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

F-50-R-29

July 2020 - June 2021
Final Report

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Investigation of Maryland's Coastal Bays and Atlantic Ocean Finfish Stocks
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Accomplishments July 1, 2020 - June 30, 2021

July - August 2020
- Collected 20 trawl samples at 20 fixed sites, monthly
- Completed data entry and quality control from prior month's sampling
- Edited the F-50-R-28 report
- Wrote the Atlantic States Marine Fisheries Commission (ASMFC) Coastal Sharks Compliance report

September - October 2020
- Collected 20 trawl samples at 20 fixed sites (monthly)
- Collected 19 beach seine samples at 19 fixed sites (September)
- Collected 16 Submerged Aquatic Vegetation Habitat Survey samples in Sinepuxent Bay (September)
- Finalized the F-50-R-28 report by September due date
- Completed data entry and quality control from prior month's sampling
- Collected five tautog opercula for ageing

November 2020
- Completed quality control for the entire dataset
- Collected 54 tautog opercula for ageing

December 2020 - March 2021
- Conducted data analyses of the 2020 surveys
- Drafted the F-50-R-29 annual report
- Collected 118 tautog opercula for ageing
- Prepped and aged 202 tautog for the 2020 fishing year
- Finfish abundance indices for black sea bass, bluefish and summer flounder were provided to the National Marine Fisheries Service Science Center for stock assessment updates

April - June 2021
- Prepared for the 2021 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 sites (monthly)
- Collected 19 beach seine samples at 19 fixed sites (June)
- Completed data entry and quality control from prior months sampling
- Edited the F-50-R-29 report
- Wrote the Atlantic States Marine Fisheries Commission’s black sea bass, scup, summer flounder, and tautog compliance reports
- Collected 112 tautog opercula for ageing

Year Round, as needed
- 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. Refinements were made to the sampling approach to improve catchability of demersal fish. The survey protocol was standardized in 2015.

Although the Sport Fish Restoration reporting period covers July 2020 through June 2021, the terminal year of data used in this report is 2020, because a full sampling season is needed for data analyses. Note that the 2020 COVID-19 pandemic prevented April 2020 trawl sampling in the coastal bays.

Executive Summary

The investigation was developed to characterize juvenile and adult fishes and their abundances in Maryland's coastal bays and the Atlantic Ocean, facilitate management decisions, and protect finfish habitats. This investigation was comprised of three surveys: Beach Seine, Submerged Aquatic Vegetation Habitat, and Trawl surveys in the bays, behind Fenwick and Assateague Islands, to characterize nearshore ocean adult finfishes. Over 30 years of continuous standardized 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, and academic research.

The investigation uses the previously mentioned surveys to meet the following objectives:

1. characterize stocks and estimate relative abundance of fishes in Maryland's coastal bays and near-shore Atlantic Ocean;
2. delineate and monitor spawning, nursery and/or forage locations for finfish; and
3. provide technical assistance by participating on inter- and intra-government committees and writing Atlantic States Marine Fisheries Commission compliance reports. Develop indices and other needed information necessary to assist in the management of regional and coastal fish stocks.

In 2020, 23,566 fish were caught in the Trawl and Beach Seine surveys (5,654 fish trawl and 17,912 fish beach seining). Collected fishes represented 74 species, which is within the normal representation range in a year. Atlantic spadefish had above average trawl and beach seine indices. Atlantic croaker, bay anchovy, bluefish, sheepshead, and summer flounder had below average trawl indices and American eel, Atlantic silverside, bluefish, and silver perch had below average beach seine indices.

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 (90 fishes) in the trawl time series (1989 - 2020) whereas Newport Bay had the lowest (68 fishes). The Beach Seine Survey time series (1989 - 2020) results indicated that Assawoman Bay and Isle of Wight Bay had the richest fish populations (87 and 88 fishes respectively) and Newport Bay was lowest (70).

Diversity is a measurement of richness and the proportion of species in the sample population. The 2020 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 - 2020) indicated that Sinepuxent Bay was most diverse whereas the St. Martin River was the least. Shannon index results for the beach seine time series (1989 - 2020) indicated that Chincoteague Bay was most diverse whereas the St. Martin River and Sinepuxent Bay were the least.

Macroalgae bycatch is ephemeral with annual variation. It is quantified in these surveys for its positive and negative effects as habitat. The 2020 trawl CPUE (51.1 L/ha) was below the grand mean and the beach seine CPUE (43 L/haul) was equal to the grand mean. Sixteen genera were collected by trawl and beach seine within the coastal bays in 2020. *Agardhiella* remained the most abundant genus for both gears. *Codium*, an invasive species from the Pacific Ocean, was observed in the Chincoteague Bay and should be monitored because it has created problems for recreational activities in other states such as Massachusetts.

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 investigation's sampling occurred during the day when the effects of low dissolved oxygen may have not been 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 Submerged Aquatic Vegetation Habitat Survey has operated with a standardized protocol since 2015. The overall catch per unit effort of fishes in the submerged aquatic vegetation, especially tautog (*Tautoga onitis*), demonstrates its importance as critical habitat in the Sinepuxent Bay. The survey also confirms that with the continued study and monitoring of fishes in this habitat stock assessment and species-specific habitat criteria can be refined.

Tautogs (202 fish) were obtained for ageing from charter and party boats. Ageing results had a wide range of year classes and large fish caught by hook and line in the Atlantic Ocean off Ocean City, Maryland. The maximum age was 24 and the mean age was eight years.

Technical expertise and field observations obtained from the previously mentioned surveys were 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 12 species.

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 - 2020.

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. delineates and monitors areas of high value, such 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. The 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 the area 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.

Gears

Trawl

Trawl sampling was conducted monthly at 20 fixed sites throughout the coastal bays from May through October (Table 1.1, Figure 1.1, Figure 1.2, and Figure 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. In 2020, trawl sampling was not conducted in April due to COVID-19 restrictions.

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 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 1.2, Figure 1.1, Figure 1.2, and Figure 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. Occasional difficulties determining tide may have resulted from inlet influences in Ocean City and Chincoteague, lack of appropriate tide stations for some sites, or 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 1.3). 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. Sex and maturity categories included immature female, male, mature female (sook) and mature female with eggs. A subsample of the first 20 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 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, biological significance as forage, or indicators of water quality.

The Geometric Mean (GM) was calculated to develop species-specific annual trawl and beach seine indices of relative abundance (1989 - 2020). That method was adopted by the 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$(x + 1) \pm$ standard error * (t value: $\alpha = 0.05$, $n - 1$)], respectively. A geometric grand mean was calculated for the time series (1989 - 2020) and used as a point estimate for comparison to the annual (2020) 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 2020. 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, and turbidity) per bay was derived from using the surface and bottom values. For both gears, the DO averages were reviewed to see if the system fell below 5 mg/L, a value considered necessary for life for some organisms, and 2 mg/L for hypoxic conditions (Chesapeake Bay Program, 2021).

Results and Discussion

Overview

The month of April was not sampled due to COVID 19 restrictions, which decreased the number of trawl samples by 14.3%. The effects of that vary by species (precision and accuracy). Data collected from April have been used for the management of summer flounder and is known as an important month for sampling forage species such as American eels, blue crabs, sand, and grass shrimps. In the 1990s and early 2000s, April sampling was important for Atlantic herring but few have been caught since 2004.

Finfish were the most abundant taxa captured in the survey. Specifically, they accounted for 23,566 fish caught trawling (5,654) and beach seining (17,912 fish) in 2020 (Table 1.4)**.** The total number of species and individual fish caught was within the range of catches the last 14 years (Table 1.5). Collected fishes represented 74 species, which is within the normal range in a year. Missing April trawls did not greatly affect the fish counts, species caught, or the long-term indices.

Atlantic spadefish had above average trawl and beach seine indices. This is the first time that Atlantic spadefish were caught in appreciable numbers by these surveys. Atlantic croaker, bay anchovy, bluefish, sheepshead, and summer flounder had below average trawl indices and American eel, Atlantic silverside, bluefish, and silver perch had below average beach seine indices (Table 1.6). Since 2014, summer flounder have had an average or below average trawl index and an average or above average seine index which may indicate a change in the shallow habitat preference for summer flounder in the coastal bays.

Crustaceans were the second most abundant taxa captured in this survey. Specifically, they accounted for 9,988 specimens caught trawling (1,947 crustaceans) and beach seining (3,053 crustaceans) in 2020 (Table 1.7). Sixteen crustaceans were identified, which is similar to the numbers found between 1989 and 2020. Crustaceans were dominated by blue crabs and shrimps (brown, 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 352 specimens caught trawling (283 molluscs) and beach seining (69 molluscs; Table 1.8). Molluscs were represented by 14 different species, which is similar to the numbers of molluscs found between 1989 and 2020.

Seventeen other types of animals and 18 plants were captured trawling and beach seining (Table 1.9, Table 1.10). 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 five of 120 trawls (4.2%) and in two of 38 beach seines (5.3%). A total of sixteen American eels were collected in trawl (13 fish) and beach seine (3 fish) samples (Table 1.4). American eel ranked 30 out of 74 species in overall finfish abundance. The trawl and beach seine CPUEs were 0.9 fish/ha and <0.1 fish/haul, respectively.

The 2020 trawl relative abundance index was equal to the grand mean and the beach seine relative abundance index was below the grand mean (Figure 1.4, Figure 1.5). 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, Birdsong, & Musick, 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.

The 12 American eels caught trawling in May and June measured 52 mm to 93 mm with a mean of 73 mm. One larger eel caught in July measured 245 mm (Table 1.11). In the Beach Seine Survey, three American eels were caught in June measuring 60 to 160 mm with a mean length of 115 mm (Table 1.12). 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 anglers, were captured in 18 of 120 trawls (15.9%) and in three of 38 beach seines (7.0%). A total of 129 juvenile Atlantic croakers were collected in trawl (125 fish) and beach seine (4 fish) samples (Table 1.4). Atlantic croakers ranked 12 out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 8.3 fish/ha and 0.1 fish/haul, respectively.

The 2020 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figure 1.6, Figure 1.7). Since 1989, the trawl index often (18 years) and the beach seine index occasionally (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. Abundance can be influenced by environmental conditions and ocean currents (Murdy, Birdsong, & Musick, 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, Birdsong, & Musick, 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 prefer 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, Gartland, Bonzek, & Johnson, 2008).

Atlantic croakers were caught in all sampled months except August and September in the Trawl Survey. The May through July monthly mean length ranged from 110 mm to 146 mm (Table 1.11). The Atlantic croakers caught in October (trawl) were young of the year and averaged 24 mm. The Beach Seine Survey mean lengths were 159 mm in June and 212 mm in September (Table 1.12). 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 16 of 120 trawls (13.4%) and in 19 of 38 beach seines (50%). Atlantic menhaden ranked first out of 74 species in overall finfish abundance. A total of 13,426 juvenile Atlantic menhaden were collected in trawl (59 fish) and beach seine (13,367 fish) samples (Table 1.4). The trawl and beach seine CPUE was 3.9 fish/ha and 351.8 fish/haul, respectively.

Both the 2020 trawl and beach seine relative abundance indices were equal to the grand means (Figure 1.8, Figure 1.9). Since 1989, the trawl index occasionally (16 years) and the beach seine index rarely (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. Good beach seine sites were widely dispersed in shallow 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 Environment, 2001). Those trawl sites likely had high chlorophyll concentrations; a desirable characteristic for a filter feeder (Wazniak, et al., 2004).

The monthly mean length of Atlantic menhaden caught by the Trawl Survey increased from a mean of 42 mm in May to a mean of 95 mm in August, followed by a decrease to 89 mm in September (Table 1.11). The Beach Seine Survey had similar results with an increase from a mean length of 47 mm in June to a mean length of 96 mm in September (Table 1.12). The increase in mean length in both the Trawl and Beach Seine surveys reflects growth of the young of the year cohort throughout the summer season.

Atlantic silverside (*Menidia menidia*)

Atlantic silversides, a forage species, were captured in four of 120 trawls (3.4%) and in 19 of 38 beach seines (50.0%). A total of 1,186 Atlantic silversides were collected in trawl (84 fish) and beach seine (1,102 fish) samples (Table 1.4). Atlantic silversides ranked fourth out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 5.6 fish/ha and 29.0 fish/haul, respectively.

The 2020 trawl relative abundance index was equal to the grand mean and the beach seine index was below the grand mean (Figure 1.10, Figure 1.11). Since 1989, the trawl index occasionally (16 years) and beach seine index rarely (6 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 frequently found occurring with spot, summer flounder, and winter flounder at multiple sites in this survey.

All but one Atlantic silverside was caught in the Trawl Survey in July and the monthly mean length was 63 mm (Table 1.11). The Beach Seine Survey mean lengths were 89 mm in June and 79 mm in September (Table 1.12). The monthly variability of the mean lengths is likely related to the lunar spawning cycle, March through July (Murdy & Musick, 2013).

Atlantic spadefish (*Chaetodipterus faber*)

Atlantic spadefish were captured in 22 of 120 trawls (18.3%) and in 12 of 19 beach seines (63%). A total of 106 Atlantic spadefish were collected in trawl (73 fish) and beach seine (33 fish) samples (Table 1.4). Atlantic spadefish ranked 13 of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 4.8 fish/ha and 0.9 fish/haul, respectively.

The 2020 trawl and beach seine indices were both above the grand means (Figure 1.12, Figure 1.13) and the highest in the time series. Since 1989, the trawl index often (23 years) and beach seine frequently (28 years) varied significantly from the grand mean. Atlantic spadefish were caught at multiple sites in both the trawl and beach seine survey indicating a wide distribution. It is not surprising that Atlantic spadefish were only caught in the warmer months of August and September as they are traditionally a more southern species. The abundance in 2020 was unusually high, but they were periodically encountered in previous years.

The monthly mean length of Atlantic spadefish in the trawl survey increased from 74 mm in August to 91 mm in September (Table 1.11). Atlantic spadefish were caught only in September in the Beach Seine Survey and the mean length was 92 mm (Table 1.12).

Bay anchovy (*Anchoa hepsetus*)

Bay anchovies, a forage species, were captured in 73 of 120 trawls (60.1%) and in 24 of 38 beach seines (63.2%). A total of 3,888 bay anchovies were collected in trawl (3,089 fish) and beach seine (799 fish) samples (Table 1.4). Bay anchovies ranked second out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 205.3 fish/ha and 21 fish/haul, respectively.

The 2020 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figure 1.14, Figure 1.15). Since 1989, the trawl

(11 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 have not fluctuated 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 preferred forage for larger fishes and have been found occurring with spot and summer flounder at multiple sites in these surveys.

The monthly mean lengths of bay anchovies in the Trawl Survey ranged between 47 mm to 67 mm (Table 1.11). The mean monthly lengths from the Beach Seine Survey were 68 mm in June and 41 mm in September (Table 1.12). Spawning occurred multiple times from May to September and peaked in July. The relatively constant size throughout the year reflects the extended recruitment through the summer.

Black sea bass (*Centropristis striata*)

Black sea bass, a species of interest to recreational anglers, were collected in 30 of 120 trawls (25.0%) and six of 38 beach seines (15.8%). A total of 74 juvenile black sea bass were collected in trawl (61 fish) and beach seine (13 fish) samples (Table 1.4). Black sea bass ranked 16 out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 4.0 fish/ha and 0.3 fish/haul, respectively.

In 2020, both the trawl and beach seine relative abundance indices were equal to the grand means (Figure 1.16, Figure 1.17). Since 1989, the trawl index often (18 years) and beach seine index rarely (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.

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 & Chigbu, 2017). Some of the preferred sample sites had a hard shell bottom that provided the needed habitat structure desired by black sea bass (Murdy, Birdsong, & Musick, 1997).

The monthly mean length of black sea bass increased from 82 mm in May to 154 mm in September in the Trawl Survey (Table 1.11). In the Beach Seine Survey, the mean length increased from 88 mm in June to 139 mm in September (Table 1.12). 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 2020.

Bluefish (*Pomatomus saltatrix*)

Bluefish, a species of interest to recreational anglers, were collected in zero of 120 trawls (0%) and in three of 38 beach seines (7.9%). Three juvenile bluefish were collected in beach seine samples (Table 1.4). Bluefish ranked 49 out of 74 species in overall finfish abundance. The beach seine CPUE was <0.1 fish/haul.

The 2020 trawl and beach seine relative abundance indices were both below the grand means (Figure 1.18, Figure 1.19). Since 1989, the trawl (8 years) index rarely varied from the grand mean and the beach seine (10 years) index 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 indicator of species abundance. That gear is also used by other state's independent surveys that are also included in the stock assessment.

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

Three bluefish were caught in the June Beach Seine Survey. The mean length was 61 mm (Table 1.12).

Sheepshead (*Archosargus probatocephalus*)

Sheepshead, a species of interest to recreational anglers, were collected in zero of 120 trawls (0%) and four of 38 beach seines (10.5%). Thirty juvenile sheepshead were collected in beach seine (30 fish) samples (Table 1.4). Sheepshead ranked 24 out of 74 species in overall finfish abundance. The beach seine CPUE was 0.8 fish/haul.

The 2020 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figure 1.20, Figure 1.21). Since 1989, the trawl (24 years) and beach seine (18 years) indices often 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. Sheepshead were absent in both surveys from 1989 to 1997. Presence has been consistent since 2011. 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 & Musick, 2013). Young of the year sheepshead were caught at locations with or near SAV or riprap. SAV is important juvenile habitat (Murdy & Musick, 2013).

Sheepshead caught in the beach seine ranged in total length from 47 mm to 250 mm with a mean of 69 mm (Table 1.12). These lengths represent a mix of young of the year and an older year class.

Silver perch (*Bairdiella chrysoura*)

Silver perch, a forage species, were collected in 34 of 120 trawls (28.3%) and 13 of 38 beach seines (34.2%). A total of 274 silver perch were collected in trawl (187 fish) and beach seine (87 fish) samples (Table 1.4). Silver perch ranked sixth out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 12.4 fish/ha and 2.3 fish/haul, respectively.

The 2020 trawl relative abundance index was equal to the grand mean and the beach seine relative abundance index was below the grand mean (Figure 1.22, Figure 1.23). Since 1989, the trawl index often (18 years) varied significantly from the grand mean and the beach seine index rarely (3 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, Birdsong, & Musick, 1997) (Murdy & Musick, 2013).

In the Trawl Survey, the monthly mean size increased from 51 mm in July to 118 mm in October (Table 1.11). Silver perch mean length increased though the summer because of young of the year cohort growth. In the Beach Seine Survey, silver perch were only caught in September and the mean length was 93 mm. (Table 1.12).

Spot (*Leiostomus xanthurus*)

Spot are important forage and to recreational anglers for bait and as a target species. Spot were collected in 77 of 120 trawls (64.2%) and 31 of 38 beach seines (81.6%). A total of 1,986 spot were collected in trawl (981 fish) and beach seine samples (1,005 fish; Table 1.4). Spot ranked third out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 65.2 fish/ha and 26.4 fish/haul, respectively.

The 2020 trawl and beach seine relative abundance indices were both equal to the grand means (Figure 1.24, Figure 1.25). Since 1989, the trawl index frequently (26 years) varied significantly from the grand mean and the beach seine (22 years) index often varied significantly from the grand mean. Spot spawn offshore; therefore, environmental conditions including global weather patterns and ocean currents may be a factor influencing relative abundance (Murdy, Birdsong, & Musick, 1997). Both indices indicated that the Maryland coastal bays are suitable nursery habitat for spot and represent an accurate picture of changes in relative abundance.

The Trawl Survey monthly mean length of spot increased from 41 mm in May to 141 mm in October (Table 1.11). In the Beach Seine Survey, the mean length increased from 75 mm in June to 139 mm in September (Table 1.12). 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 38 of 120 trawls (31.7%) and 22 of 38 beach seines (57.9%). A total of 261 summer flounder were collected in trawl (109 fish) and beach seine (152 fish) samples (Table 1.4). Summer flounder ranked seventh out of 74 species in overall finfish abundance. The trawl and beach seine CPUE was 7.2 fish/ha and 4.0 fish/haul, respectively.

The 2020 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figure 1.26, Figure 1.27). Since 1989, the trawl index often (22 years) varied significantly from the grand mean and the beach seine index occasionally (14 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. More recently, the number of summer flounder caught in beach seines increased while the number caught in trawls has decreased.

Productive summer flounder trawl and beach seine sites were located in all bays. This indicated that most of the Maryland coastal bays were 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 monthly mean length of summer flounder caught by the Trawl Survey increased from 75 mm in May to 140 mm in October with a slight decrease in September (Table 1.11). In the Beach Seine Survey, the mean length increased from 70 mm in June to 136 mm in September (Table 1.12). The increase in mean length reflects growth of the young of the year cohort throughout the summer season.

Weakfish (*Cynoscion regalis*)

Weakfish, a species of interest to recreational anglers, were collected in 28 of 120 trawls (23.3%) and eight of 38 beach seines (21%). A total of 616 juvenile weakfish were collected in trawl samples (608 fish) and beach seine samples (8 fish; Table 1.4). Weakfish ranked fifth out of 74 species in overall finfish abundance. The trawl CPUE was 40.4 fish/ha and the beach seine CPUE was 0.2 fish/ha.

The 2020 trawl and beach seine relative abundance indices were both equal to the grand means (Figure 1.28, Figure 1.29). Since 1989, the trawl (15 years) and beach seine indices (12 years) occasionally 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.

Productive trawl sample sites for weakfish were located in all coastal bays, indicating a broad distribution. Weakfish had 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 & Musick, 2013).

Weakfish mean length increased from 59 mm in July to 133 mm in October (Table 1.11). In the Beach Seine Survey, the mean length was 79 mm in September (Table 1.12). The increase in mean length from July to October 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 of richness and the proportion of those species in the sample population. In the 2020 Trawl Survey, Chincoteague Bay (27 species) held the most species of fishes and the St. Martin River (18 fishes) was the least diverse (Table 1.13). The Shannon index results indicated that Isle of Wight Bay (H = 2.3) was the most diverse whereas Newport Bay (H = 1.0) was the least diverse.

Chincoteague Bay had the highest richness (90 fishes) and annual mean richness (35.4 fishes) in the trawl 1989 - 2020 time series (Table 1.14). Newport Bay had the lowest richness (68 fishes) and mean richness (21.3 fishes) in the time series. The Shannon index results for the trawl time series indicated that Sinepuxent Bay (H = 1.7) was the most diverse whereas the St. Martin River (H = 1.3) was the least diverse.

In the 2020 Beach Seine Survey, Chincoteague Bay (41 species) held the most species of fishes and the Newport Bay (24 fishes) was the least diverse (Table 1.15). The Shannon index results indicated that the St. Martin River and Sinepuxent Bay (H = 2.4) were the most diverse whereas Assawoman Bay (H = 0.3) was the least diverse.

The Beach Seine Survey time series (1989 - 2020) results indicated that Isle of Wight Bay had the richest fish populations (88 fishes) while Chincoteague Bay had the highest mean richness (33.5 fishes; Table 1.16). Newport Bay had the lowest richness (70 fishes) and annual mean richness (20 fishes) in the time series, and terminal year richness (24 fishes). Beach Seine Survey diversity results throughout the time series were similar.

Ayers Creek is not an embayment and its habitat is not similar to the previously mentioned embayments sampled by beach seine. Those data were included in the tables to show the results of Newport Bay's headwaters, which were lower in richness and diversity than the embayments, yet show a remarkable number of fish species (44 fishes) in the time series (Table 1.16). Ayers Creek has had high abundance of Atlantic menhaden and golden shiners on a regular basis, whereas spot were infrequently encountered.

Richness and diversity are important components of a healthy estuary and can provide fish communities resilience to changes in the environment. There was not a linear relationship between the richness and diversity in the coastal bays. Results indicated that the coastal bays' richness was relatively high while diversity was generally low. A strong year class can reduce the diversity value by minimizing the effect of other fish contributions to the sample population because the analysis favors species richness proportions at equal levels in the sample population. High diversity will allow for resilience to climate change. 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.

Macroalgae

The macroalgae time series spans 15 years from 2006 - 2020. To date, 20 genera and 67,628 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 (Table 1.17). 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 2020, which was above the average (14.9 genera) in the time series (Table 1.10). The 2020 Shannon index of diversity among genera by trawl (H = 1.2) was below the time series average (H = 1.3). Results indicated that *Agardhiella* were the most abundant macroalgae (61.4%) in 2020. The only other genera that contributed more than 5% to the sample population were *Ulva* (14.6%), *Polysiphonia* (13.8 %), and *Gracilaria* (6.1%). The 2020 trawl CPUE (51.1 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.30).

Eleven genera were sampled within the coastal bays by beach seine in 2020 (Table 1.10). The Shannon index of diversity among genera (H = 1.0) was below the time series average (H = 1.1). Results indicated that *Codium* were most abundant (63.7%). The only other genera that contributed more than 5% to the sample population were *Agardhiella* (23.5%) and *Polysiphonia* (7.7%). The 2020 beach seine CPUE (43 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 1.31).

Macroalgae in Maryland's coastal bays were investigated consistently over 15 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 (2020) had 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 had 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.

Assawoman Bay
This embayment has been dominated by Rhodophyta since sampling began in 2006 (Table 1.17). Six different genera were collected by trawl in 2020, 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 = 0.7) was below the time series average (H = 0.9). *Agardhiella* (67.2%) was most abundant geuns. *Ulva* (30.5%) was the only other genus that contributed more than 5% to the sample population. The 2020 CPUE (112.6 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.32).

Eight different genera were collected by beach seine in 2020, which was above the average (6.2 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment (H = 1.1) was above the time series average (H = 0.8). *Agardhiella* (48.6%) was most abundant, followed by *Cladophora* (34.8%) and *Gracilaria* (14%). The beach seine CPUE (6.8 L/haul) was below the grand mean. Since 2006, the beach seine CPUE frequently varied significantly from the grand mean (Figure 1.33).

Isle of Wight Bay
This embayment has been dominated by Rhodophyta since sampling began in 2006 (Table 1.17). Six different genera were collected by trawl in 2020, 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 (75.4%). The only other genus that contributed more than 5% to the sample population was *Gracilaria* (23.4%). The trawl CPUE (116.7 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.34).

Nine different genera were collected by beach seine in 2020, which was above the average (6.8 genera) for this embayment in the time series. The 2020 Shannon index of diversity among genera within this embayment (H = 0.6) was below the time series average (H = 1). *Agardhiella* (86.2%) was the most abundant. The 2020 beach seine CPUE (9.9 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 1.35).

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 (Table 1.17). Two different genera of macroalgae were collected by trawl in 2020, which was below the time series average (5.1 genera). The 2020 Shannon index of diversity among genera (H = 0.5) was below the time series average (H = 0.8). *Agardhiella* (81%) was most abundant; *Ulva* (19%) was the only other genera that contributed more than 5% of the sample population. Trawl CPUE (86.7 L/ha) in 2020 was equal to the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.36).

Four different genera were collected by beach seine in 2020, which was above the average (3.4 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2020 (H = 0.8) was above the time series average (H = 0.5). *Gracilaria* (51.1%) was most abundant; *Agardhiella* (47.5%) was the only other genera that contributed more than 5% of the sample population. The 2020 beach seine CPUE (15.5 L/haul) was below the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 1.37).

Sinepuxent Bay

This embayment has been dominated by Rhodophyta in nine of the 15 years since sampling began in 2006 (Table 1.17). Eight different genera of macroalgae were collected by trawl in 2020, 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 2020 (H = 1.2) was below the average (H = 1.3). *Agardhiella* (51.9%) was most abundant; *Polysiphonia* (23.6%) and *Ulva* (18.2 %) were the only genera that contributed more than 5% of the sample population. Trawl CPUE (10.1 L/ha) in 2020 was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.38).

Five different genera were collected by beach seine in 2020, which was below the average (5.9 genera) for this embayment in the time series. The Shannon index of diversity among genera within this embayment in 2020 (H = 0.5) was below the average (H = 0.6). *Agardhiella* (84.2%) was most abundant. *Ulva* (11.5%) was the only other genera that contributed more than 5% of the sample population. The 2020 beach seine CPUE (40.8 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 1.39).

Newport Bay

This embayment has been dominated by Rhodophyta in 12 of the 15 years since sampling began in 2006 (Table 1.17). Five different genera were collected by trawl in 2020, which was below the average (6.7 genera) for this embayment in the time series. The 2020 Shannon index of diversity among genera (H = 1.2) within this embayment was above the time series average (H = 1.1). *Polysiphonia* (62.1%) was most abundant. *Champia* (11.7%), *Ceramium* (11.7%), *Agardhiella* (8.6%), and *Ulva* were the only other genera that contributed more than 5% of the sample population. Trawl CPUE (12.4 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.40).

Two genera were collected by beach seine in 2020, which was below the average (3.6 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0.5) was above the time series average (H = 0.4). *Polysiphonia* (77.5%) was most abundant. *Agardhiella* (22.5%) was the only other genera that contributed more than 5% of the sample population. The 2020 beach seine CPUE (26 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean (Figure 1.41).

Chincoteague Bay

This embayment has undergone periodic shifts in macroalgae dominance (Table 1.17). Twelve different genera were collected by trawl in 2020, which was above the times series average (11.6 genera). The 2020 Shannon index of diversity among genera (H = 1.4) was below the average (H = 1.5) within this embayment for the time series. *Polysiphonia* (50.8%) was most abundant;

Agardhiella (29.9%) and *Vaucheria* (7.6%) were the only other genera that contributed more than 5% of the sample population. The CPUE (27.8 L/ha) was below the grand mean. Since 2006, the trawl CPUE occasionally varied significantly from the grand mean (Figure 1.42).

Six different genera were collected by beach seine in 2020, which was below the average (6.7 genera) for this embayment in the time series. The Shannon index of diversity among genera (H = 0.3) was below the time series average (H = 0.9). *Codium* (92.6%) was most abundant. The 2020 beach seine CPUE (88.9 L/haul) was equal to the grand mean. Since 2006, the beach seine CPUE frequently varied significantly from the grand mean (Figure 1.43).

Chincoteague Bay was the most diverse embayment in the Trawl Survey, a condition that reacts to changes in the environment. However, Chincoteague Bay was the least diverse embayment in the Beach Seine Survey. High abundance of *Codium* on one beach was driving the index in 2020. This is concerning because *Codium* is an invasive species. It competes with eelgrass or widgeon grass, can accumulate in dense patches preventing movement of fishes, and smothers shellfish beds. It has been reported that *Codium* and other macroalgae epiphytes consisting of diatoms, zooplankton, larval species of shellfish, and sponges live on the surface (Oktay, 2008).

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 flounder 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, Cebrian, Furlong, & Valiela, 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, Peterson, & Gobler, 2018).

Water Quality

Temperature

The mean seasonal trawl temperatures varied by as much as 3.9 C (Assawoman Bay (25.0 C), Isle of Wight Bay (25.3 C), St. Martin River (26.2 C), Sinepuxent Bay (22.3 C), Newport Bay (24.1 C), and Chincoteague Bay (23.6 C)). For all bays, mean surface temperature peaked in July as expected (Figure 1.44). In Assawoman and Sinepuxent bays, water temperature was cooler in May than in October. The average trawl temperature in 2020 was 24.0 C, which was higher than the average temperature in 2019 (Figure 1.45).

For the first time since 1989, April was not sampled; therefore, a regression analysis of mean surface water temperature including and excluding April was conducted to determine effects (Figure 1.45). The time series mean annual temperatures not including April was consistently higher than the mean annual temperatures including April. April is typically one of the coolest months so this result was expected. Regression analysis of the annual May through October 1989 to 2020 mean surface water temperature indicated a significant increase in temperature over the time series ($r(32) = 0.49$, $p = 0.0041$) as did the regression including April temperature measurements (April - October 1989 - 2020 ($r(32) = 0.59$, $p = 0.0004$). The stronger regression value including April indicates that April is warming faster than the other months collectively.

During the June Beach Seine Survey, there was an 8.5 C difference between the highest (29 C at site S019) and lowest temperatures (20.5 C at site S008; Figure 1.46). In September, the temperature difference between the highest (26.9 C at site S001) and lowest temperature (19.2 C at site S019) was 7.7 C. Newport Bay (4.8 C) and the Chincoteague Bay (4.4 C) experienced the most abrupt decreases in temperature between June and September.

