Wes Moore
Governor

Josh Kurtz
Secretary

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

F-50-R-31

July 2022 - June 2023
Final Report

Prepared by:
Steve Doctor
Gary Tyler
Craig Weedon
Angel Willey

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

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

Approved by: ______________________________
Michael Luisi, Assistant Director, Fishing and Boating Services

Approved by: ______________________________
Lynn Fegley, Acting Director, Fishing and Boating Services

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Accomplishments July 1, 2022 - June 30, 2023

July - August 2022

- 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-30 report.
- Wrote the Atlantic States Marine Fisheries Commission (ASMFC) Coastal Sharks Compliance report.
- Collected two tautog opercula for ageing.

September - October 2022

- Collected 20 trawl samples at 20 fixed sites (monthly).
- Collected 19 beach seine samples at 19 fixed sites (September).
- Collected 18 Submerged Aquatic Vegetation Habitat Survey samples in Sinepuxent Bay (September).
- Finalized the F-50-R-30 report.
- Completed data entry and quality control from prior month's sampling.
- Collected seven tautog opercula for ageing.

November 2022

- Completed quality control for the entire dataset.
- Collected two tautog opercula for ageing.

December 2022 - March 2023

- Conducted data analyses of the surveys.
- Drafted the F-50-R-29 annual report.
- Collected 105 tautog opercula for ageing.
- Prepped and aged 211 tautog for the 2022 fishing year.

April - June 2023

- Prepared for the 2022 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-31 report.
- Wrote the Atlantic States Marine Fisheries Commission’s black sea bass, scup, summer flounder, and tautog compliance reports.
- Collected 149 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, the National Oceanic and Atmospheric Administration, 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 2022 through June 2023, the terminal year of data used in this report is 2022, because a full sampling season is needed for data analyses.

Acknowledgements

Staff would like to recognize the contributions of some dedicated researchers that have shared cold mornings and hot, muddy days on the coastal bays.

Debra Rosales, PhD (NOAA/UMES); Alexis Park (MD DNR), Carrie Hoover (MD DNR), Tyson Johnson (MD DNR), Carly Toulan (Maryland Coastal Bays Program), Liz Wist (Maryland Coastal Bays Program), Catlin Starks (ASMFC), Sarah Cvach (MD DNR), Paige Willey (Student), Billy Weiland (Maryland Coastal Bays Program), and Jonathon Watson (NOAA).

Executive Summary

The investigation was developed to characterize 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 Trawl, Beach Seine, and the Submerged Aquatic Vegetation Habitat surveys in the bays, behind Fenwick and Assateague Islands. 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 committees, writing Atlantic States Marine Fisheries Commission compliance reports, and contributing to environmental and permit reviews to help ensure potential impacts to fish and wildlife are avoided, minimized and/or compensated/mitigated.

In 2022, 55,321 fish were caught in the Trawl and Beach Seine surveys (9,723 fish trawling and 45,598 fish beach seining). The total number of individuals collected by trawl was within the normal range whereas the beach seine catch was the second highest in the time series. The total number of individuals for both gears combined was the third highest in the time series. Collected fishes represented 66 species, which is within the lowest quartile in the time series. Pinfish and spot had above average trawl indices while Atlantic croaker, Atlantic silverside, bay anchovy, summer flounder, and weakfish had below average trawl indices. Black sea bass, pinfish and spot had above average beach seine indices while bluefish, silver perch, and weakfish had below average indices.

Richness is the number of different fishes sampled. High richness is an indicator that the overall habitat can support many species 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 (89 fishes) in the trawl time series (1989 - 2022) whereas Newport Bay had the lowest (69 fishes). The Beach Seine Survey time series (1989 - 2022) results indicated that Assawoman Bay, Isle of Wight Bay, and Chincoteague Bay had the richest fish populations (88, 87, and 85 fishes respectively), and Newport Bay was lowest (70).

Diversity is a measurement of richness and the proportion of fishes in the sample population. The high number of spot in the trawl survey and Atlantic menhaden, spot, and bay anchovy in the beach seine survey drove down diversity in 2022. Shannon index results for the trawl time series (1989 - 2022) 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 - 2022) 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 2022 trawl and beach seine CPUE for macroalgae were equal to the time series grand means CPUE (217.4 L/ha and 21.9 L/haul, respectively). Fourteen genera were collected by trawl and beach seine in 2022. *Agardhiella* remained the most abundant genus for both gears.

The water quality at most sample sites was consistent with fish habitat requirements. Dissolved oxygen was rarely found below critical levels and the salinity range supports coastal fishes. Analysis of dissolved oxygen and fish catches from the surveys indicated that the coastal bays rarely experienced low enough dissolved oxygen to negatively impact abundances. However, the investigations sampling occurred during the day when the effects of low dissolved oxygen may not have 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 Sinepuxent Bay. The survey also confirms that with continued monitoring of fishes in this habitat, stock assessment and species-specific habitat criteria can be refined.

Tautogs (211 fish) were obtained for ageing from charter and party boats, private anglers, and the commercial bycatch fishery. Ageing results had a wide range of year classes, and large fish caught by hook and line in the Atlantic Ocean. The maximum age was 22 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 - 2021.

Over 140 adult and juvenile species of fishes, 26 molluscs, 20 macroalgae genera, and two Submerged Aquatic Vegetation (SAV) species have been collected since 1972. These surveys contribute to the investigation's 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 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.

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 on 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.

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 April through October (Table 1.1, Figure 1.1, Figure 1.2, and Figure 1.3). Except for June and September, samples were taken beginning the third week of the month. Sampling began the second week in June and September to allow enough time to incorporate beach seine collections.

The boat operator considered 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 percentage 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)), water temperature (Celsius (C)), and pH (Potential of Hydrogen). 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, water temperature, and potential of hydrogen were taken with a Yellow Springs Instrument Pro Quatro at two depths, 30 cm (1 ft) below the surface (all gears) and 30 cm (1 ft) from the bottom (trawl). The Pro Quatro cord was marked in one foot intervals. Chemical data were only taken 30 cm below the surface for each beach seine site and at trawl site T019 due to the shallow depth (< 1.1 m). The Pro Quatro 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 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.

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 - 2021). 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) ± standard error * (t value: $\alpha = 0.05$, n - 1)], respectively. A geometric grand mean was calculated for the time series (1989 - 2021) and used as a point estimate for comparison to the annual (2022) estimate of relative abundance.

Fish diversity was calculated by the Shannon index (H), which 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 2022. 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.

Linear regression, ANOVA and post hoc Duncan's Multiple Range Test (DMRT) were used to evaluate trawl survey annual and monthly mean parameter values for dissolved Oxygen, salinity, temperature, and turbidity. For both surveys, the DO was reviewed at the set level to monitor if readings 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

Finfish were the most abundant taxa captured in the survey. Specifically, they accounted for 55,321 fish caught in the Trawl and Beach Seine surveys in 2022 (9,723 fish trawling and 45,598 fish beach seining; Table 1.4). The total number of individuals collected by trawl was within the normal range whereas the beach seine catch was the second highest in the time series. The total number of individuals for both gears combined was the third highest in the time series. Although abundance was high, diversity was low. Collected fishes represented 66 species for both gears combined, which was within the lowest quartile of values in the time series.

Pinfish and spot had above average trawl indices while Atlantic croaker, Atlantic silverside, bay anchovy, bluefish, summer flounder, and weakfish had below average trawl indices. Black sea bass, pinfish and spot had above average beach seine indices while bluefish, silver perch, and weakfish had below average indices (Table 1.6). Since 2014, summer flounder have had an average or below average trawl index and an average or above average beach seine index which may indicate a preference change to shallow habitat.

Seasonal arrival and peak abundance of fishes in the coastal bays has been steady and predictable based on the known spawning behavior (Table 1.7, Table 1.8). June reflects peak arrival and abundance of juvenile fishes whereas September revealed the diversity and richness. The surveys captured crucial signals of abundance.

Crustaceans were the second most abundant taxa captured in this survey. Specifically, they accounted for 6,356 specimens caught trawling (2,142 crustaceans) and beach seining (4,214 crustaceans) in 2022 (Table 1.9). Sixteen crustacean species were identified, and the three most abundant species were grass shrimp, blue crabs, and sand shrimp all of which were excellent forage to support recreational finfish species.

The third most abundant category was other species. Twenty other species were captured including bryozoans, ctenophores, horseshoe crabs, northern diamondback terrapins, sponges, and tunicates (Table 1.10). Sea squirts were the most abundant by count (3,030) but comb jellies were the highest by volume (156.9 L).

The fourth most abundant taxa captured in the survey were molluscs. Specifically, they accounted for 848 specimens caught trawling (844 molluscs) and beach seining (4 molluscs;

Table 1.11). Molluscs were represented by 12 different species and the most abundant species were sponge slugs, solitary glass bubble snails, and Atlantic brief squid.

Sixteen plant species were captured trawling and beach seining (Table 1.12). Two species of SAV and 14 macroalgae genera were encountered. SAV accounted for 10.8 L in the trawl and 19.5 L in the beach seine. Macroalgae accounted for 3,817 L in the trawl and 789 L in the beach seine.

American eel (*Anguilla rostrata*)

American eels, a forage and bait species of interest to recreational anglers, were captured in 10 of 140 trawls (7.1%) and in four of 38 beach seines (10.5%). Thirty two American eels were collected in trawl (27 fish) and beach seine (5 fish) samples (Table 1.4). American eel ranked 23 out of 66 species in overall finfish abundance. The trawl and beach seine CPUEs were 1.5 fish/ha and 0.1 fish/haul, respectively.

Both the 2022 trawl and beach seine relative abundance indices were equal to the grand means (Figure 1.4, Figure 1.5). Since 1989, the trawl (4 years) and beach seine (7 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 protected bays or creeks with macroalgae. Many of them were caught in Turville Creek (T006), a site known to have an abundance of macroalgae, 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 American eels caught by the trawl measured 51 mm to 271 mm. The minimum length increased from April through October reflecting growth of the young of the year American eels (Table 1.13). The exception was one larger adult eel (271 mm) that was caught in the trawl survey in July. In the Beach Seine Survey, four eels from 53 to 543 mm were caught in June and an adult measuring 258 mm was caught in September (Table 1.14). 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 28 of 140 trawls (20%) and in two of 38 beach seines (5.3%). A total of 71 juvenile Atlantic croakers were collected in trawl (68 fish) and beach seine (3 fish) samples (Table 1.4). Atlantic croakers ranked 17 out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 3.9 fish/ha and <0.1 fish/haul, respectively.

The 2022 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 (20 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). According to Murdy and Musick (2013), Atlantic croakers spawn in the continental shelf waters, peaking from August through October, and are transported by ocean currents to the coastal bays.

Good trawl sites for collecting Atlantic croakers were 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 April through September in the Trawl Survey. The monthly mean length ranged from 24 mm to 170 mm and increased from April through August, then declined in September with the influx of some new young of the year individuals (Table 1.13). The Beach Seine Survey mean length in June was 35 mm. (Table 1.14).

Atlantic menhaden (*Brevoortia tyrannus*)

Atlantic menhaden, a forage species, were captured in 12 of 140 trawls (8.6%) and in 22 of 38 beach seines (57.9%). Atlantic menhaden ranked first out of 66 species in overall finfish abundance. A total of 19,839 juvenile Atlantic menhaden were collected in trawl (193 fish) and beach seine (19,646 fish) samples (Table 1.4). The trawl and beach seine CPUE was 11 fish/ha and 517 fish/haul, respectively.

Both the 2021 trawl and beach seine relative abundance indices were equal to the grand means (Figure 1.8, Figure 1.9). Since 1989, the trawl index sometimes (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 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 trawling increased from 39 mm in May to 90 mm in October, with one fish of 44 mm caught in May (Table 1.13). The Beach Seine Survey had similar results with an increase from a mean length of 52 mm in June to a mean length of 85 mm in September (Table 1.14). 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 two of 140 trawls (1.4%) and in 32 of 38 beach seines (84%). A total of 2,878 Atlantic silversides were collected in trawl (11 fish) and beach seine (2,867 fish) samples (Table 1.4). Atlantic silversides ranked forth out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 0.6 fish/ha and 75.4 fish/haul, respectively.

The 2022 trawl relative abundance index was below the grand mean and beach seine relative abundance index was equal to the grand mean (Figure 1.10, Figure 1.11). Since 1989, the trawl index sometimes (16 years) and beach seine index rarely (7 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.

The Trawl Survey mean length ranged from 37 mm to 66 mm in June and July and the (Table 1.13). The Beach Seine Survey mean lengths were 71 mm in June and 76 mm in September (Table 1.14). The monthly variability of the mean lengths is likely related to the monthly lunar spawning cycle, March through July (Murdy & Musick, 2013).

Bay anchovy (*Anchoa hepsetus*)

Bay anchovies, a forage species, were captured in 54 of 140 trawls (38.6%) and in 14 of 38 beach seines (36.8%). A total of 17,166 bay anchovies were collected in trawl (644 fish) and beach seine (16,522 fish) samples (Table 1.4). Bay anchovies ranked second out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 36.7 fish/ha and 434.8 fish/haul, respectively.

The 2022 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was equal to the grand mean (Figure 1.12, Figure 1.13). Since 1989, the trawl (14 years) and beach seine (9 years) indices sometimes 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 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 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 50 mm to 66 mm (Table 1.13). The mean monthly lengths from the Beach Seine Survey were 71 mm in June and 49 mm in September (Table 1.14). Spawning appears to occur multiple times from May to September. The presence of both smaller and larger individuals 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 28 of 140 trawls (20%) and 12 of 38 beach seines (31.6%). A total of 127 juvenile black sea bass were collected in trawl (46 fish) and beach seine (81 fish) samples (Table 1.4). Black sea bass ranked 11 out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 2.6 fish/ha and 2.1 fish/haul, respectively.

In 2022, the trawl relative abundance index was equal to the grand mean and the beach seine relative abundance index was above the grand mean (Figure 1.14, Figure 1.15). The beach seine index was the highest value in the time series. Since 1989, the trawl index often (17 years) and beach seine index sometimes (9 years) varied significantly from the grand means. The Trawl Survey usually 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. Measured water quality parameters 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 Trawl Survey mean length of black sea bass increased from 76 mm in May to 134 mm in August and then decreased to 115 mm in October (Table 1.13). The Beach Seine Survey mean length decreased from 81 mm in June to 66 mm in September (Table 1.14). Black sea bass increased in mean length at the start of the sampling season reflecting growth, then decreased in mean length with the influx young of the year fish in the later part of the summer. The coastal bays are a nursery for young of the year black sea bass through age-1.

Pinfish (*Lagodon rhomboides*)

Pinfish, a species considered forage for adult gamefish, were collected in 36 of 140 trawls (25.7) and 21 of 38 seines (71%), A total of 1,490 pinfish were collected in trawl (179 fish) and beach seine (1,311 fish; Table 1.4). Pinfish ranked 5 out of 66 species in overall fish abundance. The trawl CPUE was 10.2 fish/ha and the beach seine CPUE was 34.5 fish/haul.

The 2022 trawl and beach seine relative abundance indices were both above the grand means (Figure 1.16, Figure 1.17). Since 1989, the trawl index often (21 years) varied from the grand mean and beach seine index sometimes (15 years) sometimes varied significantly from the grand mean. Pinfish were collected 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. Pinfish are considered a warmer water species in the mid-Atlantic. The SAV Habitat Survey indicates that SAV is important juvenile habitat.

Pinfish mean length increased from 32 mm in May to 132 mm in September (Table 1.13). There was one pinfish caught in October by trawl and its length was 116 mm. The beach seine June and September mean lengths were 56 mm and 123 mm, respectively (Table 1.14). It appears that young of the year recruit to the coastal bays in May through July and grow as the summer progresses.

Sheepshead (*Archosargus probatocephalus*)

Sheepshead, a species of interest to recreational anglers, were collected in four of 140 trawls (2.9%) and seven of 38 beach seines (18.4%). A total of 47 juvenile sheepshead were collected in trawl (four fish) and beach seine (43 fish; Table 1.4). Sheepshead ranked 20 out of 66 species in overall finfish abundance. The trawl CPUE was 0.2 fish/ ha and the beach seine CPUE was 1.1 fish/haul.

The 2022 trawl and beach seine relative abundance indices were both equal to the grand means (Figure 1.18, Figure 1.19). 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 trawl between August and September ranged in length from 45 mm to 90 mm (Table 1.13). The sheepshead caught in September ranged in total length from 48 mm to 95 mm with a mean of 63 mm (Table 1.14).

Silver perch (*Bairdiella chrysoura*)

Silver perch, a forage species, were collected in 33 of 140 trawls (23.6%) and 14 of 38 beach seines (36.8%). A total of 210 silver perch were collected in trawl (127 fish) and beach seine (83 fish) samples (Table 1.4). Silver perch ranked eight out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 7.2 fish/ha and 2.2 fish/haul, respectively.

The 2022 trawl relative abundance index was below the grand mean and the beach seine relative abundance index was below the grand mean (Figure 1.20, Figure 1.21). Since 1989, the trawl index sometimes (18 years) varied significantly from the grand mean and the beach seine index rarely (4 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).

Silver perch were collected by trawl from June through October and the mean size varied from 35 mm to 165 mm. The mean length increased sequentially from July through October reflecting growth of the young of the year silver perch (Table 1.13). In the Beach Seine Survey, the mean length was 137 mm in June and 89 mm in September (Table 1.14).

Spot (*Leiostomus xanthurus*)

Spot are important forage, to recreational anglers for bait, and as a target species. Spot were collected in 96 of 140 trawls (70%) and 36 of 38 beach seines (94.7%). A total of 11,722 spot were collected in trawl (7,776 fish) and beach seine samples (3,946 fish; Table 1.4). Spot ranked third out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 442.9 fish/ha and 103.8 fish/haul, respectively.

The 2022 trawl and beach seine relative abundance indices were both above the grand means (Figure 1.22, Figure 1.23). Since 1989, the trawl index frequently (27 years) varied significantly from the grand mean and the beach seine (24 years) index often varied significantly from the grand mean. Spot spawn offshore; therefore, environmental conditions including global weather patterns, ocean currents and the North Atlantic Oscillation 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 42 mm in May to 120 mm in October (Table 1.13). In the Beach Seine Survey, the mean length increased from 88 mm in June to 121 mm in September (Table 1.14). The increase in mean length reflects growth of the young of the year cohort throughout the summer season.

Summer flounder *(Paralichthys dentatus)*

Summer flounder, a species of interest to recreational anglers, were collected in 31 of 140 trawls (22.1%) and 29 of 38 beach seines (76.3%). A total of 243 summer flounder were collected in trawl (111 fish) and beach seine (132 fish) samples (Table 1.4). Summer flounder ranked sixth out of 66 species in overall finfish abundance. The trawl and beach seine CPUE was 6.3 fish/ha and 3.5 fish/haul, respectively.

The 2022 trawl relative abundance index was below the grand mean while the beach seine index was equal to the grand mean (Figure 1.24, Figure 1.25). Since 1989, the trawl index often (24 years) varied significantly from the grand mean and the beach seine index sometimes (16 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. Since 2014, summer flounder have had an average or below average trawl index and an average or above average beach seine index which may indicate a preference change to shallow habitat (Figure 1.26).

Productive summer flounder trawl and beach seine sites were 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, pH, 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 ranged from 43 to 197 mm with the most individuals caught in July (Table 1.13). In the Beach Seine Survey, the mean length increased from 68 mm in June to 157 mm in September (Table 1.14). 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 19 of 140 trawls (13.6%) and zero of 38 beach seines. A total of 222 juvenile weakfish were collected in trawl samples (Table 1.4). Weakfish ranked seventh out of 66 species in overall finfish abundance. The trawl CPUE was 12.6 fish/ha.

The 2022 trawl relative abundance index was below the grand mean (Figure 1.27). Since 1989, the trawl (18 years) occasionally varied significantly from the grand mean. Weakfish were only caught in open water; therefore, the trawl index represents a more accurate picture of changes in relative abundance. 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. Historical productive trawl sample sites for weakfish were in all coastal bays, indicating a broad distribution, with a particular affinity towards Assawoman Bay and the St. Martin River.

Weakfish mean length increased from 58 mm in July to 131 mm in October with most individuals caught in July (Table 1.13). Young of the year recruitment was most evident from July, which follows the peak spawning period of May through June (Murdy & Musick, 2013).

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 2022 Trawl Survey, Assawoman Bay (25 species) held the most species of fishes and Newport Bay (12 fishes) was the least diverse (Table 1.15). The Shannon index results indicated that Assawoman Bay (H = 1.5) was the most diverse whereas Chincoteague Bay (H = 0.6) was the least diverse.

Over time, Chincoteague Bay had the highest richness (89 fishes) and annual mean richness (34.5 fishes) in the trawl 1989 - 2022 time series (Table 1.16). Newport Bay had the lowest richness (69 fishes) and mean richness (20.8 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 2022 Beach Seine Survey, Chincoteague Bay (38 species) held the most species of fishes, and the St. Martin River (23 fishes) had the least species of fish (Table 1.17). The Shannon index results indicated that Assawoman Bay (H = 1.6 was most diverse whereas Newport Bay (H = 0.4) was the least diverse.

The Beach Seine Survey time series (1989 - 2022) results indicated that Assawoman Bay had the richest fish populations (88 fishes) while Chincoteague Bay had the highest mean richness (33.7 fishes; Table 1.18). Newport Bay had the lowest richness (70 fishes) and annual mean richness (20.4 fishes) in the time series. Beach Seine Survey diversity results throughout the time series indicated that Chincoteague Bay (H = 1.7) was most diverse.

The Ayers Creek site is located at the intersection of tidal/non-tidal water, connected via a large pipe, grouped separately. This site has had a remarkable number of fishes (44 fishes) in the beach seine time series (Table 1.18) that is the result of shifting habitat based on rainfall and tidal influences. Atlantic menhaden (63%), spot (16.4%), and golden shiner (9.7%) were the largest contributors to the catch over time. Other fishes included alewife, black crappie, brown bullhead, sunfishes, weakfish, and spotted seatrout.

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

To date, 20 genera and 74,654 L of macroalgae were collected in Maryland's coastal bays using the trawl and beach seine from 2006 - 2022. Rhodophyta (red macroalgae) have been the dominant macroalgae in both gears (Table 1.19). Chlorophyta (green macroalgae), Phaeophyta (brown macroalgae), and Xanthophyta (yellow - green macroalgae) were also represented in the survey collections.

Fourteen genera were collected by trawl within the coastal bays in 2022, which was below the average (14.5 genera) in the time series (Table 1.12). The 2022 Shannon index of diversity among genera by trawl (H = 1.1) was below the time series average (H = 1.2). Results indicated that *Agardhiella* were the most abundant macroalgae (66%) in 2022. The other genera that contributed more than 5% to the sample population were *Polysiphonia* (17.6%), *Chaetomorpha* (7.3%), and *Ulva* (6.6%). The 2022 trawl CPUE (217.4 L/ha) was equal to the grand mean (Figure 1.28). Since 2006, the trawl CPUE occasionally varied significantly from the grand mean.

Eleven genera were collected by beach seine in 2022 (Table 1.12). The Shannon index of diversity among genera (H = 0.7) was below the time series average (H = 1.1). Results indicated that *Agardhiella* were most abundant (70.9%). The only other genera that contributed more than 5% to the sample population were *Polysiphonia* (24.1%). The 2022 beach seine CPUE (21.9 L/haul) was below the grand mean (Figure 1.29). Since 2006, the beach seine CPUE occasionally varied significantly from the grand mean.

Macroalgae in Maryland's coastal bays were investigated consistently over 17 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 shows that Rhodophyta and Chlorophyta were present at high levels in the bays closest to high human density population. The terminal year (2022) showed moderate increases in abundance compared to the three preceding years and may signal a return to the peak abundance in 2008 and 2016.

The bays north of the Ocean City Inlet had single species dominance of *Agardhiella* and subsequently had the highest CPUE when compared to the southern bays. 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 abundance, specifically sea lettuce, was variable yet appeared able to compete with the Rhodophytes when suitable conditions presented themselves.

Water Quality

These surveys collected surface water temperature and salinity since 1989. Dissolved Oxygen and turbidity were added in 1998. Bottom water quality was included at trawl sites in 2006, and pH was added in 2022 to monitor for changes in acidification that could impact fishes (Tomasetti & Gobler, 2020). There is increasing evidence that many ecologically and/or economically important shellfish and finfish that experience decreased survival and/or growth when exposed to hypoxia are further impaired by concurrent acidification.

Temperature

The ANOVA and post hoc DMRT results comparing annual surface water temperature across the time series indicated significant interannual variability ($F_{33,4719} = 4.74$, $p < 0.01$; Figure 1.30). Linear regression analysis of annual mean temperature and year showed a medium-strong relationship of increasing temperature the last thirty-four years (R^2=0.36; $F_{(33)}$=18.17, $p<0.01$). The interannual variation was most prominent during October (F33,680 = 33.71, $p < 0.01$; Figure 1.31). October linear regression results were not predictive ($p>0.05$) of increasing water temperature over time entire time series (1989-2023) due to the maximum water temperature values in 1990, and outlier year in the first decade of the time series.

Dissolved Oxygen

Dissolved oxygen was rarely found to be lower than what is considered necessary for life. Survey sites had adequate flushing and wave action (Figure 1.32). There was an overall upward trend in the time series, with the peak in 2014 (Figure 1.33). The last three years have been declining. August was typically the hottest month of the year, and the DO levels during the time series have consistently been within normal limits for marine fishes.

The Beach Seine Survey water quality was within normal limits in 2022, except for Ayers Creek in September. On this day, over 4,300 healthy Atlantic menhaden were counted on Ayres Creek, and the DO was below recommended range for fish habitat (2.41 mg/L).

Salinity
Interannual variation of mean surface salinity has varied significantly within the boundary of normal limits for mid-Atlantic fishes. Salinity was significantly reduced by rainfall in 2018 (Figure 1.34).

Turbidity
Water clarity has shown improvement over time (Figure 1.35). Deeper sunlight penetration was a benefit to eelgrass and widgeon grass habitat. These SAV are critical habitat for juvenile fishes.

pH
This was the first year (2022) of monitoring pH in these surveys, and the median pH was 7.9.

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 racetrack	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, northeast 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, northeast 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 northwest 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	North 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	Wingspan
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 April through October 2022. Species are listed by order of total abundance (T = 140, S = 38).

