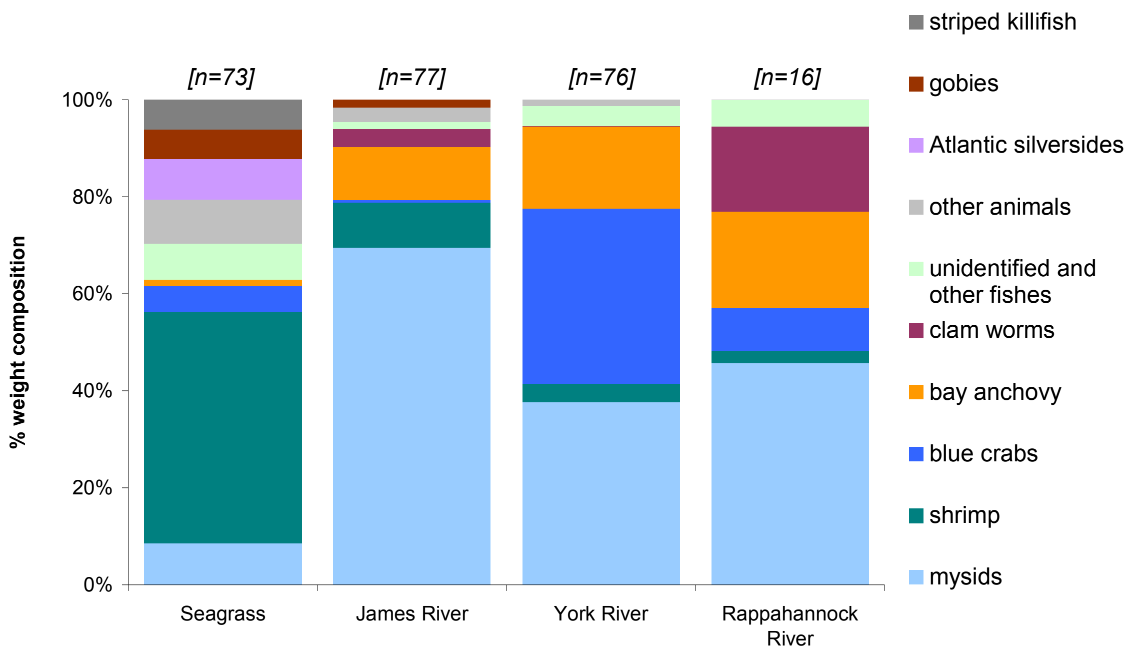
The summer flounder sampled preyed primarily on fishes and mysids (Figure 6). In the seagrass beds and the York River, spot (*Leiostomus xanthurus*) was the dominant prey by weight, although bay anchovy outnumbered spot in the diet. In the seagrass habitat, three times more bay anchovy than spot were consumed by summer flounder, and 22 times more bay anchovy than spot were consumed in the York River. Mysids (*Neomysis americana*) was the main prey type for summer flounder in the James River and bay anchovy dominated the diet of summer flounder in the Rappahannock River. Shrimp (*Palaemonetes spp.* and *Crangon septemspinosa*) were important prey items for summer flounder in the seagrass, white perch (*Morone americana*) were consumed in the James River, silver perch (*Bairdiella chrysoura*) in the York River, and Atlantic croaker (*Micropogonias undulatus*) were preyed upon in the Rappahannock River. Atlantic menhaden were also found in the summer flounder diet in the York River.

Figure 6. Diet of summer flounder captured by the VIMS Trammel Net Survey and the VIMS Juvenile Trawl Survey, 2004-2005.



