Coonamessett Farm Foundation

An intensive optical assessment of sea scallop abundance and distribution in select areas of Georges Bank and the Mid-Atlantic:

Southern Closed Area 2, Southern Flank, Nantucket Lightship South Deep, Elephant Trunk, Hudson Canyon Access Area, New York Bight, Long Island, and Block Island

Final Report

2020 Sea Scallop Research Set-Aside (RSA) Program
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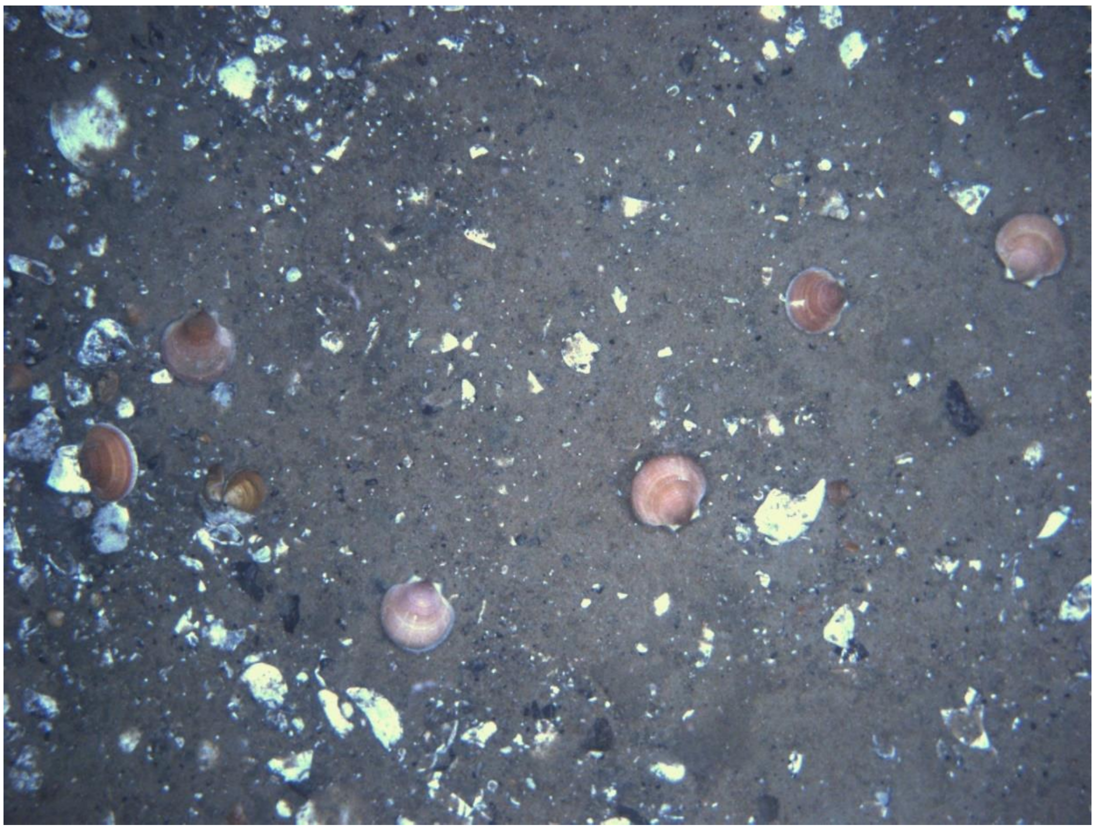

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LIST OF ACRONYMS AND TERMS

BI	Block Island SAMS area
CA2	Closed Area 2
CA2-Ext	Closed Area 2 Extension Scallop Access Area
CA2-SE	Closed Area 2 Southeast Scallop Access Area
CA2-SW	Closed Area 2 Southwest Scallop Access Area
CFF	Coonamessett Farm Foundation, Inc.
DAS	Days at Sea
DMV	Delmarva
ET	Elephant Trunk
ET-Flex	Elephant Trunk Flex Scallop Access Area
ET-Open	Elephant Trunk Open Scallop Access Area
GIS	Geographic Information System
HCS	Hudson Canyon South Scallop Access Area
LI	Long Island
m	Meters
MAB	Mid-Atlantic Bight
mm	Millimeter
mt	Metric Ton
MW	Meat Weight
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NLS	Nantucket Lightship Scallop Access Area
NLS-S	Nantucket Lightship Scallop Access Area South (previously NLS-S-Deep)
nm	Nautical Mile
NMFS	National Marine Fisheries Service or NOAA Fisheries
NYB	New York Bight
PDT	NEFMC Plan Development Team(s)
RSA	NEFMC/NEFSC Research Set Aside Program
SAMS	Scallop Area Management Simulator (model) areas
SH	Shell Height
SF	Southern Flank
SMAST	School for Marine Science and Technology, University of Massachusetts

TIF	Tagged Image Format
VIMS	Virginia Institute of Marine Science, College of William and Mary
WHOI	Woods Hole Oceanographic Institution

EXECUTIVE SUMMARY

The CFF 2020-2022 Sea Scallop RSA project entitled *"**An intensive optical assessment of sea scallop abundance and distribution in select areas of Georges Bank and the Mid-Atlantic**"* was designed to provide critical survey-based information to help inform scallop fishery management efforts. The primary objectives of this project are to:

1. Provide photographic imagery from proposed optical transects in the survey areas
2. Create GIS-based plots of scallop distribution and density by size and length-frequency distributions of scallops within the survey areas
3. Calculate overall biomass (total and exploitable) within SAMS area surveyed

Biomass estimates

In both 2020 and 2021, Georges Bank and the NLS showed greater biomass than the surveyed Mid-Atlantic areas, which is similar to survey results from previous years. Generally, the biomass of many Mid-Atlantic SAMS areas has declined in recent years, particularly in the most southern areas. Surveys conducted in the NLS-S over the last few years have shown that the NLS has consistently supplied the highest exploitable biomass in the region; however, the area has been significantly reduced since 2019. Prior to the start of the 2020 fishing season, the area was opened and experienced intense fishing pressure.

Scallop size distributions and densities

In both 2020 and 2021, the NLS-S had some of the highest densities of adult > 75 mm scallops, just as in previous survey years; however, the density and number of scallops decreased notably after the area opened to fishing. By and large, adult scallops and recruit scallops (35 - 75 mm) were found in patchy distributions throughout most areas surveyed. Notable seed settlements are discussed below.

Additional observations

In the 2020 and 2021 surveys, important seed congregations were found in various areas in Georges Bank and the Mid-Atlantic. Of particular note, seed aggregations were noted in the northeastern portion of NLS-S and the northern portion of CA2-Access, southeast of Georges Bank. In the Mid-Atlantic, substantial recruitment was noted in HCS and NYB, which spurred conversation between the Atlantic Sea Scallop PDT and survey members to enact a closure.

FINAL REPORT

BACKGROUND

The Atlantic sea scallop fishery is one of the most valuable fisheries in the US, with revenues averaging $400-$600 million since 2006 (Smolowitz 2016). The scallop resource rebounded from a depleted state in the early 1990's due, in part, to management changes implemented to protect the resource in certain areas until scallops achieve marketable size. The primary management methods responsible for this turnaround included a reduction in DAS, limits on crew size, gear modifications, and, perhaps most importantly, the institution of rotationally fished Scallop Access Areas. This last approach also included management provisions to temporarily close newly identified areas with high numbers of small scallops. These measures, coupled with the additional measures set forth in the open access areas aimed at ensuring continued growth and spawning of those populations, have aided in facilitating the current high and relatively stable output of the Atlantic sea scallop fishery (Hart 2003; NEFSC 2014).