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/ha	CPUE (S) #/haul
Atlantic menhaden	*Brevoortia tyrannus*	19,839	193	19,646	11.0	517.0
Bay anchovy	*Anchoa mitchilli*	17,166	644	16,522	36.7	434.8
Spot	*Leiostomus xanthurus*	11,722	7,776	3,946	442.9	103.8
Atlantic silverside	*Menidia menidia*	2,878	11	2,867	0.6	75.4
Pinfish	*Lagodon rhomboides*	1,490	179	1,311	10.2	34.5
Summer flounder	*Paralichthys dentatus*	243	111	132	6.3	3.5
Weakfish	*Cynoscion regalis*	222	222		12.6	
Silver perch	*Bairdiella chrysoura*	210	127	83	7.2	2.2
Striped anchovy	*Anchoa hepsetus*	202	76	126	4.3	3.3
Pigfish	*Orthopristis chrysoptera*	129	24	105	1.4	2.8
Black sea bass	*Centropristis striata*	127	46	81	2.6	2.1
Striped killifish	*Fundulus majalis*	97		97		2.5
Rainwater killifish	*Lucania parva*	93	9	84	0.5	2.2
Hogchoker	*Trinectes maculatus*	91	72	19	4.1	0.5
Blackcheek tonguefish	*Symphurus plagiusa*	83	11	72	0.6	1.9
Mummichog	*Fundulus heteroclitus*	74	5	69	0.3	1.8
Atlantic croaker	*Micropogonias undulatus*	71	68	3	3.9	<0.1
Inshore lizardfish	*Synodus foetens*	64	25	39	1.4	1.0
Northern pipefish	*Syngnathus fuscus*	50	19	31	1.1	0.8
Sheepshead	*Archosargus probatocephalus*	47	4	43	0.2	1.1
Atlantic needlefish	*Strongylura marina*	46		46		1.2
Dusky pipefish	*Syngnathus floridae*	44	14	30	0.8	0.8
American eel	*Anguilla rostrata*	32	27	5	1.5	0.1
Winter flounder	*Pseudopleuronectes americanus*	29		29		0.8
Gizzard shad	*Dorosoma cepedianum*	25		25		0.7
Oyster toadfish	*Opsanus tau*	24	5	19	0.3	0.5
White mullet	*Mugil curema*	20		20		0.5
Northern puffer	*Sphoeroides maculatus*	19	5	14	0.3	0.4
Striped blenny	*Chasmodes bosquianus*	17		17		0.4
Naked goby	*Gobiosoma bosc*	15	5	10	0.3	0.3
Striped mullet	*Mugil cephalus*	13		13		0.3
Blue runner	*Caranx crysos*	11	5	6	0.3	0.2
Lined seahorse	*Hippocampus erectus*	10	1	9	0.1	0.2
Smallmouth flounder	*Etropus microstomus*	9	3	6	0.2	0.2
Spotfin mojarra	*Eucinostomus argenteus*	9		9		0.2
Striped burrfish	*Chilomycterus schoepfii*	9	3	6	0.2	0.2
Black drum	*Pogonias cromis*	8	5	3	0.3	<0.1

Table 1.4. List of fishes collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2022. Species are listed by order of total abundance (T = 140, S = 38).

Common Name	Scientific Name	Total Number Collected	Number Collected (T)	Number Collected (S)	CPUE (T) #/ha	CPUE (S) #/haul
Golden shiner	*Notemigonus crysoleucas*	7		7		0.2
Bluefish	*Pomatomus saltatrix*	5		5		0.1
Butterfish	*Peprilus triacanthus*	5	5		0.3	
Feather blenny	*Hypsoblennius hentz*	5	1	4	0.1	0.1
Lookdown	*Selene vomer*	5	5		0.3	
Southern kingfish	*Menticirrhus americanus*	5		5		0.1
Northern searobin	*Prionotus carolinus*	4	4		0.2	
Scup	*Stenotomus chrysops*	4	4		0.2	
Southern stingray	*Dasyatis americana*	4		4		0.1
Spanish mackerel	*Scomberomorus maculatus*	4		4		0.1
Spotted seatrout	*Cynoscion nebulosus*	4		4		0.1
Striped bass	*Morone saxatilis*	4		4		0.1
Atlantic spadefish	*Chaetodipterus faber*	3	1	2	0.1	<0.1
Conger eel	*Conger oceanicus*	3		3		<0.1
Striped searobin	*Prionotus evolans*	3	1	2	0.1	<0.1
Green goby	*Microgobius thalassinus*	2	2		0.1	
Halfbeak	*Hyporhamphus unifasciatus*	2		2		<0.1
Northern kingfish	*Menticirrhus saxatilis*	2		2		<0.1
Pumpkinseed	*Lepomis gibbosus*	2		2		<0.1
Alewife	*Alosa pseudoharengus*	1		1		<0.1
Bluegill	*Lepomis macrochirus*	1		1		<0.1
Gray snapper	*Lutjanus griseus*	1		1		<0.1
Harvestfish	*Peprilus paru*	1	1		0.1	
Orange filefish	*Aluterus schoepfii*	1	1		0.1	
Planehead filefish	*Stephanolepis hispida*	1	1		0.1	
Spotted hake	*Urophycis regia*	1	1		0.1	
Striped cusk-eel	*Ophidion marginatum*	1		1		<0.1
Tautog	*Tautoga onitis*	1		1		<0.1
Windowpane	*Scophthalmus aquosus*	1	1		0.1	
Total Finfish		55,321	9,723	45,598		

Table 1.5. Number of species and individual fish caught by year and gear in the Trawl and Beach Seine surveys (T = 140, S= 38).

	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
2021	48	61	70	4,549	10,302	14,851
2022	42	55	66	9,723	45,598	55,321

Table 1.6. Summary of the 2022 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	Equal
Atlantic croaker	*Micropogonias undulatus*	Below	Equal
Atlantic menhaden	*Brevoortia tyrannus*	Equal	Equal
Atlantic silverside	*Menidia menidia*	Below	Equal
Bay anchovy	*Anchoa mitchilli*	Below	Equal
Black sea bass	*Centropristis striata*	Equal	Above
Bluefish	*Pomatomus saltatrix*	Below	Below
Pinfish	*Lagodon rhomboides*	Above	Above
Sheepshead	*Archosargus probatocephalus*	Equal	Equal
Silver perch	*Bairdiella chrysoura*	Equal	Below
Spot	*Leiostomus xanthurus*	Above	Above
Summer flounder	*Paralichthys dentatus*	Below	Equal
Weakfish	*Cynoscion regalis*	Below	Below

Table 1.7. Proportion of catch by month in the Trawl Survey time series (1989 - 2022). Green highlight indicates months of high abundance.

	Apr	May	Jun	Jul	Aug	Sep	Oct
American eel (*Anguilla rostrata*)	25.8	25.4	22.9	13.6	8.8	2.5	0.9
Atlantic croaker (*Micropogonias undulatus*)	3.0	6.6	12.1	13.5	5.8	14.2	44.8
Atlantic menhaden (*Brevoortia tyrannus*)	1.1	31.1	44.7	10.6	5.8	2.8	4.0
Atlantic silverside (*Menidia menidia*)	6.3	1.7	34.9	32.1	5.0	15.0	5.0
Bay anchovy (*Anchoa mitchilli*)	4.8	5.7	9.2	18.4	32.4	17.6	11.9
Black sea bass (*Centropristis striata*)	1.9	10.6	20.8	24.0	19.4	16.5	6.7
Pinfish (*Lagodon rhomboides*)	0.0	9.9	17.8	24.1	22.3	20.5	5.4
Sheepshead (*Archosargus probatocephalus*)	0.0	0.0	0.0	8.8	8.8	20.6	61.8
Silver perch (*Bairdiella chrysoura*)	0.0	0.3	0.8	18.6	43.1	30.1	7.1
Spot (*Leiostomus xanthurus*)	0.8	15.3	33.1	20.7	15.2	10.5	4.4
Summer flounder (*Paralichthys dentatus*)	2.7	18.3	32.2	20.6	13.6	8.5	4.1
Weakfish (*Cynoscion regalis*)	0.0	0.0	0.2	60.8	30.7	7.0	1.2

Table 1.8. Proportion of catch by month in the Beach Seine Survey the time series (1989 - 2022). Green highlight indicates months of high abundance.

	June	September
American eel (*Anguilla rostrata*)	71	29
Atlantic croaker (*Micropogonias undulatus*)	82	18
Atlantic menhaden (*Brevoortia tyrannus*)	75	25
Atlantic silverside (*Menidia menidia*)	18	82
Bay anchovy (*Anchoa mitchilli*)	37	63
Black sea bass (*Centropristis striata*)	75	25
Pinfish (*Lagodon rhomboides*)	89	11
Sheepshead (*Archosargus probatocephalus*)	6	94
Silver perch (*Bairdiella chrysoura*)	2	98
Spot (*Leiostomus xanthurus*)	79	21
Summer flounder (*Paralichthys dentatus*)	79	21
Weakfish (*Cynoscion regalis*)	2	98

Table 1.9. List of crustaceans collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2022. Species are listed by order of total abundance (T = 140, S = 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
Grass shrimp	*Palaemonetes sp.*	2,501	189	147	40	2,125	13.0	59.8
Blue crab	*Callinectes sapidus*	2,358	991	1,367			56.4	36.0
Sand shrimp	*Crangon septemspinosa*	478	221	22	75	160	16.9	4.8
Lady crab	*Ovalipes ocellatus*	422	160	262			9.1	6.9
Long-armed hermit crab	*Pagurus longicarpus*	158	122	36			6.9	0.9
Say mud crab	*Dyspanopeus sayi*	154	142	12			8.1	0.3
White shrimp	*Litopenaeus setiferus*	143	118	25			6.7	0.6
Mantis shrimp	*Squilla empusa*	72	66	6			3.8	0.2
Arrow Shrimp	*Tozeuma carolinense*	40	1	4		35	0.1	1.0
Brown shrimp	*Farfantepenaeus aztecus*	19	11	8			0.6	0.2
Atlantic mud crab	*Panopeus herbstii*	3	2	1			0.1	<0.1
Bigclaw snapping shrimp	*Alpheus heterochaelis*	3	1	2			0.1	<0.1
Peppermint shrimp	*Lysmata wurdemanni*	2	1	1			0.1	<0.1
Portly spider crab	*Libinia emarginata*	2	2				0.1	
Lesser blue crab	*Callinectes similis*	1		1				<0.1
Atlantic marsh fiddler	*Uca pugnax*							
	Total Crustaceans	**6,356**	**2,027**	**1,894**	**115**	**2,320**		

Table 1.10. List of other species collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2022. Species are listed by order of total abundance (T = 140, S = 38).

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol (L) (T)	Spec. Vol (L) (S)	Est. Vol (L) (T)	Est. Vol (L) (S)	CPUE (T) #/Hect.	CPUE (S) #/Haul	CPUE (T) #/Hect. Vol.	CPUE (S) #/Haul Vol.
Sea squirt	*Molgula manhattensis*	3,030	210		2,820		13.0				172.6		0.7	
Comb jellies	*Ctenophora*	426	387	36	3		156.9	0.8	1.0		22.2	0.9	9.0	<0.1
Sea gooseberry	*Pleurobrachia pileus*	77	27		50						4.4			
Sea nettle	*Chrysaora quinquecirrha*	55	55				1.0				3.1		<0.1	
Horseshoe crab	*Limulus polyphemus*	46	36	10							2.0	0.3		
Hairy sea cucumber	*Sclerodactyla briareus*	36	25	11							1.4	0.3		
Moon jelly	*Aurelia aurita*	33	29	4							1.6	0.1		
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	13	7	6							0.4	0.2		
Hydromedusae	*Hydrozoa*	5	5								0.3			
Unknown cnidarian	*Unknown Cnidarian*	1	1								0.1			
Beroe comb jelly	*Beroe ovata*	1	1								0.1			
Sea walnut	*Mnemiopsis leidyi*	1	1								0.1			
Goldstar tunicate	*Botryllus schlosseri*						21.2						1.2	
Sea pork	*Aplidium sp.*						15.9	0.1					0.9	
Tunicates	*Tunicata*						0.9						<0.1	
Bryozoans	*Ectoprocta*						71.1	6.0					4.0	0.2
Rubbery bryozoan	*Alcyonidium sp.*						1.6						<0.1	
Halichondria sponge	*Halichondria sp.*						43.6	2.3					2.5	<0.1
Red beard sponge	*Microciona prolifera*						146.1	12.0					8.3	0.3
Sulphur sponge	*Cliona celata*						16.7						1.0	
	Total Other	**3,724**	**784**	**67**	**2,873**		**488.0**	**21.0**	**1.0**					

Table 1.11. List of molluscs collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2022. Species are listed by order of total abundance (T = 140, S = 38).

Common Name	Scientific Name	Total Number Collected	No. Collect (T)	No. Collect (S)	Est. Cnt. (T)	Est. Cnt. (S)	Spec. Vol. (L) (T)	Spec. Vol. (L) (S)	Est. Vol. (L) (T)	Est. Vol. (L) (S)	CPUE (T) #/Hect.	CPUE (S) #Haul	CPUE Vol (T) #/Hect	CPUE Vol (S) #/Haul
Sponge slug	*Doris verrucosa*	540	14	1	525						30.7	<0.1		
Solitary glassy bubble snail	*Haminoea solitaria*	252	28		224						14.3			
Atlantic brief squid	*Lolliguncula brevis*	38	38								2.2			
Eastern mudsnail	*Nassarius obsoletus*	3	2	1							0.1	<0.1		
Northern quahog	*Mercenaria mercenaria*	3	1	2							0.1	<0.1		
Striped nudibranch	*Cratena pilata*	3	3								0.2			
Thick-lip drill	*Eupleura caudata*	3	3								0.2			
Cayenne keyhole limpet	*Diodora cayenensis*	2	2								0.1			
Atlantic oyster drill	*Urosalpinx cinerea*	1	1								0.1			
Bruised nassa	*Nassarius vibex*	1	1								0.1			
Common jingle	*Anomia simplex*	1	1								0.1			
Nudibranchs	*Nudibranchia*	1	1								0.1			
	Total Molluscs	**848**	**95**	**4**	**749**									

Table 1.12. List of Submerged Aquatic Vegetation (SAV) and macroalgae collected in Maryland's coastal bays Trawl (T) and Beach Seine (S) surveys from April through October 2022. Species are listed by order of total abundance (T= 140, S = 38).

Common Name	Genus	Specific Volume (L) (T)	Specific Volume (L) (S)
SAV			
Eelgrass	*Zostera*	10.8	19.2
Widgeon grass	*Ruppia*		0.3
	Total SAV	10.8	19.5
Macroalgae			
Brown			
Common southern kelp	*Laminaria*	0.4	
Sour weeds	*Desmarestia*	0.3	
Brown bubble algae	*Colpomenia*	0	
	Total Brown	0.7	
Green			
Green hair algae	*Chaetomorpha*	275.7	0.5
Sea lettuce	*Ulva*	252	30.6
Green tufted seaweed	*Cladophora*	31.9	0
Green Fleece	*Codium*	16.8	0.8
Hollow green weed	*Enteromorpha*	2.9	0.1
Green sea fern	*Bryopsis*		0.5
	Total Green	579.3	32.0
Red			
Agardh's red weed	*Agardhiella*	2,505	533.1
Tubed weeds	*Polysiphonia*	669	181.1
Barrel weed	*Champia*	24.9	
Banded weeds	*Ceramium*	12.5	
Hairy Basket weed	*Spyridia*	0.4	
Graceful red weed	*Gracilaria*		1.3
	Total Red	3,211.7	715.6
Yellow-Green			
Water felt	*Vaucheria*	3.7	4.6
	Total Yellow-Green	3.7	4.6
Others			
Slurry/decaying		21.6	36.3
	Total Macroalgae	3,817.1	788.6

Table 1.13. Length by month for selected fishes from the 2022 Trawl Survey.

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
American eel (*Anguilla rostrata*)	April	18	18	51	111	69.5	16.2
	May	6	6	53	70	59.7	7.3
	June	1	1	68	68	68.0	
	Aug	1	1	271	271	271.0	
	Oct	1	1	90	90	90.0	
Atlantic croaker (*Micropogonias undulatus*)	April	17	17	19	68	24.5	11.3
	May	6	6	30	81	41.7	19.9
	June	27	27	35	203	78.6	57.8
	July	11	11	47	148	104.6	33.3
	Aug	4	4	140	199	169.8	24.1
	Sep	3	3	24	193	81.7	96.4
Atlantic menhaden (*Brevoortia tyrannus*)	May	1	1	44	44	44.0	
	June	174	75	31	63	38.1	4.9
	July	12	12	51	98	67.7	12.5
	Aug	1	1	77	77	77.0	
	Sep	3	3	70	95	81.7	12.6
	Oct	2	2	80	100	90.0	14.1
Atlantic silverside (*Menidia menidia*)	June	1	1	43	43	43.0	
	July	10	10	37	66	52.4	11.0
Bay anchovy (*Anchoa mitchilli*)	April	38	38	51	83	67.5	6.5
	May	10	10	42	75	63.1	8.6
	June	122	58	29	86	66.0	11.1
	July	32	31	10	86	53.0	18.4
	Aug	240	60	26	156	58.1	18.5
	Sep	188	78	20	100	49.9	19.0
	Oct	14	14	38	72	53.2	10.1
Black sea bass (*Centropristis striata*)	May	4	4	67	90	76.5	9.9
	June	10	9	80	119	103.4	13.2
	July	10	10	96	140	115.9	18.1
	Aug	13	13	105	157	133.5	13.4
	Sep	3	3	61	155	123.7	54.3
	Oct	6	6	43	161	115.7	48.6
Pinfish (*Lagodon rhomboides*)	May	31	31	25	42	31.6	4.3
	June	17	17	33	140	67.9	28.7
	July	54	47	20	145	90.3	16.5
	Aug	40	40	89	137	121.6	10.0
	Sep	36	36	90	155	132.1	16.3
	Oct	1	1	116	116	116.0	
Sheepshead (*Archosargus probatocephalus*)	Aug	1	1	45	45	45.0	
	Sep	1	1	85	85	85.0	
	Oct	2	2	84	90	87.0	4.2

Table 1.13. Length by month for selected fishes from the 2022 Trawl Survey.

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
Silver perch (*Bairdiella chrysoura*)	June	2	2	141	180	160.5	27.6
	July	26	26	21	46	35.8	6.0
	Aug	27	27	19	107	66.2	22.0
	Sep	56	43	55	151	98.8	19.7
	Oct	16	16	75	128	110.4	15.0
Spot (*Leiostomus xanthurus*)	May	1,091	108	20	75	41.9	12.4
	June	2,527	289	26	207	81.9	16.8
	July	1,591	275	54	200	98.4	17.0
	Aug	1,116	271	86	178	113.3	12.4
	Sep	1,092	262	91	200	118.5	12.1
	Oct	359	159	98	165	120.2	8.2
Summer flounder (*Paralichthys dentatus*)	April	7	7	44	142	71.7	32.0
	May	15	15	30	62	43.5	9.5
	June	31	30	52	235	88.6	40.8
	July	51	51	60	193	88.6	29.7
	Aug	2	2	68	77	72.5	6.4
	Sep	3	3	90	295	197.3	102.8
	Oct	2	2	60	283	171.5	157.7
Weakfish (*Cynoscion regalis*)	May	1	1	164	164	164.0	
	July	125	67	39	81	58.2	9.5
	Aug	77	77	55	149	99.3	17.9
	Sep	18	18	88	135	114.8	12.6
	Oct	1	1	131	131	131.0	

Table 1.14. Length by month for selected fishes from the 2022 Beach Seine Survey.

	Month	Number Counted	Number Measured	Min Length (mm)	Max Length (mm)	Mean Length (mm)	SD
American eel	Jun	4	4	53	543	185.3	238.7
(*Anguilla rostrata*)	Sep	1	1	258	258	258.0	.
Atlantic croaker	Jun	4	4	53	543	185.3	238.7
(*Micropogonias undulatus*)	Sep						
Atlantic menhaden	Jun	15,296	312	31	167	52.1	19.5
(*Brevoortia tyrannus*)	Sep	4,350	45	62	110	85.7	16.0
Atlantic silverside	Jun	427	202	12	132	71.4	34.3
(*Menidia menidia*)	Sep	2,440	202	11	115	75.7	14.9
Bay anchovy	Jun	171	94	40	90	70.9	8.8
(*Anchoa mitchilli*)	Sep	16,351	108	25	83	48.7	6.6
Black sea bass	Jun	78	74	33	116	81.4	14.0
(*Centropristis striata*)	Sep	3	3	62	72	66.3	5.1
Silver perch	Jun	1	1	156	156	156	
(*Bairdiella chrysoura*)	Sep	100	75	43	123	88.3	17.7
Pinfish	Jun	1,240	230	34	85	55.9	9.0
(*Lagodon rhomboides*)	Sep	71	71	40	157	122.8	20.3
Sheepshead (*Archosargus*	Jun						
probatocephalus)	Sep	43	43	48	95	62.7	10.5
Silver perch	June	4	3	130	143	137.0	6.6
(*Bairdiella chrysoura*)	Sep	79	78	31	180	89.3	20.9
Spot	Jun	3,451	376	28	212	87.5	35.8
(*Leiostomus xanthurus*)	Sep	495	284	92	211	120.9	15.9
Summer flounder	Jun	122	122	32	211	67.7	22.4
(*Paralichthys dentatus*)	Sep	10	10	100	517	156.5	127.6

Table 1.15. Finfish richness and diversity by system for the 2022 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	25	1.5
St. Martin River	19	0.6
Isle of Wight Bay	22	0.9
Sinepuxent Bay	22	1.1
Newport Bay	12	1.1
Chincoteague Bay	24	0.6

Table 1.16. Finfish richness and diversity by system for the 1989 - 2022 Trawl Survey Assawoman Bay (n = 714), St. Martin River (n = 476), Isle of Wight Bay (n = 476), Sinepuxent Bay (n = 714), Newport Bay (n = 476), and Chincoteague Bay (n = 1,904)).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	82	28.0	1.4
St. Martin River	75	23.3	1.3
Isle of Wight Bay	85	30.2	1.6
Sinepuxent Bay	74	24.9	1.7
Newport Bay	69	20.8	1.4
Chincoteague Bay	89	34.5	1.4

Table 1.17. Finfish richness and diversity by system for the 2022 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	27	1.7
St. Martin River	23	1.5
Isle of Wight Bay	29	1.3
Sinepuxent Bay	28	0.8
Newport Bay	33	0.4
Chincoteague Bay	38	1.6
Ayers Creek	9	0.1

Table 1.18. Finfish richness and diversity by system for the 1989 - 2022 Beach Seine Survey: Assawoman Bay (n = 204), St. Martin River (n = 68), Isle of Wight Bay (n = 204), Sinepuxent Bay (n = 204), Newport Bay (n = 136), Chincoteague Bay (n = 408), and Ayers Creek (n = 68).

Embayment	Richness	Mean Richness	Mean Diversity
Assawoman Bay	88	30.5	1.6
St. Martin River	71	20.9	1.4
Isle of Wight Bay	87	29.4	1.6
Sinepuxent Bay	81	28.0	1.4
Newport Bay	70	20.4	1.5
Chincoteague Bay	85	33.7	1.7
Ayers Creek	44	13.9	1.1

Table 1.19. Macroalgae dominance in the Maryland Coastal Bays as sampled by the Trawl and Beach Seine surveys 2006 - 2022.

	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
2021	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta
2022	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta	Rhodophyta

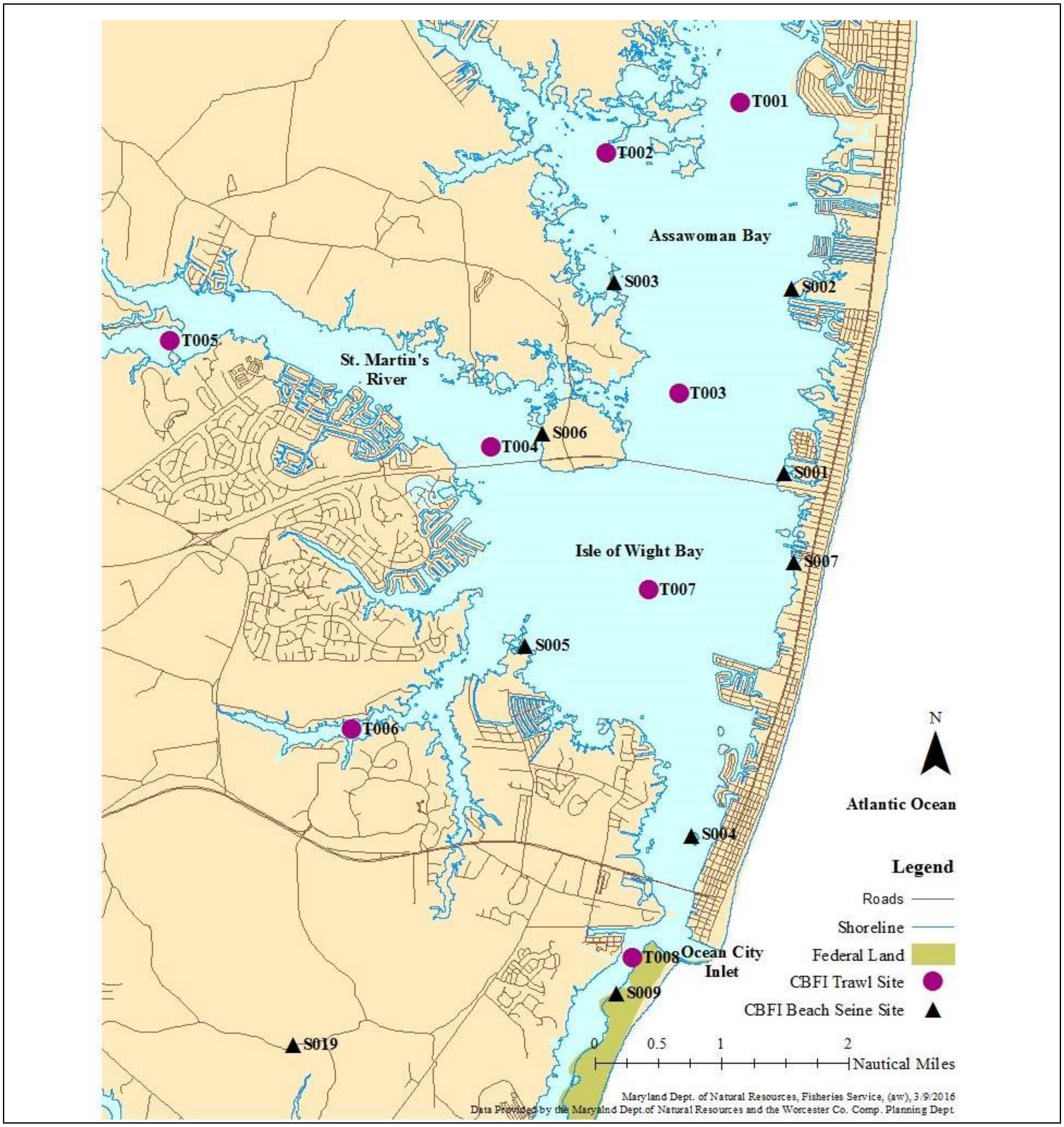

Figure 1.1. Trawl and Beach Seine surveys sampling locations in the Assawoman and Isle of Wight bays, Maryland.

