SARC 65 Appendix 3: An Overview of the Atlantic Sea Scallop Resource in the Gulf of Maine

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1.0 INTRODUCTION

The Atlantic sea scallop (*Placopecten magellanicus*) ranges Cape Hatteras to the Gulf of St. Lawrence. The scallop fishery is primarily prosecuted in concentrated areas in and around Georges Bank and off the Mid-Atlantic coast, in waters extending from the near-coast out to the edge of the continental shelf. Atlantic sea scallops occur primarily in depths less than 110 meters on sand, gravel, shells, and cobble substrates (Hart and Chute 2004). While the majority of the Atlantic sea scallop resource is found on Georges Bank and in the Mid-Atlantic, sea scallops also occur in the Gulf of Maine (GOM) in both state and federal waters. The federal scallop resource in the GOM is managed by the New England Fishery Management Council and NOAA Fisheries.

1.1 RELEVANT TERMS OF REFERENCE (SCALLOPS - A3)

This appendix is intended to address Term of Reference (TOR) A3 for SAW/SARC 65:

> *Summarize existing data, and characterize trends if possible, and define what data should be collected from the Gulf of Maine area to describe the condition of the resource. If possible, provide a basis for developing catch advice for this area.*

1.2 SUMMARY OF EXISTING DATA

Table 1 summarizes the existing data streams available for the Gulf of Maine. Examples and/or analyses of each data set are shown in the corresponding section listed below.

Table 1 - Summary of existing data for Atlantic Sea Scallops in Gulf of Maine

Existing Data	Section	Details
Dedicated scallop surveys	2.1 & 2.2	There have been periodic dredge and optical scallop surveys in portions of the Gulf of Maine. Section 2.1 provides an overview of dedicated scallop surveys, while Section 2.2 covers the results of dedicated survey work in 2016 and 2017.
Scallop catch in regional trawl surveys	2.3	Records of scallop catch in several regional trawl surveys (state, federal, shrimp). Indices of spring and fall NMFS bottom trawl surveys provided in Section 2.3.1. Spatial/temporal distribution of scallop catch in regional trawl surveys is shown in Section 2.3.2.
Observer data	3.2	Low number of observed hauls in the Gulf of Maine over the last 10 years. Majority of data collected in Stellwagen Bank region. Section 3.2.1 summarizes data from observed LA trips in the NGOM in 2017.
Vessel monitoring system data	3.1	Multiple uses: 1) Spatial extent of fishing activity in the region; 2) Required daily reports of catch. All vessels in the federal scallop fishery must have an active VMS unit to participate. Units ping vessel's location every 30 minutes and can be used to transmit fishing reports.
Vessel trip report data	3.3.2.1.1	Reports completed by vessels prior to landing. VTRs provide estimates of fishing location and landings. Estimated landing by statistical reporting area from VTR reports are provided for reference.
Landings data	3.2.1	Data available from both state and federal fisheries. Dealer reports should represent a census of landings.

Figure 1. Major physiographic features of the Gulf of Maine relative to the territorial waters boundary of the US and Canada (EEZ, red dotted line).

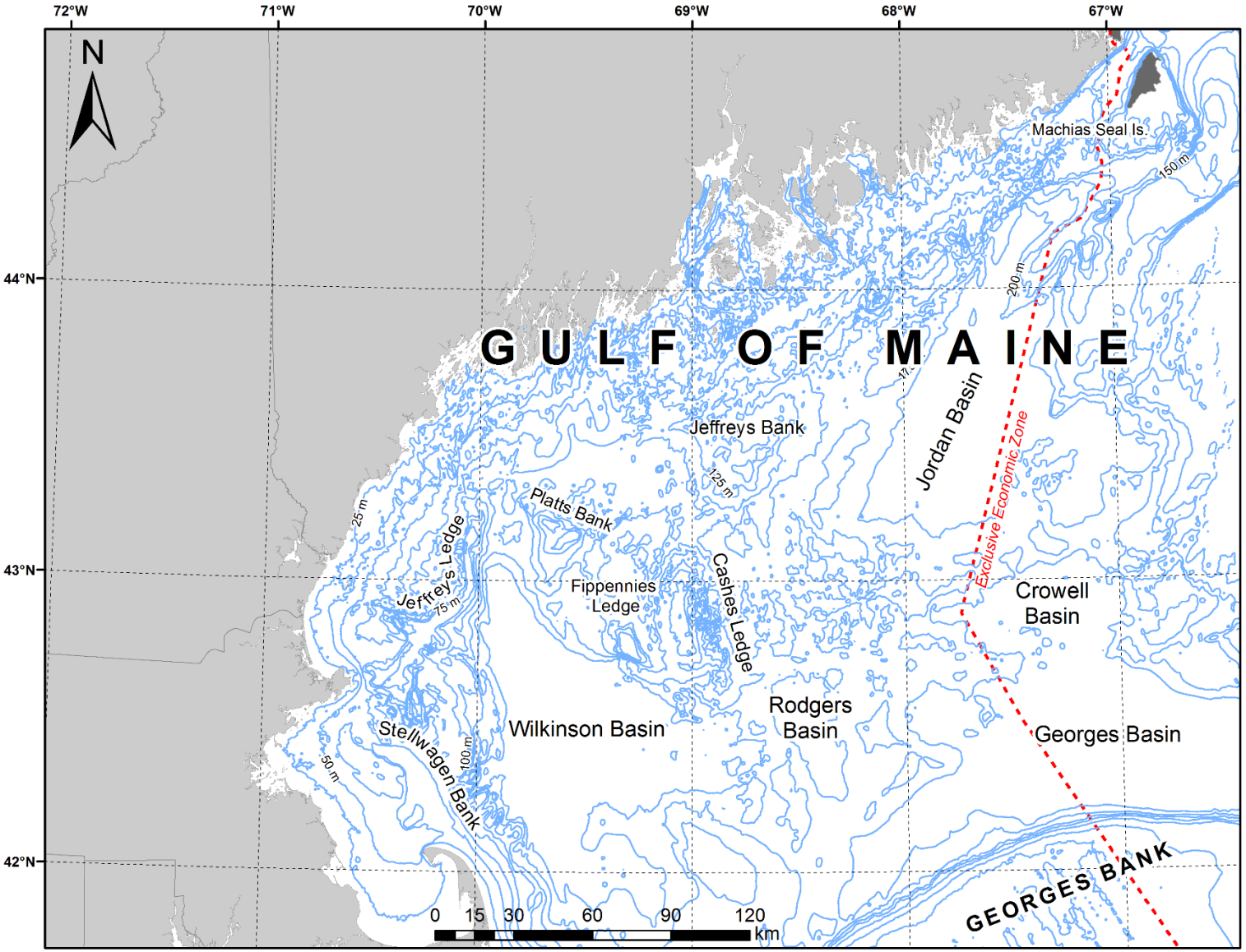


Figure 2. Management boundaries in the Gulf of Maine region including boundaries of the Northern Gulf of Maine Management Area (NGOM, in blue), Habitat Management Areas, Dedicated Habitat Research Areas, Groundfish Closures, VMS Demarcation line, State Waters, and Statistical Reporting Areas (grey lines and labels).

