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

July 2017 - June 2018

F-50-R-26

Final Report

Prepared by:
Steve Doctor
Gary Tyler
Craig Weedon
Angel Willey

UNITED STATES
DEPARTMENT OF INTERIOR
Fish & Wildlife Service
Division of Federal Assistance
Region 5

Final Performance Progress Report
Investigation of Maryland's Coastal Bays and Atlantic Ocean Finfish Stocks
July 1, 2017 through June 30, 2018

Grantee: Maryland Department of Natural Resources – Fishing and Boating Services

Grant No.: F17AF00918

Segment No.: F-50-R-26

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

Period Covered: July 1, 2017 through June 30, 2018

Prepared by: ______________________________
Angel Willey, Principal Investigator, Manager, Coastal Fisheries Program

Approved by: ______________________________
Michael Luisi, Division Director, Monitoring and Assessment

Approved by: ______________________________
David Blazer, Appointing Authority

Date Submitted: ______________________________

Statutory Funding Authority:	Sport Fish Restoration CFDA #15.605	X
	State Wildlife Grants (SWG) Cooperative Management Act	______

CFDA #15.634

Accomplishments July 1, 2017 - June 30, 2018

Completed monthly July - October 2017

- Collected 20 trawl samples at 20 fixed locations on Maryland's coastal bays
- Completed data entry and cleanup from prior month's sampling
- Accompanied commercial trawlers to gather biological information on adult finfishes in July, August and October
- Edited the F-50-R-25 report

Completed September 2017

- 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 the F-50-R-25 report

Completed October - December 2017

- Completed data entry and cleanup from October sampling
- Completed quality assurance and quality control for all data collected during 2017
- Collected 267 tautog samples from charter and party vessels for age structure, length, sex and weight

Completed January 1 - April 30, 2018

- Conducted data analyses of the 2017 surveys
- Drafted the F-50-R-26 annual report
- Prepared for the 2018 field sampling season (Trawl and Beach Seine surveys)
- Determined sampling needs for next Submerged Aquatic Vegetation Habitat Survey
- Cleaned and aged 267 tautog opercula
- Updated recreational and forage finfish indices for trend analysis
- Collected 23 tautog samples from a charter boat for age structures, length, sex and weight
- Provided summer flounder and black sea bass trawl indices to the National Oceanic and Atmospheric Administration for stock assessment updates
- Provided bluefish beach seine index for the Atlantic States Marine Fisheries Commission stock assessment.
- Provided spot and Atlantic croaker trawl indices for the Atlantic States Marine Fisheries Commission stop light trend analyses

Completed monthly April 1 - June 30, 2018

- Collected 20 trawl samples at 20 fixed locations on Maryland's coastal bays
- Completed data entry and cleanup from prior months sampling
- Edited the F-50-R-26 report

Completed June 2018

- Completed one trip onboard a trawler to gather biological information on recreational finfishes
- Conducted beach seine sampling at 19 fixed locations on Maryland's coastal bays

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 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 the data collector as well as another on board biologist after the sample workup was completed to reduce errors. The verification process includes checking for appropriate common names, values, 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 verification for 1972 - 1988 was completed in 2017. 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.

Executive Summary

The Coastal Bays Fisheries Investigation was developed to characterize juvenile and adult fishes and their abundances in Maryland's coastal bays and Atlantic Ocean, facilitate management decisions and protect finfish habitats. This investigation is comprised of four surveys: Beach Seine, Submerged Aquatic Vegetation Habitat and Trawl surveys in the bays behind Fenwick and Assateague Islands plus an Offshore Trawl Survey to characterize nearshore ocean adult finfishes. These 29 years of continuous data support management decisions including compliance with the Atlantic States Marine Fisheries Commission and stock assessments. Data were also provided to state, federal, and university partners for education, essential fish habitat designations, ground truthing submerged aquatic vegetation and academic research.

The investigation uses the previously mentioned four surveys 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.

In 2017, 28,710 fish were caught in the trawl and beach seine surveys (5,628 fish trawl and 23,082 fish beach seining)**.** Collected fishes represented 65 species which is within the normal representation range in a year. Many important recreational and forage species had below average trawl indices in 2017 including: Atlantic croaker, Atlantic silversides, black sea bass, bluefish, sheepshead, spot, summer flounder, tautog and weakfish. Black sea bass and weakfish also had below average beach seine indices. Silver perch was the only species to have an above average trawl index and summer flounder was the only species to have an above average beach seine index. In 2016 and 2017 summer flounder were frequently encountered in the April and May trawl samples but as the summer progressed they became more abundant in shallow water where they were captured in the beach seine survey.

Richness is defined as the number of different species per embayment. Chincoteague Bay had the highest richness for fishes (27 fishes) in the 2017 Trawl Survey whereas Assawoman Bay had the lowest richness (18 fishes). The Trawl Survey time series (1989 - 2017) results indicated that Chincoteague Bay had the highest mean (36 fishes) and Newport Bay had the least mean richness (22 fishes).

For 2017, Beach Seine Survey results showed that Chincoteague Bay was the richest (35 fishes) and the St. Martin River (21 fishes) was the least. The Beach Seine Survey time series (1989 - 2017) results indicated that Chincoteague Bay had the highest mean (31 fishes) and Newport Bay (19 fishes) had the lowest mean richness.

Diversity is defined by the Shannon index results, which is a measurement of species richness combined with how evenly distributed the numbers of each species were by embayment. In 2017, Newport Bay (H = 1.69) was the most diverse and Sinepuxent Bay (H = 0.68) was the least among the six trawled embayments. Diversity results from the trawl time series (1989 - 2017) indicated that Sinepuxent Bay (H = 1.68) was the most diverse whereas the St. Martin River (H = 1.36) was the least.

The 2017 Beach Seine Survey results indicated that Isle of Wight (H = 2.04) had the highest diversity whereas Newport Bay (H = 0.75) was the least. The Shannon index for the Beach Seine Survey time series (1989 - 2017) results indicated that Chincoteague Bay (H = 1.63) was the most diverse whereas the St. Martin River (H = 1.31) was the least (Table 15).

Macroalgae bycatch is ephemeral with annual variation. It is quantified in these surveys for its positive and negative effects as habitat. Seventeen genera were collected by trawl and beach seine within the coastal bays in 2017. Results showed that *Agardhiella tenera* were the most abundant macroalga (71.3 percent trawl and 76.9 percent beach seine) throughout the coastal bays in 2017.

The water quality tested at the majority of sample sites was consistent with fish habitat requirements. Dissolved oxygen was rarely found below critical levels and the salinity range supports coastal fish. Preliminary analysis of dissolved oxygen and fish catches from the surveys indicated that the coastal bays rarely experienced low enough dissolved oxygen to negatively impact abundances; however, the investigations sampling occurs during the day when the effects of low dissolved oxygen may not be evident. Dissolved oxygen levels have been improving since 1989.

All bays experienced a decline in salinity after July which fits the observed 2017 weather patterns for Ocean City, Maryland. Precipitation measured 19.9 inches in July, August and September. Sinepuxent Bay experienced the largest salinity decrease in September, dropping by seven parts per thousand.

Temperatures, while increasing over the time of the surveys, were within the acceptable range for coastal fish. For 2017, the mean surface temperature was 22.6 C. Since 1989, the mean surface temperature has increased over the course of the survey. According to a NASA (2017) time series of global temperature data from 1880 to 2017, 2016 followed by 2017 were the warmest years.

An increase in turbidity was observed in Assawoman and Isle of Wight bays and the St. Martin River from June to September for the 2017 Beach Seine Survey. The most turbid system was Assawoman Bay with an average Secchi of 44.5 centimeters. Isle of Wight and Sinepuxent bays had the best visibility for June and September, respectively. A significant ($r(11) = 0.72$, $p = 0.007$) increase in water clarity at trawl sites was observed from 2006 to 2017.

The overall catch per unit effort of fishes in the Submerged Aquatic Vegetation Habitat Survey, especially tautog, demonstrates the importance of submerged aquatic vegetation as critical habitat in Sinepuxent Bay. The survey also confirms that with continued study and monitoring of this habitat, stock assessments and species specific habitat criteria can be refined.

The Offshore Trawl Survey began in 1993 to obtain biological information on adult fishes in the nearshore Atlantic waters. Offshore sampling provides access to species and adult length groups not frequently captured in the Trawl and Beach Seine surveys that are conducted in Maryland's coastal bays. Twenty four species were collected from four trips in 2017. The prevalent fishes encountered were summer flounder (*Paralichthys dentatus*), spot (*Leiostomus xanthurus*), southern kingfish (*Menticirrhus americanus*) and clearnose skate *(Raja eglanteria).*

A total of 67 summer flounder were measured from those offshore trawls. Lengths ranged in size from 142 to 695 millimeters. The mean length was 413 millimeters and the mode was 388 millimeters. Thirty-six percent (24 fish) of the measured summer flounder were at or above the recreational minimum size limit (432 millimeters; 17 inches) and 91% (61 fish) were above 356 millimeters (14 inches), which is the length of female maturity.

Table of Contents

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 - 2017.

Over 130 adult and juvenile species of fishes, 26 molluscs and 20 macroalgae genera and two Submerged Aquatic Vegetation (SAV) species have been collected since 1972. These surveys contribute to the investigations three objectives in the following manner:

1. data are used to characterize the stocks and estimate relative abundance of juvenile marine and estuarine species in the coastal bays and near-shore Atlantic Ocean;
2. collects 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 (habitat) 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. Important tidal tributaries include: St. Martin River, Turville Creek, Herring Creek and Trappe Creek. Covering approximately 363 square kilometers (km^2 ; 140 square miles (mi^2)), these bays and associated tributaries average only 0.9 meters (m; 3 feet (ft)) in depth and are influenced by a watershed of only 453 km^2 (175 mi^2). The bathymetry of the coastal bays is characterized by a few deep holes, narrow channels and shallow sand bars.

The Ocean City and Chincoteague 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 km (34 mi) south of the Ocean City Inlet.

Ocean City on Fenwick Island is a heavily developed area and the center of a $16 billion tourism industry catering to approximately 8 million visitors annually (Greater Ocean City Chamber of Commerce 2016). The western shore of the northern bays is dominated by residential development and a small amount of farmland. Areas south of Ocean City are less developed with more *Spartina* marshes and include three parks on the eastern barrier island: 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 western shore of the southern bays is made up of farmland, a state wildlife management area, and a small amount of residential development.

Data Collection

A 25 ft C-hawk with a 225 horsepower Evinrude Etec engine was used for transportation to the sample sites and gear deployment. A Global Positioning System (GPS) was used for navigation, marking latitude and longitude coordinates in degrees and decimal minutes for each sample and monitoring speed.

Gears

Trawl

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 m (16 ft) semi-balloon trawl net was used in areas with a depth of greater than 1.1 m (3.5 ft). Each trawl was a standard six minute (0.1 hour) tow at a speed of approximately 2.5 to 2.8 knots (kts). Speed was monitored during tows using the GPS. Waypoints marking the sample start (gear fully deployed) and stop (point of gear retrieval) locations were taken using the GPS to document location of the sample. Time was tracked using a stopwatch which was started at full gear deployment.

Beach Seine

Beach 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 m X 1.8 m X 6.4 millimeter (mm) mesh (100 ft X 6 ft X 0.25 inch (in) mesh) bag seine was used at 18 fixed sites in depths less than 1.1 m (3.5 ft) along the shoreline. Some sites necessitated varying this routine to fit the available area and depth. A 15.24 m (50 ft) 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 (DO; milligrams/Liter (mg/L)), salinity (parts per thousand (ppt)) and water temperature (Celsius (C)). Physical parameters included: speed (kts), tide state, water clarity (Secchi disk; centimeters (cm)), water depth (ft), weather conditions 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 cm (1 ft) below the surface and 30 cm (1 ft) from the bottom, at each trawl site. The Pro2030 cord was marked in one foot intervals. Chemical data were only taken 30 cm below the surface for each beach seine site due to the shallow depth (< 1.1 m). 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 GPS 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 (TL) using a wooden mm measuring board with a 90-degree right angle (Table 3). A meter stick was used for species over 500 mm. 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 when counts were impractical.

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 SAV were measured volumetrically (L) using calibrated containers with small holes in the bottom to drain the excess water. Small quantities (generally ≤ 10 specimens) of invertebrates were occasionally counted or 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.

The Geometric Mean (GM) was calculated to develop species specific annual trawl and beach seine indices of relative abundance (1989 - 2017). That method was adopted by Atlantic States Marine Fisheries Commission (ASMFC) 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% 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: $\alpha = 0.05$, n - 1)], respectively. A geometric grand mean was calculated for the time series (1989 - 2017) and used as a point estimate for comparison to the annual (2017) 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 2017. The trawl measure of abundance, Catch Per Unit Effort (CPUE), was mean liters per hectare; the beach seine was mean liters per haul. Annual CPUE 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 (DO, salinity, temperature, turbidity) per bay (six systems) was derived from using the surface and bottom values. The DO averages were reviewed to see if the system overall fell below 5 mg/L (critical level of hypoxia in some systems).

Results and Discussion

Overview

Finfish were the most abundant taxa captured in the survey. Specifically, they accounted for 28,710 fish caught trawling (5,628) and beach seining (23,082 fish) in 2017 (Table 4). The total number of species and individual fish caught was similar to the last 10 years (Table 5). Collected fishes represented 65 species which is within the normal representation range in a year.

Many important recreational and forage species had below average trawl indices in 2017 including: Atlantic croaker, Atlantic silversides, black sea bass, bluefish, sheepshead, spot, summer flounder, tautog and weakfish (Table 6). Black sea bass and weakfish also had below average beach seine indices. Silver perch was the only species to have an above average trawl index and summer flounder was the only species to have an above average beach seine index. In 2016 and 2017 summer flounder were frequently encountered in the April and May trawl samples but they became more abundant in shallow water where they were more abundant in the beach seine survey as the summer progressed.

Crustaceans were the second most abundant taxa captured in this survey. Specifically, they accounted for 11,266 specimens caught trawling (6,343 crustaceans) and beach seining (4,923 crustaceans) in 2017 (Table 7). Seventeen crustaceans were identified, which is similar to the numbers found between 1989 and 2016. Crustaceans were dominated by blue crabs, grass shrimp and sand shrimp, which is typical.

The third most abundant taxa captured in the survey were molluscs. Specifically, they accounted for 1,470 specimens caught trawling (431 molluscs) and beach seining (1,039 molluscs; Table 8). Molluscs were represented by 15 different species which is similar to the numbers of molluscs found between 1989 and 2016. This category was dominated by mud snails of the genus *Nassarius*. Eighteen other types of animals were captured trawling and beach seining including: bryozoans, ctenophores, horseshoe crabs, northern diamondback terrapins, sponges and tunicates (Table 9).

Plants (SAV and macroalgae) were also captured in the trawls and beach seines (Table 10). Two species of SAV and 17 different macroalgae were encountered in 2017. Red macroalgae were most abundant for both gears in nearly equal proportions with a total of 4,390 L.

American eel (*Anguilla rostrata*)

Results

American eels were captured in five of 140 trawls (3.6%) and in seven of 38 beach seines (18.4%). A total of 29 American eels were collected in trawl (10 fish) and beach seine (19 fish) samples (Table 4). American eel ranked 28 out of 65 species in overall finfish abundance. The trawl and beach seine CPUEs were 0.6 fish/ha and 0.5 fish/haul, respectively.

The 2017 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.

The mean length of American eels increased from a mean length of 51 mm in April to 111 mm in July in the Trawl Survey (Table 11). Zero were collected trawling after July. In the Beach Seine Survey, the mean length was 234 mm in June and 153 mm in September (Table 12).

Discussion

American eels are important as forage for a variety of fishes and as bait for recreational anglers. Both trawl and beach seine gears catch a limited number of American eels but have 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 at three trawl sites located close to land in protected bays or creeks. Many of them were caught in Turville Creek where the department also conducts an annual elver survey further up the creek from the T006 sampling site. The abundance of elvers at this site was 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. The increase in mean length by month in the Trawl Survey is most likely due to growth. The decrease in mean length in the Beach Seine Survey from June to September is due to catching more and larger adults in June than September.

Atlantic croaker (*Micropogonias undulatus*)

Results

Atlantic croakers were captured in 16 of 140 trawls (11.4%) and in seven of 38 beach seines (18.4%). A total of 65 juvenile Atlantic croakers were collected in trawl (54) and beach seine (11) samples (Table 4). Atlantic croakers ranked 18 out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 3.1 fish/ha and 0.3 fish/haul, respectively.

The 2017 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean (Figures 6 and 7). Since 1989, the trawl index occasionally (seven years) varied from the grand mean and the beach seine index often (13 years) varied from the grand mean.

The mean length of Atlantic croakers caught by trawl increased from a mean of 45.3 mm in April to a mean of 161.5 mm in July. The smallest Atlantic croakers were caught in September (mean 28.7 mm) and October (mean 34 mm; Table 11). In the Beach Seine Survey, larger fish were collected in June (mean 121 mm) than in September (mean 42 mm; Table 12).

Discussion

In the history of the surveys, juvenile Atlantic croakers were more frequently caught in deeper water with the trawl and less often in beach seines. Therefore, the trawl index represents a more accurate picture of changes in relative abundance when compared to the beach seine index. Abundance can be influenced by environmental conditions and ocean currents (Murdy *et al.* 1997). Very cold winters negatively influence abundance by impacting overwintering young of the year 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 those Atlantic croakers were very small and probably did not like the stronger 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).

According to Murdy and Musick (2013) Atlantic croakers spawn in the continental shelf waters, peaking from August through October. That fact is supported by the Atlantic croakers length data collected from juveniles that immigrated into the coastal bays in the fall. The greatest number and the smallest juvenile Atlantic croakers were caught in September and October. The mean length increase from April through July reflects growth of the juvenile cohort.

Atlantic menhaden (*Brevoortia tyrannus*)

Results

Atlantic menhaden were captured in five of 140 trawls (3.6%) and in 14 of 38 beach seines (36.8%). A total of 15,890 Atlantic menhaden were collected in trawl (eight fish) and beach seine (15,882 fish) samples (Table 4). Atlantic menhaden ranked first out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 0.5 fish/ha and 417.9 fish/haul, respectively.

The 2017 trawl index was below the grand mean and the beach seine index was equal to the grand mean (Figures 8 and 9). Since 1989, the trawl index often (14 years) varied from the grand mean and the beach seine index occasionally (eight years) varied from the grand mean.

The mean length of Atlantic menhaden caught by trawl increased from a mean of 41 mm in April to a mean of 71 mm in August (Table 11). The Beach Seine Survey had similar results with an increase from a mean length of 51 mm in June to a mean length of 101 mm in September (Table 12).

Discussion
Atlantic menhaden were caught more often in near shore locations in the Beach Seine Survey. Therefore, the beach seine index represents a more accurate picture of changes in relative abundance when compared to the trawl index. Beach seine data were provided to the ASMFC for the upcoming stock assessment as well as the one conducted in 2016.

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. Good trawl sites for collecting Atlantic menhaden were located in the protected headwaters of Turville Creek (T006) and the St. Martin River (T005) which have some of the preferred traits seen in the best beach seine sites: shallow depth and muddy bottom. 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; a desirable characteristic for a filter feeder (Wazniak *et al.* 2004). The increase in mean length in both the Trawl and Beach Seine surveys reflects growth of the cohort throughout the summer season.

Atlantic silverside (*Menidia menidia*)

Results
Atlantic silversides were captured in four of 140 (2.9%) trawls and in 33 of 38 beach seines (86.8%). A total of 2,482 Atlantic silversides were collected in trawl (13 fish) and beach seine (2,469 fish) samples (Table 4). Atlantic silversides ranked third out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 0.7 fish/ha and 65.0 fish/haul, respectively.

The 2017 trawl index was below the grand mean and the beach seine index was equal to the grand mean (Figures 10 and 11). Since 1989, the trawl index often (13 years) varied from the grand mean and beach seine index rarely (five years) varied from the grand mean.

The mean length of Atlantic silversides changed little by month in the Trawl and Beach Seine surveys (Tables 11 and 12). Nine Atlantic silversides were collected from the Trawl Survey and they ranged from 30 to 128 mm. There were 2,469 collected from the Beach Seine Survey which indicated a slight increase in mean length from 75 mm in June to 80 mm in September.

Discussion
Atlantic silversides were more frequently caught with the beach seine (33 out of 38 beach seines for 2017). Significant changes in relative abundance may reflect a combination of environmental

conditions (DO, nutrient levels, salinity and water temperature) and ecological changes including shifts in species composition and habitat type. Good 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 were not collected from exposed open water sites. Atlantic silversides are known to be a preferred forage species for larger gamefish and have been found occurring with spot, summer flounder and winter flounder at multiple sites in this survey. The small increase in size of Atlantic silversides between June and September is possibly due to growth during the summer.

Bay anchovy (*Anchoa hepsetus*)

Results

Bay anchovies were captured in 88 of 140 trawls (62.9%) and in 23 of 38 beach seines (60.5%). A total of 4,673 bay anchovies were collected in trawl (3,736 fish) and beach seine (937 fish) samples (Table 4). Bay anchovies ranked second out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 212.8 fish/ha and 24.6 fish/haul, respectively.

The 2017 trawl and beach seine relative abundance indices were both equal to the grand means (Figures 12 and 13). Since 1989, the trawl (nine years) and beach seine (seven years) indices occasionally varied from the grand means.

The mean length of bay anchovies in the Trawl Survey was higher in the spring (mean length in April 69 mm, May 65 mm and June 75 mm) than in the summer and fall (mean length in July 49 mm, August 51 mm, September 56 mm and October 53 mm (Table 11). Larger bay anchovies were collected in June (mean 72 mm) than in September (53 mm) in the Beach Seine Survey (Table 12).

Discussion

Both bay anchovy indices represent an accurate picture of changes in relative abundance. Annual fluctuations in relative abundance may reflect a combination of environmental conditions (DO, 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. Females spawn multiple times from May to September and peak spawning occurs in July. The smaller fish captured in September were most likely young of the year.

Black sea bass (*Centropristis striata*)

Results

Black sea bass were collected in 24 of 140 trawls (17.1%) and two of 38 beach seines (5.3%). A total of 38 juvenile black sea bass were collected in trawl (36 fish) and beach seine (two fish) samples (Table 4). Black sea bass were ranked 25 out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 2.0 fish/ha and < 0.1 fish/haul, respectively.

The 2017 trawl and beach seine relative abundance indices were both below the grand means (Figures 14 and 15). Since 1989, the trawl index frequently (17 years) varied from the grand mean and beach seine index occasionally (seven years) varied from the grand mean.

The mean length of black sea bass increased from 76 mm in May to 166 mm in October in the Trawl Survey (Table 11). In the Beach Seine Survey, the mean length was greater in September at 160 mm than in June at 45 mm (Table 12).

Discussion
Black sea bass were caught in both gears; however, the trawl catches more than the beach seine so it is the better gear for the stock assessment. The Trawl Survey data were used in the 2016 stock assessment. This gear is used by other state's independent surveys that are also included in the stock assessment. Indices of relative abundance for both gears were included in the annual ASMFC compliance report.

Juvenile black sea bass were more abundant in the northern bays and the most southern site located closest to the Chincoteague Inlet than in the mid bays. Abiotic factors measured did not show much correlation with abundance of black sea bass so other factors such as proximity to the inlets and availability of physical structure in the bays are likely the reasons for differences in abundance between sites (Peters 2017). Some 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).

Generally, April and May catch was composed of age one black sea bass. Young of the year black sea bass recruited all summer long. Mixing of the age zero and age one year classes results in a large range of sizes through the year.

Bluefish (*Pomatomus saltatrix*)

Results
Bluefish were collected in two of 140 trawls (1.4%) and in nineteen of 38 beach seines (50%). A total of 55 juvenile bluefish were collected in trawl (two fish) and beach seine (53 fish) samples (Table 4). Bluefish ranked 19 out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and 1.4 fish/haul, respectively.

The 2017 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figures 16 and 17). Since 1989, the trawl (seven years) and beach seine (eight years) indices occasionally varied from the grand means.

There were two bluefish caught by trawl in 2017. The length increased from 82 mm in July to 208 mm in September (Table 11). In the Beach Seine Survey the mean length increased from 78 mm in June to 161 mm in September (Table 12).

Discussion
Bluefish were caught more frequently in near shore locations, therefore, the beach seine index represents a more accurate picture of changes in relative abundance when compared to the trawl index. Data from the Beach Seine Survey were used in the bluefish stock assessment and were included in the annual ASMFC compliance report. Changes in relative abundance may reflect a

combination of environmental conditions (DO, 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 Wight 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. Increases in size as the year progressed in both surveys reflects the growth of the young of the year cohort through the year.

Sheepshead (*Archosargus probatocephalus*)

Results

Sheepshead were collected in two of 140 trawls (1.4%) and five of 38 beach seines (13.2%). A total of 18 juvenile sheepshead were collected in trawl (two) and beach seine (16) samples (Table 4). Sheepshead ranked 35 out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and 0.4 fish/haul, respectively.

The 2017 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean (Figures 18 and 19). Since 1989, the trawl (24 years) and beach seine (18 years) indices frequently varied from the grand means, indicating large variability in abundance over the time period.

Sheepshead were only collected in October by trawl. The mean length of the two trawled fish was 122 mm. There were 16 caught in the September Beach Seine Survey. The mean length of those fish was 88 mm (Tables 11 and 12).

Discussion

Since 1997, there has been an increasing trend in sheepshead abundance which is of interest to recreational anglers. The recent popularity gain has anglers concerned about local depletion despite existing regulations.

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 sheepshead spawn offshore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance as well as an increase in offshore artificial reefs, structure necessary for adult sheepshead habitat (Murdy and Musick 2013). Good beach seine sites for collecting juvenile sheepshead were locations with or near SAV or rip rap. SAV is important juvenile habitat (Murdy and Musick 2013). The larger mean size of sheepshead in the October trawl than in the September Beach Seine Survey may be a result of larger fish preferring deeper water or the result of one more month of growth.

Silver perch (*Bairdiella chrysoura*)

Results

Silver perch were collected in 49 of 140 trawls (35.0%) and 15 of 38 beach seines (39.5%). A total of 1,849 silver perch were collected in trawl (625 fish) and beach seine (1,224 fish) samples conducted on Maryland's coastal bays in 2017 (Table 4). Silver perch ranked fourth out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 35.6 fish/ha and 32.2 fish/haul, respectively.

The 2017 trawl relative abundance index was above the grand mean and the beach seine relative abundance index was equal to the grand mean (Figures 20 and 21). Since 1989, the trawl index often (14 years) varied from the grand mean and beach seine index rarely (two years) varied from the grand means.

The mean length of silver perch declined from 171 mm in April to 44 mm in July and then increased to 108 mm in October in the Trawl Survey (Table 11). In the Beach Seine Survey the mean length was greater in June at 156 mm than in September.at 81 mm (Table 12).

Discussion
Silver perch are important forage species in the coastal bays. They 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 and juveniles utilize SAV, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997, Murdy and Musick 2013). 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 for this species.

The size of silver perch by month in the Trawl and Beach Seine surveys reflects the carryover of larger fish in the spring from the fall. A pulse of new recruits arrives in July. These recruits then grow and increase in mean length through October.

Spot (*Leiostomus xanthurus*)

Results
Spot were collected in 44 of 140 trawls (31.4%) and 22 of 38 beach seines (57.9%). A total of 987 spot were collected in trawl (340 fish) and beach seine (647 fish) samples (Table 4). Spot ranked fifth out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 19.4 fish/ha and 17.0 fish/haul, respectively.

The 2017 trawl relative abundance index was below the grand mean and the beach seine index was below the grand mean (Figures 22 and 23). Since 1989, the trawl (23 years) and beach seine (19 years) indices frequently varied from the grand means, indicating variability in abundance over the time period.

The mean length of spot increased from 47 mm in May to 163 mm in September in the Trawl Survey (Table 11). In the Beach Seine Survey, the mean length was greater in September at 175 mm than in June at 84 mm (Table 12).

Discussion
Spot are important to recreational anglers as a target species and as bait. They are also forage for many finfishes. 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. Data from the Trawl and Beach Seine surveys were included in the annual ASMFC compliance report. Data from those surveys were requested and evaluated for the 2016 ASMFC traffic light approach assessment.

Since spot spawn offshore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997). Juvenile spot were widely dispersed in the samples collected throughout the coastal bays. This indicated that most of the Maryland coastal bays was favorable nursery habitat for spot. An increase in mean length through the summer reflects recruitment of young of the year in the spring and growth into the fall.

Summer flounder (*Paralichthys dentatus*)

Results

Summer flounder were collected in 66 of 140 trawls (47.1%) and 25 of 38 beach seines (65.8%). A total of 545 summer flounder collected in trawl (262 fish) and beach seine (283 fish) samples (Table 4). Summer flounder ranked sixth out of 65 species in overall finfish abundance. The trawl and beach seine CPUE was 14.9 fish/ha and 7.4 fish/haul, respectively.

The 2017 trawl relative abundance index was below the grand mean and the beach seine index was above the grand mean (Figures 24 and 25). Since 1989, the trawl index frequently (17 years) varied from the grand mean and the beach seine index occasionally (nine years) varied from the grand mean.

The mean length of summer flounder caught by trawl was higher in April at 100 mm than in May at 71 mm and June at 89 mm. The mean was lowest in May but then increased monthly into October at 190 mm (Table 11). In the Beach Seine Survey, the mean length was greater in September at 157 mm. than in June at 90 mm (Table 12).

Discussion

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. Data from the Trawl Survey were used in the 2018 summer flounder benchmark stock assessment. Indices from both surveys were included in the annual ASMFC compliance report. In 2017 there were a notable number of summer flounder caught in the beach seine samples, which was a change from recent years. This was an interesting deviation that will be closely monitored.

Good summer flounder trawl and beach seine sample sites were located in all bays. This indicated that most of the habitat of the Maryland coastal bays was favorable nursery habitat. Summer flounder are pelagic spawners and changes in relative abundance may reflect a combination of environmental conditions (DO, 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.

April and October mean size was influenced by a few older fish that overshadowed the young of the year recruitment. Recruitment was evident in very small fish in April, May and June. Those fish grew through the summer months and into the fall.

Tautog (*Tautoga onitis*)

Results

Tautogs were captured in zero of 140 trawls (0%) and in one of 38 (2.6%) beach seines. Three tautogs were collected in beach seine samples (Table 4). Tautog ranked 51 out of 65 species in overall finfish abundance.

The 2017 trawl relative abundance index was below the grand mean and the beach seine index was equal to the grand mean (Figures 26 and 27). Since 1989, the trawl (10 years) and beach seine (seven years) indices occasionally varied from the grand mean.

Mean length for tautog was 81 mm and all three specimens were captured by the beach seine in September (Table 12).

Discussion

Although tautog catches were sporadic this survey correlates with the independent juvenile indices of other states. Juvenile tautogs prefer SAV and adult tautogs prefer structured habitat. Historically, these surveys indicated a site preference for beach seine sites in the northern bays where the SAV beds died and have not recovered. The department's independent Submerged Aquatic Vegetation Habitat Survey documented juveniles in the SAV beds located in Sinepuxent Bay (Chapter 2 of this report). Mean size of tautog captured by the Beach Seine Survey indicated that all specimens were young of the year. The Independent Trawl and Beach Seine surveys indices were included in the annual ASMFC compliance report. The State of Maryland is required by the ASMFC to have an independent survey and to collect opercula, lengths, weights and sex from 200 fish. Those data were collected from 267 tautog as well as 50 otoliths caught from charter and party boats in 2017 (Appendix 3). Data from this survey were used in the 2016 tautog stock assessment.

Weakfish (*Cynoscion regalis*)

Results

Weakfish were collected in 19 of 140 trawls (13.6%) and zero of 38 beach seines. A total of 109 juvenile weakfish were collected in trawl samples (109 fish; Table 4). Weakfish ranked twelfth out of 65 species in overall finfish abundance. The trawl CPUE was 6.2 fish/ha.

The 2017 trawl and beach seine relative abundance indices were both below the grand means (Figures 28 and 29). Since 1989, the trawl index often (13 years) varied from the grand mean and the beach seine index occasionally (10 years) varied from the grand mean.

The mean length of weakfish decreased from 95 mm June to 64 mm in July, and then increased to 170 mm in October in the Trawl Survey (Table 11). One age one and one young of the year weakfish were collected in the trawl in June. The remaining weakfish were young of the year.

Discussion

Weakfish were caught more frequently in open water, therefore, the trawl index represents a more accurate picture of changes in relative abundance when compared to the beach seine index. The trawl index was included in the annual ASMFC compliance report. Data from the Trawl Survey were used in the 2015 weakfish stock assessment. Weakfish were considered depleted but not overfished. The decline appears to be due to natural mortality (Northeast Fisheries Science Center 2009). Changes in relative abundance may reflect a combination of environmental conditions (DO, 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. Young of the year recruitment was most evident from July through October which follows the peak spawning period of May through June (Murdy and Musick 2013).

Richness and Diversity by Embayment

Results

Species richness is the number of species sampled in the embayment. Species diversity is defined by the Shannon index results, which is a measurement of species richness combined with how evenly distributed the numbers of each species were by embayment. The embayment with the highest richness for fishes in the trawl time series (1989 - 2017) was Chincoteague Bay (Table 13). This embayment had a total of 89 fishes collected and identified throughout the time series, an average of 36 species per year and 27 species in 2017 (Table 14). Newport Bay had the lowest richness in the time series, 67 total fishes and an average of 22 species per year but Assawoman Bay had the lowest in 2017 with 18 fishes (Table 14). The Shannon index for the trawl time series (1989 - 2017) indicated that Sinepuxent Bay (H = 1.68) was the most diverse whereas the St. Martin River (H = 1.36) was the least (Table 13). In 2017, the Shannon index results indicated that Newport Bay (H = 1.69) was the most diverse whereas Sinepuxent Bay (H = 0.68) was the least (Table 14).

The Beach Seine Survey time series (1989 - 2017) results indicated that Isle of Wight Bay was the richest (87 fishes), Chincoteague Bay had the highest average (31 fishes) and Newport Bay (66 fishes) was the least (Table 15). For 2017, Chincoteague Bay was the richest (35 species) and St. Martin River (21) was the least (Table 16). The Shannon index time series (1989 - 2017) results indicated that Chincoteague Bay (H = 1.63) was the most diverse whereas the St. Martin River (H = 1.31) was the least (Table 15). The 2017 results indicated that Isle of Wight Bay (H = 2.04) had the highest diversity whereas Newport Bay (H = 0.75) was the least (Table 16).

The Beach Seine Survey had a low salinity site on Ayers Creek which is an upper tributary of Newport Bay. The salinity has ranged from 0 to 20.7 ppt with a time series (1989 - 2017) mean of 4.76 ppt. The time series richness at this site was 44 fishes with an average of 15 fishes per year. In 2017, richness (H = 1.01) dropped below the time series average (H = 1.24) to seven species (Tables 15 and 16).

Discussion

Richness and diversity are important components of a healthy estuary and should be monitored for indicators of depleted habitat. There was not a linear relationship between the richness and diversity in the coastal bays. Results showed that the coastal bays richness was relatively high while diversity was generally low; a value of three is considered good and four is excellent. Sinepuxent Bay had strong multispecies abundance in 2011, 2009 and 2005. Spot and summer flounder abundance were much greater in those years than 2017 when the trawl catch composition was 88.26% bay anchovy.

The beach seine data also identified low diversity in Sinepuxent Bay last year because Atlantic menhaden comprised 78% of the catch. A strong year class can reduce the diversity value by minimizing the effect of other fish contributions to the sample population. Therefore, diversity alone should not be used as a single indicator for healthy fish abundance because strong inner annual year classes are required to sustain species populations that are subject to high fishing or natural mortality. Chincoteague Bay annual sample size (n = 12) was greater than Newport Bay (n = 2). Combining these embayments as one increased the richness and diversity for the time series and the terminal year of the survey. Co-variant differences among habitat for each site such as salinity, substrate, forage and protection could also serve as comparison criteria rather than or in addition to embayment.

The Ayers Creek beach seine site was not considered an embayment and was included in the table to show abundance levels upstream of Newport Bay. The salinity was highly variable in the time series and that covariate affected species diversity as that site was only sampled twice per year. Ayers Creek has shown high levels of Atlantic menhaden and golden shiner (*Notemigonus crysoleucas*) on a regular basis throughout the time series. Infrequent abundance of spot and striped bass has also been recorded.

Macroalgae

This time series spans 12 years from 2006 to 2017. To date, 19 genera and 60,068 L 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.