The average mean temperature has increased from 1989 through 2020, which has supported the abundance and species composition expansion of fishes and invertebrates into Maryland waters. These surveys have documented an increased abundance of species traditionally considered southern, such as Atlantic spadefish, pinfish, sheepshead, and penaeid shrimp. Warmer temperatures have supported range expansions into our sampling area and warrants monitoring of changes in species composition.

Dissolved Oxygen

As expected, the trawl DO generally decreased as water temperatures increased (Figure 1.47). The mean trawl DO for all bays in 2020 was 6.8 mg/L. Surface DO measured below 5 mg/L four times in 2020 and those events occurred in September. For organisms in the Chesapeake Bay, 5 mg/L is accepted as necessary for life, but that value can vary based on the organism (Chesapeake Bay Program, 2021). For example, a DO of up to 6 mg/L is necessary for larvae and eggs of spawning migratory fish, however, some bottom dwelling fish can tolerate DO levels as low as 3 mg/L (Chesapeake Bay Program, 2021).

For the first time since 1989, April was not sampled; therefore, a regression analysis of mean DO including and excluding April was conducted to determine effects (Figure 1.48). The time series mean annual DO values including April were frequently higher than excluding April. April is typically one of the coolest months so this result was expected as cooler waters have higher oxygen saturation values. Regression analysis of the annual May through October 1998 to 2020 mean DO results indicated a significantly increasing DO since 1998 ($r(23) = 0.75$, $p < 0.0001$) as did including April DO measurements (April - October 1998 - 2020; ($r(23) = 0.77$, $p < .0001$). Both regressions were similar in trend and magnitude.

The 2020 Beach Seine Survey mean DO was generally higher in June than September and above 5 mg/L for 36 out 38 samples (Figure 1.49). Despite DO being below 5 mg/L at S006 (4.02) and S019 (4.3 mg/L) catches were within normal expectations. Hypoxic conditions (below 2 mg/L) were not observed in the 2020 survey; however, it has occurred eight times since 1989. Six of those occurrences were at S019.

Dissolved oxygen peaks during the day and can actually supersaturate from photosynthesis and bottoms out at night when respiration occurs. 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 overridden by high respiration leading to hypoxic conditions.

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 2020 Trawl Survey bay wide average salinity (25.9 ppt) was higher than 2019 (25.03 ppt), although not significantly. The St. Martin River salinity was the lowest over the sampling period, which was expected, based on the sampling locations' distance from the inlet and freshwater inputs (Figure 1.50). Salinity in the remaining embayments tended to be consistent with one notable exception in Newport Bay in July. The Newport Bay average was influenced by the salinity taken at site, T012 (15 ppt), which was located in Trappe Creek, far from the inlets with multiple creeks draining into that area (Figure 1.2); however, the last rain event was on July 10 which does not explain the occurrence (Steffen Thorsen, n.d.). Chincoteague Bay had the highest average seasonal salinity (27.1 ppt) and the St. Martin River had the lowest (22.4 ppt).

For the first time since 1989, April was not sampled; therefore, a regression analysis of mean salinity including and excluding April was conducted to determine effects (Figure 1.51). The mean annual salinities in both time series were similar in values and trend. Regression analysis of the annual May through October 1989 to 2020 mean salinity results indicated no significant trend in salinity since 1989 ($r(32) = -0.047$, $p = 0.798$) as did including April salinity measurements (1989 - 2019 and May - October 2020) ($r(32) = -0.032$, $p = 0.863$). Since there was not a significant trend in salinity over time, it was not possible to determine if including or excluding April data had an effect on mean annual salinity trends.

The Beach Seine Survey bay wide salinities were similar between June and September. Chincoteague Bay had the lowest salinity in both June (24.7 ppt) and September (24.8). Isle of Wight Bay (27.3) was nearly tied with Sinepuxent Bay (27.2) for the highest salinity in June and Sinepuxent Bay was the highest in September (28.1 ppt; Figure 1.52).

Turbidity

The 2020 Trawl Survey bay wide mean turbidity was 94.3 cm. The St. Martin River was the most turbid embayment (mean = 63.7 cm) whereas Chincoteague Bay was the least (mean = 119 cm; Figure 1.53). The bottom was visible five times (4.17%) out of 120 samples. Visibility decreased during the warmer months.

For the first time in the time series, April was not sampled; therefore, a regression analysis of turbidity including and excluding April was conducted to determine effects (Figure 1.54). The average annual turbidity was generally higher with the inclusion of April data indicating that April is typically a month with lower turbidity. Regression analysis of the annual May through October 1989 to 2020 mean turbidity results indicated no significant trend in turbidity since 2006 ($r(15) = 0.50$, $p = 0.0590$) as did including April turbidity measurements (April - October 2006 - 2020) ($r(15) = 0.43$, $p = 0.1077$). The bay wide mean turbidity value over the time series was 87 cm, which was below the 2020 mean 94.3 cm. Site T020, located on the Maryland - Virginia state line, was the clearest (133.1 cm) in the time series.

The waters became less turbid in Sinepuxent, Newport, and Chincoteague bays from June to September in the 2020 Beach Seine Survey (Figure 1.55). Turbidity increased in the other three bays. Sinepuxent Bay had the worst annual visibility (60.5 cm) and Chincoteague Bay had the best mean annual visibility (70.5 cm).

Although Kemp et al (2004) found that 150 cm was a sufficient depth to allow enough light for SAV growth, most of the trawl and beach seine sites do not have SAV. Few trawl sites are suitable for SAV and are limited by depth (>5 ft), located near channels or high flow areas. Unlike trawl sites, beach seine sites are less than <5 ft deep but are mostly devoid of SAV except for a few sites on the eastern side of Chincoteague Bay. SAV may be limited at those sites by not only turbidity, but also warm summer water temperatures, bottom substrate, and macroalgae.

Table 1.1. 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 1.2. 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 1.3. Measurement types for fishes and invertebrates captured in 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 1.4. List of fishes collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of total abundance. Total trawl sites = 120, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul
Atlantic menhaden	*Brevoortia tyrannus*	13,426	59	13,367	3.9	351.8
Bay anchovy	*Anchoa mitchilli*	3,888	3,089	799	205.3	21.0
Spot	*Leiostomus xanthurus*	1,986	981	1,005	65.2	26.4
Atlantic silverside	*Menidia menidia*	1,186	84	1,102	5.6	29.0
Weakfish	*Cynoscion regalis*	616	608	8	40.4	0.2
Silver perch	*Bairdiella chrysoura*	274	187	87	12.4	2.3
Summer flounder	*Paralichthys dentatus*	261	109	152	7.2	4.0
Mummichog	*Fundulus heteroclitus*	202	9	193	0.6	5.1
Inland silverside	*Menidia beryllina*	193		193		5.1
Winter flounder	*Pseudopleuronectes americanus*	191	67	124	4.5	3.3
Striped anchovy	*Anchoa hepsetus*	181	77	104	5.1	2.7
Atlantic croaker	*Micropogonias undulatus*	129	125	4	8.3	0.1
Atlantic spadefish	*Chaetodipterus faber*	106	73	33	4.8	0.9
Pinfish	*Lagodon rhomboides*	82	4	78	0.3	2.0
White mullet	*Mugil curema*	78		78		2.0
Black sea bass	*Centropristis striata*	74	61	13	4.0	0.3
Atlantic needlefish	*Strongylura marina*	72		72		1.9
Inshore lizardfish	*Synodus foetens*	64	12	52	0.8	1.4
Hogchoker	*Trinectes maculatus*	49	11	38	0.7	1.0
Oyster toadfish	*Opsanus tau*	44	5	39	0.3	1.0
Blackcheek tonguefish	*Symphurus plagiusa*	43	6	37	0.4	1.0
Northern pipefish	*Syngnathus fuscus*	30	9	21	0.6	0.6
Rough silverside	*Membras martinica*	30		30		0.8
Sheepshead	*Archosargus probatocephalus*	30		30		0.8
Rainwater killifish	*Lucania parva*	23		23		0.6
Banded killifish	*Fundulus diaphanus*	22		22		0.6
Striped mullet	*Mugil cephalus*	22		22		0.6
Striped killifish	*Fundulus majalis*	20		20		0.5
Northern puffer	*Sphoeroides maculatus*	18	8	10	0.5	0.3
American eel	*Anguilla rostrata*	16	13	3	0.9	<0.1
Southern kingfish	*Menticirrhus americanus*	16	1	15	0.1	0.4
Pigfish	*Orthopristis chrysoptera*	15	1	14	0.1	0.4
Striped burrfish	*Chilomycterus schoepfii*	14	6	8	0.4	0.2
Dusky pipefish	*Syngnathus floridae*	13	5	8	0.3	0.2
Naked goby	*Gobiosoma bosc*	13	4	9	0.3	0.2
Black drum	*Pogonias cromis*	12	2	10	0.1	0.3
Halfbeak	*Hyporhamphus unifasciatus*	11		11		0.3

Table 1.4. cont. List of fishes collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of abundance. Total trawl sites = 120, total seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul
Spotted hake	*Urophycis regia*	11	11		0.7	
Spotted seatrout	*Cynoscion nebulosus*	10	3	7	0.2	0.2
Feather blenny	*Hypsoblennius hentz*	7	1	6	0.1	0.2
Southern stingray	*Dasyatis americana*	7		7		0.2
Golden shiner	*Notemigonus crysoleucas*	6		6		0.2
Striped blenny	*Chasmodes bosquianus*	6		6		0.2
Lookdown	*Selene vomer*	5		5		0.1
Northern kingfish	*Menticirrhus saxatilis*	5	1	4	0.1	0.1
Harvestfish	*Peprilus paru*	4		4		0.1
Lined seahorse	*Hippocampus erectus*	4	2	2	0.1	<0.1
Spotfin mojarra	*Eucinostomus argenteus*	4		4		0.1
Bluefish	*Pomatomus saltatrix*	3		3		<0.1
Northern searobin	*Prionotus carolinus*	3	1	2	0.1	<0.1
Pumpkinseed	*Lepomis gibbosus*	3		3		<0.1
Spanish mackerel	*Scomberomorus maculatus*	3	3		0.2	
Striped bass	*Morone saxatilis*	3		3		<0.1
Atlantic cutlassfish	*Trichiurus lepturus*	2	2		0.1	
Blue runner	*Caranx crysos*	2	1	1	0.1	<0.1
Bluegill	*Lepomis macrochirus*	2		2		<0.1
Butterfish	*Peprilus triacanthus*	2	2		0.1	
Gizzard shad	*Dorosoma cepedianum*	2	1	1	0.1	<0.1
Gray snapper	*Lutjanus griseus*	2		2		<0.1
Redfin pickerel	*Esox americanus americanus*	2		2		<0.1
Scup	*Stenotomus chrysops*	2	2		0.1	
Smallmouth flounder	*Etropus microstomus*	2	1	1	0.1	<0.1
Striped searobin	*Prionotus evolans*	2	2		0.1	
Tautog	*Tautoga onitis*	2		2		<0.1
Atlantic moonfish	*Selene setapinnis*	1	1		0.1	
Bluespotted cornetfish	*Fistularia tabacaria*	1	1		0.1	
Cownose ray	*Rhinoptera bonasus*	1		1		<0.1
Fourspine stickleback	*Apeltes quadracus*	1	1		0.1	
Green goby	*Microgobius thalassinus*	1	1		0.1	
Gulf kingfish	*Menticirrhus littoralis*	1	1		0.1	
Northern sennet	*Sphyraena borealis*	1		1		<0.1
Red drum	*Sciaenops ocellatus*	1		1		<0.1
Silver hake	*Merluccius bilinearis*	1		1		<0.1
Skilletfish	*Gobiesox strumosus*	1		1		<0.1
	Total Finfish	**23,566**	**5,654**	**17,912**		

Table 1.5. Number of species and individual fish caught by year and gear in the Trawl and Beach Seine surveys.

	Number of Species			Number of Fish		
Year	Trawl	Beach Seine	Combined	Trawl	Beach Seine	Combined
1989	48	59	74	20,954	7,704	28,658
1990	55	52	70	28,080	21,362	49,442
1991	51	70	82	11,460	14,798	26,258
1992	49	60	70	8,188	21,426	29,614
1993	55	66	78	25,156	24,776	49,932
1994	55	56	72	48,087	29,386	77,473
1995	57	56	75	12,295	14,062	26,357
1996	49	51	67	10,258	17,083	27,341
1997	49	58	69	25,588	33,324	58,912
1998	52	59	71	11,684	13,729	25,413
1999	56	64	80	13,828	24,571	38,399
2000	60	61	81	19,167	22,664	41,831
2001	53	63	75	9,242	6,702	15,944
2002	69	57	81	16,766	32,716	49,482
2003	51	44	62	11,676	13,227	24,903
2004	48	51	66	9,231	19,473	28,704
2005	49	56	73	13,771	21,069	34,840
2006	51	60	79	10,053	10,380	20,433
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	51	55	68	30,985	22,800	53,785
2020	46	63	74	5,654	17,912	23,566

Table 1.6. Summary of the 2020 Trawl and Beach Seine surveys; species abundance is defined as above, below or equal to the grand mean.

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

Table 1.7. List of crustaceans collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of total abundance. Total trawl sites = 120, total beach seine sites = 38.

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	Estimated Count (T)	Estimated Count (S)	CPUE (T) #/Hect.	CPUE (S) #Haul
Blue crab	*Callinectes sapidus*	1,695	1,029	666			68.4	17.5
Grass shrimp	*Palaemonetes sp.*	1,669	87	10	122	1,450	13.9	38.4
Sand shrimp	*Crangon septemspinosa*	584	109		60	415	11.2	10.9
White shrimp	*Litopenaeus setiferus*	380	218	162			14.5	4.3
Lady crab	*Ovalipes ocellatus*	290	21	269			1.4	7.1
Brown shrimp	*Farfantepenaeus aztecus*	130	101	29			6.7	0.8
Long-armed hermit crab	*Pagurus longicarpus*	124	88	36			5.8	0.9
Say mud crab	*Dyspanopeus sayi*	88	75	13			5.0	0.3
Mantis shrimp	*Squilla empusa*	19	18	1			1.2	<0.1
Portly spider crab	*Libinia emarginata*	5	5				0.3	
Atlantic rock crab	*Cancer irroratus*	3	3				0.2	
Bigclaw snapping shrimp	*Alpheus heterochaelis*	2	1	1			0.1	<0.1
Spider crabs	*Libinia*	2	2				0.1	
Lesser blue crab	*Callinectes similis*	1		1				<0.1
Longnose spider crab	*Libinia dubia*	1	1				0.1	
Peppermint shrimp	*Lysmata wurdemanni*	1	1				0.1	
	Total Crustaceans	**4,994**	**1,759**	**1,188**	**182**	**1,865**		

Table 1.8. List of molluscs collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of total abundance. Total trawl sites = 120, total beach seine sites = 38.

Common Name	**Scientific Name**	**Total Number Collected**	**No. Collect (T)**	**No. Collect (S)**	**Est. Cnt. (T)**	**Est. Cnt. (S)**	**Spec. Vol. (L) (T)**	**Spec. Vol. (L) (S)**	**Est. Vol. (L) (T)**	**Est. Vol. (L) (S)**	**CPUE (T) #/Hect.**	**CPUE (S) #Haul**
Atlantic brief squid	*Lolliguncula brevis*	164	164								10.9	
Eastern mudsnail	*Nassarius obsoletus*	68	2	36		30					0.1	1.7
Solitary glassy bubble snail	*Haminoea solitaria*	45	45								3.0	
Convex slippersnail	*Crepidula convexa*	27	27								1.8	
Gastropods	*Gastropoda*	21	1		20						1.4	
Striped nudibranch	*Cratena pilata*	13	13								0.9	
Lemon drop	*Doriopsilla pharpa*	7	7								0.5	
Ribbed mussel	*Geukensia demissa*	2		2								<0.1
Channeled whelk	*Busycotypus canaliculatus*	1	1								0.1	
Chitons	*Polyplacophora*	1	1								0.1	
Dwarf surfclam	*Mulinia lateralis*	1	1								0.1	
Longfin inshore squid	*Loligo pealeii*	1	1								0.1	
Northern quahog	*Mercenaria mercenaria*	1		1								<0.1
Atlantic awningclam	*Solemya velum*											
	Total Molluscs	**352**	**263**	**39**	**20**	**30**						

Table 1.9. List of other species collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of total abundance. Total trawl sites = 120, total beach seine sites = 38.

Common Name	**Scientific Name**	**Total Number Collected**	**No. Collect (T)**	**No. Collect (S)**	**Est. Cnt. (T)**	**Est. Cnt. (S)**	**Spec. Vol. (L) (T)**	**Spec. Vol. (L) (S)**	**Est. Vol. (L) (T)**	**Est. Vol. (L) (S)**	**CPUE (T) #/Hect.**	**CPUE (S) #/Haul**	**CPUE (T) #/Hect. Vol.**	**CPUE (S) #/Haul Vol.**
Sea nettle	*Chrysaora quinquecirrha*	513	103		410						34.1			
Comb jellies	*Ctenophora*	178	111	12	30	25	272.3	5.0	0.8		9.4	1.0	18.1	0.1
Moon jelly	*Aurelia aurita*	84	60	24							4.0	0.6		
Sea squirt	*Molgula manhattensis*	62	7		55		0.8				4.1		<0.1	
Beroe comb jelly	*Beroe ovata*	44	13	31							0.9	0.8		
Hairy sea cucumber	*Sclerodactyla briareus*	42	34	8							2.3	0.2		
Horseshoe crab	*Limulus polyphemus*	24	12	12							0.8	0.3		
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	11	2	9							0.1	0.2		
Sea cucumbers	*Cucumariidae*	6	6								0.4			
Goldstar tunicate	*Botryllus schlosseri*						0.8						<0.1	
Sea pork	*Aplidium sp.*						4.7	0.1					0.3	
Bryozoans	*Ectoprocta*						13.3	0.2					0.9	
Rubbery bryozoan	*Alcyonidium sp.*						0.0	10.0						0.3
Fig sponge	*Suberites ficus*						1.7						0.1	
Halichondria sponge	*Halichondria sp.*						8.0	4.3					0.5	0.1
Red beard sponge	*Microciona prolifera*						74.9	1.9					5.0	<0.1
Sulphur sponge	*Cliona celata*						10.1						0.7	
	Total Other	**964**	**348**	**96**	**495**	**25.0**	**386.6**	**21.5**	**0.8**					

Table 1.10. List of Submerged Aquatic Vegetation (SAV) and macroalgae collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from May through October 2020. Species are listed by order of total abundance. Total trawl sites = 120, total beach seines = 38.

Common Name	Genus	Specific Volume (L) (T)	Specific Volume (L) (S)
SAV			
Eel grass	*Zostera*	1.2	15.1
Widgeongrass	*Ruppia*	0.5	1.4
	Total SAV	**1.7**	**16.5**
Macroalgae			
Brown			
Brown bubble algae	*Colpomenia*	0.1	
Common southern kelp	*Laminaria*	0.1	
Sour weeds	*Desmarestia*	0	
		0.2	
Green			
Sea lettuce	*Ulva*	112.1	29.9
Green hair algae	*Chaetomorpha*	4.5	1.0
Green fleece	*Codium*	2.7	985.0
Hollow green weed	*Enteromorpha*	1.7	0.1
Green sea fern	*Bryopsis*	0.5	
Green tufted seaweed	*Cladophora*		14.4
		121.5	**1,030.3**
Red			
Agardh's red weed	*Agardhiella*	472.2	359.5
Tubed weeds	*Polysiphonia*	105.9	119.2
Graceful red weed	*Gracilaria*	46.7	34.4
Banded weeds	*Ceramium*	6.0	1.1
Barrel weed	*Champia*	3.8	0.2
Hairy basket weed	*Spyridia*	0	
		634.5	**514.5**
Yellow-Green			
Water felt	*Vaucheria*	12.7	1.5
		12.7	**1.5**
	Total Macroalgae	**768.9**	**1,546.3**

Table 1.11. Length by month for selected fishes from the 2020 Trawl Survey.

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
American eel (*Anguilla rostrata*)	May	6	6	52	93	72.5	13.2
	June	6	6	68	90	75.8	8.6
	July	1	1	245	245	245	
	Aug						
	Sep						
	Oct						
Atlantic croaker (*Micropogonias undulatus*)	May	18	18	80	241	111.4	39.1
	Jun	84	46	71	152	110.2	18.8
	Jul	12	12	80	200	145.9	27.6
	Aug						
	Sep						
	Oct	11	10	17	35	23.8	5.5
Atlantic menhaden (*Brevoortia tyrannus*)	May	1	1	42	42	42	
	Jun	4	3	46	66	54	10.6
	Jul	12	12	44	113	78.9	16.7
	Aug	31	29	84	120	94.7	8.3
	Sep	11	11	70	115	88.6	15.4
	Oct						
Atlantic silverside (*Menidia menidia*)	May						
	Jun						
	Jul	83	32	48	74	62.6	6.1
	Aug	1	1	91	91	91	
	Sep						
	Oct						
Atlantic Spadefish (*Chaetodipterus faber*)	May						
	Jun						
	Jul						
	Aug	23	23	58	172	73.7	22.7
	Sep	50	50	68	106	90.7	7.1
	Oct						
Bay anchovy (*Anchoa mitchilli*)	May	41	41	40	80	61.9	8.7
	Jun	216	190	50	89	67.4	8.0
	Jul	548	235	24	88	58.2	17
	Aug	455	132	25	95	52.2	15.6
	Sep	1,395	139	17	137	46.5	20.3
	Oct	434	123	12	82	53	11.6
Black sea bass (*Centropristis striata*)	May	4	4	73	90	82.3	7.4
	Jun	20	20	75	145	104.4	18.9
	Jul	13	13	105	150	112.9	11.7
	Aug	17	17	50	158	136.8	23.6
	Sep	7	7	138	167	153.7	9.1
	Oct						

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
Silver perch (*Bairdiella chrysoura*)	May						
	Jun						
	Jul	74	37	24	163	50.8	27.3
	Aug	45	48	52	191	90.8	27.4
	Sep	60	53	65	137	99.5	18.9
	Oct	8	8	106	132	118.1	10.2
Spot (*Leiostomus xanthurus*)	May	12	11	24	75	40.5	19.5
	Jun	225	166	25	195	96.7	28.7
	Jul	376	243	34	191	102.5	23.3
	Aug	193	153	56	190	126.4	15.2
	Sep	91	90	98	170	133.5	11.6
	Oct	84	49	112	205	141.2	14.6
Summer flounder (*Paralichthys dentatus*)	May	19	19	40	245	75.1	44.1
	Jun	65	65	48	378	94.8	57.3
	Jul	9	9	89	160	117.6	26.3
	Aug	10	10	90	128	116.3	11.3
	Sep	2	2	88	98	93	7.1
	Oct	4	4	115	93	140.3	35.8
Weakfish (*Cynoscion regalis*)	May						
	Jun						
	Jul	391	163	23	100	58.7	13.9
	Aug	85	65	62	186	93.8	22.2
	Sep	129	67	22	147	107.6	17.2
	Oct	3	3	103	173	133.3	35.9

Table 1.12. Length by month for selected fishes from the 2020 Beach Seine Survey.

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
American eel	Jun	3	3	60	160	115	50.7
(*Anguilla rostrata*)	Sep						
Atlantic croaker	Jun	2	2	147	170	158.5	16.3
(*Micropogonias undulatus*)	Sep	2	2	203	221	212	12.7
Atlantic menhaden	Jun	4,654	205	25	78	46.8	8.4
(*Brevoortia tyrannus*)	Sep	7,402	52	70	157	95.6	12.5
Atlantic silverside	Jun	333	163	15	134	88.8	28.4
(*Menidia menidia*)	Sep	769	196	30	104	78.6	11.8
Atlantic spadefish	Jun						
(*Chaetodipterus faber*)	Sep	33	32	57	225	91.5	30.9
Bay anchovy	Jun	441	174	30	102	67.9	9.5
(*Anchoa mitchilli*)	Sep	357	95	22	75	40.5	11.4
Black sea bass	Jun	5	5	77	110	88	13.6
(*Centropristis striata*)	Sep	8	8	50	168	139.1	37
Bluefish	Jun	3	3	53	73	61	10.6
(*Pomatomus saltatrix*)	Sep						
Sheepshead	Jun						
(*Archosargus probatocephalus*)	Sep	30	25	47	250	69.3	38.4
Silver perch	Jun						
(*Bairdiella chrysoura*)	Sep	83	74	24	127	92.5	18.5
Spot	Jun	652	185	21	187	75.2	33.4
(*Leiostomus xanthurus*)	Sep	185	161	64	212	139.4	21
Summer flounder	Jun	132	119	29	254	70.4	35.7
(*Paralichthys dentatus*)	Sep	20	20	101	226	136.3	31
Weakfish	Jun						
(*Cynoscion regalis*)	Sept	8	8	25	127	79.1	37.9

Table 1.13. Finfish richness and diversity by system for the 2020 Trawl Survey (Assawoman Bay (n = 21), St. Martin River (n = 14), Isle of Wight Bay (n = 14), Sinepuxent Bay (n = 21), Newport Bay (n = 14), and Chincoteague Bay (n = 56)).

Embayment	Richness	Diversity
Assawoman Bay	20	1.5
St. Martin River	18	1.3
Isle of Wight Bay	22	2.3
Sinepuxent Bay	20	1.7
Newport Bay	19	1
Chincoteague Bay	27	1.7

Table 1.14. Finfish richness and diversity by system for the 1989 - 2020 Trawl Survey Assawoman Bay (n = 672), St. Martin River (n = 448), Isle of Wight Bay (n = 448), Sinepuxent Bay (n = 672), Newport Bay (n = 448), and Chincoteague Bay (n = 1,736)).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	81	28.3	1.4
St. Martin River	75	23.4	1.3
Isle of Wight Bay	86	30.6	1.6
Sinepuxent Bay	75	25.3	1.7
Newport Bay	68	21.3	1.4
Chincoteague Bay	90	35.4	1.5

Table 1.15. Finfish richness and diversity by system for the 2020 Beach Seine Survey (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), and Ayers Creek (n = 2)).

Embayment	Richness	Diversity
Assawoman Bay	34	0.3
St. Martin River	25	2.4
Isle of Wight Bay	35	1.8
Sinepuxent Bay	33	2.4
Newport Bay	24	0.9
Chincoteague Bay	41	2.1
Ayers Creek	11	0.8

Table 1.16. Finfish richness and diversity by system for the 1989 - 2020 Beach Seine Survey: Assawoman Bay (n = 192), St. Martin River (n = 64), Isle of Wight Bay (n = 192), Sinepuxent Bay (n = 192), Newport Bay (n = 128), Chincoteague Bay (n = 384), and Ayers Creek (n = 64).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	87	30.5	1.5
St. Martin River	72	20.8	1.4
Isle of Wight Bay	88	29.5	1.6
Sinepuxent Bay	77	27.8	1.4
Newport Bay	70	20.0	1.6
Chincoteague Bay	85	33.5	1.7
Ayers Creek	44	13.9	1.1

Table 1.17. Macroalgae dominance in the Maryland Coastal Bays as sampled by the Trawl and Beach Seine surveys 2006 - 2020.

	Assawoman Bay	Isle of Wight Bay	St. Martin River	Sinepuxent Bay	Newport Bay	Chincoteague Bay
2006	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2007	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2008	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta	Chlorophyta	Phaeophyta
2009	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta	Chlorophyta	Chlorophyta
2010	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta	Chlorophyta
2011	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2012	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2013	Rhodophyta	Rhodophyta	Chlorophyta	Rhodophyta	Rhodophyta	Rhodophyta
2014	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2015	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta
2016	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2017	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2018	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta	Rhodophyta	Chlorophyta
2019	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2020	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Chlorophyta

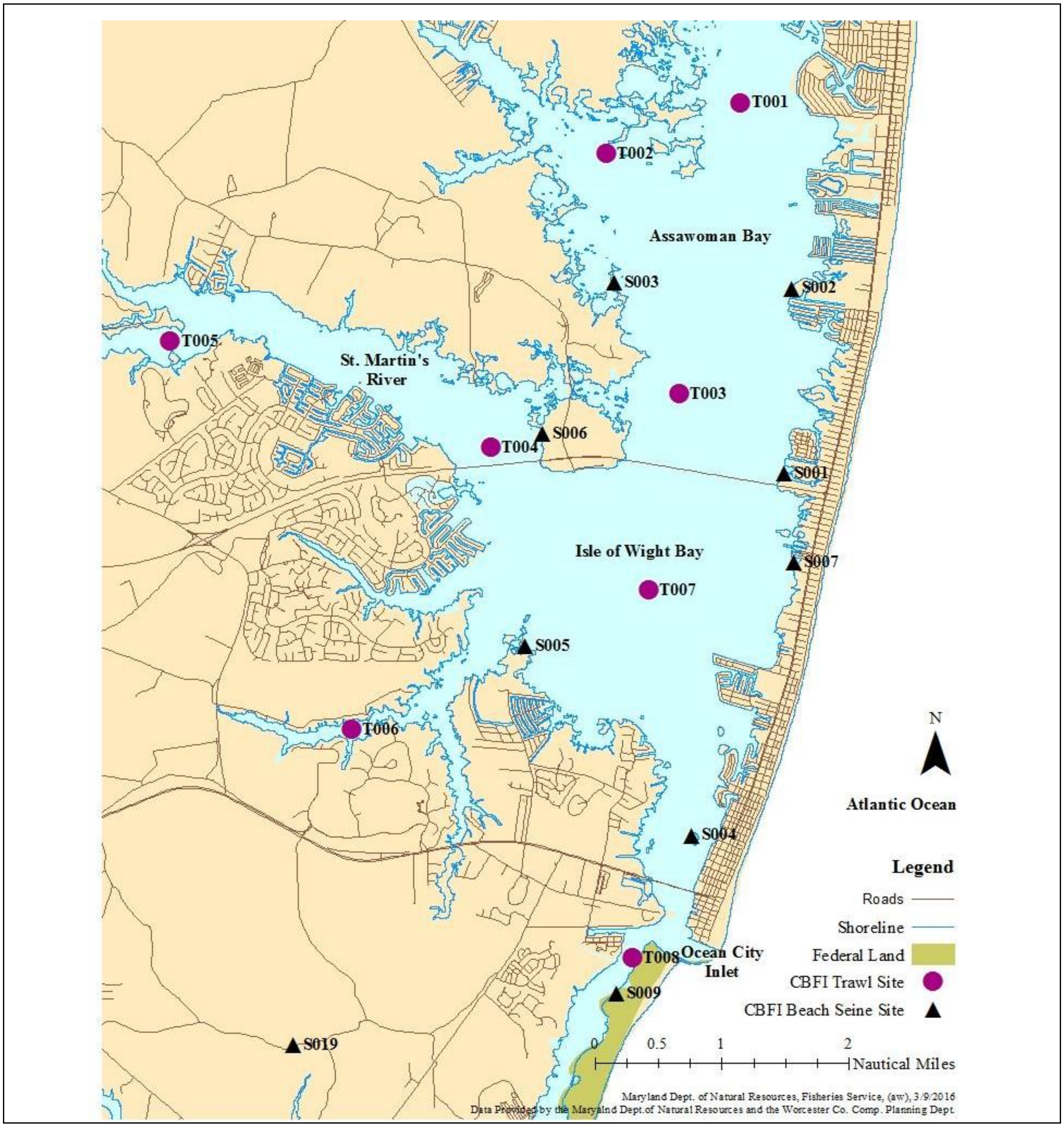

Figure 1.1. Trawl and Beach Seine surveys sampling locations in the Assawoman and Isle of Wight bays, Maryland.