Rotational management and the opening or closing of certain spatial management areas for harvest, as well as limiting effort in other management areas, is highly dependent on a sound estimation of the resource. Because the resource is spread over a large geographic area, reliance on industry-based surveys has become increasingly important in the face of limited federal resources. Traditional surveys (e.g., dredge-based), while providing critical biological information, have been shown to be potentially limited due to decreased catch efficiency in areas of dense scallop aggregation (NEFSC 2004; Gedamke et al. 2005).

Optical surveys are important components to an overall survey strategy and hold several key advantages over traditional dredge surveys. Optical surveys overcome the issue of decreased dredge efficiency which can lead to underestimation of biomass in dense aggregations. Additionally, optical surveys are able to characterize the spatial scale of areas containing seed and very small scallops, which may be missed or only qualitatively noted by dredge surveys due to size selectivity (Rudders 2015). Optical surveys can also cover large swept areas in a relatively short time frame, allowing for detection of fine-scale distribution changes. The images and metadata collected during optical surveys also holds ancillary information such as species interactions, distribution of additional flora and fauna, temperature, salinity, and substrate type. Thus, each image captured during an optical survey is essentially a complete environmental snapshot of a specific space in time.

Nantucket Lightship

In the summer of 2013, the NEFSC and VIMS RSA-sponsored scallop survey efforts located areas of high-density age-1 scallop settlement south of the Great South Channel, extending both east and west along the 30 - 40 fathom edge of the Southern New England shelf (NEFSC 2013). This 2012 scallop year-class settled in the deeper waters south of the Great South Channel and yielded a substantial exploitable biomass. The scallops in the NLS-S SAMS area were noted to be substantially smaller than those in other areas in the NLS and were dubbed "Peter Pan scallops".

In August 2013, the HabCam Group aboard the F/V *Kathy Marie* conducted a 3-day, 300 nm survey in the areas identified by the NEFSC and VIMS surveys and observed large concentration of 15 - 25 mm scallops in the NLS-S SAMS area, extending just to the south of the NLS scallop management southern border.

In the summer of 2014, the HabCam Group surveyed the 2012 set of scallops on the southern New England shelf. Dense settlements of small scallops were seen in NLS-S. In June 2015, optical survey data was collected in southern New England waters and on Georges Bank. Dense scallop concentrations were again located in the eastern two thirds of the NLS, with approximately the majority of the scallops in this region located within the NLS.

In 2017, recruit size scallops (35 - 75mm) were found in substantial numbers in approximately 75 - 80 m of water in NLS-S. After consultation with other survey groups and review of prior data, it appeared that scallops in NLS-S were not achieving the same size-at-age as scallops in other areas of the NLS and Georges Bank.

The 2018 NLS survey track (NA18NMF4540021) was similar to 2017. Pre-recruit scallops (< 35 mm) were not noted in moderate or high densities anywhere in the NLS. Recruit scallops (35 - 75 mm) were again most dense in the deep portion of the NLS-S (>70m). Scallops measured from images taken shallower than 70m in the NLS-S were significantly larger in mean scallop SH than those from the deep water.

The 2019 RSA HabCam NLS survey track (NA19NMF4540016) was similar to 2017 and 2018 within the NLS. By far, the most significant changes in the stock abundance and biomass from the 2018 survey were observed in the NLS-S and NLS-West. Pre-recruit scallops (< 35 mm) were again not found in notable densities anywhere in the NLS. Recruit sized scallops (35 – 75 mm) were most dense in NLS-S-Deep (the deep portion of the NLS-S area, now referred to as simply NLS-S). Although measured scallops in NLS-S were still smaller by SH than cohorts in other areas of the NLS, NLS-S scallop SHs increased by an average of approximately 10mm from 2018-2019 as compared to 5mm from the previous year. As in 2018, the NLS-S area continued to yield high biomass, with 2019 HabCam-derived estimates of over 21,000 mt of exploitable biomass, which increased from the 5,021 mt estimated in 2018. As these scallops reached exploitable sizes, the Scallop PDT made the decision to open the area to commercial fishing for 2020.

Georges Bank and Southern Flank

In 2012, the data from the HabCam Group (NA12NMF4540040), combined with data from the NEFSC HabCam survey, estimated a scallop biomass estimate of roughly 7,400 mt in the CA2-Access. In 2017, SMAST conducted a drop camera survey of CA2-Access and CA2-Ext, the area south of the CA2 access area. Estimated total biomass was 7,361 mt in CA2-Access and 5,153 mt in CA2-Ext. Estimated exploitable biomass was 4,577 in CA2-Access and 1,920 in CA2-Ext (Bethoney & Stokesbury 2019). In 2018, the NEFSC HabCam survey showed a moderate biomass and density of scallops in CA2-Access and CA2-Ext. Total biomass estimates from the 2018 NEFSC HabCam survey in CA2-Access (7,128 mt) were similar to 2017 SMAST survey results, while estimates in CA2-Ext (8,086 mt) were substantially higher, potentially suggesting a successful recruitment event.

Results from the 2019 RSA HabCam survey of southern CA2 (CA2-Access and CA2-Ext) and the SF (NA19NMF4540018) show a notable density of pre-recruit and recruit sized scallops, particularly in southern CA2-Access, CA2-Ext, and the eastern portion of the SF. Scallops of 100-120mm SH were widely distributed in moderate densities (1-5 scallops/m^2) in eastern CA2-

Access, and throughout most of the CA2-Ext and SF SAMS areas. Total biomass derived from RSA HabCam data in CA2-Access was 11,710 mt, which is a substantial increase from 2018 estimates. However, estimated total biomass in CA2-Ext decreased to 6,714 mt – likely due in part to moderate fishing pressure.

Mid-Atlantic

In 2015, an exceptional number of predominantly 2-year-old scallops (2013 year-class) were observed in the Mid-Atlantic scallop management areas. A large portion was located within the ET management areas, but the set area extended northwards through LI and BI. To date, this find of billions of juvenile scallops remains the most significant set in the Mid-Atlantic in recent history, with the previously most significant set having taken place in 2007. In subsequent years, intense fishing pressure and a lack of significant recruitment has resulted in declining biomass, particularly in the southernmost management areas of Virginia and Delmarva.

Generally, optical surveying of the open bottom areas in the Mid-Atlantic has been patchy. Surveys by the NEFSC have been limited in recent years, and closer attention has typically been paid to surveying and assessing Mid-Atlantic rotational areas. The LI and NYB biomass estimates have remained relatively steady in recent years, and there has recently been a greater attention placed on surveying these areas, particularly as the high density 2013-year class set in the ET has declined.

In 2019, the NEFSC conducted HabCam comprehensive tracks throughout the entire Mid-Atlantic region. The most significant biomass was found in the HCS and, ET Open and Flex areas, as in previous years. Within the open bottom areas, low abundance of recruit scallops was found, though a small patch was noted in the southern portion of NYB. Recruit and large adult (> 75 mm) scallops were found throughout LI and NYB, though not in significant densities.