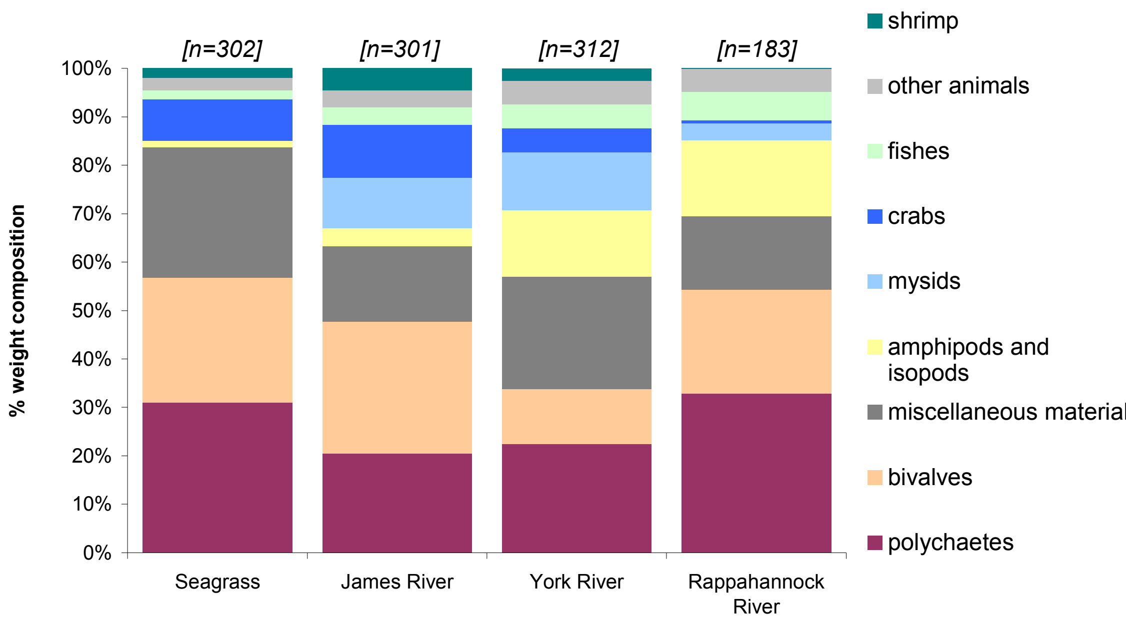
Silver perch preyed mainly on shrimp (*Palaemonetes spp.* and *Crangon septemspinosa*) in the seagrass beds and mysids (primarily *Neomysis americana*, some *Mysidopsis bigelowi* in the Rappahannock River only) (Figure7). In the York River, blue crabs comprised a significant portion of the diet by weight. However, by numerical abundance, blue crabs made up only 0.2% of the diet in the York River. Fishes (including Atlantic silversides, gobies, fourspine stickleback, striped killifish, spot, alewife, Atlantic croaker, and pipefish) were important in the diet of silver perch sampled in the seagrass beds. Bay anchovy was an important food source for silver perch in all three rivers.

Figure 7. Diet of silver perch captured by the VIMS Trammel Net Survey and the VIMS Juvenile Trawl Survey, 2004-2005.



Atlantic croaker diet was similar among the seagrass habitat and the river habitats (Figure 8). The primary prey types were polychaetes (*Nereis spp*., terebellids, *Glycera spp.*, *Clymenella torquata*, and *Pectinaria gouldi*) and bivalves (mostly *Macoma spp.*, *Mya arenaria*, *Tagelus plebeius*, *Mulinia lateralis*, and *Mytilus edulis*). Of the bivalves consumed, the softshell clam (*M. arenaria*) was the most heavily exploited species by croaker in the seagrass beds, but found only rarely in the diet of croaker in the rivers. Amphipods (mostly *Leptocheirus plumulosus*, *Gammarus spp.*, *Corophium spp.*, and *Monoculodes edwardsi*) and isopods (mostly *Cyathura polita*, *Chiridotea spp.*, and *Synidotea laevidorsalis*) were important prey types for croaker in the York and Rappahannock Rivers. Mysids (mostly *Neomysis americana*) were important in the James and York Rivers. Crabs (mostly *Callinectes spp*. and xanthids) played a role in the croaker diet in the seagrass beds and the James and York Rivers. The miscellaneous material included unidentified material, vegetation, detritus, sand, mud, and woody debris.

