New England Fishery Management Council
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MEMORANDUM

DATE: November 17, 2020

TO: Science and Statistical Committee

FROM: Scallop Plan Development Team (PDT)

SUBJECT: PDT recommendations for OFL and ABC for Framework 33 (FY2021 and FY2022 default)

This memorandum addresses the following 2020 SSC terms of reference for Atlantic sea scallops and SSC recommendations from 2019.

2020 SSC Terms of Reference:

1. Review changes to meat weights and dredge efficiency used to develop 2020 survey estimates, and growth and selectivity parameters used in the SAMS model to project biomass. Evaluate the PDT's approach for addressing survey data gaps that resulted from canceled surveys due to the COVID-19 pandemic. Provide the Council with a recommendation as to whether these changes are appropriate.
2. Using reference points updated by the management track assessment (2020), and considering the Council's Risk Policy Statement, review the Scallop PDT's updated projections for the scallop resource, and provide the Council with OFL and ABC recommendations using the Council's ABC control rule for fishing years 2021 and 2022 (default).

Updates on 2019 SSC Recommendations:

1. In the fishery access areas, the fishery is harvesting the available strong year classes, but in some areas these year-classes are disappearing faster than what was expected (specifically the Nantucket Lightship West Area) when considering both fishing and assumed natural mortality rates. This does not represent a threat to the stock at this point but is something that should be closely monitored.
2. Further investigation into the: 1) different growth rates found in different scallop harvesting areas, particularly the Nantucket Lightship region, 2) further work to develop gonad-based estimates of SSB and reference points.

The PDT met on November 5, 10, and 16, 2020 to discuss survey results, and review the OFL and ABC estimates for FY2021 and FY2022. More details will be provided during the presentation of this recommendation at the SSC meeting on November 23, 2020.

PDT Consensus Statement:

The Scallop PDT recommends that the SAMS model estimates for OFL and ABC for 2021 and 2022 (default) be presented to the SSC (Table 1). The PDT recommends the following adjustments to 2020 survey data and projections to account for unique characteristics of scallops in specific management areas. The SSC has approved these changes for several years, but the PDT feels that there is value in continuing to assess and evaluate them each year:

- Adjustments to the 2020 survey data:
    - Shell-Height and Meat Weight (SH-MW) Relationships: SH-MW parameters were updated through SARC 65. As with previous years, the PDT recommends using area-specific SH-MW parameter estimates from the dredge survey in the Nantucket Lightship region.
    - Dredge Efficiency: Dredge efficiency in high density areas continues to be an issue. For the NLS-South, the PDT recommends decreasing dredge efficiency by two thirds, from 0.4 to 0.13. This recommendation is based on peer-reviewed findings from SARC 65.
- Adjustments to projections for FY 2021 (SAMS model):
    - Growth: The 2020 management track assessment adjusted growth to assumptions to match slower growth in the Georges Bank and the Mid-Atlantic regions since the 2018 benchmark assessment. The PDT recommends that SAMS area growth assumptions ($L\infty$) be scaled to match the slower growth rates applied in the more recent growth period of the 2020 management track update, with two exceptions.
    - Selectivity: The PDT recommends applying the SARC 65 Georges Bank Open selectivity curve as estimated in the CASA model in the Nantucket South area. The Georges Bank Closed selectivity curve reflects targeting of very large scallops; however, considering that the year class in the Nantucket Lightship South area is smaller than normal, it is unlikely that the Georges Bank Closed selectivity would apply.

The PDT notes that the updated OFL and ABC values are based on updated reference points from the 2020 management track assessment (OFL F=0.61; ABC F=0.45) and are relatively lower than values used in recent years following the 2018 benchmark assessment (SARC 65, see Table 11). The updated OFL and ABC estimates for 2021 are very similar to the 2021 projection that was approved by the SSC in October 2019. Both the 2021 and 2022 biomass estimates indicate a decline from the record high levels observed in recent years. This decline is attributed to the continued harvest of the extraordinarily large 2012- and 2013-year classes, and the absence of strong recruitment in subsequent years. The exceptionally strong year classes in the Mid-Atlantic Access Area and Nantucket Lightship region no longer make up the majority of exploitable biomass. Instead, the access areas on eastern Georges Bank hold around twice the biomass of either the MAAA or Nantucket Lightship regions. Almost half of the population is considered exploitable (Table 2). The scallop fishery is expected to continue harvesting the 2012- and 2013-year-classes in FY2021 and beyond, resulting in an expected decline in biomass as these animals are removed from the population.

The PDT cautions that if higher than expected natural, incidental, or discard mortality occurs, biomass estimates will be overestimated, especially for 2022.

Looking ahead, there are several reasons for the decline in OFL and ABC estimates between 2021 and 2022: (1) the strong 2012- & 2013-year classes are being fished, and (2) an extended period of low recruitment since 2013.

Table 1 – Scallop PDT recommendation for OFL and ABC for Framework 33, Fishing years 2021 and 2022 (default). Values shown in metric tons (mt). Bold numbers are the OFL and ABC values to be considered as recommendations to the Council for 2021 and 2022.

Year	ABC-Land	ABC-Disc	**ABC-Tot**	OFL-Land	OFL-Disc	**OFL-Total**
2021	30,517	5,110	**35,627**	38,714	6,678	**45,392**
2022	28,074	4,798	**32,872**	35,636	6,290	**41,926**

Table 2 - Estimated biomass (mt) and exploitable biomass (mt) for FY 2021 and FY 2022.

Year	Biomass	Exploitable Biomass	Percent Exploitable
2021	147,298	67,026	46%
2022	137,668	74,845	54%

Background: 2020 Management Track Assessment

A management track assessment for Atlantic sea scallops was completed in 2020 (NEFSC 2020). In 2019, the stock was not overfished and overfishing was not occurring. Over the last two years (2018 and 2019), biomass is estimated to have declined from the highest point in the timeseries (2017), while fishing mortality has increased from the lowest point in the series (1975 to 2019). The PDT reviewed updated methods and key findings from the 2020 Management Track Assessment at their October 15th, 2020 meeting.

- The CASA model accounts for periodic shifts in growth rates for the Georges Bank and Mid-Atlantic regions over time and considers region-wide (i.e., Georges Bank, Mid-Atlantic) growth parameters when making retrospective estimates of biomass. The 2020 assessment update adjusted growth rates to account for slower than expected growth in the more recent time period.
- For the combined GB Closed, GB Open, and Mid-Atlantic models, fully recruited fishing mortality decreased since 2000 to an all-time low in 2017 and fully recruited biomass was at its highest point in the time series. Excluding the slow growing animals in the deep water portion of the NLS-South (i.e. "Peter Pans"), scallop biomass in 2019 was estimated to be 147,073 mt meats (roughly 324 million pounds) and fishing mortality was estimated to be 0.34. The Georges Bank closed model estimated fishing mortality in to be F=0.53 in 2019, while the Georges Bank open model estimated fishing mortality to be F=0.61. Fishing mortality was estimated to be F=0.19 in the Mid-Atlantic (see Figure 1).
- Reference points were estimated using the SYM model. The most recent period of data was used to estimate yield and biomass per recruit in meat weight, and stock-recruit curves were estimated using recruitment and spawning stock biomass estimates from CASA model runs. See Table 3 for updated reference point values.

Figure 1 – CASA model estimates of fishing mortality from 2020 management track assessment.

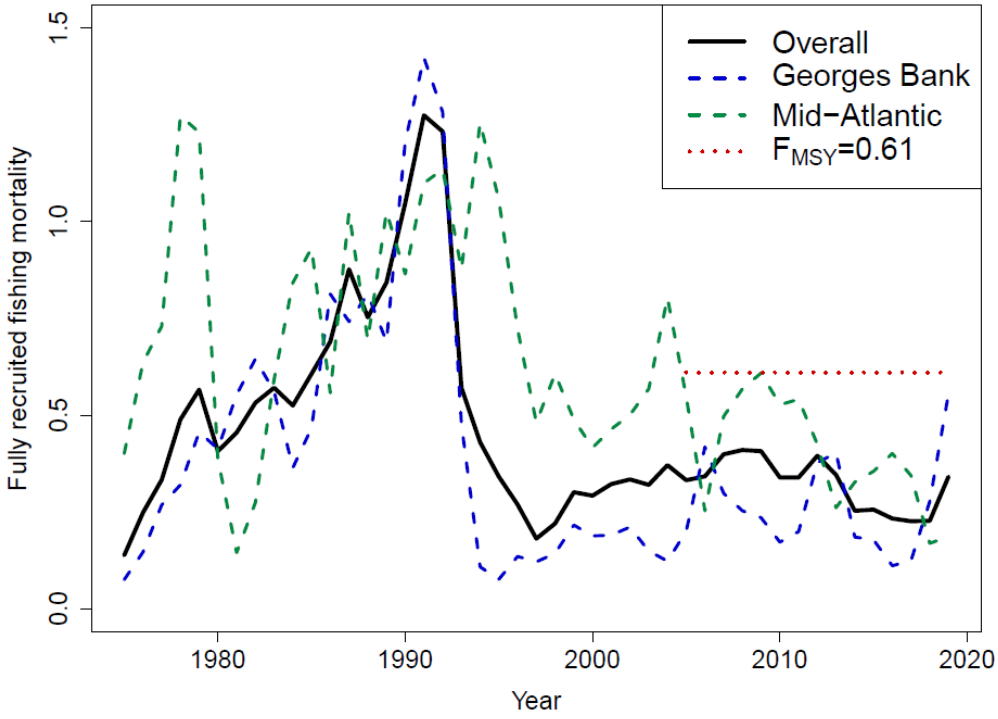


Table 3 - Comparison of biological reference points from last three scallop benchmark assessments.

	Definition in Scallop FMP	SARC 50 (2010)	SARC 59 (2014)	SARC 65 (2018)	2020 Management Track
OFL	F_{MSY}	F=0.38	F=0.48	F=0.64	F=0.61
ABC=ACL	25% probability of exceeding the OFL	F=0.32	F=0.38	F=0.51	F=0.45
B_{MSY}	B_{TARGET}	125,358 mt	96,480 mt	116,766 mt	102,657 mt
1/2 B_{MSY}	$B_{THRESHOLD}$	62,679 mt	48,240 mt	58,383 mt	51,329 mt
MSY		24,975 mt	23,798 mt	46,531 mt	32,079 mt
Overfished?	$B < B_{THRESHOLD}$	No	No	No	No
Overfishing?	$F < F_{THRESHOLD}=F_{MSY}$	No	No	No	No

Adjustments to the SAMS Forecasting Model

The CASA model accounts for periodic shifts in growth rates for the Georges Bank and Mid-Atlantic regions over time and considers region-wide (i.e., Georges Bank, Mid-Atlantic) growth parameters when making retrospective estimates of biomass. The 2020 assessment update adjusted growth rates to account for slower than expected growth in the more recent time period. This was a change from the 2018 benchmark assessment, which estimated growth in the 2012-2016 period to be the fastest on record.

In addition to the change in growth stanzas in the 2020 update assessment, slower than expected growth was observed in the 2020 surveys. The PDT compared the projected biomass for 2020 based on 2019 surveys with observations from the 2020 surveys and found that in most areas the projections were overly optimistic.

First, the PDT compared the survey estimates with projections since SARC 65 (i.e., 2019 and 2020) by calculating the projection error. The projection error is calculated as 100*(predicted - observed) /predicted. Positive error means the projection was an overestimate, and negative error means the projection was an underestimate. The most overestimated points on GB for both years was NLS-W. The two areas where the projections had the greatest negative error (i.e., underestimates) in 2020 were Closed Area II Southwest (CL2-SW) and Closed Area II Extension (CL2-Ext), likely due to strong recruitment in these areas. Similarly, overestimation in the Mid-Atlantic region during both years is in part due to poor observed recruitment.

Second, the PDT compared the observed number per tow from the 2020 survey dredge with 2020 projections based on 2019 survey data. Predicted numbers per tow were both higher and lower than what was observed in 2020, depending on the SAMS area, though most projections overestimated recruitment and growth. This suggests that some combination of realized *F*, *M*, and growth was different than what was assumed in the 2019 SAMS model run. Projections were for a 12-month period following the 2019 surveys. The 2020 survey data were collected ~14 months after the 2019 surveys due to COVID-19 delays. The PDT suspects that additional *Z* over the extra two months would be less than *Z*=0.1. Error in surveys could explain some of the difference in observed versus projected L-Fs; for example, if both the 2019 and 2020 surveys in an area have 20% CVs, projections and surveys could differ by up to 50% due to survey error alone.

The SAMS model considers area-specific (i.e., by SAMS area) growth parameters (i.e., L_∞, k) when making forward projections of biomass. The PDT discussed the variability in growth rates over time in the context of SAMS model performance in recent years, and noted that growth assumptions that are faster than realized growth could contribute to projections being overly optimistic. To address this, the PDT recommends that SAMS area-specific assumptions of L_∞ be scaled down proportionally from the most recent CASA period (i.e., 2012-2016) to the slowest growth period for the different regions included in CASA (i.e., 1993-1996 for Georges Bank, 1975-1977;1987-2003;2006 for Mid-Atlantic) (Table 4).

Figure 2 - Comparison of 2019 L-F projections with 2020 dredge survey data. See Appendix IV for all SAMS areas.

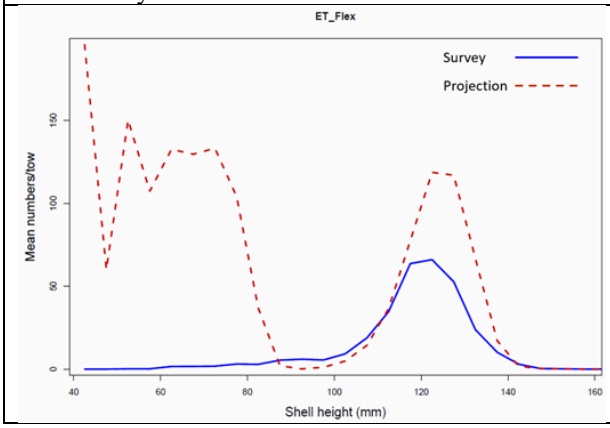
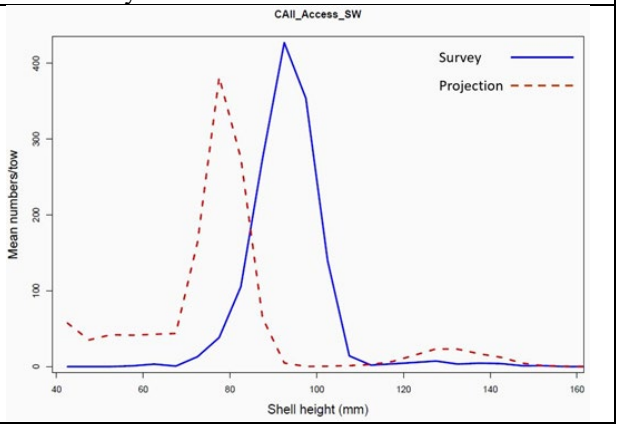
Example of projection overestimating recruitment and growth in the Elephant Trunk Flex Area relative to the 2019 surveys.	Example of projection under-estimating abundance and growth in Closed Area II Southwest relative to the 2019 surveys.
	