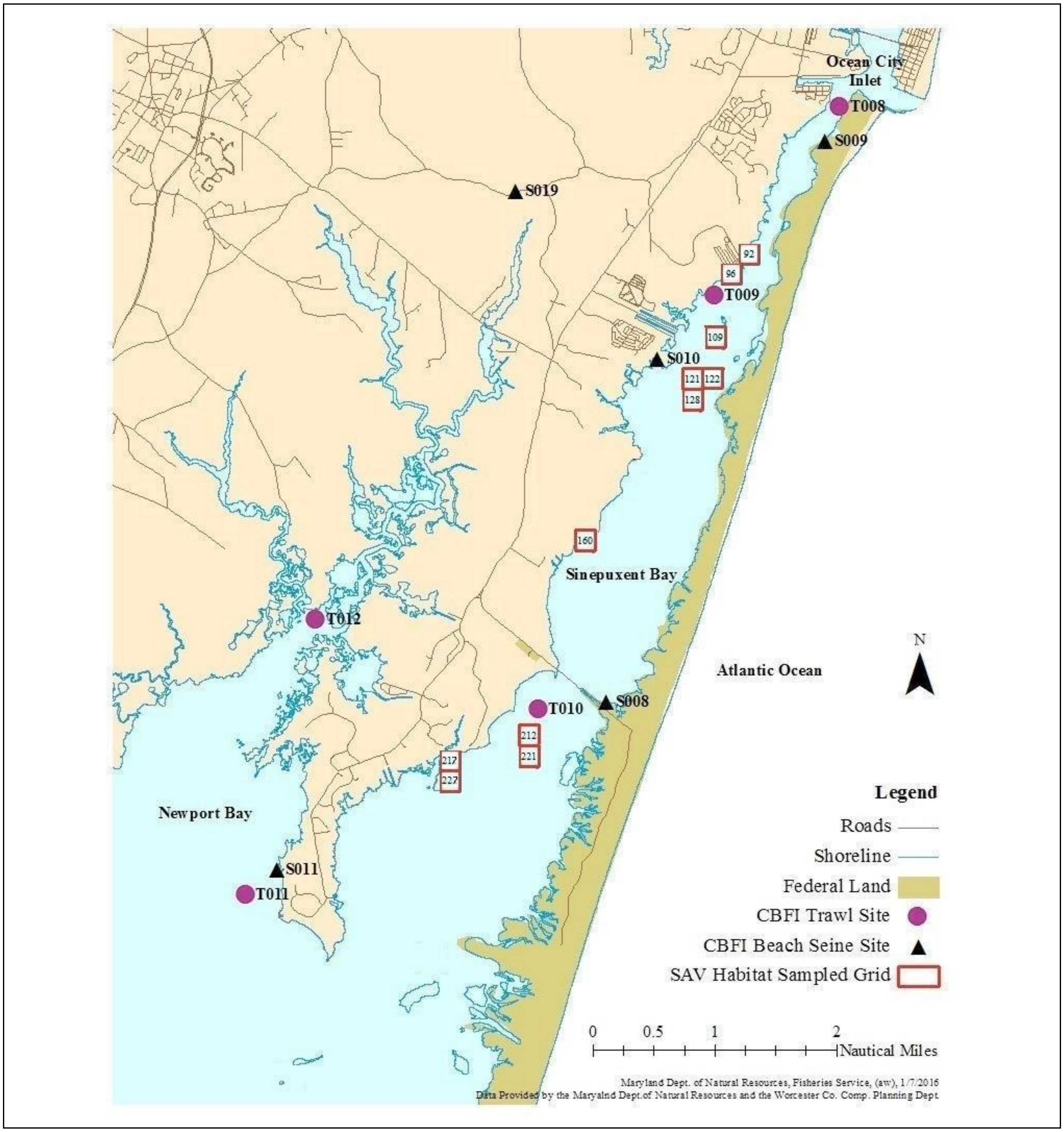

Figure 1.2. Trawl and Beach Seine surveys sampling locations in Sinepuxent and Newport bays, Maryland.

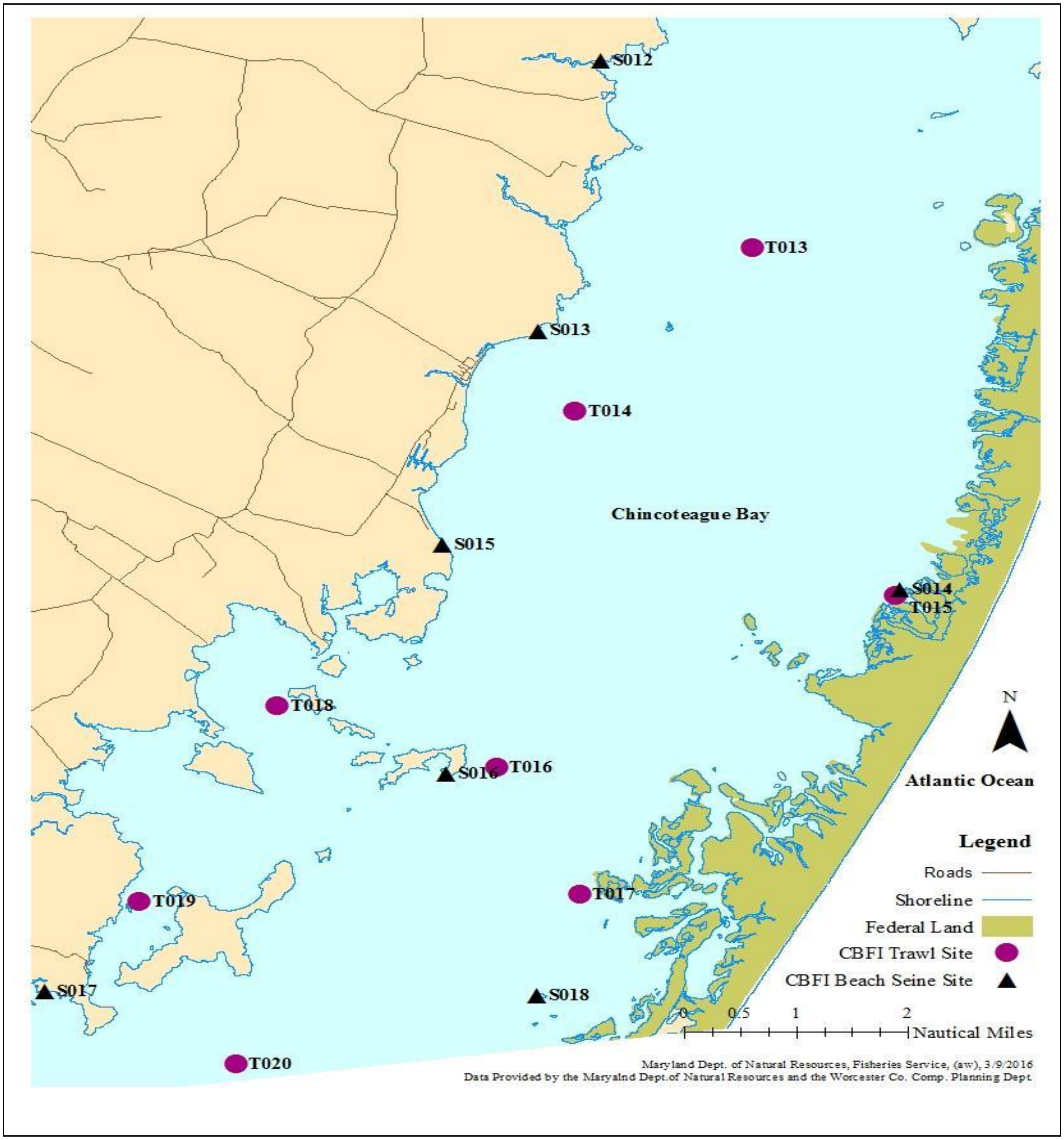

Figure 1.3. Trawl and Beach Seine surveys sampling locations in Chincoteague Bay, Maryland.

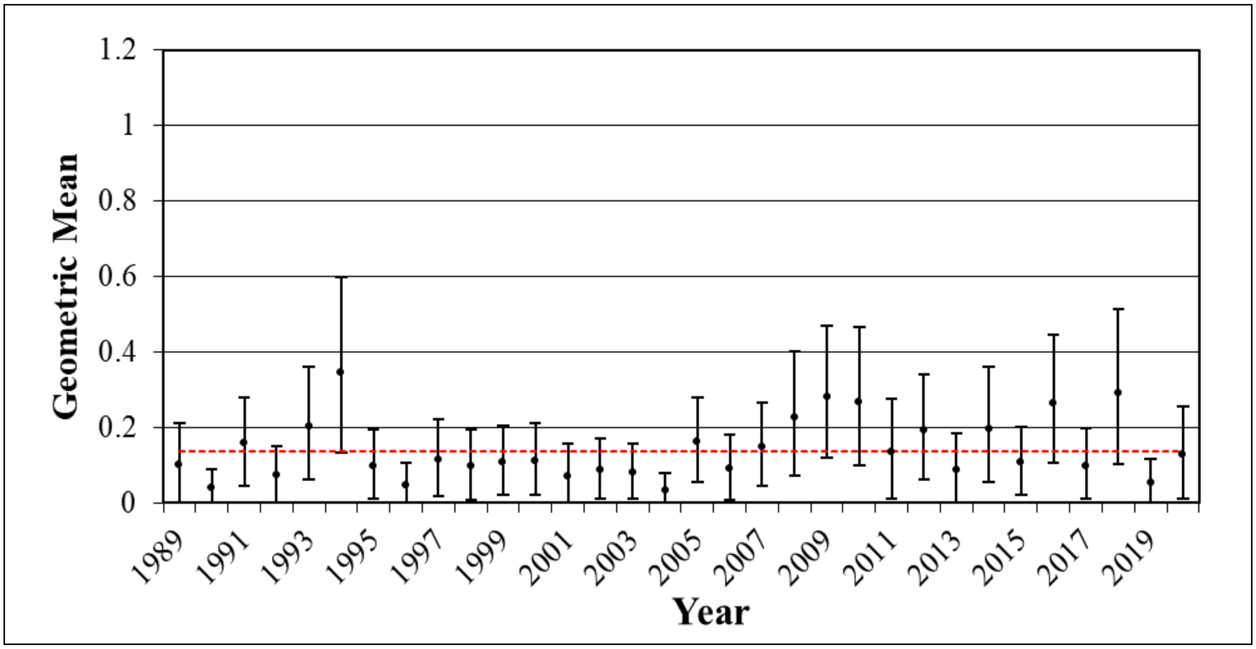

Figure 1.4. American eel (*Anguilla rostrata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

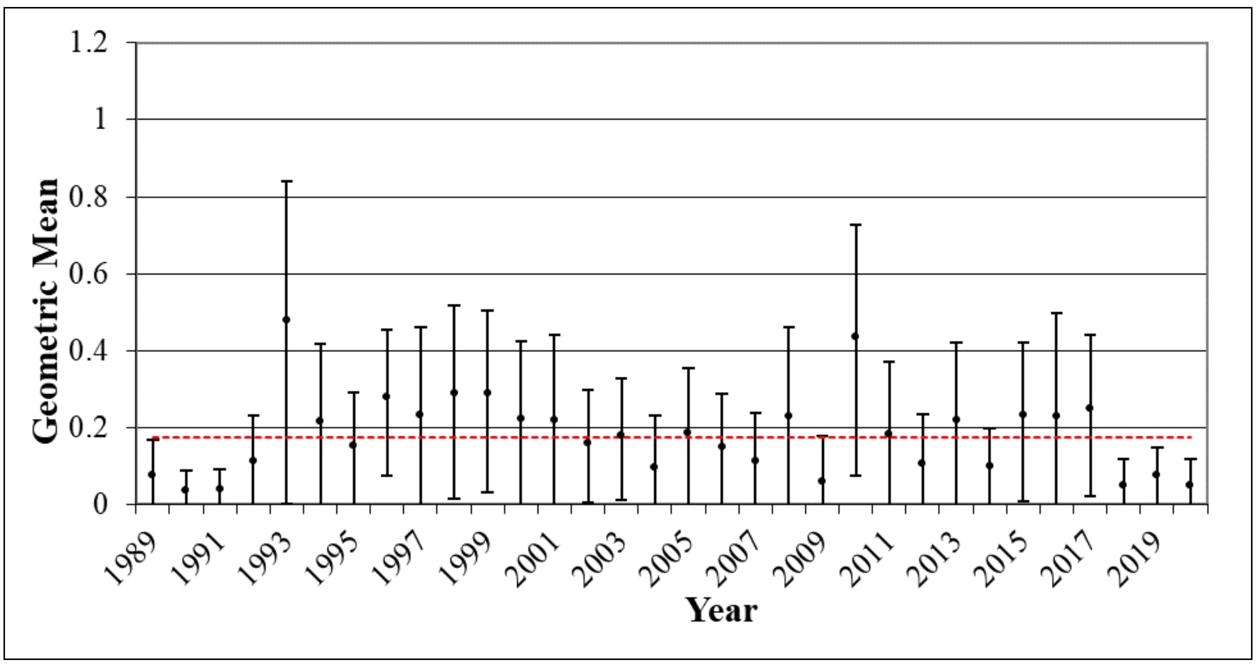

Figure 1.5. American eel (*Anguilla rostrata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

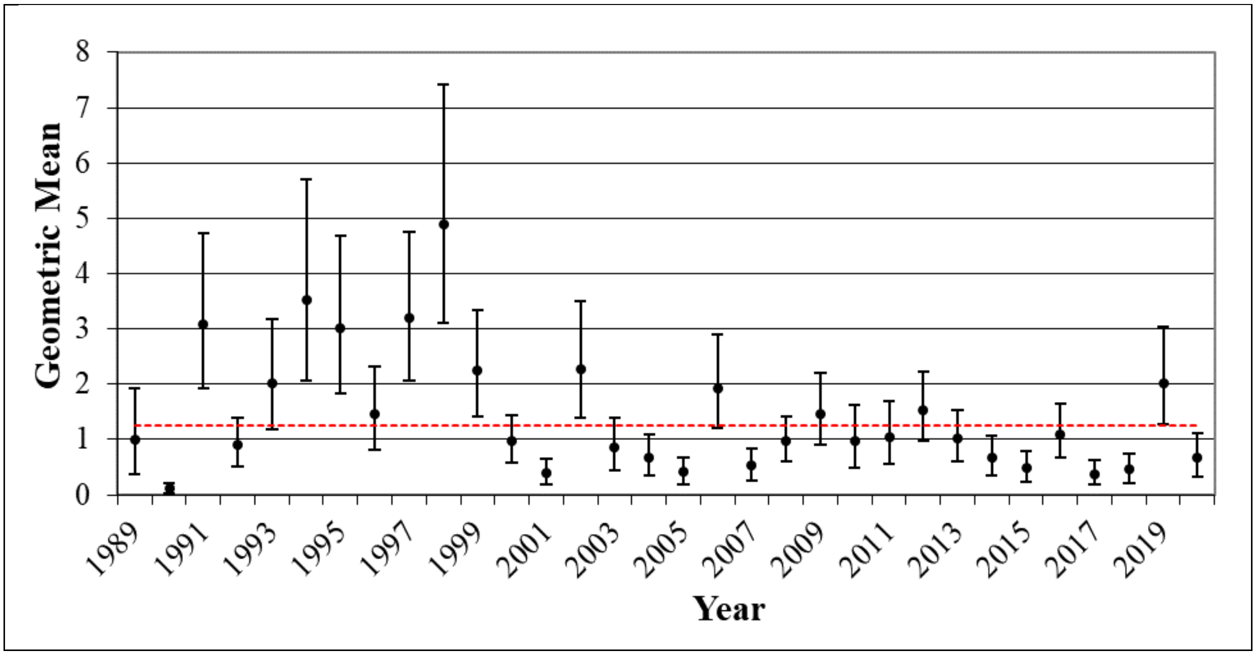

Figure 1.6. Atlantic croaker (*Micropogonias undulatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

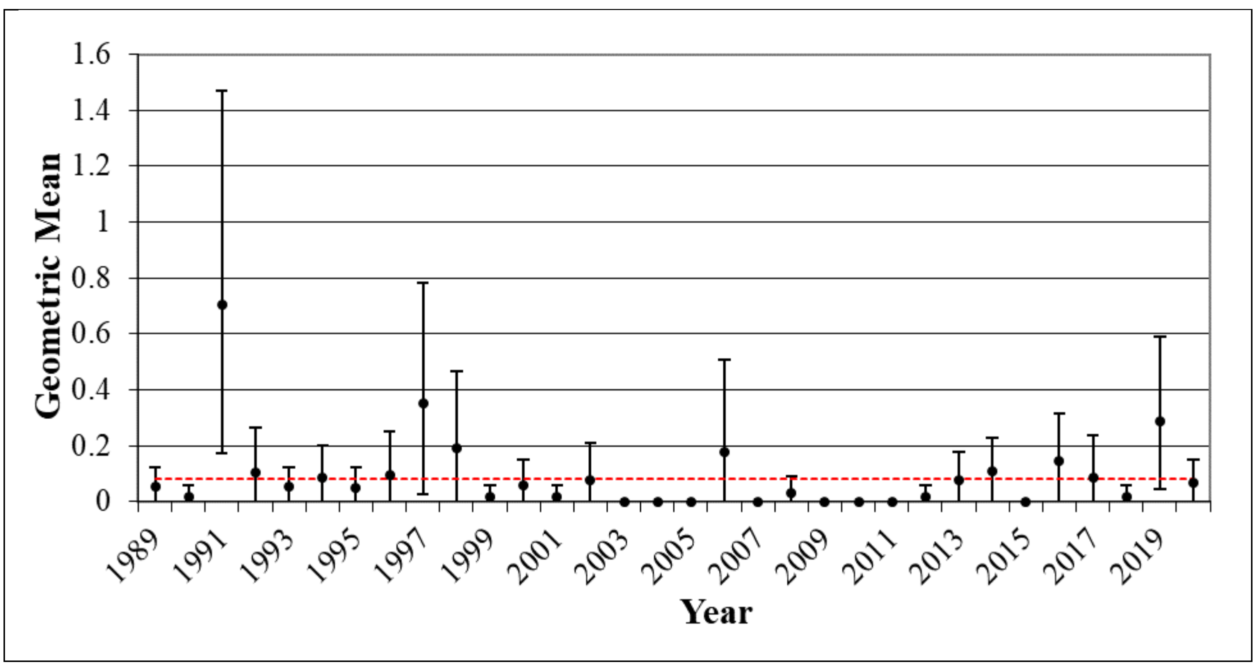

Figure 1.7. Atlantic croaker (*Micropogonias undulatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

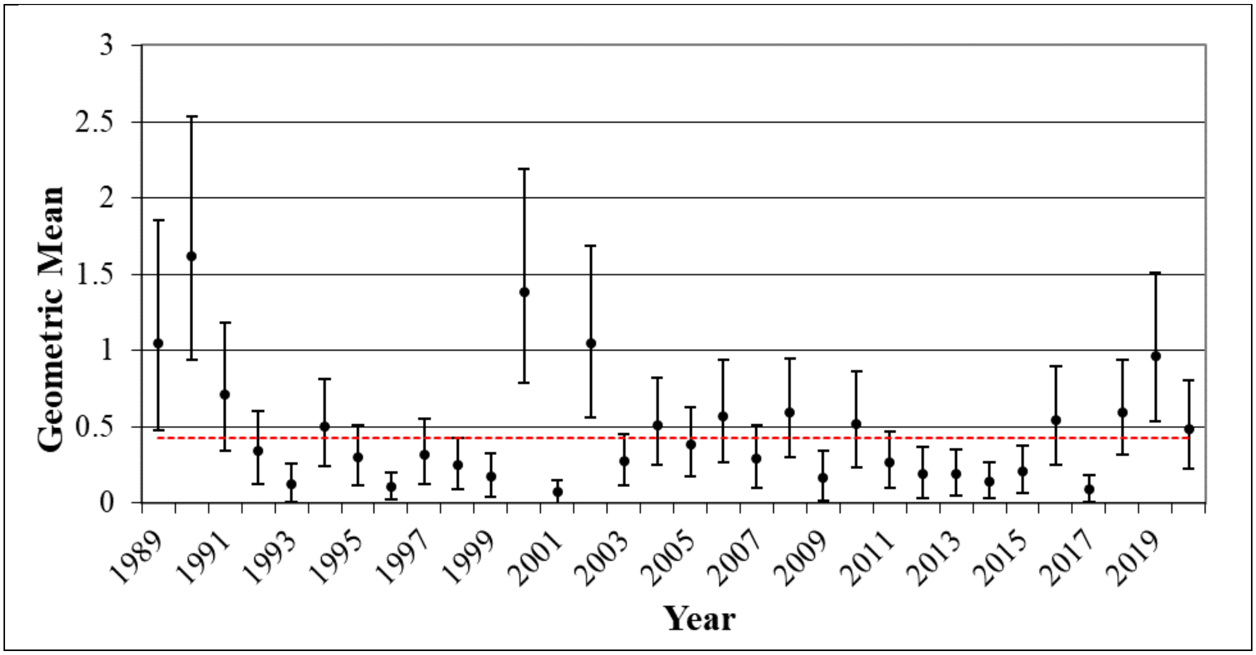

Figure 1.8. Atlantic menhaden (*Brevoortia tyrannus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\ -\ 2019}$ = 140/year, n_{2020} = 120).

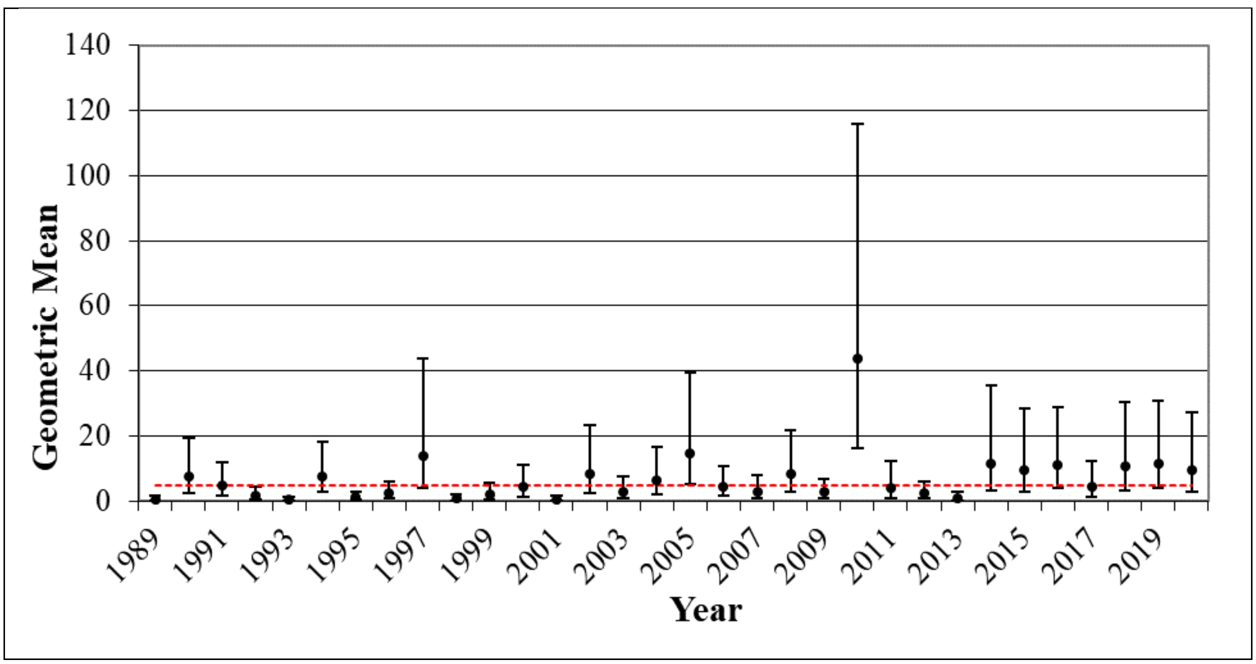

Figure 1.9. Atlantic menhaden (*Brevoortia tyrannus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

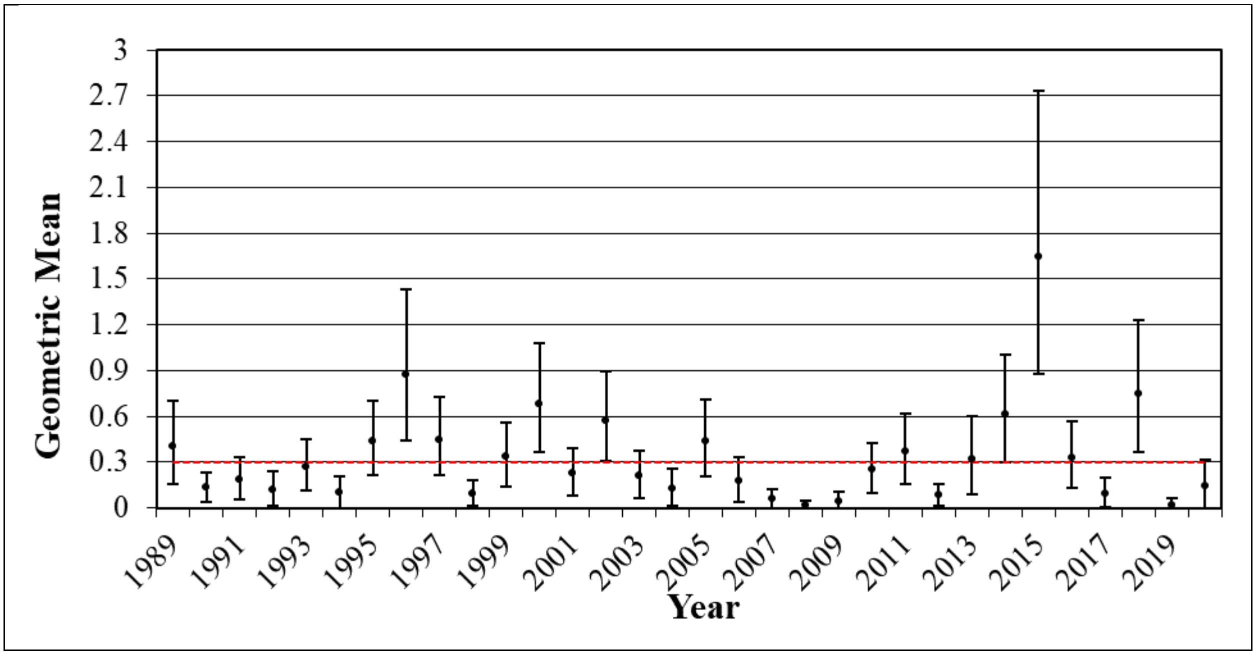

Figure 1.10. Atlantic silverside (*Menidia menidia*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

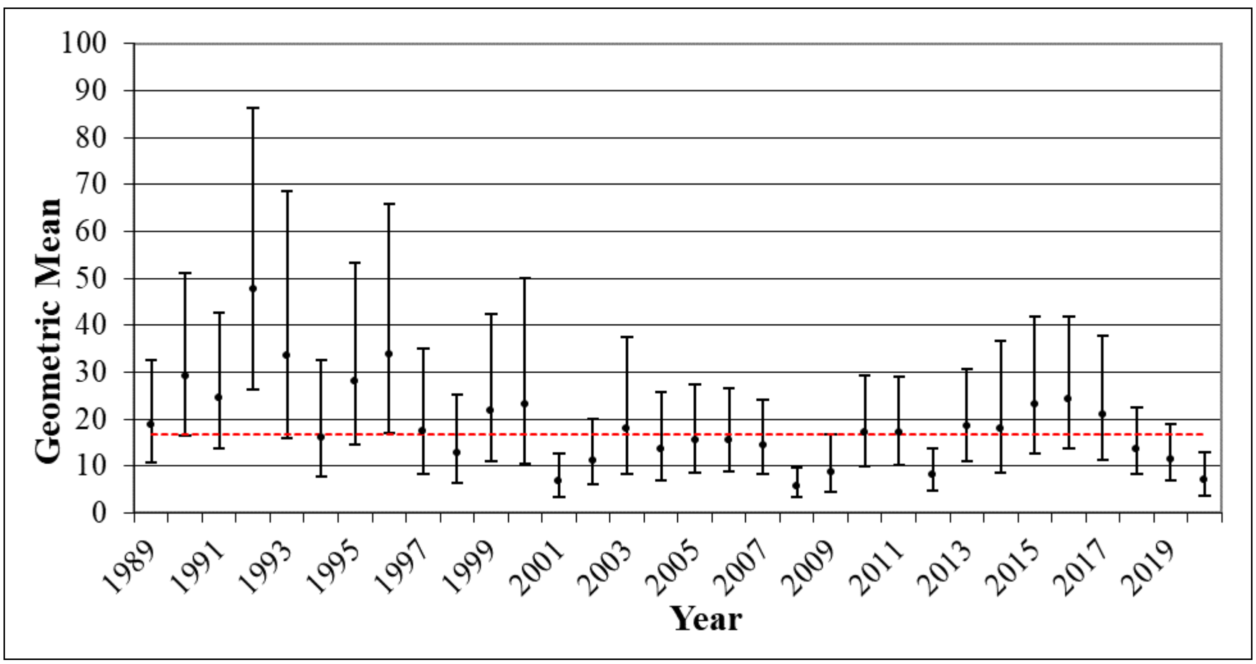

Figure 1.11. Atlantic silverside (*Menidia menidia*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

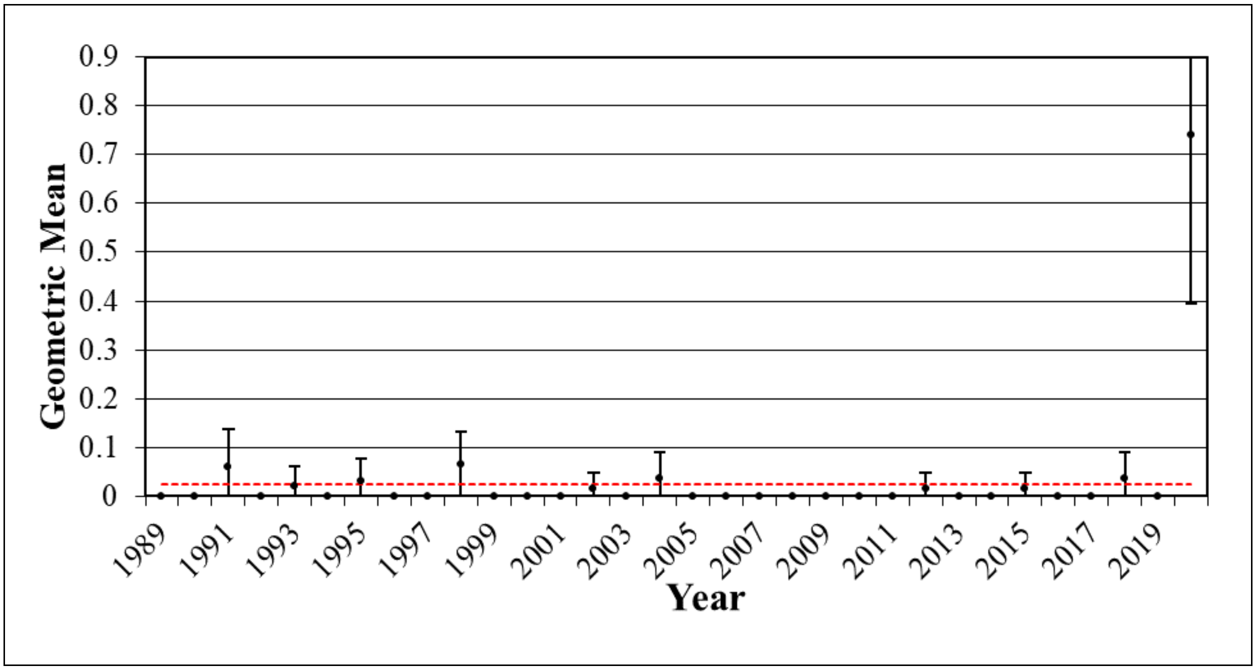

Figure 1.12. Atlantic spadefish (*Chaetodipterus faber*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\ -\ 2019}$ = 140/year, n_{2020} = 120).