PROJECT GOALS AND OBJECTIVES

The overarching goal of this survey was to provide data for biomass estimates to the Atlantic Sea Scallop PDT to inform management decisions. The primary objectives of the project were to:

1. Provide photographic imagery from proposed optical transects in the survey areas
2. Create GIS-based plots of scallop distribution and density by size and length-frequency distributions of scallops within the survey areas
3. Calculate overall biomass (total and exploitable) within each SAMS area surveyed

METHODS

In 2020, CFF collaborated with Arnie's Fisheries, Inc. and the F/V *Kathy Marie* to complete three legs of surveys which covered nearly 1,800 nm of systematic zigzag tracks in the following areas:

- **Leg 1**: CA2-SE and CA2-SW, CA2-Ext and the SF scallop management areas. The NLS-S scallop management area was also included.
- **Leg 2**: Elephant Trunk Open (ET-Open) and Flex (ET-Flex), and HCS scallop management areas.

- **Leg 3**: Mid-Atlantic open areas north of HCS including BI, LI, and the NYB scallop management areas.

In 2021, CFF collaborated with Arnie's Fisheries, Inc. and the F/V *Kathy Marie* to complete over 2,100 nm of systematic zigzag survey track in the following areas:

- **Leg 1**: CA2-SE, CA2-SW, CA2-Ext, and the SF scallop management areas. The NLS-S scallop management area was also included.
- **Leg 2**: ET-Open, ET-Flex and HCS scallop management areas (along with surrounding areas covered in NA21NMF4540018)
- **Leg 3**: Mid-Atlantic open areas north of HCS including BI, LI, and the NYB scallop management areas (part of grant **NA21NMF4540018** and are not covered in this report). These areas were covered as part of this grant in 2020 only.

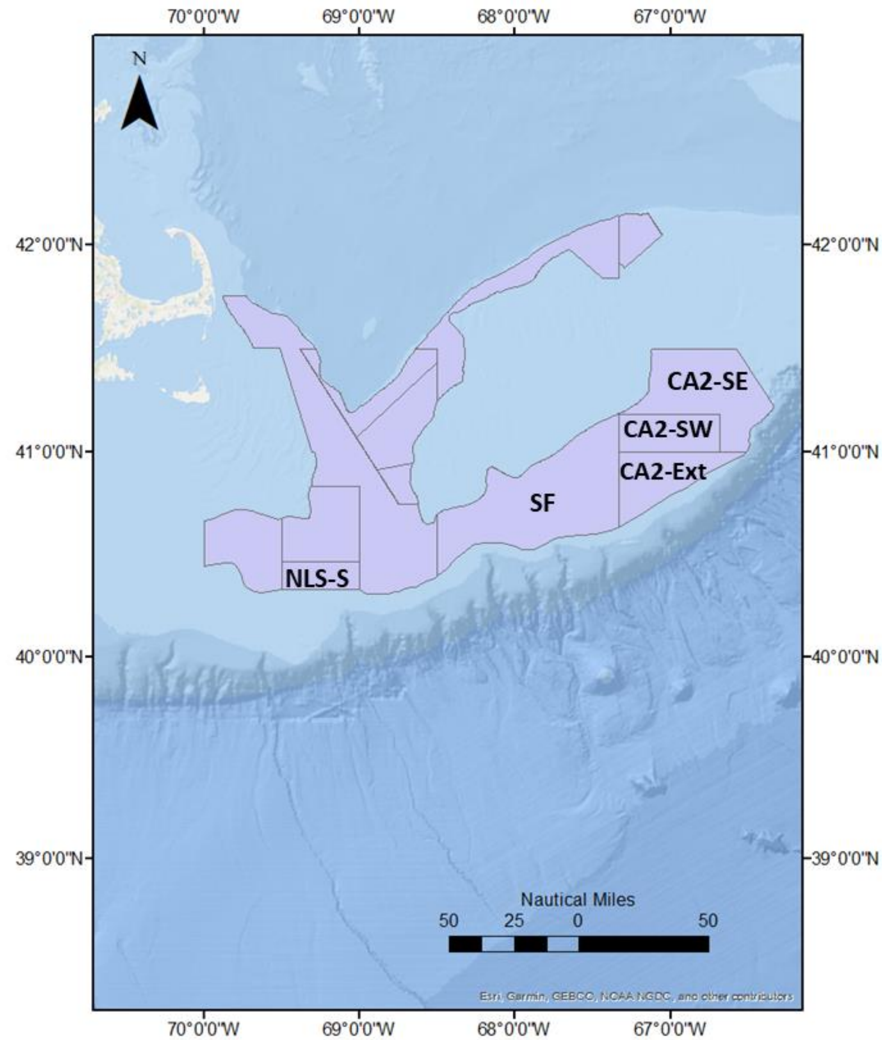

Figure 1: Map of SAMS areas in Georges Bank and NLS covered under this grant.

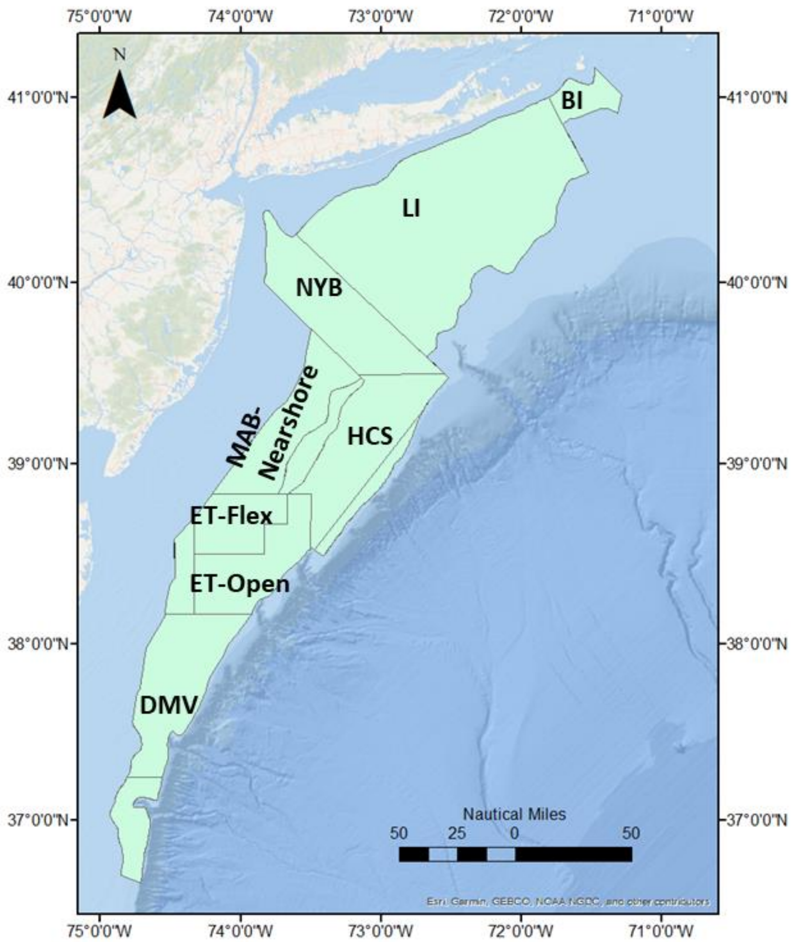

Figure 2: Map of SAMS areas in the Mid-Atlantic covered during the two years of this report.