Figure 3 - Comparison of projection error for 2019 and 2020 by region (top) and access and open areas (bottom). The percent error is calculated as 100*(predicted-observed)/predicted.

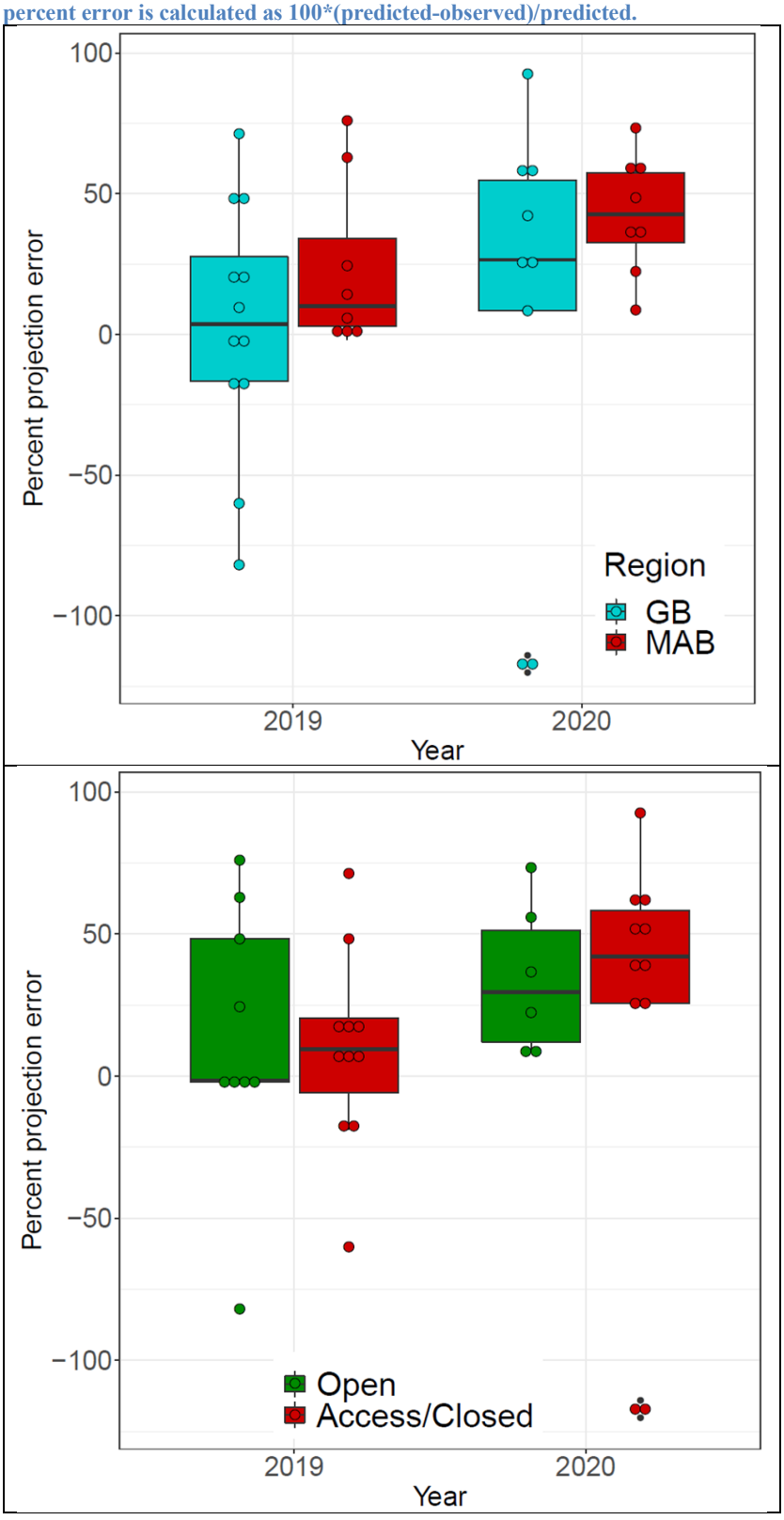


Table 4 - Comparison of SARC 65 and FW33 growth parameters

		SARC-65		FW-33	
Subarea	**Years**	**L_∞**	**K**	**L_∞**	**K**
Sch	**12-16**	**150.3**	**0.397**	**135.7**	**0.397**
NF	**12-16**	**148.8**	**0.397**	**134.3**	**0.397**
SF	**12-16**	**137.3**	**0.464**	**123.9**	**0.464**
CA-I	**12-16**	**149.4**	**0.397**	**134.5**	**0.397**
CA-II	**12-16**	**146.9**	**0.397**	**132.3**	**0.397**
CAII-SW	**12-16**	**146.9**	**0.397**	**146.9**	**0.397**
NLS	**12-16**	**151.2**	**0.397**	**136.1**	**0.397**
DSENLS	**15-16**	**110.3**	**0.423**	**110.3**	**0.423**
DMV	**08-12**	**136.4**	**0.547**	**130.5**	**0.547**
ET	**08-12**	**137.9**	**0.547**	**131.9**	**0.547**
HCS	**08-12**	**129.5**	**0.547**	**123.9**	**0.547**
NYB	**08-12**	**140.8**	**0.547**	**134.6**	**0.547**
LI	**08-12**	**139.6**	**0.547**	**133.5**	**0.547**
Inshore	**08-12**	**147.3**	**0.547**	**140.8**	**0.547**

Tracking High Densities of Scallops

Annual surveys have tracked the size and growth of scallops in high-density aggregations within the Nantucket Lightship region for several years. There is additional uncertainty associated with biomass estimates in these high-density areas. Scallops in parts of the Nantucket Lightship, such as the deep-water portion to the south, exhibited almost no growth between 2017 and 2018, moderate growth between 2018 and 2019, and very similar size distribution between 2019 and 2020 (Figure 4), which could be explained by fishing activity and(or) slower growth. Estimated abundance in the area has decreased since 2015 (Figure 6), with densities decreasing by roughly half between the 2019 and 2020 SMAST drop camera surveys of the area (Table 5). To address this uncertainty, the PDT recommends the following data treatments and modeling of scallops in the Nantucket Lightship to better account for the unique characteristics of animals in this area. Figure 1 describes FY2020 rotational management areas, SAMS estimation areas, and biomass estimates from the 2020 HabCam survey of the NLS-South.

Figure 4 – The Nantucket Lightship region, with FY2020 scallop rotational areas (black), SAMS areas (red), and predicted biomass estimates from the 2020 HabCam survey of the Nantucket Lightship South area (mt per km^2).

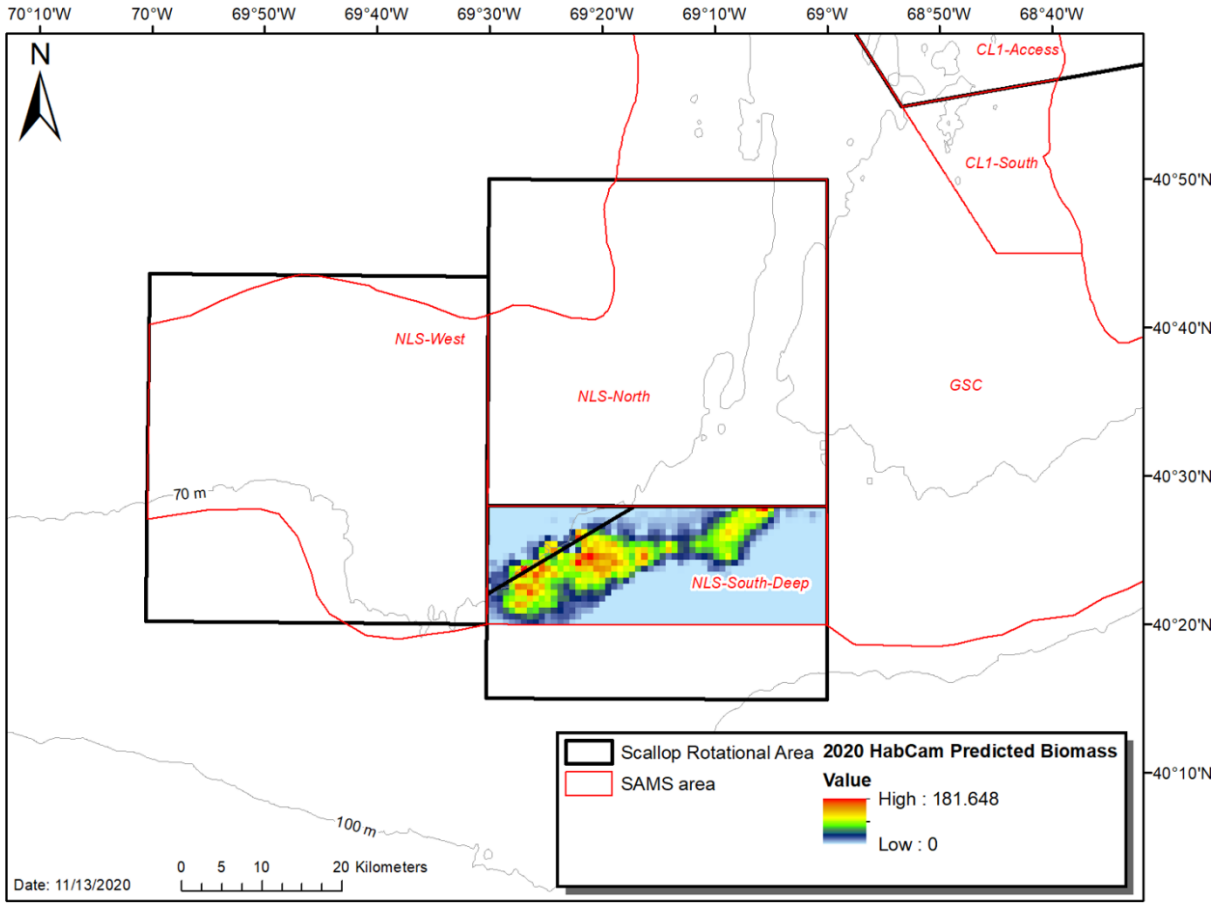


Figure 5 - Comparison of 2016 -2020 dredge survey observations in the NLS-South.

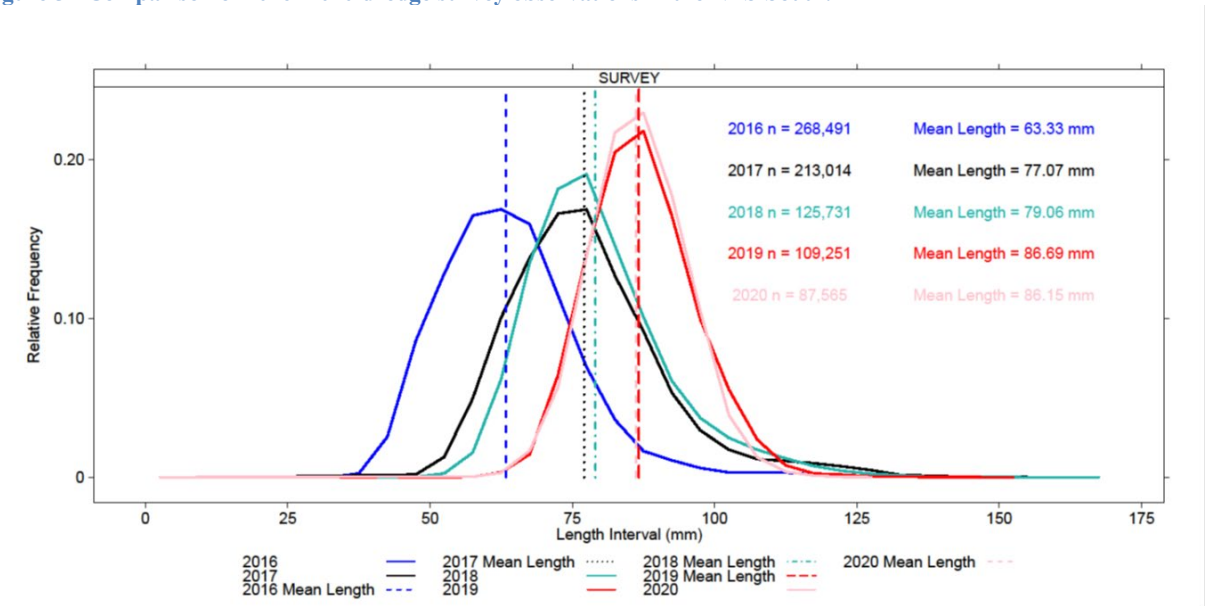
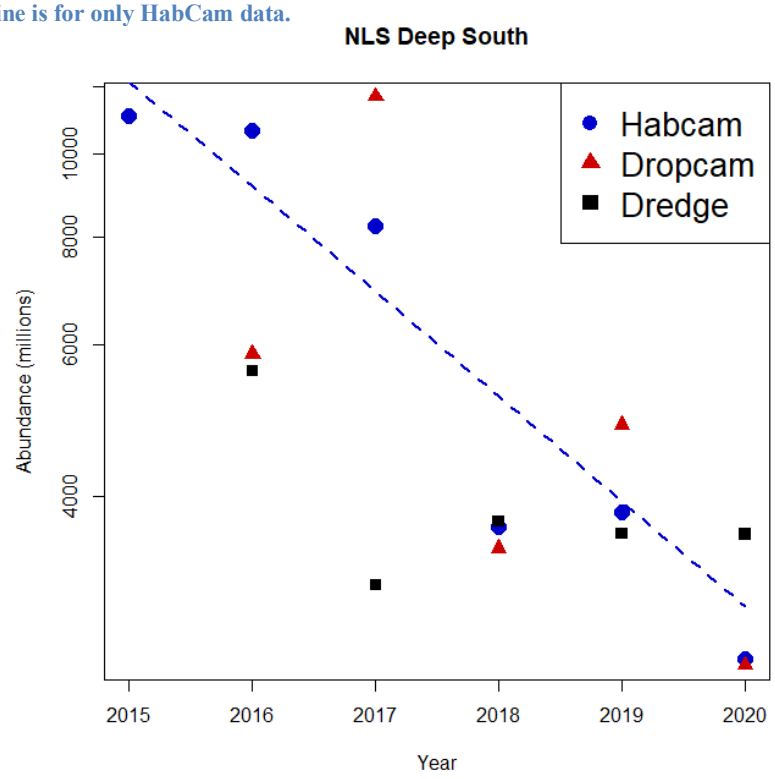


Table 5 – Scallop density per m^2 and average shell height from SMAST drop camera surveys of the NLS-South, 2017 to 2020.