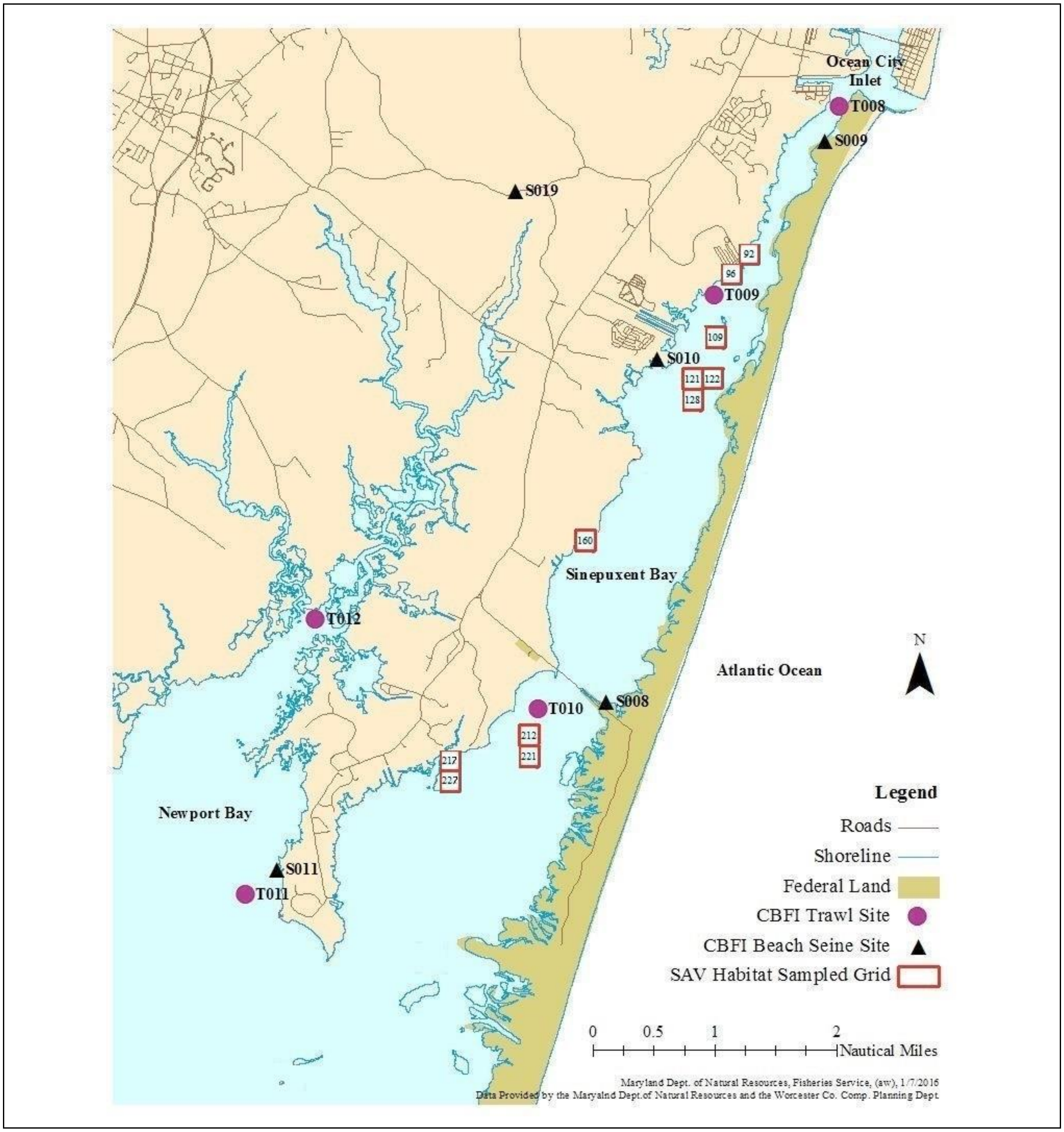

Figure 1.2. Trawl and Beach Seine surveys sampling locations in Sinepuxent and Newport bays, Maryland

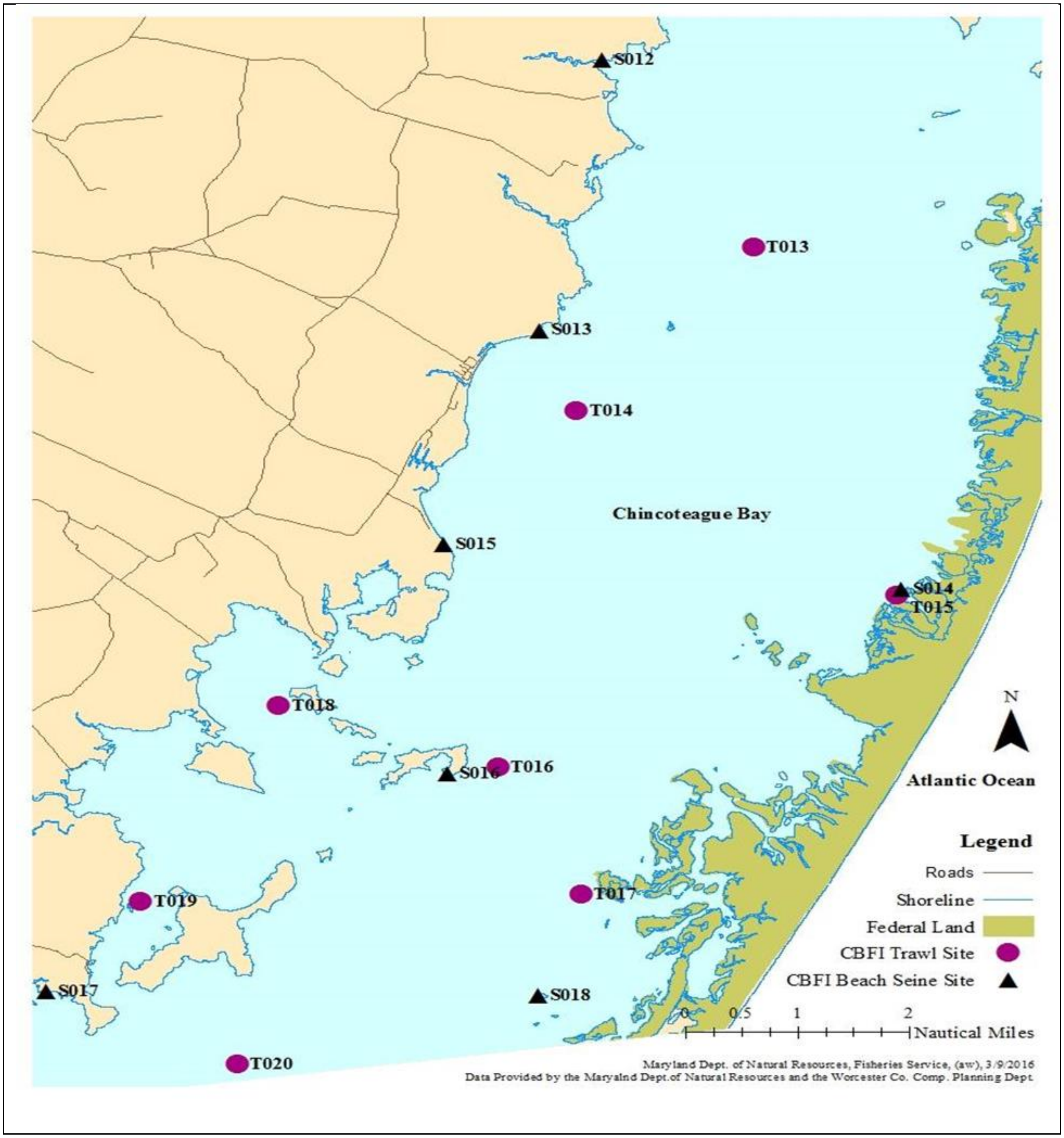

Figure 1.3. Trawl and Beach Seine surveys sampling locations in Chincoteague Bay, Maryland.

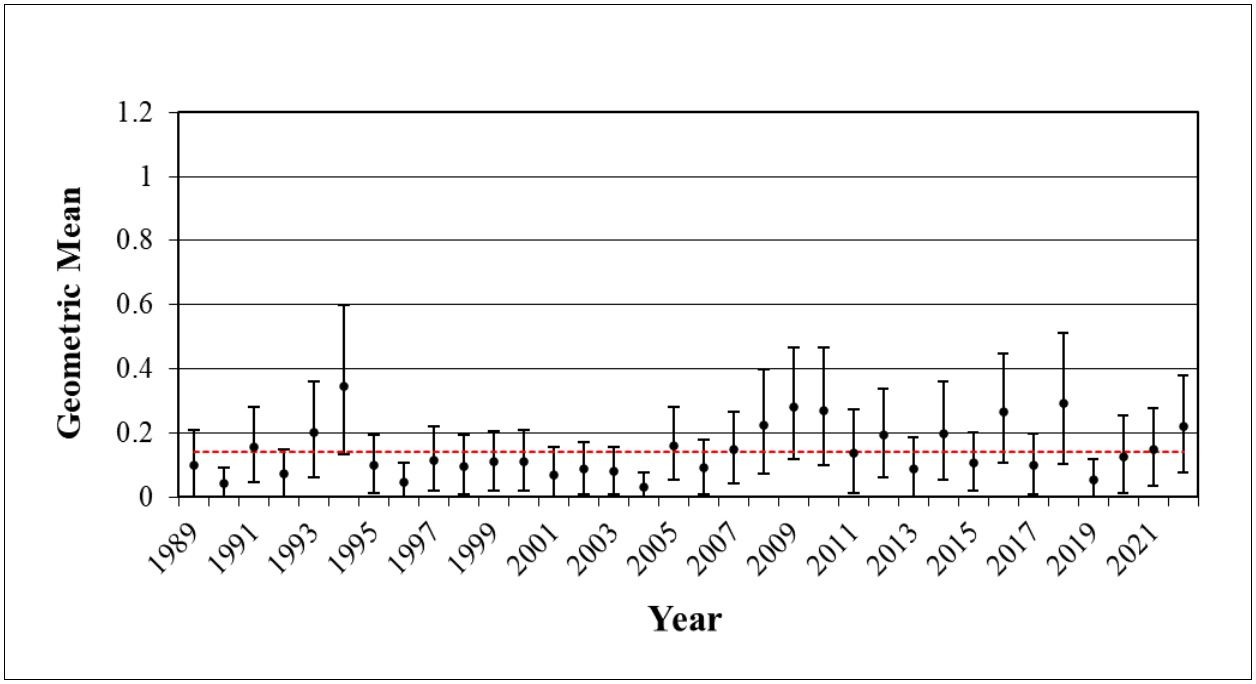

Figure 1.4. American eel (*Anguilla rostrata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\ -\ 2019,\ 2021\ -\ 2022}$ = 140/year, n_{2020} = 120).

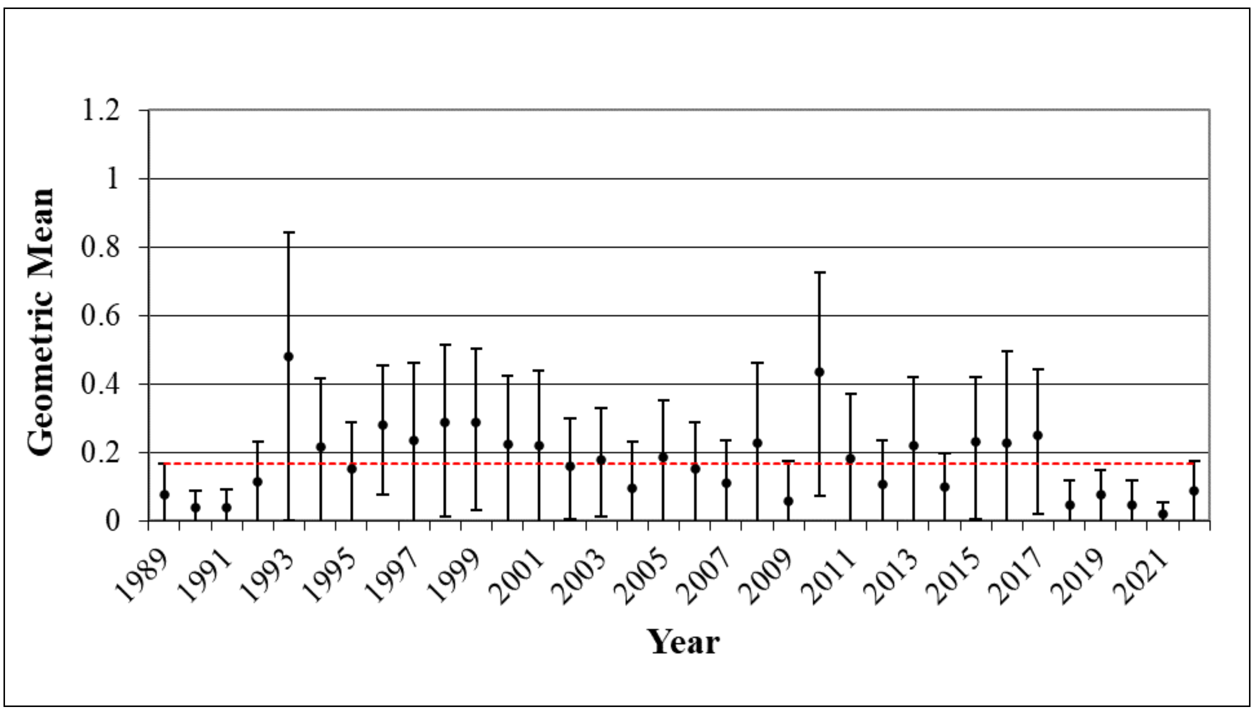

Figure 1.5. American eel (*Anguilla rostrata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

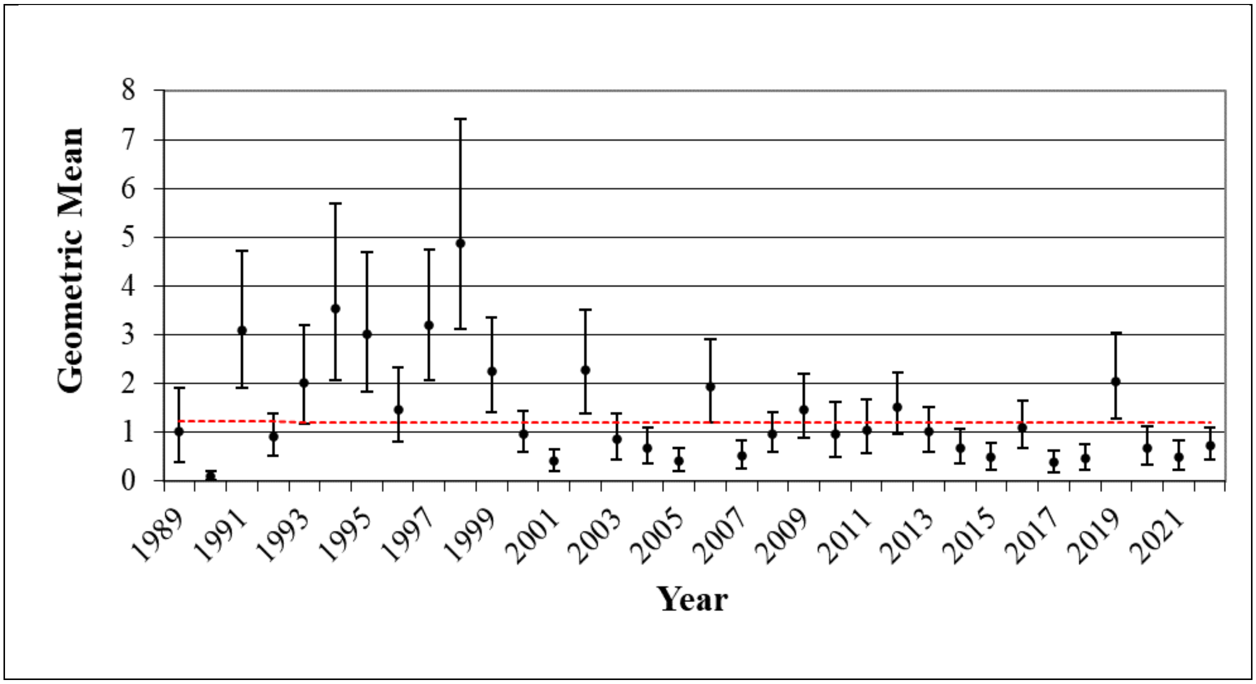

Figure 1.6. Atlantic croaker (*Micropogonias undulatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\text{ - }2019,\ 2021\text{ - }2022}$ = 140/year, n_{2020} = 120).

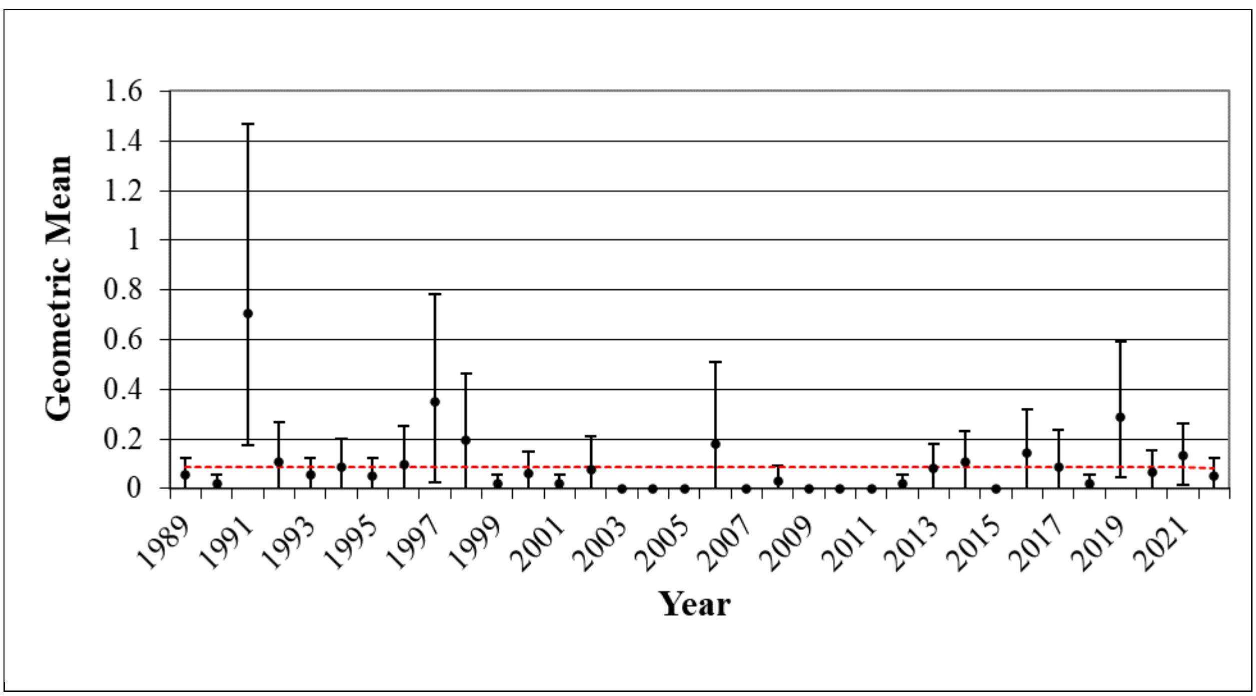

Figure 1.7. Atlantic croaker (*Micropogonias undulatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

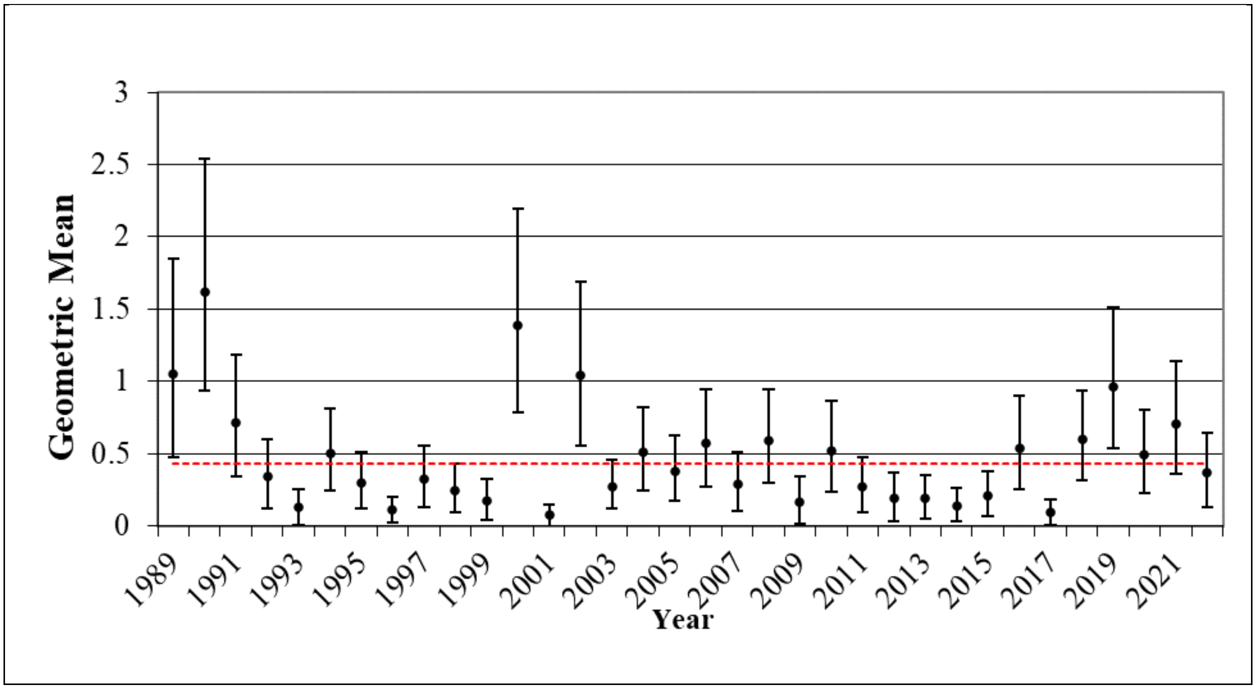

Figure 1.8. Atlantic menhaden (*Brevoortia tyrannus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\text{ - }2019,\ 2021\text{ - }2022}$ = 140/year, n_{2020} = 120).

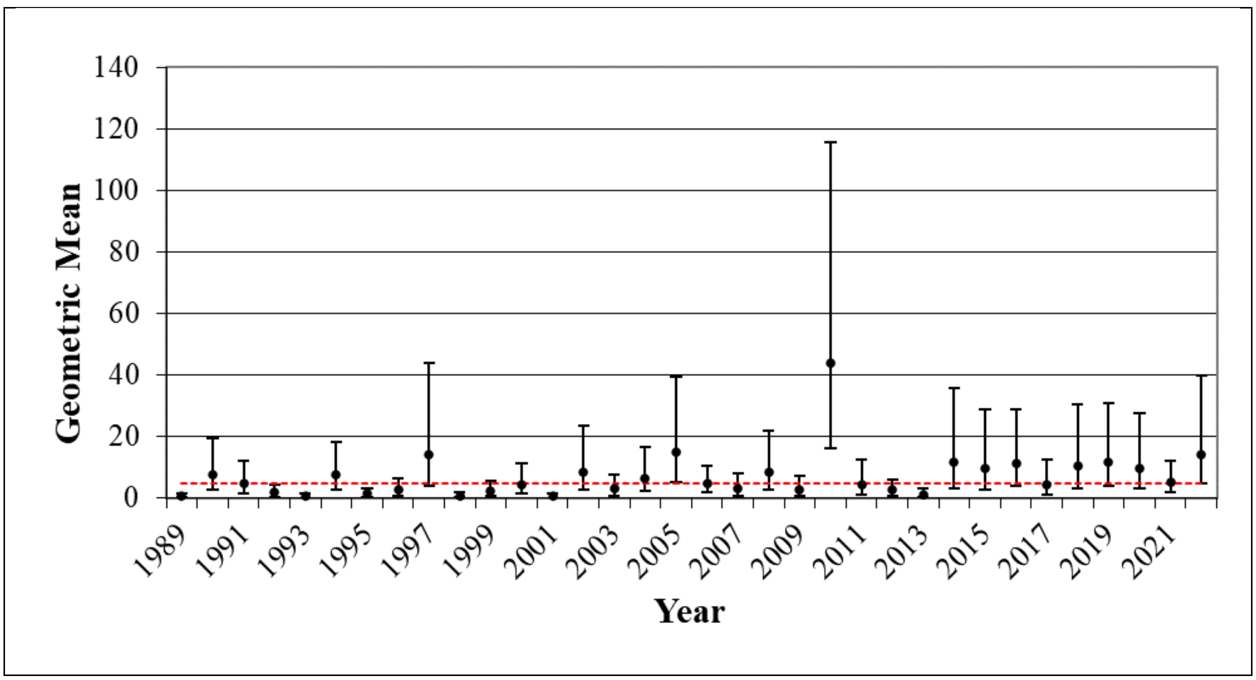

Figure 1.9. Atlantic menhaden (*Brevoortia tyrannus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

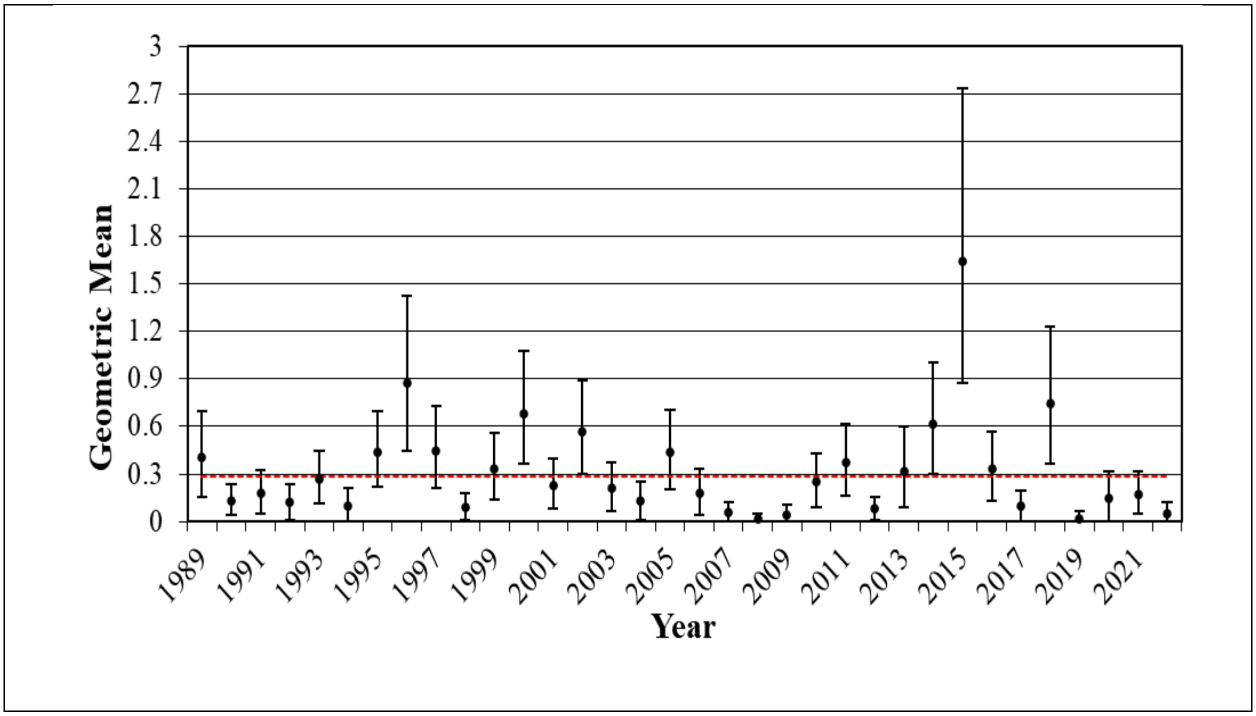

Figure 1.10. Atlantic silverside (*Menidia menidia*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989-2019, 2021-2022}$ = 140/year, n_{2020} = 120).