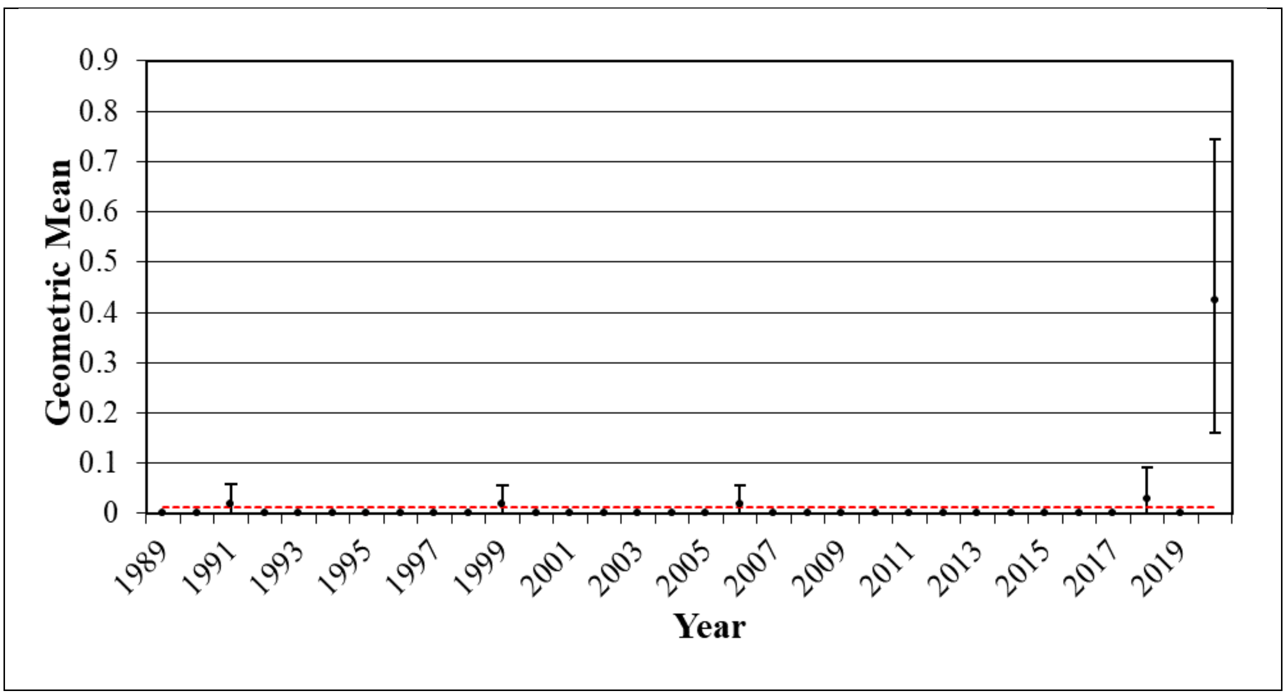

Figure 1.13. Atlantic spadefish (*Chaetodipterus faber*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

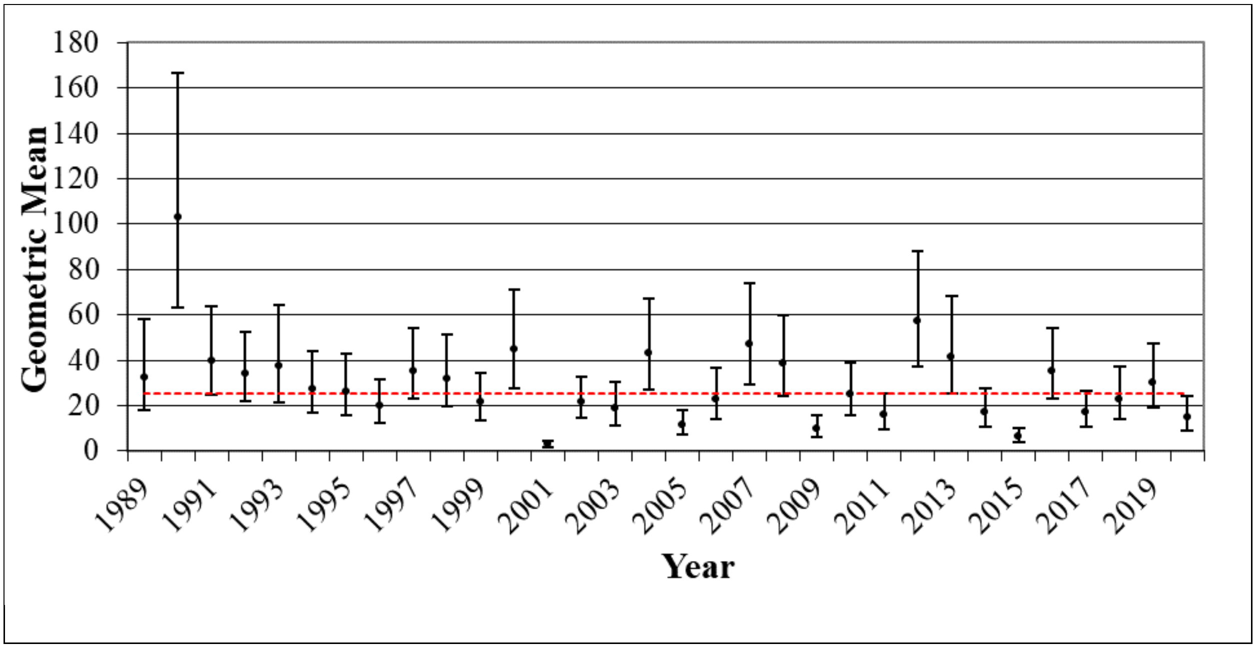

Figure 1.14. Bay anchovy (*Anchoa mitchilli*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

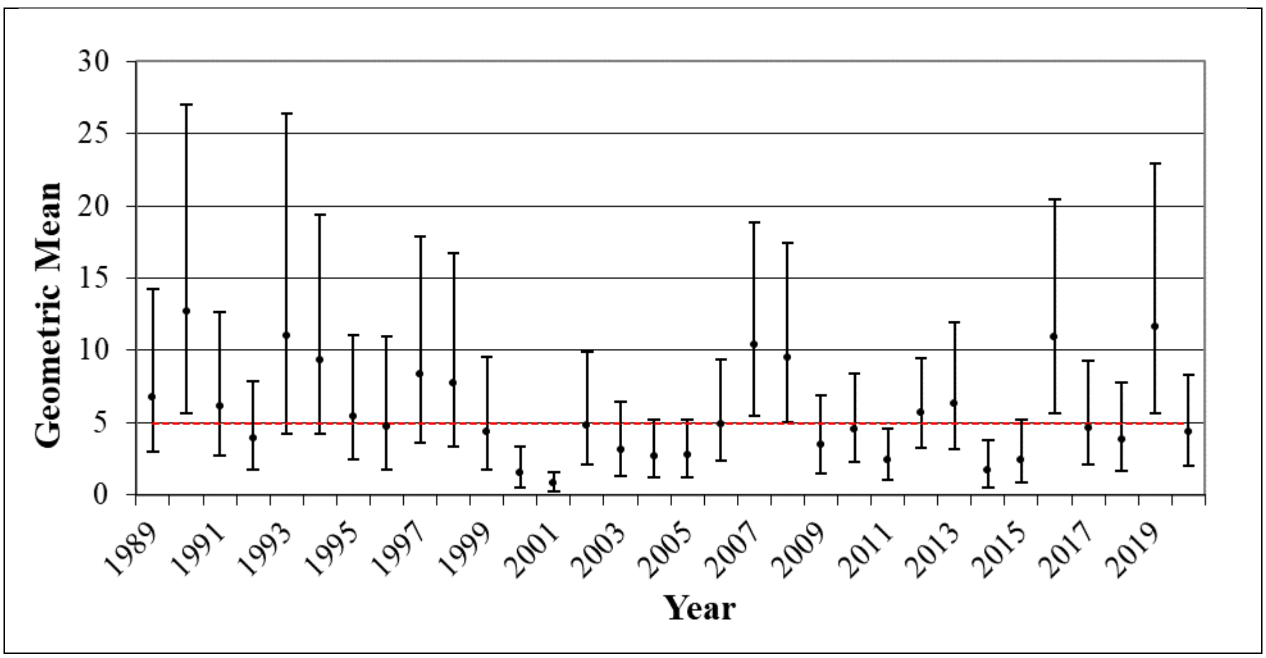

Figure 1.15. Bay anchovy (*Anchoa mitchilli*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

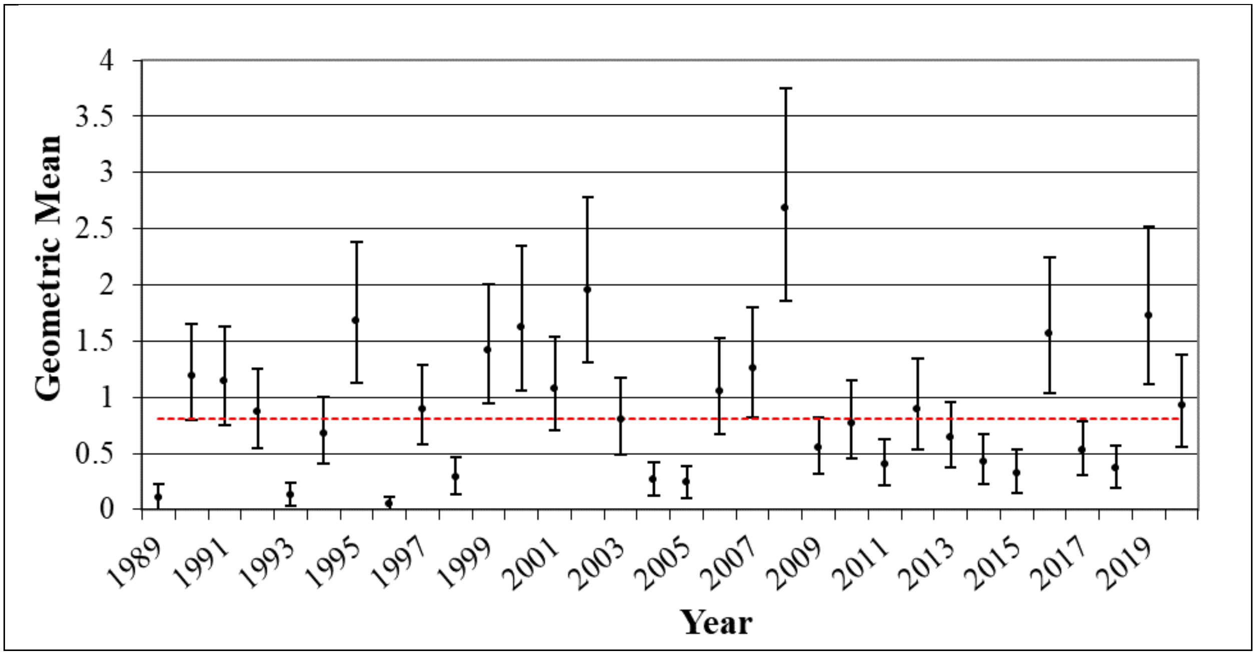

Figure 1.16. Black sea bass (*Centropristis striata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

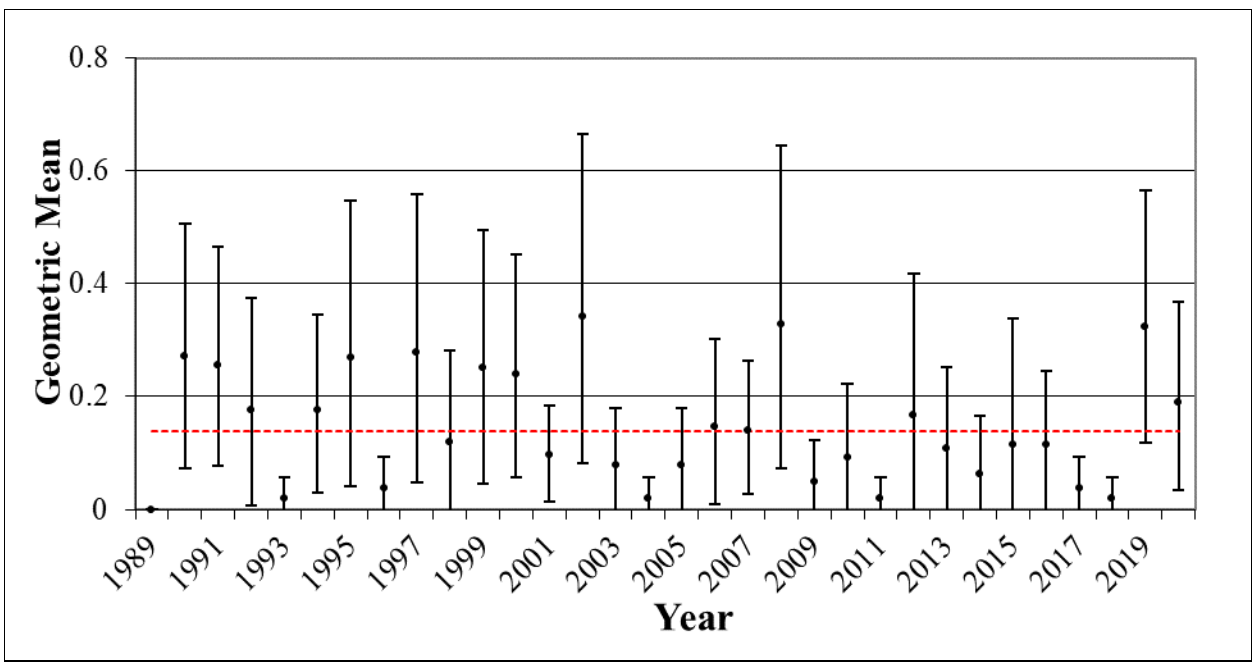

Figure 1.17. Black sea bass (*Centropristis striata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

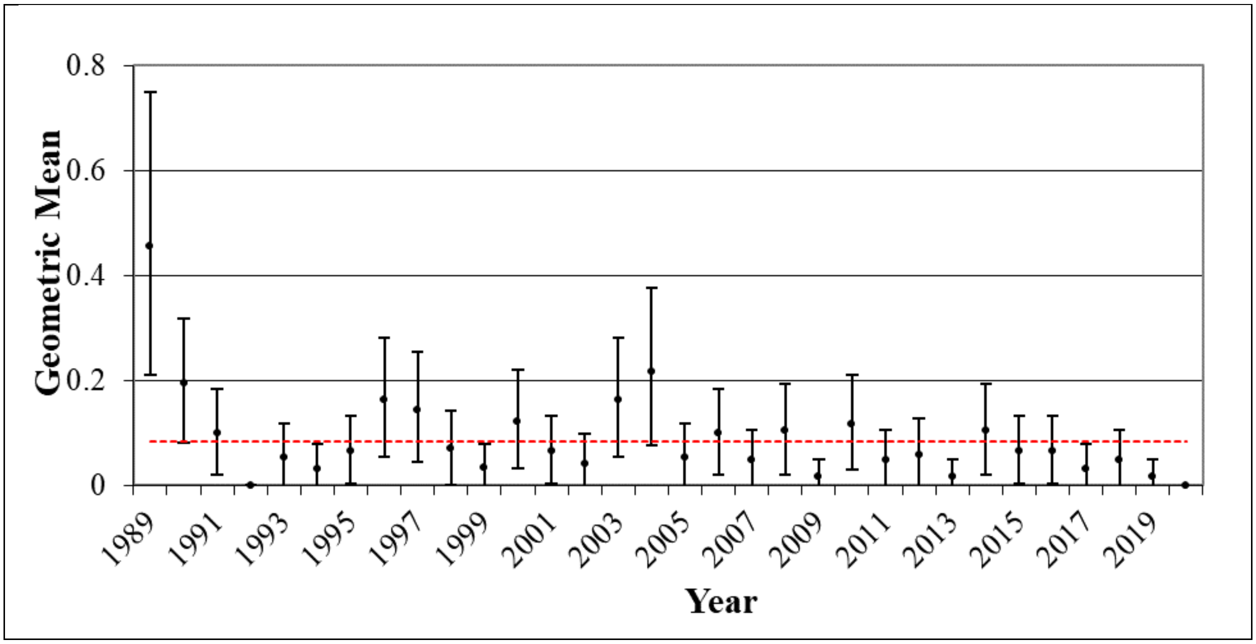

Figure 1.18. Bluefish (*Pomatomus saltatrix*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989-2019}$ = 140/year, n_{2020} = 120).

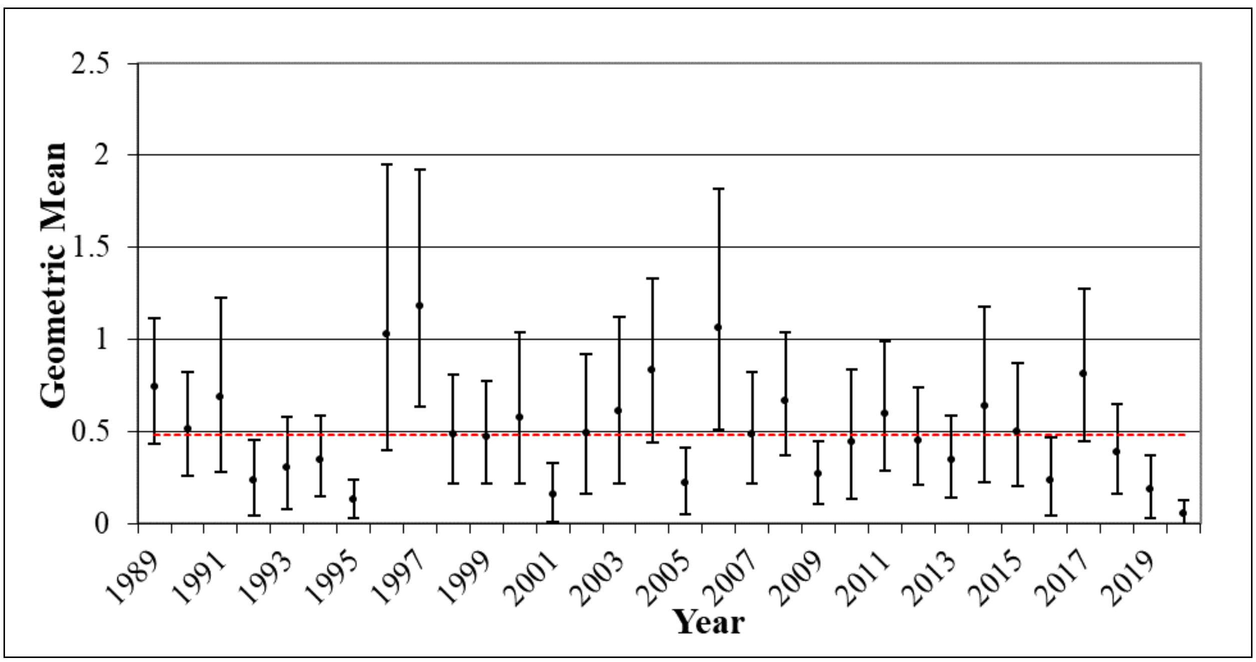

Figure 1.19. Bluefish (*Pomatomus saltatrix*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

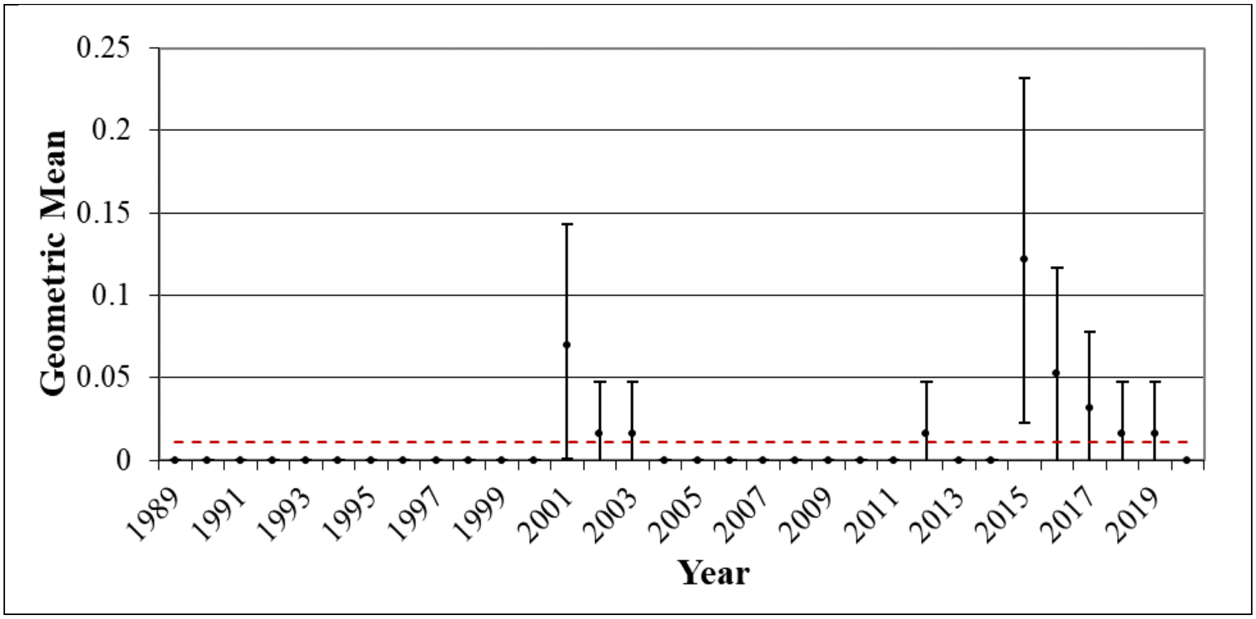

Figure 1.20. Sheepshead (*Archosargus probatocephalus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

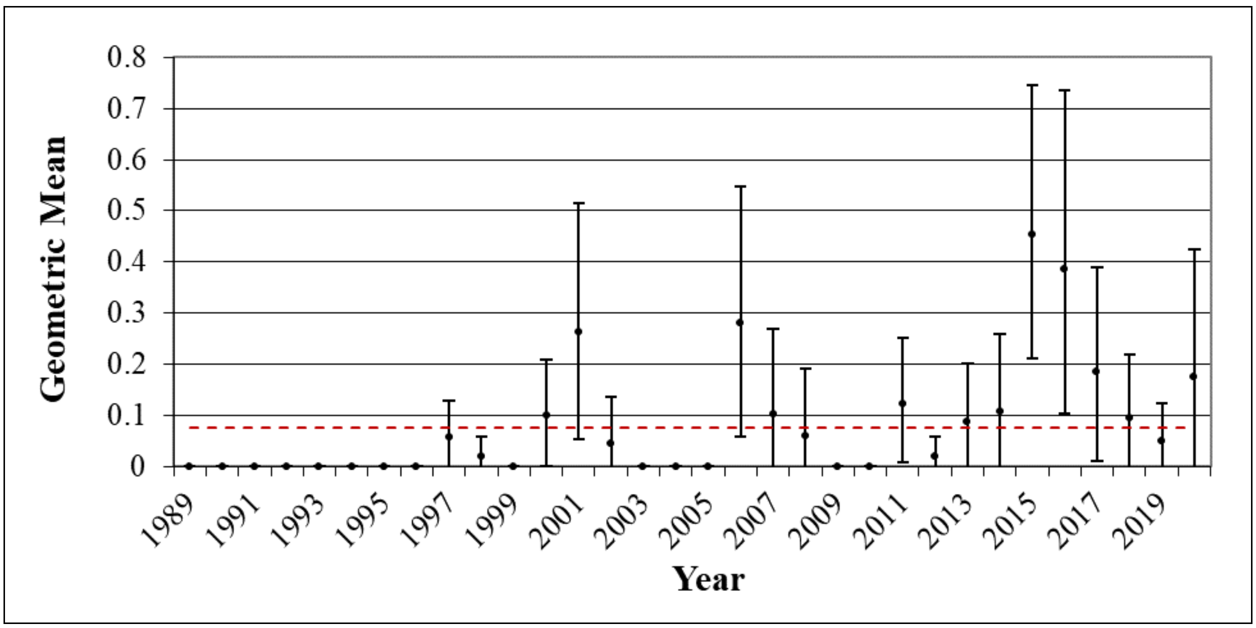

Figure 1.21. Sheepshead (*Archosargus probatocephalus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

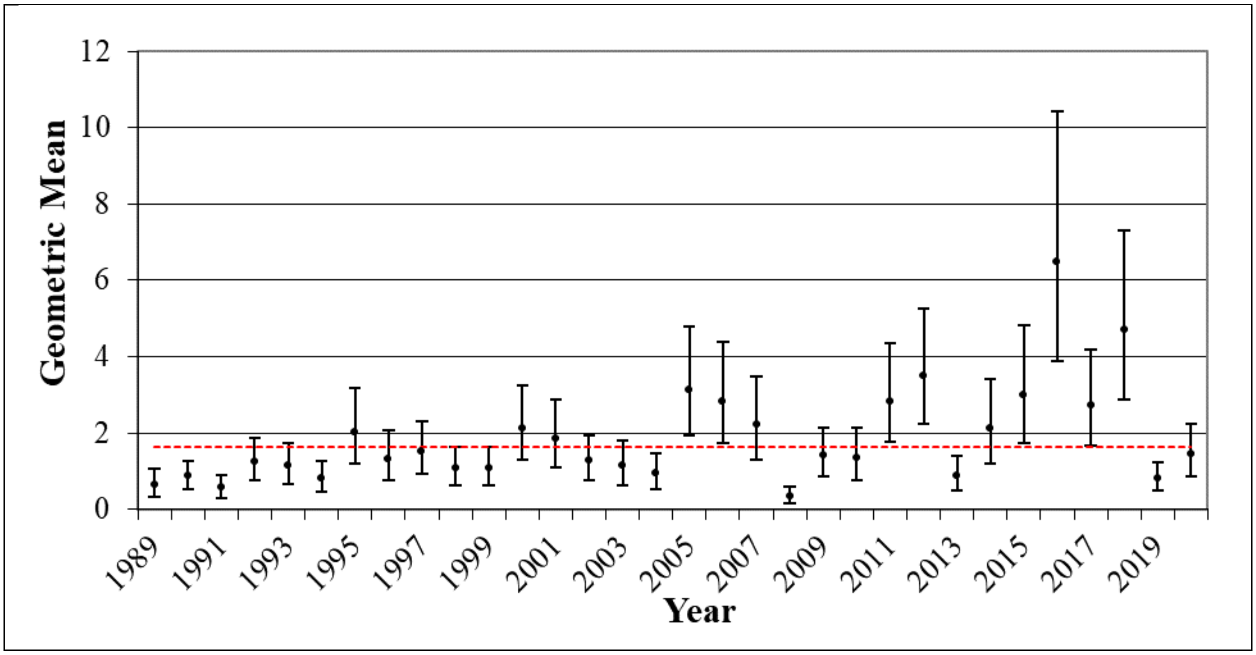

Figure 1.22. Silver perch (*Bairdiella chrysoura*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989-2019}$ = 140/year, n_{2020} = 120).

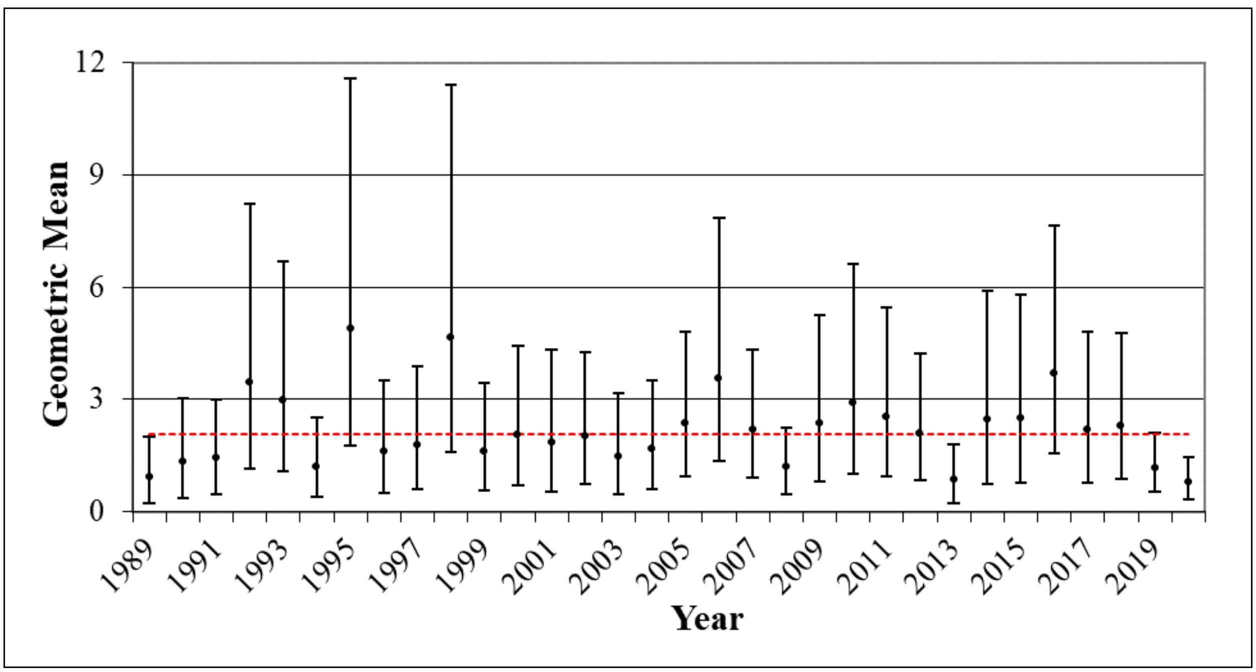

Figure 1.23. Silver perch (*Bairdiella chrysoura*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

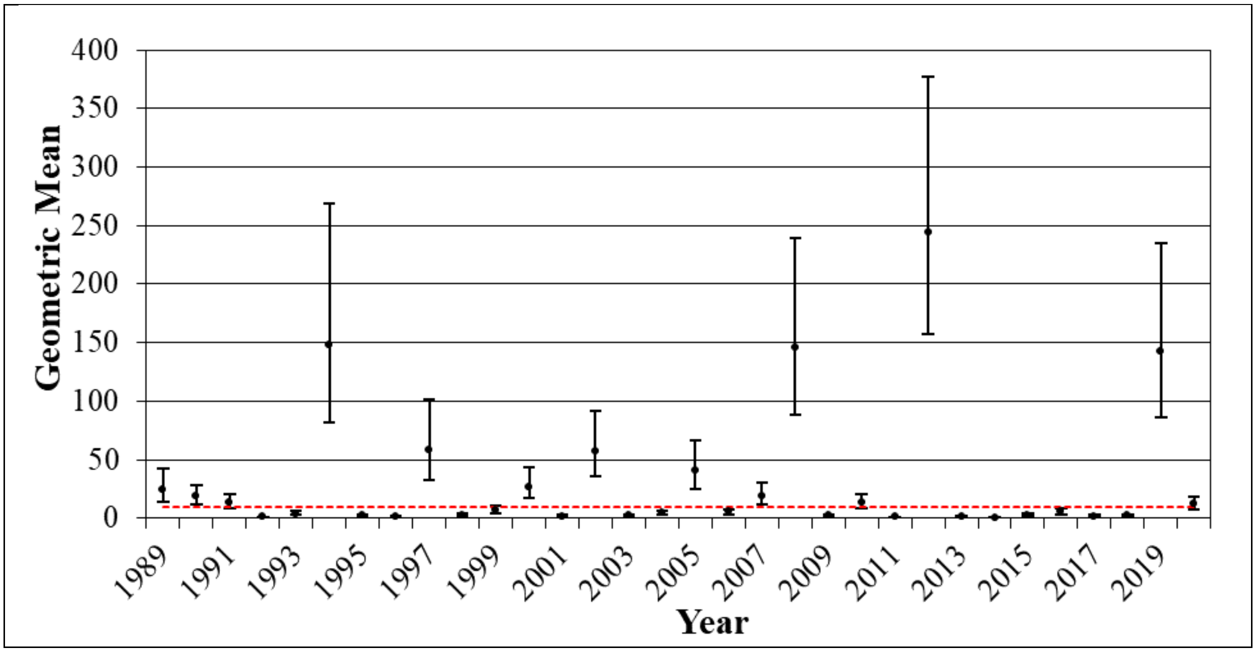

Figure 1.24. Spot (*Leiostomus xanthurus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989-2019}$ = 140/year, n_{2020} = 120).