Year	Density per m^2	Avg. Size
2017	13.66	73mm
2018	6.85	76mm
2019	6.26	87mm
2020	3.69	93mm

Figure 6 -Survey abundance estimates from 2015 – 2020 for dredge, Habcam, and Dropcamera surveys. The regression line is for only HabCam data.



Shell Height Meat Weight Parameters:

The PDT has recommended using data from recent dredge surveys to develop shell height to meat weight (SH-MW) parameters for specific areas of the Nantucket Lightship region (Table 6). This year, the PDT recommends using SH-MW parameters based on the last five years of dredge survey data. The PDT has recommended deviating from the SARC 65 SH-MW parameters in the NLS Region in the past to account for unique growth in the various SAMS areas in the Nantucket Lightship. This year, the difference in biomass estimates based on SARC 65 versus 2016-2020 dredge parameters is minimal; however, despite the apparent convergence in 2020, the PDT recommends continued use of dredge SH-MW parameters as these are based on the most recent data available and encompass several years of area specific growth in a part of the resource with unique growth characteristics.

This recommendation is also based on the difference between SH-MW estimates developed from data collected by dredge surveys since 2016 and SARC 65 estimates. The methods used to develop the VIMS 2016 – 2020 parameter estimates are described in Appendix II. The model

(nl3) included shell height, depth, and SAMS area as predictors (see Appendix II). Appendix IV provides a comparison of drop camera, HabCam, and dredge survey biomass estimates using SARC 65 and VIMS 2016 - 2020 SH-MW parameters. Note that the PDT also recommended reducing the dredge efficiency assumption from q=0.4 to q=0.13 in the NLS-S-deep, which is consistent with peer-reviewed data treatment methods in SARC 65, and results in a different final combined estimate.

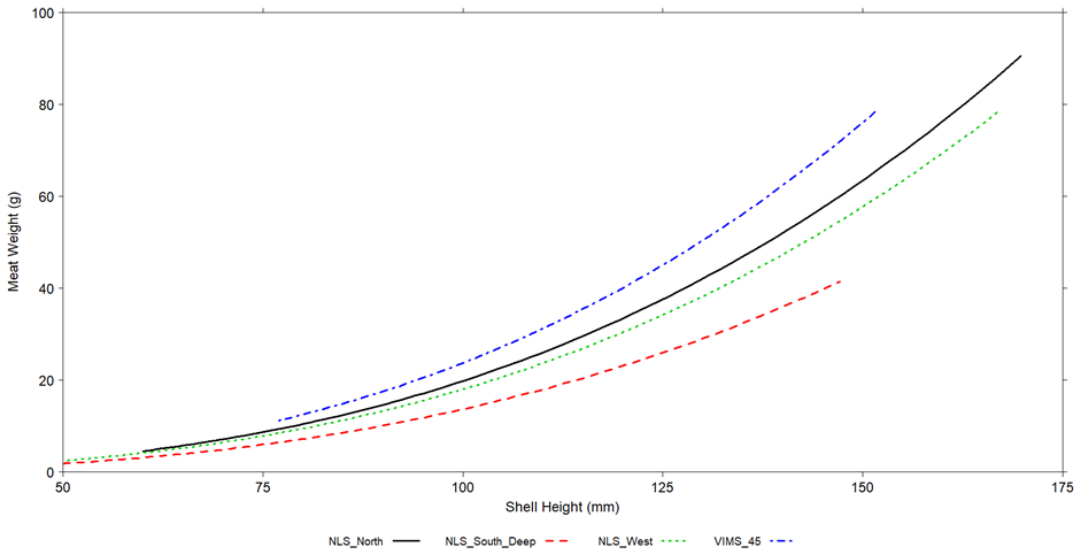
Table 6 - Description of the SH-MW changes in Nantucket Lightship SAMS areas from 2016 to 2020.

SAMS area	SH-MW applied in 2016, FW28	SH-MW applied in 2017, FW29	SH-MW applied in 2018, FW30	SH-MW applied in 2019, FW32	SH-MW applied in 2020, FW33
NLS-N	SARC 59	SARC 50	VIMS 2016-2018 Combined	VIMS 2016-2019 Combined	VIMS 2016-2020 Combined
NLS-S 'Shallow' (>70m)	SARC 59	SARC 50	VIMS 2016-2018 Combined (South Shallow only	VIMS 2016-2019 Combined	VIMS 2016-2020 Combined
NLS-S 'Deep' (<70m)	VIMS 2016	VIMS 2016/2017 Combined (NLS S)	VIMS 2016-2018 Combined (Deep only)	VIMS 2016-2019 Combined	(Merged into one SAMS area in 2020)
NLS-Ext	VIMS 2016	SARC 50	SARC 65	N/A (part of GSC)	N/A (part of GSC)
NLS-W	VIMS 2016	VIMS 2016/2017 Combined (NLS W)	VIMS 2016-2018 Combined (West only)	VIMS 2016-2019 Combined	VIMS 2016-2020 Combined
Estimate of relative meat weight were derived using the following assumptions: Length = 100 mm, mean depth by SAMS area used. Mean depth for NLS-S SAMS area calculated by depth bin. Mean latitude by SAMS area used for SARC 50.					

Table 7 - VIMS 2016 - 2020 shell-height meat weight parameter estimates (from model m4 in Appendix II).

Parameter	Parameter Estimate
Intercept	-24.04
log Shell Height	2.87
SAMS_AreasNLS_South_Deep	-0.27
SAMS_AreasNLS_West	-0.08
SAMS_AreasVIMS_45	0.02
log Depth	-0.25
Latitude	0.37

Figure 7 - Predicted SH-MW relationships by SAMS area for the NLS using model m4 (Appendix II).



Dredge Efficiency in High Density Area of Nantucket Lightship

In addition to uncertainty around assumptions of natural mortality and anomalously slow growth, there is also uncertainty related to biomass estimates in the high-density area of the Nantucket Lightship. From 2017 - 2020, there were large differences between the individual survey estimates of biomass the Nantucket Lightship South area where high densities of animals had been observed. In 2018, 2019, and 2020, the optical (i.e. HabCam and drop camera) survey estimates of biomass in the NLS-South were very similar, but several times greater than the dredge survey estimates. Generally, some level of variation between survey biomass estimates can be expected due to differences in survey methods and coverage levels by area; however, the dredge surveys have consistently been well below the optical surveys in high density areas. The PDT noted that a reduction in dredge efficiency could be a causative factor in explaining the divergence of the dredge and optical estimates in high density areas in 2020. This year, as with previous years, the PDT recommends reducing dredge efficiency by two thirds (.4*0.33) and averaging the estimates with other optical survey estimates, consistent with the approach used in SARC 65. The PDT noted that dropping the dredge estimate in this high-density area and averaging only optical estimates yields a similar result to averaging all surveys with the reduced dredge efficiency applied (Table 8).

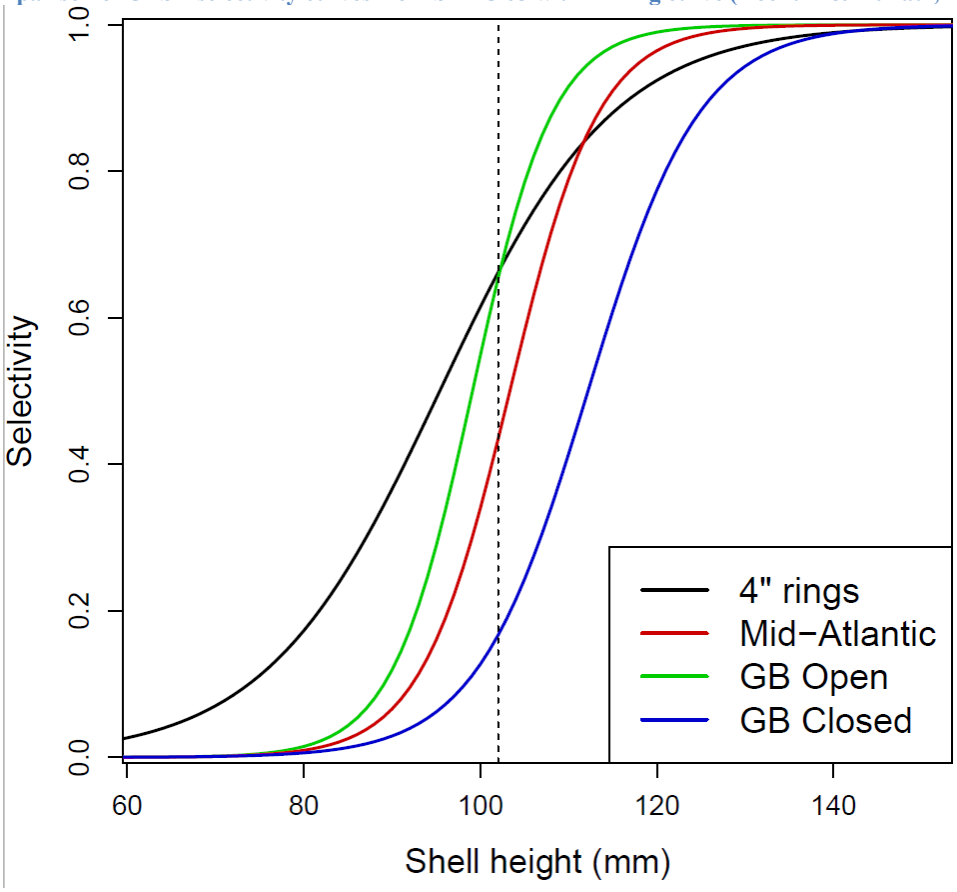
Table 8 - Comparison of 2020 survey biomass estimates in the NLS-South using VIMS 2016-2020 SH-MW parameters and varying dredge efficiency estimates (.4 and .13).

Scenario	Dredge (q=.4)	Dredge (q=.13)	DropCam	HabCam	Mean
Average 3 estimates	12,547		33,709	29,496	25,251
Average, reduce dredge efficiency from .4 to .13		38,606	33,709	29,496	33,937
Drop the dredge estimate			33,709	29,496	31,603

Selectivity in the Nantucket Lightship SAMS Area

Selectivity curves for each CASA region (Georges Bank Open, Georges Bank Closed, and Mid-Atlantic) were updated through SARC 65 and in the 2020 management track assessment. All three fishery selectivity curves are shifted to the right of the 4" ring selectivity curve (Yochum & DuPaul 2008), meaning that the fishery selects larger scallops relative to what the gear will retain (Figure 6). The Georges Bank selectivity curves are applied to finer-scale areas within the SAMS model. The Georges Bank Closed curve is normally used to calculate exploitable biomass in the Georges Bank access areas, and is expected to select around 50% of scallops at 110 mm, reflecting targeting and discarding practices that are typical in these areas, but are unlikely to occur in areas with mostly smaller scallops. The Georges Bank Closed curve selects larger scallops due the size of scallops and targeting behavior in these areas. The Georges Bank Open curve more closely follows the 4" ring curve (i.e. selects smaller scallops than the Georges Bank Closed curve) because of the size and fishing behavior in open areas under DAS management. Applying the Georges Bank Open curve allows selectivity for a larger proportion of scallops currently in the size distribution in the NLS-South. Similar to 2018 and 2019, the PDT recommends applying the Georges Bank Open selectivity curve in the Nantucket Lightship South area to select a larger proportion of the 9-year-olds in this area that have already recruited to the fishery but are not growing normally. As shown in Figure 4, the mean shell height in the NLS-South area in the 2020 surveys was 86.15mm.

Figure 8 - Comparison of CASA selectivity curves from SARC 65 with 4" ring curve (Yochum & DuPaul, 2008).



Block Island SAMS Area Data Treatment

HabCam coverage in the Block Island (BI) SAMS area was limited to a single track that did not traverse depth contours within the area. The PDT noted that it is difficult to get a geostatistical estimate from a HabCam track at a constant depth, and that the 2020 HabCam BI biomass estimate was likely an overestimate because the track went through the area with the highest abundance. The PDT recommends not using the HabCam estimate for BI (i.e., only using the dredge estimate), and modifying the HabCam track in BI in the future to ensure the area is sampled across depth contours.

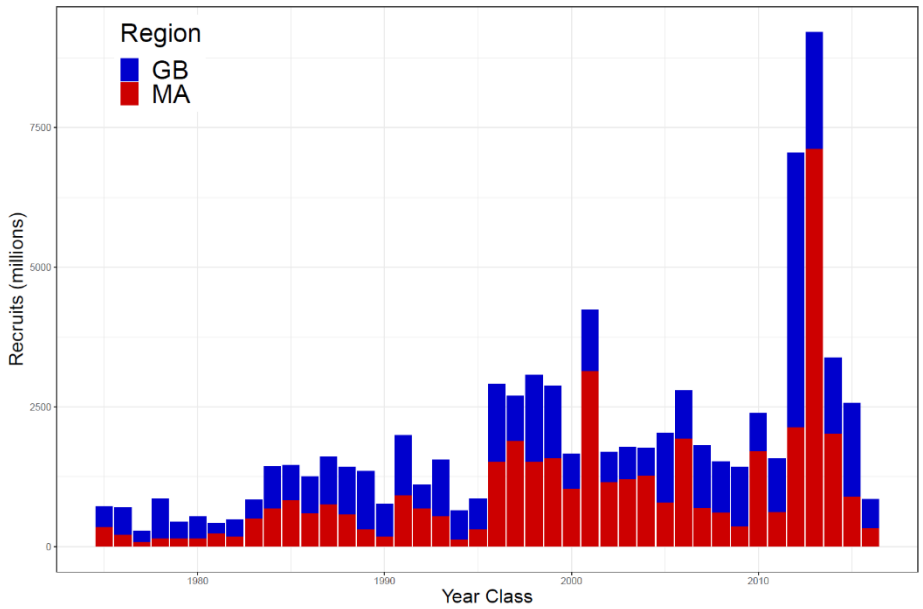
Addressing Data Gaps Caused by the 2020 COVID-19 Pandemic

Although the majority of the resource was surveyed in 2020, there were three areas that were not covered as a result of cancelled surveys stemming from the COVID-19 pandemic. The areas not surveyed were Closed Area I center (old access area), the Northern Flank and Closed Area II North SAMS areas. In the absence of updated survey information for 2020, the PDT used 2019 survey data to project 2021 biomass for these three areas; projections accounted for growth, natural mortality, and fishing that would have occurred over to two-year time period.

