Larry Hogan
Governor

Jeannie Haddaway-Riccio
Secretary

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

F-50-R-28

July 2019 - June 2020
Final Report

Prepared by:
Steve Doctor
Gary Tyler
Craig Weedon
Angel Willey

Fishing and Boating Services
580 Taylor Ave.
Annapolis, MD 21401
dnr.maryland.gov
Toll free in Maryland: 877-620-8305
Out of state call: 410-260-8305
TTY Users call via the MD Relay

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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, 2019 through June 30, 2020

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

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

Approved by: ____
William C. Anderson, Appointing Authority

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Accomplishments July 1, 2019 - June 30, 2020

Completed July - August 2019

- Collected 20 trawl samples at 20 fixed locations on Maryland’s coastal bays, monthly
- Completed data entry and cleanup from prior month's sampling
- Accompanied commercial trawlers to gather biological information on adult finfishes
- Edited the F-50-R-27 report
- Wrote the Atlantic States Marine Fisheries Commission (ASMFC) Coastal Sharks Compliance report which was due August 1
- Worked with an intern to assist the project in the field

Completed September - October 2019

- Conducted beach seine sampling at 19 fixed sites in Maryland’s coastal bays
- Conducted the Submerged Aquatic Vegetation Habitat Survey at 21 sites in Sinepuxent Bay
- Finalized the F-50-R-27 report by September due date
- Completed data entry and cleanup from sampling
- Worked with an intern to assist the project in the field

Completed November 2019

- Completed QA/QC for all data collected during the field sampling season
- Updated metadata for shark logs
- Imported shark log data into Access database from Excel
- Collected 86 tautog structures for ageing

Completed December 2019 - March 2020

- Conducted data analyses of the 2019 surveys
- Drafted the F-50-R-28 annual report
- Collected, cleaned and aged tautog opercula
- Participated in a tautog ageing study to include pelvic spines as an approved structure
- Finfish abundance indices for black sea bass, bluefish and summer flounder were provided to the National Marine Fisheries Service Science Centers
- Worked with interns to proof dependent shark data that was imported from Microsoft Excel into Access (continued proofing those data when interns were no longer able to participate due to the COVID State of Emergency)
- Collected 120 tautog structures for ageing

Completed April - June 2020

- Prepared for the 2020 field sampling season (Trawl and Beach Seine surveys)
- Determined sampling needs for the next Submerged Aquatic Vegetation Habitat Survey
- Collected 20 trawl samples at 20 fixed locations on Maryland’s coastal bays (May – June; April sampling was not completed due to COVID State of Emergency)
- Conducted beach seine sampling at 19 fixed locations on Maryland’s coastal bays (June)
- Completed data entry and cleanup from prior months sampling

- Updated the dependent shark database with 2019 records from 96 trips
- Edited the F-50-R-28 report
- Wrote the Atlantic States Marine Fisheries Commission's black sea bass, scup, summer flounder and tautog compliance reports
- Collected 20 tautog structures for ageing

<u>Completed Year Round, as needed</u>

- Technical assistance benefiting finfishes of material value for recreation as per Sport Fish Restoration guidelines
- Responded to data requests from the Atlantic States Marine Fisheries Commission technical committees, the Mid-Atlantic Fishery Management Council monitoring committees and researchers

Preface

With the receipt of Sport Fish Restoration funds in 1989, the Trawl and Beach Seine surveys were performed following standardized protocols, eliminating the biases of previous years (1972 - 1988). This report highlights trends resulting from data collected during the standardized period (1989 - present).

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.

Although the Sport Fish Restoration reporting period covers July 2019 through June 2020, the terminal year of data used in this report is 2019 because a full sampling season is needed for data analyses. Note that the 2020 Coronavirus Disease State of Emergency prevented April trawl sampling in the coastal bays and nearshore trawl sampling for adult finfish in the Atlantic Ocean. The latter survey was discontinued for the remainder of 2020 due to fleet changes and low finfish intercepts.

Executive Summary

The 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 was 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 30 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, verification of submerged aquatic vegetation and academic research.

The investigation uses the previously mentioned four surveys and fisheries dependent information to meet the following four objectives:

1. Characterize the stocks and estimate relative abundance of juvenile and adult marine and estuarine species in the Maryland's coastal bays and near-shore Atlantic Ocean.
2. 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.
3. Provide technical assistance by participating on inter- and intra-government committees and writing Atlantic States Marine Fisheries Commission compliance reports. Develop indices of age and length, relative abundance and other needed information necessary to assist in the management of regional and coastal fish stocks.
4. To enhance the knowledge of sharks that are of interest to recreational anglers.

In 2019, 53,759 fish were caught in the Trawl and Beach Seine surveys (30,979 fish trawl and 22,780 fish beach seining). Collected fishes represented 68 species, which is within the normal representation range in a year. Atlantic croaker, Atlantic menhaden, black sea bass and spot had above average trawl indices and bay anchovy, spot and summer flounder had above average beach seine indices. Six important recreational and forage species had below average trawl indices including American eel, Atlantic silverside, bluefish, silver perch, summer flounder and weakfish. American eel, bluefish and weakfish had below average beach seine indices. For the past three years, summer flounder have had an above average beach seine index and a below average trawl index. The spot catch was exceptional in both the Trawl and Beach Seine surveys for the first time since 2012.

Richness is the number of different fishes sampled. High richness is an indicator that the overall habitat can support many species of fish during their lifecycles. Embayment richness results differed by gear, which was expected, due to the different habitats sampled by each. Chincoteague Bay had the highest richness (91 fishes) in the trawl time series (1989 - 2019) whereas Newport Bay had the lowest (68 fishes). The Beach Seine Survey time series (1989 - 2019) results showed that Assawoman Bay and Isle of Wight Bay had the richest fish populations (87 fishes) and Ayers Creek was poorest (44).

Diversity is a measurement of richness and the proportion of species in the sample population. The 2019 trawl and beach seine surveys were dominated by spot (76% trawl) and Atlantic

menhaden (57% beach seine), which reduced diversity for some embayments. Shannon index results for the trawl time series (1989 - 2019) indicated that Sinepuxent Bay (H = 2.0) was the most diverse whereas it was Newport Bay (H = 2.0) for the beach seine. Lowest diversity was seen in Assawoman Bay in the trawl time series (H = 1.6) and Ayers Creek (H = 1.4) for the beach seine.

Macroalgae bycatch is ephemeral with annual variation. It is quantified in these surveys for its positive and negative effects as habitat. Sixteen genera were collected by trawl and beach seine within the coastal bays in 2019. The terminal year (2019) showed a dramatic decrease in overall abundance of macroalgae, the lowest on record since these surveys began documenting it. *Agardhiella* remained the most abundant genus for both gears.

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 fishes. 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 and salinity has varied. Temperatures, while increasing over the time of the surveys, were within the acceptable range for coastal fishes.

The overall catch per unit effort of fishes in the Submerged Aquatic Vegetation Habitat Survey, especially tautog (*Tautoga onitis*), 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.

A total of 215 tautog were examined from ten charter trips. The maximum age was 22 and the mean age was six years. Tautog ageing results showed a wide range of year classes and large fish caught by hook and line in the Atlantic Ocean off Ocean City, Maryland.

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-three species of fishes, crustaceans, molluscs and other invertebrates were collected from five trips in 2019. Fishes of recreational interest encountered from these trawls included: clearnose skate, southern kingfish, spot and summer flounder. A total of 101 summer flounder were measured from those offshore trawls. Forty-two percent (42 fish) of the measured summer flounder were at or above the recreational minimum size limit (16.5 inches) and 80.2 percent (81 fish) were above 356 millimeters (14 inches), which is the length of female maturity. Based on commercial fleet changes and low finfish intercepts from this survey in recent years, this sampling will not be continued in 2020.

Technical expertise and field observations obtained from the previously mentioned surveys are provided for research and management. With the passage of the Atlantic States Coastal Cooperative Management Act and the Magnuson-Stevens Fishery Conservation and Management Act, entities such as the Atlantic States Marine Fisheries Commission, Mid-Atlantic Fishery Management Council and the National Marine Fisheries Service require stock assessment and habitat information. Technical expertise and data were contributed for Atlantic croaker, black sea bass, bluefish, coastal sharks, spot and summer flounder.

Dependent shark records from one charter boat captain were reviewed to answer biological questions and their potential to meet F-50-R objectives to enhance the knowledge of sharks that are of interest to recreational anglers. The captain took 96 trips from May through September 2019 in three areas: offshore (greater than 20 nautical miles), nearshore (less than 20 nautical miles) and from the Assateague Island National Seashore over sand vehicle area. Nine trips were taken offshore in May and June. Blue (*Prionace glauca*), sandbar (*Carcharhinus plumbeus*) and shortfin mako (*Isurus oxyrinchus*) sharks comprised 76 percent of the offshore catch. Seventy-eight of the charter trips occurred nearshore where Atlantic sharpnose (*Rhizoprionodon terraenovae*), sandbar and spinner (*Carcharhinus brevipinna*) sharks comprised 76 percent of the nearshore catch. The remaining nine trips were reported from the over sand vehicle area of Assateague Island National Seashore, an area popular with recreational shark anglers, in July and August. Seventy-four percent of the catch was Atlantic sharpnose and sand tiger (*Carcharias taurus*) sharks. These data combined with those previously reported in Doctor *et al* (2019) confirm the range expansion of spinner sharks and the presence of pups.

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Chapter 1: Trawl and Beach Seine Surveys

Introduction

These surveys were developed to characterize fishes and their abundances in Maryland's coastal bays, facilitate management decisions and protect finfish habitats. The department has conducted the 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 - 2019.

Over 140 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 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

Data Collection

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. 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 453 km^2 (175 mi^2). The Ocean City and Chincoteague inlets provide oceanic influences to these bays. Chincoteague Inlet located in Virginia is approximately 56 km (34 mi) south of the Ocean City Inlet. Fenwick Island is heavily developed whereas Assateague Island is home to Assateague State Park and Assateague Island National Seashore. The western shore from Sinepuxent Bay north is urban whereas Chincoteague Bay is rural and in between is moderately developed Newport Bay.

A 25 ft C-hawk vessel 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.

Trawl

Trawl sampling was conducted monthly at 20 fixed sites throughout Maryland's coastal bays 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. 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.

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: tide state, water clarity (Secchi disk; centimeters (cm)), water depth (ft), weather conditions, wind direction and wind speed (kts). Data were recorded on a standardized project data sheet printed on Rite in the Rain All Weather paper.

Dissolved oxygen, salinity and water temperature were taken with a Yellow Springs Instrument Pro2030 at two depths, 30 cm (1 ft) below the surface (all gears) and 30 cm (1 ft) from the bottom (trawl). 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 - 2019). 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 - 2019) and used as a point estimate for comparison to the annual (2019) 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 (Shannon 1948). 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 four. 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 2019. 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 53,759 fish caught trawling (30,979) and beach seining (22,780 fish) in 2019 (Table 4**).** The total number of species and individual fish caught was similar to the last 10 years (Table 5). The last time this many fish were caught in the trawl was 2012, which was also the last time spot had an above average catch. Collected fishes represented 68 species, which is within the normal range in a year.

Atlantic croaker, Atlantic menhaden, black sea bass and spot had above average trawl indices and bay anchovy, spot and summer flounder had above average beach seine indices (Table 6). Six important recreational and forage species had below average trawl indices including American eel, Atlantic silverside, bluefish, silver perch, summer flounder and weakfish. American eel, bluefish and weakfish had below average beach seine indices. The spot catch was exceptional in both surveys for the first time since 2012. For the past three years, summer flounder have had an above average beach seine index and a below average trawl index which indicates a change in the importance of shallow habitat for this species.

Crustaceans were the second most abundant taxa captured in this survey. Specifically, they accounted for 13,196 specimens caught trawling (9,761 crustaceans) and beach seining (3,435 crustaceans) in 2019 (Table 7). Fifteen crustaceans were identified, which is similar to the numbers found between 1989 and 2018. Crustaceans were dominated by blue crabs, grass, sand and white shrimps all of which were excellent forage to support recreational finfish species.

The third most abundant taxa captured in the survey were molluscs. Specifically, they accounted for 627 specimens caught trawling (486 molluscs) and beach seining (141 molluscs; Table 8). Molluscs were represented by 20 different species, which is similar to the numbers of molluscs found between 1989 and 2018.

Seventeen other types of animals and 18 plants were captured trawling and beach seining (Tables 9 - 10). Animals included: bryozoans, ctenophores, horseshoe crabs, northern diamondback terrapins, sponges and tunicates. Two species of SAV and 16 macroalgae genera were encountered. Red macroalgae were most abundant for both gears.

American eel (*Anguilla rostrata*)

American eels, a forage and bait species of interest to recreational anglers, were captured in three of 140 trawls (0.2%) and in four of 38 beach seines (10.5%). A total of eight American eels were collected in trawl (4 fish) and beach seine (4 fish) samples (Table 4). American eel ranked 40 out of 68 species in overall finfish abundance. The trawl and beach seine CPUEs were 0.2 fish/ha and 0.1 fish/haul, respectively.

The 2019 trawl and beach seine relative abundance indices were both below the grand means (Figures 4 and 5). Since 1989, the trawl (4 years) and beach seine (5 years) indices rarely varied significantly from the grand means. American eels spawn in the Sargasso Sea; therefore, environmental conditions and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997).

American eels were most frequently caught close to land in shallow, weedy protected bays or creeks. Many of them were caught in Turville Creek (T006) where the department also annually conducts an elver survey further up the creek. The abundance of elvers at this site was attributed to the moderately sized freshwater source close to the ocean inlet where elvers grow to adulthood, which is supported by the two length classes of eels present in the samples.

American eels caught trawling in April and May were young of the year whereas an adult was caught in August (Table 11). In the Beach Seine Survey, there were four American eels caught in September and the mean length was 229 mm (Table 12). It is normal for both adults and juveniles to be captured in these surveys.

Atlantic croaker (*Micropogonias undulatus*)

Atlantic croakers, a species of interest to recreational anglers, were captured in 46 of 140 trawls (32.9%) and in seven of 38 beach seines (18.4%). A total of 533 juvenile Atlantic croakers were collected in trawl (499 fish) and beach seine (34 fish) samples (Table 4). Atlantic croakers ranked fifth out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 28.4 fish/ha and 0.9 fish/haul, respectively.

The 2019 trawl index was above the grand mean and the beach seine index was equal to the grand mean (Figures 6 and 7). Since 1989, the trawl index frequently (17 years) and the beach seine index often (14 years) varied significantly from the grand means. In the history of the surveys, juvenile Atlantic croakers were more frequently caught in deeper water with the trawl; therefore, the trawl index represents a more accurate picture of changes in relative abundance. Since 2007, trawl and beach seine indices have been average or below and consistently lower than the 1990’s. The decline in southern coastal abundance was also reflected in the 2018 traffic light assessment. 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 share a similar pattern of distribution to spot and summer flounder. Atlantic croakers are a known prey item for summer flounder, which may explain the co-occurrence of these species (Latour *et al.* 2008).

Young of the year Atlantic croakers were caught in April, September and October and larger fish were caught mid-summer (Tables 11 and 12). 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.

Atlantic menhaden (*Brevoortia tyrannus*)

Atlantic menhaden, a forage species, were captured in 29 of 140 trawls (20.7%) and in 23 of 38 beach seines (60.5%). Atlantic menhaden ranked second out of 68 species in overall finfish abundance. A total of 13,425 juvenile Atlantic menhaden were collected in trawl (474 fish) and beach seine (12,951 fish) samples (Table 4). The trawl and beach seine CPUE was 27.0 fish/ha and 340.8 fish/haul, respectively.

The 2019 trawl index was above the grand mean and the beach seine index was equal to the grand mean (Figures 8 and 9). Since 1989, the trawl index often (15 years) and the beach seine index occasionally (8 years) varied significantly from the grand means.

Atlantic menhaden were caught more often in nearshore locations in the Beach Seine Survey; therefore, that index represents a more accurate picture of changes in relative abundance. 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. Productive 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 likely had high chlorophyll concentrations; a desirable characteristic for a filter feeder (Wazniak *et al.* 2004).

The mean length of Atlantic menhaden caught by trawl increased from a mean of 45 mm in May to a mean of 119 mm in September (Table 11). The Beach Seine Survey had similar results with an increase from a mean length of 67 mm in June to a mean length of 125 mm in September (Table 12). 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*)

Atlantic silversides, a forage species, were captured in one of 140 (0.7%) trawls and in 34 of 38 beach seines (89.5%). A total of 1,069 Atlantic silversides were collected in trawl (2 fish) and beach seine (1,067 fish) samples (Table 4). Atlantic silversides ranked fourth out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and 28.1 fish/haul, respectively.

The 2019 trawl relative abundance index was below and the beach seine index was equal to the grand means (Figures 10 and 11). Since 1989, the trawl index often (15 years) and beach seine index rarely (5 years) varied significantly from the grand mean.

Atlantic silversides were more frequently caught in the Beach Seine Survey, which indicates a preference for shallow water habitat. Similar characteristics found at these sites were the proximity to land and/or inlets. Atlantic silversides are forage for gamefish and were found occurring with spot, summer flounder and winter flounder at multiple sites in this survey.

The mean length of trawled Atlantic silversides was 55 mm for the two fish caught in June (Table 11). The Beach Seine Survey indicated a slight increase in mean length from 66 mm in June to 70 mm in September. The increase in mean length in both surveys reflects growth of the cohort throughout the summer season.

Bay anchovy (*Anchoa hepsetus*)

Bay anchovies, a forage species, were captured in 98 of 140 trawls (70%) and in 30 of 38 beach seines (78.9%). A total of 8,370 bay anchovies were collected in trawl (5,392 fish) and beach seine (2,978 fish) samples (Table 4). Bay anchovies ranked third out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 307.1 fish/ha and 78.4 fish/haul, respectively.

The 2019 trawl relative abundance index was equal to the grand mean and beach seine relative abundance index was above the grand mean (Figures 12 and 13). Since 1989, the trawl (9 years) and beach seine (9 years) indices occasionally varied significantly from the grand means. 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 anchovy indices do not fluctuate much from year to year but stay close to the mean reflecting stable and protracted recruitment each year.

Bay anchovies were caught in both nearshore and open water locations indicating a wide distribution. Productive 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 a known preferred forage for larger fishes and have been found occurring with spot and summer flounder at multiple sites in this survey.

The mean length of bay anchovies in the Trawl Survey increased from April through June and then decreased slightly for the July through October period (Table 11). Larger bay anchovies were collected in June (mean 72 mm) than in September (46 mm) in the Beach Seine Survey (Table 12). Females spawn multiple times from May to September and peak spawning occurs in July. The relatively constant size throughout the year reflects the extended recruitment through the summer. The length distribution by month was consistent between 2018 and 2019.

Black sea bass (*Centropristis striata*)

Black sea bass, a species of interest to recreational anglers, were collected in 47 of 140 trawls (33.6%) and 10 of 38 beach seines (26.3%). A total of 216 juvenile black sea bass were collected in trawl (195 fish) and beach seine (21 fish) samples (Table 4). Black sea bass were ranked ninth out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 11.1 fish/ha and 0.6 fish/haul, respectively.

The 2019 trawl relative abundance index was above the grand mean and the beach seine index was equal to the grand mean (Figures 14 and 15). Since 1989, the trawl index frequently (17 years) and beach seine index occasionally (8 years) varied significantly from the grand means. The Trawl Survey catches more black sea bass; therefore, it was the better gear for inclusion in the 2018 ASMFC stock assessment. That gear was also used by other state's independent surveys that were 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 at sites nearest to inlets than in the mid bays. Abiotic factors measured did not show a 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).

The mean length of black sea bass increased from 44 mm in April to 180 mm in September in the Trawl Survey (Table 11). The mean length in the Trawl Survey decreased to 120 mm in October. In the Beach Seine Survey, the mean length increased from 86 mm in June to 115 mm in September (Table 12). Black sea bass increased in length throughout the sampling season reflecting growth. The coastal bays are a nursery for young of the year black sea bass through age one. Occasionally smaller young of the year juveniles recruit in the fall and a few individuals did in the fall of 2019.

Bluefish (*Pomatomus saltatrix*)

Bluefish, a species of interest to recreational anglers, were collected in one of 140 trawls (0.7%) and in seven of 38 beach seines (18.4%). A total of 16 juvenile bluefish were collected in trawl (1 fish) and beach seine (15 fish) samples (Table 4). Bluefish ranked 29 out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and 0.4 fish/haul, respectively.

The 2019 trawl and beach seine relative abundance indices were both below the grand means (Figures 16 and 17). Since 1989, the trawl (7 years) and beach seine (8 years) indices occasionally varied significantly from the grand means. 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. 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. The Beach Seine Survey catches more bluefish; therefore, it was the better gear for inclusion in the 2019 ASMFC stock assessment. That gear is also used by other state's independent surveys that are also included in the stock assessment. Indices of relative abundance from the Beach Seine Survey were included in the annual ASMFC compliance report.

Productive trawl and beach seine sites for collecting bluefish were located in Assawoman Bay, Isle of Wight Bay, Sinepuxent Bay and St. Martin River. All productive 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.

The length of the one bluefish caught by the Trawl Survey in July was 228 mm (Table 11). In the Beach Seine Survey, the mean length increased from 104 mm in June to 190 mm in September, reflecting growth (Table 12). Increases in size as the year progressed in both surveys reflect the growth of the young of the year individuals through the summer.

Pinfish (*Lagodon rhomboides*)

Pinfish, a forage species, were captured in two of 140 trawls (1.4%) and in 13 of 38 beach seines (34.2%). A total of 112 pinfish were collected in trawl (2 fish) and beach seine (110 fish) samples (Table 4). Pinfish ranked 11 out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and 2.9 fish/haul, respectively.

The 2019 trawl and beach seine relative abundance indices were both equal to the grand means (Figures 18 and 19). Since 1989, the trawl index (19 years) frequently and the beach seine index (15 years) often varied significantly from the grand means. Pinfish were caught more frequently in shallow water; therefore, the beach seine index represents a more accurate picture of changes in relative abundance. Pinfish abundance has improved since 1989, which may be tied to an increase in temperature over time.

Pinfish mean length was 150 mm in September in the Trawl Survey (Table 11). Mean length increased from 53 mm in June to 131 mm in September in the Beach Seine Survey (Table 12). The increase in mean length reflects growth of the cohort throughout the summer season.

Sheepshead (*Archosargus probatocephalus*)

Sheepshead, a species of interest to recreational anglers, were collected in one of 140 trawls (0.7%) and two of 38 beach seines (5.3%). A total of four juvenile sheepshead were collected in trawl (1 fish) and beach seine (3 fish) samples (Table 4). Sheepshead ranked 52 out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 0.1 fish/ha and <0.1 fish/haul, respectively.

The 2019 trawl and beach seine relative abundance indices were both equal to the grand means (Figures 20 and 21). Since 1989, the trawl (23 years) and beach seine (18 years) indices frequently varied significantly from the grand means. Sheepshead were caught more frequently in shallow water; therefore, the beach seine index represents a more accurate picture of changes in relative abundance when compared to the trawl index. There were no sheepshead caught by trawl or beach seine before 1997 and they have become more consistently caught since 2011 and are a growing recreational interest. Sheepshead spawn offshore; therefore, environmental conditions such as weather patterns and ocean currents may be a factor influencing relative abundance. Offshore artificial reefs, structure necessary for adult sheepshead habitat, may also influence abundance (Murdy and Musick 2013). Young of the year sheepshead were caught at locations with or near SAV or rip rap. SAV is important juvenile habitat (Murdy and Musick 2013).

There was one fish caught by trawl in October and it measured 110 mm (Table 11). There were three fish caught by beach seine in September and they ranged from 60 mm to 71 mm with a mean length of 64 mm (Table 12).

Silver perch (*Bairdiella chrysoura*)

Silver perch, a forage species, were collected in 31 of 140 trawls (22.1%) and 18 of 38 beach seines (47.4%). A total of 217 silver perch were collected in trawl (74 fish) and beach seine (143 fish) samples (Table 4). Silver perch ranked eighth out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 4.2 fish/ha and 3.8 fish/haul, respectively.

The 2019 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figures 22 and 23). Since 1989, the trawl index frequently (16 years) varied significantly from the grand mean and beach seine index rarely (2 years) varied from the grand mean.

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. They were caught in both near shore and open water 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).

In the Trawl Survey, the largest fish were captured in the spring and fall and the smallest in July and August (Table 11). The mean size of silver perch increased from 94 mm in June to 101 mm in September in beach seine (Table 12).

Spot (*Leiostomus xanthurus*)

Spot are important forage and are important to recreational anglers for bait and as a target species. Spot were collected in 112 of 140 trawls (80%) and 36 of 38 beach seines (94.7%). A total of 27,957 spot were collected in trawl (23,588 fish) and beach seine samples (4,369 fish; Table 4). Spot ranked first out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 1,343.4 fish/ha and 115 fish/haul, respectively.

The 2019 trawl and beach seine relative abundance indices were both above the grand mean (Figures 24 and 25). Since 1989, the trawl (27 years) and beach seine (22 years) indices frequently varied significantly from the grand means. The species was doing poorly for the previous six years. Spot spawn offshore; therefore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy *et al.* 1997). Both indices indicated that the Maryland coastal bays were favorable nursery habitat for spot and represent an accurate picture of changes in relative abundance. This observation was confirmed by the ASMFC traffic light assessment, which received those data in 2019. Data from the Trawl and Beach Seine surveys were included in the annual ASMFC compliance report.

The mean length of spot increased from 45 mm in April to 117 mm in October in the Trawl Survey (Table 11). In the Beach Seine Survey, the mean length increased from 91 mm in June to 119 mm in October (Table 12). The increase in mean length reflects growth of the cohort throughout the summer season.

Summer flounder (*Paralichthys dentatus*)

Summer flounder, a species of interest to recreational anglers, were collected in 68 of 140 trawls (48.6%) and 24 of 38 beach seines (63.1%). A total of 421 summer flounder collected in trawl (215 fish) and beach seine (206 fish) samples (Table 4). Summer flounder ranked sixth out of 68 species in overall finfish abundance. The trawl and beach seine CPUE was 12.2 fish/ha and 5.4 fish/haul, respectively.

The 2019 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was above the grand mean (Figures 26 and 27). Since 1989, the trawl index frequently (18 years) varied significantly from the grand mean and the beach seine index often (13 years) varied from the grand mean. In the past, summer flounder were caught more frequently in open water trawls; therefore, the trawl index represented a more accurate picture of changes in relative abundance when compared to the beach seine index. In recent years, the number of summer flounder caught in beach seines increased while the number caught in trawls has been below the grand mean. Data from the Trawl Survey were used in the 2018 joint ASMFC and the Mid Atlantic Fishery Management Council summer flounder benchmark stock assessment. Indices from both surveys were included in the annual ASMFC compliance report.

Productive summer flounder trawl and beach seine sample sites were located in all bays. This indicated that most 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.

The mean length of summer flounder caught by trawl increased from 49 mm in April to 172 mm in October (Table 11). In the Beach Seine Survey, the mean length increased from 93 mm in June to 155 mm in September (Table 12). The increase in mean length reflects growth of the cohort throughout the summer season.

Weakfish (*Cynoscion regalis*)

Weakfish, a species of interest to recreational anglers, were collected in 10 of 140 trawls (7.1%) and zero of 38 beach seines. A total of 15 juvenile weakfish were collected in trawl samples (15 fish; Table 4). Weakfish ranked 31 out of 68 species in overall finfish abundance. The trawl CPUE was 0.9 fish/ha.

The 2019 trawl and beach seine relative abundance indices were both below the grand mean (Figures 28 and 29). Since 1989, the trawl (15 years) and beach seine indices (12 years) often varied significantly from the grand means. 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. 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. Data from the Trawl Survey were used in the 2015 ASMFC weakfish stock assessment. Weakfish were considered depleted but not overfished. The decline appears to be due to natural mortality (Northeast Fisheries Science Center 2009). The trawl index was included in the annual ASMFC compliance report.

Productive trawl sample sites for weakfish were located in all bays indicating a broad distribution in the coastal bays. Weakfish 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).

Weakfish mean length increased from 91 mm in July to 143 mm in August (Table 11). The increase in mean length from July to August reflects growth of the young of the year weakfish.

Richness and Diversity

Richness is the number of different fishes sampled. Diversity is defined by the Shannon index results, which is a measurement richness and the proportion of those species in the sample population. Chincoteague Bay had the highest richness (91 fishes) and annual mean richness (35.8 fishes) in the trawl 1989 - 2019 time series (Table 13). However, in the terminal year of this survey (2019), Assawoman Bay (31 fishes) exceeded Chincoteague Bay (29 species) for the second time in thirty-one years (Table 14). Newport Bay had the lowest richness in the time series (68 fishes) and annual mean richness (21.4 fishes). This embayment also had the lowest richness, tied with St. Martin River (23 fishes) in 2019 (Table 14). The Shannon index results for the trawl time series indicated that Sinepuxent Bay (H = 2.0) was the most diverse whereas the St. Martin River (H = 1.6) was the least diverse (Table 13). For 2019, the Shannon index results indicated that Sinepuxent Bay (H = 1.5) was the most diverse whereas Assawoman Bay (H = 0.6) was the least diverse (Table 14).

The Beach Seine Survey time series (1989 - 2019) results indicated that Assawoman Bay and Isle of Wight Bay had the richest fish populations (87 fishes) while Chincoteague Bay had the highest annual mean richness (30.8 fishes) and terminal year (2019) richness (35 fishes; Tables 15 and 16). St. Martin River and Newport Bay (72 fishes) were the lowest in the time series. St. Martin River had the lowest annual mean richness (20.6 fishes) and lowest fish diversity (22 fishes) in 2019. Ayers Creek is not an embayment and its habitat is not similar to the previously mentioned embayments. Those data were included to show the results of Newport Bay's headwaters, which were lower in richness and diversity that the embayments yet show a remarkable number of fish species (44 fishes) in the time series. Ayers Creek has had high abundance of Atlantic menhaden and golden shiners on a regular basis whereas spot were infrequently encountered.

Results for both surveys showed overall high richness in fish populations over thirty-one years. This richness was most impressive for Maryland's coastal bays and was an indicator that the overall habitat can support many fishes during their lifecycle. Terminal year diversity results should be higher, but were not alarming. Factors that drove down diversity in Assawoman Bay in 2019 were large schools of menhaden and the massive increase in spot abundance. Proportionally, the other fishes such as bay anchovies, summer flounder and winter flounder were diminished due to their low abundance in comparison to menhaden and spot.

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. 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.

The embayment sample size clearly has an influence on the richness and diversity for the time series and the terminal year of the survey. Co-variant differences among habitats for each site such as salinity, substrate, forage and protection could also serve as comparison criteria rather than or in addition to embayment.

Macroalgae

This time series spans 14 years from 2006 - 2019. To date, 20 genera and 66,533 L of macroalgae were 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 gears. Chlorophyta (green macroalgae) was the second most abundant macroalgae in the time series. Phaeophyta (brown macroalgae) and Xanthophyta (yellow - green macroalgae) were also represented in the survey collections.

Fifteen genera were collected by trawl within the coastal bays in 2019, which was above the average (14.6 genera) in the time series (Table 10). The 2019 Shannon index of diversity among genera by trawl (H = 1.41) was above the time series average (H = 1.25). Results showed that *Agardhiella* were the most abundant macroalgae (50.3%) in 2019. The only other genera that contributed more than 5% to the sample population were *Polysiphonia* (24.8%) and *Ulva* (13.8%). The 2019 trawl CPUE (21.1 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 30).

Eight genera were sampled within the coastal bays by beach seine in 2019 (Table 10). The Shannon index of diversity among genera (H = 1.2) was above the time series average (H = 1.13). Results showed that *Agardhiella* were most abundant (59.9%). The only other genera that contributed more than 5% to the sample population were *Gracilaria* (12.4%), *Spyridia* (12.3%) and *Ulva* (11.1%). The 2019 beach seine CPUE (17 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 31).

Assawoman Bay
This embayment has been dominated by Rhodophyta since sampling began in 2006. Five different genera were collected by trawl in 2019, which was below the average (7.5 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 0.4) was below the time series average (H = 0.9). Results showed that *Agardhiella* (86.6%) was most abundant. *Ulva* (12.8%) was the only other genus that contributed more than 5% to the sample population. The 2019 CPUE (24.7 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 32).

Two different genera were collected by beach seine in 2019, which was below the average (6 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 0.3) was below the time series average (H = 0.7). Results showed that *Agardhiella* (92.5%) was most abundant, followed by *Ulva* (7.5%) The beach seine CPUE (0.7 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 33).

Isle of Wight Bay
This embayment has been dominated by Rhodophyta since sampling began in 2006. Three different genera were collected by trawl in 2019, which was below the average (6.7 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 0.6) was below the time series average (H = 0.7). *Agardhiella* was most abundant (77%). The only other genus that contributed more than 5% to the sample population was *Ulva* (21.2%). The trawl CPUE (16 L/ha) was below the grand mean. Since 2006, the trawl CPUE rarely varied significantly from the grand mean (Figure 34).

Three different genera were collected by beach seine in 2019, which was below the average (6.6 genera) for this embayment in the time series. The 2019 Shannon index of diversity among genera within this embayment (H = 0.7) was below the time series average (H = 1). *Agardhiella* (66.4%) was the most abundant; *Ulva* (30.2%) was the only other genus that contributed more than 5% of the sample population. The 2019 beach seine CPUE (7.4 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 35).

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. Three different genera of macroalgae were collected by trawl in 2019, which was below the time series average (5.4 genera). The 2019 Shannon index of diversity among genera (H = 1) was above the time series average (H = 0.79). *Agardhiella* (54.3%) was most abundant; *Ulva* (26.7%) and *Enteromorpha* (19%) were the only other genera that contributed more than 5% of the sample population. Trawl CPUE (8.1 L/ha) in 2019 was below the grand mean. Since 2006, the trawl CPUE rarely varied significantly from the grand mean (Figure 36).

One genus was collected by beach seine in 2019, which was below the average (3.3 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2019 (H = 0) was below the time series average (H = 0.4). *Agardhiella* (100%) was the only genus collected. The 2019 beach seine CPUE (0.1 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 37).