The HabCam v3 optical imaging system was "flown" 1.5 to 2.5 meters off the seafloor while being towed at 4-5 knots. Raw image stereo pairs were captured and saved as 12-bit high dynamic range Tagged Image Format (TIF) files to a Synology Network Attached Storage system. The TIF files also contain image-specific associated metadata (e.g., date, time, latitude, longitude, temperature, conductivity, speed, vessel sounder depth, and heading). After collection, copies of the lefthand raw TIF files were processed into 8-bit JPG image files, which were used for annotation. Of the ~15 million stereo image pairs collected, over 16,000 were annotated in 2020. In 2021, fewer SAMS areas were surveyed in the Mid-Atlantic under this grant. Of the areas surveyed, more than 10 million were collected and over 10,000 images were annotated.

Images were annotated using a modified version of software developed by the Visual Geometry Group at Oxford University for image annotation (Dutta & Zisserman, 2019). The new image annotation GUI has been optimized from VIA Version 3 (available at http://www.robots.ox.ac.uk/~vgg/software/via/) for current data acquisition methods and needs with the addition of sliders for adjusting image contrast and brightness, new zoom features to aid in identification of small objects, and improvements to GUI layout. Scallops were counted and measured, while fish, sea stars, and other organisms of interest were counted (bound by box). Scallop SHs were measured when the hinge was visible – if this was not possible, scallop shell width was used in lieu of height.

All annotated images were reviewed for quality control prior to final data being sent to the NEFSC for biomass modeling. QA/QC was performed on a minimum of 50% of the annotated images although most surveys achieved 100% QA/QC rate for annotations.

Data files containing raw annotation data and image metadata were supplied to NEFSC Population Dynamic Branch staff for biomass modeling. The resulting image-based annotation data was also plotted for scallop size distributions (numbers of scallops per image) and scallop length-frequency distributions by SAMS area. Additionally, CFF supplied NEFSC with all raw TIFF files collected for each day for both 2020 and 2021 surveys.

Biomass estimates

Scallop lengths were initially recorded in pixels and were subsequently converted into SHs in millimeters based on the image field of view. Each SH measured from the HabCam images was converted to a meat weight (MW) in grams using published location-specific SH-MW equations that include depth as a covariate (e.g., Hennen and Hart 2012).

CFF biomass estimates were derived using a stratified mean estimation by depth, with images aggregated over 1,000m to 2,000m segments to minimize spatial autocorrelation along tracks. Total and exploitable biomass estimates were supplied to NEFSC and the Scallop PDT. Raw annotation data were additionally supplied to the NEFSC to generate resource-wide, model-based biomass estimates (Chang et al. 2017), with HabCam v3 data combined with HabCam data from NEFSC surveys.

Maps showing the spatial distribution of scallops, grouped by SH, as well as other spatial data, was generated using geospatial packages in R (R Core Team 2017). Growth, as a function of SH, and assessed using length-frequency analysis by SAMS area.

Results and Discussion

Biomass estimates

Table 1: Table of 2020 Total Biomass estimates from CFF surveys. Note that BI was surveyed in 2020 but biomass estimates were not included in this report as not enough area was surveyed to derive appropriate estimates.

GB	**NumMil**	**BmsMT**	**SE**	**MeanWt**	**Avg. Size mm**	**ExpBms**	**SE**	**Scallop density**	**HabCam images annotated**
CL2-Southeast	731.69	12607	3951.4	16.13	78.54	9886.7	3132.7	0.38	1134
CL2-Southwest	1028.23	21861.82	6687.15	21.17	93.49	11758.4	3546.5	0.88	723
CL2-Ext	876.91	11033.66	2271.93	12.73	74.19	4946.5	1113.7	0.7	1077
NLS-South-Deep	3054.63	41971.4	10693.01	14.11	95.31	23998.4	6074.1	5.35	858
SF	1063	14815.33	4031.5	13.56	79.98	8351.6	2426.9	0.29	2457
MidAtlantic									
LI	493.35	11469.75	6016.32	22.95	101.23	9101.0	4916.8	0.04	3834
NYB	474.54	8369.05	4333.63	19.75	95.79	5700.4	2937.8	0.1	1916
HCS	259.17	6337.05	2537.46	25.38	114.37	5489.8	2209.8	0.07	2007
ET-Open	351.66	10031.41	3543.14	28.22	116.66	9141.5	3265.1	0.14	1456
ET-Flex	240.31	6130.3	2746.84	27	113.25	5343.8	2440.0	0.13	1086

Table 2: Table of 2021 Total Biomass estimates from CFF surveys. Note that BI, LI, NYB, DMV, and MAB-Nearshore (highlighted) were surveyed under NA21NMF4540018.

CFF HabCam Total Biomass in 2021

Georges Bank	**NumMil**	**BmsMT**	**SE**	**MeanWt**	**Avg. Size mm**	**ExpBms MT**	**SE**	**Scallop density**	**HabCam images annotated**
CL2-Southeast	321.6	5192.6	1661.3	14.2	82	3407	1094.4	0.21	1624
CL2-Southwest	526.6	15313.9	4830.1	28.8	105.5	11547.5	3642.5	0.65	770
CL2-Ext	1069.1	19945	5514.2	18.8	91	11085.8	3165.7	0.88	939
NLS-South	1595.9	20347.2	7053.3	13	93	10709.3	3640.7	2.69	844
Southern Flank	703.5	12084	3631.7	16.7	91.2	7266.3	2519.4	0.20	1940
MidAtlantic									
BI	32.9	813.6	486.4	25.1	103.8	664.5	435.8	0.04	368
LI	632.9	14100	4197.2	21.8	99.5	11190.3	3482.9	0.05	4115
NYB	411.6	6123.8	2231.7	15.7	88.3	3666.2	1495.2	0.08	2047
MAB-Nearshore	31.3	919.1	533.2	31	116.1	804.2	491.7	0.01	1171
HCS	176.9	3818.3	1122.6	21.8	106.6	3115.8	1004.7	0.05	1796
ET-Open	69.1	1243.4	515	16.8	92.4	968.2	435.2	0.04	1530
ET-Flex	30.1	632.7	265.1	21.4	103.3	498.4	234.2	0.02	862
DMV	17.5	211.8	185.9	12.3	83.6	91	88.8	0.00	1510

CFF utilizes an industry-funded sister vehicle to the NEFSC's HabCam v4, and often runs supplementary tracks to those completed by the NEFSC. As the data produced from both vehicles are similar, the NEFSC combines CFF data with HabCam v4 data in their estimates, when deriving their biomass estimates. All scallop RSA-survey groups, including CFF, derive biomass estimates using independent methods which differ from those utilized by the NEFSC. Estimates derived by CFF have only been used as an extra data set for comparison when estimates from the other surveys vary significantly. The NEFSC generally applies a geostatistical model that includes a generalized additive model (GAM), with location and depth covariates to account for large scale trends, coupled with ordinary kriging (OK) of the model residuals to account for smaller scale variability specifically in the surveyed areas (GAM+OK model). When data limitations are an issue, the NEFSC may also use a design-based stratified mean estimation.