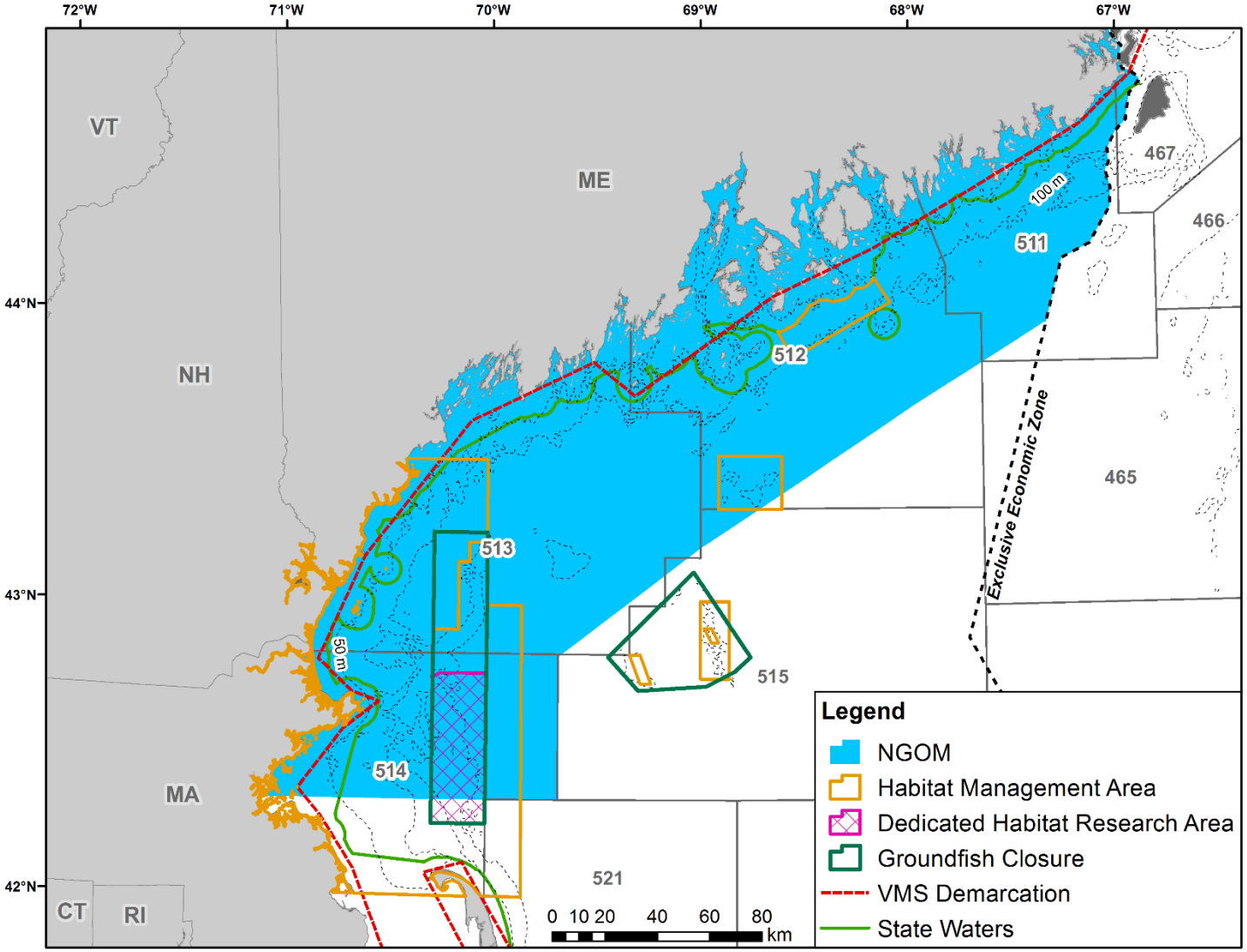
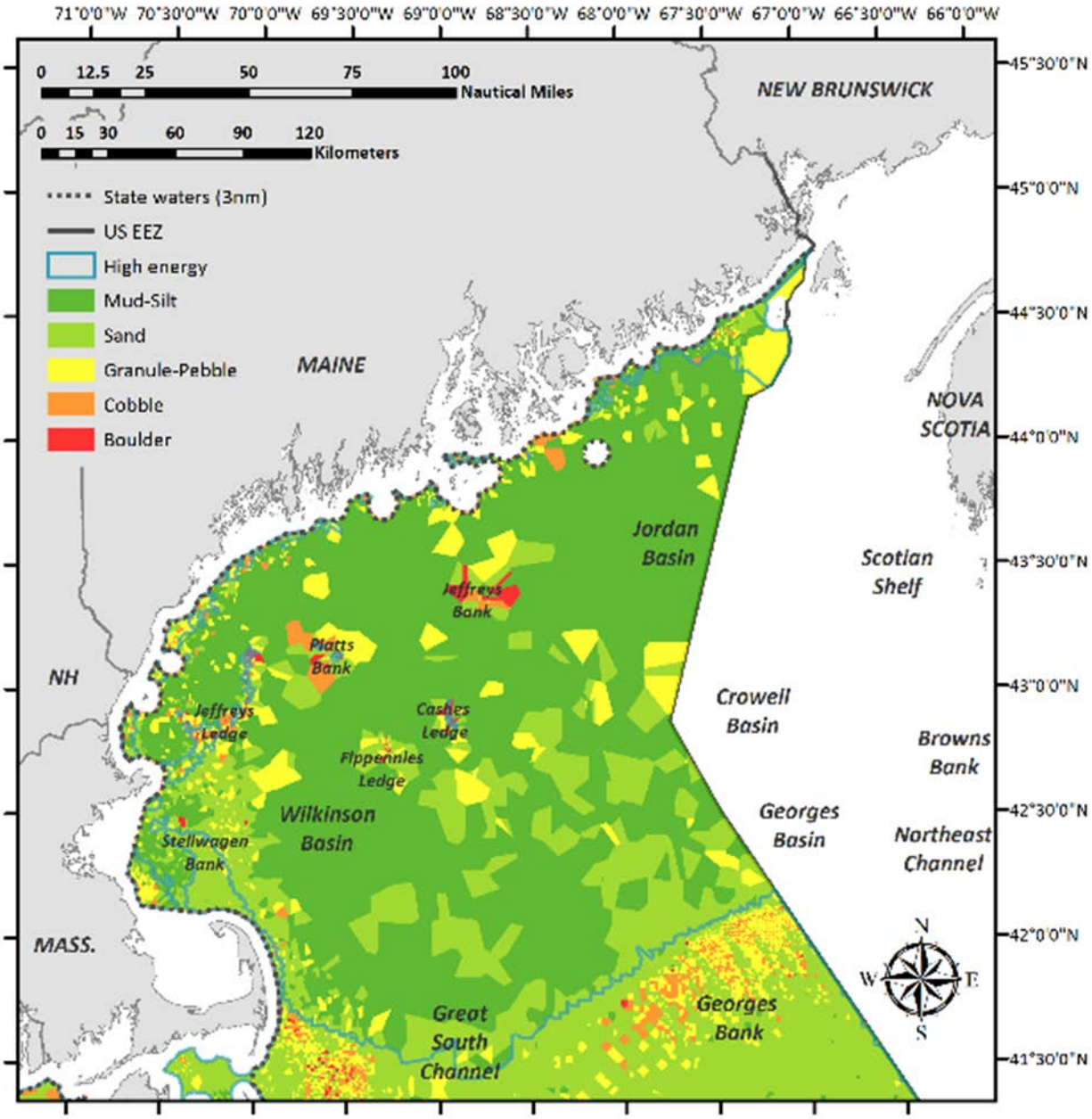


Figure 3 -Sedimentary features of the Gulf of Maine (NEFMC, 2016).



2.0 RESOURCE SURVEYS

Scallops are captured in both dedicated resource surveys and incidentally in trawl surveys. This section describes the history of both dedicated survey work, as well as the available information from trawl surveys.

2.1 DEDICATED SCALLOP SURVEYS IN THE GULF OF MAINE

Truesdell et al (2014) noted in SAW59 that there was a limited amount of fishery independent data available for the Gulf of Maine Region (Figure 1). Since the last scallop assessment additional dredge and optical surveys have been completed since the last benchmark, however the region remains data-limited relative to Georges Bank and the Mid-Atlantic. Some of the earliest dedicated scallop surveys of the region took place in the early 1980's (Serchuk, 1983). Later, dredge surveys focusing on the Northern Gulf of Maine Management Area were conducted by Maine Department of Marine Resources/University of Maine in 2002, 2006, 2010, 2012, and 2016 (Table 2). Coverage of this survey has varied each year and recently has focused mostly on areas with known aggregations of scallops commonly targeted in the NGOM. Additional drop camera surveys were conducted by the School for Marine Science and Technology (University of Massachusetts Dartmouth) in 2009, 2010, 2011, 2013, 2014, and 2015 (Table 2; Stokesbury et al. 2010, Bethoney et al. 2016, Asci et al. 2018). SMAST drop camera surveys covered areas that have been closed to fishing (Jeffreys Ledge, Cashes Ledge, and Fippennies Ledge) and covered one area open to fishing in the NGOM (Platts Bank).

Data collected from these surveys have been useful in estimating localized scallop abundance, size distribution, and exploitable biomass; however, the relatively small proportion of the Gulf of Maine actually surveyed and lack of annual survey effort suggests our knowledge of the Gulf of Maine scallop population is highly uncertain.

Table 2 - Northern Gulf of Maine scallop surveys, 2009-2017

	Northern Gulf of Maine (NGOM) scallop surveys, 2009-2017											
	Year	2009		2010	2011	2012	2013	2014	2015	2016	2017	
	Month(s)	June-July	August	August	August	May-June	August	August	July-August	May-June	July	July
	Organization	ME DMR/ UMaine	SMAST	SMAST	SMAST	ME DMR/ UMaine	SMAST	SMAST	SMAST	ME DMR/ UMaine	SMAST	CFF
	Method	dredge	drop camera	drop camera	drop camera	dredge	drop camera	drop camera	drop camera	dredge	drop camera	HabCam/ dredge
Area(s) surveyed	**northern Stellwagen**	X				X				X	X	X
	parts of Stellwagen		X				X					
	southern Jeffreys Ledge	X				X	X	X	X	X		X
	Ipswich Bay	X				X				X		
	northern Jeffreys Ledge(closed)		X	X	X		X	X	X			
	Platts Bank	X	X	X	X	X	X	X	X	X		
	Fippennies Ledge (closed)		X	X	X	X	X	X	X	X		
	Cashes Ledge (closed)		X	X	X		X	X	X			
	Jeffreys Bank (closed)		X	X								
	Mt. Desert/ Isle au Haut	X				X				X		
	eastern ME	X				X				X		

2.2 RECENT DEDICATED SCALLOP SURVEYS

The following section briefly summarizes findings from 2016 and 2017 scallop surveys in the Gulf of Maine. The specific areas covered by these efforts are shown in Table 2.

2.2.1 2017 SMAST Drop Camera Survey

The SMAST drop camera was used to survey the portion of Stellwagen Bank that was fished by Limited Access, LAGC IFQ, and LAGC NGOM vessels in FY2017 (Figure 4). The survey stations were fixed on a high-resolution (1.5 km^2) grid and were sampled between July 7th and July 13th, 2017.

Survey findings suggest very few smaller scallops (< 75 mm) were in the area and that most scallops observed were approximately 100 mm in length (Figure 2). Density was estimated to be roughly 0.1 +/- 0.02 scallops m^{-2}, which translates to a harvestable density similar to what would be seen on Georges Bank. Total biomass was estimated at 356 mt and exploitable biomass was estimated at 228 mt. SARC 50 SH:MW parameter estimates were used when calculating total and exploitable biomass.

Figure 4. Observed scallop density m^{-2} at survey stations completed by the SMAST drop camera in 2017.