Seventeen genera were collected by trawl within the coastal bays in 2017, which was above the average (14.6 genera) in the time series. The 2017 Shannon index of diversity among genera by trawl (H = 1.09) was below the time series average (H = 1.26). Results showed that *Agardhiella* were the most abundant macroalgae (71.3%) in 2017. The only other genera that contributed more than 5% to the sample population was *Polysiphonia* (11.9%; Table 10). The 2017 trawl CPUE (144.1 L/ha) was equal to the grand mean. Since 2006, the trawl CPUE rarely varied from the grand mean (Figure 30).

Eleven genera were sampled within the coastal bays by beach seine in 2017. The Shannon index of diversity among genera (H = 0.86) was below the time series average (H = 1.16). Results showed that *Agardhiella* were most abundant (76.9%). The only other genera that contributed more than 5% to the sample population were *Ulva* (12.1%; Table 10). The 2017 beach seine CPUE (75.8 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE rarely varied from the grand mean (Figure 31).

Over the trawl time series, mean CPUE 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 32). The beach seine time series showed a similar trend in CPUE while the Shannon index was variable among those areas littoral zone (Figure 33).

Assawoman Bay: This embayment has been dominated by *Rhodophyta* since sampling began in 2006. Nine different genera were collected by trawl in 2017, which was above the average (7.8 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 0.74) was below the time series average (H = 0.92). Results showed that *Agardhiella* (81.7%) was most abundant; *Ceramium* (6.7%) and *Gracilaria* (5.1%) were the only other genera that contributed more than 5% to the sample population. The 2017 CPUE (108.2 L/ha) was below the grand mean. Since 2006, the trawl CPUE rarely varied from the grand mean (Figure 34).

Seven different genera were collected by beach seine in 2017, which was above the average (6.6 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 0.99) was above the time series average (H = 0.82). Results showed that *Agardhiella* (71.1%) was most abundant; *Codium* (10.9%) and Ulva (10.9%) were the only other genera that contributed more than 5% to the sample population. The beach seine CPUE (8.9 L/haul) was below the grand mean. Since 2006, the beach seine CPUE often varied from the grand mean (Figure 35).

Isle of Wight Bay: This embayment has been dominated by *Rhodophyta* since sampling began in 2006. Nine different genera were collected by trawl in 2017, which was above the average (7.2 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2017 (H = 0.11) was below the time series average (H = 0.74). *Agardhiella* was most abundant (98.1 %). The trawl CPUE (557.1 L/ha) was equal to the grand mean. Since 2006, the trawl CPUE rarely varied from the grand mean (Figure 36).

Six different genera were collected by beach seine in 2017, which was below the average (seven genera) for this embayment in the time series. The 2017 Shannon index of diversity among genera within this embayment (H = 1.19) was above the time series average (H = 1.07). *Ulva* (43.6%) was the most abundant; *Agardhiella* (40.9%) and *Polysiphonia* (5.3%) were the only other genera that contributed more than 5% of the sample population. The 2017 beach seine CPUE (117.5 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE rarely varied from the grand mean (Figure 37).

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. Eight different genera of macroalgae were collected by trawl in 2017, which was above the time series average (5.7 genera). The 2017 Shannon index of diversity among genera (H = 1.13) was above the times series average (H = 0.81). *Agardhiella* (68.5%) was most abundant; *Ulva* (13%) and *Ceramium* (6.7%) were the only other genera that contributed more than 5% of the sample population. Trawl CPUE (58.2 L/ha) in 2017 was below the grand mean. Since 2006, the trawl CPUE occasionally varied from the grand mean (Figure 38).

Two different genera were collected by beach seine in 2017, which was below the average (3.4 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2017 (H = 0.06) was below the time series average (H = 0.43). *Agardhiella* (99%) was most abundant. The 2017 beach seine CPUE (274.7 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE rarely varied from the grand mean (Figure 39).

Sinepuxent Bay: This embayment has been dominated by *Rhodophyta* in nine of the eleven years since sampling began in 2006. *Chlorophyta* were dominant in 2008 and 2009. Ten different genera of macroalgae were collected by trawl in 2017, which was average (10 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2017 (H = 0.76) was below the average (H = 1.32). *Agardhiella* (80.4%) and *Ulva* (9.3%) were the only genera that contributed more than 5% of the sample population. Trawl CPUE (19.0 L/ha) in 2017 was lower than grand mean. Since 2006, the trawl CPUE often varied from the grand mean (Figure 40).

Five different genera were collected by beach seine in 2017, which was below the average (6.25 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2016 (H = 0.22) was below the average (H = 0.54). *Agardhiella* (95.1%) was most abundant and only genera that contributed more than 5% of the sample population. The 2017 beach seine CPUE (59.7 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE rarely varied from the grand mean (Figure 41).

Newport Bay: This embayment has been dominated by *Rhodophyta* in eight of the 11 years since sampling began in 2006. *Chlorophyta* were dominant in 2008 - 2010. Six different genera were collected by trawl in 2017, which was below the average (6.8 genera) for this embayment in the time series. The 2017 Shannon index of diversity among genera (H = 0.86) within this embayment was below the time series average (H = 1.04). *Agardhiella* (67%) and *Ceramium* (27%) were the only genera that contributed more than 5% of the sample population. Trawl CPUE (4.8 L/ha) was below to the grand mean. Since 2006, the trawl CPUE occasional varied from the grand mean (Figure 42).

Three different genera were collected by beach seine in 2017, which was below the average (3.5 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0.07) was below the time series average (H = 0.38). *Agardhiella* (98.9%) was most abundant. The 2017 beach seine CPUE (29.0 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE often varied from the grand mean (Figure 43).

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 - 2017. Fifteen different genera were collected by trawl in 2017, which was above the times series average (11.5 genera). The 2017 Shannon index of diversity among genera (H = 1.48) was below the average (H = 1.56) within this embayment for the time series. *Agardhiella* (44.8%) was most abundant; *Polysiphonia* (26.7%) and *Chaetomorpha* (15.7%) were the only genera that contributed more than 5% of the sample population. The CPUE (157.4 L/ha) was above to the grand mean. Since 2006, the trawl CPUE rarely varied from the grand mean (Figure 44).

Nine different genera were collected by beach seine in 2017, which was above the average (7.1 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0.70) was below the time series average (H = 0.93). *Agardhiella* (81.9%) was most abundant; *Desmarestia* (8.2%) and *Polysiphonia* (6.5%) were the only other genera that contributed more than 5% of the sample population. The 2017 beach seine CPUE (78.9 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE often varied from the grand mean (Figure 45).

Discussion

Macroalgae in Maryland's coastal bays were investigated consistently over 12 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 CPUE 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 suitable conditions presented themselves.

Chincoteague Bay was the most diverse embayment for macroalgae which can have both positive and negative impacts. Macroalgae may benefit the coastal bays in nutrient cycling and by providing cover, food and habitat for crustaceans, fishes and other organisms. Timmons (1995) found summer flounder from the south shores of Rehoboth Bay and Indian River have a preference for sand but have been captured near large aggregations of *Agardhiella tenera* only when large numbers of grass shrimp (*Palaemonetes vulgaris*) were present. This survey has also captured large numbers of summer founder in association with *Agardhiella tenera* and *Ulva*. Underwater visualization is needed to confirm those interactions because the catch was bundled together in the codend when the tow was complete.

Dense macroalgae canopies covering SAV were observed in Chincoteague and Sinepuxent bays which can indirectly inhibit the productivity of seagrasses through changes in the biogeochemical environment (Hauxwell *et al*. 2001). Shifts in the dominance of macroalgae over seagrasses in estuaries have been primarily attributed to nutrient overloading and light limitation. In estuaries where *Ulva* and *Zostera* co-exist and compete, climate change and eutrophication driven increases in carbon dioxide are likely to be important in promoting the dominance of *Ulva* over *Zostera* (Young *et al.* 2018).

Water Quality and Physical Characteristics

Temperature

Analysis of the 2017 Trawl Survey water quality data beginning in April showed increasing average water temperatures for Assawoman Bay, Isle of Wight Bay, St. Martin River, Newport Bay and Chincoteague Bay through July. Isle of Wight, Newport and Chincoteague Bays' water temperatures remained high from July to August before decreasing (Figure 46). Sinepuxent Bay peaked twice: once in June and then again in August after a slight dip in July. The highest surface (31.8 C) and bottom temperatures (30.7 C) were recorded at site T005 in July 2017 in the St. Martin River. Both the lowest surface (14.0 C) and bottom temperatures (12.4 C) for all bays were recorded in April at site T007 in Isle of Wight Bay, one of the closest sites to the Ocean City inlet.

The average temperature in 2017 from all trawl samples was 22.6 C, which was similar to 2016 (22.2 C). Newport Bay and the St. Martin River were the warmest bodies of water with both averaging 23.2 C. Chincoteague, Assawoman and Sinepuxent bays were similar with 22.9 C, 22.4 C and 22.2 C, respectively. For 2017, the mean surface temperature was 22.6 C. A significant increase in mean surface water temperature was observed from 1989 to 2017 ($r(28) = 0.58$, $p = 0.001$; Figure 47).

The Beach Seine Survey has two rounds of sampling in June and September; therefore, related water quality information does not show the gradual progression of measurements (temperature, salinity, DO and turbidity) possible from graphically representing data. There was a 4.7 C difference between the highest recorded temperature (28.6 C) and lowest temperature (23.9 C) during the month of June. In September, the temperature range was 3.8 C. The most abrupt decreases in temperature were seen at the Assawoman and Chincoteague bays sites in September with average temperature dropping 3.7 and 3.5 C, respectively. Those bays also experienced the largest drops in temperature compared to the other bays in 2016 with a decline of 2.4 C for Assawoman and 4.0 C for Chincoteague bays. The average temperature in Sinepuxent and Newport bays experienced a 2.8 C drop between the beach seining periods during 2017. In 2016, the temperature did not change for Sinepuxent Bay between the seining months and Newport Bay experienced a slight increase (0.4 C for September). The St. Martin River temperature did not change between sampling months for 2017 (Figure 48).

Dissolved Oxygen

As expected, trawl DO levels generally decreased as water temperatures increased (Figure 49). The surface DO levels never went below 5 mg/L. Bottom DO was below 5 mg/L 14 times in 2017 with the lowest reading of 1.1 mg/L in August at site T006 (Isle of Wight Bay, Turville Creek) which brought that bay's average down. The majority of occurrences for low DO tended to be in the northern bays. A significant increase in DO has been observed from 1989 to 2017 for all sites grouped together ($r(24) = 0.62$, $p = 0.0009$).

For the 2017 Beach Seine Survey, the DO was above 5 mg/L for all samples except two (Figure 50). Both instances occurred at the site accessed from land, S019 Ayers Creek.

Salinity

The 2017 Trawl Survey average salinity for all bays was 24.4 ppt which was lower than 2016 (25.6 ppt). Sinepuxent Bay had the highest average salinity at 26.7 ppt and the St. Martin River had the lowest (21.9 ppt). Sinepuxent Bay also had the highest salinity for 2016 (30.7 ppt). Chincoteague Bay salinity remained the most stable of the bays with minor fluctuations throughout the sampling season (Figure 51). The salinity was highest in July for all bays although Sinepuxent Bay reached that again in October.

For the 2017 Beach Seine Survey, salinity decreased from June to September at all sites. Sinepuxent Bay experienced the largest salinity decrease in September, dropping by 7 ppt (Figure 52).

Turbidity

As expected, the 2017 Trawl Survey Secchi analysis showed monthly turbidity fluctuations in all systems (Figure 53). Newport Bay was the most turbid water system (67.7 cm) whereas Isle of Wight Bay was the least (101.5 cm). The bottom was visible eight times (5.7%) out of 140 samples. A comparison of 2016 and 2017 trawl Secchi data demonstrates a decrease in visibility across the warmer months and 2017 (96.5 cm) was less turbid than 2016 (80.3 cm). Monitoring of turbidity was initiated in 2006 and continued through 2017. A significant increase in water clarity has been observed from 2006 to 2017 ($r(11) = 0.72$, $p = 0.007$; Figure 54).

An increase in turbidity was observed in Assawoman and Isle of Wight bays and the St. Martin River from June to September for the 2017 Beach Seine Survey (Figure 55). The most turbid system was Assawoman Bay with an average Secchi of 44.5 cm. Isle of Wight Bay had the best visibility for June and Sinepuxent Bay in September.

Discussion

Mean surface temperature has increased over the course of the survey since 1989. According to a time series of global temperature data from 1880 to 2017, 2016 was the warmest year, followed by 2017 (NASA 2017). Sustained increases in water temperature overtime will create habitat for southern fish species while reducing habitat for fish that cannot tolerate or prefer cooler water.

Of the water quality parameters, DO concentrations can 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 DO concentrations give rise to the concern that hypoxia is occurring in the Maryland coastal bays during the summer months.

Hypoxia exists when DO levels can no longer support the majority of life; the DO level for this condition is usually set below 2 mg/L. For organisms in the Chesapeake Bay, 5 mg/L is usually accepted as necessary for life, but can vary based on the organism. For example, a DO of 6 mg/L is necessary for larvae and eggs of migratory fish, however, some animals such as crabs and bottom dwelling fish can tolerate DO levels as low as 3 mg/L (Chesapeake Bay Program 2007).

Preliminary analysis of DO and fish catches from the surveys indicates that the coastal bays rarely experience low enough DO's to negatively impact fish abundances. DO peaks during the day and can actually supersaturate from photosynthesis and bottoms out at night when respiration occurs. Our sampling occurs during the day when low DO events impacts on fish catches may not be evident. Shen *et al*. (2008) investigated hypoxia in a Virginia tributary to the Chesapeake Bay, utilizing a DO-algae model to examine DO fluctuations beginning in July and ending in the fall. Experiments with the model demonstrated that macroalgae influenced the net ecosystem metabolism because of its respiration and growth rates. Nutrient input due to human activity would encourage blooms of macroalgae which would yield high DO levels during the day. During nighttime hours, DO levels were over-ridden by high respiration and hypoxia would result.

All bays experienced a decline in salinity after July which fits the observed 2017 weather patterns for Ocean City, Maryland. Precipitation measured 7.5 inches (19.1 cm) in July, 8.5 inches in August (21.6 cm) and 3.9 inches in September (9.9 cm; Wunderground, Inc. 2018). The increase in precipitation between the two months contributed to the salinity decreases.

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 2017. 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. Although mean surface temperature has risen since 2006, there was no statistical link between that increase and water clarity.

Carter *et al*. (1994) studied Potomac River water quality and weather data from 1980 to 1989 and reported that SAV coverage decreased when Secchi depths fell below 65 cm. Analysis of trawl Secchi values demonstrated a significant increase in water clarity ranging from an annual mean of 71.4 cm in 2006 to 104.3 cm for 2017 for all sites grouped together. These means are well above 65 cm. The turbidity in Maryland's Coastal Bays appears conducive for SAV growth.

Differences in DO, salinity, temperature and turbidity were influenced by the residence times of these systems. Donkers and Zimmerman define residence time as "the time it takes for any water parcel of the sample to leave the lagoon through its outlet to the sea." Residence times in the coastal bays increases with distance from an inlet and flow: Assawoman Bay 37 - 52 days; Isle of Wight Bay 5 - 6 days; Sinepuxent Bay 9 - 10 days; Newport Bay 47 - 92 days; and Chincoteague Bay 83 - 97 days (Maryland Department of Environment 2014).

References

Atlantic States Marine Fisheries Commission. Addendum III to Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden. 2006. Accessed July 06, 2017 from asmfc.org/uploads/file/546b96d4AtlMenhadenAddendumIII_06.pdf.org/uploads/file//546b96d4AtlMenhadenAddendumIII_06.pdf.

Beck, M.W, K.L. Heck Jr., K.W. Able, D.L. Childers, D.B. Eggleston, B.M. Gillanders, B.S. Halpern, C.G. Hays, K.H and T.J. Minello, The role of nearshore ecosystems as fish and shellfish nurseries. Issues of Ecology. Ecological Society of America. 2003;(11).

Carter, V., N.B. Rybicki, J.M. Landwehr and M. Turtora. Role of weather and water quality in population dynamics of submersed macrophytes in the tidal Potomac Estuaries. 1994: 17(2): 417-426.

Chesapeake Bay Program. Dissolved Oxygen-About the Bay. Chesapeake Bay Program. 2007. Accessed July 9 10, 2018 from chesapeakebay.net/discover/ecosystem.

Dennison, W. C., J. E. Thomas, C. J. Cain, T. J. B. Carruthers, M. R. Hall, R. V. Jesien, C. E. Wazniak, and D. E. Wilson. Shifting sands: Environmental and cultural changes in Maryland's coastal bays. Cambridge, MD: University of Maryland Center for Environmental Science; 2009.

Donker, J. and J.T.F. Zimmerman. Some principles of mixing in tidal lagoons. Oceanologica ACTA. (1982): 107-117.

Greater Ocean City Chamber of Commerce 2016 Legislative Priorities. 2016. Ocean City, MD: Greater Ocean City, Maryland Chamber of Commerce; Accessed July 06, 2017 from oceancity.org/wp-content/uploads/2014/12/2016-Legislative-priorities-with-detail-2.pdf.

Hauxwell, J., J. Cebrian, C. Furlong, and I. Valiela. 2001. Macroalgal canopies contribute to eelgrass (Zostera marina) decline in temperate estuarine ecosystems. Ecology 82 (4): 1007–1022.

Latour, R.J., J. Gartland, C. Bonzek and R.A. Johnson. The trophic dynamics of Summer Flounder in Chesapeake Bay. Fishery Bulletin. 2008;106(1):47-57. Accessed July 06, 2017 from http://fishbull.noaa.gov/1061/latour.pdf.

Maryland Department of the Environment. 2001. Total Maximum Daily Loads of Nitrogen and Phosphorus for Five Tidal Tributaries in the Northern coastal bays System Worcester County. Baltimore, MD: Maryland Department of the Environment.

Maryland Department of the Environment. 2014.Total Maximum Daily Loads of Nitrogen and Phosphorus for Assawoman Bay, Isle of Wight Bay, Sinepuxent Bay, Newport Bay and Chincoteague Bay in the Coastal Bays Watersheds in Worcester County, Maryland. Baltimore, MD: Maryland Department of the Environment.

Mid-Atlantic Fishery Management Council. Unmanaged Forage Omnibus Amendment. Council Actions. Web. 2017. Accessed August 4, 2017 from mafmc.org/actions/unmanaged-forage.

Murdy, E., R.S. Birdsong, and J.M. Musick. Fishes of Chesapeake Bay. Illustrated edition. Washington, DC. Smithsonian Institution Press; 1997.

Murdy, E. and J.M. Musick. Field Guide to Fishes of the Chesapeake Bay. Baltimore, MD. The Johns Hopkins University Press; 2013.

NASA. Global Climate Change: Evidence. NASA Global Climate Change and Global Warming: Vital Signs of the Planet. Jet Propulsion Laboratory / National Aeronautics and Space Administration, 18 January 2018. Accessed July 06, 2018 from climate.nasa.gov/evidence.

NOAA. Essential fish habitat source document: summer flounder, *Paralichthys dentatus*, life history and habitat characteristics. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NE-151. 1999. Accessed July 06, 2017 from nefsc.noaa.gov/nefsc/publications/tm/tm151/tm151.pdf.

Northeast Fisheries Science Center. 48th Northeast regional stock assessment workshop assessment summary report. US Dept. Commerce, National Marine Fisheries Service. 2009. Ref Doc. 09-10; 50 p. Accessed July 06, 2017 from nefsc.noaa.gov/nefsc/publications/.

Peters, R. and P. Chigbu. 2017. Spatial and temporal patterns of abundance of juvenile black sea bass (Centropristis striata) in Maryland coastal bays. Fish Bull.115:504-516 (2017).

Ricker, W. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada. Bulletin 191.

Shannon, C.E. A mathematical theory of communication. Bell System Technical Journal. 1948;27: 379–423.

Shen, J., T. Wang, J. Herman, P.D. Mason and G. Arnold. Hypoxia in a Coastal Embayment of the Chesapeake Bay: A Model Diagnostic Study of Oxygen Dynamics. Estuaries and Coasts 31: 652 (2008).

Timmons, M. 1995. Relationships between macroalgae and juvenile fishes in the inland bays of Delaware. Ph.D. dissertation, Univ. Delaware, Newark, DE. 155 p.

Virginia Institute of Marine Science. Monitoring - Interactive Map: Submerged Aquatic Vegetation (SAV) Monitoring Program. "SAV Monitoring in Chesapeake Bay and Coastal Bays." 2015. Accessed July 06, 2017 from web.vims.edu/bio/sav/maps.html.

Wazniak, C., D. Wells and M. Hall. 2004. Maryland's Coastal Bays: Ecosystem Health Assessment. The Maryland Coastal Bays Ecosystem. Document Number: DNR-12-1 02-0009. Chapter 1.2: Pg.9-20. Maryland Department of Natural Resources.

Wazniak, Catherine, D. Goshorn, M. Hall, D. Blazer, R. Jesien, D. Wilson, C. Cain, W. Dennison, J. Thomas, T. Carruthers and B. Sturgis. 2004. State of the Maryland Coastal Bays. Maryland Department of Natural Resources: Maryland Coastal Bays Program. University of Maryland Center for Environmental Science: Integration and Application Network.

Weather Underground. The Weather Company, LLC; 2018. Accessed August 15, 2018. wunderground.com.

Young, C.S., B.J. Peterson and C.J. Gobler. 2018. The Bloom-Forming Macroalgae, Ulva, Outcompetes the Seagrass, *Zostera marina*, Under High CO2 Conditions. Estuaries and Coasts: doi.org/10.1007/s12237-018-0437-0.

List of Tables

List of Figures

List of Figures (con't.)

List of Figures (con't.)

List of Figures (con't.)

List of Figures (con't.)

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, 2017. Species are listed by order of total abundance. Total trawl sites = 140, total beach 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*	15,890	8	15,882	0.5	417.9
Bay anchovy	*Anchoa mitchilli*	4,673	3,736	937	212.8	24.6
Atlantic silverside	*Menidia menidia*	2,482	13	2,469	0.7	65.0
Silver perch	*Bairdiella chrysoura*	1,849	625	1,224	35.6	32.2
Spot	*Leiostomus xanthurus*	987	340	647	19.4	17.0
Summer flounder	*Paralichthys dentatus*	545	262	283	14.9	7.4
Rough silverside	*Membras martinica*	257		257		6.8
Pinfish	*Lagodon rhomboides*	245	6	239	0.3	6.3
Golden shiner	*Notemigonus crysoleucas*	184		184		4.8
Hogchoker	*Trinectes maculatus*	152	132	20	7.5	0.5
Mummichog	*Fundulus heteroclitus*	125	6	119	0.3	3.1
Weakfish	*Cynoscion regalis*	109	109		6.2	
Oyster toadfish	*Opsanus tau*	96	34	62	1.9	1.6
Naked goby	*Gobiosoma bosc*	95	47	48	2.7	1.3
Winter flounder	*Pseudopleuronectes americanus*	81	23	58	1.3	1.5
Spotfin mojarra	*Eucinostomus argenteus*	74		74		1.9
Striped anchovy	*Anchoa hepsetus*	70	38	32	2.2	0.8
Atlantic croaker	*Micropogonias undulatus*	65	54	11	3.1	0.3
Bluefish	*Pomatomus saltatrix*	55	2	53	0.1	1.4
Striped killifish	*Fundulus majalis*	52		52		1.4
Dusky pipefish	*Syngnathus floridae*	49	10	39	0.6	1.0
Northern pipefish	*Syngnathus fuscus*	44	17	27	1.0	0.7
Halfbeak	*Hyporhamphus unifasciatus*	43		43		1.1
White mullet	*Mugil curema*	42		42		1.1
Black sea bass	*Centropristis striata*	38	36	2	2.0	<0.1
Pigfish	*Orthopristis chrysoptera*	34	5	29	0.3	0.8
Atlantic needlefish	*Strongylura marina*	31		31		0.8
American eel	*Anguilla rostrata*	29	10	19	0.6	0.5
Brown bullhead	*Ameiurus nebulosus*	29		29		0.8
Northern searobin	*Prionotus carolinus*	26	17	9	1.0	0.2
Black drum	*Pogonias cromis*	24	4	20	0.2	0.5
Smallmouth flounder	*Etropus microstomus*	24	10	14	0.6	0.4
Striped blenny	*Chasmodes bosquianus*	22	4	18	0.2	0.5
Rainwater killifish	*Lucania parva*	19	11	8	0.6	0.2
Sheepshead	*Archosargus probatocephalus*	18	2	16	0.1	0.4
Striped mullet	*Mugil cephalus*	17		17		0.4
Striped burrfish	*Chilomycterus schoepfii*	16	14	2	0.8	<0.1

Table 4. List of fishes collected in Maryland's Coastal Bays Trawl (T) and Beach Seine (S) Surveys from April through October, 2017. 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
Spotted seatrout	*Cynoscion nebulosus*	15	9	6	0.5	0.2
Lined seahorse	*Hippocampus erectus*	12	6	6	0.3	0.2
Northern kingfish	*Menticirrhus saxatilis*	12	6	6	0.3	0.2
Striped bass	*Morone saxatilis*	10		10		0.3
Northern puffer	*Sphoeroides maculatus*	9	8	1	0.5	<0.1
Seaweed pipefishes	*Syngnathus sp.*	9		9		0.2
Green goby	*Microgobius thalassinus*	6	2	4	0.1	0.1
Southern stingray	*Dasyatis americana*	6	1	5	0.1	0.1
Bluespotted cornetfish	*Fistularia tabacaria*	4	4		0.2	
Spotted hake	*Urophycis regia*	4	4		0.2	
Clearnose skate	*Raja eglanteria*	3	3		0.2	
Pumpkinseed	*Lepomis gibbosus*	3		3		<0.1
Red drum	*Sciaenops ocellatus*	3		3		<0.1
Tautog	*Tautoga onitis*	3		3		<0.1
Blackcheek tonguefish	*Symphurus plagiusa*	2		2		<0.1
Gray snapper	*Lutjanus griseus*	2		2		<0.1
Lookdown	*Selene vomer*	2	2		0.1	
Southern kingfish	*Menticirrhus americanus*	2		2		<0.1
Striped searobin	*Prionotus evolans*	2	2		0.1	
Windowpane	*Scophthalmus aquosus*	2	2		0.1	
Blue runner	*Caranx crysos*	1	1		0.1	
Butterfish	*Peprilus triacanthus*	1	1		0.1	
Conger eel	*Conger oceanicus*	1	1		0.1	
Harvestfish	*Peprilus paru*	1	1		0.1	
Skilletfish	*Gobiesox strumosus*	1		1		<0.1
Spotfin butterflyfish	*Chaetodon ocellatus*	1		1		<0.1
Sunfishes	*Centrarchidae*	1		1		<0.1
Unknown juvenile fish	*Unknown Juvenile Fish*	1		1		<0.1
	Total Finfish	**28,710**	**5,628**	**23,082**		

Table 5. Number of species and individual fish caught by year and gear from 2007 to 2017.

	Number of Species			Number of fish		
Year	Trawl	Seine	Combined	Trawl	Seine	Combined
2007	58	61	79	12,937	12,373	25,310
2008	56	59	79	26,942	19,122	46,065
2009	56	59	78	5,385	13,775	19,160
2010	49	59	74	10,887	34,552	45,439
2011	56	50	70	8,232	20,666	28,898
2012	52	57	71	36,002	11,289	47,291
2013	50	60	76	14,213	7,640	21,853
2014	46	58	68	7,586	52,093	60,329
2015	59	59	74	8,568	33,139	41,777
2016	44	63	71	9,480	18,187	27,667
2017	44	54	65	5,628	23,082	28,710

Table 6. Summary of 2017 species abundance: defined as above, below, or equal to the grand mean.

Common Name	**Scientific Name**	**Trawl**	**Beach Seine**
American eel	*Anguilla rostrata*	Equal to =	Equal to =
Atlantic croaker	*Micropogonias undulatus*	Below -	Equal to =
Atlantic menhaden	*Brevoortia tyrannus*	Below -	Equal to =
Atlantic silverside	*Menidia menidia*	Below -	Equal to =
Bay anchovy	*Anchoa mitchilli*	Equal to =	Equal to =
Black sea bass	*Centropristis striata*	Below -	Below -
Bluefish	*Pomatomus saltatrix*	Below -	Equal to =
Sheepshead	*Archosargus probatocephalus*	Below -	Equal to =
Silver Perch	*Bairdiella chrysoura*	Above +	Equal to =
Spot	*Leiostomus xanthurus*	Below -	Below -
Summer flounder	*Paralichthys dentatus*	Below -	Above +
Tautog	*Tautoga onitis*	Below -	Equal to =
Weakfish	*Cynoscion regalis*	Below -	Below -

Table 7. List of crustaceans collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2017. Species are listed by order of total abundance. Total trawl sites = 140, total beach 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*	4,770	2,455	2,315			139.8	61.2
Grass shrimp	*Palaemonetes sp.*	2,657	118	14	410	2,115	30.1	56.0
Sand shrimp	*Crangon septemspinosa*	2,468	591	8	1,844	25	138.7	1.9
Lady crab	*Ovalipes ocellatus*	413	141	272			8.0	10.3
Say mud crab	*Dyspanopeus sayi*	404	378	26			21.5	0.7
White shrimp	*Litopenaeus setiferus*	263	227	36			12.9	0.9
Long-armed hermit crab	*Pagurus longicarpus*	222	133	89			7.6	2.4
Brown shrimp	*Farfantepenaeus aztecus*	28	12	16			0.7	0.4
Atlantic mud crab	*Panopeus herbstii*	13	13				0.7	
Atlantic rock crab	*Cancer irroratus*	13	13				0.7	
Mud shrimp	*Gilvossius setimanus*	5		5				0.1
Spider crabs	*Libinia*	3	2	1			0.1	<0.1
Portly spider crab	*Libinia emarginata*	2	2				0.1	
Unknown crustacean	*Unknown Crustacean*	2	2				0.1	
Bigclaw snapping shrimp	*Alpheus heterochaelis*	1	1				0.1	
Iridescent swimming crab	*Portunus gibbesii*	1	1				0.1	
Snapping shrimps	*Alpheidae*	1		1				<0.1
	Total Crustaceans	**11,266**	**4,089**	**2,783**	**2,254**	**2,140**		

Table 8. List of molluscs collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2017. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	No. Collec (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
Mudsnails	*Nassarius sp.*	435	5	5	25	400					1.7	10.7		
Eastern mudsnail	*Nassarius obsoletus*	384	5	19		360					0.3	10.0		
Blue mussel	*Mytilus edulis*	267	2		265						15.2			
Convex slippersnail	*Crepidula convexa*	252	1	1		250					0.1	6.6		
Solitary glassy bubble snail	*Haminoea solitaria*	87	12		75						5.0			
Atlantic brief squid	*Lolliguncula brevis*	24	24								1.4			
Atlantic oyster drill	*Urosalpinx cinerea*	8	5	3							0.3	<0.1		
Northern quahog	*Mercenaria mercenaria*	3	3								0.2			
Dwarf surfclam	*Mulinia lateralis*	2	2								0.1			
Lemon drop	*Doriopsilla pharpa*	2	2								0.1			
Purplish tagelus	*Tagelus divisus*	2	2								0.1			
Bruised nassa	*Nassarius vibex*	1	1								0.1			
Common jingle	*Anomia simplex*	1	1								0.1			
Ribbed mussel	*Geukensia demissa*	1		1								<0.1		
Stout tagelus	*Tagelus plebeius*	1	1								0.1			
	Total Molluscs	**1,470**	**66**	**29**	**365**	**1,010**								

Table 9. List of other species collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2017. Species are listed by order of total abundance. Total trawl sites = 140, total beach 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*	1,253	153	12	738	350	3.4				50.7	9.5	0.2	
Comb jellies	*Ctenophora*	588	77	6	460	45	424.2	256.2	7.7	3.0	30.6	1.3	24.6	6.8
Sea nettle	*Chrysaora quinquecirrha*	374	233	5	136		7.7		5.0		21.0	0.1	0.7	
Hairy sea cucumber	*Sclerodactyla briareus*	195	84	11		100					4.8	2.9		
Horseshoe crab	*Limulus polyphemus*	65	39	26							2.2	0.8		
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	22	3	19							0.2	0.5		
Beroe comb jelly	*Beroe ovata*	17	17								1.0			
Moon jelly	*Aurelia aurita*	9	8	1					2.0		0.5	<0.1	0.1	
Common sea cucumber	*Cucumaria pulcherrima*	3	2	1							0.1	<0.1		
Sea cucumbers	*Cucumariidae*	2	1	1							0.1	<0.1		
Goldstar tunicate	*Botryllus schlosseri*						3.5	5.7					0.2	0.2
Sea pork	*Aplidium sp.*						14.6	0.6					0.8	<0.1
Bryozoans	*Ectoprocta*						179.0	17.3	0.3				10.2	0.5
Rubbery bryozoan	*Alcyonidium sp.*						10.7	0.9					0.6	<0.1
Fig sponge	*Suberites ficus*						0.0							
Halichondria sponge	*Halichondria sp.*						234.6	31.2					13.4	0.8
Red beard sponge	*Microciona prolifera*						69.9	1.3					4.0	<0.1
Sulphur sponge	*Cliona celata*						89.7						5.1	
	Total Other	**2,528**	**617**	**82**	**1,334**	**495.0**	**1,037.3**	**313.2**	**14.9**	**3.0**				

Table 10. List of Submerged Aquatic Vegetation (SAV) and macroalgae collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October, 2017. 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					
Eelgrass	*Zostera*	6.4	58.6		
Widgeon grass	*Ruppia*	4.5	17.8		
Unknown freshwater SAV	*Unknown*		0.3		
	Total SAV	**10.9**	**76.7**		
Macroalgae					
Brown					
Sour weeds	*Desmarestia*	5.0	77.5		
Common southern kelp	*Laminaria*	0.3			
Rockweed	*Fucus*	0.1			
Brown bubble algae	*Colpomenia*	0.1			
		5.5	**77.5**		
Green					
Green hair algae	*Chaetomorpha*	179.6	4.4		
Sea lettuce	*Ulva*	61.9	329.5	0.3	
Green fleece	*Codium*	42.7	71.4		
Hollow green weed	*Enteromorpha*	10.6	13.6		
Green tufted seaweed	*Cladophora*	7.8	0.2		
Green sea fern	*Bryopsis*	1.0			
		303.6	**419.1**	**0.3**	
Red					
Agardh’s red weed	*Agardhiella*	1,804.0	2,100.9	0.5	
Tubed weeds	*Polysiphonia*	301.2	101.9		
Banded weeds	*Ceramium*	56.5	8.4		
Graceful red weed	*Gracilaria*	14.7			
Hairy basket weed	*Spyridia*	1.9			
Barrel weed	*Champia*	0.3	0.2		
		2,178.5	**2,211.4**	**0.5**	
Yellow-Green					
Water felt	*Vaucheria*	41.7	20.9		
		41.7	**20.9**		
	Total Macroalgae	**2,529.2**	**2,728.9**	**0.8**	

Table 11. Length by month for selected fishes from the Trawl Survey in 2017.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
American eel (*Anguilla rostrata*)	Apr	1	1	51	51	51	
	May	5	5	48	64	57	6
	Jun	1	1	60	60	60	
	Jul	3	3	81	150	111.3	35.2
	Aug						
	Sep						
	Oct						
Atlantic croaker (*Micropogonias undulatus*)	Apr	6	6	25	87	45.3	26.4
	May	10	10	31	120	71.4	33.6
	Jun	1	1	141	141	141	
	Jul	2	2	159	164	161.5	3.5
	Aug						
	Sep	3	3	25	31	28.7	3.2
	Oct	32	30	16	62	34.2	12
Atlantic menhaden (*Brevoortia tyrannus*)	Apr	1	1	41	41	41	
	May	5	5	41	56	50.4	5.7
	Jun						
	Jul						
	Aug	2	2	57	85	71	19.8
	Sep						
	Oct						
Atlantic silverside (*Menidia menidia*)	Apr						
	May						
	Jun	5	5	38	128	86.6	33.7
	Jul						
	Aug	4	4	80	90	83.5	4.4
	Sep	4	4	30	83	65.8	24.4
	Oct						
Bay anchovy (*Anchoa mitchilli*)	Apr	45	36	38	88	68.6	12.5
	May	42	42	30	90	65.2	12.1
	Jun	159	107	53	91	74.8	8.6
	Jul	796	215	22	106	49.1	19.6
	Aug	1,307	241	31	95	50.5	15.4
	Sep	1,186	263	21	101	56.1	12.4
	Oct	201	91	24	86	53.3	12.9

Table 11 cont. Length by month for selected fishes from the Trawl Survey in 2017.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
Black sea bass (*Centropristis striata*)	Apr	1	1	90	90	90	
	May	3	3	55	111	76.3	30.3
	Jun	4	4	89	120	106.5	13
	Jul	8	8	107	146	124.5	13.6
	Aug	7	7	121	176	148.6	21.4
	Sep	5	5	64	180	126.8	53.3
	Oct	8	8	98	190	166.4	29.7
Bluefish (*Pomatomus saltatrix*)	Apr						
	May						
	Jun						
	Jul	1	1	82	82	82	
	Sep	1	1	208	208	208	
	Oct						
Sheepshead (*Archosargus probatocephalus*)	Apr						
	May						
	Jun						
	Jul						
	Sep						
	Oct	2	2	122	122	122	
Silver perch (*Bairdiella chrysoura*)	Apr	1	1	171	171	171	
	May	2	2	127	135	131	5.7
	Jun	1	1	121	121	121	
	Jul	217	118	15	121	44.2	17.9
	Aug	197	135	50	180	87.1	18.6
	Sep	199	145	40	165	97.6	19.6
	Oct	8	8	91	125	107.6	11.6
Spot (*Leiostomus xanthurus*)	Apr						
	May	10	10	22	105	47.4	23.3
	Jun	246	124	31	145	79.5	29.5
	Jul	40	40	68	181	124.4	21.8
	Aug	31	31	98	185	150.2	19.8
	Sep	13	13	134	181	163.4	13.2
	Oct						

Table 11 cont. Length by month for selected fishes from the Trawl Survey in 2017. Tautog (*Tautoga onitis*) were not present in the survey and were not included.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
Summer flounder (*Paralichthys dentatus*)	Apr	15	15	24	462	100	131
	May	72	55	30	190	71.1	26.1
	Jun	77	77	45	360	89	45.8
	Jul	35	35	82	336	114.2	43.4
	Aug	45	45	42	339	126.4	53.6
	Sep	13	13	102	327	138.5	58.4
	Oct	5	5	99	430	189.8	136
Weakfish (*Cynoscion regalis*)	Apr						
	May						
	Jun	2	2	27	162	94.5	95.5
	Jul	65	44	32	119	64.3	19
	Aug	31	30	40	146	96.5	23.4
	Sep	10	10	115	156	132	15.4
	Oct	1	1	170	170	170	

Table 12. Length by month for selected fishes from the Beach Seine Survey in 2017. Weakfish (*Cynoscion regalis*) were not present in the survey and were not included.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
American eel	Jun	11	11	60	485	234.3	130.6
(*Anguilla rostrata*)	Sep	8	8	65	210	153	55.9
Atlantic croaker	Jun	10	10	100	140	121.3	12.4
(*Micropogonias undulatus*)	Sep	1	1	42	42	42	
Atlantic menhaden	Jun	15,578	193	34	100	50.8	10.6
(*Brevoortia tyrannus*)	Sep	304	22	70	152	100.5	19.5
Atlantic silverside	Jun	709	277	20	175	74.7	30.6
(*Menidia menidia*)	Sep	1,760	260	45	103	80	11.6
Bay anchovy	Jun	338	134	35	90	72.1	9.9
(*Anchoa mitchilli*)	Sep	599	152	25	74	52.9	7.7
Black sea bass	Jun	1	1	45	45	45	
(*Centropristis striata*)	Sep	1	1	160	160	160	
Bluefish	Jun	27	27	58	123	78.3	17.8
(*Pomatomus saltatrix*)	Sep	26	26	102	238	160.9	36.6
Sheepshead	Jun						
(*Archosargus probatocephalus*)	Sep	16	16	62	117	88.1	14.8
Silver perch	Jun	11	11	120	181	155.7	20.6
(*Bairdiella chrysoura*)	Sep	1,213	184	34	188	80.8	26.3
Sheepshead	Jun						
(*Archosargus probatocephalus*)	Sep	16	16	62	117	88.1	14.8
Spot	Jun	607	316	30	141	84.2	26.7
(*Leiostomus xanthurus*)	Sep	40	37	42	210	174.9	29.2
Summer flounder	Jun	262	187	35	325	89.7	28.3
(*Paralichthys dentatus*)	Sep	21	21	100	396	156.6	64.6
Tautog	Jun						
(*Tautoga onitis*)	Sep	3	3	68	90	81	11.5

Table 13**.** Finfish richness and diversity by embayment for the 1989 - 2017 Trawl Survey. Richness is the number of different species sampled in the embayment. Diversity is defined by the Shannon index, which is a measurement of richness combined with how evenly distributed the numbers of each species are by embayment. Sample size: Assawoman Bay (n = 609); St. Martin River (n = 406); Isle of Wight Bay (n = 406); Sinepuxent Bay (n = 609); Newport Bay (n = 406); Chincoteague Bay (n = 1624).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	78	28	1.41
St. Martin River	75	23	1.36
Isle of Wight Bay	84	31	1.63
Sinepuxent Bay	74	25	1.68
Newport Bay	67	22	1.45
Chincoteague Bay	89	36	1.49

Table 14. Finfish richness and diversity by embayment for the 2017 Trawl Survey. Richness is the number of different species sampled in the embayment. Diversity is defined by the Shannon index, which is a measurement of richness combined with how evenly distributed the numbers of each species are by embayment. Sample size: Assawoman Bay (n = 21); St. Martin River (n = 14); Isle of Wight Bay (n = 14); Sinepuxent Bay (n = 21); Newport Bay (n = 14); Chincoteague Bay (n = 56).