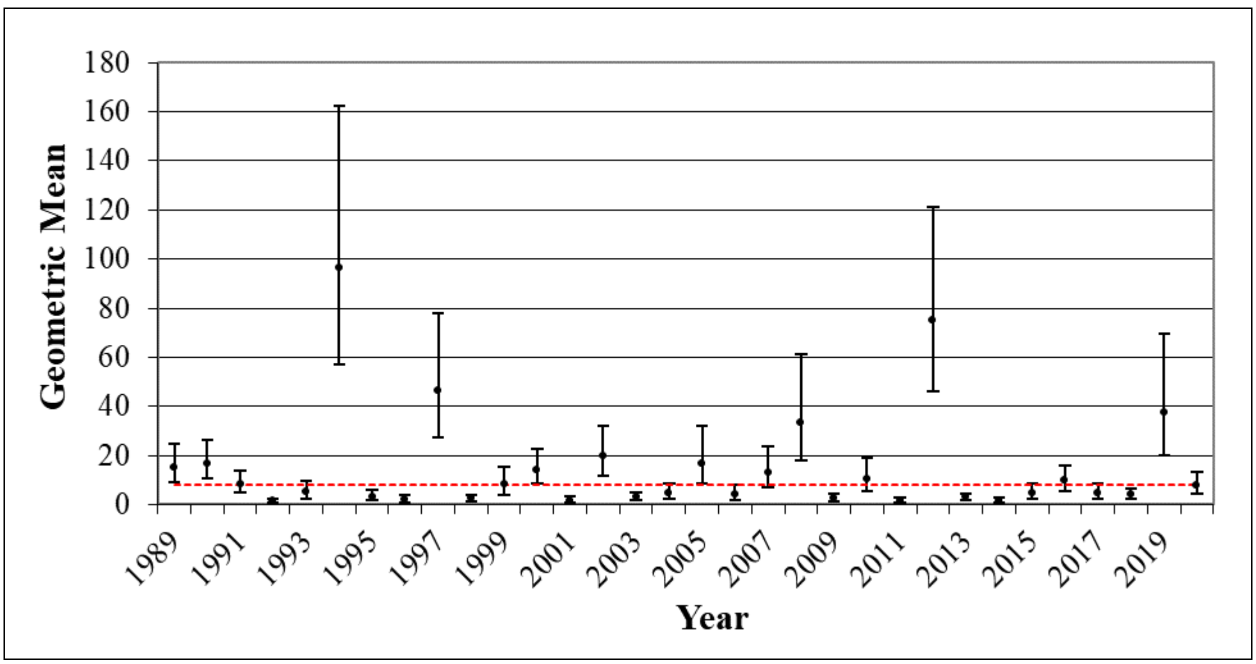

Figure 1.25. Spot (*Leiostomus xanthurus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

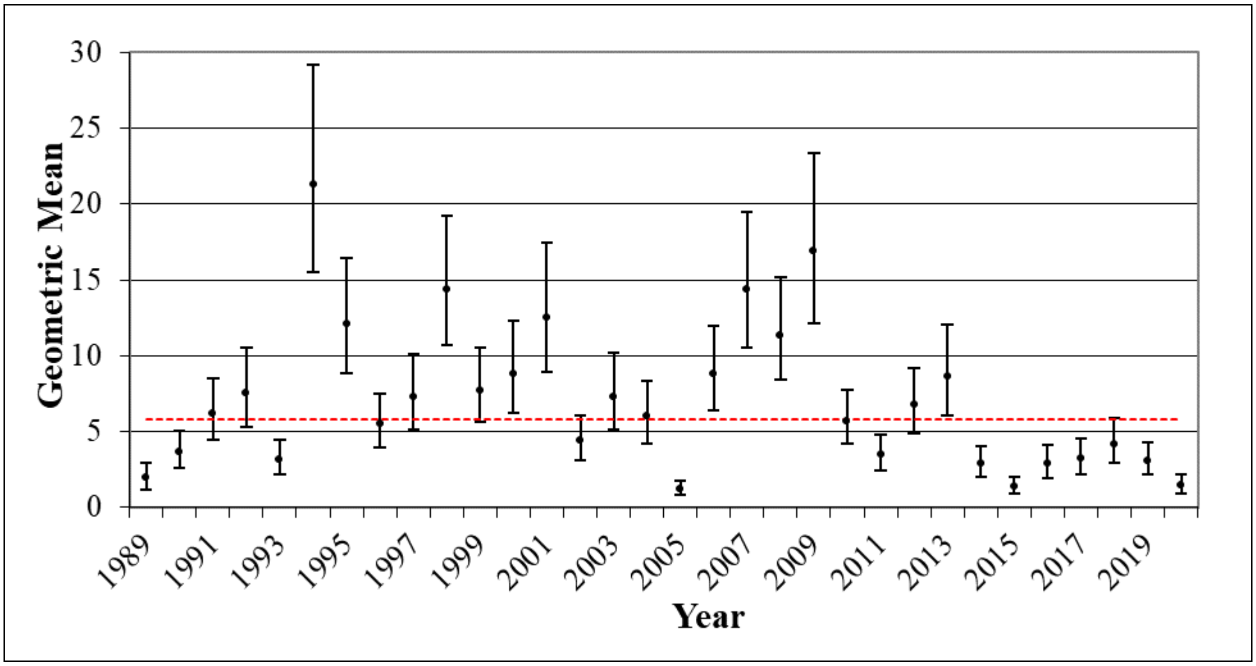

Figure 1.26. Summer flounder (*Paralichthys dentatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989\text{ - }2019}$ = 140/year, n_{2020} = 120).

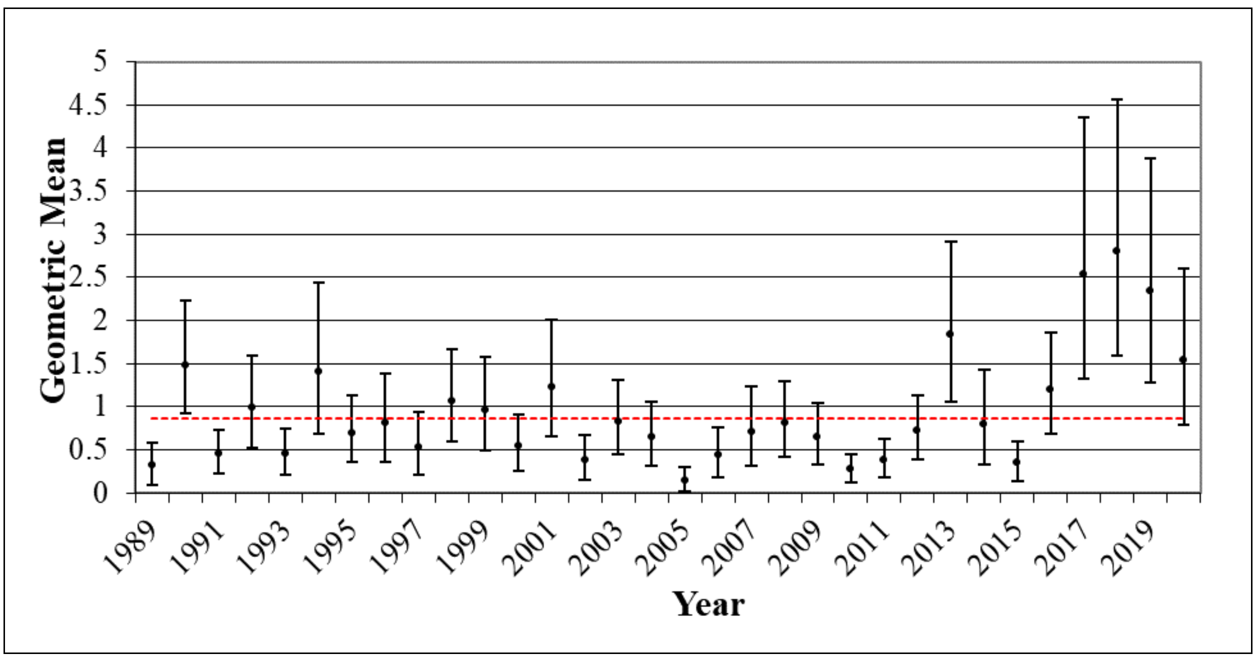

Figure 1.27. Summer flounder (*Paralichthys dentatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

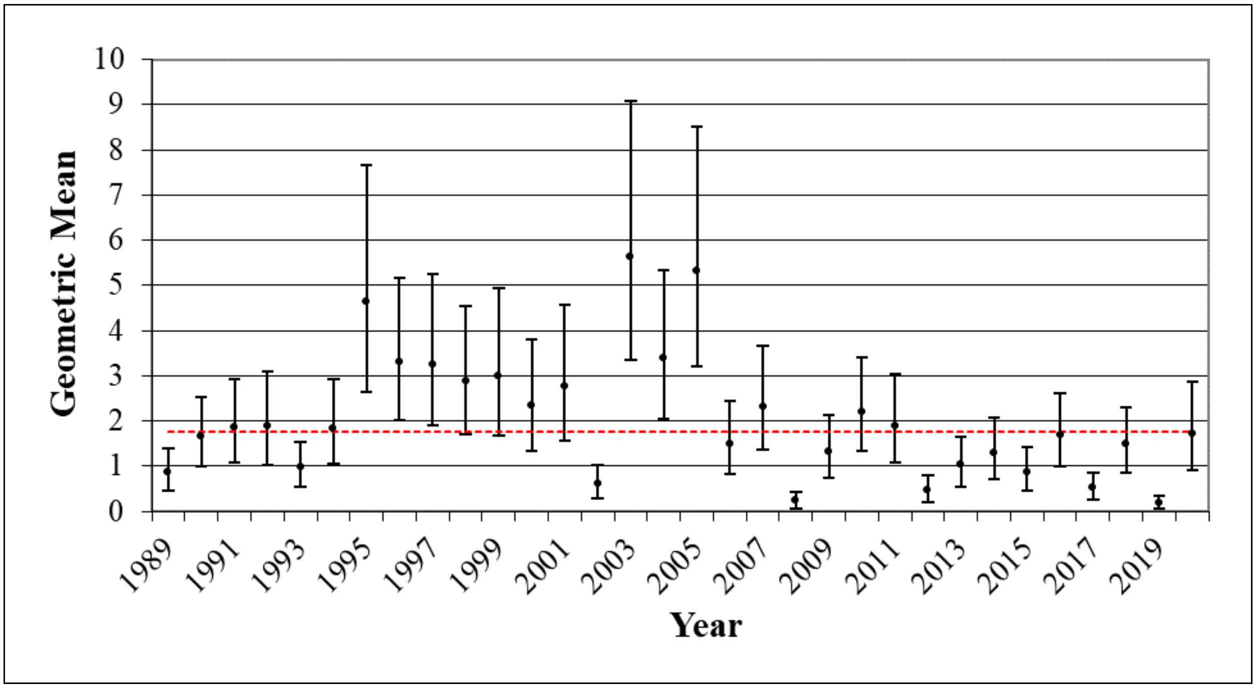

Figure 1.28. Weakfish (*Cynoscion regalis)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean ($n_{1989-2019}$ = 140/year, n_{2020} = 120).

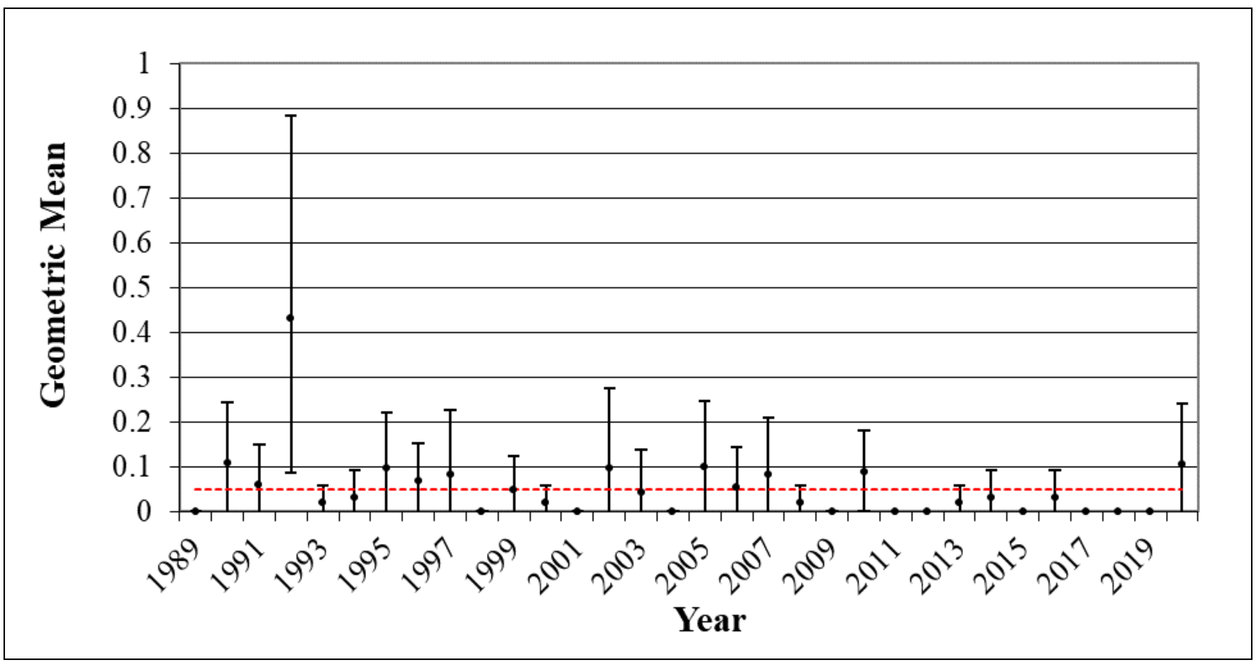

Figure 1.29. Weakfish (*Cynoscion regalis)* beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2020). Dotted line represents the 1989 - 2020 time series grand mean (n = 38/year).

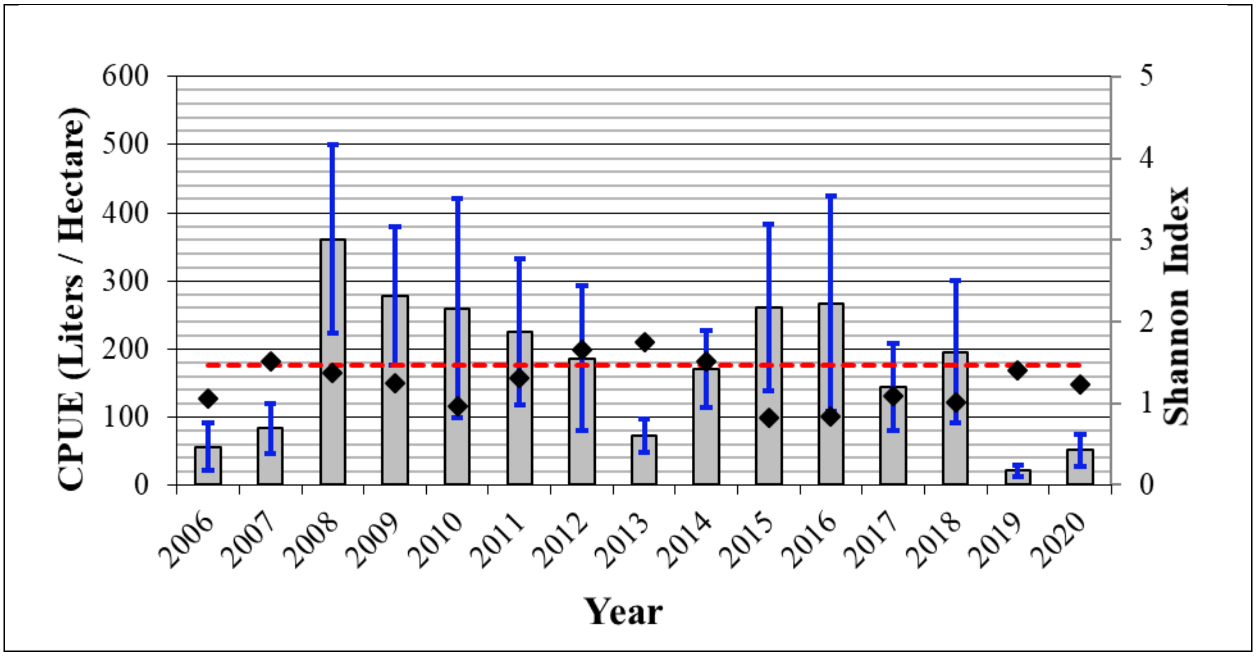

Figure 1.30. Coastal bays trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 140/year). Black diamond represents the Shannon index of diversity.

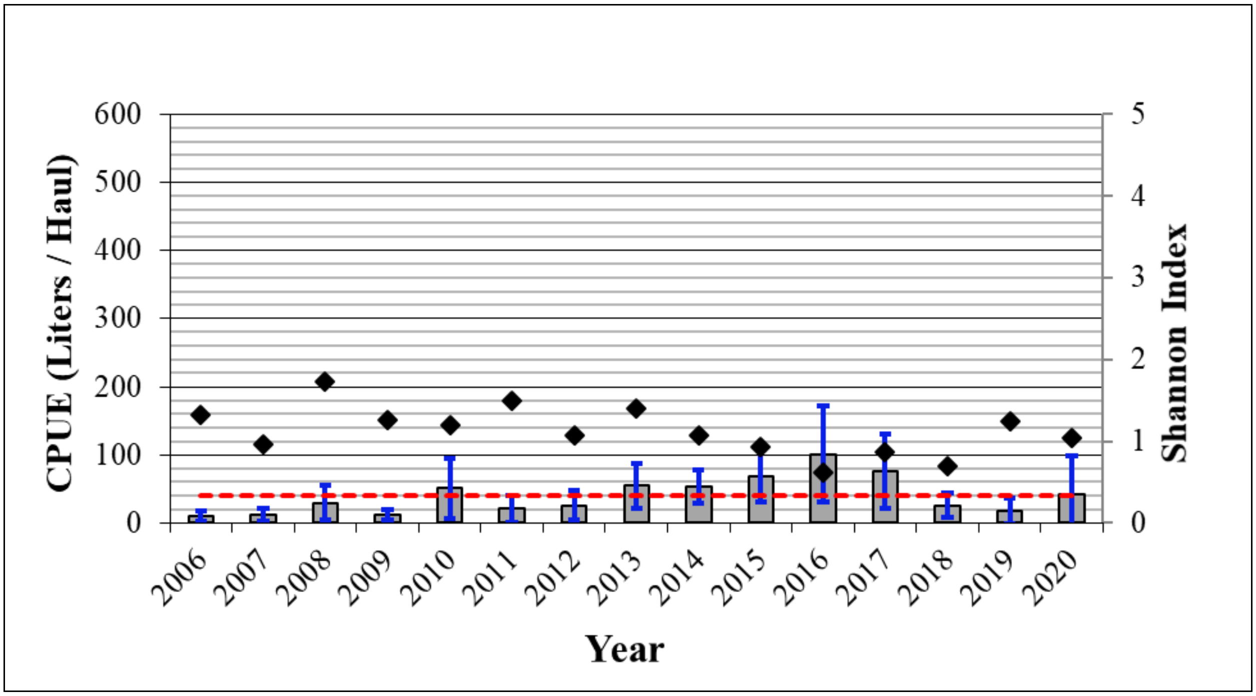

Figure 1.31. Coastal bays beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 36/year). Black diamond represents the Shannon index of diversity

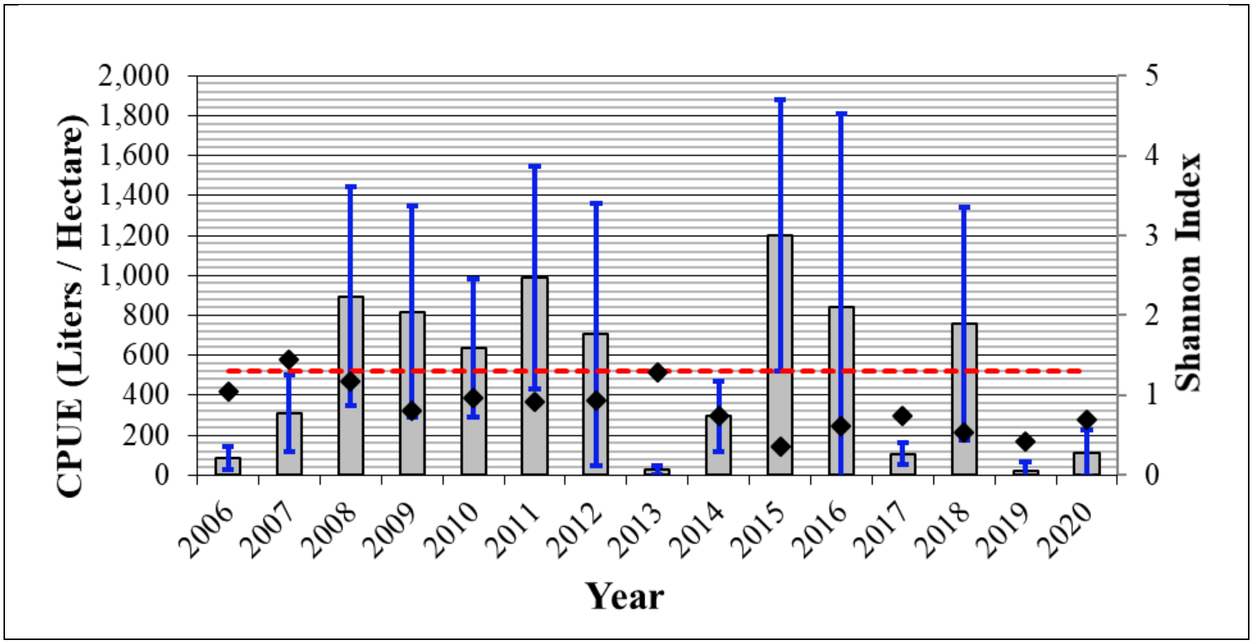

Figure 1.32. Assawoman Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

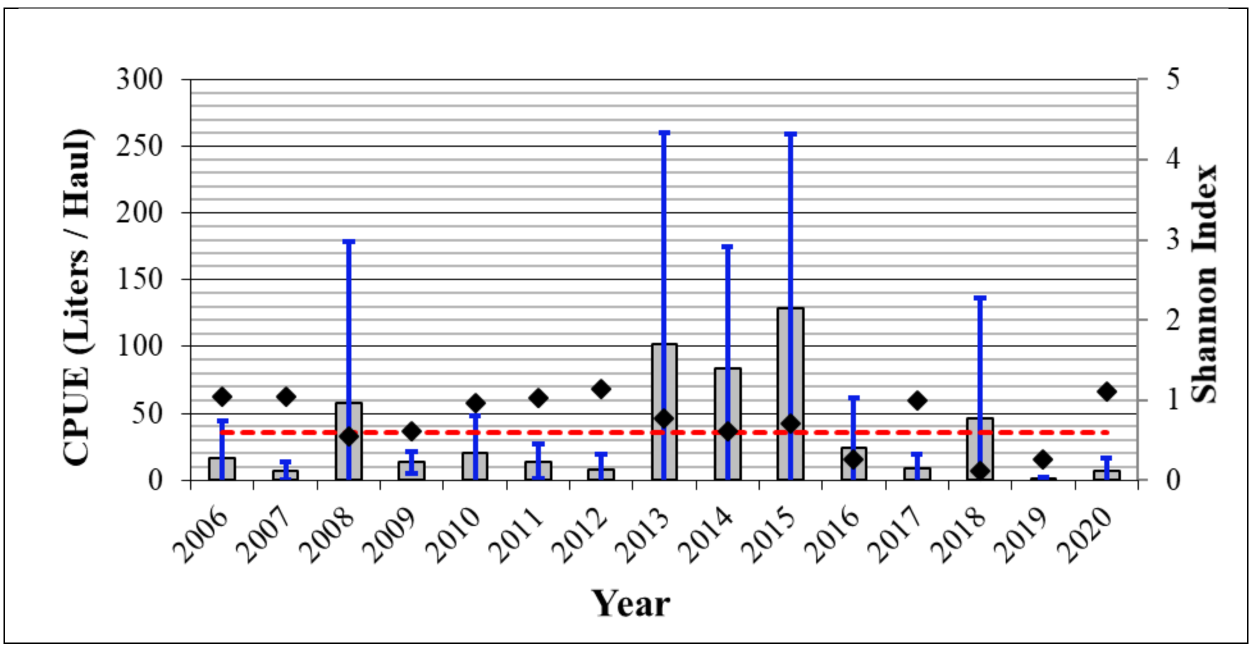

Figure 1.33. Assawoman Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Dotted line represents the 2006 - 2020 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index.

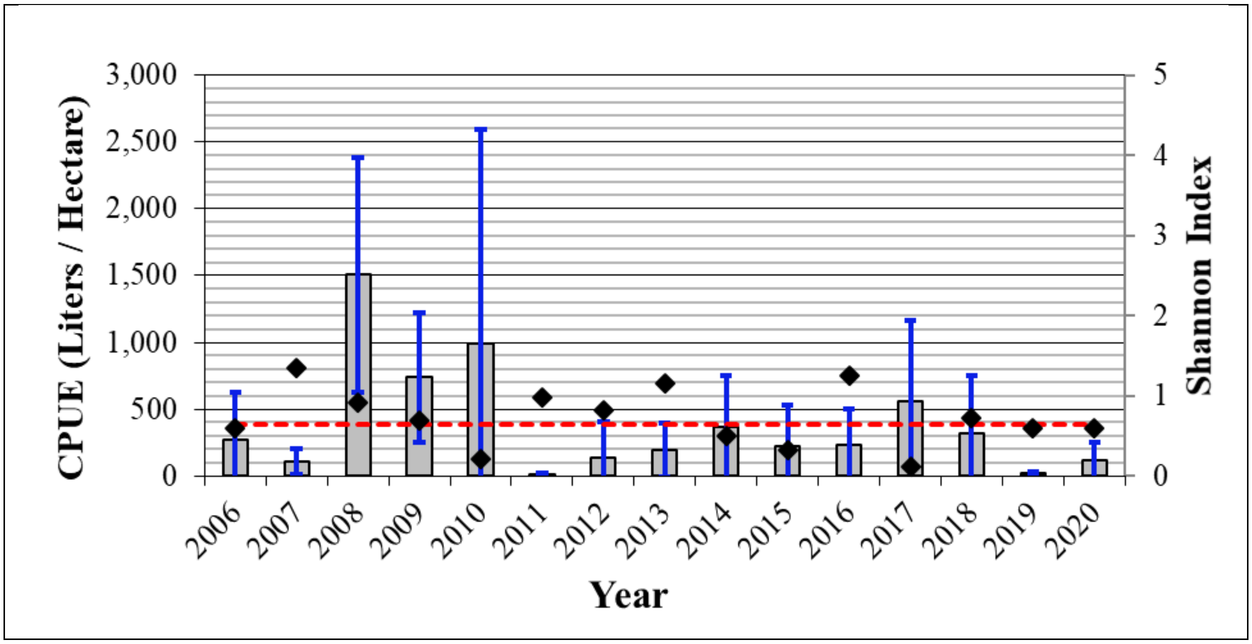

Figure 1.34. Isle of Wight Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

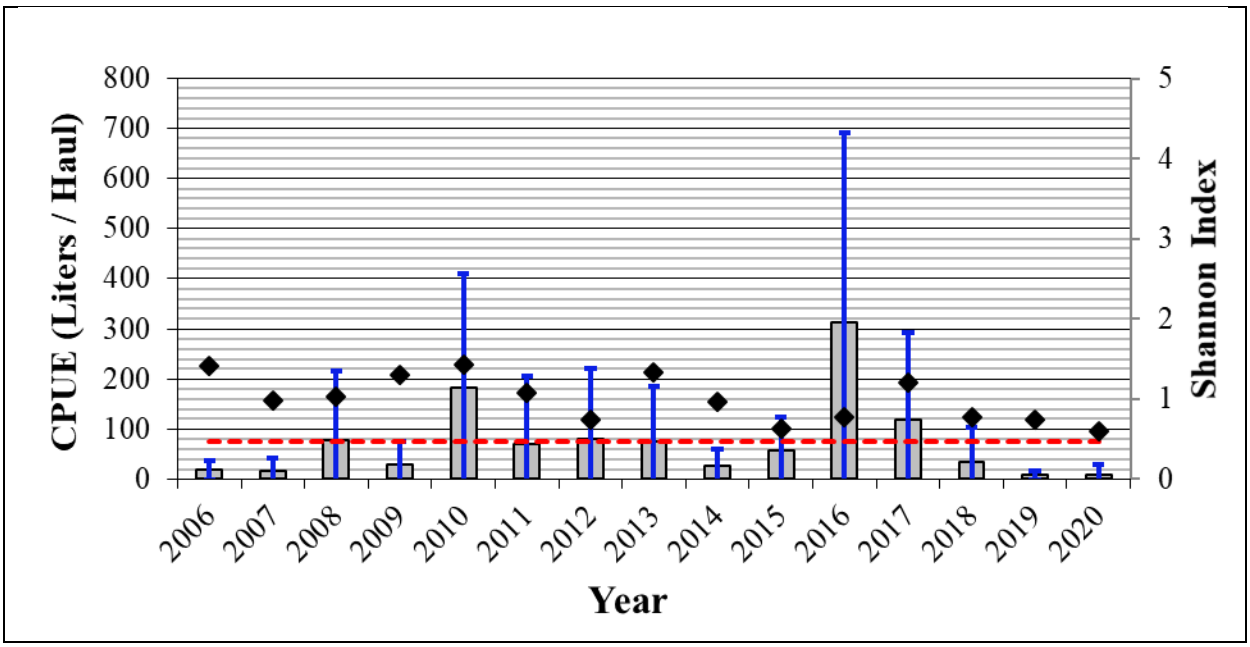

Figure 1.35. Isle of Wight Bay beach seine index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index.

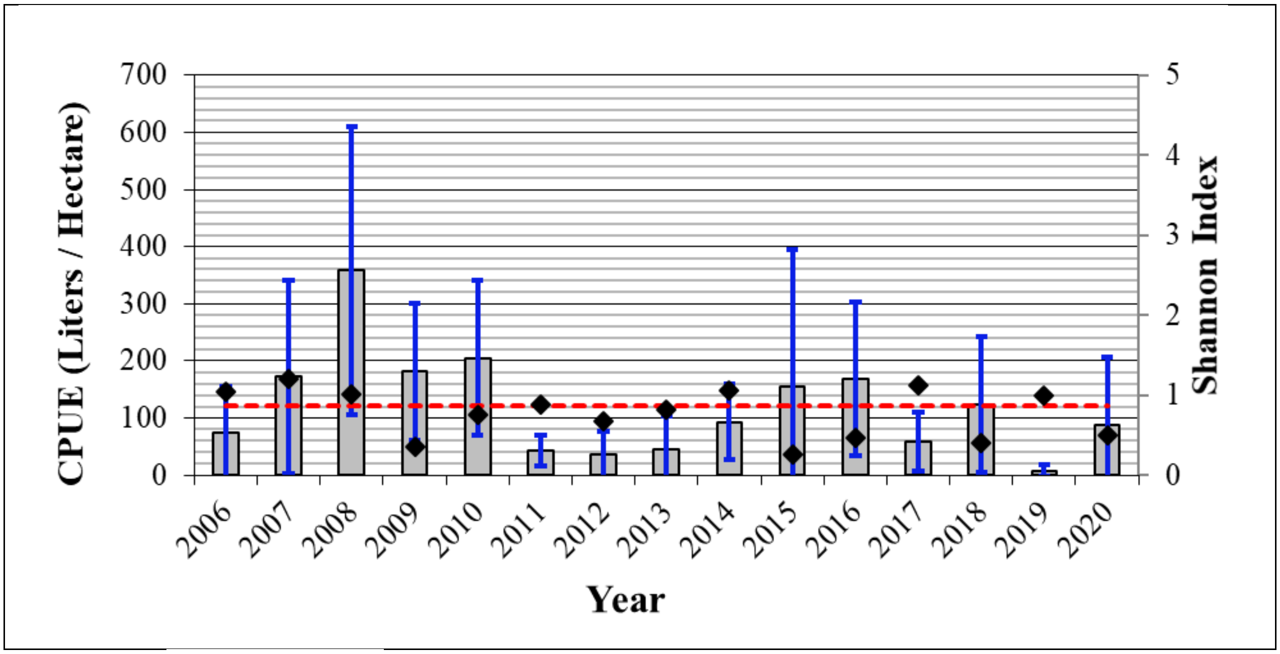

Figure 1.36. St. Martin River trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

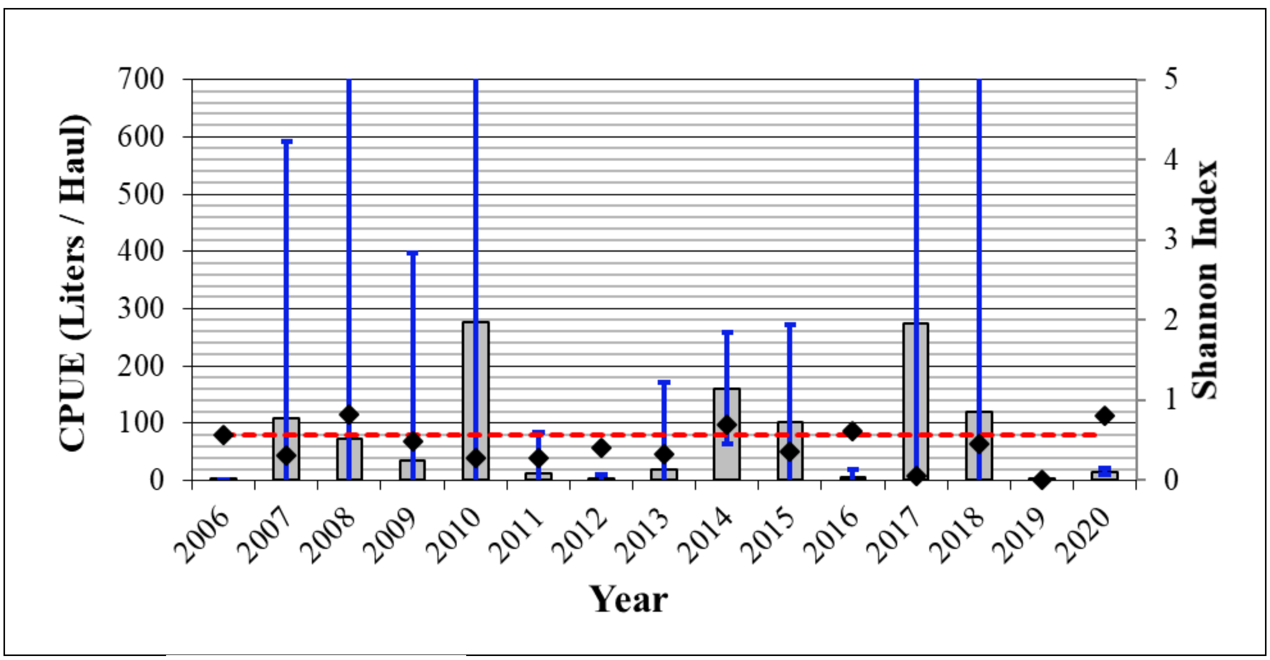

Figure 1.37. St. Martin River beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 2/year). Black diamond represents the Shannon index of diversity.

