Investigation of
Maryland's Coastal Bays
and Atlantic Ocean Finfish Stocks

July 2016 - June 2017 Final Report

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Final Performance Progress Report
Investigation of Maryland's Coastal Bays and Atlantic Ocean Finfish Stocks
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Acknowledgements

The Coastal Bays Fisheries Investigation has been sampling fishes in the coastal bays for 44 years. Although the survey began in 1972, it did not have dedicated funding until 1989. Consistent funding allowed staff to specifically dedicate time and make improvements to the sampling protocol that resulted in significant beneficial contributions to the fisheries of the coastal bays. We would like to thank the past and present staff that dedicated their careers to the Coastal Bays Fisheries Investigation for having the knowledge, initiative, and dedication to get it started and maintained. Additionally, staff of the Coastal Fisheries Program would like to thank all of the department employees who assisted with the operations, field work, and annual reports over the years whether it was for a day or a few months. We would also like to extend our gratitude to the University of Maryland Eastern Shore graduate students Kristen Lycett, Detbra Rosales, and Rebecca Peters as well as the numerous volunteers from outside the department who assisted with field collection work over the years.

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Lastly, we want to thank interns, Sarah Cvach, Sam Jackson and Isabel Whaling, for their hard work in the field and office. They dedicated their summers and senior years to working and learning with us.

Accomplishments

The following milestones were completed July 1, 2016 through June 30, 2017.

Completed monthly July - October 2016

- Collected 20 trawl samples at 20 fixed locations on Maryland's coastal bays each month
- Completed data entry and cleanup from prior month's sampling
- Updated current finfish indices for trend analysis
- Accompanied commercial trawlers to gather biological information on important recreational and commercial finfish species from July through November.

Completed September 2016

- Conducted beach seine sampling at 19 fixed locations on Maryland's coastal bays
- Conducted the Submerged Aquatic Vegetation Habitat Survey beach seines at 14 sites in Sinepuxent Bay
- Completed data entry and cleanup from prior month's sampling

Completed October – December 2016

- Completed data entry and cleanup from October sampling
- Completed quality assurance and quality control for all data collected during the 2016 field sampling season

Completed January 1 through March 31, 2017

- Conducted data analyses of the 2016 surveys
- Wrote the F-50-R-25 annual report draft
- Prepared for the 2017 field sampling season (beach seine and trawl survey)
- Determined sampling needs for submerged aquatic vegetation habitat analysis
- Cleaned and aged 200 tautog opercula
- Length, weight, sex, and opercula were collected from 19 tautog samples obtained from a charter boat. Otoliths were extracted from select fish.

Completed monthly April 1 through June 30, 2017

- Collected 20 trawl samples at 20 fixed locations on Maryland's coastal bays each month
- Completed data entry and cleanup from prior months sampling

Completed May 2017

- Edited the F-50-R-25 report

Completed June 2017

- Completed one trip onboard a commercial trawler to gather biological information on important recreational and commercial finfish species
- Conducted beach seine sampling at 19 fixed locations on Maryland's coastal bays
- Edited F-50-R-25 report

Preface

Analyses of the Trawl and Beach Seine Surveys data revealed seasonal and temporal biases in the data collection (1972-1988) which significantly affected the analyses of the overall time series dataset (1972-present). These biases resulted from prioritization of resources by the department coupled with limited staff availability and lack of funding prior to 1989. Beginning in 1989, this survey was performed following a standardized sampling protocol, eliminating the biases of previous years. This report highlights trends resulting from data collected during the standardized (1989-present) time period. No historical data (1972-1988) were included in these analyses.

In 2006, modifications to the sampling protocol were implemented. Changes included:

- collecting bottom water quality, latitude and longitude;
- developing a field identification guide of fishes and invertebrates;
- developing a voucher collection and annual staff review;
- estimating the percent opening of the beach seine;
- identifying bryozoans, macroalgae, and sponges as well as estimating the percent of the total volume collected per sample;
- identifying the bottom type at beach seine sites;
- labeling estimates of counts and volume;
- measuring the first 20 individuals of all fishes;
- measuring the total volume of comb jellies;
- using an anemometer and depth finder; and
- using a standardized datasheet.

Beginning in 2010, field data sheets were reviewed by a biologist that did not record the data after the sample workup was completed to reduce errors. The verification process includes checking for appropriate common names, completeness, confusing information and legibility.

Beginning in 2008, all data from the Beach Seine, Drop Net, and Trawl surveys were incorporated into a centralized database. During 2009, all data imported into the new database from 1989 to the present were verified and cleaned using the original field sheets or related transcribed copies from that time. Data from 1972-1975 and 1977-1988 have also been verified. Species codes were eliminated but common and scientific names were used to ensure correct species identification.

The Submerged Aquatic Vegetation Habitat Survey was added in 2012. After the 2012 pilot year, the east and west Sinepuxent Bay zones were combined into one. Further refinements were made to the sampling approach in 2014 by circling the beach seine for greater catchability of demersal fish. Sinepuxent Bay was selected as the study area in 2015 to reduce the covariant effects of location and allow for comparison of fish abundance results with other survey information from a balanced sampling design.

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Chapter 1
Trawl and Beach Seine Surveys

Introduction

The Coastal Bays Fisheries Investigation was developed to characterize fishes and their abundances in Maryland's coastal bays, facilitate management decisions and protect finfish habitats. The department has conducted the investigations Trawl and Beach Seine surveys in Maryland's coastal bays since 1972, sampling with a standardized protocol since 1989. These gears target finfish although bycatch of crustaceans, macroalgae, molluscs and sponges were common. This report includes data from 1989 – 2016.

Over 130 adult and juvenile species of fishes, 26 molluscs and 20 macroalgae genera and two submerged aquatic vegetation species have been collected since 1972. The investigation was designed to meet the following three objectives:

1. characterize the stocks and estimate relative abundance of juvenile and adult marine and estuarine species in the coastal bays and near-shore Atlantic Ocean;
2. develop annual indices of age and length, specific relative abundance and other needed information necessary to assist in the management of regional and coastal fish stocks; and
3. delineate and monitor areas of high value as spawning, nursery and/or forage locations for finfish in order to protect against habitat loss or degradation.

Methods

Study Area
The coastal bays are separated from the Atlantic Ocean to the east by Fenwick Island and Assateague Island. From north to south, Maryland's coastal bays are comprised of Assawoman, Isle of Wight, Sinepuxent, Newport and Chincoteague bays. Also included are several important tidal tributaries: St. Martin River, Turville Creek, Herring Creek, and Trappe Creek. Covering approximately 363 square kilometers (140 square miles), these bays and associated tributaries average only 0.9 meters (3 feet) in depth and are influenced by a watershed of only 453 square kilometers (175 square miles). The bathymetry of the coastal bays is characterized by a few deep holes, narrow channels, and shallow sand bars.

Two inlets provide oceanic influences to these bays. Ocean City Inlet is formed at the boundaries of south Fenwick Island and north Assateague Island and is located at the convergence of Isle of Wight Bay and Sinepuxent Bay. Chincoteague Inlet located in Virginia is approximately 56 kilometers (34 miles) south of the Ocean City Inlet.

Ocean City is a heavily developed commercial area and the center of a $16 billion tourism industry catering to approximately 8 million visitors annually. Ocean City visitor expenditures alone exceed $1.4 billion and support 8,580 jobs (Greater Ocean City Chamber of Commerce 2016). Assateague Island is owned by the State of Maryland and the National Park Service.

These entities operate Assateague Island National Seashore, Assateague State Park, and Chincoteague National Wildlife Refuge. These properties have beach front, campgrounds, dunes, marshes, off road vehicle access, and small buildings.

The coastal bays western shoreline habitat consists of forest, marinas, residential development, small islands, and *Spartina* marshes. Assawoman Bay is bordered by Maryland and Delaware and is characterized by commercial and residential development, farmland, small islands and *Spartina* spp. marshes. Isle of Wight Bay south into Sinepuxent Bay is a heavily developed commercial and residential area. A public boat launch, two seafood dealers and approximately 20 to 50 transient and permanent commercial fishing vessels utilize the commercial harbor located directly west of the Ocean City Inlet. In addition to the commercial harbor, the majority of marinas in Ocean City are located in Isle of Wight Bay. Residential development expansion has begun moving south into Chincoteague Bay. Vast *Spartina* marshes and numerous small islands characterize Chincoteague Bay.

Submerged aquatic vegetation and macroalgae are common plants in these bays that can provide habitat and foraging sites for fishes and shellfish (Beck *et al.* 2003). Two species of submerged aquatic vegetation are found in Maryland's coastal bays: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). Common species of macroalgae include Agardh's red weed and sea lettuce.

Data Collection

A 25 foot Chawk with a 225 horsepower Evinrude Etec engine was used for transportation to the sample sites and gear deployment. A global positioning system was used for navigation, marking latitude and longitude coordinates in degrees and decimal minutes for each sample and monitoring speed.

Gears

<u>*Trawl*</u>

Trawl sampling was conducted at 20 fixed sites throughout Maryland's coastal bays on a monthly basis from April through October (Table 1, Figures 1-3). With the exception of June and September, samples were taken beginning the third week of the month. Sampling began the second week in June and September in order to allow enough time to incorporate beach seine collections.

The boat operator took into account wind and tide (speed and direction) when determining trawl direction. A standard 4.9 meter (16 feet) semi-balloon trawl net was used in areas with a depth of greater than 1.1 meters (3.5 feet). Each trawl was a standard 6 minute (0.1 hour) tow at a speed of approximately 2.5 to 2.8 knots. Speed was monitored during tows using the global positioning system. Waypoints marking the sample start (gear fully deployed) and stop (point of gear retrieval) locations were taken using the global positioning system to document location of the sample. Time was tracked using a stopwatch which was started at full gear deployment.

Seine

Seines were used to sample the shallow regions of the coastal bays frequented by juvenile fishes. Shore beach seine sampling was conducted at 19 fixed sites beginning in the second weeks of June and September (Table 2, Figures 1-3).

A 30.5 meter X 1.8 meter X 6.4 millimeter mesh (100 feet X 6 feet X 0.25 inch mesh) bag seine was used at 18 fixed sites in depths less than 1.1 meters (3.5 feet.) along the shoreline. Some sites necessitated varying this routine to fit the available area and depth. A 15.24 meter (50 foot) version of the previously described net was used at site S019 due to its restricted sampling area. Coordinates were taken at the start and stop points as well as an estimated percent of net open.

Water Quality and Physical Characteristics

For each sampling method, chemical and physical data were documented at each location. Chemical parameters included: dissolved oxygen (milligrams/liter), salinity (parts per thousand) and water temperature (Celsius). Physical parameters included: speed (knots), tide state, water clarity (Secchi disk; centimeters), water depth (feet), weather condition and wind direction. Data were recorded on a standardized project data sheet printed on Rite in the Rain All Weather paper (Appendices 1 and 2).

Dissolved oxygen, salinity, and water temperature were taken with a Yellow Springs Instrument Pro2030 at two depths, 30 centimeters (1 foot) below the surface and 30 centimeters (1 foot) from the bottom, at each trawl site. The Pro2030 cord was marked in one foot intervals. Chemical data were only taken 30 centimeters below the surface for each beach seine site due to the shallow depth (<1.1 meters). The Pro2030 was calibrated at the beginning of each sampling round.

Water turbidity was measured with a Secchi disk. Secchi readings were taken on the shaded side of the boat without the user wearing sunglasses. The Secchi disk was lowered into the water until it could not be seen. It was then raised until the black and white pattern could just be seen. The biologist marked the position on the string with their fingers and measured the length of the string to the end of the disk.

Both beginning and ending depths for each trawl were read on a depth finder and recorded. At beach seine sites, depth was estimated by the biologists pulling the seine. Wind speed measurements were acquired using a handheld anemometer with digital readout. Measurements were taken facing into the wind. Tidal states were from the global positioning system tide feature or occasionally estimated by checking the published tide tables for the sampled areas. Difficulties determining tide resulted from inlet influences in Ocean City and Chincoteague, lack of appropriate tide stations for some sites and wind driven tidal influences.

Sample Processing

Fishes and invertebrates were identified, counted and measured for total length using a wooden millimeter measuring board with a 90-degree right angle (Table 3). A meter stick was used for species over 500 millimeters. At each site, a subsample of the first 20 fish (when applicable) of each species were measured and the remainder counted. On occasion, invertebrate species counts were estimated.

Blue crabs were measured for carapace width, sex was determined, and female maturity stage identified (Table 3). Sex and maturity categories included: immature female, male, mature female (sook) and mature female with eggs. A subsample of the first 50 blue crabs at each site was measured and the rest were counted. Sex and maturity status of the rest of the blue crabs were not recorded.

Bryozoans, ctenophores, jellyfishes, macroalgae, sponges and submerged aquatic vegetation were measured volumetrically (liters) using calibrated containers with small holes in the bottom to drain the excess water. Small quantities (generally ≤ 10 specimens) of invertebrates were occasionally counted. Slightly larger quantities of invertebrates were sometimes visually estimated. Bryozoans, macroalgae and sponges were combined for one volume measurement and a biologist estimated the percentage of each species in the sample. Unknown species were placed in Ziploc bags on ice or kept in a bucket of water and taken to the office for identification.

Data Analysis

Statistical analyses were conducted on species that historically were most abundant in the trawl and beach seine catch data. Additional species were added to the analyses dependent on their recreational importance and biological significance as forage for adult gamefish and indicators of water quality. Species rarely encountered and/or not considered recreationally important, including forage significance, were removed from the analyses.

The geometric mean was calculated to develop species specific annual trawl and beach seine indices of relative abundance (1989-2016). That method was adopted by the Atlantic States Marine Fisheries Commission Striped Bass Technical Committee as the preferred index of relative abundance to model stock status. The mean was calculated using catch per area covered for trawl and catch per haul for beach seine. The geometric mean was calculated from the $\log_e(x+1)$ transformation of the catch data and presented with 95 percent confidence intervals (Ricker 1975). The geometric mean and confidence intervals were calculated as the antilog [$\log_e$-mean(x+1)] and antilog [$\log_e$-mean(x+1) ± standard error * (t value: α=0.05, n-1)], respectively. A geometric grand mean was calculated for the time series (1989-2016) and used as a point estimate for comparison to the annual (2016) estimate of relative abundance.

Fish diversity was calculated by the Shannon index (H). Shannon's index accounts for both abundance and evenness of the species present. The proportion of species relative to the total number of species (pi) is calculated and then multiplied by the natural logarithm of this proportion (lnpi). The resulting product is summed across species and multiplied by -1. Typical values were generally between 1.5 and 3.5 in most ecological studies and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase.

Statistical analyses were conducted on all macroalgae from 2006 to 2016. The trawl measure of abundance, catch per unit effort, was mean liters per hectare; the beach seine was mean liters per haul. Annual catch per unit effort was compared to the time series grand mean. Macroalgae diversity was calculated by the Shannon index.

To evaluate water quality at trawl sites, the mean for each parameter (dissolved oxygen, salinity, temperature, turbidity) per bay (six systems) was derived from using the surface and bottom values. The dissolved oxygen averages were reviewed to see if the system overall fell below 5.0 milligrams per liter (critical level of hypoxia in some systems).

Results and Discussion

Finfish were the most abundant taxa captured in the survey. Specifically, they accounted for 27,667 fish caught trawling (9,480 fish) and beach seining (18,187 fish) in 2016 (Table 4**).** The total number of fish caught was similar to the last 10 years. Collected fishes represented 71 species which is a normal representation of species in a year. Black sea bass and silver perch had above average trawl indices. Above average beach seine indices were produced for bay anchovies, sheepshead and striped bass.

Below average indices were produced for spot and summer flounder in the trawl and bluefish and tautog from the beach seine. Nearly all other species of recreational and commercial interest had average indices of abundance.

Crustaceans were the second most abundant taxa captured in this survey. Specifically, they accounted for 24,542 specimens caught trawling (13,739 crustaceans) and beach seining (10,803 crustaceans) in 2016 (Table 5). Sixteen crustacean species were identified, which is similar to the numbers of crustaceans found between 1989 and 2015. Brown shrimp were above average abundance in the trawl and beach seine.

The third most abundant taxa captured in the survey were molluscs. Specifically, they accounted for 585 specimens caught trawling (496 molluscs) and beach seining (89 molluscs; Table 6). Molluscs were represented by 26 different species which is similar to the numbers of molluscs found between 1989 and 2015.

Other types of animals captured trawling and beach seining included: ctenophores, horseshoe crabs, sponges, terrapins and tunicates (Table 7). Eighteen of these species were identified. In addition to animals, plants (submerged aquatic vegetation and macroalgae) were also captured in the trawls and beach seines (Table 8). An above average trawl catch of horseshoe crabs was produced.

Species Results: American eel (*Anguilla rostrata*)

American eels were captured in 12 of 140 trawls (8.6 percent) and in three of 38 beach seines (7.9 percent). A total of 83 American eels were collected in trawl (31 fish) and beach seine (52 fish) samples (Table 4). American eel ranked 19 out of 71 species in overall finfish abundance.

The trawl and beach seine catch per unit efforts were 1.8 fish/hectare and 1.4 fish/haul, respectively.

The relative abundance indices for the trawl and beach seine were both equal to the grand means (Figures 4 and 5). Since 1989, the trawl (three years) and beach seine (four years) indices rarely varied from the grand means.

Discussion

The relative abundance indices for trawl and beach seine were both equal to the grand means (1989-2016). Both gears catch a limited number of American eels but may have some value in assessing the abundance because the estimates vary little from year to year. Since American eels spawn in an area north of the Bahamas known as the Sargasso Sea, environmental conditions and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997).

American eels were most frequently caught in the trawls at three sites close to land in protected bays or creeks located off the main bays. Trawl site T006, where many American eels were caught, is in Turville Creek where the department conducts an annual elver survey further up the creek from our sampling site. The abundance of elvers at this site were attributed to a moderately sized freshwater source close to the ocean inlet. The elvers were probably drawn to this area in search of freshwater in which to grow to adulthood. The distribution of preferred beach seine sites was likely due to their habitat preference for near shore, shallow weedy areas.

Management

American eels were managed by the State of Maryland in cooperation with Atlantic States Marine Fisheries Commission. Maryland's 2016 recreational American eel regulations were comprised of a 25 fish creel and a nine-inch minimum size limit (Table 9). Commercial restrictions included a nine-inch minimum size (Table 10). Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Atlantic croaker (*Micropogonias undulatus*)

Atlantic croakers were captured in 39 of 140 trawls (24.3 percent) and in four of 38 beach seines (10.5 percent). A total of 137 juvenile Atlantic croakers were collected in trawl (125) and beach seine (12) samples (Table 4). Atlantic croakers ranked 14 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 7.1 fish/hectare and 0.3 fish/haul, respectively.

The trawl and beach seine relative abundance indices were both equal to the grand means (Figures 6 and 7). Since 1989, the trawl index occasionally (six years) varied from the grand mean and the beach seine index often (13 years) varied from the grand mean.

Discussion

The relative abundance indices for trawl and beach seine were both equal to the grand means. Juvenile Atlantic croakers were more frequently caught in deeper water with the trawl and rarely in beach seines. Therefore, the trawl index represents a more accurate picture of changes in relative abundance when compared to the beach seine index.

Since Atlantic croakers spawn on the continental shelf, environmental conditions and ocean currents may be a factor influencing relative abundance. Winter weather conditions appear to heavily influence abundance by impacting overwintering young of the year more significantly and pushing spawning activity further south on the Atlantic coast in colder years (Murdy *et al.* 1997).

Good trawl sites for collecting Atlantic croakers were located in the relatively protected areas of Assawoman Bay, the St. Martin River and Newport Bay. Most of the Atlantic croakers caught by the survey were very small and probably do not like the higher currents found in Sinepuxent Bay. Juvenile Atlantic croakers seem to prefer the sheltered coves and creeks and share a similar pattern of distribution to spot and summer flounder. Atlantic croakers are a known prey item for summer flounder and may explain the co-occurrence of these species (Latour *et al.* 2008).

Management

Atlantic croakers were managed by the State of Maryland in cooperation with the Atlantic States Marine Fisheries Commission. Maryland's 2016 recreational Atlantic croaker regulations were comprised of a 25 fish creel and a nine inch minimum size limit (Table 9). Commercial restrictions included a nine inch minimum size and an open season from March 16 until December 31 (Table 10). Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Atlantic menhaden (*Brevoortia tyrannus*)

Atlantic menhaden were captured in 17 of 140 trawls (12.1 percent) and in 24 of 38 beach seines (63.2 percent). A total of 7,891 Atlantic menhaden were collected in trawl (192 fish) and beach seine (7,699 fish) samples (Table 4). Atlantic menhaden ranked first out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 10.9 fish/hectare and 202.9 fish/haul, respectively.

The 2016 trawl and beach seine indices were both equal to the grand means (Figures 8 and 9). Since 1989, the trawl index often (13 years) varied from the grand mean and beach seine index occasionally (eight years) varied from the grand mean.

Discussion

The relative abundance indices for trawl and beach seine were both equal to the grand means. Atlantic menhaden were caught more often in near shore locations (beach seine). Therefore, the beach seine index represents a more accurate picture of changes in relative abundance when compared to the trawl index. Significant changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and/or overfishing.

Good trawl sites for collecting Atlantic menhaden were in protected areas at the head of Turville Creek (T006) and the St. Martin River (T005). Turville Creek is known to have high nutrient levels and may attract the prey sources of Atlantic menhaden (Maryland Department of the Environment 2001). Those trawl sites are likely to have high chlorophyll concentrations and shallow water, a desirable characteristic for a filter feeder (Wazniak *et al.* 2004). In 2016, the best beach seine site (S019) for Atlantic menhaden was located in a muddy protected creek. In past years' good beach seine sites displayed a geographically wide dispersion that indicated a preference for shallow water shoreline edge habitat with either muddy or sandy bottoms.

Management
Atlantic menhaden were managed by the State of Maryland in cooperation with the Atlantic States Marine Fisheries Commission. There was no recreational creel or size limits for this species in 2016. The commercial unlimited fishery is open until the statewide quota is met (Table 10). At that point the fishery switches to the permitted fishery (Atlantic States Marine Fisheries Commission 2006). Recent action by the Atlantic States Marine Fisheries Commission will possibly change the menhaden commercial harvest in coming years. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Atlantic silverside (*Menidia menidia*)
Atlantic silversides were captured in 13 of 140 (9.3 percent) trawls and in 35 of 38 beach seines (92.1 percent). A total of 3,241 Atlantic silversides were collected in trawl (112 fish) and beach seine (3,129 fish) samples (Table 4). Atlantic silversides ranked 4 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 6.4 fish/hectare and 82.3 fish/haul, respectively.

The 2016 trawl and beach seine indices were equal to the grand means (Figures 10 and 11). Since 1989, the trawl index often (12 years) varied from the grand mean and beach seine index rarely (five years) varied from the grand mean.

Discussion
The relative abundance indices for trawl and beach seine were equal to the grand means. Atlantic silversides were more frequently caught in the beach seines (35 out of 38 beach seines for 2016). Significant changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including shifts in species composition and habitat type.

Good trawl and beach seine sites for collecting Atlantic silversides were located in the shallow areas of all bays. Similar characteristics found at these sites were the proximity to land and inlets. They were also collected from sites in Sinepuxent Bay which indicates that they were not affected by current. They do not seem to prefer large expanses of exposed open water. Atlantic silversides are known to be a preferred forage species for larger game fish and have been found occurring with spot, summer flounder and winter flounder at multiple sites in this survey.

Management
The Mid-Atlantic Fishery Management Council passed the Unmanaged Forage Omnibus Amendment to protect unmanaged forage fish. The intention of this amendment is to "prohibit

the development of new, or expansion of existing, directed fisheries on unmanaged forage species until adequate scientific information is available to promote ecosystem sustainability" (Mid-Atlantic Fishery Management Council 2017). There were no recreational or commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Bay anchovy (*Anchoa hepsetus*)
Bay anchovies were captured in 103 of 140 trawls (73.6 percent) and in 30 of 38 beach seines (78.9 percent). A total of 5,511 bay anchovies were collected in trawl (3,948 fish) and beach seine (1,563 fish) samples (Table 4). Bay anchovies ranked 2 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 224.8 fish/hectare and 41.1 fish/haul, respectively.
The 2016 trawl relative abundance index was equal to the grand mean and the beach seine index was above the grand mean (Figures 12 and 13). Since 1989, the trawl (nine years) and beach seine (seven years) indices occasionally varied from the grand means.

Discussion
The trawl relative abundance index was equal to the grand mean and the beach seine index above the grand mean. Therefore, both indices represent an accurate picture of changes in relative abundance. Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including shifts in species composition and habitat type.

Bay anchovies were caught in both nearshore and open water locations indicating a wide distribution. Good trawl and beach seine sites for collecting bay anchovies were located in the northern bays for trawl and in the southern bays for beach seine. Bay anchovies are known to be a preferred forage species for larger game fish and have been found occurring with spot and summer flounder at multiple sites in this survey.

Management
The Mid-Atlantic Fishery Management Council passed the Unmanaged Forage Omnibus Amendment to protect unmanaged forage fish. The intention of this amendment is to "prohibit the development of new, or expansion of existing, directed fisheries on unmanaged forage species until adequate scientific information is available to promote ecosystem sustainability" (Mid-Atlantic Fishery Management Council 2017). There were no recreational or commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Black sea bass (*Centropristis striata*)
Black sea bass were collected in 47 of 140 trawls (33.6 percent) and four of 38 beach seines (10.5 percent). A total of 135 juvenile black sea bass were collected in trawl (127 fish) and beach seine (eight fish) samples (Table 4). Black sea bass were ranked 15 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 7.2 fish/hectare and 0.2 fish/haul, respectively.

The 2016 trawl relative abundance index was above the grand mean and the beach seine index was equal to the grand mean (Figures 14 and 15). Since 1989, the trawl index frequently (16 years) varied from the grand mean and beach seine index occasionally (six years) varied from the grand mean.

Discussion
The 2016 trawl relative abundance index was above the grand mean and the beach seine index was equal to the grand mean. Black sea bass were commonly caught in both gears; however, the trawl gear catches more than the beach seine so it is a better gear to assess black sea bass. Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including shifts in species composition and habitat type.

Good trawl and beach seine sites for collecting black sea bass were locations with or near structure such as channels, crab pots, drop offs or rip rap. As natural and artificial reef increase structure necessary for black sea bass habitat, there may be an increase in black sea bass recruitment to Maryland waters. Many of the preferred sample sites had a hard shell bottom that provided the needed habitat structure desired by black sea bass (Murdy *et al.* 1997).

Management
Black sea bass were managed by the State of Maryland in cooperation with Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council. Maryland's recreational black sea bass regulations for 2016 included a 12.5 inch total length minimum size limit, 15 fish per day creel limit and an open season from May 15 until September 21 and October 22 through December 31 (Table 9). Commercial restrictions included an 11 inch minimum size and a state permit (Table 10). Commercially licensed fishermen without a permit were allowed to land 50 pounds per day as bycatch. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Bluefish (*Pomatomus saltatrix*)
Bluefish were collected in four of 140 trawls (three percent) and in seven of 38 beach seines (18.4 percent). A total of 24 juvenile bluefish were collected in trawl (four fish) and beach seine (20 fish) samples (Table 4). Bluefish ranked 38 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 0.2 fish/hectare and 0.5 fish/haul, respectively.

The 2016 trawl relative abundance index was equal to the grand mean and the beach seine relative abundance index was below the grand mean (Figures 16 and 17). Since 1989, the trawl (six years) and beach seine (eight years) indices varied from the grand means.

Discussion
The 2016 trawl relative abundance index was equal to the grand mean and the beach seine relative abundance index was below the grand mean. Bluefish were caught more frequently in near shore (beach seine) locations. Therefore, the beach seine index represents a more accurate

picture of changes in relative abundance when compared to the trawl index. Anecdotal evidence from offshore fishing indicated that there were good numbers of two to three-year-old bluefish available offshore in the fall; however, it doesn't correspond back to an above average juvenile index for 2013-2014. There was no corresponding bump in the beach seine index in those years. Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including, shifts in species composition and habitat type.

Good trawl and beach seine sites for collecting bluefish were located in Assawoman Bay, Isle of Wright Bay, Sinepuxent Bay and St. Martin River. All good sites were located north of the Ocean City Inlet with the exception of site S010 in Sinepuxent Bay. Bluefish may be drawn to the abundance of forage and the higher flushing rates of the areas close to the inlet.

Management

Bluefish were managed by the State of Maryland in cooperation with Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council. Maryland's 2016 recreational bluefish regulations were comprised of a 10 fish creel and an eight inch minimum size limit (Table 9). Commercial restrictions included an eight inch minimum size and no seasonal closures (Table 10). Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Sheepshead (*Archosargus probatocephalus)*

Sheepshead were collected in three of 140 trawls (2.1 percent) and nine of 38 seines (23.7 percent). A total of 42 juvenile sheepshead were collected in trawl (4) and beach seine (38) samples (Table 4). Sheepshead ranked 27 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 0.2 fish/hectare and 1.0 fish/haul, respectively. An increasing trend in sheepshead abundance is evident in recent years so they were added to the data analysis in 2015.

The 2016 trawl relative abundance index was equal to the grand mean and the beach seine index was above the grand mean for the second year in a row (Figures 18 and 19). Since 1989, the trawl (23 years) and beach seine (18 years) indices frequently varied from the grand means, indicating large variability in abundance over the time period.

Discussion

The 2016 trawl relative abundance index was equal to the grand mean and beach seine index was above the grand mean. Sheepshead were caught more frequently in shallow water (beach seine). Therefore, the beach seine index represents a more accurate picture of changes in relative abundance when compared to the trawl index. Since 1997, sheepshead have begun to show up more frequently in our samples. Whether this is a range expansion or an anomaly time will tell. Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including, shifts in species composition and habitat type.

Management
Sheepshead were managed in the state of Maryland in cooperation with the Mid-Atlantic Fishery Management Council and the South Atlantic Fishery Management Council as part of the snapper grouper complex. The recreational creel limit was 20 or in combination with some other species also included in that complex. Regulations pertaining to sheepshead are located in the Code of Maryland Regulations, dsd.state.md.us/comar/comarhtml/08/08.02.05.29.htm. There were no commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Silver perch (*Bairdiella chrysoura*)
Silver perch were collected in 61 of 140 trawls (43.6 percent) and 20 of 38 beach seines (52.6 percent). A total of 3,411 silver perch were collected in trawl (2,401 fish) and beach seine (1,010 fish) samples conducted on Maryland's coastal bays in 2016 (Table 4). Silver perch ranked third out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 136.7 fish/hectare and 26.6 fish/haul, respectively.

The 2016 trawl relative abundance index was above average and the beach seine index was equal to the grand mean (Figures 20 and 21). Since 1989, the trawl index often (13 years) varied from the grand mean and beach seine index rarely (two years) varied from the grand mean.

Discussion
The 2016 trawl relative abundance index was above average and the beach seine index was equal to the grand mean. There have recently been several years with above average abundance in the trawls. Silver perch were caught in both near shore (beach seine) and open water (trawl) locations. Therefore, both indices represent an accurate picture of changes in relative abundance. Since silver perch spawn offshore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997).

Silver perch were widely dispersed in samples collected throughout the coastal bays. This indicates that most of the habitat of the Maryland coastal bays is favorable nursery habitat for this species.

Management
In the Mid-Atlantic, silver perch were not managed. There were no recreational or commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Spot (*Leiostomus xanthurus*)
Spot were collected in 62 of 140 trawls (44.3 percent) and 32 of 38 beach seines (84.2 percent). A total of 2,077 spot were collected in trawl (1,198 fish) and beach seine (879 fish) samples (Table 4). Spot ranked fifth out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 68.2 fish/hectare and 23.1 fish/haul, respectively.

The 2016 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean (Figures 22 and 23). Since 1989, the trawl (22 years) and beach seine (19 years) indices frequently varied from the grand means, indicating variability in abundance over the time period.

Discussion
The 2016 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean. Spot were caught in both near shore (beach seine) and open water (trawl) locations. Therefore, both indices represent an accurate picture of changes in relative abundance. Since spot spawn offshore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997).

Spot were widely dispersed in the samples collected throughout the coastal bays. This indicates that most of the habitat of the Maryland coastal bays is favorable nursery habitat for this species.

Management
In the Mid-Atlantic, spot were managed by the State of Maryland in cooperation with the Atlantic States Marine Fisheries Commission. There were no recreational or commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Striped bass (*Morone saxatilis*)
Striped bass were collected in three of 140 trawls (2.1 percent) and nine of 38 beach seines (23.7 percent). A total of 55 striped bass were collected in trawl (three fish) and beach seine (52 fish) samples (Table 4). Striped bass ranked 25 out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 0.2 fish/hectare and 1.4 fish/haul, respectively.

The 2016 trawl relative abundance index was equal to the grand mean and the beach seine index was above the grand mean (Figures 24 and 25). Since 1989, the trawl index frequently (16 years) and the beach seine index occasionally (six years) varied from the grand means.

Discussion
The 2016 trawl relative abundance index was equal to the grand mean and the beach seine index was above the grand mean. Striped bass were included in this report because 2016 was the first time an index was above the grand mean. Striped bass were caught most often at near shore (beach seine) locations. Therefore, the beach seine would be the best indicator for changes in relative abundance. Striped bass spawn in estuaries including the Chesapeake Bay. Environmental conditions may be a factor influencing relative abundance.

Striped bass were mostly near shore in the Assawoman and Newport Bays. They seem to prefer areas near the mouth of creeks close to the inlet.

Management
In the Mid-Atlantic, striped bass were managed by the State of Maryland in cooperation with the Atlantic States Marine Fisheries Commission. Recreational coastal fishing regulations in 2016

included two fish per person per day between 28 inches and 38 inches or 44 inches or larger for Maryland Ocean (0-3 miles) and coastal bays (Table 9). Coastal commercial fishing regulations included a 24 inch minimum size, an eight month season, limited days per week and a striped bass permit was required (Table 10). Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Summer flounder (*Paralichthys dentatus*)
Summer flounder were collected in 61 of 140 trawls (61 percent) and 22 of 38 beach seines 57.9 percent). A total of 356 summer flounder collected in trawl (277 fish) and beach seine (79 fish) samples (Table 4). Summer flounder ranked nine out of 71 species in overall finfish abundance. The trawl and beach seine catch per unit efforts were 15.8 fish/hectare and 2.1 fish/haul, respectively.

The 2016 trawl relative abundance index was below the grand mean and beach seine index was equal to the grand mean (Figures 26 and 27). Since 1989, the trawl index frequently (16 years) varied from the grand mean and the beach seine index occasionally (eight years) varied from the grand mean.

Discussion
The 2016 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean. Summer flounder were caught more frequently in open water trawls. Therefore, the trawl index represents a more accurate picture of changes in relative abundance when compared to the beach seine index. Summer flounder are pelagic spawners and changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including shifts in forage species composition and habitat type. Those variables may have affected spawning and juvenile success.

Good trawl and beach seine sample sites were located in all bays. This indicates that most of the habitat of the Maryland coastal bays is favorable nursery habitat for this species.

Management
Summer flounder were managed by the State of Maryland in cooperation with Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council. Maryland’s 2016 recreational summer flounder regulations were comprised of a four fish creel and 16 inch minimum size limit. The season was open year round (Table 9). Commercial restrictions included a 14 inch minimum size for all gears with the exception of hook and line which had size regulations consistent with recreational measures (Table 10). Permitted fishermen in the Atlantic Ocean and coastal bays can harvest 5,000 pounds per day while non-permitted fishermen can land 100 or 50 pounds per day in the Atlantic/coastal bays and Chesapeake Bay, respectively. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Tautog (*Tautoga onitis)*

Tautogs were captured in two of 140 trawls (1.4 percent) and in zero of 38 beach seines. A total of three tautogs were collected in trawl (three fish) and beach seine (zero fish) samples (Table 4). Tautog ranked 55 out of 71 species in overall finfish abundance. The trawl catch per unit effort was 0.2 fish/hectare.

The 2016 trawl relative abundance index was equal to the grand mean and the seine index was below the grand mean (Figures 28 and 29). Since 1989, the trawl (nine years) and beach seine (seven years) indices occasionally varied from the grand mean.

Discussion

The relative abundance index for trawl was equal to the grand mean and the beach seine index was below the grand mean. Although tautog catches were sporadic this survey correlates with the juvenile indices of other states. Juvenile tautogs prefer submerged aquatic vegetation and adult tautogs prefer structured habitat. Our survey in past years indicated a site preference for beach seine sites in the northern bays.

Management

Tautogs were managed by the State of Maryland in cooperation with Atlantic States Marine Fisheries Commission. Maryland's 2016 recreational tautog regulations were comprised of a 16 inch minimum size limit and a four fish creel from January 1 to May 15 and November 1 through November 30 and a two fish creel from May 16 to October 31. Tautog fishing was closed in Maryland for the month of December (Table 9). Maryland's 2016 recreational and commercial regulations were the same (Figures 9 and 10).

The 2016 stock assessment indicated that overfishing is not occurring in the Delmarva region. Projections indicated that the Delmarva spawning stock biomass will reach the spawning stock biomass threshold with 50 percent probability by the year 2022 if the removals remain constant at 77 metric tons. There were no biological surveys being conducted in our region targeting tautog but the Coastal Fisheries Program does age and growth sampling from charter boats, commercial vessels and party boats.

Species Results: Weakfish (*Cynoscion regalis*)

Weakfish were collected in 36 of 140 trawls (25.7 percent) and one of 38 beach seines (2.6 percent). A total of 389 juvenile weakfish were collected in trawl samples (387 fish) and beach seine samples (two fish; Table 4). Weakfish ranked eighth out of 71 species in overall finfish abundance. The trawl catch per unit effort was 22.0 fish/hectare and the beach seine catch per unit effort was <0.1 fish per/haul respectively.

The 2016 trawl and beach seine relative abundance indices were both equal to the grand means (Figures 30 and 31). Since 1989, the trawl index often (11 years) varied from the grand mean and the beach seine index occasionally (nine years) varied from the grand mean.

Discussion
The 2016 relative abundance indices were both equal to the grand means. Weakfish were caught more frequently in open water (trawl). Therefore, the trawl index represents a more accurate picture of changes in relative abundance when compared to the beach seine index. Weakfish were considered depleted but not overfished. The recent declines appear to be due to natural mortality (Northeast Fisheries Science Center 2009). Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including, shifts in species composition and habitat type.

Good trawl sample sites for weakfish were located in all bays indicating a broad distribution in the coastal bays. They show a particular affinity to trawl sites in Assawoman Bay and the St. Martin River.

Management
Weakfish were managed by the State of Maryland in cooperation with the Atlantic States Marine Fisheries Commission. Maryland's 2016 recreational weakfish regulations were comprised of a one fish creel and a 13 inch minimum size limit (Table 9). Commercial regulations in 2016 restricted fisherman to a 12 inch minimum size (Table 10). The commercial fishery was managed as a bycatch fishery with a 100 pound catch limit on the Atlantic coast and a 50 pound limit on the Chesapeake Bay. Monitoring will continue in the Trawl and Beach Seine surveys.

Species Results: Brown Shrimp (*Farfantepenaeus aztecus*)
Brown shrimp were collected in 26 of 140 trawls (18.6 percent) and 14 of 38 beach seines (36.8 percent). A total of 297 brown shrimp were collected in trawl (193) and beach seine (104) samples conducted on Maryland's coastal bays in 2016 (Table 5). Brown shrimp ranked seven out of 16 crustacean species in overall abundance. The trawl and beach seine catch per unit efforts were 11.0 shrimp/hectare and 2.7 shrimp/haul, respectively.