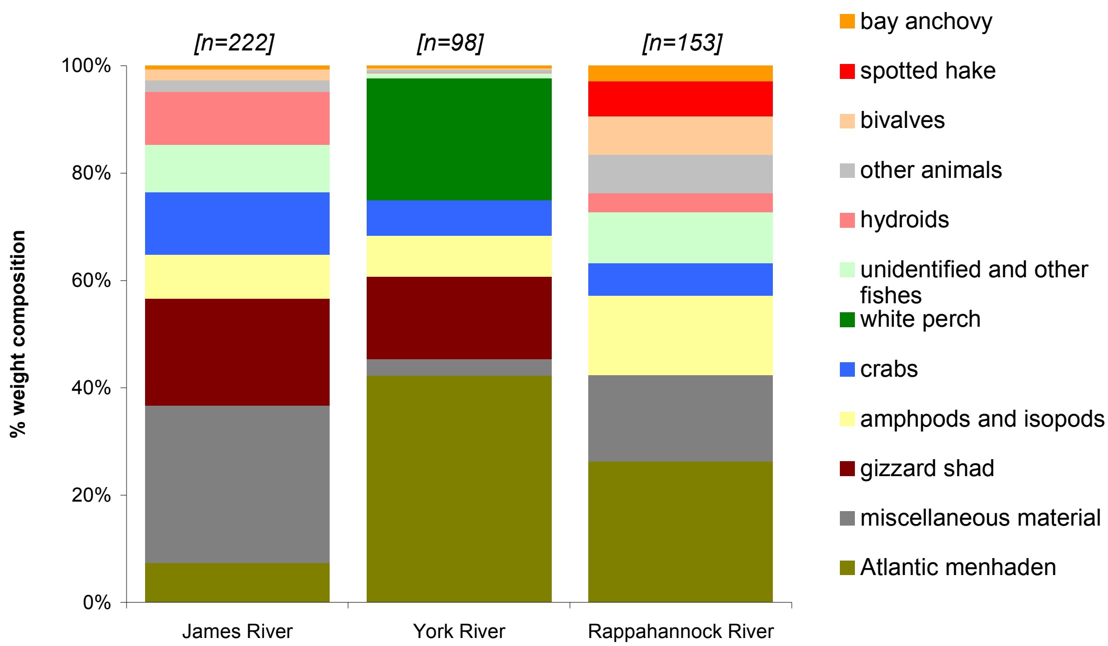
Figure 8. Diet of Atlantic croaker captured by the VIMS Trammel Net Survey and the VIMS Juvenile Trawl Survey, 2004-2005.



