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Final Report

A Cooperative High Precision Dredge Survey to Assess the Mid-Atlantic Sea Scallop Resource Area in 2021 and 2022

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VIRGINIA INSTITUTE OF MARINE SCIENCE
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Project Summary

For the sea scallop, *Placopecten magellanicus*, current and accurate information related to the abundance and distribution of adult and juvenile scallops is essential for effective management of the resource. Scallop management is a combination of input and output controls, with a focus on spatial area management. The continued prosperity of the scallop resource and fishery is dependent on both periodic and large incoming year classes, as well as a mechanism to delineate the scale of a recruitment event and subsequently monitor the growth and abundance of these scallops over time.

Acknowledging the importance of accurate, timely, and meaningful information necessary to meet the management objectives and support the fishery, the Virginia Institute of Marine Science (VIMS) conducted a synoptic high resolution stratified random survey of the Mid-Atlantic Bight (MAB) scallop resource from the VA/NC border to Block Island, RI encompassing the Mid-Atlantic Access Areas, as well as the open areas of the MAB resource area during the spring/summer of 2021 and 2022. The primary objective of these surveys was to assess the abundance and distribution of sea scallops in this area, culminating with spatially explicit annual estimates of total and exploitable biomass by Scallop Area Management Simulator (SAMS) Area. Secondary project objectives for each survey year included: 1. Finfish bycatch species composition and catch rates, 2. Scallop biological sampling (length:weight relationship, disease, product quality parameters, and shell samples for ageing), and 3. Sea scallop dredge performance (commercial and survey dredges).

Survey results were presented to the Sea Scallop Plan Development Team (PDT) to inform management decisions for fishing years (FY) 2021 and 2022 (i.e., access area access and catch allocation). Survey data were also provided to the Northeast Fisheries Science Center (NEFSC) in 2021 and 2022 for use in projections for the annual specification process for FY 2021 and 2022 and for use in upcoming stock assessments. Results indicated that the exploitable biomass in the traditional access areas and open area off of Long Island remained high in both years, although recruitment was limited. Analysis of relative gear performance for the Coonamessett Farm Turtle Deflector Dredge (TDD) suggested that this dredge is more efficient than the New Bedford style dredge.

Project Background

The sea scallop, *Placopecten magellanicus*, supports a fishery that landed over 29 million pounds of meats with an ex-vessel value in excess of US $442 million in 2022 (NOAA, 2023). These landings resulted in the sea scallop fishery being one of the most valuable wild caught fisheries along the U.S East Coast. While historically subject to extreme cycles of productivity, the fishery has benefited from management measures intended to bring stability and sustainability. These measures include: limited entry, total effort (days-at-sea), gear and crew restrictions, and a strategy to improve yield by protecting scallops through rotational area management.

Amendment #10 to the Sea Scallop Fishery Management Plan officially introduced the concept of area rotation to the fishery. This strategy seeks to increase the yield and reproductive potential of the sea scallop resource by identifying and protecting discrete areas of high densities of juvenile scallops from fishing mortality. By delaying capture, the rapid growth rate of scallops is exploited to realize substantial gains in yield over short time periods. In recent years, spatial management of the scallop resource has become more adaptive and conducted at finer spatial scales to provide protection for observed recruitment events to meet management and fishery objectives. Examples of this adaptive management in the MAB include the division of the traditional Elephant Trunk Access Area into two discrete areas, as well as reverting the more southern Virginia Beach and Delmarva Access Areas to open area.

In order to effectively manage the fishery and carry out a robust rotational area management strategy, current and detailed information regarding the abundance and distribution of sea scallops in the MAB resource area is essential. This information forms the basis for assessment of the species and specifications for the next fishing year, as well as the potential establishment of additional closed areas. Amendment #10 specifies that an area is a candidate to be closed when the annual growth potential in that area is greater than 30%. Additionally, when the annual growth rate is reduced to less than 15% the area is available for a controlled re-opening. Certain other criteria exist regarding the spatial requirements for a closed area, but growth rates which are determined by the age structure of the population within that area is a key component of that determination. The collection of abundance and age distribution information from discrete areas is a major component of this strategy, and the use of commercial vessels provides a flexible and efficient platform to collect the required information.

Cooperative dredge surveys have been successfully completed with the involvement of industry, academic, and governmental partners since 2000 through funding from the Sea Scallop Research Set-Aside Program (RSA). The additional information provided by these surveys has been vital in the determination of appropriate Total Allowable Catches (TAC) in the subsequent re-openings of closed areas, and determination of the number of open area days-at-sea (DAS). This type of survey, using commercial fishing vessels, provides an excellent opportunity to gather required information and also involve stakeholders in the management of the resource.

In addition to collecting data to assess the abundance and distribution of sea scallops in the areas surveyed, the operational characteristics of commercial scallop vessels allow for the simultaneous towing of two dredges. As in past surveys, two dredges were towed at each survey station. One dredge was a standard sea scallop survey dredge used by the National Marine Fisheries Service (NMFS) since the 1970s and modified in 2008 (NEFSC, 2015). The other dredge was a commercial dredge, which consisted of one of two general configurations commonly used in the fishery (New Bedford style (NBD) or Coonamessett Farm Turtle Deflector Dredge). This paired design, using one non- size selective gear (NMFS survey dredge) and one size selective commercial gear, allowed for the estimation of the size selectivity characteristics of the commercial dredge. While gear performance (i.e., size selectivity and relative efficiency) information for both commercial dredges have been documented (Yochum and DuPaul, 2008; NEFSC 2018; Roman and Rudders, 2019), continuing to evaluate the performance of the gear will allow for changes in selectivity and efficiency to be monitored and quantified. Understanding time varying changes for the commercial dredges is beneficial for two reasons. First, it could be an important consideration for the scallop stock assessment in that it provides the current size selectivity characteristics for the most recent and commonly used gear configuration. In addition, size selectivity analyses using the Selfisher method provide insight to the relative efficiency of the two gears used in the study (Brooks et al, 2022). The relative efficiency measure from this experiment can be used to refine existing absolute efficiency estimates for the commercial dredges.

An advantage of a sea scallop dredge survey is that one can access and sample the target species. This has a number of advantages including accurate measurement of animal length and the ability to collect biological specimens. One such attribute that is routinely measured is the shell height:meat weight relationship. While this relationship is used to determine swept area biomass for the area surveyed at that time, it can also be used to document seasonal shifts in the relationship due to environmental and biological factors. For this reason, data on the shell height:meat weight relationship is routinely gathered by both the NMFS and VIMS scallop surveys. While this relationship may not be a direct indicator of animal health in and of itself, long term data sets may be useful in evaluating changing environmental conditions, food availability, and density dependent interactions.

For this study, we pursued multiple objectives. The primary objective was to collect information to characterize the abundance and distribution of sea scallops within the MAB resource area, ultimately culminating in estimates of scallop biomass that were used as the basis for subsequent fishery management actions. Utilizing the same catch data with a different analytical approach, we estimated both the size selectivity characteristics and relative efficiency of the commercial sea scallop dredge. A third objective of this study resulted in the collection of biological samples to estimate time and area specific shell height:meat weight relationships, assess product quality and to monitor spatio-temporal patterns in scallop diseases/parasites. Sea scallop shells were also collected to supplement the NMFS shell collection for ageing.

Methods

Survey Area and Sampling Design

Sampling stations for the surveys were selected using a stratified random sampling design, with strata based on those used by NMFS since the 1970 for sea scallops, surf clams (*Spisula solidissima*) and ocean quahogs (*Arctica islandica*). Station locations were determined using a hybrid approach consisting of both proportional and optimal allocation techniques based on stratum area, the biomass (weight) of scallops, and number of animals observed during the VIMS 2019 and 2020 surveys of the same area. To assure all strata were sampled, a minimum of two stations were allocated to each stratum to allow for the calculation of mean catch and variance. A fraction of the total pool of samples is allocated proportionally based on stratum area with the remaining samples allocated using the Neyman approach that allocates samples based upon the biomass and number of animals observed in the prior year's survey. In both years a total of 450 stations were allocated in the survey domain.

Sampling Protocols

While at sea, the vessels simultaneously towed two dredges. A NMFS sea scallop survey dredge, 8 ft. in width equipped with 2-inch rings, 3.5-inch diamond mesh twine top, and a 1.5-inch diamond mesh liner was towed on one side of the vessel. On the other side of the vessel, a 14 ft. TDD, equipped with 4-inch rings, a 10-inch diamond mesh twine top, and no liner was utilized. In this paired design, it is assumed that the dredges cover a similar area of substrate and sample from the same population of scallops.

For each survey tow, the dredges were fished for 15 minutes with a towing speed of approximately 3.8-4.0 kts. High-resolution navigational logging equipment was used to accurately determine and record vessel position. A Star-Oddi™ sensor that records dredge angle, depth and temperature was secured to the survey dredge in both years (Figure 1). In 2021, a DST sensor was used, and in 2022 a Starmon tilt sensor was used. Dredge angle data from the StarOddi sensors were used to estimate the start and end of each tow by evaluating the angle of attack. Synchronous time stamps on both the navigational log and StarOddi sensors were used to estimate the linear distance for each tow and ultimately provide a representative characterization of area swept by the dredges.

Sampling of the catch was conducted in the same manner described by DuPaul and Kirkley (1995), which has been utilized during all of our scallop surveys since 2005. For each station, the entire scallop catch from both the survey and commercial dredges was kept separate and placed in traditional scallop baskets to quantify total catch. Total scallop catch or a subsample, depending upon the volume of the catch, was measured to the nearest mm to determine size frequency. This protocol allows for the determination of the size frequency of the entire catch by expanding the catch at each shell height by the fraction of total number of baskets sampled. This calculation results in an estimate of the total number and size of the scallops caught for each dredge at each station. These catch data were also used to calculate biomass for both dredges and to estimate the commercial gear selectivity.

Finfish and invertebrate bycatch were also quantified at each station for each gear, with commercially important finfish and barndoor skates being sorted by species and measured to the nearest mm (total length (TL)). All other skate species (consisting predominantly of little (*Leucoraja erinacea*) and winter skates (*Leucoraja ocellata*)) were grouped into an unclassified category and enumerated. A systematic sampling approach was used to sample sea scallop predators. At every fifth station predators were enumerated and weighed. These predators, which included mainly crabs and starfish, were identified to the genus or species level and enumerated. Depending on catch volume, either a full bushel basket or subsample was taken to sample predators.

Samples from sea scallops were taken to determine area specific shell height:meat weight relationships, as well as monitor animal health and product quality. At every station with scallop catch, up to 15 animals encompassing the size distribution observed at the station were selected for sampling. First, shell height was measured to the nearest mm. Each scallop was then carefully shucked and the adductor muscle and gonad were separated from the remaining soft tissue. Both the adductor muscle and gonad were individually weighed at sea with a Marel™ M2200 motion compensating scale to the nearest 0.01 gram. In addition to shell height and meat weight data collected, biological characteristics and product quality information were collected. Biological data included sex and reproductive stage. Sex was identified based on gonad color as either female (red gonad) or male (white gonad). An additional unknown category is used for immature scallops, where sex cannot be determined, or for hermaphrodite scallops, where the gonad is white and red. Seven reproductive stages were assessed by visual examination of the gonad. The stages include immature, resting, rebuilding, mature, spawning, spent, and unknown. Product quality was evaluated through visual inspection of each adductor muscle and shell using a semi-qualitative ordinal coding scheme for each characteristic assessed. Characteristics evaluated included overall market condition, color, texture, and the presence of blister disease. The presence/absence and number of nematode (*Sulcascaris sulcata*) lesions observed on each adductor muscle was also quantified through gross observation.

Up to 15 scallop shells were collected at every fifth station from samples selected for shell height:meat weight assessment for ageing purposes. Shells were selected if there was no shell damage (i.e., broken shell, damaged margin of shell or deformed). Shells were aged using the external ring method described in Hart and Chute (2009), as well as a novel method involving the resilium, which is being developed at VIMS by Dr. Roger Mann's lab (Mann and Rudders, 2019). A subset of shells was added to the archived collection housed at VIMS.

Station level catch and location information were entered into FEED (Fisheries Environment for Electronic Data), a data acquisition program developed by Chris Bonzek at VIMS. Time-stamped location data from the bridge were entered into FEED using an integrated GPS input. Station level data included location, time, tow-time (brake-set/brake-release), tow speed, water depth, weather, and comments relative to the quality of the tow. FEED was also used to record detailed catch information at the station level for scallops, finfish, and predator sampling. Catch by species was entered into FEED as either the number of baskets caught and measured (scallops) or number of animals (finfish, skates, etc.) caught. Length measurements were recorded using the Ichthystick measuring board input to the FEED program that allows for automatic recording of length measurements. Shell height:meat weight and product quality data were also recorded using FEED. The Marel scale was connected to FEED to allow for automatic recording of adductor muscle and gonad weight data.

Data Analysis

Absolute swept area biomass within the area surveyed was estimated by Scallop Area Management Simulator (SAMS) Area (Figure 2). The methodology to estimate biomass is similar to that used in previous survey work by VIMS. In essence, we estimate a stratified mean catch weight of either all scallops or the fraction available to the commercial gear (exploitable) from the point estimates and scale that value up to the entire area of the domain sampled following methods from Cochran (1977) for calculating a stratified random size of a population. These calculations are given as:

Stratified mean biomass per tow in stratum and subarea of interest:

$$\bar{C}_h = \frac{1}{n_h}\sum_{i=1}^{h} C_{i,h} \qquad (1)$$

Variance Equation 1

$$Var(\bar{C}_h) = \frac{1}{n_h(n_h-1)}\sum_{i=1}^{n_h}(C_{i,h}-\bar{C}_h)^2$$

Stratified mean biomass per tow in subarea of interest:

$$\bar{C}_s = \sum_{h=1}^{L} W_h \cdot \bar{C}_h \qquad (2)$$

Variance Equation 2

$$Var(\bar{C_s}) = \sum_{h=1}^{L} W_h^2 \cdot Var(\bar{C}_h)$$

Total biomass in subarea of interest:

$$\widehat{B_s} = \left(\frac{\left(\frac{\bar{C}_s}{\bar{a}_s}\right)}{E_s}\right) A_s \qquad (3)$$

Variance Equation 3

$$Var\left(\widehat{B_s}\right) = Var(\bar{C_s}) \cdot \left(\frac{A_s}{\bar{a}_s}\right)^2$$

where:

L = # of strata
n = # of stations in stratum h
h = stratum
i = station i in stratum h
s = subarea s in survey of interest
A_s = area of survey of interest in subarea s
E_s = gear efficiency estimate for subarea s
$\bar{a}_s$ = mean area swept per tow in subarea s
$\hat{B}_s$ = total biomass in subarea s
$\bar{C}_s$ = stratified mean biomass caught per tow for subarea s
$\bar{C}_{h,s}$ = mean biomass caught per tow in stratum h for subarea s
W_h = proportion of survey/subarea area in stratum h

Stratified mean catch weight per tow of exploitable scallops was calculated from the raw catch data as an expanded size frequency distribution with a SARC 65 or SAMS Area appropriate shell height:meat weight relationship applied (NEFSC, 2018). Shell height:meat weight relationships used to convert the number of scallops to weight were determined by the Scallop PDT. In both 2021 and 2022, SARC 65 shell height:meat weight relationships were used for all SAMS Areas (NEFSC, 2018). Exploitable biomass, defined as the fraction of the population vulnerable to capture by the currently regulated commercial gear, was calculated using two approaches. The observed catch at length data from the survey dredge (assumed to be non-size selective) was adjusted based upon the size selectivity characteristics of the commercial gear (Roman and Rudders, 2019). The observed catch at length data from the commercial dredge was not adjusted due to the fact that these data already represent the fraction of the population that is subject to exploitation by the currently regulated commercial gear.