The 2016 trawl and seine relative abundance indices were both above the grand means (Figures 32 and 33). Since 1989, the trawl index frequently (16 years) varied from the grand mean and the beach seine index often (11 years) varied from the grand mean.

Discussion
It was an unusually high year of abundance for brown shrimp for the second year in a row.
The 2016 trawl and seine relative abundance indices were above the grand means. Brown shrimp were caught more frequently in trawls. Therefore, the trawl index currently represents a more accurate picture of changes in relative abundance. Changes in relative abundance may reflect a combination of environmental conditions (dissolved oxygen, nutrient levels, salinity and water temperature) and ecological changes including shifts in species composition and habitat type.

Brown shrimp were most abundant in Turville Creek and the St. Martin River. They were found in the greatest numbers in the months of July through September. Brown shrimp were a great forage opportunity for fishes.

Management
Brown shrimp were not managed by the State of Maryland. There were no recreational or commercial fishing regulations for this species. Monitoring will continue in the Trawl and Beach Seine surveys.

Diversity and abundance by Embayment
The most diverse embayment for fishes in the trawl time series (1989-2016) was Sinepuxent Bay (H=2.07) and the least diverse embayment was Assawoman Bay (H=1.66; Table 11; Figure 34). This trend was not consistent with the observed in 2016. The highest diversity was found in Isle of Wight bay; the lowest St. Martin River (H=1.54) and Chincoteague Bay (H=1.54; Table 12).

The most diverse embayment for fishes in the beach seine time series (1989-2016) was Newport Bay (H=2.13) and the least diverse embayment was St. Martin River (H=1.45; Table 13; Figure 35). In 2016, Newport Bay remained the most diverse (H=2.16) but Sinepuxent Bay diversity decreased for the lowest value of the six embayments in 2016 (H=1.23; Table 14).

Finfish relative abundance in the trawl time series (1989-2016) was highest in St. Martin River (1195 fish/ha) and lowest in Sinepuxent Bay (546 fish/ha; Figure 34). The beach seine time series (1989-2016) resulted in St. Martin River with the highest abundance (850 fish/haul) and Chincoteague Bay as the least abundant embayment (288 fish/haul; Figure 35).

Macroalgae
This time series spans 11 years from 2006 to 2016. To date, 20 genera and over 54,500 liters of macroalgae have been collected in Maryland's coastal bays by the trawl and beach seine. Since this time series began, *Rhodophyta* (red macroalgae) have been the dominant macroalgae in both trawl and beach seine collections. *Chlorophyta* (green macroalgae) was the second most abundant macroalgae in the time series. *Phaeophyta* (brown macroalgae) and *Xanthophyta* (yellow-green macroalgae) were also represented in the survey collections.

Fifteen genera were collected by trawl within the coastal bays in 2016, which was average in the time series. Results showed that *Agardhiella* were the most encountered macroalgae (82.2 percent) in 2016. Other genera that contributed more than five percent to the sample population in 2016 were *Ulva* (6.8 percent) and *Cladophora* (5.5 percent; Table 8). The 2016 Shannon index of diversity (evenness) among genera collected in the coastal bays by trawl was (H=0.83), which was below the time series average (H=1.52). The 2016 trawl catch per unit effort (267.1 liters/hectare) was equal to the grand mean (198.8 liters/hectare; Figure 36).

Eleven genera were sampled within the coastal bays by beach seine in 2016. The beach seine results showed that *Agardhiella* were the most encountered macroalgae (82.5 percent) in 2016. The only other genera that contributed more than five percent to the sample population in 2016, was *Ulva* (13.5 percent; Table 8). The Shannon index of diversity among genera in the coastal bays (H=0.62) was below the beach seine time series average (H=1.40). The 2016 beach seine catch per unit effort (101.3 liters/haul) was not different than the grand mean (39.9 liters/haul; Figure 37).

Over the trawl time series, mean catch per unit effort was higher in the embayments north of Ocean City Inlet. However, these areas had lower average Shannon index values than areas south of the inlet (Figure 38). The beach seine time series showed a similar trend in catch per unit effort while the Shannon index was variable among those areas littoral zone (Figure 39).

Assawoman Bay: This embayment has been dominated by *Rhodophyta* since sampling began in 2006. Six different genera were collected by trawl in 2016, which was below the average (eight genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 was (H=0.62), which was below the time series average (H=0.95). *Agardhiella* (82.7 percent) was the most abundant genus. *Cladophora* (10.5 percent) and *Ulva* (5.7 percent) were the only other genera that contributed more than five percent to the sample population. The 2016 catch per unit effort (844.7 liters/hectare) was equal to the grand mean (618 liters/hectare; Figure 40).

Five different genera were collected by beach seine in 2016, which was below the average (6.7 genera). The Shannon index of diversity among genera within this embayment in 2016 (H=0.26) was below the time series average (H=0.80). *Agardhiella* (95 percent) was the most abundant and only genera that contributed more than five percent of the sample population. The beach seine catch per unit effort (24.2 liters/haul) was equal to the grand mean (41.8 liters/haul; Figure 41).

Isle of Wight Bay: This embayment has been dominated by *Rhodophyta* since sampling began in 2006. Nine different genera were collected by trawl in 2016, which was above the average (seven genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H=1.24) was above the time series average (H=0.81). *Agardhiella* was most abundant (54.3 percent); *Gracilaria* (24.9 percent) and *Cladophora* (5.6 percent) were the only other genera that contributed more than five percent to the sample population. The trawl catch per unit effort (235.1 liters/hectare) was equal to the grand mean (430.7 liters/hectare; Figure 42).

Nine different genera were collected by beach seine in 2016, which was above the average (seven genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H=0.78) was below the time series average (H=1.06). *Agardhiella* (71.7 percent) was the most abundant; *Ulva* (24.6 percent) was the only other genera that contributed more than five percent of the sample population. The 2016 beach seine catch per unit effort (313.3 liters/haul) was not different than the grand mean (82.5 liters/haul; Figure 43).

St. Martin River: This river has been dominated by *Rhodophyta* since sampling began in 2006, except in 2013, when *Chlorophyta* were dominant in the deeper water sampled by the trawl. Five different genera of macroalgae were collected by trawl in 2016, which was below the time series average (5.5 genera). The Shannon index of diversity among genera in 2016 (H=0.47) was below average (H=0.77). *Agardhiella* (85.1 percent) was the most abundant; *Ulva* (13.7 percent) was the only other genera that contributed more than five percent of the sample population. Trawl catch per unit effort (168.1 liters/hectare) in 2016 was equal to the grand mean (138.9 liters/hectare; Figure 44).

Three different genera were collected by beach seine in 2016, which was below the average (3.6 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H = 0.61) was above the time series average (H = 0.49). *Agardhiella* (80.6 percent) was the most abundant. *Gracilaria* (13.2 percent) and *Ulva* (6.2 percent) were the only genera that contributed to the sample population. The 2016 beach seine catch per unit effort (6.1 liters/haul) was below the grand mean (67.0 liters/haul; Figure 45).

Sinepuxent Bay: This embayment has been dominated by *Rhodophyta* in eight of the eleven years since sampling began in 2006. *Chlorophyta* were dominant in 2008 and 2009. Eleven different genera of macroalgae were collected by trawl in 2016, which was average (11 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H = 1.25) was below the average (H = 1.38). *Agardhiella* (44.1 percent) and *Ulva* (42.5 percent) were the only genera that contributed more than five percent of the sample population. The catch per unit effort (22.3 liters/hectare) in 2016 was lower than grand mean (42.9 liters/hectare; Figure 46).

Four different genera were collected by beach seine in 2016, which was below the average (6.4 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H = 0.2) was below the average (H = 0.6). *Agardhiella* (95 percent) was most abundant only genera that contributed more than five percent of the sample population. The 2016 beach seine catch per unit effort (117.7 liters/haul) was equal to the grand mean (33.6 liters/haul; Figure 47).

Newport Bay: This embayment has been dominated by *Rhodophyta* in seven of the 11 years since sampling began in 2006. *Chlorophyta* were dominant in 2008-2010. Three different genera were collected by trawl in 2016, which was below the average (6.9 genera) for this embayment in the time series. The Shannon index of diversity among genera (H=0.49) within this embayment in 2016 was below the time series average (H = 1.1). *Agardhiella* (83.7 percent) and *Ulva* (14.8 percent) were the only genera that contributed more than five percent of the sample population. The catch per unit effort (56.8 liters/hectare) was equal to the grand mean (96.7 liters/hectare; Figure 48).

Five different genera were collected by beach seine in 2016, which was above the average (3.5 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0.29) was below the time series average (H = 0.42). *Agardhiella* (94.3 percent) was most abundant and the only genera that contributed more than five percent of the sample population. The 2016 beach seine catch per unit effort (54.3 liters/haul) was equal to the grand mean (33.9 liters/haul; Figure 49).

Chincoteague Bay: This embayment has undergone shifts in dominance from *Rhodophyta* in 2006-2007, *Phaeophyta* in 2008, *Chlorophyta* in 2009-2010, *Rhodophyta* in 2011-2014, *Chlorophyta* in 2015 and *Rhodophyta* in 2016. Nine different genera were collected by trawl in 2016, which was below the times series average (11.5 genera). The Shannon index of diversity among genera in 2016 (H=0.68) was below the average (H=1.60) within this embayment for the time series. *Agardhiella* (83.6 percent) and *Polysiphonia* (6.0 percent) were the only genera that contributed more than five percent of the sample population. The catch per unit effort (227.7 liters/hectare) was not different than the grand mean (82.7 liters/hectare; Figure 50).

Seven different genera were collected by beach seine in 2016, which was above the average (6.9 genera) for this embayment in the time series. The Shannon index of diversity among genera (H=0.31) was below the time series average (H=0.95). *Agardhiella* (92.3 percent) was most abundant; *Polysiphonia* (5.6 percent) was the only other genera that contributed more than five percent of the sample population. The 2016 beach seine catch per unit effort (57.2 liters/haul) was not different than the grand mean (14.1 liters/haul; Figure 51).

Discussion

Macroalgae in Maryland's coastal bays were investigated consistently over eleven years. The results of this investigation show distribution and abundance of macroalgae encountered by each gear. These data are highly variable and the survey designs were not developed to perform a population assessment for macroalgae. Abundances of *Chlorophyta, Phaeophyta, Rhodophyta and Xanthophyta* may not be accurate because the Trawl and Beach Seine surveys did not sample macroalgae habitat such as bulkheads, jetties and rocks where macroalgae have been observed. However, those data show that *Rhodophyta* and *Chlorophyta* were present at high levels in the embayments closest to high human density population.

The embayments north of the Ocean City Inlet showed single species dominance of *Agardhiella* and subsequently had the highest catch per unit effort when compared to the southern embayments. This stronghold of abundance must be driven by the environmental conditions that favor this genus such as clarity, nutrient levels, salinity and water temperature; however, these effects on macroalgae production are not clear. *Chlorophyta,* specifically sea lettuce abundance was variable, yet appeared able to compete with the *Rhodophytes* when the suitable conditions presented themselves. Chincoteague Bay was the most diverse embayment. Dense macroalgae canopies covering submerged aquatic vegetation were observed there and in Sinepuxent Bay. Macroalgae may benefit the coastal bays in nutrient cycling and by providing cover, food and habitat for crustaceans, fishes and other organisms. Macroalgae production should be investigated to ensure the proper balance in the ecosystem.

Management

The State of Maryland began to manage the commercial harvest of macroalgae in 2015. Only one permit was requested and issued in 2016. The permit limited the harvester to one bushel per day of wet red or green macroalgae taken by hand or a garden style rake less than 20 inches wide. The harvester was restricted from collecting macroalgae above the mean high tide waterline, west and south of a line from the northern most point of Assateague Island to the western terminus of the Route 50 Bridge and within 200 meters of any sewage outfall. All bycatch was required to be returned to the water. Monthly landing reports were required; those reports were confidential.

Water Quality and Physical Characteristics Results

Temperature

Analysis of the 2016 Trawl Survey water quality data beginning in April showed increasing average water temperature for Assawoman Bay, Isle of Wright Bay, St. Martin River and Newport Bay through August. Unlike the rest of the bays, Sinepuxent and Chincoteague bays water temperatures peaked in July rather than August (Figure 52). The highest surface temperature (32.8 Celsius) and highest bottom temperature (32.3) during 2016 trawl sampling were recorded at site T004 in August (St. Martin River). Both the lowest surface temperature (10.4 Celsius) and lowest bottom temperature (10.4 Celsius) for all bays were recorded in April at site T008, where the lowest surface and bottom temperatures were also found in 2015 during the same month.

The overall average in 2016 from all trawl samples was 22.2 Celsius, which was similar to 2015 (22.4 Celsius). St. Martin River was the warmest, just as it was for 2015, with a combined average of 23.2 Celsius. Isle of Wight and Newport Bays followed close behind with 22.8 Celsius and 22.7 Celsius, respectively. The system with the lowest combined average water temperature was Sinepuxent (20.2 Celsius).

Combined May trawl surface temperature averages were examined over a 10-year period (Figure 54). May 2016 was cooler compared to most of the preceding years for Assawoman, Sinepuxent and Chincoteague bays. These bays exhibited their lowest combined average surface temperatures in 2016. The lowest combined average surface temperatures for Isle of Wight, Newport bays and the St. Martin River were in 2010.

Combined August trawl surface temperature averages were examined over a 10-year period. August 2016 was very warm for the majority of the coastal bay sites (Figure 55). Over the same decade, combined surface temperature averages were higher for August 2016 in Newport, Isle of Wight, Assawoman bays and the St. Martin River.

The Beach Seine Survey for 2016 only has two rounds of sampling; therefore, related water quality information does not show the gradual progression of measurements (temperature, salinity, dissolved oxygen and turbidity) possible from graphically representing data. There was a 12.0 Celsius difference between the highest temperature (32.0 Celsius) and lowest temperature (20.0 Celsius) during the month of June. In September, the temperature ranged from 26.0 Celsius to 21.6 Celsius. The most abrupt decreases in temperature were seen at the Assawoman and Chincoteague bay sites in September with average temperature dropping 2.4 and 4.0 Celsius, respectively. The average temperature in Newport Bay did not change between the beach seining periods (Figure 53).

Dissolved Oxygen

As expected, trawl dissolved oxygen levels generally decreased as water temperatures increased (Figure 56). Dissolved oxygen was below five milligrams/liter for five samples in the Trawl Survey for 2016. Occurrences of low dissolved oxygen tended to be in the northern bays. For the 2016 Beach Seine Survey, the dissolved oxygen was above five milligrams/liter at all sites (Figure 57).

Salinity

For 2016, the Trawl Survey overall average salinity for all bays combined was 25.6 parts per thousand which was lower than 2015 (27.8 parts per thousand). Chincoteague Bay salinity remained the most stable of the bays, with limited changes except for the drop recorded in October which was also seen in all other bays (Figure 58). When all the salinity averages were analyzed for each bay, Sinepuxent Bay had the highest average at 29.2 parts per thousand and the St. Martin River had the lowest (22.9 parts per thousand). Sinepuxent Bay also had the highest salinity for 2015 (30.7 parts per thousand). Newport Bay had the lowest salinity average in 2015 (26.2 parts per thousand).

For the Beach Seine Survey in 2016, salinity increased only slightly in September for Assawoman, Chincoteague, Newport and Sinepuxent bays and the St. Martin River. The Isle of Wight Bay experienced only a small salinity decrease in September (Figure 59).

Turbidity

Results of the 2016 Trawl Survey Secchi analysis showed variations for turbidity levels from April to October for all systems (Figure 60). The most turbid water system was Isle of Wight Bay with an overall average Secchi reading of 61.6 centimeters. Sinepuxent Bay was the least turbid in 2016 (100.1 centimeters) as it was for 2015. Out of all turbidity measurements, bottom was visible four times (2.9 percent). A review of trawl Secchi data from the years, 2016 and 2015, demonstrates a decrease in visibility across the warmer months. Upon viewing a combination of turbidity averages from every month for all bays, it is clear that 2016 (80.3 centimeters) was more turbid than 2015 (89.7 centimeters).

For the Beach Seine Survey in 2016, Assawoman, Chincoteague and Sinepuxent showed only slight changes in turbidity when the sites were visited in September (Figure 61). The most turbid system was Sinepuxent Bay with a combined Secchi average of 42.7 centimeters. Visibility was far better for Isle of Wight Bay compared to the other sites. The biggest declines in visibility were evident at sites located in both the St. Martin River and Newport Bay in September.

Discussion

Differences in dissolved oxygen, salinity, temperature and turbidity were influenced by the flushing times of these systems. Lung (1994) reported flushing times of 21.1 to 21.3 days for Assawoman Bay, 8.0 to 15.8 days for the St. Martin River and 9.3 to 9.6 days for Isle of Wight Bay. Prichard (1960) predicted that Chincoteague Bay required 62 days to replace 99 percent of its water. Flushing rates for both Sinepuxent Bay and Newport Bay were not known (Wazniak *et al.* 2004). Given the proximity to the Ocean City Inlet, one can assume that flushing rates for

Sinepuxent Bay would be relatively fast (more like Isle of Wight Bay) while the flushing rate in Newport Bay would be much longer (more like Chincoteague Bay).

Of the water quality parameters, dissolved oxygen concentrations have the greatest immediate impact on fisheries resources. Dissolved oxygen typically decreases from April through the warmer months and then increases again in the fall as temperatures decrease. Some of the dissolved oxygen concentrations give rise to the concern that hypoxia is occurring in the Maryland coastal bays during the summer months. Hypoxia exists when dissolved oxygen levels can no longer support the majority of life; the dissolved oxygen level for this condition is usually set below two milligrams/liter. For organisms in the Chesapeake Bay, five milligrams/liter are usually accepted as necessary for life, but can vary based on the organism. For example, a dissolved oxygen of six milligrams/liter is necessary for larvae and eggs of migratory fish, however, some animals such as crabs and bottom dwelling fish can tolerate dissolved oxygen levels as low as three milligrams/liter (Chesapeake Bay Program 2007).

Low dissolved oxygen events were uncommon in 2016 and never fell below two milligrams/liter. In the Trawl Survey, dissolved oxygen fell below five milligrams/liter five times in 2016. For example, at site T004 in August, dissolved oxygen fell below five milligrams/liter which coincides with the hottest temperature of the 2016 summer; the low dissolved oxygen was approaching hypoxia thresholds.

The decrease in salinity noticed for all bays and the St. Martin River in October may be due to the amount of precipitation which occurred in late September and early October. From Wednesday, September 28 through Friday September 30, 11.9 centimeters (4.7 inches) of precipitation was recorded at the Ocean City Municipal Airport. From October 8 - 9, 12.4 centimeters (4.85 inches) of precipitation were recorded at this same station (Weather Underground 2017). The low salinity readings in October were likely the result of precipitation associated with Hurricane Matthew.

Brown tides, precipitation and wind can create turbidity. Turbidity generally increases in the coastal bays as the water becomes warmer and this pattern was observed for 2016. The 2004 National Park Service precipitation study indicated that turbidity was not influenced by precipitation to the same extent as chlorophyll *a* for the same period. Precipitation did not influence turbidity to the extent that chlorophyll *a* did (Dennison *et al.* 2009).

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Table 1. Trawl Survey site descriptions.

Site Number	Bay	Site Description	Longitude	Latitude
T001	Assawoman Bay	On a line from Corn Hammock to Fenwick Ditch	38 26.243	75 04.747
T002	Assawoman Bay	Grey's Creek (mid creek)	38 25.859	75 06.108
T003	Assawoman Bay	Assawoman Bay (mid bay)	38 23.919	75 05.429
T004	Isle of Wight Bay	St. Martin River, mouth	38 23.527	75 07.327
T005	Isle of Wight Bay	St. Martin River, in lower Shingle Landing Prong	38 24.425	75 10.514
T006	Isle of Wight Bay	Turville Creek, below the race track	38 21.291	75 08.781
T007	Isle of Wight Bay	Middle of Isle of Wight Bay, north of the shoals in bay (False Channel)	38 22.357	75 05.776
T008	Sinepuxent Bay	Day marker 2, south for 6 minutes (north end of Sinepuxent Bay)	38 19.418	75 06.018
T009	Sinepuxent Bay	Day marker 14, south for 6 minutes (Sinepuxent Bay north of Snug Harbor)	38 17.852	75 07.310
T010	Sinepuxent Bay	Day marker 20, south for 6 minutes (0.5 miles south of the Assateague Island Bridge)	38 14.506	75 09.301
T011	Chincoteague Bay	Newport Bay, across mouth	38 13.024	75 12.396
T012	Chincoteague Bay	Newport Bay, opposite Gibbs Pond to Buddy Pond, in marsh cut	38 15.281	75 11.603
T013	Chincoteague Bay	Between day marker 37 and 39	38 10.213	75 13.989
T014	Chincoteague Bay	1 mile off village of Public Landing	38 08.447	75 16.043
T015	Chincoteague Bay	Inlet Slough in Assateague Island (also known as Jim's Gut)	38 06.370	75 12.454
T016	Chincoteague Bay	300 yards off east end of Great Bay Marsh, west of day marker (also known as, south of day marker 20)	38 04.545	75 17.025
T017	Chincoteague Bay	Striking Marsh, south end about 200 yards	38 03.140	75 16.116
T018	Chincoteague Bay	Boxiron (Brockatonorton) Bay (mid-bay)	38 05.257	75 19.494
T019	Chincoteague Bay	Parker Bay, north end	38 03.125	75 21.110
T020	Chincoteague Bay	Parallel to and just north of the Maryland/Virginia state line, at channel	38 01.328	75 20.057

Table 2. Beach Seine Survey site descriptions.

Site Number	Bay	Site Description	Latitude	Longitude
S001	Assawoman Bay	Cove behind Ocean City Sewage Treatment Plant, 62nd street	38 23.273	75 04.380
S002	Assawoman Bay	Bayside of marsh at Devil's Island, 95th street	38 24.749	75 04.264
S003	Assawoman Bay	Small cove, east side, small sand beach; sandspit, bayside of Goose Pond	38 24.824	75 06.044
S004	Isle of Wight Bay	North side of Dredge Spoil Island across east channel from 4th street, north east corner of the Ocean City Flats	38 20.388	75 05.390
S005	Isle of Wight Bay	Beach on sandspit north of Cape Isle of Wight (also known as, in cove on marsh spit, east and south of mouth of Turville Creek	38 21.928	75 07.017
S006	Isle of Wight Bay	Beach on west side of Isle of Wight, St. Martin River (also known as Marshy Cove, west side of Isle of Wight, north of route 90 Bridge)	38 23.627	75 06.797
S007	Isle of Wight Bay	Beach, 50th street (next to Seacrets)	38 22.557	75 04.301
S008	Sinepuxent Bay	Sandy beach, north east side, Assateague Island Bridge at National Seashore	38 14.554	75 08.581
S009	Sinepuxent Bay	Sand beach 0.5 miles south of Inlet on Assateague Island	38 19.132	75 06.174
S010	Sinepuxent Bay	Grays Cove, in small cove on north side of Assateague Pointe development's fishing pier	38 17.367	75 07.977
S011	Chincoteague Bay	Cove, 800 yards north west of Island Point	38 13.227	75 12.054
S012	Chincoteague Bay	Beach north of Handy's Hammock (also known as, north side, mouth of Waterworks Creek)	38 12.579	75 14.921
S013	Chincoteague Bay	Cove at the mouth of Scarboro Creek	38 09.340	75 16.426
S014	Chincoteague Bay	South east of the entrance to Inlet Slew	38 06.432	75 12.404
S015	Chincoteague Bay	Narrow sand beach, south of Figgs Landing	38 07.000	75 17.578
S016	Chincoteague Bay	Cove, east end, Great Bay Marsh (also known as Big Bay Marsh)	38 04.482	75 17.597
S017	Chincoteague Bay	Beach, south of Riley Cove in Purnell Bay	38 02.162	75 22.190
S018	Chincoteague Bay	Cedar Island, south side, off Assateague Island	38 02.038	75 16.619
S019	Chincoteague Bay	Land site - Ayers Creek At Sinepuxent Road	38 18.774	75 09.414

Table 3. Measurement types for fishes and invertebrates captured during the Trawl and Beach Seine surveys.

Species	**Measurement Type**
Crabs	Carapace width
Finfishes (most species)	Total length
Horseshoe Crabs	Prosomal width
Rays	Wing span
Sharks	Total length
Shrimp	Rostrum to telson
Squid	Mantle length
Turtles	Carapace length
Whelks	Tip of spire to anterior tip of the body whorl

Table 4. List of fishes collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul
Atlantic menhaden	*Brevoortia tyrannus*	7,891	192	7,699	10.9	202.6
Bay anchovy	*Anchoa mitchilli*	5,511	3,948	1,563	224.8	41.1
Silver perch	*Bairdiella chrysoura*	3,411	2,401	1,010	136.7	26.6
Atlantic silverside	*Menidia menidia*	3,241	112	3,129	6.4	82.3
Spot	*Leiostomus xanthurus*	2,077	1,198	879	68.2	23.1
Mummichog	*Fundulus heteroclitus*	1,126	100	1,026	5.7	27.0
Striped anchovy	*Anchoa hepsetus*	986	28	958	1.6	25.2
Weakfish	*Cynoscion regalis*	389	387	2	22.0	<0.1
Summer flounder	*Paralichthys dentatus*	356	277	79	15.8	2.1
Pinfish	*Lagodon rhomboides*	290	3	287	0.2	7.5
White mullet	*Mugil curema*	250		250		6.6
Striped killifish	*Fundulus majalis*	191		191		5.0
Rainwater killifish	*Lucania parva*	154	7	147	0.4	3.9
Atlantic croaker	*Micropogonias undulatus*	137	125	12	7.1	0.3
Black sea bass	*Centropristis striata*	135	127	8	7.2	0.2
Atlantic herring	*Clupea harengus harengus*	121	121		6.9	
Oyster toadfish	*Opsanus tau*	109	16	93	0.9	2.4
Inland silverside	*Menidia beryllina*	104		104		2.7
American eel	*Anguilla rostrata*	83	31	52	1.8	1.4
Spotfin mojarra	*Eucinostomus argenteus*	83	35	48	2.0	1.3
Winter flounder	*Pseudopleuronectes americanus*	79	34	45	1.9	1.2
Hogchoker	*Trinectes maculatus*	77	71	6	4.0	0.2
Dusky pipefish	*Syngnathus floridae*	70	43	27	2.4	0.7
Northern searobin	*Prionotus carolinus*	66	61	5	3.5	0.1
Striped bass	*Morone saxatilis*	55	3	52	0.2	1.4
Pumpkinseed	*Lepomis gibbosus*	46		46		1.2
Sheepshead	*Archosargus probatocephalus*	42	4	38	0.2	1.0
Northern pipefish	*Syngnathus fuscus*	41	24	17	1.4	0.4
Rough silverside	*Membras martinica*	40		40		1.1
Striped mullet	*Mugil cephalus*	38		38		1.0
Atlantic needlefish	*Strongylura marina*	37		37		1.0
Striped blenny	*Chasmodes bosquianus*	37	3	34	0.2	0.9
Northern puffer	*Sphoeroides maculatus*	36	18	18	1.0	0.5
Halfbeak	*Hyporhamphus unifasciatus*	34		34		0.9
Naked goby	*Gobiosoma bosc*	29	16	13	0.9	0.3
Brown bullhead	*Ameiurus nebulosus*	26		26		0.7
Spotted hake	*Urophycis regia*	25	25		1.4	

Table 4. List of fishes collected in Maryland's Coastal Bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul
Bluefish	*Pomatomus saltatrix*	24	4	20	0.2	0.5
Bluegill	*Lepomis macrochirus*	24		24		0.6
Banded killifish	*Fundulus diaphanus*	21		21		0.6
Blueback herring	*Alosa aestivalis*	17	3	14	0.2	0.4
Striped burrfish	*Chilomycterus schoepfii*	17	13	4	0.7	0.1
Smallmouth flounder	*Etropus microstomus*	16	14	2	0.8	<0.1
Black drum	*Pogonias cromis*	15	4	11	0.2	0.3
Golden shiner	*Notemigonus crysoleucas*	13		13		0.3
Southern kingfish	*Menticirrhus americanus*	11	5	6	0.3	0.2
Sheepshead minnow	*Cyprinodon variegatus*	10		10		0.3
Southern stingray	*Dasyatis americana*	10		10		0.3
Green goby	*Microgobius thalassinus*	9	7	2	0.4	<0.1
Pipefishes	*Gasterosteiformes*	8		8		0.2
Inshore lizardfish	*Synodus foetens*	5	3	2	0.2	<0.1
Lined seahorse	*Hippocampus erectus*	5	4	1	0.2	<0.1
Pigfish	*Orthopristis chrysoptera*	5	1	4	0.1	0.1
Scup	*Stenotomus chrysops*	4	4		0.2	
Spotted seatrout	*Cynoscion nebulosus*	4		4		0.1
Gray snapper	*Lutjanus griseus*	3		3		<0.1
Largemouth bass	*Micropterus salmoides*	3		3		<0.1
Tautog	*Tautoga onitis*	3	3		0.2	
Butterfish	*Peprilus triacanthus*	2	2		0.1	
Harvestfish	*Peprilus paru*	2		2		<0.1
Red drum	*Sciaenops ocellatus*	2		2		<0.1
Threespine stickleback	*Gasterosteus aculeatus*	2		2		<0.1
Atlantic stingray	*Dasyatis sabina*	1		1		<0.1
Blackcheek tonguefish	*Symphurus plagiusa*	1		1		<0.1
Feather blenny	*Hypsoblennius hentz*	1		1		<0.1
Gizzard shad	*Dorosoma cepedianum*	1	1		0.1	
Mosquitofish	*Gambusia affinis*	1		1		<0.1
Redfin pickerel	*Esox americanus americanus*	1		1		<0.1
Sand eel	*Ammodytes america*	1	1		0.1	
Smooth butterfly ray	*Gymnura micrura*	1		1		<0.1
Striped searobin	*Prionotus evolans*	1	1		0.1	
	Total Finfish	**27,667**	**9,480**	**18,187**		

Table 5. List of crustaceans collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	Estimated Count (T)	Estimated Count (S)	CPUE (T) #/Hect.	CPUE (S) #Haul
Blue crab	*Callinectes sapidus*	10,144	6,039	4,095	10		344.5	108.3
Sand shrimp	*Crangon septemspinosa*	6,431	253	1	5,070	1,107	303.2	29.2
Grass shrimp	*Palaemonetes sp.*	6,094	252	23	774	5,045	58.4	133.5
Lady crab	*Ovalipes ocellatus*	564	180	384			10.3	10.1
Say mud crab	*Dyspanopeus sayi*	548	191	7	350		30.8	0.2
White shrimp	*Litopenaeus setiferus*	317	313	4			17.8	0.1
Brown shrimp	*Farfantepenaeus aztecus*	297	193	104			11.0	2.7
Long-armed hermit crab	*Pagurus longicarpus*	92	68	24			3.9	0.7
Barnacles	*Cirripedia*	15	15				0.9	
Atlantic rock crab	*Cancer irroratus*	14	13	1			0.7	<0.1
Atlantic mud crab	*Panopeus herbstii*	6	6				0.3	
Portly spider crab	*Libinia emarginata*	6	6				0.3	
Iridescent swimming crab	*Portunus gibbesii*	5		5				0.1
Mantis shrimp	*Squilla empusa*	5	5				0.3	
Hermit crabs	*Pagurus sp.*	3		3				<0.1
Bigclaw snapping shrimp	*Alpheus heterochaelis*	1	1				0.1	
	Total Crustaceans	**24,542**	**7,535**	**4,651**	**6,204**	**6,152**		

Table 6. List of molluscs collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol. (L) (T)	Spec. Vol. (L) (S)	Est. Vol. (L) (T)	Est. Vol. (L) (S)	CPUE (T) #/Hect.	CPUE (S) #Haul	CPUE Vol. (T) #/Hect	CPUE Vol. (S) #/Haul
Solitary glassy bubble snail	*Haminoea solitaria*	108	3		105						6.2			
Convex slippersnail	*Crepidula convexa*	102	11		90	1					5.8	<0.1		
Atlantic brief squid	*Lolliguncula brevis*	100	100								5.7			
Slippershells	*Crepidula sp.*	94	94								5.3			
Mudsnails	*Nassarius sp.*	50				50						1.3		
Eastern white slippersnail	*Crepidula plana*	45	35		10						2.6			
Eastern mudsnail	*Nassarius obsoletus*	33		33								0.9		
Atlantic oyster drill	*Urosalpinx cinerea*	7	6	1							0.3	<0.1		
Threeline mudsnail	*Nassarius trivittatus*	7	7								0.4			
Bruised nassa	*Nassarius vibex*	6	5	1							0.3	<0.1		
Common Atlantic slippersnail	*Crepidula fornicata*	5			5						0.3			
Bay scallop	*Argopecten irradians*	4	4								0.2			
Dwarf surfclam	*Mulinia lateralis*	3	3								0.2			
Northern quahog	*Mercenaria mercenaria*	3	1	2							0.1	<0.1		
Thick-lip drill	*Eupleura caudata*	3	3								0.2			
Atlantic awningclam	*Solemya velum*	2	1	1							0.1	<0.1		
Atlantic surfclam	*Spisula solidissima*	2	2								0.1			
Lemon drop	*Doriopsilla pharpa*	2	2								0.1			
Purplish tagelus	*Tagelus divisus*	2	2								0.1			
Stout tagelus	*Tagelus plebeius*	2	2								0.1			
Angelwing	*Cyrtopleura costata*	1	1								0.1			
Atlantic razor	*Siliqua costata*	1	1								0.1			
Blue mussel	*Mytilus edulis*	1	1								0.1			
Cayenne keyhole limpet	*Diodora cayenensis*	1	1								0.1			
Common jingle	*Anomia simplex*	1	1								0.1			
Marsh periwinkle	*Littorina irrorata*							0						
	Total Molluscs	**585**	**286**	**38**	**210**	**51**		**0.2**						

Table 7. List of other species collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol. (L) (T)	Spec. Vol. (L) (S)	Est. Vol. (L) (T)	Est. Vol. (L) (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul	CPUE (T) #/Hect. Vol.	CPUE (S) #/Haul Vol.
Sea squirt	*Molgula manhattensis*	1,577	16	1	1,560						89.8	<0.1		
Sea nettle	*Chrysaora quinquecirrha*	261	25		235	1	14.5				14.8	<0.1	0.8	
Hairy sea cucumber	*Sclerodactyla briareus*	216	201	15							11.4	0.4		
Comb jellies	*Ctenophora*	142	72		70		268.0	17.0	6.0	100.5	8.1	0.2	15.6	3.1
Horseshoe crab	*Limulus polyphemus*	67	49	18							2.8	0.5		
Beroe comb jelly	*Beroe ovata*	19	17	2							1.0	<0.1		
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	19	7	12							0.4	0.3		
Common sea cucumber	*Cucumaria pulcherrima*	15	10	5							0.6	0.1		
Moon jelly	*Aurelia aurita*	13	10	3							0.6	<0.1		
Sea cucumbers	*Cucumariidae*	3	3								0.2			
Sea walnut	*Mnemiopsis leidyi*	1	1								0.1			
Goldstar tunicate	*Botryllus schlosseri*						33.0	2.6					1.9	<0.1
Sea pork	*Aplidium sp.*						21.3	1.6					1.2	<0.1
Bryozoans	*Ectoprocta*						125.0	1.3		<0.1			7.1	<0.1
Rubbery bryozoan	*Alcyonidium sp.*						45.0	0.4					2.6	<0.1
Halichondria sponge	*Halichondria sp.*						242.0	22.4					13.8	0.6
Red beard sponge	*Microciona prolifera*						41.5	7.2					2.4	0.2
Sulphur sponge	*Cliona celata*						11.8						0.7	
	Total Other	**2,333**	**411**	**56**	**1,865**	**1.0**	**802.1**	**52.5**	**6.0**	**100.6**				

Table 8. List of submerged aquatic vegetation and macroalgae collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2016. Species are listed by order of total abundance. Total trawl sites = 140, total beach seine sites = 38.

Common Name	Genus	Specific Volume (L) (T)	Specific Volume (L) (S)	Estimated Volume (L) (T)	Estimated Volume (L) (S)
Submerged Aquatic Vegetation					
Eel grass	*Zostera*	30.1	37.8		
Widgeongrass	*Ruppia*	2.9	39.1		
Total Submerged Aquatic Vegetation		**33.0**	**76.9**		
Macroalgae					
Brown					
Rockweed	*Fucus*	2.5			
Common southern kelp	*Laminaria*	0.7			
Brown bubble algae	*Colpomenia*	0.4	2.3		
		3.5	**2.3**		
Green					
Sea lettuce	*Ulva*	321.3	491.1		
Green tufted seaweed	*Cladophora*	258.7	1.6		
Hollow green weed	*Enteromorpha*	61.7	4.7		
Green hair algae	*Chaetomorpha*	48.9	4.8		
Green sea fern	*Bryopsis*	9.9			
Green fleece	*Codium*	0.7	8.2		
		701.1	**510.5**		
Red					
Agardh's red weed	*Agardhiella*	3,763.5	3,008.9		
Graceful red weed	*Gracilaria*	110.9	32.3		
Tubed weeds	*Polysiphonia*	100.9	69.3		
Hooked red weed	*Hypnea*	3.2			
Banded weeds	*Ceramium*	1.6	14.4		
		3,980.1	**3,124.8**		
Yellow-Green					
Water felt	*Vaucheria*	5.7	10.3		
		5.7	**10.3**		
	Total Macroalgae	**4,690.5**	**3,648.0**		

Table 9. Summary of Maryland's Atlantic ocean and coastal bays recreational fishing regulations for 2016.

Species	Minimum Size Limit (inches)	Creel (person/day)	Season
American Eel	9	25	Year round
Atlantic Croaker	9	25	Year round
Black Sea Bass	12.5	15	May 15 – September 21 October 22 - December 31
Bluefish	8	10	Year round
*Sheepshead	None	20 or in combination (see snapper grouper complex regulations)	Year round
Striped Bass	between 28 inches and 38 inches or 44 inches or larger	2	Year round
Summer Flounder	16	4	Year round
Tautog	16	4	January 1 - May 15 November 1 – November 26
		2	May 16 - October 31
Weakfish	13	1	Year round

*Sheepshead are included in the snapper grouper complex regulations which can be found here: http://www.dsd.state.md.us/comar/comarhtml/08/08.02.05.29.htm

Table 10. Summary of Maryland's Atlantic ocean and coastal bays commercial fishing regulations for 2016.

Species	Minimum Size (inches) Gear	Season	Creel/Special Conditions/Comments
American Eel	9 All gear	January 1 - August 31	
	9 Spear, baited trap or eel pot only	September 1 - December 31	Closed to all other gear.
Atlantic Croaker	9 All gear	March 16- December 31	
Atlantic Menhaden	None All gear	January 1 – December 31	Unlimited fishery is open until statewide quota is met. After this, it switches to the permitted fishery.
Black Sea Bass	11 Pot, Trap, Trawl (ocean)	Year Round	Catch limit is 50 pounds without a permit.
Bluefish	8 All gear	Year Round	
Striped Bass	24 or greater Trawl, Drift Gill Net	January 1 – May 31 Monday - Friday October - December Monday - Friday	Permit required
Summer Flounder	14 All gear except hook and line	Year Round	Coastal without a permit: 100 pounds/person/day Tidal Chesapeake Bay and tributaries without a permit: 50 pounds/person/day
	16 Hook and line		
Tautog	16 All Gear	January 1 - May 15, November 1 – November 26	4 fish
		May 16 – October 31	2 fish
Weakfish	12 Trawl and all gear other than hook and line	Year Round Monday - Friday	100 pounds/day or trip whichever is longer The weight of the catch of the other species on board the vessel cannot be exceeded by weight of weakfish.