Embayment	Richness	Diversity
Assawoman Bay	18	1.27
St. Martin River	19	1.42
Isle of Wight Bay	25	1.38
Sinepuxent Bay	23	0.68
Newport Bay	19	1.69
Chincoteague Bay	27	1.12

Table 15. Finfish richness and diversity by embayment for the 1989 - 2017 Beach Seine Survey. Richness is the number of different species sampled in the embayment. Diversity is defined by the Shannon index, which is a measurement of richness combined with how evenly distributed the numbers of each species are by embayment. Ayers Creek was not considered an embayment. Sample size: Assawoman Bay (n = 174); St. Martin River (n = 58); Isle of Wight Bay (n = 174); Sinepuxent Bay (n = 174); Newport Bay (n = 116); Chincoteague Bay (n = 348); Ayers Creek (n = 58).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	85	30	1.62
St. Martin River	70	20	1.31
Isle of Wight Bay	87	29	1.61
Sinepuxent Bay	76	25	1.35
Newport Bay	66	19	1.60
Chincoteague Bay	76	31	1.63
Ayers Creek	44	15	1.24

Table 16. Finfish richness and diversity by embayment for the 2017 Beach Seine Survey. Richness is the number of different species sampled in the embayment. Diversity is defined by the Shannon index, which is a measurement of richness combined with how evenly distributed the numbers of each species are by embayment. Ayers Creek was not considered an embayment. Sample size: Assawoman Bay (n = 6); St. Martin River (n = 2); Isle of Wight Bay (n = 6); Sinepuxent Bay (n = 6); Newport Bay (n = 4); Chincoteague Bay (n = 12); Ayers Creek (n = 2).

Embayment	Richness	Diversity
Assawoman Bay	26	1.87
St. Martin River	21	1.61
Isle of Wight Bay	30	2.04
Sinepuxent Bay	28	0.97
Newport Bay	28	0.75
Chincoteague Bay	35	1.29
Ayers Creek	7	1.01

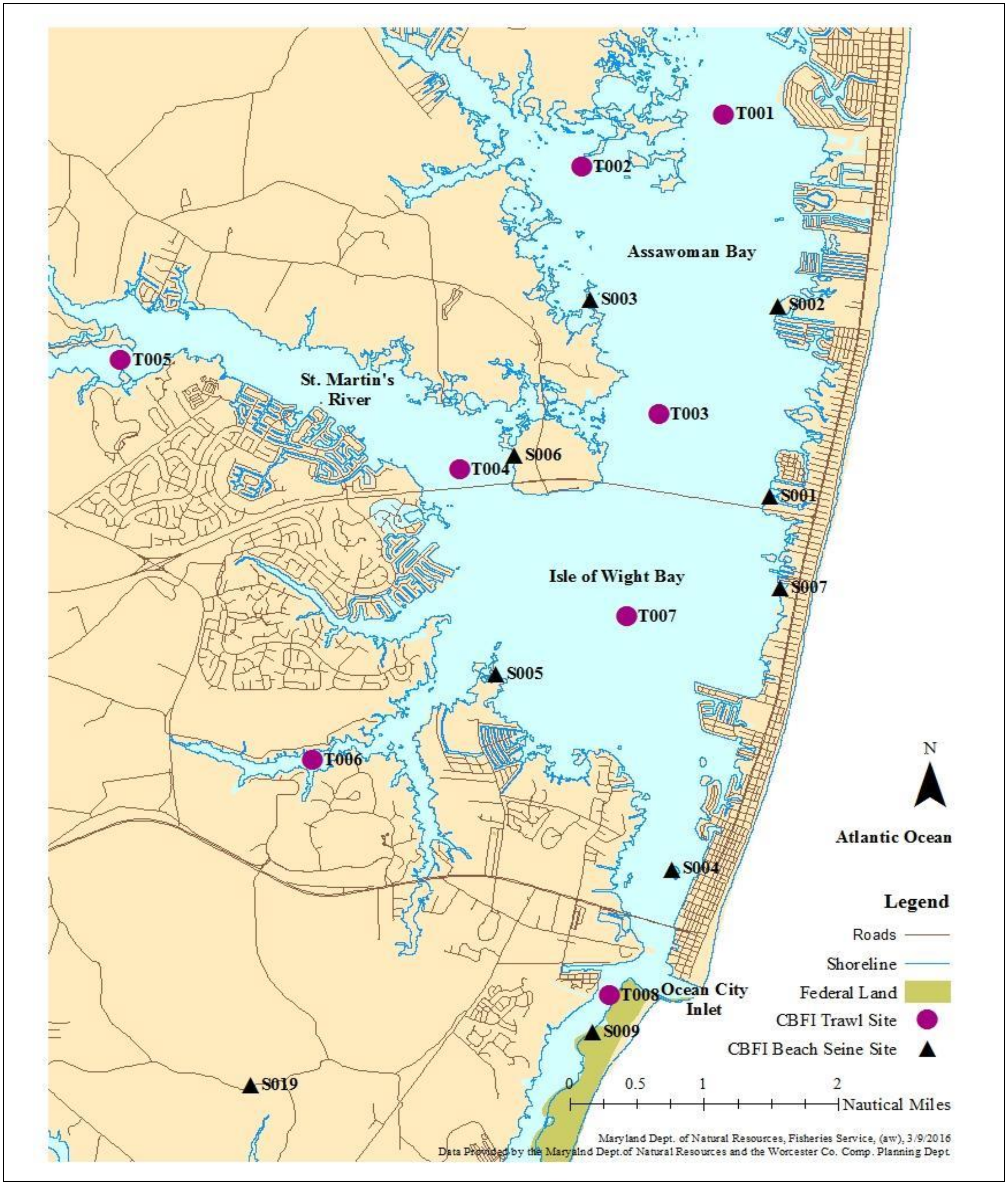

Figure 1. Trawl and Beach Seine surveys 2017 sampling locations in the Assawoman and Isle of Wight Bays, Maryland.

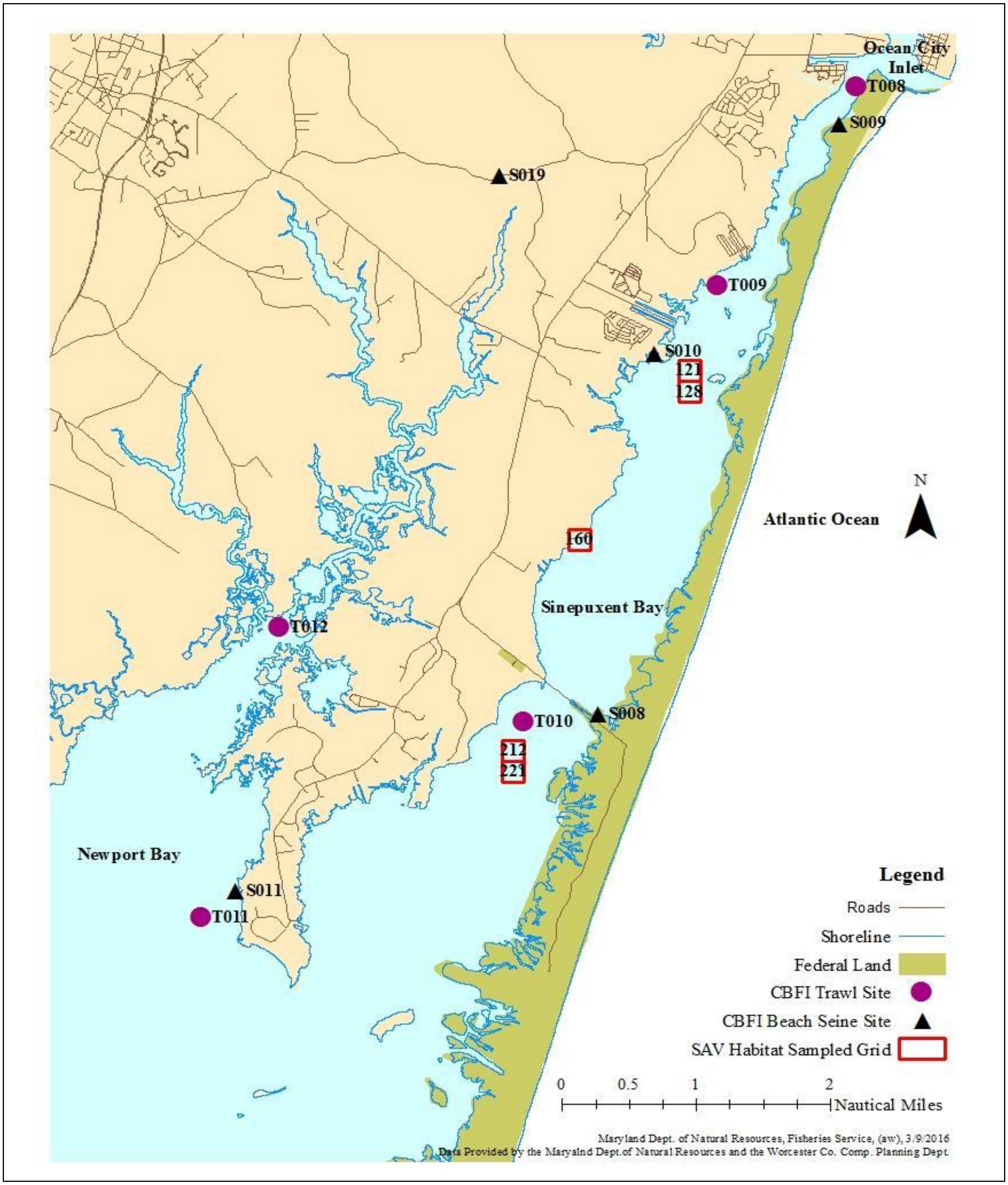

Figure 2. Trawl and Beach Seine surveys 2017 sampling locations in Sinepuxent and Newport bays, Maryland.

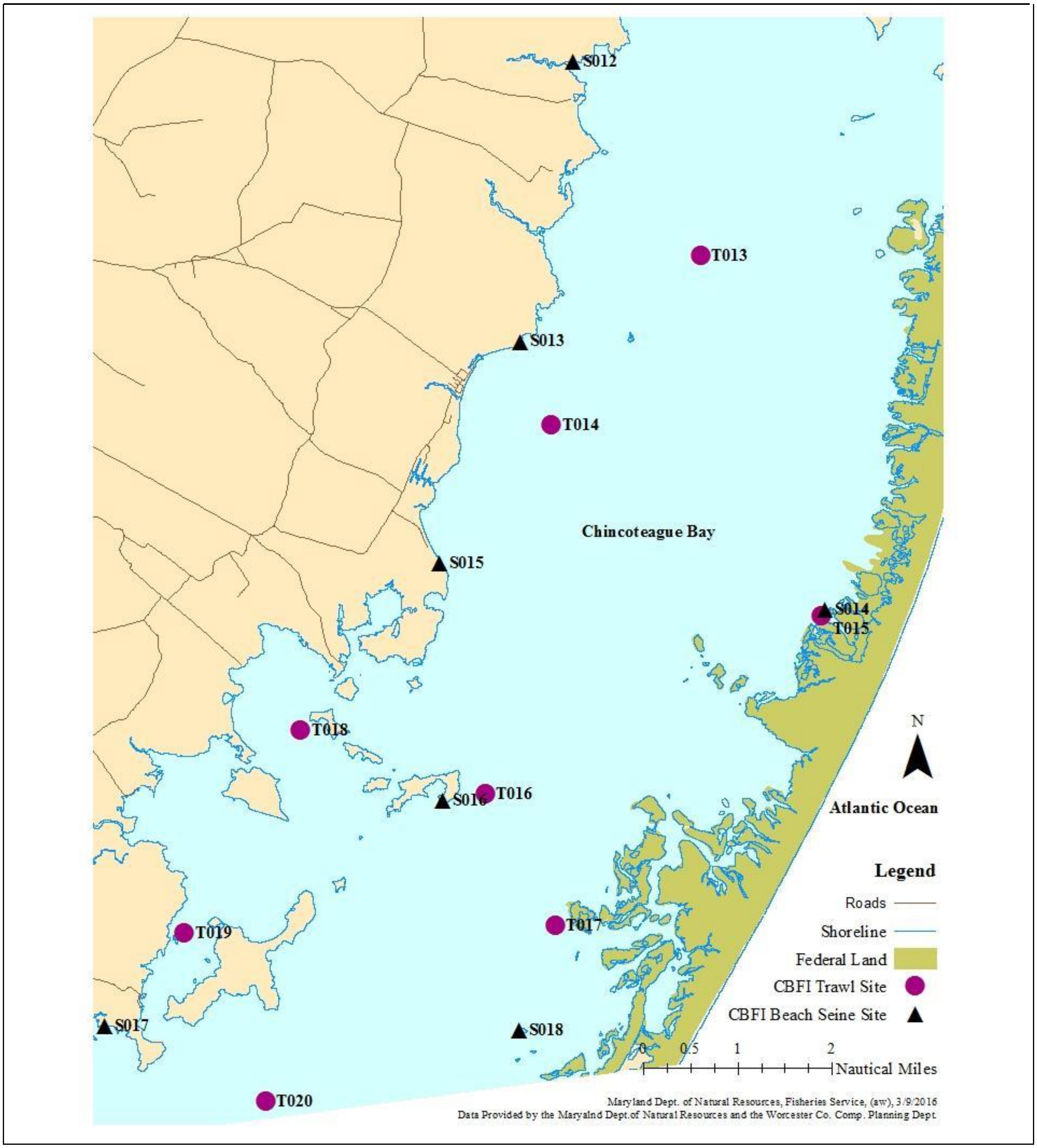

Figure 3. Trawl and Beach Seine surveys 2017 sampling locations in Chincoteague Bay, Maryland.

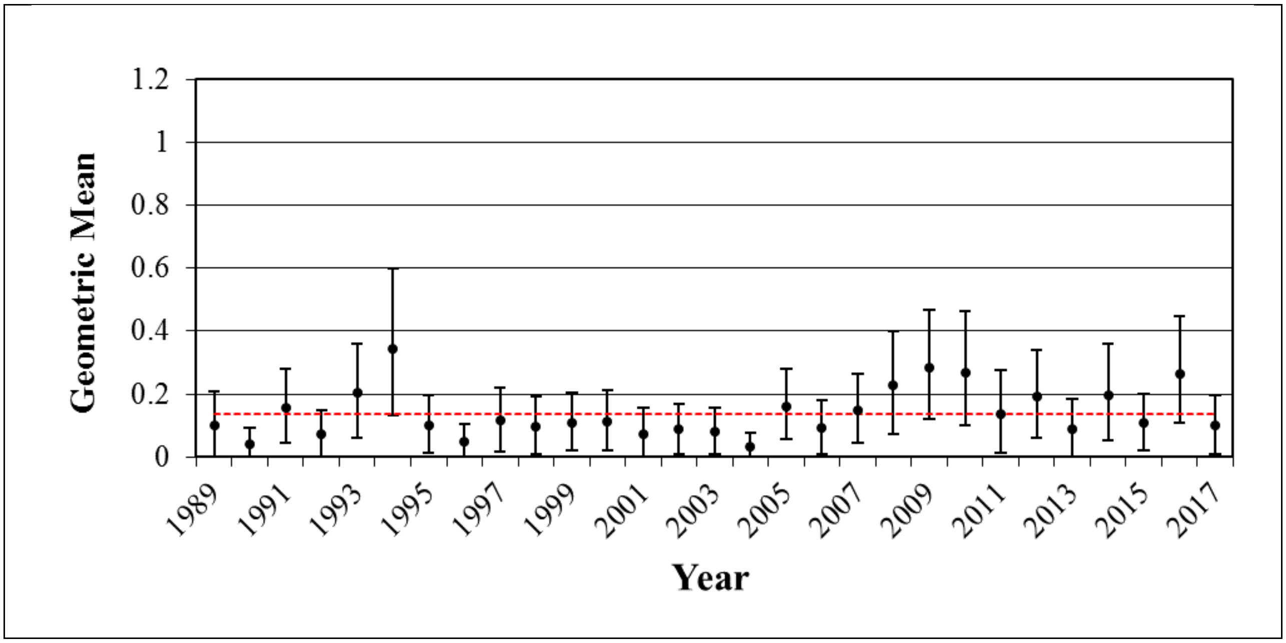

Figure 4. American eel (*Anguilla rostrata)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

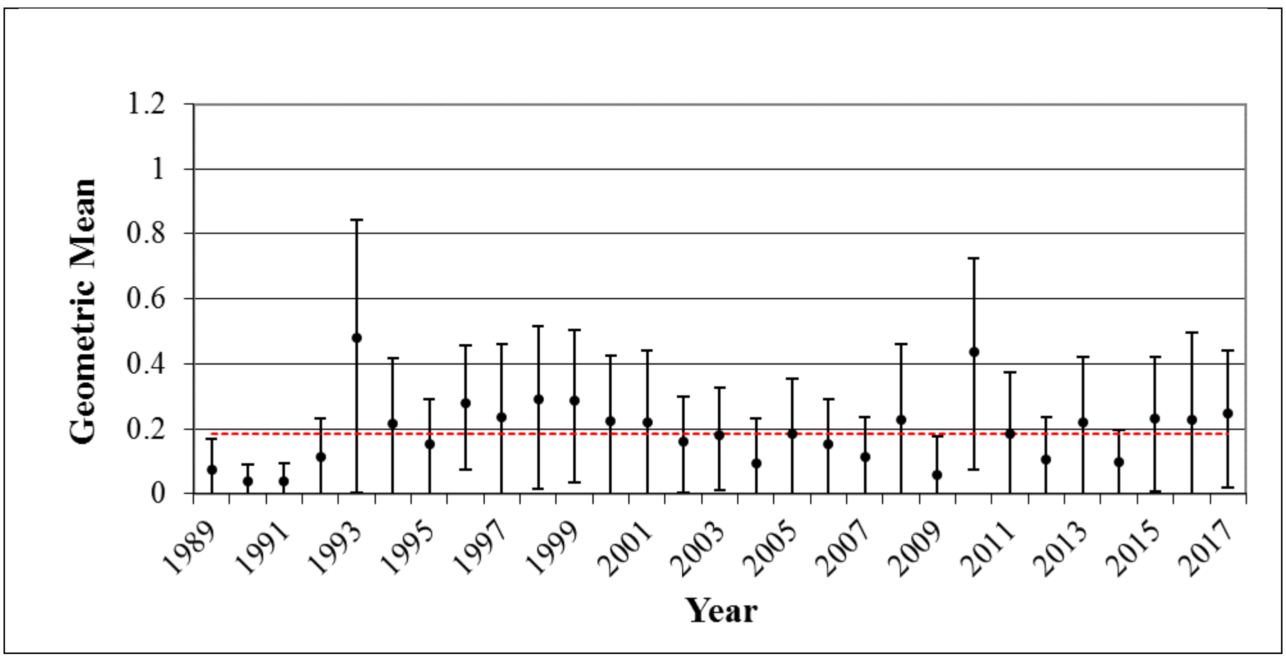

Figure 5. American Eel (Anguilla rostrata) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

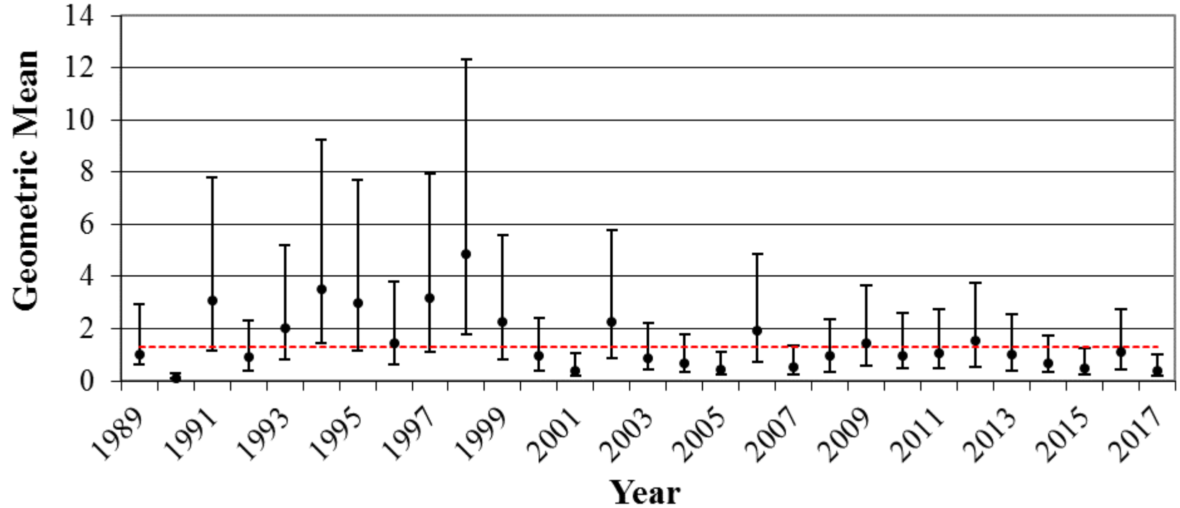

Figure 6. Atlantic croaker (*Micropogonias undulates*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

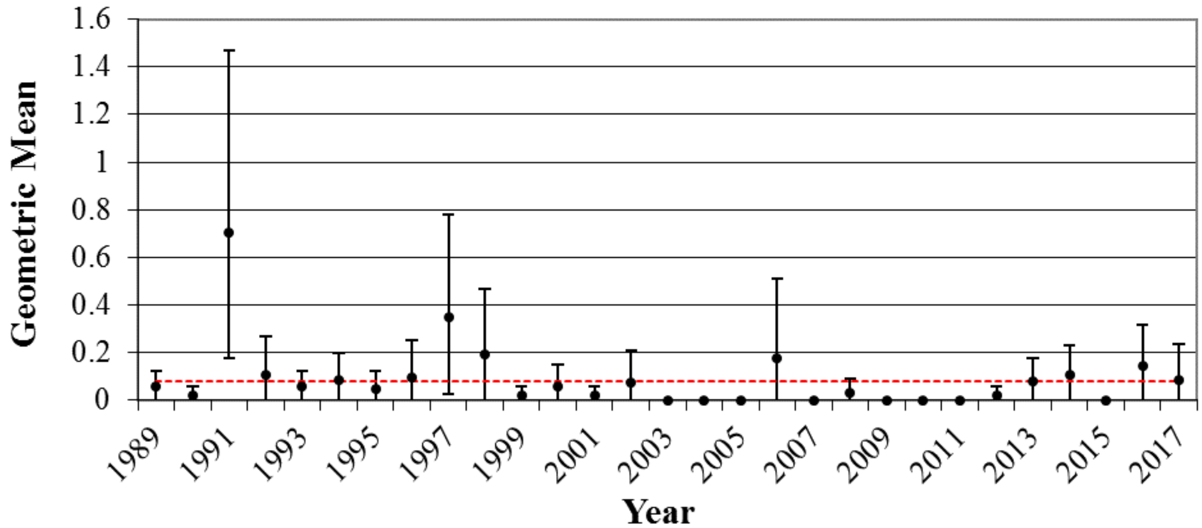

Figure 7. Atlantic croaker (*Micropogonias undulates*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

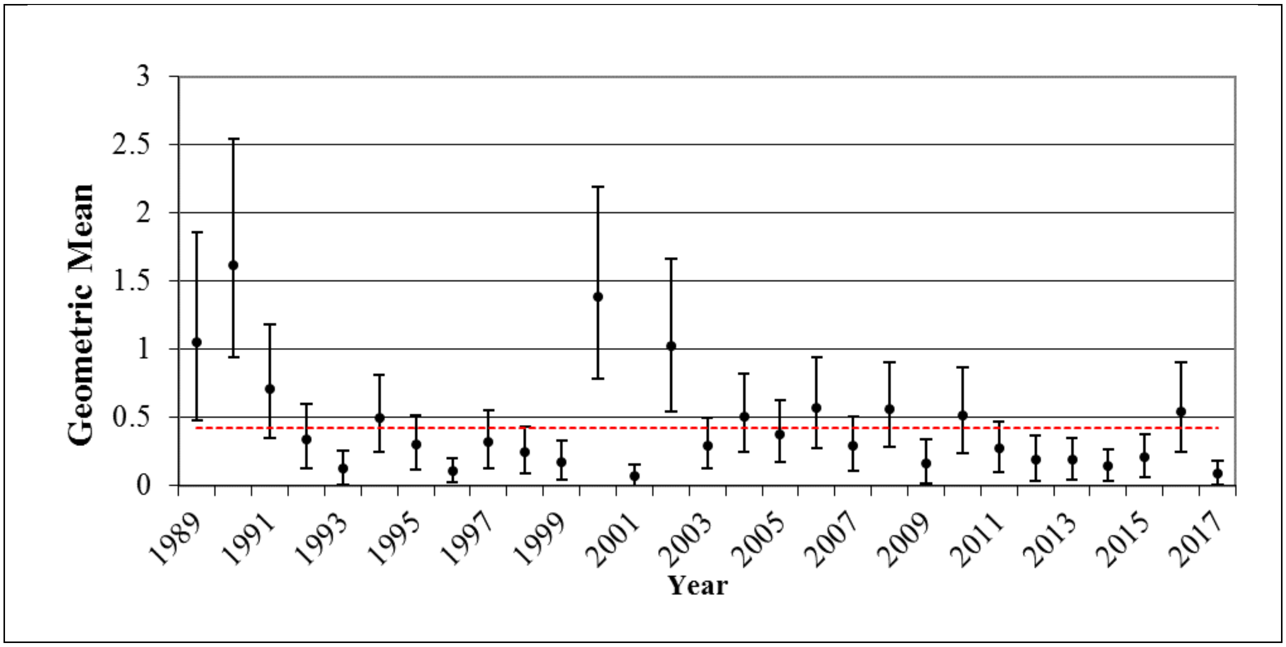

Figure 8. Atlantic menhaden (Brevoortia tyrannus) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

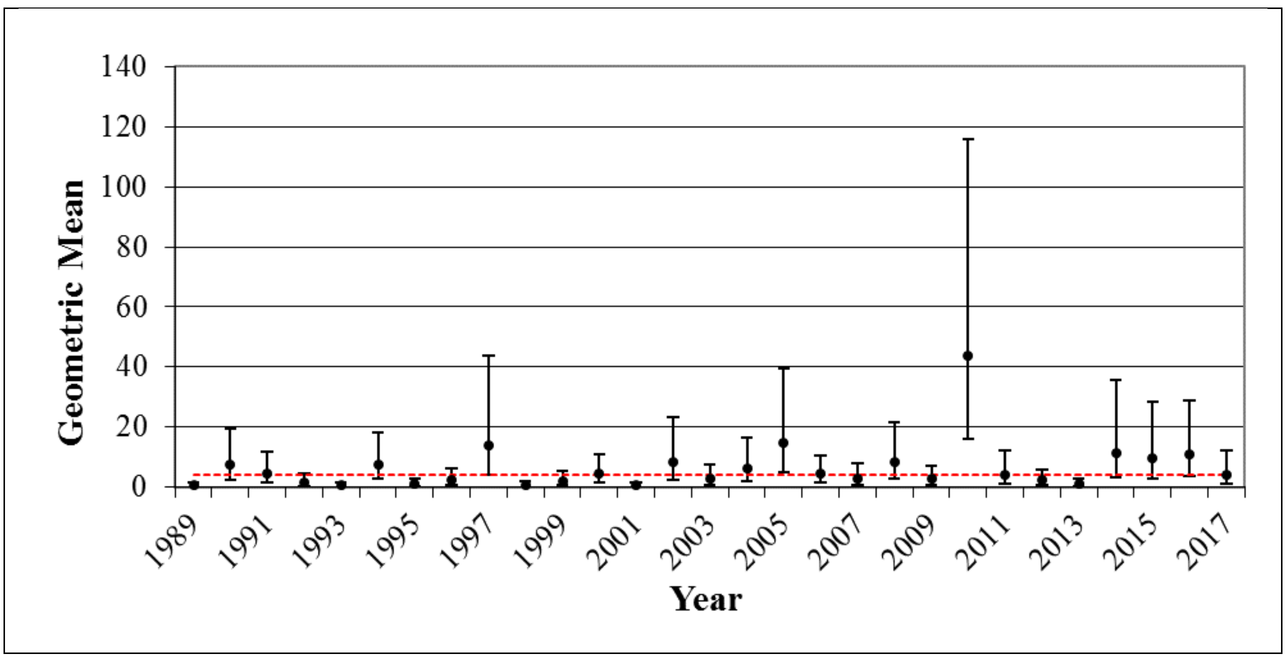

Figure 9. Atlantic menhaden (*Brevoortia tyrannus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

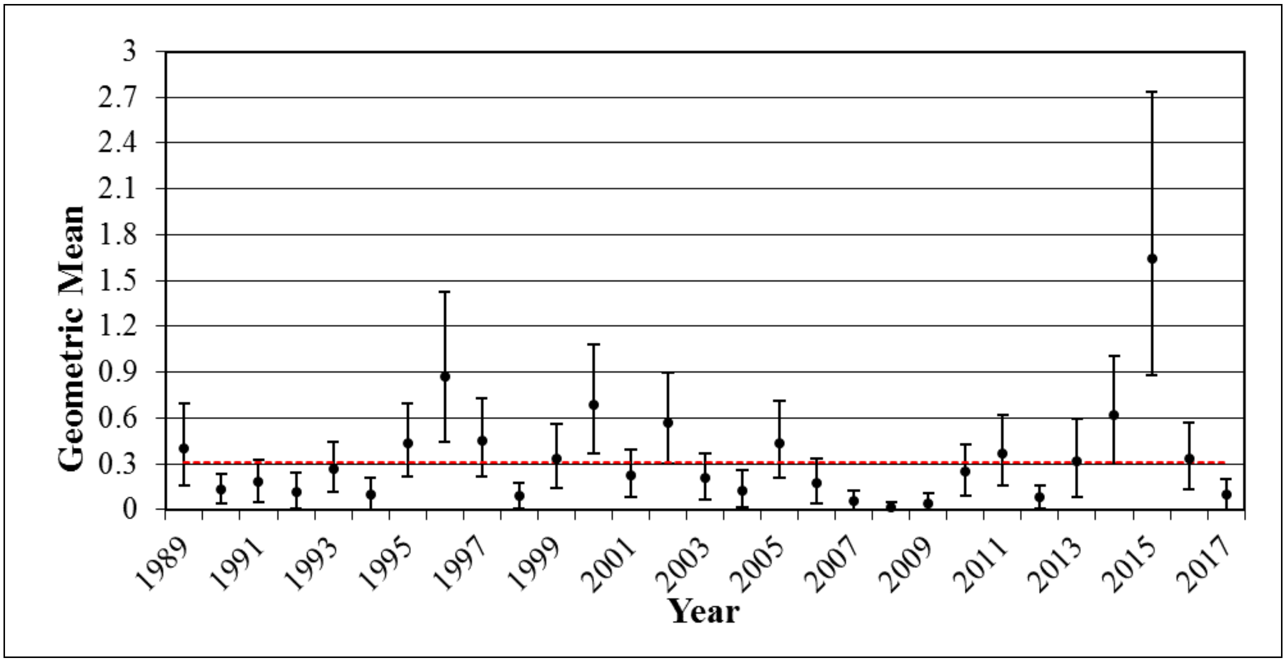

Figure 10. Atlantic silverside (*Menidia menidia*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