As noted in the methods section, CFF biomass estimates were derived using a simple stratified mean estimation method, with strata defined by depth and images aggregated over 1,000-to-2,000-meter segments to minimize spatial autocorrelation along tracks. CFF began testing this method hearing from commercial fisherman that they were weary of estimates derived using geostatistical models due to their complexity. CFF's goal has been to develop a method for deriving biomass estimates from HabCam data that is as concise and easy to replicate as methods used by SMAST and VIMS to derive their biomass estimates. Different methods (geostatistical model vs stratified mean estimation) and geostatistical models using different assumptions or covariates can produce different biomass estimates. Stratified mean estimates are also less accurate when sample coverage is not similar in all of the defined strata. Consequently, differences between the biomass estimates derived by CFF and the NEFSC are not surprising. NEFSC and CFF estimates have been similar overall since we began this effort in 2019, and CFF estimates also align well by scallop management area with other RSA-funded survey results. We plan to continue our efforts to develop an alternative and easily understood method for deriving biomass estimates from HabCam data and will refine our methods as needed.

Scallop size distributions and densities

2020 **2021**

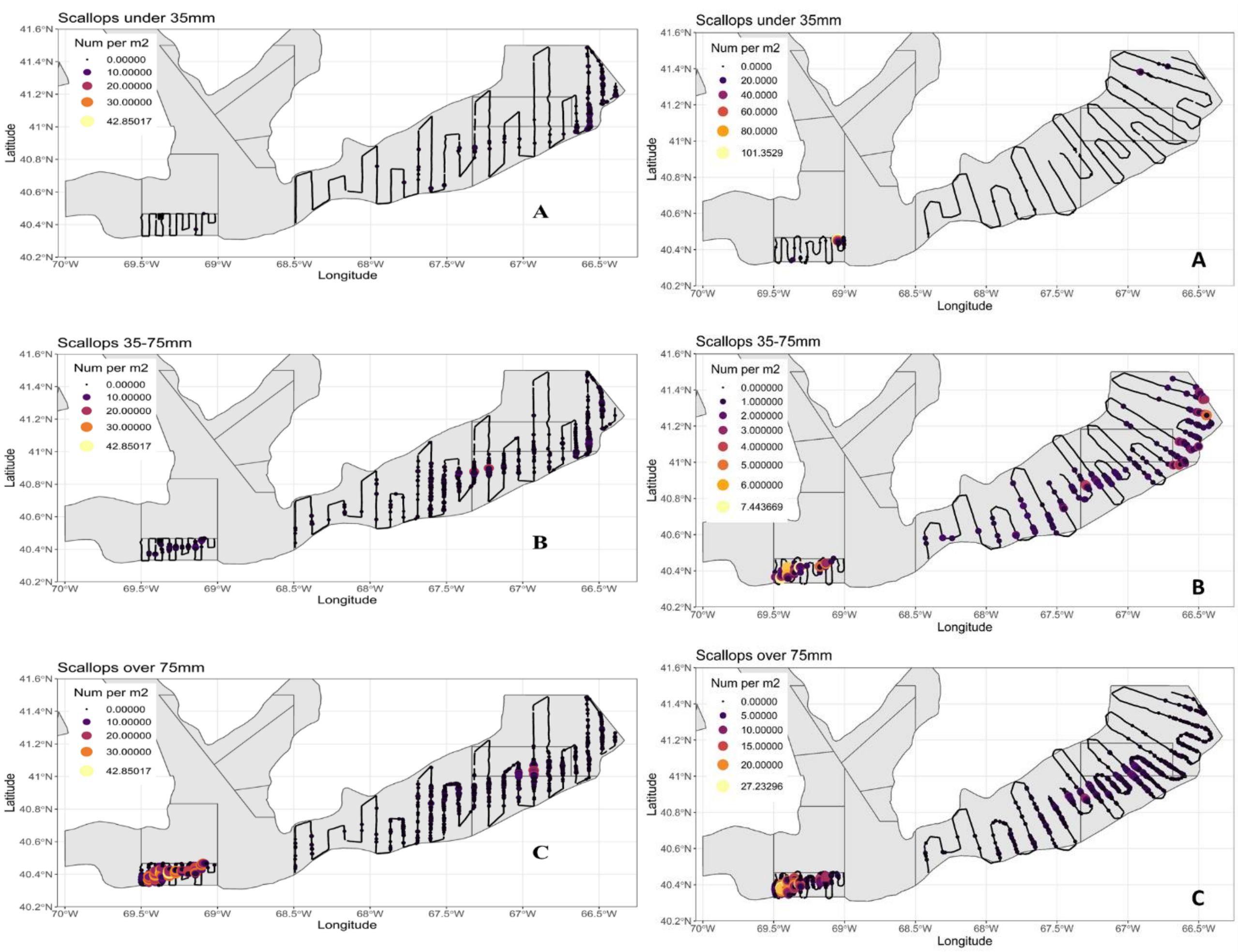

Figure 3: Density and distribution of sea scallops **A**:pre-recruit, **B**: recruits and **C**: adults in NLS-S and Georges Bank in 2020 and 2021. 2020 results are in the left column and 2021 is in the right column. Note that scales may not be the same between years and sizes.

The NLS-S opened to fishing prior to the 2020 field season. We noted signs of fishing pressure in 2020, such as increased dead scallop shells during our survey, and experienced increased water turbidity due to the high volume of scallop dredge vessels in the area. Intense fishing pressure continued through the 2021 fishing season and in the 2021 survey, the density and biomass of large scallops in the NLS-S was noticeably diminished from the 2020 and 2019 field seasons.

In 2020, relatively large quantity of pre-recruit (< 35 mm) scallops was seen in the most eastern portion of the CA2, including the CA2-SE and CA2-Ext (**Figure 3A**). This was by far the greatest quantity observed in Georges Bank on the CFF Survey, although smaller quantities were observed in small, patchy distributions throughout much of the track. In 2021, a small quantity of pre-recruit (< 35 mm) scallops was seen in the most northern portion of the CA2 (**Figure 3A**). The sediment in this area was characterized mainly by patches of thick bryozoans and sand.

In 2020, a strong number of recruit (35 mm – 75 mm) scallops were observed throughout Leg 1, but with patchy distribution in some areas (**Figure 3B**). Notably, this included an area in the eastern portion of the SF where pre-recruit scallops were observed in 2019. In 2020 and 2021, the greatest density of scallops > 75 mm was observed in the NLS (**Figure 3C**, both 2020 and 2021), just as in 2019. In 2021, the overall greatest numbers of scallops were found in NLS-S, followed closely by CA2-Ext.

In 2020 in the Mid-Atlantic, a relatively significant quantity of pre-recruit scallops was observed through the southeastern portion of LI and the adjoining eastern portion of NYB (**Figure 4A**). Large adult > 75 mm scallops comprised the vast majority of scallops found throughout all surveyed SAMS areas in the Mid-Atlantic in 2020 (**Figure 4C**) and recruit scallops (35 mm-75 mm) scallops were sparse throughout SAMS areas surveyed in the Mid-Atlantic (**Figure 4B**).