Recruitment and Outlook

One of the reasons for the decline in OFL and ABC estimates between 2021 and 2022 is low recruitment in recent years. Results from the 2020 management track assessment suggest that recruitment tailed off following two exceptional year classes (Figure 7) in 2012 and 2013. Annual optical and dredge surveys of the scallop resource have not detected recruitment at this magnitude for the past four years (not shown in Figure 7), though there are now several year classes on eastern Georges Bank. Within this region, biomass is expected to increase between 2021 and 2022 as younger cohorts recruit into the fishery. Recruitment was observed during the 2020 surveys on eastern Georges Bank and to a lesser extent in parts of the Long Island region. Based on recent survey data, the scallop resource is not projected to return to the record high biomass observed in 2018 in the short-term.

Figure 9 - Sea scallop recruitment (age 1) by region, 1975-2016. Regions are: Mid-Atlantic (MA, red) and Georges Bank (GB, blue). (Source: 2020 assessment update).



Scallop Rotational Management

While the OFL and ABC establish bounds for resource removals, in recent years, scallop rotational management has resulted in realized harvests (and corresponding fishing mortality rates) far below these legal limits. For example, in fishing year 2020, the ABC was set at 45,414 mt (not including discards), whereas fishery allocations were 22,370 mt. Based on initial discussions around rotational management measures to be considered in FW33, is it reasonable to expect that fishery removals in FY2021 will continue to be well below OFL and ABC estimates for 2021. The Council considers a range of additional issues and uncertainties as part of the annual rotational management process, such as the proportion of available biomass that the fishery is likely to target ('effective biomass').

Updates on 2019 SSC Recommendations:

Last year the SSC recommended further investigation into:

1. *In the fishery access areas, the fishery is harvesting the available strong year classes, but in some areas these year-classes are disappearing faster than what was expected (specifically the Nantucket Lightship West Area) when considering both fishing and assumed natural mortality rates. This does not represent a threat to the stock at this point but is something that should be closely monitored.*

The PDT has continued to monitor scallops in the NLS-West and formed a sub-group to further investigate the downturn in biomass observed in this area between 2018 and 2019. Details on the PDT's NLS-West sub-group work-to-date are provided in Appendix V.

2. *Further investigation into the: 1) different growth rates found in different scallop harvesting areas, particularly the Nantucket Lightship region, 2) further work to develop gonad-based estimates of SSB and reference points*.

The PDT has continued to monitor growth rates in different parts of the scallop resource and has discussed variation in growth rates among different harvesting areas, including the Nantucket Lightship region. Comparisons of L-F observations over time in the Nantucket Lightship, adjustments to growth rates for the NLS-South, and other points related to growth in this part of the resource are addressed throughout this memo.
Beginning in 2018, the VIMS dredge survey began taking gonad samples that could be used to support the development of gonad-based estimates of SSB and reference points. Gonad samples were taken on a limited basis in 2018, but expanded across all surveyed areas in 2019 and 2020 with that protocol in place for the foreseeable future. Up to 15 gonad samples are taken at each station.

References:

Hennen, D.R. and Hart, D.R. 2012. Shell Height-to-Weight Relationships for Atlantic Sea Scallops (Placopecten magellanicus) in Offshore U.S. Water. Journal of Shellfish Research, 31(4):1133-1144.

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Yochum, N. and DuPaul, W.D. 2008. Size-selectivity of the northwest Atlantic sea scallop (*Placopecten magellanicus*) dredge. Journal of Shellfish Research, Vol. 27, No.2, 265-271.

Table 9 – Final combined survey estimates for 2020 by SAMS area.

		Dredge				DropCam				Habcam				Mean				F32 Projections		
Region	Subarea	Num	Bmsmt	SE	MeanWt	Num	Bmsmt	SE	MeanWt	Num	Bmsmt	SE	MeanWt	Num	Bmsmt	SE	MeanWt	Num	Bmsmt	%Change
GB	CL1ACC													*52.0*	*829*		*15.9*	52	829	
GB	CL1NA	60.2	1490	271	24.8									60.2	1490	271	24.8	143	3300	-54.8%
GB	CL-2(N)													*301.0*	*6347*		*21.1*	301	6347	
GB	CL-2SE	370.6	5185	528	14.0	505	5083	842	10.1	406	6718	57	16.5	427.3	5662	332	13.3	892	14763	-61.6%
GB	CL-2SW	1079.0	21357	4722	19.8	790	17769	3442	22.5	775	14693	354	19.0	881.3	17940	1951	20.4	757	8385	113.9%
GB	CL2Ext	913.8	12924	1524	14.1	1048	15401	1986	14.7	856	11055	200	12.9	939.3	13127	837	14.0	109	5965	120.1%
GB	SF-Rest									262	4165.6	28.5	15.9	262.4	4166	29	15.9			
GB	SF-VIMS	765.7	6747	124	8.8					622	9393.5	145	15.1	693.8	8070	95	11.6	472	8820	-8.5%
GB	NLSAccN	44.5	1725	223	38.7	101	3,990	775	39.4					72.8	2858	403	39.3	176	4619	-38.1%
GB	NLSAccS-Deep	3613	38606	8270	10.7	2544	34918	6595	13.7	2591	29496	1020	11.4	2916.0	34340	3542	11.8	3544	44995	-23.7%
GB	NLS-W	11.4	255	41	22.6									11.4	255	41	22.6	200	3706	-93.1%
GB	NF													*109.0*	*1434*		*13.2*	109	1434	
GB	GSC	241.8	6056	851	25.0	329	6077	2917	18.5					285.4	6067	1519	21.3	149	8056	-24.7%
GB	GSC-45	0.3	13	6	43.3									0.3	13	6	43.3			
GB	**TOTAL**	**7100.4**	**94358**	**9704**	**13.3**									**7012.1**	**102596**	**4441**	**14.6**	**6904**	**111219**	**-7.8%**
MAB	BI	25.3	809	118	32.0				*removed HabCam data*					25.3	809	118	32.0	130	1450	-44.2%
MAB	LI	294.9	6151	338	20.9					557	11228	2359	20.2	426.0	8690	1192	20.4	1079	9512	-8.6%
MAB	NYB	256.4	4007	230	15.6					388	6905	924	17.8	322.2	5456	476	16.9	603	8613	-36.7%
MAB	MA inshore	10.1	309	46	30.6									10.1	309	46	30.6	105	1163	-73.4%
MAB	HCSAA	174.7	4095	233	23.4					302	7949	847	26.4	238.2	6022	439	25.3	586	9393	-35.9%
MAB	ET Open	265.7	7811	370	29.4	453	12469	1171	27.6	393	10771	881	27.4	370.4	10350	504	27.9	663	20145	-48.6%
MAB	ET Flex	113.9	3208	283	28.2	262	8143	1127	31.1	242.4	5697	246	23.5	206.0	5683	396	27.6	1359	14990	-62.1%
MAB	DMV	37.0	352	61	9.5									37.0	352	61	9.5	304	799	-55.9%
MAB	VIR	16.1	71	11	4.4									16.1	71	11	4.4	50	110	-35.5%
MAB	**TOTAL**	**1194.1**	**26813**	**677**	**22.5**									**1651.2**	**37742**	**1507**	**22.9**	**4879**	**66175**	**-43.0%**
TOTAL	**TOTAL**	**8295**	**121171**	**9727**	**14.6**									**8663**	**140338**	**4690**	**16.2**	**11783**	**177394**	**-20.9%**

Figure 10 - 2020 Georges Bank SAMS Areas.

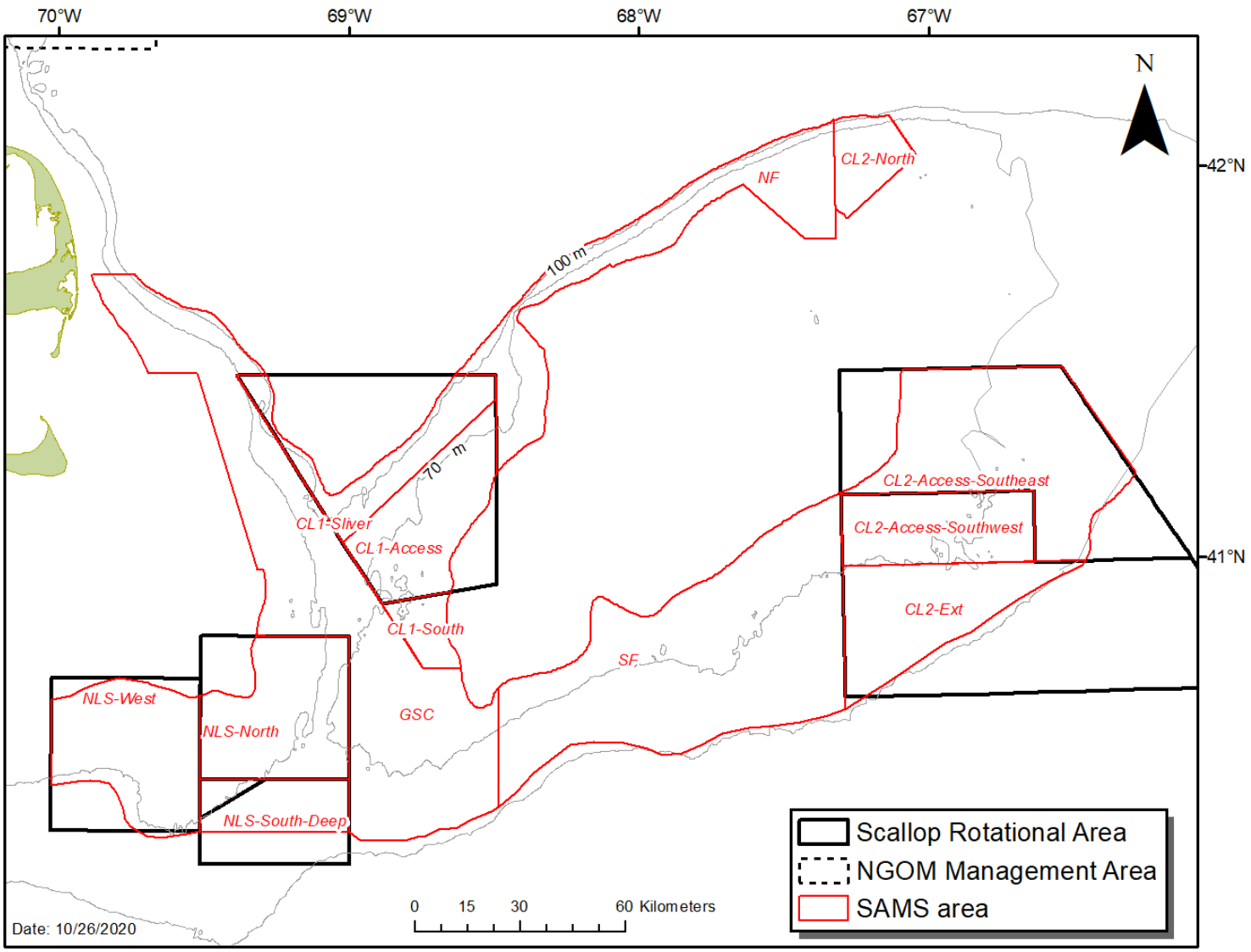


Figure 11 – 2020 Mid-Atlantic Bight SAMS Areas.