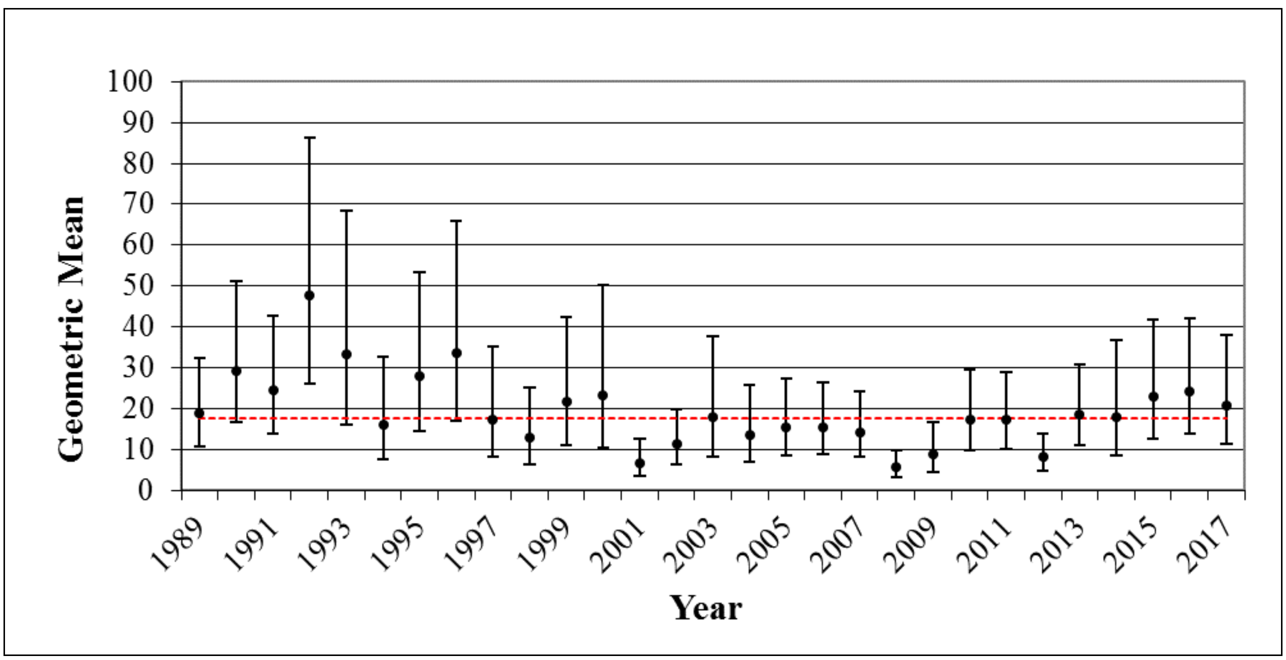

Figure 11. Atlantic silverside (*Menidia menidia*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

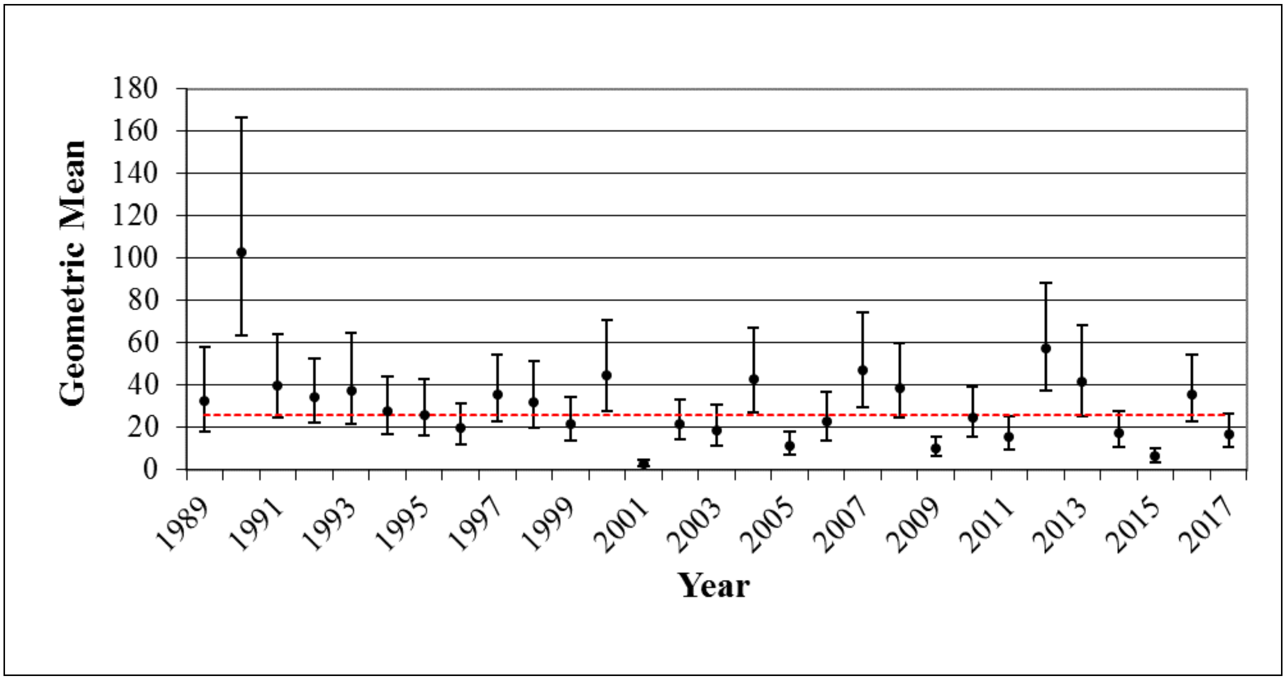

Figure 12. Bay anchovy (*Anchoa mitchilli*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

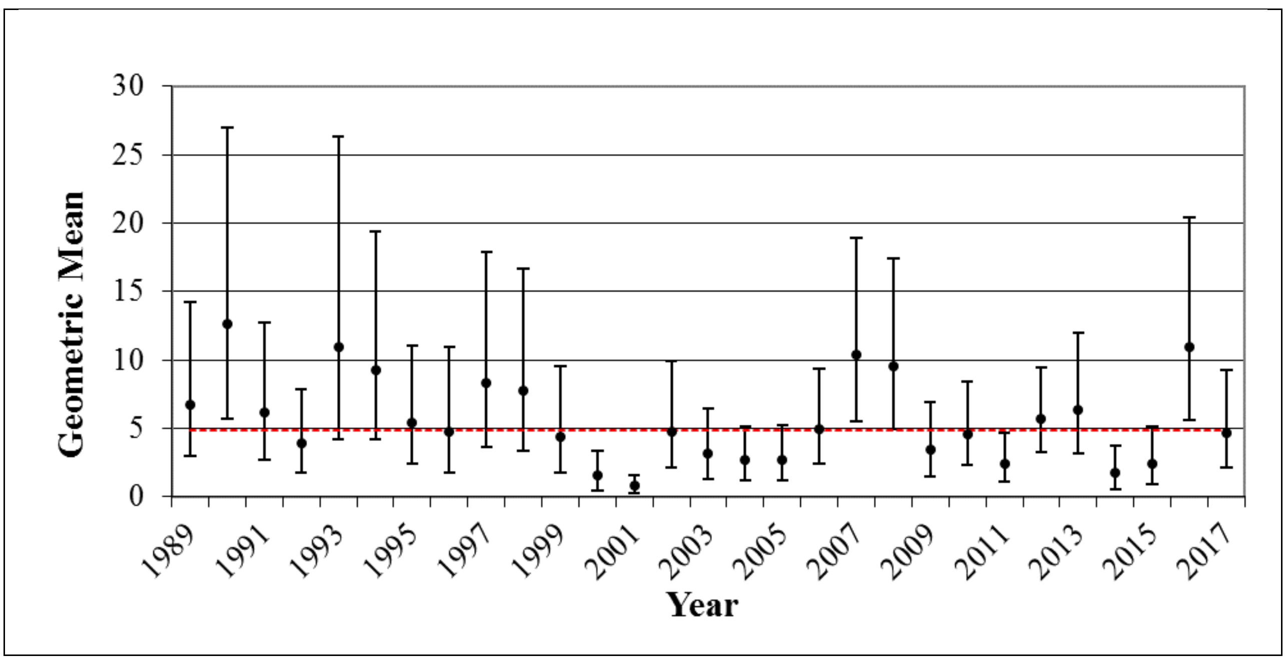

Figure 13. Bay anchovy (*Anchoa mitchilli*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

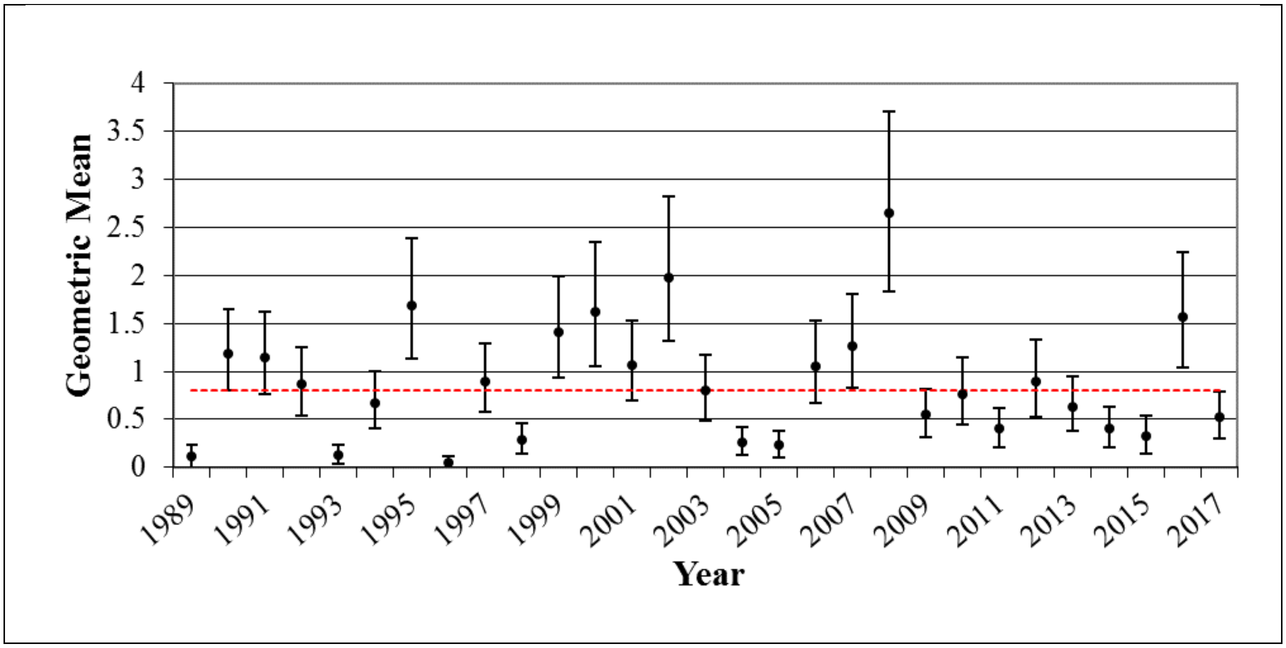

Figure 14. Black sea bass (*Centropristis striata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

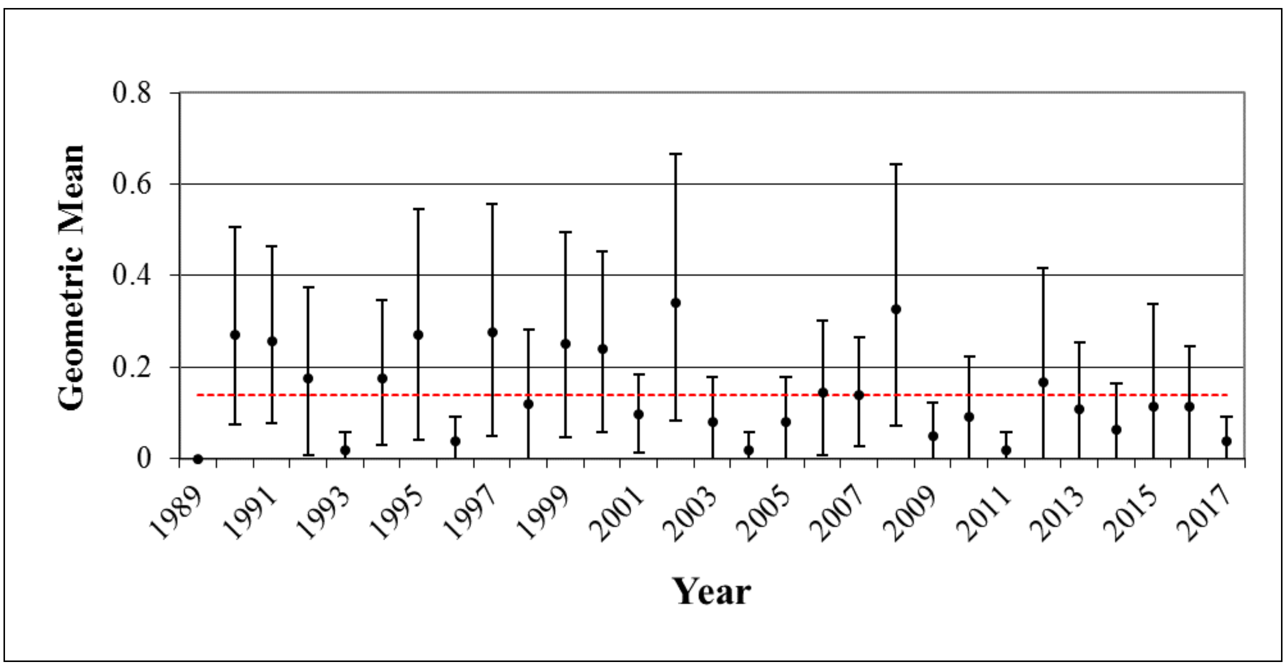

Figure 15. Black sea bass (*Centropristis* striata) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

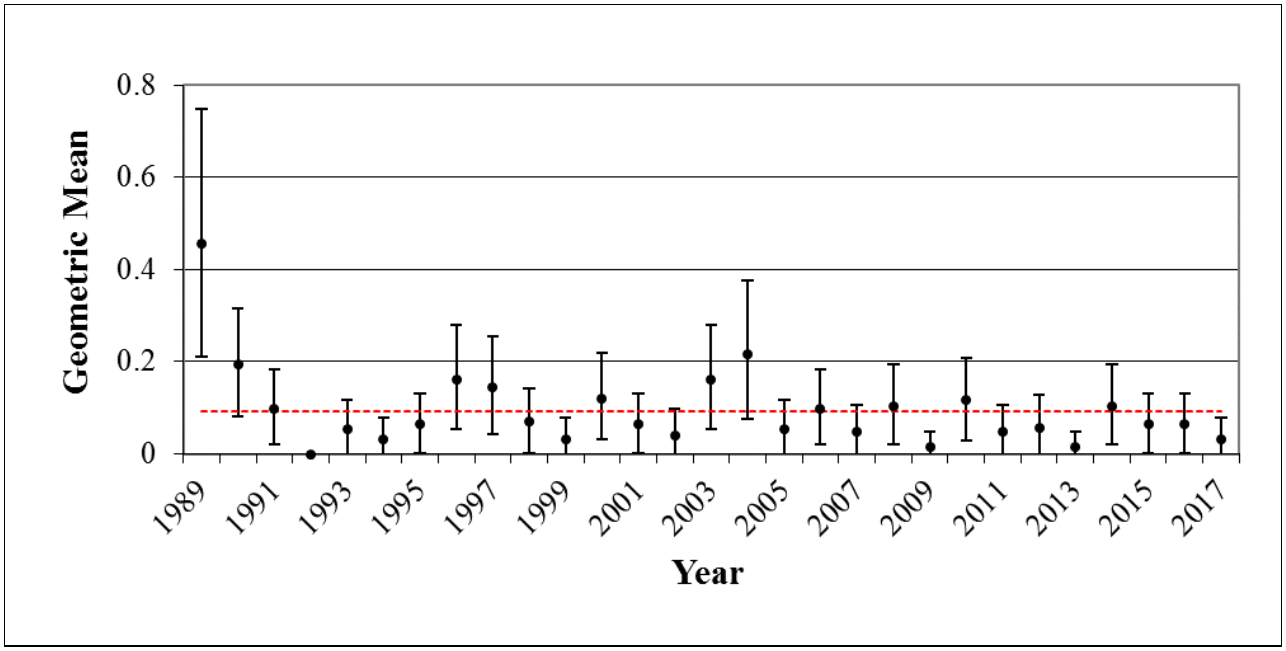

Figure 16. Bluefish (*Pomatomus saltatrix*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

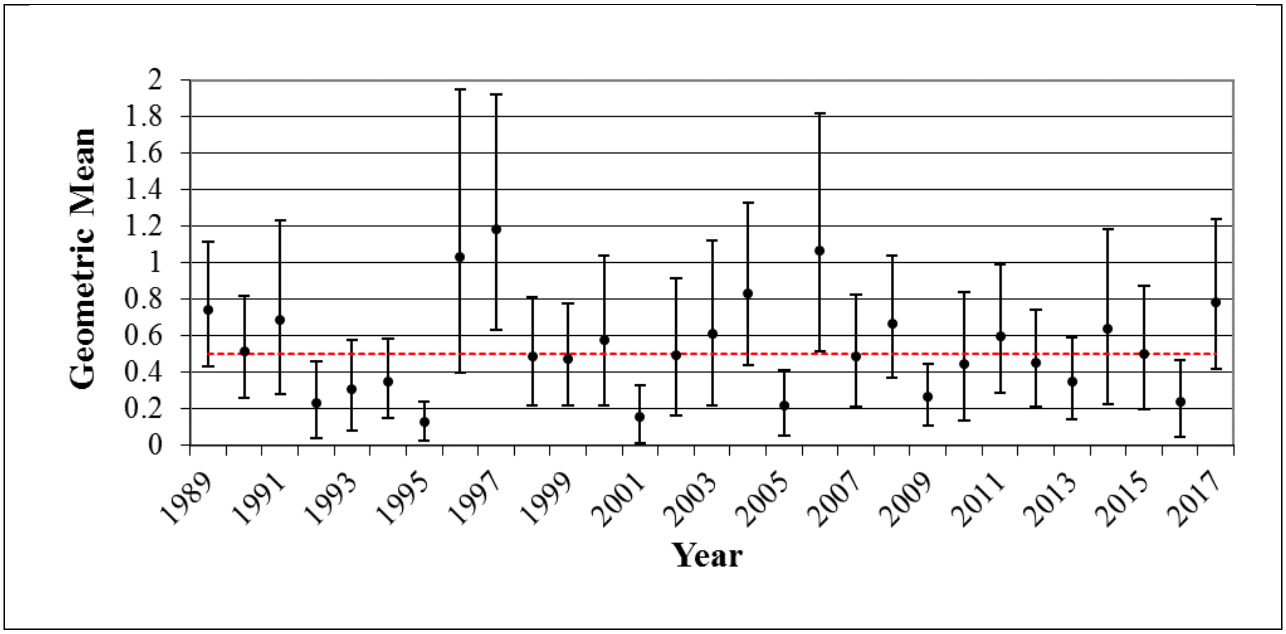

Figure 17. Bluefish (*Pomatomus saltatrix*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

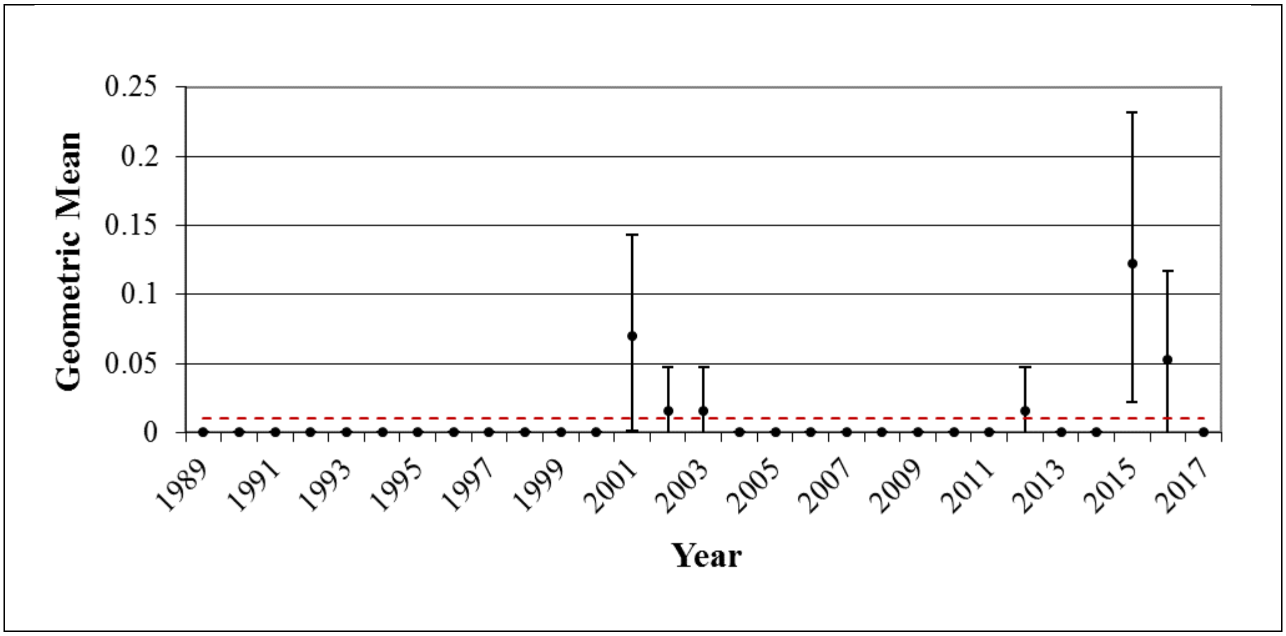

Figure 18. Sheepshead (*Archosargus probatocephalus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

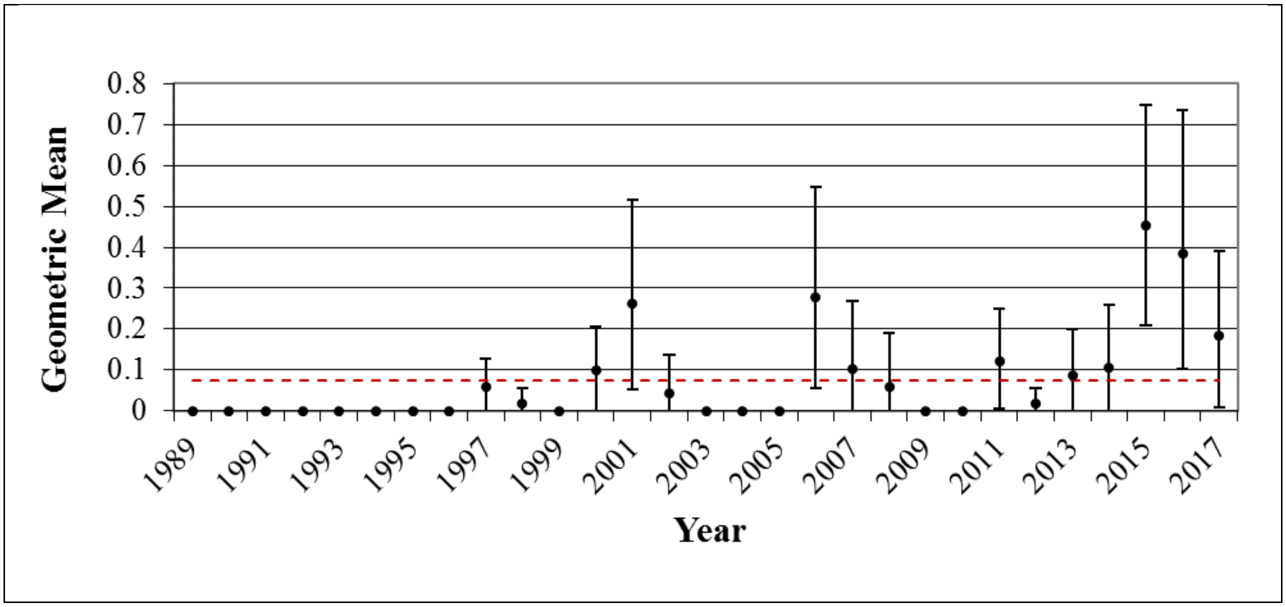

Figure 19. Sheepshead (*Archosargus probatocephalus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

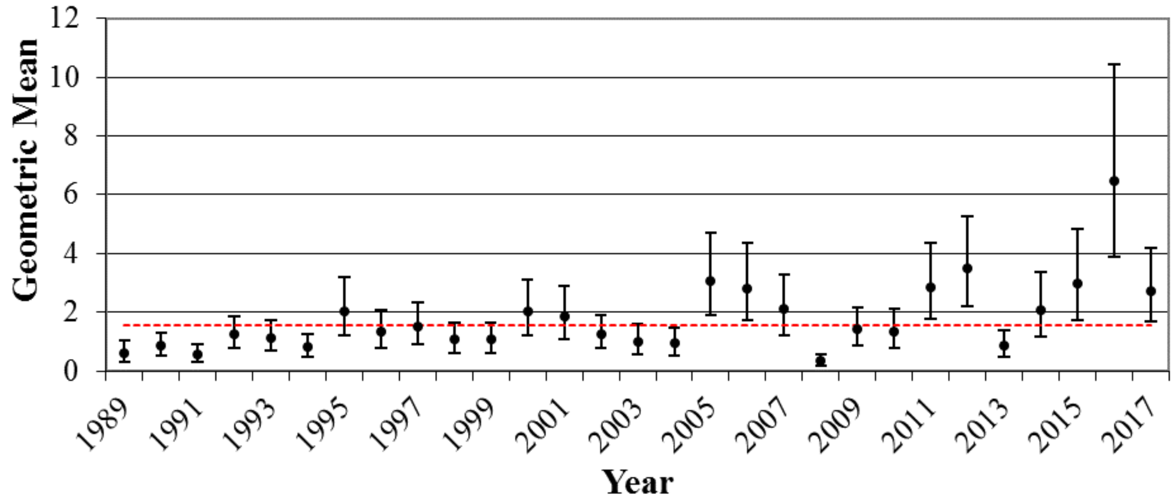

Figure 20. Silver perch (*Bairdiella chrysoura*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

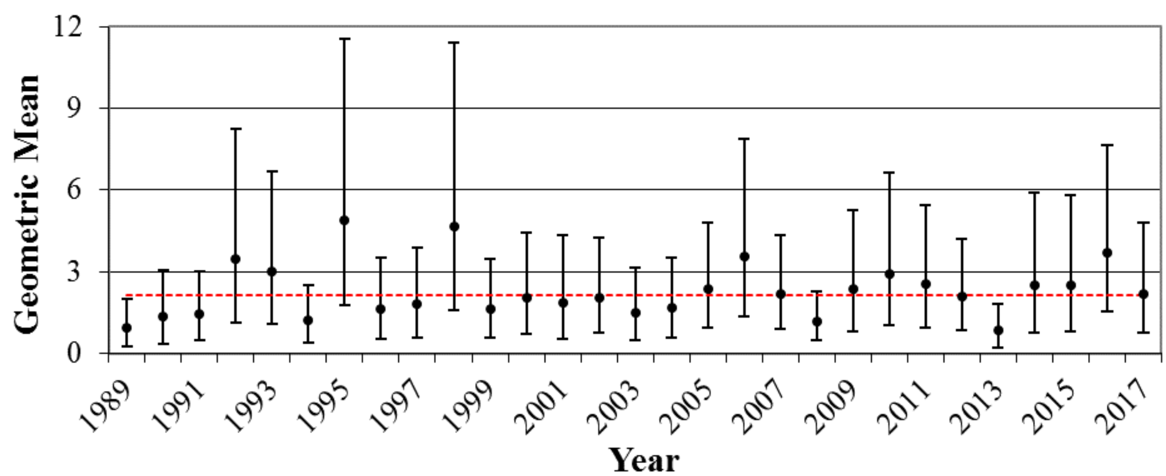

Figure 21. Silver perch (*Bairdiella chrysoura*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

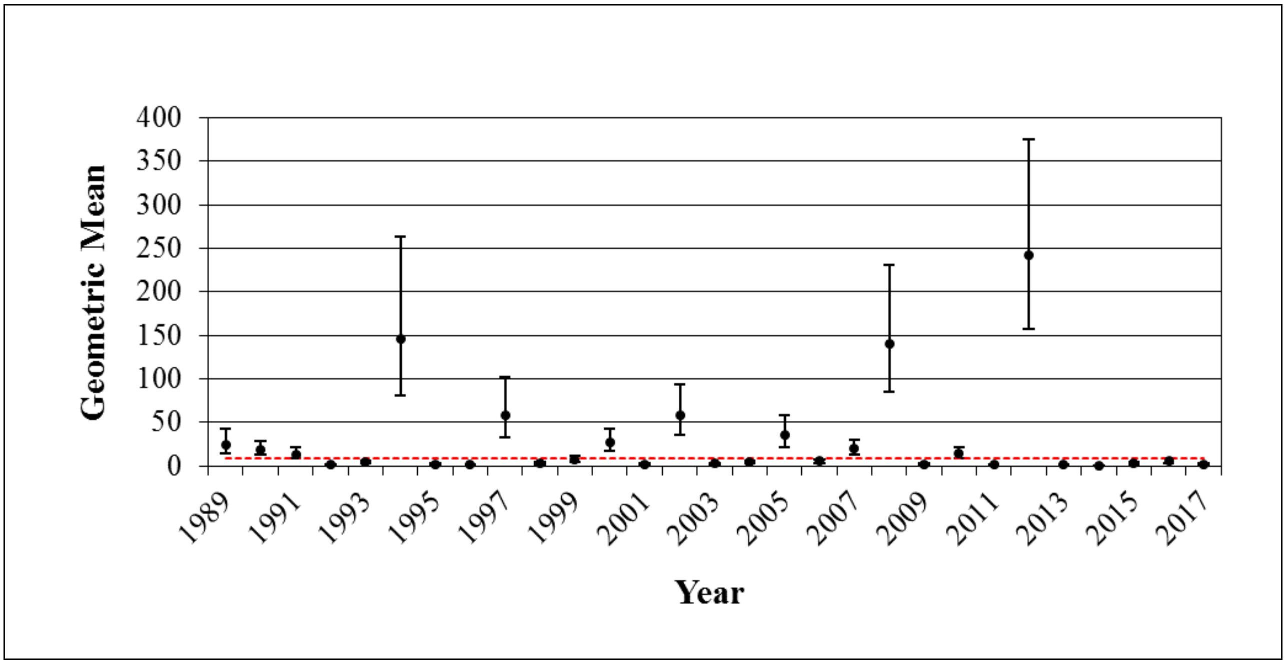

Figure 22. Spot (*Leiostomus xanthurus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

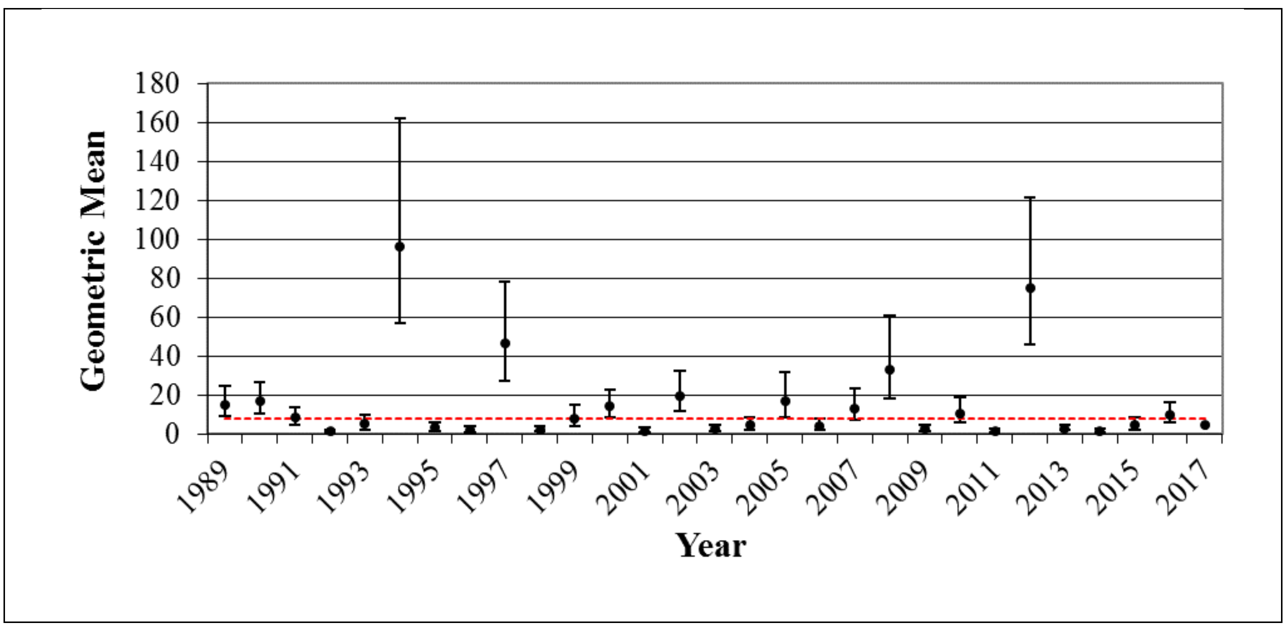

Figure 23. Spot (*Leiostomus xanthurus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

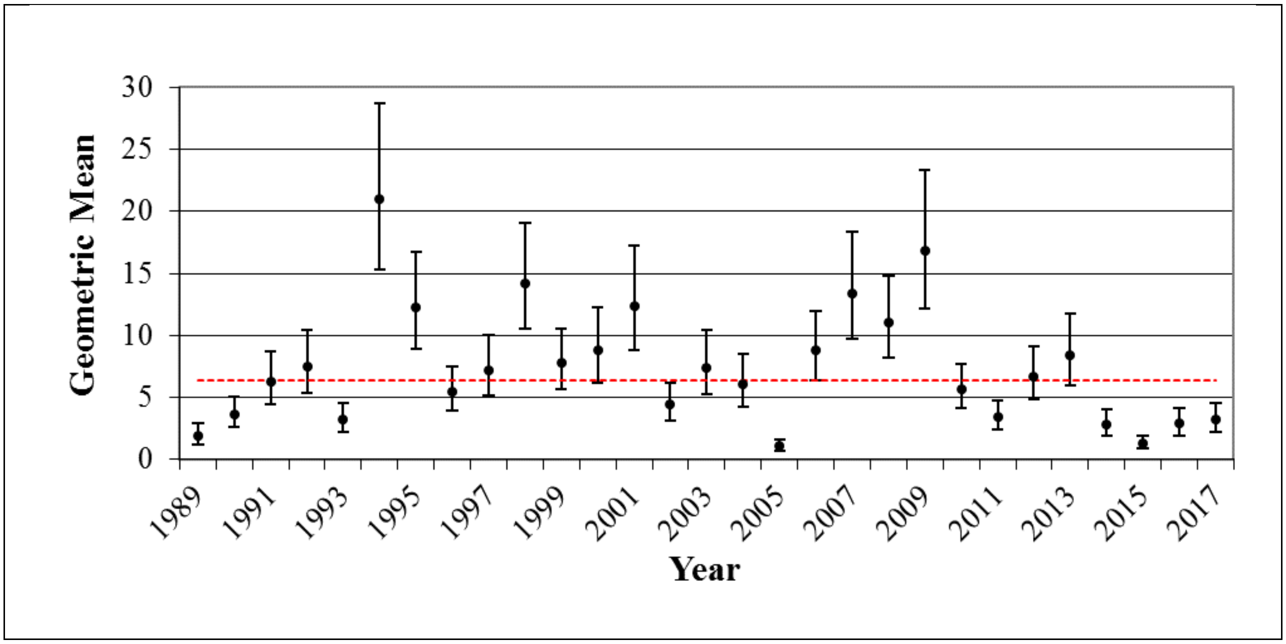

Figure 24. Summer flounder (*Paralichthys dentatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