Utilizing the information obtained from the high resolution GPS, an estimate of area swept per tow was calculated. Throughout the cruise, the location of the ship was logged every second. By determining the start and end of each tow based on the recorded times as delineated by the StarOddi sensor data, a survey tow can be represented by a series of consecutive coordinates (latitude, longitude). The linear distance of the tow is calculated by:

$$TowDist = \sum_{i=1}^{n} \sqrt{(long_2 - long_1)^2 + (lat_2 - lat_1)^2}$$

The linear distance of the tow is multiplied by the width of the gear (14 ft. for the commercial dredge and 8 ft. for the survey dredge.) for an estimate of the area swept during a given survey tow.

The final two components of the estimation of biomass are constants and not determined from experimental data obtained during the cruises. The Miller et al. (2019) and SARC 65 (NEFSC, 2018) efficiency (q) estimates for the NMFS survey dredge (40%) and the commercial dredge (65%) were used to scale relative biomass to absolute biomass. To scale the estimated stratified mean scallop catch to the full domain, the total area of each resource subunit within the survey domain was calculated in ArcGIS v. 10.1. Biomass estimates were calculated for the SAMS Areas for the entire survey domain, including area outside of the SAMS Areas that were surveyed (Figure 2). Area surveyed outside the pre-determined SAMS Areas were included with the adjacent SAMS Areas within the survey domain. SAMS Areas were consistent between years.

Shell Height:Meat Weight

The relationship between shell height and meat weight was estimated using a generalized linear mixed effects model (gamma distribution, log link, and a random effect of station) using the glmer function in the lme4 package in R v. 4.1 (Bates et al., 2015; R Core Team, 2021). The relationship was estimated with the following general model:

$$\mu = X'\beta + Z\gamma + \varepsilon$$

where μ is the predicted weight (grams), X' is a design matrix of covariates, β is a vector of coefficients, Z is a design matrix of random effects, γ is a vector of random effect parameters and ε is the error term.

Models were developed with forward selection and variables were retained in the model if the Akaike Information Criterion (AIC) was reduced by three or more units. Variables were added to the model based on individual model AIC values. SAMS Area was included in all models to allow for the estimation of a SAMS Area effect. The model with the lowest AIC was selected as the preferred model and used to predict shell height:meat weight relationships by SAMS Area. If models had AIC values within three units of each other, a likelihood ratio test was used to test for a significant difference between models. If there was no significant difference between the candidate models, the more parsimonious model was selected as the preferred model. Variables considered were: ln shell height, ln depth (average depth of a tow), SAMS Area (retained in all models), latitude (beginning latitude of a tow), and an interaction term of shell height and depth. Models with maturity stage were developed following similar model development as described above. If maturity stage was in the preferred model, a Tukey's honest significance test (HSD) was used to conduct *post hoc* pairwise comparisons to test for significant differences between maturity stage factor levels (Miller, 1981). The glht function in the multcomp R package was used to carry out the post-hoc tests (Hothorn et al., 2008). Statistical significance (α) was equal to 0.05 for all analyses. Models with and without maturity stage were also compared by examining parameter estimates and predicted shell height:meat weight relationships.

Size Selectivity

Size selectivity for the commercial dredge was estimated based on a comparative analysis of the catches from the two dredges used in the survey. For this analysis, the NMFS survey dredge is assumed to be non-selective (i.e., a scallop that enters the dredge is retained by the dredge). Catch at length from the selective gear (commercial dredge) was compared to the non-selective gear via the Selfisher method (Brooks et al., 2022). With this analytical approach, the selective properties (i.e., the length based probability of retention) of the commercial dredge were estimated. In addition to estimates of the length based probabilities of capture by the commercial dredge, this method characterizes a measure of relative fishing intensity. This type of model accounts for overdispersion, often observed in these types of experiments, by allowing for a random effect of the tow pair and allowing for bootstrapping of parameter estimate for the preferred model. These models can also account for differences in subsampling rates between gears and tows (referred to as the qratio) and tow distance between tow pairs through the addition of an offset term in the model that can occur during field trials. The models can be fit with either polynomial or spline methods for the length term. Assuming a known quantity of efficiency for one of the two gears (in this case the survey dredge at 40%), insight into the efficiency of the other gear (commercial dredge) can be obtained.

Prior to analysis, all comparative tows were evaluated. Any tows that were deemed to have had problems during deployment or at any point during the tow (flipped, hangs, crossed towing wires, etc.) were removed from the analysis. In addition, tows where zero scallops or less than 20 scallops were captured by both dredges were also removed (Yochum and DuPaul, 2008; Roman and Rudders, 2019). The remaining tow pairs were then used to analyze the size selective properties of the commercial dredge. Individual cruises were analyzed separately, subsequently tows were aggregated across the entire resource area. Length data were binned into five mm length bins.

Model selection followed methods described by Brooks et al. (2022). The response variable was a proportion, the number of scallops caught at length in the experimental dredge divided by the total number of scallops caught at length in both dredges. Length was modelled as either a polynomial term to the third order or a spline with three degrees of freedom to determine the best fit to the data. The split parameter (*p*) was also modelled as either fixed or estimated for each length term model. The model with the lowest Bayesian information criterion (BIC) value was selected as the preferred model. Confidence intervals for the preferred model were estimated with bootstrapping, after removing the random effect of tow, to evaluate population level estimates (replications n = 1,000). An offset term for differences in tow duration (log tow duration for each tow pair) was included in models, as well as a qratio (sampling $ratio_{expermiental}$ gear/sampling $ratio_{control}$ gear for each tow pair) for each species or group. The logit link was the selected link function. All analyses were completed in R (R Core Team, 2021). The preferred models were used to estimate selectivity parameters: L_{25}, L_{50}, L_{75}, SR (selection range), and the split parameter as well as the predicted selectivity curves. This approach was completed at the trip level and then all trips were combined for a pooled analysis across trips and years.

Meat Quality and Shell Blisters

During the survey, shell blister and meat quality observations were made for all scallops sampled at shell height:meat weight stations. Adductor meats were assessed for quality issues pertaining to color, texture, and overall marketability. The presence and severity of shell blisters were scored as well. All assessments were done using a semi-qualitative scoring index (Table 1).

Nematode Monitoring

All scallops sampled at shell height:meat weight stations were also visually examined for the presence and incidence of the parasitic nematode. Gross observation was used to identify scallop meats that were infected with the parasite and the number of parasites was enumerated (incidence) by counting the number of rust colored lesions present on the adductor muscle.

Data on nematode distribution and prevalence from the VIMS 2015-2022 surveys of the MAB resource area were mapped to understand the spatial extent of infections and data were also compared across survey years to assess shifts in the spatial distribution of infected scallops. Analyses for the comparison between years included mapping the distribution and intensity of nematode infected scallops throughout the survey domain by year, as well as by size class. Spatial distribution maps were created using the inverse distance weighting method.

Results

Survey Characteristics

The MAB resource area was surveyed in May of 2021 and May-June of 2022. The first survey leg was conducted onboard the F/V *Carolina Boy* (CruiseID 202101) from 5/7/2021-5/16/2021 out of Seaford, VA and 223 stations were occupied. The F/V *Carolina Capes II* (CruiseID 202102) completed the second leg from 5/27/2021-6/7/2021 and surveyed 227 stations. For 2022, The F/V *Carolina Capes II* (CruiseID 202201) completed the first survey leg from 5/12/2022-5/22/2022 and the F/V *Italian Princess* (CruiseID 202202) completed the second leg from 6/1/2022-6/11/2022. All proposed 450 stations were occupied over the two legs (Figures 4-5). Boxplots depicting the estimated linear distances covered per tow by survey leg are shown in Figure 6. The mean tow length in 2021 for CruiseID 202101 was 1,696.64 m with a standard deviation of 141.71 m. The mean tow length in 2021 for CruiseID 202102 was 1,778.87 m with a standard deviation of 89.72 m. The mean tow length in 2022 for CruiseID 202201 was 1,862.45 m with a standard deviation of 40.71 m. The mean tow length in 2022 for CruiseID 202202 was 1,869.80 m with a standard deviation of 52.11 m.

Abundance and Distribution

Length frequency distributions for scallops captured by the survey dredge during the survey by SAMS area and year are shown in Figures 7-8. Maps depicting the spatial distribution of the catches partitioned into three size classes of scallops (<35 mm, 35-75 mm, and >75mm shell height) are shown in Figure 9-10. Total and exploitable biomass calculated using the SARC 65 area-specific shell height:meat weight coefficients and total number of animals by year, gear type, and SAMS area are shown in Tables 2-5 (total biomass and number of animals from the commercial dredge are not estimated due to the selective properties of the commercial gear).

Shell Height Meat Weight

Shell height:meat weight relationships were estimated by SAMS Area within the survey domain by year. In 2021, a total of 4,843 scallops from 376 stations were included in the analysis. The preferred model showed shell height, depth, and SAMS Area were significant predictors of meat weight (Table 6). The parameters estimated are shown in Table 7. The predicted shell height:meat weight relationships by SAMS Areas are shown in Figure 11.

In 2022, data collected from 4,813 scallops at 380 stations were used for predicting shell height:meat weight relationships. Predictors in the preferred model were an interaction term of shell height and depth, and SAMS Area (Table 8). The preferred model indicated the interaction term of shell height and depth along with SAMS Area had significant impacts on meat weight. The resulting parameters estimated for the preferred model in 2022 are shown in Table 9. The predicted shell height:meat weight relationships by SAMS Areas are shown in Figure 12. Overall, the shell height:meat weight relationships observed in 2021 and 2022 followed the latitudinal and depth gradients that have persisted for this resource area over time.

Bycatch

Catch per unit of effort for finfish bycatch for the survey is shown in Table 10. Length frequency distributions for finfish bycatch with sufficient sample sizes are shown in Figures 13 and 14 by gear and year.

Predator Sampling

The spatial distribution and number of animals counted by species or genus for 2021 and 2022 predator sampling stations are provided in Figures 15 and 16. The number of animals represents either the number enumerated in the subsample or the entire sample taken at a given station. Subsampled counts have not been expanded.

Size Selectivity

Summary information by cruise for the selectivity analysis is provided in Table 11 and include CruiseID, surveyed area, year, and sample sizes. For the MAB survey analysis, 530 stations and 34 five mm length bins were used. A total of 47 stations were removed because no scallops were caught and 320 stations were excluded because less than 20 scallops were caught in either dredge.

Models that estimated the split parameter were preferred over the fixed split parameter models for all analyses. A spline fit for the length term was also preferred over the polynomial length term for all models. Selectivity parameter estimates by cruise are shown in Table 12, and estimates for the combined MAB resource are in Table 13. Split parameter and L_{50} estimates with 95 percent confidence intervals are shown in Figure 18 for each survey. Predicted selectivity curves by survey and resource area are shown in Figure 17.

The analysis indicated the several parameter estimates were unrealistic compared to the observed data despite model convergence. For example, L_{50} estimates across all cruises was over 100 mm (Table 12). This issue with the L_{50} estimate is likely driving the significant differences observed between some of the Cruises, where 95 percent confidence intervals did not overlap (Figure 18). Cruises 202101 and 202202 have significantly different L_{50} estimates compared to Cruises 202102 and 202201. The pooled analysis L_{50} was also above 100 mm, with an estimate of 111.51 mm. Split parameter estimates from all cruises and the pooled estimate were comparable (Figure 18). All estimated split parameters (0.73 – 0.86) were similar or greater than reported in Yochum and DuPaul (2008) for the New Bedford Style dredge (0.77), suggesting that the TDD is can be efficient than the New Bedford Style dredge. The pooled *p* was estimated at 0.8. Several of the estimated split parameters were similar to the value of 0.83 reported in Roman and Rudders (2019). The SR values between cruises ranged from 11-18, and the pooled analysis SR was estimated at 17.

Meat Quality and Shell Blisters

A total of 9,656 scallops were sampled at shell height:meat weight stations over the two-year period. In 2021, a total of 4,843 scallops were sampled, with 2,199 scallops sampled on the first cruise and 2,644 sampled on the second cruise. In 2022, 2,278 were sampled on the first cruise and 2,535 were sampled on the second cruise, for a total of 4,813 scallops processed. Summary information on sex, market category, color, texture and blister disease stage are provided in Table 16. Table 1 provides the classifications for market category, color, texture and blister codes. The majority of scallops were classified as marketable with no texture or color deviations. Scallops with observed nematode lesions were assigned a lower overall market classification. Approximately 15 percent of scallops regardless of sex were observed to have some form of shell blister disease in 2021. This decreased to 11 percent in 2022.

Nematode Monitoring

All scallops assessed for meat quality and shell blisters were also assessed for nematode infections. In 2021, 17 percent of scallops were observed to be infected, dropping to 12 percent in 2022.This is a decrease compared to the previous two years, where the percentage of scallops infected ranged from 21 to 16 percent. The number of lesions observed in a scallop ranged from 1 to 12 lesions.

The spatial distribution of infected scallops from 2015 through 2022 showed some shifts in the distribution of scallops infected for both prevalence and intensity (Figures 19-20). Prevalence is defined as the number of scallops observed to be infected out of all scallops sampled. Intensity is defined as the number of lesions observed in infected scallops. In 2015, the majority of infected scallops were located in the Delmarva. In 2016, there was a northward shift into the Elephant Trunk and the infected scallops were observed at their largest extent. The range of infected scallops extended from the most southern portion of the resource area to the northern boundary of the Hudson Canyon (Figure 19). We observed a contraction in this range in 2017, with the locus of the observations in the northern portion of the Delmarva and Elephant Trunk. In 2018, the majority of infected scallops were again observed in the Delmarva. The least number of infected scallops was observed in 2019 and in 2020 there was an increase in the number of infected scallops, with a hotspot identified in the Elephant

Trunk. This hotspot has persisted into 2021 and 2022, generating some concern for the recruitment observed in this SAMS Area. Smaller size scallops have continued showing signs of infection, suggesting that these infection rates may persist even as larger scallops are removed from the population. The NYB closure area is also of some concern, as the percentage of infected scallops increased in 2022. Continued monitoring may provide important information for harvest strategy, as we track these areas across subsequent years.