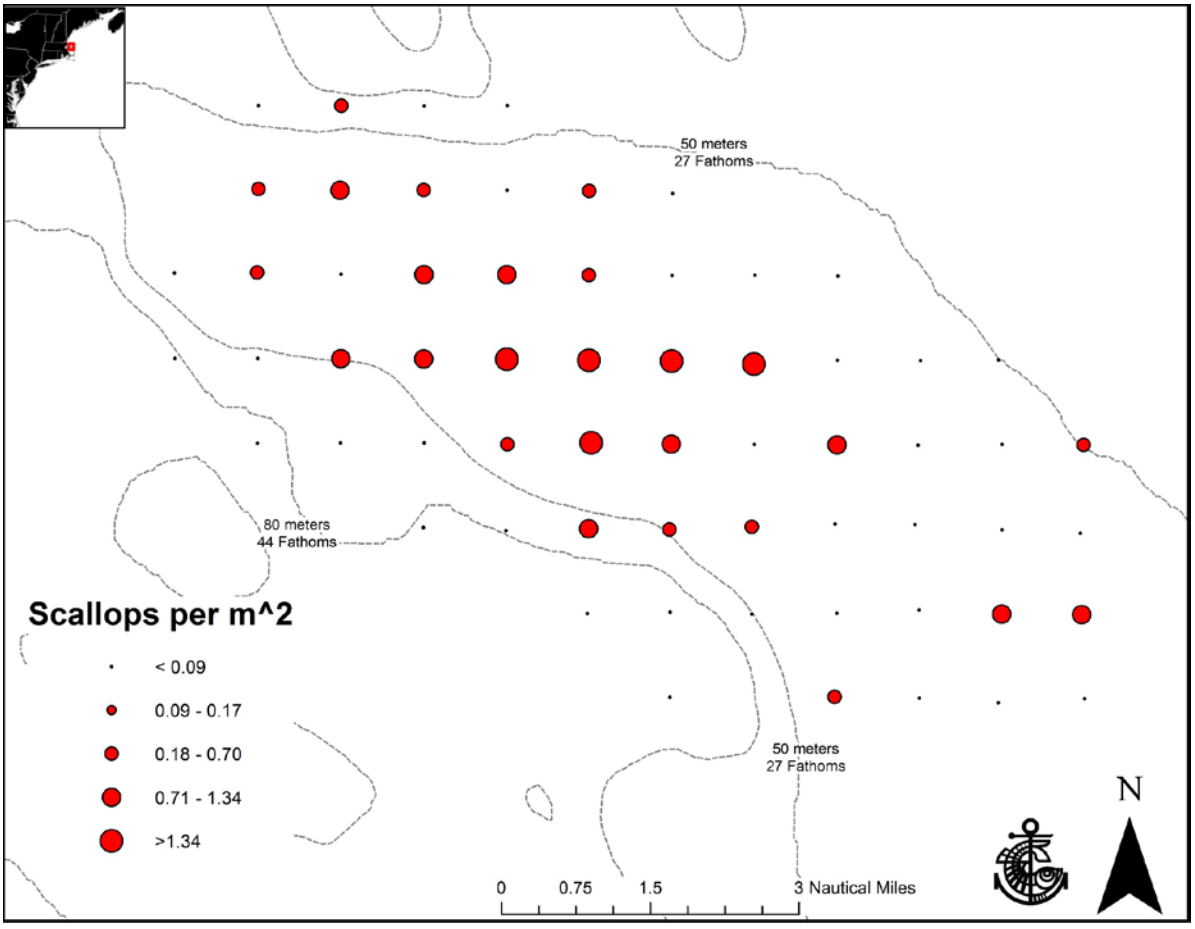
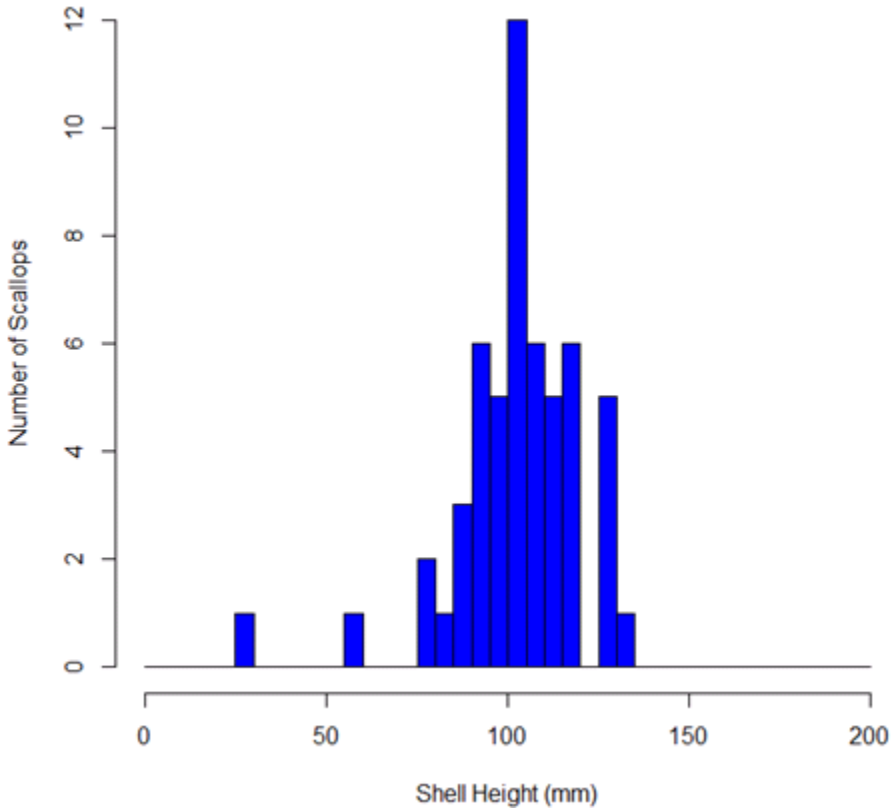


Figure 2. Shell height distribution of scallops in the Stellwagen Bank priority area based on digital still camera images.



2.2.2 2017 RSA HabCam v3 Survey, Northern Gulf of Maine

Between July 8th and July 9th, 2017, the Coonamessett Farm Foundation surveyed portions of the NGOM that were fished in FY2016 (southern Jeffreys Ledge, see Figure 6) and FY2017 (Stellwagen Bank, see Figure 8) using HabCam v3 and a survey dredge. HabCam tracks covered approximately 67 NM on Stellwagen Bank and 22 NMon southern Jeffreys Ledge. Six dredge tows were conducted on Stellwagen to collect biological samples and length frequency data. Due to the high density of fixed gear on Jeffreys Ledge, it was not possible to complete dredge tows in this area.

Both HabCam and dredge data indicated very few recruits (<= 75 mm) on Stellwagen Bank. Scallops > 75 mm appeared to be spread out across the top of Stellwagen (Figure 7). There was some evidence of recruits in the southwest part of Jeffreys Ledge, and scallops > 75 mm seemed to be distributed across the survey area (Figure 5). The smaller scallops on Jeffreys Ledge were observed with notable densities of sea stars. Total biomass on Stellwagen Bank was estimated to be roughly 459 mt and biomass on southern Jeffreys Ledge was estimated to be roughly 152 mt.

Figure 5. Scallop size distribution observed by the CFF HabCam survey of Jeffreys Ledge in 2017.

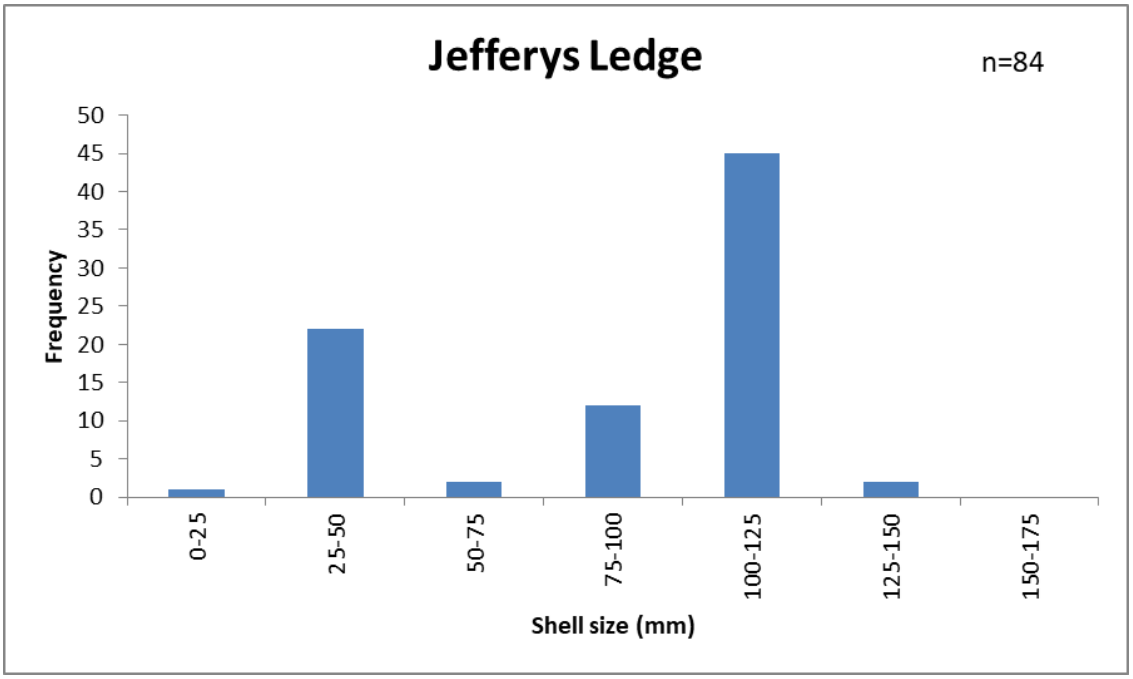


Figure 6. Biomass heatmap from the CFF HabCam survey of Jeffreys Ledge in 2017.