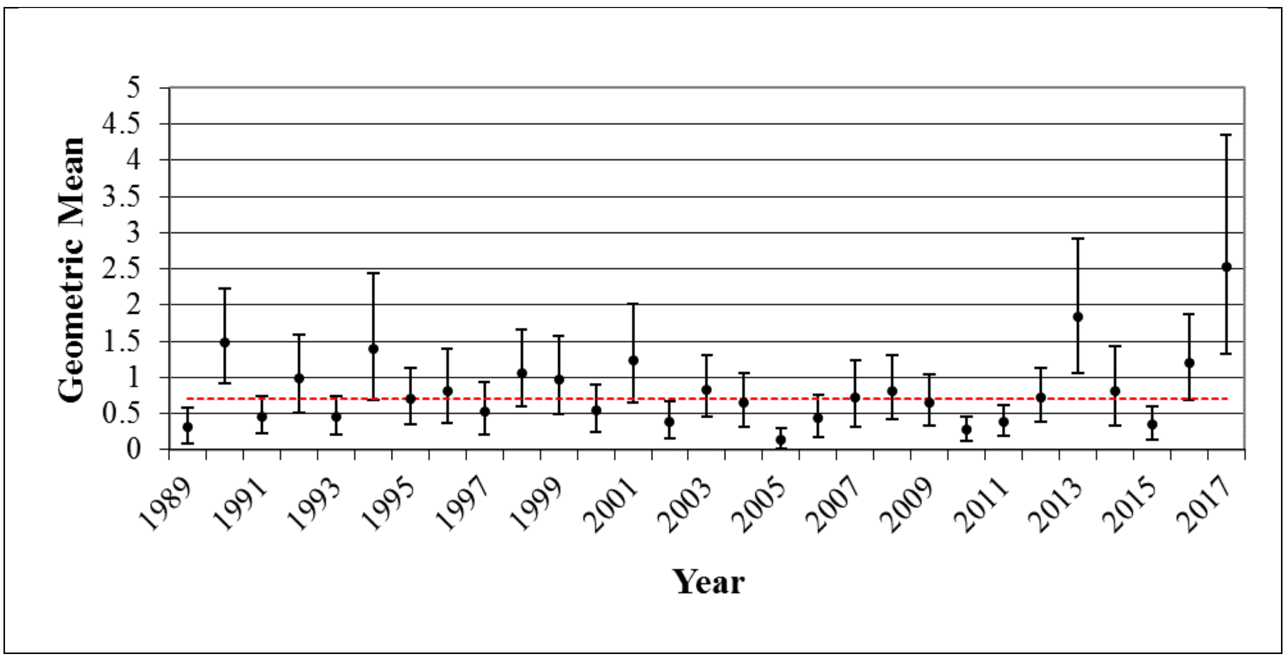

Figure 25. Summer flounder (*Paralichthys dentatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

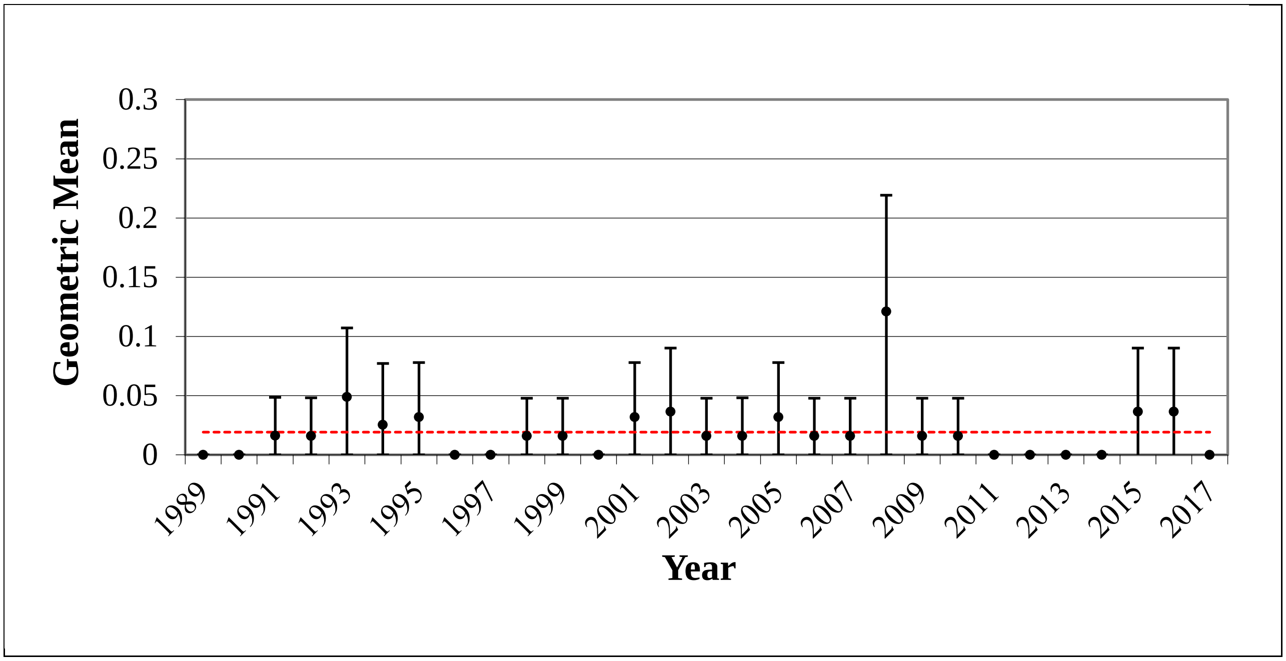

Figure 26. Tautog (*Tautoga onitis)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

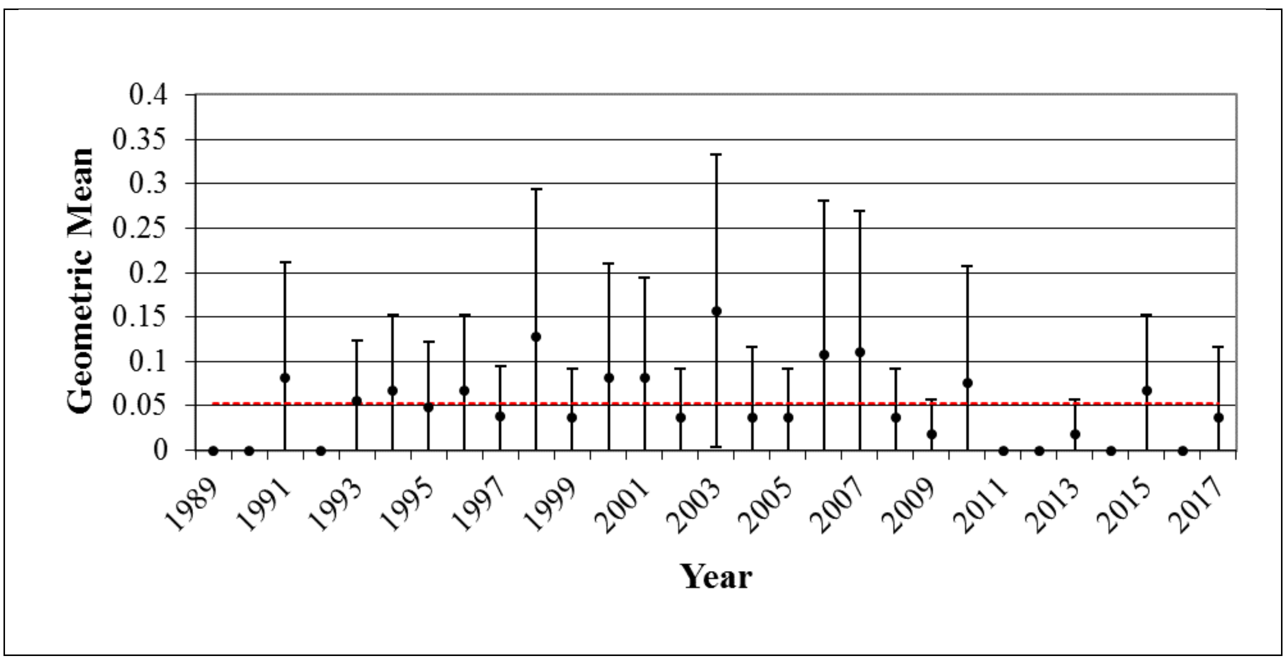

Figure 27. Tautog (*Tautoga onitis)* beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

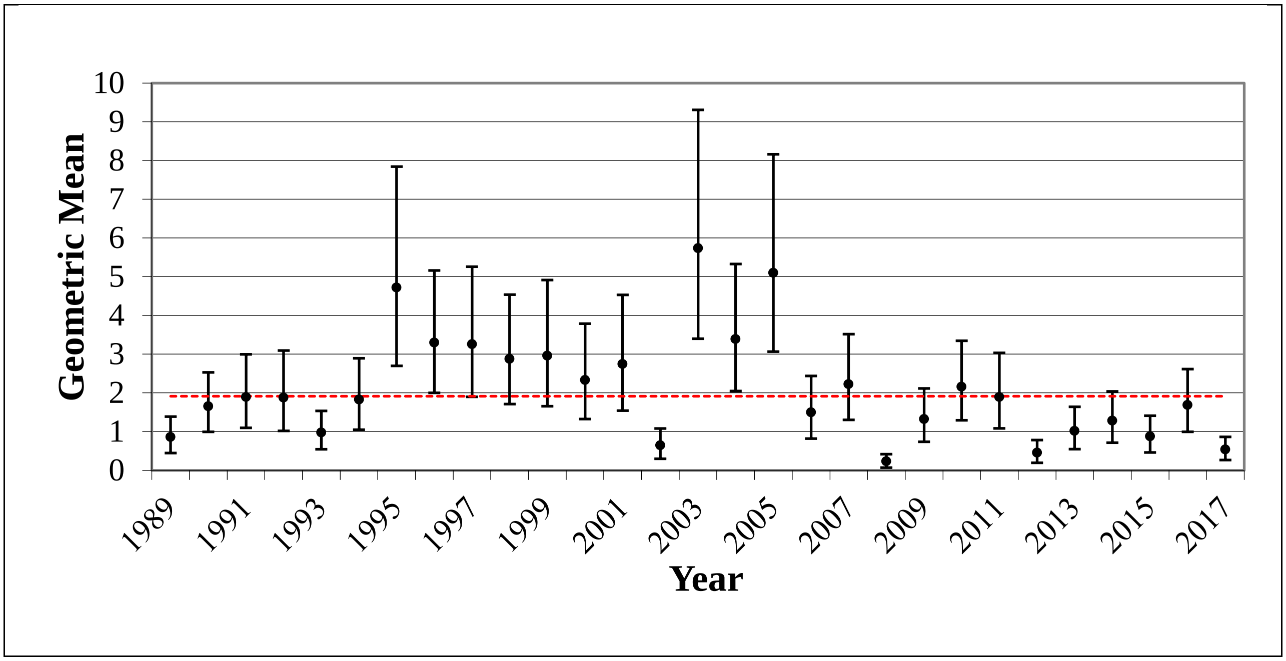

Figure 28. Weakfish (*Cynoscion regalis)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 140/year).

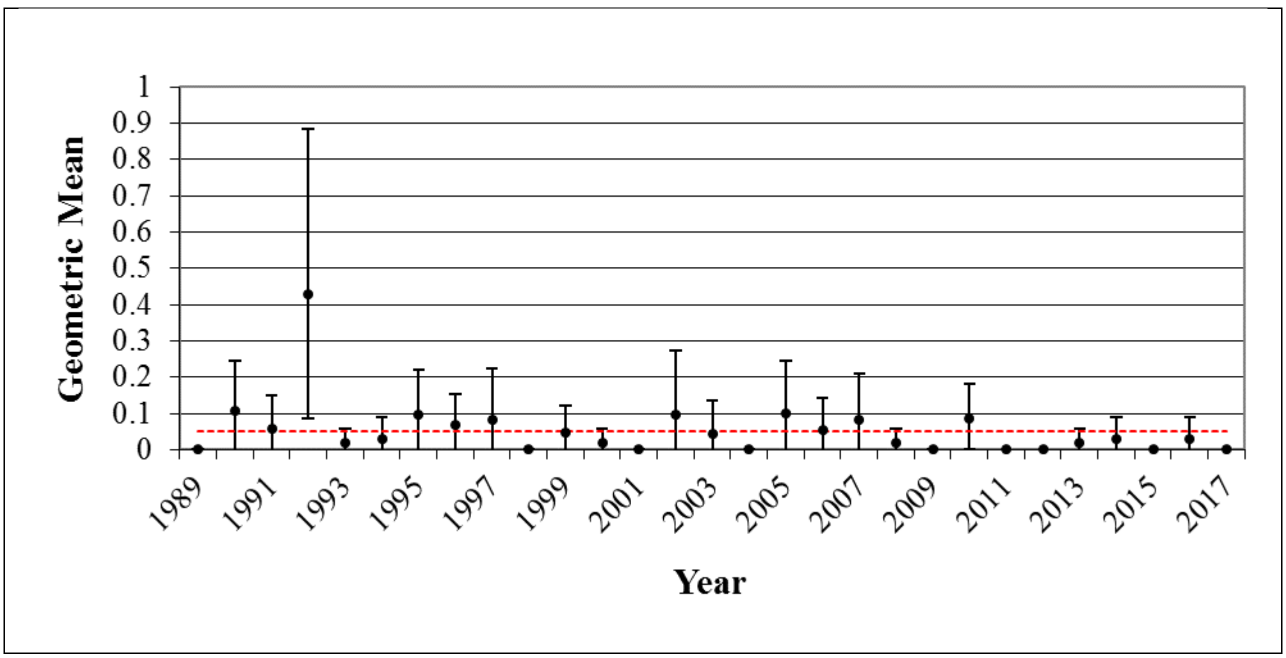

Figure 29. Weakfish (*Cynoscion regalis)* beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2017). Dotted line represents the 1989 - 2017 time series grand mean. Protocols of the Coastal Bays Fisheries Investigation Trawl and Beach Seine Survey were standardized in 1989 (n = 38/year).

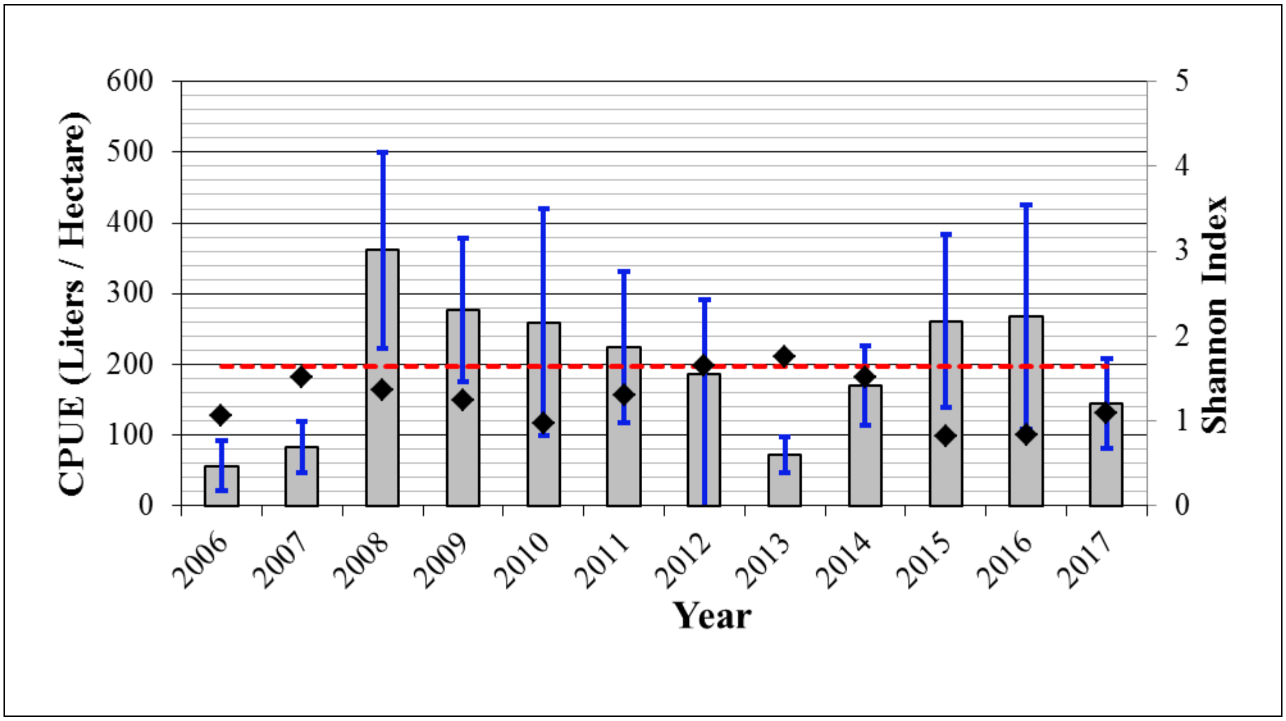

Figure 30. Coastal bays trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 140/year). Black diamond represents the Shannon index of diversity.

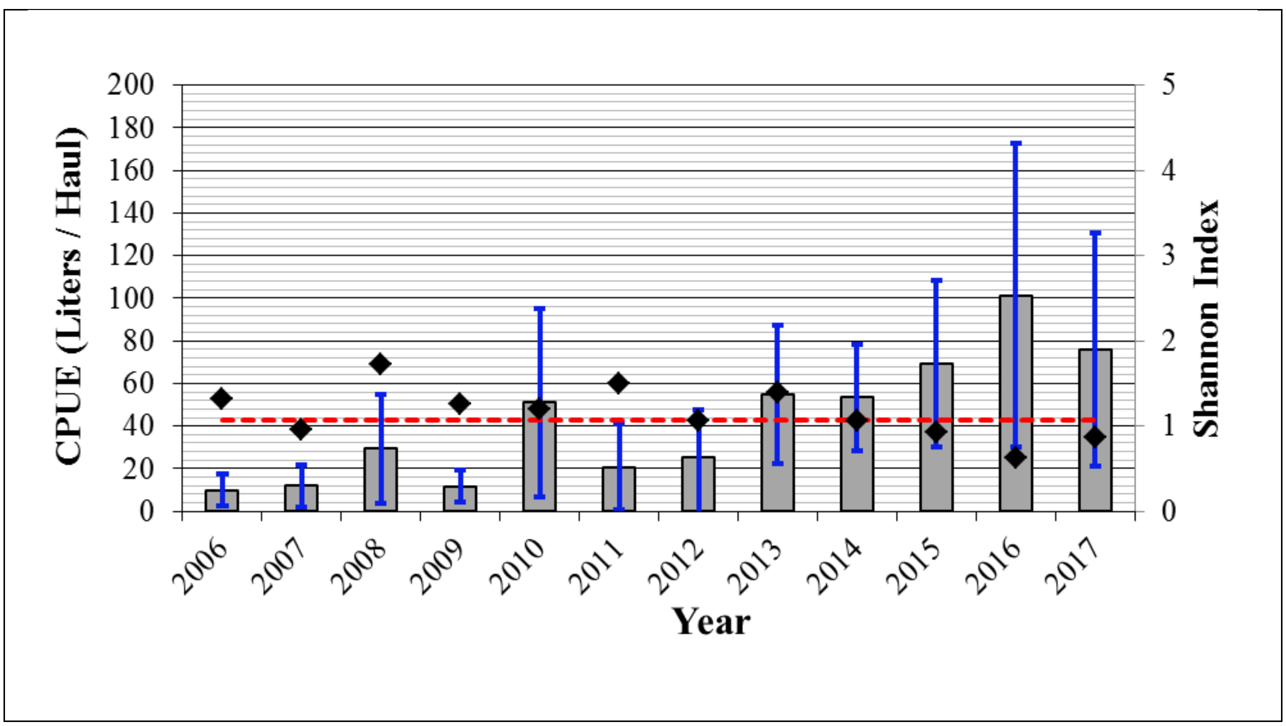

Figure 31**.** Coastal bays beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 36/year). Black diamond represents the Shannon index of diversity.

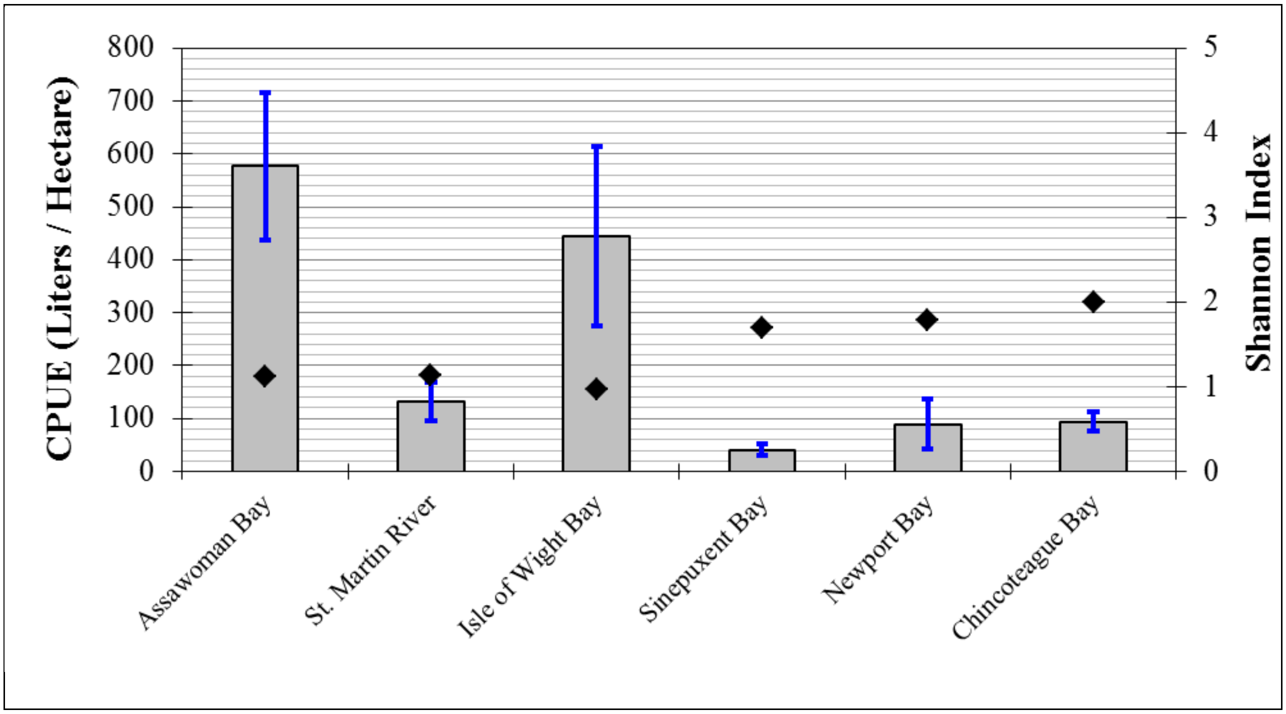

Figure 32. Coastal bays trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Black diamond represents the 2006 - 2017 time series Shannon index of diversity.

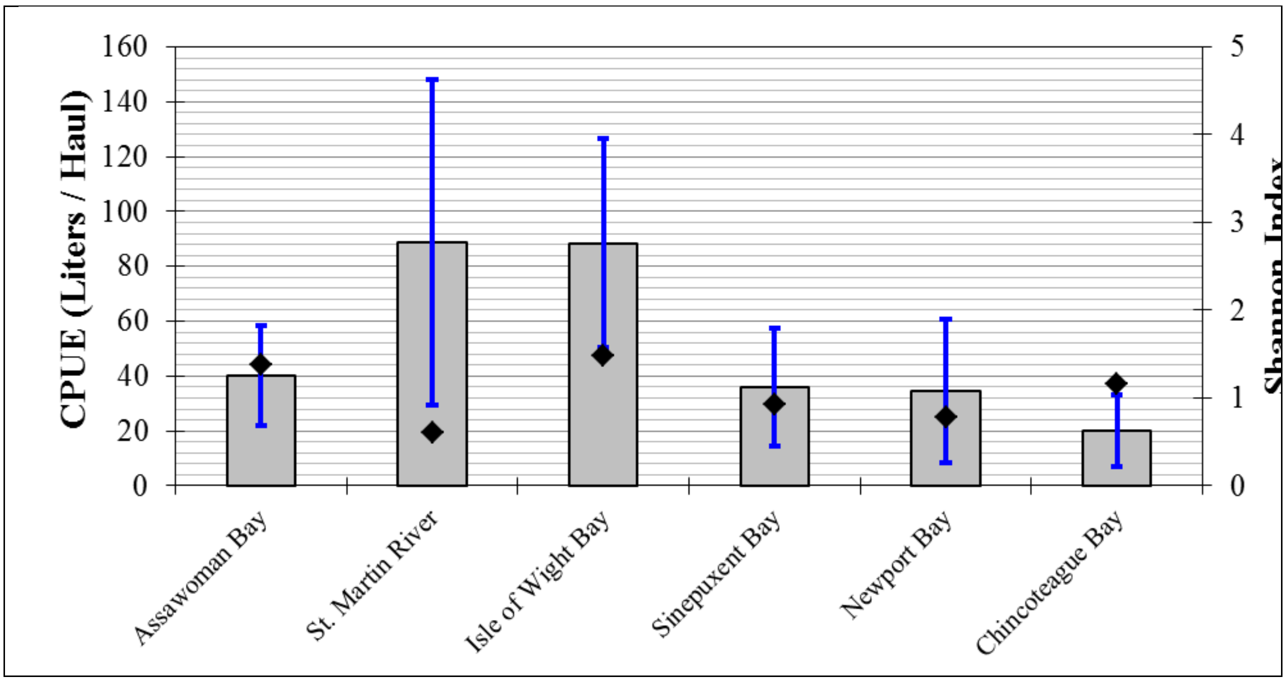

Figure 33. Beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Black diamond represents the 2006 - 2017 time series Shannon index of diversity.

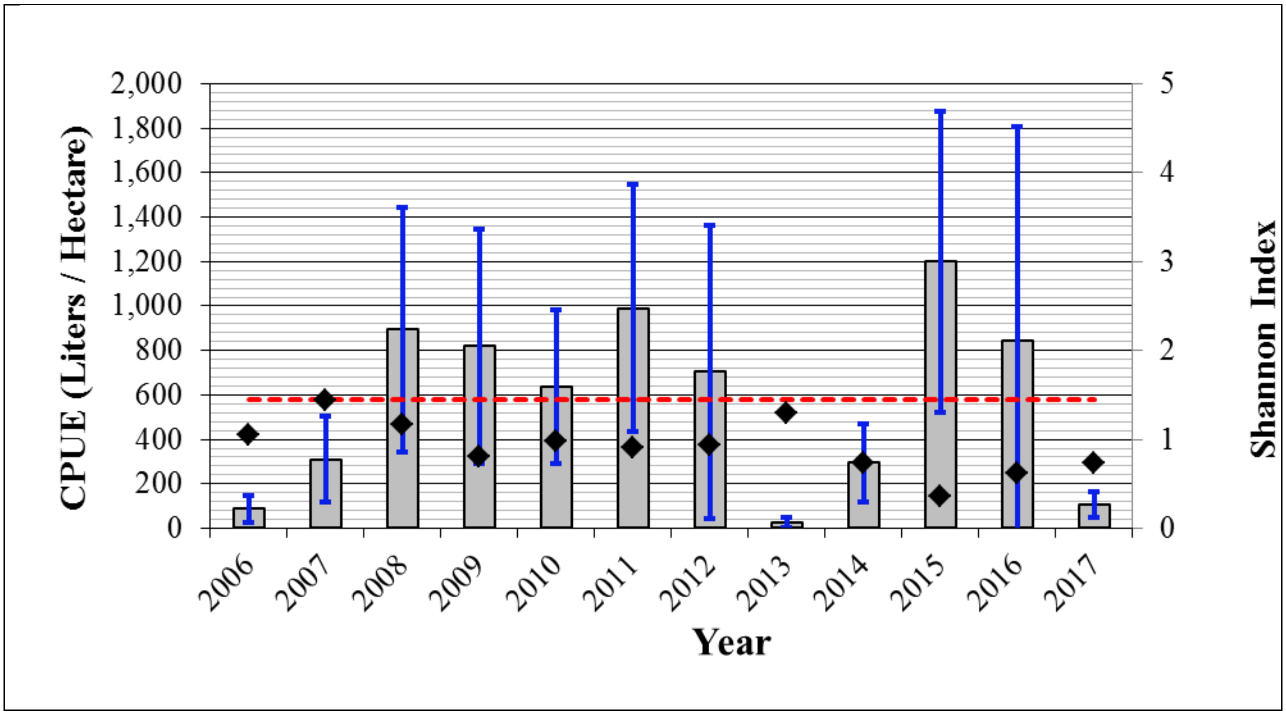

Figure 34. Assawoman Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

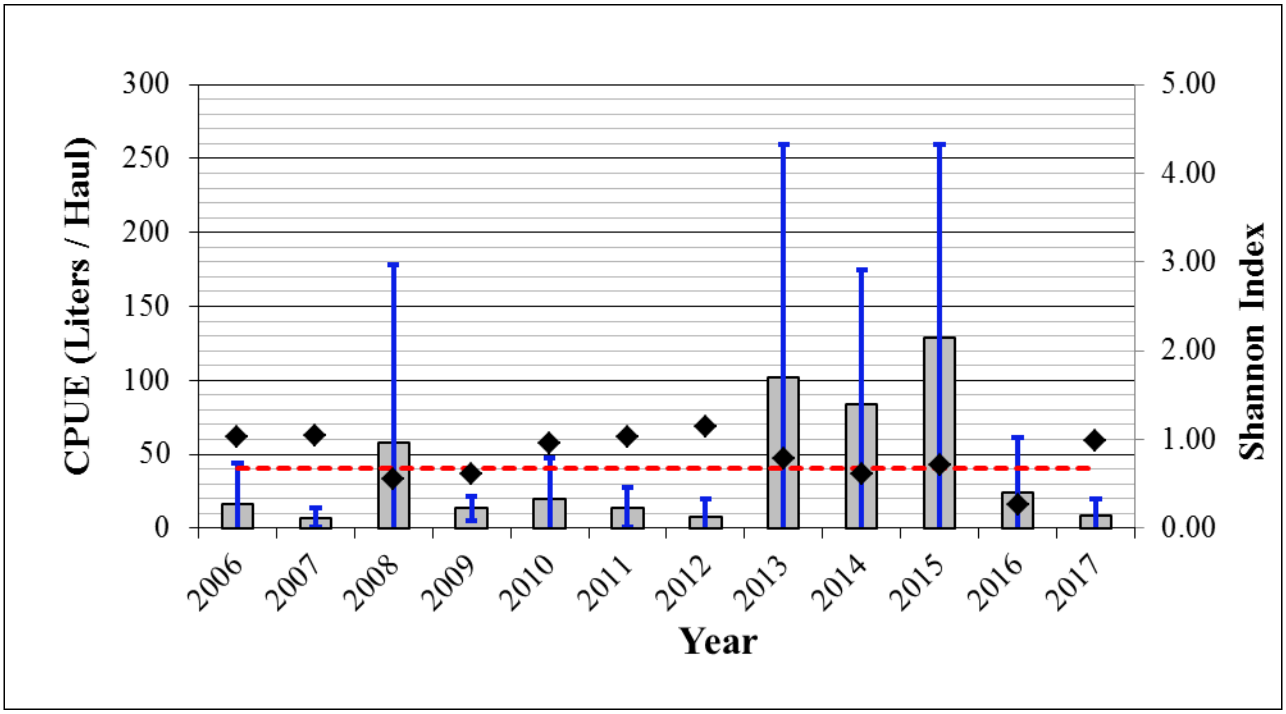

Figure 35. Assawoman Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Dotted line represents the 2006 - 2017 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index of diversity.

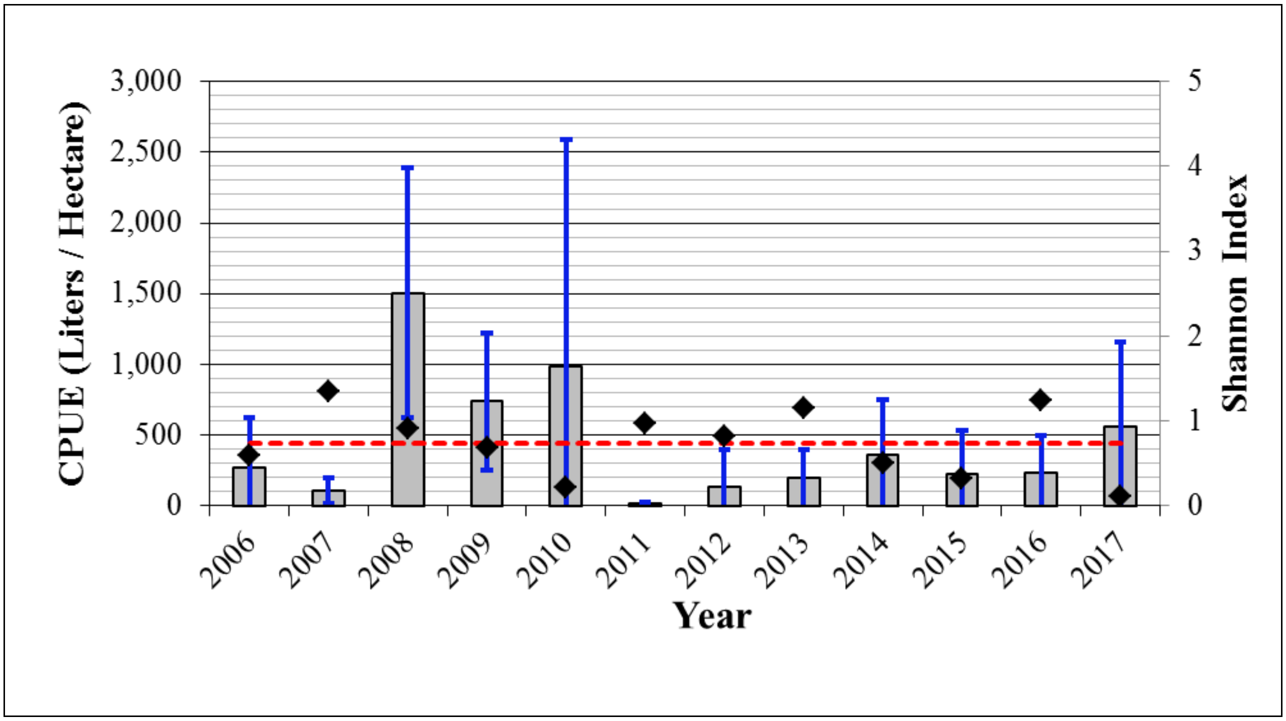

Figure 36. Isle of Wight Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

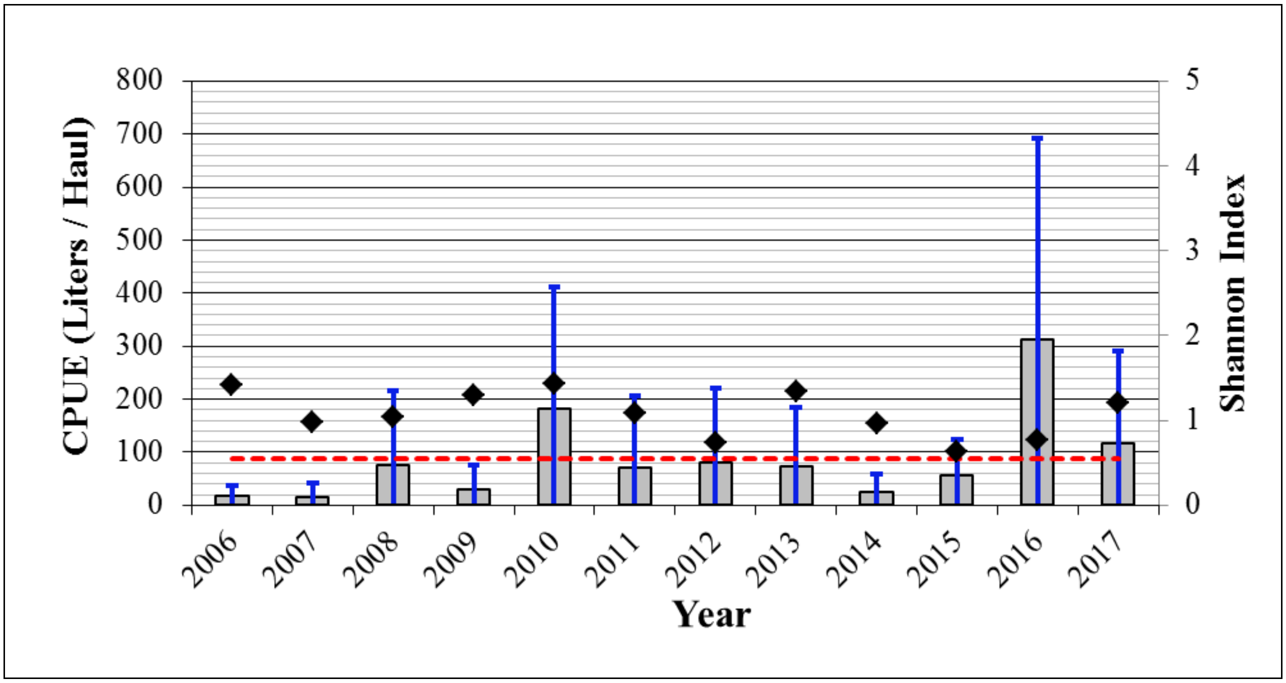

Figure 37. Isle of Wight Bay beach seine index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index of diversity.