The trend in the spatial distribution for intensity was similar to that for prevalence (Figure 20). However, overall intensity of infections in 2022 has decreased from previous years, even if prevalence remained consistent.

Scallop Shells

A total of 801 scallop shells were collected and aged in 2021. In 2022, 724 shells were collected and aged. A subset of shell samples were archived at VIMS. For the 2022 operational stock assessment, age data from 2016-2021 were provided to the NEFSC assessment scientists.

Outreach

As part of the outreach component of this project, a presentation detailing the annual results of each survey was compiled. These presentations were delivered to the Sea Scallop PDT at their virtual meeting in September 2021 and at their Falmouth, MA meeting in August 2022. At the same meetings, presentations were also given to the Sea Scallop PDT summarizing disease prevalence for nematode infected scallops and shell blister disease. As requested by the NEFMC staff, a short report summarizing survey results was also drafted for each year. These reports were submitted to the NEFMC for distribution to the Sea Scallop PDT, Scallop Advisory Panel, and Scallop Committee. An annual industry report was generated to summarize results from the VIMS 2021 and 2022 survey efforts and distributed to stakeholders. Industry reports can be downloaded from: https://www.vims.edu/research/units/centerspartners/map/comfish/scallop/publications/industryreports/index.php.

Graduate Student Involvement

Ms. Kaitlyn Clark, a Ph.D. candidate under Dr. Rudders, participated in both surveys.

Discussion

Surveys of important resource areas like the MAB resource area are an important endeavor. These surveys provide information about a critical component of the resource unit that includes rotational access areas and open area. Additionally, the timing of industry-based surveys can be tailored to give managers current information to guide important management decisions. This information can help time access to closed areas, set allowable catches for re-opening of access areas, and determine the number of allowable DAS for open area fishing. Finally, this type of survey is important in that it involves the stakeholders of the fishery in the management of the resource.

Our results suggest that significant biomass existed in the traditional access areas of MAB resource area in 2021 and 2022. Biomass in the open areas off of Long Island was high, though somewhat reduced in 2022, and will be able to support open DAS fishing in both years. The Elephant Trunk had a large recruitment event in 2022, while smaller recruitment events occurred in NYB in 2021. Nematode infected scallops in 2021 and 2022 were largely constrained to the ET, but the impact on the fishery in terms of limiting effort in the southern portion of the MAB may continue as a result of the persistent presence of nematode infected scallops. Biomass in the Delmarva and Virginia SAMS Areas continues to decline. The cause of the decline in biomass in this portion of the MAB should be investigated and is likely impacted by warming water temperature.

The use of commercial scallop vessels in a project of this magnitude presents some interesting challenges. One such challenge is the use of the commercial gear. This gear is not designed to be a survey gear; it is designed to be efficient in a commercial setting. The design of this current experiment, however, provides insight into the utility of using a commercial gear as a survey tool. One advantage of the use of this gear is that the catch from this dredge represents exploitable biomass and no further correction is needed. A disadvantage lies in the fact that there is very little ability of this gear to detect recruitment events. However, since this survey is designed to estimate exploitable biomass, this is not a critical issue.

The concurrent use of two different dredge configurations provides a means to not only test for agreement of results between the two gears, but also simultaneously conduct size selectivity experiments. In this instance, our experiment provided information regarding the TDD based on information collected in 2021 and 2022. Selectivity of the New Bedford style dredge was estimated by Yochum and DuPaul (2008) and for the TDD by Roman and Rudders (2019). Our results indicated the TDD continues to be slightly more efficient than the New Bedford style dredge. This information is useful for managers and assessment scientists to understand the selectivity and relative efficiency of this dredge type.

Biomass estimates are sensitive to other assumptions made about the biological characteristics of the resource; specifically, the use of appropriate shell height:meat weight parameters. Parameters generated from data collected during the course of the study were appropriate for the area and time sampled. There is, however, a large variation in this relationship as a result of many factors. Seasonal and inter-annual variation can result in some of the largest differences in shell height:meat weight values.

Traditionally, when the sea scallop undergoes its annual spawning cycle, metabolic energy is directed toward the production of gametes and the somatic tissue of the scallop is still recovering and is at some of their lowest levels relative to shell size (Smolowitz and Serchuk, 1989). While accurately representative for the month of the survey, biomass has the potential to be different relative to other times of the year. Area and time specific shell height:meat weight parameters are another topic that merits continued study.

Data generated from the surveys were used to support fishery management decisions for fishing years 2022 and 2023, as well as for the 2022 operational stock assessment. Other data collected from the surveys were submitted to the NEFSC for monkfish.

The project budget and project compensation are included as Appendix A.

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Figure 1. An example of the output from the Star-Oddi™ sensor. Arrows indicate the interpretation of the start and end of the dredge tow. The green trace line is the dredge angle reading at three second intervals.

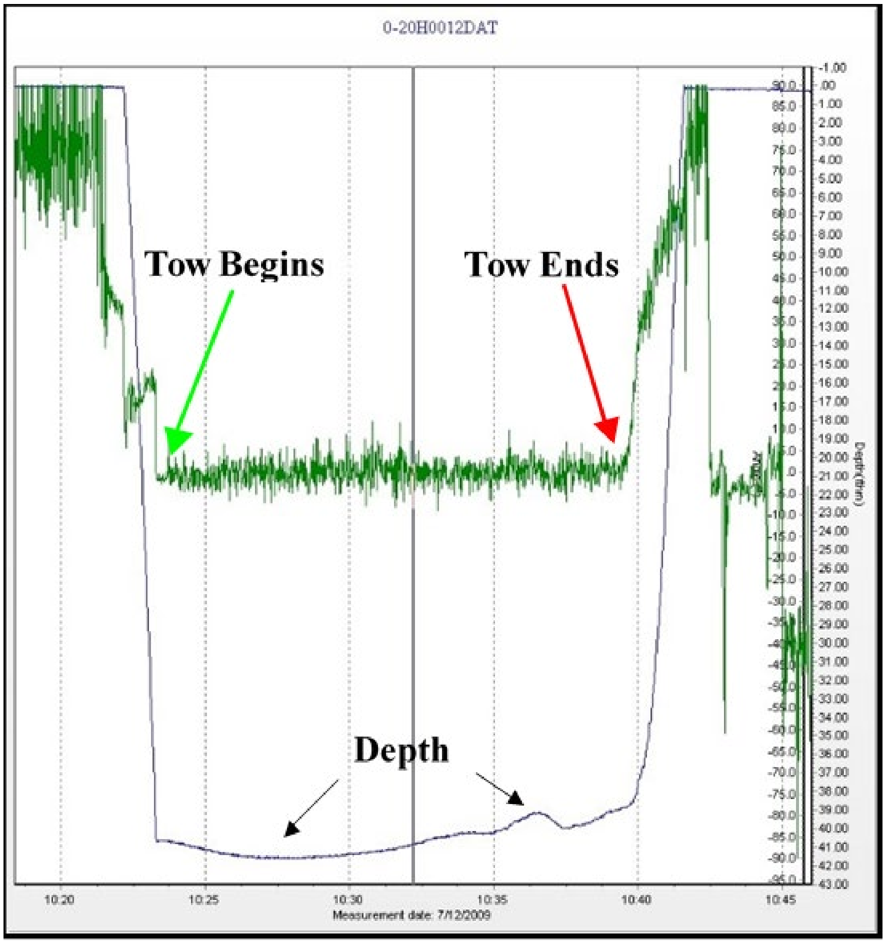


Figure 2. Map of the 2021 survey domain for the survey of the Mid-Atlantic Bight resource area with the SAMS Area designations.

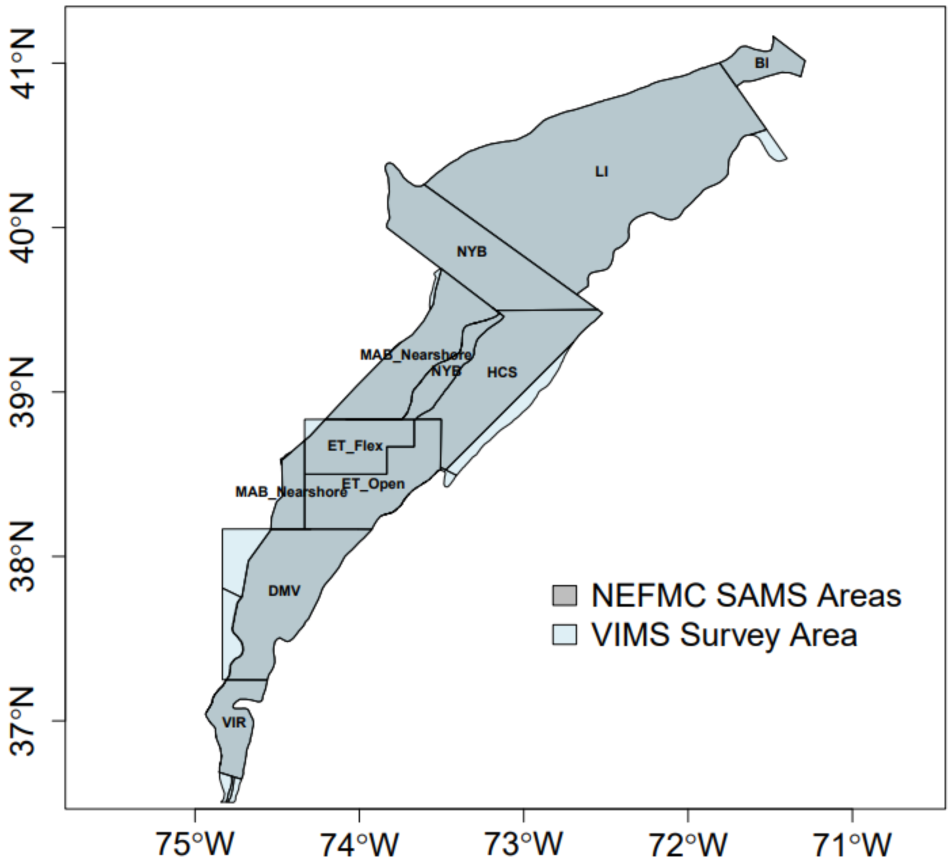


Figure 3. Map of the 2022 survey domain for the survey of the Mid-Atlantic Bight resource area with the SAMS Area designations.

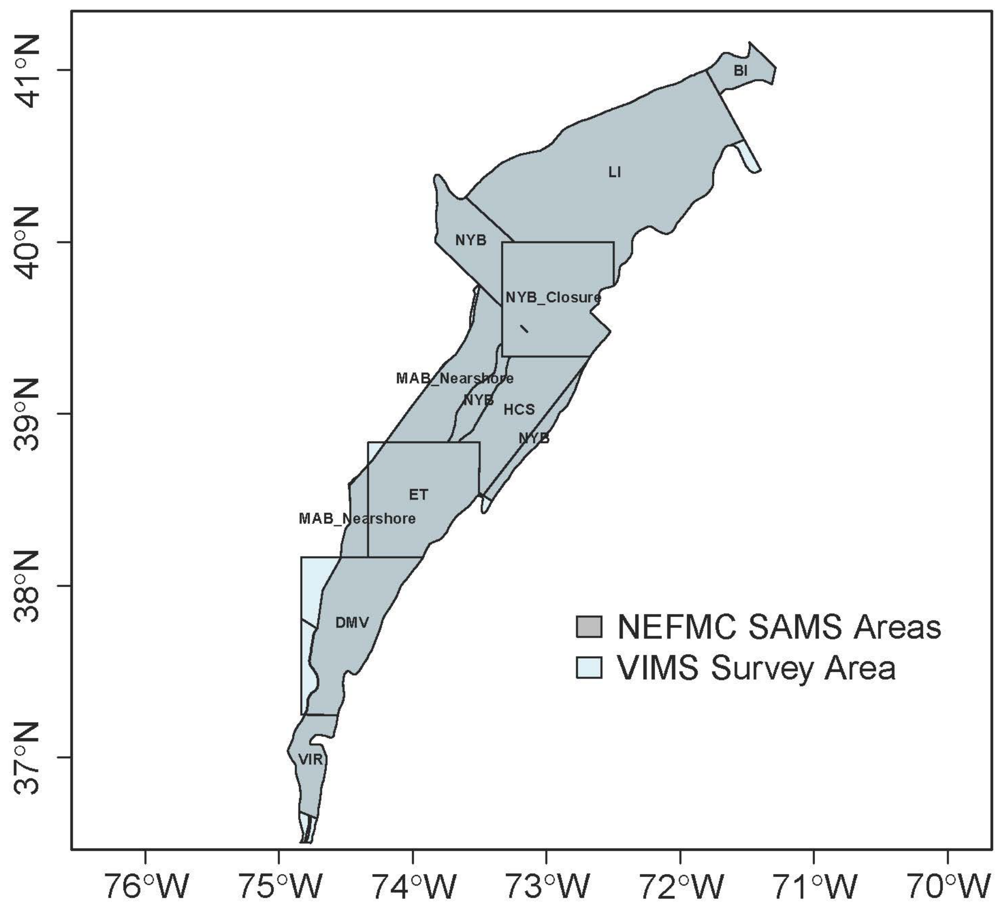


Figure 4. Locations of sampling stations for the 2021 survey of the Mid-Atlantic Bight resource area by survey leg.