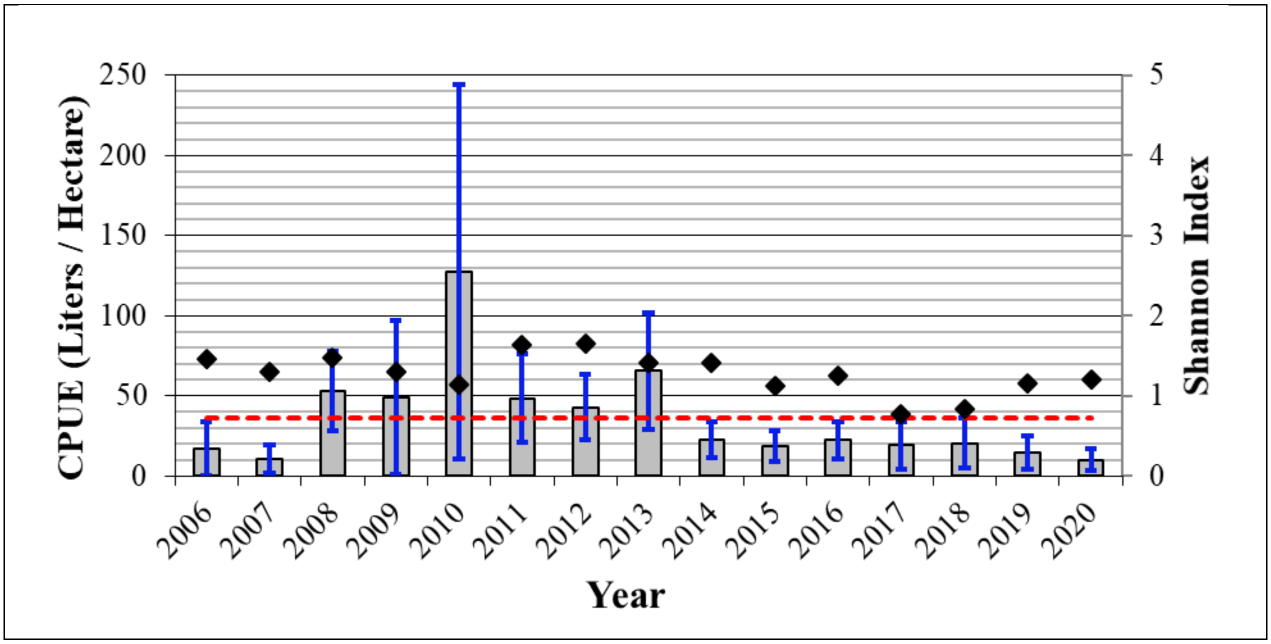

Figure 1.38. Sinepuxent Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 21/year). Black diamond represents the Shannon index of diversity.

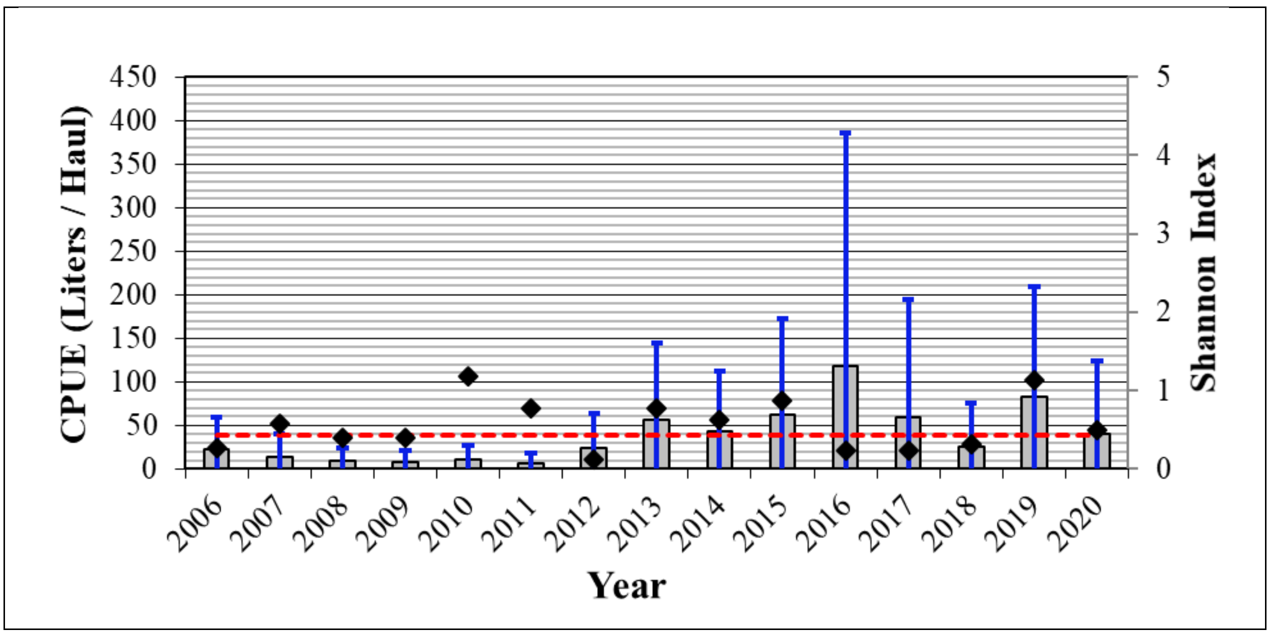

Figure 1.39. Sinepuxent Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 6/year). Black diamond represents the Shannon index of diversity.

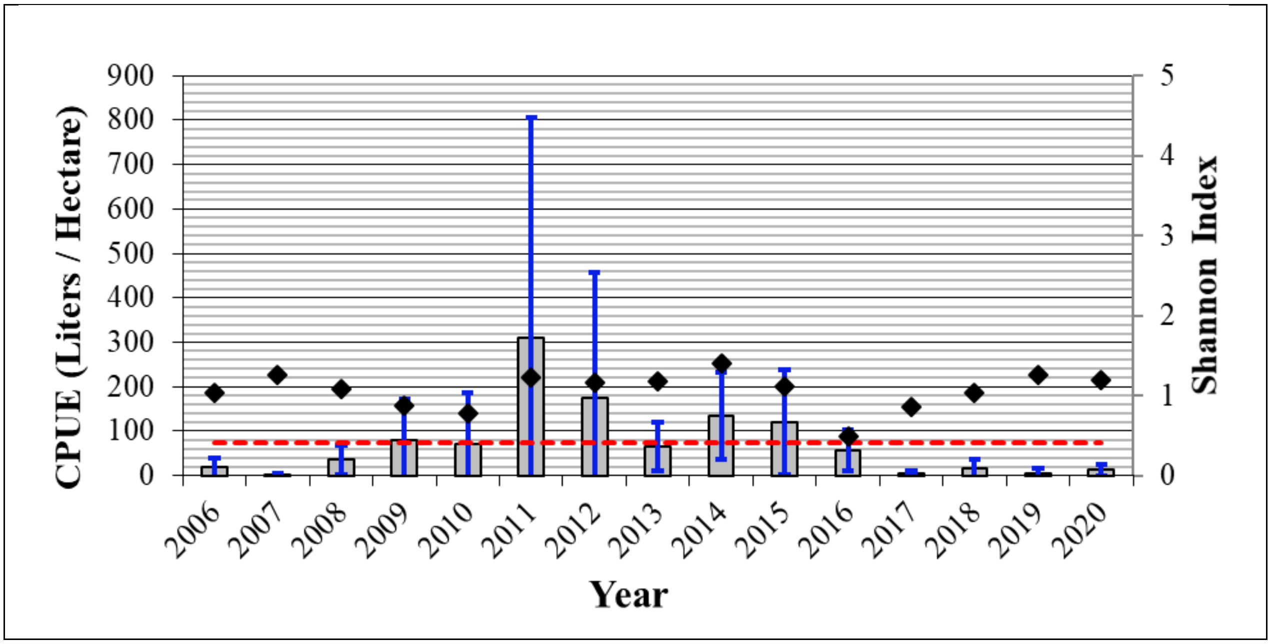

Figure 1.40. Newport Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 14/year). Black diamond represents the Shannon index of diversity.

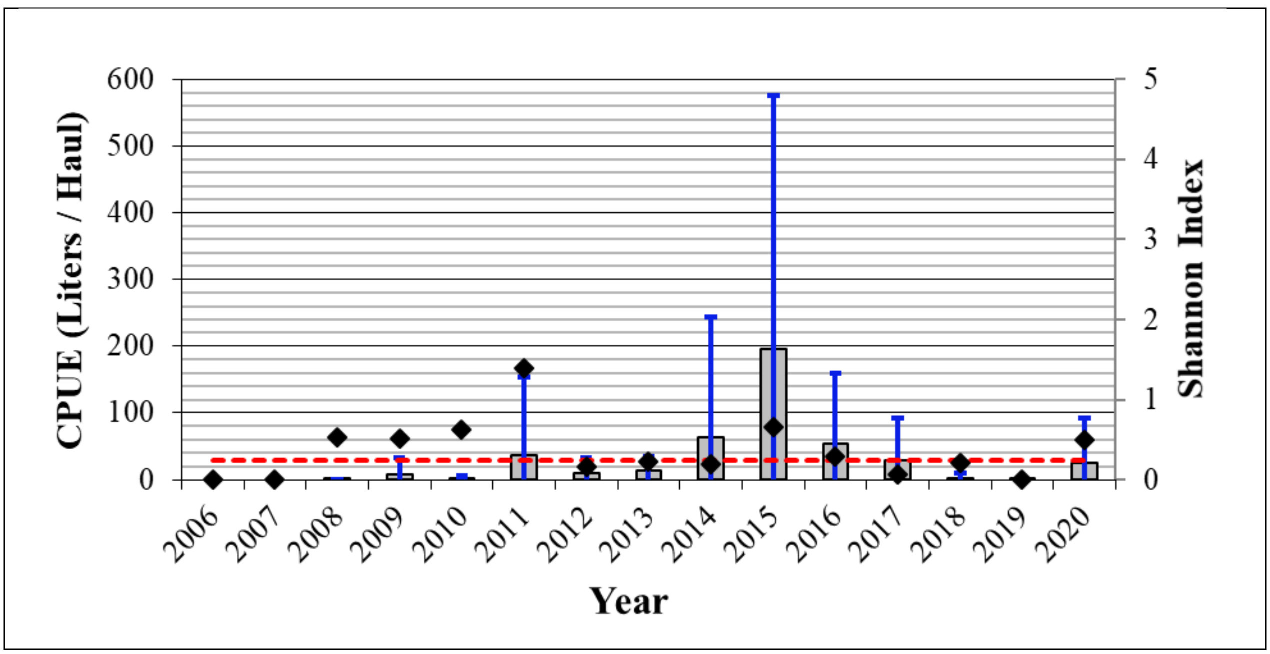

Figure 1.41. Newport Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 4/year). Black diamond represents the Shannon index of diversity.

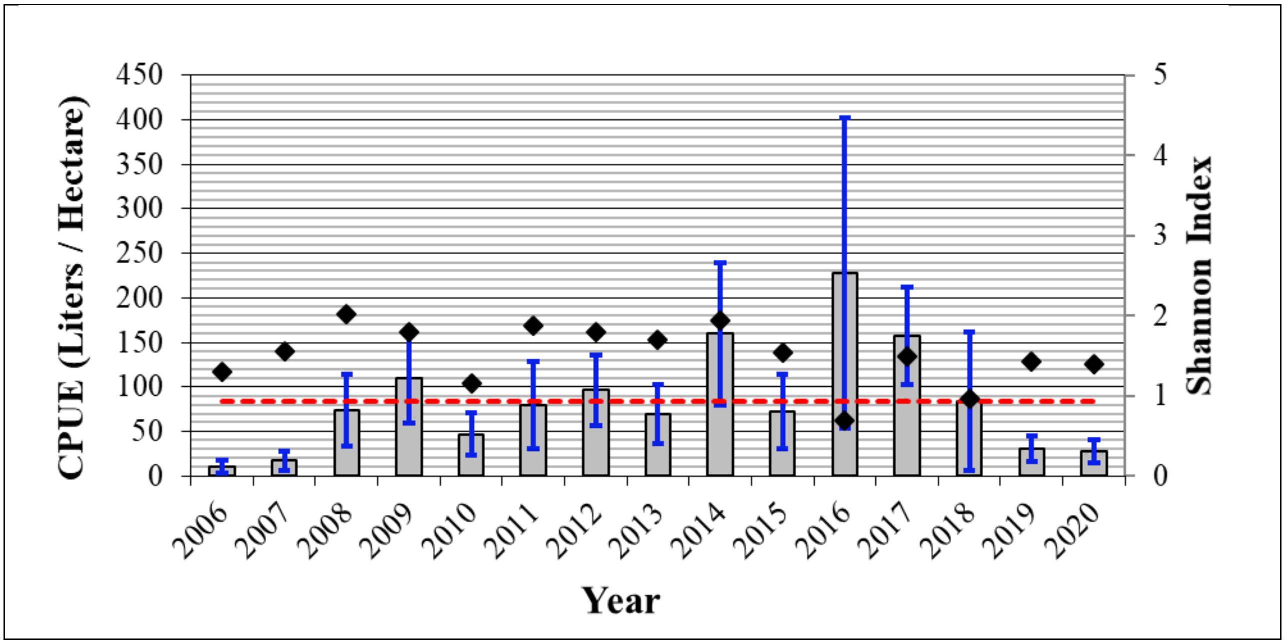

Figure 1.42. Chincoteague Bay trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2020). Dotted line represents the 2006 - 2020 time series CPUE grand mean, (n = 56/year). Black diamond represents the Shannon index of diversity.

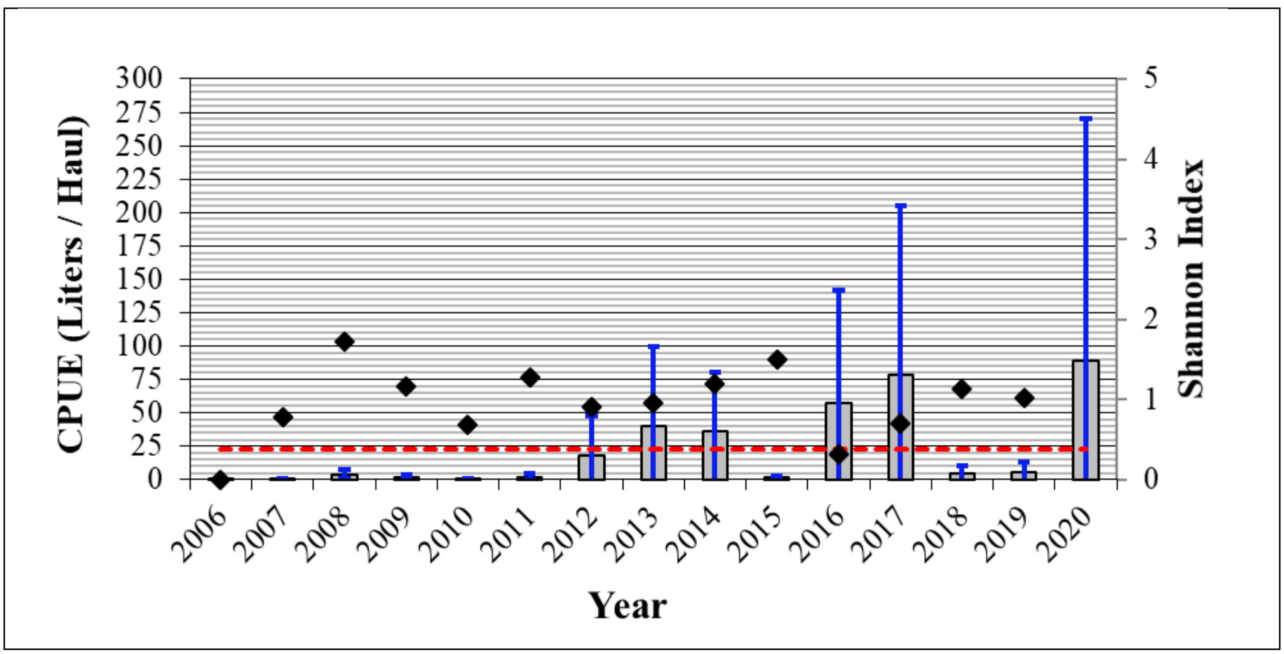

Figure 1.43. Chincoteague Bay beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2020). Red line represents the 2006 - 2020 time series CPUE grand mean, (n = 12/year). Black diamond represents the Shannon index of diversity.

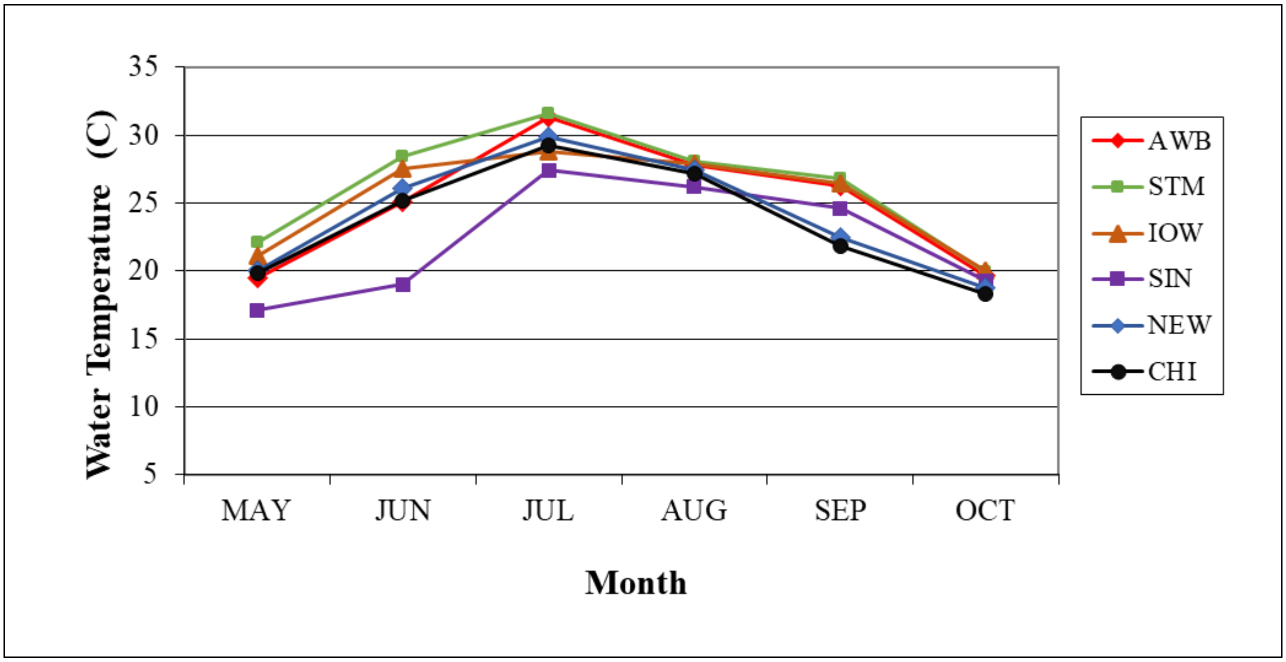

Figure 1.44. Trawl Survey (2020) mean water temperature (C) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

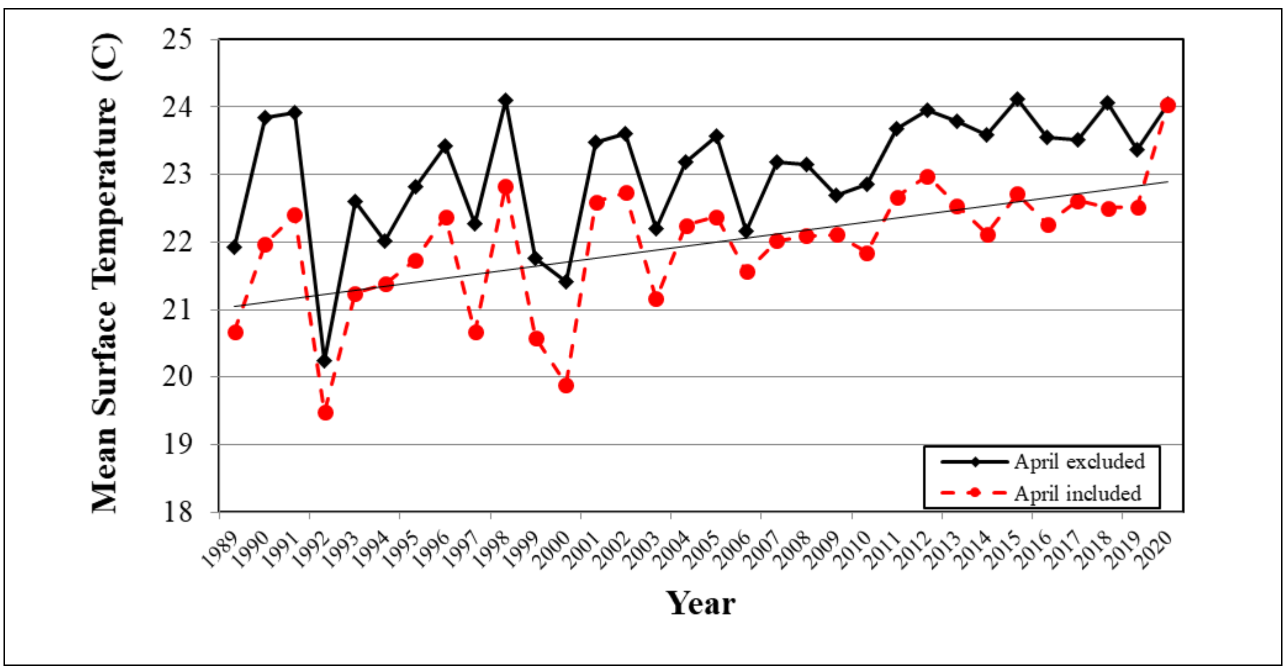

Figure 1.45. Evaluation of the mean annual April Trawl Survey surface water temperature (C).

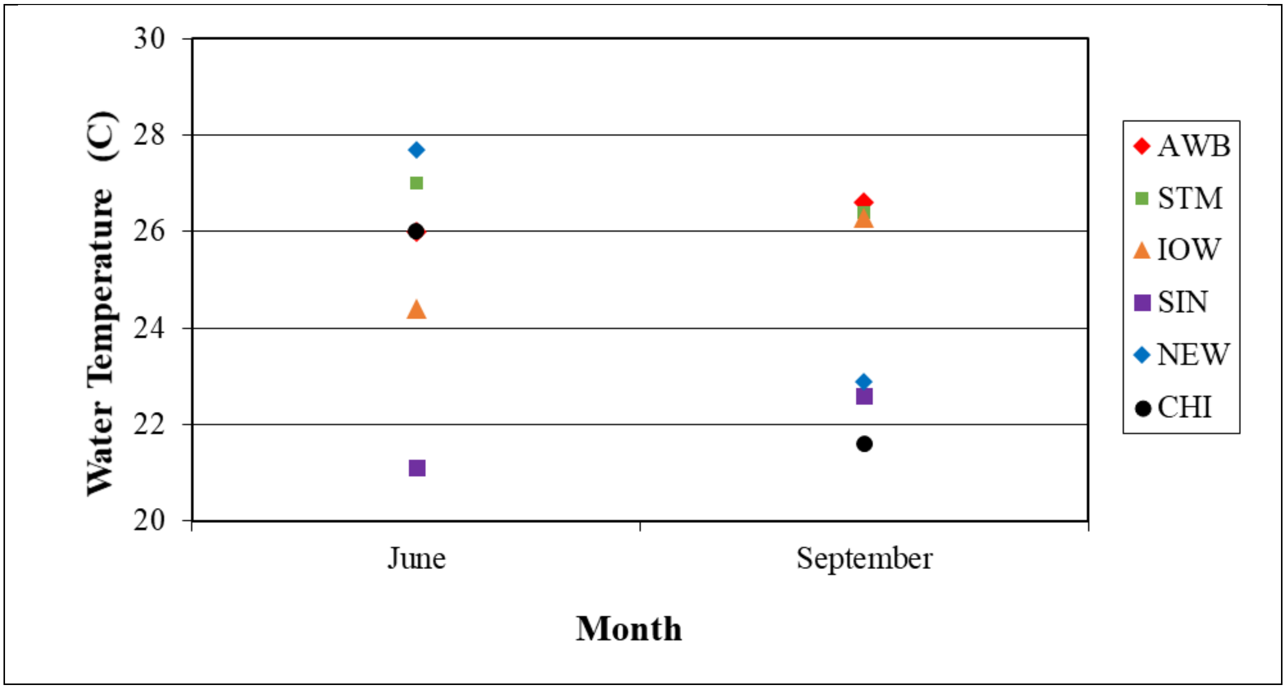

Figure 1.46. Beach Seine Survey (2020) mean water temperature (C) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

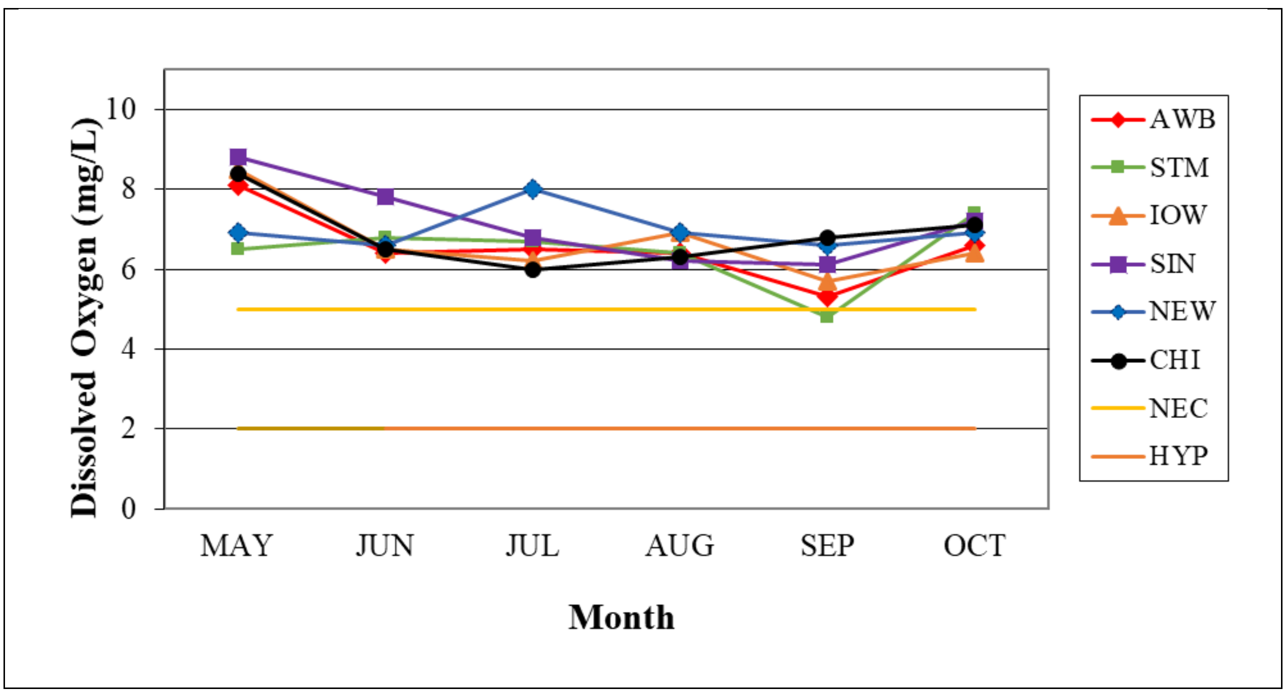

Figure 1.47. Trawl Survey (2020) mean Dissolved Oxygen (DO; mg/L) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI). A DO value of 5 mg/L was considered necessary for life (NEC). Hypoxic conditions (HYP) occur when DO drops to 2 mg/L or less.

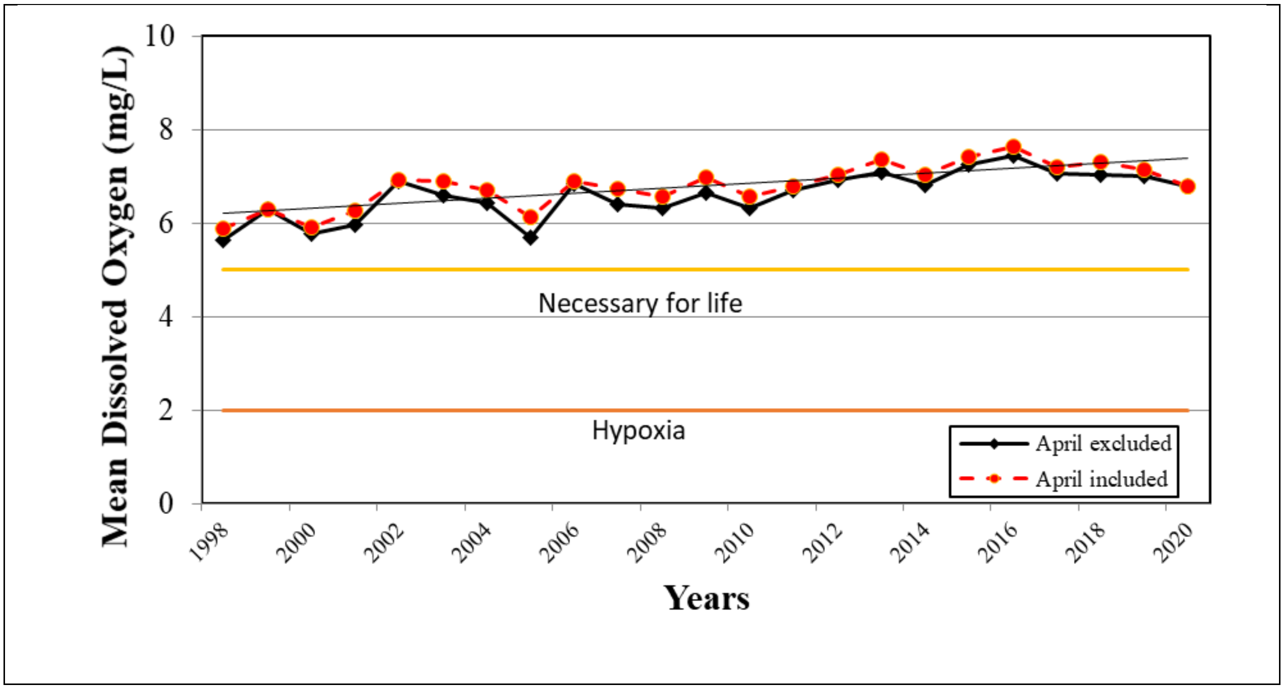

Figure 1.48. Trawl Survey annual mean Dissolved Oxygen (DO; mg/L) by year. A DO value of 5 mg/L was considered necessary for life. Hypoxic conditions occur when DO drops below 2 mg/L.