Table 11. Shannon index and number of fish species by embayment collected by trawl (1989-2016).

Area	Shannon Index (H)	Number of Species
Assawoman Bay	1.66	79
St. Martin River	1.69	77
Isle of Wight	1.83	84
Sinepuxent Bay	2.07	74
Newport Bay	1.67	66
Chincoteague Bay	1.67	91

Table 12. Shannon index and number of fish species by embayment collected by trawl (2016).

Area	Shannon Index (H)	Number of Species
Assawoman Bay	1.56	28
St. Martin River	1.54	22
Isle of Wight	2.04	33
Sinepuxent Bay	1.82	23
Newport Bay	1.57	17
Chincoteague Bay	1.54	27

Table 13. Shannon index and number of fish species by embayment collected by beach seine (1989-2016).

Area	Shannon Index (H)	Number of Species
Assawoman Bay	1.96	87
St. Martin River	1.45	71
Isle of Wight	1.92	89
Sinepuxent Bay	1.58	76
Newport Bay	2.13	68
Chincoteague Bay	1.92	79

Table 14. Shannon index and number of fish species by embayment collected by beach seine (2016).

Area	Shannon Index (H)	Number of Species
Assawoman Bay	1.72	35
St. Martin River	2.05	25
Isle of Wight	2.12	36
Sinepuxent Bay	1.23	31
Newport Bay	2.16	26
Chincoteague Bay	1.97	39

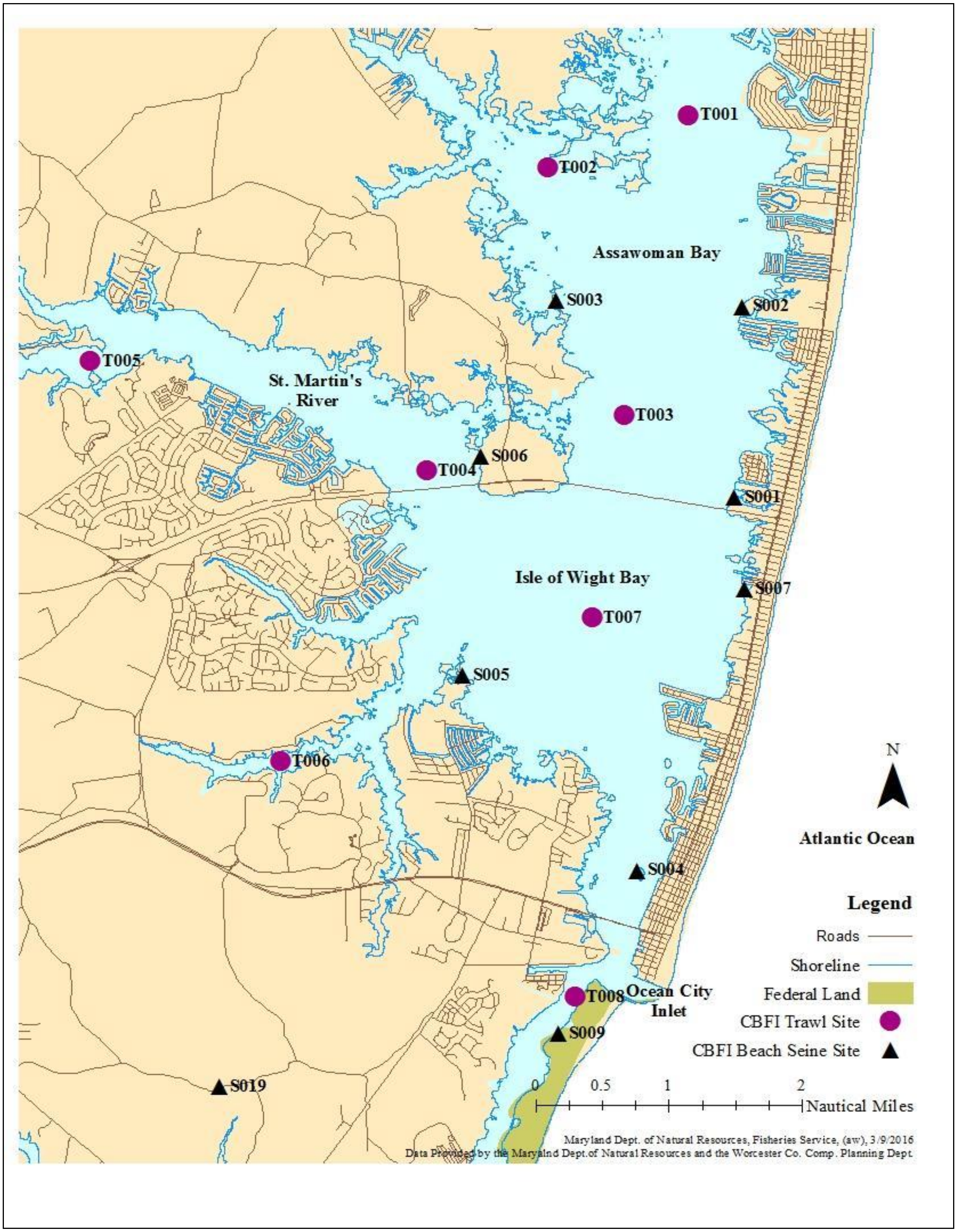

Figure 1. Trawl and Beach Seine surveys 2016 sampling locations in the Assawoman and Isle of Wight Bays, Maryland.

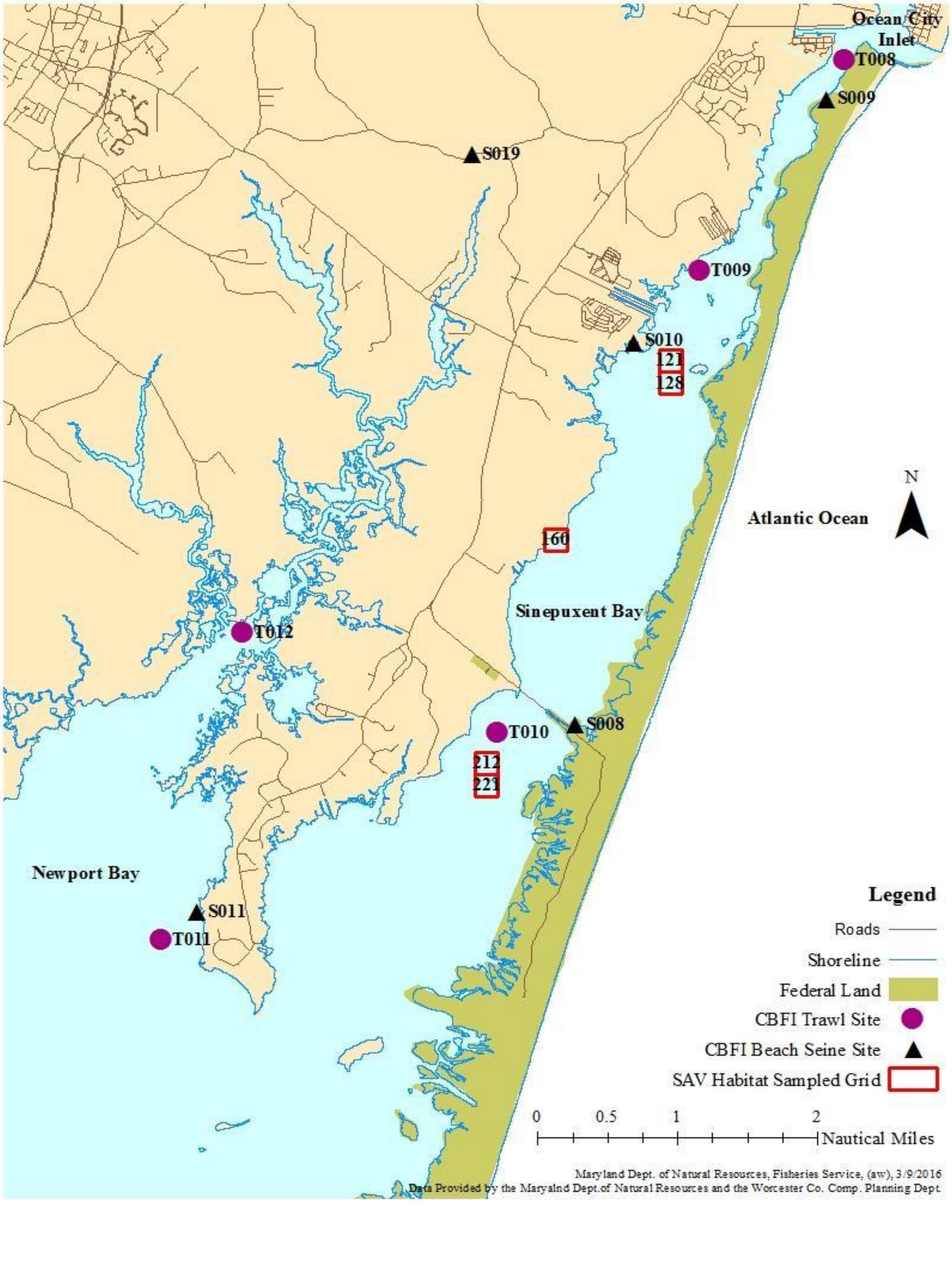

Figure 2. Trawl and Beach Seine surveys 2016 sampling locations in Sinepuxent and Newport bays, Maryland.

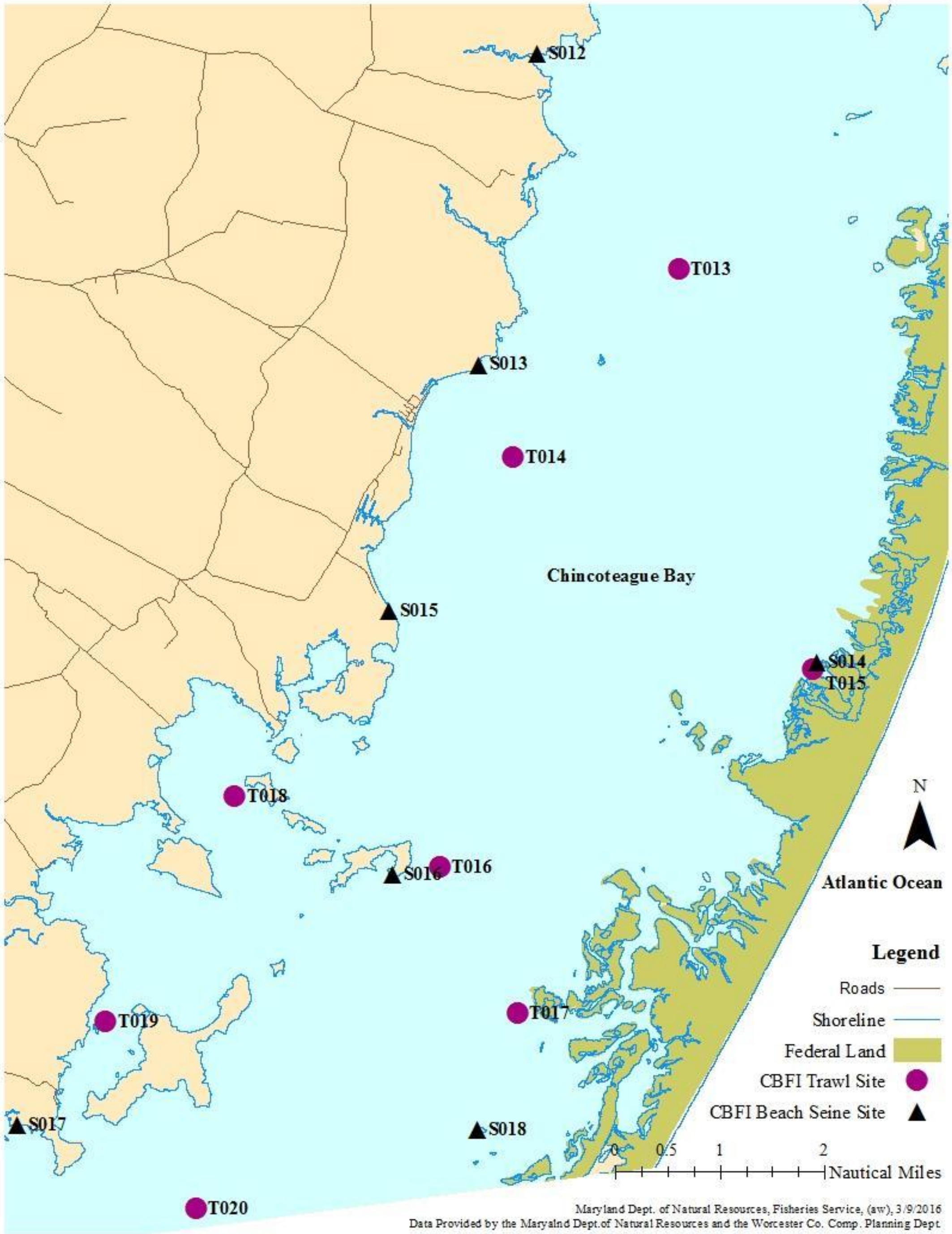

Figure 3. Trawl and Beach Seine surveys 2016 sampling locations in Chincoteague Bay, Maryland.

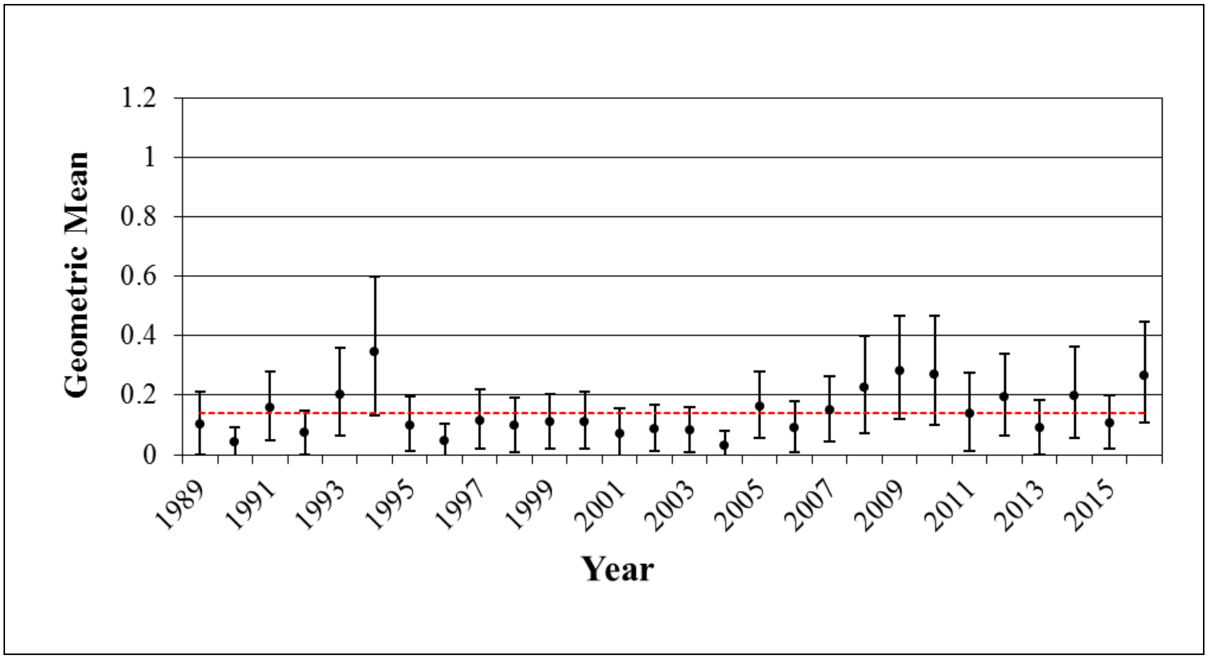

Figure 4. American eel (*Anguilla rostrata)* trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

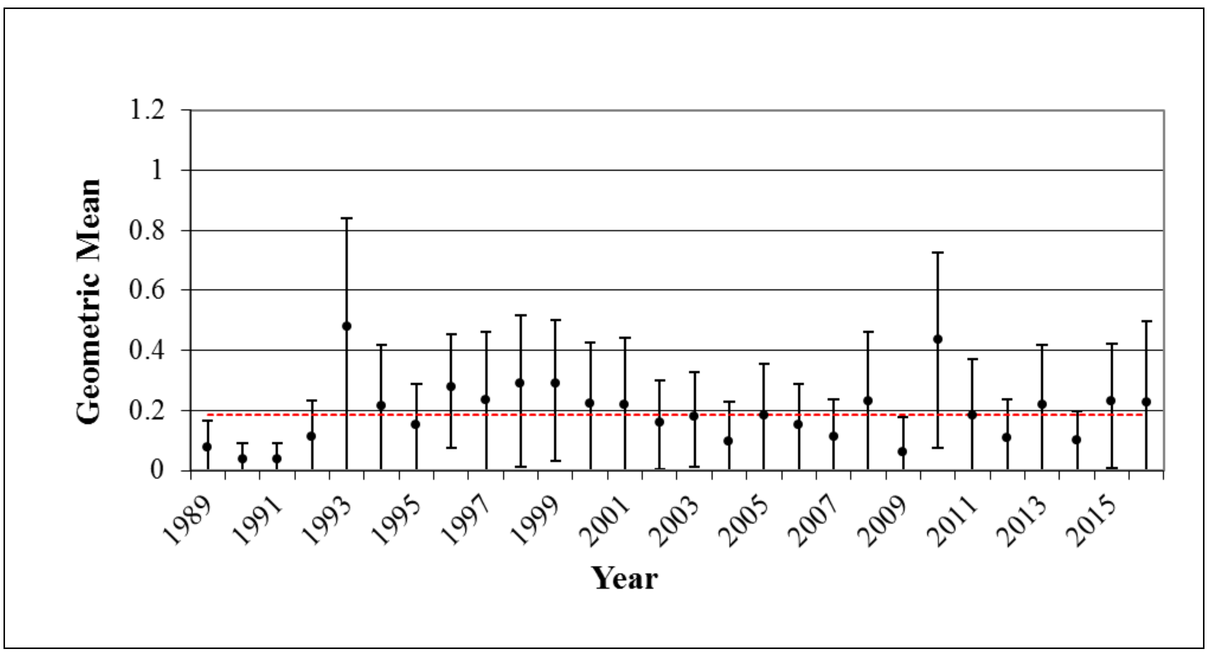

Figure 5. American Eel (*Anguilla rostrata*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

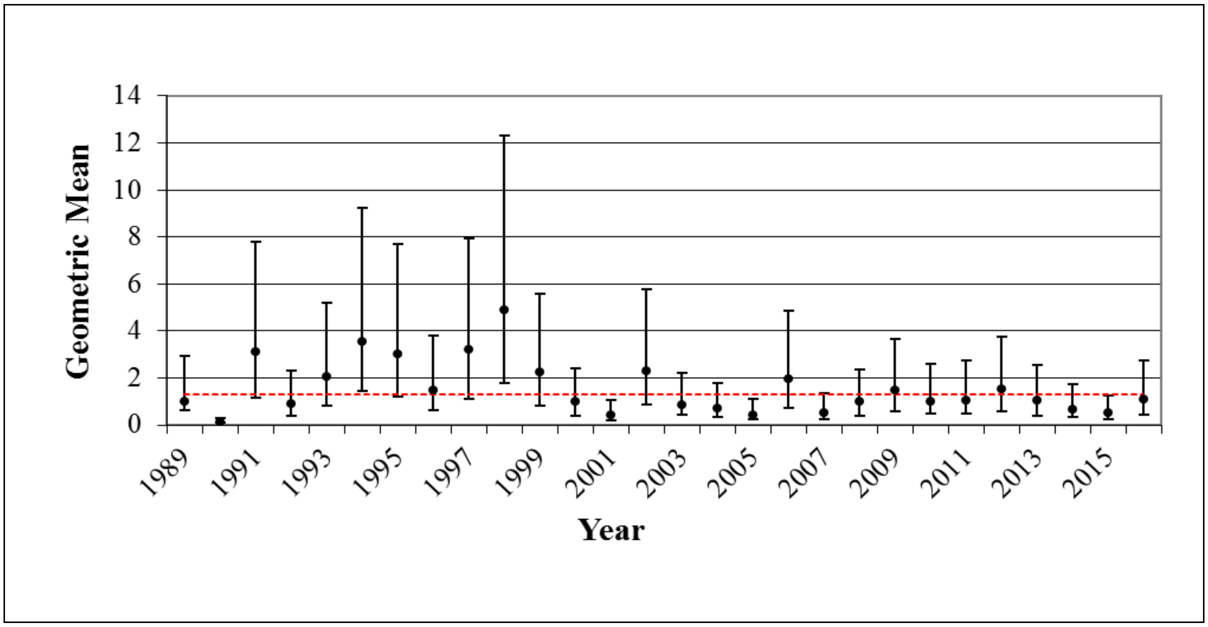

Figure 6. Atlantic croaker (*Micropogonias undulates*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

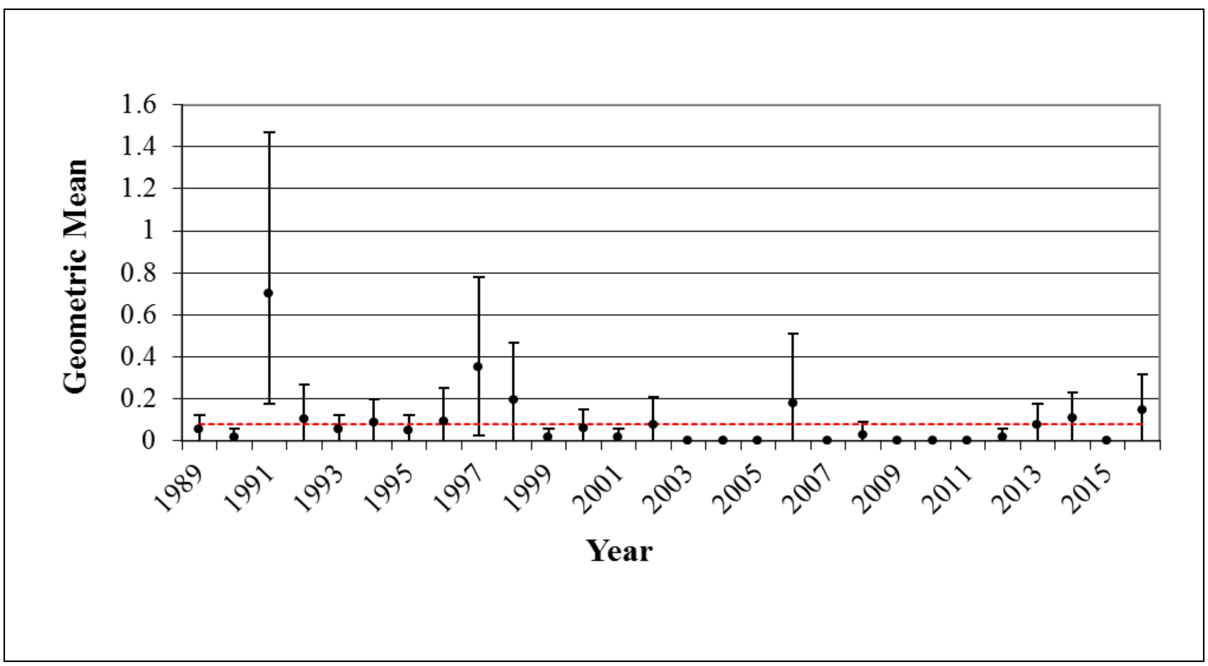

Figure 7. Atlantic croaker (*Micropogonias undulates*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

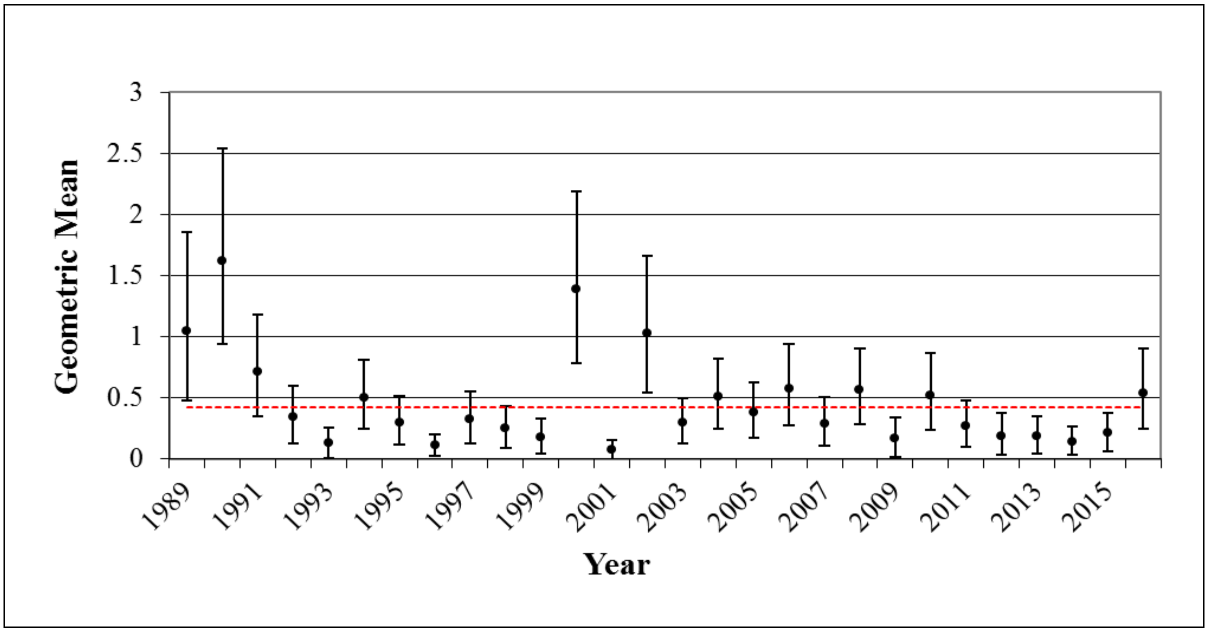

Figure 8. Atlantic menhaden (*Brevoortia tyrannus*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

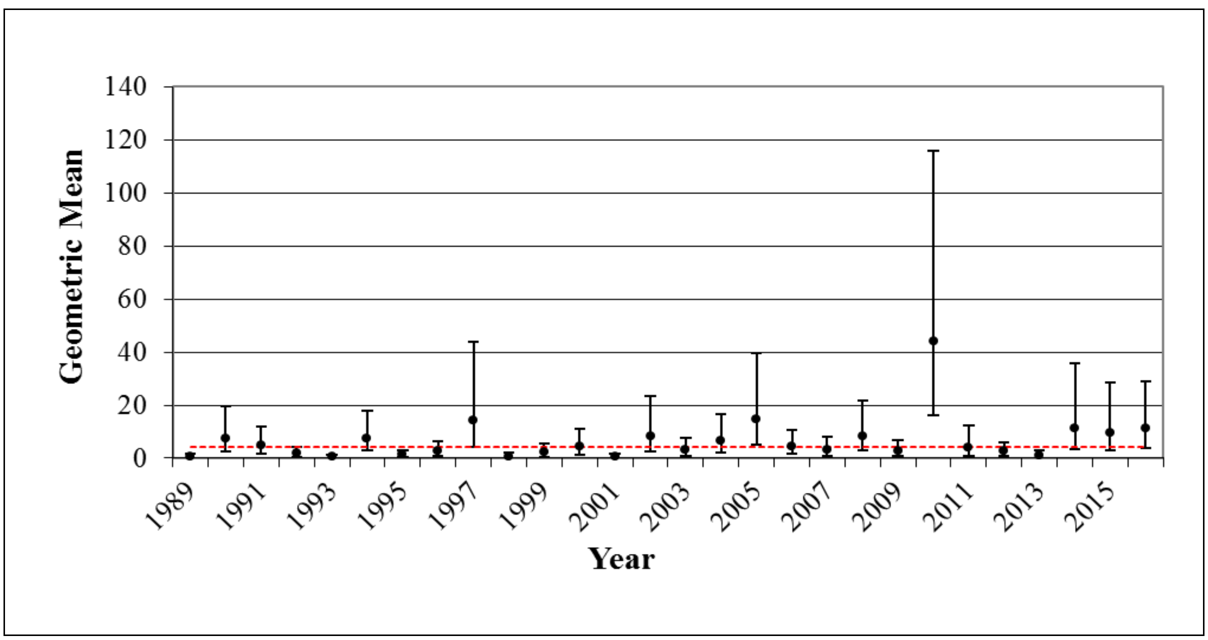

Figure 9. Atlantic menhaden (*Brevoortia tyrannus*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

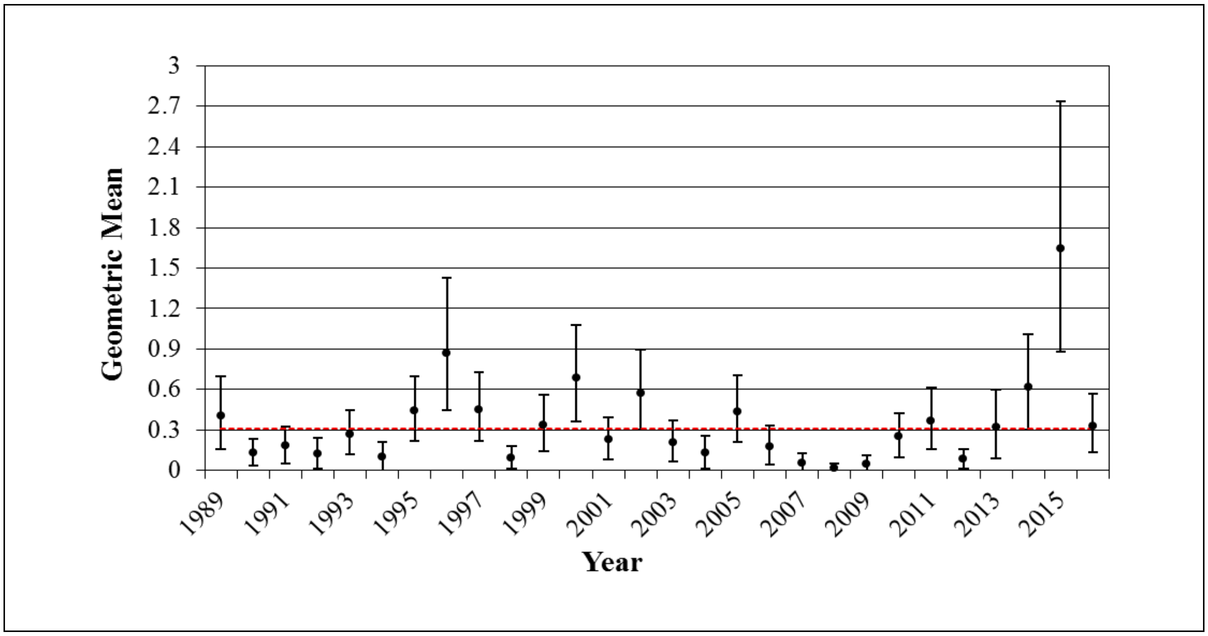

Figure 10. Atlantic silverside (*Menidia menidia*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

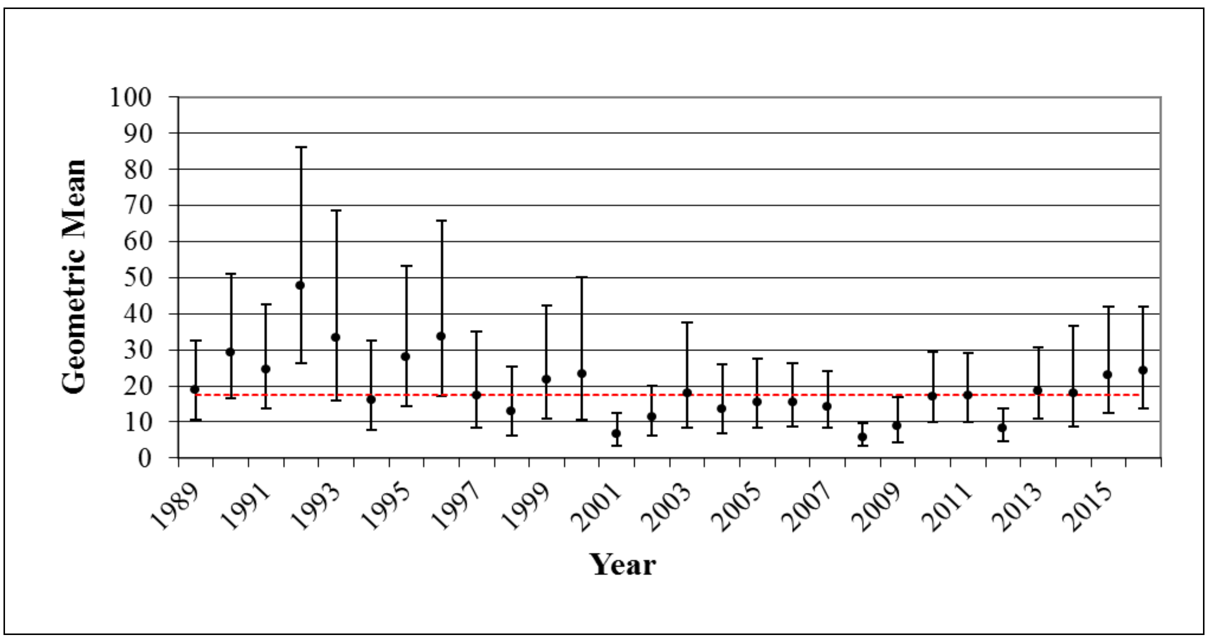

Figure 11. Atlantic silverside (*Menidia menidia*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

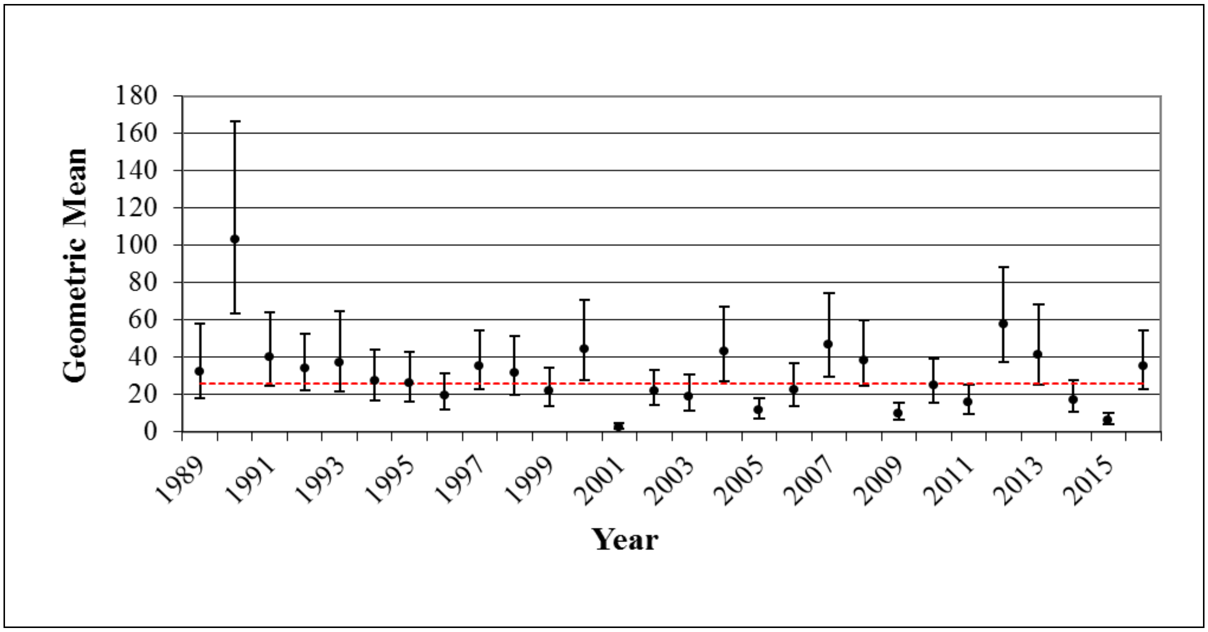

Figure 12. Bay anchovy (*Anchoa mitchilli*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

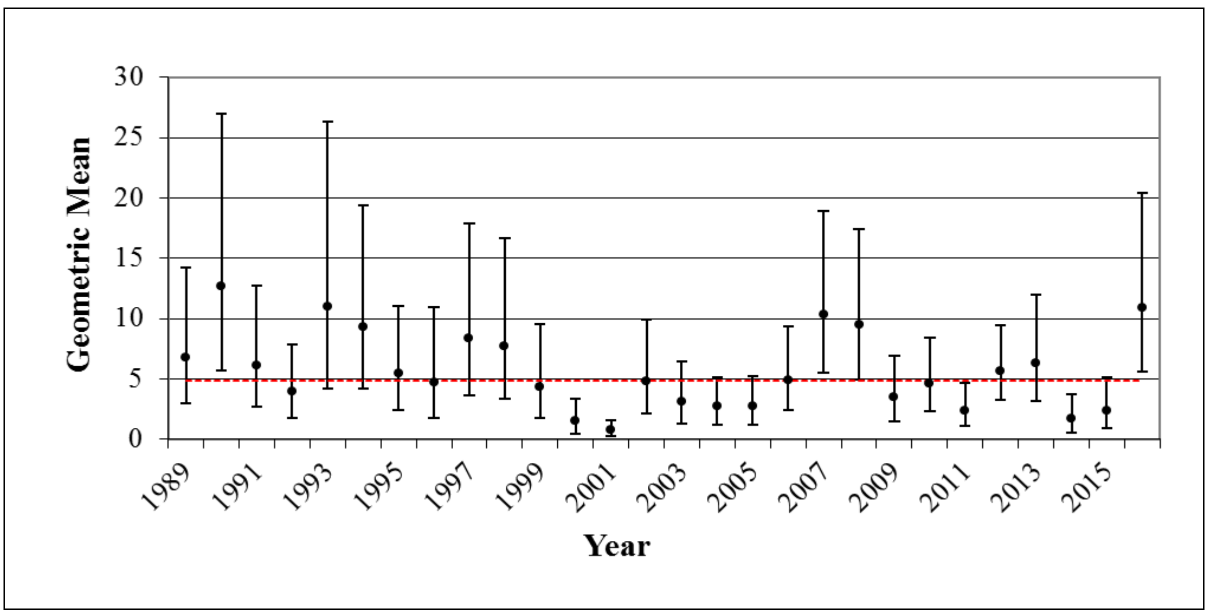

Figure 13. Bay anchovy (*Anchoa mitchilli*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