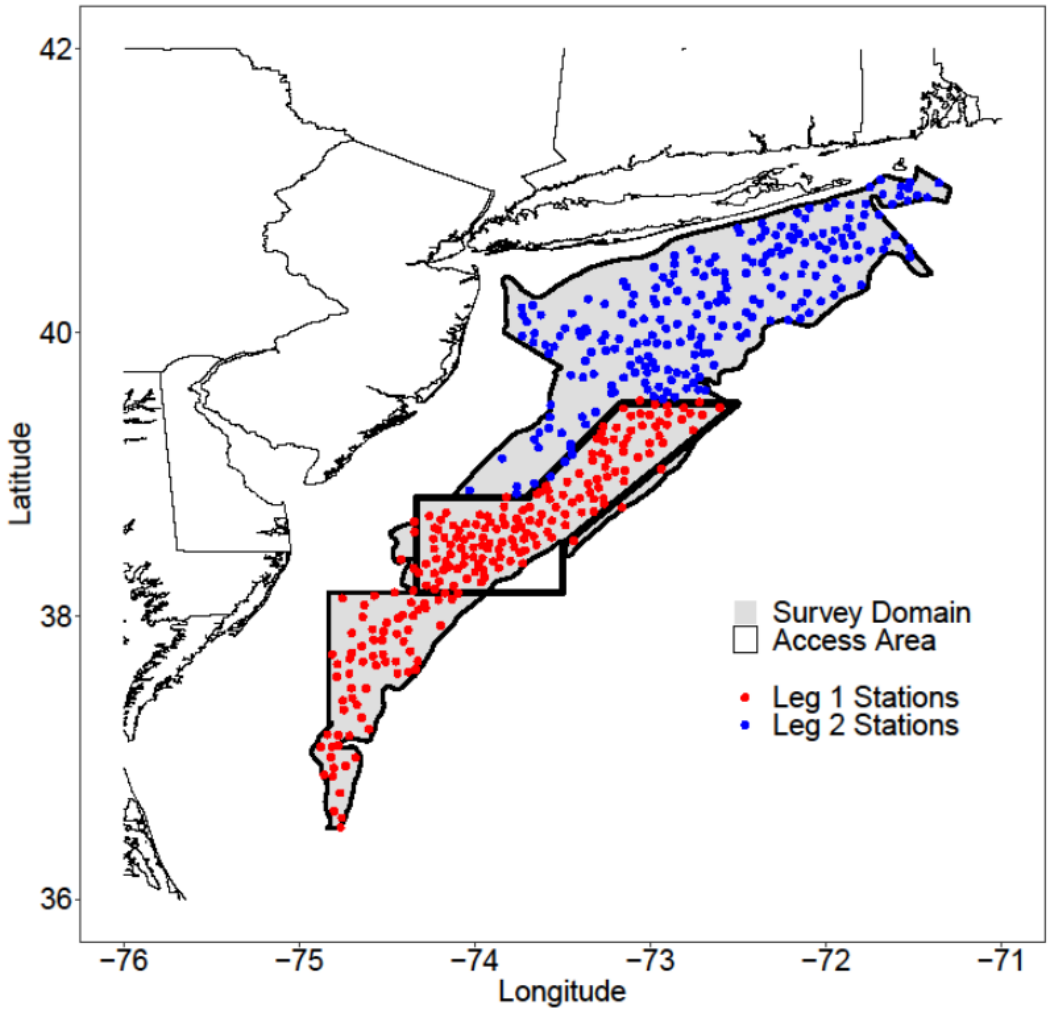


Figure 5. Locations of sampling stations for the 2022 survey of the Mid-Atlantic Bight resource area by survey leg.

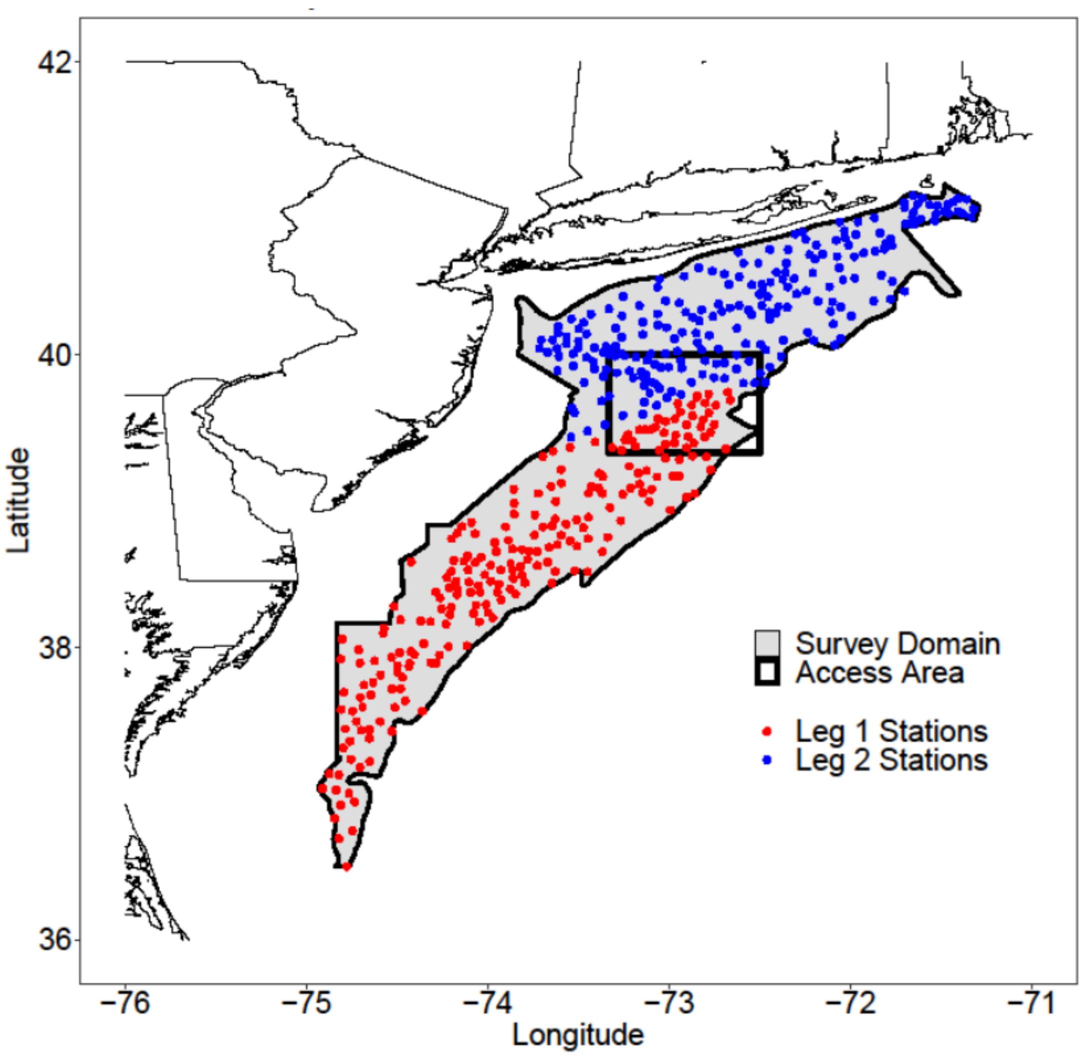


Figure 6. Boxplots of calculated tow lengths from the 2021 and 2022 surveys by CruiseID for the Mid-Atlantic Bight resource area survey.

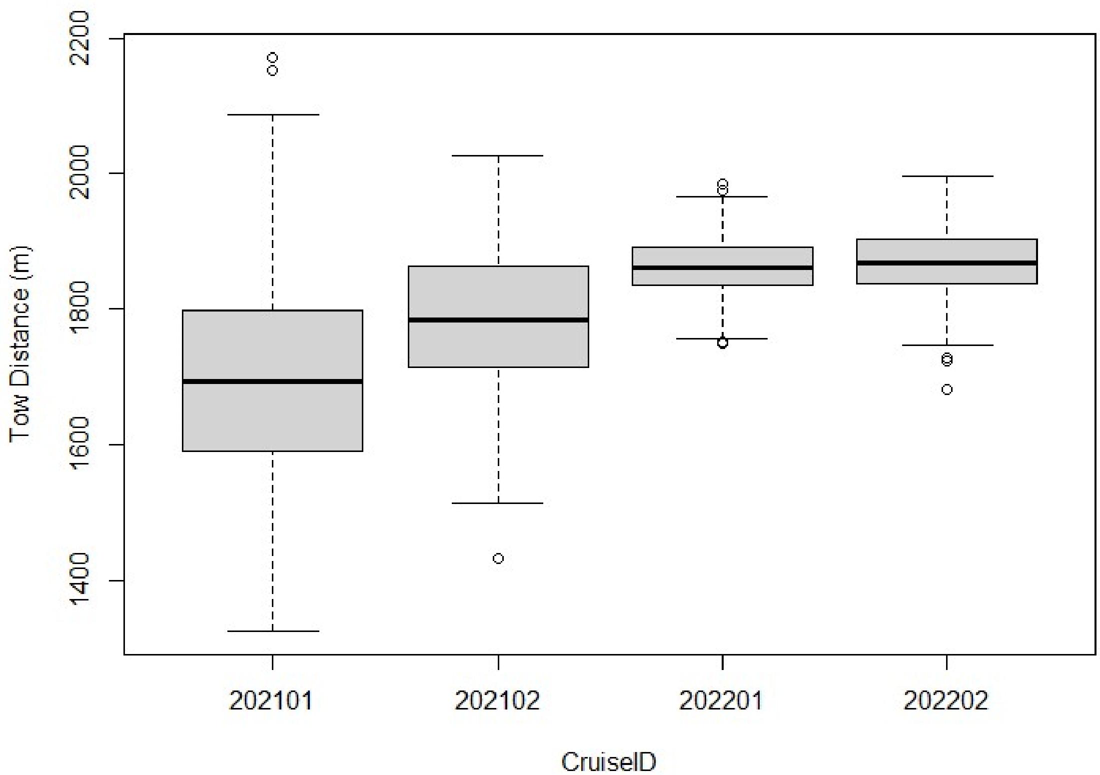


Figure 7. Scallop relative length frequency distributions generated from catch data obtained from both the survey and the commercial dredges during the VIMS/Industry cooperative survey of the Mid-Atlantic Bight resource area in 2021 by SAMS Area. Number of scallops (n) measured and mean length by gear are also included.

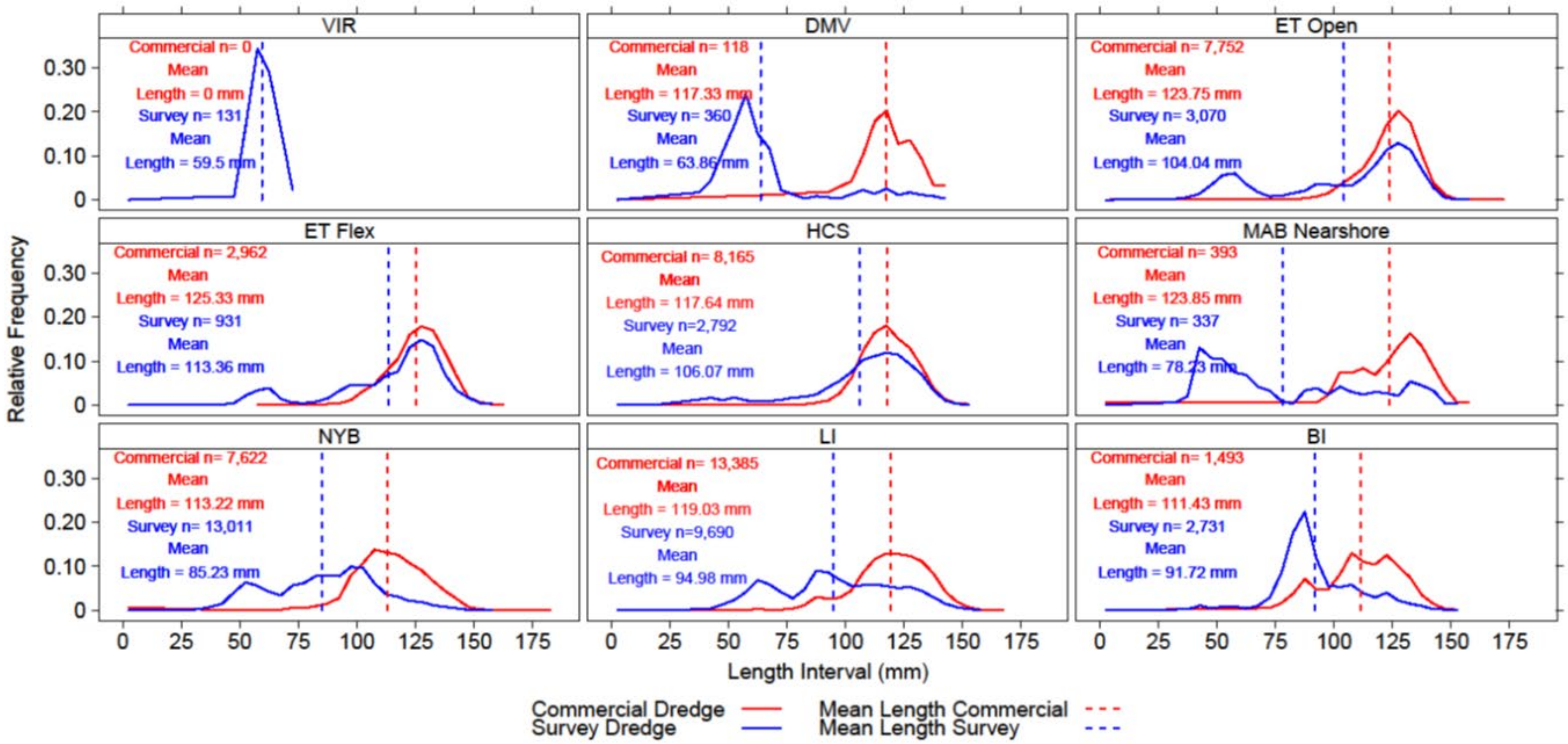


Figure 8. Scallop relative length frequency distributions generated from catch data obtained from both the survey and the commercial dredges during the VIMS/Industry cooperative survey of the Mid-Atlantic Bight resource area in 2022 by SAMS Area. Number of scallops (n) measured and mean length by gear are also included.