Sinepuxent Bay
This embayment has been dominated by Rhodophyta in nine of the 12 years since sampling began in 2006. *Chlorophyta* were dominant in 2008 - 2009 and 2018. Nine different genera of macroalgae were collected by trawl in 2019, which was below the average (9.8 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2019 (H = 1.2) was below the average (H = 1.3). *Ulva* (53.9%) and *Agardhiella* (33.7%) were the only genera that contributed more than 5% of the sample population. Trawl CPUE (14.5 L/ha) in 2019 was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 38).

Six different genera were collected by beach seine in 2019, which was equal to the average (six genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2019 (H = 1.3) was above the average (H = 0.6). *Agardhiella* (59.3%) was most abundant. *Gracilaria* (15.2%), *Spyridia* (15.2%) and *Ulva* (9.8%) were the only other genera that contributed more than 5% of the sample population. The 2019 beach seine CPUE (82.4 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 39).

Newport Bay
This embayment has been dominated by Rhodophyta in eight of the 12 years since sampling began in 2006; although, *Chlorophyta* were dominant in 2008 - 2010 and 2018. Six different genera were collected by trawl in 2019, which was below the average (6.8 genera) for this embayment in the time series. The 2019 Shannon index of diversity among genera (H = 1.3) within this embayment was above the time series average (H = 1.1). *Ulva* (42.2%) was most abundant. *Polysiphonia* (26.5%) and *Agardhiella* (26.2%) were the only other genera that contributed more than 5% of the sample population. Trawl CPUE (6 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 40).

One genus, *Gracilaria*, was collected by beach seine in 2019, which was below the average (3.2 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0) was below the time series average (H = 0.3). The 2019 beach seine CPUE (0.1 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 41).

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, Rhodophyta in 2016 - 2017, Chlorophyta in 2018 and Rhodophyta in 2019. Twelve different genera were collected by trawl in 2019, which was above the times series average (11.4 genera). The 2019 Shannon index of diversity among genera (H = 1.4) was below the average (H = 1.5) within this embayment for the time series. *Polysiphonia* (40.5%) was most abundant; *Agardhiella* (39.6%) was the only other genus that contributed more than 5% of the sample population. The CPUE (30.5 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 42).

Four different genera were collected by beach seine in 2019, which was below the average (6.7 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 1) was above the time series average (H = 0.95). *Agardhiella* (57.4%) was most abundant; *Chaetomorpha* (30%) and *Ulva* (7.8%) were the only other genera that contributed more than 5% of the sample population. The 2019 beach seine CPUE (5.8 L/haul) was below the grand mean. Since 2006, the beach seine CPUE frequently varied significantly from the grand mean (Figure 43).

Macroalgae in Maryland's coastal bays were investigated consistently over 14 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 are representative of our samples. The Trawl and Beach Seine surveys did not sample macroalgae habitat such as bulkheads, jetties and rocks where macroalgae have been observed. However, the survey data show that Rhodophyta and Chlorophyta were present at high levels in the embayments closest to high human density population. The terminal year (2019) showed a dramatic decrease in overall abundance of macroalgae, the lowest on record since this survey began. *Agardhiella* remained the most abundant genus at low levels compared to the time series.

In previous years, 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 water 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

Temperature

Trawl water temperatures were lowest in April and peaked in July as expected (Figure 44). The average trawl temperature in 2019 was 22.5 C, which was the same as 2018 (Figure 45). The mean seasonal temperatures were Assawoman Bay (21.5 C) Chincoteague Bay (23.4 C), Newport Bay (23.1 C) and the St. Martin River (22.4 C). Results from a regression analysis indicated a significant increase in mean surface water temperature from 1989 to 2019 ($r(31) = 0.59$, $p = 0.0004$; Figure 45).

During the June Beach Seine Survey, there was a 7.4 C difference between the highest recorded temperature (27.9 C at site S012) and lowest temperature (20.5 C at site S019; Figure 46). In September, the temperature difference between the highest recorded temperature (26.5 C at site S017) and lowest temperature (19.6 C at site S012) was 6.9 C. The most abrupt decreases in temperature measured between June and September was at sites in Newport Bay (7.1 C) and the St. Martin River (3.8 C).

The average mean temperature has increased from 1989 through 2019, which seems to be affecting the fishes and invertebrates collected. Data showed an increased abundance of forage species such as pinfish and penaeid shrimp. The same was true for species of recreational interest such as sheepshead.

Dissolved Oxygen

As expected, trawl DO levels generally decreased as water temperatures increased (Figure 47). The mean trawl DO for all bays in 2019 was 7.2 mg/L. A significant increase in surface DO has been observed from 1998 to 2019 for all trawl sites grouped together ($r(21) = 0.8$, $p = 0.0002$; Figure 48). The surface DO level only dipped below 5 mg/L five time in 2019 and those events occurred in July and August.

The 2019 Beach Seine Survey mean DO was generally higher in June than September and was above 5 mg/L for all samples except two (Figure 49). 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 indicated that the coastal bays rarely experience low enough DO to negatively impact fish abundances. Dissolved oxygen 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.

Out of the four water quality parameters, DO concentrations had 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 although at this point it is infrequent and long term consequences have not been apparent (i.e. fish kills).

Salinity

The 2019 Trawl Survey bay wide average salinity (24.5 ppt) was higher than 2018 (23 ppt), although the difference was not significant. The widest range of Trawl Survey salinity results among the embayments occurred in April, May and October. This range was narrowest in July. Chincoteague Bay had the highest average seasonal salinity (26.2 ppt) and Newport Bay had the lowest (21.1 ppt; Figure 50).

The bay wide salinities were lower on average in June than September for the beach seine survey. Newport Bay was the lowest in June (21.9 ppt), and Sinepuxent was the highest in September (28.0 ppt; Figure 51).

Turbidity

Monitoring of turbidity was initiated in 2006 and continued through 2019. Sinepuxent Bay was the most turbid embayment (mean yearly = 56.4 cm) in the 2019 Trawl Survey whereas Chincoteague Bay was the least (mean yearly = 90.2 cm). The bottom was visible two times (1.43%) out of 140 total samples. Visibility decreased during the warmer months (Figure 52). Mean turbidity by year showed a decrease in 2018 and 2019 (Figure 53, $r(14) = 0.39$, $p = 0.1705$).

The waters became less turbid in all bays from June to September for the 2019 Beach Seine Survey (Figure 54). St. Martins had the worst annual visibility (43.5 cm) and Sinepuxent Bay had the best visibility mean annual visibility (60.5 cm).

Secchi readings were showing a trend of increasing clarity until 2017 but turbidity increased in 2018 and 2019. The increase in turbidity was accompanied by a decrease in macroalgae and a decrease in SAV. It is hypothesized that an increase in phytoplankton in the past two years has shaded the macroalgae and SAV, retarding their growth.

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Table 1. Trawl Survey site descriptions.

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

Table 2. Beach Seine Survey site descriptions.

Site Number	Bay	Site Description	Latitude	Longitude
S001	Assawoman Bay	Cove behind Ocean City Sewage Treatment Plant, 62nd street	38 23.273	75 04.380
S002	Assawoman Bay	Bayside of marsh at Devil's Island, 95th street	38 24.749	75 04.264
S003	Assawoman Bay	Small cove, east side, small sand beach; sand spit, 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 sand spit 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 2019. 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
Spot	*Leiostomus xanthurus*	27,957	23,588	4,369	1343.4	115.0
Atlantic menhaden	*Brevoortia tyrannus*	13,425	474	12,951	27.0	340.8
Bay anchovy	*Anchoa mitchilli*	8,370	5,392	2,978	307.1	78.4
Atlantic silverside	*Menidia menidia*	1,069	2	1,067	0.1	28.1
Atlantic croaker	*Micropogonias undulatus*	533	499	34	28.4	0.9
Summer flounder	*Paralichthys dentatus*	421	215	206	12.2	5.4
Striped anchovy	*Anchoa hepsetus*	301	92	209	5.2	5.5
Silver perch	*Bairdiella chrysoura*	217	74	143	4.2	3.8
Black sea bass	*Centropristis striata*	216	195	21	11.1	0.6
Blackcheek tonguefish	*Symphurus plagiusa*	122	9	113	0.5	3.0
Pinfish	*Lagodon rhomboides*	112	2	110	0.1	2.9
Inshore lizardfish	*Synodus foetens*	92	55	37	3.1	1.0
White mullet	*Mugil curema*	80	8	72	0.5	1.9
Northern searobin	*Prionotus carolinus*	79	72	7	4.1	0.2
Hogchoker	*Trinectes maculatus*	67	67		3.8	
Spotfin mojarra	*Eucinostomus argenteus*	61	6	55	0.3	1.4
Smallmouth flounder	*Etropus microstomus*	55	23	32	1.3	0.8
Atlantic herring	*Clupea harengus harengus*	44	44		2.5	
Northern puffer	*Sphoeroides maculatus*	44	20	24	1.1	0.6
Rough silverside	*Membras martinica*	38		38		1.0
Winter flounder	*Pseudopleuronectes americanus*	38	2	36	0.1	0.9
Striped killifish	*Fundulus majalis*	36		36		0.9
Northern pipefish	*Syngnathus fuscus*	33	19	14	1.1	0.4
Atlantic needlefish	*Strongylura marina*	31		31		0.8
Dusky pipefish	*Syngnathus floridae*	25	12	13	0.7	0.3
Golden shiner	*Notemigonus crysoleucas*	21		21		0.6
Mummichog	*Fundulus heteroclitus*	21	1	20	0.1	0.5
Alewife	*Alosa pseudoharengus*	17		17		0.4
Bluefish	*Pomatomus saltatrix*	16	1	15	0.1	0.4
Spotted hake	*Urophycis regia*	16	16		0.9	
Weakfish	*Cynoscion regalis*	15	15		0.9	
Oyster toadfish	*Opsanus tau*	13	6	7	0.3	0.2
Naked goby	*Gobiosoma bosc*	11	3	8	0.2	0.2
Pigfish	*Orthopristis chrysoptera*	11	10	1	0.6	<0.1
Striped bass	*Morone saxatilis*	11		11		0.3
Southern stingray	*Dasyatis americana*	10	1	9	0.1	0.2
Striped mullet	*Mugil cephalus*	10		10		0.3

Table 4. List of fishes collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2019. 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
Lined seahorse	*Hippocampus erectus*	9	6	3	0.3	<0.1
Rainwater killifish	*Lucania parva*	9	2	7	0.1	0.2
American eel	*Anguilla rostrata*	8	4	4	0.2	0.1
Southern kingfish	*Menticirrhus americanus*	8	2	6	0.1	0.2
Striped burrfish	*Chilomycterus schoepfii*	8	5	3	0.3	<0.1
Inland silverside	*Menidia beryllina*	7	1	6	0.1	0.2
Lookdown	*Selene vomer*	7	3	4	0.2	0.1
Scup	*Stenotomus chrysops*	7	7		0.4	
Atlantic moonfish	*Selene setapinnis*	6	6		0.3	
Black drum	*Pogonias cromis*	6	4	2	0.2	<0.1
Skilletfish	*Gobiesox strumosus*	5		5		0.1
Spotted seatrout	*Cynoscion nebulosus*	5	1	4	0.1	0.1
Striped searobin	*Prionotus evolans*	5	3	2	0.2	<0.1
Pumpkinseed	*Lepomis gibbosus*	4		4		0.1
Sheepshead	*Archosargus probatocephalus*	4	1	3	0.1	<0.1
Crevalle jack	*Caranx hippos*	3	3		0.2	
Northern sennet	*Sphyraena borealis*	3		3		<0.1
Banded killifish	*Fundulus diaphanus*	2		2		<0.1
Butterfish	*Peprilus triacanthus*	2	2		0.1	
Northern kingfish	*Menticirrhus saxatilis*	2	1	1	0.1	<0.1
American sand lance	*Ammodytes americanus*	1	1		0.1	
Blue runner	*Caranx crysos*	1		1		<0.1
Conger eel	*Conger oceanicus*	1	1		0.1	
Cownose ray	*Rhinoptera bonasus*	1		1		<0.1
Green goby	*Microgobius thalassinus*	1	1		0.1	
Halfbeak	*Hyporhamphus unifasciatus*	1		1		<0.1
Harvestfish	*Peprilus paru*	1		1		<0.1
Ladyfish	*Elops saurus*	1		1		<0.1
Sheepshead minnow	*Cyprinodon variegatus*	1		1		<0.1
Striped blenny	*Chasmodes bosquianus*	1	1		0.1	
Tautog	*Tautoga onitis*	1	1		0.1	
	Total Finfish	**53,759**	**30,979**	**22,780**		

Table 5. Number of species and individual fish caught by year and gear in the Trawl and Beach Seine surveys from 2007 - 2019.

	Number of Species			Number of Fish		
Year	Trawl	Beach Seine	Combined	Trawl	Beach 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
2018	55	59	73	8,881	33,677	42,558
2019	52	57	68	30,979	22,780	53,759

Table 6. Summary of the 2019 Trawl and Beach Seine surveys species abundance defined as above, below or equal to the grand mean.

Common Name	Scientific Name	Trawl		Beach Seine	
American eel	*Anguilla rostrate*	Below	-	Below	-
Atlantic croaker	*Micropogonias undulatus*	Above	+	Equal	=
Atlantic menhaden	*Brevoortia tyrannus*	Above	+	Equal to	=
Atlantic silverside	*Menidia menidia*	Below	-	Equal to	=
Bay anchovy	*Anchoa mitchilli*	Equal to	=	Above	+
Black sea bass	*Centropristis striata*	Above	+	Equal	=
Bluefish	*Pomatomus saltatrix*	Below	-	Below	-
Pinfish	*Lagodon rhomboides*	Equal to	=	Equal to	=
Sheepshead	*Archosargus probatocephalus*	Equal to	=	Equal to	=
Silver Perch	*Bairdiella chrysoura*	Below	-	Equal to	=
Spot	*Leiostomus xanthurus*	Above	+	Above	+
Summer flounder	*Paralichthys dentatus*	Below	-	Above	+
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 2019. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	Estimated Count (T)	Estimated Count (S)	CPUE (T) #/Hect.	CPUE (S) #Haul
White shrimp	*Litopenaeus setiferus*	5,942	5,501	441			313.3	11.6
Blue crab	*Callinectes sapidus*	3,667	2,150	1,517			122.5	39.9
Grass shrimp	*Palaemonetes sp.*	1,236	112	129	220	775	18.9	23.8
Sand shrimp	*Crangon septemspinosa*	1,096	312	27	735	22	59.6	1.3
Brown shrimp	*Farfantepenaeus aztecus*	447	418	29			23.8	0.8
Long-armed hermit crab	*Pagurus longicarpus*	356	82	274			4.7	7.2
Lady crab	*Ovalipes ocellatus*	256	48	208			2.7	5.5
Say mud crab	*Dyspanopeus sayi*	139	135	4			7.7	0.1
Mantis shrimp	*Squilla empusa*	31	29	2			1.6	<0.1
Atlantic mud crab	*Panopeus herbstii*	8	8				0.5	
Lesser blue crab	*Callinectes similis*	8	2	6			0.1	0.2
Portly spider crab	*Libinia emarginata*	4	3	1			0.2	<0.1
Unknown shrimp	*Unknown shrimp*	3	3				0.2	
Mud crab	*Panopeus sp.*	2	2				0.1	
Snapping shrimps	*Alpheidae*	1	1				0.1	
	Total Crustaceans	**13,196**	**8,806**	**2,638**	**955**	**797**		

Table 8. List of molluscs collected in Maryland's coastal cays Trawl (T) and Beach Seine (S) surveys from April through October 2019. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol. (L) (T)	Spec. Vol. (L) (S)	Est. Vol. (L) (T)	Est. Vol. (L) (S)	CPUE (T) #/Hect.	CPUE (S) #Haul	CPUE Vol. (T) #/Hect	CPUE Vol. (S) #/Haul
Solitary glassy bubble snail	*Haminoea solitaria*	304	4		300						17.3			
Atlantic brief squid	*Lolliguncula brevis*	123	123								7.0			
Eastern mudsnail	*Nassarius obsoletus*	63	13	50							0.7	1.3		
Mudsnails	*Nassarius sp.*	40	3	12		25					0.2	1.0		
Eastern oyster	*Crassostrea virginica*	31	1	30							0.1	0.8		
Convex slippersnail	*Crepidula convexa*	30	3	2	25						1.6	<0.1		
Eastern white slippersnail	*Crepidula plana*	16		16								0.4		
Northern quahog	*Mercenaria mercenaria*	4	3	1							0.2	<0.1		
Atlantic oyster drill	*Urosalpinx cinerea*	2	1	1							0.1	<0.1		
Bruised nassa	*Nassarius vibex*	2	1	1							0.1	<0.1		
Purplish tagelus	*Tagelus divisus*	2	2								0.1			
Stout tagelus	*Tagelus plebeius*	2	2								0.1			
Thick-lip drill	*Eupleura caudata*	2	1	1							0.1	<0.1		
Dwarf surfclam	*Mulinia lateralis*	1	1								0.1			
Eastern beaded chiton	*Chaetopleura apiculata*	1	1								0.1			
Lemon drop	*Doriopsilla pharpa*	1		1								<0.1		
Ribbed mussel	*Geukensia demissa*	1		1								<0.1		
Slippershells	*Crepidula sp.*	1	1								0.1			
Striped nudibranch	*Cratena pilata*	1	1								0.1			
Softshell clam	*Mya arenaria*													
	Total Molluscs	**627**	**161**	**116**	**325**	**25**								

Table 9. List of other species collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2019. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol. (L) (T)	Spec. Vol. (L) (S)	Est. Vol. (L) (T)	Est. Vol. (L) (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul	CPUE (T) #/Hect.Vol.	CPUE (S) #/Haul Vol.
Sea nettle	*Chrysaora quinquecirrha*	347	132		215		8.5				19.8		0.5	
Beroe comb jelly	*Beroe ovata*	294	154	90	50						11.6	2.4		
Comb jellies	*Ctenophora*	282	185	6	81	10	499.8	42.2	<0.1	101.8	15.1	0.4	28.5	3.8
Sea squirt	*Molgula manhattensis*	86	66		20		7.0				4.9		0.4	
Hairy sea cucumber	*Sclerodactyla briareus*	59	49	10							2.8	0.3		
Horseshoe crab	*Limulus polyphemus*	52	32	20							1.8	0.5		
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	14	1	13							0.1	0.3		
Moon jelly	*Aurelia aurita*	12	10	2							0.6	<0.1		
Sand shrimp	*Crangon septemspinosa*	2	2								0.1			
Bryozoans	*Ectoprocta*	1	1				24.1	0.9	<0.1	<0.1	0.1		1.4	<0.1
Goldstar tunicate	*Botryllus schlosseri*							0.0						
Sea pork	*Aplidium sp.*						104.9	0.8					6.0	<0.1
Rubbery bryozoan	*Alcyonidium sp.*						0.9	2.3					<0.1	<0.1
Halichondria sponge	*Halichondria sp.*						14.6	4.9					0.8	0.1
Red beard sponge	*Microciona prolifera*						144.2	2.7					8.2	<0.1
Sulphur sponge	*Cliona celata*						25.6						1.5	
Halichondria sponge	*Halichondria sp.*						0.0							
	Total Other	**1,149**	**632**	**141**	**366**	**10.0**	**829.9**	**53.8**	**0.1**	**101.9**				

Table 10. List of Submerged Aquatic Vegetation (SAV) and macroalgae collected in Maryland's coastal cays Trawl (T) and Beach Seine (S) surveys from April through October 2019. Species are listed by order of total abundance. Total trawl sites = 140, total seine sites = 38.

Common Name	Genus	Specific Volume (L) (T)	Specific Volume (L) (S)	Estimated Volume (L) (T)	Estimated Volume (L) (S)
SAV					
Eel grass	*Zostera*	31.2	76.2		
Widgeongrass	*Ruppia*	1.0	1.6		
	Total SAV	**32.2**	**77.8**		
Macroalgae					
Brown					
Common southern kelp	*Laminaria*	1.3			
Rockweed	*Fucus*	0.2			
Sour weeds	*Desmarestia*	0.1			
		1.6			
Green					
Sea lettuce	*Ulva*	51.2	67.8	<0.1	
Hollow green weed	*Enteromorpha*	11.6	1.3		
Green fleece	*Codium*	2.9	1.5		
Green hair algae	*Chaetomorpha*	2.7	21.0		
Green tufted seaweed	*Cladophora*	0.1			
Brittlewort	*Nitella*		2.0		
		68.4	**93.5**	**<0.1**	
Red					
Agardh's red weed	*Agardhiella*	185.9	366.9	0.4	
Tubed weeds	*Polysiphonia*	91.8	3.3		
Banded weeds	*Ceramium*	10.3		0.5	
Graceful red weed	*Gracilaria*	5.1	75.8		
Barrel weed	*Champia*	0.7			
Hairy basket weed	*Spyridia*	0	75.3		
		293.9	**521.4**	**0.9**	
Yellow-Green					
Water felt	*Vaucheria*	6.3			
		6.3			
	Total Macroalgae	**370.2**	**614.9**	**1.0**	

Table 11. Length by month for selected fishes from the Trawl Survey in 2019.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
American eel (*Anguilla rostrata*)	Apr	2	2	55	57	56	1.4
	May	1	1	51	51	51	0
	June						
	July						
	Aug	1	1	480	480	480	0
	Sep						
	Oct						
Atlantic croaker (*Micropogonias undulatus*)	Apr	127	85	15	89	33.6	12.4
	May	218	43	58	162	84.8	17.3
	Jun	87	38	90	143	115.4	10.2
	Jul	16	16	45	177	108.4	52.0
	Aug	8	8	170	208	187.6	12.2
	Sep	7	7	22	188	76.1	69.4
	Oct	36	36	12	79	34.8	13.6
Atlantic menhaden (*Brevoortia tyrannus*)	Apr						
	May	11	11	35	34	44.6	5.7
	Jun	399	63	32	92	45.5	10.2
	Jul	27	27	72	203	102.0	28.2
	Aug	25	25	94	317	119.1	42.7
	Sep	6	6	91	217	119.0	49.4
	Oct	6	6	109	120	114.5	26.6
Atlantic silverside (*Menidia menidia*)	Apr						
	May						
	Jun	2	2	55	55	55	0
	Jul						
	Aug						
	Sep						
	Oct						
Bay anchovy (*Anchoa mitchilli*)	Apr	115	37	34	82	60.4	10.7
	May	220	136	45	92	67.2	9.0
	Jun	386	245	50	95	70.7	8.3
	Jul	1094	292	22	92	57.1	19.4
	Aug	2762	266	10	88	44.7	13.4
	Sep	556	203	23	90	49.3	10.3
	Oct	259	147	22	92	53.7	10.1

Table 11. cont. Length by month for selected fishes from the Trawl Survey in 2019.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
Black sea bass (*Centropristis striata*)	Apr	1	1	44	44	44	
	May	9	9	63	92	75.7	8.3
	Jun	59	32	67	132	100.9	16.7
	Jul	58	58	73	170	113.6	19.4
	Aug	23	23	48	155	121.5	22.8
	Sep	33	31	98	180	144.0	18.7
	Oct	12	11	30	170	120.6	46.7
Bluefish (*Pomatomus saltatrix*)	Apr						
	May						
	Jun						
	Jul	1	1	228	228	228	
	Sep						
	Oct						
Pinfish (*Lagodon rhomboides*)	Apr						
	May						
	Jun						
	Jul						
	Aug						
	Sep	2	2	140	160	150	14.1
	Oct						
Sheepshead (*Archosargus probatocephalus*)	Apr						
	May						
	Jun						
	Jul						
	Sep						
	Oct	1	1	110	110	110	
Silver perch (*Bairdiella chrysoura*)	Apr						
	May	7	7	130	175	144.4	6.2
	Jun	8	8	26	192	126.6	22.5
	Jul	21	21	34	157	61.9	7.4
	Aug	19	19	40	169	92.0	6.9
	Sep	16	16	108	178	130.8	5.4
	Oct	3	3	110	144	127.0	9.8
Spot (*Leiostomus xanthurus*)	Apr						
	May	5118	279	23	90	45.3	14.8
	Jun	8094	379	38	140	89.8	19.9
	Jul	4425	379	63	160	105.6	17.6
	Aug	3453	333	69	198	116.3	19.2
	Sep	1861	296	29	165	118.5	15.7
	Oct	6371	214	83	220	117.4	16.5

Table 11 cont. Length by month for selected fishes from the Trawl Survey in 2019.

	Month	Number counted	Number measured	Min length (mm)	Max length (mm)	Mean Length (mm)	SD
Summer flounder (*Paralichthys dentatus*)	Apr	7	7	23	166	48.5	52.0
	May	37	37	38	271	62.9	37.7
	Jun	58	58	50	415	86.5	61.5
	Jul	59	59	42	351	94.1	72.6
	Aug	31	31	63	258	91.6	48.6
	Sep	11	11	70	280	102.2	59.4
	Oct	11	11	69	465	172.6	128.6
Weakfish (*Cynoscion regalis*)	Apr						
	May						
	Jun						
	Jul	7	7	65	132	91.4	25.1
	Aug	7	7	74	212	143	41.6
	Sep	1					
	Oct						

Table 12. Length by month for selected fishes from the Beach Seine Survey in 2019. 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	4	3	166	300	229	67.4
(*Anguilla rostrata*)	Sep						
Atlantic croaker	Jun	29	29	112	225	153.4	44.6
(*Micropogonias undulatus*)	Sep	5	5	38	224	92.2	81.6
Atlantic menhaden	Jun	11970	228	22	350	67.1	41.7
(*Brevoortia tyrannus*)	Sep	981	4	77	219	125	63.8
Atlantic silverside	Jun	672	239	29	117	65.6	19.0
(*Menidia menidia*)	Sep	395	225	40	125	69.9	11.1
Bay anchovy	Jun	2203	235	46	108	71.9	9.0
(*Anchoa mitchilli*)	Sep	775	181	19	71	46.1	8.1
Black sea bass	Jun	20	20	63	114	85.6	14.4
(*Centropristis striata*)	Sep	1	1	115	115	115	
Bluefish	Jun	14	14	80	141	103.9	15.4
(*Pomatomus saltatrix*)	Sep	1	1	190	190	190	
Pinfish	Jun	94	59	27	73	53.2	9.4
(*Lagodon rhomboides*)	Sep	16	16	102	172	131.3	20.4
Sheepshead	Jun						
(*A. probatocephalus*)	Sep	3	3	60	71	64.3	5.9
Silver perch	Jun	64	61	25	183	94.3	57.3
(*Bairdiella chrysoura*)	Sep	79	55	52	229	100.9	29.7
Spot	Jun	3388	341	36	205	90.6	22.8
(*Leiostomus xanthurus*)	Sep	981	227	39	230	118.9	20.0
Summer flounder	Jun	171	150	35	428	93.3	58.9
(*Paralichthys dentatus*)	Sep	35	35	56	265	155.2	90.7

Table 13**.** Finfish richness and diversity by system for the 1989 - 2019 Trawl Survey. Sample size: Assawoman Bay (n = 672); St. Martin River (n = 448); Isle of Wight Bay (n = 448); Sinepuxent Bay (n = 672); Newport Bay (n = 448); Chincoteague Bay (n = 1,736).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	80	28.2	1.6
St. Martin River	75	23.6	1.7
Isle of Wight Bay	85	30.8	1.8
Sinepuxent Bay	75	25.3	2.0
Newport Bay	68	21.4	1.7
Chincoteague Bay	91	35.8	1.7

Table 14. Finfish richness and diversity by system for the 2019 Trawl Survey. 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	31	0.6
St. Martin River	23	0.9
Isle of Wight Bay	25	0.8
Sinepuxent Bay	27	1.5
Newport Bay	23	1.3
Chincoteague Bay	29	0.8

Table 15. Finfish richness and diversity by system for the 1989 - 2019 Beach Seine Survey. Sample size: Assawoman Bay (n = 672); St. Martin River (n = 448); Isle of Wight Bay (n = 448); Sinepuxent Bay (n = 672); Newport Bay (n = 448); Chincoteague Bay (n = 1,736).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	87	30.4	1.9
St. Martin River	72	20.6	1.5
Isle of Wight Bay	87	29.3	1.8
Sinepuxent Bay	76	27.7	1.6
Newport Bay	72	23.4	2.0
Chincoteague Bay	81	32.1	1.9
Ayers Creek	44	14.3	1.4

Table 16. Finfish richness and diversity by system for the 2019 Beach Seine Survey. 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	1.3
St. Martin River	22	1.6
Isle of Wight Bay	30	1.6
Sinepuxent Bay	31	0.6
Newport Bay	24	1.5
Chincoteague Bay	35	1.5
Ayers Creek	9	0.3

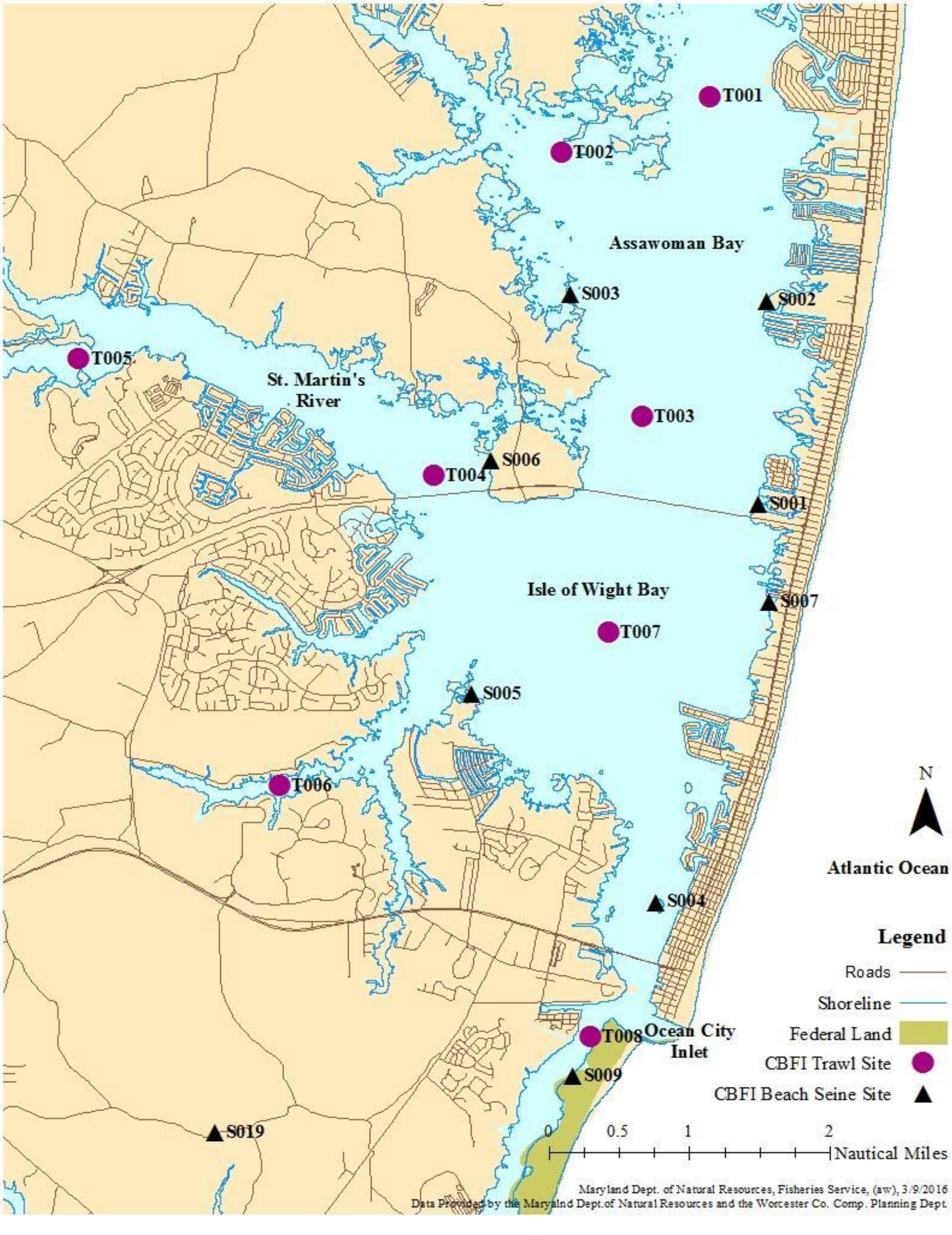

Figure 1. Trawl and Beach Seine surveys 2019 sampling locations in the Assawoman and Isle of Wight bays, Maryland.

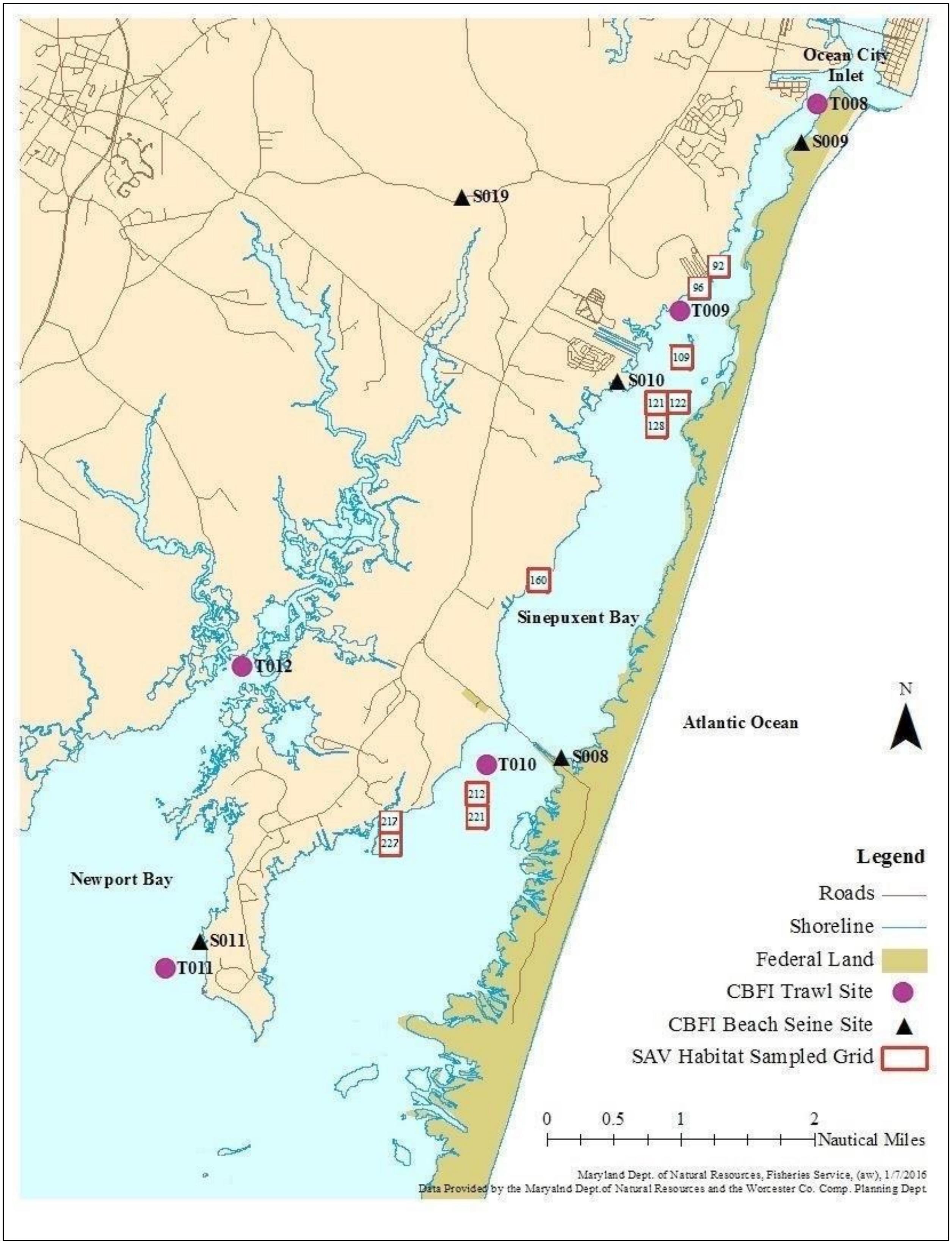

Figure 2. Trawl and Beach Seine surveys 2019 sampling locations in Sinepuxent and Newport bays, Maryland.