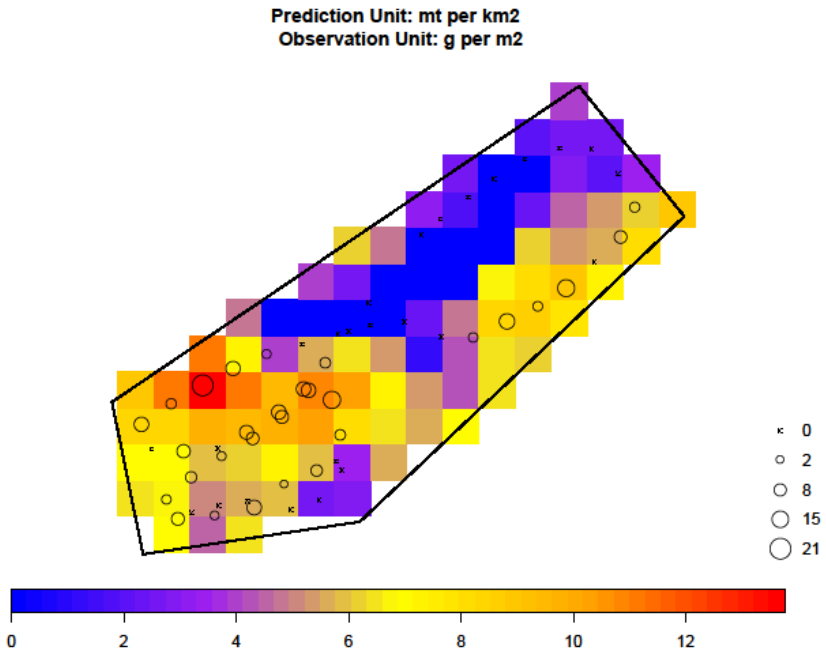


Figure 7. Scallop size distribution observed by the CFF HabCam survey of Stellwagen Bank in 2017.

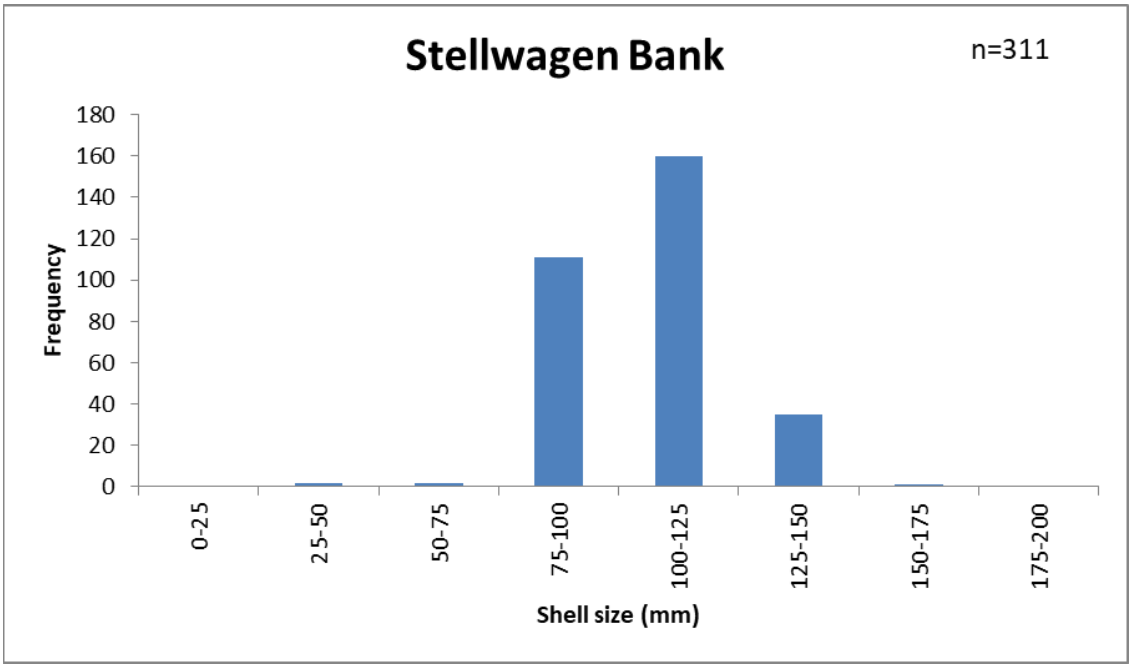
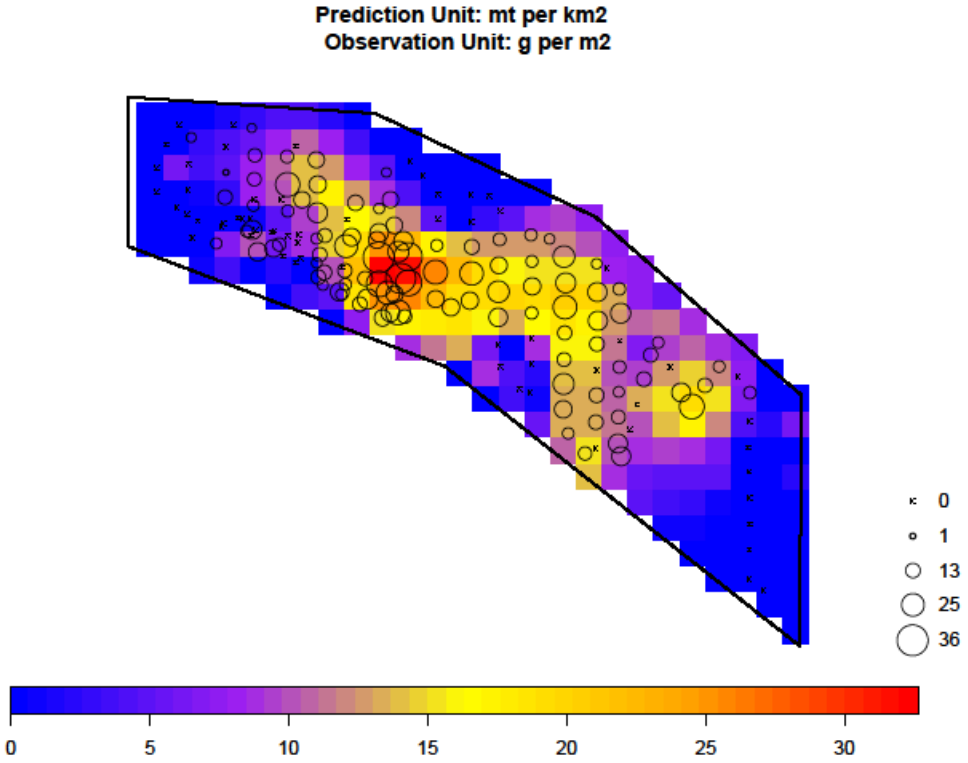


Figure 8. Biomass heatmap from the CFF HabCam survey of Stellwagen Bank in 2017.



2.2.3 2016 UMaine/Maine DMR Dredge Survey of Northern Gulf of Maine

In order to effectively allocate survey effort to areas with high scallop biomass, the southern three survey areas (Ipswich Bay, Jeffreys Ledge and Northern Stellwagen Bank; the areas of highest fishing activity within the NGOM) were subdivided into high, medium, and low density sub-strata. The delineation of these substrata was informed by fishermen input, VTR, and VMS, as well as previous survey data from 2009 and 2012. Tows were allocated among these sub-strata according to the Neyman's allocation, which ensures that sampling effort is allocated to areas of high variance to increase precision of abundance indices and refine the resulting biomass estimates:

$$n_h = n\frac{W_h S_h}{\sum_{h=1}^{H} W_h S_h}$$

where n is the total number of sampling stations for the survey area, H is the total number of strata, W_h is the proportion of stratum h area over the survey area, and S_h is the estimated standard deviation of historical data in stratum h.