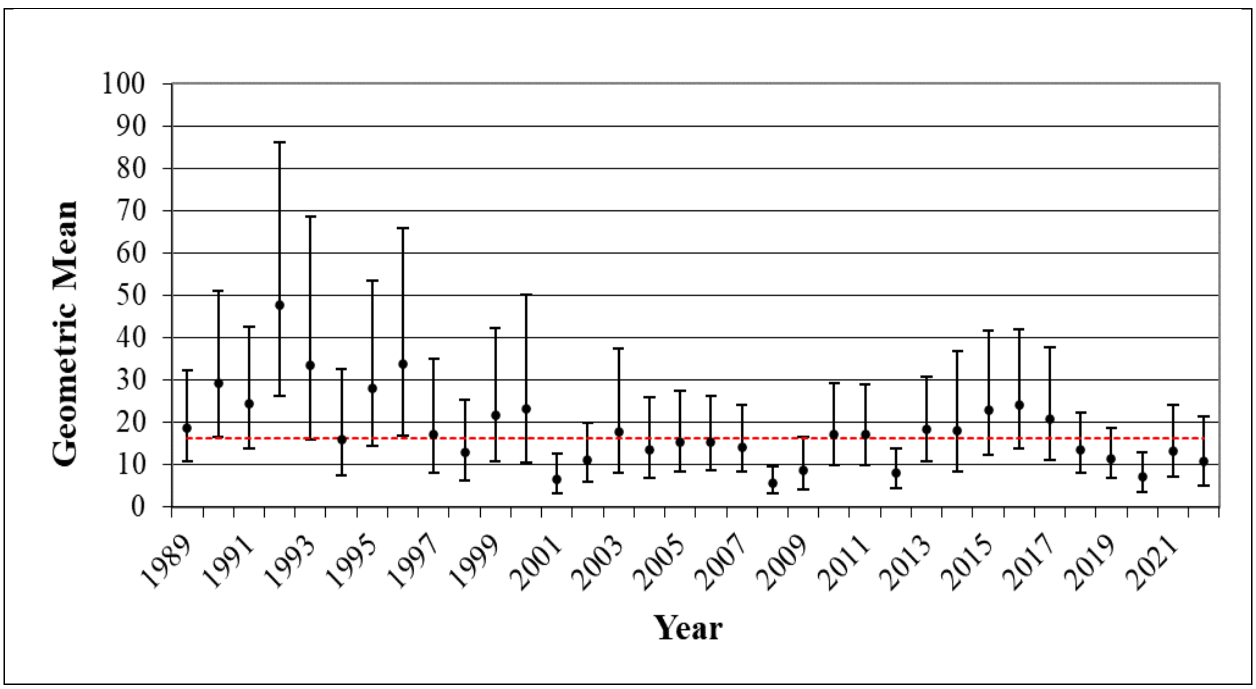

Figure 1.11. Atlantic silverside (*Menidia menidia*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

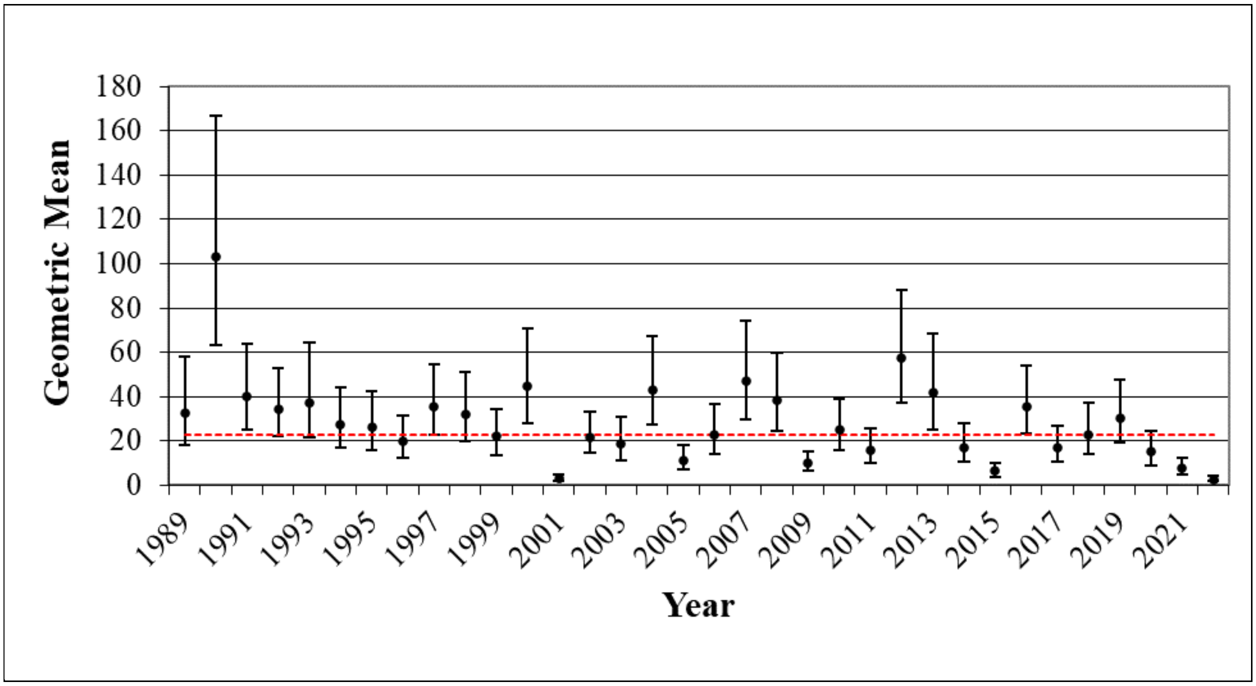

Figure 1.12. Bay anchovy (*Anchoa mitchilli*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\ -\ 2019,\ 2021\ -\ 2022}$ = 140/year, n_{2020} = 120).

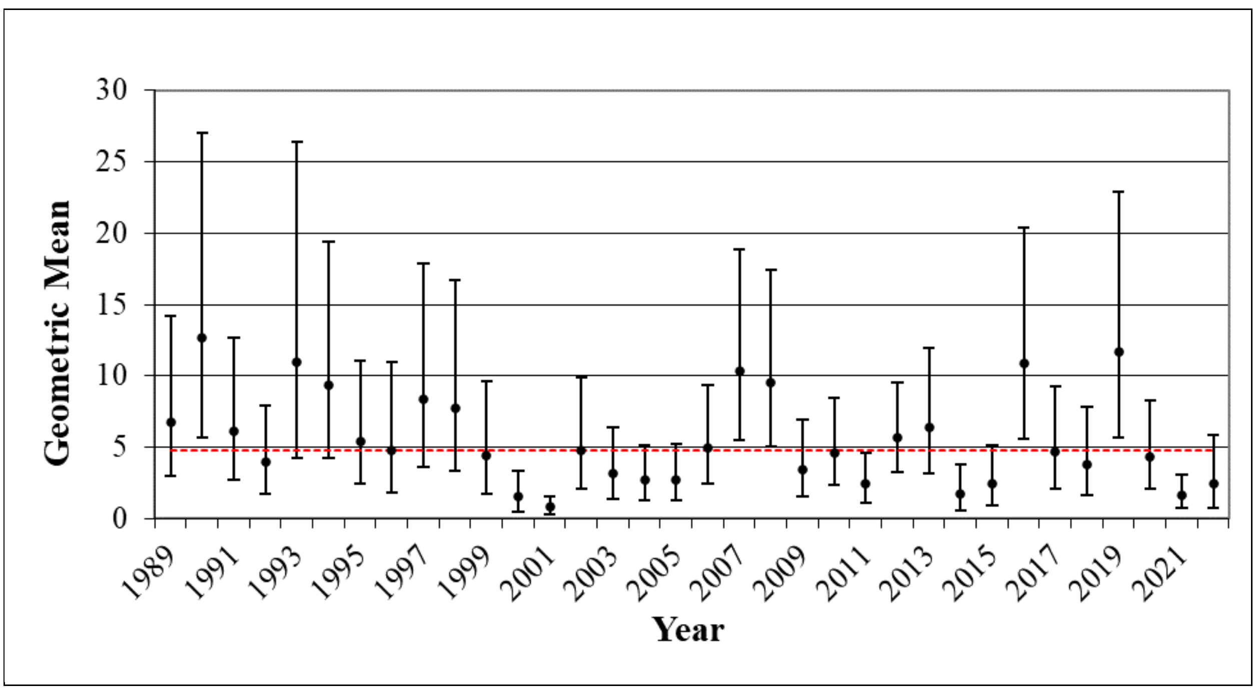

Figure 1.13. Bay anchovy (*Anchoa mitchilli*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

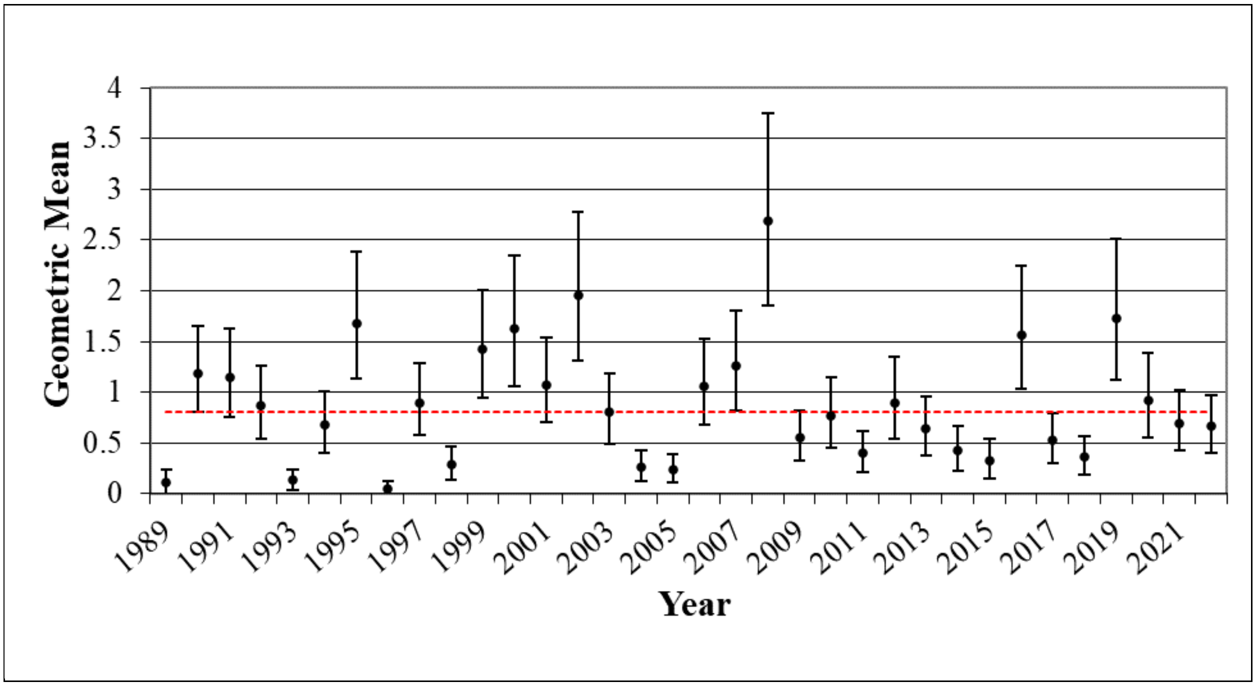

Figure 1.14. Black sea bass (*Centropristis striata*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989-2019, 2021-2022}$ = 140/year, n_{2020} = 120).

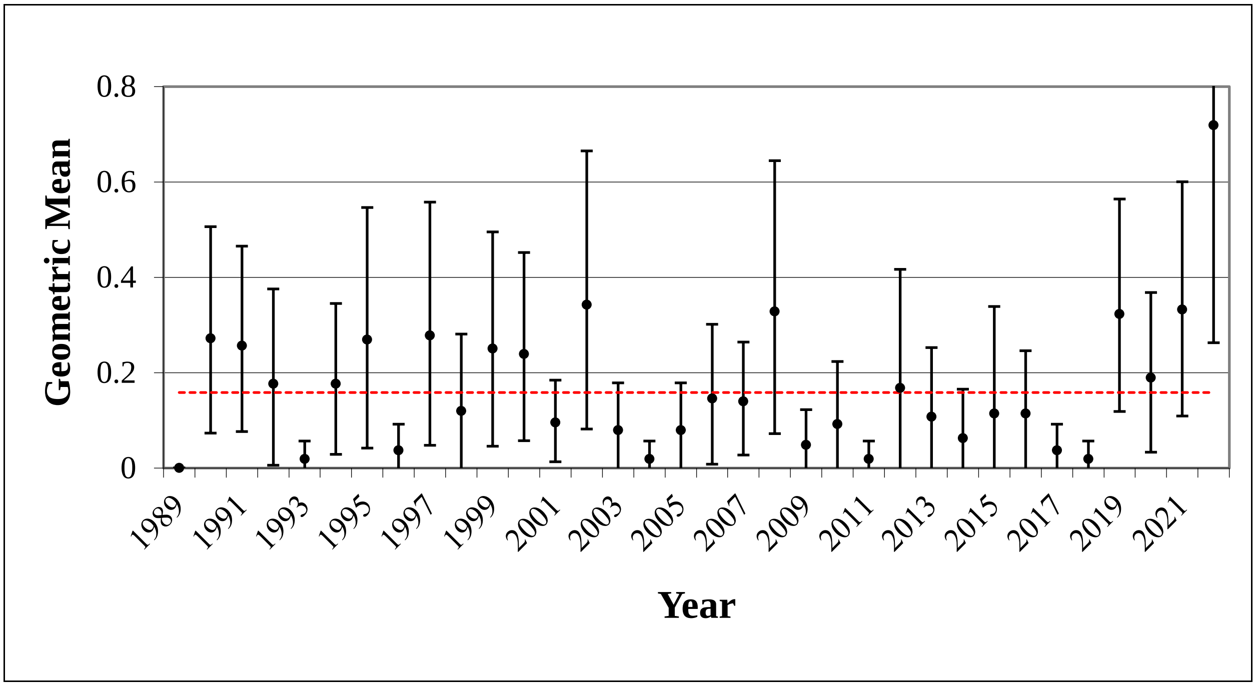

Figure 1.15. Black sea bass (*Centropristis striata*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

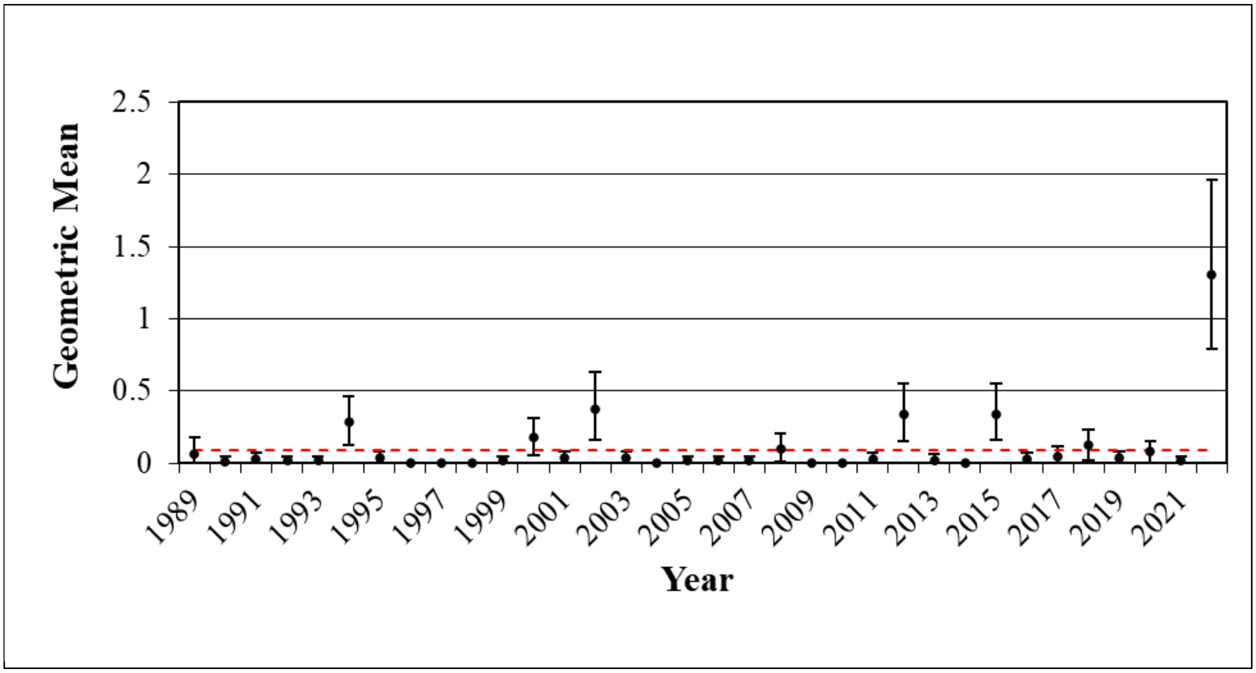

Figure 1.16. Pinfish (*Lagodon rhomboides*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989 - 2019, 2021 - 2022}$ = 140/year, n_{2020} = 120).

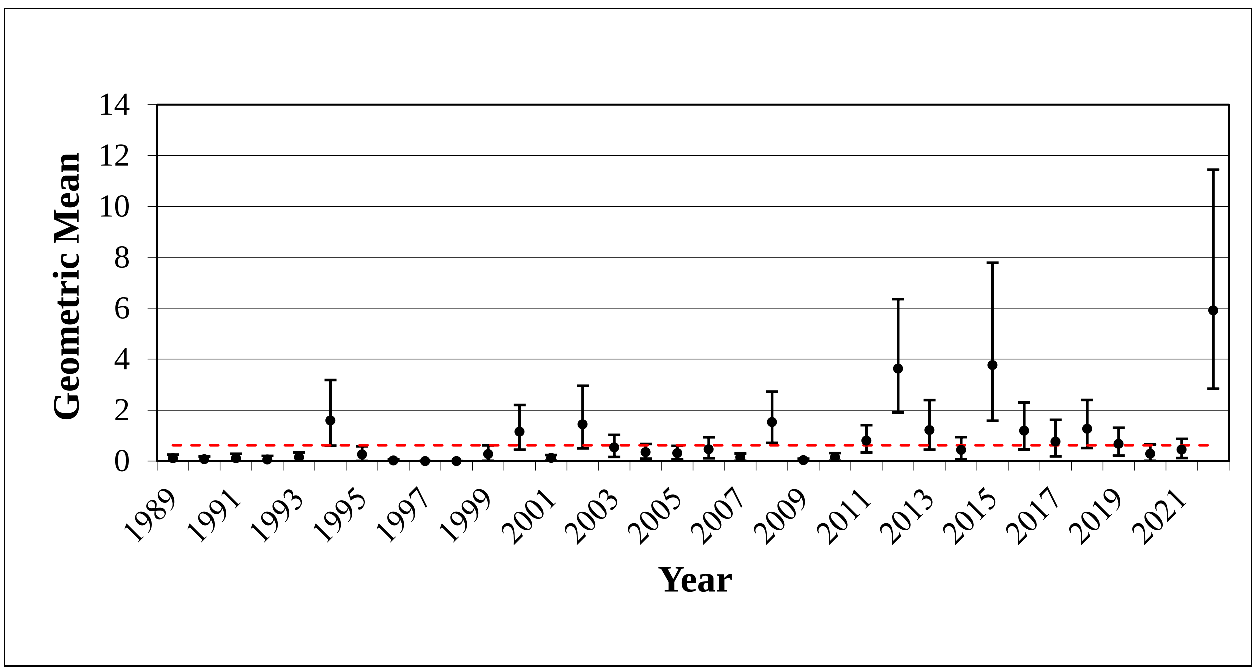

Figure 1.17. Pinfish (*Lagodon rhomboides*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

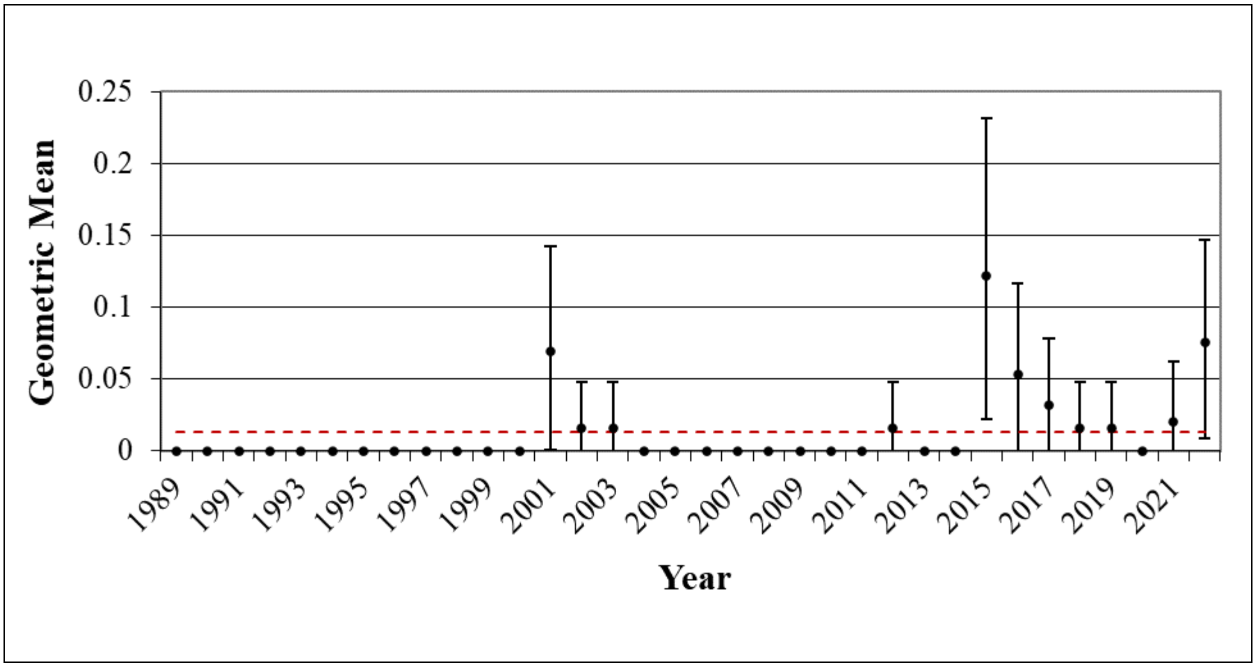

Figure 1.18. Sheepshead (*Archosargus probatocephalus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\text{ - }2019,\ 2021\text{ - }2022}$ = 140/year, n_{2020} = 120).