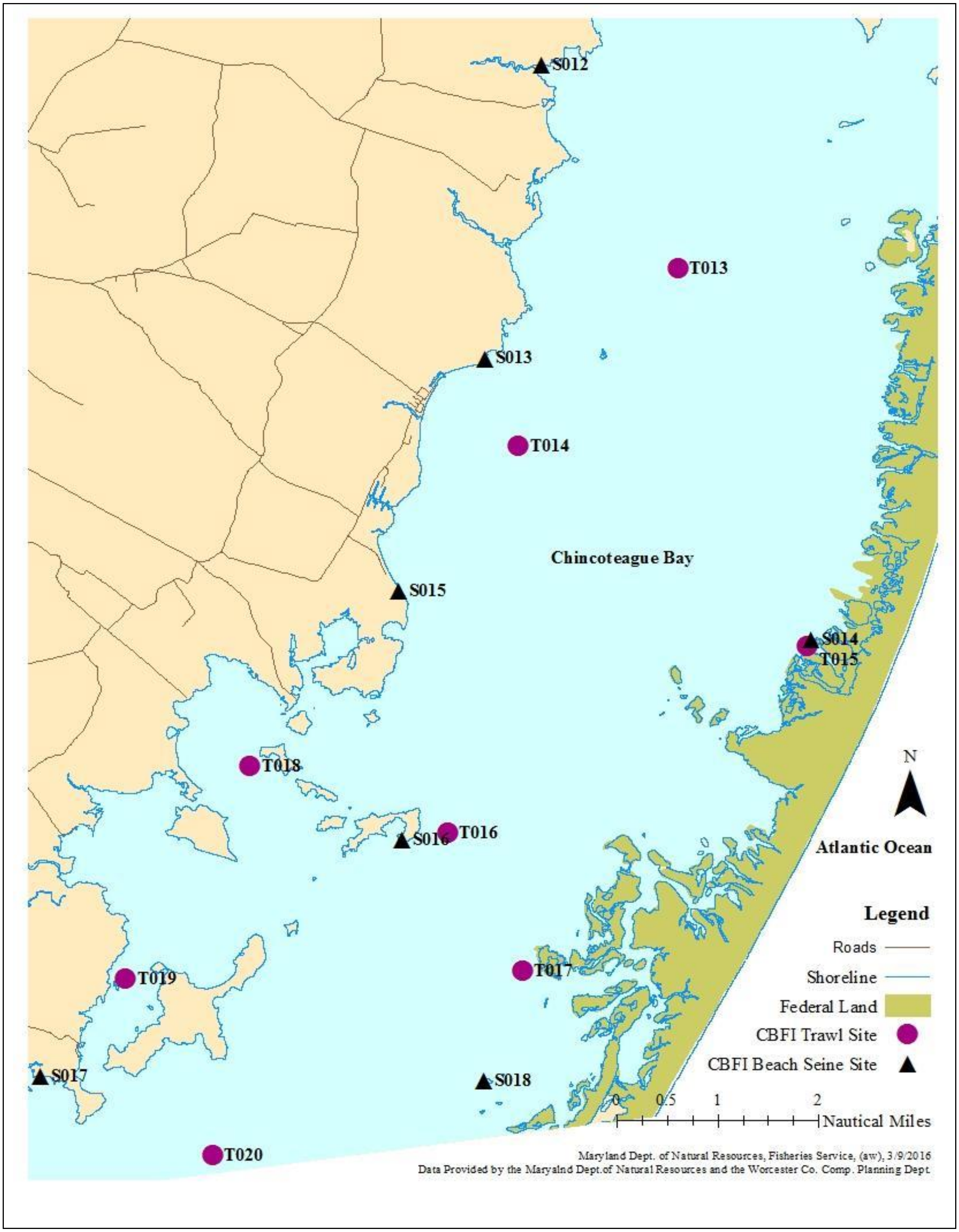

Figure 3. Trawl and Beach Seine surveys 2019 sampling locations in Chincoteague Bay, Maryland.

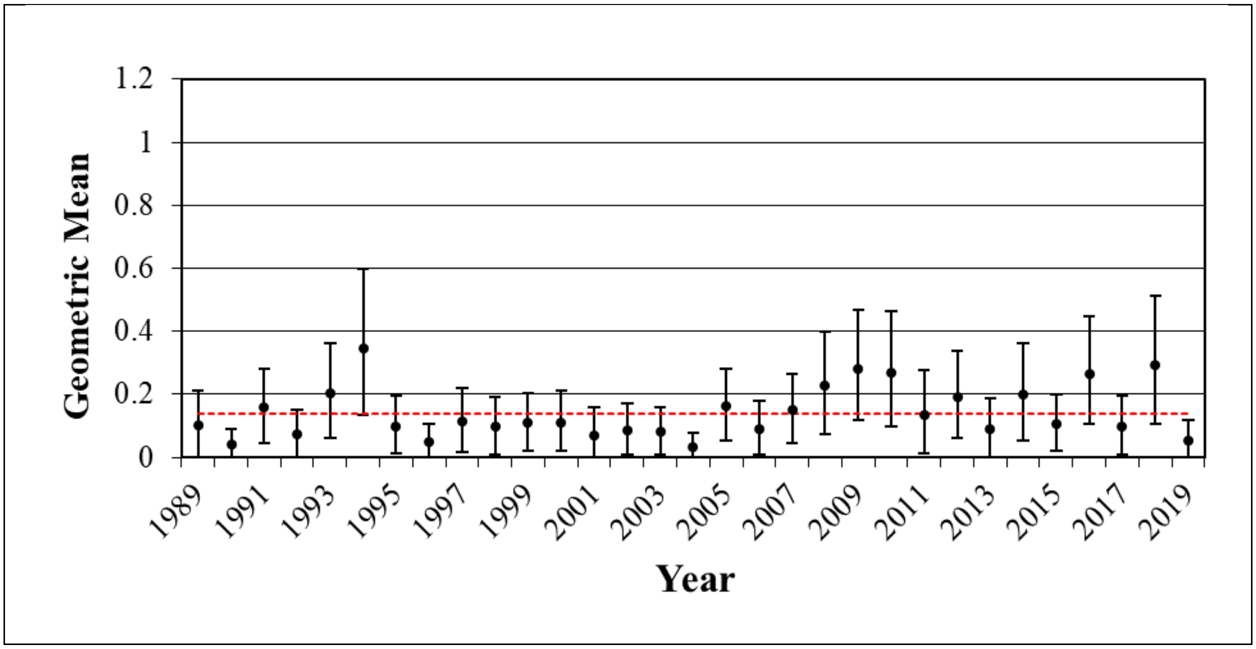

Figure 4. American eel (*Anguilla rostrata)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

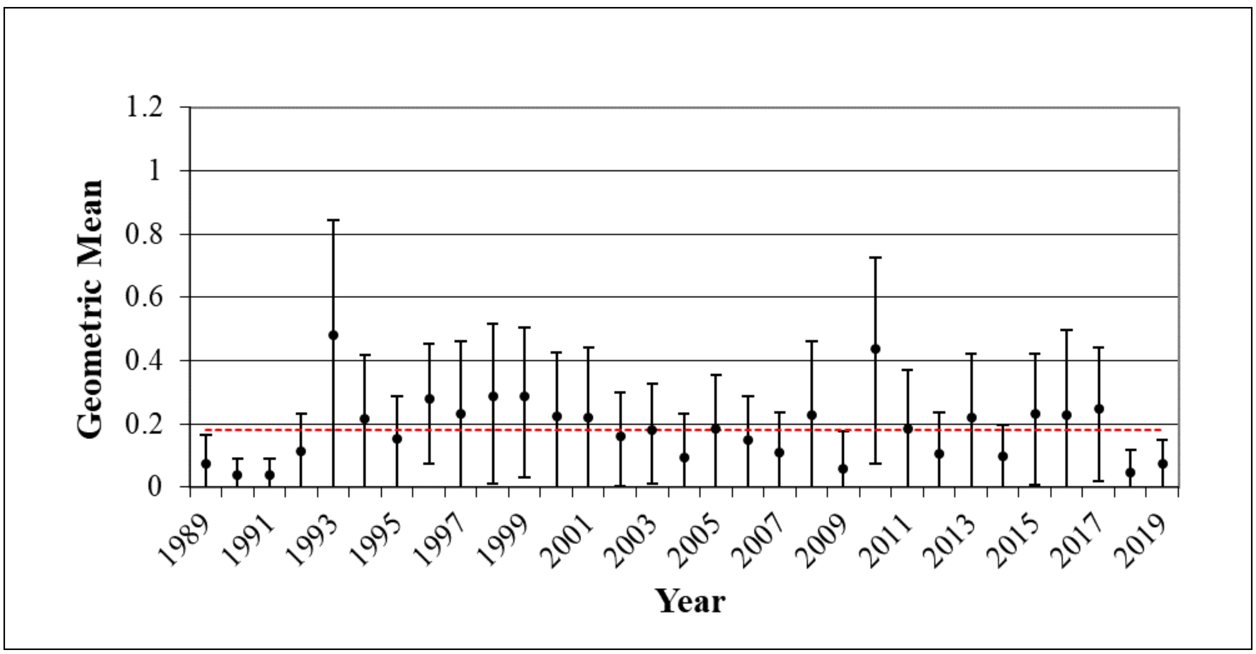

Figure 5. American Eel (*Anguilla rostrata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

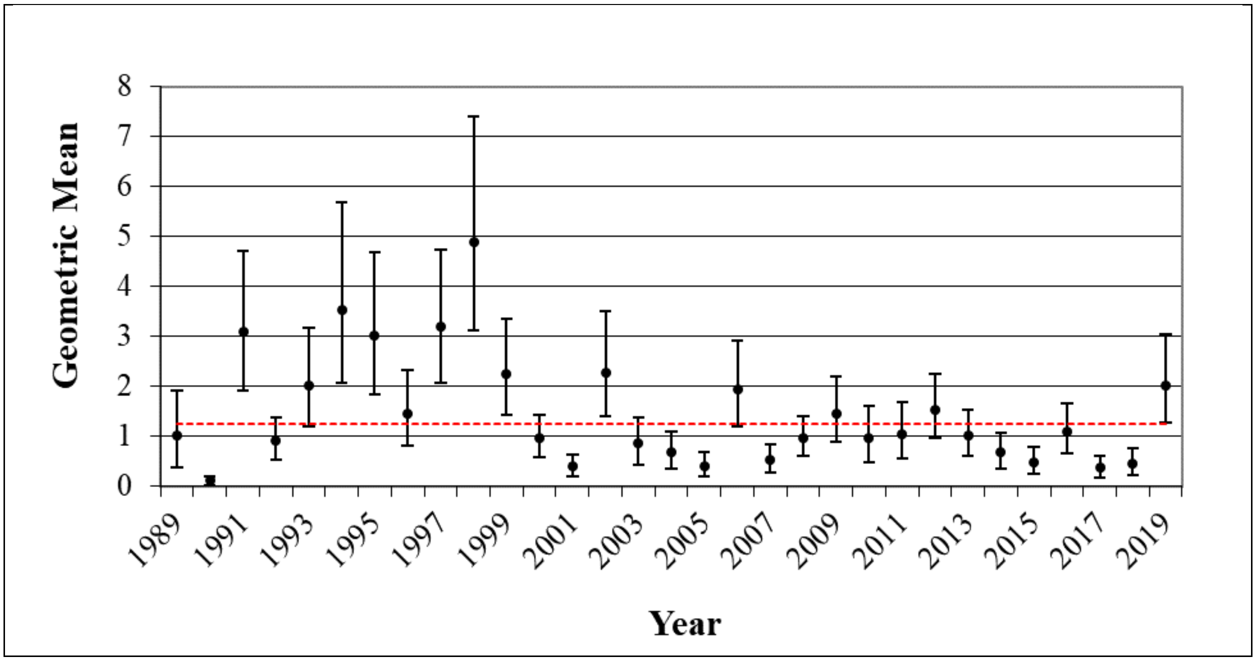

Figure 6. Atlantic croaker (*Micropogonias undulatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

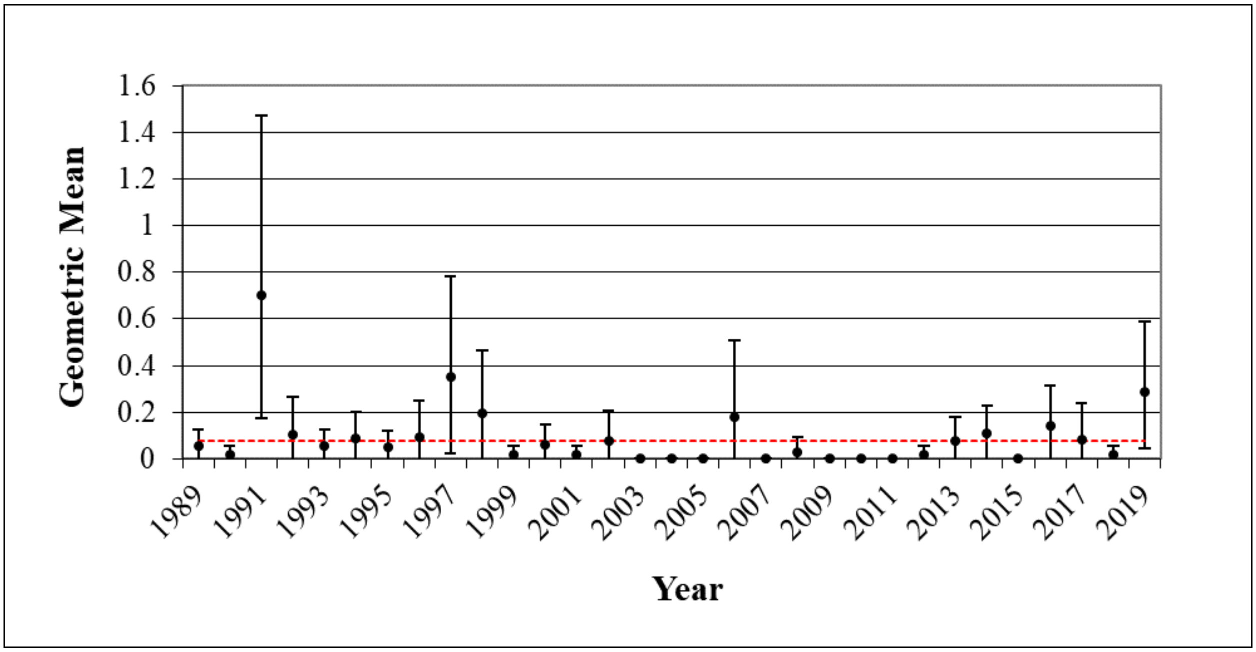

Figure 7. Atlantic croaker (*Micropogonias undulatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

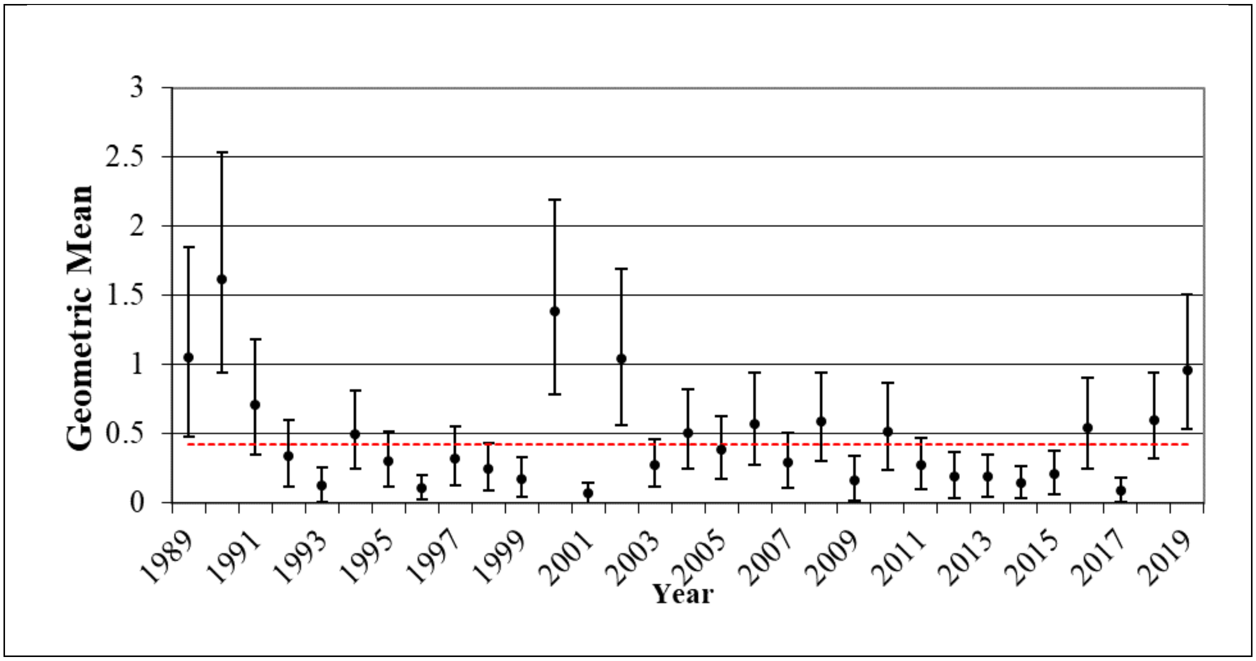

Figure 8. Atlantic menhaden (*Brevoortia tyrannus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

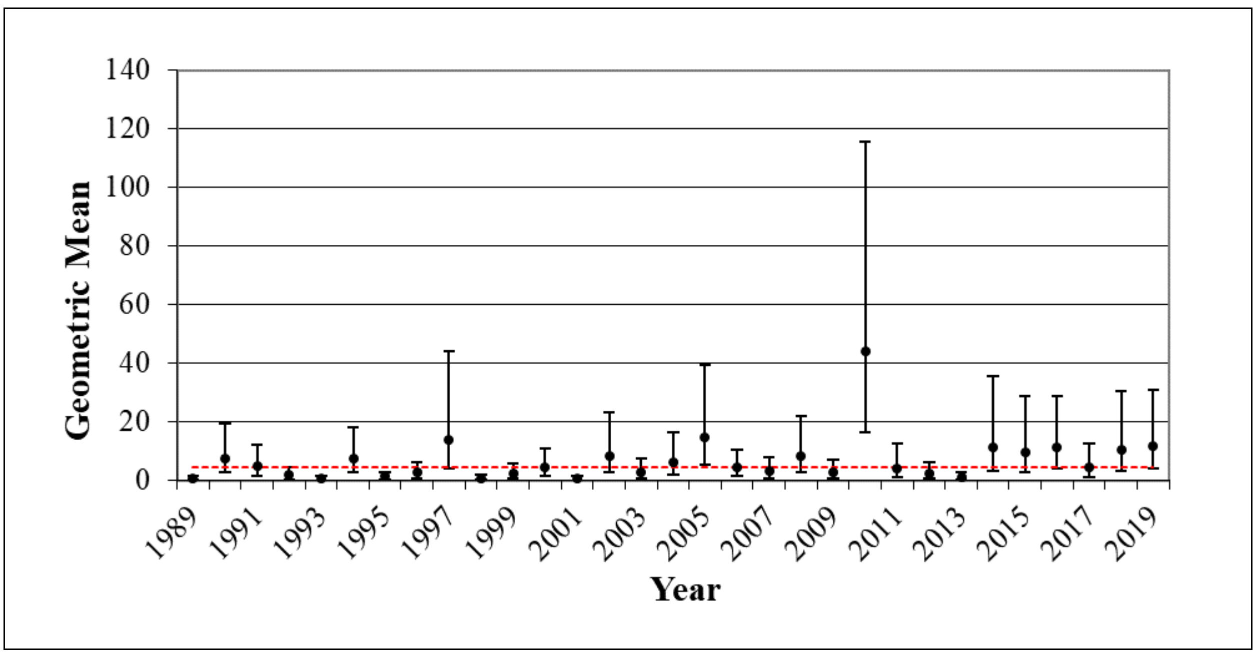

Figure 9. Atlantic menhaden (*Brevoortia tyrannus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

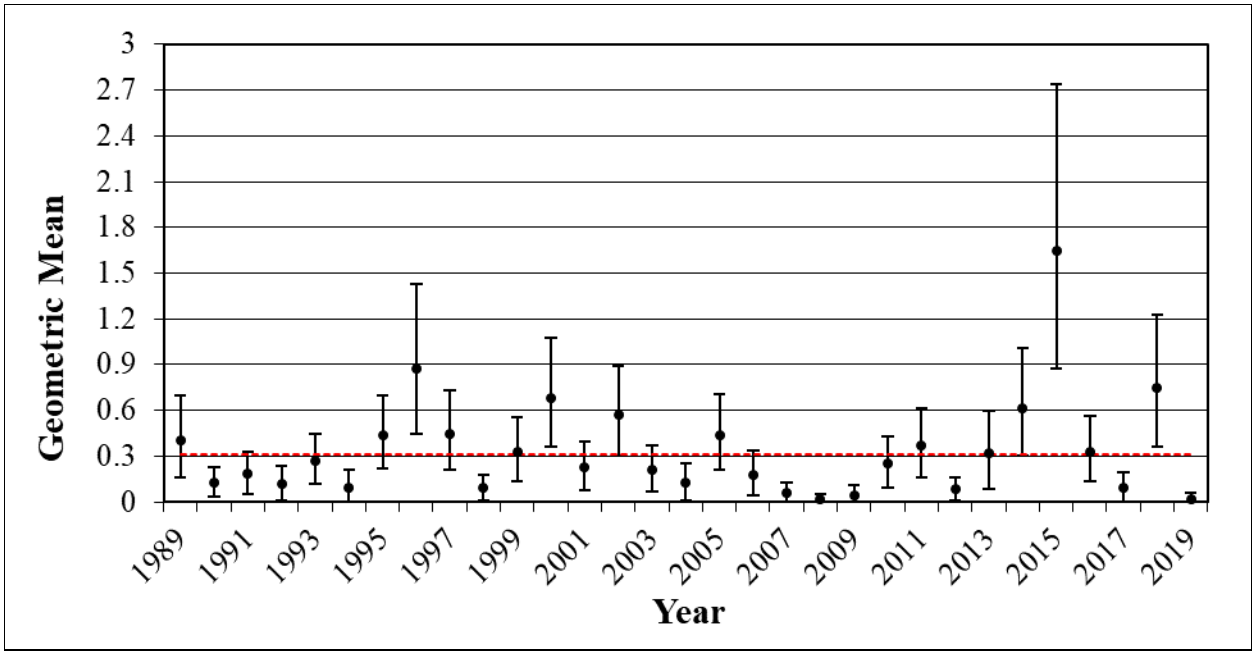

Figure 10. Atlantic silverside (*Menidia menidia*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

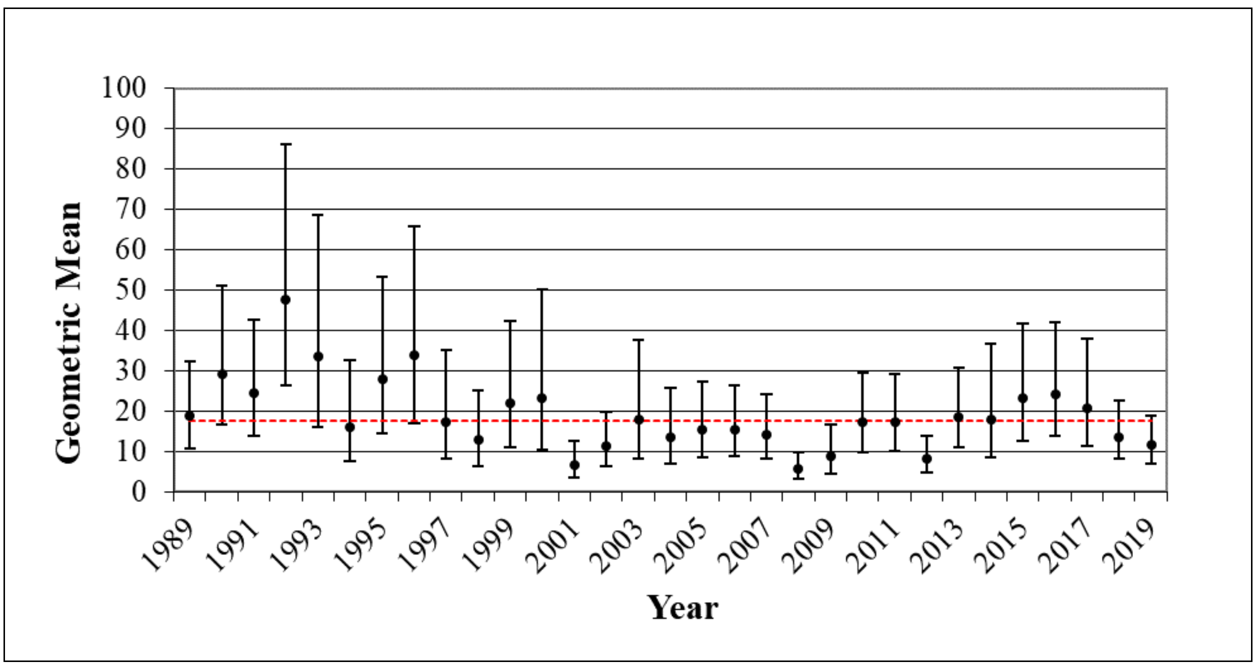

Figure 11. Atlantic silverside (*Menidia menidia*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

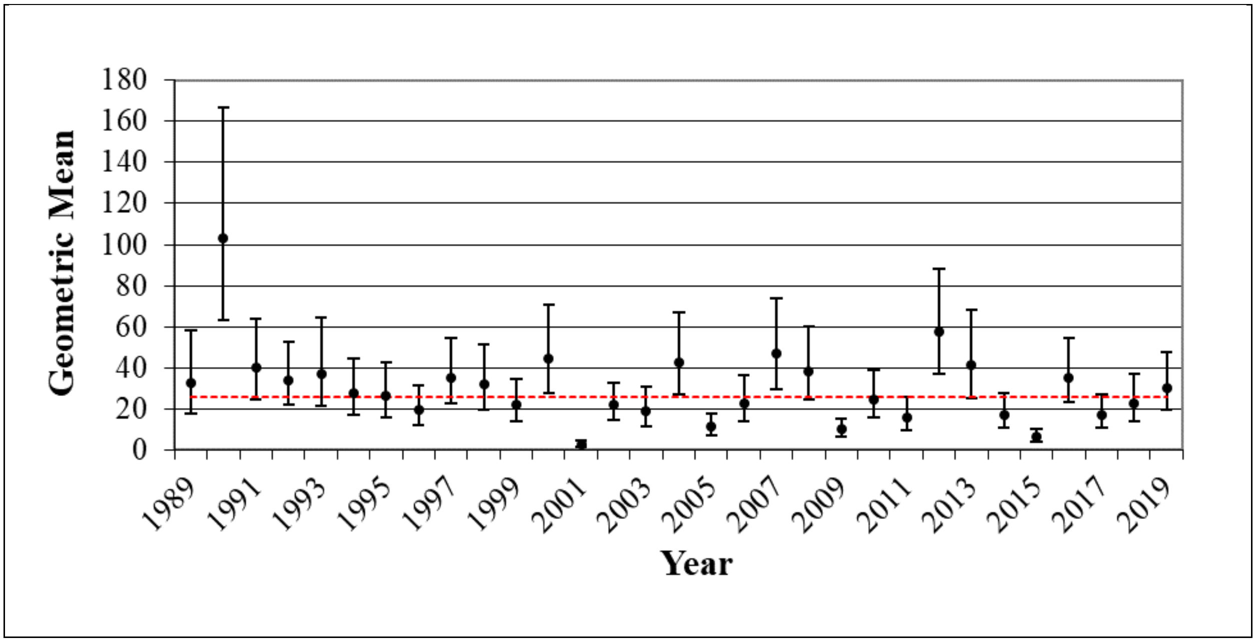

Figure 12. Bay anchovy (*Anchoa mitchilli*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

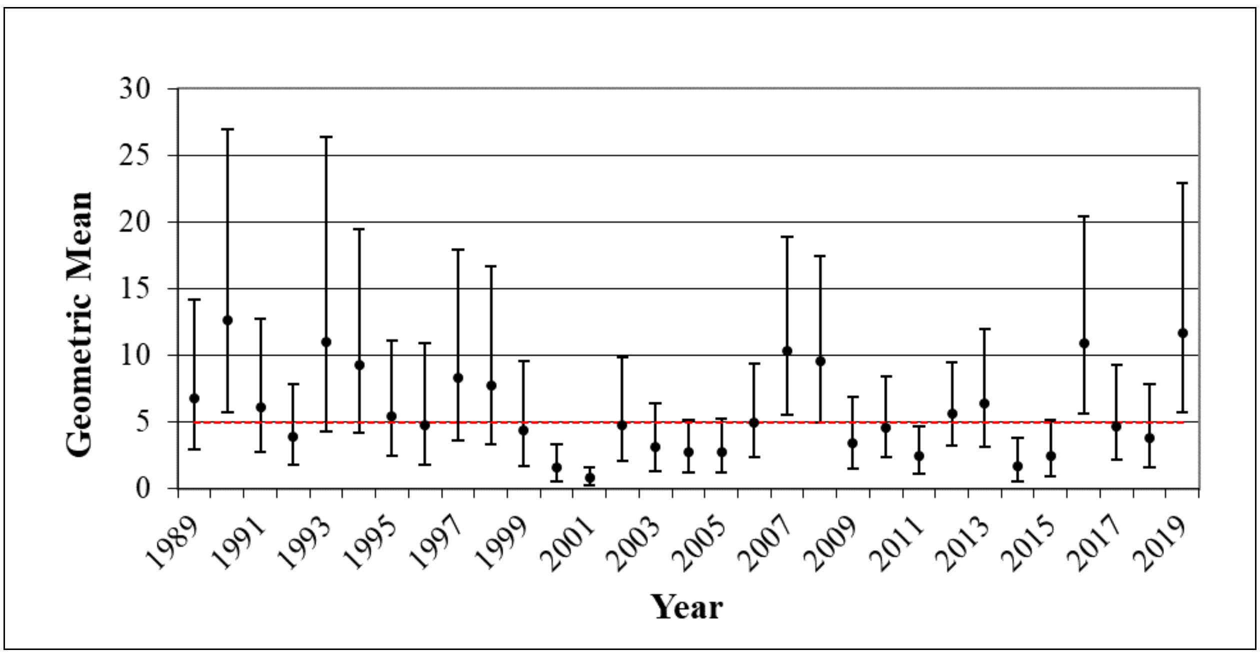

Figure 13. Bay anchovy (*Anchoa mitchilli*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

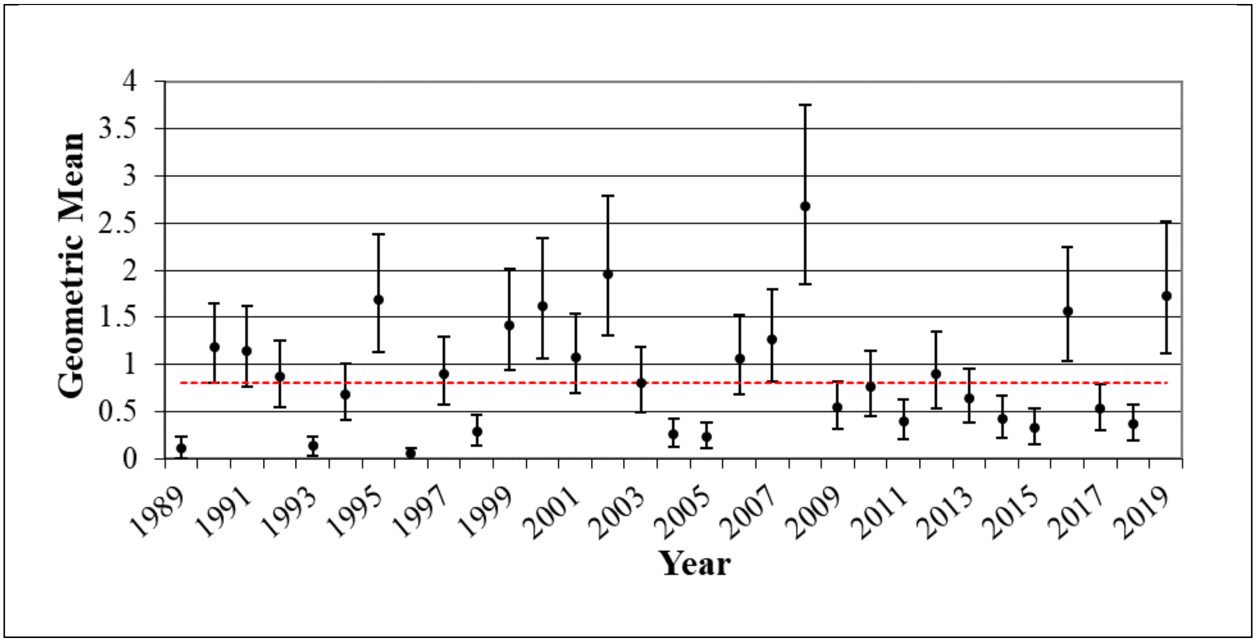

Figure 14. Black sea bass (*Centropristis striata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