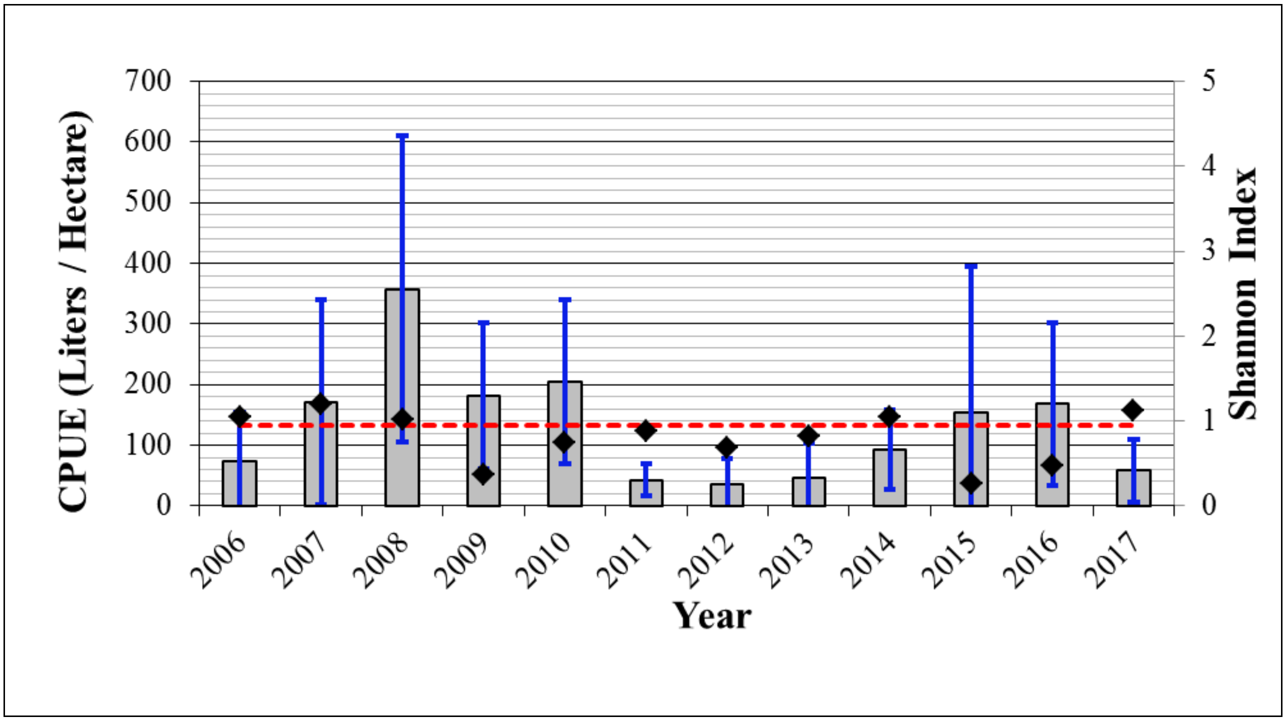

Figure 38. St. Martin River trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

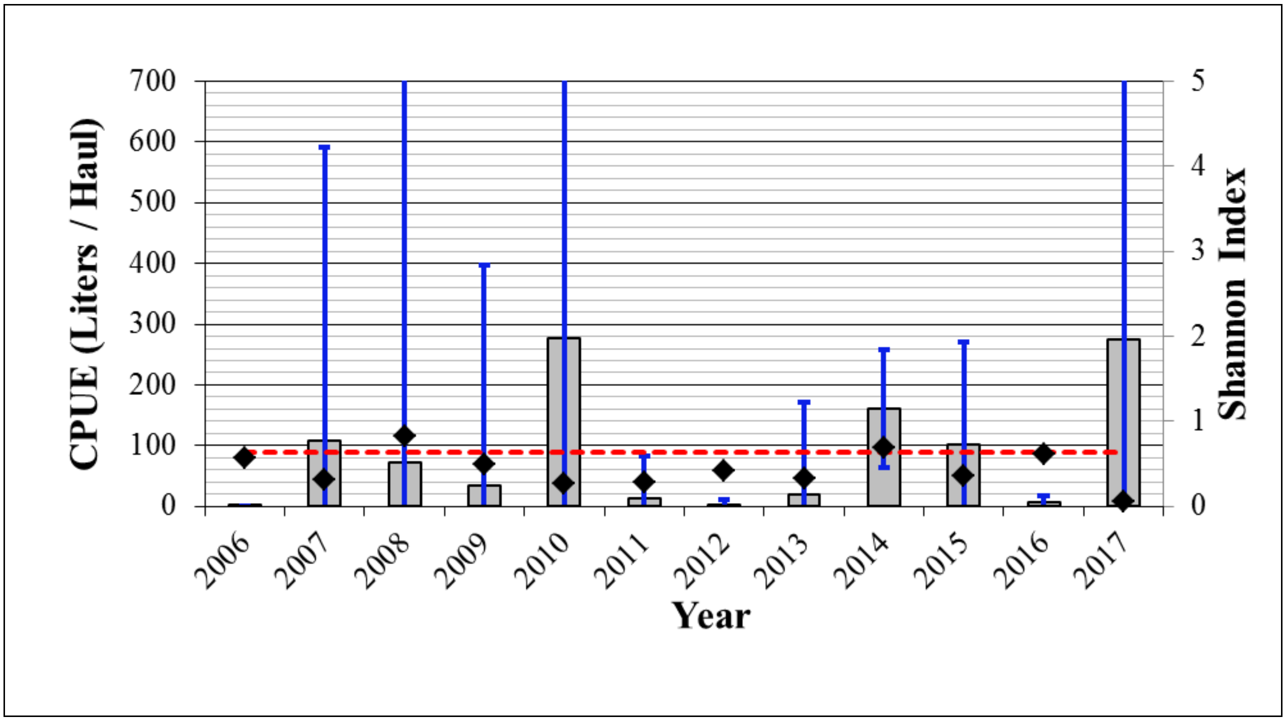

Figure 39. St. Martin River beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 2/year). Black diamond represents the Shannon index of diversity.

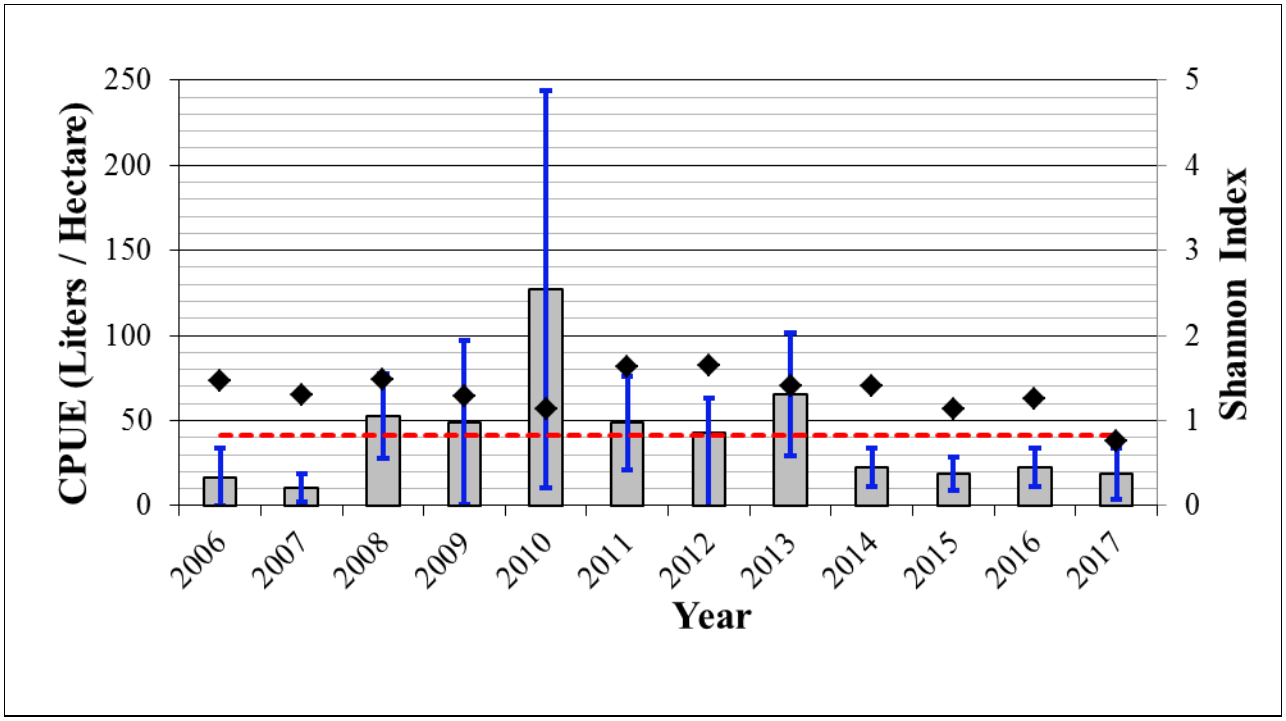

Figure 40. Sinepuxent Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

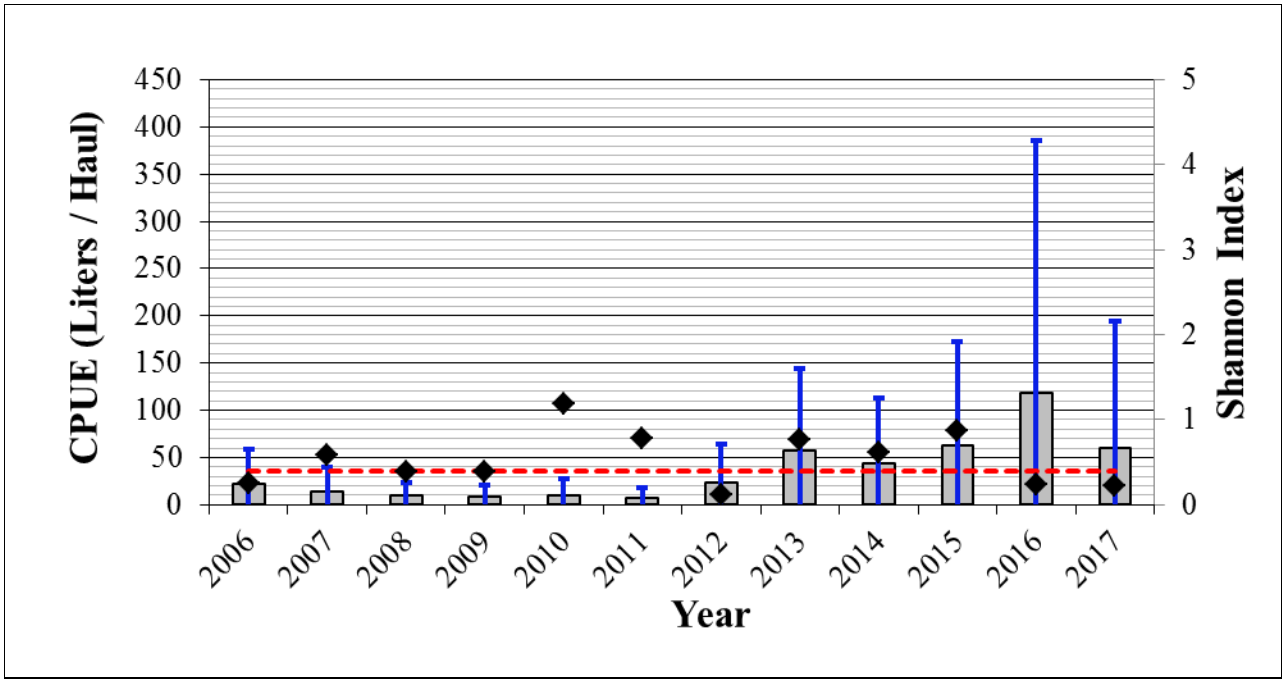

Figure 41. Sinepuxent Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index of diversity.

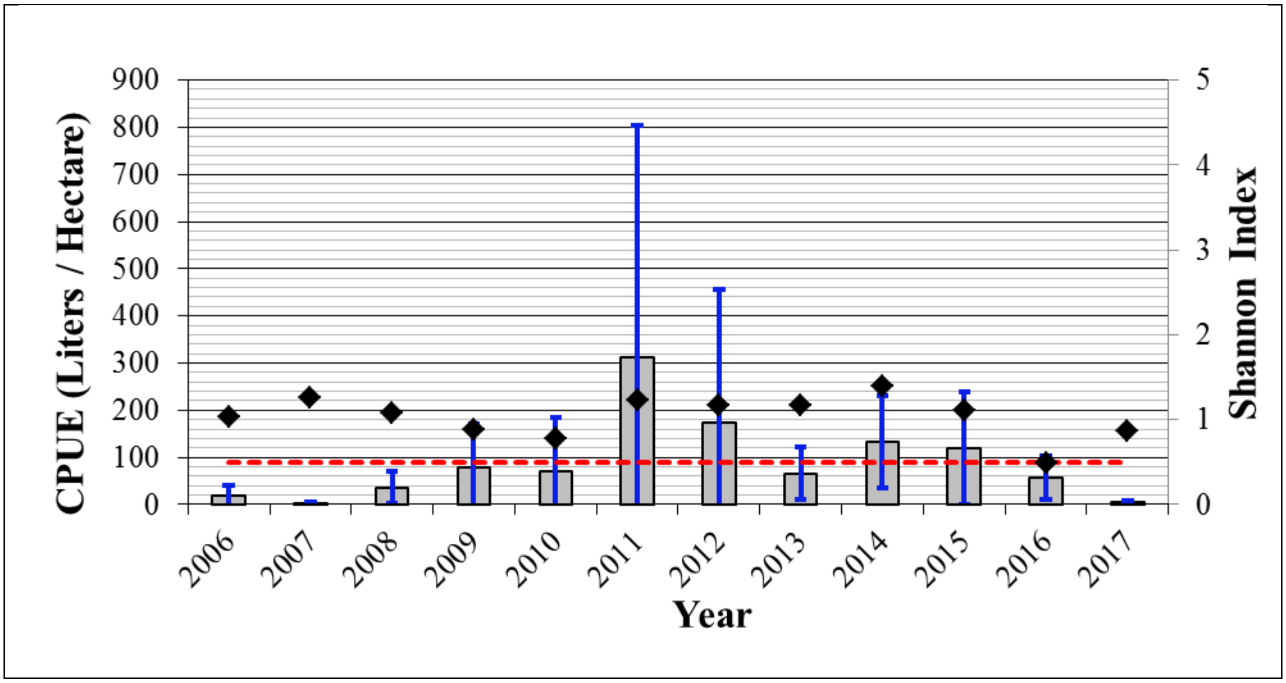

Figure 42. Newport Bay trawl index of relative macroalgae abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

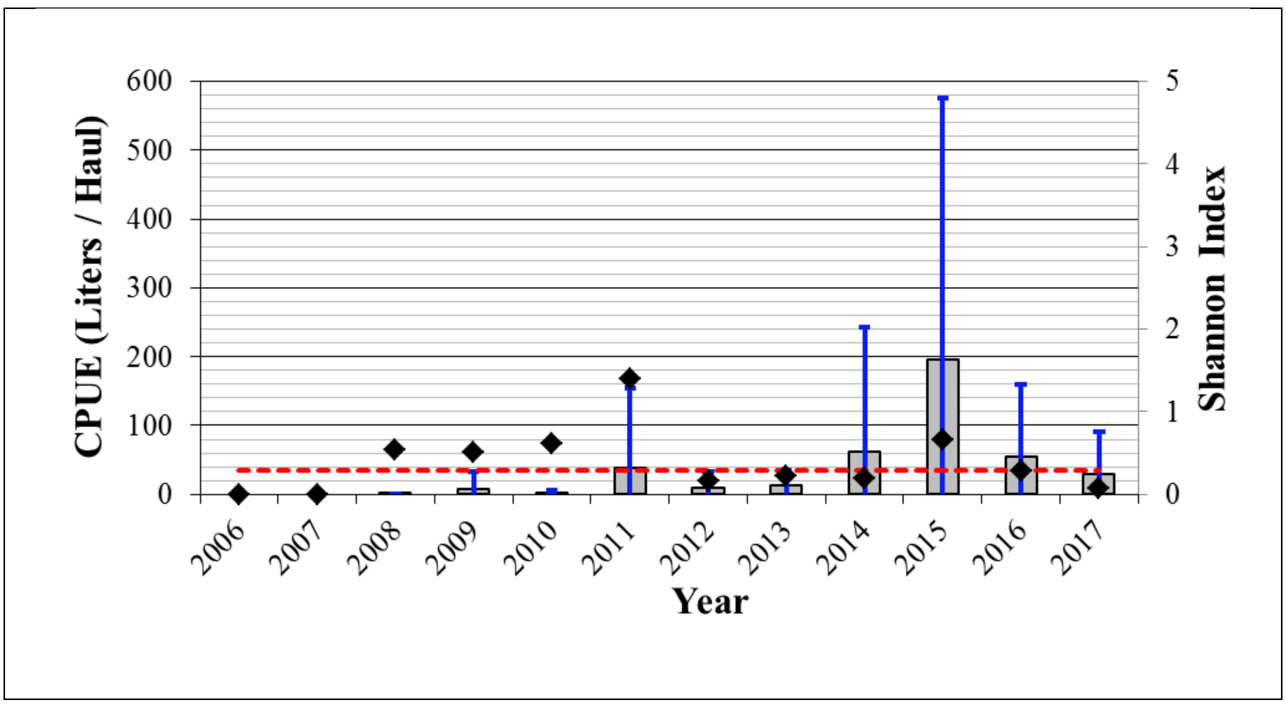

Figure 43. Newport Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2017). Red line represents the 2006 - 2017 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index of diversity.

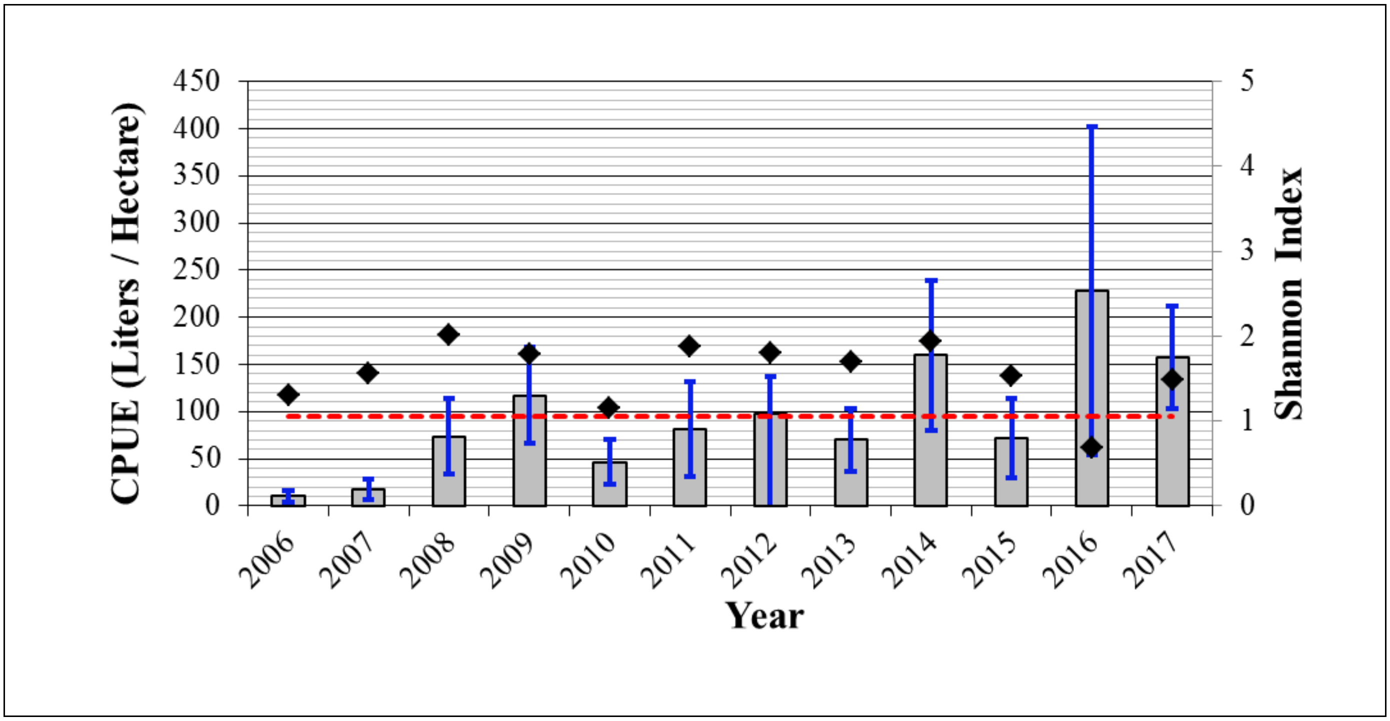

Figure 44. Chincoteague Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2016). Dotted line represents the 2006 - 2016 time series CPUE grand mean, (n = 56/year). Black diamond represents the Shannon index of diversity.

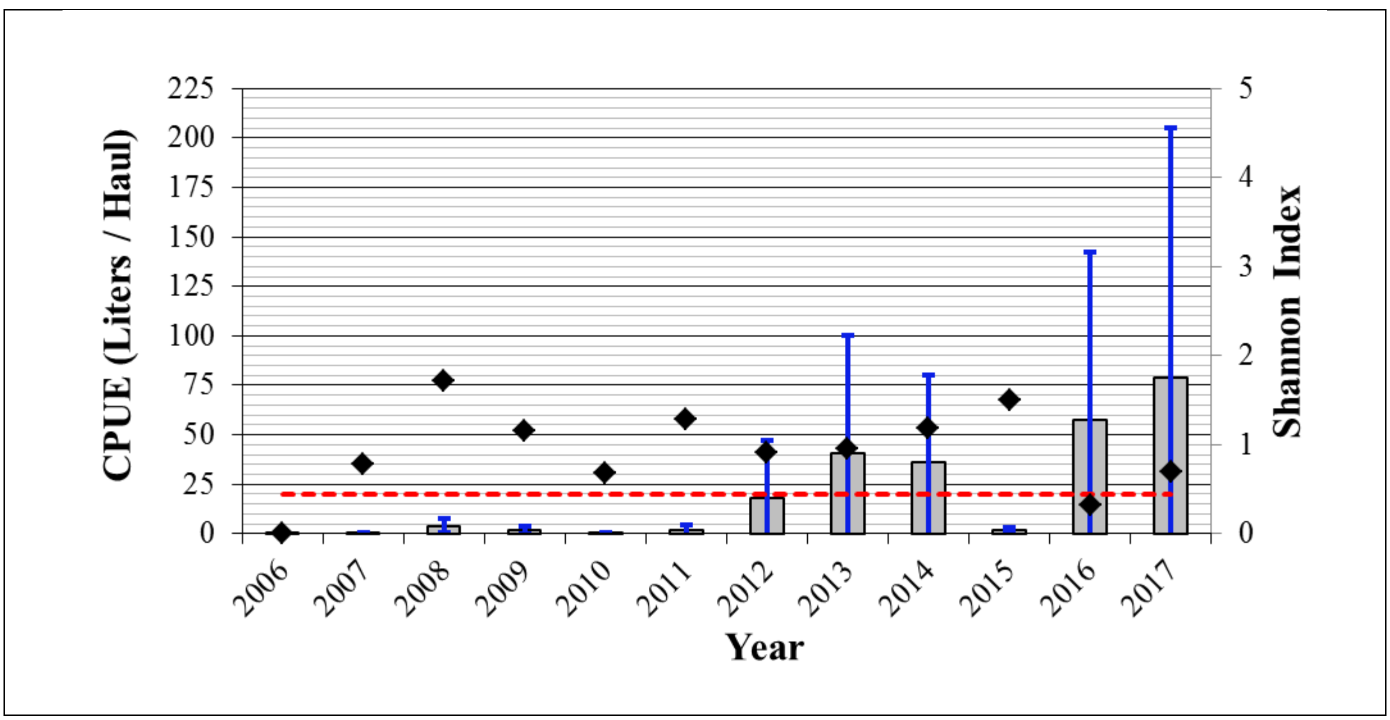

Figure 45. Chincoteague Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2016). Red line represents the 2006 - 2016 time series CPUE grand mean, (n = 12/year). Black diamond represents the Shannon index of diversity.

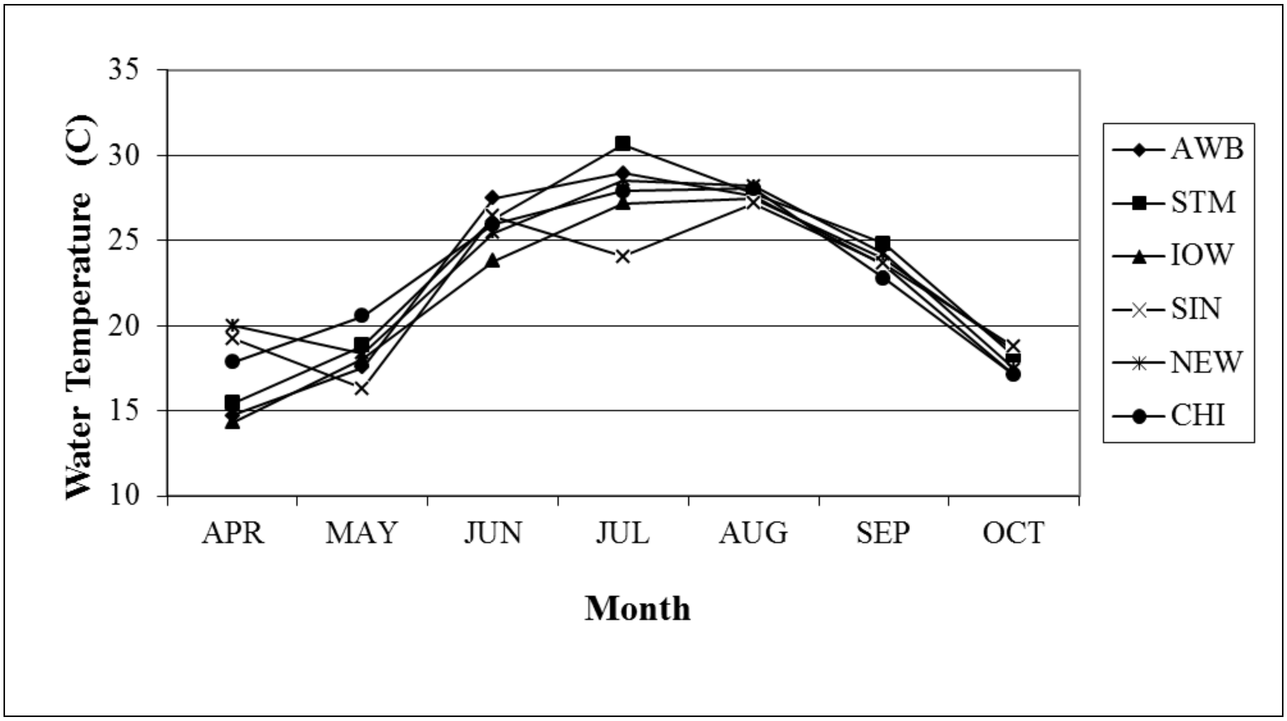

Figure 46. 2017 Trawl Survey mean water temperature (Celsius) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

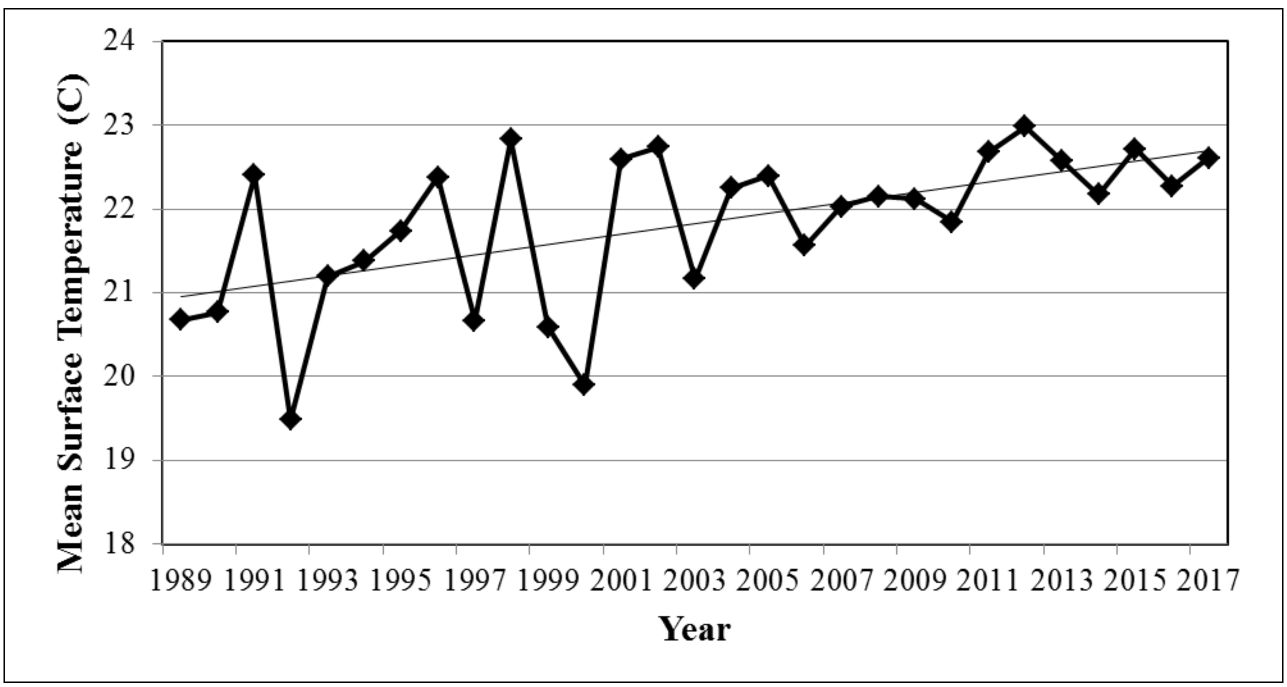

Figure 47. 2017 Trawl Survey mean surface water temperature (Celsius) by year for all bays (1989 - 2017).

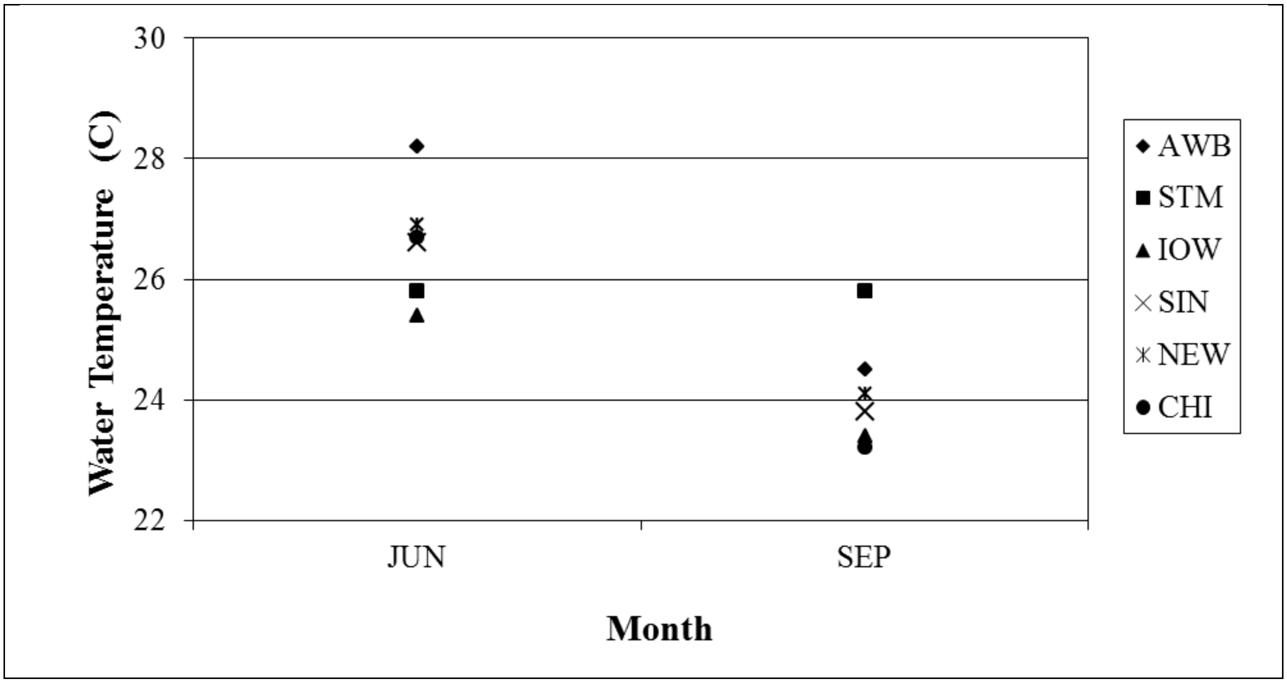

Figure 48. Beach Seine Survey mean water temperature (Celsius) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

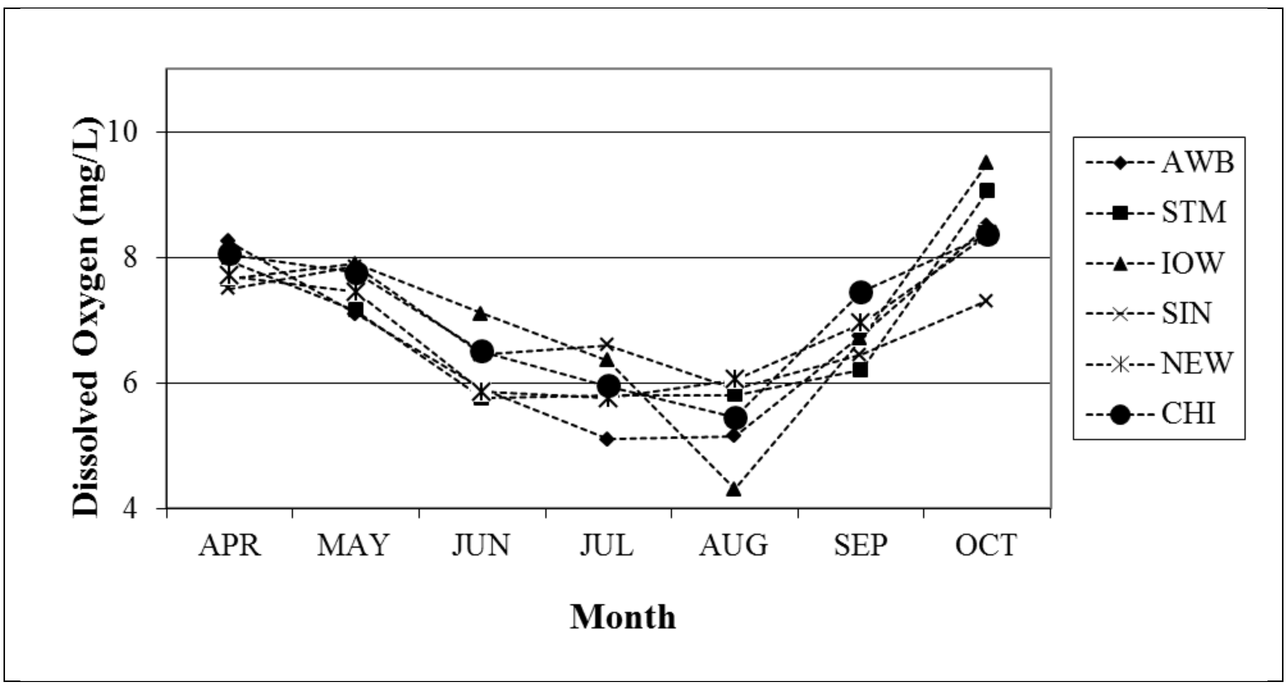

Figure 49. 2017 Trawl Survey mean dissolved oxygen (mg/L) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