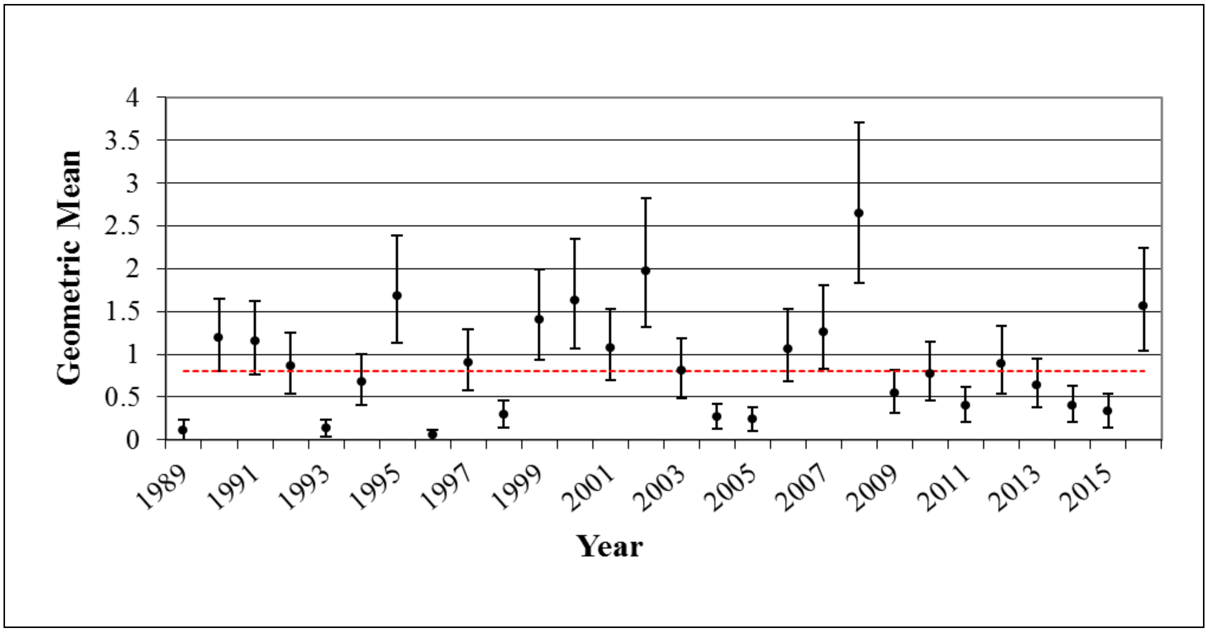

Figure 14. Black sea bass (*Centropristis striata*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

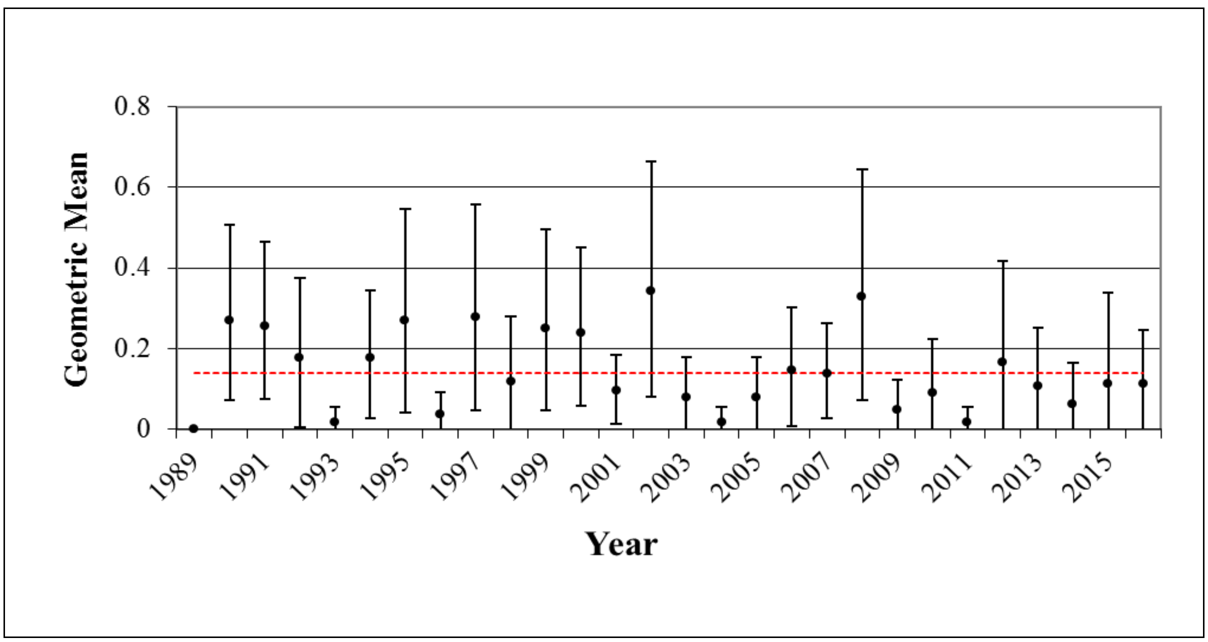

Figure 15. Black sea bass (*Centropristis striata*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

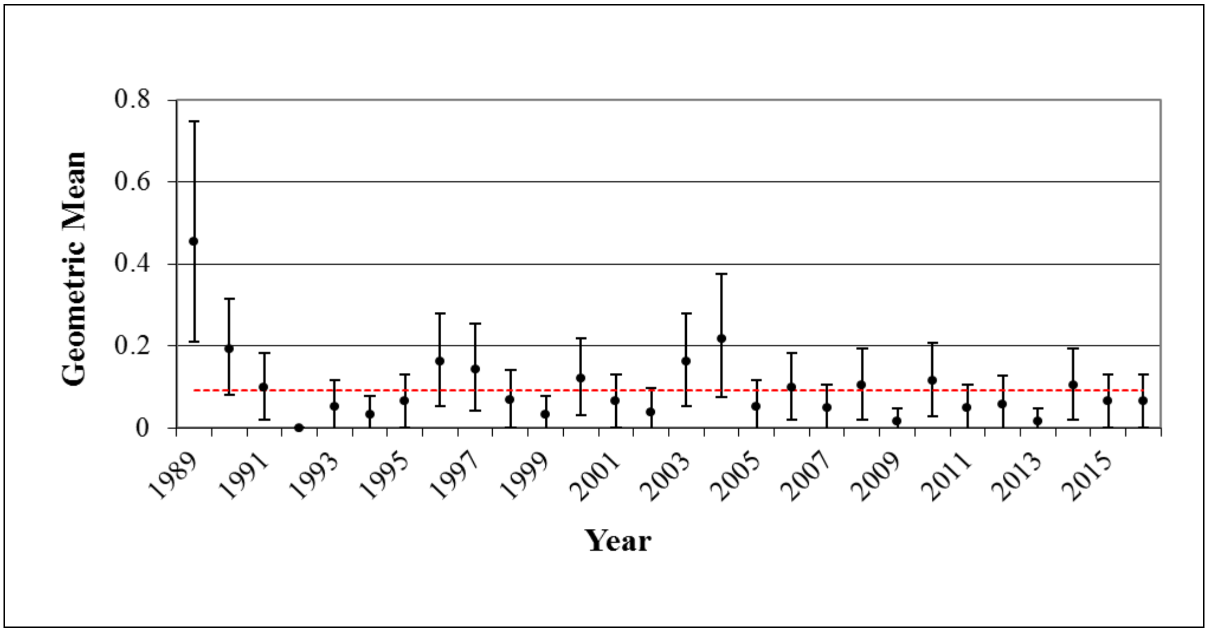

Figure 16. Bluefish (*Pomatomus saltatrix*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

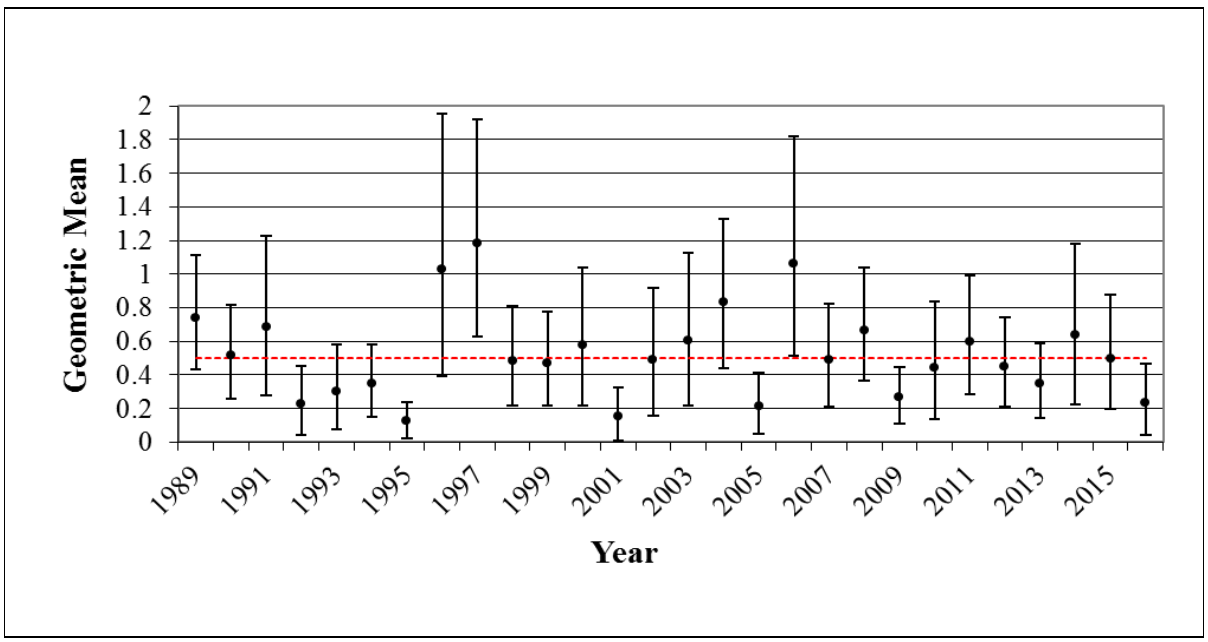

Figure 17. Bluefish (*Pomatomus saltatrix*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

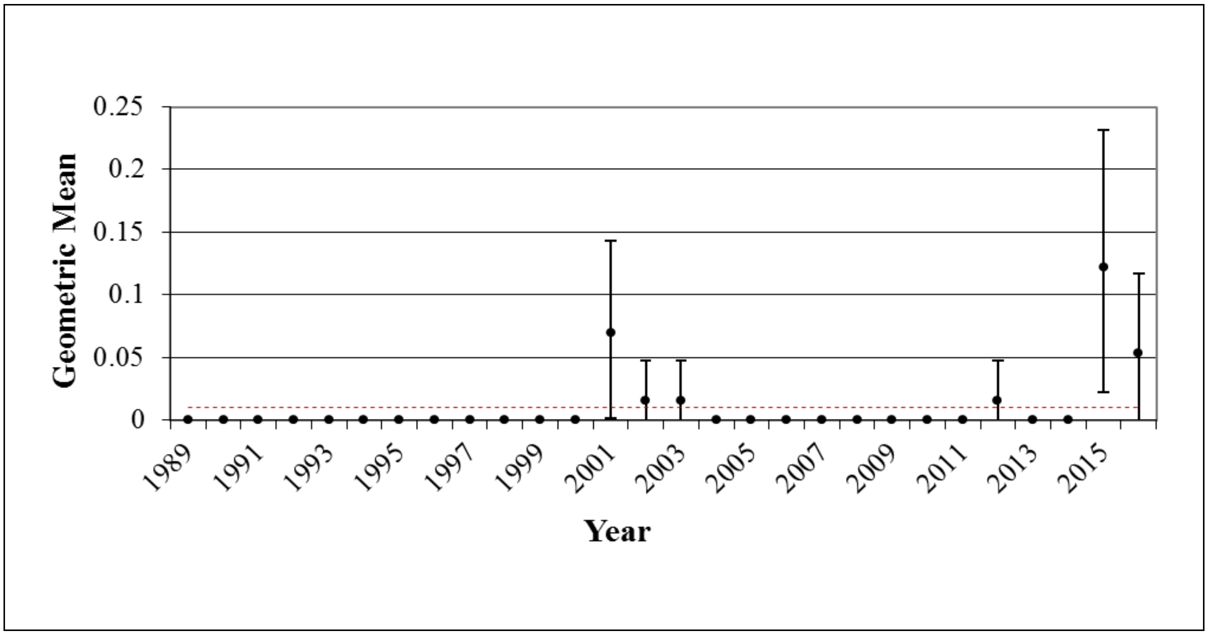

Figure 18. Sheepshead (*Archosargus probatocephalus*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

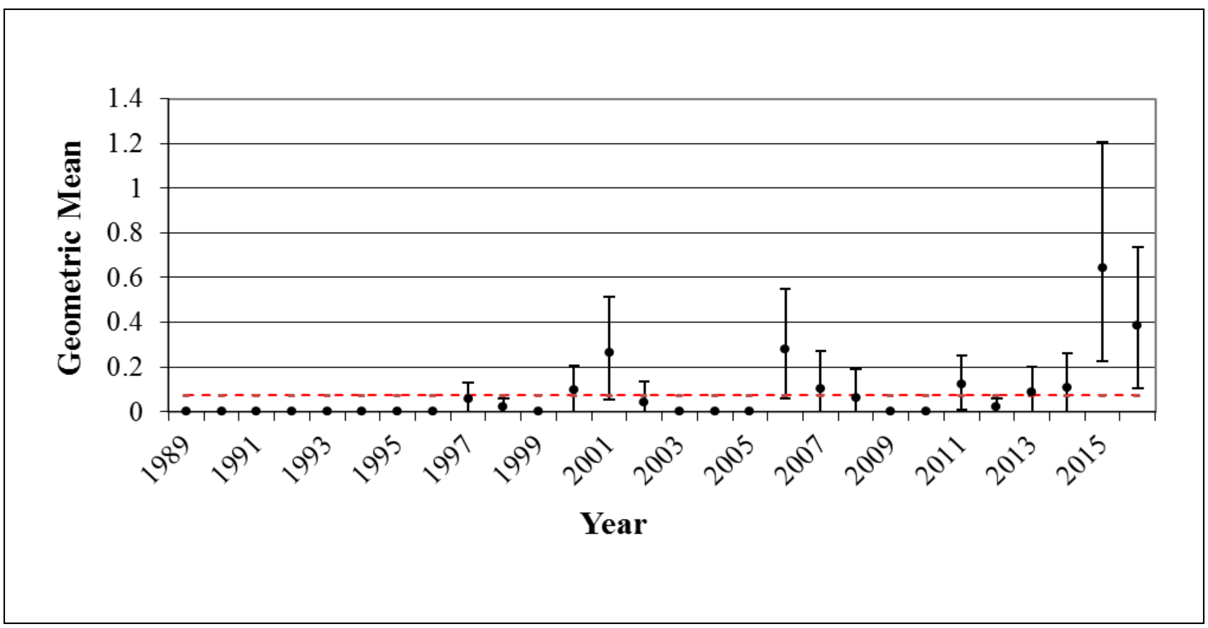

Figure 19. Sheepshead (*Archosargus probatocephalus*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

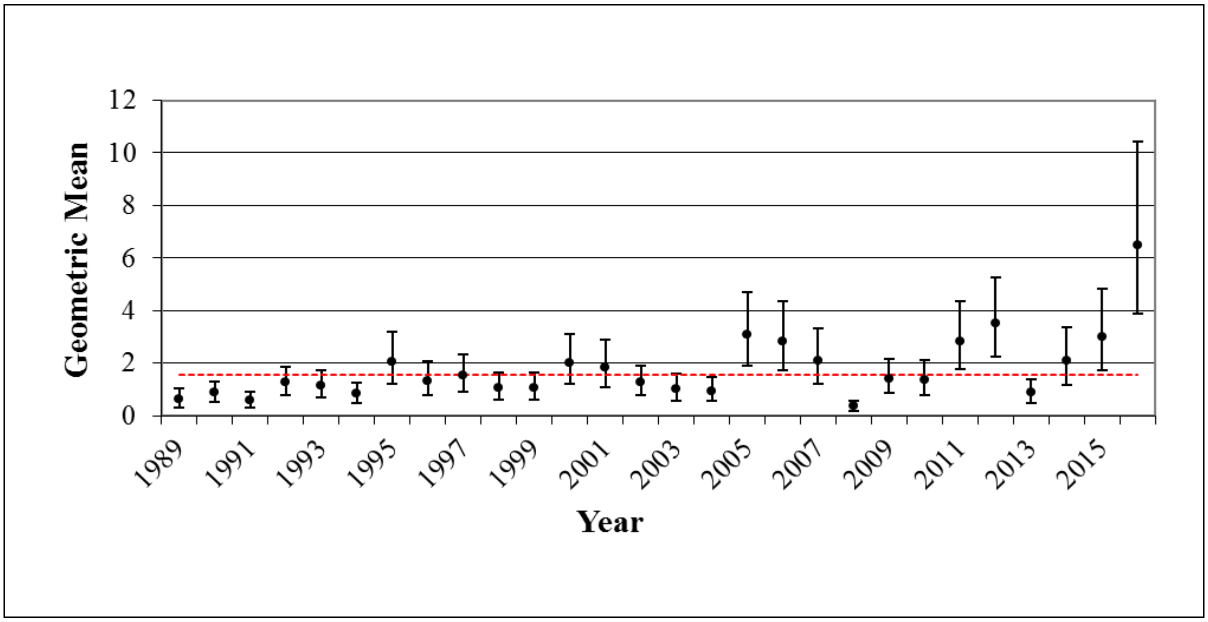

Figure 20. Silver perch (*Bairdiella chrysoura*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

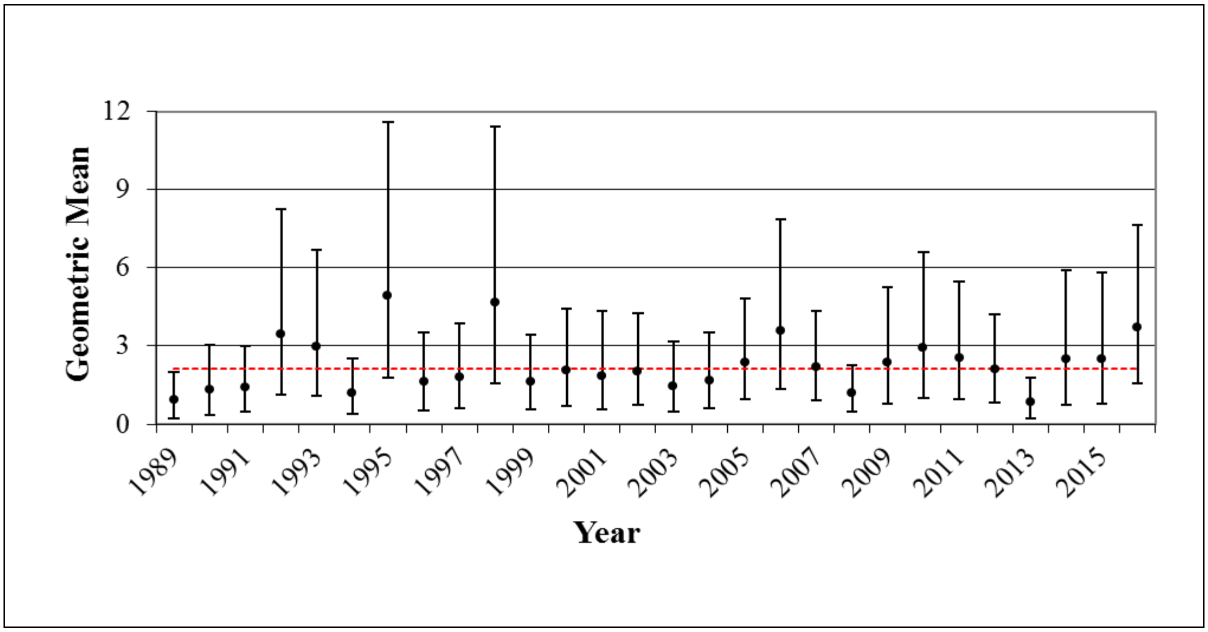

Figure 21. Silver perch (*Bairdiella chrysoura*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

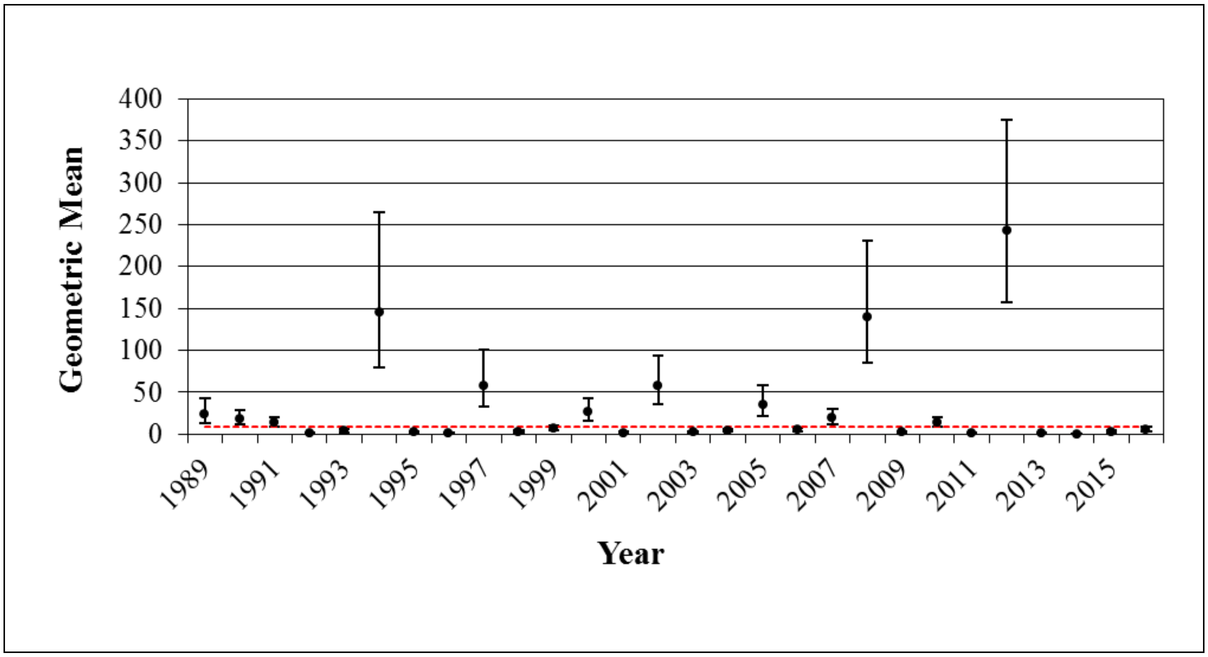

Figure 22. Spot (*Leiostomus xanthurus*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

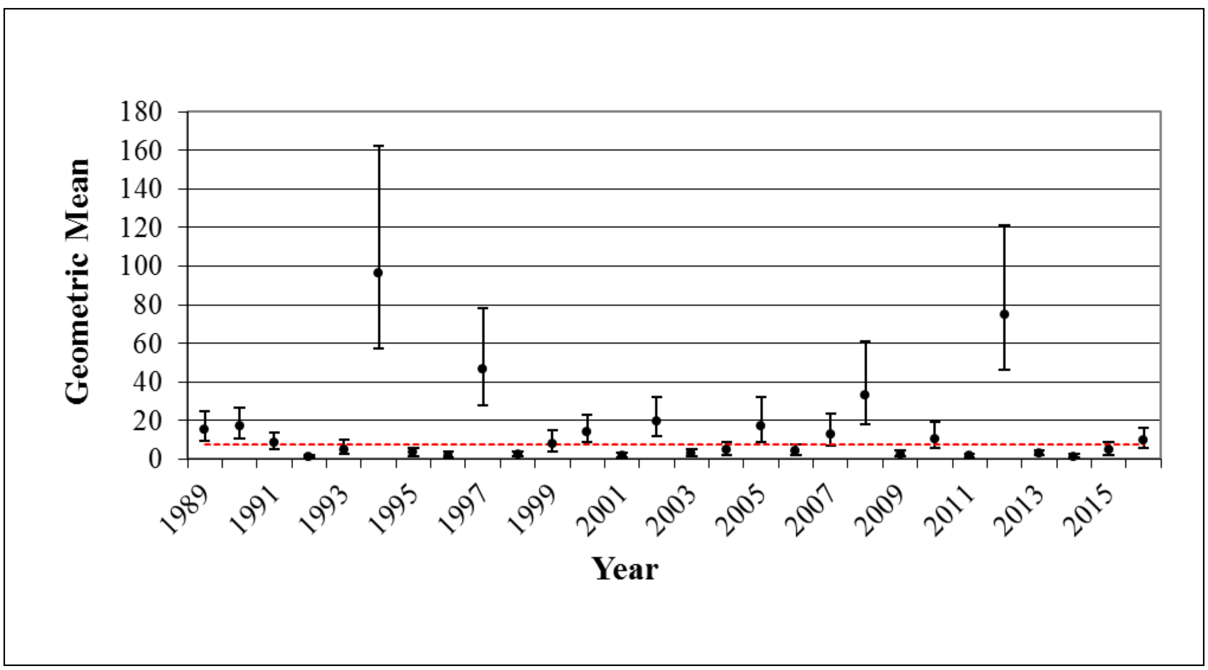

Figure 23. Spot (*Leiostomus xanthurus*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

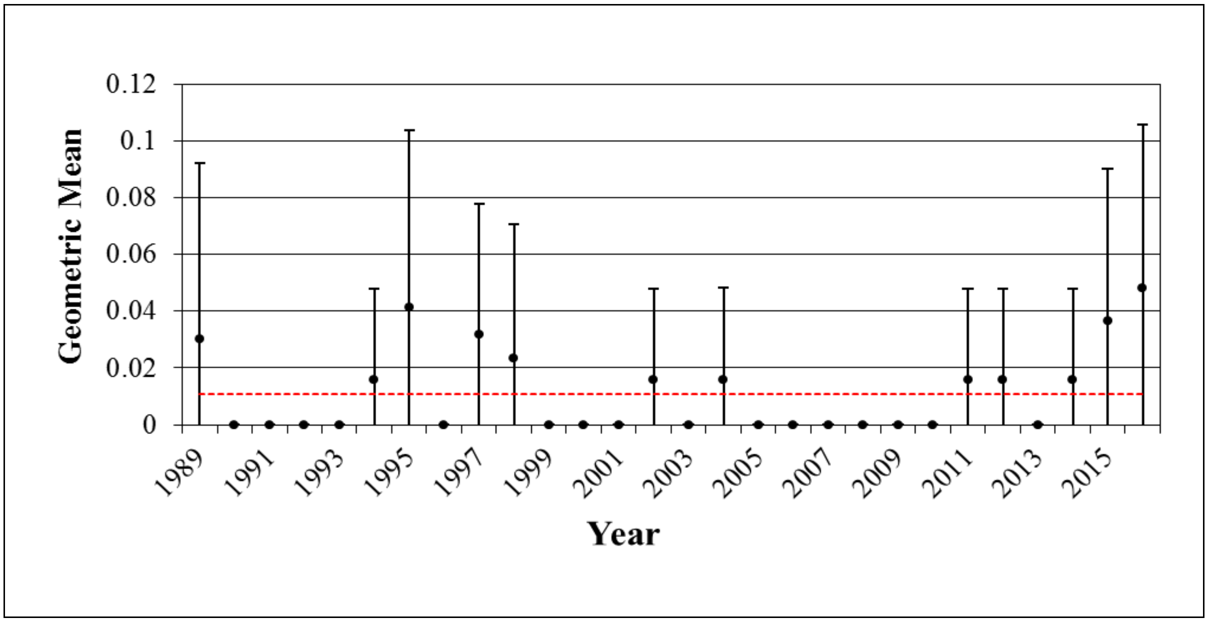

Figure 24. Striped Bass (*Morone saxatilis*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

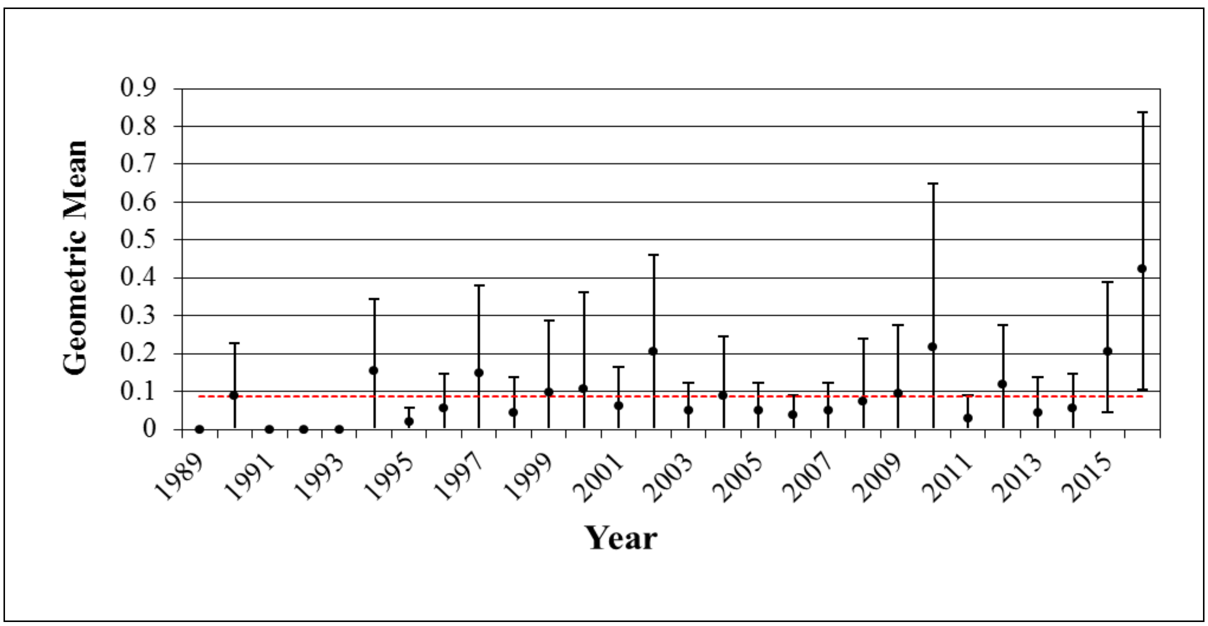

Figure 25. Striped Bass (*Morone saxatilis*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

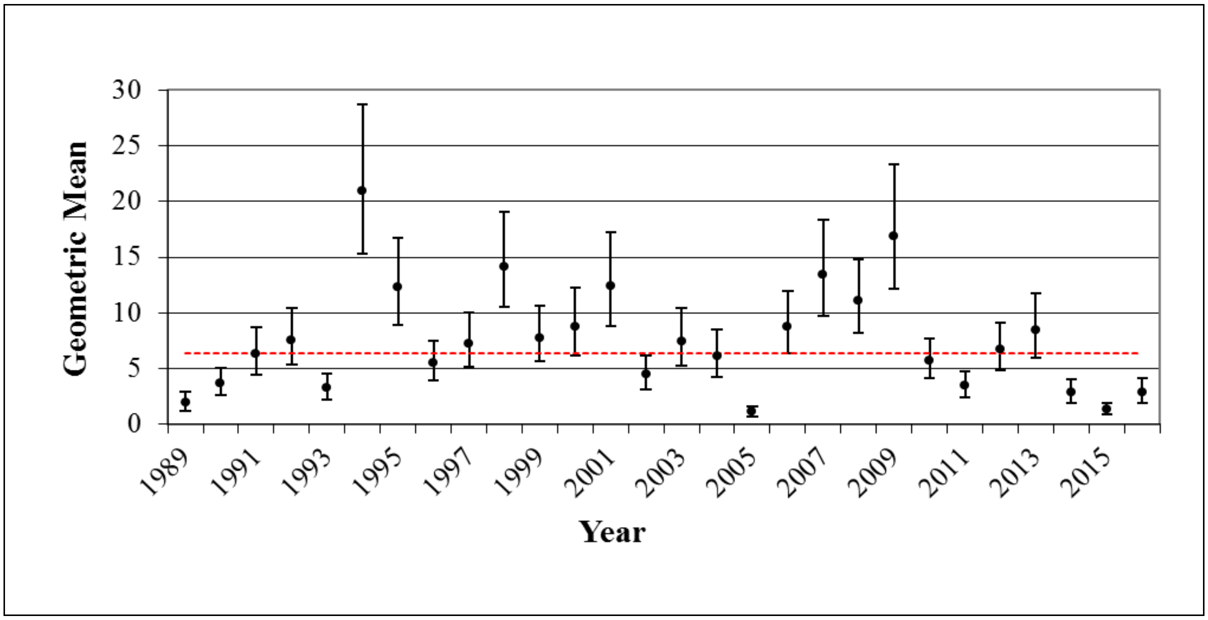

Figure 26. Summer flounder (*Paralichthys dentatus*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

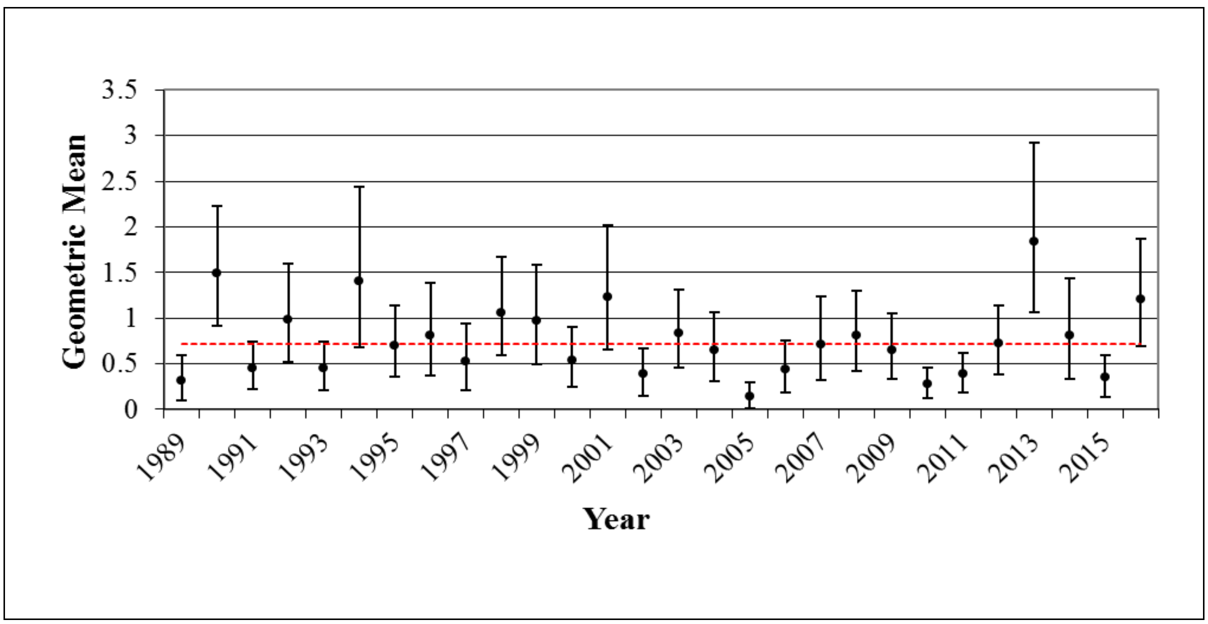

Figure 27. Summer flounder (*Paralichthys dentatus*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

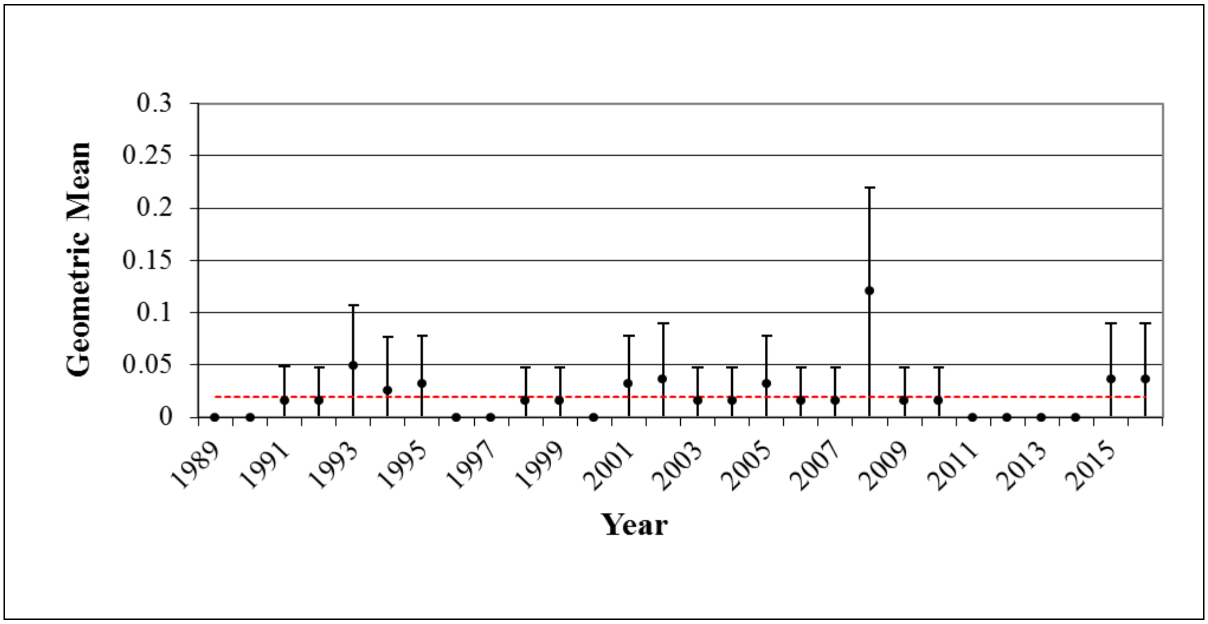

Figure 28. Tautog (*Tautoga onitis)* trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

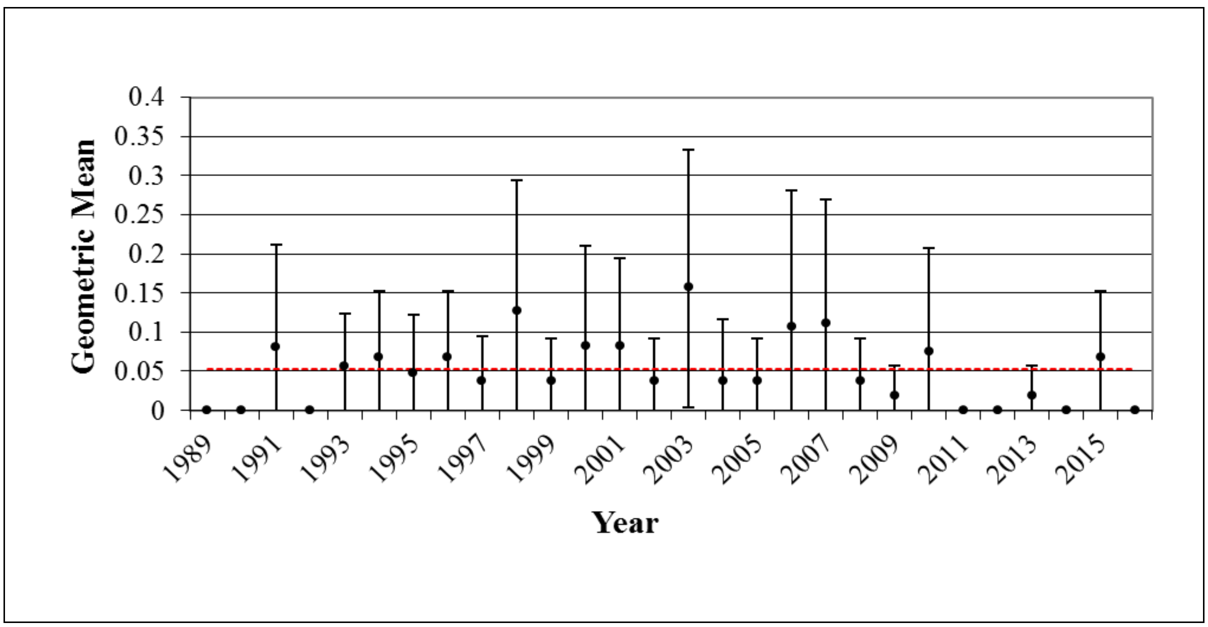

Figure 29. Tautog (*Tautoga onitis)* beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