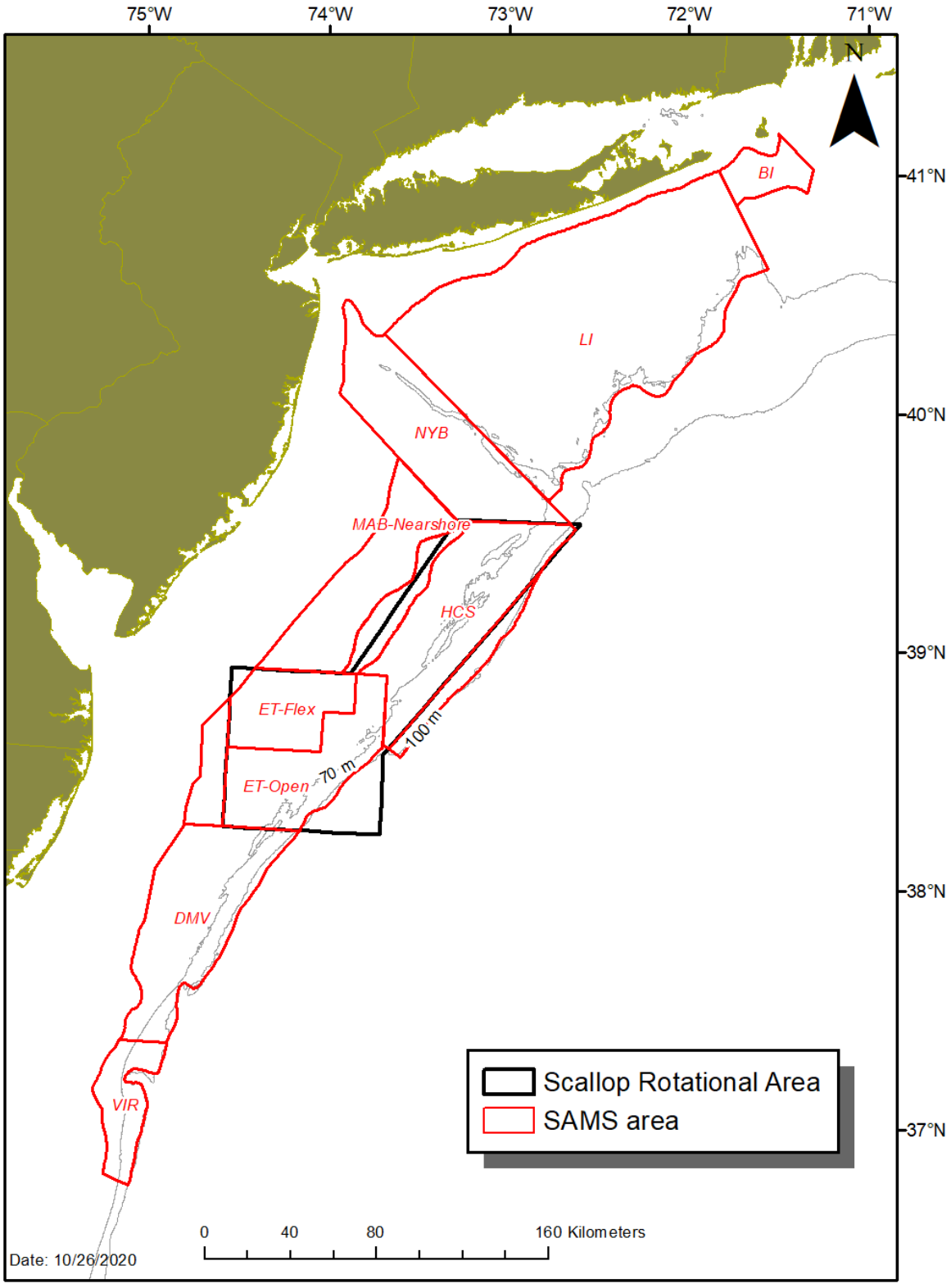
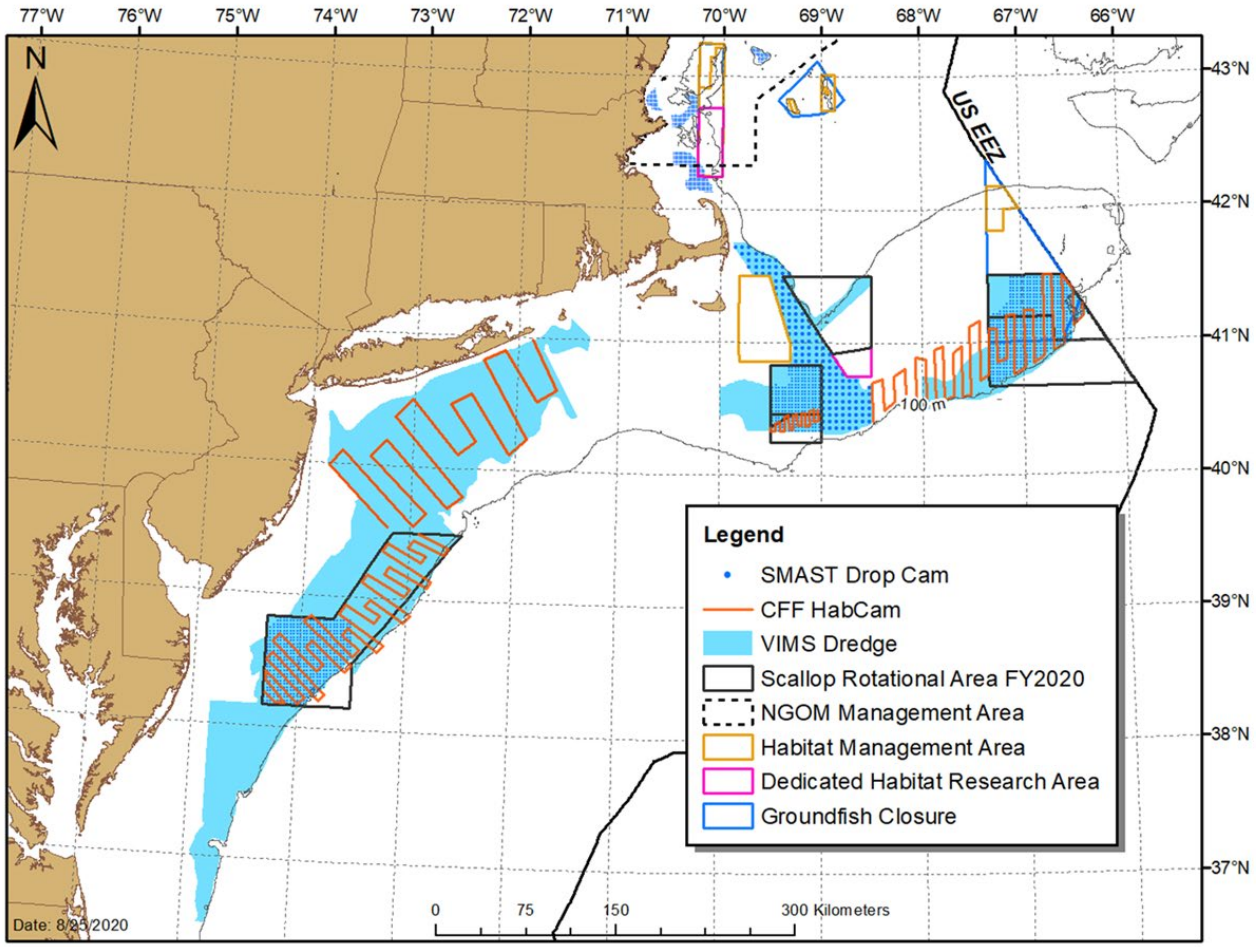


Figure 12 - 2020 Scallop Survey Coverage



Appendix I: 2021 Projections - Outputs and Assumptions

Projections for 2021:

1. Model configured the same as in Framework 32, with 8 areas in MA and 12 in GB. In 2019, the Closed Area II access area was partitioned into CAII-SW and CAII-SE.
2. Initialized using the average (mean) of available 2020 survey data. In areas where no new survey data was available, projection for 2020 from the 2019 model were applied (CAI-Mid, NF, CA2-N). In Block Island, only dredge estimate was used.
3. L_∞ in NLS-S-deep was set to 110 mm to match observed growth (SARC 65).
4. L_∞ was reduced in all SAMS areas except CAII-SW and NLS-South to match observed growth.

Table 10 - Projected exploitable biomass for 2021 by SAMS area.

SAMS Area	**2021 Exploitable Biomass**
HCS	3,589
Etop	7,720
ETFlex	4,259
Dmv	209
NYB	3,901
LI	8,602
Vir	14
BI+Inshore	1,132
Total	**29,426**
CL1-N	498
CL1-mid	378
CL2-N	3,186
CL2-SE	1,777
CL2-SW	14,630
NLS-W	225
NLS-N	1,292
NLS-S	12,594
CL2-Ext	10,697
GSC	2,737
NF	743
SF	6,989
Total	**55,746**

Table 11 - Comparison of the meat weight and growth parameters used in recent SAMS configurations.

	Meat weight	Growth
2015	SARC 59	SARC 59
2016	SARC 59, with changes to SH-MW parameters using VIMS 2016 data (NLS-S, NLS-NA, NLS-ext)	SARC 59, with reductions to growth in NLS
2017	SARC 50, with changes to SH-MW parameters in NLS using VIMS 2016 & 2017 data (NLS-S, NLS-NA).	SARC 59, with reductions to growth in NLS-S deep (>70m) based on observed growth between 2016 and 2017. Change ET-Flex L infinity to 110 mm based on observed growth in 2016 and 2017.
2018	SARC 65, with changes to SH-MW parameters in the NLS using VIMS 2016 – 2018 data	SARC 65, with reduction in L_∞ in NLS-W to 119mm. SARC 65 set the L_∞ of scallops in the NLS-S-deep at 110 mm.
2019	SARC 65, with changes to SH-MW parameters in the NLS using VIMS 2016 – 2019 data	SARC 65, with reduction in L_∞ in NLS-W to 119mm. SARC 65 set the L_∞ of scallops in the NLS-S-deep at 110 mm.
2020	SARC 65, with changes to SH-MW parameters in the NLS using VIMS 2016 – 2020 data (NLS-S, NLS-N, NLS-W)	SARC 65, scaled to the growth expectations from the 2020 management track assessment for all areas except NLS-South and CAII-SW.

Table 12 - 2020 Survey Data Treatments by SAMS area

GB	***SHMW equation, Dredge Efficiency***	***Treatment***
CL1-Access	SARC 65	Projection from FW32
CL1-Sliver	SARC 65	VIMS Dredge Data (no other survey data)
CL1-South	SARC 65	*No Data* (a few dredge tows in 2019 indicated very low scallop density)
CL2-North	SARC 65	Projection from FW32
CL2-SE	SARC 65	Survey mean
CL2-SW	SARC 65	Survey mean
CL2-Ext	SARC 65	Survey mean
NLS-North	VIMS 16-20	Survey mean
NLS-South-Deep	VIMS 16-20, q=0.13	Survey mean
NLS-West	VIMS 16-20	VIMS Dredge Data (no other survey data)
NF	SARC 65	Projection from FW32
GSC	SARC 65	Survey mean
SF-VIMS	SARC 65	Develop HabCam estimate that is based on the VIMS survey domain, calculate the mean of dredge and HabCam.
SF-Rest	SARC 65	Use only HabCam data – (no other survey data)
MidAtlantic		
BI	SARC 65	Drop HabCam – low sampling. Use VIMS dredge data only.
LI	SARC 65	Survey mean
NYB	SARC 65	Survey mean
MAB-Nearshore	SARC 65	Survey mean
HCS	SARC 65	Survey mean
ET Open	SARC 65	Survey mean
ET Flex	SARC 65	Survey mean
DMV	SARC 65	VIMS Dredge Data (no other survey data)
VIR	SARC 65	VIMS Dredge Data (no other survey data)

Appendix II: VIMS Shell-Height Meat-Weight Analysis

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September 22, 2020

Methods

Shell height meat weight relationships (SHMW) were estimated for the Nantucket Lightship (NL) survey by SAMS Area with VIMS survey data. SHMW relationships were developed using a combined dataset from 2016 - 2020. Surveys from 2016 - 2019 occurred in June or July of a given year. The 2020 survey was delayed due to COVID-19 travel restrictions and was completed in late September of 2020.

Station-level data from the 2016 - 2019 surveys were reassigned to 2020 SAMS Areas for analysis. VIMS' protocols dictate that at every station with scallop catch, 15 scallop that encompass the length distribution of scallops at a given station are sampled to collect data on meat weight, gonad weight, meat quality, sex, maturity stage, and disease prevalence. The shell height is taken for each scallop assessed, and then the adductor muscle and gonad are carefully removed. The adductor muscle and gonad are weighed with a Marel M200 motion compensating scale. Maturity stage is assessed by visual examination of the gonad. VIMS classifies maturity into six stages: rebuilding, mature, spent, spawning, resting, and unknown.

SHMW mixed effect models were developed with forward selection and variables were retained in the model if the AIC was reduced three or more units. SAMS area was included in all models to estimate the SAMS area effect. The model with the lowest AIC was selected as the preferred model and used to predict SHMW relationships by SAMS area. If models were within three units of each other, a likelihood ratio test was used to test for significant differences between model. If there was no significant difference between the models, the more parsimonious model was selected as the preferred model. Variables considered were: ln shell height, ln depth (average depth for a station), SAMS Area (retained in all models), latitude (beginning latitude of a station), an interaction term of shell height and depth, year, and maturity stage. Maturity stage was included to account for the delay of the 2020 survey. Models with and without maturity stage were compared to assess the need to include this variable. Post-hoc multiple pairwise comparisons for the levels of maturity stage were also completed. The interaction term was not considered in model development if the term was not significant in the individual model. Year was included to test for a year effect, and was not significant. Tables provided below include the SHMW models with parameters and AIC by SAMS area. Parameter estimates for the preferred model and predicted SHMW relationships are also provided.

A sensitivity analysis was also completed to assess the impact of removing stations located in the 2020 NL Triangle Closed Area. This area is closed to fishing effort in 2020 and located in the NL_South_Deep SAMS Area. Seventeen stations were completed in this area from 2016 - 2020. All station SHMW data from these stations were removed and model predictions were compared to the preferred model including all data from 2016 - 2020.

Results

Maturity stage was not considered in final model development based on a comparison of predicted SHMW curves with and without maturity stage, as well as a lack of significance between maturity factor levels in the preferred model, and post-hoc pairwise comparisons between maturity stage levels. The preferred model included shell height, SAMS Area, latitude, and depth as fixed effects (Table 1). All variables were significant (Table 2). The NL_South_Deep and NLS_West SAMS Areas were significantly different from the reference

SAMS Area, the NLS_North SAMS Area. Predicted SHMW curves indicate the NLS_South_Deep continues to have lower meat weights across all lengths compared to the other three SAMS Areas (Figure 1). Exclusion of stations from 2016 - 2020 located in the NL Triangle Closed Area did not change variables in the preferred model, predicted SHMW curves or coefficient estimates (Figure 2, Table 3). All parameter estimates and the predicted SHMW curves for the preferred model in Figure 1 and Table 2 include all data from all stations within the VIMS NL survey domain for 2016 - 2020.

Table 1. SHMW models for the 2016 - 2020 VIMS NL survey data. Bold variables indicate significance. Model in red was selected as the preferred model. The number of parameters (K), AIC, Delta_AIC, AIC weight (AICWt), and Deviance explained are also included.

Modnames	Parameters	K	AIC	Delta_AIC	AICWt	Deviance
m4	~1 + **Shell Height + SAMS Area + Depth + Latitude**	9	44,086.29	0	0.76	74.23
m1	~1 + **Shell Height*Depth + SAMS Area + Latitude**	10	44,088.80	2.51	0.22	74.22
m3	~1 + **Shell Height + SAMS Area + Depth**	8	44,094.13	7.83	0.02	74.22
m2	~1 + **Shell Height*Depth + SAMS Area**	9	44,097.46	11.17	0	74.2
m5	~1 + **Shell Height + SAMS Area + Latitude**	8	44,097.62	11.32	0	74.24
null	~1	3	58,821.82	10,734.82	0	

Table 2. Parameter estimates for model m4 from Table 1.