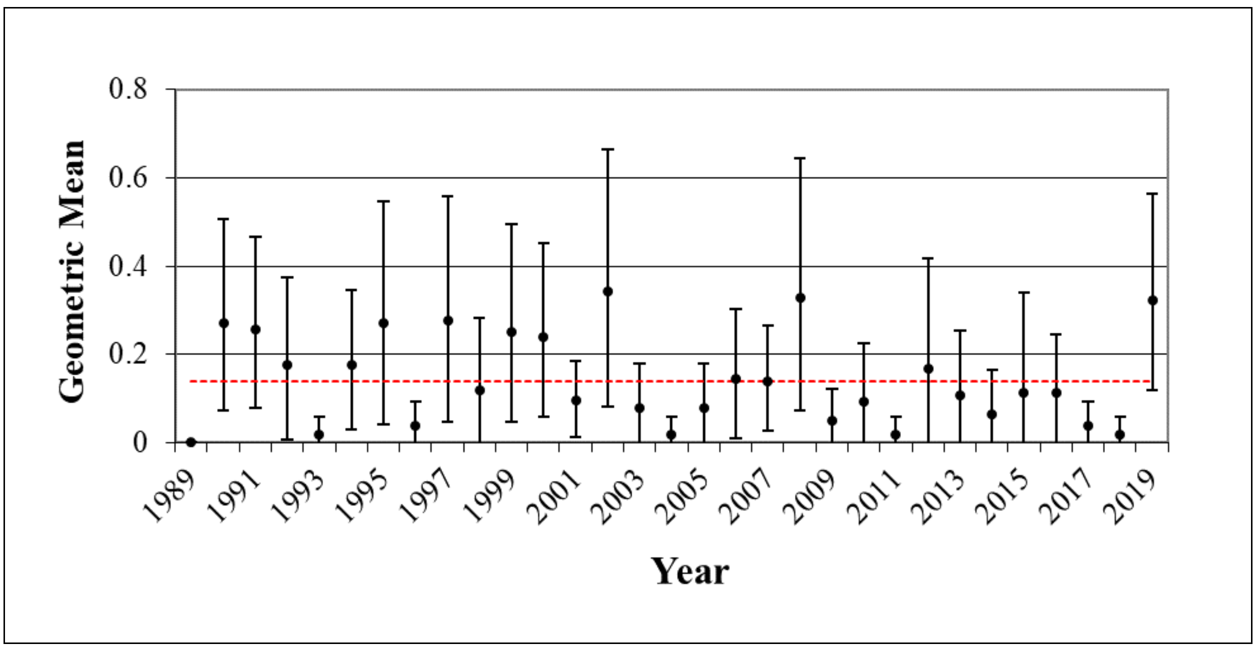

Figure 15. Black sea bass (*Centropristis striata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

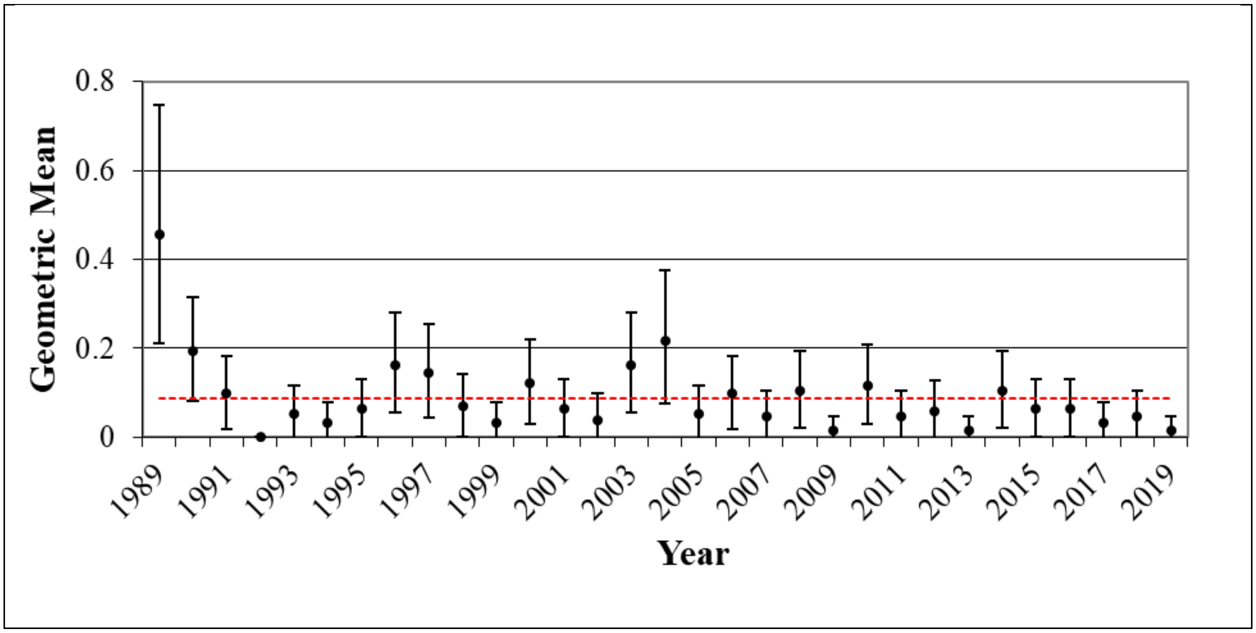

Figure 16. Bluefish (*Pomatomus saltatrix*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

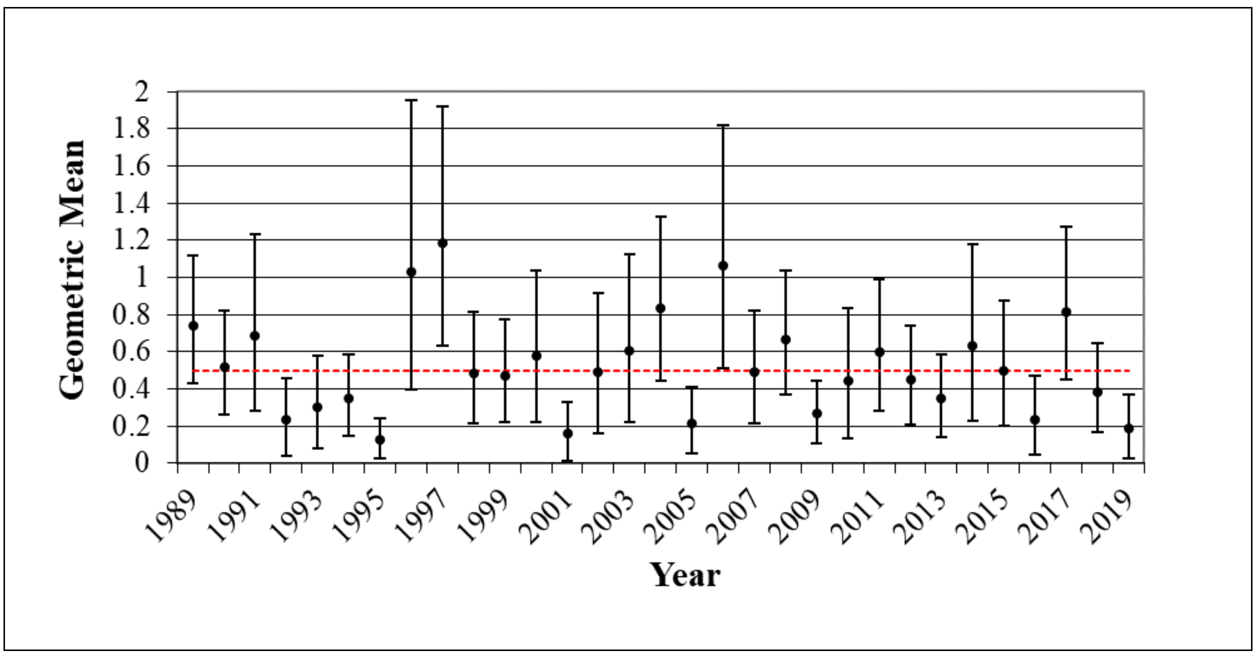

Figure 17. Bluefish (*Pomatomus saltatrix*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

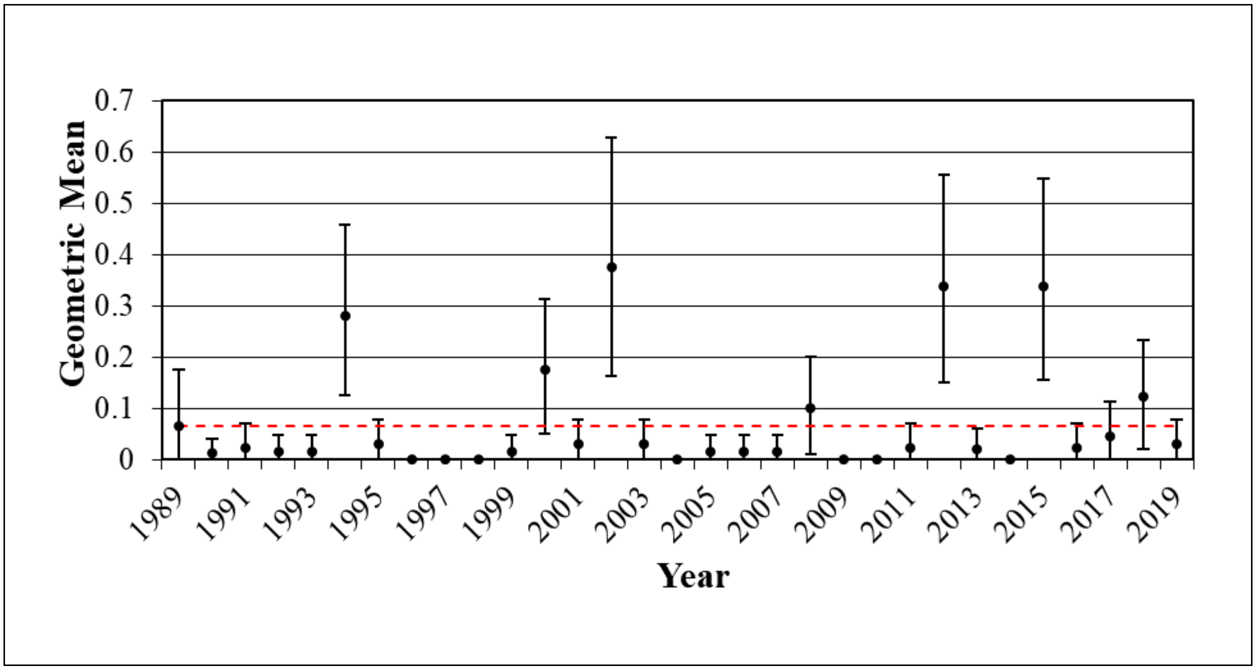

Figure 18. Pinfish (*Lagodon rhomboides)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

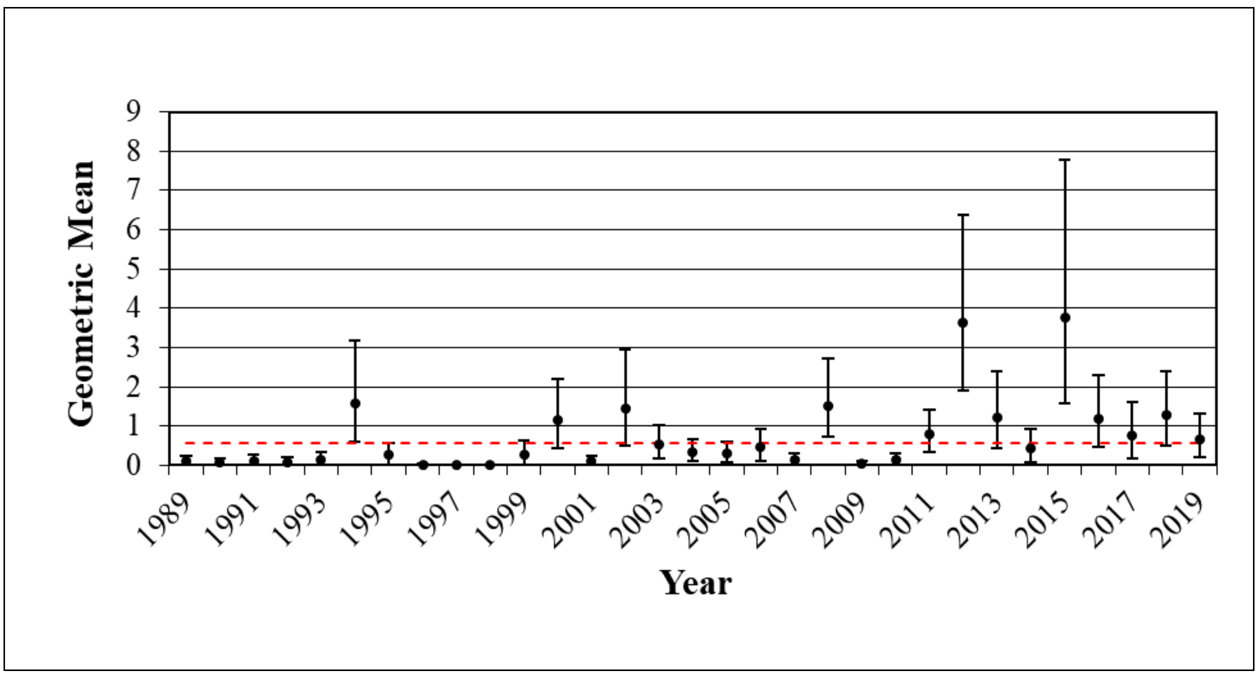

Figure 19. Pinfish (*Lagodon rhomboides)* beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

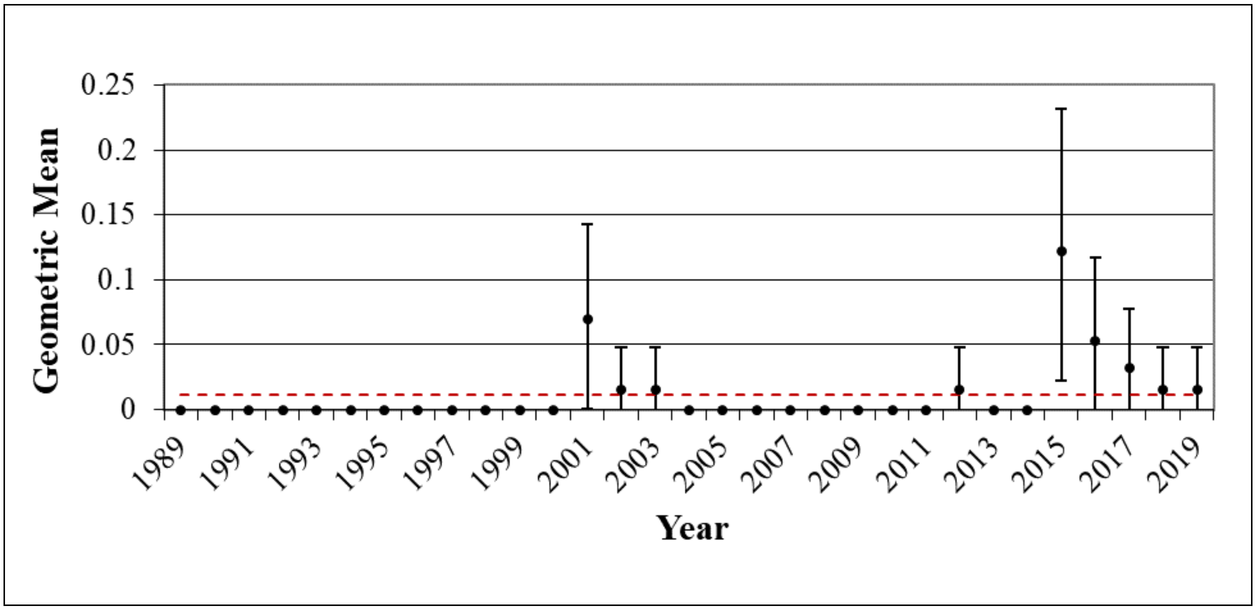

Figure 20. Sheepshead (*Archosargus probatocephalus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

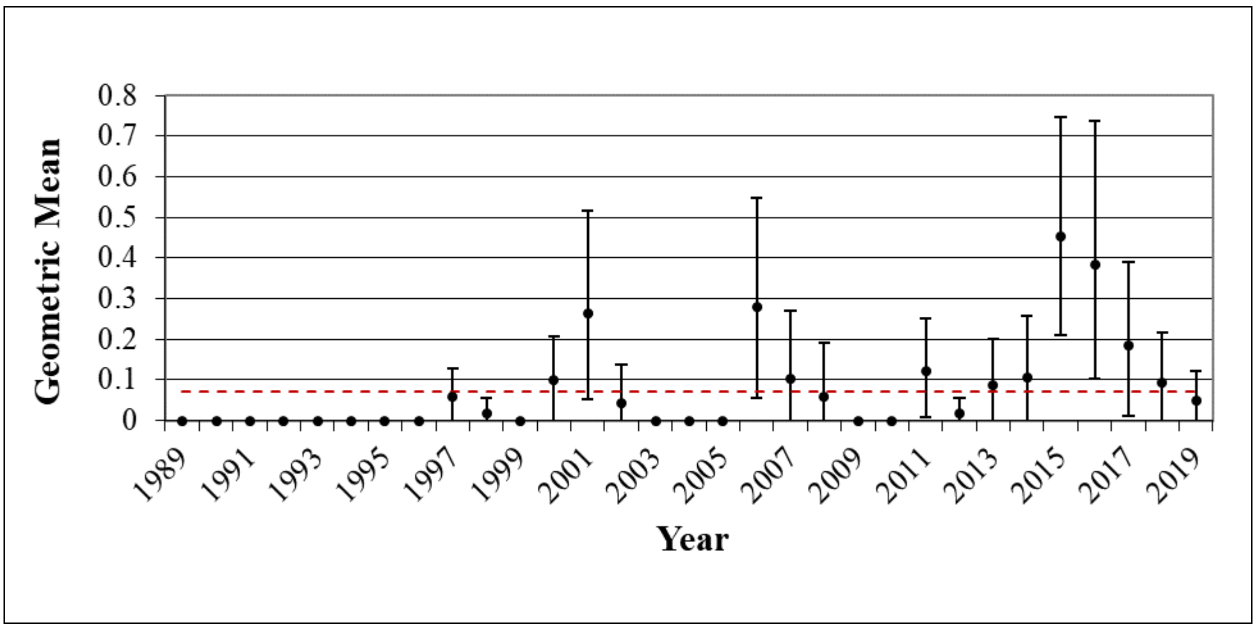

Figure 21. Sheepshead (*Archosargus probatocephalus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

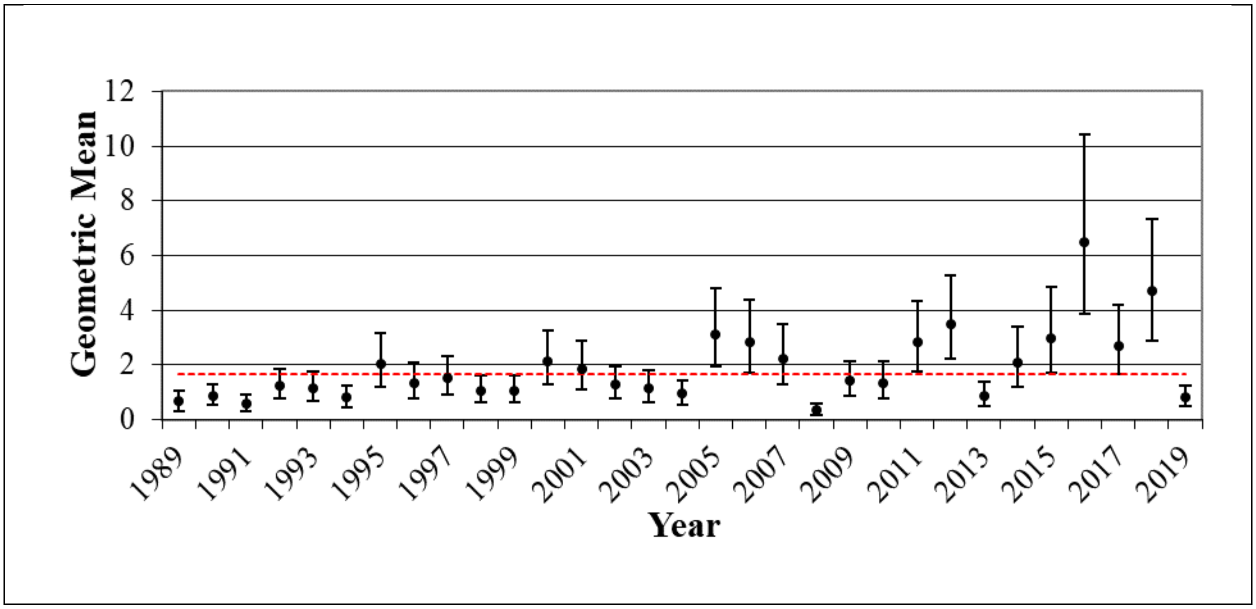

Figure 22. Silver perch (*Bairdiella chrysoura*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

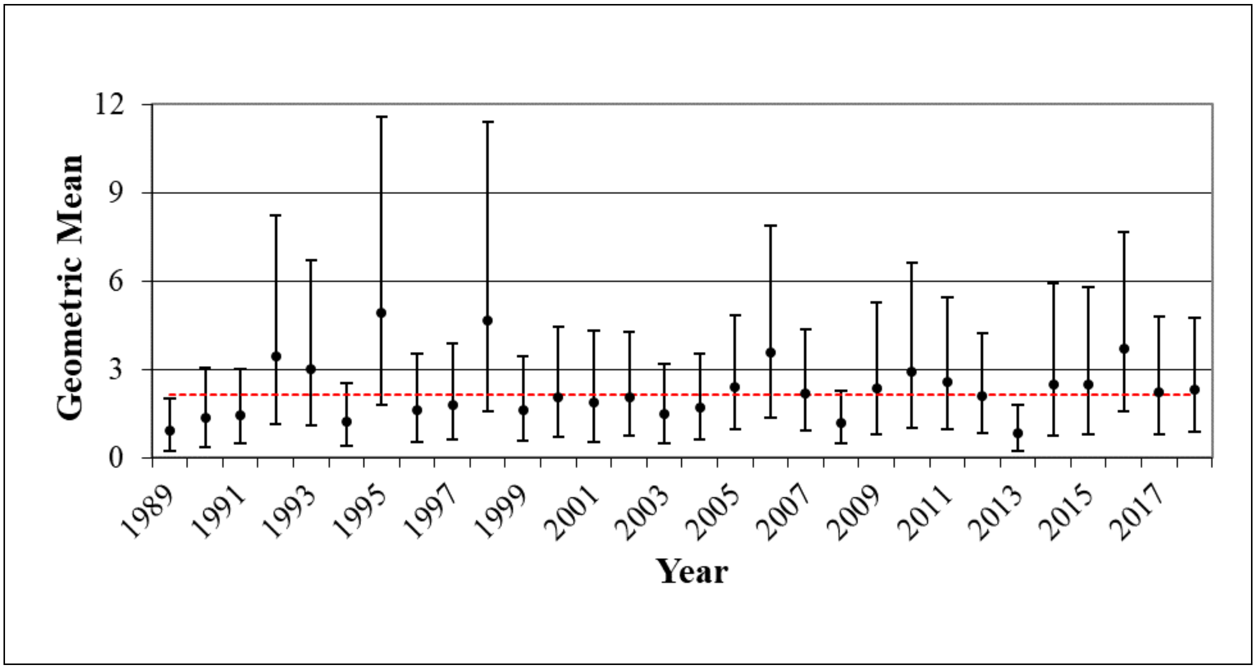

Figure 23. Silver perch (*Bairdiella chrysoura*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

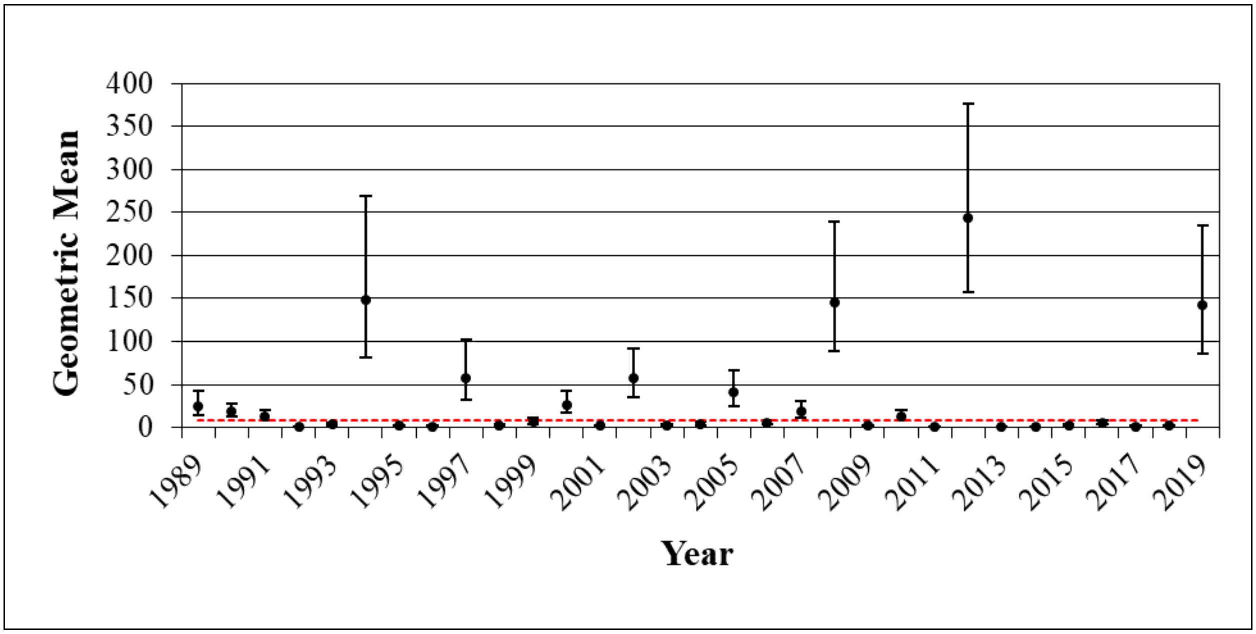

Figure 24. Spot (*Leiostomus xanthurus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

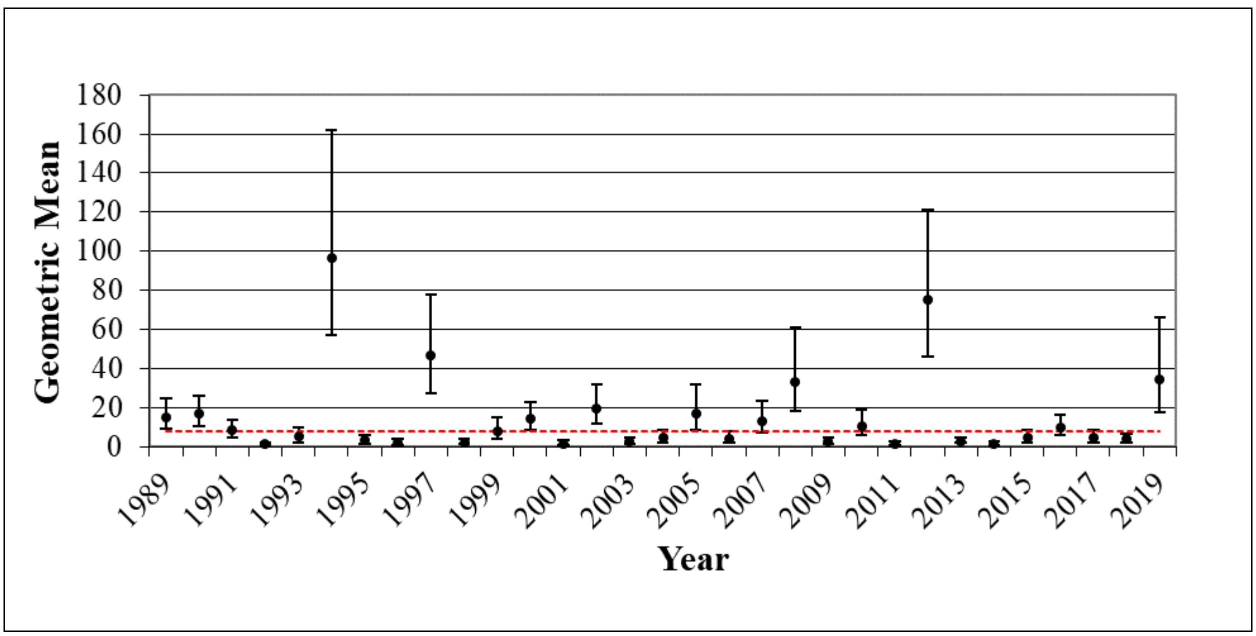

Figure 25. Spot (*Leiostomus xanthurus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

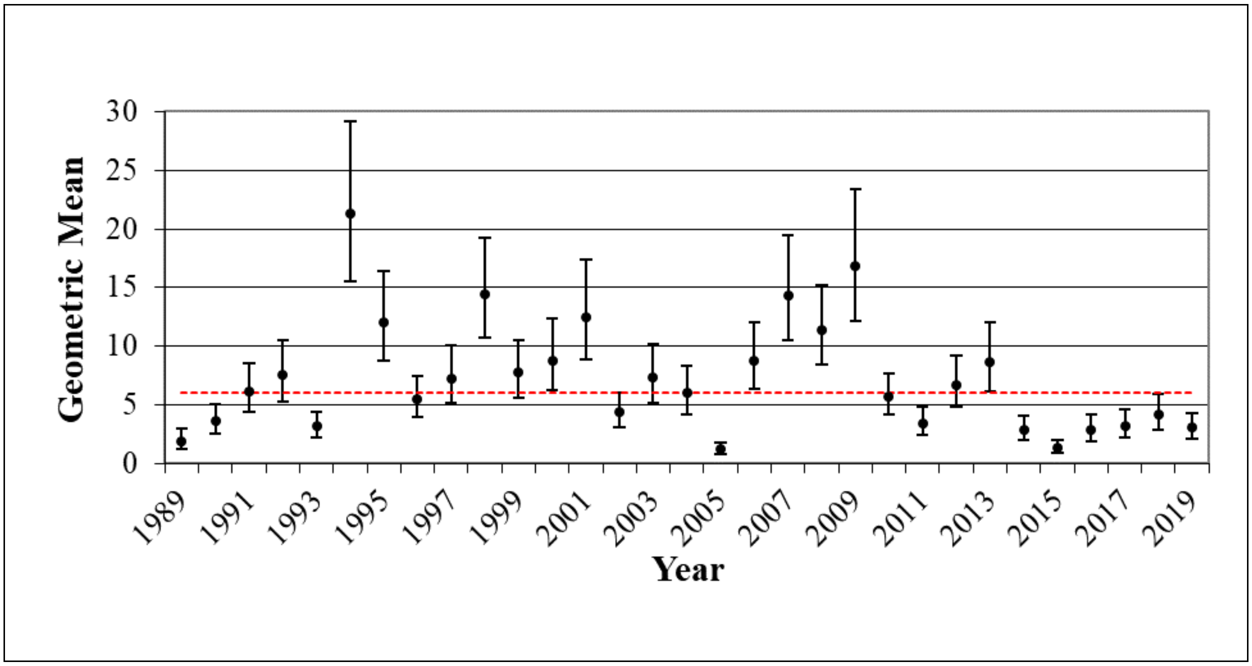

Figure 26. Summer flounder (*Paralichthys dentatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

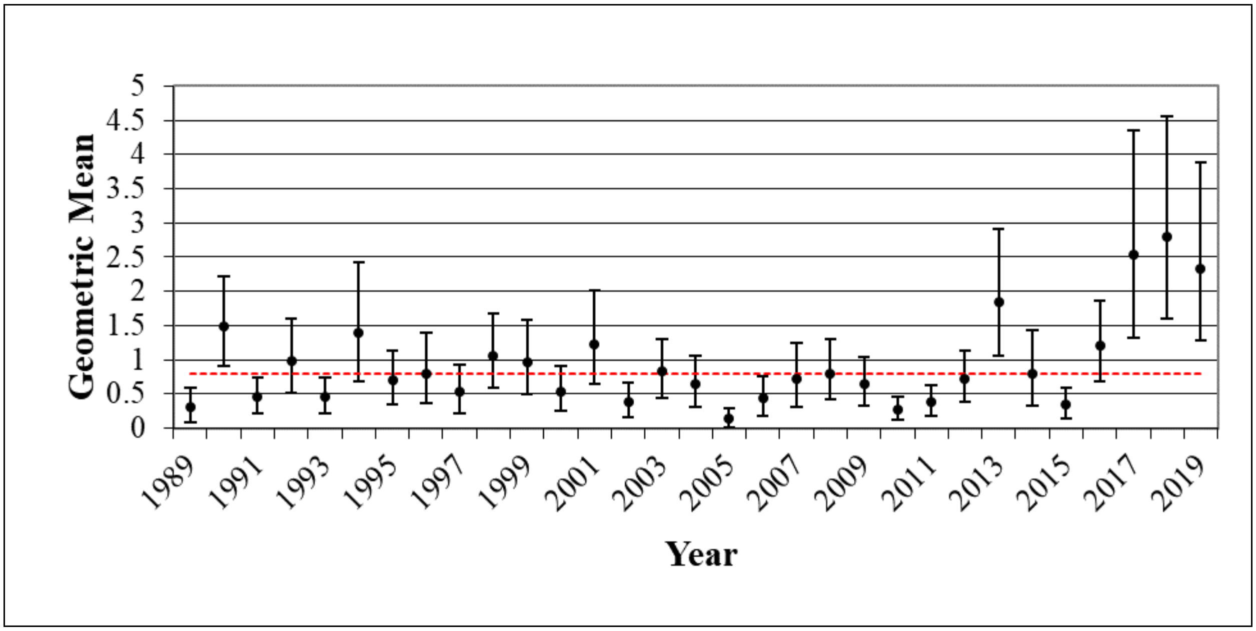

Figure 27. Summer flounder (*Paralichthys dentatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

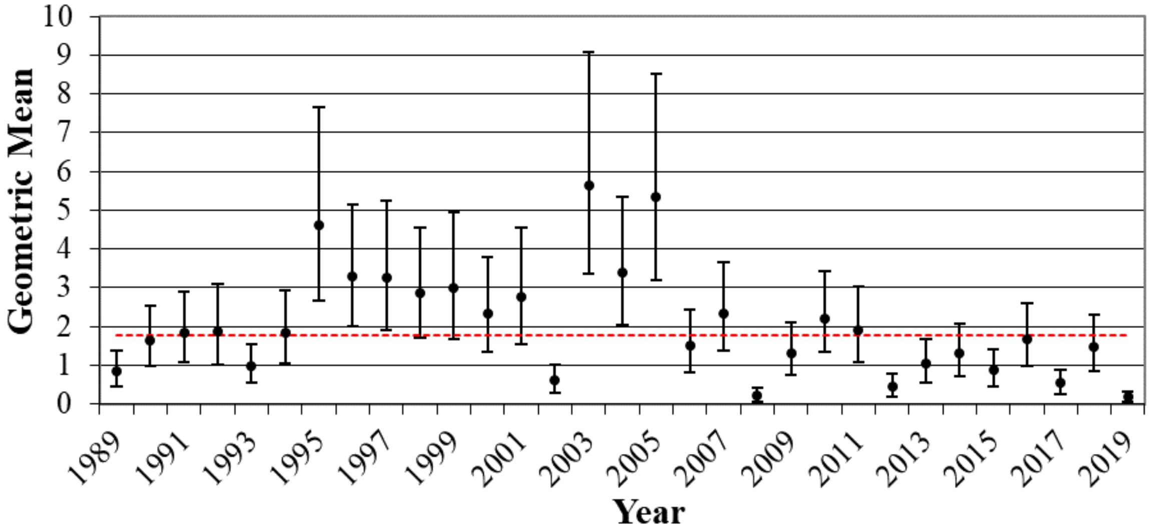

Figure 28. Weakfish (*Cynoscion regalis)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 140/year).