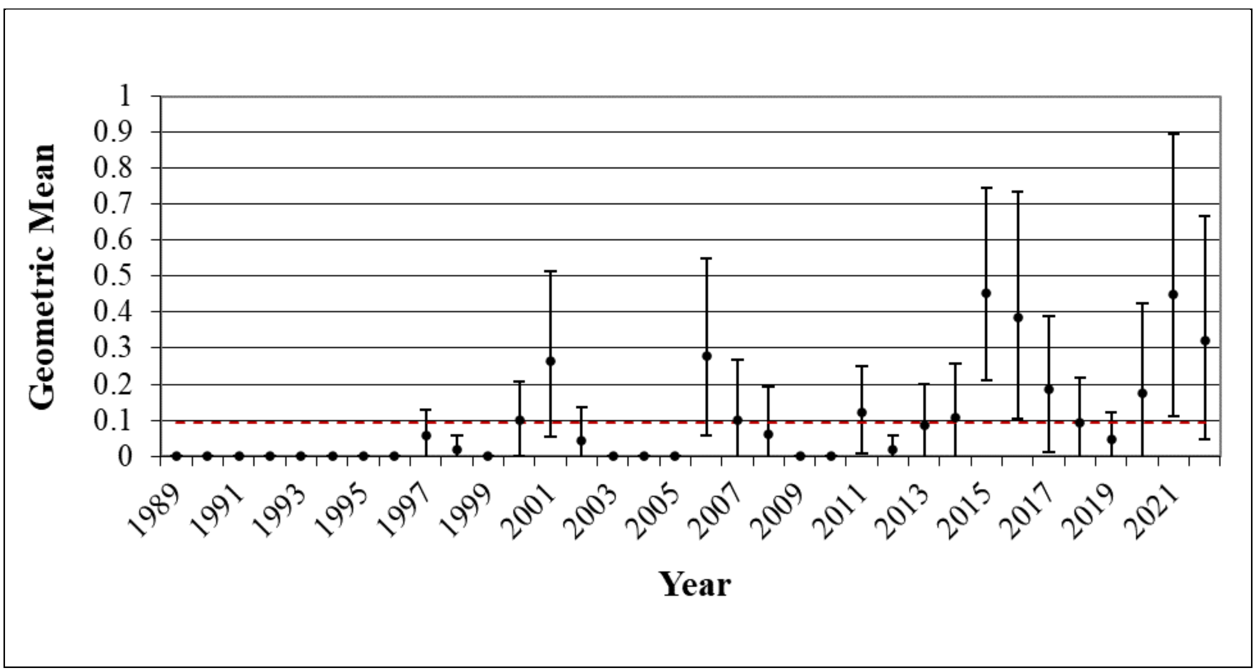

Figure 1.19. Sheepshead (*Archosargus probatocephalus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 – 2022 time series grand mean (n = 38/year).

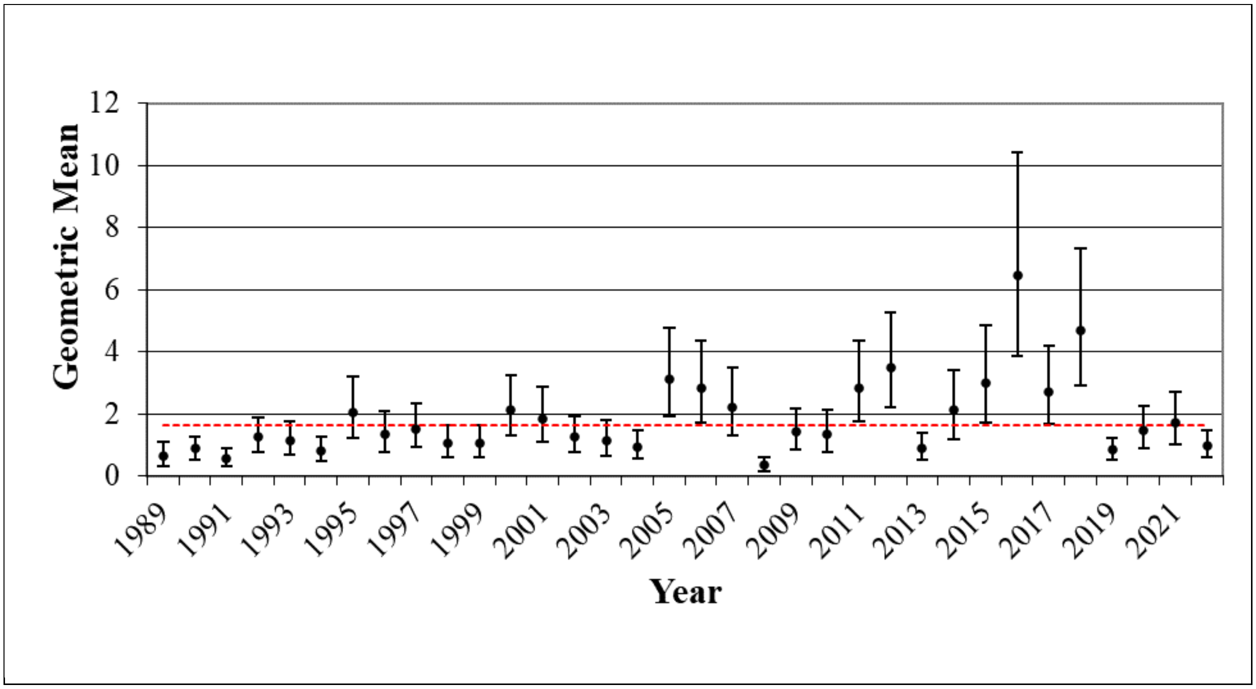

Figure 1.20. Silver perch (*Bairdiella chrysoura*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989 - 2019, 2021 - 2022}$ = 140/year, n_{2020} = 120).

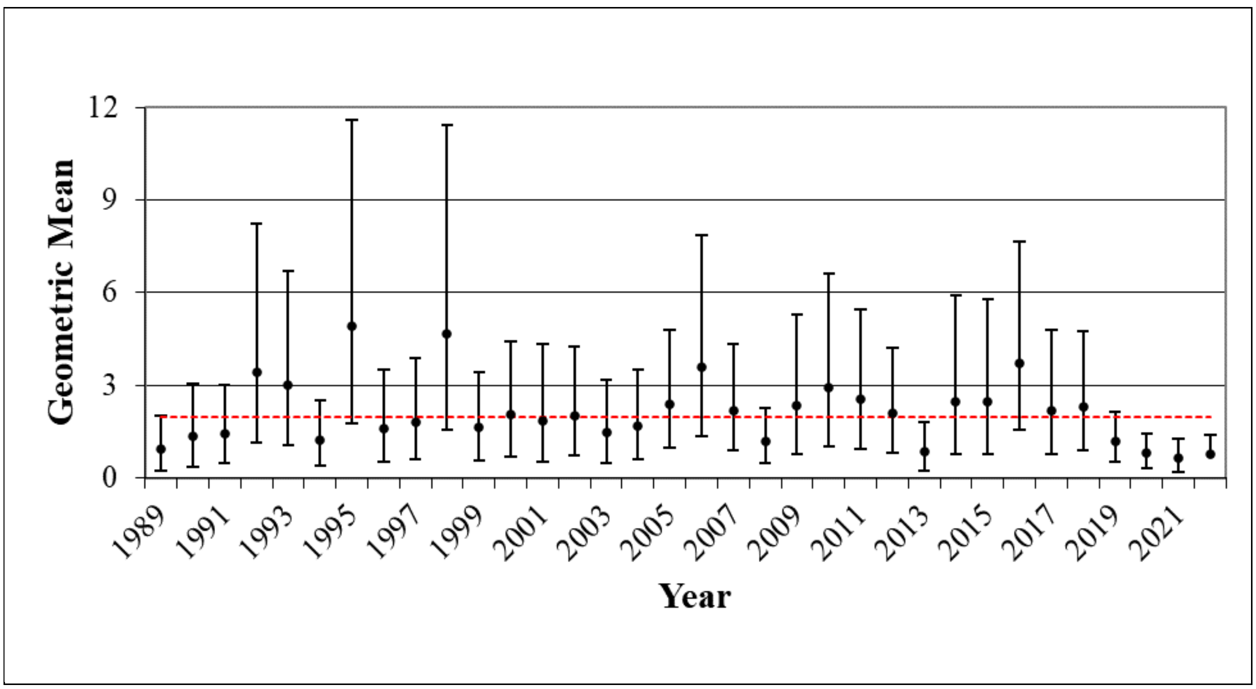

Figure 1.21. Silver perch (*Bairdiella chrysoura*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

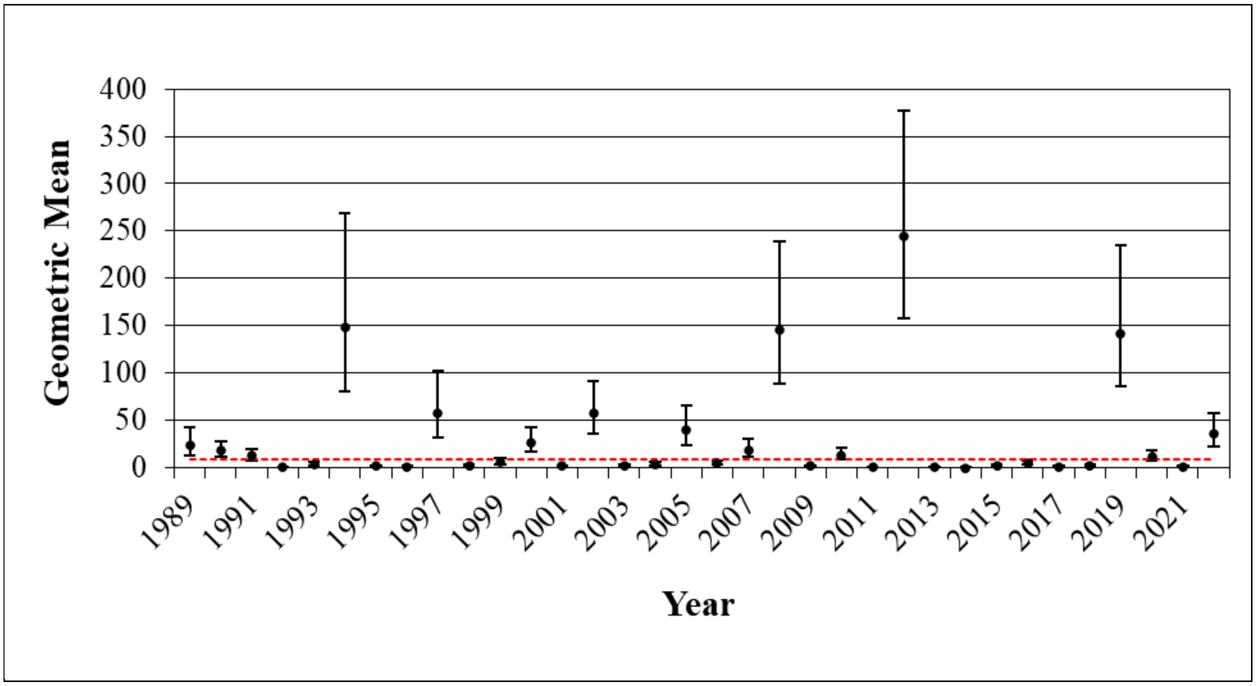

Figure 1.22. Spot (*Leiostomus xanthurus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\text{ - }2019,\ 2021\text{ - }2022}$ = 140/year, n_{2020} = 120).

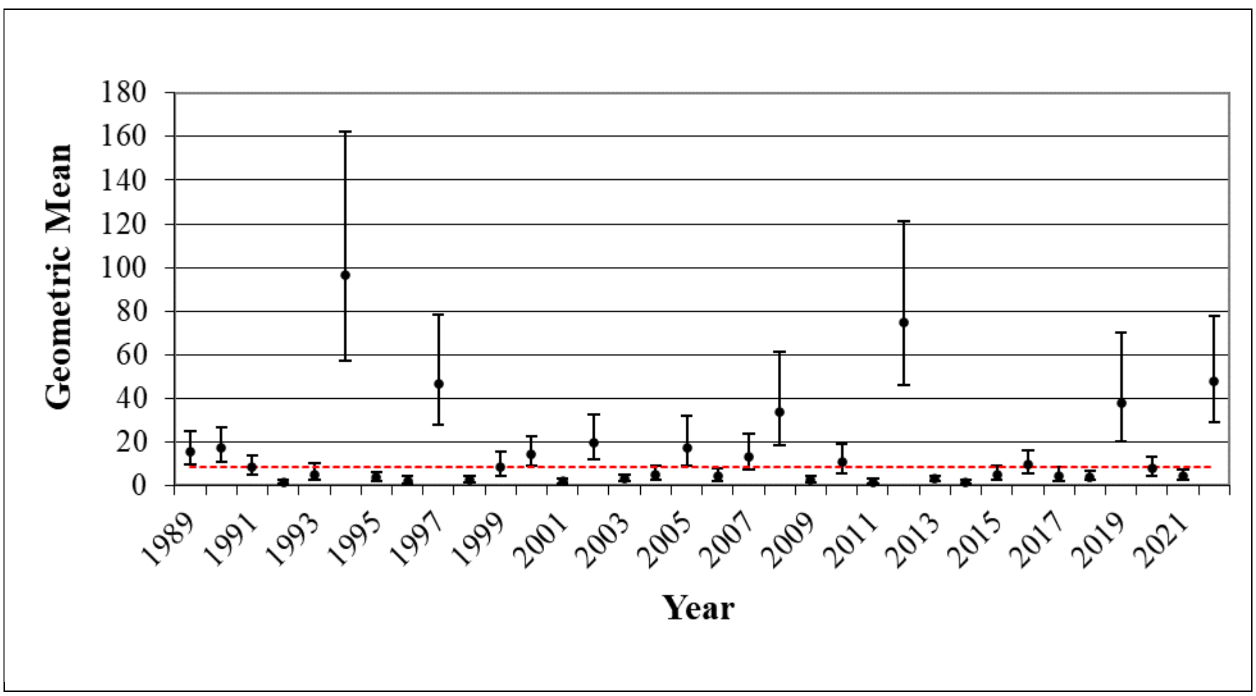

Figure 1.23. Spot (*Leiostomus xanthurus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

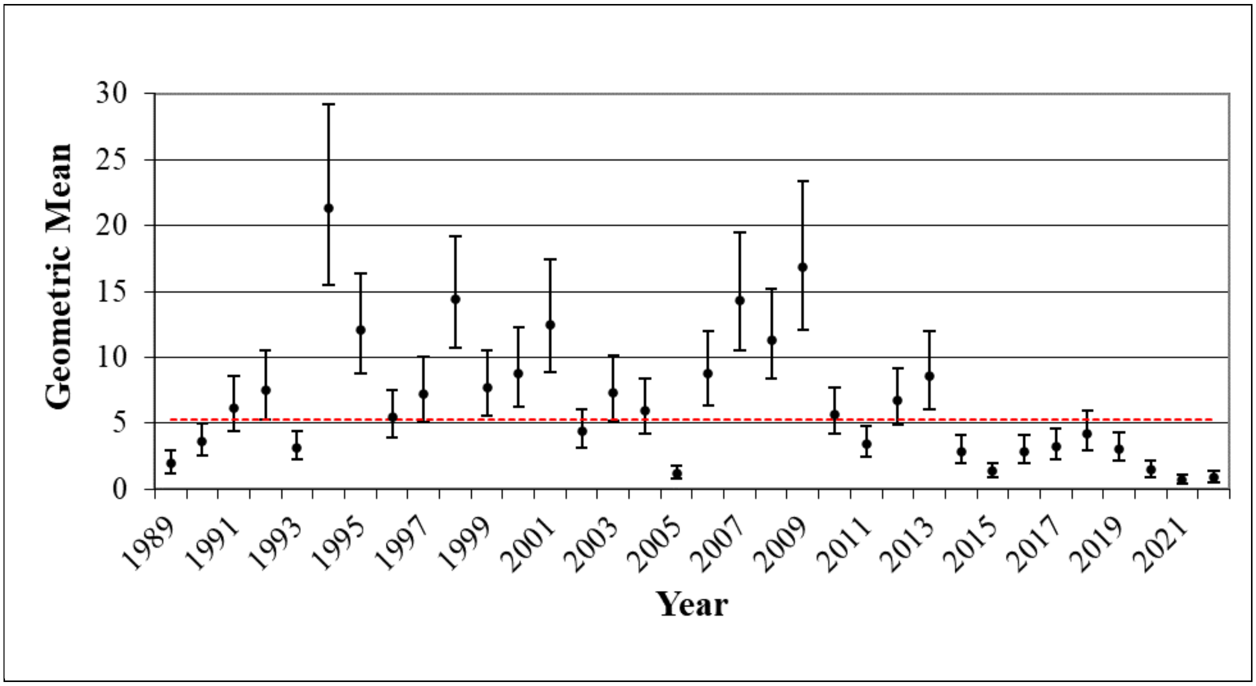

Figure 1.24. Summer flounder (*Paralichthys dentatus*) trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989 - 2019, 2021 - 2022}$ = 140/year, n_{2020} = 120).

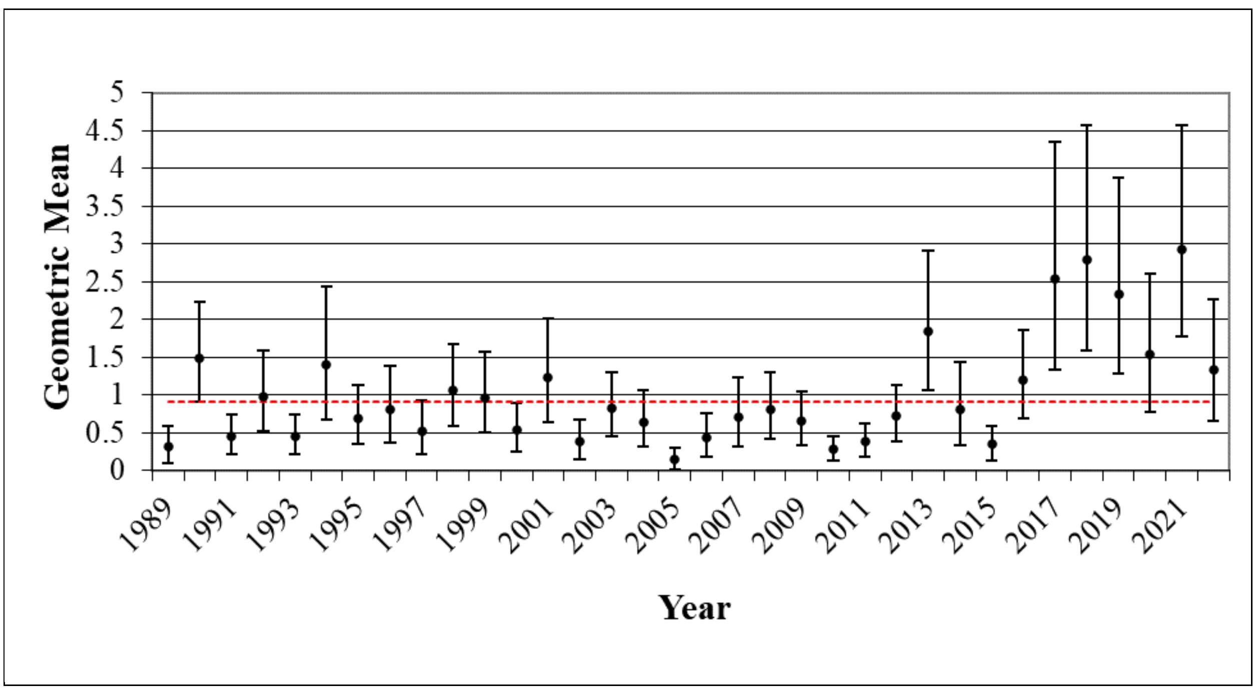

Figure 1.25. Summer flounder (*Paralichthys dentatus*) beach seine index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean (n = 38/year).

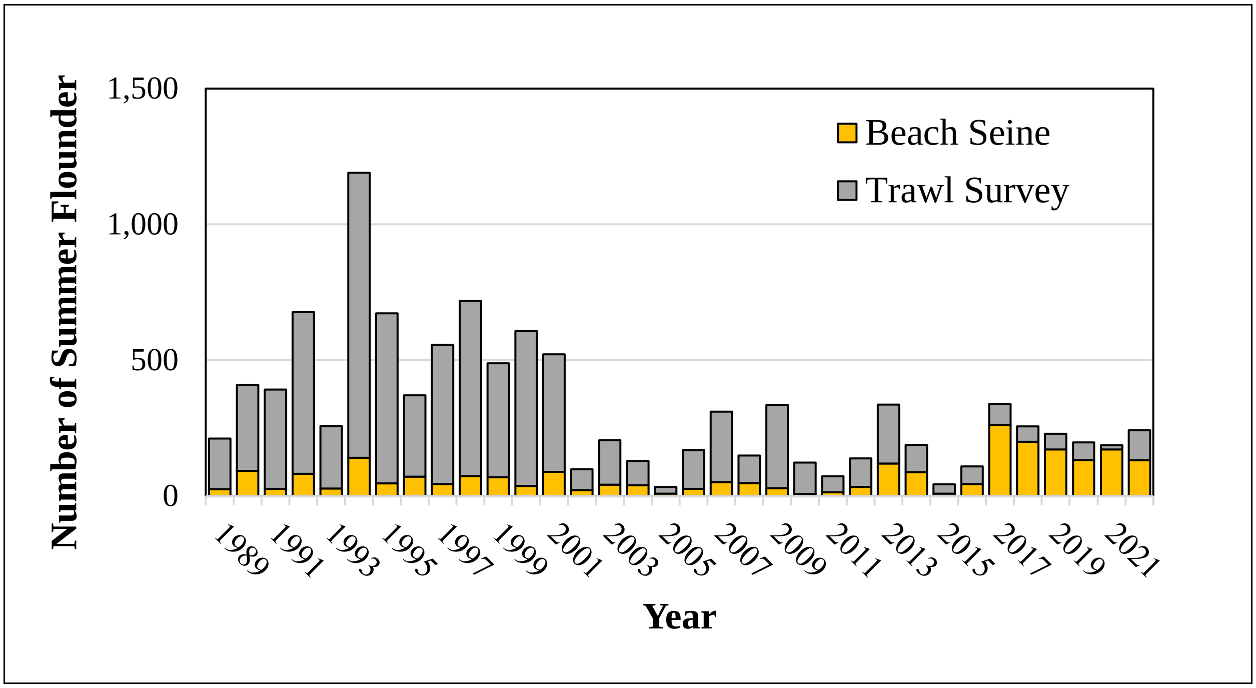

Figure 1.26. Summer flounder (*Paralichthys dentatus*) relative abundance shift toward shallow water in June.

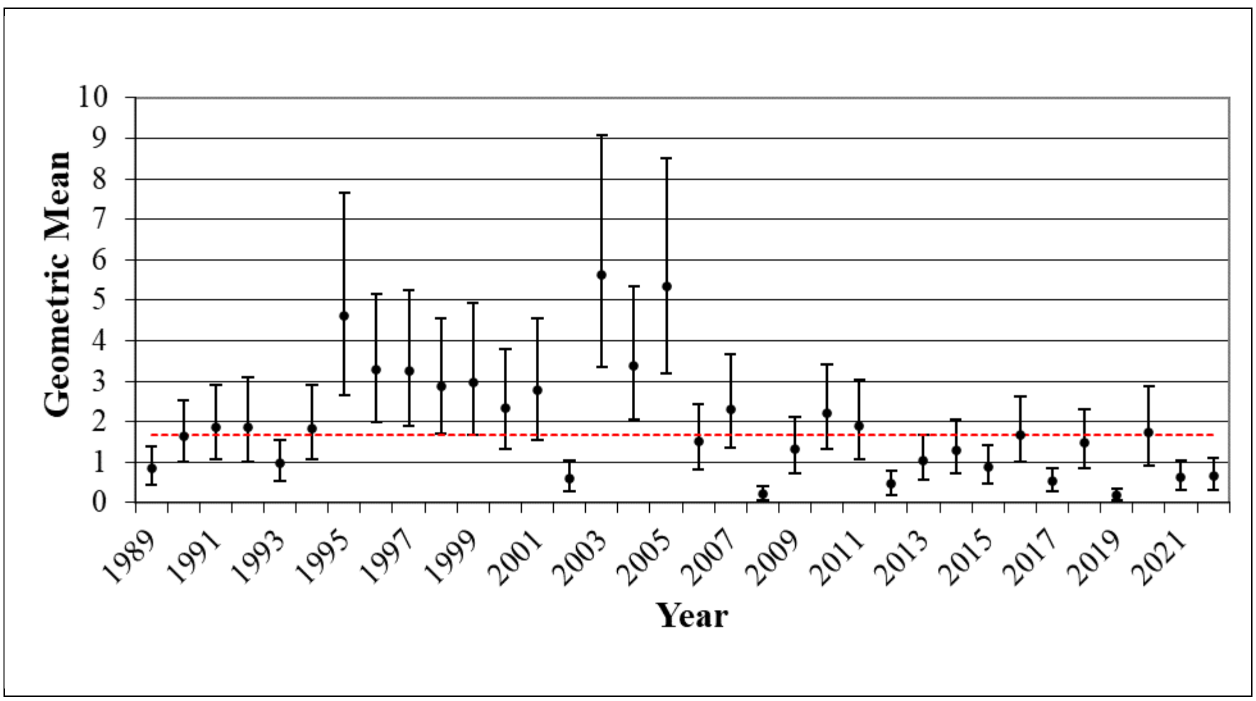

Figure 1.27. Weakfish (*Cynoscion regalis)* trawl index of relative abundance (geometric mean) with 95% confidence intervals (1989 - 2022). Dotted line represents the 1989 - 2022 time series grand mean ($n_{1989\text{ - }2019,\ 2021\text{ - }2022}$ = 140/year, n_{2020} = 120).