Non-indigenous species

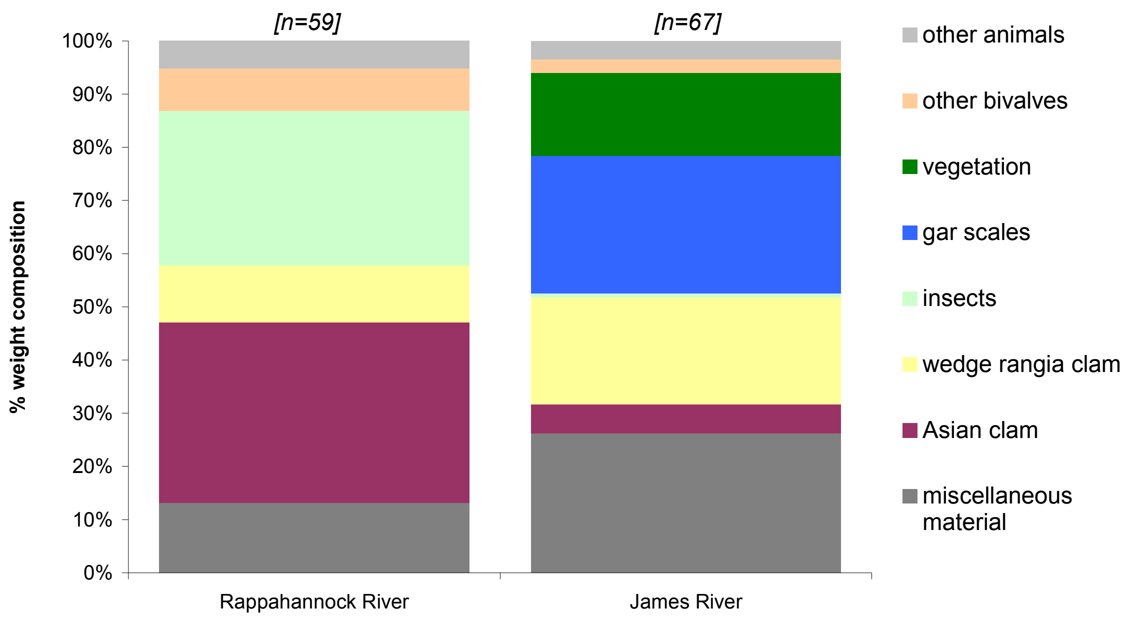
The blue catfish diet was diverse, which reflects the scavenger feeding behavior of this non-indigenous species (Figure 9). The apparent importance of fish in the diet of blue catfish is represented by only a few large prey fish. For example, the Atlantic menhaden, gizzard shad (*Dorosoma cepedianum*), and white perch were eaten in very small numbers by only a few fish, although they were large prey and therefore contribute a large proportion of the diet. Other fishes consumed included spotted hake (*Urophycis regia*), bay anchovy, Atlantic croaker, hogchokers (*Trinectes maculatus*), gobies, and an American eel (*Anguilla rostrata*). The prey types found more frequently and consistently in the blue catfish diet were amphipods, isopods, and mud crabs (species comparable to those eaten by Atlantic croaker in the three rivers). Miscellaneous material included unidentified material, detritus, sand, mud, shell, woody debris, vegetation, rocks, sand, peanuts, plastic trash, and pieces of scrap bait.

Figure 9. Diet of blue catfish captured by the VIMS Juvenile Trawl Survey, 2004-2005.



Blue catfish were captured by the VIMS Juvenile Striped Bass Seine Survey in only the Rappahannock and James Rivers. The main prey types in the Rappahannock River were the exotic Asian clam (*Corbicula fluminea*) and insects (mostly Chironomid larvae and pupae, mayfly nymphs, and caddisfly larvae). In the James River, the blue catfish preyed mostly on wedge rangia clams (*Rangia cuneata*). The remainder of the diet reflected scavenging behavior, as significant quantities of scales, especially those of longnose gar (*Lepisosteus osseus*), and vegetation were found. Miscellaneous material consumed by the blue catfish in both rivers included unidentified material, rocks, sand, and wood.

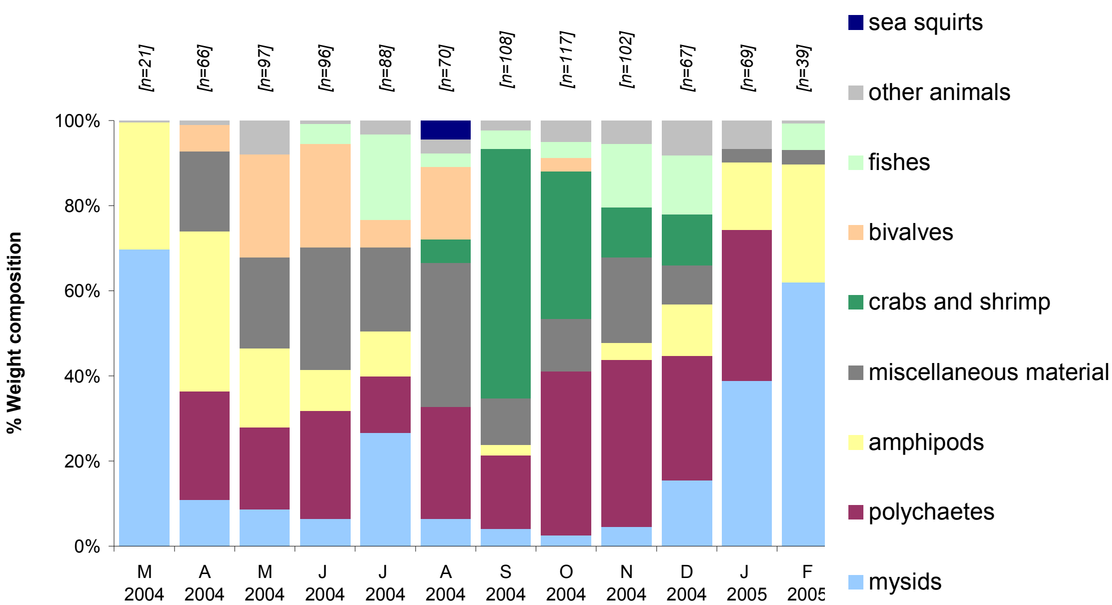
Figure 10. Diet of blue catfish captured by the VIMS Juvenile Striped Bass Seine Survey, 2004-2005.