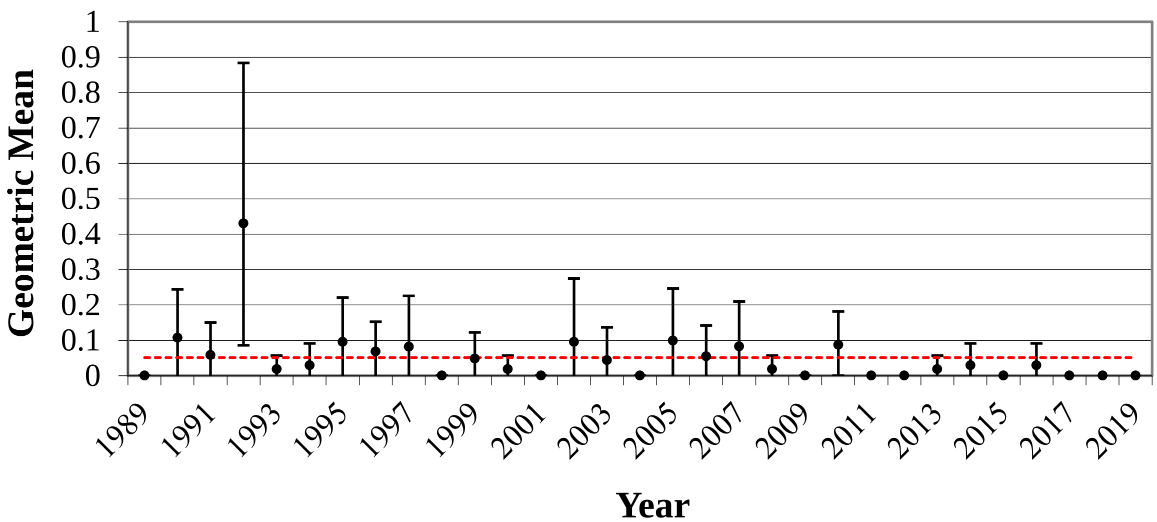

Figure 29. Weakfish (*Cynoscion regalis)* beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2019). Dotted line represents the 1989 - 2019 time series grand mean (n = 38/year).

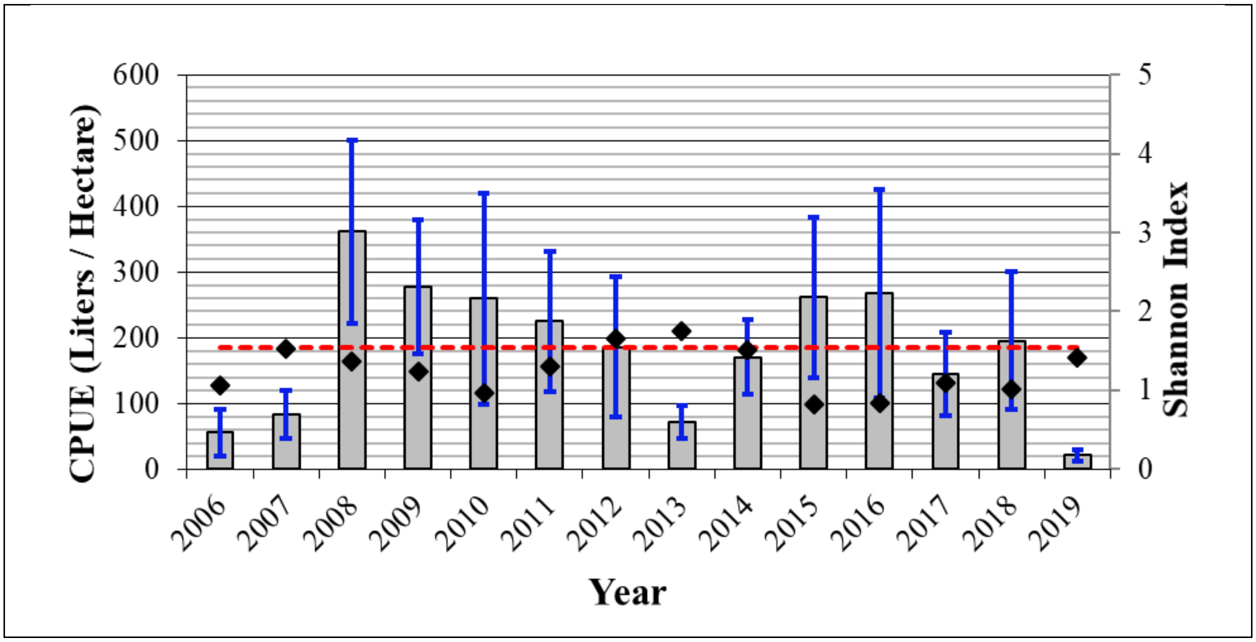

Figure 30. Coastal bays trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 140/year). Black diamond represents the Shannon index of diversity.

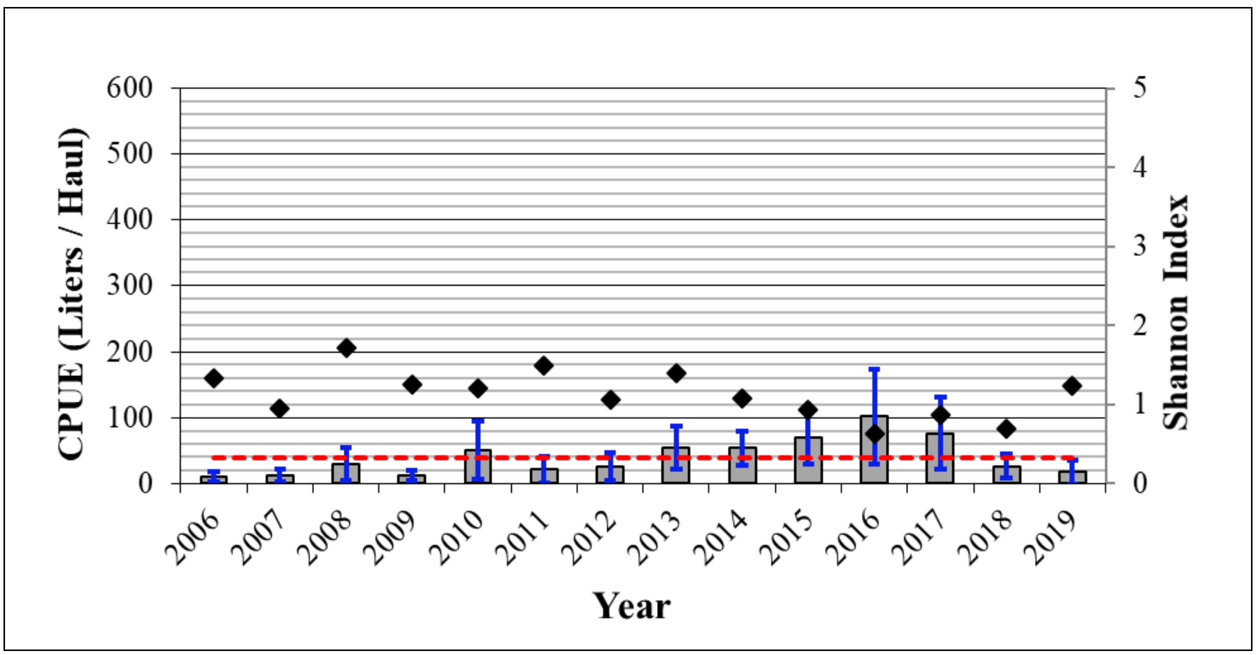

Figure 31**.** Coastal bays beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 36/year). Black diamond represents the Shannon index of diversity.

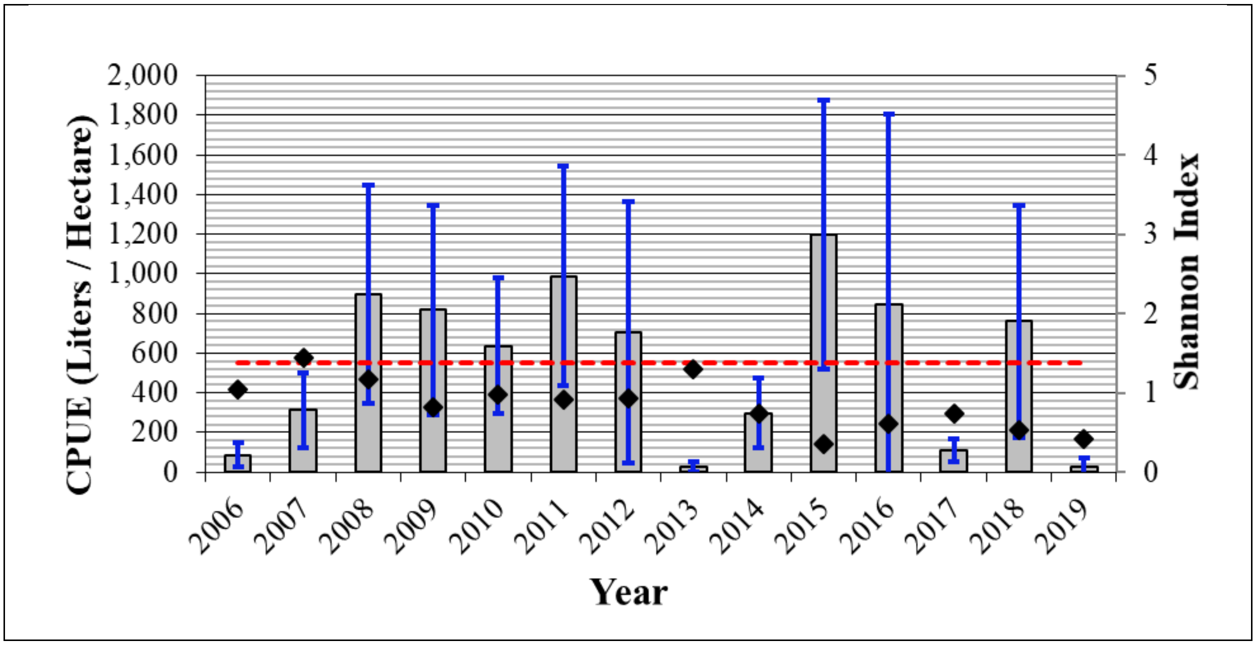

Figure 32. Assawoman Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

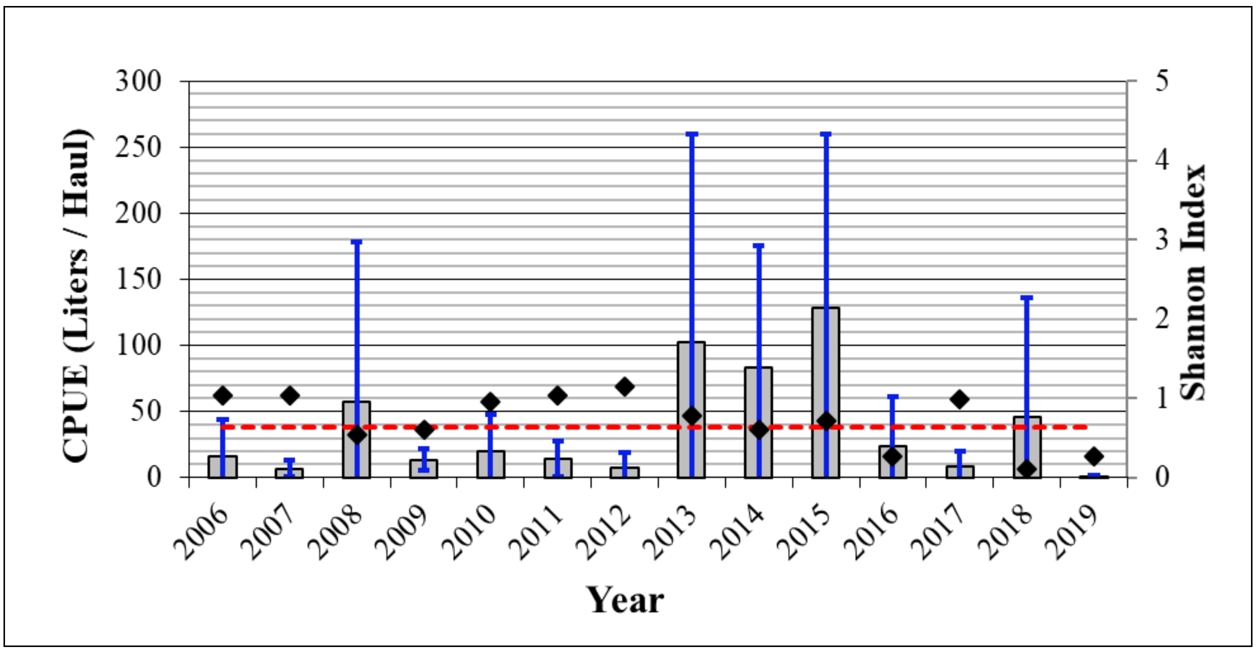

Figure 33. Assawoman Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Dotted line represents the 2006 - 2019 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index.

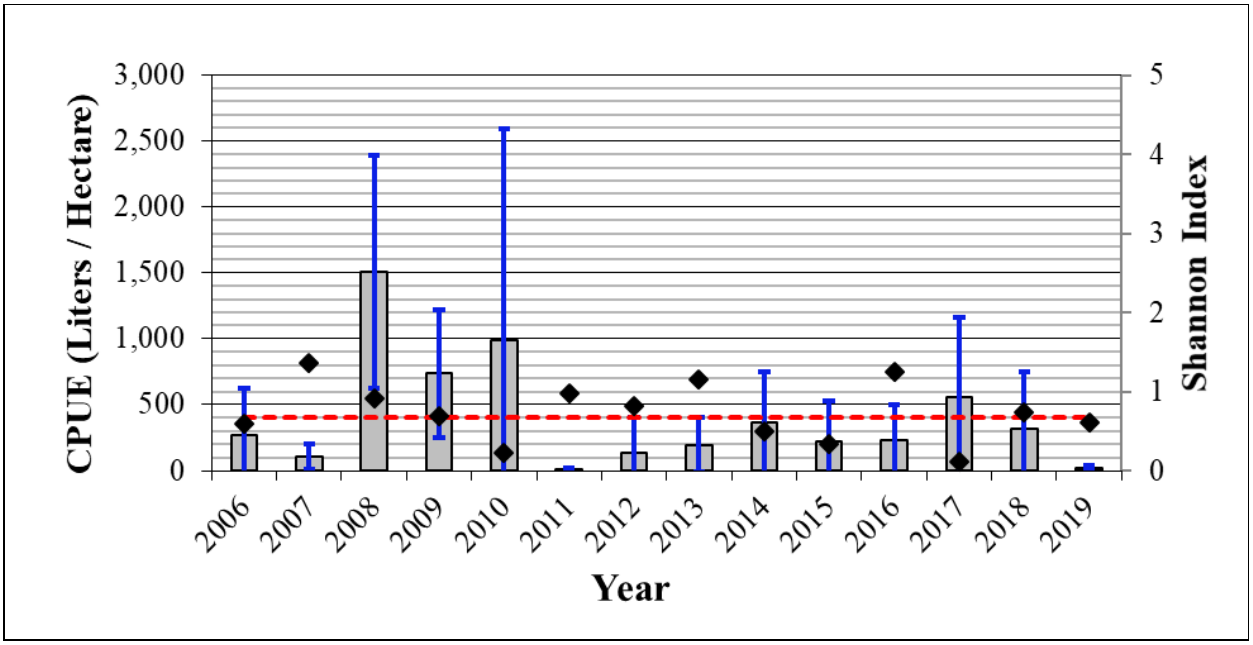

Figure 34. Isle of Wight Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

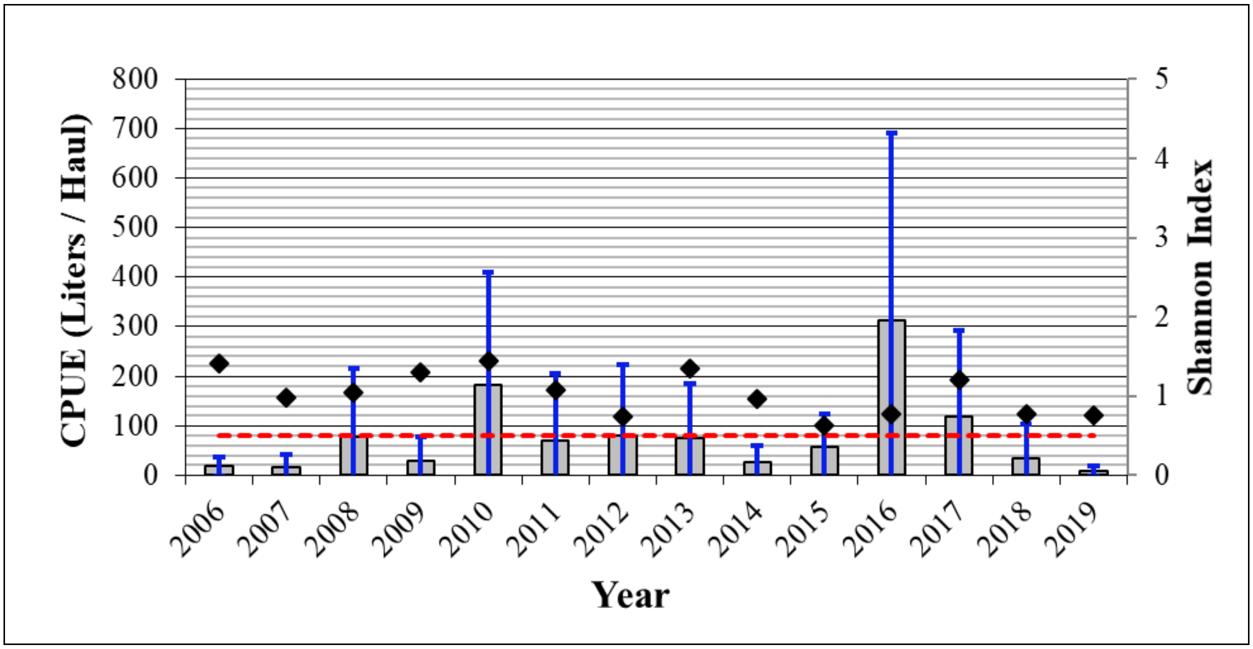

Figure 35. Isle of Wight Bay beach seine index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index.

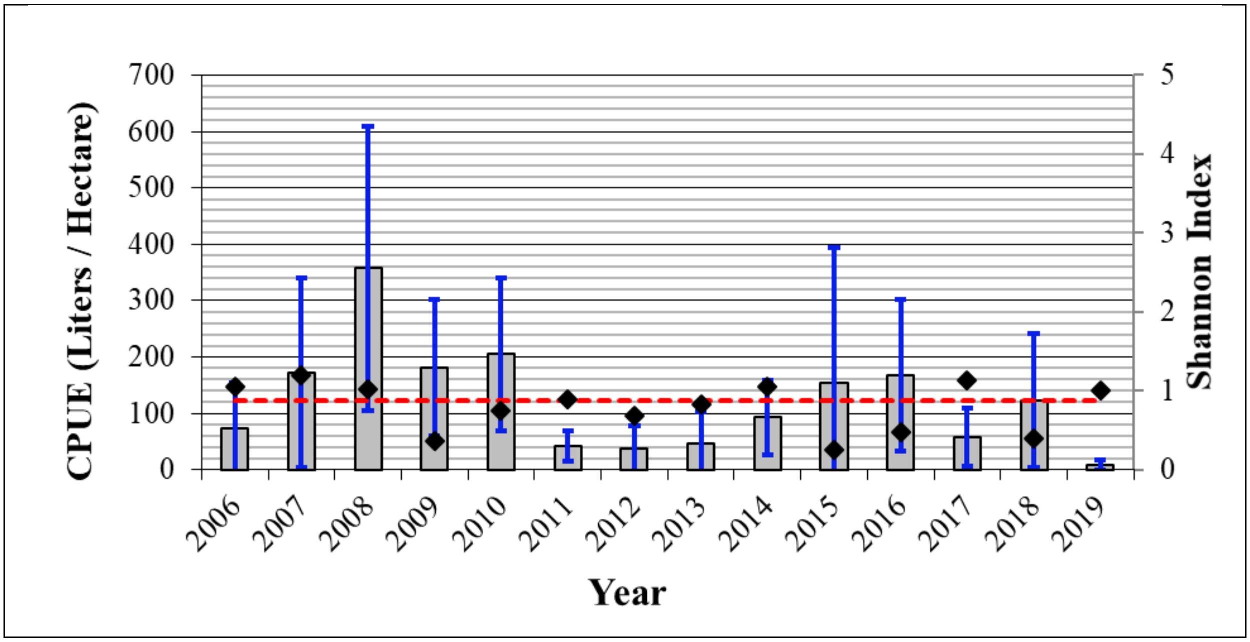

Figure 36. St. Martin River trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

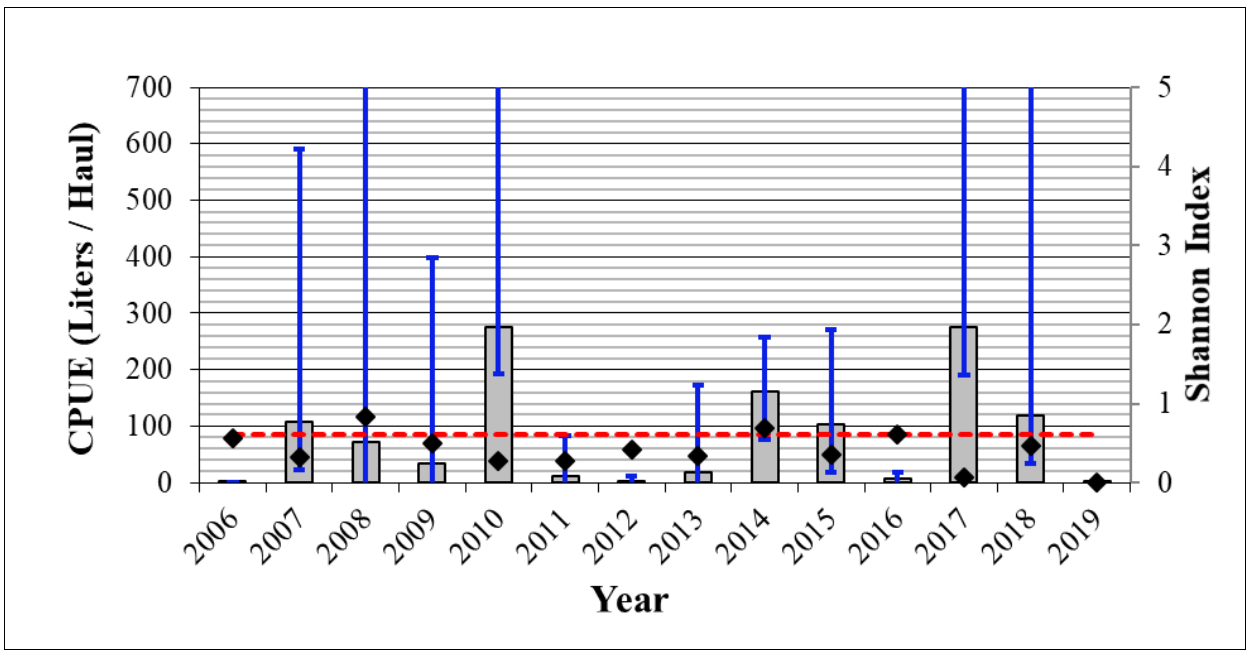

Figure 37. St. Martin River beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 2/year). Black diamond represents the Shannon index of diversity.

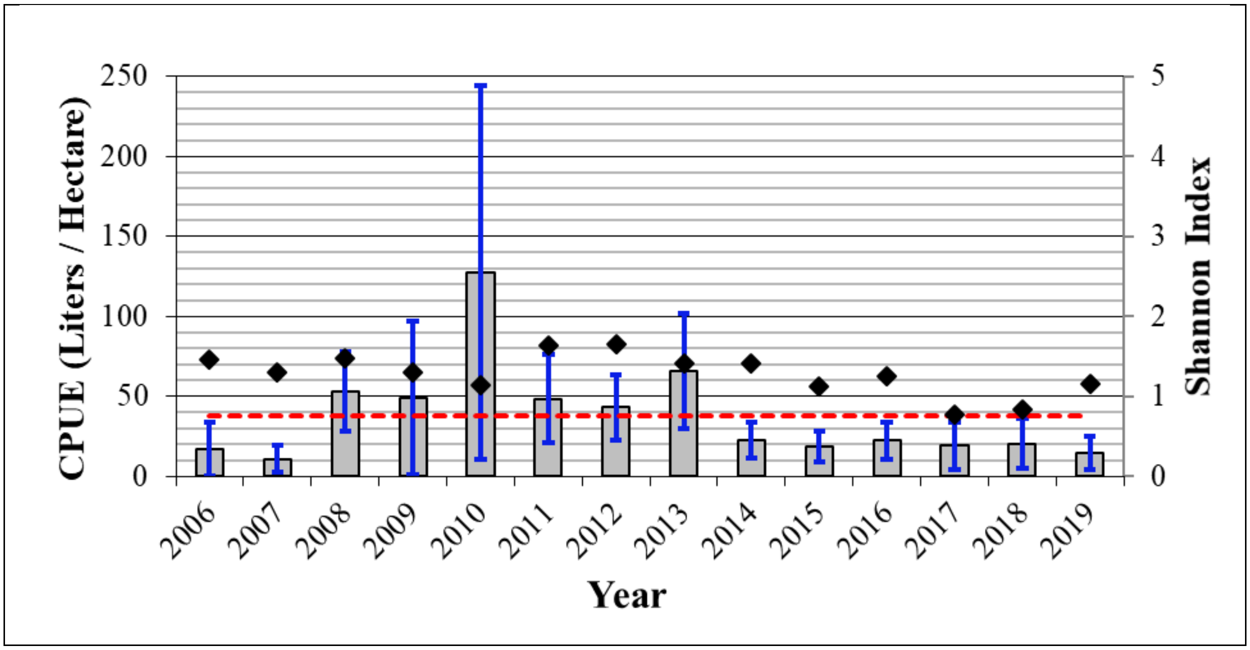

Figure 38. Sinepuxent Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

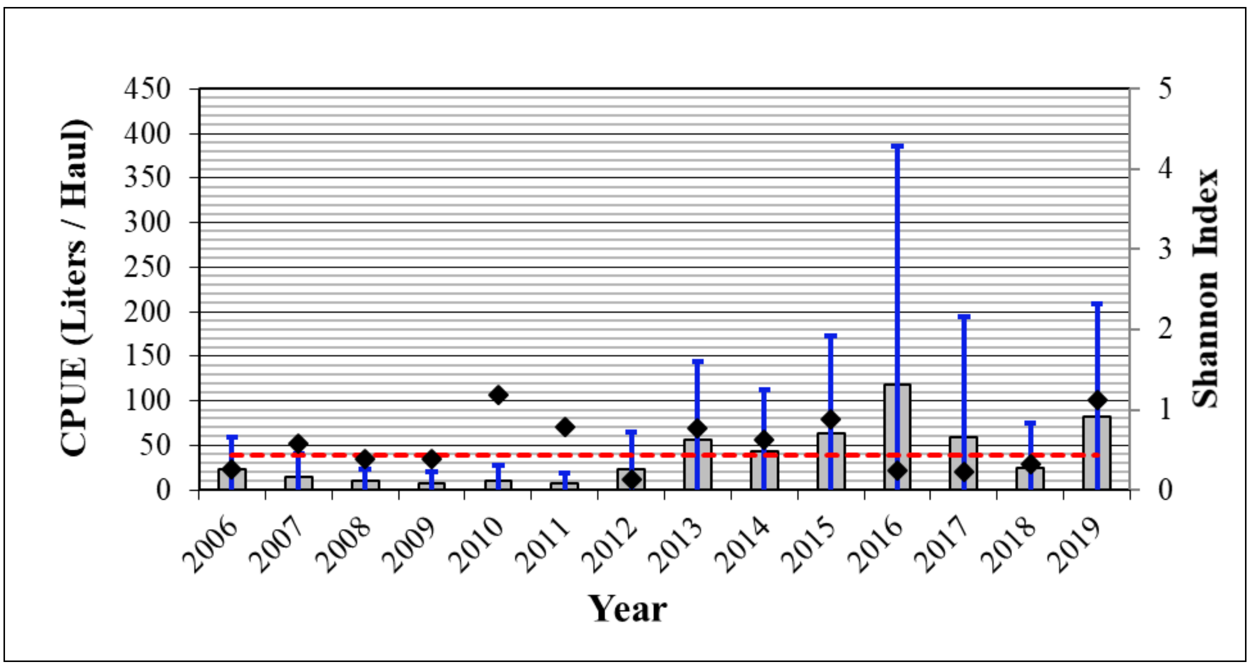

Figure 39. Sinepuxent Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index of diversity.

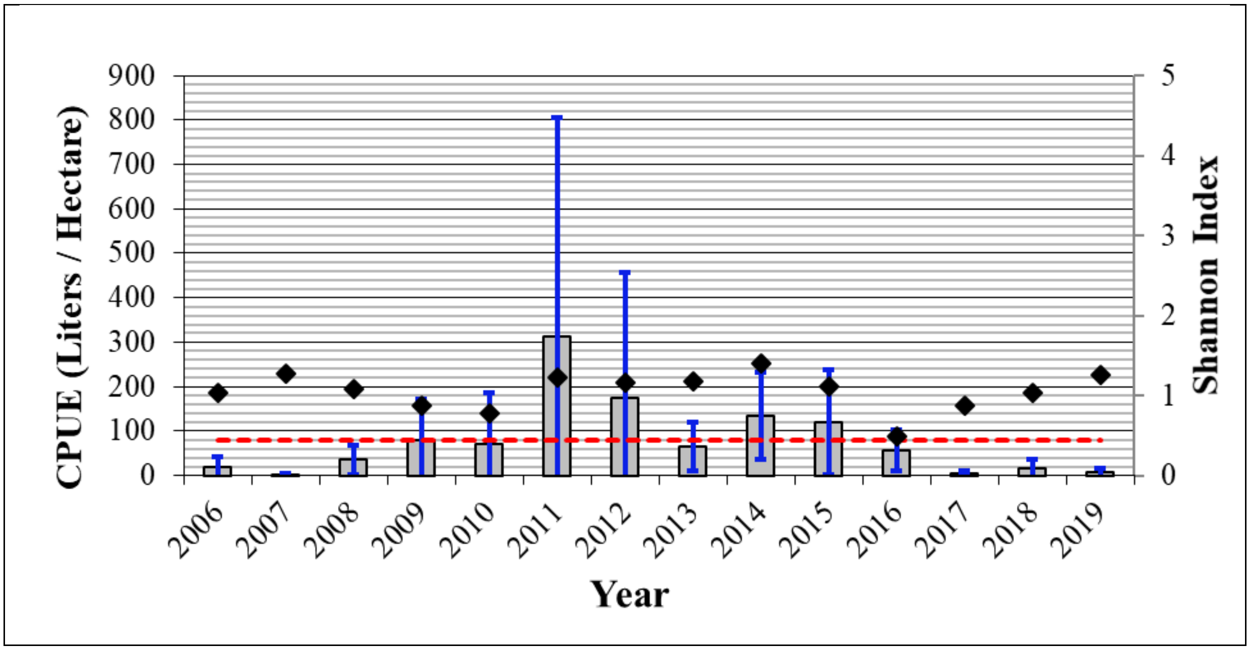

Figure 40. Newport Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

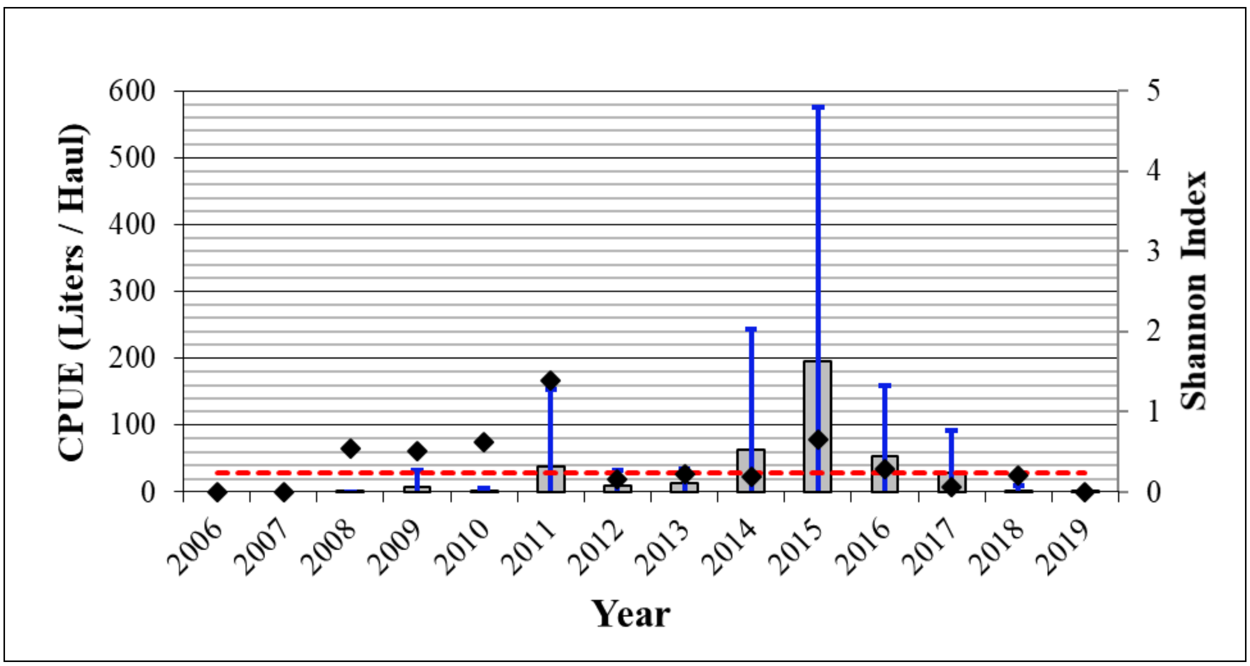

Figure 41. Newport Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index of diversity.