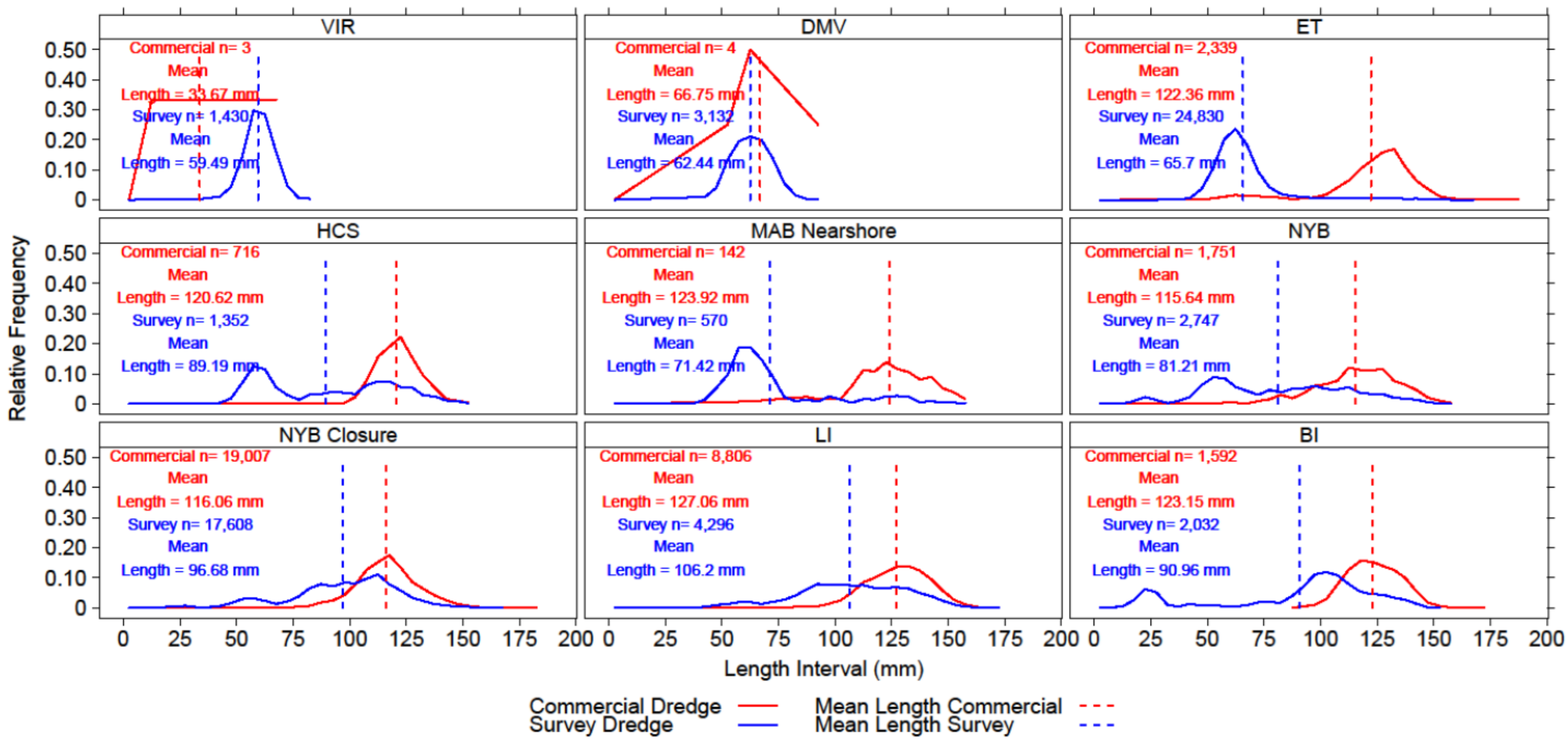


Figure 9. Spatial distribution of the number of sea scallops caught per m^2 in the NMFS survey dredge during the VIMS/Industry cooperative survey of the Mid-Atlantic Bight resource area in 2021. This figure represents the catch of three size classes of sea scallops (<35mm (top), 35mm-75mm (middle), and >75mm (bottom)).

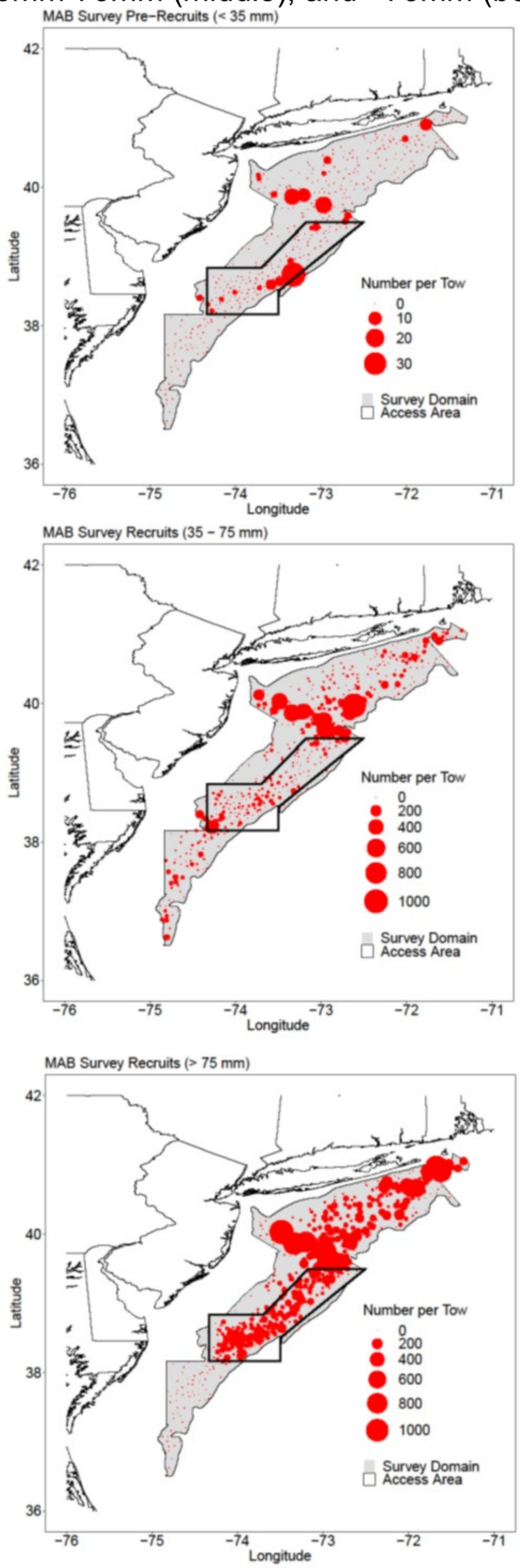


Figure 10. Spatial distribution of the number of sea scallops caught per m^2 in the NMFS survey dredge during the VIMS/Industry cooperative survey of the Mid-Atlantic Bight resource area in 2022. This figure represents the catch of three size classes of sea scallops (<35mm (top), 35mm-75mm (middle), and >75mm (bottom)).

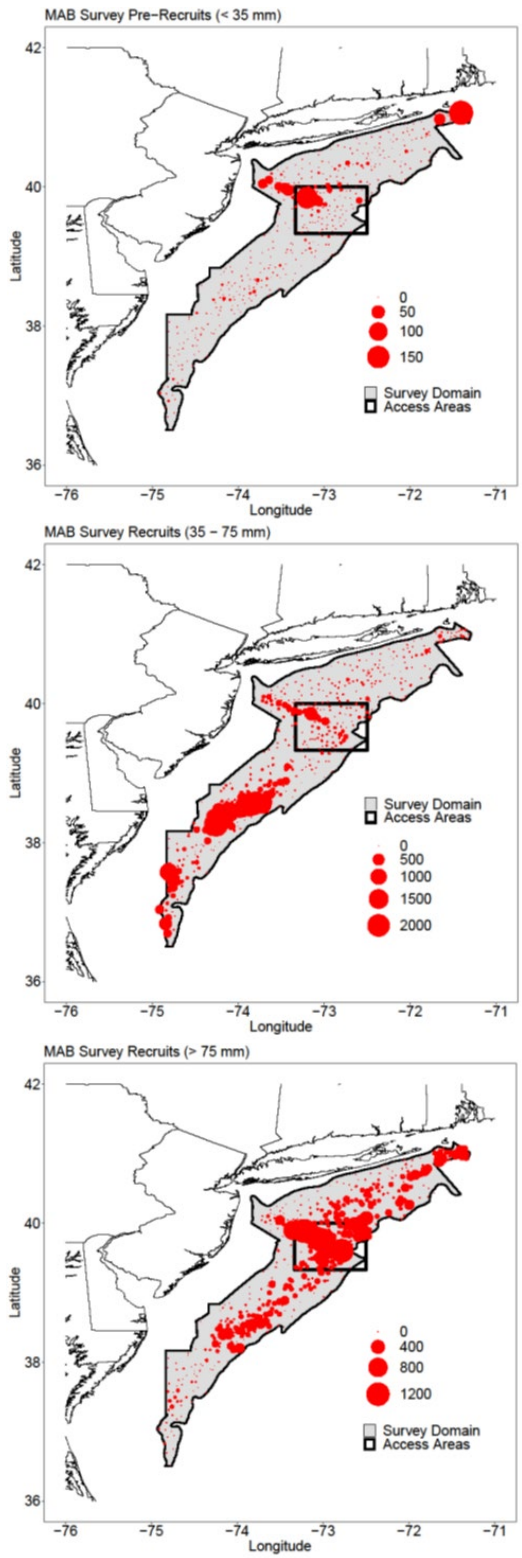


Figure 11. Predicted shell height:meat weight relationships by SAMS Area estimated from scallops sampled in the Mid-Atlantic Bight resource area in 2021.

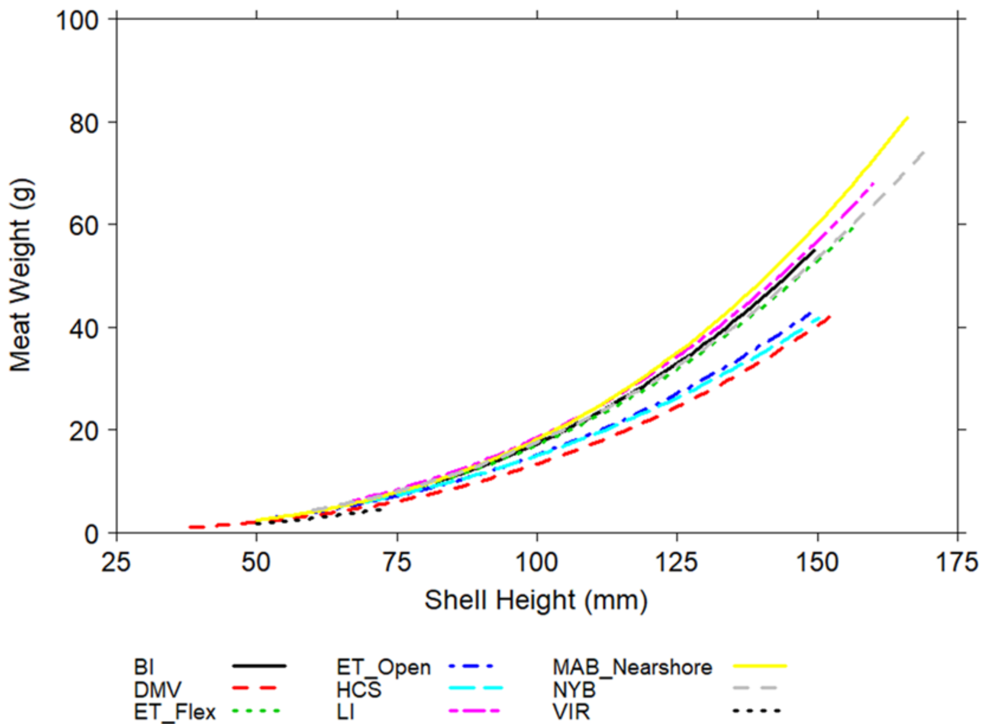


Figure 12. Predicted shell height:meat weight relationships by SAMS Area estimated from scallops sampled in the Mid-Atlantic Bight area in 2022.

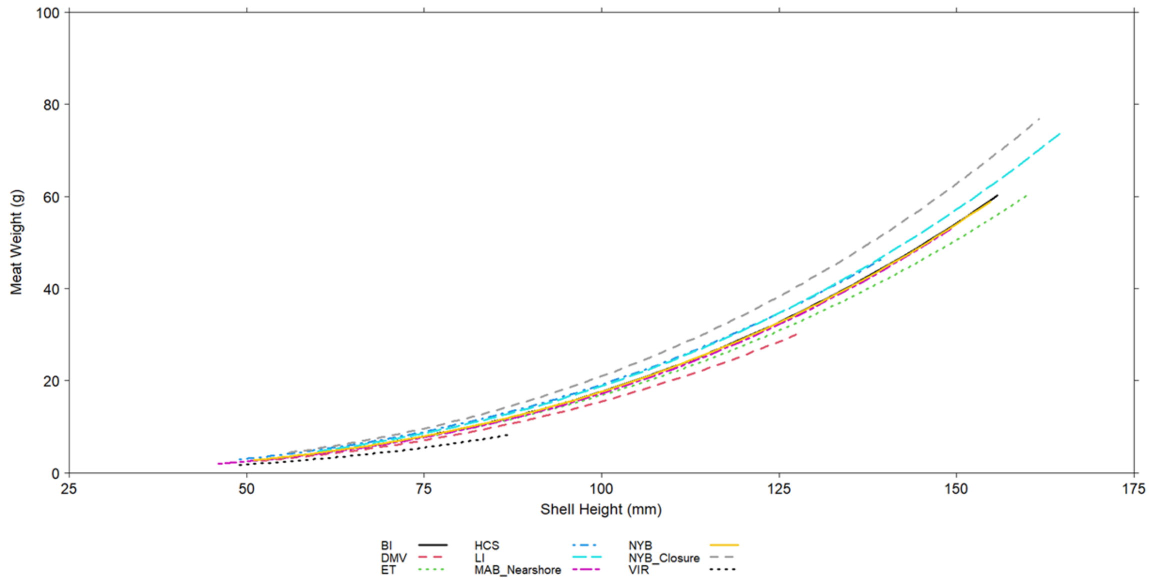


Figure 13. Length frequency distributions of bycatch for the NMFS survey dredge with sufficient sample sizes for the Mid-Atlantic Bight resource area in 2021 (top row) and 2022 (bottom row).

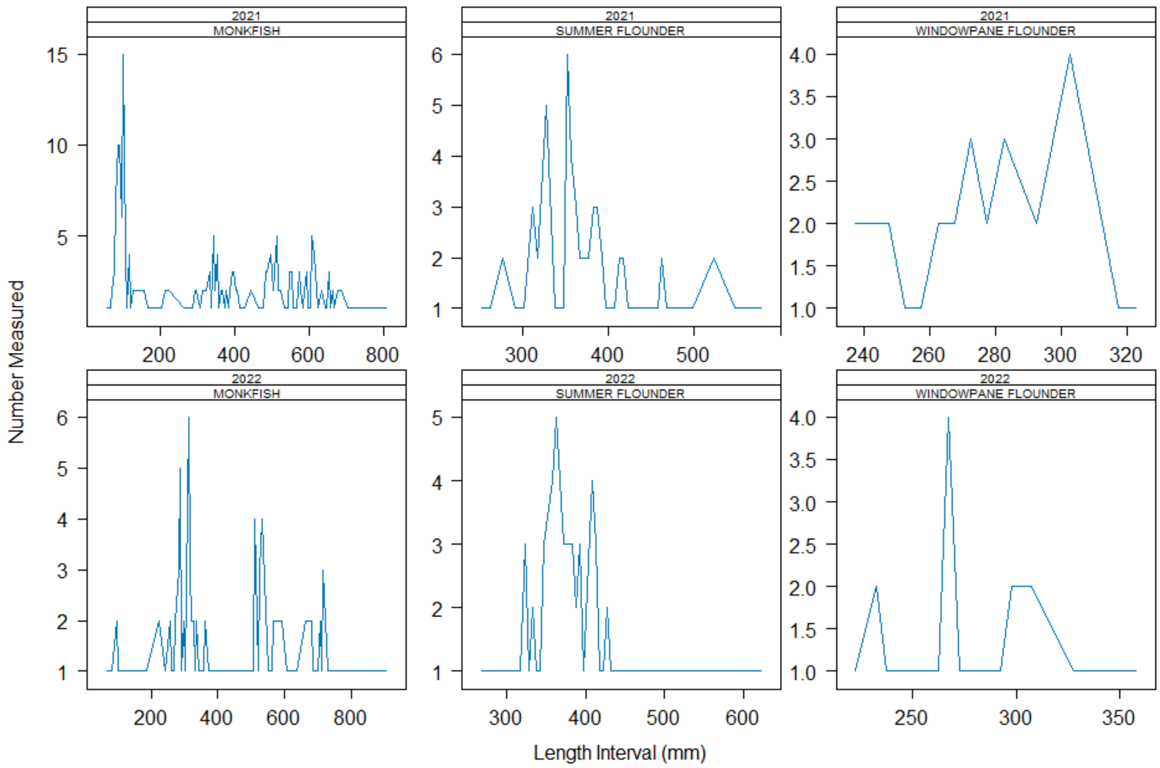


Figure 14. Length frequency distributions of bycatch for the commercial dredge with sufficient sample sizes for the Mid-Atlantic Bight resource area in 2021 (top row) and 2022 (bottom row).