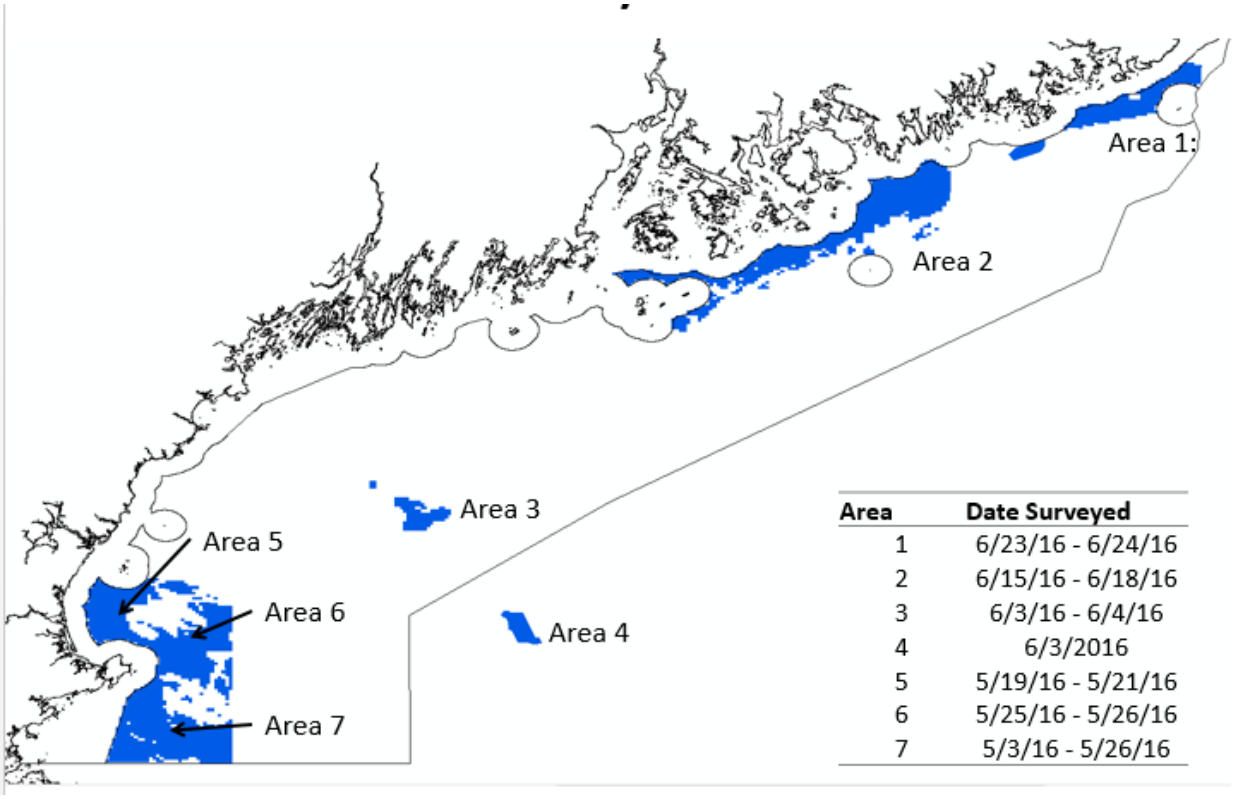
The highest scallop biomass observed in the 2016 ME DMR/UMaine dredge survey was on Stellwagen Bank (Figure 10, Figure 11). Smaller concentrations of biomass (>101mm) were seen in Machias/Seal Island, and on Platts Bank. Total biomass in the NGOM, assuming a dredge efficiency of 0.4 and selecting a conservative value (q0.10 on the bootstrapped distribution), was estimated at 1.75 million lbs. (Table 3). Using an exploitation rate of 0.2, the removable biomass was calculated to be approximately 350,000 lbs. (Table 3). This information was used to inform a TAC for the NGOM for FY 2017.

Biomass estimates were substantially higher in 2016 (Table 3) than they were in 2012 (approximately 416,000 lbs). Biomass estimates were presented to managers in 2016 using an exploitation rate of 0.38 and an 0.26. Managers requested a new model run using an exploitation rate equal to 0.2, with estimates at the q0.25 and q0.10.

Table 3 - Biomass estimates from 2016 NGOM survey (F=0.2, Dredge Efficiency=0.4).

Exploitation Rate = 0.20 **Dredge Efficiency = 0.40**	**q0.05**	**q0.10**	**q0.15**	**q0.20**	**q0.25**	**Mean**
Biomass Estimate (MT)	657	795	932	1018	1090	1651
TAC(MT)	131	159	186	204	218	330
Biomass Estimate (lbs)	1,447,797	1,751,822	2,055,240	2,244,263	2,402,140	3,640,385
TAC(lbs)	289,559	350,364	411,048	448,853	480,428	728,077

Figure 9 - 2016 ME DMR NGOM Survey Areas.



Area	Date Surveyed
1	6/23/16 - 6/24/16
2	6/15/16 - 6/18/16
3	6/3/16 - 6/4/16
4	6/3/2016
5	5/19/16 - 5/21/16
6	5/25/16 - 5/26/16
7	5/3/16 - 5/26/16

Figure 10 - 2016 ME DMR NGOM survey - estimates of harvestable biomass from each survey area.

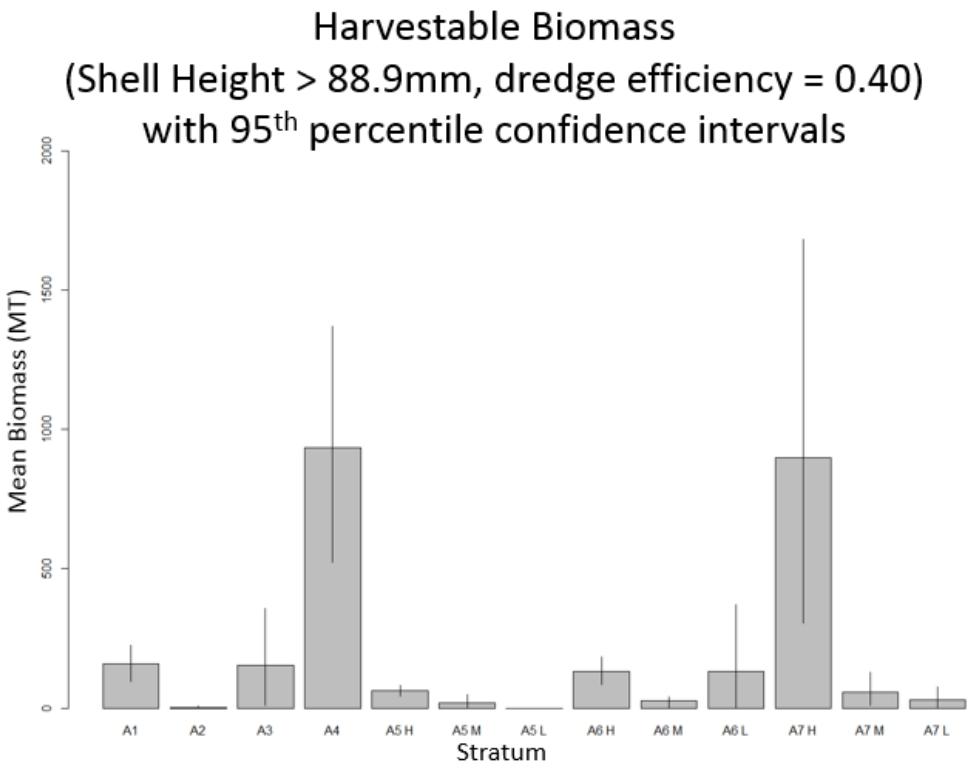
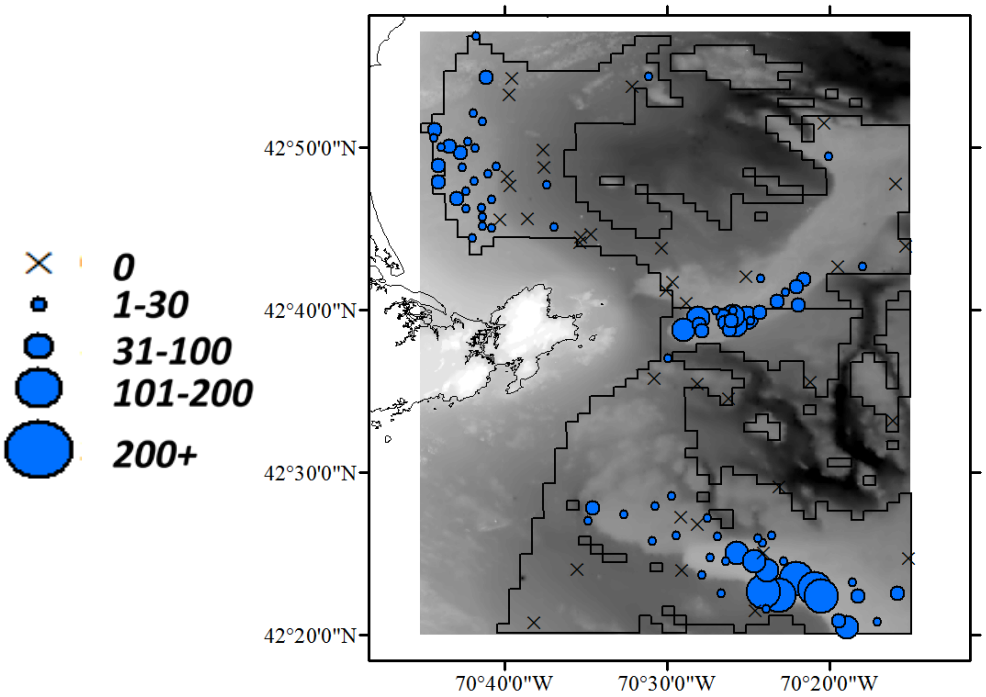


Figure 11 - 2016 ME DMR NGOM survey – Distribution of scallop abundance on Ipswich Bay, Jeffreys Ledge and Stellwagen Bank.



2.3 OVERVIEW OF SCALLOP CATCH IN REGIONAL TRAWL SURVEYS

In addition to dedicated dredge and optical surveys, Atlantic sea scallops are captured in several regional trawl surveys. To summarize existing data, a time series of scallop catch in Gulf of Maine strata was compiled using the NEFSC bottom trawl survey (Section 2.3.1). The spatial distribution of scallops in the Gulf of Maine was examined in Section 2.3.2 using data from the NEFSC bottom trawl survey, the NEFSC shrimp trawl survey, the Massachusetts Division of Marine Fisheries trawl survey, and the New Hampshire/Maine Department of Marine Resources inshore trawl survey.

There are several important caveats to be aware of when reviewing the following figures. First, note that these trawl surveys were not targeting popular scallop grounds or areas with known scallop habitat. Second, trawl survey gear has different selectivity and efficiency compared to dredge survey gear, meaning scallop catches in trawl surveys are not directly comparable to scallop catches in dredge surveys. It is worth noting that the field methods and gear configuration varies between each of these trawl surveys and also that these trawl surveys have evolved over the roughly 50-year time series being considered.

2.3.1 Scallop catch in NEFSC bottom trawl survey

Indices of scallop catch from the spring and fall Northeast Fisheries Science Center (NEFSC) bottom trawl surveys in the Gulf of Maine are shown in Figure 12 and Figure 13. Note that there is a break in the time series between 2008 and 2009 when the survey was shifted from the R/V Albatross to the R/V Bigelow. The survey indices appear to detect recent recruitment events in the Gulf of Maine that supported increases in fishing activity and removals from the region in 2015, 2016, and 2017 (see also Figure 20 and Figure 22).