Parameter	Parameter Estimate
Intercept	-24.04
log Shell Height	2.87
SAMS_AreasNLS_South_Deep	-0.27
SAMS_AreasNLS_West	-0.08
SAMS_AreasVIMS_45	0.02
log Depth	-0.25
Latitude	0.37

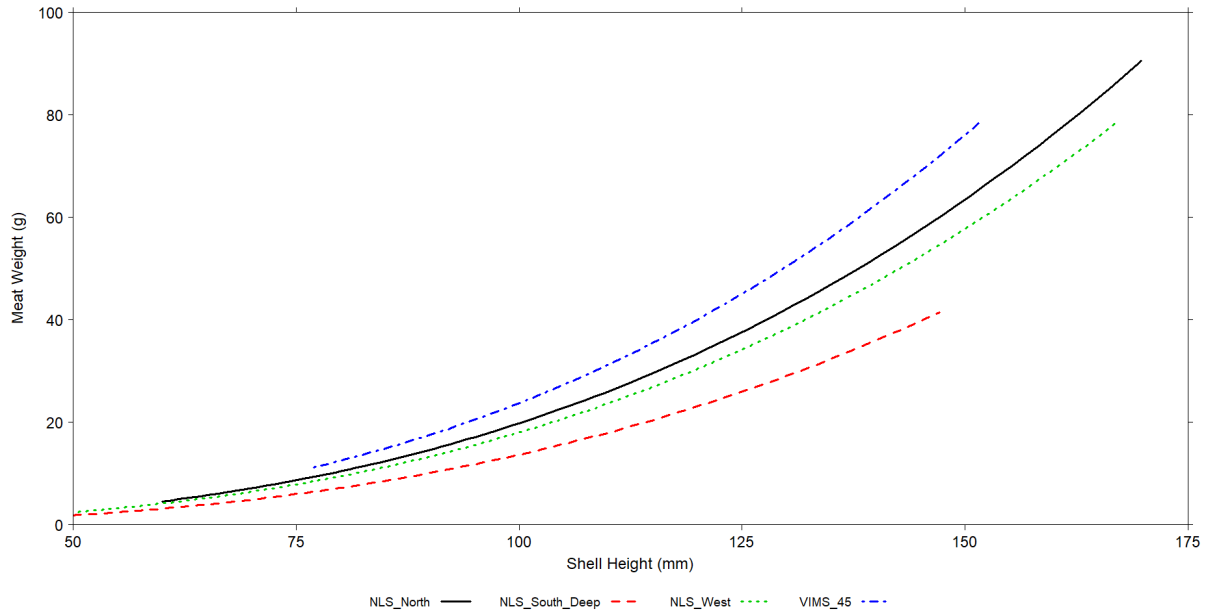


Figure 1. Predicted SHMW relationships by SAMS Area for the NL using model m4 from Table2.

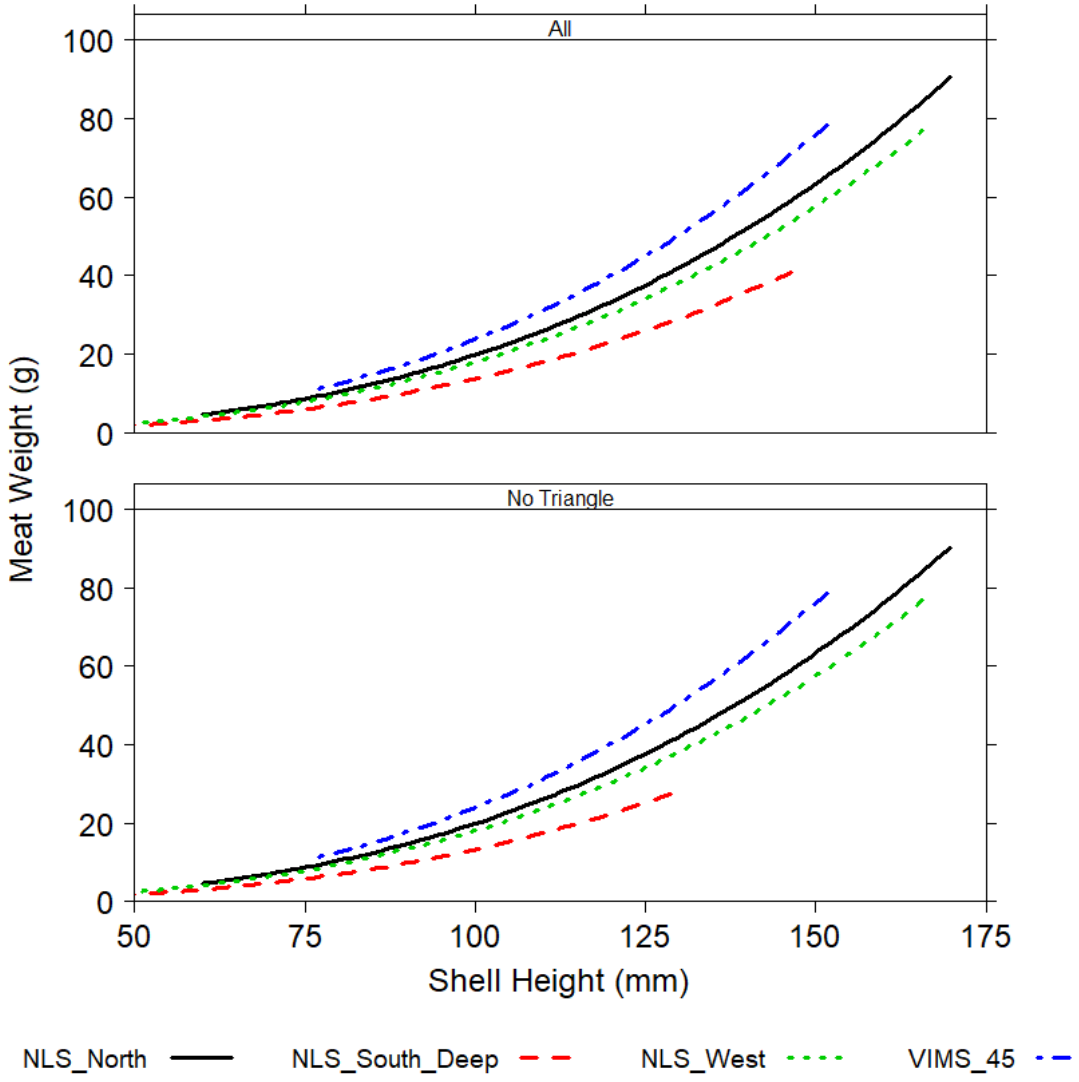


Figure 2. Predicted SHMW relationships by SAMS Area for the NL excluding stations in the NL Triangle Closed Area (No Triangle panel – bottom) and with all data (All panel – top).

Table 3. Parameter estimates for the sensitivity analysis excluding stations in the NL Triangle Closed Area.

Parameter	Parameter Estimate
Intercept	-31.97
log Shell Height	2.86
SAMS_AreasNLS_South_Deep	-0.25
SAMS_AreasNLS_West	-0.07
SAMS_AreasVIMS_45	-0.01
log Depth	-0.25
Latitude	0.56

Discussion

SHMW relationships in the NL continue to show a similar trend across years. The South_Deep SAMS Area continues to have a lower meat weight at shell height compared to the other SAMS areas. This SAMS Area is significantly different from the reference case, NLS_North SAMS Area, for the 2020 analysis (not included) and the combined analysis for this year. Biomass estimates for the VIMS NL Survey domain have not been calculated yet, but the assumption of reduced dredge efficiency in the high density area in the South_Deep SAMS area is believed to persist.

For Reference:

2019 Approach:

Parameter estimates for shell height meat weight relationships for the NLS derived from 2016-2019 VIMS dredge survey data.

Parameter	Parameter Estimate
Intercept	-50.333
ln shell height	2.862
Latitude	1.007
ln depth	-0.169
NLS_South_Deep	-0.127
NLS_South_Shallow	0.095
NLS_West	-0.049
VIMS_45	-0.027

2018 Approach:
Parameter estimates for shell height meat weight relationships for the NLS derived from 2016-2018 VIMS dredge survey data.

Parameter	Parameter Estimate
Intercept	-9.29
ln shell height	2.82
ln depth	-0.14
NLS_EXT	-0.22
NLS_NA	-0.24
Deep	-0.35
Shallow	-0.38
VIMS_45	0.04

2017 Approach:
Parameter estimates for shell height meat weight relationships for the NLCA derived from 2016 and 2017 VIMS dredge survey data without an interaction variable.

Parameter	Parameter Estimate
Intercept	-8.46
logsh	2.67
logdepth	-0.17
Southern Area	-0.39
Extension	-0.29
NA Area	-0.27
VIMS 45 Area	0.02

2016 Approach:
Parameter estimates for shell height meat weight relationships for the NLCA derived from 2016 VIMS dredge survey data using the updated region/zone designations. log = ln

Equation:
Meatweight= intercept+(B1* logsh)+(B2*logdepth)+(B3*(logsh*logdepth)) + SAMS_zone_2016

Parameter	Parameter Estimate
Intercept	-25.7615
B1 logsh	6.7540
B2 logdepth	4.1120
B3 logsh:logdepth	-1.0054
SAMS_zone_2016NLS_AC_S	-0.4917
SAMS_zone_2016NLS_EXT	-0.2214
SAMS_zone_2016NLS_NA	-0.3743
SAMS_zone_2016VIMS_45	-0.2198

Appendix III:

SH-MW Parameters for Biomass Estimation
Comparison of Biomass Estimates Using SARC 65 vs. VIMS 2016-2020
Nantucket Lightship SAMS Areas

Note: Biomass values in mt.

Total VIMS dredge biomass estimates (mt) for the NL using SARC 65 parameter estimates and VIMS 2016-20 parameter estimates the current SAMS areas. Dredge efficiency issues persist in high density area in the South_Deep SAMS Area.

SAMS Area	SARC 65 SH/MW	VIMS SH/MW 2016-2020
NLS-North	1,713.41	1,725.24
NLS-West	277.64	254.55
NLS-South	11,715.14	12,547.05

Total biomass estimates from the 2020 SMAST drop camera survey in the Nantucket Lightship area using the 65th SARC or the 2016-2020 Virginia Institute of Marine Science (VIMS) shell-height to meat-weight formulas.

SAMS Area	SARC 65 SH/MW		VIMS SH/MW 2016-2020	
	BMS (mt)	MeanWt	BMS (mt)	MeanWt
NLS-North	3,643	35.9	3,990	39.4
NLS-South-Deep	33,709	13.3	34,918	13.7

Comparison of 2020 Habcam biomass estimates (40+ mm) using VIMS 2016-2020, VIMS 2016-2019, and SARC 65 SH-MW equations for Nantucket Lightship Area. Percent difference was calculated using biomass estimates (VIMS - SARC 65)/(VIMS).

SAMS Area	BmsMT (VIMS 16-20)	BmsMT (VIMS 16-19)	BmsMT (SARC 65)	%Diff (VIMS 16-19 V.S. 16-20)	%Diff (SARC 65 V.S. 16-20)
NLS-South-Deep	29496	28655	27360	-2.85	-7.24

Appendix IV: Comparison of 2020 Surveys with Projections using 2019 Data

On October 28, 2020 the Scallop PDT reviewed an analysis comparing the length frequencies from 2020 survey data with projections from the SAMS model for 2020. The "2019 run" of the SAMS model was initialized using survey data from 2019, and model results account for various factors including fishing mortality, natural mortality, discard mortality, and recruitment. Observed length frequencies from the 2020 VIMS dredge survey were used to compare to the 2020 projections for all areas, except the Southern Flank (SF), because the dredge did not cover the entire SF SAMS area.

The plots in Table 13 display L-Fs by SAMS areas from across Georges Bank and the Mid-Atlantic. The length-frequencies are shown by mean number per tow.

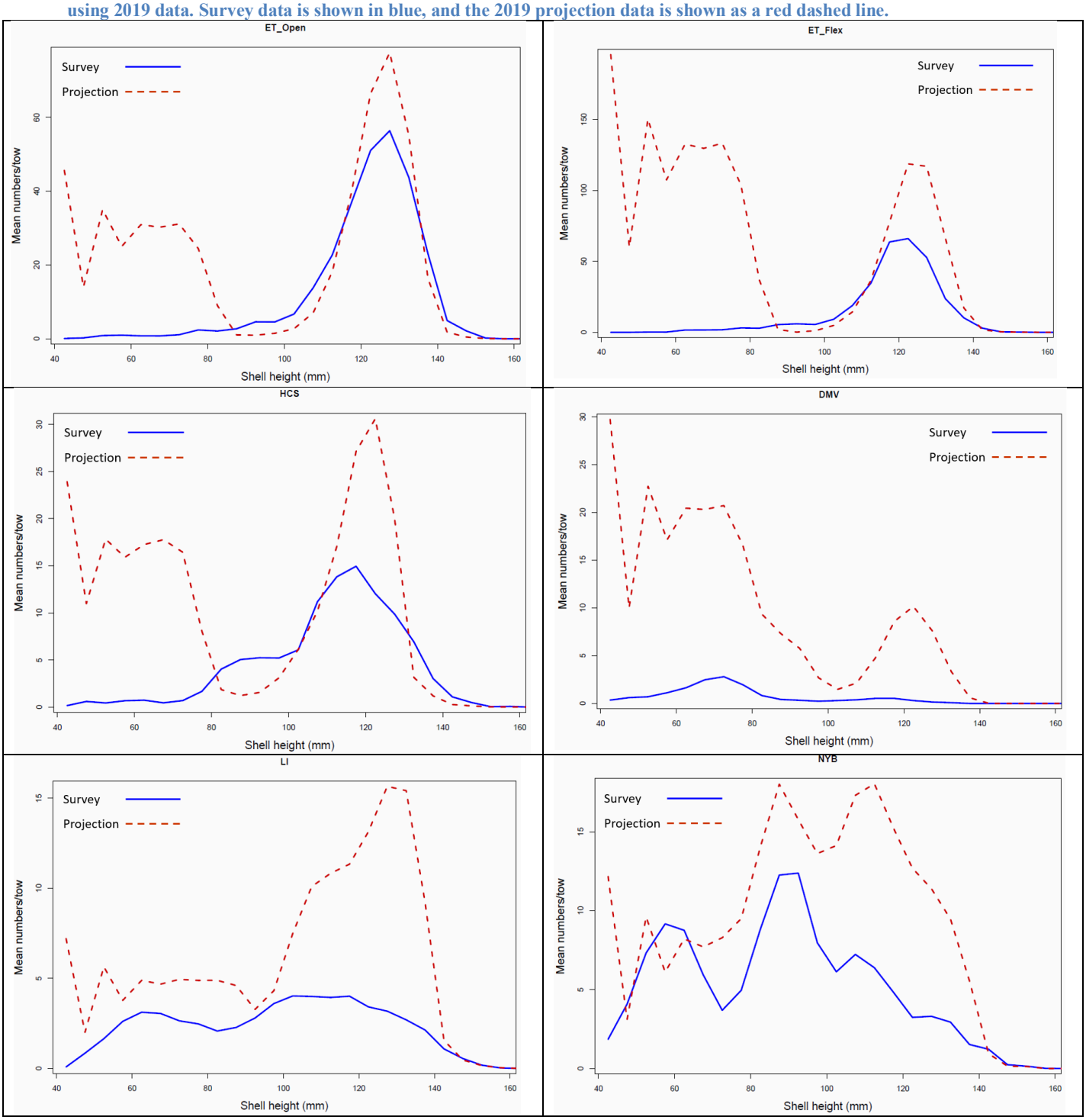
Discussion:

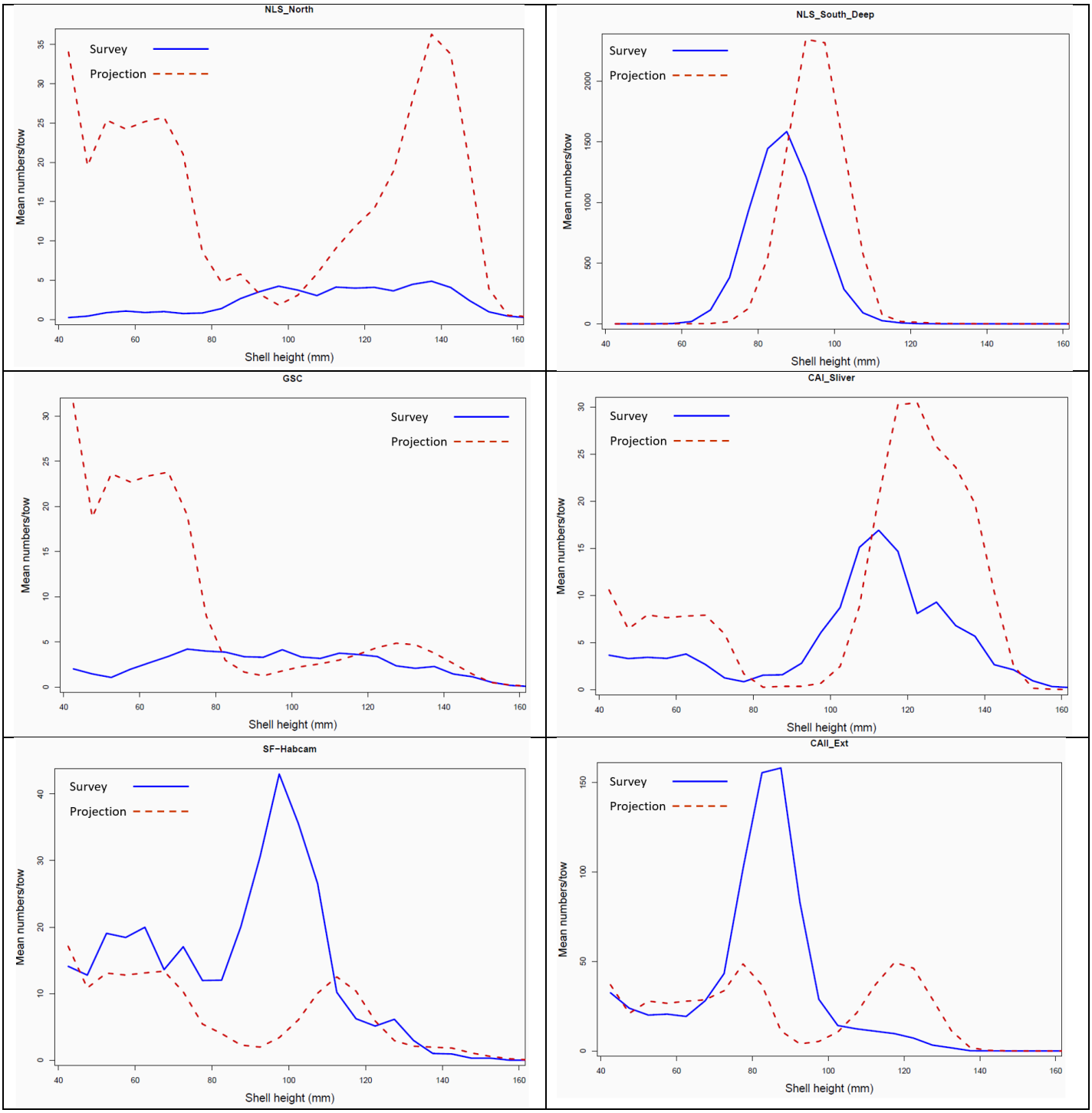
- Observed number per tow from the 2020 survey data are both higher and lower than the 2020 projections, depending on the SAMS area. This suggests that some combination of realized F, M, and growth was different than what was assumed in the 2019 SAMS model run.
- Projections were for a 12-month period following the 2019 surveys. The 2020 survey data were collected ~14 months after the 2019 surveys due to COVID-19 delays. The PDT suspects that additional Z over the extra two months would be less than Z=0.1.
- Error in surveys could explain some of the difference in observed versus projected L-Fs - for example, if both the 2019 and 2020 surveys in an area have 20% CVs, projections and surveys could differ by up to 50% due to survey error alone.

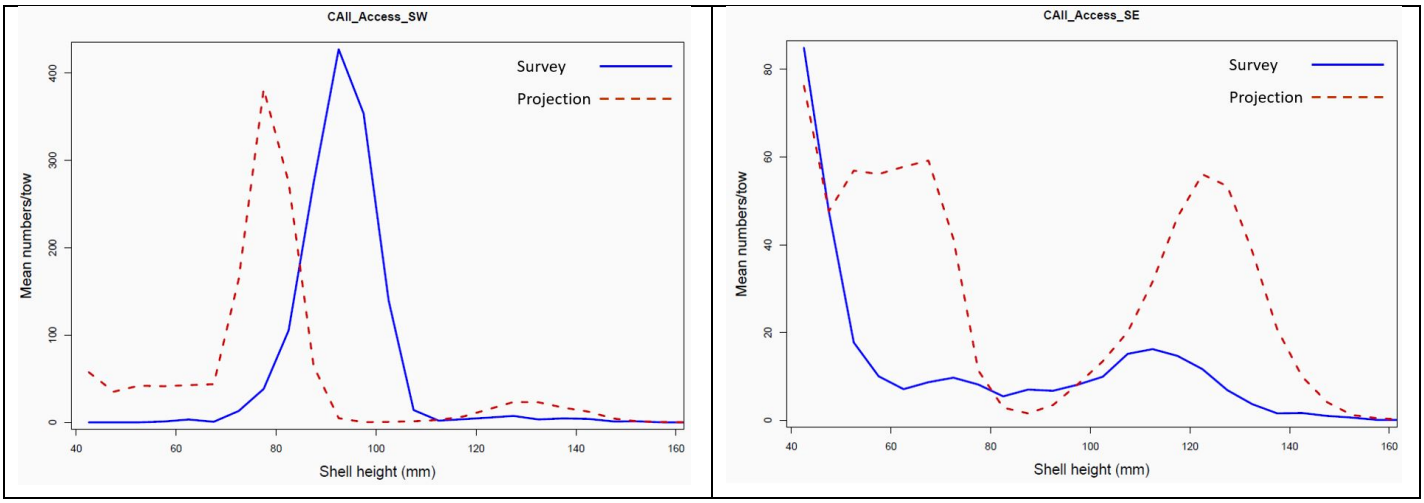
Results:

- The number of scallops per tow in the 2020 surveys were below projections in most areas, though there were some exceptions. Across the Mid-Atlantic region, it appears that projections were overly optimistic compared to observed L-Fs from the dredge survey. On Georges Bank, the scallops in the CAII-SW area grew faster than expected, reaching an average of nearly 100mm over a 14-month period when they were projected to reach only about 75-80mm over 12 months. This growth supports the PDT's recommendation to not change $L\infty$ for the CAII-SW area.
- Some of the divergence between surveys and the projections can be explained by poor recruitment (i.e., below average). As shown in the top panel for the Elephant Trunk Open and Elephant Trunk Flex, the model predicted average recruitment which did not show up in the 2020 surveys.
- Survey error and the two extra months between surveys are other plausible reasons for the projections to appear overly optimistic relative to the survey data.
- The comparison shows that the 2020 projections for SAMS areas in the Mid-Atlantic estimated more scallops than were observed in the 2020 surveys. While the survey data and projections generally tracked the shell-heights of the dominant 2013 year class in the Mid-Atlantic Access Area (ET-Open, ET-Flex, and HCS), the 2019 projections overestimated recruitment in these three areas. The 2020 projections estimated more scallops per tow than were observed in the 2020 surveys in the MAAA.

Table 13 – Length frequency plots comparing mean number of scallops per tow using 2020 survey data to projection using 2019 data. Survey data is shown in blue, and the 2019 projection data is shown as a red dashed line.




NLS_North
Survey
Projection
Mean numbers/tow
Shell height (mm)
NLS_South_Deep
Survey
Projection
Mean numbers/tow
Shell height (mm)
GSC
Survey
Projection
Mean numbers/tow
Shell height (mm)
CAI_Sliver
Survey
Projection
Mean numbers/tow
Shell height (mm)
SF-Habcam
Survey
Projection
Mean numbers/tow
Shell height (mm)
CAII_Ext
Survey
Projection
Mean numbers/tow
Shell height (mm)


CAII_Access_SW
Survey
Projection
Mean numbers/tow
Shell height (mm)
CAII_Access_SE
Survey
Projection
Mean numbers/tow
Shell height (mm)

Appendix V: Update on Nantucket Lightship West

Overview:
Scallops from an exceptional 2012 year class settled across the Nantucket Lightship region, including an area to the west of the traditional Nantucket Lightship Rotational Access Area, now known as the Nantucket Lightship North (Figure 1). When the scallops were identified in surveys, they were within the habitat and groundfish closures in the Nantucket Lightship region. These areas were opened following the partial approval of the Omnibus Habitat Amendment 2 and the New England Fishery Management Council incorporated the Nantucket Lightship West into rotational management.

Harvest of scallops in the Nantucket Lightship West began in fishing year 2018, when roughly 12 million pounds were allocated. This decision was based on data from three survey types (i.e., dredge, drop camera, and HabCam) that were collected during the 2017 field season (roughly May – July). The 2018 surveys, which were conducted over the same time period, May – July, coincided with the first year of fishery access to the Nantucket Lightship West access area in FY2018 (i.e., observed biomass was consistent with projections which accounted for fishing in FY2018, natural mortality, and growth). Using projections based on data collected during summer of 2018, the Council recommended allocating roughly 18 million pounds to this area for FY2019. The 2019 fishing year began on April 1, 2019 and three surveys of the NLS-West were conducted in the late spring/early summer. The combined 2019 survey results suggested a major decline in biomass in this area compared to projections based on 2018 survey data and accounting for fishing and natural mortality. This difference was more than 50 million pounds.

1.1 What happened between the 2018 and 2019 surveys?

On April 30, 2020, a sub-group of the Scallop Plan Development team was formed to discuss the notable downturn of biomass in this area. The focus of meetings thus far has been to better understand what happened between the 2018 and 2019 surveys that led to a 50-million-pound difference between projections and survey estimates, and lessons that managers could take away from this experience. Available fishery and biological information could be used to inform plausible explanations of what happened to the scallops in the NLS-West that were not landed, and the group is in the process of developing recommendations (i.e., research tracks, management measures) that the Council could consider at a later date regarding spatial management in high-density areas.
The sub-group has suggested pursuing two tracks of analyses:

1. Survey and projection error. This includes point estimates from independent surveys, data treatments such as adjustments to dredge efficiency and SH/MW, combining survey estimates, and assumptions about growth in the projection model. The group noted that there is uncertainty in the survey estimates, particularly with the unique high-density situation in this access area.
2. Finer scale examination of NLS-West area in terms of scallop distribution and biomass, and fishing effort. The PDT is interested in understanding when and where mortality may have happened (in different parts of the NLS-West at different times?)

Based on available data, members of the sub-group have hypothesized that the downturn in biomass was the combination of several factors, some of which may be unique to this area. These include, but are not limited to poor scallop habitat (i.e., silty substrate and low water flow), limited food availability, concentrated fishing effort in a short period of time, fishing stirring up

sediment and clogging the gills of scallops, higher than expected discarding, deck loading, increase in natural mortality.

Figure 13 – Nantucket Lightship region, with FY2019 scallop rotational areas (black), SAMS areas (red), and predicted biomass estimates from the 2019 HabCam survey of the Nantucket Lightship region (mt per km^2).