Monthly shifts in diet

The diet of Atlantic croaker foraging in the midwater habitats of the James, York, and Rappahannock Rivers displayed shifts in diet throughout the year (Figure 11). From March 2004 to March 2005, mysids (largely *Neomysis americana*) were found in the croaker diet every month, and polychaetes (*Nereis spp.*, *Glycera spp.*, Terebellids, *Clymenella torquata*, and *Pectiaria gouldi*) were present in all but two months. In general, mysids, amphipods (primarily *Leptocheirus plumulosus*, *Gammarus spp.*, *Monoculodes edwardsi*, and *Corophium spp.*), and polychaetes dominated in the spring; clams (*Macoma spp.*, *Mya arenaria*, and *Mulinia lateralis*) and polychaetes were dominant in the summer; crabs (primarily *Callinectes sapidus*, *Rhithropanopeus harrissii*, and *Pagurus spp.*), shrimp (*Crangon septemspinosa*) and polychaetes were the primary prey in the fall; and mysids and polychaetes were most important in the winter. The changes in diet may be a result of the availability of prey, the size classes of fish inhabiting the sample location each month, or the presence of other competing species for resources. These questions will be addressed via formal statistical analyses of the diet data coupled with the survey catch data.

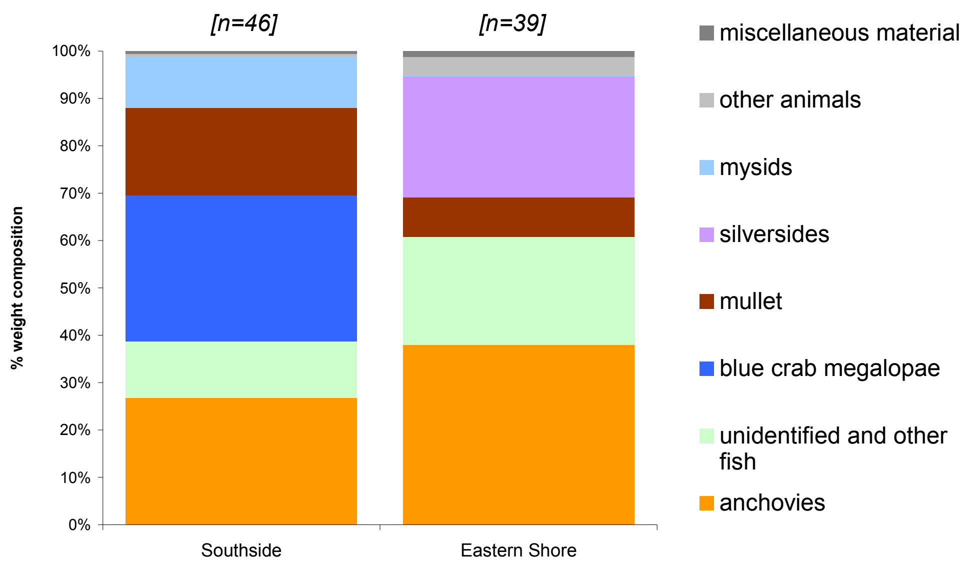
Figure 11. Monthly diet of Atlantic croaker captured by the VIMS Juvenile Trawl Survey in the James, York, and Rappahannock River, March 2004 to February 2005.