Figure 12 - GOM Survey Indices (40mm+) from NMFS Bottom Trawl Survey (1978 – 2017)

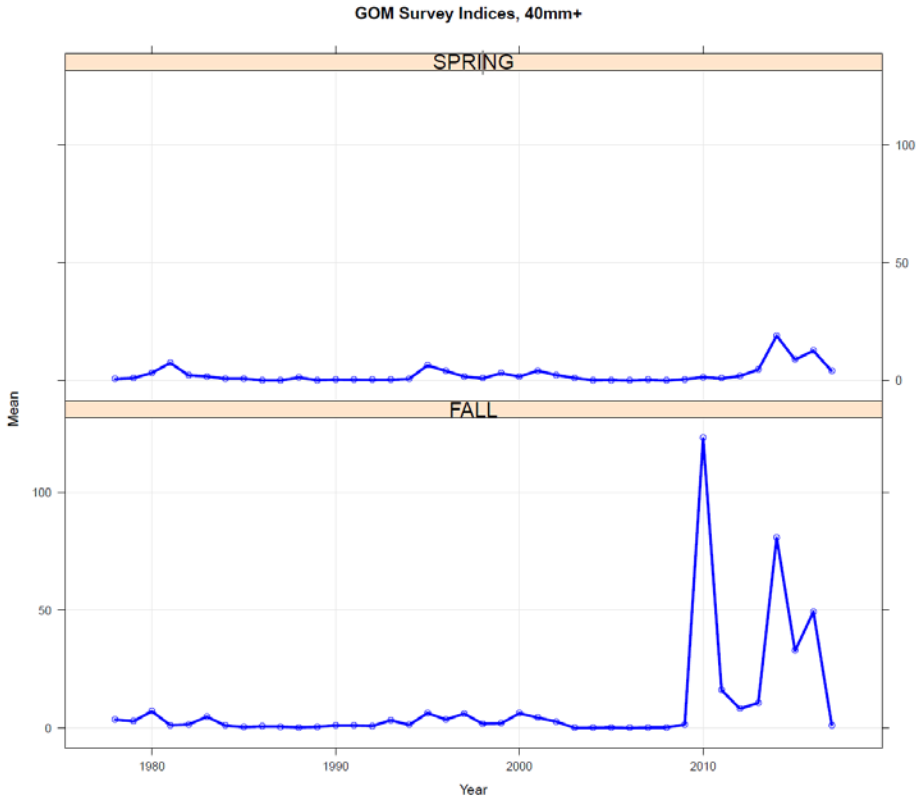


Figure 13 - GOM Survey Indices (80mm+) from NMFS Bottom Trawl Survey (1978 – 2017)

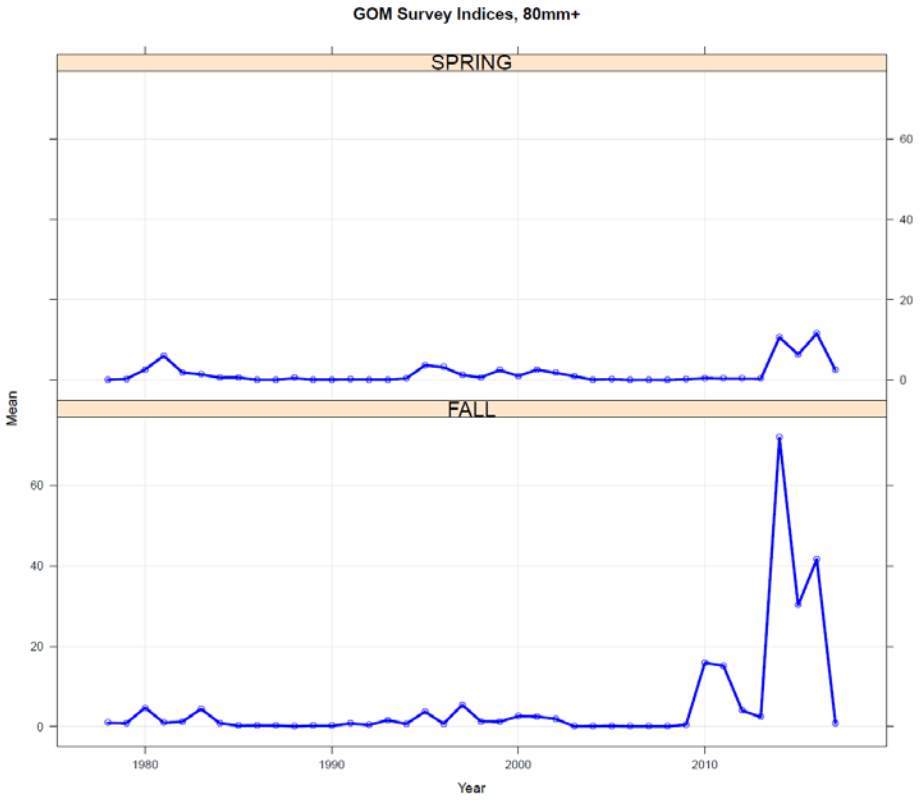
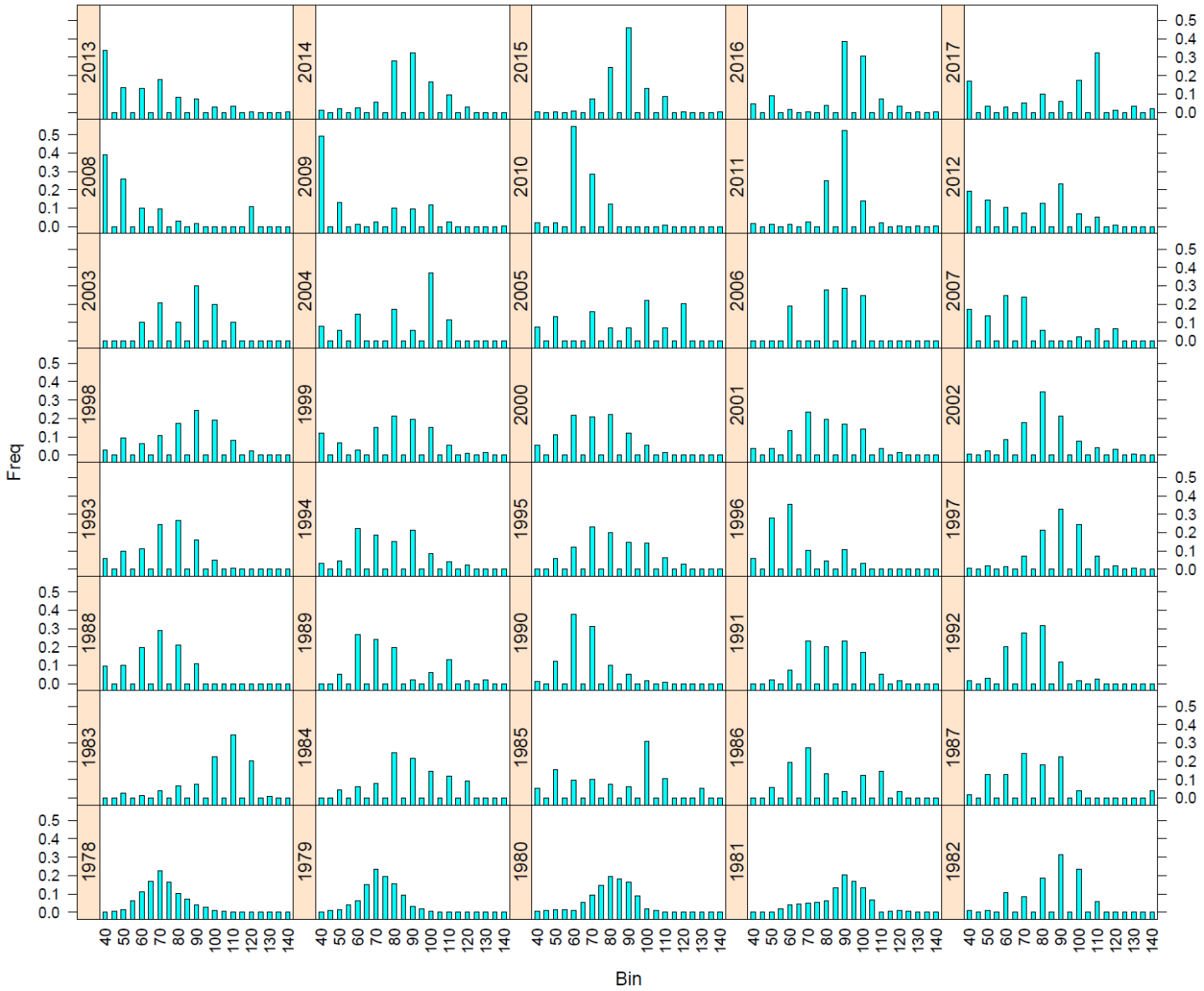


Figure 14 – Length composition of scallops captured in the GOM during the NMFS Fall Bottom Trawl Survey



2.3.2 Spatial distribution of scallop catches in historic GOM surveys

Data from four regional trawl surveys in the Gulf of Maine were compiled to describe historic observations of scallop catch across the region. The survey data series included:

1. National Marine Fisheries Service Bottom Trawl Survey (1963-2014)
2. National Marine Fisheries Service Shrimp Trawl Survey (1983-2014)
3. Massachusetts Division of Marine Fisheries Bottom Trawl Survey (1978-2014)
4. New Hampshire/Maine Dept. of Marine Resources Inshore Trawl Survey (2000-2012)

There were 17,043 tows recorded in the Gulf of Maine between the NMFS Bottom Trawl, NMFS Shrimp Trawl, and MADMF Bottom Trawl surveys. Of the 17,043 recorded tows, 2,962 observed scallops. Tows with scallop catch were mostly attributed to inshore areas or to shallower ledges and banks in the central Gulf of Maine. These numbers do not include the NH/ME DMR Inshore Trawl survey because of its much shorter time series. However, NH/ME DMR Inshore Trawl survey catches were included in the figures to offer an additional look at regional scallop catches.