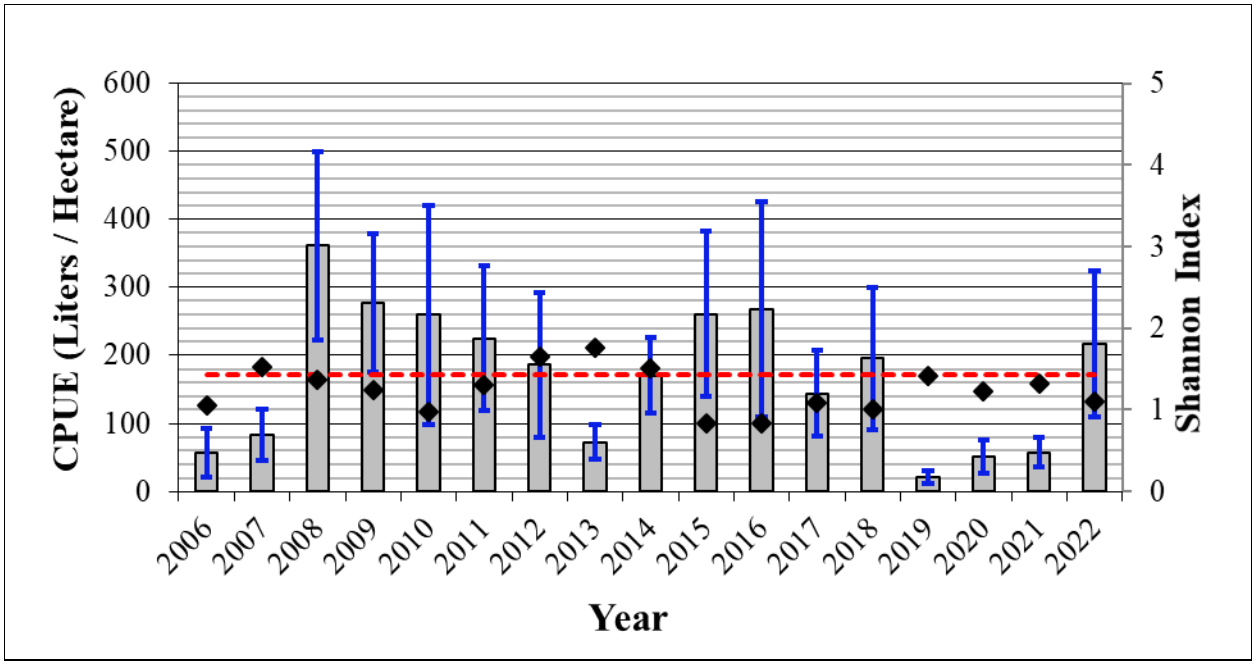

Figure 1.28. Coastal bays trawl index of macroalgae relative abundance (CPUE; L/ha) with 95% confidence intervals (2006 - 2022). Red line represents the 2006 - 2022 time series CPUE grand mean ($n_{1989 - 2019, 2021 - 2022}$ = 140/year, n_{2020} = 120). Black diamond represents the Shannon index of diversity.

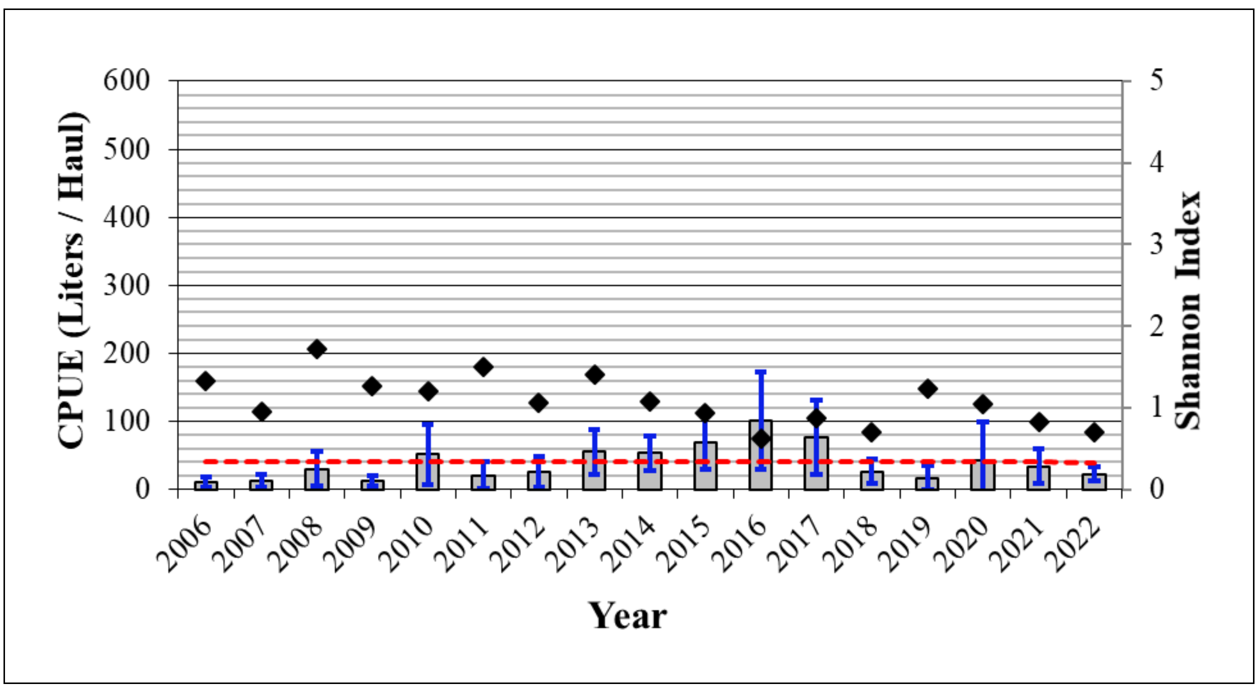

Figure 1.29. Coastal bays beach seine index of macroalgae relative abundance (CPUE; L/haul) with 95% confidence intervals (2006 - 2022). Red line represents the 2006 - 2022 time series CPUE grand mean (n = 36/year). Black diamond represents the Shannon index of diversity

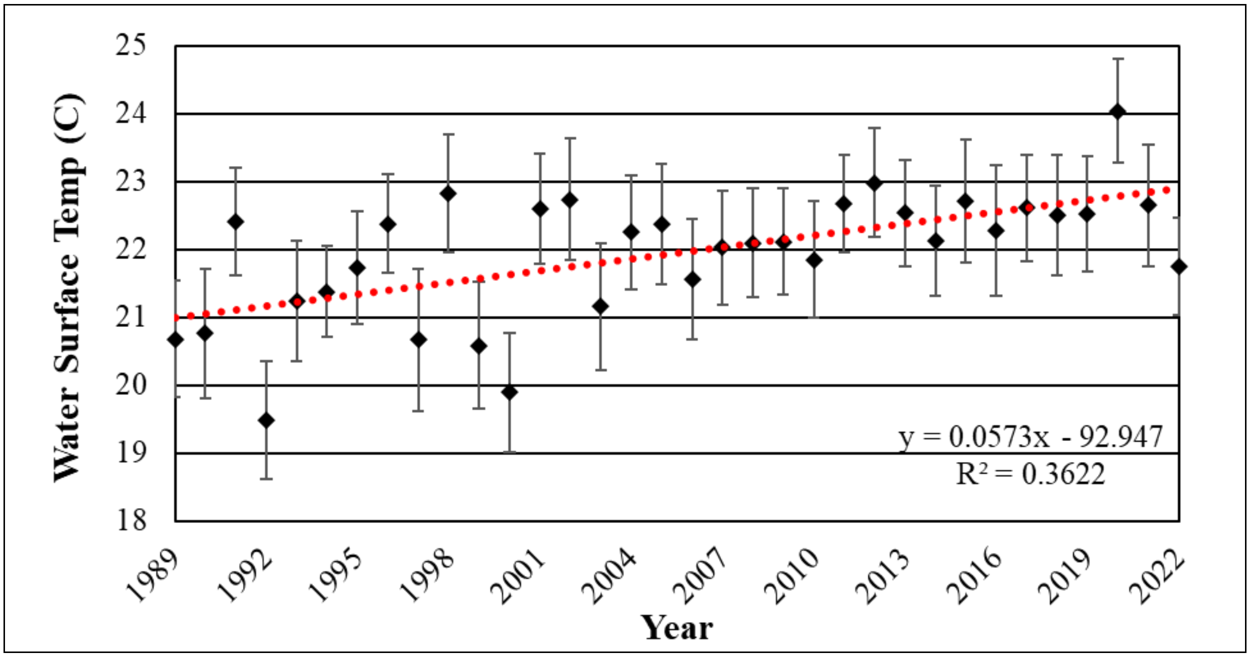

Figure 1.30. Distribution of annual mean surface water temp (C) with 95% confidence intervals from the Trawl Survey (1989 - 2022).

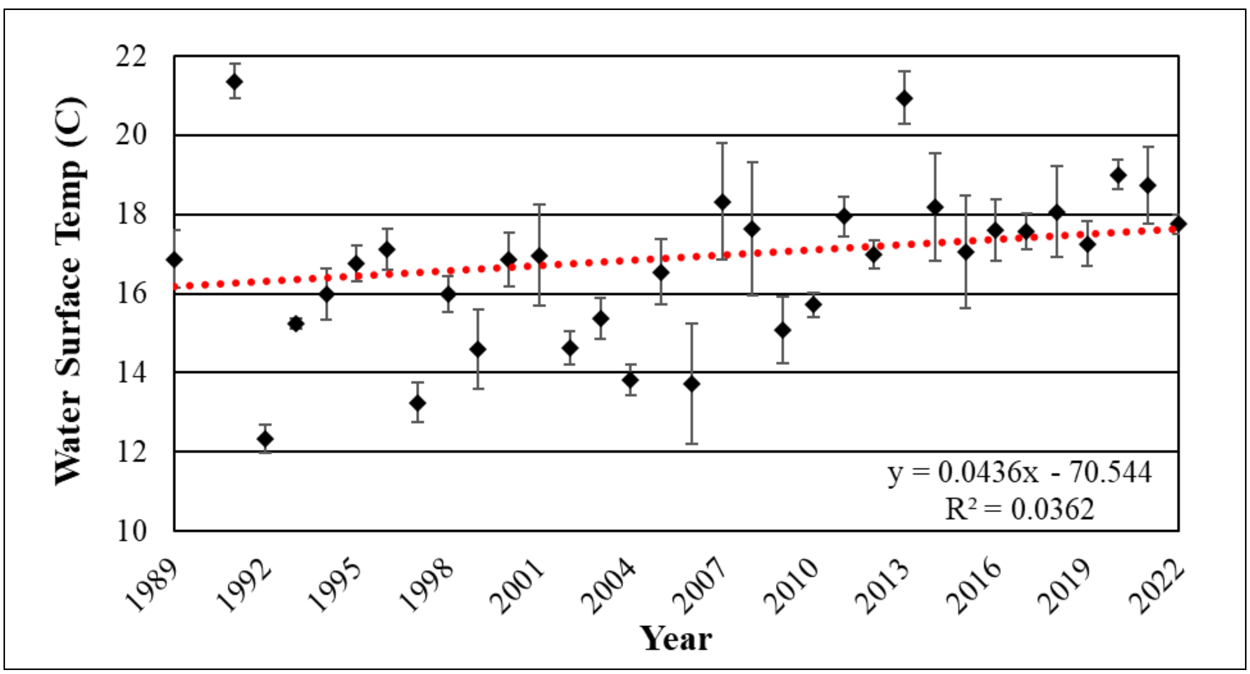

Figure 1.31. Distribution of October mean surface water temp (C) with 95% confidence intervals from the Trawl Survey (1993 - 2022).

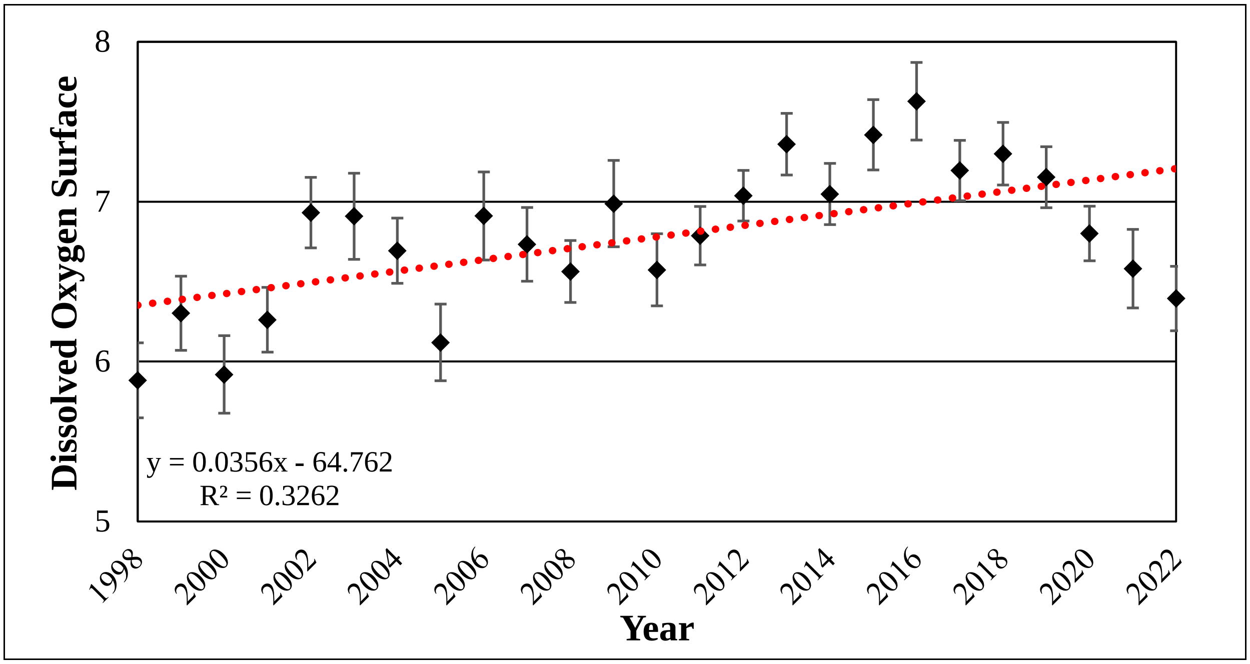

Figure 1.32. Distribution of annual mean surface dissolved oxygen (mg/L) with 95% confidence intervals from the Trawl Survey (1998 - 2022).

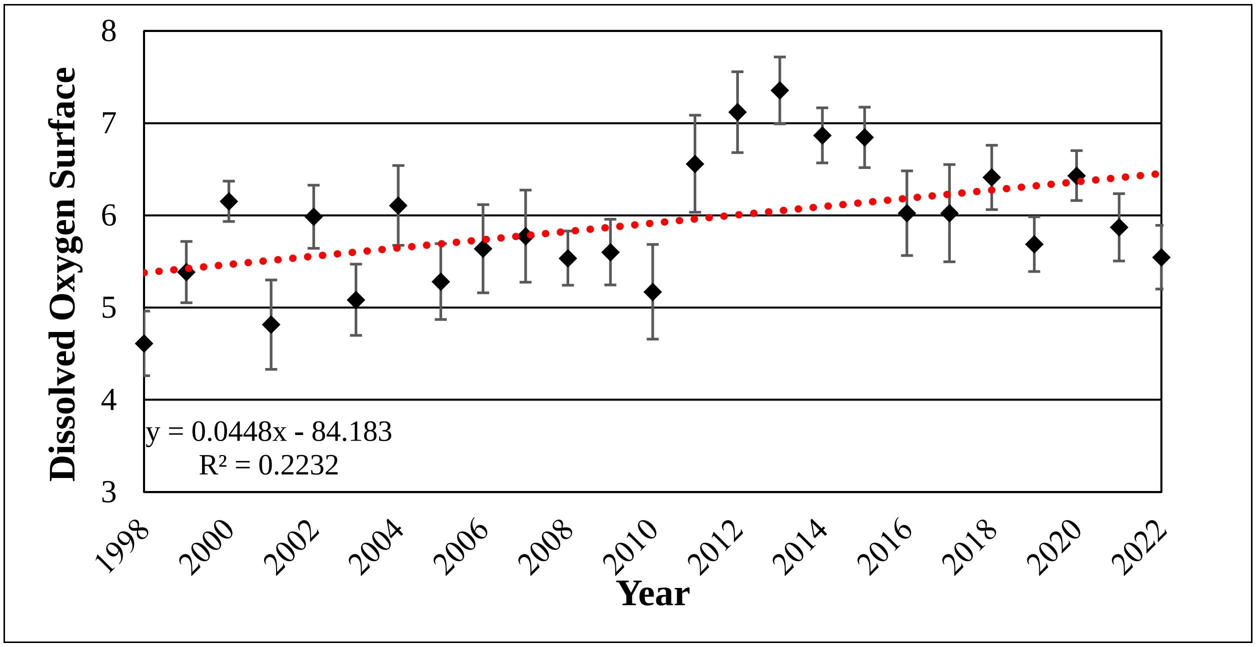

Figure 1.33. Distribution of August mean surface dissolved oxygen (mg/L) with 95% confidence intervals from the Trawl Survey (1998 - 2022).

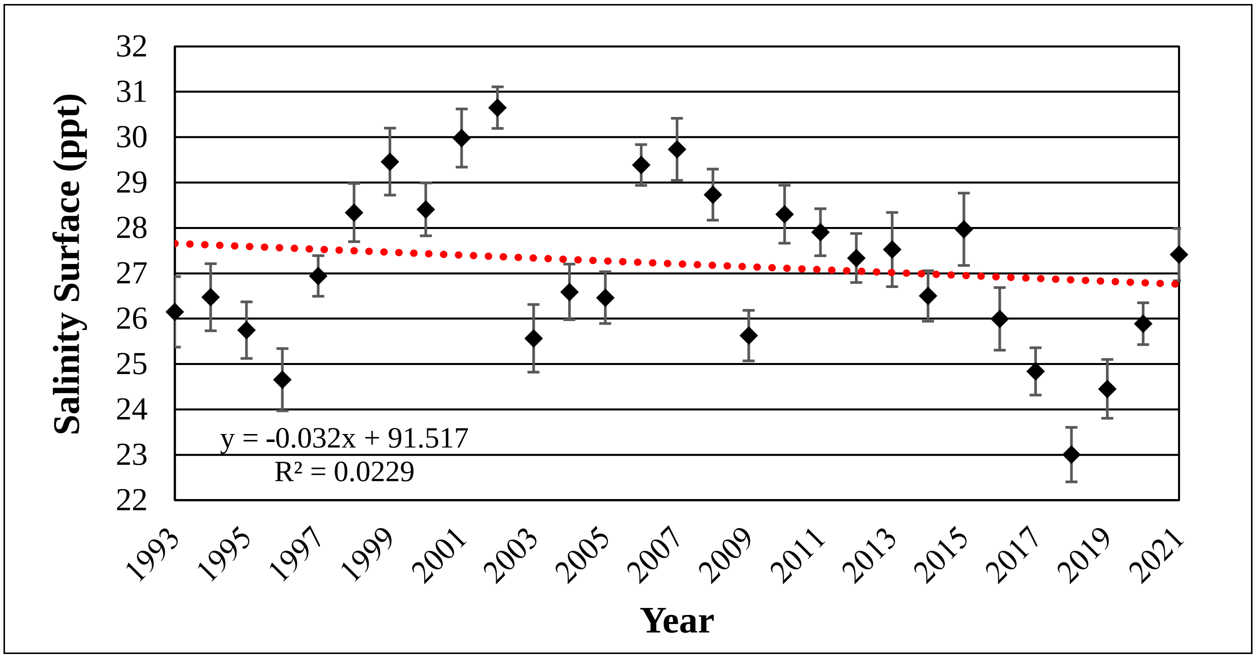

Figure 1.34. Distribution of annual mean surface salinity with 95% confidence intervals from the Trawl Survey (1993 - 2022).

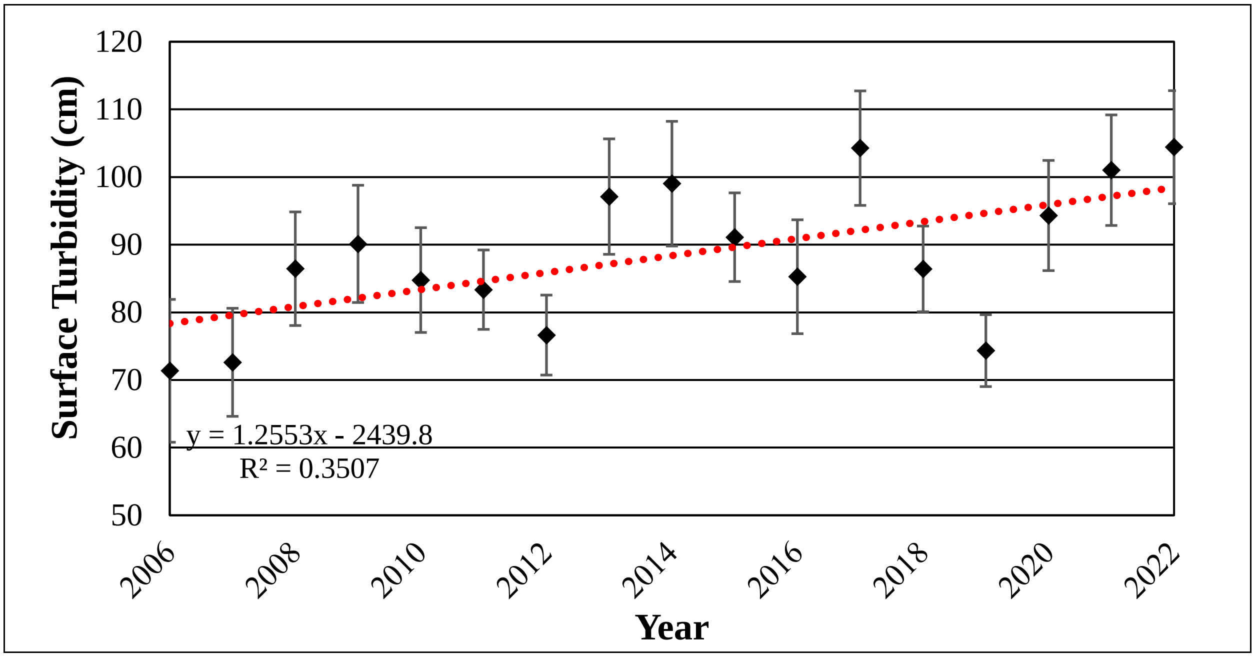

Figure 1.35. Distribution of annual mean turbidity (cm) with 95% confidence intervals from the Trawl Survey (2006 - 2022).

Chapter 2 Submerged Aquatic Vegetation Habitat Survey

Introduction
Two species of Submerged Aquatic Vegetation (SAV) are 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. 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 (2021). 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 seven year period from 2015 - 2022. 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 except for increasing the length sample targets for specific fishes of interest such as black sea bass, tautog, and summer

flounder for better precision to evaluate habitat utilization by fish size or lifecycle. 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 CPUE = catch/haul, and further normalized for survey comparisons of abundance in fish per hectare. Area swept for this survey was estimated as 0.04004919 ha/seine haul. The Beach Seine Survey was estimated as 0.0906704 ha/seine haul and the Trawl Survey was 0.125415 ha/trawl. 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 133 beach seine hauls conducted within fourteen SAV grids from 2015 – 2022 (Table 2.1, Figure 2.1). An average of 16 stratified samples per year were distributed between four categories of SAV coverage: 25% or less (22 samples), 26% - 50% (27 samples), 51% - 75% (39 samples), and 76% - 100% (45 samples). These samples were also categorized by primary substrate as either sand (hard bottom; 59 samples) or mud (soft bottom; 74 samples). Additionally, each sample's dominant SAV species was identified; eelgrass was most abundant (106 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 2022 sampling collected 26 fishes and 2,111 fish (Table 2.3). The most abundant species in 2022 were Atlantic silversides, silver perch, tautog, striped anchovy, and black sea bass. Smallmouth flounder were present in 2022 for the first time in the survey. The most abundant crustaceans were blue crabs and grass shrimp while brown shrimp was not present in 2022 (Table 2.4).

Over the time series, a total of 50 fishes and 17,642 fish were collected (Table 2.3). Silver perch relative abundance has declined since 2015 whereas black sea bass, tautog, and sheepshead abundance has increased (Table 2.3). CPUE results from this survey showed higher relative abundance for many popular species such as tautog, sheepshead, halfbeak, and black sea bass compared to those in Chapter 1. Blue crab, grass shrimp, and brown shrimp also showed the same results (Table 2.5). Atlantic menhaden, spot, and summer flounder relative abundance was greater in areas without SAV, as expected based on results from Chapter 1.

Tautog relative abundance in 2022 was the second highest 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. Tautog abundance results from the SAV Habitat Survey were compared to the surveys in Chapter 1, which sample other coastal bays habitat such as sandy beaches, macroalgae assemblages, and deeper muddy bottom in the channels and river systems. The results show that SAV Habitat is essential to sustain juvenile tautog populations in Sinepuxent Bay. 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 and Trawl surveys are not appropriate for tautog management because they do not sample in SAV.

Fish relative abundance within SAV was further characterized by percent SAV coverage, primary substrate, and dominant SAV species. Overall, the results of the Kruskal-Wallis test (KWt) indicated significant differences of fish abundance for these habitat characteristics (10 fishes, 3 crustaceans; Table 2.6). 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. The KWt results with significant interactions were further investigated by ANOVA and post hoc DMRT to determine if the abundance levels differences.

SAV coverage results from the ANOVA identified four fishes (dusky pipefish, pigfish, pinfish, and tautog) with significant differences in relative abundance. Moreover, the DMRT analysis also identified northern pipefish, sheepshead, brown shrimp, and grass shrimp with significant difference in abundance by SAV coverage (Table 2.7). Pipefishes and tautog preferred the densest SAV coverage while pigfish, sheepshead, and grass shrimp preferred medium - high SAV coverage. Primary substrate ANOVA and DMRT showed a significant difference in abundance for sheepshead and brown shrimp towards sand substrate (Table 2.8). Dominant SAV species ANOVA results had higher abundance within eelgrass for pipefishes and tautog while gray snapper, blue crab, and brown shrimp preferred widgeon grass. The post hoc DMRT results found significant differences in relative abundance for those species as well as pigfish, which preferred eelgrass. Black sea bass results were not significant; however, mean abundance was higher in eelgrass (Table 2.9).

While many of the species within the SAV did not indicate a significant preference for a particular SAV coverage, substrate, or SAV species, this could be due to the inability to isolate the specific secondary characteristics during the analysis. When conducting a test on a particular characteristic, the secondary and tertiary interactions may have influenced the results. While the annual stratified samples were unbalanced, overall, they provide a representation of how SAV habitat supported many important species at higher abundance than other habitats within the coastal bays (Table 2.3).

Fish Species Richness and Diversity by Habitat Category

Fish richness (number of species) was generally high (50 fishes total, 26.6 average per year) throughout the time series except in the multivariate categories that contained widgeon grass over mud (Table 2.10). While this specific habitat was uncommon throughout the time series, widgeon grass over sand was also uncommon and contained more fishes in the low to medium - high SAV coverage (Table 2.2).

Diversity (evenness of those species) results indicated that medium and medium - high SAV coverage categories (26 - 50% and 51 - 75%) with sand substrate (hard bottom) and eelgrass was the most diverse (H = 2.3; Table 2.11). 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 resiliency to climate change.