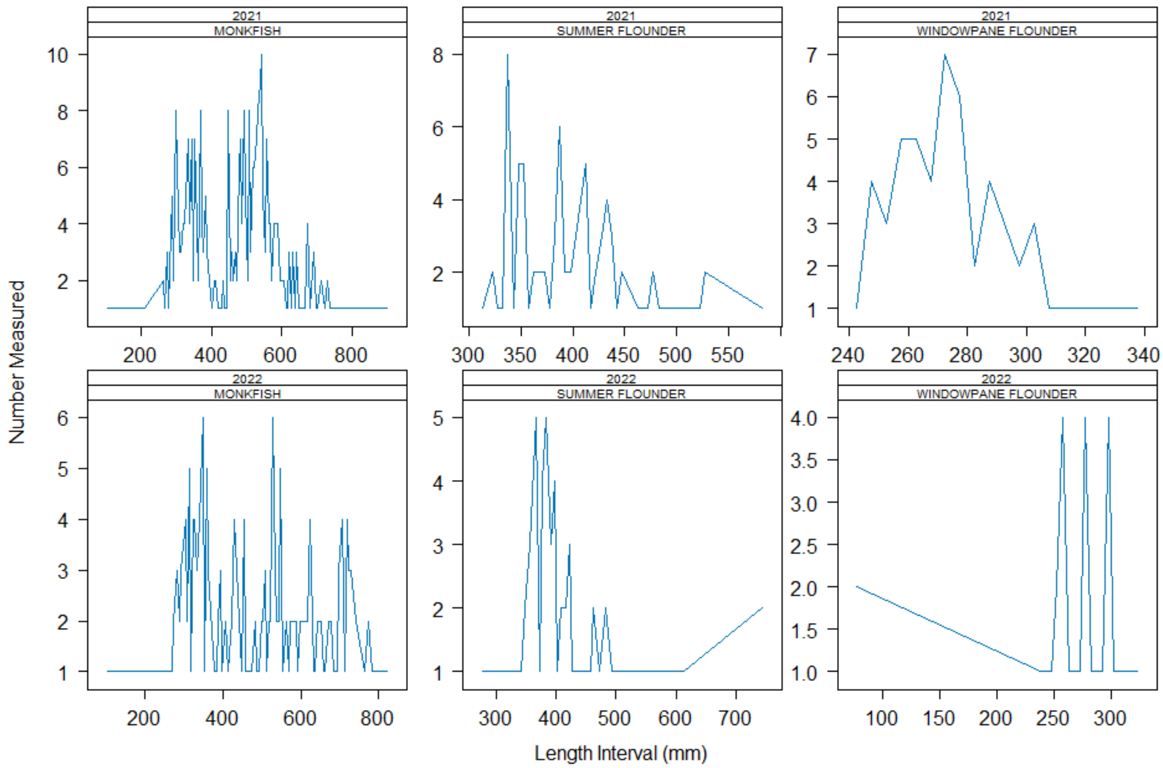


Figure 15. Spatial distribution and number of predators counted by species or genus for the 2021 MAB resource survey predator sampling stations. The number of animals represents either the number enumerated in the subsample or entire sample taken at a given station. Subsampled counts are not expanded.

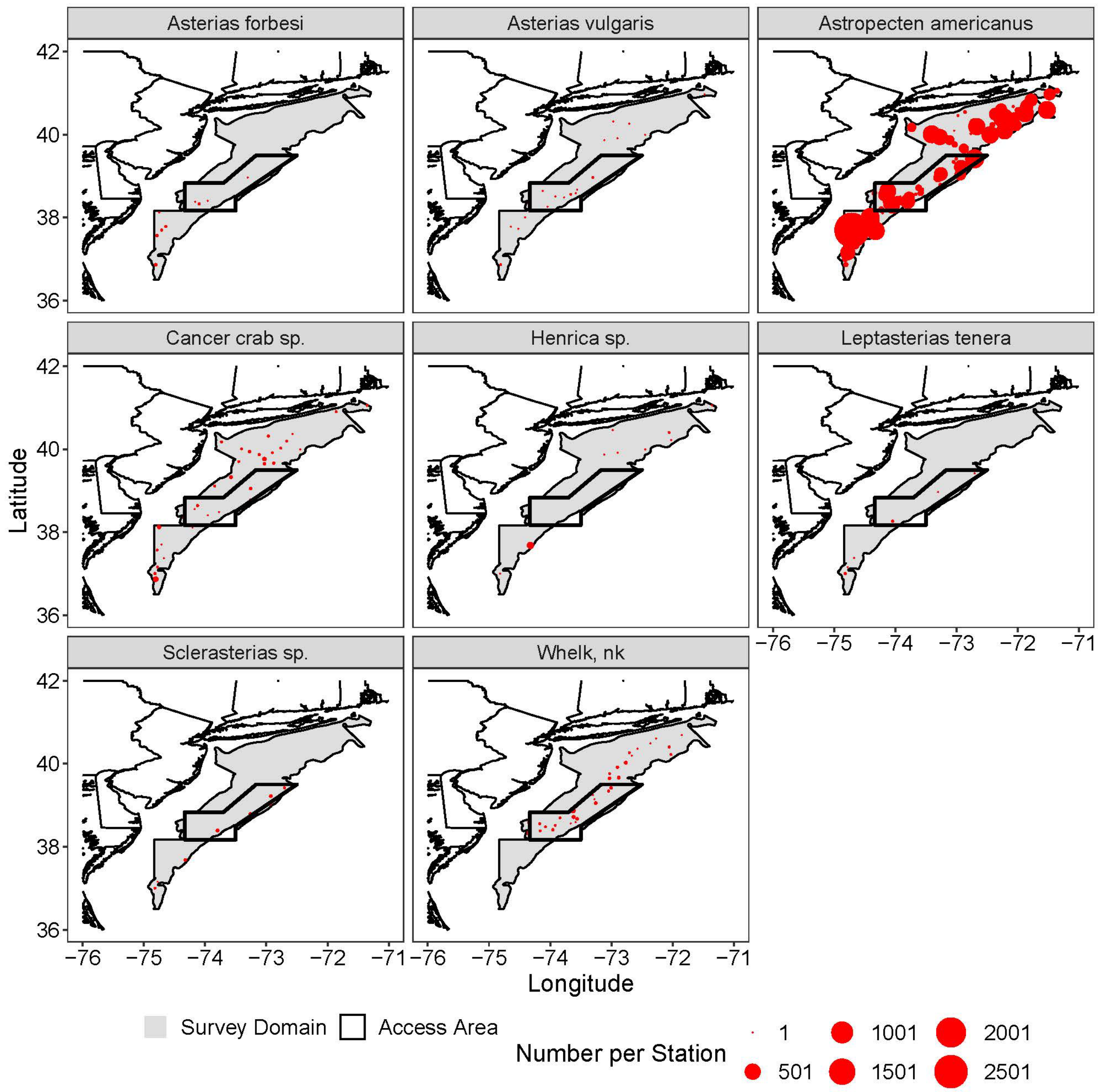


Figure 16. Spatial distribution and number of predators counted by species or genus for the 2022 MAB resource survey predator sampling stations. The number of animals represents either the number enumerated in the subsample or entire sample taken at a given station. Subsampled counts are not expanded.

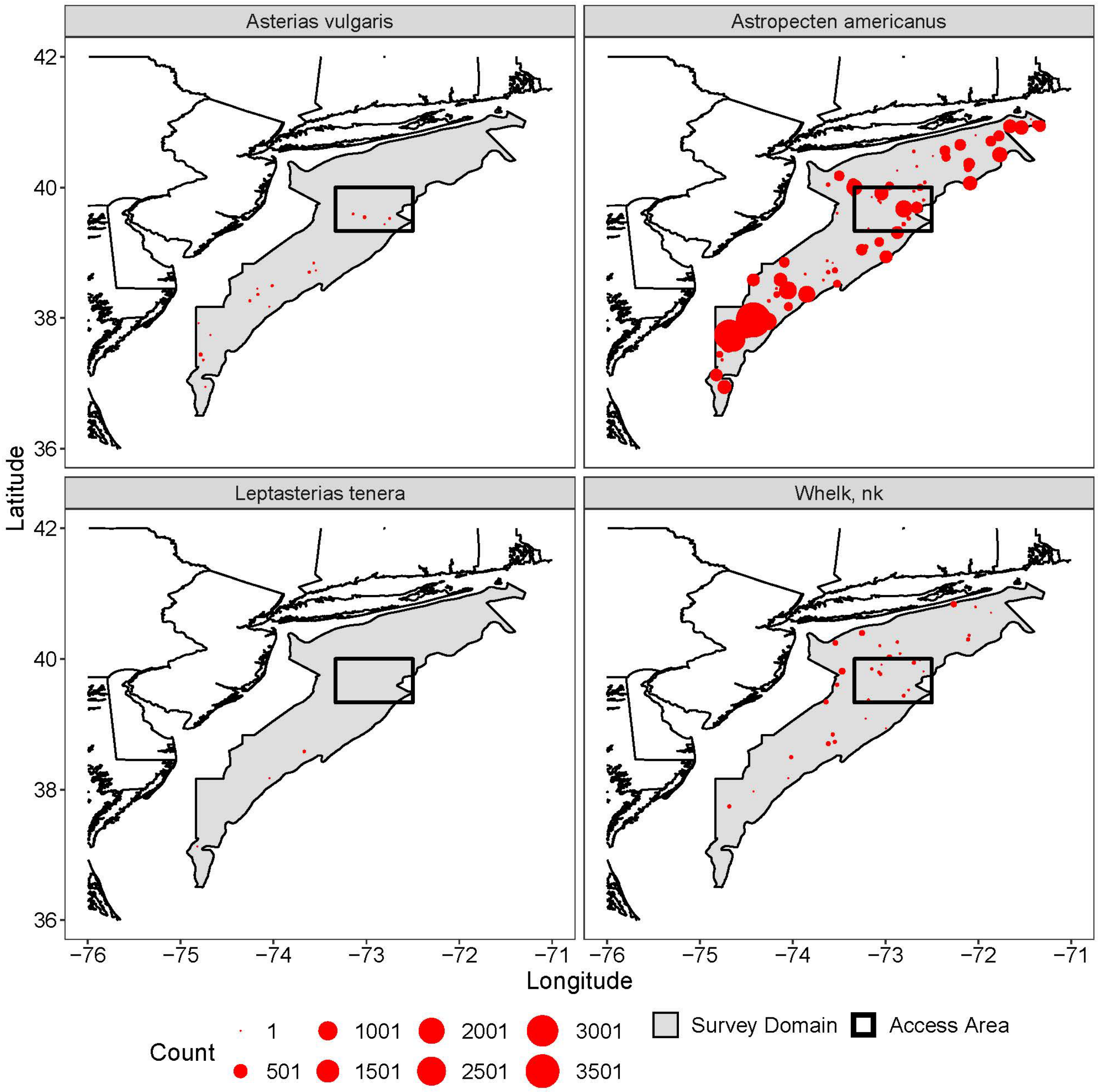
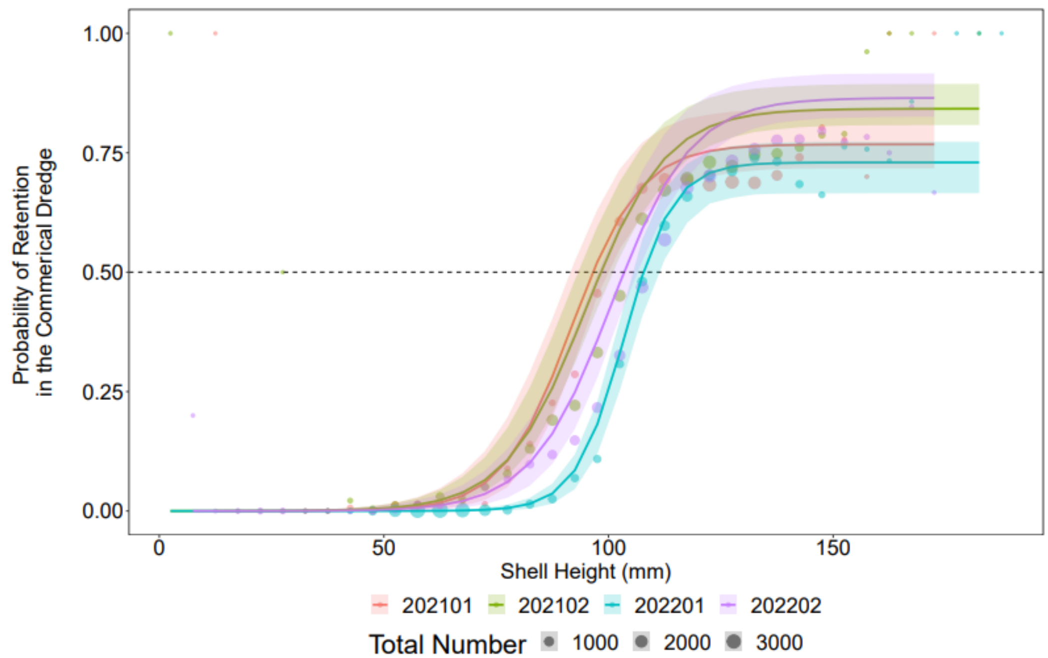


Figure 17. Predicted and observed retention probabilities by trip (top) and for the pooled analysis (bottom) for the turtle deflector dredge estimated with the Selfisher method.