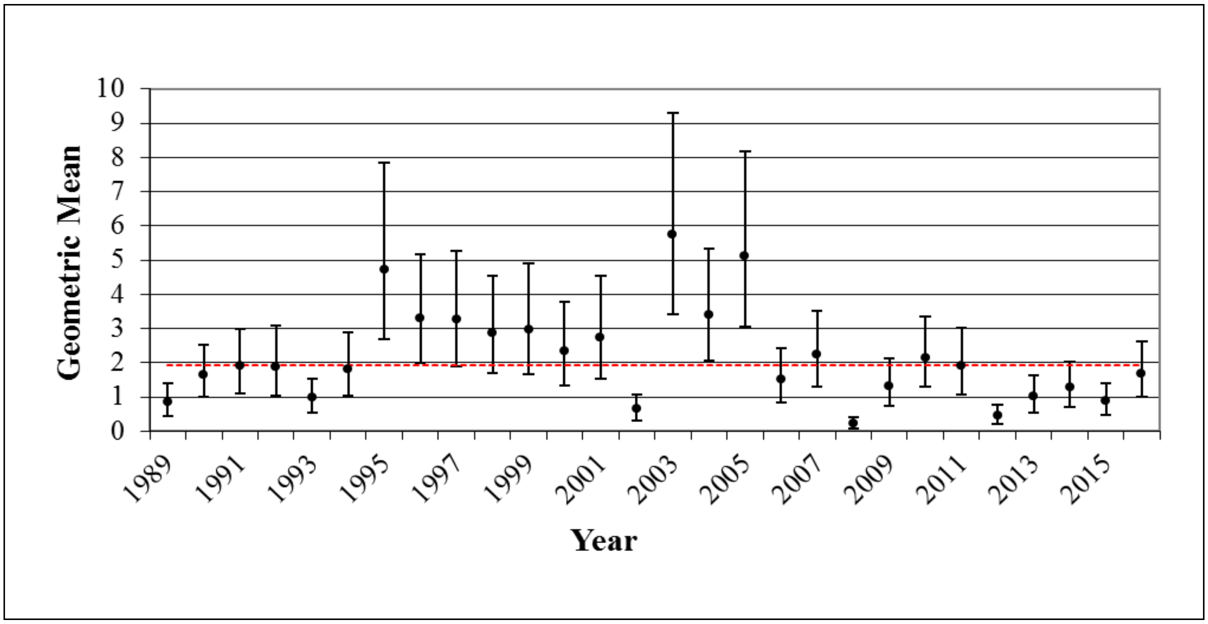

Figure 30. Weakfish (*Cynoscion regalis)* trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

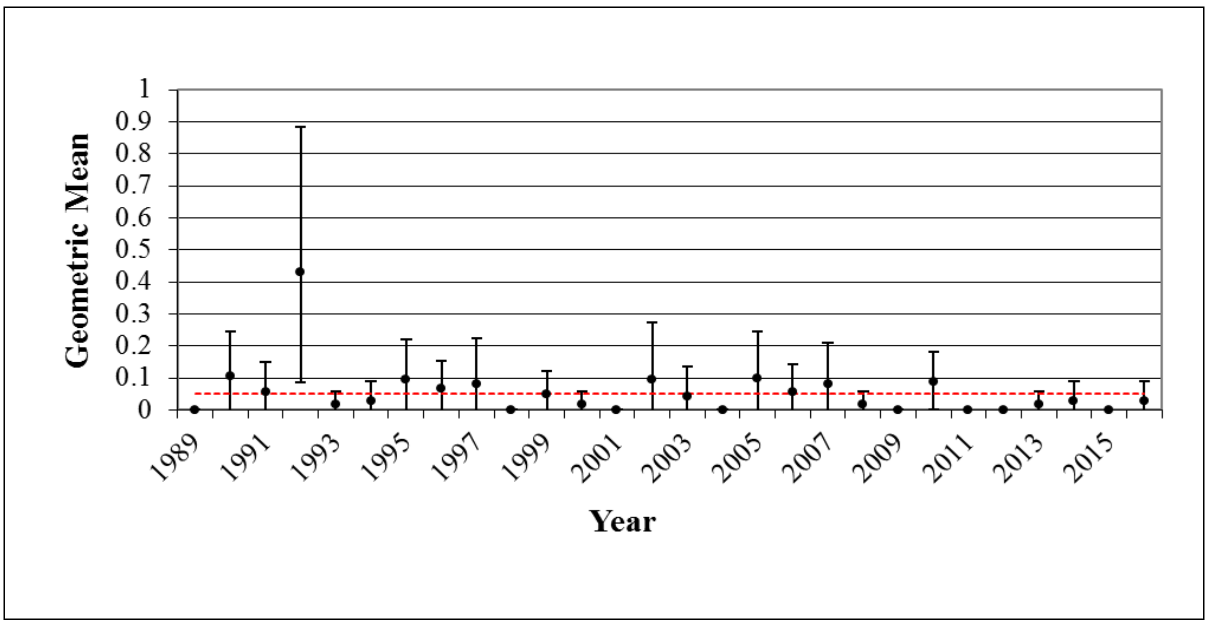

Figure 31. Weakfish (*Cynoscion regalis)* beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

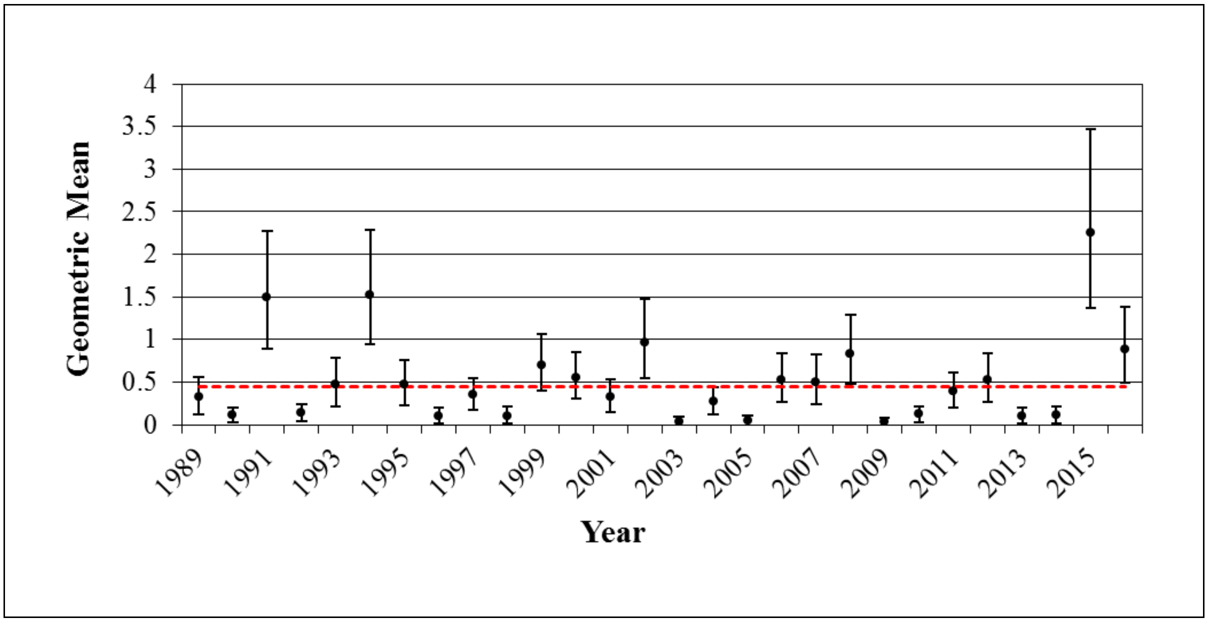

Figure 32. Brown Shrimp (*Farfantepenaeus aztecus*) trawl index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=140/year).

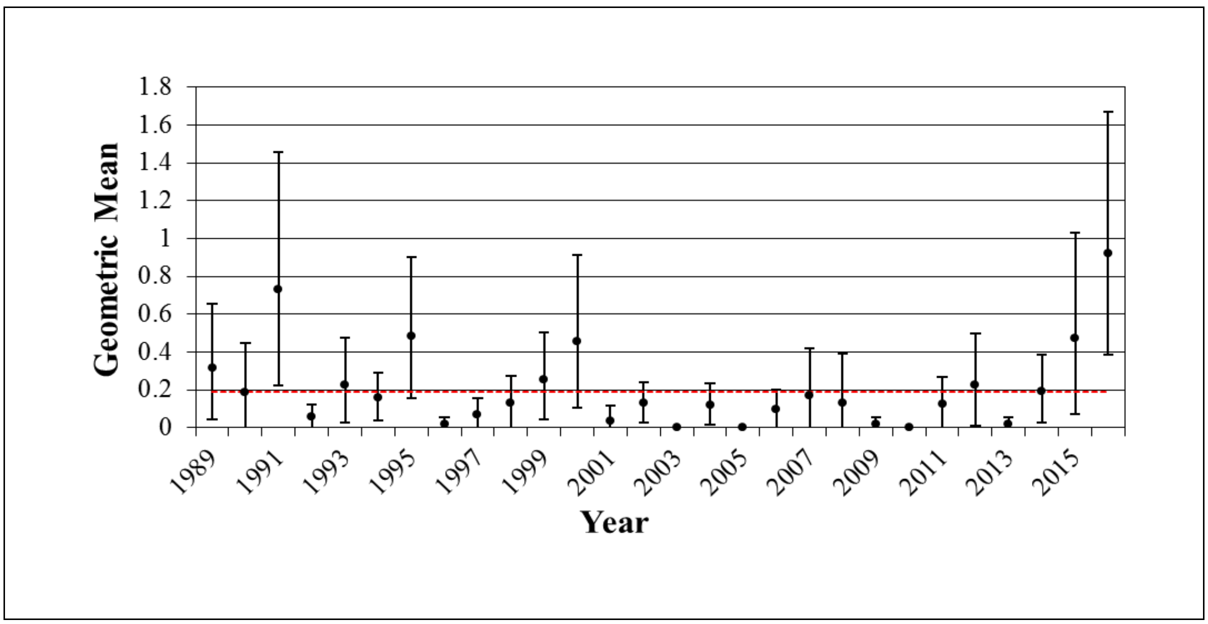

Figure 33. Brown Shrimp (*Farfantepenaeus aztecus*) beach seine index of relative abundance (geometric mean) with 95 percent confidence intervals (1989-2016). Dotted line represents the 1989-2016 time series grand mean. Protocols of the Trawl and Beach Seine surveys were standardized in 1989 (n=38/year).

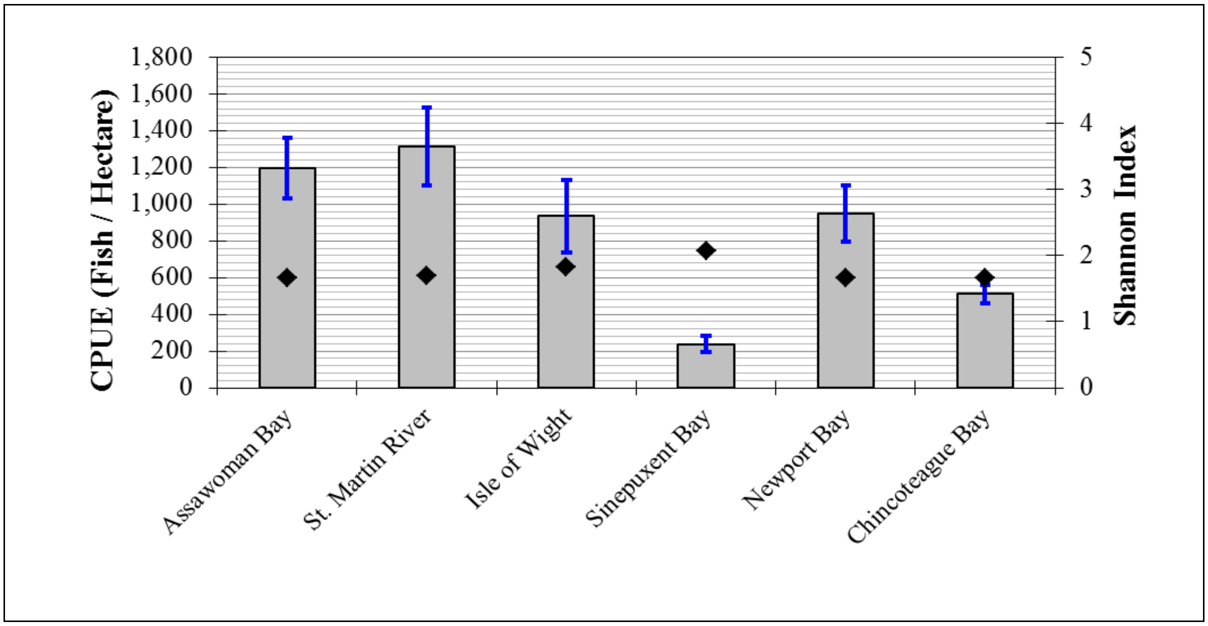

Figure 34. Trawl index of finfish relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (1989-2016). Black diamond represents the 1989-2016 time series Shannon index of diversity.

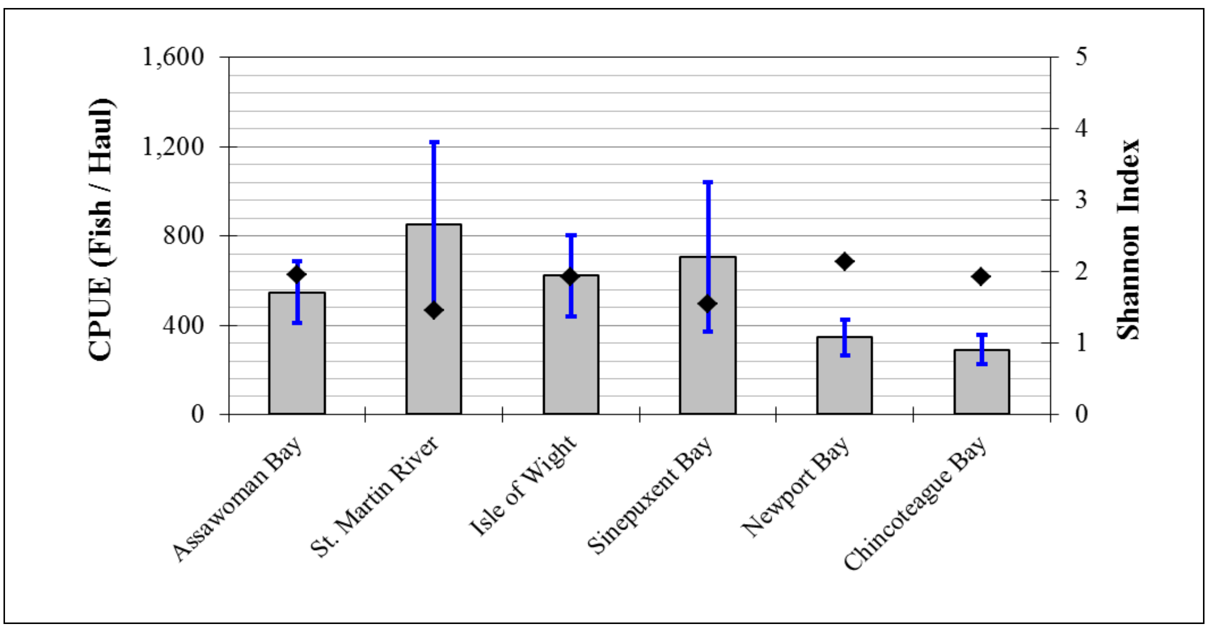

Figure 35. Beach seine index of finfish relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (1989-2016). Black diamond represents the 1989-2016 time series Shannon index of diversity.

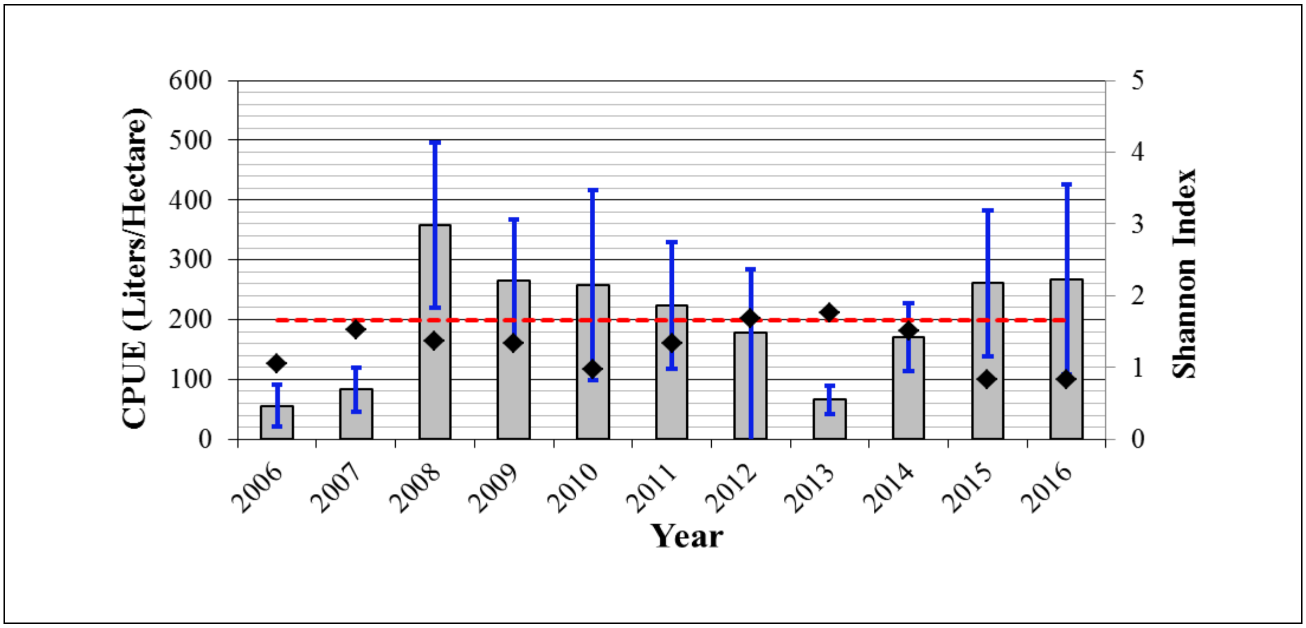

Figure 36. Trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=140/year). Black diamond represents the Shannon index of diversity.

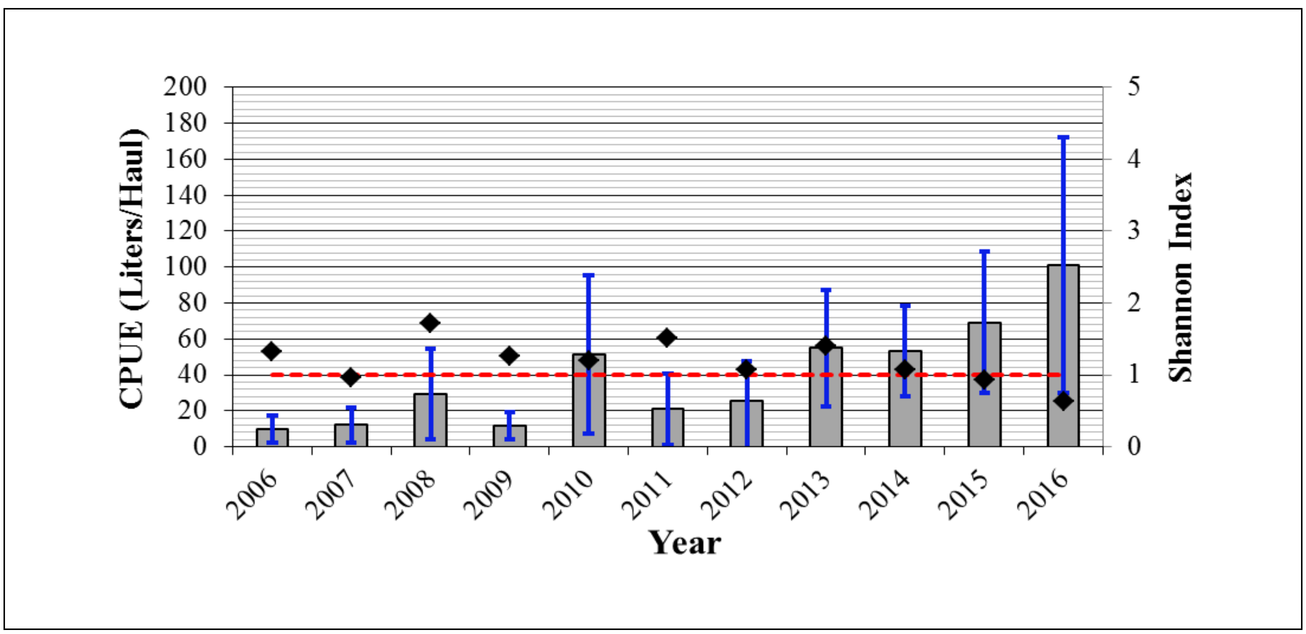

Figure 37. Beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=36/year). Black diamond represents the Shannon index of diversity.

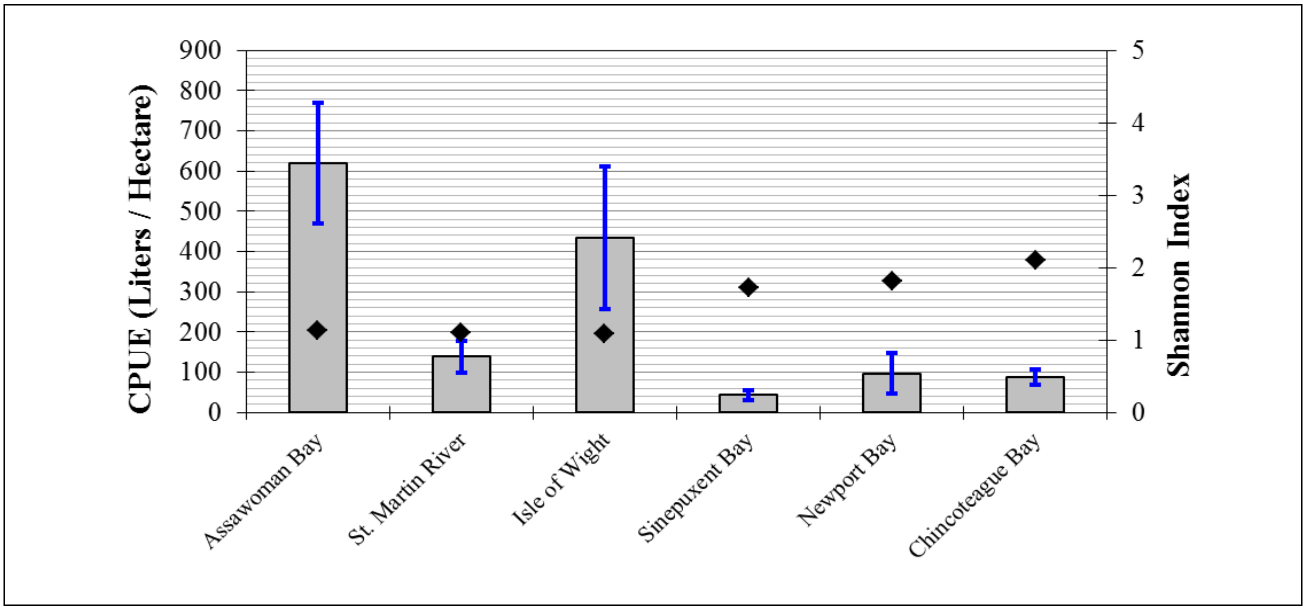

Figure 38. Trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Black diamond represents the 2006-2016 time series Shannon index of diversity.

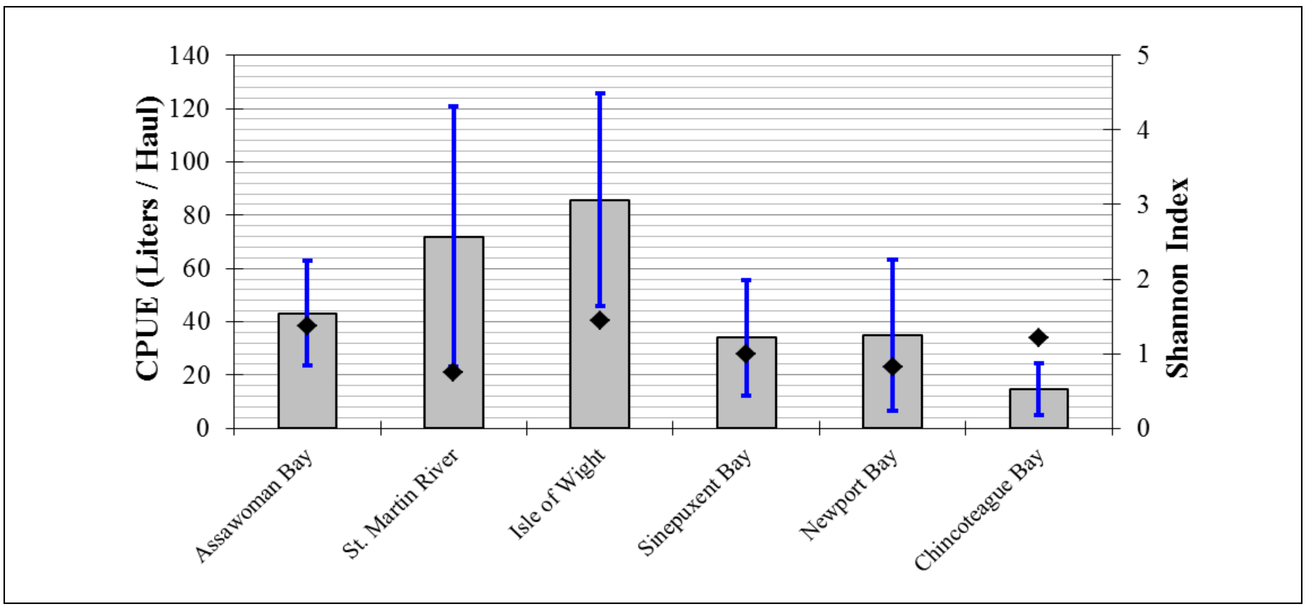

Figure 39. Beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Black diamond represents the 2006-2016 time series Shannon index of diversity.

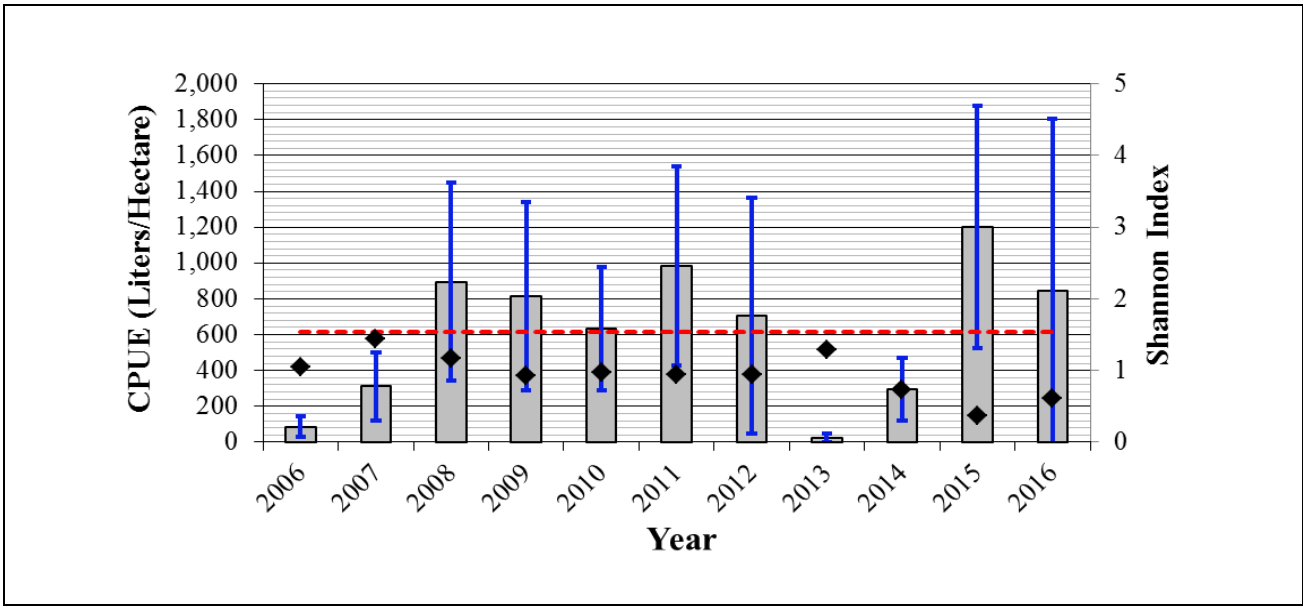

Figure 40. Assawoman Bay trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=21/year). Black diamond represents the Shannon index of diversity.

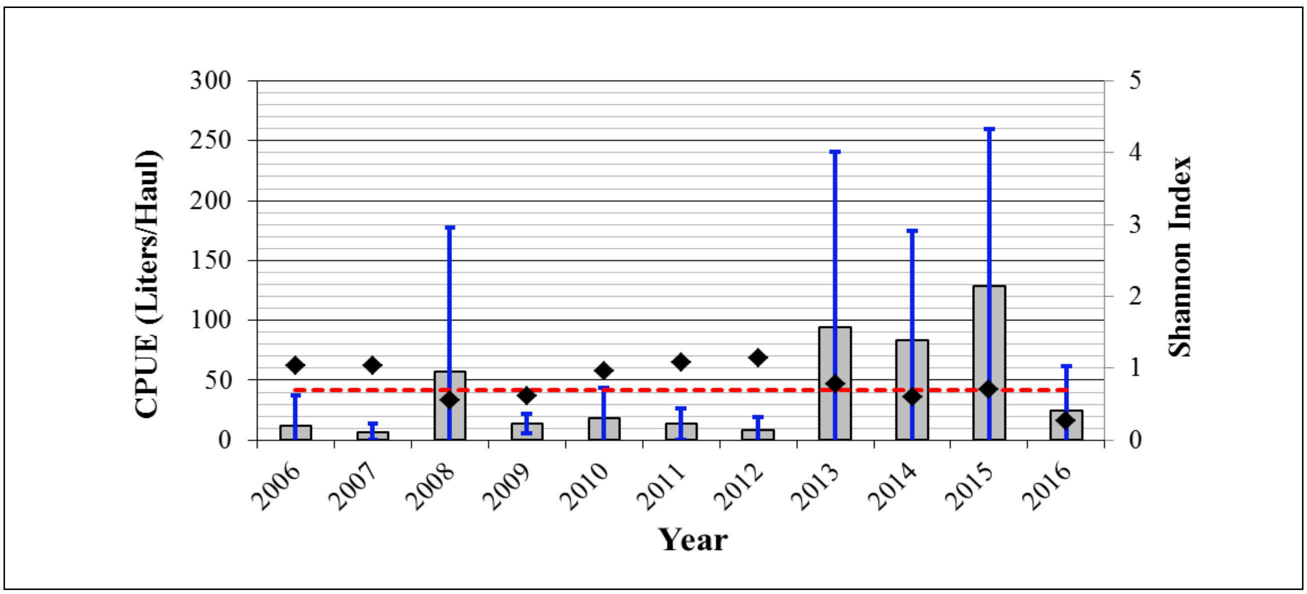

Figure 41. Assawoman Bay beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Dotted line represents the 2006-2016 time series catch per unit effort grand mean, (n=6/year). Black diamond represents the Shannon index of diversity.

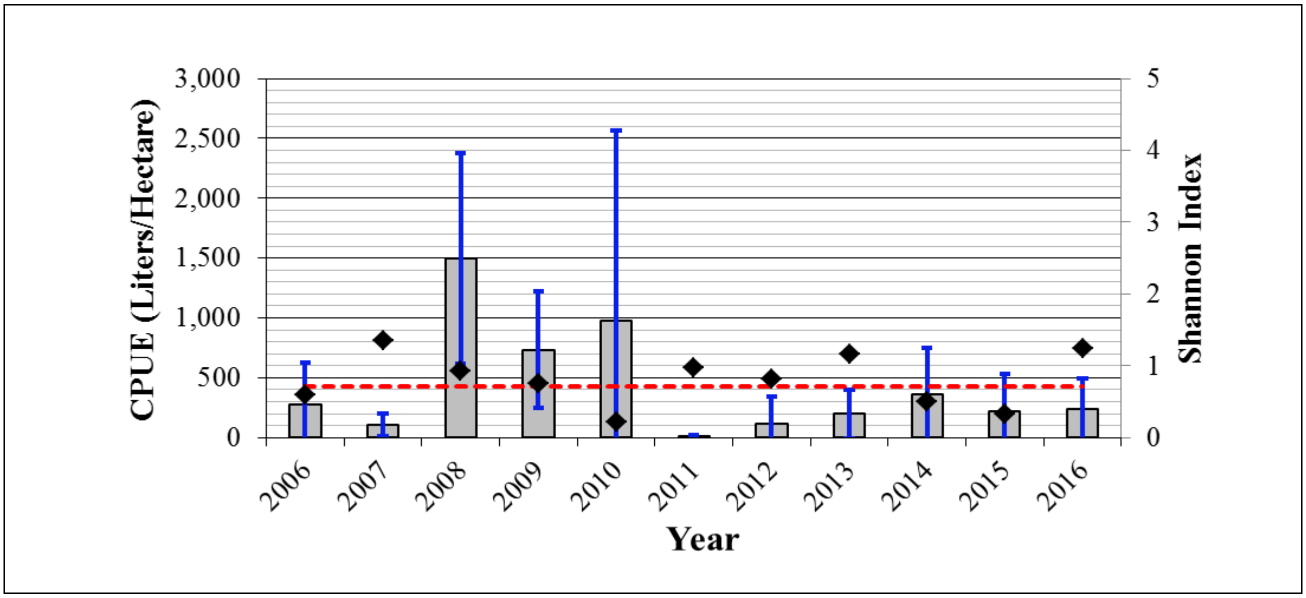

Figure 42. Isle of Wight Bay trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=14/year). Black diamond represents the Shannon index of diversity.

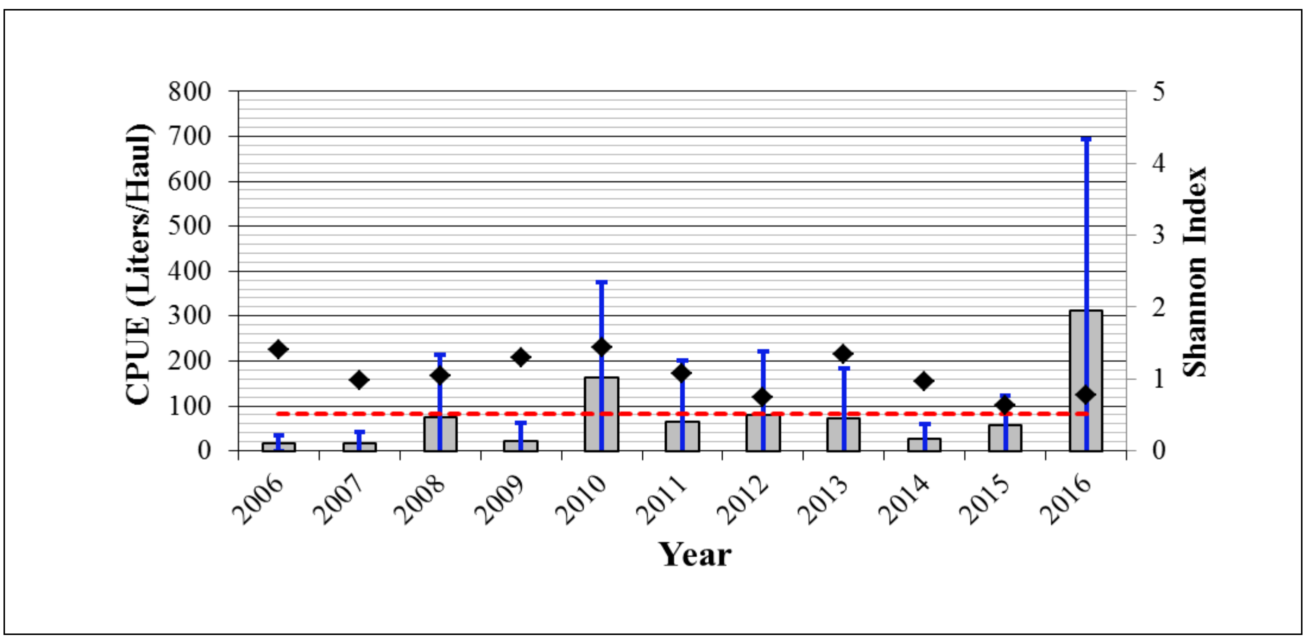

Figure 43. Isle of Wight Bay beach seine index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=4/year). Black diamond represents the Shannon index of diversity.

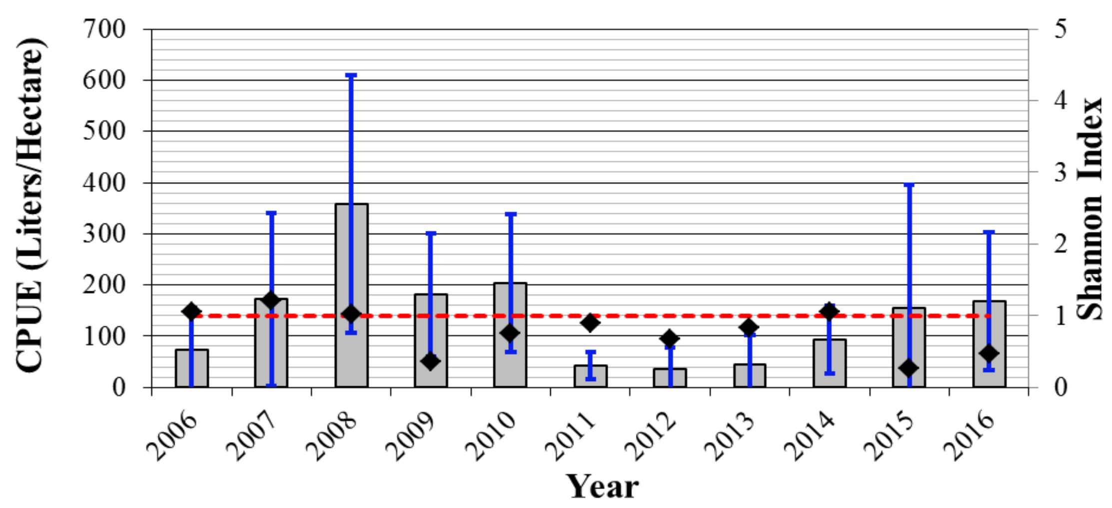

Figure 44. St. Martin River trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=14/year). Black diamond represents the Shannon index of diversity.