Fish Length Composition by Habitat Category

Relationships of total length and habitat characteristics were investigated for significant interactions. Black sea bass, sheepshead, silver perch, and tautog were selected for ANOVA and DMRT analysis (Table 2.12). SAV coverage ANOVA and DMRT results indicated significant differences in length for black sea bass, silver perch, and tautog. Black sea bass and silver perch were largest in low coverage SAV beds. Tautog were the largest in medium-high and high SAV and smaller in the sparser coverage categories. While larger tautogs were caught in medium-high SAV coverage, they were all young of year (age-0). Denser 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 post hoc DMRT results found significant differences in length for silver perch, and tautog (Table 2.13). Silver perch were larger in SAV beds within sand substrate whereas tautog were larger within muddy or soft bottom SAV beds. Dominant SAV ANOVA and DMRT results showed significant differences in length for black sea bass and tautog (Table 2.14). Black sea bass mean length was smaller in eelgrass while tautog were smaller in widgeon grass. This mean length difference may not be biologically significant but may show that YOY tautog that survive longer select eelgrass habitat over widgeon grass. Widgeon grass habitat was underrepresented at higher density SAV, which was typically eelgrass. 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. The SAV coverage category may be the driving factor regardless of substrate or SAV species in regards toward fish length or abundance.

Water Quality

The water temperature, salinity, DO, and turbidity results were within acceptable limits for fishes and forage crustaceans throughout the survey time series. The ANOVA and DMRT results comparing annual water quality across the timeseries indicated significant interannual variability, especially in 2018, which was a wet year. The mean water temperature and salinity in 2018 (29.7 C; 25.4 ppt) was close to the SAV threshold (30.0 C), but water temperature has decreased since then in Sinepuxent Bay. This year (2022) showed average temperatures, higher salinity, average dissolved oxygen, and lower turbidity. Increases in water clarity was promising for SAV growth.

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
095	SAV beds vicinity Castaways, West of Tiki Bar	38°17.980	75°07.311	6
096	SAV beds vicinity Castaways Jackspot Waterfront Tiki bar	38 18.019	75 07.177	22
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	23
122	East of Snug Harbor, west of small island; pulled towards the south	38 17.167	75 07.523	2
127	Southeast of Devils Island, near channel edge on east side of marsh	38°17.075	75°07.793	4
128	South of duck blind, east of green marker	38 17.061	75 07.659	24
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 - 2022).

	Percent SAV Coverage					
	Low < 25%	Medium 26 - 50%	Medium - High 51 - 75%	High 76 - 100%	Total by Characteristic	Grand Total
Eelgrass (*Zostera marina*)	14	19	32	41	106	133
Widgeon grass (*Ruppia maritima*)	8	8	7	4	27	
Sand	13	16	15	15	59	133
Mud	9	11	24	30	74	
Sand - Eelgrass (*Z. marina*)	6	12	13	12	43	133
Mud - Eelgrass (*Z. marina*)	8	7	19	29	63	
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 - 2022). Catch per unit of effort (CPUE) was fish/haul.

Specimen Name	2015 - 2022 (n = 133)			2022 (n = 18)		
	Count	x̄ CPUE	x̄ length	Count	CPUE	x̄ length
Atlantic silverside (*Menidia menidia*)	7,919	59.5	83	1,019	56.6	85
Silver perch (*Bairdiella chrysoura*)	6,193	46.6	76	308	17.1	84
Tautog (*Tautoga onitis*)	778	5.8	76	212	11.8	85
Sheepshead (*Archosargus probatocephalus*)	459	3.5	70	39	2.2	65
Striped anchovy (*Anchoa hepsetus*)	319	2.4	79	154	8.6	86
Black sea bass (*Centropristis striata*)	309	2.3	76	121	6.7	75
Halfbeak (*Hyporhamphus unifasciatus*)	238	1.8	148	13	0.7	155
Pinfish (*Lagodon rhomboides*)	185	1.4	122	87	4.8	122
Dusky pipefish (*Syngnathus floridae*)	175	1.3	156	41	2.3	160
Pigfish (*Orthopristis chrysoptera*)	165	1.2	82	57	3.2	71
Northern pipefish (*Syngnathus fuscus*)	136	1.0	178	9	0.5	192
Spotfin mojarra (*Eucinostomus argenteus*)	136	1.0	79			
Striped blenny (*Chasmodes bosquianus*)	108	0.8	63	10	0.6	72
Oyster toadfish (*Opsanus tau*)	99	0.7	70	1	0.1	114
Spot (*Leiostomus xanthurus*)	74	0.6	128	7	0.4	120
Bay anchovy (*Anchoa mitchilli*)	72	0.5	67	1	0.1	80
Bluespotted cornetfish (*Fistularia tabacaria*)	29	0.2	332	10	0.6	307
Northern puffer (*Sphoeroides maculatus*)	28	0.2	130	3	0.2	82
Summer flounder (*Paralichthys dentatus*)	27	0.2	173			
Striped burrfish (*Chilomycterus schoepfii*)	26	0.2	171	6	0.3	139
Gray snapper (*Lutjanus griseus*)	24	0.2	72			
Spotfin butterflyfish (*Chaetodon ocellatus*)	16	0.1	60	2	0.1	46
Atlantic menhaden (*Brevoortia tyrannus*)	11	0.1	112			
Atlantic needlefish (*Strongylura marina*)	11	0.1	298	1	0.1	338
White mullet (*Mugil curema*)	10	0.1	171			

Table 2.3 continued. List of fishes collected from the Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey (2015 - 2022). Catch per unit of effort (CPUE) was fish/haul.

Specimen Name	2015 - 2022 (n = 133)			2022 (n = 18)		
	Count	x̄ CPUE	x̄ length	Count	CPUE	x̄ length
Rainwater killifish (*Lucania parva*)	9	0.1	38		0.0	
Feather blenny (*Hypsoblennius hentz*)	8	0.1	69	1	0.1	60
Bluefish (*Pomatomus saltatrix*)	6	0.0	120	2	0.1	119
Lined seahorse (*Hippocampus erectus*)	6	0.0	108	2	0.1	80
Naked goby (*Gobiosoma bosc*)	6	0.0	36			
Spotted seatrout (*Cynoscion nebulosus*)	6	0.0	116			
Southern kingfish (*Menticirrhus americanus*)	5	0.0	103			
American eel (*Anguilla rostrata*)	4	0.0	318			
Blackcheek tonguefish (*Symphurus plagiusa*)	4	0.0	88			
Inshore lizardfish (*Synodus foetens*)	4	0.0	166	2	0.1	162
Northern kingfish (*Menticirrhus saxatilis*)	4	0.0	121			
Striped mullet (*Mugil cephalus*)	4	0.0	197			
Black drum (*Pogonias cromis*)	3	0.0	133			
Atlantic croaker (*Micropogonias undulatus*)	2	0.0	57			
Atlantic spadefish (*Chaetodipterus faber*)	2	0.0	83			
Southern stingray (*Dasyatis americana*)	2	0.0	420			
Striped bass (*Morone saxatilis*)	2	0.0	482	2	0.1	482
Cobia (*Rachycentron canadum*)	1	0.0	147			
Gag (*Mycteroperca microlepis*)	1	0.0	168			
Harvestfish (*Peprilus paru*)	1	0.0	30			
Lookdown (*Selene vomer*)	1	0.0	82			
Skilletfish (*Gobiesox strumosus*)	1	0.0	46			
Smallmouth flounder (*Etropus microstomus*)	1	0.0	60	1	0.1	60
Spanish mackerel (*Scomberomorus maculatus*)	1	0.0	170			
Striped killifish (*Fundulus majalis*)	1	0.0	107			

Table 2.4. List of forage crustaceans collected from the Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey (2015 - 2022). Catch per unit of effort (CPUE) was fish/haul.

Specimen Name	2015 – 2022 (n =133)			2022 (n = 18)		
	Count	x̄ CPUE	x̄ length	Count	CPUE	x̄ length
Blue crab (*Callinectes sapidus*)	4,542	34.2	57	181	10.1	82
Grass shrimp (*Palaemonetes sp.*)	2,452	18.4		122	7.8	
Brown shrimp (*Farfantepenaeus aztecus*)	765	5.8	81			

Table 2.5. September species abundance survey comparisons in Maryland's coastal bays (2015 - 2022). Catch per unit of effort (CPUE) was normalized as individual/hectare.

Specimen Name	SAV Habitat Survey September n = 133		Beach Seine Survey September n = 152		Trawl Survey September n = 160	
	Count	x̄ CPUE	Count	x̄ CPUE	Count	x̄ CPUE
Silver perch (*Bairdiella chrysoura*)	6,193	1,162.7	5,372	389.8	1,971	98.2
Tautog (*Tautoga onitis*)	778	146.1	17	1.2		
Sheepshead (*Archosargus probatocephalus*)	459	86.2	216	15.7	6	0.3
Black sea bass (*Centropristis striata*)	309	58.0	31	2.2	96	4.8
Halfbeak (*Hyporhamphus unifasciatus*)	238	44.7	118	8.6		
Pinfish (*Lagodon rhomboides*)	185	34.7	296	21.5	49	2.4
Pigfish (*Orthopristis chrysoptera*)	165	31.0	215	15.6	39	1.9
Spot (*Leiostomus xanthurus*)	74	13.9	2,285	165.8	3,260	162.5
Summer flounder (*Paralichthys dentatus*)	27	5.1	228	16.5	154	7.7
Northern puffer (*Syngnathus maculatus*)	28	5.3	76	5.5	35	1.7
Gray snapper (*Lutjanus griseus*)	24	4.5	13	0.9		
Atlantic menhaden (*Brevoortia tyrannus*)	11	2.1	28,171	2,044.1	95	4.7
Striped bass (*Morone saxatilis*)	2	0.4	84	6.1	1	0.0
Blue crab (*Callinectes sapidus*)	4,542	852.7	3,943	286.1	2,563	127.7
Grass shrimp (*Palaemonetes sp.*)	2,452	460.3	2,969	215.4	345	17.2
Brown shrimp (*Farfantepenaeus aztecus*)	765	143.6	432	31.3	757	37.7

Table 2.6. Results of the Submerged Aquatic Vegetation Habitat Survey's (2015 - 2022) 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.	($\chi 2(1) = 5.67$, $p < 0.05$)
Black sea bass (*Centropristis striata*)	n.s.	n.s.	($\chi 2(1) = 7.31$, $p < 0.01$)
Dusky pipefish (*Syngnathus floridae*)	($\chi 2(3) =17.8$, $p < 0.01$)	n.s.	($\chi 2(1) = 10.01$, $p < 0.01$)
Gray snapper (*Lutjanus griseus*)	n.s.	n.s.	($\chi 2(1) = 20.1$, $p < 0.01$)
Halfbeak (*Hyporhamphus unifasciatus*)	($\chi 2(3) =7.9$, $p < 0.05$)	n.s.	n.s.
Northern pipefish (*Syngnathus fuscus*)	($\chi 2(3) = 10.13$, $p < 0.01$)	($\chi 2(1) = 6.5$, $p < 0.05$)	($\chi 2(1) = 5.6$, $p < 0.05$)
Pigfish (*Orthopristis chrysoptera*)	($\chi 2(3) = 13.1$, $p < 0.01$)	n.s.	($\chi 2(1) = 6.88$, $p < 0.01$)
Pinfish (*Lagodon rhomboides*)	n. s	n.s.	n.s.
Sheepshead (*Archosargus probatocephalus*)	($\chi 2(3) = 9.5$, $p < 0.05$)	n.s.	n.s.
Silver perch (*Bairdiella chrysoura*)	($\chi 2(3) = 9.55$ $p < 0.05$)	n.s.	n.s.
Tautog (*Tautoga onitis*)	($\chi 2(3) =24.8$, $p < 0.01$)	n.s.	($\chi 2(1) = 23.3$, $p < 0.01$)
Blue crab (*Callinectes sapidus*)	($\chi 2(3) =10.08$, $p < 0.05$)	n.s.	($\chi 2(1) = 5.2$, $p < 0.05$)
Brown shrimp (*Farfantepenaeus aztecus*)	($\chi 2(3) =9.4$, $p < 0.05$)	($\chi 2(1) = 8.08$, $p < 0.01$)	($\chi 2(1) = 17.5$, $p < 0.01$)
Grass shrimp (*Palaemonetes sp.*)	($\chi 2(3) =11.5$, $p < 0.01$)	n.s.	n.s.

Table 2.7. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 – 2022) 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*) ($F_{3,132} = 4.3$, $p < 0.01$)	$\bar{x} = 0.32$ C	$\bar{x} = 0.67$ B / C	$\bar{x} = 1.46$ A / B	$\bar{x} = 2.1$ A
Northern pipefish (*Syngnathus fuscus*) ($F_{3,132} = 2.33$, p = n.s.)	$\bar{x} = 0.18$ B	$\bar{x} = 1$ A / B	$\bar{x} = 1.2$ A	$\bar{x} = 1.3$ A
Pigfish (*Orthopristis chrysoptera*) ($F_{3,132} = 3.06$, $p < 0.05$)	$\bar{x} = 0.32$ B	$\bar{x} = 1.18$ A / B	$\bar{x} = 2$ A	$\bar{x} = 1.1$ A / B
Pinfish (*Lagodon rhomboides*) ($F_{3,132} = 3.33$, $p < 0.05$)	$\bar{x} = 1.27$ A / B	$\bar{x} = 0.74$ B	$\bar{x} = 0.85$ B	$\bar{x} = 2.3$ A
Sheepshead (*Archosargus probatocephalus*) ($F_{3,132} = 1.97$, p = n.s.)	$\bar{x} = 0.96$ B	$\bar{x} = 1.96$ A / B	$\bar{x} = 5.7$ A	$\bar{x} = 3.64$ A / B
Silver perch (*Bairdiella chrysoura*) ($F_{3,132} = 0.92$, p = n.s.)	$\bar{x} = 15.6$ A	$\bar{x} = 54.2$ A	$\bar{x} = 56.2$ A	$\bar{x} = 48.8$ A
Tautog (*Tautoga onitis*) ($F_{3,132} = 2.92$, $p < 0.05$)	$\bar{x} = 3$ B	$\bar{x} = 2.7$ B	$\bar{x} = 6.2$ A / B	$\bar{x} = 8.4$ A
Blue crab (*Callinectes sapidus*) ($F_{3,132} = 1.52$, p = n.s.)	$\bar{x} = 19.5$ A	$\bar{x} = 37.1$ A	$\bar{x} = 33.3$ A	$\bar{x} = 40.3$ A
Brown shrimp (*Farfantepenaeus aztecus*) ($F_{3,132} = 0.43$, p = n.s.)	$\bar{x} = 7.7$ A	$\bar{x} = 6.7$ A	$\bar{x} = 7.0$ A	$\bar{x} = 3.1$ A

Table 2.8. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) ANOVA and Duncan's multiple range test for CPUE and primary substrate.

Specimen Name	Primary Substrate	
	Sand	Mud
Northern pipefish (*Syngnathus fuscus*)	($F_{1,132} = 0.4$, p = n.s.)	
	$\bar{x} = 0.9$	$\bar{x} = 1.1$
	A	A
Sheepshead (*Archosargus probatocephalus*)	($F_{1,132} = 5.91$, $p < 0.05$)	
	$\bar{x} = 5.36$	$\bar{x} = 1.93$
	A	B
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,132} = 4.6$, $p < 0.05$)	
	$\bar{x} = 9.7$	$\bar{x} = 2.6$
	A	B

Table 2.9. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) ANOVA and Duncan's multiple range test for CPUE and dominant SAV.

Specimen Name	Dominant SAV Species	
	Eelgrass	Widgeon Grass
Atlantic silverside (*Menidia menidia*)	($F_{1,132} = 0.08$, p = n.s.)	
	$\bar{x} = 58$	$\bar{x} = 65.7$
	A	A
Black sea bass (*Centropristis striata*)	($F_{1,132} = 3.31$, p = n.s.)	
	$\bar{x} = 2.8$	$\bar{x} = 0.5$
	A	A
Dusky pipefish (*Syngnathus floridae*)	($F_{1,132} = 6.35$, $p < 0.05$)	
	$\bar{x} = 1.6$	$\bar{x} = 0.37$
	A	B
Gray snapper (*Lutjanus griseus*)	($F_{1,132} = 22.31$, $p < 0.01$)	
	$\bar{x} = 0.02$	$\bar{x} = 0.8$
	B	A
Northern pipefish (*Syngnathus fuscus*)	($F_{1,132} = 4.33$, $p < 0.05$)	
	$\bar{x} = 1.2$	$\bar{x} = 0.4$
	A	B
Pigfish (*Orthopristis chrysoptera*)	($F_{1,132} = 3.11$, p = n.s.)	
	$\bar{x} = 5.7$	$\bar{x} = 0$
	A	B
Tautog (*Tautoga onitis*)	($F_{1,132} = 4.07$, $p < 0.05$)	
	$\bar{x} = 6.7$	$\bar{x} = 2.4$
	A	B
Blue crab (*Callinectes sapidus*)	($F_{1,132} = 5.44$, $p < 0.05$)	
	$\bar{x} = 30.3$	$\bar{x} = 49.3$
	B	A
Brown shrimp (*Farfantepenaeus aztecus*)	($F_{1,132} = 17.9$, $p < 0.01$)	
	$\bar{x} = 2.4$	$\bar{x} = 19$
	B	A

Table 2.10. Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) 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)	32	38	40	36
Eelgrass (*Zostera marina*)	24	30	32	34
Widgeon grass (*Ruppia maritima*)	27	26	28	15
Sand	29	34	36	25
Mud	20	24	28	32
Sand - Eelgrass (*Z. marina*)	19	26	28	22
Mud - Eelgrass (*Z. marina*)	19	23	26	32
Sand - Widgeon grass (*R. maritima*)	26	24	25	12
Mud - Widgeon grass (*R. maritima*)	6	9	18	8

Table 2.11. Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) 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	1.6	1.6	1.5
Eelgrass (*Zostera marina*)	1.5	2.2	1.6	1.5
Widgeon grass (*Ruppia maritima*)	1.4	1.1	1.2	1
Sand	1.4	1.6	1.7	1.3
Mud	1.5	1.5	1.3	1.6
Sand - Eelgrass (*Z. marina*)	1.3	2.3	1.9	1.3
Mud - Eelgrass (*Z. marina*)	1.4	1.7	1.3	1.6
Sand - Widgeon grass (*R. maritima*)	1.4	1.1	1	0.9
Mud - Widgeon grass (*R. maritima*)	1.7	1	1.3	1.1

Table 2.12. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) 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%
Black sea bass (*Centropristis striata*)	($F_{3,307} = 2.97$, $p < 0.01$)			
	$\bar{x} = 86.2$ A	$\bar{x} = 71.3$ B	$\bar{x} = 73.9$ B	$\bar{x} = 79.5$ A / B
Sheepshead (*Archosargus probatocephalus*)	($F_{3,448} = 0.14$, p = n.s.)			
	$\bar{x} = 69.9$ A	$\bar{x} = 70$ A	$\bar{x} = 72$ A	$\bar{x} = 70$ A
Silver perch (*Bairdiella chrysoura*)	($F_{3,2675} = 40.67$ $p < 0.01$)			
	$\bar{x} = 85.5$ A	$\bar{x} = 76.4$ B	$\bar{x} = 76.9$ B	$\bar{x} = 72.3$ C
Tautog (*Tautoga onitis*)	($F_{3,775} = 22.94$, $p < 0.01$)			
	$\bar{x} = 63.7$ B	$\bar{x} = 66.6$ B	$\bar{x} = 80.2$ A	$\bar{x} = 76.8$ A

Table 2.13. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2021) 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
Black sea bass (*Centropristis striata*)	($F_{1,307} = 0.25$, p = n.s.)	
	$\bar{x} = 75.7$ A	$\bar{x} = 77$ A
Sheepshead (*Archosargus probatocephalus*)	($F_{1,448} = 0.94$, p = n.s.)	
	$\bar{x} = 70.7$ A	$\bar{x} = 69.5$ A
Silver perch (*Bairdiella chrysoura*)	($F_{1,2675} = 14.09$, $p < 0.01$)	
	$\bar{x} = 74.4$ B	$\bar{x} = 77.1$ A
Tautog (*Tautoga onitis*)	($F_{1,775} = 77.67$, $p < 0.01$)	
	$\bar{x} = 81.3$ A	$\bar{x} = 70.3$ B

Table 2.14. Results of the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022) 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
Black sea bass (*Centropristis striata*)	($F_{1,307} = 4.37$, $p < 0.05$)	
	$\bar{x} = 75.7$ B	$\bar{x} = 88.6$ A
Sheepshead (*Archosargus probatocephalus*)	($F_{1,449} = 0.52$, p = n.s.)	
	$\bar{x} = 69.7$ A	$\bar{x} = 70.9$ A
Silver perch (*Bairdiella chrysoura*)	($F_{1,2675} = 2.58$, p = n.s.)	
	$\bar{x} = 75.5$ A	$\bar{x} = 75.8$ A
Tautog (*Tautoga onitis*)	($F_{1,775} = 44.6$, $p < 0.01$)	
	$\bar{x} = 77.1$ A	$\bar{x} = 61.8$ B

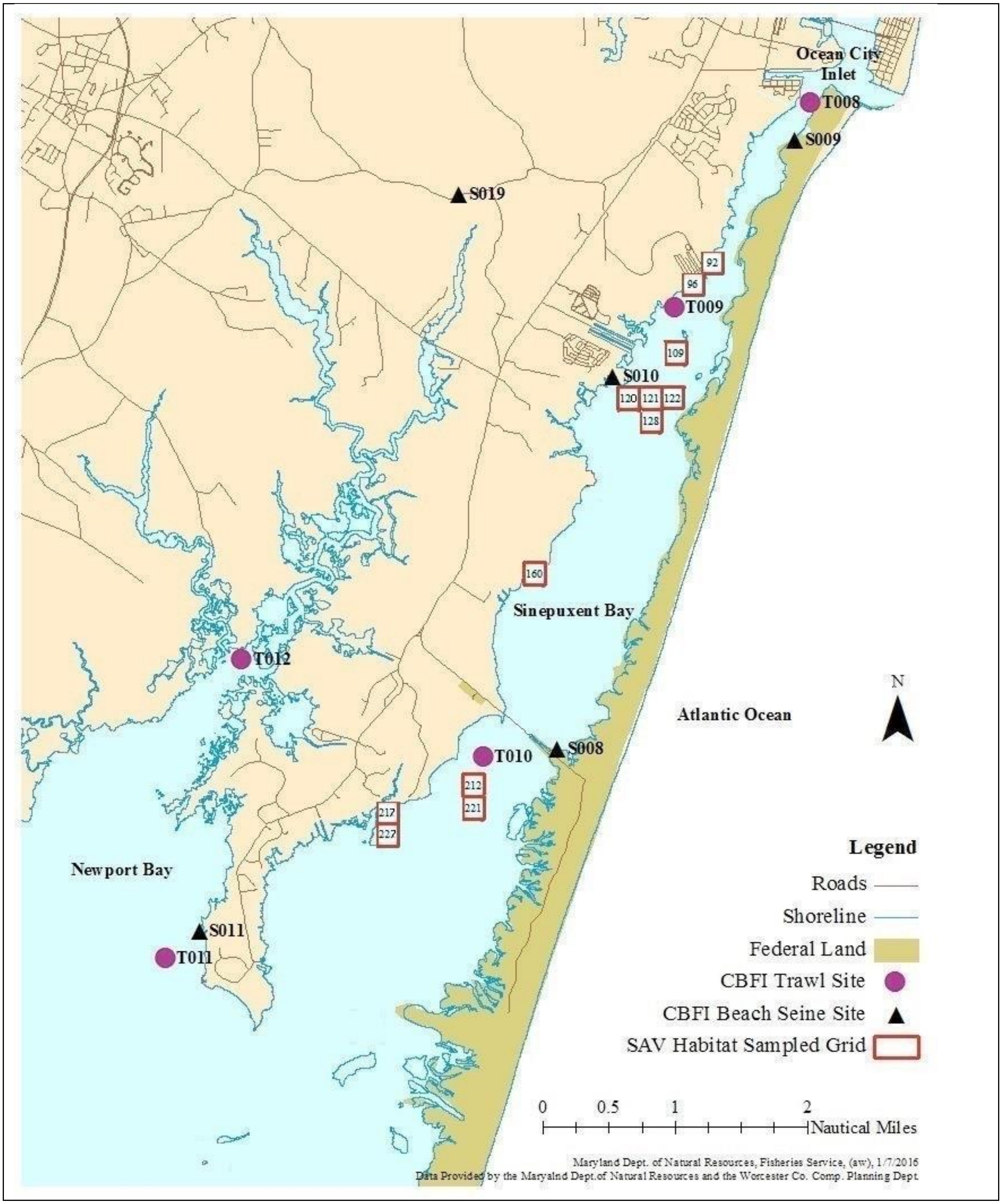

Figure 2.1. Sinepuxent Bay Submerged Aquatic Vegetation Habitat Survey and Trawl and Beach Seine surveys sample site locations (2015 - 2022).

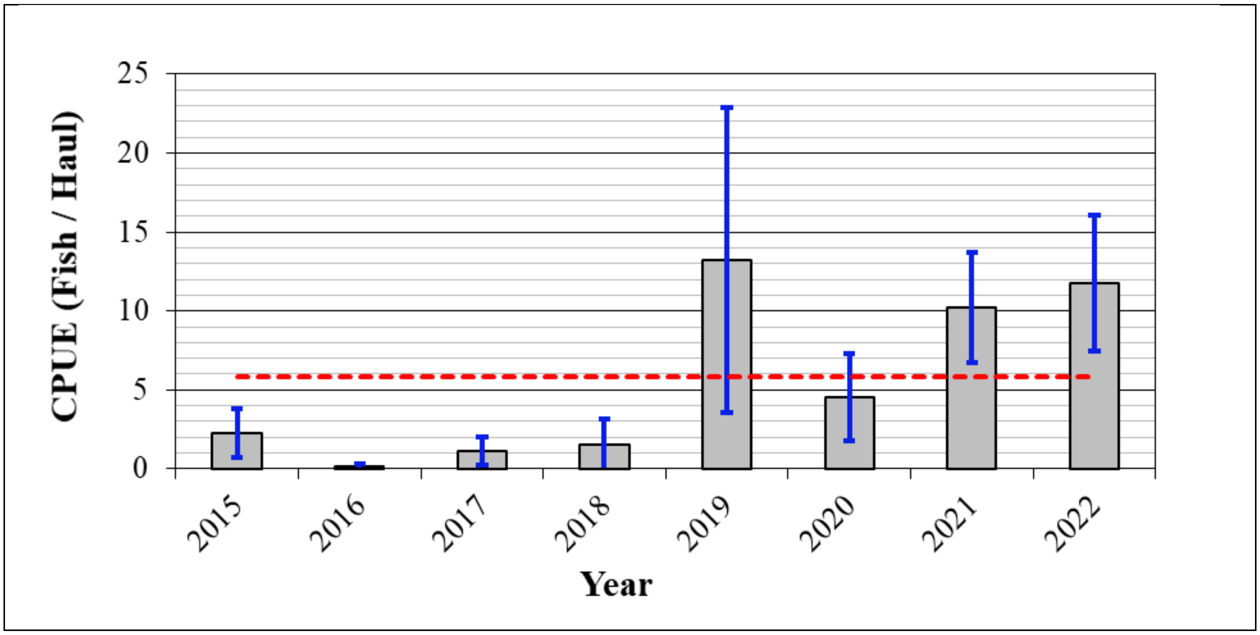

Figure 2.2. Tautog CPUE from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022). Dotted line represents the 2015 - 2022 time series grand mean (n = 133).