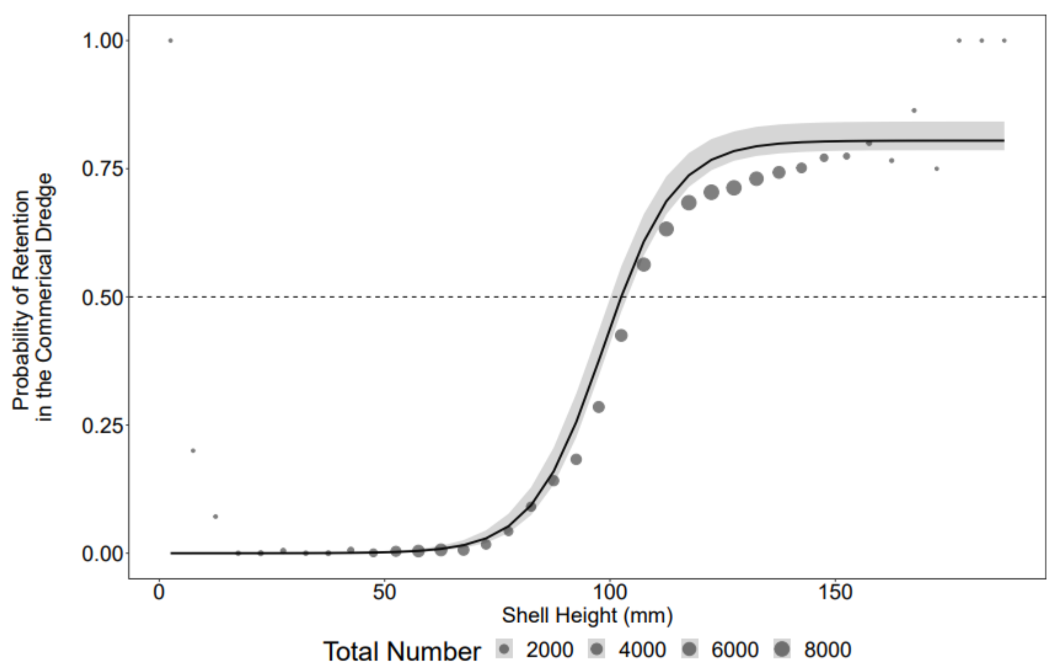


Figure 18. Split parameter *p* (bottom) and L_{50} (top) estimates with 95 percent confidence intervals by survey estimated with the Selfisher method.

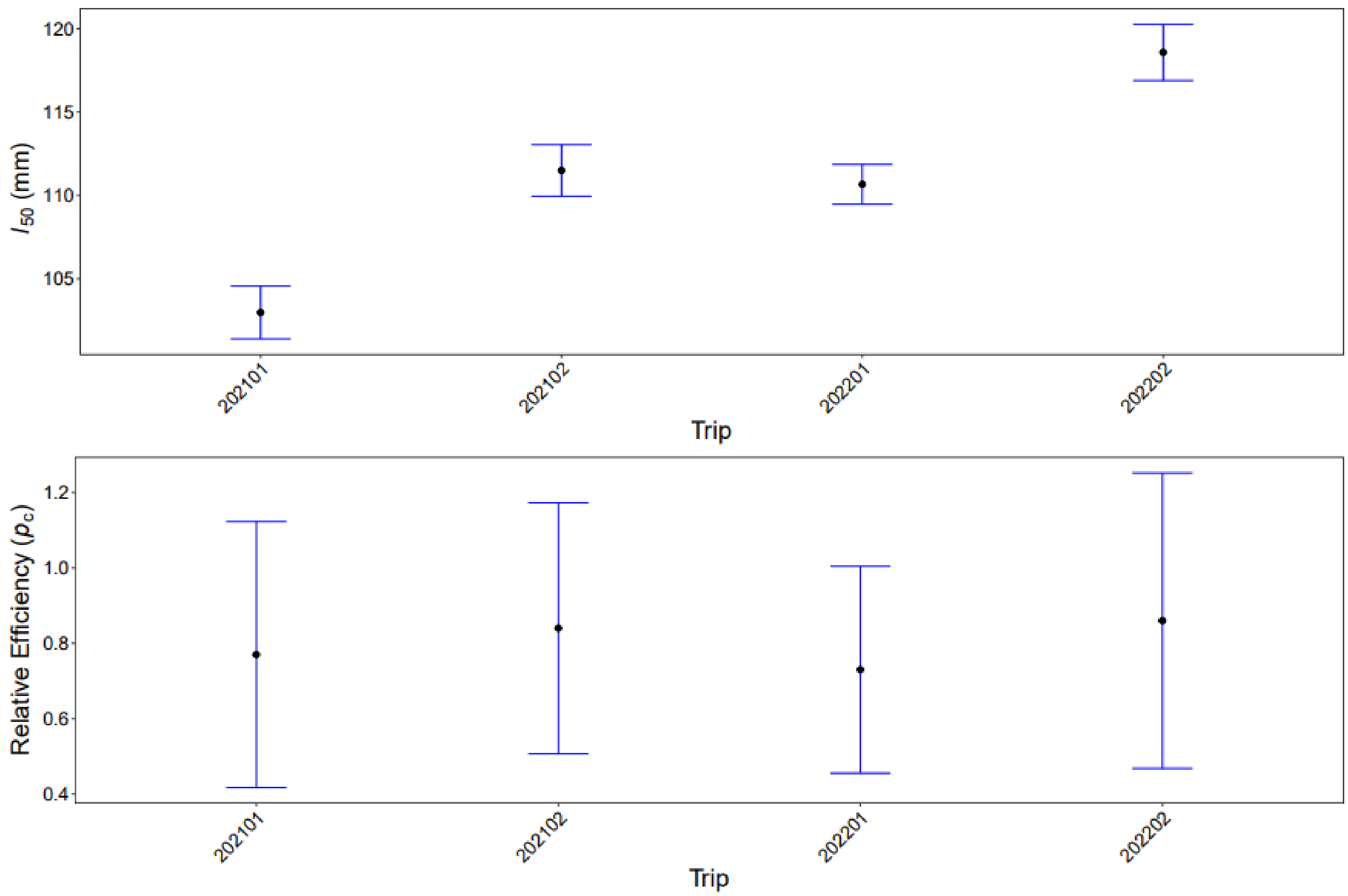


Figure 19. Percentage of scallops infected with the nematode parasite (prevalence) observed in the MAB resource area from 2015-2022.

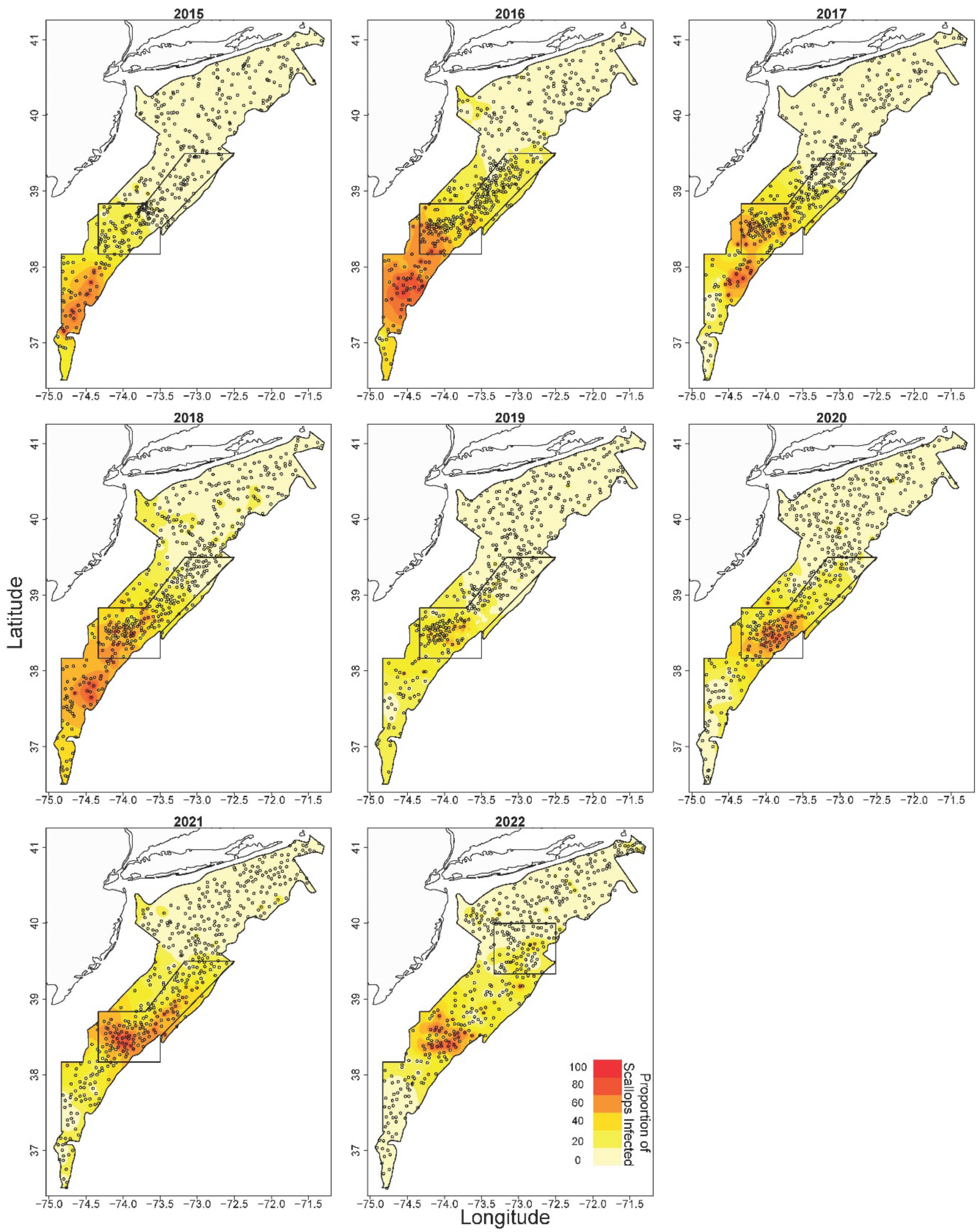


Figure 20. Average number of nematodes observed in infected scallops (intensity) in the MAB resource area from 2015-2022.

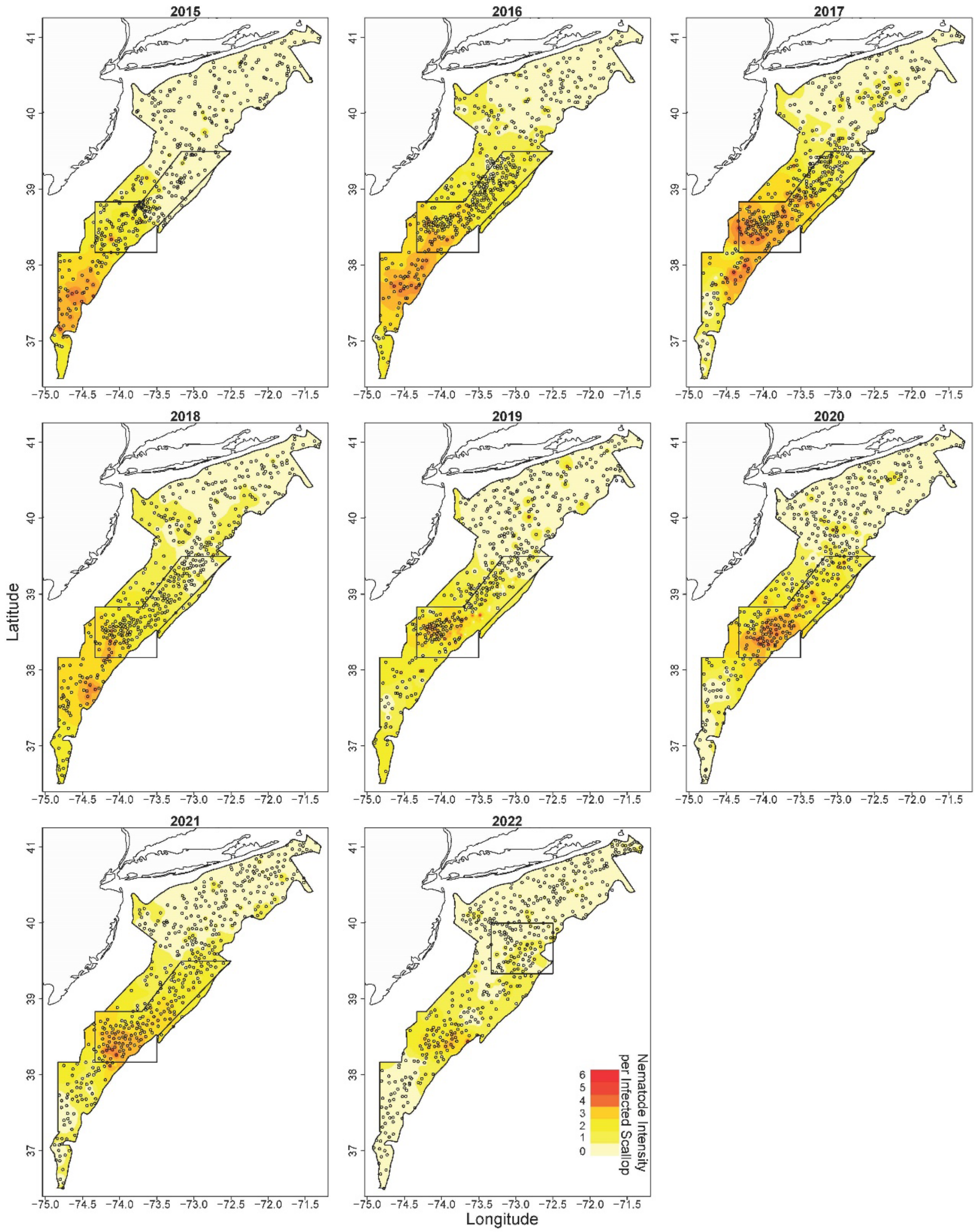


Table 1. Description of marketability, color, texture, and blister codes.

Classification	Color	Texture	Marketability	Blister
1	Extreme color deviation	Extreme stringiness, tearing, flaccid	Unmarketable	Blister in advanced stage
2	Noticeable color deviation	Noticeable stringiness, tearing, flaccid	Marginally marketable	Moderate blister severity
3	Slight color deviation	Slight stringiness, tearing, flaccid	Slightly inferior marketability	Blister in early stage
4	No color deviation	No texture concern	Marketable	No blister present

Table 2. Estimated total and exploitable biomass for the NMFS survey dredge for the survey domain in 2021 by SAMS Area. Standard error (SE), coefficient of variation (CV), average density (scallops/m^2), average meat weight (grams), and number of scallops are also provided.