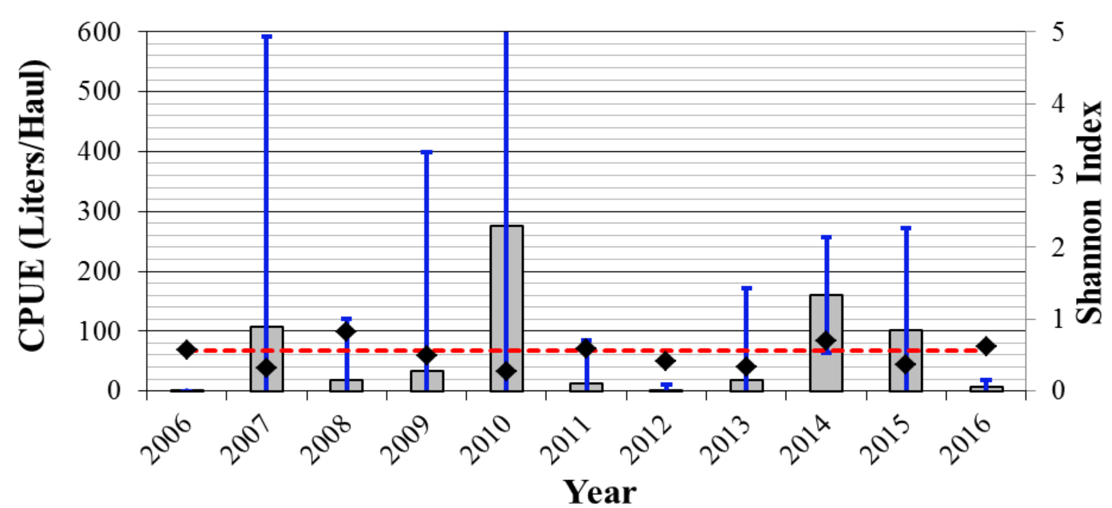

Figure 45. St. Martin River beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=2/year). Black diamond represents the Shannon index of diversity.

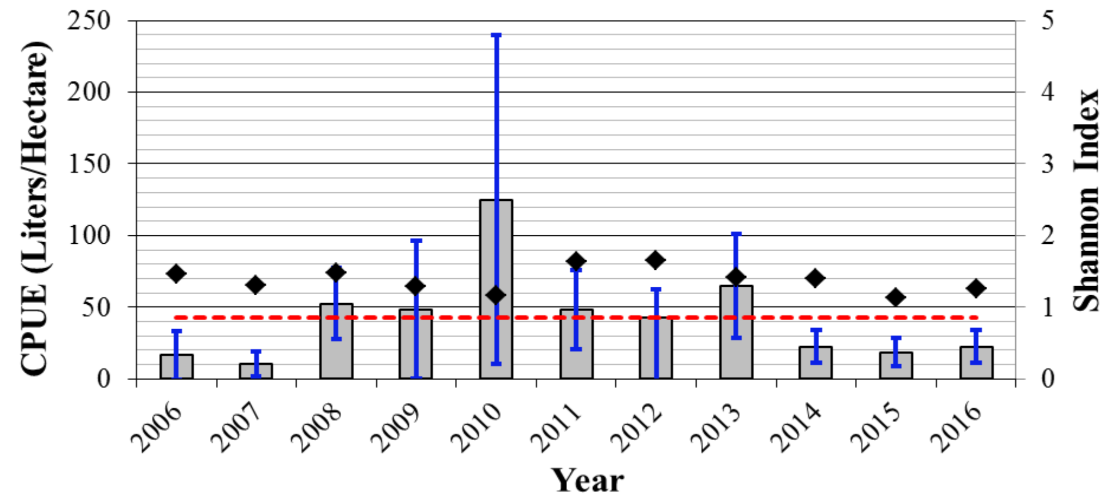

Figure 46. Sinepuxent Bay trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=21/year). Black diamond represents the Shannon index of diversity.

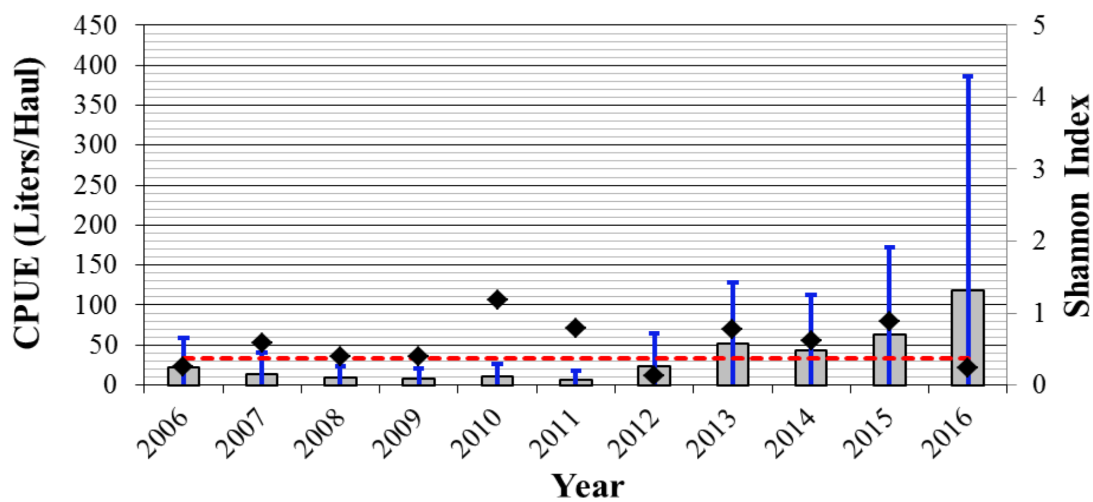

Figure 47. Sinepuxent Bay beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=6/year). Black diamond represents the Shannon index of diversity.

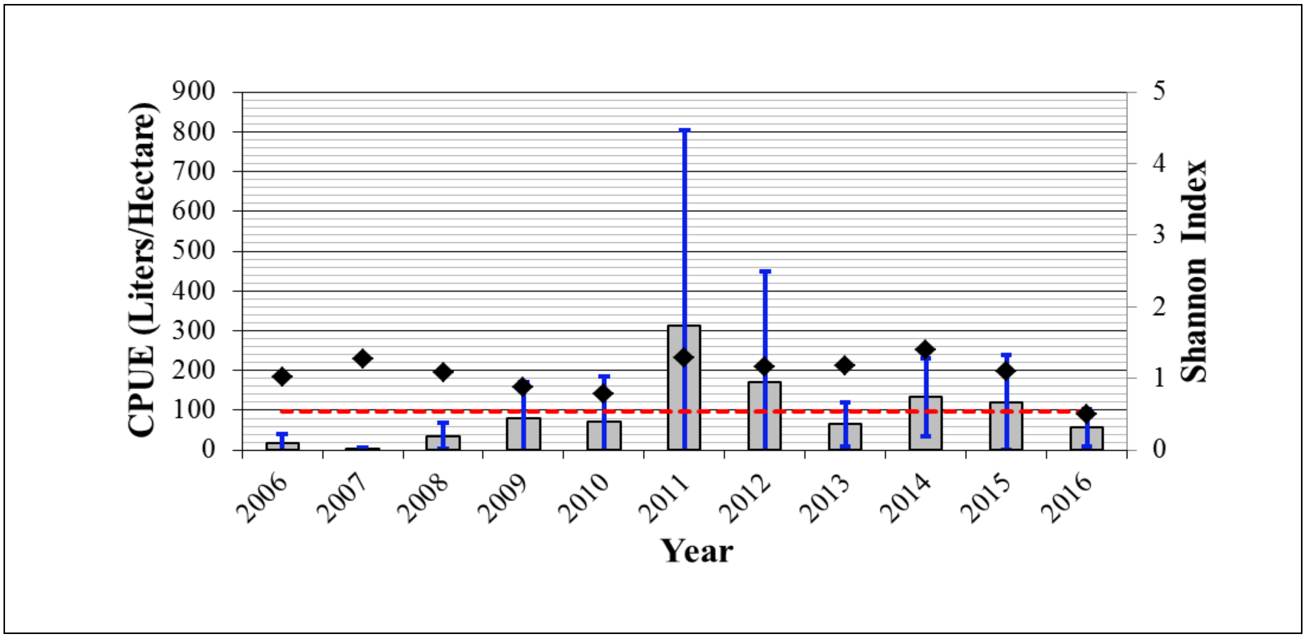

Figure 48. Newport Bay trawl index of relative macroalgae abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=14/year). Black diamond represents the Shannon index of diversity.

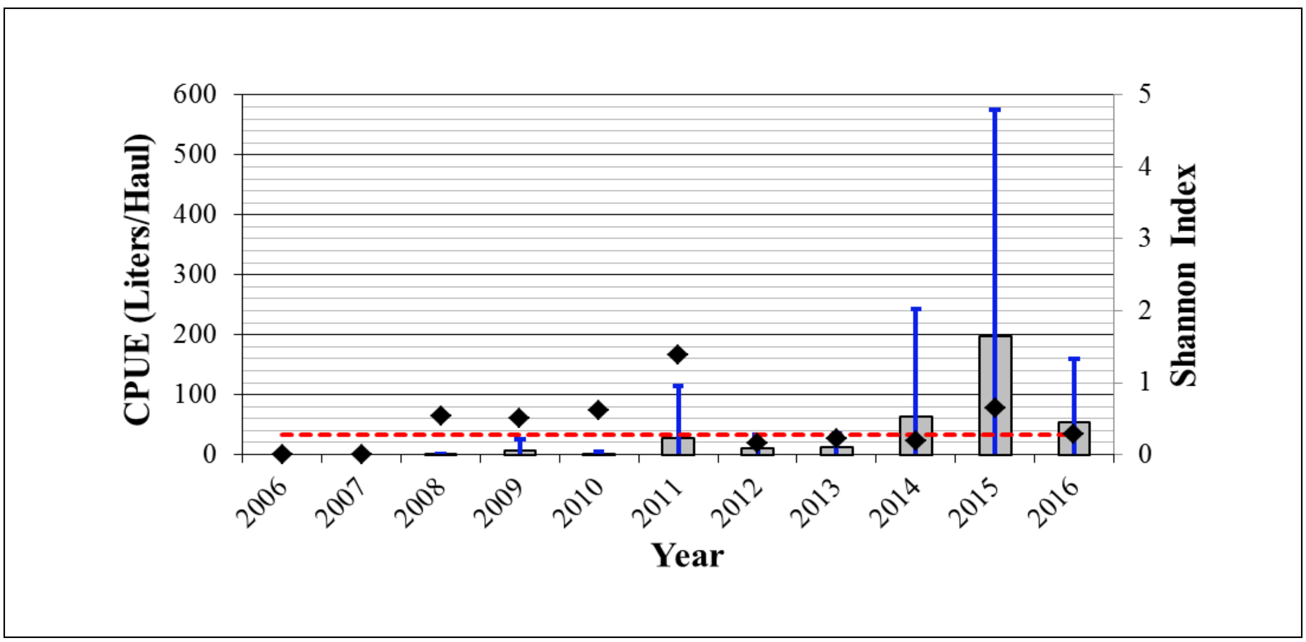

Figure 49. Newport Bay beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=4/year). Black diamond represents the Shannon index of diversity.

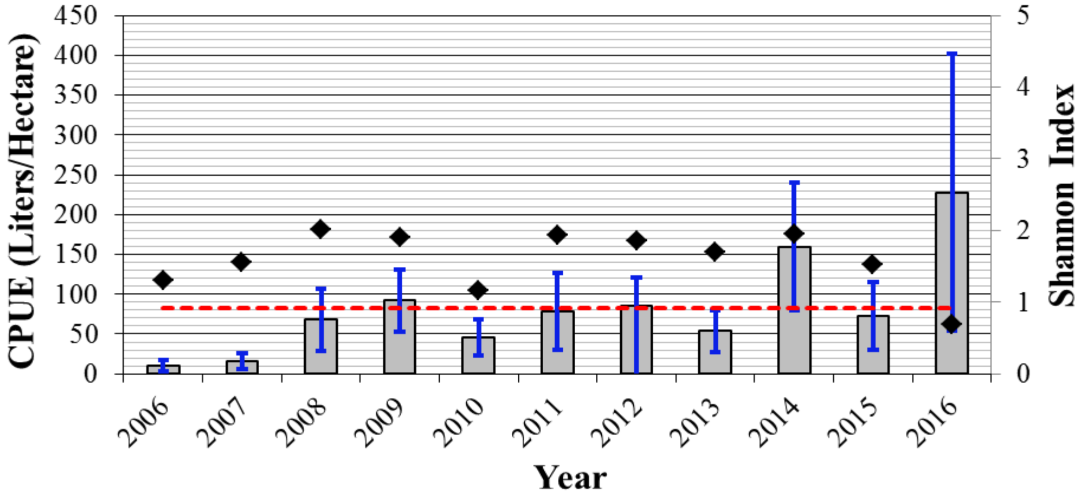

Figure 50. Chincoteague Bay trawl index of macroalgae relative abundance (catch per unit effort; liters/hectare) with 95 percent confidence intervals (2006-2016). Dotted line represents the 2006-2016 time series catch per unit effort grand mean, (n=56/year). Black diamond represents the Shannon index of diversity.

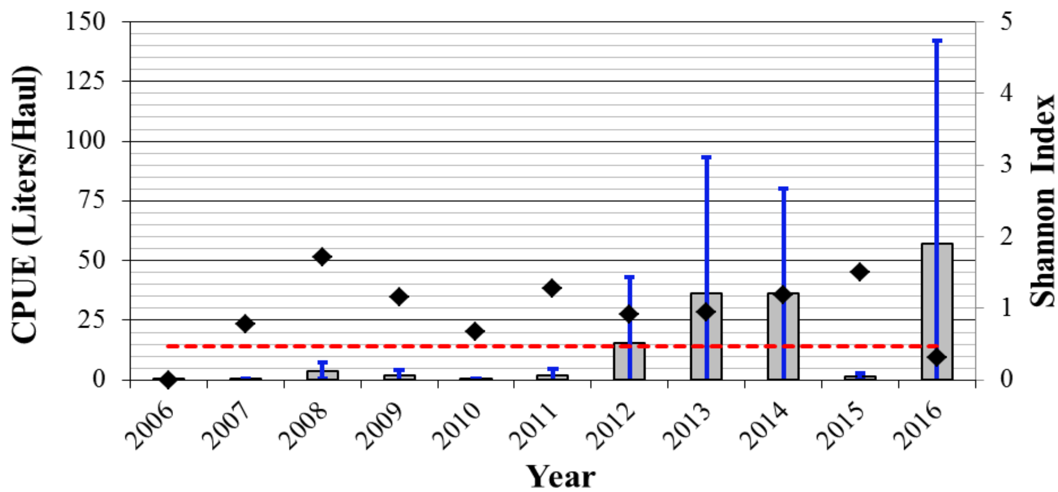

Figure 51. Chincoteague Bay beach seine index of macroalgae relative abundance (catch per unit effort; liters/haul) with 95 percent confidence intervals (2006-2016). Red line represents the 2006-2016 time series catch per unit effort grand mean, (n=12/year). Black diamond represents the Shannon index of diversity.

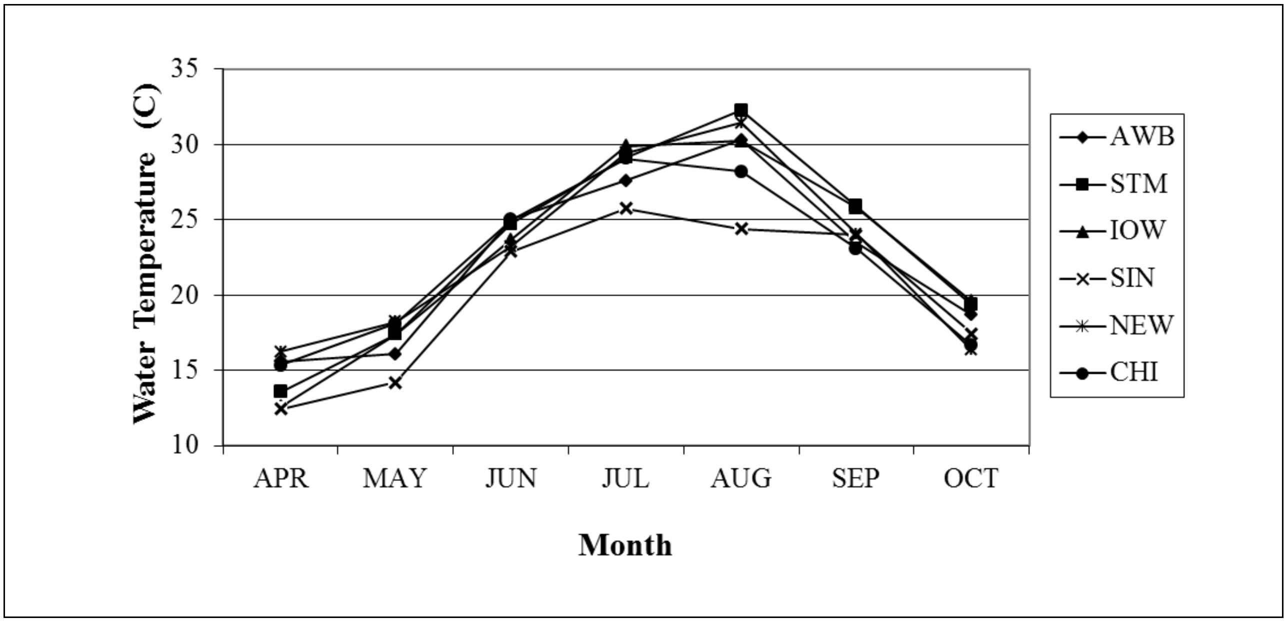

Figure 52. 2016 Trawl Survey mean water temperature (Celsius) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

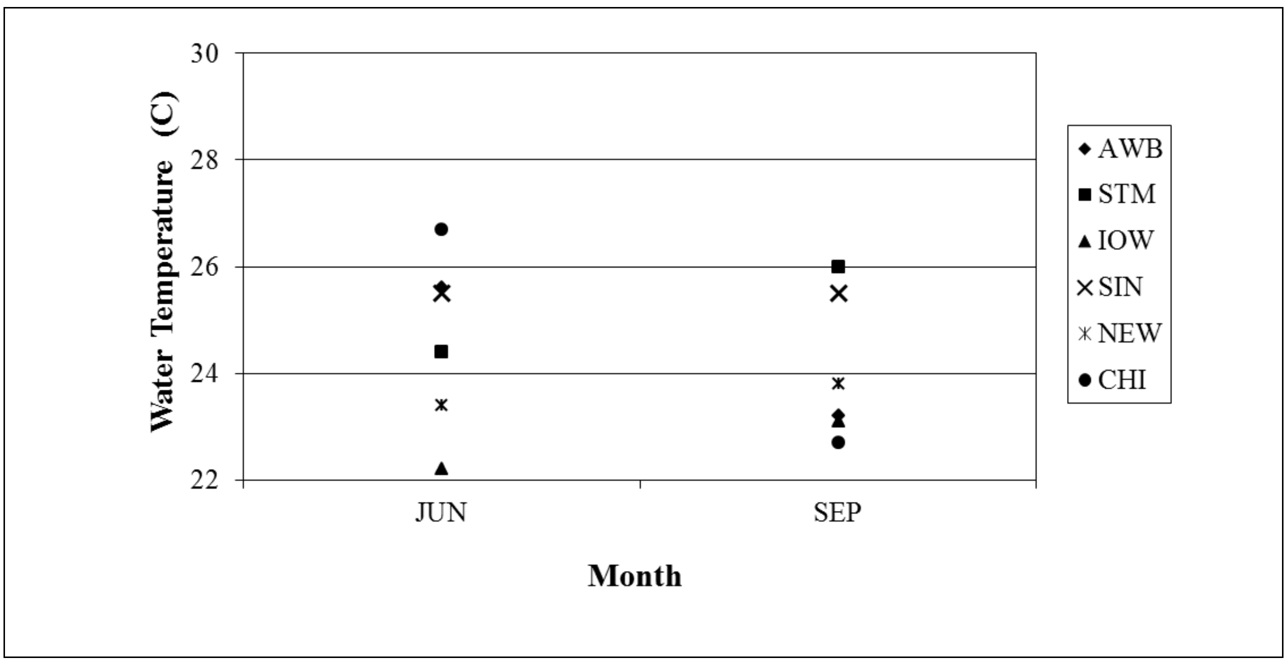

Figure 53. 2016 Beach Seine Survey mean water temperature (Celsius) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

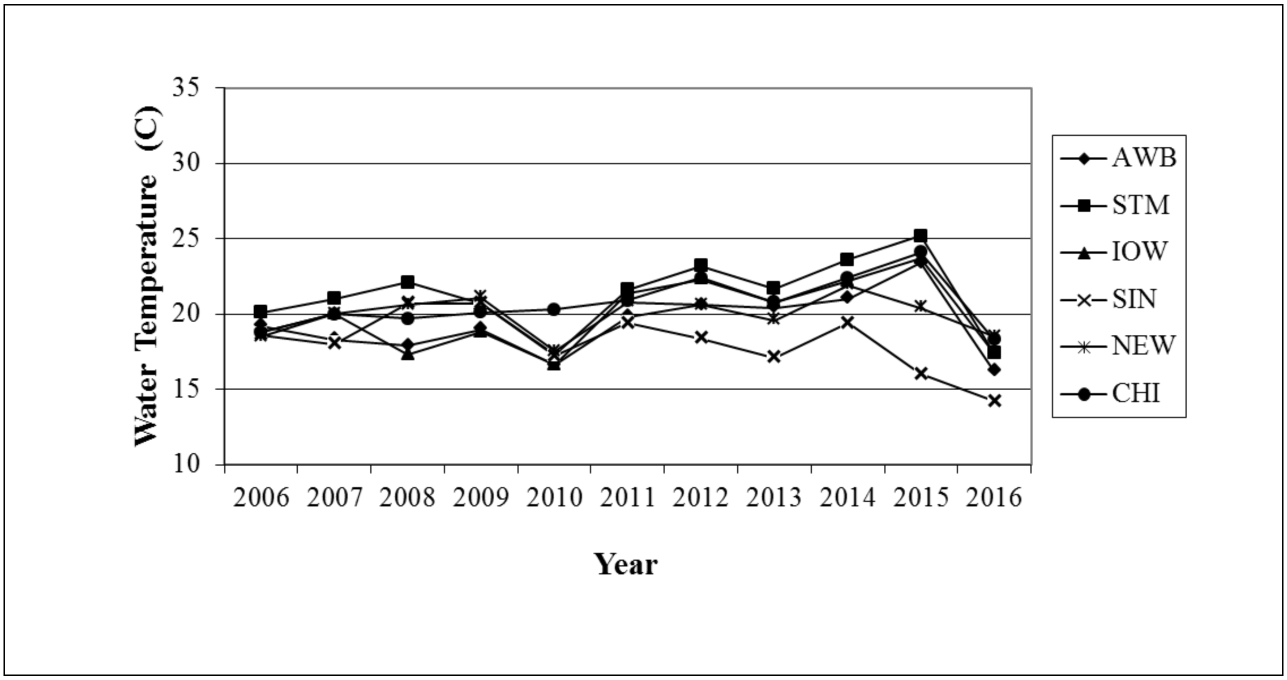

Figure 54. 2016 Trawl Survey May mean water temperature (Celsius) by year for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW) Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

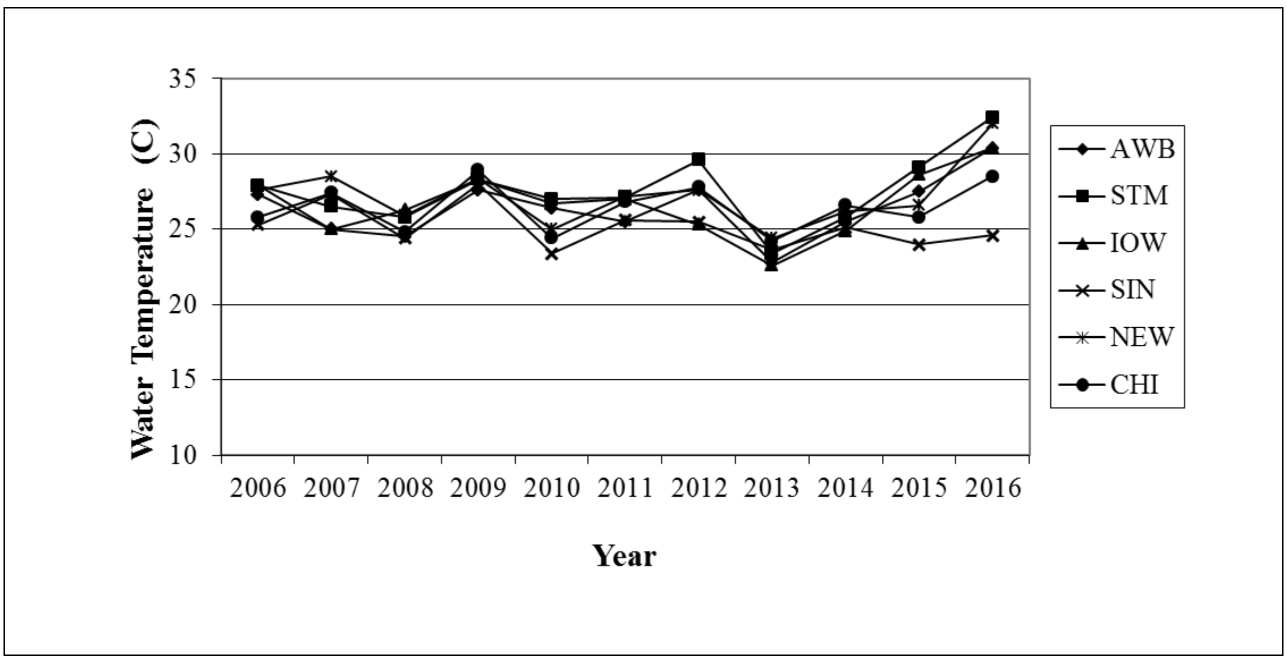

Figure 55. 2016 Trawl Survey August mean water temperature (Celsius) by year for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW) Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

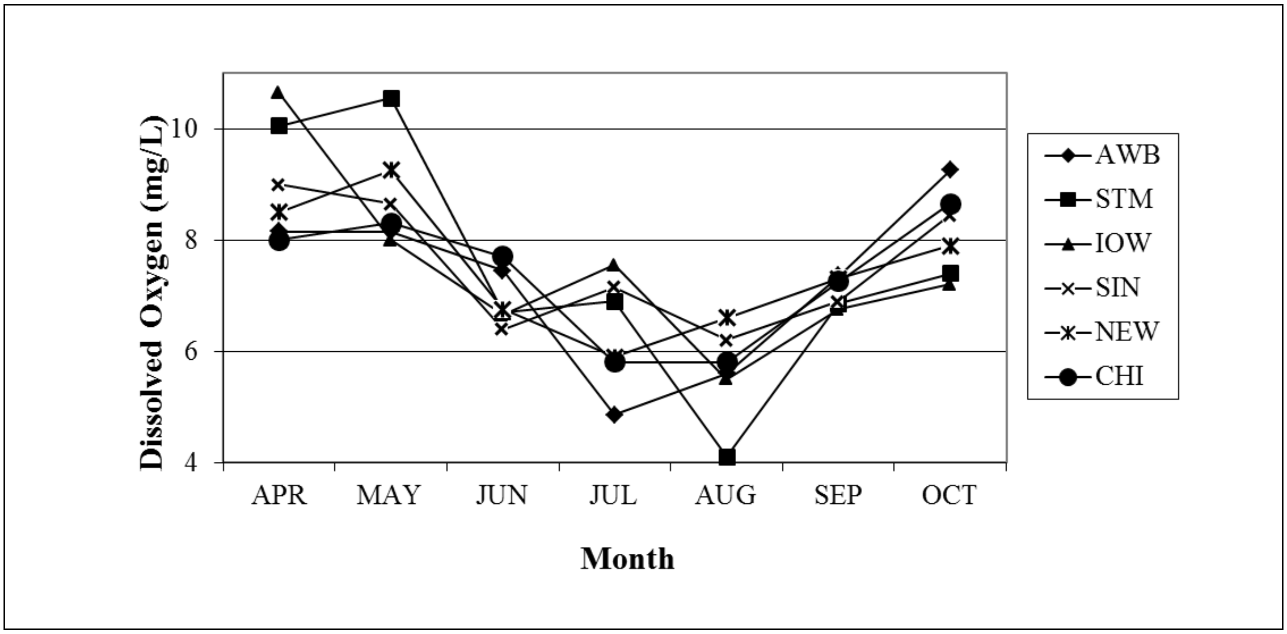

Figure 56. 2016 Trawl Survey mean dissolved oxygen (milligrams/liter) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

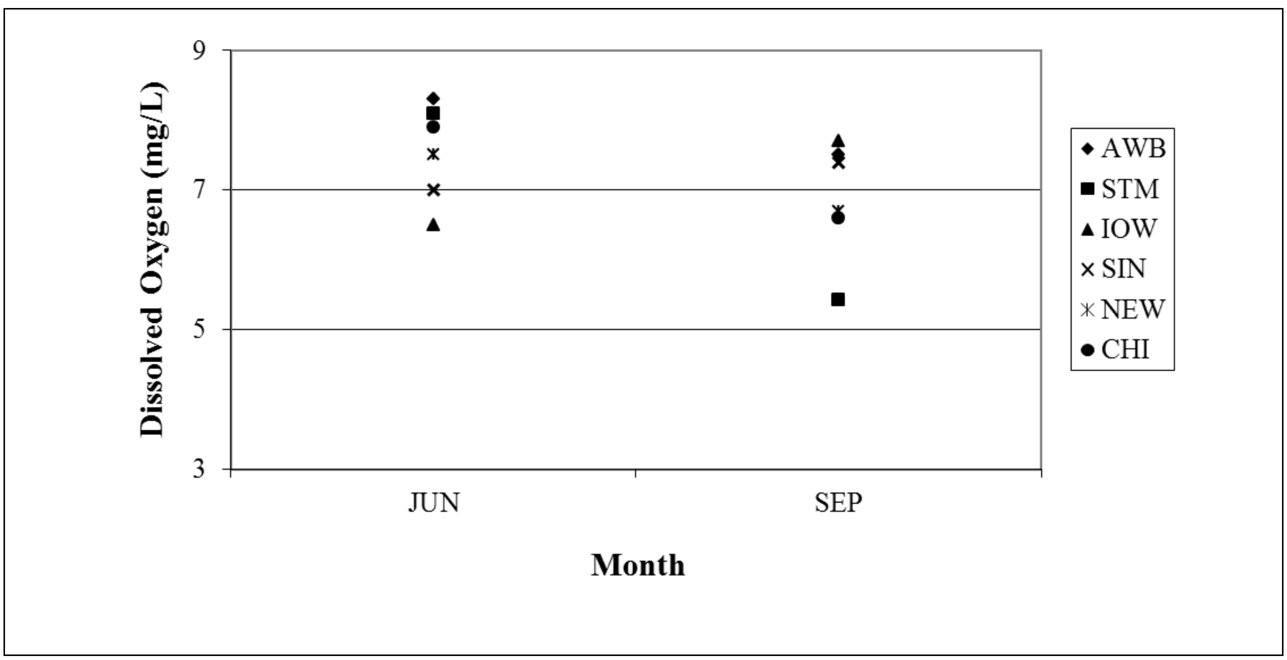

Figure 57. 2016 Beach Seine Survey mean dissolved oxygen (milligrams/liter) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

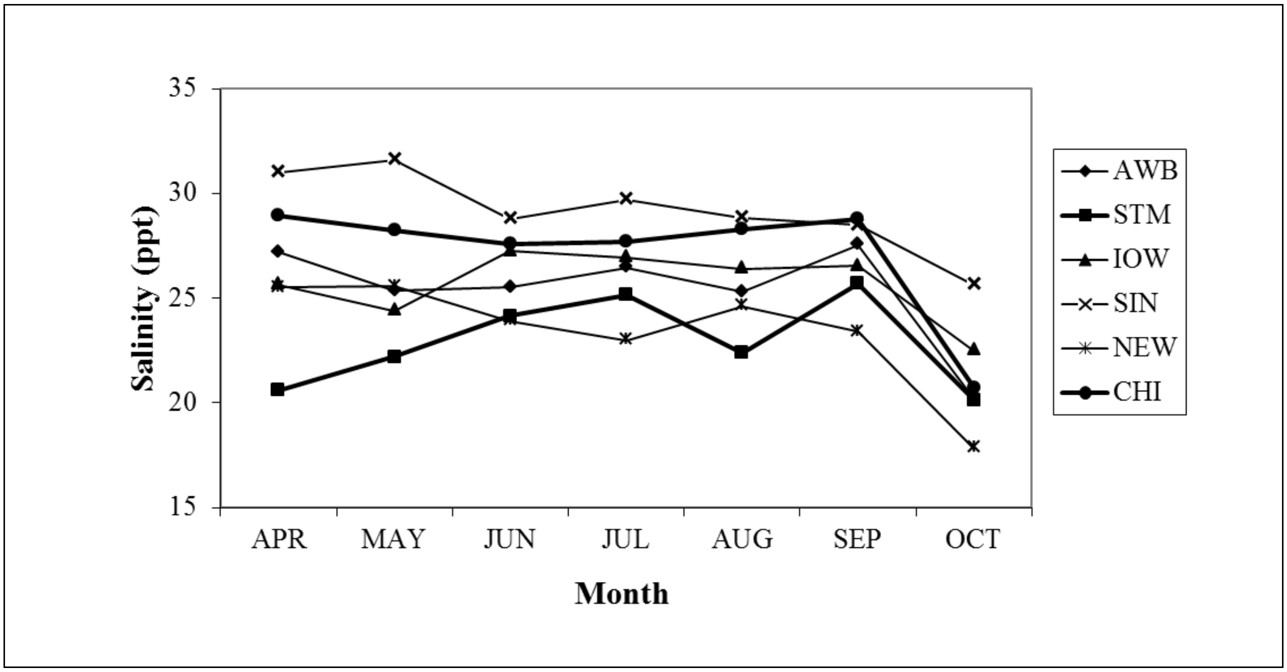

Figure 58. 2016 Trawl Survey mean salinity (parts per thousand) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

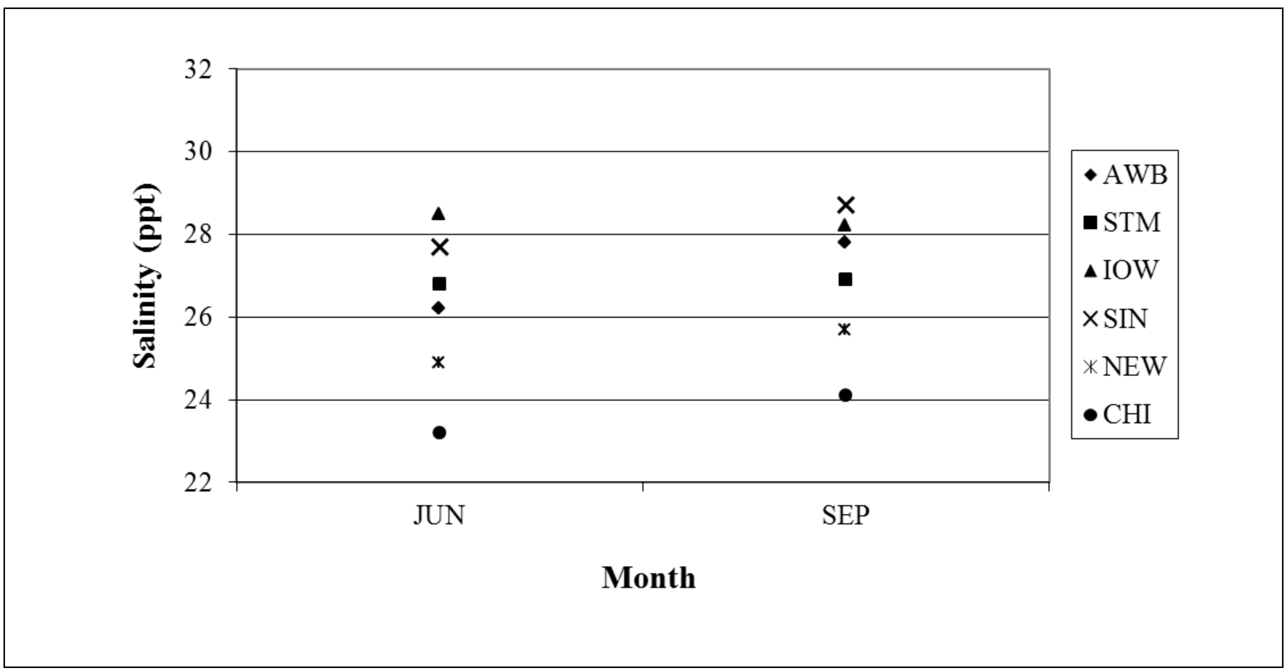

Figure 59. 2016 Beach Seine Survey mean salinity (parts per thousand) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

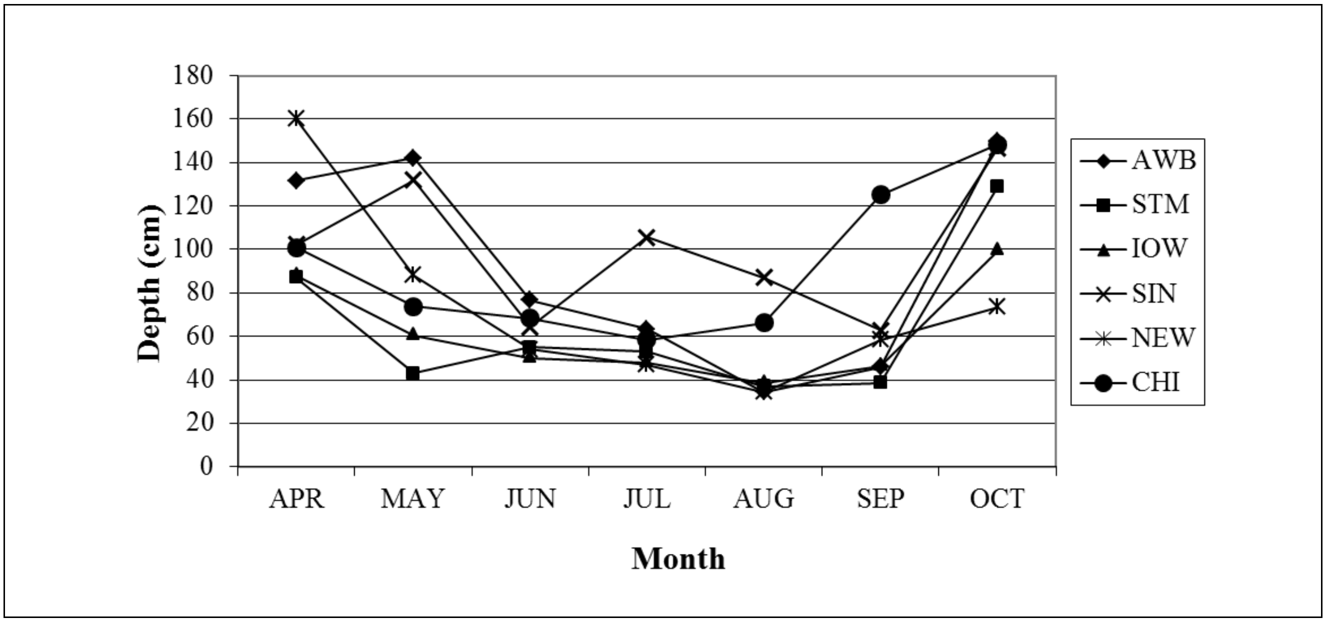

Figure 60. 2016 Trawl Survey mean turbidity (centimeters) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

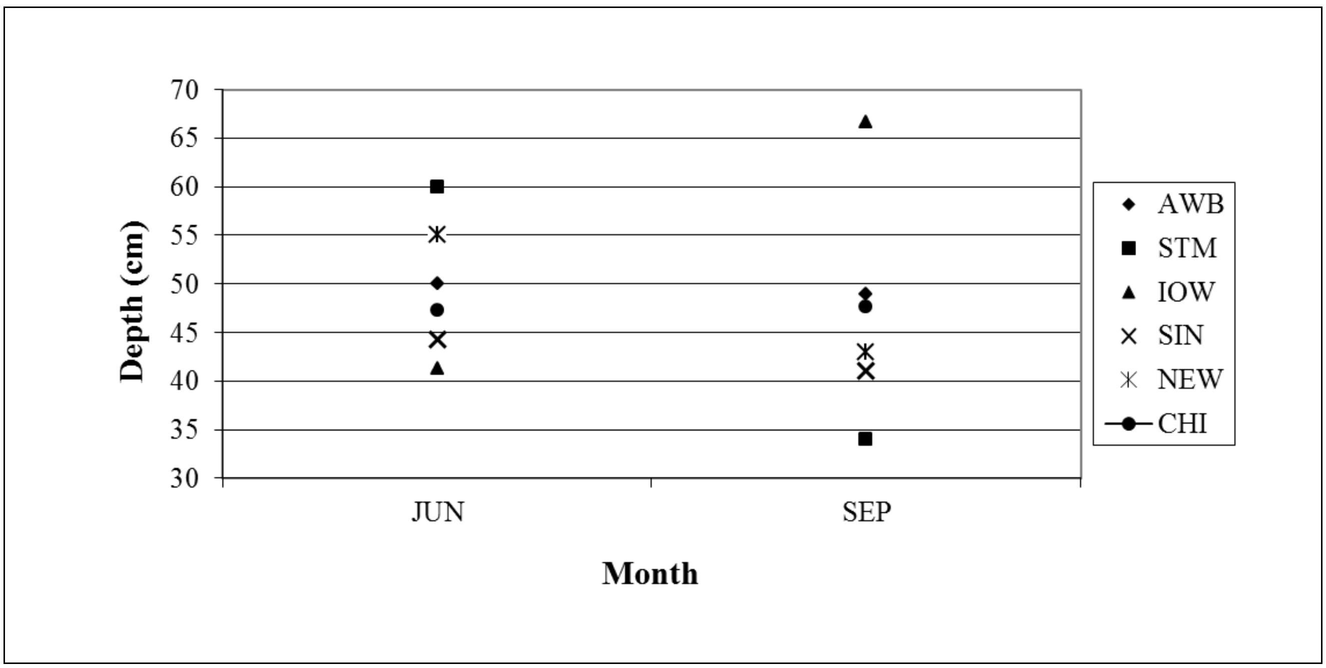

Figure 61. 2016 Beach Seine Survey mean turbidity (centimeters) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

Chapter 2
Submerged Aquatic Vegetation Habitat Survey

Introduction

The department has been conducting the Trawl and Beach Seine surveys since 1972, with a standardized protocol since 1989. The survey was designed to characterize and quantify juvenile finfish abundance but the gears also encounter bycatch that includes crustaceans, molluscs, sponges, and macroalgae. Those gears rarely sample sites in submerged aquatic vegetation. Currently, there is limited information specific to Maryland's coastal bays submerged aquatic vegetation beds as critical or essential habitat for living resources.