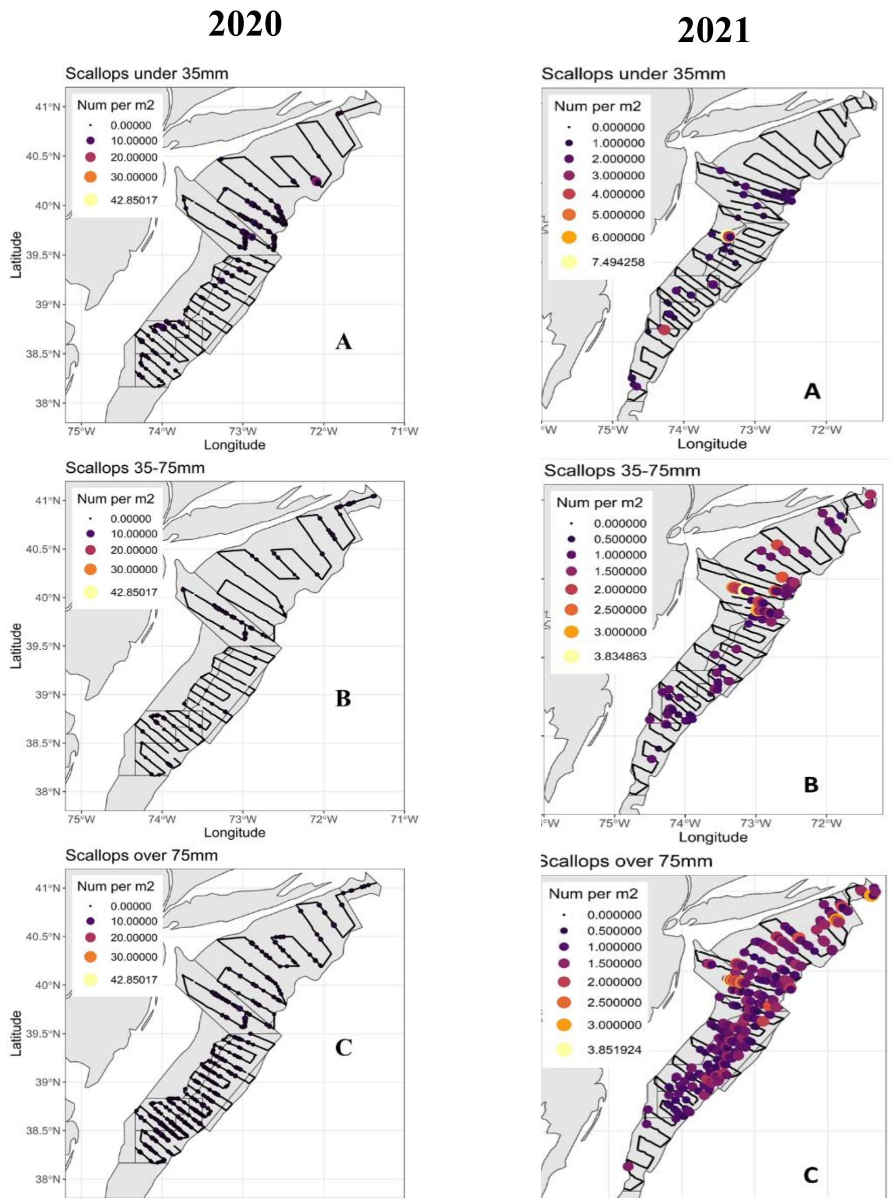

Figure 4: Density and distribution of sea scallops **A**:pre-recruits, **B**: recruits and **C**: adults in the Mid-Atlantic for 2020 and 2021. Note that the maps do not have the same scale between years.

In 2021, only HCS and the ET-Open and -Flex were surveyed under this grant in the Mid-Atlantic. Of these areas, the largest proportion of pre-recruit scallops (< 35 mm) were noted in the northernmost areas of HCS, which extended into the southern portion of NYB (**Figure 4A**). This encouraged conversations between the Scallop PDT and survey members to enact a closure. In 2020 and 2021, pre-recruit and recruit scallops (35 mm – 75 mm) were found in patchy distributions throughout all surveyed areas; however, adult scallops >75 mm were the most prevalent in both years in HCS, ET-Flex and -Open (**Figure 4C**).

Length-frequency distributions

In 2019, CFF noted a ~10 mm increase in average SHs in NLS-S. This was significant at the time, as the “Peter Pan” scallops had typically grown at a much lower rate. From 2020 to 2021 the average SH decreased by nearly 2 mm (**Figures 5 and 6**). Prior to the 2020 field season, the area had been opened to fishing, as previously noted. Thus, this change in average height was likely due to the increased fishing pressure on large adult scallops rather than a decrease in growth. In Georges Bank, the average scallop sizes for all four areas surveyed increase between 3 mm and 17 mm (**Figures 5 and 6**).

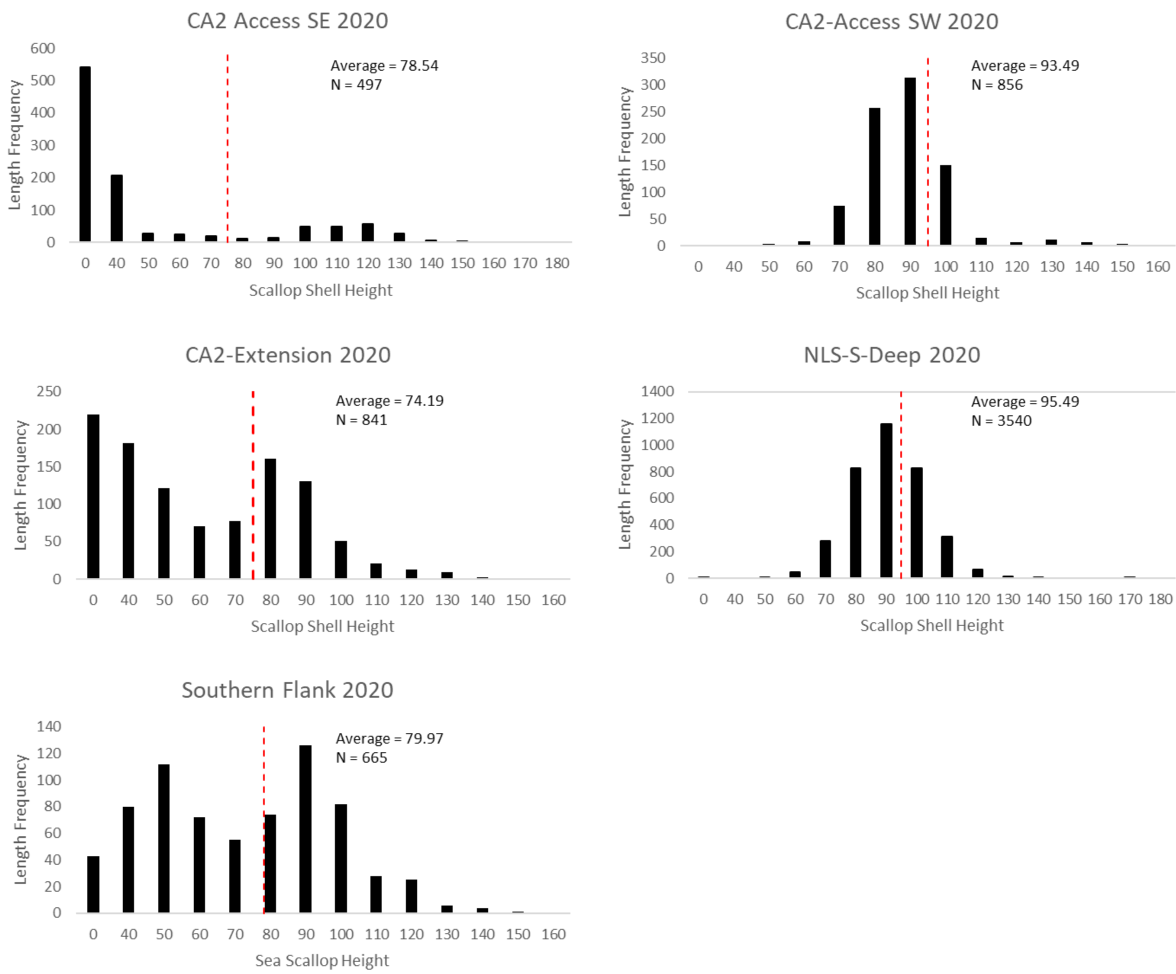

Figure 5: Length Frequency graphs for SAMS areas in Georges Bank and NLS in 2020. All lengths given in mm. All scallop lengths under 40 mm are aggregated in the 0 bin. Scallop average length and numbers include only scallops greater than or equal to 40mm.