	SAMS Area	Total Biomass (mt)	SE	CV	Density (scal/m^2)	Avg MW (g)	Total Number
Total	BI	1,516	261.34	43.11	0.14	16.6	92,957,827
	LI	9,041	394.17	10.9	0.04	20.92	436,496,307
	NYB	6,301	461.50	18.31	0.11	14.94	414,752,525
	MAB_Nearshore	588	51.35	21.85	0.01	17.42	33,964,176
	HCS	2,017	93.14	11.55	0.03	22.79	89,350,604
	ET_Flex	893	66.51	18.62	0.02	29.54	33,096,750
	ET_Open	1,790	70.06	9.78	0.04	22.47	80,967,964
	DMV	90	12.55	34.92	0	5.67	17,544,959
	VIR	11	1.67	38.35	0	3.06	3,564,875
Exploitable	BI	830	118.45	35.7	0.06	21.59	39,052,723.83
	LI	6,365	226.53	8.9	0.02	29.64	213,316,961.76
	NYB	3,671	252.22	17.17	0.04	22.15	158,543,955.38
	MAB_Nearshore	438	44.14	25.18	0	37.41	11,722,480.20
	HCS	1,609	76.82	11.94	0.02	26.14	61,841,076.81
	ET_Flex	750	61.96	20.65	0.01	34.57	21,483,637.31
	ET_Open	1,487	59.62	10.02	0.02	29.51	51,882,905.31
	DMV	36	10.09	70.07	0	17.11	2,220,777.65
	VIR	0.68	0.11	40.21	0	3.36	201,368.78

Table 3. Estimated exploitable biomass for the Turtle Deflector commercial dredge in the survey domain in 2021 by SAMS Area. Standard error (SE), coefficient of variation (CV), average density (scallops/m2), average meat weight (grams), and number of scallops are also provided.

	SAMS Area	Exp Biomass (mt)	SE	CV	Density (scal/m^2)	Avg MW (g)	Exp Number
Exploitable	BI	459	66.65	22.34	0.03	27.79	16,606,923
	LI	7,992.76	433.20	8.34	0.02	34.9	222,101,837
	NYB	2,611.19	220.04	12.96	0.02	28.83	87,473,638
	MAB_Nearshore	613.56	115.18	28.88	0	42.36	14,483,496
	HCS	2,446.45	194.52	12.23	0.03	26.42	92,898,248
	ET_Flex	1,384.82	181.73	20.19	0.02	36.53	35,837,104
	ET_Open	2,282.88	184.87	12.46	0.03	30.17	78,438,915
	DMV	36.63	18.10	76.03	0	21.89	1,678,374
	VIR	0	0	0	0	0	0

Table 4. Estimated total and exploitable biomass for the NMFS survey dredge for the survey domain in 2022 by SAMS Area. Standard error (SE), coefficient of variation (CV), average density (scallops/m^2), average meat weight (grams), and number of scallops are also provided.

	SAMS Area	Total Biomass (mt)	SE	CV	Density (scal/m^2)	Avg MW (g)	Total Number
Total	BI	679.65	47.87	17.61	0.04	23.54	28,820,859
	LI	5,402.99	280.38	12.97	0.02	24.88	224,639,736
	NYB	1,183.27	92.95	19.64	0.04	13.19	90,672,656
	NYB_Closure	8,626.10	495.72	14.37	0.12	20.13	422,815,488
	MAB_Nearshore	499.88	98.31	49.17	0.01	10.06	52,039,048
	HCS	1,141.92	97.19	21.28	0.03	16.15	70,738,527
	ET	4,733.39	258.53	13.65	0.2	6.85	675,961,939
	DMV	756.21	99.77	32.98	0.04	5.57	141,130,494
	VIR	327.25	46.74	35.71	0.06	4.73	69,137,547
Exploitable	BI	492.91	32.57	16.52	0.03	27.23	18,021,657
	LI	4,184.29	193.99	11.59	0.01	30.52	141,400,235
	NYB	750.25	58.95	19.64	0.01	22.17	30,021,487
	NYB_Closure	6,057.03	339.78	14.02	0.06	25.72	233,308,866
	MAB_Nearshore	242.37	77.42	79.86	0	25.06	9,906,017
	HCS	805.87	63.05	19.56	0.01	25.85	31,190,705
	ET	1,384.66	56.48	10.2	0.02	15.81	84,250,242
	DMV	66.50	6.06	22.79	0	6.7	10,194,509
	VIR	22.10	3.18	35.97	0	5.36	4,116,627

Table 5. Estimated exploitable biomass for the Turtle Deflector commercial dredge in the survey domain in 2022 by SAMS Area. Standard error (SE), coefficient of variation (CV), average density (scallops/m2), average meat weight (grams), and number of scallops are also provided.

	SAMS Area	Exp Biomass (mt)	SE	CV	Density (scal/m^2)	Avg MW (g)	Exp Number
Exploitable	BI	325.36	30.73	14.53	0.01	34.81	9,271,770
	LI	5,586.36	347.87	9.58	0.01	36.8	153,368,977
	NYB	598.35	72.76	18.71	0.01	26.03	19,370,879
	NYB_Closure	4,626.65	473.82	15.76	0.04	27.31	166,491,340
	MAB_Nearshore	144.60	69.11	73.53	0	34.65	4,172,843
	HCS	383.70	43.68	17.51	0.01	29.04	13,213,232
	ET	821.24	53.24	9.97	0.01	32.16	25,085,877
	DMV	0.65	0.24	58.12	0	6.94	107,991
	VIR	0.11	0.06	84.52	0	2.2	53,972

Table 6. Shell height:meat weight models for the 2021 VIMS survey data for the Mid-Atlantic resource area. Bold variables indicate significant terms. The model in red was selected as the preferred model based on AIC value and model selection criteria. The number of parameters (K), AIC, ΔAIC, and Deviance explained are also included.

Model	Parameters	K	AIC	ΔAIC	Deviance
mab1	**~ 1 + shell height*depth + SAMS Area**	**14**	**28,091.15**	**0**	**78.74**
mab2	~ 1 + Shell Height *Depth + SAMS Area + Latitude	15	28,092.47	1.32	78.74
mab4	~ 1 + Shell Height + Depth + SAMS Area + Latitude	14	28,206.00	114.85	78.27
mab3	~ 1 + Shell Height + Depth + SAMS Area	13	28,206.92	115.78	78.26

Table 7. Shell height:meat weight parameters estimated from the preferred model for the 2021 VIMS survey data for the Mid-Atlantic resource area. Predictor variables in bold indicate terms are significant.

Parameter	Estimate
Intercept	-27.66
ln Shell Height	**6.88**
ln Depth	**4.47**
DMV	**-0.22**
ET_Flex	0.003
ET_Open	-0.07
HCS	-0.04
LI	0.08
MAB_Nearshore	0.08
NYB	0.04
VIR	**-0.40**
Shell Height:Depth	**-1.03**

Table 8. Shell height:meat weight models for the 2022 VIMS survey data for the Mid-Atlantic resource area including maturity stage as a predictor. Bold variables indicate significant terms. The model in red was selected as the preferred model based on AIC value and model selection criteria. The number of parameters (K), AIC, ΔAIC, and Deviance explained are also included.

Model	Parameters	K	AIC	ΔAIC	Deviance
mab1	**~ 1 + Shell Height*Depth + SAMS Area**	**14**	**28,755.46**	**-**	**79.46**
mab2	~ 1 + Shell Height *Depth + SAMS Area + Latitude	15	28,756.35	0.89	79.45
mab3	~ 1 + Shell Height + Depth + SAMS Area	13	28,767.32	11.86	79.40
mab4	~ 1 + Shell Height + Depth + SAMS Area + Latitude	14	28,767.71	12.25	79.40

Table 9. Shell height:meat weight parameters estimated from the preferred for the 2022 VIMS survey data for the Mid-Atlantic resource area. Predictor variables in bold indicate terms are significant.

Parameter	Estimate
Intercept	**-15.96**
Shell Height	**4.06**
Depth	**1.57**
DMV	**-0.13**
ET	-0.05
HCS	0.07
LI	0.06
MAB_Nearshore	-0.02
NYB	-0.002
NYB_Closure	**0.17**
VIR	**-0.39**
Shell Height:Depth	**-0.33**

Table 10. Total catch (number of animals) and catch per unit effort for bycatch for the 2021 and 2022 surveys for the NMFS survey dredge and the commercial dredges.

Survey	Common Name	Commercial Gear Catch (Number)	Commercial Gear CPUE	Survey Gear Catch (Number)	Survey Gear CPUE
2021	AMERICAN LOBSTER	4	0.009	5	0.011
2021	RED HAKE	15	0.033	638	1.418
2021	SPOTTED HAKE	8	0.018	1533	3.407
2021	BARNDOOR SKATE	21	0.047	5	0.011
2021	CHAIN DOGFISH	2	0.004	25	0.056
2021	FOURSPOT FLOUNDER	45	0.1	526	1.169
2021	LOLIGO SQUID	1	0.002	15	0.033
2021	BLACK SEA BASS	7	0.016	95	0.211
2021	NORTHERN SEAROBIN	225	0.5	1138	2.529
2021	GREY SOLE	2	0.004	6	0.013
2021	MONKFISH	307	0.682	219	0.487
2021	BLACKBACK FLOUNDER	1	0.002	17	0.038
2021	UNCLASSIFIED SKATES	4577	10.171	1883	4.184
2021	GULFSTREAM FLOUNDER	9	0.02	1955	4.344
2021	STRIPED SEAROBIN	3	0.007	6	0.013
2021	WINDOWPANE FLOUNDER	54	0.12	28	0.062
2021	HORSESHOE CRAB	220	0.489	59	0.131
2021	SILVER HAKE	7	0.016	431	0.958
2021	SUMMER FLOUNDER	85	0.189	69	0.153
2021	BUTTERFISH	0	0	8	0.018
2021	OCEAN POUT	0	0	42	0.093
2021	SPINY DOGFISH	0	0	2	0.004
2021	SCUP	0	0	9	0.02
2021	ILLEX SQUID	0	0	23	0.051
2021	TORPEDO RAY	0	0	1	0.002
2021	SMOOTH DOGFISH	0	0	2	0.004
2021	SQUID UNCL	0	0	11	0.024
2021	CUSK	0	0	1	0.002
2022	BLACK SEA BASS	3	0.007	90	0.201
2022	HORSESHOE CRAB	61	0.136	29	0.065
2022	SILVER HAKE	1	0.002	270	0.604
2022	BARNDOOR SKATE	12	0.027	3	0.007
2022	GREY SOLE	2	0.004	2	0.004
2022	LOLIGO SQUID	2	0.004	89	0.199
2022	BLACKBACK FLOUNDER	1	0.002	17	0.038
2022	STRIPED SEAROBIN	2	0.004	11	0.025
2022	UNCLASSIFIED SKATES	3948	8.832	1794	4.013
2022	MONKFISH	182	0.407	107	0.239
2022	RED HAKE	3	0.007	214	0.479
2022	SUMMER FLOUNDER	60	0.134	67	0.15
2022	WINDOWPANE FLOUNDER	25	0.056	21	0.047
2022	NORTHERN SEAROBIN	128	0.286	1066	2.385
2022	FOURSPOT FLOUNDER	19	0.043	423	0.946
2022	CHAIN DOGFISH	0	0	28	0.063
2022	BUTTERFISH	0	0	14	0.031
2022	GULFSTREAM FLOUNDER	0	0	489	1.094
2022	SCUP	0	0	32	0.072
2022	AMERICAN LOBSTER	0	0	2	0.004
2022	SQUID UNCL	0	0	10	0.022
2022	OCEAN POUT	0	0	6	0.013
2022	ILLEX SQUID	0	0	40	0.089
2022	SPINY DOGFISH	0	0	2	0.004
2022	SMOOTH DOGFISH	0	0	2	0.004
2022	SPOTTED HAKE	0	0	46	0.103
2022	YELLOWTAIL FLOUNDER	0	0	1	0.002
2022	FAWN CUSK EEL	0	0	29	0.065

Table 11. Selectivity analysis summary information for each cruise included in the analysis along with resource area, commercial dredge information, number of stations, and number of five mm length bins.

CruiseID	Area	Year	Dredge	Dredge Width	Number of Stations	Number of 5 mm Length Bins
202101	MAB	2021	Turtle	14 ft	128	32
202102	MAB	2021	Turtle	14 ft	149	31
202201	MAB	2022	Turtle	14 ft	110	34
202202	MAB	2022	Turtle	14 ft	143	34

Table 12. Selectivity analysis parameter values estimated with a logistic curve and estimated split parameter (p) by cruise.

Trip	Parameter	Parameter Estimate	SE
CruiseID 202101	p	0.77	0.18
	L_{25}	94.5	0.66
	L_{50}	102.98	0.81
	L_{75}	111.46	1.12
	SR	16.96	0.85
CruiseID 202102	p	0.84	0.17
	L_{25}	101.61	0.61
	L_{50}	111.5	0.79
	L_{75}	121.39	1
	SR	19.78	0.51
CruiseID 202201	p	0.73	0.14
	L_{25}	104.67	0.49
	L_{50}	110.66	0.61
	L_{75}	116.65	0.75
	SR	11.97	0.38
CruiseID 202202	p	0.86	0.2
	L_{25}	108.74	0.68
	L_{50}	118.58	0.86
	L_{75}	128.42	1.08
	SR	19.68	0.53

Table 13. Selectivity analysis parameter values estimated with a logistic curve and estimated split parameter (*p*) by entire survey area.

Area	Parameter	Parameter Estimate	SE
MAB	*p*	0.8	0.09
	L_{25}	102.8	0.3
	L_{50}	111.51	0.38
	L_{75}	120.22	0.49
	SR	17.41	0.25
	Intercept	-14.07	0.17
	Length	0.13	0

Table 14. Summary for scallops assessed for marketability, color, texture, and blister disease at shell height:meat weight stations by sex during the 2021 and 2022 surveys by year.

Year	Sex	Market Classification			
		1	2	3	4
2021	Female	296	235	437	1,355
	Male	252	208	370	1,354
	Unknown	36	12	70	112
2022	Female	301	48	126	1,935
	Male	239	67	134	1,939
	Unknown	6	1	3	6
		Color Classification			
		1	2	3	4
2021	Female	70	120	668	1,465
	Male	64	113	550	1,457
	Unknown	17	16	85	112
2022	Female	15	28	158	2,209
	Male	16	32	174	2,157
	Unknown	4	0	3	9
		Texture Classification			
		1	2	3	4
2021	Female	72	245	703	1,303
	Male	70	215	622	1,277
	Unknown	18	25	77	110
2022	Female	20	58	325	2,007
	Male	14	71	313	1,981
	Unknown	3	4	2	7
		Disease Classification			
		1	2	3	4
2021	Female	75	101	158	1,989
	Male	71	101	165	1,847
	Unknown	21	9	27	173
2022	Female	73	67	122	2,148
	Male	76	64	123	2,116
	Unknown	2	1	2	11