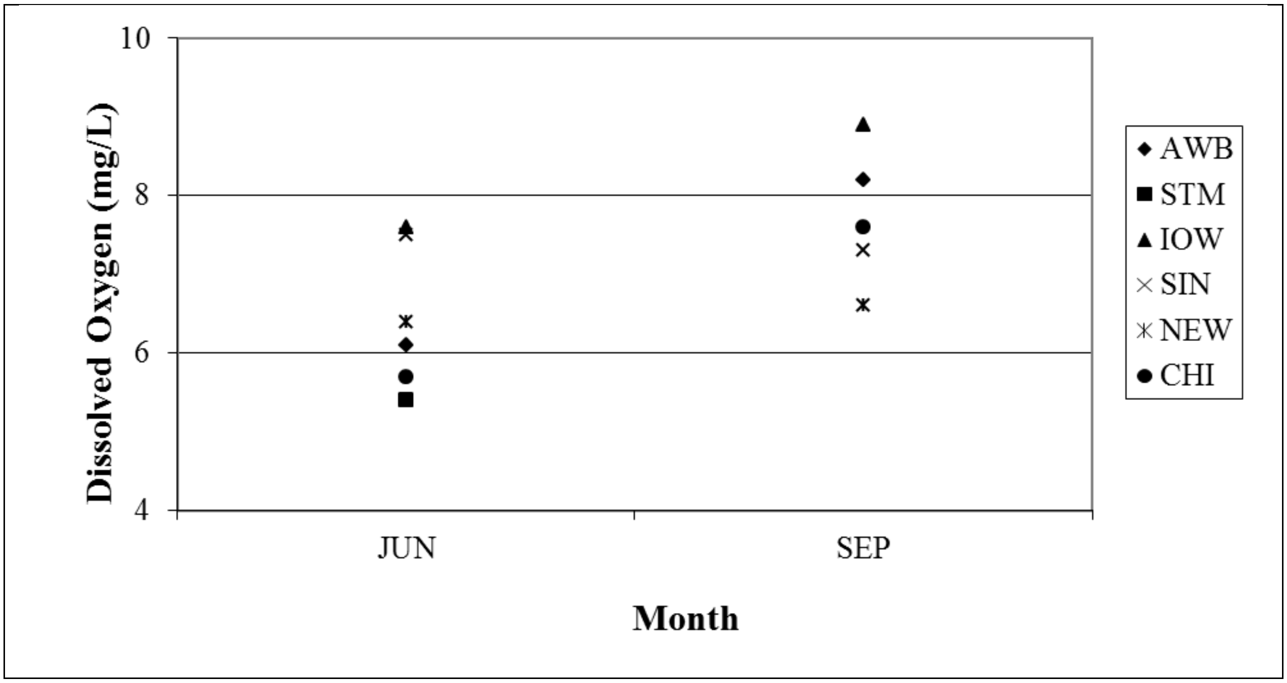

Figure 50. 2017 Beach Seine Survey mean dissolved oxygen (mg/L) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

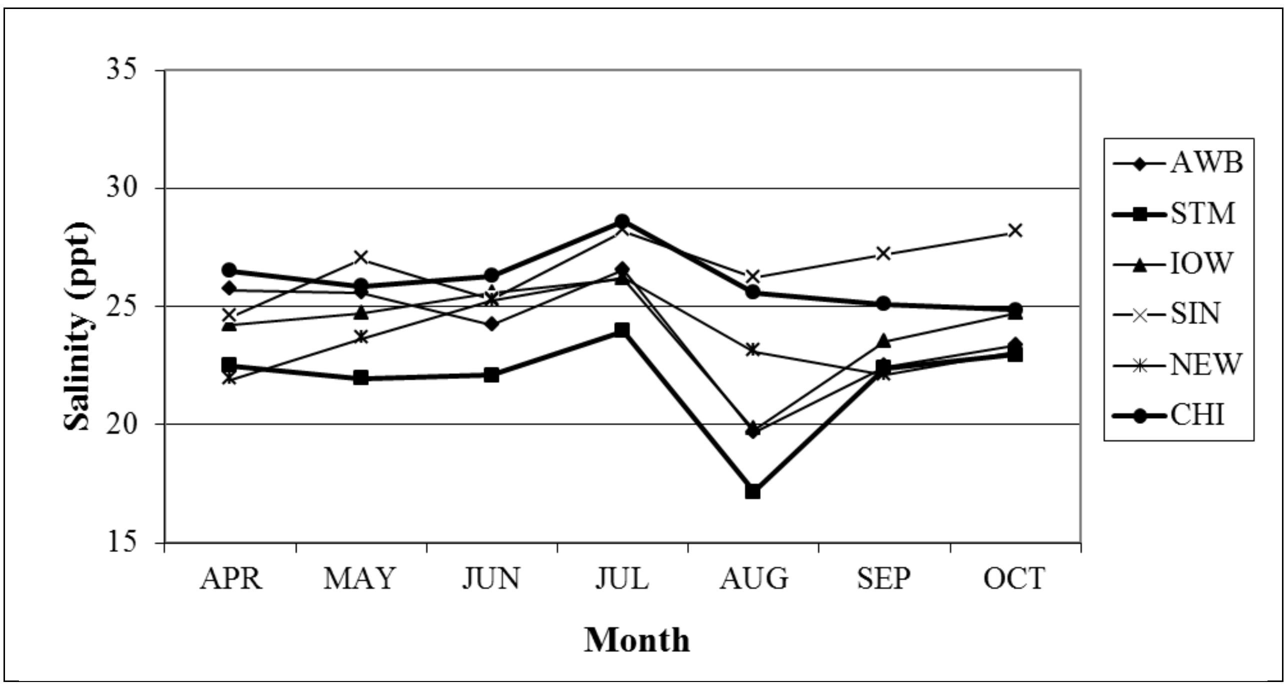

Figure 51. 2017 Trawl Survey mean salinity (parts per thousand) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

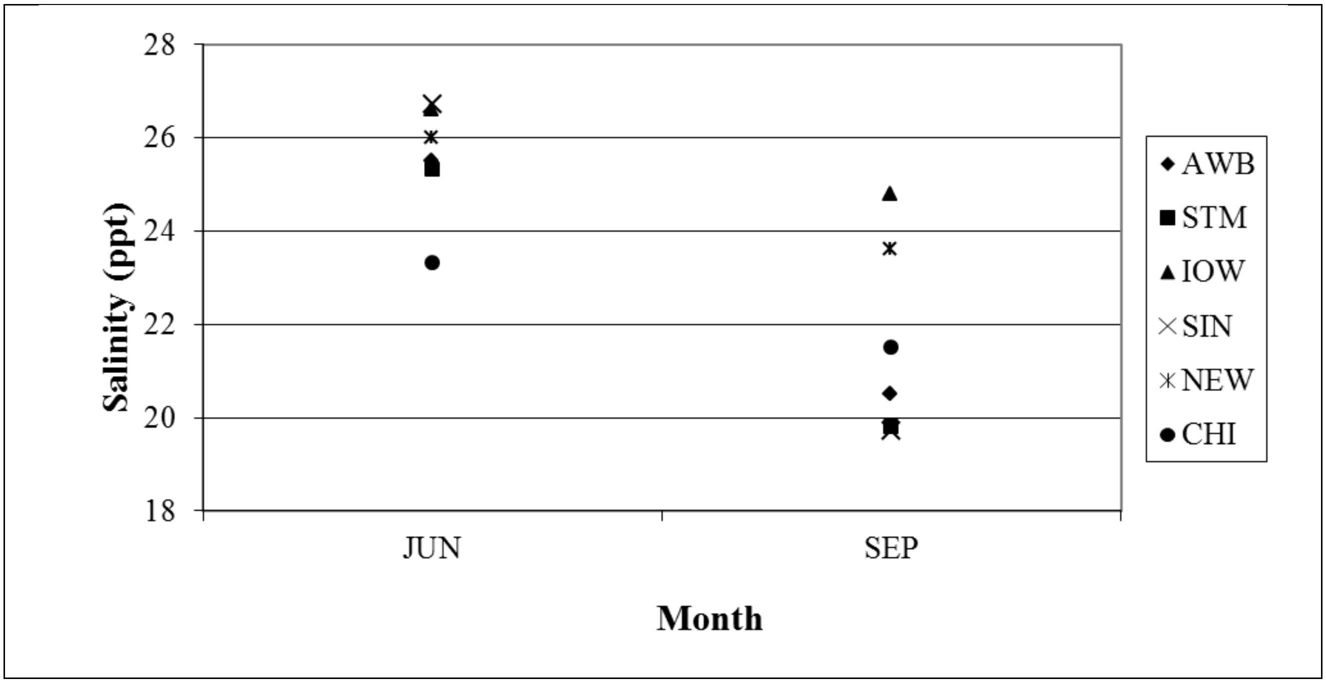

Figure 52. 2017 Beach Seine Survey mean salinity (parts per thousand) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

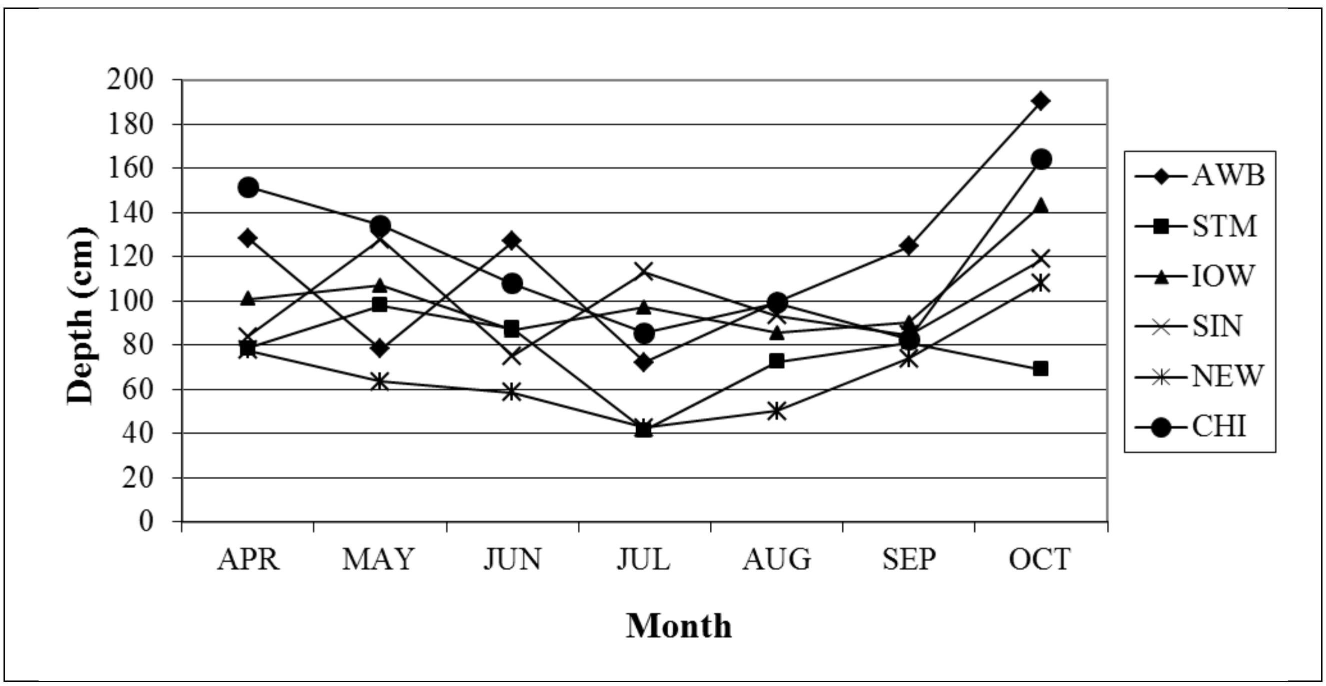

Figure 53. 2017 Trawl Survey mean turbidity (centimeters) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

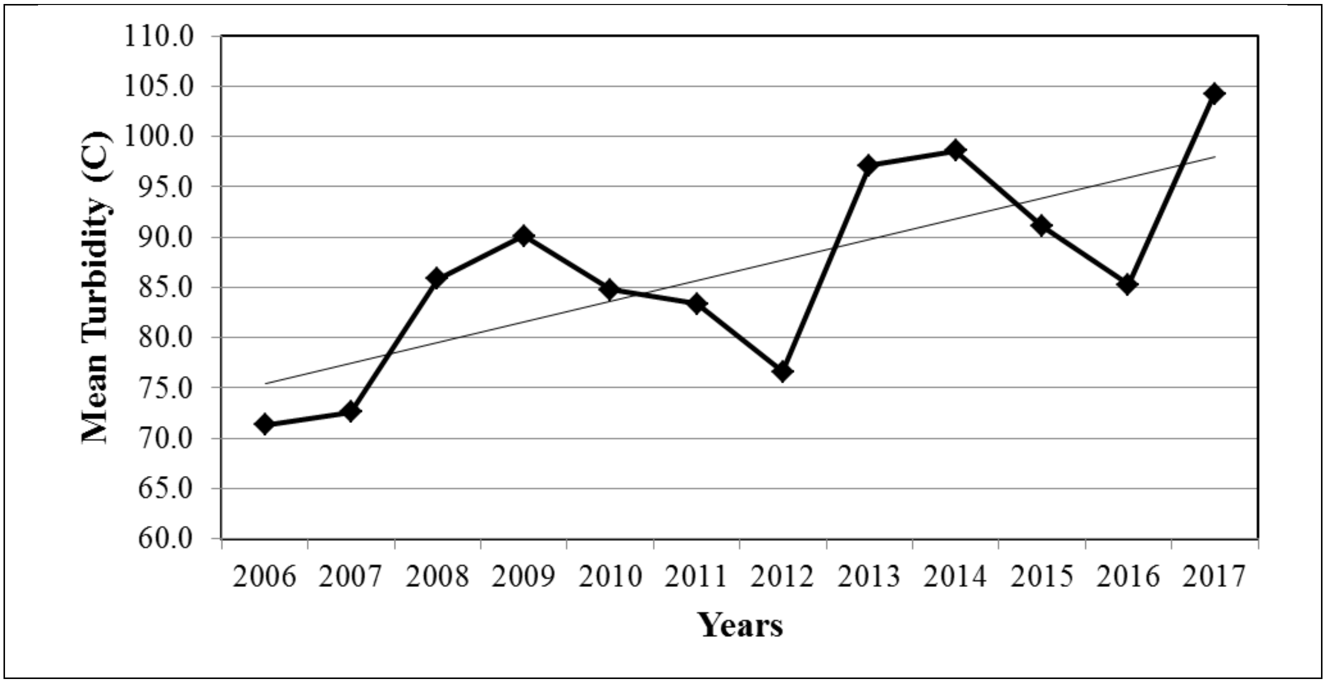

Figure 54. 2017 Trawl Survey mean turbidity (centimeters) by year for all bays.

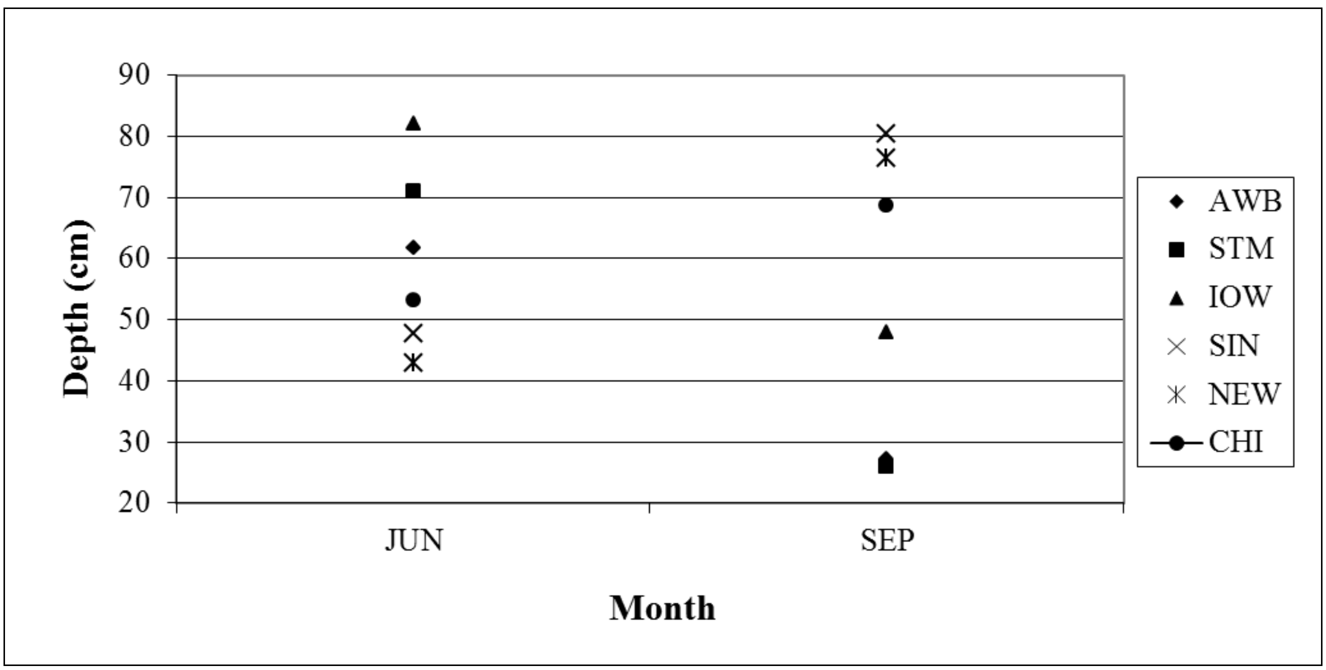

Figure 55. 2017 Beach Seine Survey mean turbidity (centimeters) by month for Assawoman Bay (AWB), St. Martins River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

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. That survey was designed to characterize and quantify juvenile finfish abundance but those gears rarely sample sites in SAV. Currently, there is limited information specific to Maryland's coastal bays submerged aquatic vegetation beds as critical or essential habitat for living resources.

There are two SAV species found in Maryland's coastal bays: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). While SAV 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 lower abundance. Both SAV 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 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 SAV 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 SAV beds in 2012. This survey was designed to meet the following two objectives:

1. characterize SAV 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 daylight on six days in September over a three year period: 2015 September 1; 2016 September 13, 15 and 2017 September 7, 8 and 12.

Study Area

Sinepuxent Bay was selected in 2015 because it had the most readily available SAV beds in proximity with our established Trawl and Beach Seine surveys sites discussed in Chapter 1 (Figure 1 and Table 1). Site verification was conducted in 2015 to confirm SAV 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 m X 305 m grid overlaying areas where SAV 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 SAV survey. Potential sites were selected from the reconnaissance if SAV was present and the site was not too deep to seine. The sites sampled in 2015 were revisited in 2016 and 2017.

Data Collection

A 25ft C-hawk 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 m X 1.8 m X 6.4 mm mesh (50 ft X 6 ft X 0.25 in mesh) zippered bag seine was used. This gear was called the SAV beach seine. Staff estimated percent of net open and a range finder was used to quantify the 35 meter seine haul. 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 m). 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 the exception of increasing the number of fish measured in 2016 and 2017. Length targets were adjusted to improve statistical precision to evaluate habitat utilization by size. The 2016 target of 100 fish lengths per beach seine haul for silver perch (*Bairdiella chrysoura*) and Atlantic silversides (*Menidia menidia*) was reduced to 50 fish lengths per beach seine haul in 2017 based on evaluation of the 2016 data. Those data indicated that the 100 fish target was set to high.

Data Analysis

Comparisons of fish abundance were based on the SAV beach seine catch from each habitat type. Habitat types were characterized by SAV coverage quantified by the estimated percent of SAV in the sample area, bottom type substrate, and the dominant SAV species in sample area. Catch per unit of effort was calculated as the mean catch of fish per hectare. The alpha value of 0.05 was used for all tests. The Kruskal-Wallis H test, Duncan's multiple range tests and least-squares means were used to measure and compare independent variable main effects and interactions relative to species abundance. 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.

Results

Sample Size and Distribution

These results were based on 43 unbalanced random samples collected from 2015 to 2017 within five SAV grids (Table 1 and Figure 1). The samples were distributed between four categories of SAV coverage: 25% or less (11 samples), 26% - 50% (seven samples), 51% - 75% (12 samples) and 76% - 100% (13 samples). The samples were also categorized by substrate as either mud (28 samples) or sand (15 samples). Additionally, each sites dominant SAV species was identified; eelgrass was most abundant (29 samples) followed by widgeon grass (14 samples). Furthermore, sites were also investigated for habitat interaction such as SAV coverage and substrate (Table 2).

Fish Species Abundance by Habitat Category

A total of 38 species and 5,815 fish were collected during this three-year investigation. The most abundant species were silver perch and Atlantic silversides (Table 3). Species with adequate abundance were selected for statistical analysis to determine if there were significant habitat effects or interaction on species abundance. Gray snapper, sheepshead and tautog were selected along with halfbeak, pigfish and pinfish. Forage species such as Atlantic silverside, bay anchovy, silver perch were also selected with blue crab and brown shrimp (Table 4).

The results of the Kruskal-Wallis test for CPUE and percent SAV coverage showed significant effects on abundance for pigfish ($\chi2(3) = 13.58$, $p = 0.0035$), silver perch ($\chi2(3) = 12.69$, $p = 0.0054$) and blue crab ($\chi2(3) = 8.71$, $p = 0.0334$; Table 5). The other species did not demonstrate any effect from SAV coverage. The results of the Kruskal-Wallis test for CPUE and primary substrate within SAV beds of multiple coverage showed significant effects for pigfish ($\chi2(1) = 5.74$, $p = 0.0166$), sheepshead ($\chi2(1) = 6.87$, $p = 0.0088$) and brown shrimp ($\chi2(1) = 9.11$, $p = 0.0025$). The other species did not demonstrate any effect from primary substrate (Table 5).
The results of the Kruskal-Wallis test for CPUE and dominant SAV within beds of multiple levels of percent SAV coverage showed significant effects for Atlantic silverside ($\chi2(1) = 7.07$, $p = 0.0078$), bay anchovy ($\chi2(1) = 8.43$, $p = 0.0037$), gray snapper ($\chi2(1) = 8.31$, $p = 0.0039$), tautog ($\chi2(1) = 4.88$, $p = 0.0272$), blue crab ($\chi2(1) = 5.51$, $p = 0.0189$) and brown shrimp ($\chi2(1) = 6.31$, $p = 0.0120$). The other species did not demonstrate any effect from dominant widgeon grass or eelgrass (Table 5).

An unbalanced analysis of variance and Duncan's Multiple Range Test was performed on pigfish, silver perch and blue crab to determine the effects of SAV coverage on abundance. The results showed that pigfish ($F_{3,42} = 5.73$, $p = 0.0025$) had higher mean abundance in the medium and medium-high SAV categories (26% - 50%; 51% - 75%). Silver perch ($F_{3,42} = 4.13$, $p = 0.0127$) were most abundant in the medium-high SAV categories (51% - 75%; 76 - 100%; Table 6). Blue crab ($F_{3,42} = 1.58$, $p = 0.2158$) was most abundant in the medium-high SAV category (51-75%; Table 6). An unbalanced analysis of variance and Duncan's Multiple Range Test was performed on pigfish, sheepshead and brown shrimp to determine the effects of primary substrate on abundance. The results showed that pigfish ($F_{1,42} = 7.27$, $p = 0.0105$) had higher mean abundance in sand compared to mud. Sheepshead ($F_{1,42} = 13.15$, $p = 0.0009$) and brown shrimp ($F_{1,42} = 4.34$, $p = 0.0443$) also had higher mean abundance in sand (Table 7).

An unbalanced analysis of variance and Duncan's Multiple Range Test was performed on six species that had significant results from the Kruskal-Wallis test for effect of dominant SAV species on abundance. The results showed that Atlantic silverside ($F_{1,42} = 6.78$, $p = 0.0132$), bay anchovy ($F_{1,42} = 5.23$, $p = 0.0280$), gray snapper ($F_{1,42} = 4.33$, $p = 0.0444$), blue crab ($F_{1,42} = 6.31$, $p = 0.0165$) and brown shrimp ($F_{1,42} = 3.41$, $p = 0.0727$) had higher mean abundance in widgeon grass compared to eelgrass habitat. Tautog ($F_{1,42} = 4.69$, $p = 0.0.0369$) showed higher mean abundance in eelgrass (Table 8).

Fish Species Richness and Diversity by Habitat Category

Fish species richness (number of species) and diversity (evenness of those species) was investigated among habitat categories. Richness values were high across all SAV categories. The medium-high SAV coverage category (51 - 75%) contained the most species (Table 9). Diversity results showed that medium SAV coverage (26 - 50% SAV) was most diverse (Table 10).

Fish Length Composition Habitat Category

Fish length was investigated among SAV coverage, substrate and dominant SAV. Atlantic silverside, silver perch and tautog were selected based on sample size. Blue crab was selected as a forage indicator as well. The unbalanced analysis of variance and Duncan's Multiple Range Test results showed differences in mean total length for Atlantic silverside ($F_{3,1136} = 4.73$, $p = 0.0028$) and silver perch ($F_{3,904} = 14.05$, $p < 0.001$) by SAV coverage; both fishes mean length was smallest in the 76 - 100% SAV bed category. Tautog and blue crab mean length differences by SAV coverage were not significant (Table 11). Results for mean length and primary substrate showed that Atlantic silverside ($F_{1,1361} = 4.24$, $p = 0.0053$) were smaller in mud while blue crab ($F_{1,955} = 38.76$, $p < 0.001$) mean length was smaller in sand. Silver perch and tautog mean length differences by substrate were not significant (Table 12).

The unbalanced analysis of variance and Duncan's Multiple Range Test results showed differences in mean length and dominant SAV species for silver perch ($F_{1,904} = 12.83$, $p = 0.0004$) and blue crab ($F_{1,955} = 23.78$, $p < 0.001$). Silver perch mean length was smaller in eelgrass while blue crab mean length was smaller in widgeon grass. Results for Atlantic silverside and tautog were not significant (Table 13).

Water Quality

The water quality tested at all sampling locations was consistent with fish habitat requirements. The average dissolved oxygen measured was 7.46 mg/L and ranged from 4.49 –12.3 mg/L. The water temperature average was 24.1 C and ranged from 21.5 - 26.8 C. The salinity averaged 28.6 ppt and ranged from 24.4 - 33.4 ppt. The Secchi disk average was 62.4 cm and ranged from 27 - 96 cm.

Discussion

Open water beach seine sampling of SAV beds was difficult and the certainty of collecting all the fishes in the sample area was not 100%. While capture efficiency was not measured directly, it was more difficult to seine in thicker grass beds than those with a smooth bottom and less SAV coverage. The CPUE may be higher in the thicker grass beds than calculated and the differences in abundance between low and high coverage beds may be greater than reported. Based on the length frequency data collected, fishes were collected as small as 5 mm; however, the probability of efficiently capturing fish that small was low.

The growth of juvenile tautogs and other juvenile fishes is affected by a number of factors in a nursery habitat. The major factors known to contribute to habitat quality are temperature, oxygen, salinity, predators, water depth, food, habitat structure, and hydrodynamics (Gibson 1994; Beck *et al*. 2001). During our study, all water chemistry values were within typical ranges for Sinepuxent Bay and within physiological tolerances for fishes and invertebrates. The study design was successful in reducing the variance for many of these influences in an attempt to isolate the habitat structures as independent variables that affect fish abundance. The interannual variation of the SAV composition within the coastal bays presented a challenge to compare data from year to year and increased sampling effort was required, these results seemed reasonable considering the sample size and collection effort for this investigation.

The abundance results and the preference of Atlantic silversides, bay anchovy, gray snapper, blue crab and brown shrimp to select widgeon grass over eelgrass was unexpected because it was less available than eelgrass. Tautog was the only fish which preferred eelgrass habitat which is surprising since tautogs forage on crustaceans, such as blue crabs and shrimps, which preferred widgeon grass.

Most striking was the general abundance of tautog in this study compared to those in Chapter 1. Dorf and Powell (1997) suggested that macroalgae is habitat was better than no cover for juvenile tautog since eelgrass disappeared from Narraganset Bay, Rhode Island. The northern coastal bays in Maryland have undergone a similar situation. Macroalgae abundance has increased over time while eelgrass beds have disappeared or changed in size and composition, but the Trawl and Beach Seine surveys rarely encounter tautogs. While eelgrass (and widgeon grass) were still available in Sinepuxent Bay, it is questionable that without submerged aquatic vegetation habitat, tautog would utilize macroalgae because there would be evidence of that already from the Trawl and Beach Seine surveys.

Based on an otolith-estimated mean growth rate of 0.5 mm per day, fish hatched in May and collected in September should be about 50 - 60 mm; therefore, assuming the same juvenile growth rate as fish from Narragansett Bay, the tautogs collected in Sinepuxent Bay were split between young of year and age 1 (Dorf 1994). This estimate is likely more conservative toward age 1 considering the warmer water temperatures in Maryland compared to Rhode Island. The annual CPUE estimate from this study could be an important input from Maryland to the regional stock assessment for tautog. The overall CPUE of fishes in this study, especially tautog, demonstrates the importance of SAV as critical habitat in Sinepuxent Bay.

The species richness of fishes in the Sinepuxent grass beds was high, especially in the medium and medium-high coverage categories. Fish diversity (evenness among species) was relatively low, with a slight exception for the SAV beds with medium coverage. The large abundance of silver perch and Atlantic silversides drove down the diversity index. Richness of fishes in sand substrate was higher than mud only in the low and medium SAV categories; otherwise richness was the same for substrate. There was no trend for fish diversity among substrate, except that it was generally low.

Previous growth history as well as size-selective mortality may also influence interpretation of juvenile growth rates (Meekan and Fortier 1996; Searcy and Sponaugle 2001; Bergenius *et al.* 2002; Grorud-Colvert and Spounagle 2006; Searcy *et al.* 2007). Growth rates may also be affected by mechanisms such as selective mortality of slower growing individuals and negative density dependence (Searcy *et al.* 2007; Mateo *et al.* 2011). Two species, silver perch and Atlantic silversides, the most abundant fish in this study, had the smallest mean length in dense SAV coverage. The larger silver perch (average 76 mm) preferred widgeon grass, as did the smaller blue crabs (average 42.1 mm; Table 13). Larger silver perch may likely be attracted to the forage composition within the SAV bed such as these smaller and more abundant blue crabs. The results of this three-year study have revealed the importance of SAV habitat and stock assessment benefits that can be gained with continue study and monitoring.

References

Beck, M. W., K. L. Heck Jr., K. W. Able, D. L. Childers, D. B. Eggleston, B. M. Gillanders, B.Halpern, C. A. Hays,K.Hoshino, T. J. Minello,R. J.Orth, P. F. Sheridan, and M. P. Weinstein. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. BioScience 51:633–641.

Bergenius, M. A., M. E. Meekan, D. R. Robertson, and M. I.McCormick. 2002. Larval growth predicts the recruitment success of a coral reef fish. Oecologia (Heidelberg) 131:521–525.

Coastal Bays Sensitive Areas Technical Task Force. 2004. Maryland Coastal Bays Aquatic Sensitive Initiative. Edited by Conley, M. Maryland Department of Natural Resources Coastal Zone Management Division.

Connolly, R. M. and J. S. Hindell. Review of nekton patterns and ecological processes in seagrass landscapes. Estuarine, Coastal and Shelf Science. 2006;68:433-444.

Der, G. and Everitt, B.S. A Handbook of Statistical Analyses using SAS, Second Edition. Boca Raton, Florida. Chapman and Hall/CRC.; 2002.

Dorf, B. A., and J. C. Powell. 1997. Distribution, abundance, and habitat characteristics of juvenile tautog (Tautoga onitis, Family Labridae) in Narragansett Bay, Rhode Island, 1988–1992. Estuaries 20:589–600.

Gibson, R. N. 1994. Impact of habitat quality and quantity on the recruitment of juvenile flatfishes. Netherland Journal of Sea Research 32:191–206.

Grorud-Colvert, K., and S. Sponaugle. 2006. Influence of condition on behavior and survival potential of a newly settled coral reef fish. Marine Ecology Progress Series 327:279–388.

Mateo, I., E.G. Durbin, D.A. Bengtson and Daisy Durant. 2011. Variations in Growth of Tautog in Nursery Areas in Narragansett Bay and Rhode Island Coastal Ponds, Marine and Coastal Fisheries, 3:1, 271-278.

Meekan, M. G., and L. Fortier. 1996. Selection for fast growth during the larval life of Atlantic cod Gadus morhua on the Scotian Shelf. Marine Ecology Progress Series 137:25–37.

Murdy, E., R.S. Birdsong, and J.M. Musick. Fishes of Chesapeake Bay. Washington, DC.: Smithsonian Institution Press; 1997.

Searcy, S. P., D. B. Eggleston, and J. A. Hare. 2007. Is growth a reliable indicator of habitat quality and essential fish habitat for a juvenile estuarine fish? Canadian Journal of Fisheries and Aquatic Sciences 64:681–691.

Searcy, S. P., and S. Sponaugle. 2001. Selective mortality during the larval juvenile transition in two coral reef fishes. Ecology (Washington, D.C.) 82:2452–2470.

Steimle, F.W. and P.A. Shaheen. 1999. Tautog (*Tautoga onitis*) Life History and Habitat Requirements. NOAA Technical Memorandum NMFS-NE-118.

Livingston, Robert J. Trophic Organization of Fishes in a Coastal Seagrass System. Marine Ecology Progress Series 1982; 7:1-12.

List of Tables

List of Figures

Table 1. 2015 - 2017 Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey site descriptions.

Grid Number	Site Description	Latitude	Longitude	Number of Samples
121	East of Snug Harbor; West of Small Island	38 17.221	75 07.651	11
128	South of Duck Blind; East of Green Marker	38 17.061	75 07.659	7
160	700 meters northeast of Potfin Road along the shoreline	38 15.900	75 08.761	14
212	South of Verrazano Bridge; West of Sandy Point Island; on channel edge	38 14.295	75 09.404	4
221	Southwest of Small Island; South of Verrazano Bridge	38 14.147	75 09.402	7

Table 2. 2015 - 2017 Submerged Aquatic Vegetation Habitat Survey sample size by habitat characteristics.

	Percent SAV					
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%	Total by Characteristic	Grand Total
Eelgrass (*Zostera marina*)	8	3	6	12	29	43
Widgeon grass (*Ruppia maritima*)	3	4	6	1	14	
Sand	6	4	3	2	15	43
Mud	5	3	9	11	28	
Sand - Widgeon grass (*Ruppia m.*)	3	2	1	1	7	43
Mud - Widgeon grass (*Ruppia m.)*	0	2	5	0	7	
Sand - Eelgrass (*Zostera m.*)	3	2	2	1	8	
Mud - Eelgrass (*Zostera m.)*	5	1	4	11	21	

Table 3. Fishes collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year 2015 - 2017. Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 - 2017		2017		2016		2015	
	# of fish	CPUE	# of fish	CPUE	# of fish	CPUE	# of fish	CPUE
Silver perch (*Bairdiella chrysoura*)	2,670	1,550.4	469	688.9	496	884.6	1,705	3,547.7
Atlantic silverside (*Menidia menidia*)	2,419	1,404.7	932	1,368.9	967	1,724.7	520	1,082.0
Halfbeak (*Hyporhamphus unifasciatus*)	194	112.7	86	126.3	85	151.6	23	47.9
Sheepshead (*Archosargus probatocephalus*)	84	48.8	39	57.3	29	51.7	16	33.3
Dusky pipefish (*Syngnathus floridae*)	74	43.0	58	85.2	15	26.8	1	2.1
Northern pipefish (*Syngnathus fuscus*)	69	40.1	39	57.3	17	30.3	13	27.1
Tautog (*Tautoga onitis*)	48	27.9	19	27.9	2	3.6	27	56.2
Striped blenny (*Chasmodes bosquianus*)	36	20.9	19	27.9	15	26.8	2	4.2
Oyster toadfish (*Opsanus tau*)	27	15.7	9	13.2	15	26.8	3	6.2
Pigfish (*Orthopristis chrysoptera*)	26	15.1	13	19.1	11	19.6	2	4.2
Bay anchovy (*Anchoa mitchilli*)	21	12.2			19	33.9	2	4.2
Spot (*Leiostomus xanthurus*)	20	11.6			19	33.9	1	2.1
Pinfish (*Lagodon rhomboides*)	18	10.5	5	7.3	2	3.6	11	22.9
Gray snapper (*Lutjanus griseus*)	16	9.3	2	2.9	13	23.2	1	2.1
Spotfin mojarra (*Eucinostomus argenteus*)	16	9.3	12	17.6	4	7.1		
Striped burrfish (*Chilomycterus schoepfii*)	14	8.1	4	5.9	8	14.3	2	4.2
Northern puffer (*Sphoeroides maculatus*)	8	4.6	2	2.9	2	3.6	4	8.3
Rainwater killifish (*Lucania parva*)	7	4.1	5	7.3			2	4.2
Summer flounder (*Paralichthys dentatus*)	6	3.5	1	1.5	3	5.4	2	4.2
Naked goby (*Gobiosoma bosc*)	5	2.9			5	8.9	4	8.3
Southern kingfish (*Menticirrhus americanus*)	5	2.9			5	8.9		
Spotfin butterflyfish (*Chaetodon ocellatus*)	4	2.3						
Spotted seatrout (*Cynoscion nebulosus*)	4	2.3			4	7.1		
Striped mullet (*Mugil cephalus*)	4	2.3			4	7.1		
White mullet (*Mugil curema*)	4	2.3			3	5.4	1	2.1

Table 3 continued. Fishes collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year 2015 - 2017. Catch Per Unit of Effort (CPUE) was fish/hectare.