The National Marine Fisheries Service (NMFS) Dredge Survey does not include survey strata in the Gulf of Maine; however, the NMFS Dredge Survey did some exploratory surveying in the Gulf of Maine in 1983, 1984, and 1987. Dredge stations in these exploratory surveys mostly covered known scallop fishing grounds in the Gulf of Maine, such as Fippennies Ledge, Jeffreys Ledge, Stellwagen Bank, and the deeper water north east of Platts Bank. 84 of the 102 non-random dredge tows observed scallops, primarily on southern Jeffreys Ledge and Fippennies Ledge.

Though drawing quantitative conclusions from compiled trawl and dredge surveys in the Gulf of Maine may be difficult, some qualitative points regarding scallop distribution over time can be made:

1) Trawl surveys have consistently observed scallops in the area north of Provincetown, MA, extending towards the southern edge of Stellwagen Bank. This finding is consistent with our knowledge of this area being a popular fishing ground based on the VMS data described in Section 3.1.
2) All trawl surveys have consistently observed scallops in Ipswich Bay over the time-series meaning and may be an area of interest for future surveying.

Figure 15. Compiled scallop catches from the NMFS Bottom Trawl Survey (1963-2014), NMFS Shrimp Trawl Survey (1983-2014), MA DMF Bottom Trawl Survey (1978-2014), and NH/ME DMR Inshore Trawl Survey (2000-2012). The black "x" marks show survey tows with no scallops.

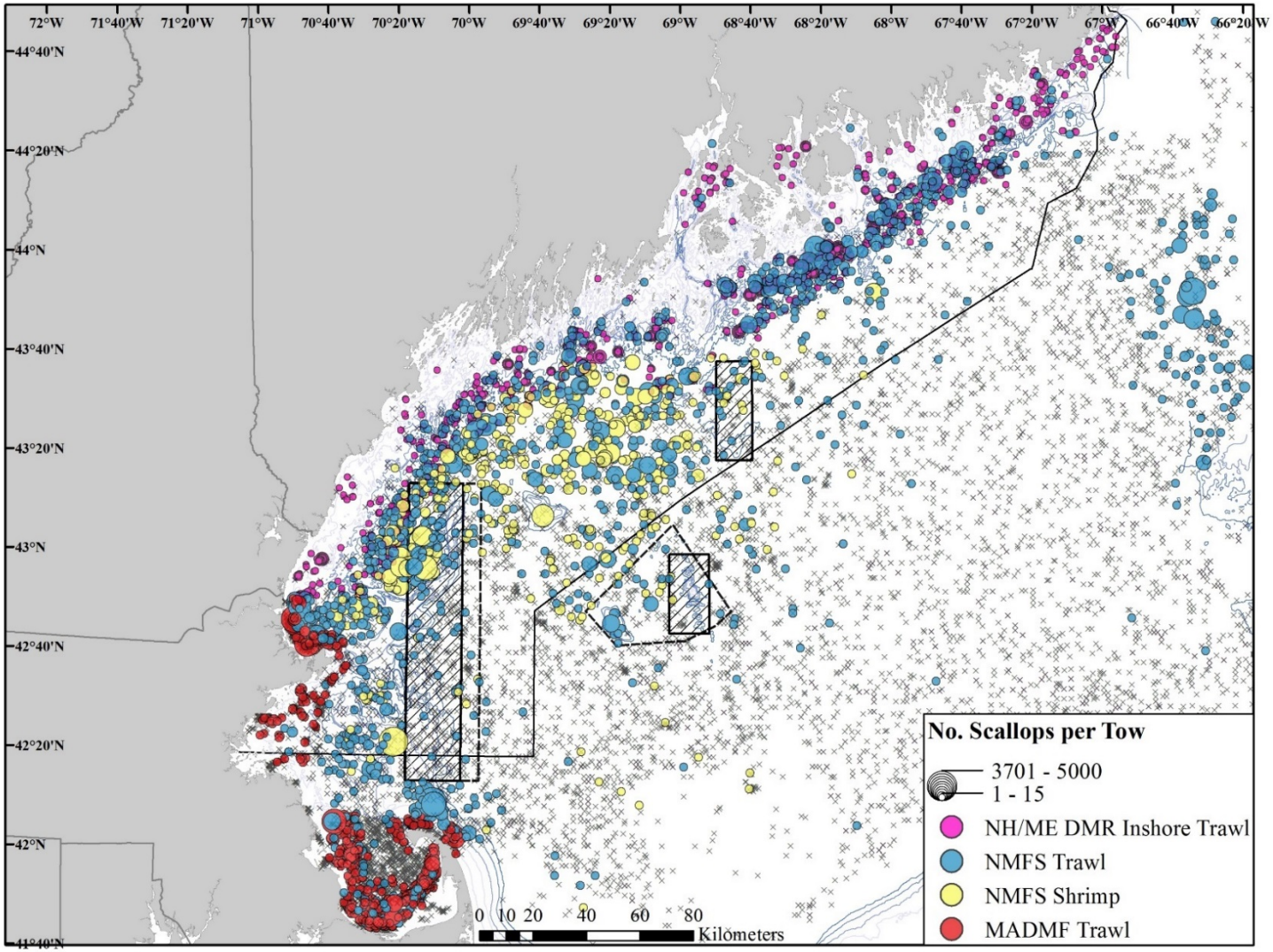


Figure 16 Compiled scallop catches from the NMFS Bottom Trawl Survey (1963-2014), NMFS Shrimp Trawl Survey (1983-2014), MA DMF Bottom Trawl Survey (1978-2014), and NH/ME DMR Inshore Trawl Survey (2000-2012), excluding survey tows with zero scallop catch.

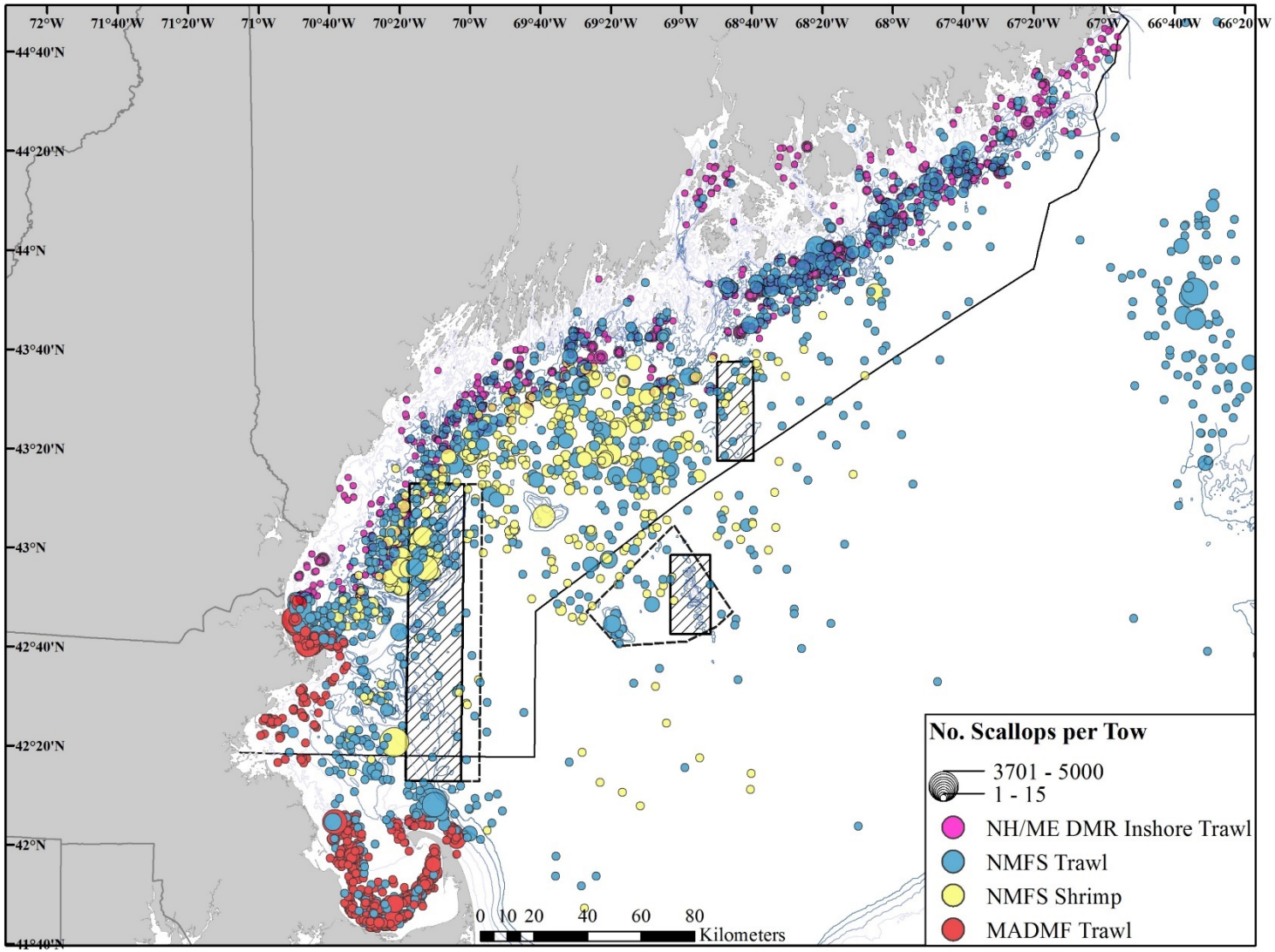


Figure 17. Compiled scallop catches from the NMFS Bottom Trawl Survey (1963-2014), NMFS Shrimp Trawl Survey (1983-2014), MA DMF Bottom Trawl Survey (1978-2014), and NH/ME DMR Inshore Trawl Survey (2000-2012) relative to 2016 and 2017 scallop fishery activity. Black "x" marks show tows with zero scallops.