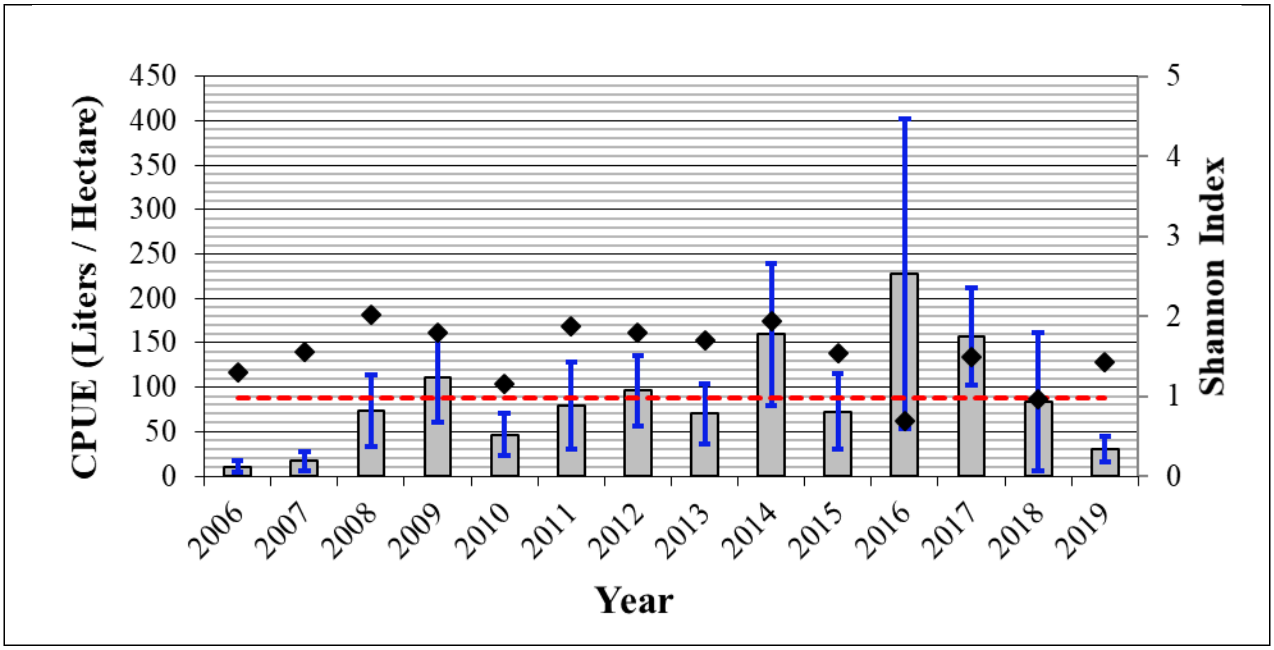

Figure 42. Chincoteague Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2019). Dotted line represents the 2006 - 2019 time series CPUE grand mean, (n = 56/year). Black diamond represents the Shannon index of diversity.

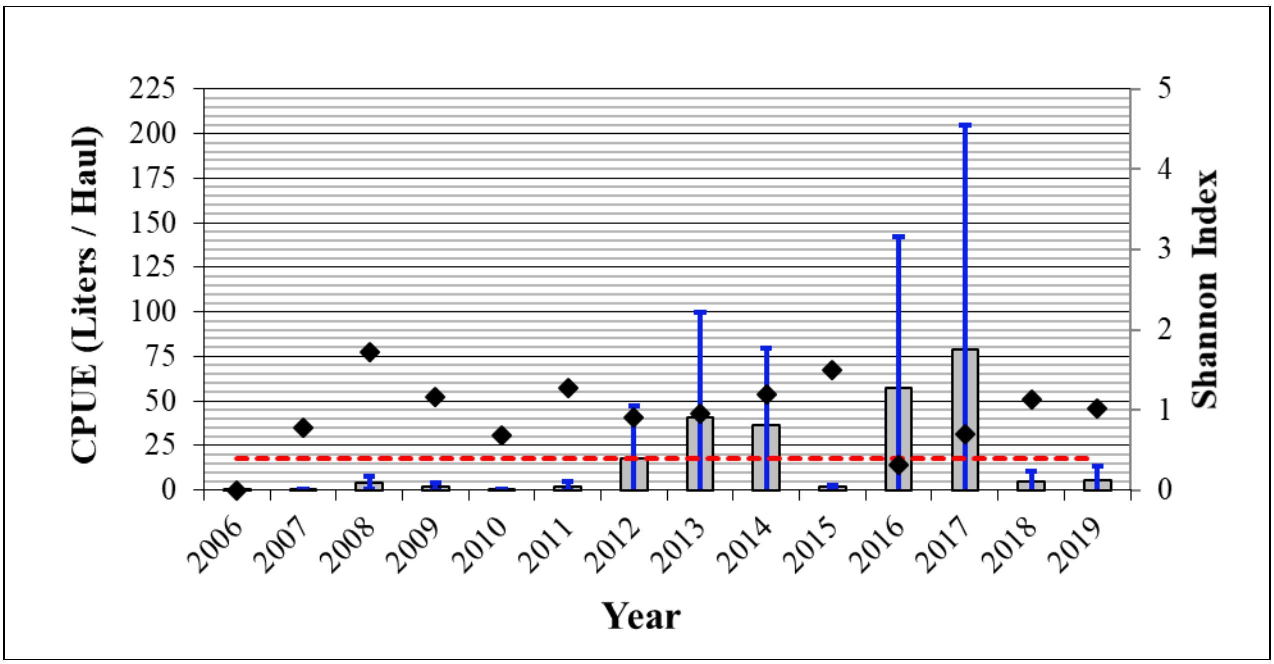

Figure 43. Chincoteague Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2019). Red line represents the 2006 - 2019 time series CPUE grand mean, (n = 12/year). Black diamond represents the Shannon index of diversity.

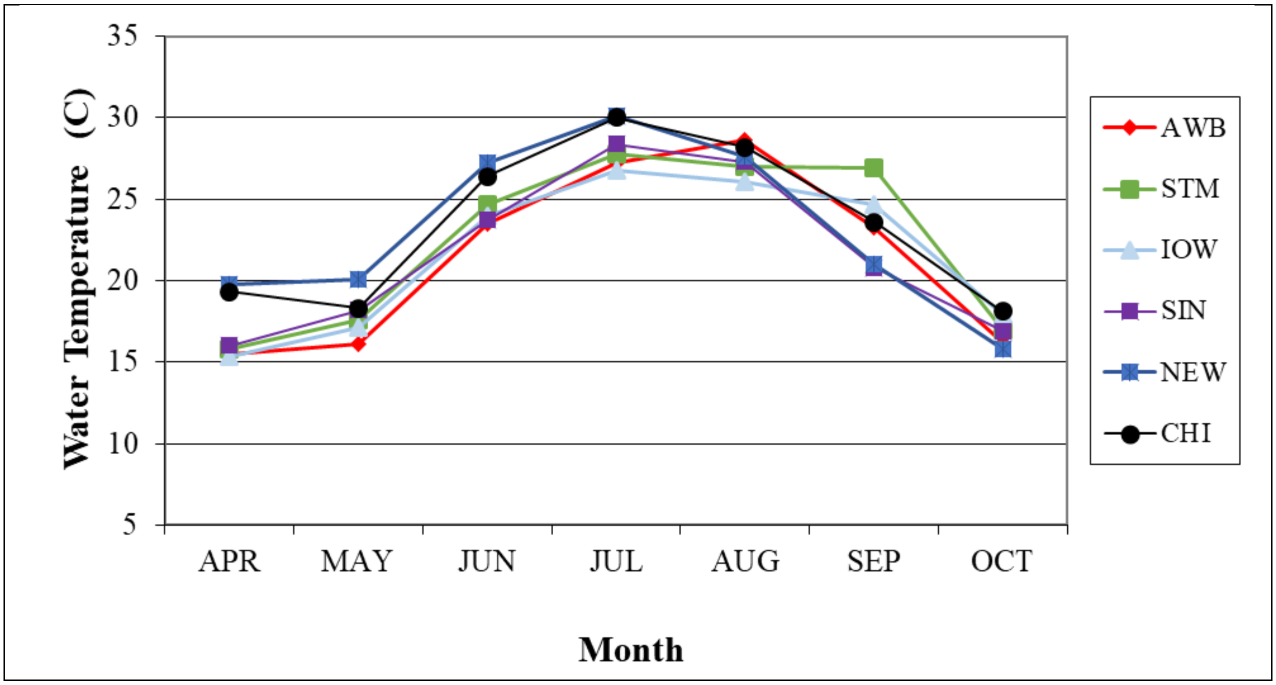

Figure 44. Trawl Survey mean water temperature (Celsius) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

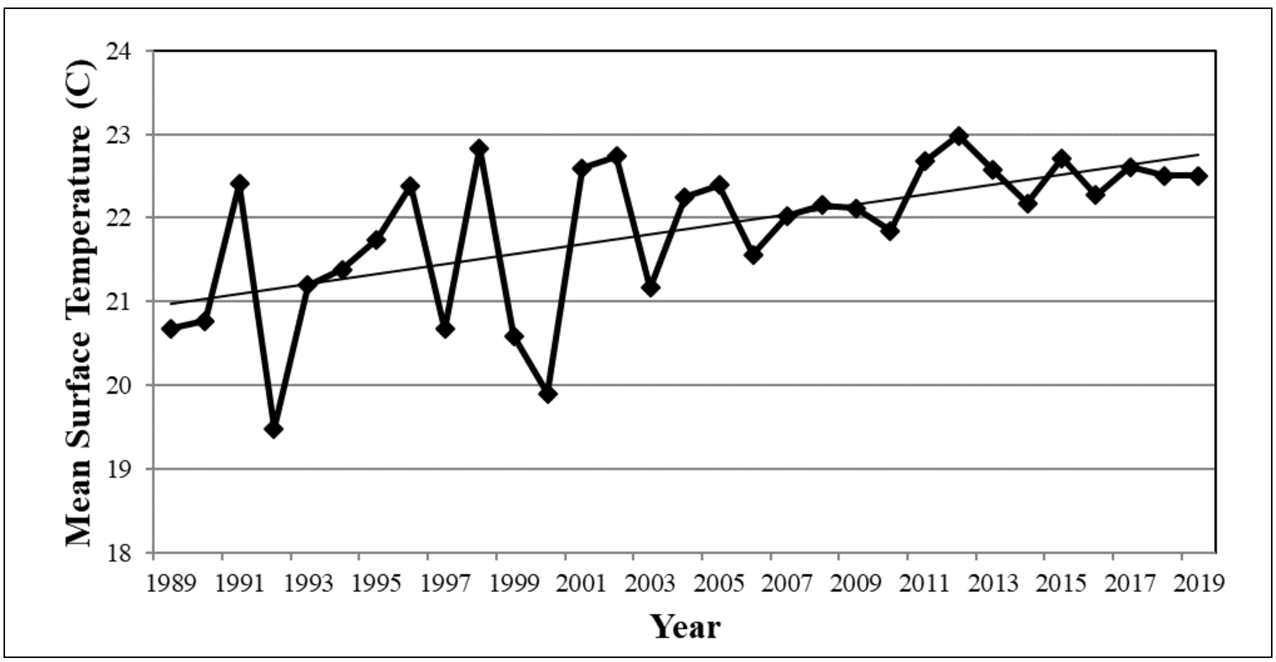

Figure 45. Trawl Survey mean surface water temperature (Celsius) by year for all bays (1989 - 2019, (r(31) = 0.59, p = 0.0004)).

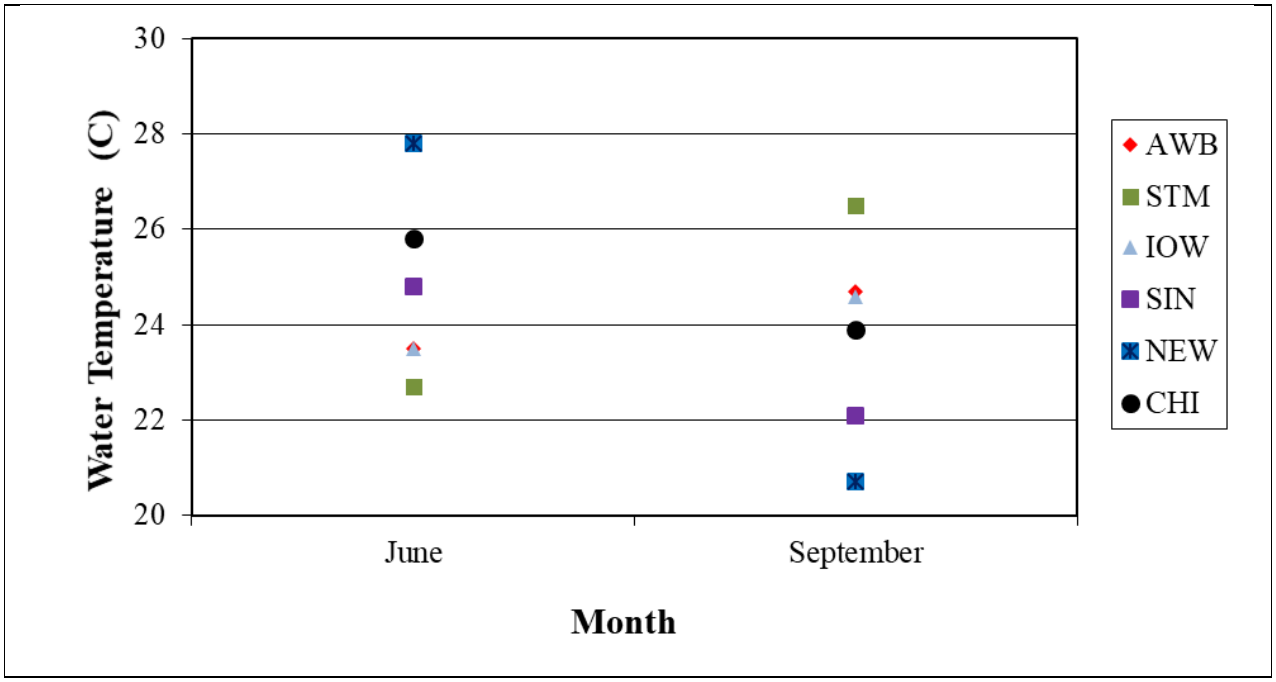

Figure 46. Beach Seine Survey mean water temperature (Celsius) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

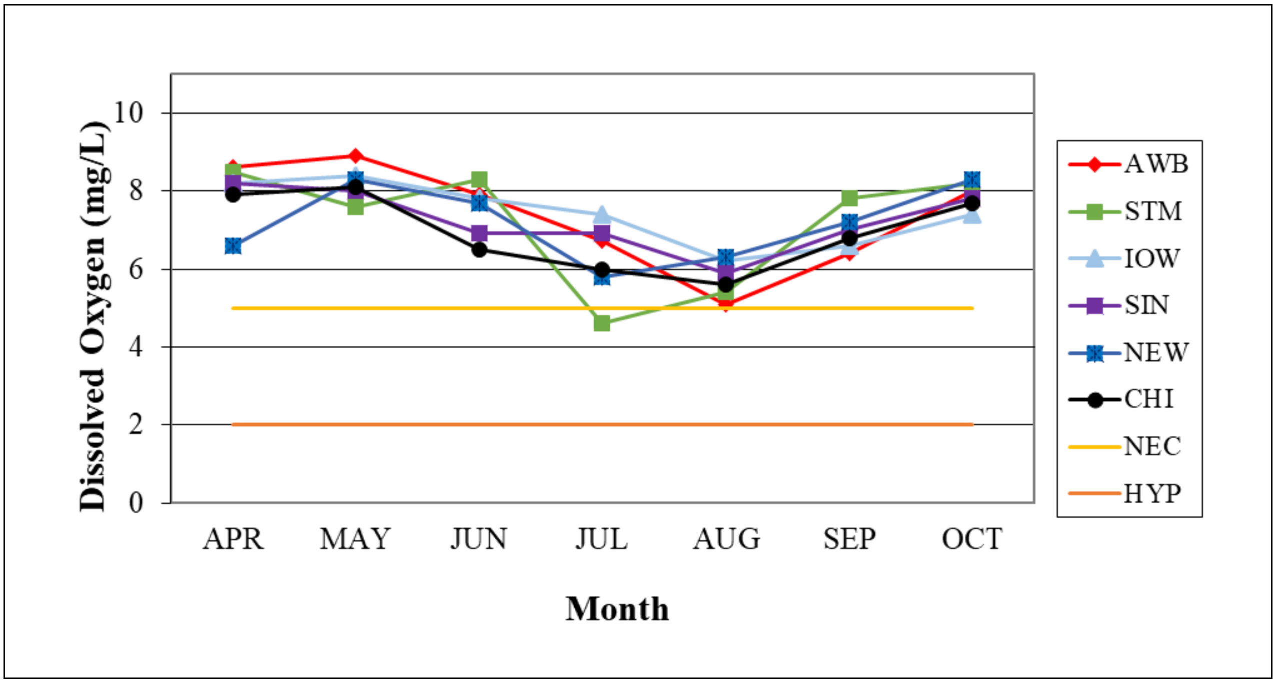

Figure 47. Trawl Survey mean dissolved oxygen (mg/L) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI). A dissolved oxygen (DO) value of 5 mg/L was considered necessary for life (NEC). Hypoxic conditions (HYP) can occur when DO drops to 2 mg/L or less.

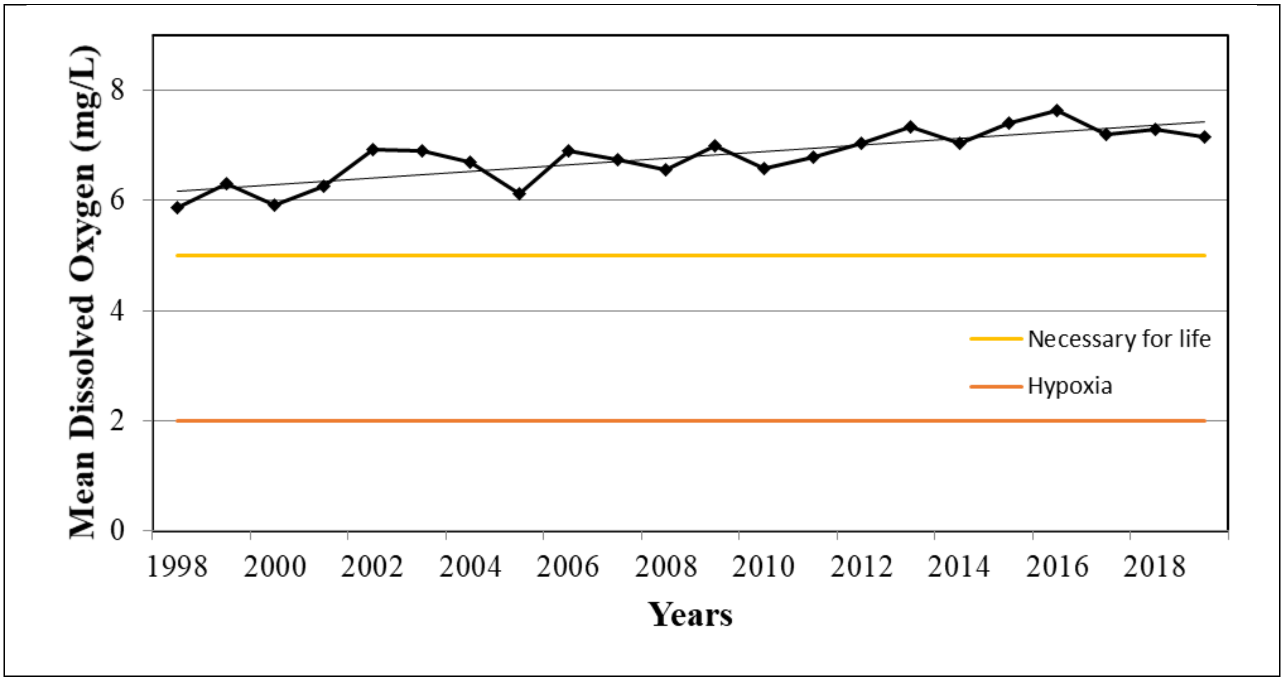

Figure 48. Trawl Survey mean dissolved oxygen by year for all bays (1998 - 2019, (r(21) = 0.8, p = 0.0002)). A dissolved oxygen (DO) value of 5 mg/L was considered necessary for life. Hypoxic conditions can occur when DO drops to 2 mg/L or less.

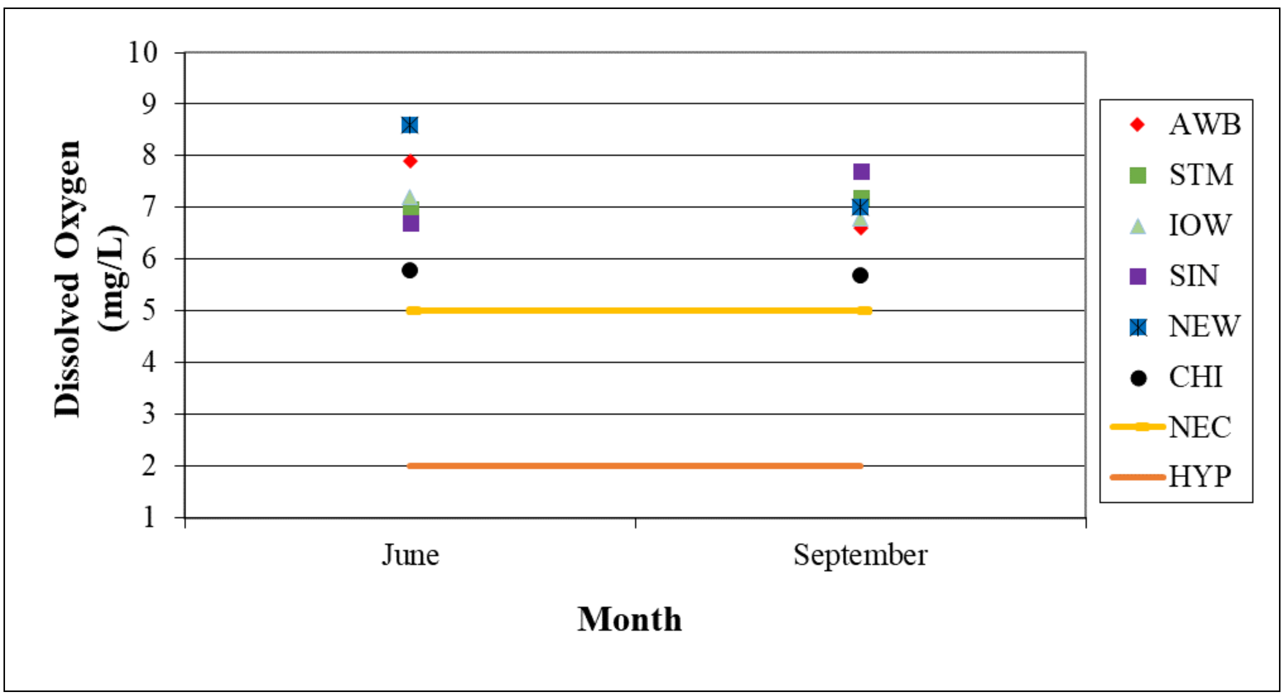

Figure 49. Beach Seine Survey mean dissolved oxygen (mg/L) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI). A dissolved oxygen (DO) value of 5 mg/L was considered necessary for life (NEC). Hypoxic conditions (HYP) can occur when DO drops to 2 mg/L or less.

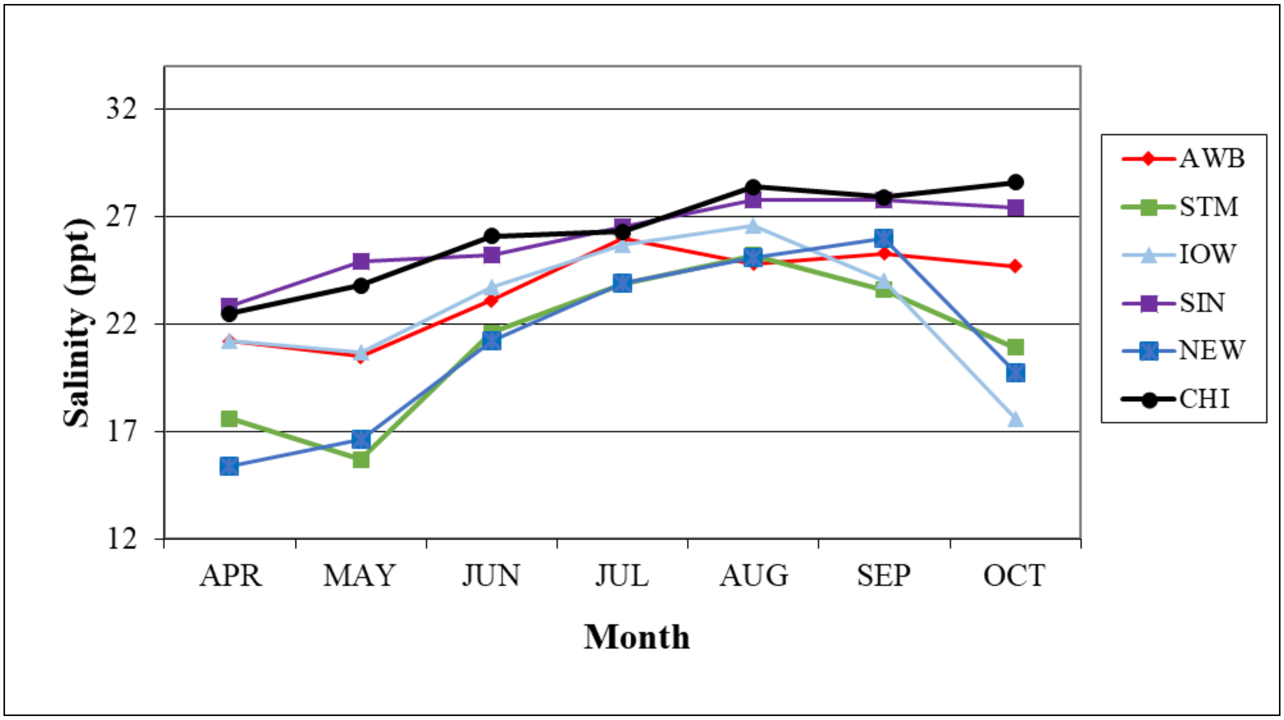

Figure 50. Trawl Survey mean salinity (parts per thousand) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

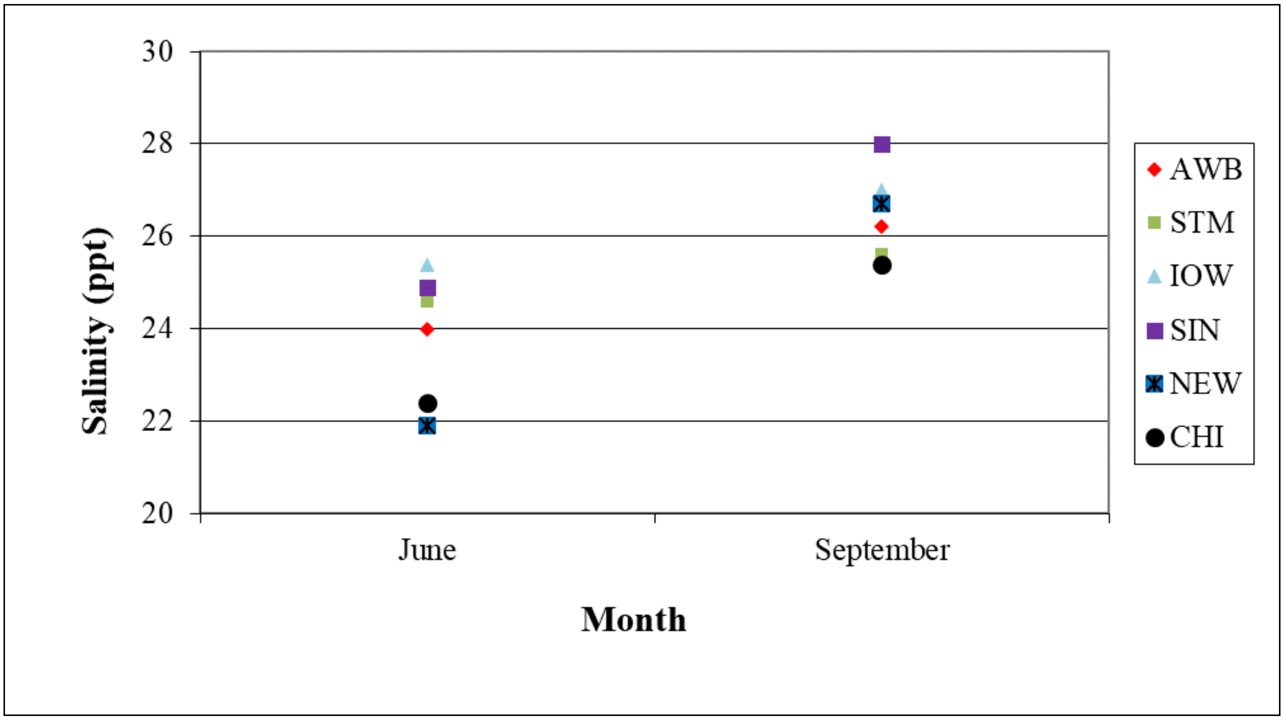

Figure 51. Beach Seine Survey mean salinity (parts per thousand) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

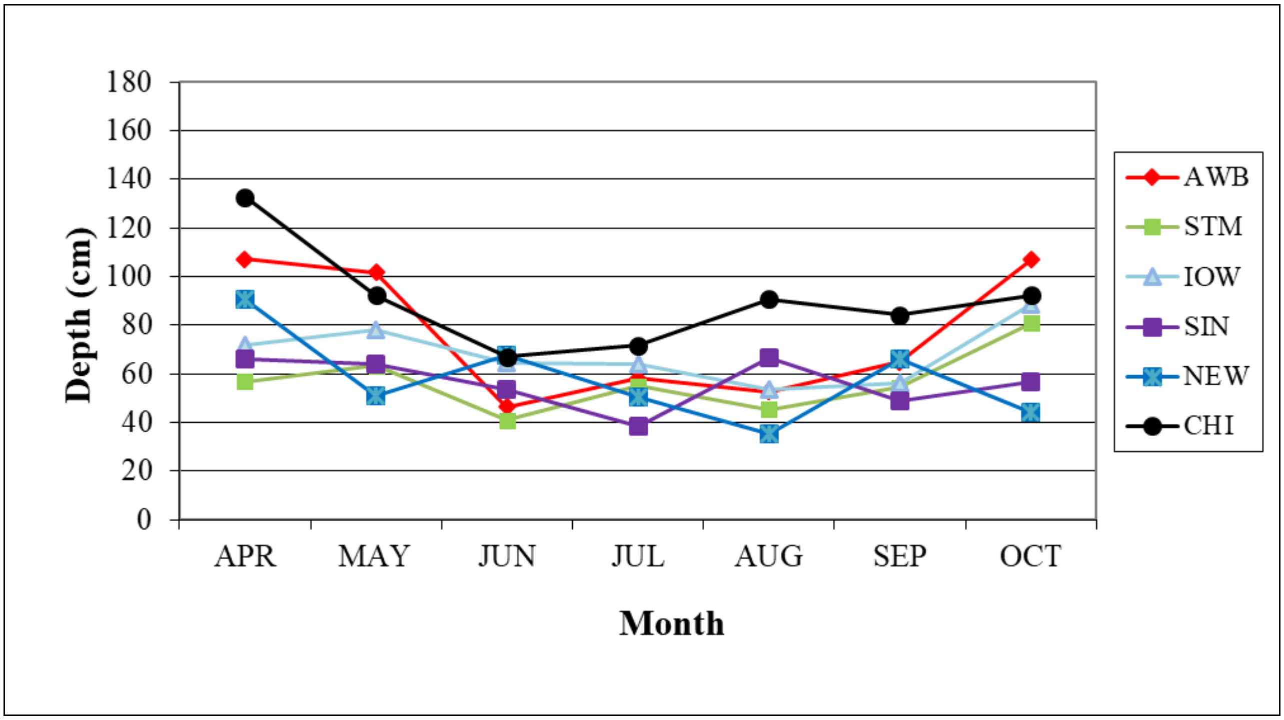

Figure 52. Trawl Survey mean turbidity (centimeters) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

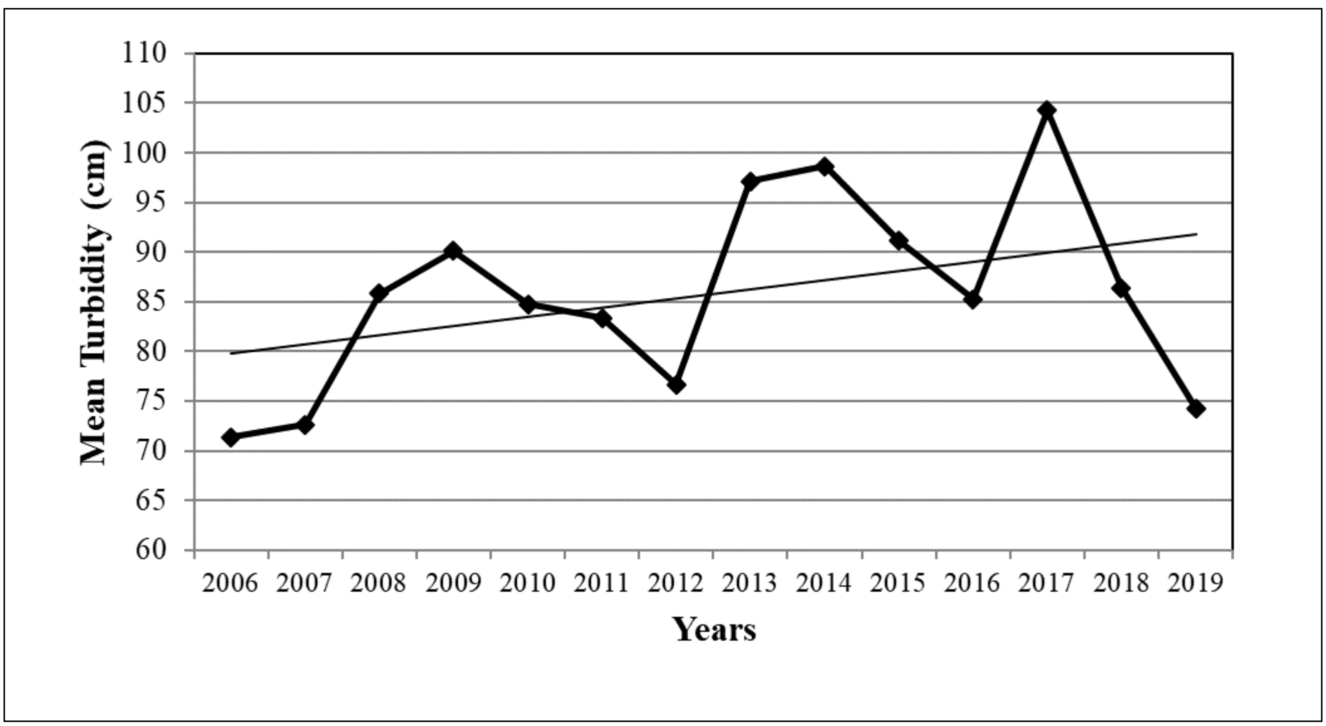

Figure 53. Trawl Survey mean turbidity (centimeters) by year for all bays (2019, (r(14)=0.39, p = 0.1705)).