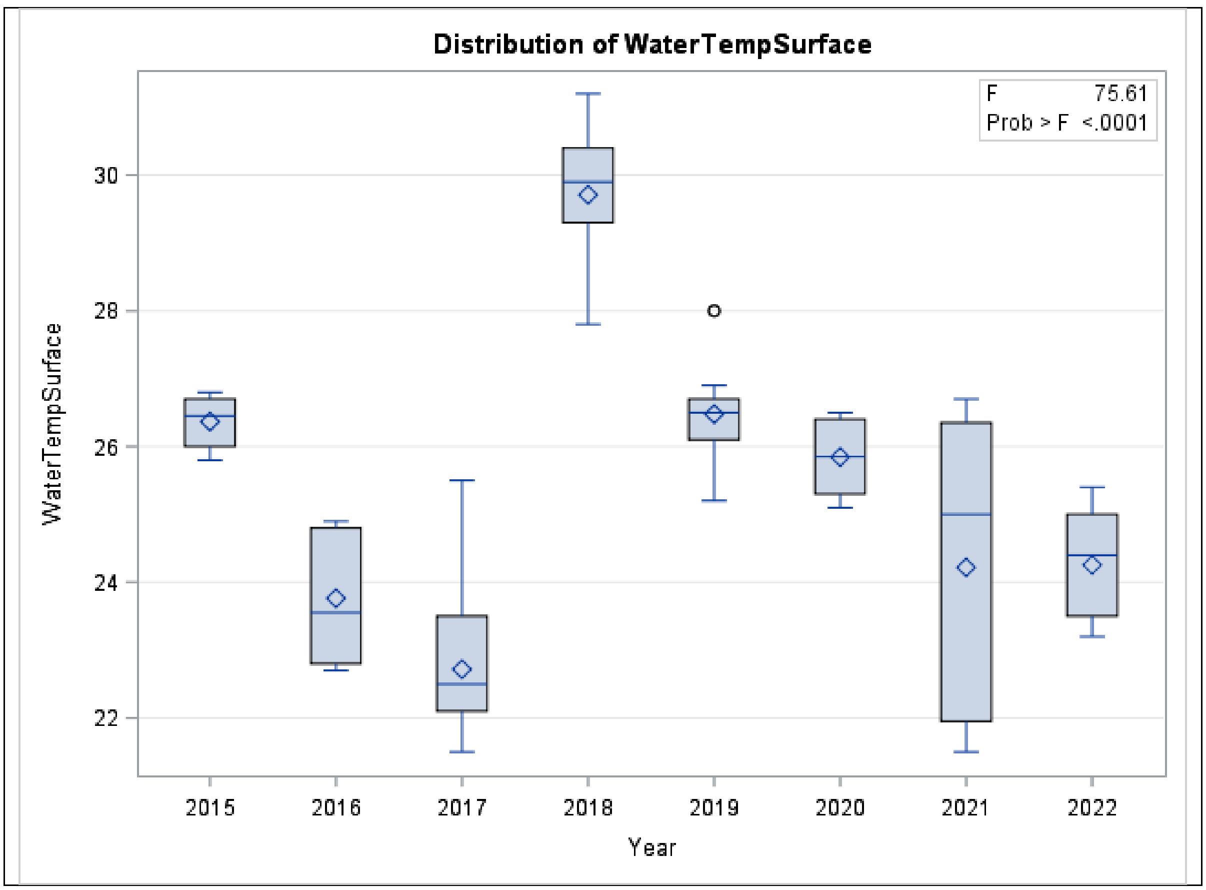

Figure 2.3. Distribution of surface water temperature from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022).

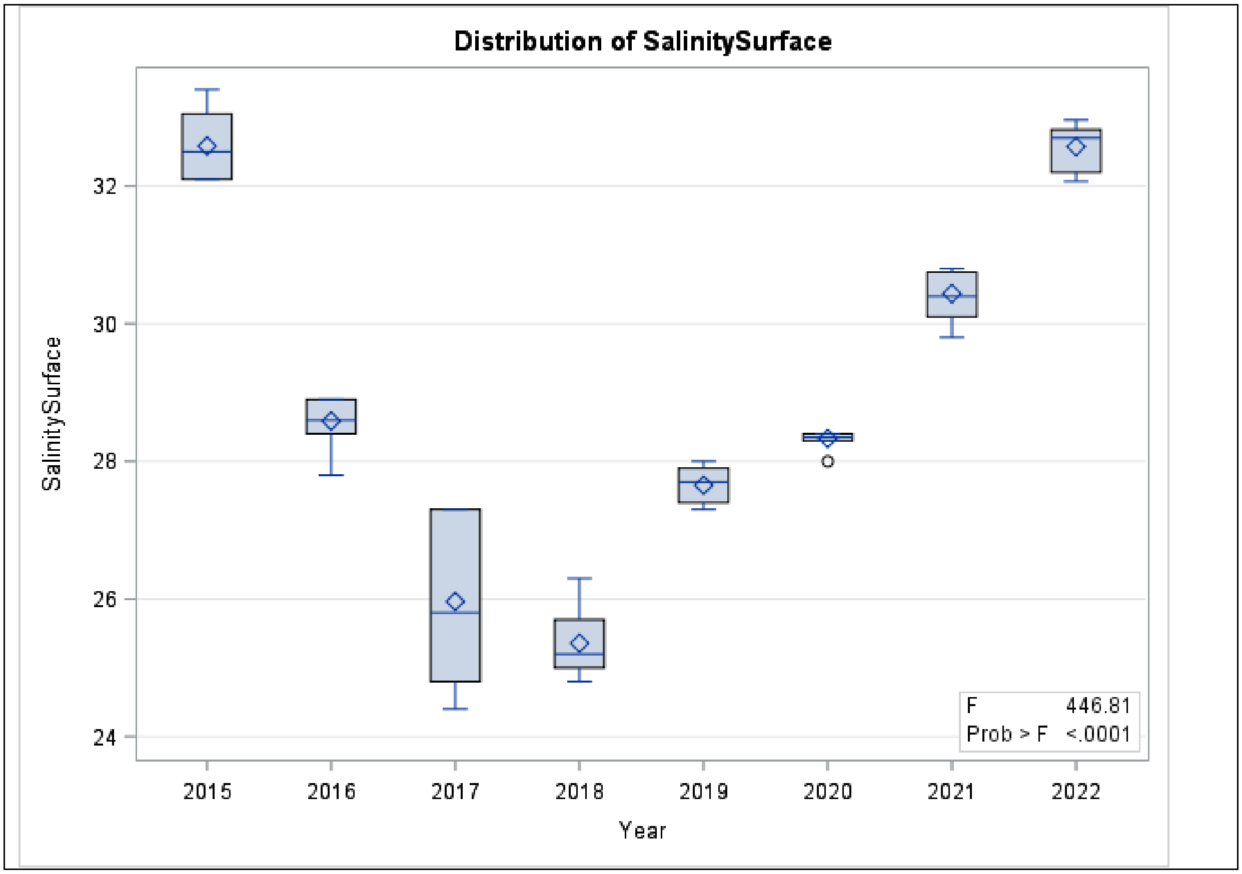

Figure 2.4. Distribution of surface salinity from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022).

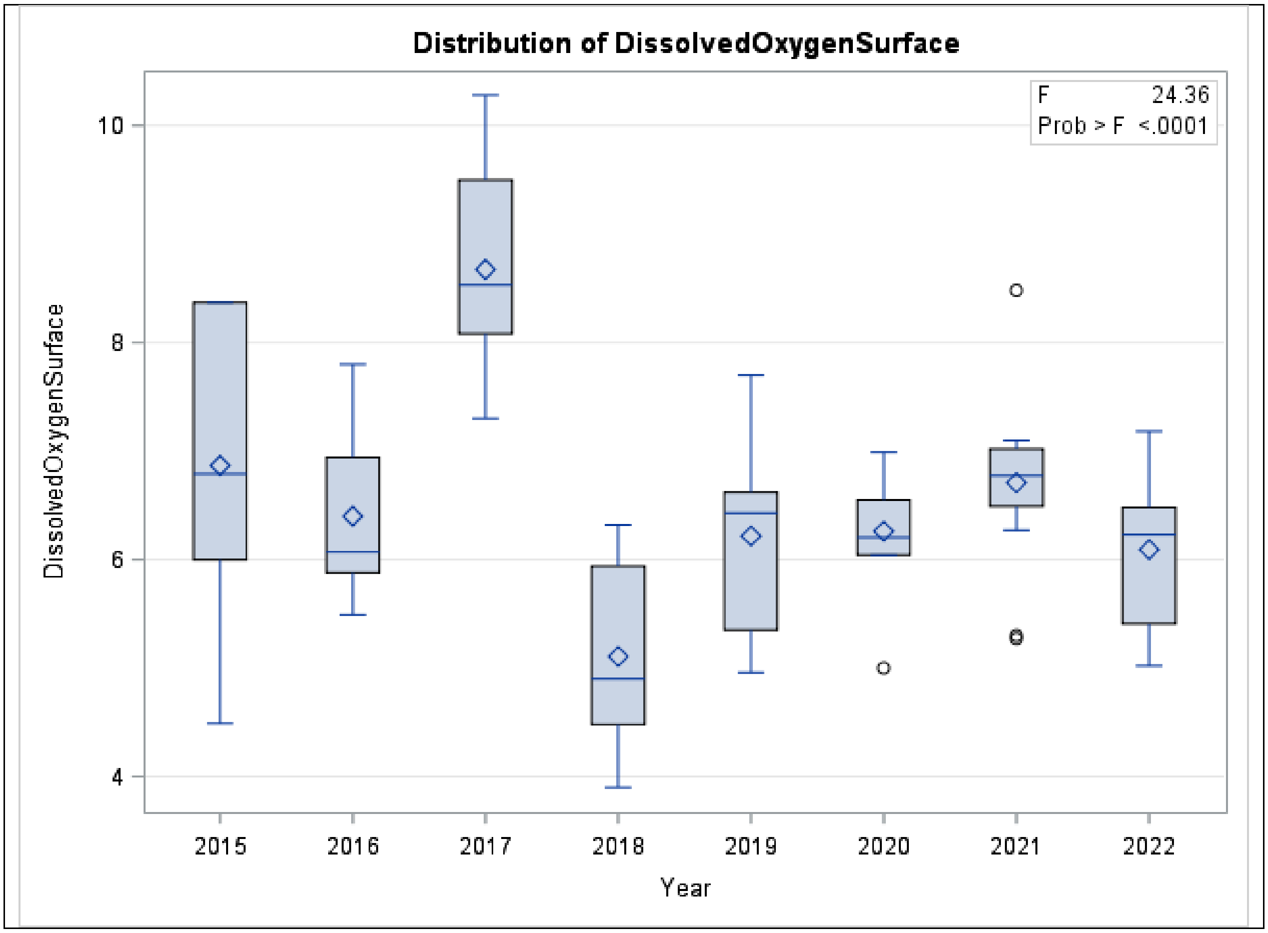

Figure 2.5. Distribution of surface dissolved Oxygen from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022).

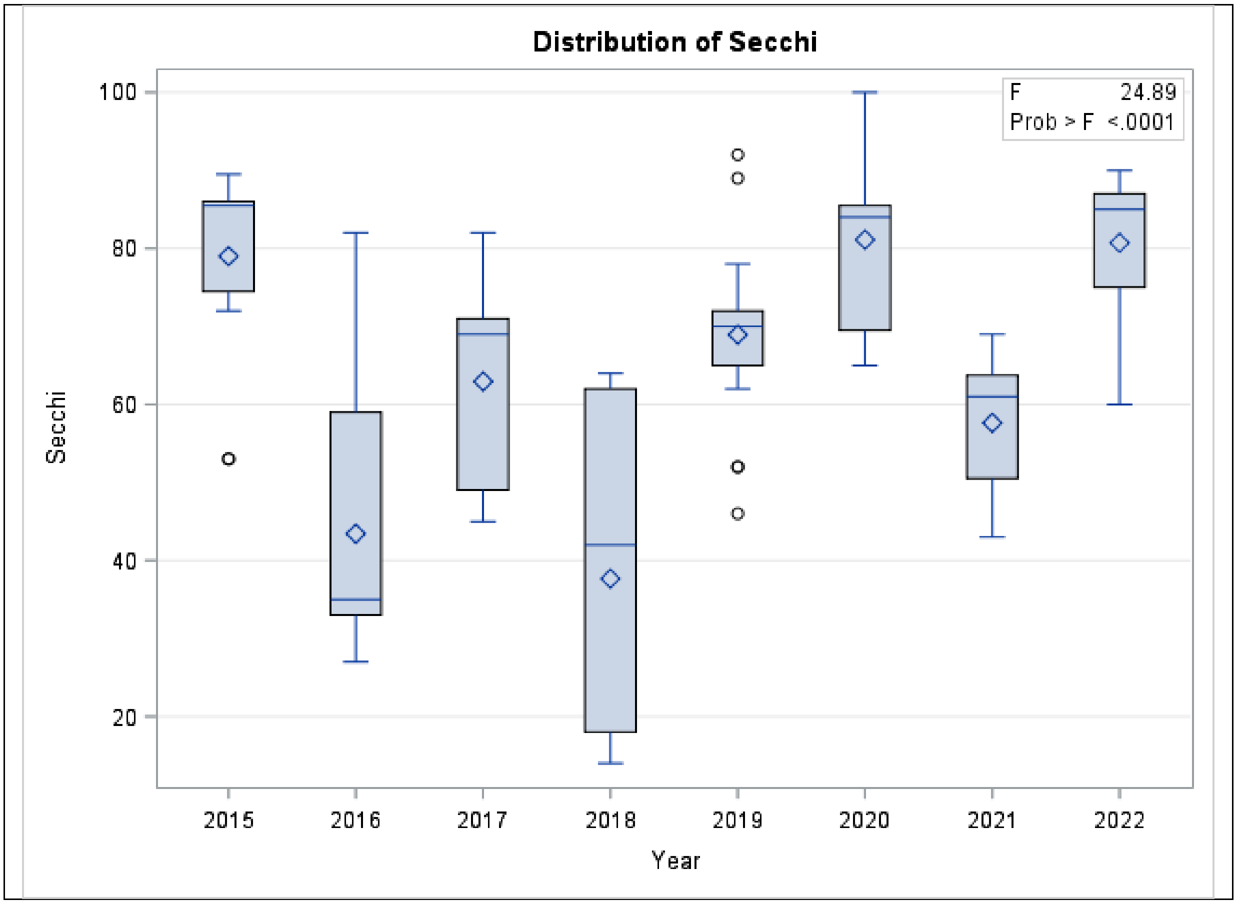

Figure 2.6. Distribution of turbidity from the Submerged Aquatic Vegetation Habitat Survey (2015 - 2022).

Chapter 3 Fisheries Dependent Tautog (*Tautoga onitis*) Data Collection (2016 - 2022)

Tautog biological collections in 2022 targeted recreational caught fish that were legal size fish (406 mm /16 in). The length, sex, and opercula were collected from 211 tautog from April to December. Most were racks obtained from the Ocean City charter fleet (94%) but a small percentage were obtained from commercial harvest (1.4%), and by spearfishing (4.6%). Those samples represented the range of fish lengths commonly caught in the recreational fishery in Maryland. Age data was determined on 210 tautog and were combined with the historical state data. Those will be submitted to the ASMFC Tautog Stock Assessment Subcommittee for the Delmarva Regional Age Length Key.

The 2022 sample total lengths ranged from 390 mm to 715 mm, mean length was 478 mm, and median length was 465 mm for both sexes combined. Female fish comprised 61.4% (n = 129) and were smaller (414 mm) than the male fish (485 mm; 38.6%; n = 81). The 431.8 mm/17 in length bin had the highest proportion of catch (20.5%; Table 3.1). Fish age ranged from three to 20 years, mean age was eight years, and the median age was seven years. Age-seven tautog comprised 21% of the samples and was the largest age bin (Table 3.2). The 2022 mean and median age was eight years for females and seven years for males. The age range for recruit size tautog (406 mm/16 in) in 2022 ranged from 5 to 8 years old.

The combined sex age frequency results from 2016 - 2022 (n = 1,477) included both legal and sublegal fish. These results indicated that five-year old tautog were most frequently caught by recreational anglers over that time series (Figure 3.1). The von Bertalanffy growth curve was fitted to the 2016 - 2022 length-age data (n = 1,477) using three parameter estimates (m = 3): asymptotic length in centimeters (Linf ∞), growth rate (K), and age at zero size (t0). The growth curve estimate results were like the previous parameters in the stock assessment (Linf, 70.85; k, 0.11 and t0, -2.07; Figure 3.2).

Overall, the Maryland recreational tautog fishery was performing well, with a broad range of year classes. The charter fleet has moved towards promoting catch and release of large fish, especially females.

Table 3.1. Tautog proportion at length of samples collected from Ocean City, Maryland (2022; n = 210). Red cells indicate undersized fish (> 406.4 mm/16 in).

Length (mm)	381	406.4	431.8	457.2	482.6	508	533.4	558.8	584.2	609.6	635	Over	787.4
Length (in)	15	16	17	18	19	20	21	22	23	24	25		31
Percent	0.5	16.7	20.5	13.3	17.6	7.6	11.9	5.7	1.9	0.5	1.4		2.4

Table 3.2. Tautog proportion at age of samples collected from Ocean City, Maryland (2022; n = 210).

Age	3	4	5	6	7	8	9	10	11	12	13	14	15	*Over*	20
Percent	1.0	2.4	12.4	13.3	21.0	18.6	9.5	9.5	2.9	1.9	1.9	2.9	1.0		2.0

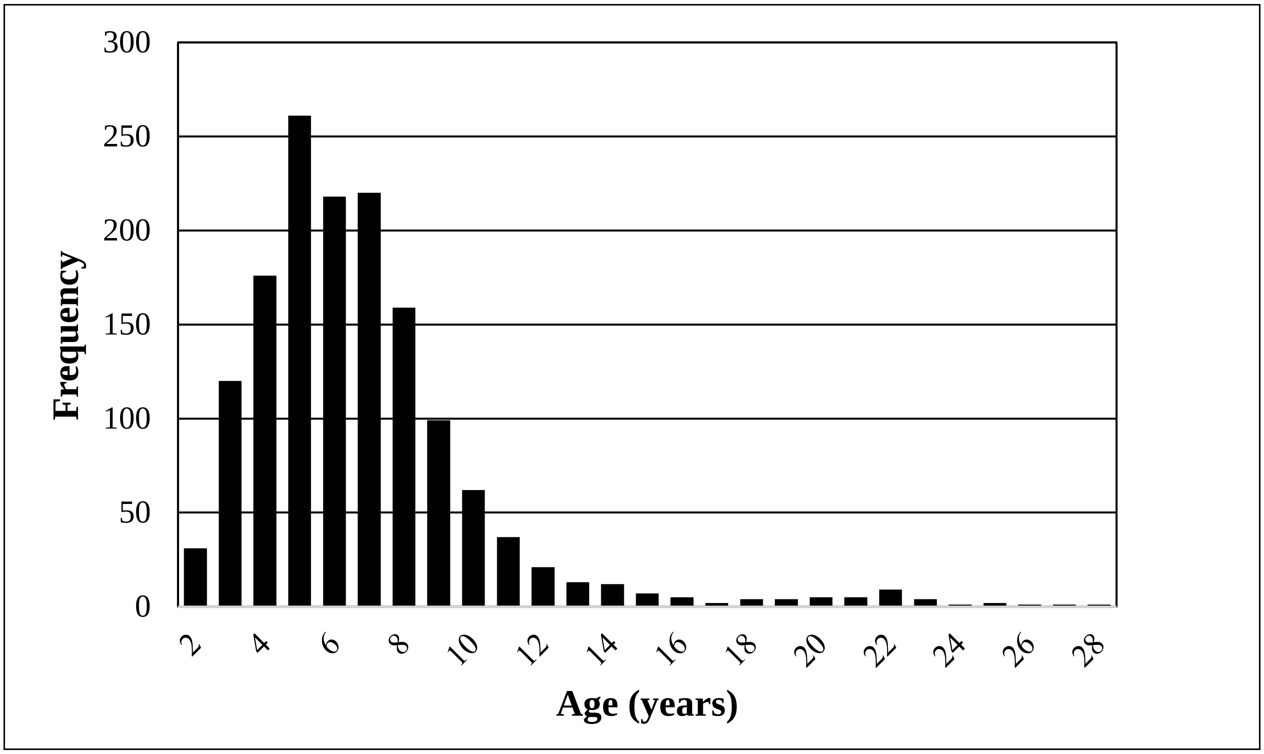

Figure 3.1. Tautog age frequency representing fish commonly caught in the recreational fishery in Ocean City, Maryland, (2016 - 2022; n = 1,477).

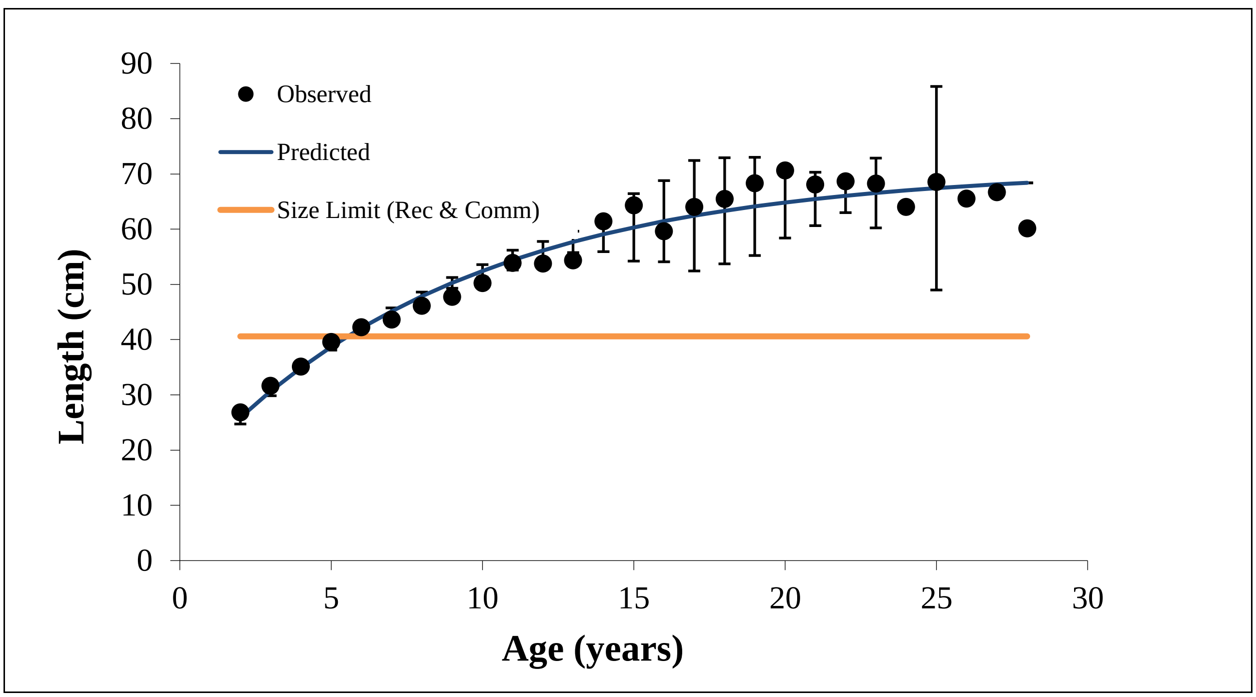

Figure 3.2. Tautog length-at-age and von Bertalanffy growth curve results with 95% confidence intervals, Ocean City, Maryland (2016 - 2022; n = 1,477).

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 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 for July 1, 2022 – June 30, 2023.

Data Requested	Committee Participation F-50 Support	Data included in the ASMFC Compliance Report	ASMFC Compliance Report F-50 Support	Data Provided During 2022/2023 Assessment/Update	Data Provided to Researchers
Atlantic croaker		Trawl		Trawl	
Atlantic menhaden		Trawl/Beach Seine		Trawl	
Black drum		Beach Seine		Beach Seine	
Black sea bass	ASMFC/MAFMC	Trawl/Beach Seine	Yes	Trawl	Trawl/Beach Seine
Bluefish		Beach Seine		Trawl/Beach Seine	
Coastal sharks	ASMFC		Yes		
Cobia		Beach Seine			
Cownose ray					Trawl/Beach Seine
Gray triggerfish					Trawl/Beach Seine
Pinfish					Trawl/Beach Seine
Horseshoe Crab		Trawl		Trawl	
Multispecies					Trawl/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	Trawl	
Tautog	ASMFC	Trawl/Beach Seine/SAV Habitat Survey/Dependent Collection	Yes	Trawl/Beach Seine/SAV Habitat Survey/Dependent Collection	
Weakfish		Trawl			
Water Quality					Trawl
Other Technical Committee Expertise					
ASMFC, Northeast Area Monitoring and Assessment Program					
DNR, Chesapeake and Coastal Services, Climate Fellowship					
National Estuary Program, Maryland Coastal Bays Program Science and Technical Advisory Committee					
National Oceanic and Atmospheric Administration Highly Migratory Species Advisory Panel					

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