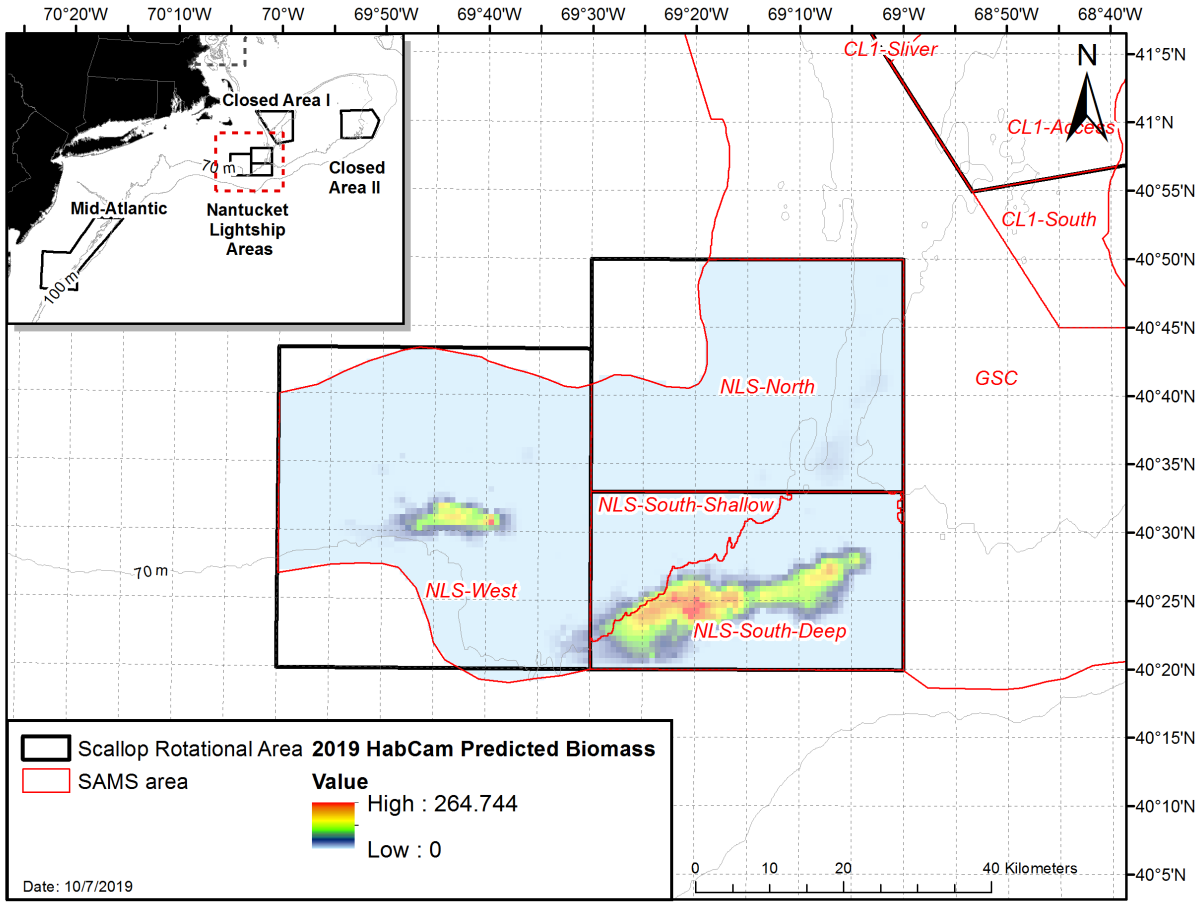
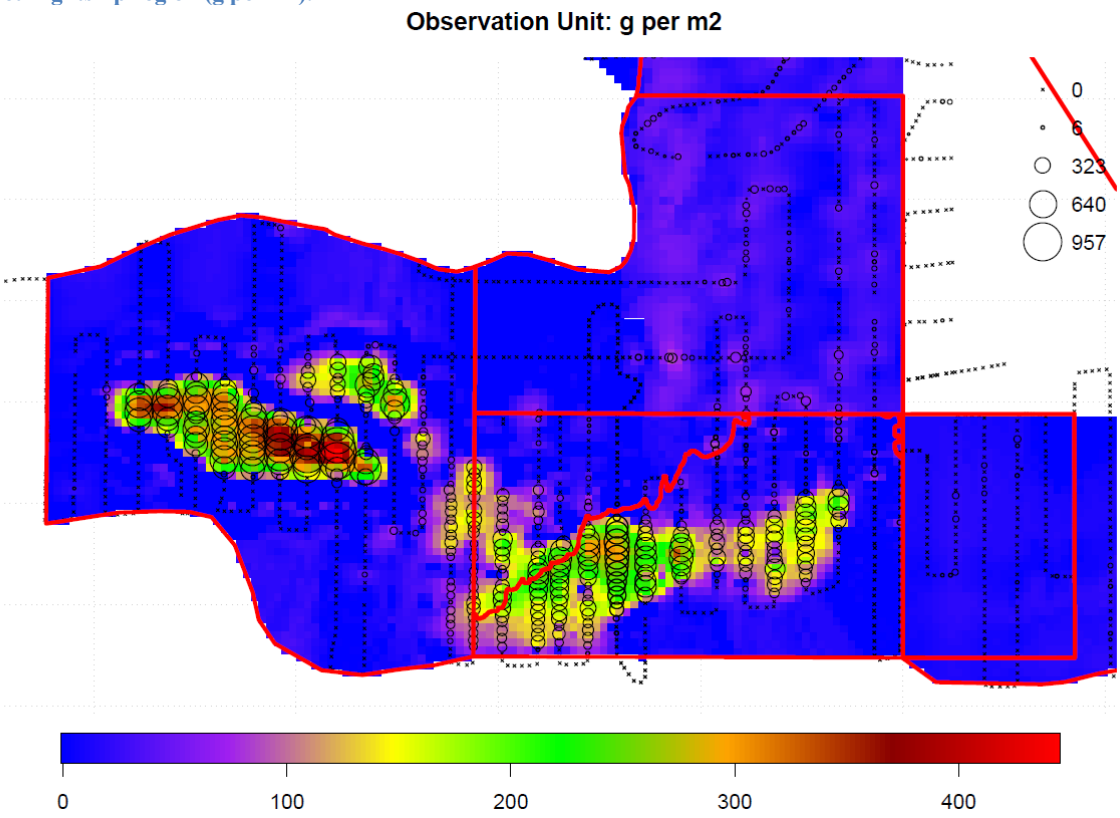


Figure 14 – 2018 SAMS area boundaries (red) and predicted biomass estimates from the 2018 HabCam survey of the Nantucket Lightship region (g per m^2).



Survey Data and Data Treatments:

- Between 2015 and 2020, there were 16 independent surveys of this area. From 2015 – 2019, the area was surveyed using a dredge, the Drop Camera, and HabCam each year. Predicted biomass heatmaps from the 2018 and 2019 HabCam surveys of the Nantucket Lightship region, including the NLS-West, are provided in Figure 12 and Figure 9, respectively.
- Following the methods approved in SARC 65 (2018), the assumed dredge efficiency in this area was reduced from .4 to .13 to account for reduced dredge efficiency in this high-density area.
- The shell heigh to meat weight relationship used to calculate survey biomass was modified to reflect the relationship more accurately in this area.
- Length infinity and growth ($L\infty$ and K) assumption were also modified to capture the slower than anticipated annual growth in this area.

Figure 15 -Survey Biomass Estimates from dredge, Drop Camera, and HabCam from 2015-2020, with mean biomass estimate shown as a black dashed line. The projection model is initialized using the survey mean.

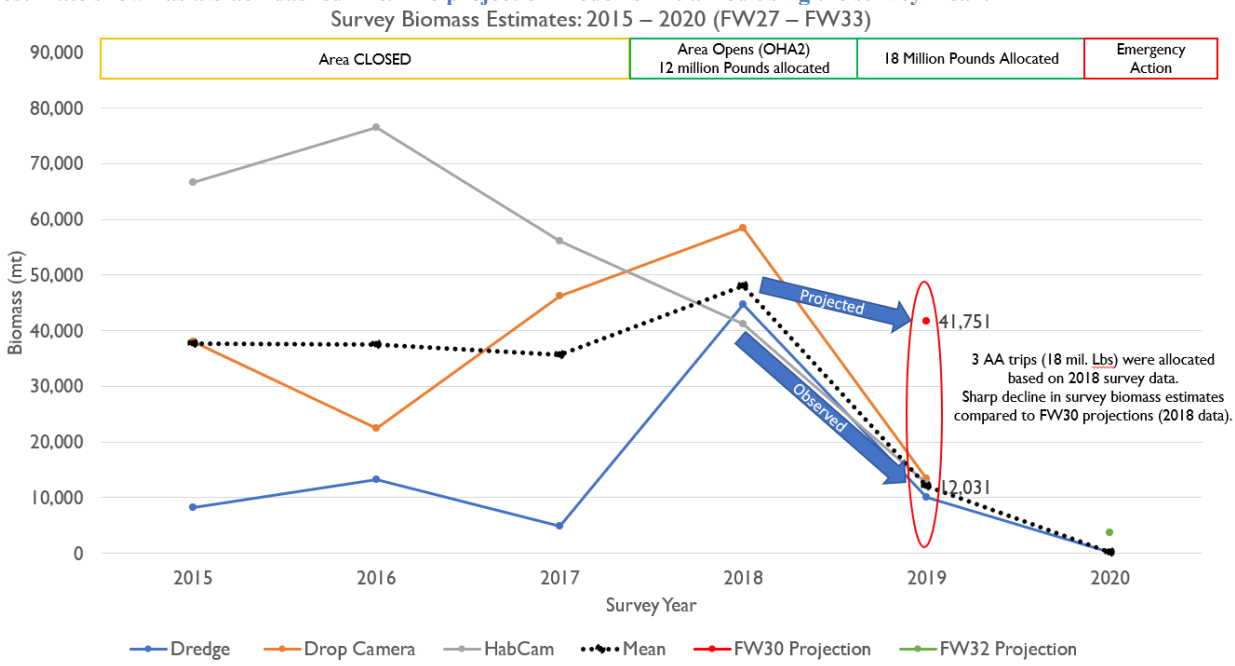


Table 14 - Survey biomass estimates in the NLS-West (2015-2020).

Action	FW27	FW28	FW29	FW30	FW32	FW33
SAMS Name	NLS-NA	NLS-NA	NLS-NA	NLS-West	NLS-West	NLS-West
Year	2015	2016	2017	2018	2019	2020
Dredge	8,174	13,313	4843	44,790*	10,080.4*	255*
Drop Camera	38,041	22,499	46250	58,500	13,438	
HabCam	66,706	76,561	56066	41,155	12,575	
Mean (mt)	***37,640***	***37,458***	***35720***	***48,148***	***12,031***	***255***
FW30 Projection					41,751	
FW32 Projection						3,706
*Dredge efficiency reduced from .4 to .13 to account for reduced dredge efficiency in high density areas.						

Table 15 – Survey abundance estimates in the NLS-West (2015 – 2020).

Abundance						
	FW27	FW28	FW29	FW30	FW32	FW33
SAMS Name	NLS-NA	NLS-NA	NLS-NA	NLS-W	NLS-W	NLS-W
Year	2015	2016	2017	2018	2019	2020
Dredge		1,274	221	2395.2	600.8	11.4
Drop Camera		1,768	2597	3482	838	
HabCam		5,229	2906	2262	623	
Mean		2,757	1908	2713	687.4	11.4
FW30 Projection						
FW32 Projection						200

NLS-West Biomass and Fishing Effort

- Scallops have not regularly settled in the NLS-West area. The physical environment in this area has a lower sheer stress, which can contribute to anerobic conditions. Scallops in this area have a black underside, this suggests low circulation in the area. Changes in the environment caused by fishing, such dispersing sediment, may have had an adverse impact on scallops in the area. However, other areas like the Elephant Trunk have been fished heavily before (4 trips in one year), and a downturn in estimated survey biomass was not observed.
- Effort in the NLS-West occurred in two distinct sub-areas over the course of FY2018 and FY2019 – as shown in Figure 3 and Figure 4, fishing in FY2018 was focused mostly in sub-area A and then shifted to sub-area B around the start of FY2019. Both of these sub-areas are small (i.e., ~144 square miles and ~125 square miles, respectively) and fishing was highly concentrated within each sub-area over the course of FY2018 and FY2019. Area A was predominately fished from April 2018 – January of 2019, with effort shifting to Area B around February of 2019.
- Fishing intensity in the area, with over 4 million pounds of scallops landed in a month, may have also contributed to less-than-favorable environmental conditions for scallops in this area. At 20 scallops per pound, around 80 million scallops were shucked for *landings* alone in a 30-day period. Fishermen reported dredges full of cut scallops (soft tissue, viscera) while fishing the area.
- The observer data from 2018 and 2019 suggests that discards represent a small proportion of kept catch. Observers reported that most discarding was done by shoveling. Discard weights are estimated, and usually extrapolated from a sub-sample. Fishermen reported deck loading while fishing in this area.

Figure 16 – Observed meat weight (kg) in the NLS-West area from FY2018 through February of FY2019. Sub-areas fished within the NLS-West are bounded in red and blue.

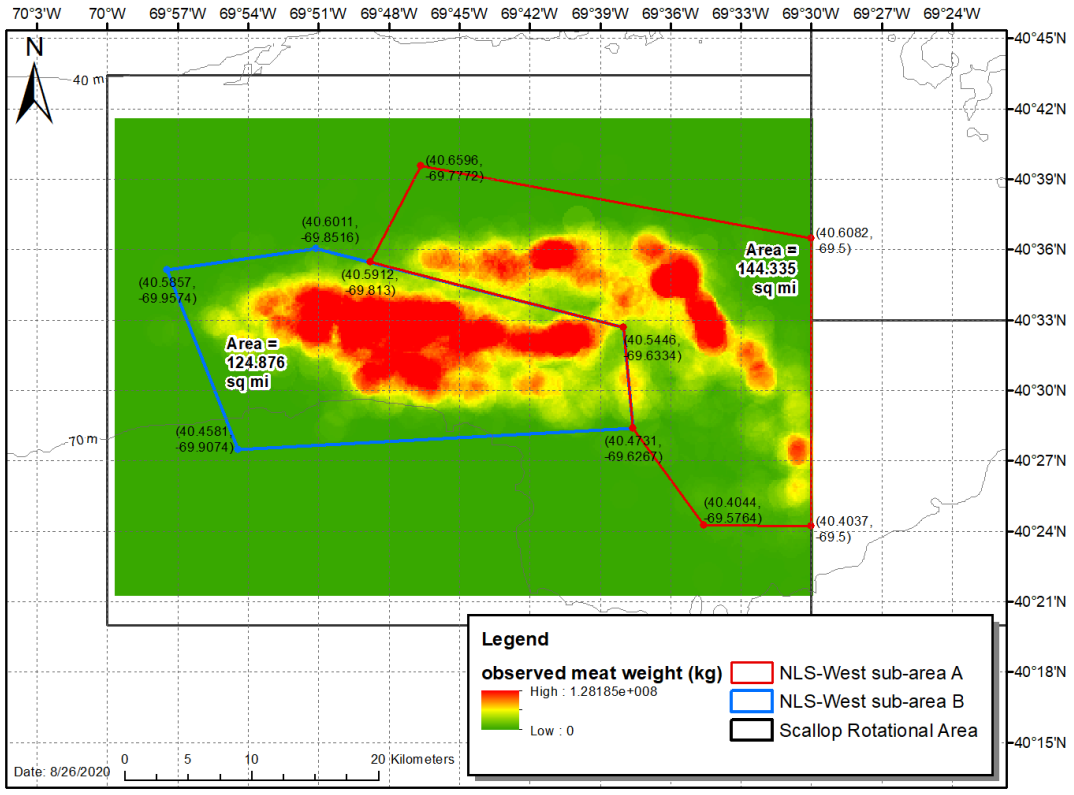


Figure 17 – Observed haul duration heat maps from May 2018 through October 2019 in the NLS-West.