Juvenile piscivores

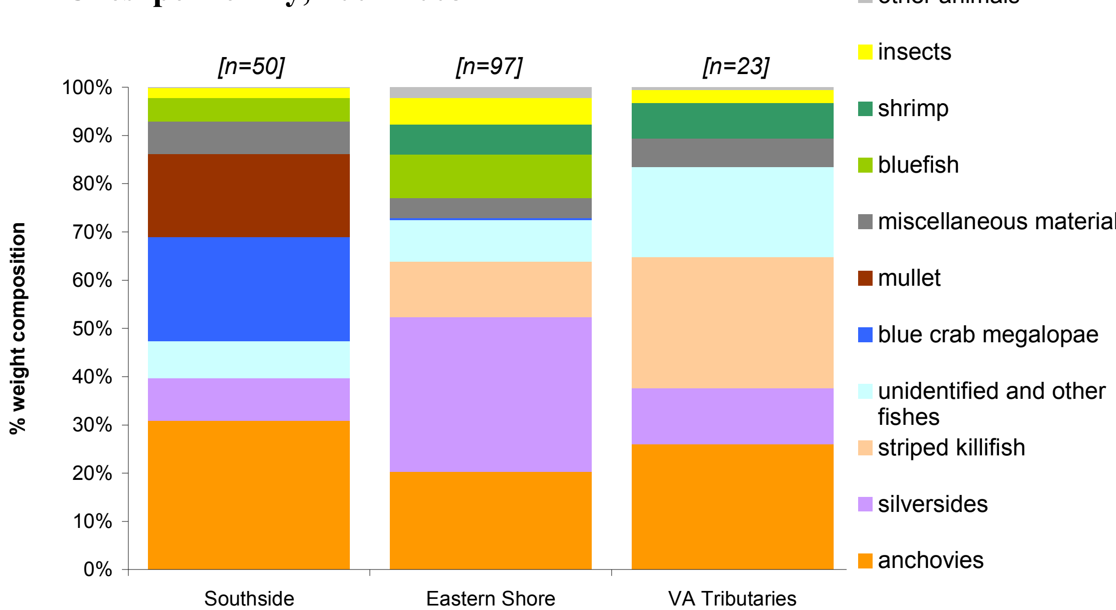
The diet of young-of-the-year bluefish sampled at Eastern Shore and Southside locations of Chesapeake Bay were slightly different (Figure 12). The primary prey, by weight, of bluefish captured at the Southside locations was the megalope stage of blue crabs followed closely by anchovies (*Anchoa hepsetus* and *A. mitchilli*). Mullet (*Mugil spp.*) and mysids (*Mysidopsis bigelowi* and *Neomysis americana*) were also important prey types. At the Eastern Shore locations, the bluefish diet was dominated by anchovies and silversides. Mullet were found, but blue crabs were absent from the diet of fish sampled at these locations.

Figure 12. Diet of YOY bluefish captured by the VIMS Juvenile Bluefish Seine Survey at Southside and Eastern Shore locations of Chesapeake Bay, 2004-2005



The diet of Atlantic needlefish sampled from the Eastern Shore and Virginia tributary locations displayed a similar diet of anchovies (*Anchoa mitchilli* and *A. hepsetus*), silversides, and striped killifish (*Fudulus majalis*). Silversides were more dominant in the Eastern Shore needlefish diet, while in the Virginia tributary needlefish diet striped killifish were more dominant. The diet of needlefish from the Southside locations was slightly different. Here, anchovies were the primary prey, but blue crab megalopae and mullet were also important (Figure 13).