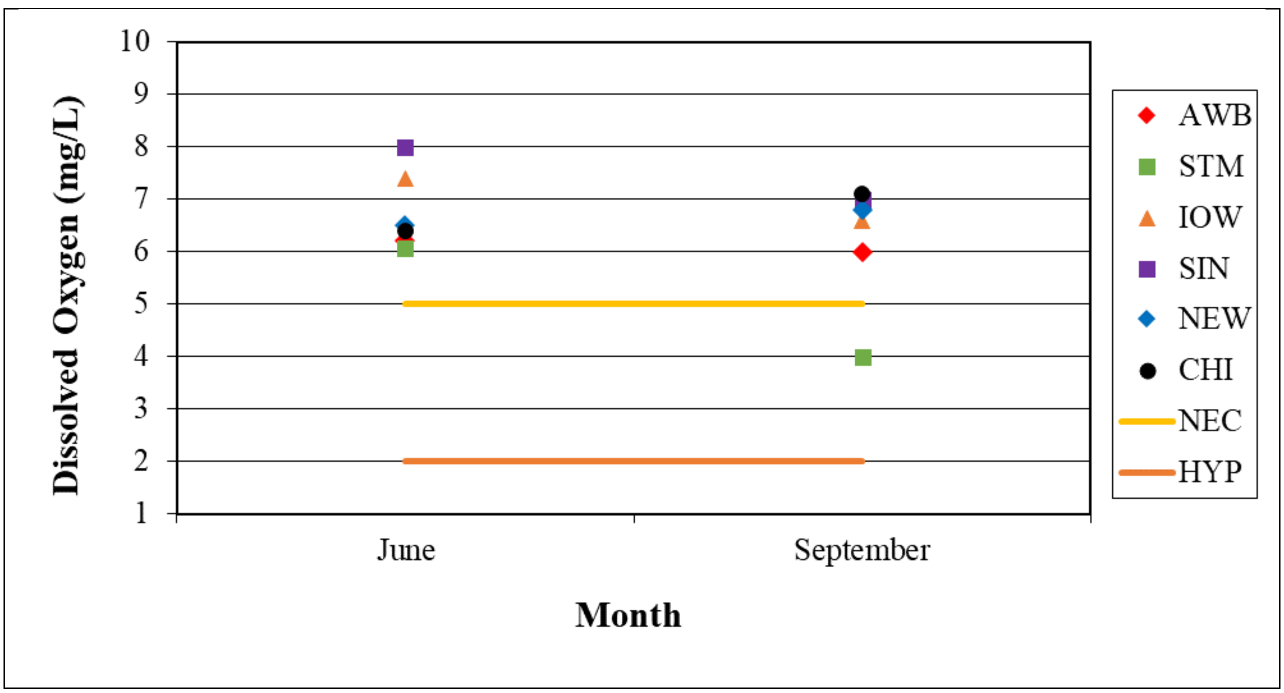

Figure 1.49. Beach Seine Survey (2020) mean Dissolved Oxygen (DO; mg/L) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI). A DO value of 5 mg/L was considered necessary for life (NEC). Hypoxic conditions (HYP) occur when DO drops below 2 mg/L.

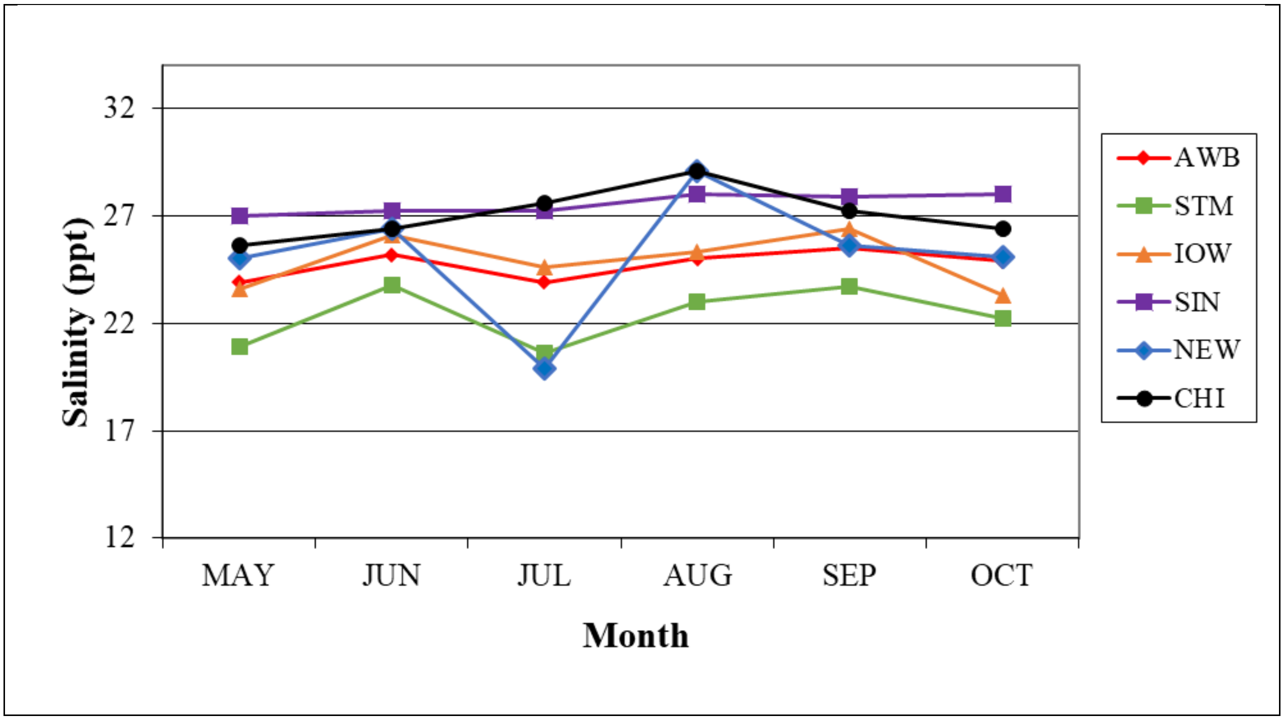

Figure 1.50. Trawl Survey (2020) mean salinity (ppt) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

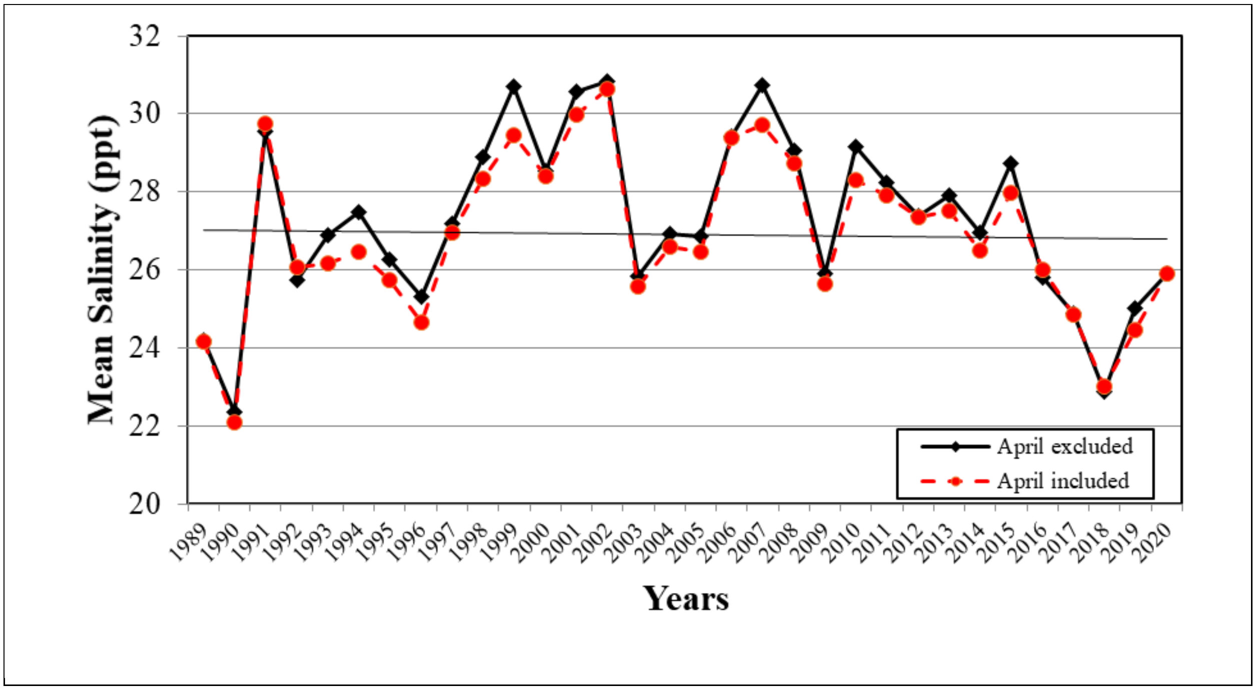

Figure 1.51. Evaluation of the mean annual April Trawl Survey salinity (ppt).

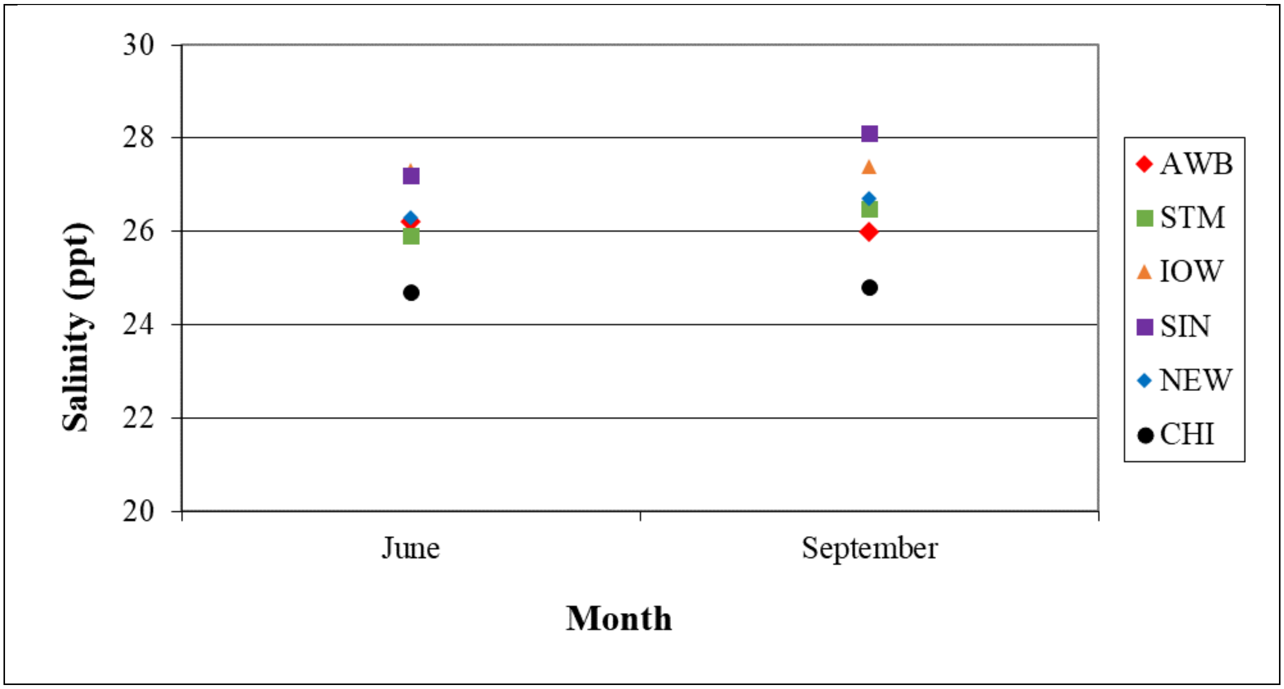

Figure 1.52. Beach Seine Survey(2020) mean salinity (ppt) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

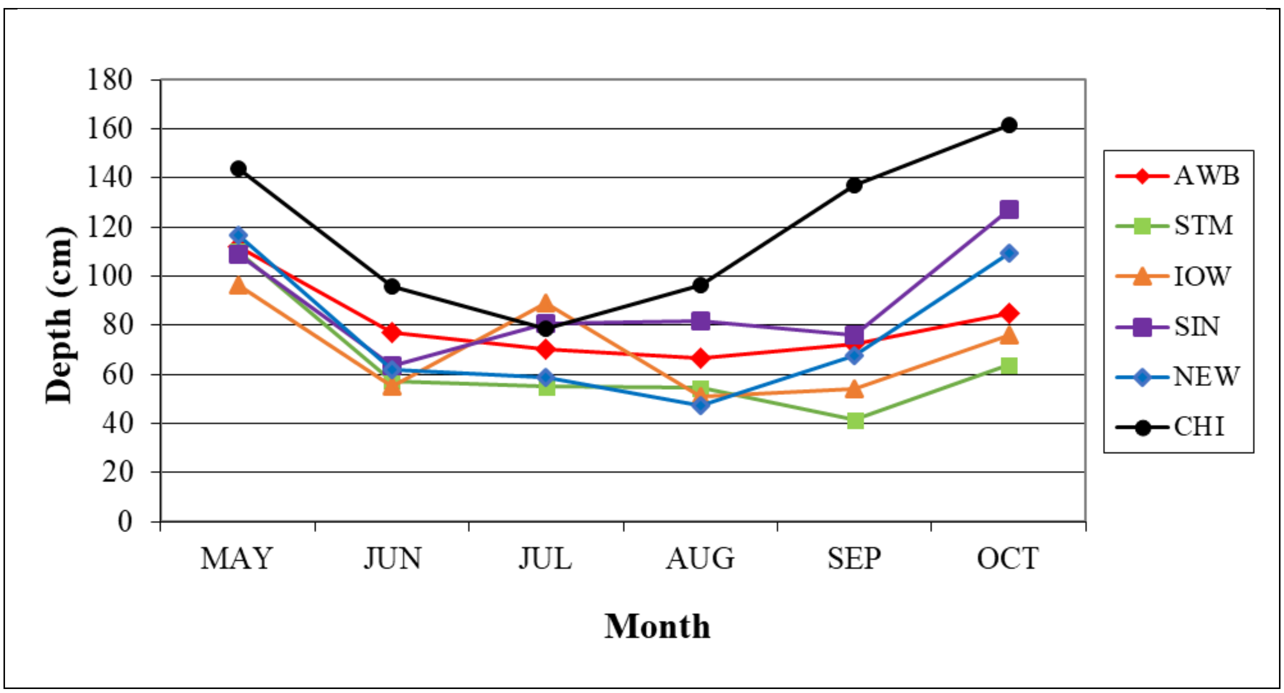

Figure 1.53. Trawl Survey (2020) mean turbidity (cm) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

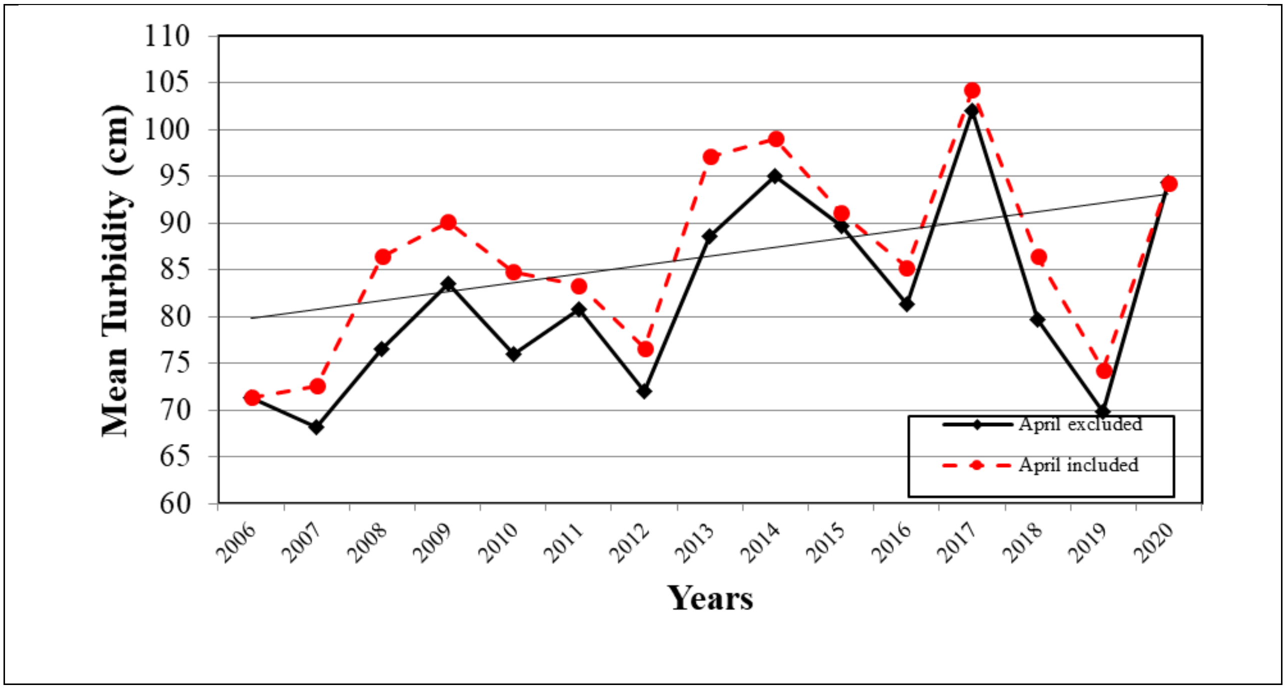

Figure 1.54. Evaluation of the mean annual April Trawl Survey turbidity (cm).

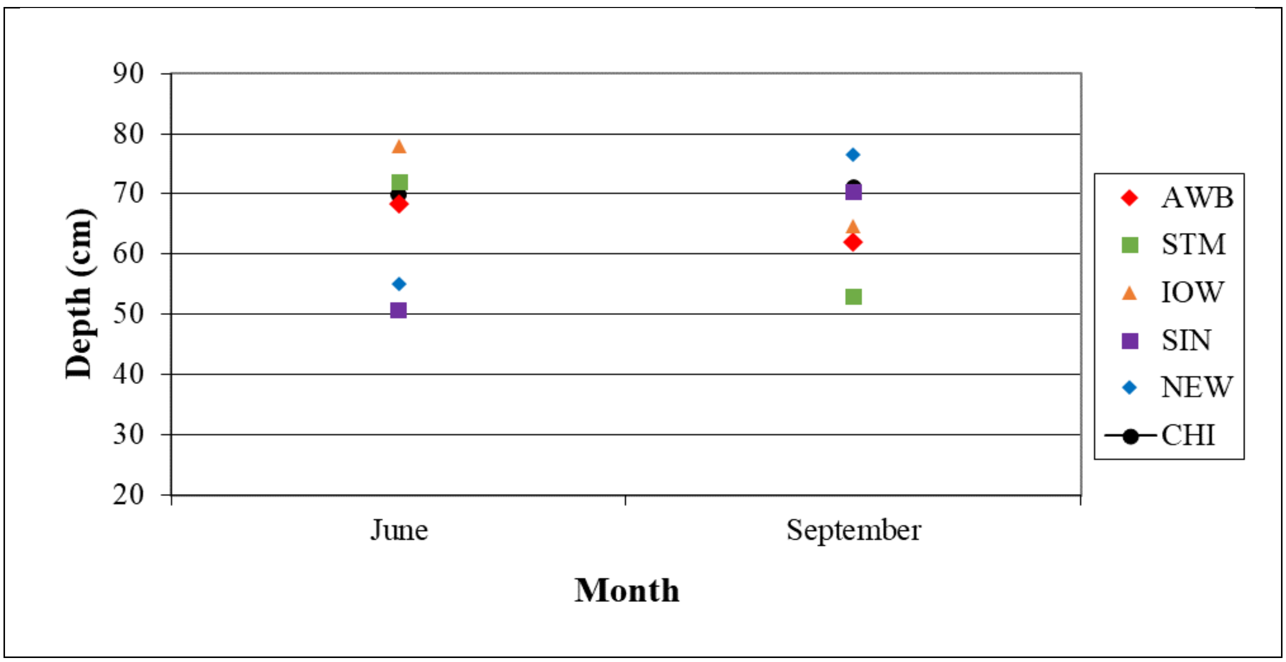

Figure 1.55. Beach Seine Survey (2020) mean turbidity (cm) by month in Assawoman Bay (AWB), St. Martin River (STM), Isle of Wight Bay (IOW), Sinepuxent Bay (SIN), Newport Bay (NEW), and Chincoteague Bay (CHI).

Chapter 2 Submerged Aquatic Vegetation Habitat Survey

Introduction
There are two Submerged Aquatic Vegetation (SAV) species found in Maryland’s coastal bays: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). SAV beds were once found throughout the coastal bays but the majority were located along the Assateague Island shoreline. 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 & Hindell, 2006). As a result, the department began sampling the SAV beds in 2012 with standardization in 2015. 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 to 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 2.1, Figure 2.1). 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 an annual reconnaissance to ensure SAV was present and the beach seine could be deployed properly.

All sampling was conducted from a 25 ft C-hawk during daylight in September over a six year period from 2015 - 2020. Latitude and longitude coordinates 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 each beach seine haul.

The SAV beach seine with a zippered bag measured 15.24 m X 1.8 m X 6.4 mm mesh (50 ft X 6 ft X 0.25 in mesh). Staff estimated percent of net open, and a rangefinder was used to quantify the 35 meter seine hauls. Staff ensured that the lead line remained on the bottom until the catch was enclosed in the 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 Atlantic silverside length target was reduced from 50 to 20 fish per beach seine haul in 2020.

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 maximum 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 CPUE, 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.

Results and Discussion

Sample Size and Distribution

These results were based on 99 unbalanced random samples collected from 2015 to 2020 within 12 SAV grids (Table 2.1, Figure 2.1). The number of beach seine hauls (samples) each year was 12, 14, 17, 21, 19, and 16 respectively. Those samples were distributed between four categories of SAV coverage: 25% or less (22 samples), 26% - 50% (22 samples), 51% - 75% (25 samples) and 76% - 100% (30 samples). These samples were also categorized by primary substrate as either sand (42 samples) or mud (57 samples). Additionally, each sample's dominant SAV species was identified; eelgrass was most abundant (72 samples) followed by widgeon grass (27 samples). Furthermore, samples were categorized for habitat interaction such as SAV coverage, substrate, and dominant SAV species (Table 2.2).

Abundance by Habitat Category

The survey's 2020 sampling collected 30 species and 1,445 fish (Table 2.3). The most abundant species by count were Atlantic silversides, silver perch, striped anchovies, and tautog. Four new fishes caught in the survey were Atlantic spadefish, cobia, feather blenny, and Spanish mackerel. Notably absent from the 2020 survey, or nearly so, were all but one sciaenid species, gray snapper, halfbeaks, and spotfin mojarra. The most abundant crustaceans by count were blue crabs, grass shrimp, and brown shrimp (Table 2.4).

A total of 46 species and 11,740 fish were collected during this six-year investigation (Table 2.3). Time series results were similar to 2020 except that silver perch counts ranked first followed by Atlantic silversides. Six different sciaenid species have been caught since 2015. Of those six species, silver perch were the most abundant on an annual basis. It is notable that the 2020 silver perch abundance (268 fishes) was below average (966 fishes) for the time series.

Catch per unit effort (CPUE) increased or decreased by the specific SAV habitat characteristics. Silver perch, Atlantic silverside, tautog, and sheepshead abundancies were relatively high in the terminal year (2020) and time series indicating a preference for SAV habitat (Table 2.3). Tautog abundance was the second highest on record in this survey (Figure 2.2). This increase may be a direct result of modifying recreational regulations in 2018 to protect this species during the peak spawning periods. The tautog abundance results from the SAV Habitat Survey were compared to the surveys in Chapter 1 by ANOVA and post hoc DMRT. Those comparisons indicated significant ($F_{3,344} = 12.99$, $p < 0.01$) differences between the three surveys within Sinepuxent Bay in September (Table 2.5). The result demonstrated that SAV Habitat is required to sustain juvenile tautog populations in the coastal bays. This survey's abundance indices will be considered for inclusion in the next stock assessment. Those data are a reliable indicator of Maryland tautog spawning success, whereas the Beach Seine Survey and Trawl Survey are not appropriate for tautog management.

Fish abundance was further characterized by percent SAV coverage, primary substrate, and dominant SAV species. The results of the Kruskal-Wallis test (KWt) indicated significant differences of fish abundance for these habitat characteristics (15 fishes, 3 crustaceans; Table 2.6). SAV coverage KWt results had significant differences in abundance for dusky pipefish, northern pipefish, silver perch, tautog, blue crab, and grass shrimp. Primary substrate KWt results had significant differences in abundance for spotfin mojarra and brown shrimp. Dominant SAV species KWt results had significant differences in abundance for Atlantic silverside, dusky pipefish, gray snapper, northern pipefish, striped burrfish, tautog, and brown shrimp. The KWt identified potential selectivity preferences for SAV habitat characteristics with the assumption that higher species abundance in a particular defined characteristic demonstrated a preferred habitat. While the KWt indicated differences in abundance were present, it did not reveal which characteristic held the highest or lowest abundance. Therefore, the KWt results with significant interactions were further investigated by ANOVA and post hoc DMRT to determine the abundance levels were indeed different and the preference selectivity by abundance levels by species.

The results from the ANOVA and post hoc DMRT confirmed the KWt results for eight fishes and all three forage crustaceans within the sample population (Table 2.7, Table 2.8 Table 2.9). SAV coverage ANOVA and DMRT results had significant differences in abundance for pipefishes, blue crab, and grass shrimp (Table 2.7). Pipefishes and blue crab preferred denser SAV coverage and grass shrimp abundance peaked in medium - high SAV coverage. Although the results were not significant for silver perch and tautog, mean abundance was highest in the high SAV coverage. Primary substrate ANOVA and DMRT results only had a significant difference in abundance for brown shrimp towards sand substrate (Table 2.8). Dominant SAV species ANOVA and DMRT results had higher abundance within widgeon grass for Atlantic silverside, gray snapper, and brown shrimp, whereas pipefishes and striped burrfish preferred eelgrass. Tautog results were not significant; however, mean abundance was higher in eelgrass (Table 2.9).

The previous CPUE results were supplemented by these SAV characteristic results, and while many of the species sampled did not indicate a significant preference for a particular SAV characteristic, this could be due to inadequate sample size or the inability to isolate the characteristics during the analysis. When conducting a test on a particular characteristic, the secondary and tertiary interactions may have influenced the lack of a preference result. Overall, the SAV coverage toward higher density beds influenced increased species abundance.

Fish Species Richness and Diversity by Habitat Category

Fish richness (number of species) was generally high (46 fishes) throughout the time series except in the multivariate categories that contained low SAV coverage of widgeon grass over mud (five fishes) and very high coverage of widgeon grass over mud (eight fishes; Table 2.10).

This result may be bias of sample size as that specific habitat was uncommon throughout the time series (Table 2.2).

Diversity (evenness of those species) results indicated that medium - high SAV coverage category (51 - 75%) with sand substrate and eelgrass was the most diverse (H = 2.1; Table 2.11). Eelgrass in general held more diversity. The large abundance of Atlantic silverside and silver perch reduced the diversity index results because the analysis favors species richness proportions at equal levels in the sample population. High diversity will allow for resilience to climate change.

Fish Length Composition by Habitat Category

Relationships of total length and habitat characteristics were investigated for significant interactions. Sheepshead, silver perch, tautog, blue crabs, and brown shrimp were selected for ANOVA and DMRT analysis (Table 2.12). SAV coverage ANOVA and DMRT results indicated significant differences in length for silver perch, tautog, and brown shrimp. Silver perch were smallest in high coverage SAV beds. The other species varied without trend or the length differences may be misleading as they were rather similar in size biologically. Larger tautogs were caught in medium-high SAV coverage; however, tautogs from all coverages were most likely young of year as the Narragansett Bay tautog estimated mean growth rate was 0.5 mm per day (Dorf & Powell, 1997). Medium-high SAV coverage may be more suitable habitat for growth and protection as size - selective predation influences natural mortality (Meekan & Fortier, 1996) (Searcy & Sponaugle, 2001) (Bergenius, Meekan, Robertson, & McCormick, 2002) (Grorud-Colvert & Sponaugle, 2006) (Searcy, Eggleston, & Hare, 2007).

Primary substrate ANOVA and DMRT results had significant differences in length for sheepshead, silver perch, tautog, and brown shrimp (Table 2.13). Silver perch were smaller in SAV beds within mud substrate whereas tautog and brown shrimp were smaller within sandy SAV beds. Dominant SAV ANOVA and DMRT results had significant differences in length for silver perch, tautog, blue crab, and brown shrimp (Table 2.14). The length difference for silver perch was only 2.1 mm and the sensitivity of the analysis resulted in a difference that was biologically insignificant. The same conclusion may be applied towards tautog, as the mean length difference was 7.1 mm. Brown shrimp were smaller in SAV beds with widgeon grass.

Regarding the primary substrate and dominant SAV results, multivariate habitat selection by fish length 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 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 to 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 - 2019 time series and the terminal year (2020) indicated a significant increase in water clarity in 2020 (Table 2.15). The increase in water clarity is promising for SAV growth. The mean water temperature in 2018 (29.7 C) was borderline close to the SAV threshold (30.0 C); however, this did decrease over time to 25.8 C in 2020. The survey design performed well to reduce the effects of water quality variation in order to compare habitat selection over the time series.

Table 2.1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey site descriptions.

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	10
109	East of Snug Harbor Road, Middle of Sinepuxent Bay, South of Small Island	38 17.622	75 07.376	4
120	East of Gray's Cove and south of Frontier Town	38 17.130	75 07.724	3
121	East of Snug Harbor, West of Small Island	38 17.221	75 07.651	20
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	15
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 2.2. Submerged Aquatic Vegetation Habitat Survey sample size by habitat characteristics (2015 - 2020).