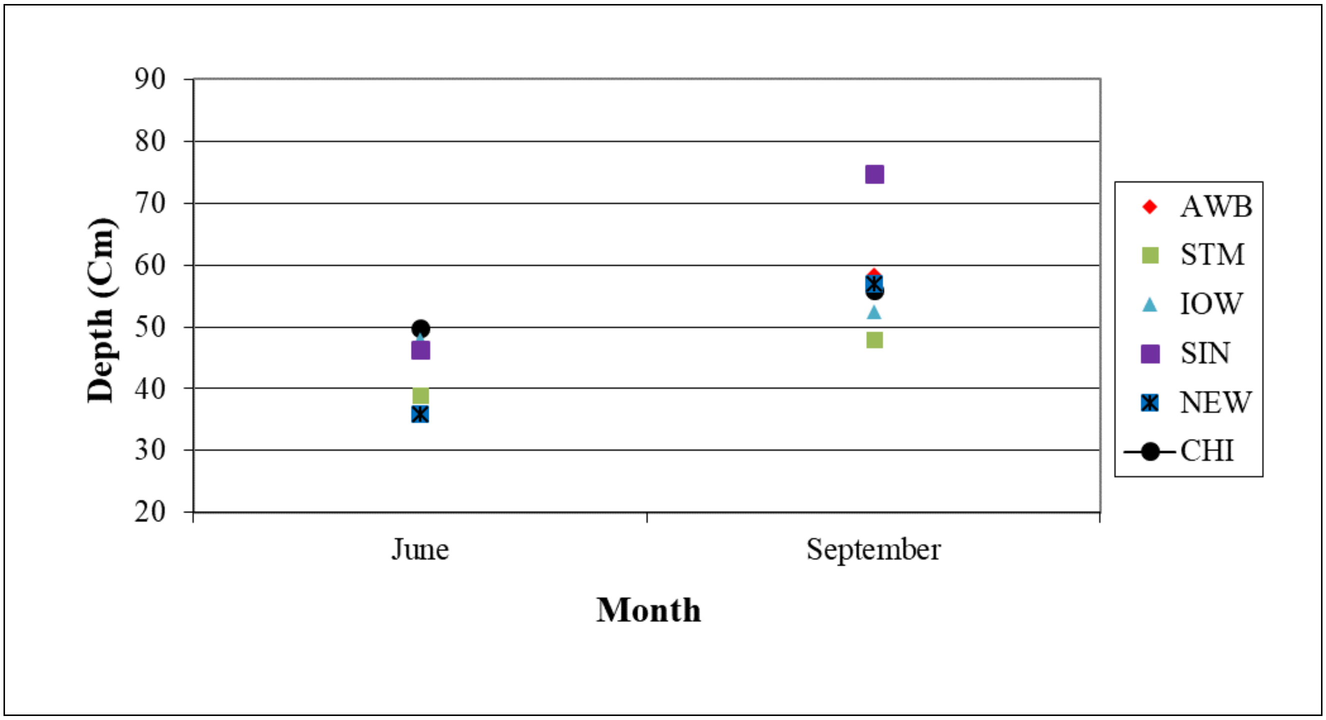

Figure 54. Beach Seine Survey mean turbidity (centimeters) by month (2019) in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW) and Chincoteague Bay (CHI).

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 Submerged Aquatic Vegetation (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

Data Collection

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 (Table 1, Figure 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 (2015). Potential sites were selected from the reconnaissance if SAV was present and the site was not too deep to seine.

All sampling was conducted during daylight in September over a five year period from 2015 - 2019. A 25 ft 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.

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. 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 beginning in 2017, based on evaluation of the 2016 data. All tautog from sampling year 2019 were collected for ageing.

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, an unbalanced analysis of variance (ANOVA) and post hoc Duncan's Multiple Range Test (DMRT) 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 test. Tautog were aged to determine size at age and to augment the age length key.

Results and Discussion

Sample Size and Distribution

These results were based on 83 unbalanced random samples collected from 2015 to 2019 within 11 SAV grids (Table 1, Figure 1). The number of beach seine hauls (samples) each year was 12, 14, 17, 21 and 19 respectively. Those samples were distributed between four categories of SAV coverage: 25% or less (21 samples), 26% - 50% (17 samples), 51% - 75% (18 samples) and 76% - 100% (27 samples). These samples were also categorized by primary substrate as either sand (38 samples) or mud (45 samples). Additionally, each samples dominant SAV species was identified; eelgrass was most abundant (56 samples) followed by widgeon grass (27 samples). Furthermore, samples were categorized for habitat interaction such as SAV coverage, substrate and dominant SAV species (Table 2).

Fish Species Abundance by Habitat Category

A total of 42 species and 10,295 fish were collected during this five-year investigation. The most abundant species by individual count were silver perch, Atlantic silverside and tautog (Table 3). The most abundant crustacean species by individual count in this survey were blue crabs, grass shrimp and brown shrimp (Table 4). Catch per unit effort (CPUE) mirrored the individual count for the overall survey; however, CPUE increased or decreased by the specific SAV habitat characteristics.

Sheepshead, tautog, pinfish, pigfish and gray snapper abundances were relatively high in this survey, indicating a preference for SAV habitat. Tautog abundance was the highest on record and this increase may be a direct result of modifying recreational regulations in 2018 to protect this species during the peak spawning period (Table 3). The tautog abundance in the SAV Habitat Survey was higher than the Trawl and Beach Seine surveys in Chapter 1; although, the results were not directly comparable due to differences in survey design (Chapter 1 Table 4, Chapter 2

Table 3). In those surveys, the total number of tautog captured since 1991 was 150 fish, of which only 14 were captured since 2015. In comparison, the SAV Habitat Survey, with much less effort captured 331 tautog since 2015. The five-year tautog CPUE data were submitted for inclusion in the 2020 ASMFC stock assessment (Figure 2). Those data may be accepted as a reliable indicator of Maryland tautog spawning success in the future.

The results of the Kruskal-Wallis test (hereafter abbreviated as KWt) indicated significant differences of species abundance and habitat characteristics. This occurred toward 14 fishes and three forage crustacean species within the sample population (Table 5). SAV coverage KWt results showed significant differences in abundance for dusky pipefish, halfbeak, northern pipefish, silver perch, tautog, blue crabs and grass shrimp. Primary substrate KWt results showed significant differences in abundance for northern pipefish, pigfish, pinfish, sheepshead, spotfin mojarra and brown shrimp in regards toward sand or mud substrate within the SAV bed. Dominant SAV KWt results showed significant differences in abundance for Atlantic silverside, dusky pipefish, gray snapper, northern pipefish, sheepshead, striped burrfish, tautog, blue crab and brown shrimp.

The KWt results with significant interactions were subject to further statistical testing. Those results from the ANOVA and post hoc DMRT confirmed the KWt results for eight of the fishes and all three forage crustacean species within the sample population (Tables 6-8). The KWt identified many interactions among habitat characteristics. This knowledge supplements the fact that SAV is critical habitat. The secondary interactions of dominant SAV (eelgrass verses widgeon grass) and substrate (sand verses mud) had more substantiated results from the ANOVA and post hoc DMRT than the SAV coverage categories.

SAV coverage ANOVA and DMRT results showed significant differences in abundance for pipefishes and grass shrimp (Table 6). Pipefishes preferred denser SAV coverage and grass shrimp abundance peaked in medium - high SAV coverage. Although the ANOVA results were not significant for silver perch and blue crab, the DMRT results showed differences in abundance among the SAV coverage categories. Silver perch preferred medium - high SAV density. Blue crab abundance was significantly less in the low density SAV.

Primary substrate ANOVA and DMRT results showed significant differences in abundance for pigfish, pinfish, sheepshead and brown shrimp; all preferred SAV with sand as the primary substrate to mud (Table 7). Northern pipefish and spotfin mojarra ANOVA and DMRT results were not significant. Dominant SAV ANOVA and DMRT results showed higher abundance within widgeon grass for Atlantic silverside, gray snapper, sheepshead and brown shrimp. Pipefish and striped burrfish abundance was higher in eelgrass (Table 8).

Fish Species Richness and Diversity by Habitat Category

Fish richness (number of species) was generally high except in the multivariate categories that contained low coverage of widgeon grass over mud (six fishes) and very high coverage of widgeon grass over mud (eight fishes; Table 10). This result may be bias of sample size as that specific habitat was not readily available throughout the time series (Table 2).

Diversity (evenness of those species) results showed that medium - high SAV coverage category (51 - 75%) with sand substrate and eelgrass was the most diverse (H = 2.0; Table 10). Mud substrate had slightly less diversity compared to sand overall, but trends were not readily apparent. Diversity values were generally low and driven down by the large abundance of silver perch and Atlantic silverside.

Fish Length Composition by Habitat Category

Relationships of total length and habitat characteristics were investigated for significant interactions. Atlantic silverside, sheepshead, silver perch, tautog, blue crabs and brown shrimp were selected for ANOVA and DMRT analysis (Table 11). SAV coverage ANOVA and DMRT results showed significant differences in length for Atlantic silverside, silver perch, tautog and brown shrimp. Atlantic silversides and silver perch, the most abundant fishes in this survey, were smallest in high coverage SAV beds. Tautog and brown shrimp were smallest in medium coverage SAV, but then varied without trend among the other three coverage categories. Differences in mean length were not significant for sheepshead and blue crab. Previous growth history as well as size - selective predation mortality may also influence interpretation of juvenile growth rates (Meekan and Fortier 1996; Searcy and Sponaugle 2001; Bergenius *et al.* 2002; Grorud-Colvert and Sponaugle 2006; Searcy *et al.* 2007).

Tautog mean length was smallest in the medium coverage SAV. These fish were most likely age 0 ($\bar{x}$ = 64.8 mm), while those in low and medium-high coverage were age 1 ($\bar{x}$ = 88.4 and 93.7 mm, respectively). Narraganset Bay tautog otolith - estimated mean growth rate is 0.5 mm per day (Dorf 1994). Those fish most likely grow a bit slower in the cooler temperatures of Rhode Island than Maryland.

Primary substrate ANOVA and DMRT results showed significant differences in length for all species tested except blue crabs (Table 12). Atlantic silversides and silver perch were smaller in SAV beds within mud substrate. Sheepshead, tautog and brown shrimp were smaller within sandy SAV beds.

Dominant SAV ANOVA and DMRT results showed significant differences in length. Atlantic silversides and silver perch were smaller in SAV beds with dominant eelgrass whereas tautog, blue crabs and brown shrimp were smaller in SAV beds with dominant widgeon grass (Table 13).

Regarding the primary substrate and dominant SAV results, multivariate habitat selection by length size of fish may be due to food availability specific for the life stage of the fish, or shelter adequate for successful protection. The ANOVA and DMRT sensitivity may have found size differences, such as Atlantic silversides that were not worthy of distinction for habitat selection. Further study by multivariate habitat selection will require more data to eliminate sample bias. The SAV coverage category may be the driving factor regardless of substrate or SAV species in regard toward fish length. Year class differences may exist in the silver perch by habitat category; however, the abundance results are more meaningful for management purposes.

Water Quality

Water temperature, salinity, dissolved oxygen and turbidity results were within acceptable limits for fishes and forage crustaceans throughout the survey time series. ANOVA and DMRT results comparing those values from the 2015 - 2018 time series and the terminal year (2019) showed significant increase in water clarity in 2019 (Table 14). The mean water temperature (29.7 C, 2018) that was borderline close to the SAV threshold decreased to 26.4 C in 2019. The survey design performed well to reduce the effects of water quality variation in order to compare habitat selection over the time series. The increase in water clarity is promising for SAV growth.

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List of Tables and Figures

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Table 1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey site descriptions (2015 - 2019).

Grid Number	Site Description	Latitude	Longitude	Number of Samples
092	Between Eagles Nest and OC Airport; W side of channel	38 18.263	75 06.987	2
096	SAV beds vicinity Castaways Jackspot Waterfront Tiki bar	38 18.019	75 07.177	4
109	East of Snug Harbor Road, Middle of Sinepuxent Bay, South of Small Island	38 17.622	75 07.376	4
121	East of Snug Harbor; West of Small Island	38 17.221	75 07.651	16
122	East of Snug Harbor; West of Small Island; Pulled Towards the South	38 17.167	75 07.523	2
128	South of Duck Blind; East of Green Marker	38 17.061	75 07.659	12
160	700 meters northeast of Potfin Road along the shoreline	38 15.900	75 08.761	21
212	South of Verrazano Bridge; West of Sandy Point Island; on channel edge	38 14.295	75 09.404	9
217	Northwest shoreline along Rum Point	38 14.116	75 10.160	3
221	Southwest of Small Island; South of Verrazano Bridge	38 14.147	75 09.402	9
227	Southwest shoreline along Rum Point	38 13,953	75 10.217	1

Table 2. Submerged Aquatic Vegetation Habitat Survey sample size by habitat characteristics (2015 - 2019).

	Percent SAV				Total by Characteristic	Grand Total
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%		
Eelgrass (*Zostera marina*)	13	9	11	23	56	83
Widgeon grass (*Ruppia maritima*)	8	8	7	4	27	
Sand	12	11	5	10	38	83
Mud	9	6	13	17	45	
Sand - Eelgrass (*Z. marina*)	5	7	3	7	22	83
Mud - Eelgrass (*Z. marina*)	8	2	8	16	34	
Sand - Widgeon grass (R. *maritima*)	7	4	2	3	16	
Mud - Widgeon grass (R. *maritima*)	1	4	5	1	11	

Table 3. Fishes collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year (2015 - 2019). Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 – 2019 (n = 83)			2019 (n = 19)		
	# of fish	CPUE	x̄ length	# of fish	CPUE	x̄ length
Silver perch (*Bairdiella chrysoura*)	5532	1664.2	74	298	391.6	81
Atlantic silverside (*Menidia menidia*)	3161	950.9	83	205	269.4	82
Tautog (*Tautoga onitis*)	331	99.6	68	251	329.9	64
Halfbeak (*Hyporhamphus unifasciatus*)	205	61.7	148	2	2.6	157
Spotfin mojarra (*Eucinostomus argenteus*)	136	40.9	79	101	132.7	80
Sheepshead (*Archosargus probatocephalus*)	116	34.9	72	18	23.7	57
Northern pipefish (*Syngnathus fuscus*)	102	30.7	185	6	7.9	172
Dusky pipefish (*Syngnathus floridae*)	95	28.6	160	8	10.5	174
Pinfish (*Lagodon rhomboides*)	85	25.6	123	37	48.6	124
Oyster toadfish (*Opsanus tau*)	72	21.7	72	6	7.9	86
Spot (*Leiostomus xanthurus*)	66	19.9	129	45	59.1	118
Pigfish (*Orthopristis chrysoptera*)	64	19.3	95	19	25.0	113
Striped blenny (*Chasmodes bosquianus*)	60	18.1	65	3	3.9	59
Black sea bass (*Centropristis striata*)	38	11.4	91	35	46.0	87
Bay anchovy (*Anchoa mitchilli*)	34	10.2	66	11	14.5	70
Gray snapper (*Lutjanus griseus*)	23	6.9	73			
Northern puffer (*Sphoeroides maculatus*)	23	6.9	138	8	10.5	121
Summer flounder (*Paralichthys dentatus*)	21	6.3	185	8	10.5	152
Striped burrfish (*Chilomycterus schoepfii*)	18	5.4	182	1	1.3	174
Striped anchovy (*Anchoa hepsetus*)	15	4.5	78	7	9.2	78
Spotfin butterflyfish (*Chaetodon ocellatus*)	12	3.6	63	1	1.3	59
Atlantic menhaden (*Brevoortia tyrannus*)	9	2.7	114			
Rainwater killifish (*Lucania parva*)	9	2.7	38			
White mullet (*Mugil curema*)	9	2.7	173	1	1.3	165
Bluespotted cornetfish (*Fistularia tabacaria*)	7	2.1	339	5	6.6	333

Table 3 continued. Fishes collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year (2015 - 2019). Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 – 2019 (n = 83)			2019 (n = 19)		
	# of fish	CPUE	x̄ length	# of fish	CPUE	x̄ length
Atlantic needlefish (*Strongylura marina*)	6	1.8	281	3	3.9	303
Spotted seatrout (*Cynoscion nebulosus*)	6	1.8	116			
Naked goby (*Gobiosoma bosc*)	5	1.5	39			
Southern kingfish (*Menticirrhus americanus*)	5	1.5	103			
American eel (*Anguilla rostrata*)	4	1.2	318			
Northern kingfish (*Menticirrhus saxatilis*)	4	1.2	121			
Striped mullet (*Mugil cephalus*)	4	1.2	197			
Black drum (*Pogonias cromis*)	3	0.9	133			
Blackcheek tonguefish (*Symphurus plagiusa*)	3	0.9	98	3	3.9	98
Bluefish (*Pomatomus saltatrix*)	3	0.9	133	1	1.3	98
Atlantic croaker (*Micropogonias undulatus*)	2	0.6	57			
Inshore lizardfish (*Synodus foetens*)	2	0.6	171	2	2.6	171
Gag (*Mycteroperca microlepis*)	1	0.3	168			
Lined seahorse (*Hippocampus erectus*)	1	0.3	130			
Skilletfish (*Gobiesox strumosus*)	1	0.3	46			
Southern stingray (*Dasyatis americana*)	1	0.3	230			
Striped killifish (*Fundulus majalis*)	1	0.3	107	3	3.9	303

Table 4. Forage crustaceans collected in Maryland's coastal bays Submerged Aquatic Vegetation Habitat Survey from Sinepuxent Bay in September by year (2015 - 2019). Catch per unit of effort (CPUE) was individual/hectare.

Specimen Name	2015 – 2019 (n = 83)			2019 (n = 19)		
	# of ind.	CPUE	x̄ length	# of ind.	CPUE	x̄ length
Blue crab (*Callinectes sapidus*)	3155	949.1	57	258	339.1	66
Grass shrimp (*Palaemonetes sp.)*	1350	406.1		35	46.0	
Brown shrimp (*Farfantepenaeus aztecus*)	738	222.0	81	53	69.7	97

Table 5. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2019) Kruskal - Wallis test for percent SAV coverage, primary substrate and dominant SAV on fish abundance. Alpha of 0.05 was 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.	(χ2(1) = 10.91, p < 0.01)
Bay anchovy (*Anchoa mitchilli*)	n.s.	n.s.	n.s.
Dusky pipefish (*Syngnathus floridae*)	(χ2(3) =15.93, p < 0.01)	n.s.	(χ2(1) = 6.02, p < 0.05)
Gray snapper (*Lutjanus griseus*)	n.s.	n.s.	(χ2(1) = 12.33, p < 0.01)
Halfbeak (*Hyporhamphus unifasciatus*)	(χ2(3) = 8.16, p < 0.05)	n.s.	n.s.
Northern pipefish (*Syngnathus fuscus*)	(χ2(3) = 16.14, p < 0.01)	(χ2(1) = 3.90, p < 0.05)	(χ2(1) = 8.22, p < 0.01)
Pigfish (*Orthopristis chrysoptera*)	n.s.	(χ2(1) = 4.64, p < 0.05)	n.s.
Pinfish (*Lagodon rhomboides*)	n.s.	(χ2(1) = 7.91, p < 0.01)	n.s.
Sheepshead (*Archosargus probatocephalus*)	n.s.	(χ2(1) = 5.67, p < 0.05)	(χ2(1) = 5.75, p < 0.05)
Silver perch (*Bairdiella chrysoura*)	(χ2(3) = 17,18 p < 0.01)	n.s.	n.s.
Spotfin mojarra (*Eucinostomus argenteus*)	n.s.	(χ2(1) = 4.47, p < 0.05)	n.s.
Striped blenny (*Chasmodes bosquianus*)	n.s.	n.s.	n.s.
Striped burrfish (*Chilomycterus schoepfii*)	n.s.	n.s.	(χ2(1) = 7.29, p < 0.01)
Tautog (*Tautoga onitis*)	(χ2(3) =11.78, p < 0.01)	n.s.	(χ2(1) = 9.89, p < 0.01)
Blue crab (*Callinectes sapidus*)	(χ2(3) =15.23, p < 0.01)	n.s.	(χ2(1) = 3.95, p < 0.05)
Brown shrimp (*Farfantepenaeus aztecus*)	n.s.	(χ2(1) = 8.50, p < 0.01)	(χ2(1) = 6.76, p < 0.01)
Grass shrimp (*Palaemonetes sp.*)	(χ2(3) =13.47, p < 0.01)	n.s.	n.s.

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

Specimen Name	Percent SAV Low < 25%	Medium 26 - 50%	Medium-High 51 - 75%	High 76 - 100%
Dusky pipefish (*Syngnathus floridae*)	($F_{3,82}$ = 3.39, $p < 0.05$)			
	x̄ = 4.8	x̄ = 13.3	x̄ = 30.5	x̄ = 55.5
	B	B	A/B	A
Halfbeak (*Hyporhamphus unifasciatus*)	($F_{3,82}$ = 1.65, p = n.s.)			
	x̄ = 22.6	x̄ = 74.9	x̄ = 20.8	x̄ = 111
	A	A	A	A
Northern pipefish (*Syngnathus fuscus*)	($F_{3,82}$ = 3.77, $p < 0.05$)			
	x̄ = 4.8	x̄ = 22	x̄ = 41.6	x̄ = 49
	B	A / B	A	A
Silver perch (*Bairdiella chrysoura*)	($F_{3,82}$ = 2.24, p = n.s.)			
	x̄ = 406.6	2,038.70	x̄ = 2,757.7	x̄ = 1,677.6
	B	A / B	A	A / B
Tautog (*Tautoga onitis*)	($F_{3,82}$ = 0.73, p = n.s.)			
	x̄ = 77.3	x̄ = 42.6	x̄ = 90.2	x̄ = 159.1
	A	A	A	A
Blue crab (*Callinectes sapidus*)	($F_{3,82}$ = 2.66, p = n.s.)			
	x̄ = 400	x̄ = 1,179.4	x̄ = 1,082	x̄ = 1,143
	B	A	A	A
Grass shrimp (*Palaemonetes sp.*)	($F_{3,82}$ = 4.94, $p < 0.01$)			
	x̄ = 39.2	x̄ = 343.7	x̄ = 928	x̄ = 383
	A	A	B	A

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

Specimen Name	Primary Substrate	
	Sand	Mud
Northern pipefish (*Syngnathus fuscus*)	($F_{1,82} = 0.08$, p = n.s.)	
	$\bar{x} = 29$	$\bar{x} = 32.2$
	A	A
Pigfish (*Orthopristis chrysoptera*)	($F_{1,82} = 5.7$, $p < 0.05$)	
	$\bar{x} = 30.2$	$\bar{x} = 10$
	A	B
Pinfish (*Lagodon rhomboides*)	($F_{1,82} = 10.27$, $p < 0.01$)	
	$\bar{x} = 40.7$	$\bar{x} = 12.8$
	A	B
Sheepshead (*Archosargus probatocephalus*)	($F_{1,82} = 10.5$, $p < 0.01$)	
	$\bar{x} = 59.1$	$\bar{x} = 14.3$
	A	B
Spotfin mojarra (*Eucinostomus argenteus*)	($F_{1,82} = 2.71$, p = n.s.)	
	$\bar{x} = 68.3$	$\bar{x} = 17.7$
	A	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,82} = 4.3$, $p < 0.05$)	
	$\bar{x} = 368.6$	$\bar{x} = 98.2$
	A	B

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

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
Atlantic silverside (Menidia menidia)	($F_{1,82} = 8.15$, $p < 0.01$)	
	$\bar{x} = 618.9$	$\bar{x} = 1639.7$
	B	A
Dusky pipefish (Syngnathus floridae)	($F_{1,82} = 4.08$, $p < 0.05$)	
	$\bar{x} = 37.9$	$\bar{x} = 9.25$
	A	B
Gray snapper (Lutjanus griseus)	($F_{1,82} = 11.85$, $p < 0.01$)	
	$\bar{x} = 0.4$	$\bar{x} = 20.35$
	B	A
Northern pipefish (Syngnathus fuscus)	($F_{1,82} = 6.97$, $p < 0.01$)	
	$\bar{x} = 40.6$	$\bar{x} = 10.2$
	A	B
Sheepshead (Archosargus probatocephalus)	($F_{1,82} = 5.70$, $p < 0.05$)	
	$\bar{x} = 23.2$	$\bar{x} = 59.2$
	B	A
Striped burrfish (Chilomycterus schoepfii)	($F_{1,82} = 6.30$, $p < 0.05$)	
	$\bar{x} = 8.0$	$\bar{x} = 0$
	A	B
Tautog (Tautoga onitis)	($F_{1,82} = 0.84$, p = n.s.)	
	$\bar{x} = 118.6$	$\bar{x} = 60.1$
	A	A
Blue crab (Callinectes sapidus)	($F_{1,82} = 2.87$ p = n.s.)	
	$\bar{x} = 812.8$	$\bar{x} = 1,231.8$
	A	A
Brown shrimp (Farfantepenaeus aztecus)	($F_{1,82} =7.67$, $p < 0.01$)	
	$\bar{x} = 100.3$	$\bar{x} = 474.4$
	B	A

Table 9. Submerged Aquatic Vegetation 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)	31	35	33	28
Eelgrass (*Zostera marina*)	22	26	22	24
Widgeon grass (*Ruppia maritima*)	27	26	28	15
Sand	28	33	29	20
Mud	20	15	24	22
Sand - Eelgrass (*Z. marina*)	14	24	16	16
Mud - Eelgrass (*Z. marina*)	19	11	21	21
Sand - Widgeon grass (*R. maritima*)	26	24	25	12
Mud - Widgeon grass (*R. maritima*)	6	9	18	8

Table 10. Submerged Aquatic Vegetation 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)	1.68	1.38	1.22	1.36
Eelgrass (*Zostera marina*)	1.64	1.9	0.97	1.65
Widgeon grass (*Ruppia maritima*)	1.42	1.1	1.2	1.43
Sand	1.64	1.4	1.52	1.27
Mud	1.49	1.15	0.93	1.4
Sand - Eelgrass (*Z. marina*)	1.9	1.92	2	1.37
Mud - Eelgrass (*Z. marina*)	1.4	1.21	0.73	1.4
Sand - Widgeon grass (*R. maritima*)	1.37	1.1	1	0.93
Mud - Widgeon grass (*R. maritima*)	1.7	0.97	1.26	1.07

Table 11. Results of the Submerged Aquatic Vegetation 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*)	($F_{3,1565} = 22.01$, $p < 0.01$)			
	$\bar{x} = 84$	$\bar{x} = 83$	$\bar{x} = 83$	$\bar{x} = 80$
	A	A / B	B	C
Sheepshead (*Archosargus probatocephalus*)	($F_{3,115} = 0.45$, p = n.s.)			
	$\bar{x} = 85$	$\bar{x} = 76$	$\bar{x} = 75$	$\bar{x} = 69$
	A	A	A	A
Silver perch (*Bairdiella chrysoura*)	($F_{3,2144} = 35.21$, $p < 0.01$)			
	$\bar{x} = 85$	$\bar{x} = 76$	$\bar{x} = 75$	$\bar{x} = 69$
	A	B	B	C
Tautog (*Tautoga onitis*)	($F_{3,330} = 8.02$, $p < 0.01$)			
	$\bar{x} = 63$	$\bar{x} = 59$	$\bar{x} = 75$	$\bar{x} = 68$
	B / C	C	A	B
Blue crab (*Callinectes sapidus*)	($F_{3,2093} = 0.82$, p = n.s.)			
	$\bar{x} = 58$	$\bar{x} = 57$	$\bar{x} = 56$	$\bar{x} = 58$
	A	A	A	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{3,477} = 8.8$, $p < 0.01$)			
	$\bar{x} = 88$	$\bar{x} = 75$	$\bar{x} = 82$	$\bar{x} = 83$
	A	C	B	A / B

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

Specimen Name	Primary Substrate	
	Mud	Sand
Atlantic silverside (*Menidia menidia*)	($F_{1,1565}$ = 8.99, $p < 0.01$)	
	$\bar{x}$ = 81	$\bar{x}$ = 83
	B	A
Sheepshead (*Archosargus probatocephalus*)	($F_{1,115}$ = 22.89, $p < 0.01$)	
	$\bar{x}$ = 83	$\bar{x}$ = 69
	A	B
Silver perch (*Bairdiella chrysoura*)	($F_{1,2144}$ = 19.2, $p < 0.01$)	
	$\bar{x}$ = 73	$\bar{x}$ = 76
	B	A
Tautog (*Tautoga onitis*)	($F_{1,330}$ = 33.7, $p < 0.01$)	
	$\bar{x}$ = 75	$\bar{x}$ = 64
	A	B
Blue crab (*Callinectes sapidus*)	($F_{1,2093}$ = 1.48, p = n.s.)	
	$\bar{x}$ = 58	$\bar{x}$ = 56
	A	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,477}$ = 5.87, $p < 0.05$)	
	$\bar{x}$ = 84	$\bar{x}$ = 79
	A	B

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

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
Atlantic silverside (*Menidia menidia*)	($F_{1,1565}$ = 54.43, $p < 0.01$)	
	$\bar{x}$ = 81	$\bar{x}$ = 84
	B	A
Sheepshead (*Archosargus probatocephalus*)	($F_{1,115}$ = 1.63, p = n.s.)	
	$\bar{x}$ = 52	$\bar{x}$ = 64
	A	A
Silver perch (*Bairdiella chrysoura*)	($F_{1,2144}$ = 7.11, $p < 0.01$)	
	$\bar{x}$ = 74	$\bar{x}$ = 77
	B	A
Tautog (*Tautoga onitis*)	($F_{1,330}$ = 9.58, $p < 0.01$)	
	$\bar{x}$ = 69	$\bar{x}$ = 62
	A	B
Blue crab (*Callinectes sapidus*)	($F_{1,2093}$ = 11.48, $p < 0.01$)	
	$\bar{x}$ = 59	$\bar{x}$ = 54
	A	B
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,477}$ = 49.6, $p < 0.01$)	
	$\bar{x}$ = 88	$\bar{x}$ = 74
	A	B

Table 14. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for mean surface water quality parameters (water temperature, salinity, dissolved oxygen and water turbidity) by time period.