Figure 13. Diet of Atlantic needlefish captured by seine at Southside, Eastern Shore, and Virginia tributary locations of Chesapeake Bay, 2004-2005



CONCLUSION

The disparity in diet composition shown emphasizes the importance of collecting diet data from a variety of surveys, which expands the spatial and temporal coverage as well as the size range of fish sampled. Further, combining data from a variety of surveys provides a comprehensive diet composition database, and therefore, more reliable parameterization of multispecies fisheries assessment models. Because CTILS is designed to be used both as a reference for diet information throughout as many combinations of species and temporal and spatial scales as possible and as data to be applied to adaptive ecosystem models, the results included in this report should serve only as a few examples of the output that can be generated via this program.

REFERENCES

Boynton, W.R., T.T. Polgar, and H.H. Zion. 1981. Importance of juvenile striped bass food habits in the Potomac estuary. Transactions of the American Fisheries Society. 110:56-63.

Buckel, J.A. and D.O. Conover. 1997. Movements, feeding periods, and daily ration of piscivorous young-of-the-year bluefish, *Pomatomus saltatrix*, in the Hudson River estuary. Fishery Bulletin 95: 665-679.

Buckel, J.A., D.O. Conover, N.D. Steinberg, and K.A. McKown. 1999. Impact of age-0 bluefish (*Pomatomus saltatrix*) predation on age-0 fishes in the Hudson River estuary: evidence for density-dependent loss of juvenile striped bass (*Morone saxatilis*). Canadian Journal of Fisheries and Aquatic Sciences 56:275-287.

Christensen V., A. Beattie, C. Buchanan, S.J.D. Martell, R.J. Latour, D. Preikshot, H. Townsend, J.H. Uphoff, C.J. Walters, and R.J. Wood. 2006. Fisheries ecosystem model of the Chesapeake Bay: Methodology, parameterization and model exploration. Draft Technical Report for submission to NOAA Tech Rep. Series.

Griffin, J.C. 2001. Dietary habits of an historical striped bass, *Morone saxatilis*, population in Chesapeake Bay. Master's thesis, Princess Anne, University of Maryland Eastern Shore, MD, USA: 135 pp.

Harding, J.M. and R. Mann. 2001. Diet and habitat use by bluefish, *Pomatomus saltatrix*, in a Chesapeake Bay estuary. Environmental Biology of Fishes 60: 401-409.

Hartman, K.J. and S.B. Brandt. 1995. Trophic resource partitioning, diets and growth of sympatric estuarine predators. Transactions of the American Fisheries Society 124:520-537.

Hyslop, E.J. 1980. Stomach content analysis – a review of methods and their application. Journal of Fish Biology 17:411-429.

Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD.

Juanes, F., J.S. Buckel, and F.S. Scharf. 2001. Predatory behavior and selectivity of a primary piscivore: comparison of fish and non-fish prey. Marine Ecology Progress Series 217: 157-165.

Latour, R.J., M.J. Brush, and C.F. Bonzek. 2003. Toward ecosystem-based fisheries management; strategies for multispecies modeling and associated data requirements. Fisheries 28:10-22.

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

Montane, M.M and W.A. Lowery. 2005. Estimating Relative Juvenile Abundance of Ecologically Important Finfish and Invertebrates in the Virginia Portion of Chesapeake Bay. Annual Report. School of Marine Science, College of William and Mary. Virginia Institute of Marine Science. Gloucester Point, Virginia 23062.

Murdy, E.O., R.S. Birdsong, and J.A. Musick. 1997. Fishes of Chesapeake Bay. Smithsonian Institution Press. Washington D.C.

Pauly, D., V. Christensen, and C. Walters. 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science 57:697-706.

Richards, S.W. 1976. Age, growth, and food of bluefish (*Pomatomus saltatrix*) from East-Central Long Island Sound from July through November 1975. Transactions of the American Fisheries Society 105: 523-525.

Uphoff, J.H. Jr. 2003. Predator-prey analysis of striped bass and Atlantic menhaden in upper Chesapeake Bay. Fisheries Management and Ecology 10:313-322.

United States Geological Survey. 2005. http://nas.er.usgs.gov/.

Walter, J.F. III and H.M. Austin. 2003. Diet composition of large striped bass (*Morone saxatilis*) in Chesapeake Bay. Fishery Bulletin 101:414-423.