	Percent SAV Coverage				Total by Characteristic	Grand Total
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%		
Eelgrass (*Zostera marina*)	14	24	18	26	72	99
Widgeon grass (*Ruppia maritima*)	8	8	7	4	27	
Sand	13	12	7	10	42	99
Mud	9	10	18	20	57	
Sand - Eelgrass (*Z. marina*)	6	8	5	7	26	99
Mud - Eelgrass (*Z. marina*)	8	6	13	19	46	
Sand - Widgeon grass (R. *maritima*)	7	4	2	3	16	
Mud - Widgeon grass (R. *maritima*)	1	4	5	1	11	

Table 2.3. List of fishes collected from the Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey (2015 - 2020). Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 - 2020 (n = 99)			2020 (n = 16)		
	Count	CPUE	x̄ length	Count	CPUE	x̄ length
Silver perch (*Bairdiella chrysoura*)	5,800	1,462.8	74	268	418.2	75
Atlantic silverside (*Menidia menidia*)	3,993	1,007.1	83	832	1,298.4	85
Tautog (*Tautoga onitis*)	403	101.6	68	72	112.4	68
Halfbeak (*Hyporhamphus unifasciatus*)	206	52.0	148	1	1.6	185
Sheepshead (*Archosargus probatocephalus*)	148	37.3	70	32	49.9	61
Spotfin mojarra (*Eucinostomus argenteus*)	136	34.3	79			
Northern pipefish (*Syngnathus fuscus*)	119	30.0	183	17	26.5	168
Dusky pipefish (*Syngnathus floridae*)	118	29.8	157	23	35.9	141
Striped anchovy (*Anchoa hepsetus*)	99	25.0	73	84	131.1	72
Pinfish (*Lagodon rhomboides*)	97	24.5	121	12	18.7	109
Oyster toadfish (*Opsanus tau*)	91	23.0	69	19	29.7	57
Pigfish (*Orthopristis chrysoptera*)	77	19.4	91	13	20.3	71
Striped blenny (*Chasmodes bosquianus*)	68	17.2	64	8	12.5	56
Spot (*Leiostomus xanthurus*)	67	16.9	129	1	1.6	.
Bay anchovy (*Anchoa mitchilli*)	59	14.9	66	25	39.0	66
Black sea bass (*Centropristis striata*)	52	13.1	89	14	21.8	81
Northern puffer (*Sphoeroides maculatus*)	24	6.1	135	1	1.6	85
Gray snapper (*Lutjanus griseus*)	23	5.8	73			
Summer flounder (*Paralichthys dentatus*)	23	5.8	181	2	3.1	134
Striped burrfish (*Chilomycterus schoepfii*)	20	5.0	181	2	3.1	173
Spotfin butterflyfish (*Chaetodon ocellatus*)	13	3.3	62	1	1.6	42
Atlantic menhaden (*Brevoortia tyrannus*)	10	2.5	114	1	1.6	112
White mullet (*Mugil curema*)	10	2.5	171	1	1.6	156
Atlantic needlefish (*Strongylura marina*)	9	2.3	286	3	4.7	295
Rainwater killifish (*Lucania parva*)	9	2.3	38			

Table 2.3 continued. List of fishes collected from the Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey (2015 - 2020). Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 - 2020 (n = 99)			2020 (n = 16)		
	Count	CPUE	x̄ length	Count	CPUE	x̄ length
Bluespotted cornetfish (*Fistularia tabacaria*)	8	2.0	332	1	1.6	280
Naked goby (*Gobiosoma bosc*)	6	1.5	36	1	1.6	22
Spotted seatrout (*Cynoscion nebulosus*)	6	1.5	116			
Feather blenny (*Hypsoblennius hentz*)	5	1.3	73	5	7.8	73
Southern kingfish (*Menticirrhus americanus*)	5	1.3	103			
American eel (*Anguilla rostrata*)	4	1.0	318			
Northern kingfish (*Menticirrhus saxatilis*)	4	1.0	121			
Striped mullet (*Mugil cephalus*)	4	1.0	197			
Black drum (*Pogonias cromis*)	3	0.8	133			
Blackcheek tonguefish (*Symphurus plagiusa*)	3	0.8	98			
Bluefish (*Pomatomus saltatrix*)	3	0.8	133			
Inshore lizardfish (*Synodus foetens*)	3	0.8	171	1	1.6	
Atlantic croaker (*Micropogonias undulatus*)	2	0.5	57			
Atlantic spadefish (*Chaetodipterus faber*)	2	0.5	83	2	3.1	83
Southern stingray (*Dasyatis americana*)	2	0.5	420	1	1.6	610
Cobia (*Rachycentron canadum*)	1	0.3	147	1	1.6	147
Gag (*Mycteroperca microlepis*)	1	0.3	168			
Lined seahorse (*Hippocampus erectus*)	1	0.3	130			
Skilletfish (*Gobiesox strumosus*)	1	0.3	46			
Spanish mackerel (*Scomberomorus maculatus*)	1	0.3	170	1	1.6	170
Striped killifish (*Fundulus majalis*)	1	0.3	107			

Table 2.4. List of forage crustaceans collected from the Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey (2015 - 2020). Catch per unit of effort (CPUE) was fish/hectare.

Specimen Name	2015 - 2020 (n = 83)			2020 (n = 19)		
	Count	CPUE	x̄ length	Count	CPUE	x̄ length
Blue crab (*Callinectes sapidus*)	3,940	993.7	55	785	1,225.1	42
Grass shrimp (*Palaemonetes sp.*)	1,694	427.3		344	536.8	
Brown shrimp (*Farfantepenaeus aztecus*)	750	189.2	81	12	18.7	88

Table 2.5. Select September species abundance survey comparisons in Maryland's coastal bays (2015 - 2020). Catch per unit of effort (CPUE) was individual/hectare.

Specimen Name	SAV Habitat Survey n = 99		Beach Seine Survey Sinepuxent Bay n = 18		Beach Seine Survey All Bays n = 108		Trawl Survey All Bays n = 120	
	Count	CPUE	Count	CPUE	Count	CPUE	Count	CPUE
Silver perch (*Bairdiella chrysoura*)	5,800	1,462.8	298	182.6	4,926	503	1,797	119.4
Tautog (*Tautoga onitis*)	403	101.6	2	1.2	7	0.7		
Halfbeak (*Hyporhamphus unifasciatus*)	206	52			100	10.2		
Sheepshead (*Archosargus probatocephalus*)	148	37.3	45	27.6	114	11.6	3	0.2
Pinfish (*Lagodon rhomboides*)	97	24.5	10	6.1	206	21	13	0.9
Pigfish (*Orthopristis chrysoptera*)	77	19.4	5	3.1	59	6	18	1.2
Spot (*Leiostomus xanthurus*)	67	16.9	129	79.0	1,684	172	2148	142.7
Black sea bass (*Centropristis striata*)	52	13.1	4	2.5	17	1.7	87	5.8
Northern puffer (*Sphoeroides maculatus*)	24	6.1	6	3.7	54	5.5	30	2
Gray snapper (*Lutjanus griseus*)	23	5.8	3	1.8	12	1.2		
Summer flounder (*Paralichthys dentatus*)	23	5.8	29	17.8	167	17.1	147	9.8
Atlantic menhaden (*Brevoortia tyrannus*)	10	2.5	544	333.3	19,116	1,952	81	5.4
Blue crab (*Callinectes sapidus*)	3,940	993.7	318	194.8	3,514	358.8	2,423	161.0
Grass shrimp (*Palaemonetes sp.*)	1,694	427.3	732	448.5	2,659	271.5	716	47.6
Brown shrimp (*Farfantepenaeus aztecus*)	750	189.2	109	66.8	393	40.1	323	21.5

Table 2.6. Results of the Submerged Aquatic Vegetation Habitat Survey's (2015 - 2020) Kruskal - Wallis test for percent SAV coverage, primary substrate, and dominant SAV on fish abundance (results greater than 0.05 were not significant (n.s.)).

Specimen Name	Percent SAV Coverage	Primary Substrate	Dominant SAV Species
Atlantic silverside (*Menidia menidia*)	n.s.	n.s.	($\chi 2(1) = 7.74$, $p < 0.01$)
Bay anchovy (*Anchoa mitchilli*)	n.s.	n.s.	n.s.
Dusky pipefish (*Syngnathus floridae*)	($\chi 2(3) = 14.18$, $p < 0.01$)	n.s.	($\chi 2(1) = 6.93$, $p < 0.05$)
Gray snapper (*Lutjanus griseus*)	n.s.	n.s.	($\chi 2(1) = 16.05$, $p < 0.01$)
Halfbeak (*Hyporhamphus unifasciatus*)	n.s.	n.s.	n.s.
Northern pipefish (*Syngnathus fuscus*)	($\chi 2(3) = 18.64$, $p < 0.01$)	n.s.	($\chi 2(1) = 9.10$, $p < 0.01$)
Pigfish (*Orthopristis chrysoptera*)	n.s.	n.s.	n.s.
Pinfish (*Lagodon rhomboides*)	n.s.	n.s.	n.s.
Sheepshead (*Archosargus probatocephalus*)	n.s.	n.s.	n.s.
Silver perch (*Bairdiella chrysoura*)	($\chi 2(3) = 15.08$ $p < 0.01$)	n.s.	n.s.
Spotfin mojarra (*Eucinostomus argenteus*)	n.s.	($\chi 2(1) = 5.75$, $p < 0.05$)	n.s.
Striped blenny (*Chasmodes bosquianus*)	n.s.	n.s.	n.s.
Striped anchovy (*Anchoa hepsetus*)	n.s.	n.s.	n.s.
Striped burrfish (*Chilomycterus schoepfii*)	n.s.	n.s.	($\chi 2(1) = 6.52$, $p < 0.05$)
Tautog (*Tautoga onitis*)	($\chi 2(3) = 13.60$, $p < 0.01$)	n.s.	($\chi 2(1) = 12.55$, $p < 0.01$)
Blue crab (*Callinectes sapidus*)	($\chi 2(3) = 12.82$, $p < 0.01$)	n.s.	n.s.
Brown shrimp (*Farfantepenaeus aztecus*)	n.s.	($\chi 2(1) = 9.66$, $p < 0.01$)	($\chi 2(1) = 10.29$, $p < 0.01$)
Grass shrimp (*Palaemonetes sp.*)	($\chi 2(3) = 10.89$, $p < 0.05$)	n.s.	n.s.

Table 2.7. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for CPUE and percent SAV coverage (results greater than 0.05 were not significant (n.s.)).

Specimen Name	Percent SAV Coverage Low < 25%	 Medium 26 - 50%	 Medium - High 51 - 75%	 High 76 - 100%
Dusky pipefish *(Syngnathus floridae*)	($F_{3,98}$ = 3.4, $p <$ 0.05)			
	$\bar{x}$ = 7.9	$\bar{x}$ = 14.8	$\bar{x}$ = 34	$\bar{x}$ = 53.3
	B	B	A/B	A
Northern pipefish (*Syngnathus fuscus*)	($F_{3,98}$ = 4.17, $p <$ 0.01)			
	$\bar{x}$ = 4.5	$\bar{x}$ = 25	$\bar{x}$ = 34	$\bar{x}$ = 48.3
	B	A / B	A	A
Silver perch (*Bairdiella chrysoura*)	($F_{3,98}$ = 1.57, p = n.s.)			
	$\bar{x}$ = 406.6	$\bar{x}$ = 1,643.4	$\bar{x}$ = 1,613.8	$\bar{x}$ = 2,060.5
	A	A	A	A
Tautog (*Tautoga onitis*)	($F_{3,98}$ = 1.05, p = n.s.)			
	$\bar{x}$ = 74.9	$\bar{x}$ = 52.2	$\bar{x}$ = 90.9	$\bar{x}$ = 166.5
	A	A	A	A
Blue crab (*Callinectes sapidus*)	($F_{3,98}$ = 2.4, $p <$ 0.05)			
	$\bar{x}$ = 485.8	$\bar{x}$ = 1,066.9	$\bar{x}$ = 1,099.5	$\bar{x}$ = 1,224.3
	B	A	A	A
Grass shrimp (*Palaemonetes sp.*)	($F_{3,98}$ = 5.41, $p <$ 0.01)			
	$\bar{x}$ = 67	$\bar{x}$ = 287.1	$\bar{x}$ = 876.9	$\bar{x}$ = 419.5
	B	B	A	B

Table 2.8. 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
Spotfin mojarra (*Eucinostomus argenteus*)	($F_{1,98}$ = 1.39, p = n.s.)	
	$\bar{x}$ = 61.8	$\bar{x}$ = 14
	A	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,98}$ = 3.05, $p < 0.05$)	
	$\bar{x}$ = 335.3	$\bar{x}$ = 81.5
	A	B

Table 2.9. 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*)	($F_{1,98}$ = 5.42, $p < 0.05$)	
	$\bar{x}$ = 769.2	$\bar{x}$ = 1639.7
	B	A
Dusky pipefish (*Syngnathus floridae*)	($F_{1,98}$ = 3.10, $p < 0.05$)	
	$\bar{x}$ = 37.5	$\bar{x}$ = 9.25
	A	B
Gray snapper (*Lutjanus griseus*)	($F_{1,98}$ = 12.14, $p < 0.01$)	
	$\bar{x}$ = 0.35	$\bar{x}$ = 20.35
	B	A
Northern pipefish (*Syngnathus fuscus*)	($F_{1,98}$ = 4.37, $p < 0.05$)	
	$\bar{x}$ = 37.1	$\bar{x}$ = 10.7
	A	B
Striped burrfish (*Chilomycterus schoepfii*)	($F_{1,98}$ = 5.52, $p < 0.05$)	
	$\bar{x}$ = 6.9	$\bar{x}$ = 0
	A	B
Tautog (*Tautoga onitis*)	($F_{1,82}$ = 1.01, p = n.s.)	
	$\bar{x}$ = 117.2	$\bar{x}$ = 60.1
	A	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,98}$ =10.89 , $p < 0.01$)	
	$\bar{x}$ = 82.2	$\bar{x}$ = 474.4
	B	A

Table 2.10. Submerged Aquatic Vegetation Habitat Survey Richness of fishes by habitat category.

	Percent SAV Coverage			
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%
Combined (All SAV and Substrate)	33	38	34	30
Eelgrass (*Zostera marina*)	23	29	26	26
Widgeon grass (*Ruppia maritima*)	28	27	27	15
Sand	30	33	29	19
Mud	19	22	25	26
Sand - Eelgrass (*Z. marina*)	14	24	19	15
Mud - Eelgrass (*Z. marina*)	19	21	23	25
Sand - Widgeon grass (*R. maritima*)	26	25	24	12
Mud - Widgeon grass (*R. maritima*)	5	9	18	8

Table 2.11. Submerged Aquatic Vegetation Habitat Survey Shannon - Index Diversity H values of fishes by habitat category.

	Percent SAV Coverage			
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%
Combined (All SAV and Substrate)	1.5	1.4	1.3	1.4
Eelgrass (*Zostera marina*)	1.5	1.9	1.3	1.5
Widgeon grass (*Ruppia maritima*)	1.4	1.1	1.2	1
Sand	1.4	1.4	1.6	1.2
Mud	1.5	1.4	1.1	1.5
Sand - Eelgrass (*Z. marina*)	1.3	1.9	2.1	1.3
Mud - Eelgrass (*Z. marina*)	1.4	1.6	1.1	1.5
Sand - Widgeon grass (*R. maritima*)	1.3	1.1	1	0.9
Mud - Widgeon grass (*R. maritima*)	1.5	1	1.3	1.1

Table 2.12. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for mean length and percent SAV coverage (results greater than 0.05 were not significant (n.s.)).

Specimen Name	Percent SAV Coverage Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%
Sheepshead (*Archosargus probatocephalus*)	($F_{3,147}$ = 0.01, p = n.s.)			
	$\bar{x}$ = 69.9	$\bar{x}$ = 69.7	$\bar{x}$ = 69.8	$\bar{x}$ = 70
	A	A	A	A
Silver perch (*Bairdiella chrysoura*)	($F_{3,2357}$ = 63.52, p < 0.01)			
	$\bar{x}$ = 85	$\bar{x}$ = 76.2	$\bar{x}$ = 75.7	$\bar{x}$ = 69
	A	B	B	C
Tautog (*Tautoga onitis*)	($F_{3,401}$ = 6.79, p < 0.01)			
	$\bar{x}$ = 63.7	$\bar{x}$ = 62.6	$\bar{x}$ = 73.6	$\bar{x}$ = 67.6
	B	B	A	B
Blue crab (*Callinectes sapidus*)	($F_{3,2391}$ = 1.53, p = n.s.)			
	$\bar{x}$ = 58	$\bar{x}$ = 55.9	$\bar{x}$ = 55.5	$\bar{x}$ = 52.9
	A	A / B	B	A / B
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{3,477}$ = 8.8, p < 0.01)			
	$\bar{x}$ = 88.2	$\bar{x}$ = 75.8	$\bar{x}$ = 81.9	$\bar{x}$ = 82.8
	A	C	B	A / B

Table 2.13. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for mean length and primary substrate (results greater than 0.05 were not significant (n.s.)).

Specimen Name	Primary Substrate Mud	Sand
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 2.14. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for mean length and dominant SAV (results greater than 0.05 were not significant (n.s.)).

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
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 2.15. Results of the Submerged Aquatic Vegetation Habitat Survey ANOVA and Duncan's multiple range test for mean surface water quality parameters by time period (results greater than 0.05 were not significant (n.s.)).

Parameter	Time Period	
	2015 - 2019	2020
Temperature (C)	($F_{1,82}$ = 0.44, p = n.s.)	
	$\bar{x}$ = 25.9	$\bar{x}$ = 26.4
	A	A
Salinity (ppt)	($F_{1,98}$ = 1.42, p = n.s.)	
	$\bar{x}$ = 27.6	$\bar{x}$ = 28.3
	A	A
Dissolved oxygen (mg/L)	($F_{1,98}$ = 0.59, p = n.s.)	
	$\bar{x}$ = 6.6	$\bar{x}$ = 6.3
	A	A
Turbidity (Secchi depth cm)	($F_{1,98}$ = 18.4, p < 0.01)	
	$\bar{x}$ = 57	$\bar{x}$ = 81.1
	B	A

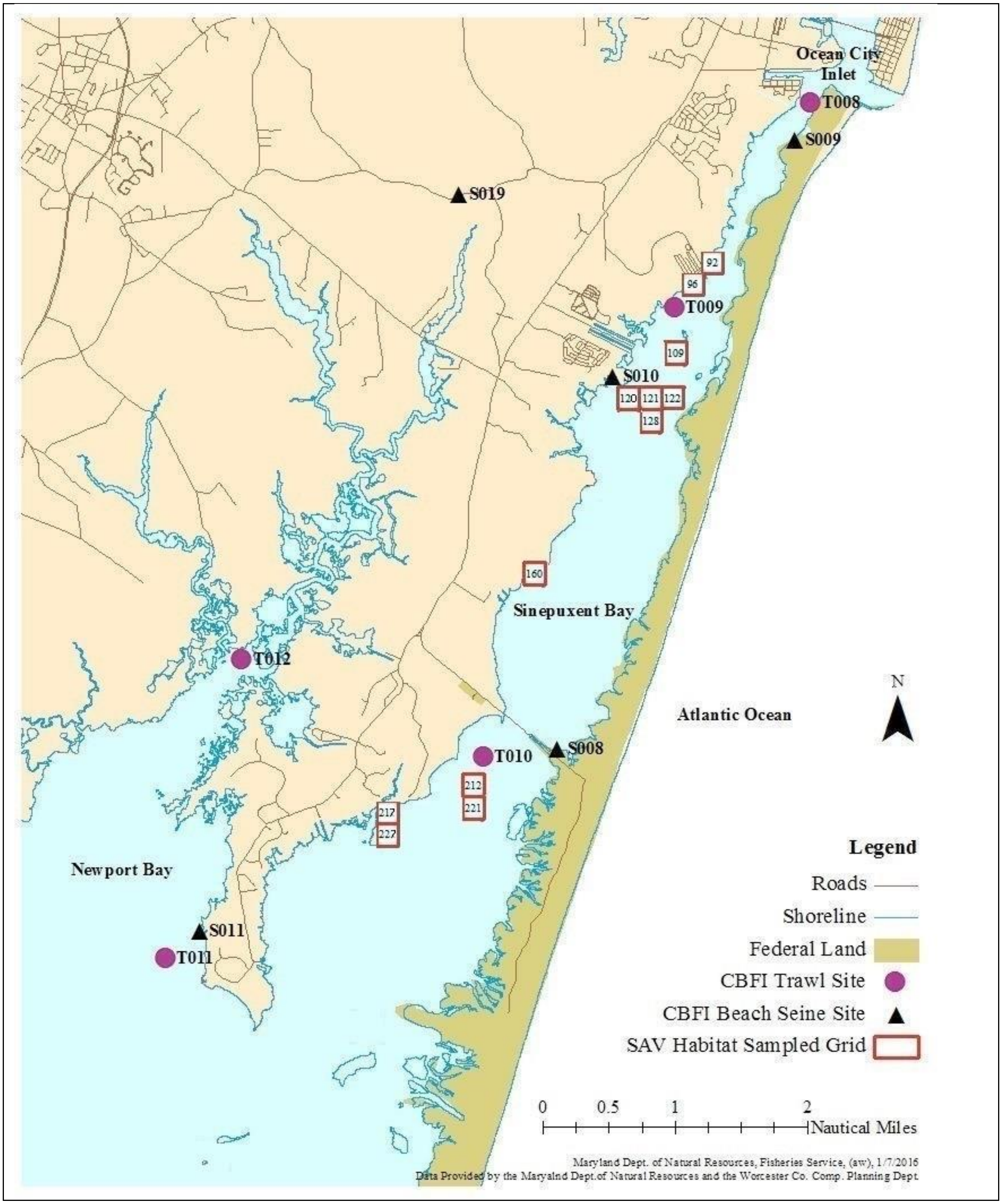

Figure 2.1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey and Trawl and Beach Seine surveys sample site locations (2015 - 2020).

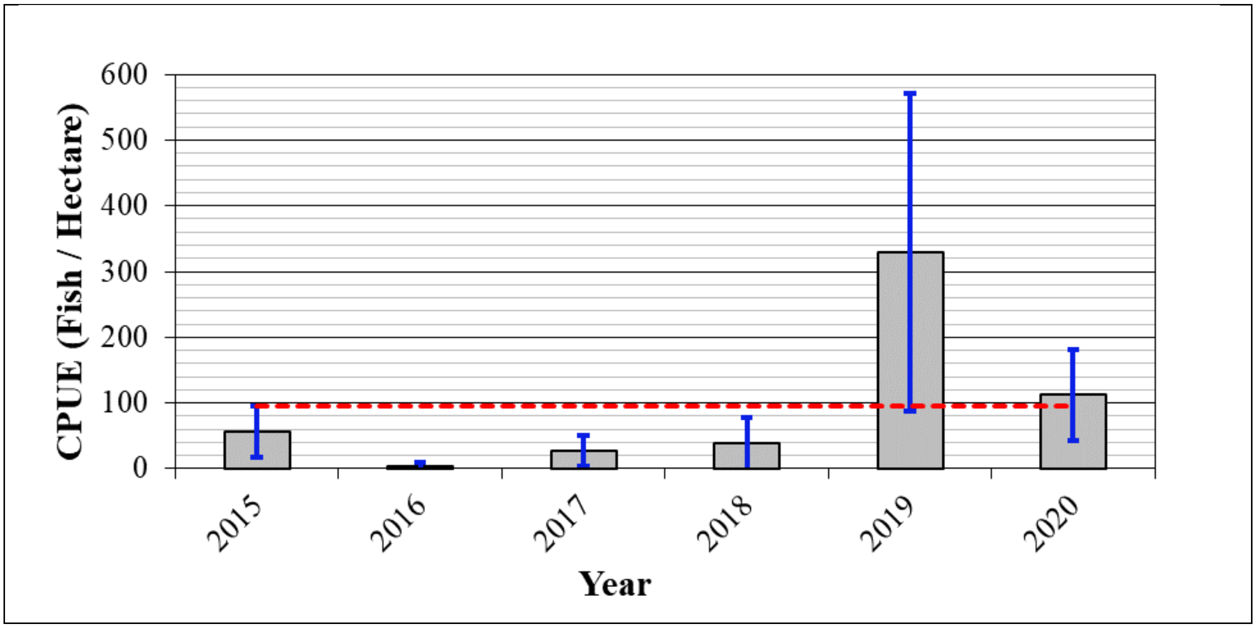

Figure 2.2. Tautog CPUE from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2020). Dotted line represents the 2015 - 2020 time series grand mean (n = 99).

Chapter 3 Fisheries Dependent Tautog (*Tautoga onitis*) Data Collection

Total length, sex, and opercula were collected dockside from 200 tautog during 12 trips in 2020. The ASMFC mandated ageing structures were collected from Ocean City charter and party boat trips taken in January (1 trip, n = 7 fish), February (2 trips, n = 10 fish), May (1 trip, n = 8 fish), October (1 trip, n = 5 fish, November (2 trips, n = 52 fish), and December (5 trips, n = 118 fish). Those samples represented the range of fish lengths commonly caught in the recreational fishery in Maryland. Moreover, two undersize fish were intercepted by law enforcement in November and were included in this study.

Aged fish total lengths ranged from 285 mm to 772 mm, mean length was 476 mm, and median length was 452 mm for both sexes combined. Females comprised 52% (n = 105) of the samples with a mean length of 463 mm and median length of 440 mm. Males comprised 48% (n = 97) of the samples with a mean length of 487 mm and median length of 470 mm. The 430 mm length bin had the highest proportion of catch (21.3%) followed by the adjacent length bins (Table 3.1). The 95% confidence interval was affected by the sample size.

Fish age ranged from two to 24 years, mean age was 7.9 years, and the median age was seven years. Six-year-old tautog comprised 21.3% of the samples and was the largest age bin (Table 3.2). The mean and median age was seven years for females and eight years and seven years for males. The combined sex age frequency results from 2016 - 2020 (n = 1,074) indicated that five-year old tautog were most frequently caught by recreational anglers (Figure 3.1).

Von Bertalanffy growth curve was fitted to the 2016 - 2020 length-age data (n = 1,074) using three parameter estimates (m = 3): asymptotic length in centimeters (Linf), growth rate (K), and age at zero size (t0). Tautog length-at-age data and the von Bertalanffy growth curve estimate results were similar to the previous parameters in the stock assessment (Linf, 70.65; k, 0.11 and t0, -2.11; Figure 3.2). The 95% confidence interval range was affected by the sample size.

Table 3.1. Tautog proportion at length of samples collected from Ocean City, Maryland (2020; n = 202). Green cells indicate legal fish (406 mm/16 in).

mm	280	360	410	430	460	480	510	530	560	580	610	640	660	690	740	760
in	11	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30
percent	0.5	0.5	19.3	21.3	17.3	11.9	8.9	5.9	3.0	4.0	1.5	1.5	2.5	0.5	1.0	0.5

Table 3.2. Tautog proportion at age of samples collected from Ocean City, Maryland (2020; n = 202).

age	3	4	5	6	7	8	9	10	11	12	13	14	16	17	18	19	20	21	22	23	24
percent	1.5	5.4	17.3	21.3	17.3	11.4	4.5	6.4	3.0	2.0	2.0	1.5	0.5	0.5	0.5	0.5	1.0	0.5	1.0	1.5	0.5

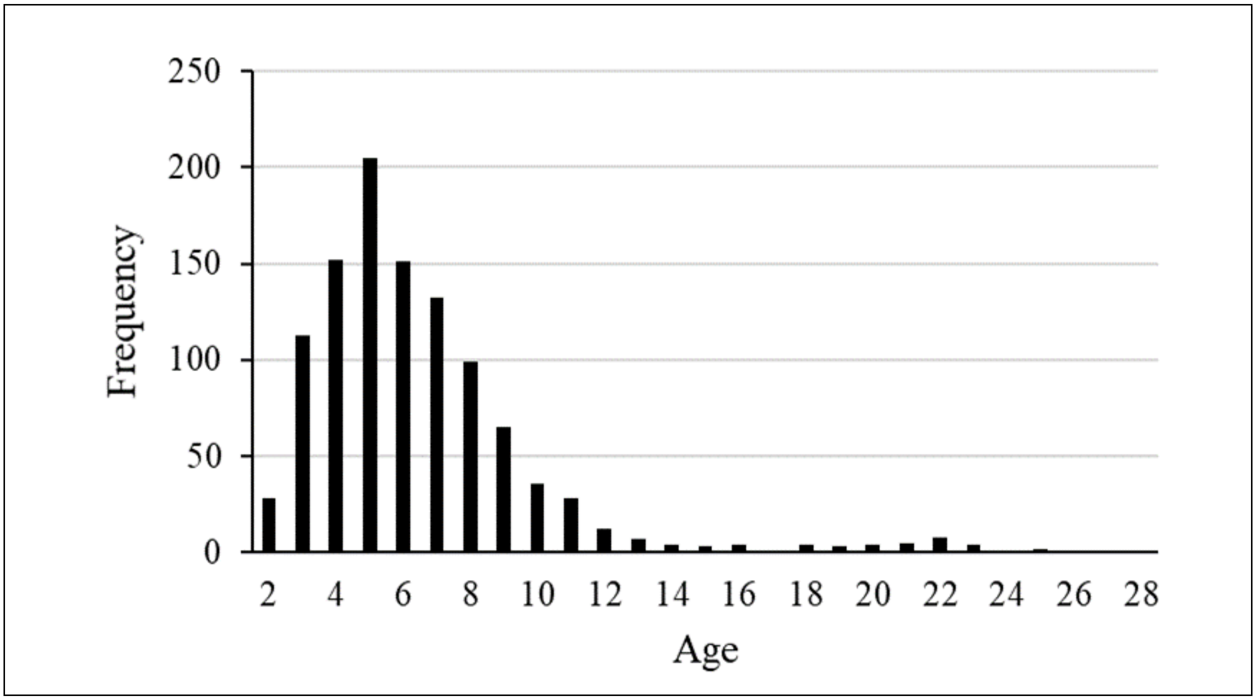

Figure 3.1. Tautog age frequency representing fish commonly caught in the recreational fishery in Ocean City, Maryland, (2016 - 2020; n = 1,074).

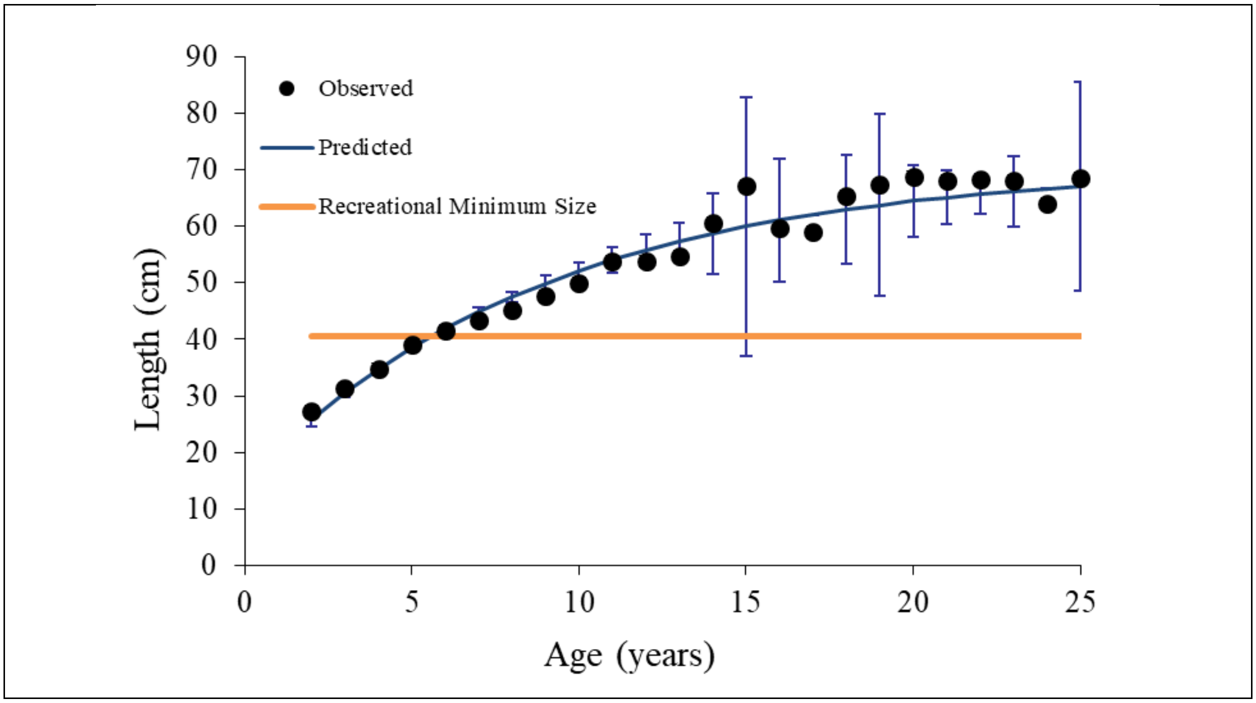

Figure 3.2. Tautog length-at-age and von Bertalanffy growth curve results with 95% confidence intervals, Ocean City, Maryland (2016 - 2020; n = 1,074).

Chapter 4 Technical Assistance

One of the grant 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 and provided evidence of compliance with state and federal fisheries management plans. A summary of the participation and contributions are presented in Table 4.1.

Table 4.1. Summary of technical assistance.

Species	Technical Committee Participation	Data Provided for the ASMFC Compliance Report	F-50-R Staff Wrote the ASMFC Compliance Report	Data Provided During 2020/2021 Assessment/Update	2020/2021 Stock Assessment/Update Participation
Atlantic croaker		Trawl			
Black drum		Beach Seine			
Black sea bass	ASMFC/MAFMC	Trawl/Beach Seine	Yes	Trawl	
Bluefish		Beach Seine			
Coastal sharks	No ASMFC meetings held		Yes		
Cobia		Beach Seine			
Red Drum				Beach Seine	
Scup	ASMFC/MAFMC		Yes		
Spot		Trawl/Beach Seine			
Spotted seatrout		Beach Seine			
Summer flounder	ASMFC/MAFMC	Trawl/Beach Seine	Yes		
Tautog	ASMFC	Trawl/Beach Seine/SAV Habitat	Yes	Trawl/Beach Seine/SAV Habitat	Yes

		Survey/Dependent Collection		Survey/Dependent Collection	
Weakfish		Trawl			
Other Expertise					
ASMFC, Northeast Area Monitoring and Assessment Program					
DNR, Chesapeake and Coastal Services, Climate Change Planning Committee					
DNR, Ecosystem Health Assessment, Fisheries Investigation					
National Estuary Program, Maryland Coastal Bays Program Science and Technical Advisory Committee					

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