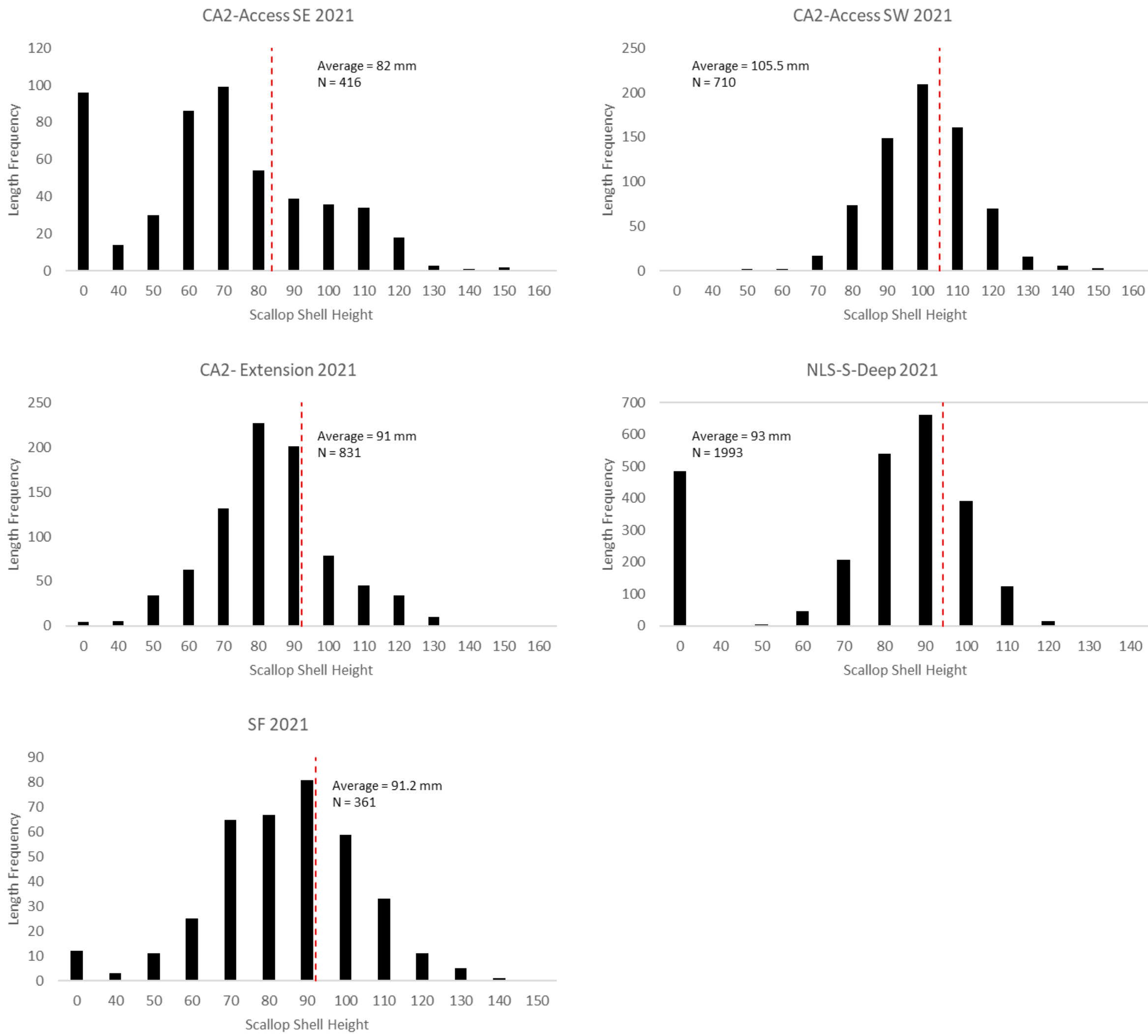

Figure 6: Length Frequency graphs for SAMS areas in Georges Bank and NLS in 2021. All lengths given in mm. All scallop lengths under 40 mm are aggregated in the 0 bin. Scallop average length and numbers include only scallops greater than or equal to 40mm.

In the Mid-Atlantic, only HCS and the ET-Open and -Flex were surveyed under this grant in both 2020 and 2021. The average scallop sizes for all three areas decreased slightly from 2020-2021 (**Figures 7 and 8**), though all three areas were predominantly composed of large adult scallops and had average shell heights above 75 mm.