Parameter	Time Period	
	2015 – 2018	2019
	($F_{1,82} = 0.44$, p = n.s.)	
Temperature (C)	$\bar{x} = 25.9$	$\bar{x} = 26.4$
	A	A
	($F_{1,82} = 0.91$, p = n.s.)	
Salinity (ppt)	$\bar{x} = 27.5$	$\bar{x} = 27.6$
	A	A
	($F_{1,82} = 1.23$, p = n.s.)	
Dissolved oxygen (mg/L)	$\bar{x} = 6.6$	$\bar{x} = 6.2$
	A	A
	($F_{1,82} = 8.0$, $p < 0.01$)	
Turbidity (Secchi depth cm)	$\bar{x} = 53$	$\bar{x} = 68$
	B	A

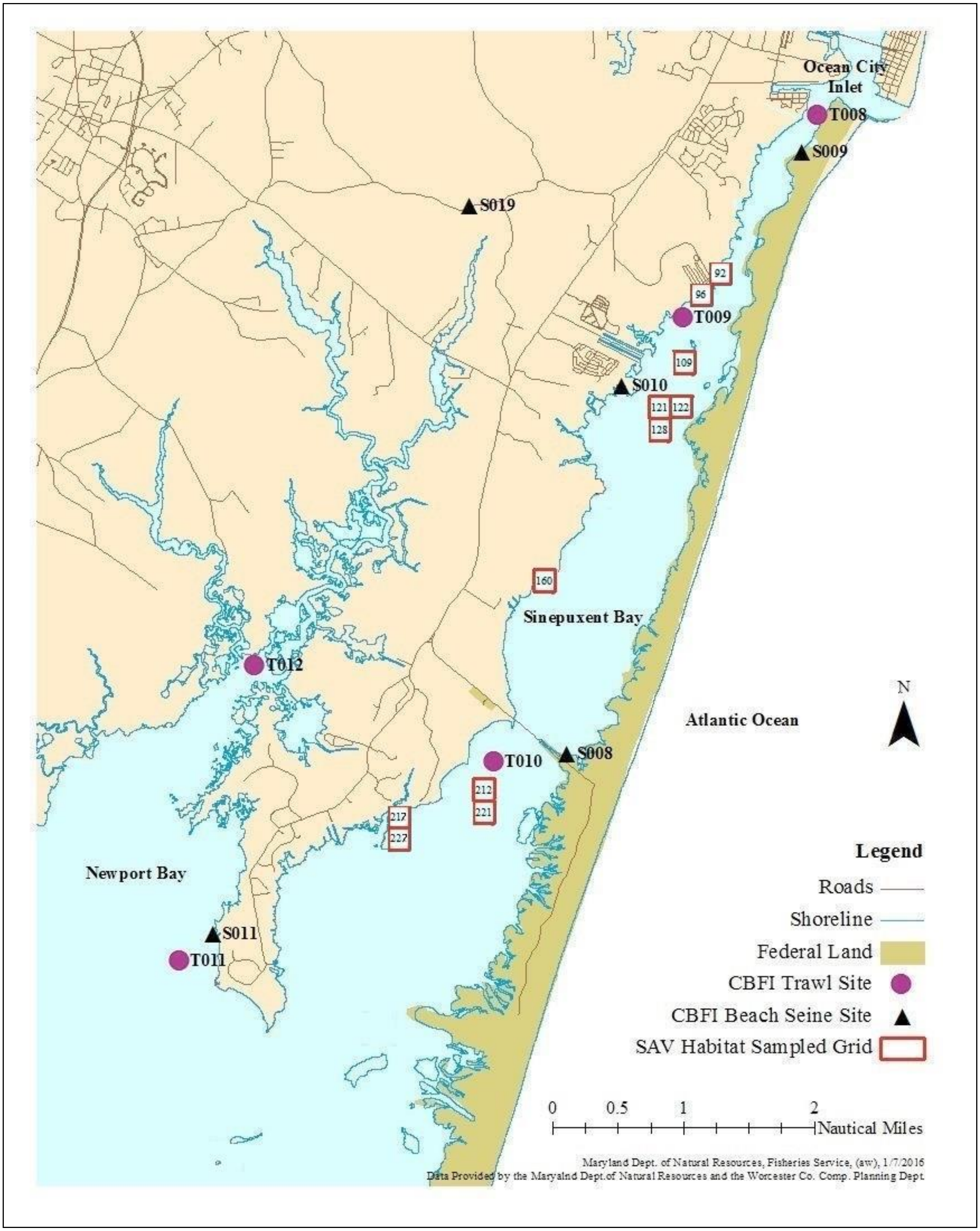

Figure 1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey and Trawl and Beach Seine surveys sample site locations (September 2015 - 2019).

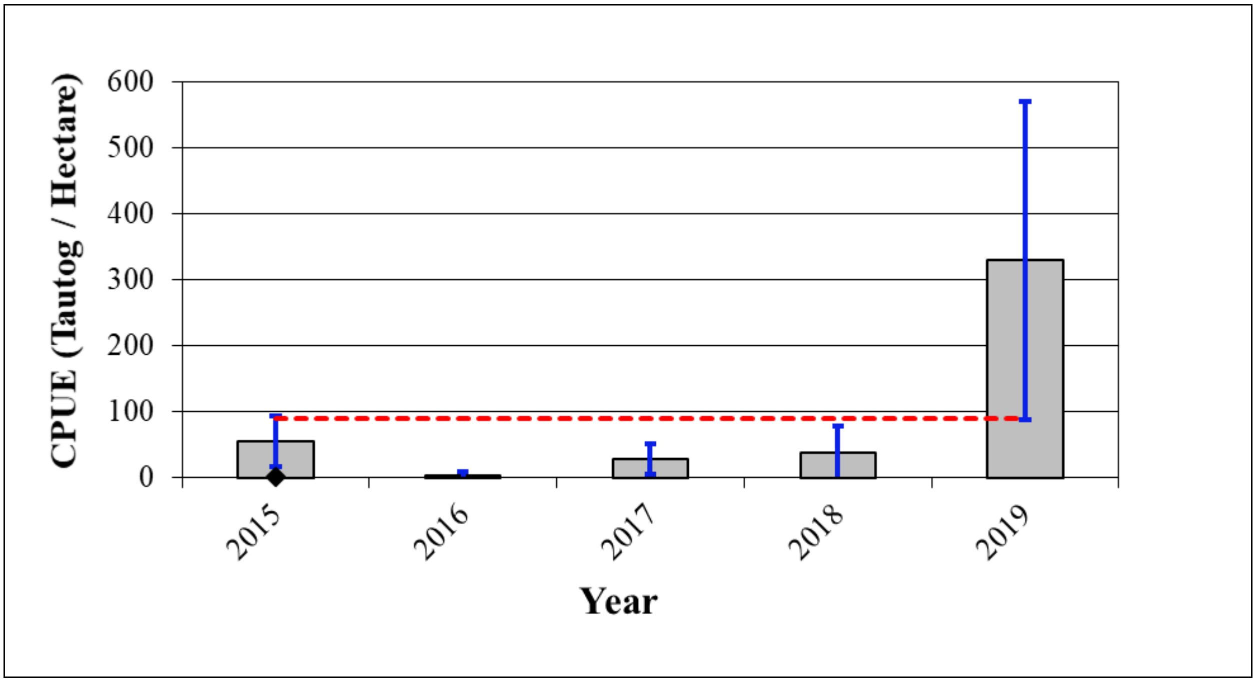

Figure 2. Tautog CPUE from the Submerged Aquatic Vegetation Habitat Survey (September 2015 - 2019). Dotted line represents the 2015 - 2019 time series grand mean (n = 83).

Chapter 3: Fisheries Dependent Tautog Data Collection

The ASMFC mandated ageing structures were collected between the Ocean City charter and party boat fleet. Length, sex and opercula were collected from 215 tautog during 10 recreational trips in 2019. One charter and two party boats provided those trips during February (1 trip, n = 9 fish), November (3 trips, n = 86 fish) and December (6 trips, n = 120 fish). Those samples represented the range of fish lengths commonly caught in the recreational fishery in Maryland. All fish were collected dockside, except for 19 fish collected seaside. Age data was determined on 203 tautog.

Aged fish length (n = 203) ranged from 235 mm to 660 mm, mean length was 437 mm and median length was 430 mm for both sexes combined. Females comprised 53.2% (n = 108) of the samples. Their mean length was 433 mm and median length was 425 mm. Males comprised 46.8% (n = 95) of the samples. Their mean length was 441 mm and median length was 430 mm. Length distribution bins were derived and shows the highest proportion of fish aged were just above the legal size (432 mm; 17 in; Table 1).

Fish age ranged from two to 22 years, mean age was seven years and median age was six years for both sexes combined. Five-year-old tautog comprised 24.6% of the samples (Table 2). The Female mean and median age was seven years. Male mean and median age was six years.

Tautog size at age resulted in wide distributions across the length bins in the larger length bins (Figure 1). This was expected and has been confirmed with previous results. Size at age by sex data is available but not used by the ASMFC Tautog Stock Assessment at this time.

List of Tables and Figures

Table 1. Tautog proportion at length from samples collected from charter and party boats, Ocean City Maryland (2019; n = 203).

mm	229	254	279	305	330	356	381	406	432	457	483	508	533	559	584	610	635	660
in	9	10	11	12	13	15	15	16	17	18	19	20	21	22	23	24	25	26
%	0.5	0.0	2.0	2.5	1.0	1.5	2.0	25.6	33.0	9.9	9.9	4.9	2.5	1.5	1.0	1.0	0.5	1.0

Table 2. Tautog proportion at age from samples collected from charter and party boats, Ocean City Maryland (2019; n = 203).

Age	2	3	4	5	6	7	8	9	10	11	12	13	Over
%	1.5	2.0	5.9	24.6	18.7	11.8	11.3	8.9	6.4	4.4	1.5	1.0	2.0

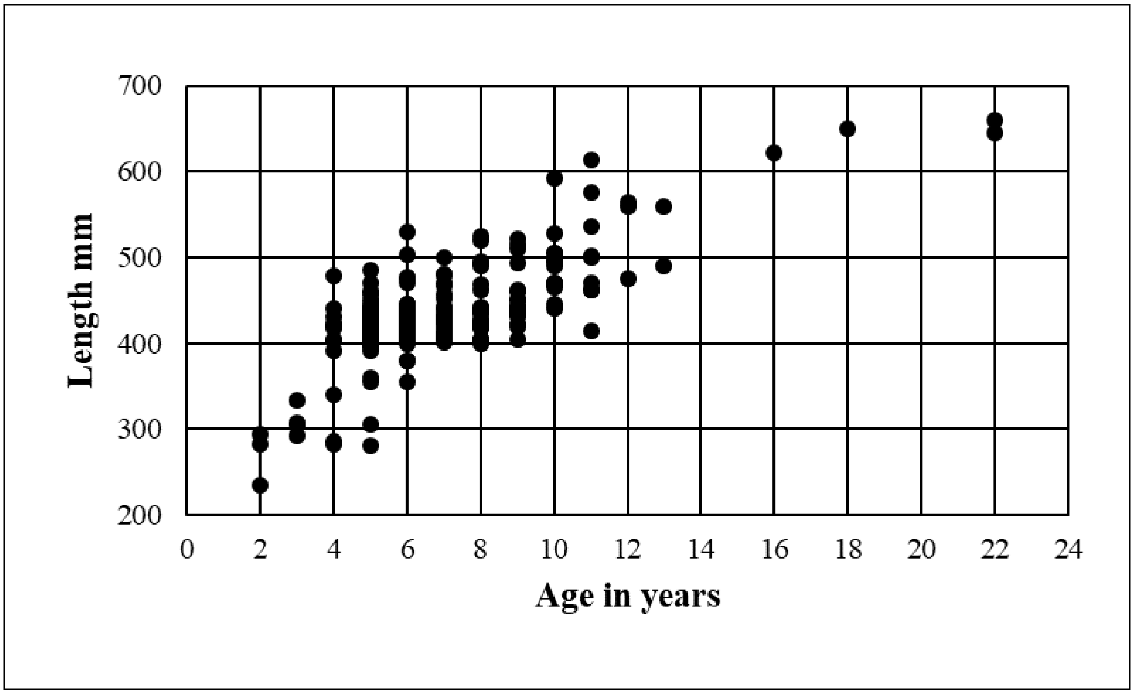

Figure 1. Tautog length distribution by age collected from charter and party boats, Ocean City, Maryland (2019; n = 203).

Chapter 4: 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 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

Data Collection

Sampling trips (5) were conducted commercial trawlers at night on June 24, July 15, August 12, September 16 and October 19 in 2019. A standard summer flounder bottom trawl net was used on all trips (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. Start depth (feet (ft)), time, surface water temperature (Celsius (C)), weather and wind direction were recorded when the trawl net was 100 percent deployed. Wind speed (knots (kts)) was taken using an anemometer. End time and stop depth was recorded at haul back. Data were recorded on a standardized data sheet.

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 were measured. All fishes and invertebrates were measured as in Chapter 1 and all prohibited species were released. Staff were trained and equipped to conduct endangered species protocols if required. Gosner (1978) and Robins and Ray (1986) books were available for assistance with species identification.

Data Analysis

Statistical analyses were conducted on all species. Abundance estimates of selected species were extrapolated from the subsampling regime proportional catch calculations.

Results and Discussion

Trawl time varied between 18 and 125 minutes. Water temperature ranged from a high of 25.7 C in August to a low of 18.2 C in October. Depth over the course of the surveys ranged from 9.2 m to 17.0 m (Table 2).

Numbers of species collected ranged from six to 14 per trip (Table 2). Fishes of recreational interest encountered from these trawls include clearnose skate (*Raja eglanteria*), southern kingfish (*Menticirrhus americanus*) and summer flounder (*Paralichthys dentatus;* Table 3).

Common invertebrates were horseshoe crabs (*Limulus polyphemus*), portly spider crab (*Libinia emarginata*), blue crab *(Callinectes sapidus*), channeled whelk (*Busycotypus canaliculatus*) and knobbed whelk (*Busycon carica*).

From all trips combined, 101 summer flounder were measured (Table 3). Lengths ranged in size from 230 mm (9.1 inches (in)) to 590 mm (23.2 in; Figure 1). The mean was 406.4 mm (16 in) and the mode was 400 mm (15.7 in). Sixty-three percent (63 fish) of the measured summer flounder were at or above the recreational minimum size limit (419.1 mm; 16.5 in) and 80.2 % (81 fish) were above 355.6 mm (Table 4). The majority of summer flounder measured in 2019 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). The proportion of summer flounder less than 355.6 mm and 419.1 mm was examined over time in order to identify potential recruitment pulses in the nearshore population. The results varied without trend over the 2015 - 2019 time series. The mean percent less than 419.1 mm (16.5 in) was 54.2%.

More southern kingfish, a recreational species, were captured in 2019 than in 2018. 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.

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 can be 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. In recent years the fleet switched target species and no longer catches large numbers of finfish; therefore, this survey will be discontinued in 2020.

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List of Tables and Figures

Table 1. Gear specifications for the subsampled commercial trawls off Ocean City, Maryland from June - October 2019.

Trip Date	Net Codend Mesh (cm)	Net Body Mesh (cm)	Head Rope Width (m)	Foot Rope Width (m)
June 24	14.0	15.2	33.5	39.0
July 24	14.0	15.2	30.5	33.5
August 12	14.0	15.2	30.5	33.5
September 16	14.0	15.2	30.5	33.5
October 28	14.0	15.2	30.5	33.5

Table 2. Commercial trawl subsample summary off Ocean City, Maryland from June - October 2019.

Trip Date	Sets	Depth Range (m)	Surface Temperature (C)	Species		
				Number Present	Number Counted	Number Measured
June 24	1	9.2 - 12.2	22.2	14	81	70
July 24	1	15.3 - 15.4	25	6	74	69
August 12	2	15.5 - 17.0	24 - 25.7	11	157	153
September 16	2	9.3 - 12.5	25.1	13	154	124
October 28	2	10.1 - 13.1	18.2	7	73	61

Table 3. List of species collected in subsampled commercial offshore trawls off Ocean City, Maryland from June - October 2019, n = 539. Species were grouped (finfish, crustaceans, molluscs and other) and listed by order of extrapolated total number, n = 10,228.

Common Name	Scientific Name	Total Number Counted	Total Number Extrapolated
Finfish Species			
Clearnose skate	*Raja eglanteria*	33	328
Atlantic angel shark	*Squatina dumeril*	6	202
Bullnose ray	*Myliobatis freminvillei*	11	184
Spot	*Leiostomus xanthurus*	6	134
Summer flounder	*Paralichthys dentatus*	101	101
Spiny butterfly ray	*Gymnura altavela*	2	100
Southern kingfish	*Menticirrhus americanus*	21	85
Southern stingray	*Dasyatis americana*	1	15
Weakfish	*Cynoscion regalis*	6	6
Northern puffer	*Sphoeroides maculatus*	2	2
Butterfish	*Peprilus triacanthus*	2	2
Striped burrfish	*Chilomycterus schoepfii*	2	2
Roughtail stingray	*Dasyatis centroura*	1	1
Cownose ray	*Rhinoptera bonasus*	1	1
Striped searobin	*Prionotus evolans*	1	1
	Total Finfish	196	1,164
Crustacean Species			
Portly spider crab	*Libinia emarginata*	16	625
Blue crab	*Callinectes sapidus*	9	294
White shrimp	*Litopenaeus setiferus*	1	1
	Total Crustaceans	26	920
Mollusc Species			
Knobbed whelk	*Busycon carica*	32	341
Channeled whelk	*Busycotypus canaliculatus*	3	3
Atlantic brief squid	*Lolliguncula brevis*	1	1
	Total Molluscs	36	345
Other Species			
Horseshoe crab	*Limulus polyphemus*	280	7,766
Hairy sea cucumber	*Sclerodactyla briareus*	1	33
	Total Other	281	7,799

Table 4. Percent of summer flounder (*Paralichthys dentatus)* bycatch below the female length at maturity and recreational minimum size from 2015 - 2019 subsampled commercial offshore trawls off Ocean City, Maryland.

Year	Number of Trawls	Percent Below 355.6 mm (14 in)	Percent Below 419.1 mm (16.5 in)	Catch Per Unit Effort #/Trawl
2015	6	38.5	53.8	6.5
2016	14	17.4	58.1	6.1
2017	13	9.0	53.7	5.2
2018	15	7.9	53.7	21
2019	8	19.8	58.4	12.6

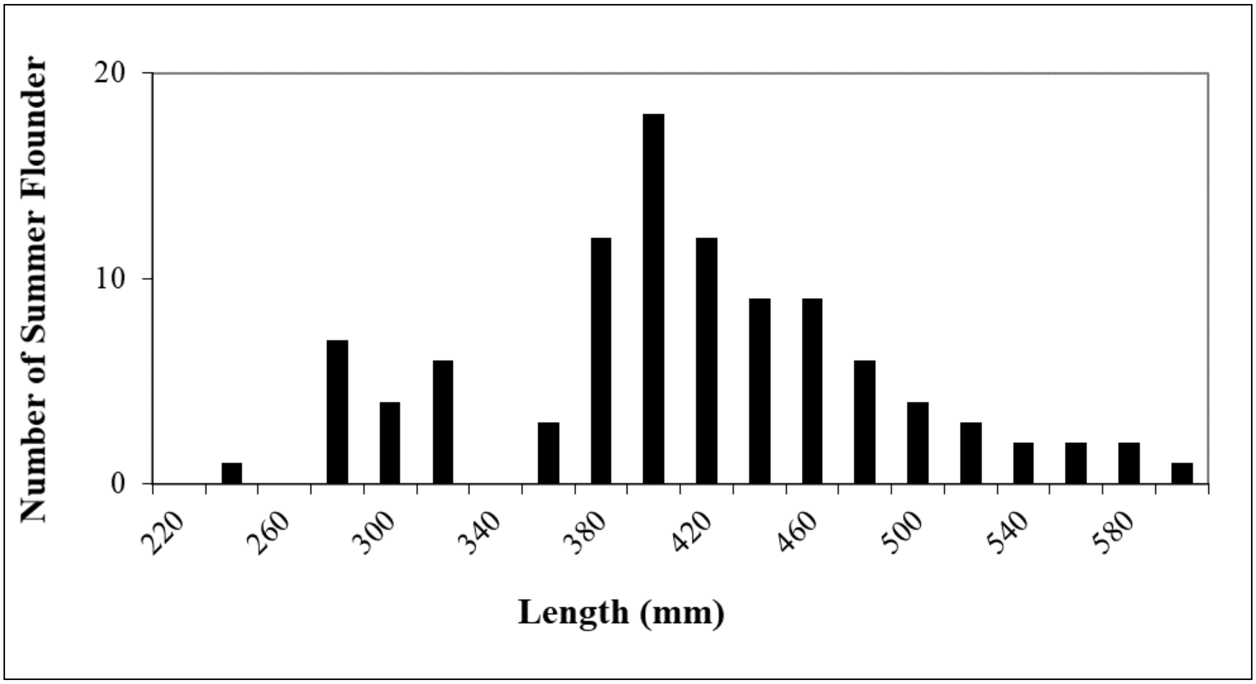

Figure 1. Summer flounder (*Paralichthys dentatus*) length (mm) frequency from commercial offshore trawls subsampled off Ocean City, Maryland from June - October 2019, n = 101. Data were derived from five trips (8 trawls total) taken at different water depths.

Chapter 5: Technical Assistance

One of the objectives was to contribute technical expertise and field observations from surveys to various research and management forums regarding finfish species found in the Maryland coastal bays and near shore Atlantic waters. With the passage of the Atlantic Coastal Fisheries Cooperative Management Act, various entities such as the Atlantic States Marine Fisheries Commission (ASMFC), Mid-Atlantic Fishery Management Council (MAFMC) and the National Marine Fisheries Service (NMFS) require stock assessment information in order to assess management measures.

Direct participation by Survey personnel as representatives to these various management entities provided effective representation of Maryland interests through the development, implementation and refinement of management options for Maryland as well as coastal fisheries management plans. In addition, survey information was used to formulate management plans for eight finfish species as well as providing evidence of compliance with state and federal fisheries management plans. A summary of the participation and contributions are presented below.

Atlantic croaker

Project staff provided Atlantic croaker data utilized for stock assessment to the ASMFC.

Black sea bass

Project staff provided black sea bass data and expertise utilized for the ASMFC, MAFMC and NMFS stock assessment. Assigned staff participated on the ASMFC Technical Committee and prepared our state compliance report.

Bluefish

Project staff provided bluefish data utilized for stock assessment to the ASMFC, MAFMC and NMFS.

Coastal sharks

Assigned staff participated on the ASMFC Technical Committee and prepared our state compliance report. Shark data from the Offshore Trawl Survey was included in Maryland's ASMFC compliance report.

Spot

Project staff provided spot data utilized for the traffic light assessment to the ASMFC.

Summer flounder

Project staff provided summer flounder data and expertise utilized for the ASMFC, MAFMC and NMFS stock assessment. Assigned staff participated on the ASMFC Technical Committee and prepared our state compliance report.

Tautog

Project staff provided tautog data and expertise utilized for the ASMFC stock assessment. Assigned staff participated on the ASMFC Technical Committee and prepared our state compliance report.

Weakfish

Project staff provided weakfish data utilized for stock assessment to the ASMFC.

Chapter 6: Dependent Shark Review

Introduction

Recreational shark fishing is gaining in popularity at Maryland beaches and in Chincoteague Bay. This review evaluated the ability of shark records from Ocean City, Maryland charterboat Captain, Mark Sampson, to answer biological questions and their potential to meet an F-50-R objective, to enhance the knowledge of sharks that are of interest to recreational anglers. Those records may improve biological knowledge leading to better angler experiences.

Methods

Captain Sampson specializes in shark fishing out of Ocean City, Maryland. He provided the department his personal fishing records from 2019. Recorded information included: species, total length, fork length, sex, maturity, estimated weight, date, depth, catch location and hooking location. Total length of large sharks was sometimes estimated. All prohibited species were released as well as most others. Paper records from those charter trips were entered into an Access database. Metadata was updated.

Results and Discussion

The captain ran 96 charter trips in 2019 (Table 1). Nine of those trips occurred offshore (>20 nautical miles) in May and June. Offshore fishing in late spring was often hampered by unfavorable weather conditions, resulting in reduced effort and was reflected in the number of trips taken. Seven species were caught on the offshore charter trips. Sandbar (*Carcharhinus plumbeus*; 25 sharks), shortfin mako (*Isurus oxyrinchus*; 8 sharks) and blue sharks (*Prionace glauca*; 6 sharks) comprised 76% of the offshore catch; however, this a function of the fishing location rather than availability (Table 2). Anecdotal reports indicated blue sharks were offshore all summer, but effort was directed toward other species. Of the 25 sexed sharks in May, the female to male ratio was nearly 1:1 (Table 3). Most of the sandbar sharks caught and released were females (18; Table 4).

Most trips (78) were nearshore, within 20 nautical miles of land, from June through September (Table 1). Eight of those nearshore trips concluded without any sharks caught. Seven species were caught of which spinner (*Carcharhinus brevipinna*), Atlantic sharpnose (*Rhizoprionodon terraenovae*) and sandbar sharks (*Carcharhinus plumbeus*) comprised 76% of the catch (Table 2). Mature males were only present for Atlantic sharpnose and sand tiger sharks (Table 5).

The remaining nine trips were reported from the over sand vehicle area of Assateague Island National Seashore, an area popular with recreational shark anglers, in July and August. Six different species were caught (Table 2). Sand tiger (*Carcharias taurus*; 16), Atlantic sharpnose (13) and sandbar sharks (6) comprised 90% of the catch. All of the Atlantic sharpnose sharks and most of the sand tiger sharks were mature males whereas all sandbar sharks were females (Table 6).

These data combined with those reported in Doctor *et al* (2019) confirm the range expansion of spinner sharks (Castro 1993; Schulze-Haugen *et al* 2003). Castro (1993) reported the northern range as North Carolina and 10 years later Schulze-Haugen *et al* (2003) reported the northern range as Virginia. Sampson's records from 2007 to present show a gradual increase in the numbers of spinner sharks caught off Maryland, which documents the continued range expansion. Reports of spinner shark catches from the recreational public were uncommon. These data could indicate identification error or that these sharks were mostly available from boats. Additionally, these data document the presence of pups, which are 24 to 30 inches at birth and juveniles (Table 7 and Figure 1; Castro 1993). This area is likely a summer nursery as water temperatures drop in the fall and winter.

Review of the 2019 records indicated that useful biological information can be obtained from dependent sources to improve recreational fishing opportunities. These charter records demonstrated that recreational anglers had access to a variety of sharks, including those eligible for landing. The two most commonly caught species from those charter trips, spinner and Atlantic sharpnose sharks, were not prohibited species. Of note, there were zero great white sharks (*Carcharodon carcharias*) or bull sharks (*Carcharhinus leucas*) in those records although anecdotal information indicates their presence.

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List of Tables and Figures

Table 1. Trip locations by month from an Ocean City, Maryland charter boat in 2019.

	May	June	July	August	September	Total
Offshore	5	4				9
Nearshore		16	29	21	12	78
National Seashore			2	7		9
Total	5	20	31	28	12	96

Table 2. Monthly shark catch frequency by area from an Ocean City, Maryland charter boat in 2019.

	Offshore (9 Trips)		Nearshore (78 Trips)				National Seashore (9 Trips)	
Species	May	June	June	July	August	September	July	August
Atlantic sharpnose (*Rhizoprionodon terraenovae*)			35	39	9	2	9	4
Blue shark (*Prionace glauca*)	5	1						
Common thresher shark (*Alopias vulpinus*)				1	1			
Dusky shark (*Carcharhinus obscurus*)		4	2	6	5	25		2
Hammerhead shark, scalloped (*Sphyrna lewini*)				2		3		1
Hammerhead shark, smooth (*Sphyrna zygaena*)		1						
Sand tiger shark (*Carcharias taurus*)			2	23	12	1	3	13
Sandbar shark (*Carcharhinus plumbeus*)	15	10	8	13	17	8	3	3
Shortfin mako shark (*Isurus oxyrinchus*)	4	4						
Smooth dogfish (*Mustelus canis*)								1
Spinner shark (*Carcharhinus brevipinna*)		5	15	61	31	25		
Tiger shark (*Galeocerdo cuvier*)	1	1						
Total	25	26	62	145	75	64	15	24

Table 3. Frequency of sexed (F = female, M = male, MM = mature male, U = unknown) sharks by month from an Ocean City, Maryland charter boat in 2019.

	May			June				July				August				September				
Species	F	M	MM	F	M	MM	U	F	M	MM	U	F	M	MM	U	F	M	MM	U	Total
Atlantic sharpnose (*Rhizoprionodon terraenovae*)				18	2	14	1	14	1	31	2		1	12				2		98
Blue shark (*Prionace glauca*)	2		3	1																6
Common thresher shark (*Alopias vulpinus*)									1				1							2
Dusky shark (*Carcharhinus obscurus*)				1	4		1	4	1		1	3	4			10	13		2	44
Hammerhead shark, scalloped (*Sphyrna lewini*)									2			1				2	1			6
Hammerhead shark, smooth (*Sphyrna zygaena*)					1															1
Sand tiger shark (*Carcharias taurus*)						2		14	4	8		11	3	9	2		1			54
Sandbar shark (*Carcharhinus plumbeus*)	8	4	3	14	4			12	4			16	4			5	3			77
Shortfin mako shark (*Isurus oxyrinchus*)	2		2	2	2															8
Smooth dogfish (*Mustelus canis*)															1					1
Spinner shark (*Carcharhinus brevipinna*)				11	7	2		25	28		8	16	13		2	14	8		3	137
Tiger shark (*Galeocerdo cuvier*)	1			1																2
Total	13	4	8	48	20	18	2	69	41	39	11	47	26	21	5	31	26	2	5	436

Table 4. Frequency of sexed (F = female, M = male, MM = mature male, U = unknown) sharks by month from an Ocean City, Maryland charter boat fishing offshore in 2019.

Species	Female	Male	Mature Male	Unknown
Blue shark (*Prionace glauca*)	3		3	
Dusky shark (*Carcharhinus obscurus*)	1	2		1
Hammerhead shark, smooth (*Sphyrna zygaena*)		1		
Sandbar shark (*Carcharhinus plumbeus*)	18	4	3	
Shortfin mako shark (*Isurus oxyrinchus*)	4	2	2	
Spinner shark (*Carcharhinus brevipinna*)	2	1	2	
Tiger shark (*Galeocerdo cuvier*)	2			

Table 5. Frequency of sexed (F = female, M = male, MM = mature male, U = unknown) sharks by month from an Ocean City, Maryland charter boat fishing nearshore in 2019.

Species	Female	Male	Mature Male	Unknown
Atlantic sharpnose (Rhizoprionodon terraenovae)	32	4	46	3
Common thresher shark (Alopias vulpinus)		2		
Dusky shark (Carcharhinus obscurus)	16	19		3
Hammerhead shark, scalloped (Sphyrna lewini)	2	3		
Sand tiger shark (Carcharias taurus)	21	6	10	1
Sandbar shark (Carcharhinus plumbeus)	31	15		
Spinner shark (Carcharhinus brevipinna)	64	55		13

Table 6. Frequency of sexed (F = female, M = male, MM = mature male, U = unknown) sharks by month from an Ocean City, Maryland charter captain fishing at the Assateague Island National Seashore in 2019.

Species	Female	Male	Mature Male	Unknown
Atlantic sharpnose (*Rhizoprionodon terraenovae*)			13	
Dusky shark (*Carcharhinus obscurus*)	1	1		
Hammerhead shark, scalloped (*Sphyrna lewini*)	1			
Sand tiger shark (*Carcharias taurus*)	4	1	10	1
Sandbar shark (*Carcharhinus plumbeus*)	6			
Smooth dogfish (*Mustelus canis*)				1

Table 7. Summary of spinner shark total lengths from 2007 - 2019 from an Ocean City, Maryland charter boat in 2019.

Year	Minimum	Maximum
2007	31	73
2008	29	84
2009	24	66
2010	26	77
2011	28	69
2012	26	78
2013	26	85
2014	23	85
2015	24	90
2016	26	99
2017	24	84
2018	21	90
2019	20	84

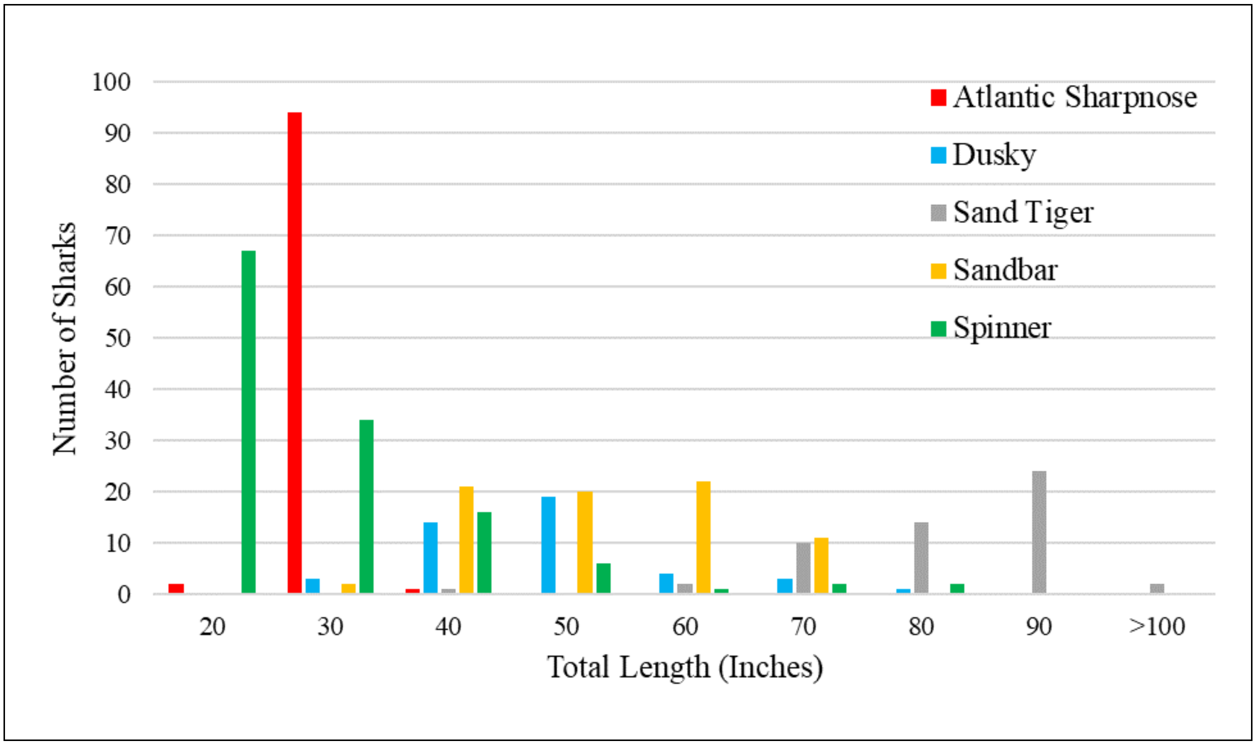

Figure 1. Histogram of sharks caught and measured from an Ocean City, Maryland charter boat in 2019. All prohibited species, spinner and most Atlantic sharpnose sharks were released.