Although there are many species of submerged aquatic vegetation in the Mid-Atlantic, there are only two species found in Maryland's coastal bays: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*; Coastal Bays Sensitive Areas Technical Task Force 2004). While submerged aquatic vegetation beds are found throughout the coastal bays, they are not distributed evenly. The majority of the eelgrass beds are located along the Assateague Island shoreline; widgeon grass is also present but at a lower abundance. Both submerged aquatic vegetation species provide a wide variety of functions essential to the ecological health of the bays; foremost among them is as prime nursery habitat. The young of many commercially, recreationally, and ecologically important species depend upon the grass beds for protection and feeding at some point in their life cycle (Coastal Bays Sensitive Areas Technical Task Force 2004). With submerged aquatic vegetation playing such a significant role in the life cycle of many fishes and its susceptibility to anthropogenic perturbations, the characterization of fisheries resources within these areas is important (Connolly and Hindell 2006). As a result, the department expanded the project to include sampling the submerged aquatic vegetation beds in 2012. This survey was designed to meet the following two objectives:

1. characterize submerged aquatic vegetation habitat usage by fish assemblages in Maryland's coastal bays; and
2. incorporate the results of this study to better guide management decisions.

Methods

Sampling Period
All sampling was conducted during the day on 13 and 15 September 2016.

Study Area
Based on previous results, Sinepuxent Bay was selected for a three-year investigation (2015-2017) to meet our objectives (Figure 1, Table 1). This small location was considered the best solution to minimize unwanted effects from multiple variable interactions and dynamics of other embayments. Moreover, Sinepuxent Bay had the most readily available submerged aquatic vegetation beds in proximity with our established Trawl and Beach Seine surveys sites discussed in Chapter 1.

Site verification was conducted in 2015 to confirm submerged aquatic vegetation presence because it has been declining since the geographic information systems maps were created for this survey back in 2012. That map used a 305-meter X 305-meter grid overlaying areas where submerged aquatic vegetation beds had been present for at least five years prior to the implementation of this survey and was based on data from the Virginia Institute of Marine Sciences submerged aquatic vegetation survey. Potential sites were selected from the reconnaissance if submerged aquatic vegetation was present and the site was not too deep. The sites sampled in 2015 were revisited in 2016.

Data Collection

A 25 foot Chawk with a 225 horsepower Evinrude Etec engine was used as the sampling platform in September. Latitude and longitude coordinates (waypoints) in degrees and decimal minutes were used to navigate to sample locations. The global positioning system was also used to obtain coordinates at the start and stop points of the seine haul.

A 15.24 meter X 1.8 meter X 6.4 millimeter mesh (50 feet X 6 feet X 0.25 inch mesh) zippered bag seine was used. This gear was called the submerged aquatic vegetation beach seine. Staff estimated percent of net open and a range finder was used to quantify the distance of the seine haul. The haul distance was 35 meters. Staff ensured that the lead line remained on the bottom until the catch was enclosed in the zipper bag. The catch was taken to the boat for processing.

Water quality and physical characteristic data were collected using the same method and parameters described in Chapter 1. Only surface data were collected due to the shallow depth (less than 1.5 meters). Data were recorded on a standardized project data sheet printed on Rite in the Rain All Weather paper (Appendix 4).

Sample Processing

Samples were processed using the same methods described in Chapter 1 with one exception. At each site, a subsample of the first 100 fish (when applicable) of each species were measured and the remainder were counted.

Data Analysis

Measures of Fish Abundance, Diversity and Length Composition by Habitat Category

Comparisons of fish abundance were based on the submerged aquatic vegetation beach seine haul deployed at each habitat type during each set. Habitat types were characterized by submerged aquatic vegetation coverage quantified by the estimated percent of submerged aquatic vegetation in the sample area, bottom type substrate, and the dominant submerged aquatic vegetation species in sample area. Catch per unit of effort was calculated as the mean catch of fish per hectare. The main effects of submerged aquatic vegetation coverage type, substrate and dominant submerged aquatic vegetation on fish abundance was performed by analysis of variance and Duncan’s multiple range tests on all main-effect means. Fish diversity was calculated using the Shannon index. Fish length compositions were compared among selected habitat types using analysis of variance and Duncan’s multiple range tests (Der and Everitt 2001).

Results

Sample Size and Distribution

These results were based on 14 samples collected in 2016 within five submerged aquatic vegetation grid sites (Table 1 and Figure 1). The samples were distributed between four categories of submerged aquatic vegetation coverage: 25 percent or less (two samples), 26 percent to 50 percent (three samples), 51 percent to 75 percent (three samples) and 76 percent to 100 percent (six samples). The samples were also categorized by substrate as either mud (nine samples) or sand (five samples). Additionally, each sites dominant submerged aquatic vegetation species was identified. There was an even split between eelgrass (seven samples) and widgeon grass (seven samples).

Fish Species Abundance by Habitat Category

A total of 31 species and 1,754 fish were collected in 2016. The most abundant species were Atlantic silversides and silver perch (Table 2). The results of the analysis of variance indicated no significant differences in mean catch per unit effort among submerged aquatic vegetation coverage categories for the most abundant fishes: Atlantic silversides (p=0.072) and silver perch (p=0.717; Figure 2). However, there were significant main effect differences in abundance among submerged aquatic vegetation coverage for bay anchovies (p=0.001), spot (p=0.01) and striped blennies (p=0.0005; Figure 3). Duncan’s multiple range test results showed that each species preferred a specific submerged aquatic vegetation coverage level. Bay anchovies were more abundant in 25-50 percent submerged aquatic vegetation coverage, spot were more abundant in 25 percent or less submerged aquatic vegetation coverage and striped blennies were more abundant in 76 to 100 percent submerged aquatic vegetation coverage.

The main effect of primary bottom type habitat (substrate = sand or mud) was investigated. The results of the analysis of variance indicated significant differences in mean catch per unit effort by substrate for Atlantic silversides (p=0.0003), bay anchovies (p=0.021), gray snapper (p=0.022), sheepshead (p=0.018) and spot (p=0.014). Silver perch was not significant (p=0.081; Figure 4). Duncan’s multiple range test results showed that Atlantic silversides, bay anchovies, gray snapper, sheepshead and spot preferred sand substrate over mud.

The main effect of dominant submerged aquatic vegetation species (widgeon grass or eelgrass) was investigated. The results of the analysis of variance indicated significant differences in mean catch per unit effort by dominant submerged aquatic vegetation species for bay anchovies (p=0.0006), gray snapper (p=0.024), sheepshead (p=0.022), spot (p=0.025) and striped blennies (p=0.002). Silver perch (p=0.443) and Atlantic silversides (p=0.094) were not significant (Figure 5). Duncan’s multiple range test results showed that bay anchovies, gray snapper, sheepshead, spot and striped blennies preferred widgeon grass beds over eelgrass beds.

Fish Species Diversity by Habitat Category

Fish species richness (number of species) and diversity (evenness of those species) was investigated among submerged aquatic vegetation coverage categories. The species richness values for all submerged aquatic vegetation habitat categories (submerged aquatic vegetation coverage, primary substrate and dominant submerged aquatic vegetation species) were generally high. The results of the Shannon index for submerged aquatic vegetation coverage were moderate in the 26-50 percent submerged aquatic vegetation coverage (H =1.9; 17 species). The remainder of diversity values by submerged aquatic vegetation coverage was poor: 51-75 percent submerged aquatic vegetation coverage (H=1.4; 22 species); 76-100 percent submerged aquatic vegetation coverage (H=1.2; 11 species); 25 percent or less submerged aquatic vegetation coverage (H=0.5; 12 species; Figure 6).

Primary substrate investigation resulted in higher diversity in mud substrate (H=2.2; 20 species). Sand substrate diversity was lower (H=1.2, 27 species), however, species richness exceeded mud substrate. The dominant submerged aquatic vegetation investigation resulted in slightly higher diversity in widgeon grass (H=1.3, 27 species) and almost double the richness compared to eelgrass (H=1.2, 15 species; Figure 7).

Fish Length Composition Habitat Category

Fish maturity was investigated among submerged aquatic vegetation coverage, substrate and dominant submerged aquatic vegetation. Atlantic silversides and silver perch were selected based on abundance (Atlantic silversides, n=522; silver perch, n=274). The analysis of variance results indicated significant differences in mean total length for silver perch by submerged aquatic vegetation coverage ($p<0.001$; Figure 8).

Silver perch were smaller (mean total length 67 millimeters) in the highest submerged aquatic vegetation coverage (76-100 percent) and increased in total length as the submerged aquatic vegetation coverage decreased (74.8 millimeters; 86.0 millimeters; 118.5 millimeters) respectively. Duncan’s multiple range test results showed silver perch mean length was significantly different between the lowest submerged aquatic vegetation coverage (up to 25 percent) and all the other submerged aquatic vegetation coverage categories. Mean length in second lowest submerged aquatic vegetation coverage category (26-50 percent) was also significantly different to the highest submerged aquatic vegetation coverage category (76-100 percent). Atlantic silverside mean length did not show the pattern of decreasing length with increasing submerged aquatic vegetation coverage. Mean length ranged from 80.8 to 86.4 millimeters across the four submerged aquatic vegetation coverage categories. However, the analysis of variance results indicated significant differences in mean length for Atlantic silversides by submerged aquatic vegetation coverage ($p<0.001$). The mean length was the largest in the 51-75 percent submerged aquatic vegetation coverage (86.4 millimeters; Figure 8). Duncan’s multiple range test results showed different mean length among submerged aquatic vegetation coverage categories, except between the 26-50 percent and 76-100 percent categories.

The effect of dominant submerged aquatic vegetation species on mean length for silver perch was significant ($p<0.0001$). Silver perch mean length (79.5 millimeters) was greater in widgeon grass beds whereas those caught in eelgrass beds were smaller (70.4 millimeters). The effect of dominant submerged aquatic vegetation species on mean length for Atlantic silversides was also significant ($p<0.0001$). Atlantic silverside mean length (84.2 millimeters) was greater in widgeon grass beds whereas in eelgrass beds it was smaller (80.9 millimeters). The effect of primary substrate on mean length for Atlantic silversides and silver perch was not significant ($p=0.058$; $p=0.433$ respectively).

Water Quality

The water quality tested at all sampling locations was consistent with fish habitat requirements. The average dissolved oxygen measured was 6.4 milligrams/liter and ranged from 5.99 –7.8 milligrams/liter. The water temperature average was 23.8 Celsius and ranged from 22.7 – 24.9 Celsius. The salinity averaged 28.6 parts per thousand and ranged from 27.8 – 28.9 parts per thousand. The Secchi disk reading depth average was 43.4 centimeters and ranged from 27 – 82 centimeters.

Discussion

Thirty-one species of finfishes were collected occupying the submerged aquatic vegetation beds in September. Those fishes were residents and non-residents representing, benthivores, carnivores, omnivores, and planktivores. They were also representative of the fishes collected by previous surveys. Open water beach seine sampling of submerged aquatic vegetation beds is difficult and the certainty of collecting all the fish in the sample area, especially in thick grass beds, is reduced when compared to one that is beached. Moreover, the interannual variation of the submerged aquatic vegetation composition within the coastal bays presented a challenge to compare data from year to year without increased sampling effort. Many grass bed fishes can adapt to extreme seasonal changes in habitat and diet and it is difficult to make linear associations of population distribution with multivariate analyses of specific habitat characteristics (Livingston, 1982). This particular survey attempted to take a closer look at discrete submerged aquatic vegetation habitats to determine if fishes select or prefer specific habitat composition such as thick submerged aquatic vegetation beds, or a specific submerged aquatic vegetation species or substrate type. The results seemed reasonable considering the sample size and collection effort for this investigation. An encouraging observation was widgeon grass abundance appeared to have increased within our sampling grids in 2016. This reemergence of widgeon grass may provide a foothold for submerged aquatic vegetation expansion in Sinepuxent Bay.

The results indicated that bay anchovies, spot and striped blennies prefer a specific submerged aquatic vegetation coverage over another. Results also suggested that silver perch, the most dominant benthivore in the survey, showed no general preference for any specific submerged aquatic vegetation coverage. However, silver perch were identified to have different mean length composition by submerged aquatic vegetation coverage, suggesting a size selectivity pattern for habitat selection. The smaller silver perch may prefer greater submerged aquatic vegetation coverage for protection and food, and then move toward less submerged aquatic vegetation coverage as they grow larger requiring different protection and diet needs. Atlantic silversides, the most dominant omnivore collected also demonstrated different mean length composition by submerged aquatic vegetation coverage, but there was no distinct pattern similar to silver perch.

Those results are not informative considering the growth rate of this fish. This common species is known to have a lunar-related spawning cycle with the first activity occurring at a new or full moon, followed by spawning peaks at two-week intervals from March to July (Murdy et al., 1997). The difference in mean length across submerged aquatic vegetation coverage may have occurred by the chance of collecting different schools of fish from adjacent hatches separated by a few weeks of growth and within the size range to have similar diet and protection requirements. Atlantic silversides appeared to prefer sand substrate compared to mud, however, this common species is abundant throughout the coastal bays.

The species richness of fishes in the Sinepuxent grass beds was high. Many different species were collected across all submerged aquatic vegetation coverage categories. However, fish diversity was generally poor, except for the submerged aquatic vegetation beds with 26-50 percent coverage. The large abundance of silver perch and Atlantic silversides were driving down the diversity index. The Shannon index increases as both the richness and the evenness of the community increase. Species richness of fishes in sand substrate was higher than mud; however, the evenness of those species in sand was lower and less diverse compared to mud.

Recommendations

Due to increased abundance of widgeon grass in Sinepuxent Bay we were able to have four submerged aquatic vegetation coverage categories compared to only two in 2015. Sampling the submerged aquatic vegetation beds during these changes in composition could provide important data. We should continue the final year of sampling in 2017 and publish a comprehensive report of the findings. The results of this report should determine the future efforts for this investigation. The 2017 sampling protocol should be changed to reduce the maximum number of fish measured per sample from 100 fish lengths to 50 fish per species.

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Table 1. 2016 Submerged Aquatic Vegetation Habitat Survey site descriptions.

Grid Number	Bay	Site Description	Latitude	Longitude	Number of Samples
121	Sinepuxent Bay	East of Snug Harbor; West of Small Island	38 17.221	75 07.651	4
128	Sinepuxent Bay	South of Duck Blind; East of Green Marker	38 17.061	75 07.659	2
160	Sinepuxent Bay	700 meters northeast of Potfin Road along the shoreline	38 15.900	75 08.761	4
212	Sinepuxent Bay	South of Verrazano Bridge; West of Sandy Point Island; on channel edge	38 14.295	75 09.404	2
221	Sinepuxent Bay	Southwest of Small Island; South of Verrazano Bridge	38 14.147	75 09.402	2

Table 2. List of fishes collected in Maryland's costal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September 2016.

Common Name	Scientific Name	Total Number Collected	Catch Per Unit Effort (fish/hectare)	Mean Length (millimeters)
Atlantic silverside	*Menidia menidia*	967	1,724.7	83.4
Silver perch	*Bairdiella chrysoura*	496	884.6	75.2
Halfbeak	*Hyporhamphus unifasciatus*	85	151.6	143.3
Sheepshead	*Archosargus probatocephalus*	29	51.7	72.6
Bay anchovy	*Anchoa mitchilli*	19	33.9	65.5
Spot	*Leiostomus xanthurus*	19	33.9	155.6
Northern pipefish	*Syngnathus fuscus*	17	30.3	196.5
Dusky pipefish	*Syngnathus floridae*	15	26.8	166.9
Oyster toadfish	*Opsanus tau*	15	26.8	74.6
Striped blenny	*Chasmodes bosquianus*	15	26.8	65.6
Gray snapper	*Lutjanus griseus*	13	23.2	81.5
Pigfish	*Orthopristis chrysoptera*	11	19.6	83.8
Striped burrfish	*Chilomycterus schoepfii*	8	14.3	179.5
Naked goby	*Gobiosoma bosc*	5	8.9	39
Southern kingfish	*Menticirrhus americanus*	5	8.9	102.6
Spotfin mojarra	*Eucinostomus argenteus*	4	7.1	58.3
Spotted seatrout	*Cynoscion nebulosus*	4	7.1	117.5
Striped mullet	*Anchoa hepsetus*	4	7.1	196.8
Summer flounder	*Chasmodes bosquianus*	3	5.4	171.7
White mullet	*Tautoga onitis*	3	5.4	169.3
American eel	*Anguilla rostrata*	2	3.6	450
Atlantic menhaden	*Brevoortia tyrannus*	2	3.6	126
Atlantic needlefish	*Strongylura marina*	2	3.6	248.5
Northern puffer	*Sphoeroides maculatus*	2	3.6	138.5
Pinfish	*Lagodon rhomboides*	2	3.6	153.5
Tautog	*Paralichthys dentatus*	2	3.6	80

Table 2. (continued) List of fishes collected in Maryland's costal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September 2016.

Common Name	Scientific Name	Total Number Collected	Catch Per Unit Effort (fish/hectare)	Mean Length (millimeters)
Atlantic croaker	*Micropogonias undulatus*	1	1.8	41
Black drum	*Pogonias cromis*	1	1.8	150
Black sea bass	*Centropristis striata*	1	1.8	140
Striped anchovy	*Anchoa hepsetus*	1	1.8	73
Striped killifish	*Eucinostomus argenteus*	1	1.8	107
	Total	**1,754**	**Average 100.9**	**Average 129.2**

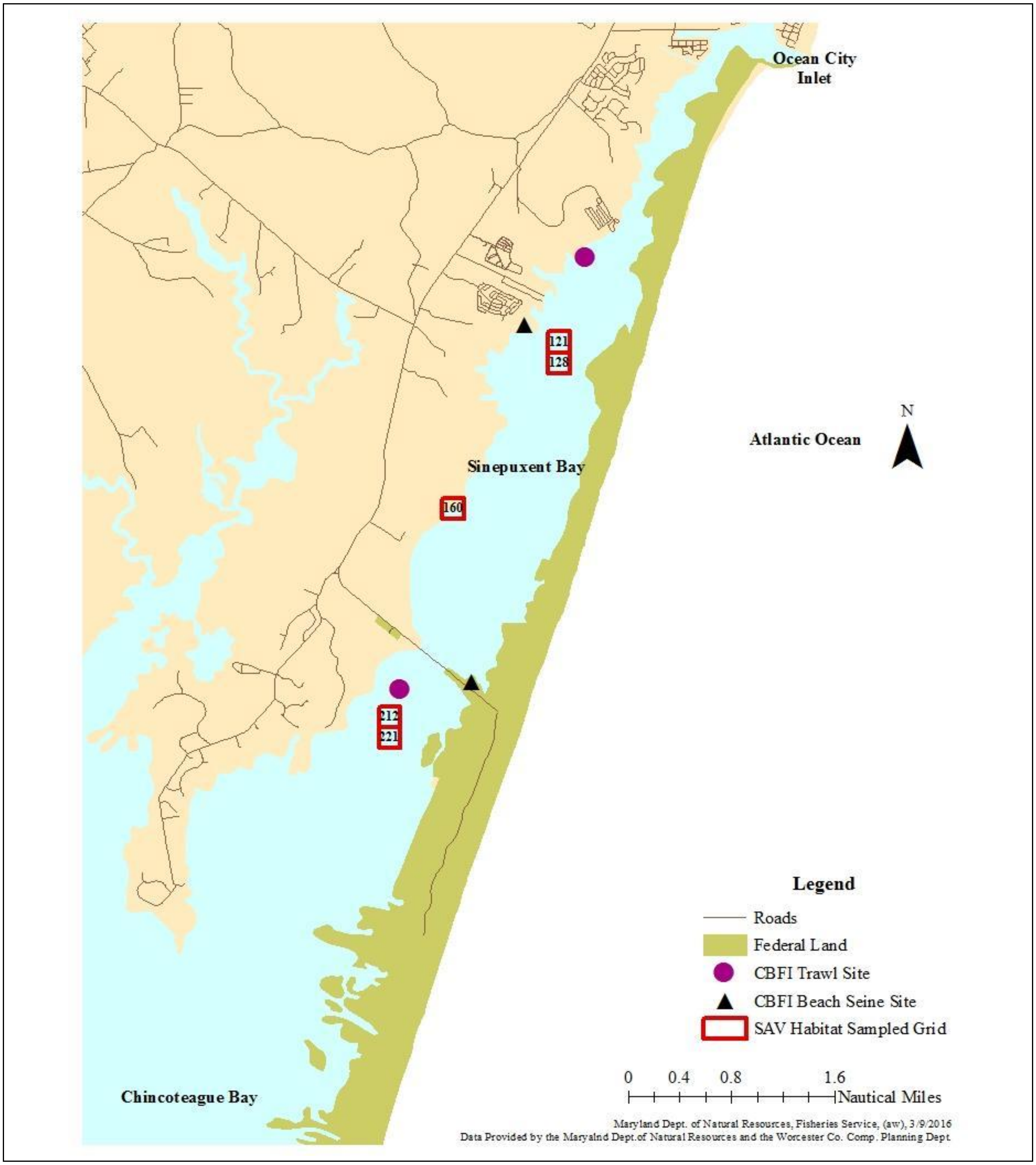

Figure 1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey and Trawl and Beach Seine surveys sample site locations (September, 2016).

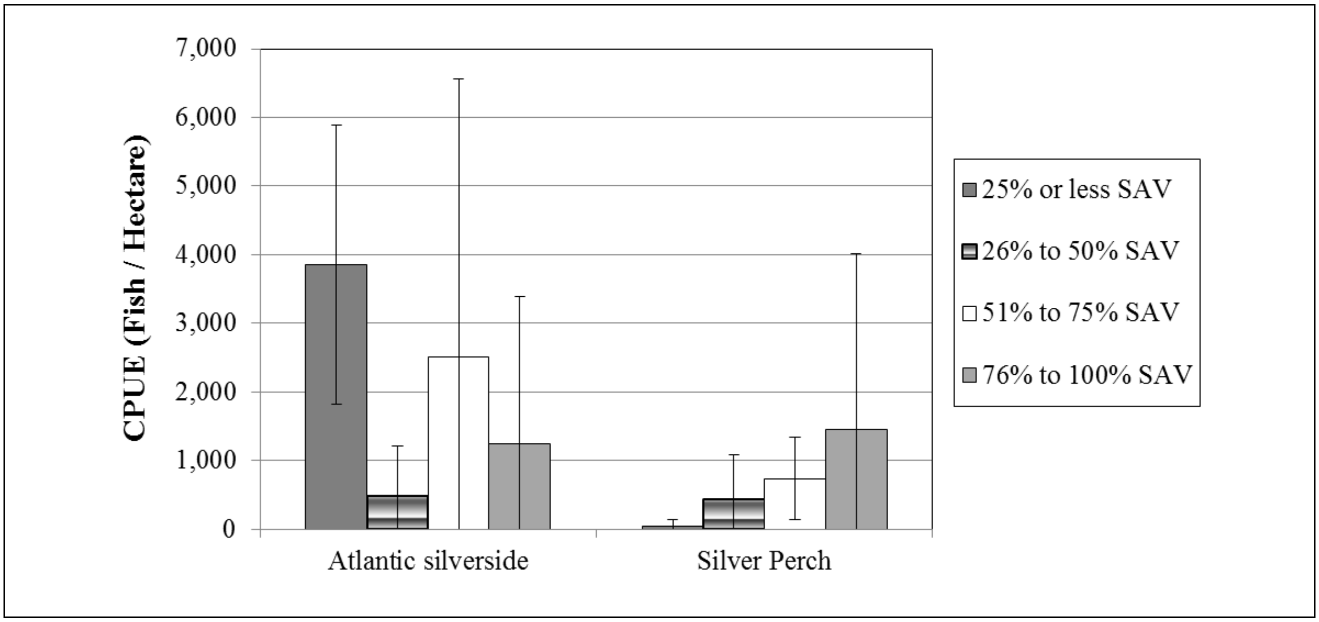

Figure 2. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey species abundance (catch per unit effort=fish/hectare, mean 95 percent confidence interval) by submerged aquatic vegetation coverage (September, 2016). The results of analysis of variance for Atlantic silversides and silver perch indicated no significant differences (p>0.05) in catch per unit effort among submerged aquatic vegetation coverage.

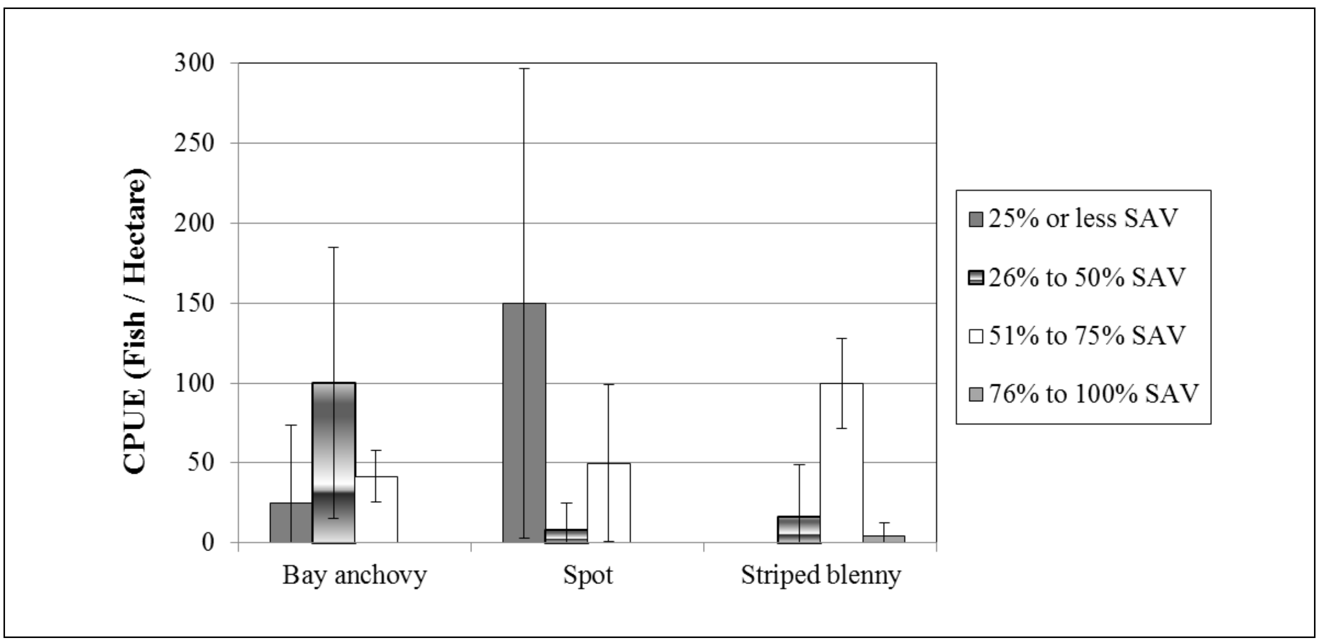

Figure 3. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey species abundance (catch per unit effort=fish/hectare, mean 95 percent confidence interval) by submerged aquatic vegetation coverage (September, 2016). The results of analysis of variance for bay anchovies (p=0.001), spot (p=0.01) and striped blennies (p=0.005) indicated significant differences in abundance among submerged aquatic vegetation coverage.

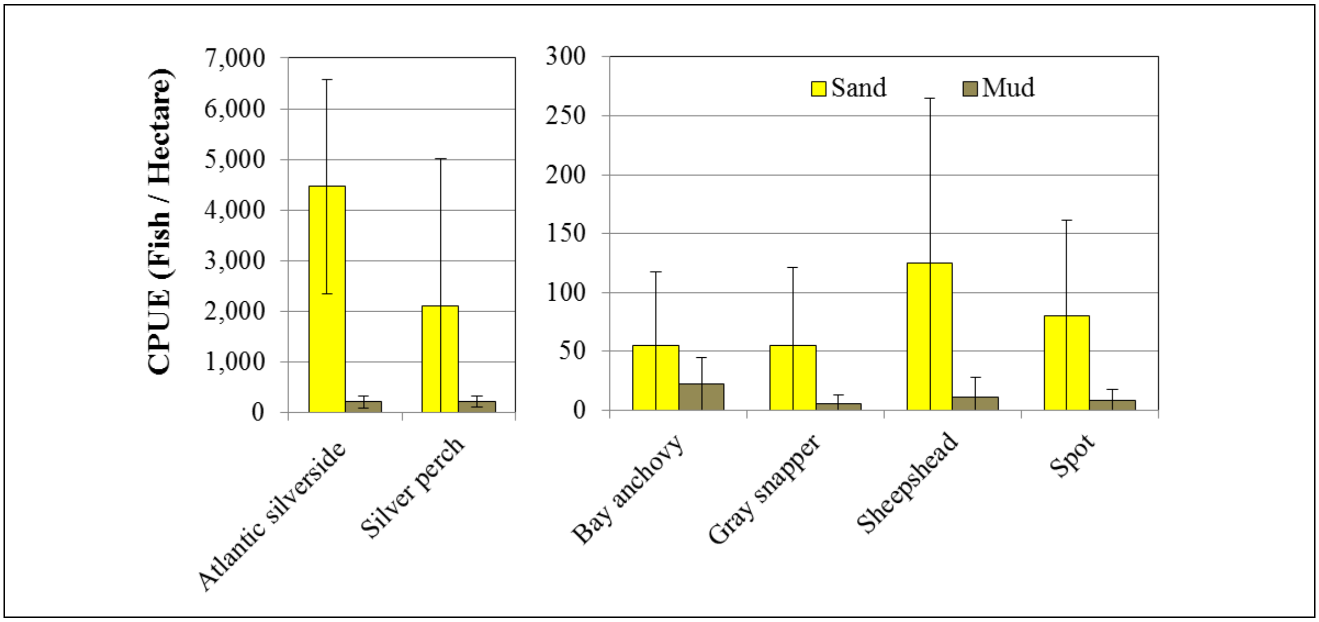

Figure 4. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey species abundance (catch per unit effort=fish/hectare, mean 95 percent confidence interval) by submerged aquatic vegetation substrate (September, 2016). The results of analysis of variance indicated significant differences in abundance by substrate for Atlantic silversides (p=0.0003), bay anchovies (p=0.021), gray snapper (p=0.022), sheepshead (p=0.018) and spot (p=0.014). Silver perch was not significant (p=0.81).

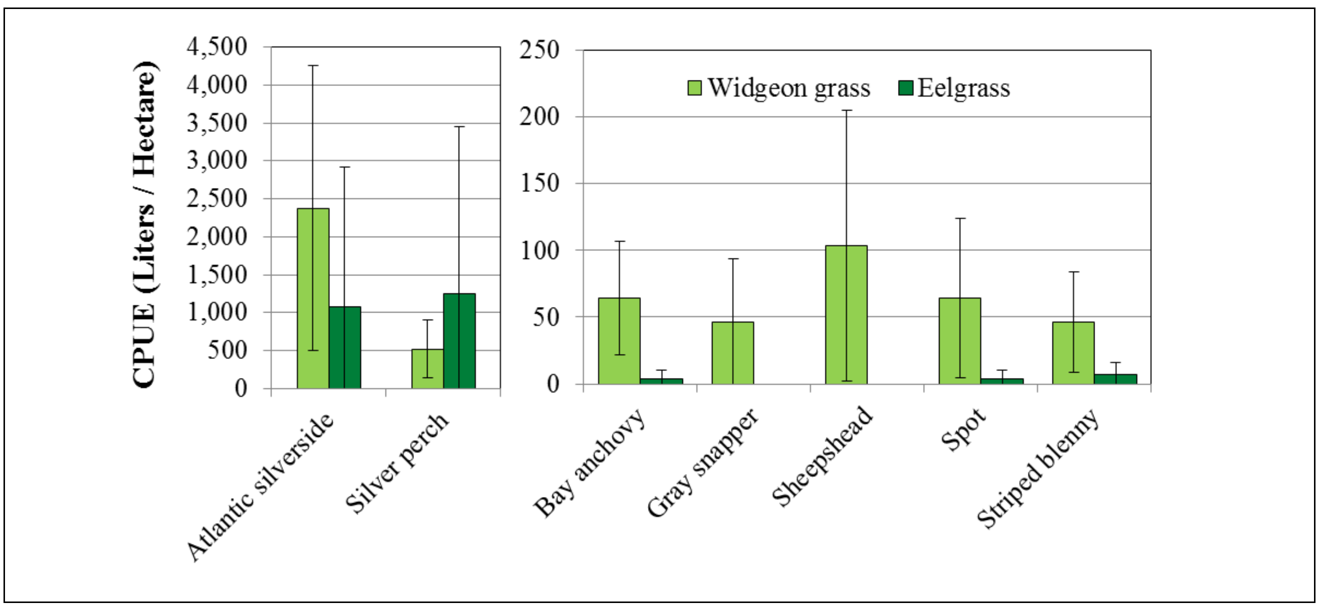

Figure 5. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey species abundance (catch per unit effort=fish/hectare, mean 95 percent confidence interval) by dominant submerged aquatic vegetation species (September, 2016). The results of analysis of variance indicated significant differences in abundance by dominant submerged aquatic vegetation species for bay anchovies (p=0.0006), gray snapper (p=0.024), sheepshead (p=0.022), spot (p=0.025) and striped blennies (p=0.002). Silver perch (p=0.443) and Atlantic silversides (p=0.094) were not significant.

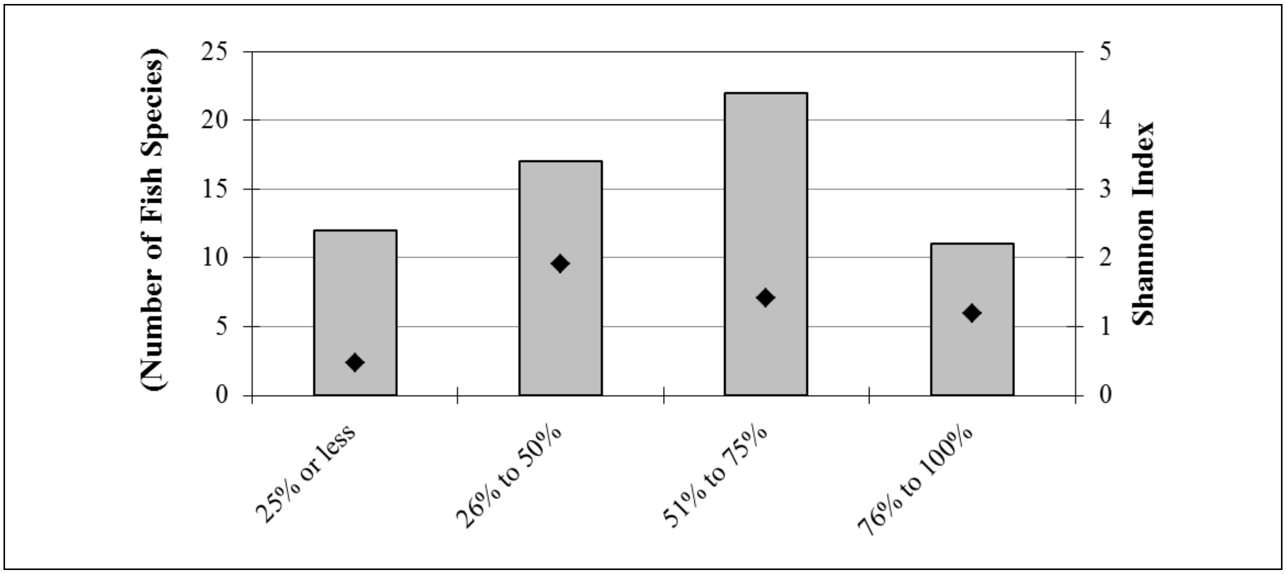

Figure 6. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey relative fish diversity by submerged aquatic vegetation coverage (September, 2016). Black diamond represents the Shannon index on secondary axis. Diversity was highest in 26-50 percent submerged aquatic vegetation coverage (H =1.9) and lowest in 25 percent or less submerged aquatic vegetation coverage (H=0.5).