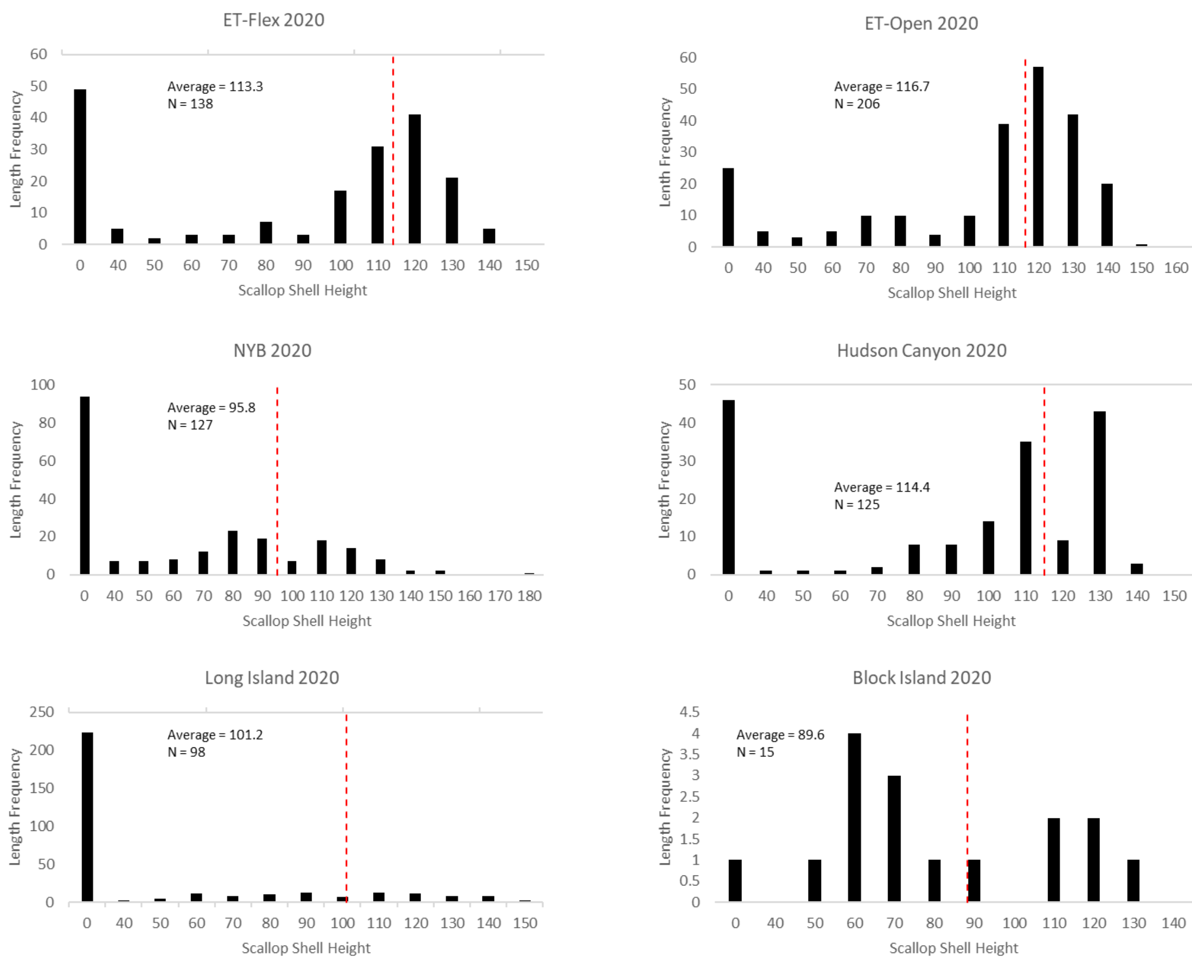

Figure 7: Length Frequency graphs for SAMS areas in the Mid-Atlantic and SNE in 2020. All lengths given in mm. All scallop lengths under 40 mm are aggregated in the 0 bin. Scallop average length and numbers include only scallops greater than or equal to 40mm.

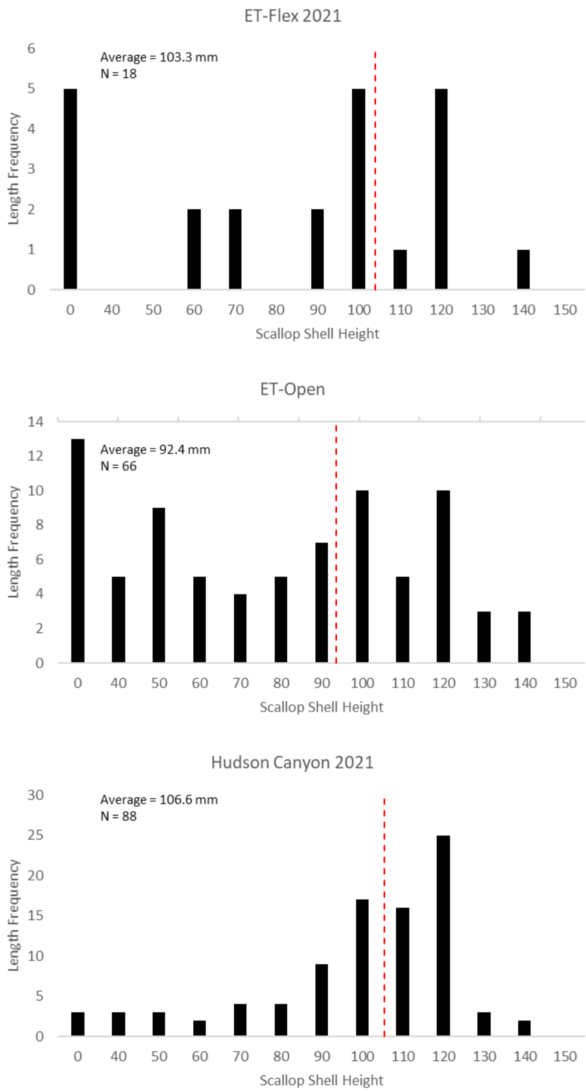

Figure 8: Length frequency graphs for the Mid-Atlantic SAMS areas surveyed by CFF in 2021 as part of this RSA-funded grant. All lengths are in mm. All scallop lengths under 40 mm are aggregated in the 0 bin. Scallop average length and numbers include only scallops greater than or equal to 40mm.

ACCOMPLISHMENTS BY OBJECTIVE

Objective 1: Provide photographic imagery from proposed optical transects in the survey areas

CFF was able to provide timely estimates of scallop counts and size distributions throughout fully surveyed SAMS areas in both years. Biomass estimates and size distributions (length-frequency and spatial distribution) for the entire tracks by SAMS areas were presented to the Atlantic Sea Scallop PDT in September of 2020 and 2021.

Objective 2: Create GIS-based plots of scallop distribution and density by size and length-frequency distributions of scallops within the survey areas

CFF was able to derive SAMS-area-specific length-frequency distributions within all fully surveyed SAMS areas.

Objective 3: Calculate overall biomass (total and exploitable) within each SAMS area surveyed

Total and exploitable biomass estimates were derived and provided to the Scallop PDT in September/October of each year (**Tables 1 and 2**).

ADDITIONAL OBSERVATIONS

A notable number of seed scallops were found in the northeast corner of the NLS-S (**Figure 9**). Up to 70-100 per/m^2 were found in a subset of annotated imagery. Although other small seed areas were noted throughout both the 2020 and 2021 season, this was unique as the numbers per/m^2 were particularly significant, and a large seeding event has not been noted recently in this area. This area will be surveyed by CFF in 2022 and tracking this potential cohort of scallops will be a focus of survey efforts in this area.

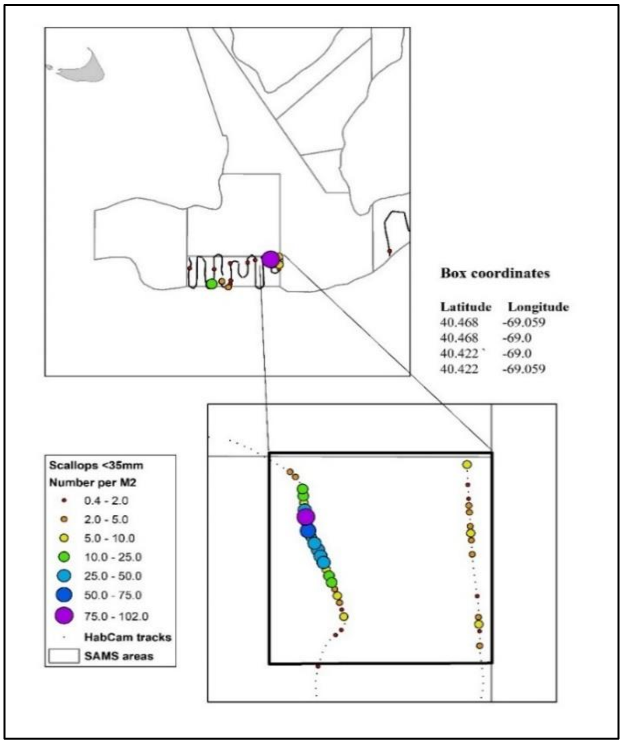

Figure 9: Map of notable seed observation in NLS-S in 2021.

FUTURE RESEARCH RECOMMENDATIONS

The range of annotation rates required for accurate estimates of biomass and abundance for scallop assessments have been widely discussed during scallop survey workgroup, and Scallop PDT meetings. It would be beneficial to compare estimates of biomass and abundance by SAMS areas using a range of annotation rates since this has not been done recently. Currently, there is not a firm understanding regarding what level of annotations are needed for each SAMS area at current scallop densities to accurately assess the distributions of biomass and abundance using the preferred geostatistical methods or other models for estimation.

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