Specimen Name	2015 - 2017		2017		2016		2015	
	# of fish	CPUE	# of fish	CPUE	# of fish	CPUE	# of fish	CPUE
Black sea bass (*Centropristis striata*)	3	1.7	2	2.9	1	1.8		
American eel (*Anguilla rostrata*)	2	1.2			2	3.6		
Atlantic menhaden (*Brevoortia tyrannus*)	2	1.2			2	3.6		
Atlantic needlefish (*Strongylura marina*)	2	1.2			2	3.6		
Bluespotted cornetfish (*Fistularia tabacaria*)	2	1.2	1	1.5			1	2.1
Atlantic croaker (*Micropogonias undulatus*)	1	0.6			1	1.8		
Black drum (*Pogonias cromis*)	1	0.6			1	1.8		
Southern stingray (*Dasyatis americana*)	1	0.6	1	1.5				
Striped anchovy (*Anchoa hepsetus*)	1	0.6			1	1.8		
Striped killifish (*Fundulus majalis*)	1	0.6			1	1.8		

Table 4. Forage crustaceans collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year 2015 - 2017. Catch Per Unit of Effort (CPUE) was individual/hectare.

Specimen Name	2015 - 2017		2017		2016		2015	
	# of ind.	CPUE	# of ind.	CPUE	# of ind.	CPUE	# of ind.	CPUE
Blue crab (*Callinectes sapidus*)	1,194	693.3	694	1,019.3	358	638.5	142	295.5
Brown shrimp (*Farfantepenaeus aztecus*)	389	225.9	35	51.4	349	622.4	5	10.4

Table 5. Results of the SAV Habitat Survey Kruskal - Wallis test for CPUE and percent SAV coverage, primary substrate and dominant SAV. Alpha of 0.05 was used as the cutoff for significance; results greater than 0.05 were not significant (n.s.).

Specimen Name	Percent SAV	Primary Substrate	Dominant SAV
Atlantic silverside (*Menidia menidia*)	n.s.	n.s.	($\chi 2(1) = 7.07$, $p < 0.01$)
Bay anchovy (*Anchoa mitchilli*)	n.s.	n.s.	($\chi 2(1) = 8.43$, $p < 0.01$)
Gray snapper (*Lutjanus griseus*)	n.s.	n.s.	($\chi 2(1) = 8.31$, $p < 0.01$)
Halfbeak (*Hyporhamphus unifasciatus*)	n.s.	n.s.	n.s.
Pigfish (*Orthopristis chrysoptera*)	($\chi 2(3) = 13.58$, $p < 0.01$)	($\chi 2(1) = 5.74$, $p < 0.05$)	n.s.
Pinfish (*Lagodon rhomboides*)	n.s.	n.s.	n.s.
Sheepshead (*Archosargus probatocephalus*)	n.s.	($\chi 2(1) = 6.87$, $p < 0.01$)	n.s.
Silver perch (*Bairdiella chrysoura*)	($\chi 2(3) = 12.69$, $p < 0.01$)	n.s.	n.s.
Tautog (*Tautoga onitis*)	n.s.	n.s.	($\chi 2(1) = 4.88$, $p < 0.01$)
Blue crab (*Callinectes sapidus*)	($\chi 2(3) = 6.17$, $p < 0.05$)	n.s.	($\chi 2(1) = 5.51$, $p < 0.05$)
Brown shrimp (*Farfantepenaeus aztecus*)	n.s.	($\chi 2(1) = 9.11$, $p < 0.01$)	($\chi 2(1) = 6.31$, $p < 0.05$)

Table 6. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for CPUE and percent SAV coverage.

	Percent SAV			
Specimen Name	Low < 25%	Medium 26 - 50%	Medium-High 51 - 75%	High 76 - 100%
	($F_{3,42} = 5.73$, $p < 0.005$)			
Pigfish (*Orthopristis chrysoptera*)	$\bar{x} = 0$ B	$\bar{x} = 28.54$ A	$\bar{x} = 35.37$ A	$\bar{x} = 1.92$ B
	($F_{3,42} = 4.13$, $p < 0.05$)			
Silver perch (*Bairdiella chrysoura*)	$\bar{x} = 372$ B	$\bar{x} = 556$ B	$\bar{x} = 3{,}581$ A	$\bar{x} = 1{,}208$ A / B
	($F_{3,42} = 1.58$, $p = 0.21$)			
Blue crab (*Callinectes sapidus*)	$\bar{x} = 272.4$ B	$\bar{x} = 745.5$ A / B	$\bar{x} = 1{,}150.7$ A	$\bar{x} = 599.3$ A / B

Table 7. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for CPUE and primary substrate.

Specimen Name	Primary Substrate	
	Mud	Sand
	($F_{1,42} = 7.27$, $p < 0.05$)	
Pigfish (*Orthopristis chrysoptera*)	$\bar{x} = 8.03$	$\bar{x} = 28.3$
	A	B
	($F_{1,42} = 13.15$, $p < 0.001$)	
Sheepshead (*Archosargus probatocephalus*)	$\bar{x} = 19.6$	$\bar{x} = 103.2$
	A	B
	($F_{1,42} = 4.34$, $p < 0.05$)	
Brown shrimp (*Farfantepenaeus aztecus*)	$\bar{x} = 33$	$\bar{x} = 585.9$
	A	B

Table 8. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for CPUE and dominant SAV.

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
	($F_{1,42} = 6.78$, $p < 0.05$)	
Atlantic silverside (*Menidia menidia*)	$\bar{x} = 1{,}010$	$\bar{x} = 2{,}222.3$
	A	B
	($F_{1,42} = 5.23$, $p < 0.05$)	
Bay anchovy (*Anchoa mitchilli*)	$\bar{x} = 2.6$	$\bar{x} = 32.1$
	A	B
	($F_{1,42} = 4.33$, $p < 0.05$)	
Gray snapper (*Lutjanus griseus*)	$\bar{x} = 0.9$	$\bar{x} = 26.8$
	A	B
	($F_{1,42} = 4.69$, $p < 0.05$)	
Tautog (*Tautoga onitis*)	$\bar{x} = 37.9$	$\bar{x} = 7.1$
	A	B
	($F_{1,42} = 6.31$, $p < 0.05$)	
Blue crab (*Callinectes sapidus*)	$\bar{x} = 643.2$	$\bar{x} = 1{,}170$
	A	B
	($F_{1,42} = 3.41$, $p = 0.07$)	
Brown shrimp (*Farfantepenaeus aztecus*)	$\bar{x} = 32.7$	$\bar{x} = 626$
	A	B

Table 9. SAV Habitat Survey Richness of fishes by habitat category.

	Percent SAV			
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%
Combined (All SAV and Substrate)	23	24	29	16
Eelgrass (*Zostera marina*)	18	17	17	15
Widgeon grass (*Ruppia maritima*)	14	17	25	17
Sand	18	21	21	13
Mud	12	9	22	13
Sand - Widgeon grass (*Ruppia m.)*	14	15	18	7
Mud - Widgeon grass (*Ruppia m.)*		6	18	
Sand - Eelgrass (*Zostera m.)*	11	14	10	10
Mud - Eelgrass (*Zostera m.)*	12	7	15	13

Table 10. SAV Habitat Survey Shannon - Index Diversity H values of fishes by habitat category.

	Percent SAV			
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%
Combined (All SAV and Substrate)	1.16	1.88	1.08	1.17
Eelgrass (*Zostera marina*)	1.38	1.77	0.77	1.2
Widgeon grass (*Ruppia maritima*)	0.56	1.61	1.27	0.55
Sand	1.01	1.88	1.51	0.95
Mud	1.15	1.27	0.86	1.3
Sand - Widgeon grass (*Ruppia m.)*	0.56	1.65	1.05	0.55
Mud - Widgeon grass (*Ruppia m.)*		1.01	1.26	
Sand - Eelgrass (*Zostera m.)*	1.64	1.63	0.92	0.92
Mud - Eelgrass (*Zostera m.)*	1.15	1.83	0.61	1.3

Table 11. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for mean length and percent SAV coverage.

Specimen Name	Percent SAV			
	Low < 25%	Medium 26 - 50%	Medium-High 51 - 75%	High 76 - 100%
Atlantic silverside (*Menidia menidia*)		($F_{3,1136}$ = 4.73, $p < 0.01$)		
	$\bar{x}$ = 84.5	$\bar{x}$ = 85.1	$\bar{x}$ = 83.4	$\bar{x}$ = 81
	A/B	A	B	C
Silver perch (*Bairdiella chrysoura*)		($F_{3,904}$ = 14.05, $p < 0.001$)		
	$\bar{x}$ = 73.4	$\bar{x}$ = 73.3	$\bar{x}$ = 73.1	$\bar{x}$ = 65.8
	A	A	A	B
Tautog (*Tautoga onitis*)		($F_{3,47}$ = 0.63, $p = 0.60$)		
	$\bar{x}$ = 88.4	$\bar{x}$ = 79	$\bar{x}$ = 93.8	$\bar{x}$ = 81.9
	A	A	A	A
Blue crab (*Callinectes sapidus*)		($F_{3,955}$ = 0.65, $p = 0.58$)		
	$\bar{x}$ = 46.2	$\bar{x}$ = 43.7	$\bar{x}$ = 51.7	$\bar{x}$ = 45.7
	A	A	A	A

Table 12. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for mean length and primary substrate.

Specimen Name	Primary Substrate	
	Mud	Sand
	($F_{1,1136} = 4.24$, $p < 0.01$)	
Atlantic silverside (*Menidia menidia*)	$\bar{x} = 81.9$	$\bar{x} = 84.0$
	A	B
	($F_{1,904} = 0.30$, $p = 0.87$)	
Silver perch (*Bairdiella chrysoura*)	$\bar{x} = 70.1$	$\bar{x} = 70.6$
	A	A
	($F_{1,47} = 0.13$, $p = 0.72$)	
Tautog (*Tautoga onitis*)	$\bar{x} = 89.3$	$\bar{x} = 82.5$
	A	A
	($F_{1,955} = 38.76$ $p < 0.001$)	
Blue crab (*Callinectes sapidus*)	$\bar{x} = 51.8$	$\bar{x} = 40.1$
	A	B

Table 13. Results of the SAV Habitat Survey ANOVA and Duncan's multiple range test for mean length and dominant SAV.

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
	($F_{1,136} = 3.38$, $p = 0.06$)	
Atlantic silverside (*Menidia menidia*)	$\bar{x} = 81.3$	$\bar{x} = 84.4$
	A	A
	($F_{1,904} = 12.83$, $p < 0.001$)	
Silver perch (*Bairdiella chrysoura*)	$\bar{x} = 68.3$	$\bar{x} = 76$
	A	B
	($F_{1,47} = 0$, $p = 0.96$)	
Tautog (*Tautoga onitis*)	$\bar{x} = 88.1$	$\bar{x} = 89.5$
	A	A
	($F_{1,955} = 23.78$, $p < 0.001$)	
Blue crab (*Callinectes sapidus*)	$\bar{x} = 51.9$	$\bar{x} = 42.1$
	A	B

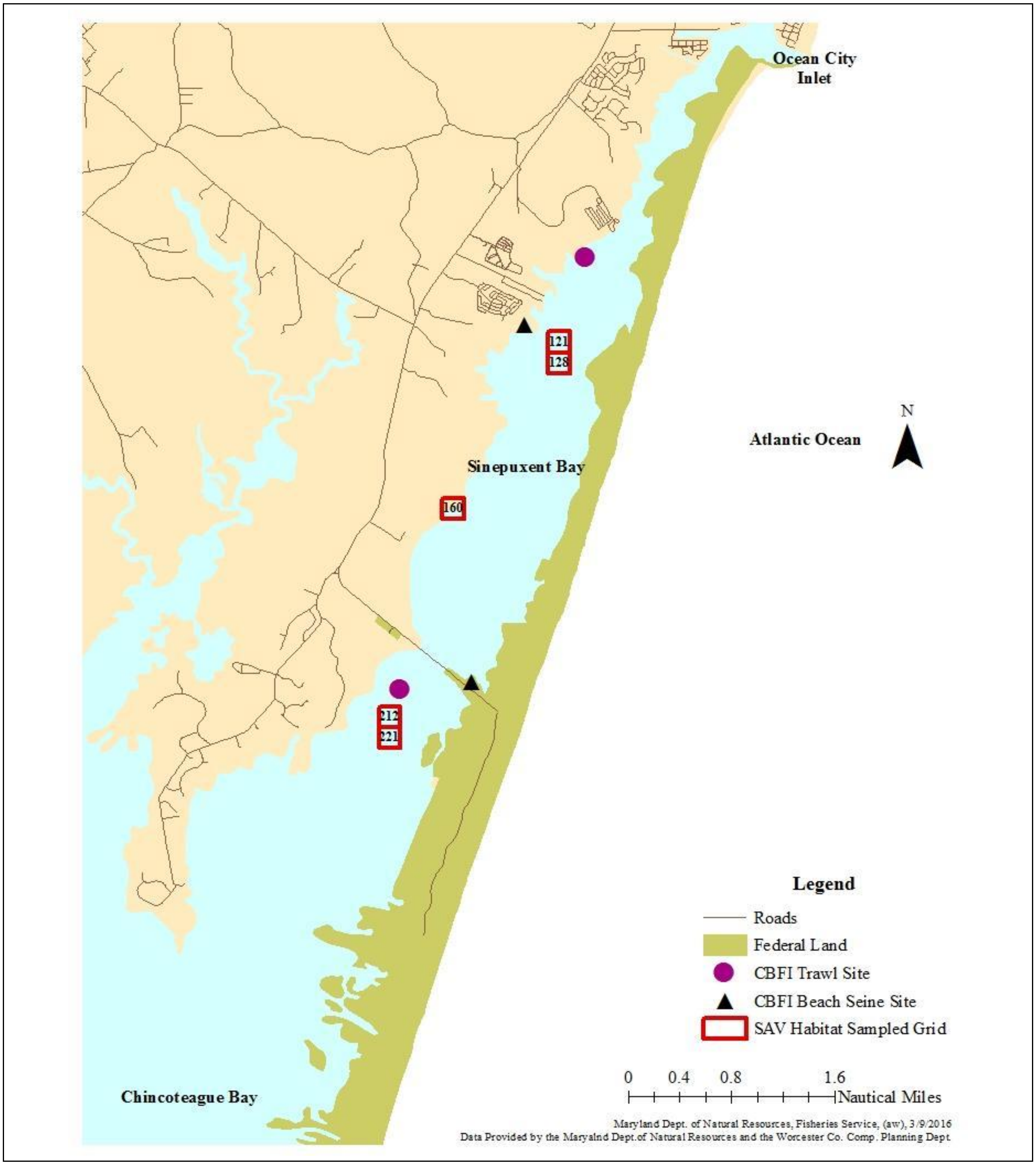

Figure 1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey and Trawl and Beach Seine surveys sample site locations (September, 2015 - 2017).

Chapter 3: Offshore Trawl Survey

Introduction

The department has conducted the Offshore Trawl Survey since 1993 to obtain biological information on adult fishes in the nearshore Atlantic waters. Offshore sampling provides access to species and adult length groups not frequently captured in the Trawl and Beach Seine surveys conducted in Maryland's coastal bays. This survey contributes to the investigations three objectives by collecting data that can be used to:

1. characterize the stocks and estimate relative abundance of adult marine and estuarine species in the coastal bays and near-shore Atlantic Ocean;
2. develop annual indices of age and length, relative abundance, and other 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

Time

Sampling trips were conducted during 2017 on June 2, July 13, August 14 and October 19. Trawls usually occurred at night in order to increase the legal size catch of horseshoe crabs, but the October trip was conducted during the day.

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 (ft) and time, water temperature (C); available from onboard electronics), weather and wind direction were recorded when the trawl net was 100 percent deployed. Wind speed (kts) 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 5).

Sample Processing

A representative subsample of the catch was collected from each haul and placed into a 100 Liter (L) tub. The total catch of horseshoe crabs was counted and used to calculate the proportion each subsample represented to the total catch. Species of interest such as summer flounder were sorted from the main catch and all individuals of these species are measured. All fishes and invertebrates were measured as in Chapter 1. Staff biologists consulted the *Peterson Field Guide Atlantic Seashore* (1978) and *Peterson Field Guide Atlantic Coast Fishes* (1986) for assistance with species identification.

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 20 and 70 minutes. Water temperature ranged from a high of 23.9 C in August to a low of 18.3 C in October. Depth over the course of the surveys ranged from 9.8 m to 16.2 m (Table 2).

Numbers of species collected ranged from 10 to 24 per trip (Table 2). The prevalent fishes encountered from all of the trawls were summer flounder (*Paralichthys dentatus*), spot (*Leiostomus xanthurus*), southern kingfish (*Menticirrhus americanus*) and clearnose skate *(Raja eglanteria*; Table 3). Horseshoe crabs (*Limulus polyphemus*), portly spider crab *(Libinia emarginata)* and knobbed whelk (*Busycon carica*) were common invertebrates (Table 3). One sturgeon was encountered over the season and measured 1828.8 millimeters (mm) and was reported in Appendix 5 of the 2016 – 2017 F-50-R-25 report (2017).

From all trips combined, a total of 67 summer flounder were measured (Table 3). Lengths ranged in size from 142 mm (5.6 inches (in)) to 695 mm (27.4 in; Figure 1). The mean was 413 mm (16.3 in) and the mode was 388 mm (15.3 in). Thirty-six percent (24 fish) of the measured summer flounder were at or above the recreational minimum size limit (431.8 mm; 17 in) and 91% (61 fish) were above 355.6 mm (14 in; Table 4). The proportion of summer flounder less than 355.6 mm (14 in length at female maturity) and 431.8 mm (17 in) was examined over time in order to identify potential recruitment pulses in the nearshore population. The results varied without trend over the 2013 - 2017 time series. The mean percent less than 431.8 mm (17 in) was 64.1%.

In 2017 there were 30 southern kingfish measured and the mean length was 252 mm. The largest was 325 mm and the smallest was 127 mm.

Discussion

This survey provides information on the seasonality and relative abundance of adult sportfishes and forage species in nearshore waters including summer flounder, spot and southern kingfish. The GPS data are used to document fish abundances from nearshore shoals, slews and open areas. Data from this survey indicated that this is an important habitat area for southern kingfish, spot, summer flounder and elasmobranchs. It also documents presence of different finfish life stages (e.g. elasmobranchs and summer flounder) in these habitats. The majority of summer flounder measured in 2017 had reached the length of maturity which is 355.6 mm (14 in) for females and 304.8 mm (12 in) for males (Manooch 1984).

Southern kingfish are harvested by recreational fishermen. Adults of this demersal species prefer the sandy substrates of ocean beaches (Murdy and Musick 2013). Southern kingfish can also be found in muddy to sandy substrates which is the substrate often encountered in the trawls of this survey.

References

Doctor, S., G. Tyler, C. Weedon, and A. Willey. 2017. Investigation of Maryland's Coastal Bays and Atlantic Ocean Finfish Stocks: July 2016 - June 2017 Final Report. Federal Aid Project No. F-50-R-25. Maryland Department of Natural Resources. Annapolis, MD. 110 pp.

Gosner, K. L. 1978. Peterson Field Guide-Atlantic Seashore. Boston. Houghton Mifflin Company.

Manooch, C. S. 1984. Fisherman’s Guide: Fishes of the Southeastern United States. North Carolina State Museum of Natural History. Raleigh, NC. 362 pp.

Robins, R. C. and G. C. Ray. 1986. Peterson Field Guide: Atlantic Coast Fishes. Boston. Houghton Mifflin Company. 354 pp.

Tarnowski, M.. 2010. Personal Communication. Maryland Department of Natural Resources. Memo.

List of Tables

List of Figures

Table 1. Gear specifications for the subsampled commercial trawls off Ocean City, Maryland from June - October 2017.

Trip Date	Net Codend Mesh (cm)	Net Body Mesh (cm)	Head Rope Width (m)	Foot Rope Width (m)
June 2	14.6	15.3	33.5	39.6
July 13	14.0	14.0	24.4	30.5
August 14	14.0	14.0	24.4	30.5
October 19	14.0	14.0	24.4	30.5

Table 2. Commercial trawl subsample trip characteristics off Ocean City, Maryland from June - October 2017.

Trip Date	Number of Tows	Depth Range (m)	Temperature (C)	Species		
				Number Present	Number Counted	Number Measured
June 2	3	14.0 - 15.2	20.6	15	247	217
July 13	4	9.8 - 11.9	21.1	10	126	120
August 14	3	14.6 - 16.2	23.9	15	168	150
October 19	3	9.9 - 12.6	18.3	24	220	206

Table 3. List of species collected in subsampled commercial offshore trawls off Ocean City, Maryland from June - October 2017, n = 761. Species were grouped (finfish, crustaceans, mollusks, and other) and listed by order of extrapolated total number, n = 17,341.

Common Name	Scientific Name	Total Number Counted	Total Number Extrapolated
Finfish Species			
Clearnose skate	*Raja eglanteria*	23	622
Spot	*Leiostomus xanthurus*	10	189
Southern kingfish	*Menticirrhus americanus*	30	131
Summer flounder	*Paralichthys dentatus*	67	67
Striped burrfish	*Chilomycterus schoepfii*	11	57
Spotted hake	*Urophycis regia*	11	50
Northern puffer	*Sphoeroides maculatus*	5	22
Southern stingray	*Dasyatis americana*	6	21
Spiny butterfly ray	*Gymnura altavela*	12	12
Butterfish	*Peprilus triacanthus*	11	11
Weakfish	*Cynoscion regalis*	10	10
Atlantic Angel Shark	*Squatina dumeril*	8	8
Smooth dogfish	*Mustelus canis*	2	2
Bullnose ray	*Myliobatis freminvillei*	6	6
Bay anchovy	*Anchoa hepsetus*	1	1
Sand tiger shark	*Carcharias taurus*	1	1
Common thresher shark	*Alopias vulpinus*	1	1
Sandbar Shark	*Carcharhinus plumbeus*	1	1
Hogchoker	*Trinectes maculatus*	1	1
Black drum	*Pogonias cromis*	1	1
Atlantic Sturgeon	*Acipenser oxyrinchus*	1	1
	Total Finfish	**219**	**1,215**
Crustacean Species			
Portly spider crab	*Libinia emarginata*	27	795
Lady crab	*Ovalipes ocellatus*	12	368
Blue crab	*Callinectes sapidus*	8	273
Six-spined spider crab	*Libinia dubia*	2	90
Long-armed hermit crab	*Pagurus longicarpus*	7	49
Rock crab	*Cancer irroratus*	1	20
Broad claw hermit crab	*Pagurus pollicaris*	1	16
White shrimp	*Litopenaeus setiferus*	2	2
	Total Crustaceans	**60**	**1,613**
Mollusc Species			
Knobbed whelk	*Busycon carica*	30	885
Channeled whelk	*Busycotypus canaliculatus*	5	60
	Total Molluscs	**35**	**945**
Other Species			
Horseshoe crab	*Limulus polyphemus*	447	13,568
	Total Other	**447**	**13,568**

Table 4. Percent of summer flounder (*Paralichthys dentatus)* bycatch below the female length at maturity and recreational minimum size from subsampled commercial offshore trawls off Ocean City, Maryland from 2013 - 2017.

Year	Number of Trawls	Percent Below 355.6 mm (14 in)	Percent Below 431.8 mm (17 in)	Catch Per Unit Effort #/Trawl
2013	12	17.1	75.6	3.4
2014	12	23.0	66.7	10.5
2015	6	20.5	47.1	5.7
2016	14	17.4	66.3	6.1
2017	13	9.0	64.2	5.2

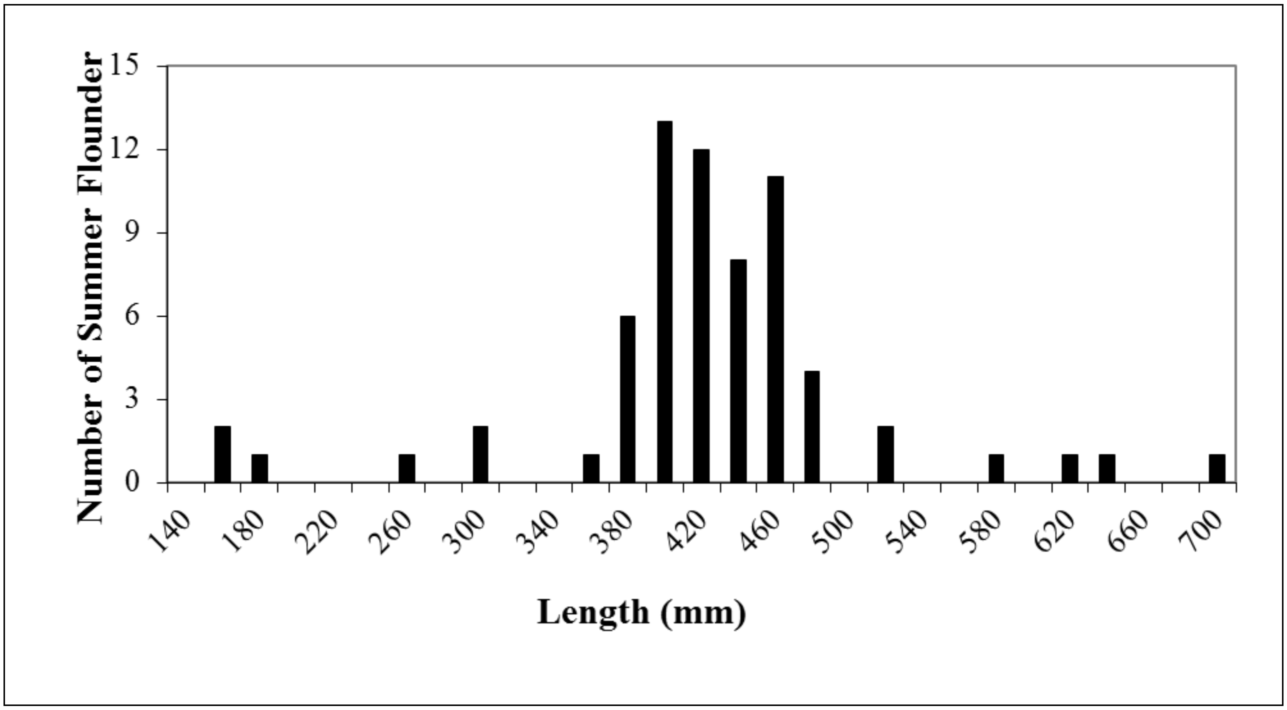

Figure 1. Summer flounder (*Paralichthys dentatus*) length (mm) frequency from commercial offshore trawls subsampled off Ocean City, Maryland from June - October 2017, n = 67. Data were derived from four trawl trips taken at different water depths.

Appendix 1. Trawl Survey Data Sheet

MD DNR Coastal Bays Trawl Data Sheet

Date	Start Time (12 hr)	Collector	Set#
_____/_____/2017			

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)	To Bottom ☐	Weather	Tide
38° .	38° .				

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

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

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

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

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) _____/_____/2017	Start Time (12 hr)	Collector	Set#
Site# **S0**	Station Description		
Seine Length: 100 foot 50 foot		Temp (°C)	Sal (ppt)
Waypoint Start	Waypoint Stop	DO (mg/L)	Secchi (cm) To Bottom ☐
Latstrt 38° .	Latstop 38° .	Weather	Tide
Longstrt 75° .	Longstop 75° .	Depth (ft)	Est. % Net Open
%SAV – Choose One 0–No SAV in sample area 1-up to 25% 2-26-50% 3-51%-75%, 4-76%-100% 5-SAV present 6-Undeterminable – give reason	SAV Species Present: 1. 2. Circle Dominant Species	Bottom Type 1. 2. Use N/A for line 2 if only 1 type	Wind Direction & Speed (Knots) @

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

List species collected for vouchers & quantities

21 L Bucket Cnt

Comments

L Count:
Number of Fish/L:
Species:
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

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

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. Fisheries Dependent Tautog Data Collection
Maryland 2017 Compliance Report to the Atlantic States Marine Fisheries Commission Excerpt

Fisheries dependent data was collected among the charter boat fleet in Ocean City while obtaining the required aging structures for the year. A total of 266 age samples were collected in the Atlantic Ocean by hook and line (21 Feb, n = 19; 16 Nov, n = 61; 17 Nov, n = 70 and 4 Dec; n = 50 and 7 Dec; n = 66). The samples taken represented the range of fish lengths commonly caught in the Atlantic Ocean. During these trips the entire catch was sacrificed and aged. Fish length (n = 266) ranged from 223 mm to 735 mm, mean length was 364 mm (SE±5.2); median length was 340 mm for all fish collected. Females comprised 65% (n = 173) of the samples, mean length was 353 mm (SE±6.2); the median length was 337 mm. Males comprised 34.6% (n = 92) of the samples, mean length was 383 mm (SE±9.2); the median length was 364 mm (Figure 1). Unknown sex comprised 0.4% (n = 1) of the samples, its length was 300 mm.

Fish weight (n = 266) ranged from 0.22 kg to 8.73 kg, mean weight was 1.08 kg (SE±0.07); median weight was 0.74 kg for all fish collected. Females comprised 65% (n = 173) of the samples, mean weight was 0.99 kg (SE±0.8); the median weight was 0.66 kg. Males comprised 34.6% (n = 92) of the samples, mean weight was 1.22 kg (SE±0.13); the median weight was 0.86 kg (Figure 1). Unknown sex comprised 0.4% (n = 1) of the samples and weighed 0.68 kg.

Fish age (n = 265) ranged from two to 25 years, mean age was 5.28 years (SE±0.21); median age was four years for all fish collected. Females comprised 64.9% (n = 172) of the samples, mean age was 5.17 years (SE±0.25); the median age was 4 years. Males comprised 34.7% (n = 92) of the samples, mean age was 5.5 years (SE±0.38); the median age was five years (Figure 1). Unknown sex comprised 0.4% (n = 1) of the samples and was four years old. One fish collected, measured and weighed could not be aged and was excluded from the age analyses.

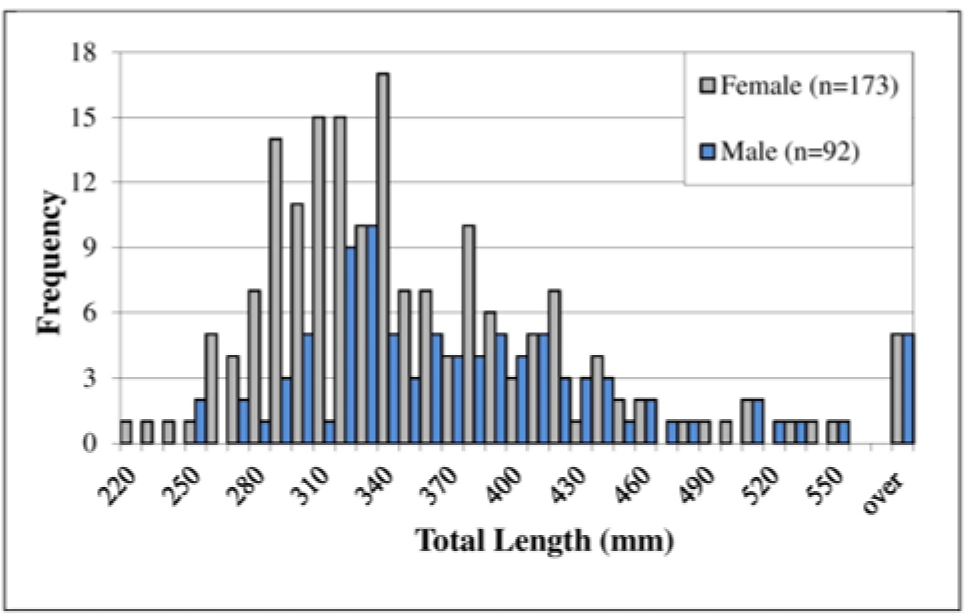

Figure 1. Length distribution of tautog sampled by sex obtained from charter boats near Ocean City, MD (2017; n=265).

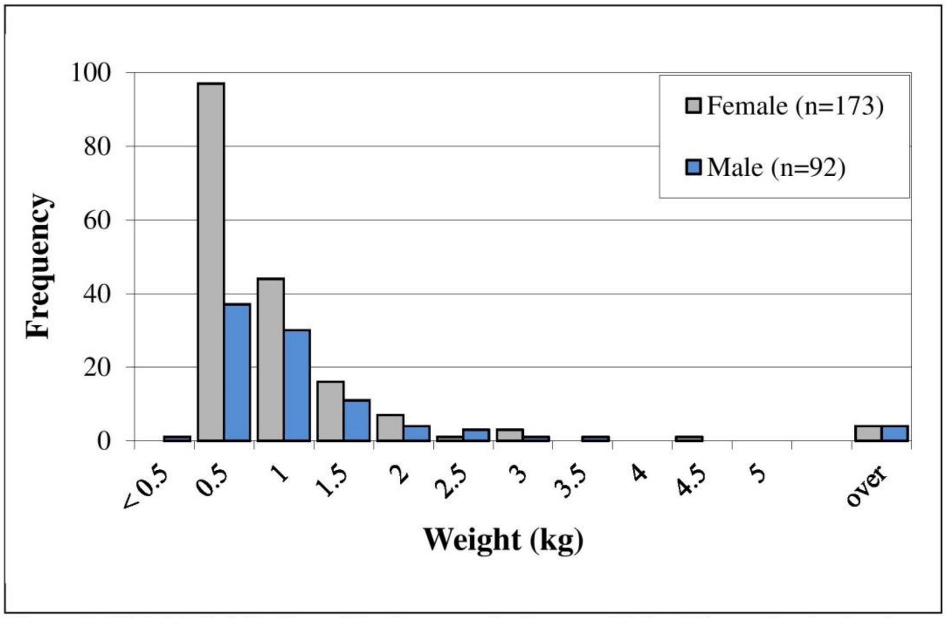

Figure 2. Weight distribution of tautog samples by sex obtained from charter boats near Ocean City, MD (2017; n=265).

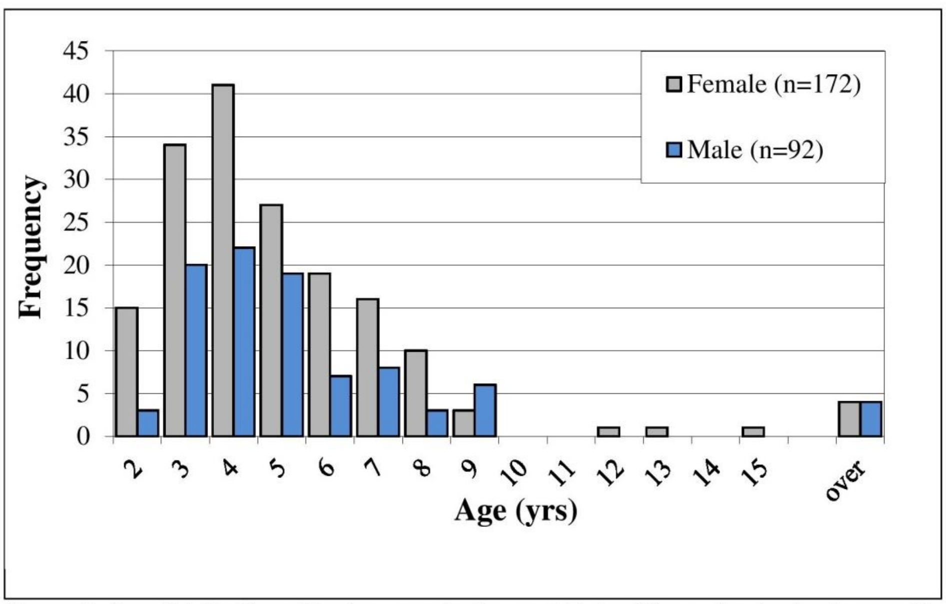

Figure 3. Age distribution of tautog samples by sex obtained from charter boats near Ocean City, MD (2017; n=264).

Appendix 4. Submerged Aquatic Vegetation Habitat Survey Data Sheet

Date (MM/DD/YYYY) ______/______/2017	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
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
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.	

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 5. Offshore Trawl Survey 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 100 liters	Lat stop	Sub-sample percentage of catch		
	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

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 Payment voucher ID books/Keys Measuring boards Digital Camera Live tank/ Sample Buckets Cell Phone Dinner/H_2O Pencils/ Sharpener