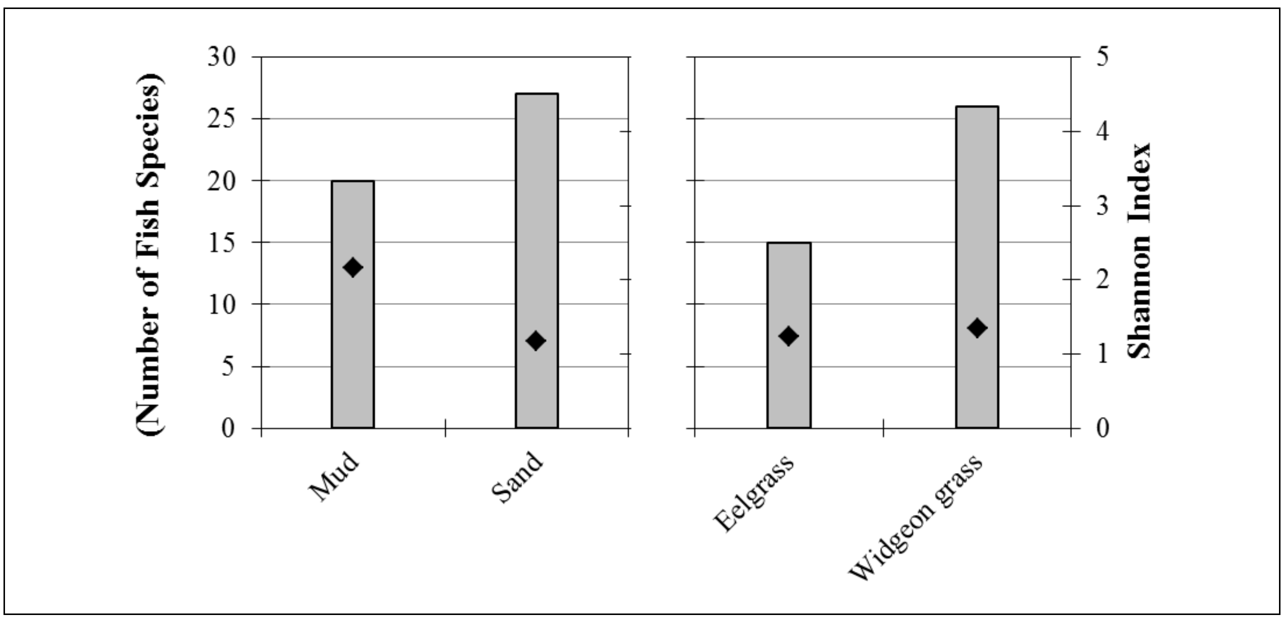

Figure 7. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey relative fish diversity by substrate and dominant submerged aquatic vegetation species (September, 2016). Black diamond represents the Shannon index on secondary axis. Mud substrate was more diverse (H=2.2) than sand (H=1.2). Widgeon grass was more diverse (H=1.3) than eelgrass (H=1.2).

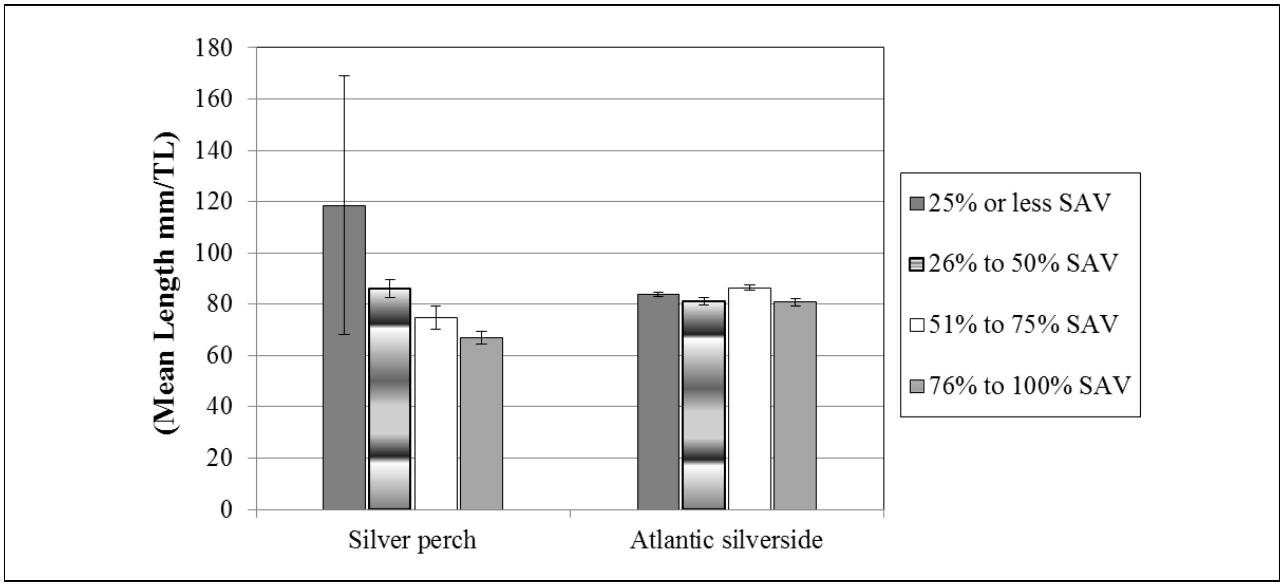

Figure 8. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey length composition by submerged aquatic vegetation coverage with 95 percent confidence intervals (September, 2016). The results of analysis of variance indicated significant differences in mean total length (millimeters) for silver perch and Atlantic silversides among multiple submerged aquatic vegetation coverage categories (p=0.001; p=0.001).

Chapter 3
Offshore Trawl Survey

Introduction

In an effort to obtain information on adult fishes in the near-shore Atlantic waters, catches onboard cooperating commercial trawlers operating out of Ocean City, Maryland were sampled. Length and abundance data were taken and used to supplement the Trawl and Beach Seine surveys. Offshore sampling provides access to species and length groups not frequently available from Maryland's coastal bays. In addition, these data were used to meet Atlantic States Marine Fisheries Commission data requirements and were included in compliance reports for coastal sharks, horseshoe crabs (*Limulus polyphemus*), spiny dogfish (*Squalus acanthias*) and summer flounder (*Paralichthys dentatus*).

Methods

Time

Commercial sampling trips targeting horseshoe crabs were conducted during 2016 on June 13, July 6, August 29, September 21, October 19 and November 2. Trawls usually occurred at night in order to increase the legal size catch of horseshoe crabs.

Gear and Location

Sampling was conducted on commercial trawlers using a standard summer flounder bottom trawl net (Table 1). Sites were determined by the fishing vessel captains on a trip by trip basis depending on the target species. All trawls were conducted one to three miles from shore.

Trawling

Start depth (feet) and time, water temperature (Celsius; available from onboard electronics), weather and wind direction were recorded when the trawl net was 100 percent deployed. Wind speed (knots) was taken using an anemometer. End time and stop depth was recorded at haul back. When multiple trawls were conducted, the start data for the subsequent set was the same as the end data of the previous set. Data were recorded on a standardized data sheet (Appendix 4).

Sample Processing

A representative subsample of the catch was collected from each haul and placed into a 1000 liter tub. All fishes and invertebrates were measured as in Chapter 1 with the exception of whelks. In addition to measuring whelks for length from the tip of the spire to the anterior tip of the body whorl, width was also measured at the widest part of the shell. Staff biologists consulted the *Peterson Field Guide Atlantic Seashore* (1978) and *Peterson Field Guide Atlantic Coast Fishes* (1986) for assistance with species identification.

When targeting horseshoe crabs for biomedical research the total catch was counted and sexed per haul. These enumerations were used to calculate the proportion each subsample represented to the total catch. Subsample proportion estimations were conducted by a visual inspection for trawls targeting other species.

Data analysis
Statistical analyses were conducted on all species. Abundance estimates, sex and size by selected species were extrapolated from the subsampling regime proportional catch calculations.

Results

Trawl time varied with time ranging between 44 and 75 minutes. Water temperature ranged from a high of 25.4 Celsius in August to a low of 16.7 Celsius in November. Depth over the course of the surveys ranged from 7.9 meters to 15.4 meters (Table 2).

Numbers of species collected ranged from eight to 20 per trip (Table 2). The prevalent species encountered from all the trawls were horseshoe crabs, summer flounder, clearnose skates *(Raja eglanteria)*, portly spider crab *(Libinia emarginata)* and knobbed whelk (*Busycon carica*; Table 3). Appendix 5 provides the sea turtle and sturgeon interaction summary from July 2016 through June 2017.

From June to November 2016, prosomal widths were collected for 421 horseshoe crabs (Figure 1). Prosomal width ranged from 102 millimeters to 370 millimeters. There were 145 females with a mean prosomal width of 214 millimeters and mode of 280 millimeters. Prosomal widths for females ranged from 103 millimeters to 370 millimeters. There were 275males with a mean prosomal width of 189.7 millimeters and mode of 190 millimeters. Male prosomal widths ranged from 102 millimeters to 248 millimeters. The sex and prosomal length for one of the horseshoe crabs was unknown. The ratio of male to female horseshoe crabs was 1.9:1 (Table 4). The majority of both male and female animals (≥ 200 millimeters) were adults. Adult prosomal width ranges from 177.8 millimeters (seven inches) to 304.8 millimeters (12 inches). Figure 1 presents a maturing population of both sexes with more adults than juveniles. During the offshore trip on July 6, a tagged horseshoe crab (number 348929) was caught. It was previously released by the Center for Inland Bays on June 2, 2016 at James Farm Beach Indian River Bay, Delaware.

From all trips combined, a total of 86 summer flounder were measured (Table 3). Lengths ranged in size from 127 millimeters to 512 millimeters (Figure 2). The mean was 396.7 millimeters and the mode was 412 millimeters. Most of the measured summer flounder were legal, ≥ 14 inches (Table 5). The proportion of summer flounder less than 355.6 millimeters (14 inches) and 406.4 millimeters (16 inches) was examined over time in order to identify potential recruitment pulses in the near shore population. The results varied without trend over the 2012-2016 time series. The average percent less than 355.6 millimeters were 16.1 percent and the average percent less than 406.4 millimeters were 37.3 percent.

Forty-seven knobbed whelks were measured (Figure 3). Lengths ranged from 100 millimeters to 215 millimeters. The mean length for knobbed whelks was 170.7 millimeters and the mode was 182 millimeters. Widths ranged from 60 millimeters to 160 millimeters. The average and mode for width was 101.3 millimeters and 110 millimeters, respectively.

Discussion

Fishermen have decreased the number of tows in recent years because of an increased abundance of the target species, horseshoe crabs. The increased abundance of horseshoe crabs reduces the number of tows needed to reach the daily possession limit which reduces the utility of the data for other species such as summer flounder since fewer were caught.

Horseshoe crabs continued to be a productive resource for both biomedical and bait harvest. This survey indicated that the population appears to be robust (they are easily captured) and it supplies information that characterizes the horseshoe crab fishery. From 100 millimeters to 140 millimeters, females slightly outnumber males with 28 animals compared to 23 animals. Males dominated the 150 to 230 millimeters range. Over 230 millimeters, females were more represented. It is often assumed the population contains more males than females as this is what is observed on the spawning beaches. These data indicate that males were slightly more abundant (65.5 percent/34.5 percent) than females in the commercial catch, and it is likely that male horseshoe crabs remain on the spawning beaches longer than the females, giving rise to the perception that there are more males in the population.

The majority of summer flounder measured in 2016 had reached the length of maturity. Summer flounder typically obtain sexual maturity at 355.6 millimeters (14 inches) for females and 304.8 millimeters (12 inches) for males (Manooch 1984). Most (71) were above the 355.6 millimeters minimum size limit required for commercial fishing nets, pots, traps, trotlines, or seines. A smaller number (51) of fish were above the minimum size (406.4 millimeters; 16 inches) for recreational hook and line (Figure 2).

More knobbed whelks (47) were measured in 2016 compared to 2015 (35). The majority were over the minimum size of 152.4 millimeters (Figure 3). A study was conducted on knobbed whelks raised under lab conditions from egg cases collected in Virginia. These animals reached maturity at nine years old and all were males. At 12.4 years, the first egg case was laid (embryos were absent from the case) by a 172 millimeters long individual with a width of 95 millimeters. After a decade of growing in the lab, the average size was 144 millimeters. At 14 years, the average shell length had become 168.7 millimeters (Castagna and Kraeuter 1994). Research concerning knobbed whelks harvested off Georgia found that female whelks achieved maturity at six years old with a length of 100 millimeters while males became mature much younger (four years) with lengths of 85-90 millimeters (Power *et al*. 2009). Based on these two studies, it might be concluded that there were no young animals present in the sample for 2016. A similar conclusion was reached from the 2015 sampling data. It has been postulated that harvesting based upon size might select for females (Castagna and Kraeuter 1994). With males obtaining maturity at smaller sizes in Georgia, this might not necessarily be the case.

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Table 1. Gear specifications for the subsampled commercial trawls from June through November 2016.

Trip Date	Net Codend Mesh (centimeters)	Net Body Mesh (centimeters)	Head Rope Width (meters)	Foot Rope Width (meters)
June 13	14.0	15.2	21.3	29.0
July 6	14.0	15.2	21.6	29.0
August 29	14.0	15.2	21.3	29.0
September 21	14.0	15.2	21.9	29.0
October 19	14.0	15.2	21.9	29.0
November 2	14.0	15.2	21.9	29.0

Table 2. Commercial trawl subsample trip characteristics from June through November 2016.

Trip Date	Number of Tows	Depth Range (meters)	Temperature (Celsius)	Species		
				Number Present	Number Counted	Number Measured
June 13	2	9.1-12.2	18.3	15	159	132
July 6	1	9.2-13.1	22.3	12	57	51
August 29	2	13.3-15.4	25.4	8	127	88
September 21	3	11.0-14.6	22.9	18	222	148
October 19	3	7.9-15.0	20.0-20.5	15	155	111
November 2	3	14.2-14.8	16.7-16.8	20	136	115

Table 3. List of species collected in subsampled commercial offshore trawls from June through November 2016, n= 856. Species were grouped (finfish, crustaceans, mollusks, and other) and listed by order of extrapolated total number, n= 17,070.

Common Name	Scientific Name	Total Number Counted	Total Number Extrapolated
Finfish Species			
Clearnose skate	*Raja eglanteria*	59	404
Southern kingfish	*Menticirrhus americanus*	16	355
Summer flounder	*Paralichthys dentatus*	86	158
Striped burrfish	*Chilomycterus schoepfii*	10	98
Winter skate	*Leucoraja ocellata*	3	70
Cownose ray	*Rhinoptera bonasus*	35	54
Little skate	*Leucoraja erinacea*	1	25
Northern puffer	*Sphoeroides maculatus*	3	21
Southern stingray	*Dasyatis americana*	16	16
Atlantic angel shark	*Squatina dumeril*	5	5
Spiny butterfly ray	*Gymnura altavela*	5	5
Smooth butterfly ray	*Gymnura micrura*	4	4
Spiny dogfish	*Squalus acanthias*	3	3
Spotted hake	*Urophycis regia*	2	2
Bullnose ray	*Myliobatis freminvillei*	1	1
Gray triggerfish	*Balistes capriscus*	1	1
Smooth dogfish	*Mustelus canis*	1	1
Sand tiger shark	*Carcharias taurus*	1	1
Hogchoker	*Trinectes maculatus*	1	1
Red drum	*Sciaenops ocellatus*	1	1
Sheepshead	*Archosargus probatocephalus*	1	1
Spot	*Leiostomus xanthurus*	1	1
	Total Finfish	**256**	**1,228**
Crustacean Species			
Portly spider crab	*Libinia emarginata*	64	1344
Blue crab	*Callinectes sapidus*	14	499
Lady crab	*Ovalipes ocellatus*	6	201
Rock crab	*Cancer irroratus*	2	35
Broad claw hermit crab	*Pagurus pollicaris*	4	65
Brown shrimp	*Farfantepenaeus aztecus*	4	4
Long-armed hermit crab	*Pagurus longicarpus*	1	1
Iridescent swimming crab	*Portunus gibbesii*	1	1
	Total Crustaceans	**96**	**2,150**
Mollusc Species			
Knobbed whelk	*Busycon carica*	69	913
Channeled whelk	*Busycotypus canaliculatus*	5	100
Long-finned squid	*Loligo pealeii*	5	5
Brief squid	*Lolliguncula brevis*	4	4
	Total Molluscs	**83**	**1,022**
Other Species			
Horseshoe crab	*Limulus polyphemus*	421	12,670
	Total Other	**421**	**12,670**

Table 4. Total number of male and female horseshoe crabs (*Limulus polyphemus*) and sex ratio from subsampled commercial offshore trawls from 2012-2016.

Year	Number of Tows	Number of Males	Number of Females	Number of Unknown	Male:Female Ratio
2012	16	287	247		1.2:1
2013	12	234	214		1.1:1
2014	12	279	169		1.7:1
2015	6	153	119		1.3:1
2016	14	275	145	1	1.9:1

Table 5. Percent of summer flounder (*Paralichthys dentatus)* bycatch below 14 inches and 16 inches from subsampled commercial offshore trawls from 2012-2016.

Year	Number of Tows	Percent Below 14 inches	Percent Below 16 inches	Number Fish per Tow (catch per unit effort)
2012	16	2.5%	15.2%	4.9
2013	12	17.1%	43.9%	3.4
2014	12	23.0%	46.8%	10.5
2015	6	20.5%	35.2%	5.7
2016	14	17.4%	45.3%	6.1

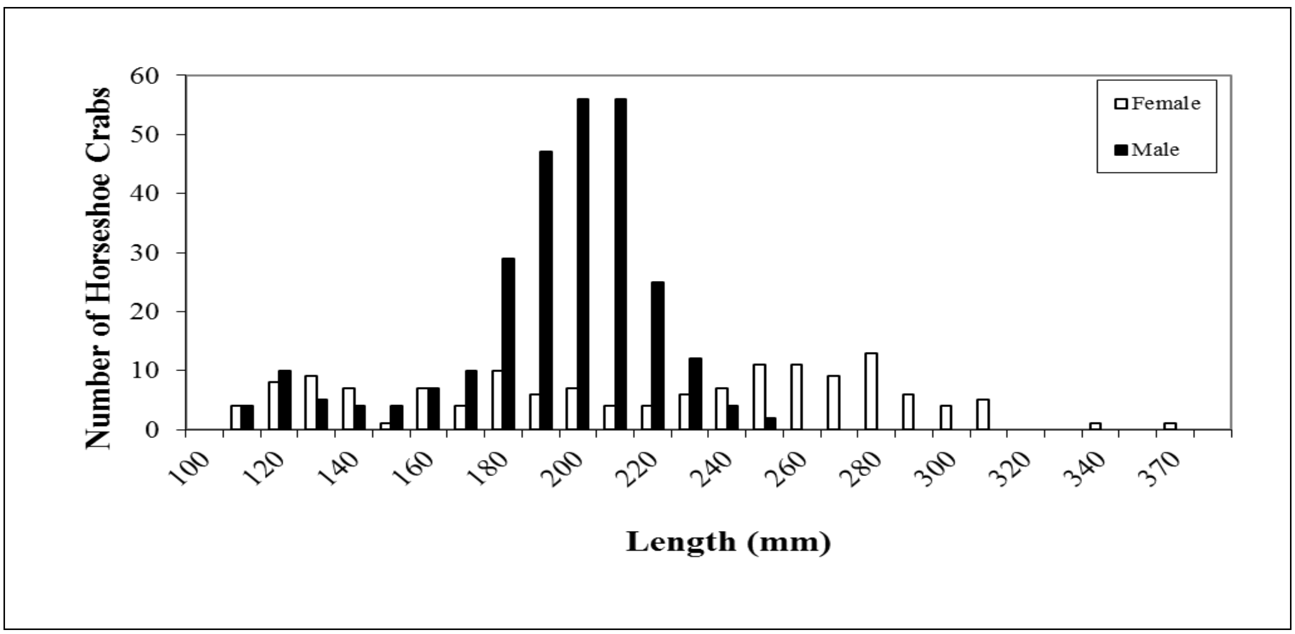

Figure 1. Horseshoe crabs (*Limulus polyphemus*) length (millimeters) frequency from commercial offshore trawls subsampled from June to November 2016, n= 420. Data were derived from six trawl trips taken at different water depths targeting horseshoe crabs.

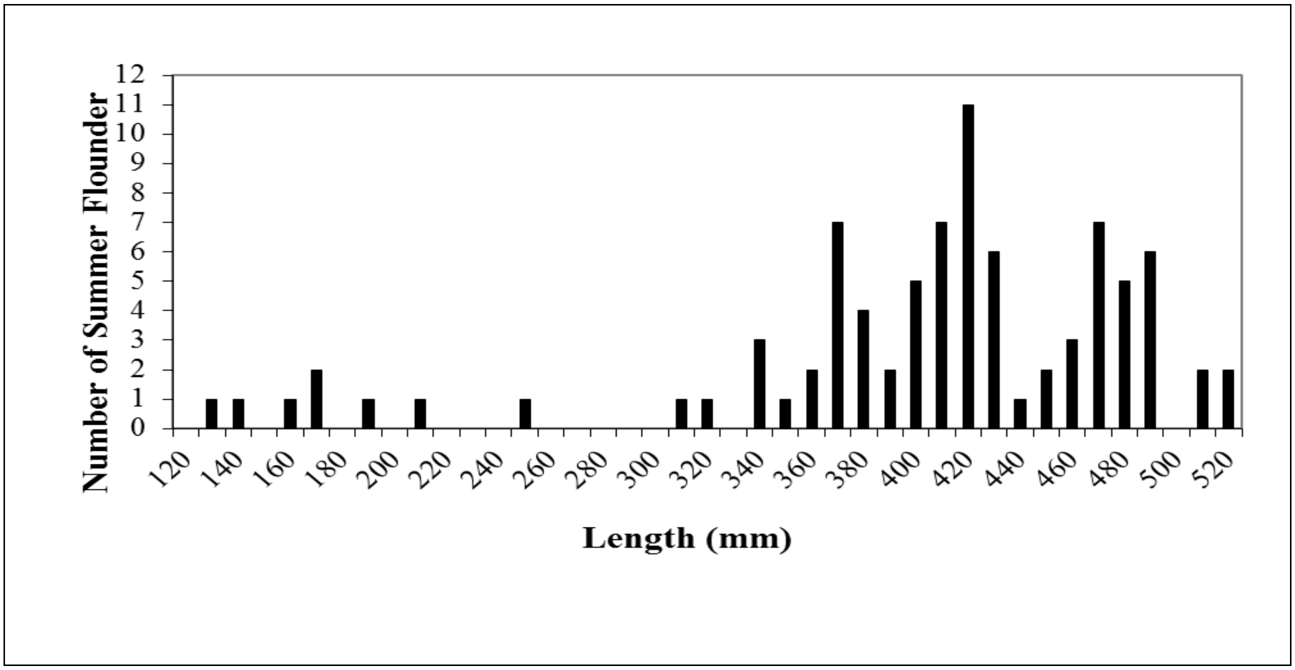

Figure 2. Summer flounder (*Paralichthys dentatus)* length (millimeters) frequency from commercial offshore trawls subsampled from June and November 2016, n= 86. Data were derived from six trawl trips taken at different water depths targeting horseshoe crabs.

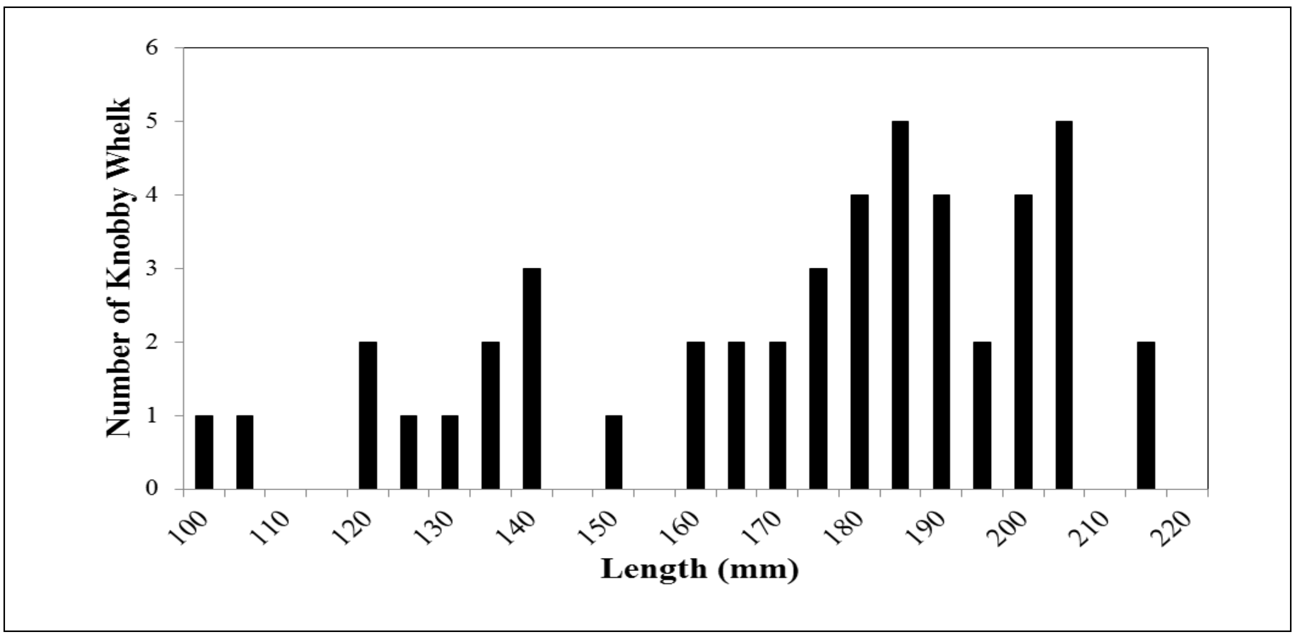

Figure 3. Knobbed whelk (*Busycon carica*) length (millimeters) frequency from commercial offshore trawls subsampled from June to November 2016, n= 47. Data were derived from six trips taken at different water depths targeting horseshoe crabs.

Appendix 1. Trawl Survey Data Sheet

Date	Start Time (12 hr)	Collector	Set#
______/_____/2016			

Site#	Station Description
T0	

Waypoint Start	Waypoint Stop	Temp (C)	Sal (ppt)	DO (mg/L)
		Surface	Surface	Surface
		Bottom	Bottom	Bottom

Latstrt	Latstop	Secchi (cm)	Weather	Tide
38° .	38° .			

Longstrt	Longstop	Depth (ft)	Wind Direction & Speed (Knots)
75° .	75° .	Start	@
		Stop	

List species collected for vouchers & quantities

21 L Bucket Cnt

Comments

Survey Checklist:
Datasheets/Protocol
Pencils/Sharpener
YSI, GPS
Depth Finder/Sounding Pole
AA Batteries
YSI (6)
GPS (2)
Camera (2)
4 measuring boards
Stop watch
Buckets
Cell Phone
ID books/Keys
Plastic bags/sharpie/labels
Cooler
Digital Camera
Secchi Disk

Tide Codes
HF ≡ High flood
HS ≡ High slack
HE ≡ High Ebb
LF ≡ Low flood
LS ≡ Low slack
LE ≡ Low ebb

Weather Codes
0 ≡ clear, no clouds
1 ≡ partly cloudy
2 ≡ overcast
3 ≡ Waterspout
4 ≡ fog, haze
5 ≡ drizzle
6 ≡ rain
7 ≡ mixed snow and/or rain
8 ≡ showers
9 ≡ thunderstorms

Bottom Type Codes
S ≡ Sand M ≡ mud
O ≡ shell R ≡ rubble
G ≡ gravel C ≡ clay
A = SAV NT ≡ not taken

Miscellaneous
Collector ≡ person taking data
Tot ≡ total
Cts ≡ Counts
Spp ≡ Species
WTR ≡ Water
Specvol ≡ Actual vol. measured in Liters (L)
Estimatevol ≡ Visual volume estimate in L
Estimatecnt ≡ Visual estimate of the number of individuals
% ≡ Percentage of catch
TotSpecVol ≡ Total volume of all species combined and within the bracket
Est. % Net Open ≡ Width of seine opening

People Checklist:
Lunch/H_20
Hat/Sunglasses/sun screen
Oil Skins

Boat Checklist:
Sharp knife/tools
Anchors/line
Gas/oil for generator/boat
Life Jackets, flares, sound device, throw ring, paddle
Sun block/first aid kit/horn
Gas card/credit card

EstimateVol (L)	EstimateCnt	SpecVol (L)	%	TotSpecVol (L)	Species Name
				Draw bracket for grouped spp.	

Appendix 1. Trawl Survey Data Sheet

Draw line separating ♂ and ♀ crabs. Start females in the right column and work towards the middle.
Place ● next to sook and a 2nd ● to indicate with eggs (ex: 60 mm sook with eggs is abbrev. 60●● and sook with no eggs 60●

♂ Blue Crab														♀ Blue crab
Cts												**Total Blue Crabs**		

Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.
Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.

Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.
Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.

Species Name	Counts	Total

Species Name	Counts	Total

Appendix 2. Beach Seine Survey Data Sheet

Date (MM/DD/YYYY)	Start Time (12 hr)	Collector	Set#
______/______/2016			
Site# S0	**Station Description**		
Seine Length: 100 foot 50 foot		**Temp (°C)**	**Sal (ppt)**
Waypoint Start	**Waypoint Stop**	**DO (mg/L)**	**Secchi (cm)**
Latstrt 38° .	**Latstop** 38° .	**Weather**	**Tide**
Longstrt 75° .	**Longstop** 75° .	**Depth (ft)**	**Est. % Net Open**
%SAV – Choose One 0–No SAV in sample area 2-26-50% 4-76%-100% 6-Undeterminable – give reason	1-up to 25% 3-51%-75%, 5-SAV present	**Bottom Type** 1. 2. Use N/A for line 2 if only 1 type	**Wind Direction & Speed (Knots)** @

List species collected for vouchers & quantities

21 L Bucket Cnt	Comments Species: Number of Fish/L: L Count: Subsample	**Survey Checklist:** Datasheets/Protocol Pencils/Sharpener YSI, GPS Depth Finder/Sounding Pole AA Batteries YSI (6) GPS (2) Camera (2) 4 measuring boards Stop watch Buckets Cell Phone ID books/Keys Plastic bags/sharpie/labels Voucher buckets Cooler Digital Camera Secchi Disk

Tide Codes
HF ≡ High flood
HS ≡ High slack
HE ≡ High Ebb
LF ≡ Low flood
LS ≡ Low slack
LE ≡ Low ebb

Weather Codes
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Bottom Type Codes
S ≡ Sand M ≡ mud
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A = SAV NT ≡ not taken

Miscellaneous
Collector ≡ person taking data
Tot ≡ total
Cts ≡ Counts
Spp ≡ Species
WTR ≡ Water
Specvol ≡ Actual vol. measured in Liters (L)
Estimatevol ≡ Visual volume estimate in L
Estimatecnt ≡ Visual estimate of the number of individuals
% ≡ Percentage of catch
TotSpecVol ≡ Total volume of all species combined and within the bracket
Est. % Net Open ≡ Width of seine opening

People Checklist:
Lunch/H_2O
Hat/Sunglasses/sun screen
Oil Skins

Boat Checklist:
Sharp knife/tools
Anchors/line
Gas/oil for generator/boat
Life Jackets, flares, sound device, throw ring, paddle
Sun block/first aid kit/horn
Gas card/credit card

Estimate Vol (L)	EstimateCnt	SpecVol (L)	%	TotSpecVol (L)	Species Name
				Draw bracket for grouped spp.	

Appendix 2. Beach Seine Survey Data Sheet

Draw line separating ♂ and ♀ crabs. Start females in the right column and work towards the middle.
Place ● next to sook and a 2nd ● to indicate with eggs (ex: 60 mm sook with eggs is abbrev. 60●● and sook with no eggs 60●

♂ Blue Crab														♀ Blue crab
Cts													**Total Blue Crabs**	

Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.
Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.

Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.	Sp.
Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.	Tot.

Species Name	Counts	Total

Species Name	Counts	Total

Appendix 3. Submerged Aquatic Vegetation Habitat Survey Data Sheet

Date (MM/DD/YYYY) _____/_____/2016	**Start Time (12 hr)**	**Collector**	**Set#**
Zone: **NB SB** **CB**	**Grid Number/Site Description**		
	Seine Length: 50 foot **Distance of Haul: 35 meters**	**Temp (°C)**	**Sal (ppt)**
Waypoint Start	**Waypoint Stop**	**DO (mg/L)**	**Secchi (cm)**
Latstrt **38° .**	**Latstop** **38° .**	**Weather**	**Tide**
Longstrt **75° .**	**Longstop** **75° .**	**Depth (ft)**	**Est. % Net Open**
%SAV Present 1 – up to 25% 2 – 26%-50% 3 – 51%-75% 4 – 76%-100%	**SAV Species Present:** **1.** **2.** **Circle Dominant Species**	**Bottom Type** **1.** **2.** **SAV not an option**	**Wind Direction & Speed (Knots)** @

Tide Codes
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HS ≡ High slack
HE ≡ High Ebb
LF ≡ Low flood
LS ≡ Low slack
LE ≡ Low ebb

Weather Codes
0 ≡ clear, no clouds
1 ≡ partly cloudy
2 ≡ overcast
3 ≡ Waterspout
4 ≡ fog, haze
5 ≡ drizzle
6 ≡ rain
7 ≡ mixed snow and/or rain
8 ≡ showers
9 ≡ thunderstorms

Bottom Type Codes
S ≡ Sand M ≡ mud
O ≡ shell R ≡ rubble
G ≡ gravel C ≡ clay
A = SAV NT ≡ not taken
N/A if only one type

Miscellaneous
Collector ≡ person taking data
Tot ≡ total
Cts ≡ Counts
Spp ≡ Species
WTR ≡ Water
Specvol ≡ Actual vol. measured in Liters (L)
Estimatevol ≡ Visual volume estimate in L
Estimatecnt ≡ Visual estimate of the number of individuals
% ≡ Percentage of catch
TotSpecVol ≡ Total volume of all species combined and within the bracket
Est. % Net Open ≡ Width of seine opening

People Checklist:
Lunch/H_20
Hat/Sunglasses/Oil Skins

Boat Checklist:
Sharp knife/tools
Anchors/line
Gas/oil for generator/boat
Life Jackets, flares, sound device, throw ring, paddle
Sun block/first aid kit/horn
Credit card

List species collected for vouchers & quantities

21 L Bucket Cnt

Comments:

Survey Checklist:
Datasheets/Protocol
Pencils/Sharpener
YSI, GPS
Rangefinder
Depth Finder/Sounding Pole
AA Batteries
YSI (6), GPS (2)
Camera (2)
4 measuring boards
Buckets
Cell Phone
ID books/Keys
Plastic bags/sharpie/labels
Digital Camera
Secchi Disk
Beach Seine

EstimateVol (L)	EstimateCnt	SpecVol (L)	%	TotSpecVol (L)	Species Name
				Draw bracket for grouped spp.	

Appendix 3. Submerged Aquatic Vegetation Habitat Survey Data Sheet

Draw line separating ♂ and ♀ crabs. Start females in the right column and work towards the middle.
Place ● next to sook and a 2nd ● to indicate with eggs (ex: 60 mm sook with eggs is abbrev. 60●● and sook with no eggs 60●

♂ Blue Crab														♀ Blue crab
Cts												**Total Blue Crabs**		

Sp.		Sp.		Sp.		Sp.		Sp.		Sp.		Sp.		Sp.	
Cts.		Cts.		Cts.		Cts.		Cts.		Cts.		Cts.		Cts.	
Tot.		Tot.		Tot.		Tot.		Tot.		Tot.		Tot.		Tot.	

Sp.		Sp.		Sp.		Sp.		Sp.		Sp.		Sp.		Sp.	
Cts.		Cts.		Cts.		Cts.		Cts.		Cts.		Cts.		Cts.	
Tot.		Tot.		Tot.		Tot.		Tot.		Tot.		Tot.		Tot.	

Species Name	Counts	Total

Species Name	Counts	Total

Appendix 4. Offshore Trawl Data Sheet

Date		Boat	Boat length (ft)	Captain		Collector
Set		Net codend mesh	Net body mesh	Head rope width	Foot rope width	Weather

	Start time	Lat start	Depth start	Water Temp (C)	* If all individuals of a species are measured instead of sub-sampled, please circle the species name and put a check mark next to the species name.
	End time	Long Start	Depth end	Wind Dir & Speed (knots)	
	Sub-sample volume	Lat stop	Sub-sample percentage of catch		
	1000 liters	Long stop			

Draw line separating ♂ and ♀ crabs. Start females in the right column and work towards the middle. I for Immature													
♂ Horseshoe crabs						0142					♀ Horseshoe crabs		
Counts												Total	

Spp. Code & Name	Counts	Total

Spp.					Spp.					Spp.				
Counts				Total	Counts				Total	Counts				Total

Spp.					Spp.					Spp.				
Counts				Total	Counts				Total	Counts				Total

Appendix 4. Offshore Trawl Data Sheet

Spp.					Spp.					Spp.				
Counts				Total	Counts				Total	Counts				Total

Spp.			Spp.			Spp.			Spp.		Spp.		Spp.	
Len	Width	Tip	Len	Width	Tip	Len	FL	Sex	Len	Sex	Len	Sex	Len	Sex
Cts.		Tot	Cts.		Tot	Cts.		Tot	Cts.	Tot	Cts.	Tot	Cts.	Tot

Place ● next to sook and another ● to indicate with eggs (ex: 60 mm sook with eggs is abbrev. 60●● and sook with no eggs 60●													
♂						Blue Crabs							♀
Counts												Total	

Spp. Code & Name	Counts	Total

Comments	**Survey Checklist:** Datasheets/Protocol/Pencils/ Sharpener Payment voucher ID books/Keys Measuring boards Digital Camera Live tank/ Sample Buckets Cell Phone Dinner/$H_2 0$

Appendix 5. Sea Turtle and Sturgeon Interaction Summary, July – June 2016
Project Number: F-50-R-25

Summary
The primary objective of the Coastal Bays Fisheries Investigation, F-50-R-25 was to monitor and biologically characterize fishes in Maryland's coastal bays. This document will summarize any interactions of these biological surveys with endangered species such as Atlantic sturgeon, shortnose sturgeon and sea turtles. There was one documented Atlantic sturgeon encounter during the 2016-2017 Offshore Trawl Survey from the Atlantic Ocean.

Project: Coastal Bays Fisheries Investigation
The Coastal Bays Fisheries Investigation was developed to characterize fishes and their abundances in Maryland's coastal bays, facilitate management decisions, and protect finfish habitats. This investigation was designed to meet the following three objectives:

1. characterize the stocks and estimate relative abundance of juvenile and adult marine and estuarine species in the coastal bays and near-shore Atlantic Ocean;
2. develop annual indices of age and length, specific relative abundance and other needed information necessary to assist in the management of regional and coastal fish stocks; and
3. delineate and monitor areas of high value as spawning, nursery and/or forage locations for finfish in order to protect against habitat loss or degradation.

Research Surveys:
1. Trawl and Beach Seine surveys
2. Submerged Aquatic Vegetation Habitat Survey
3. Offshore Trawl Survey

Atlantic Sturgeon Interactions
No Atlantic sturgeon were sampled or observed in the Trawl and Beach Seine surveys or the Submerged Aquatic Vegetation Habitat Survey during the period of July 1, 2016 through June 30, 2017. One Atlantic sturgeon was captured and released during the Offshore Trawl Survey on June 12, 2017.

Shortnose Sturgeon and Sea Turtle Interactions
No sea turtles or shortnose sturgeon were sampled or observed during the period of July 1, 2016 through June 30, 2017 for any of the research surveys.

Incident Report: ESA Listed Species Take
Observer's full name: Angel Willey, Maryland Department of Natural Resources
Reporter's full name: Same
Survey: Offshore Trawl Survey
Species Identification: Atlantic Sturgeon
How documented: identified to species by biologist
Type of gear and length of deployment: trawl, see below

Encounter:
Date: June 12, 2017
Time: 9:52 PM
Location: Atlantic Ocean, North 38 18.281, West 75 03.147
Water Temp: 69° Fahrenheit
Wind: East at 10 knots
Gear: trawl, 6 inch stretch mesh, duration 46 minutes
Total Length: estimated 1828.8 millimeters (6 feet)
Condition/description of specimen: released unharmed
Photograph taken? No
Genetics sample taken? No