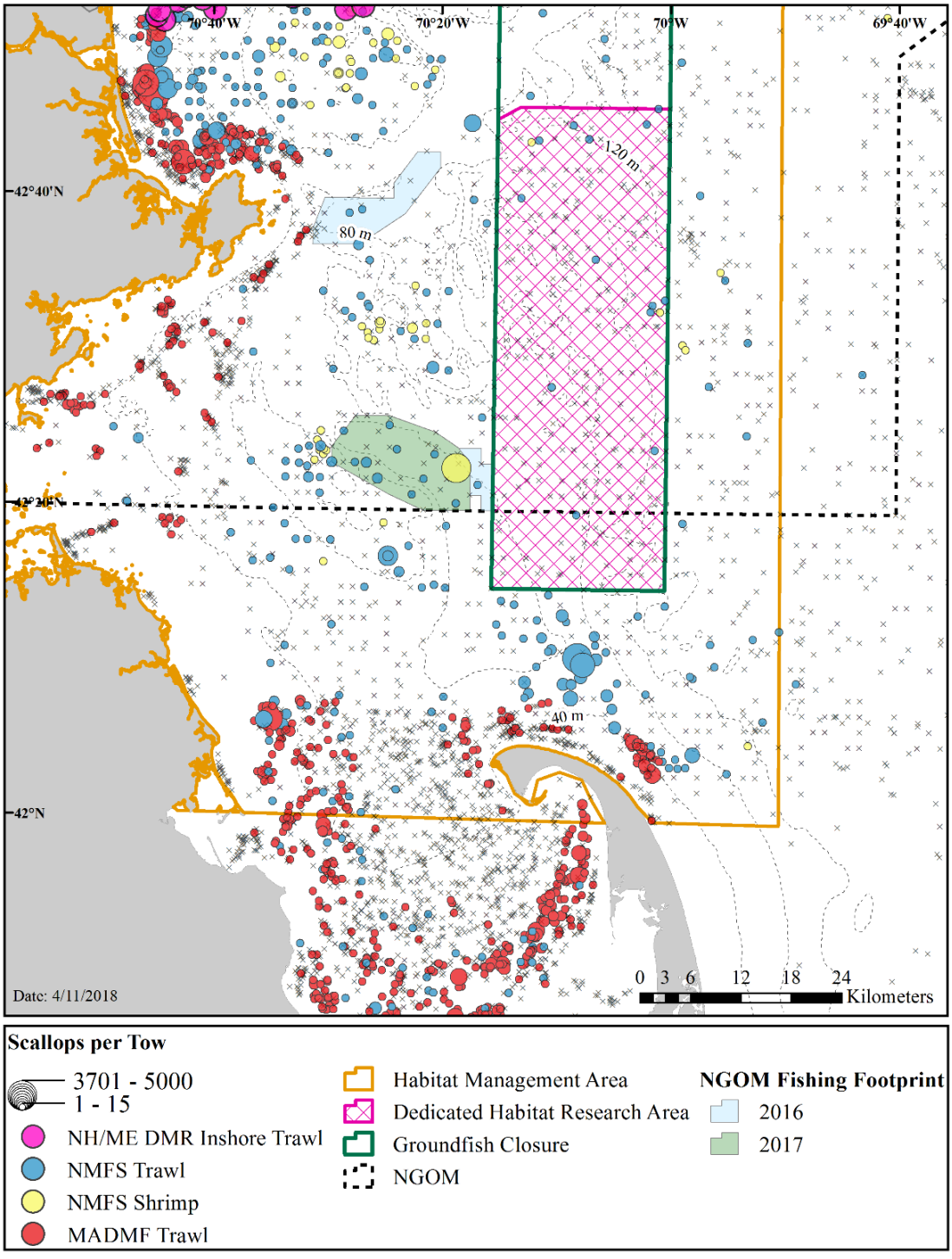
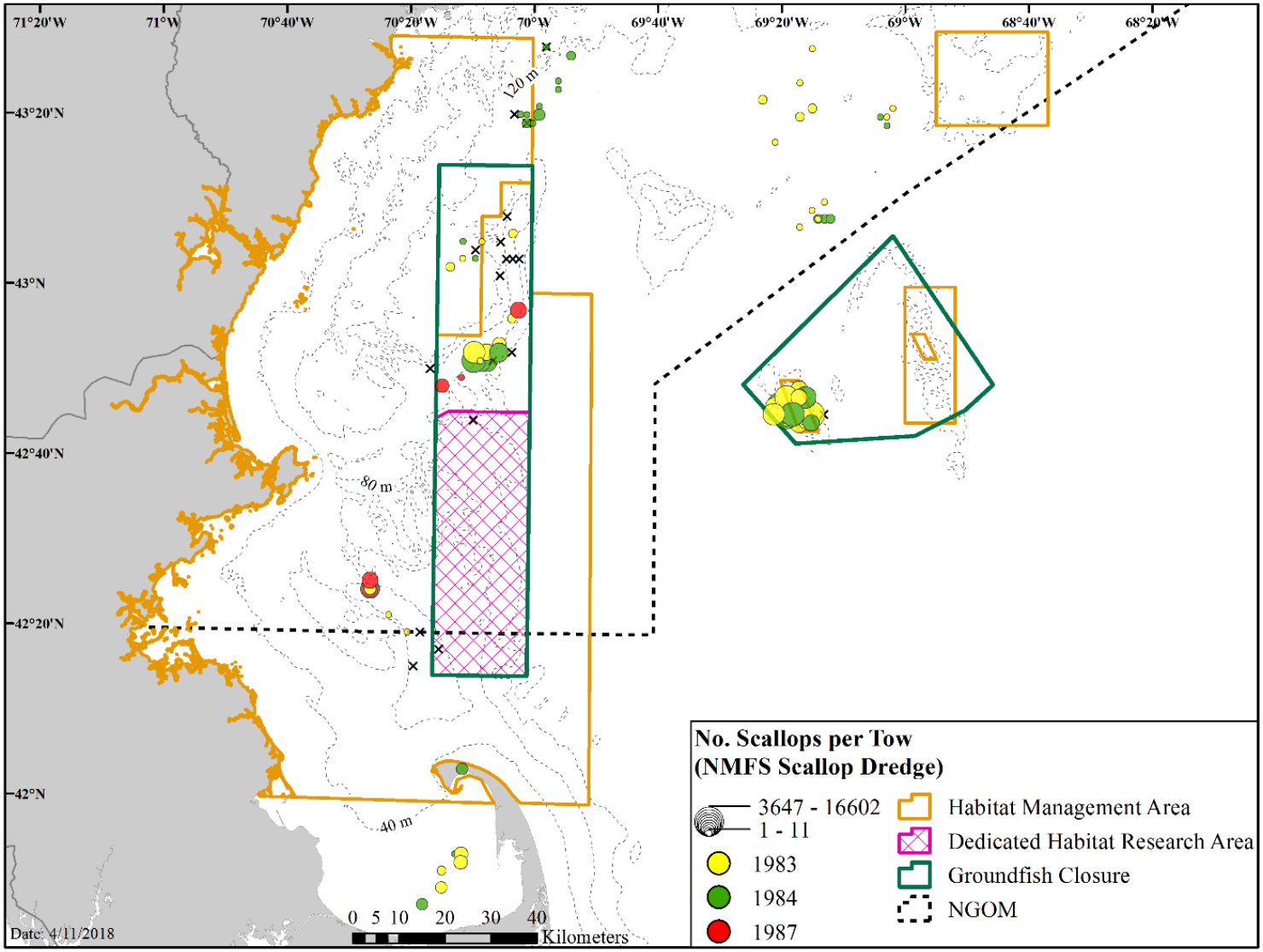


Figure 18 - Scallop catch per tow in the 1983, 1984, and 1987 NMFS dredge surveys in the Gulf of Maine



3.0 FISHERY DEPENDENT DATA

Several streams of fishery dependent data were used to characterize the sea scallop resource in the Gulf of Maine. Section 3.1 describes fishery trends using Vessel Monitoring System (VMS data) and Section 3.2 describes existing observer data in the Gulf of Maine.

3.1 FISHING EFFORT (VESSEL MONITORING SYSTEM DATA)

Federally permitted scallop vessels are required to carry vessel monitoring systems (VMS) that track the position of the vessel every 30 minutes ("pings"). VMS data can be pooled to determine activity by fleets in spatially distinct regions. Figure 19 illustrates the relative fishing activity in six areas of the Gulf of Maine: Stellwagen Bank north and south of 42' 20°, Platts Bank, Jeffreys Ledge, New Hampshire/Northern Massachusetts state waters (includes Ipswich Bay), and other regions of the Gulf of Maine that are marked as unclassified. The majority of fishing activity in the Gulf of Maine region occurs in the Stellwagen-South region, located due north of Provincetown, which is outside of the Northern Gulf of Maine Management area.

Figure 19 - Total number of VMS pings per region (thousands) by year in Gulf of Maine.

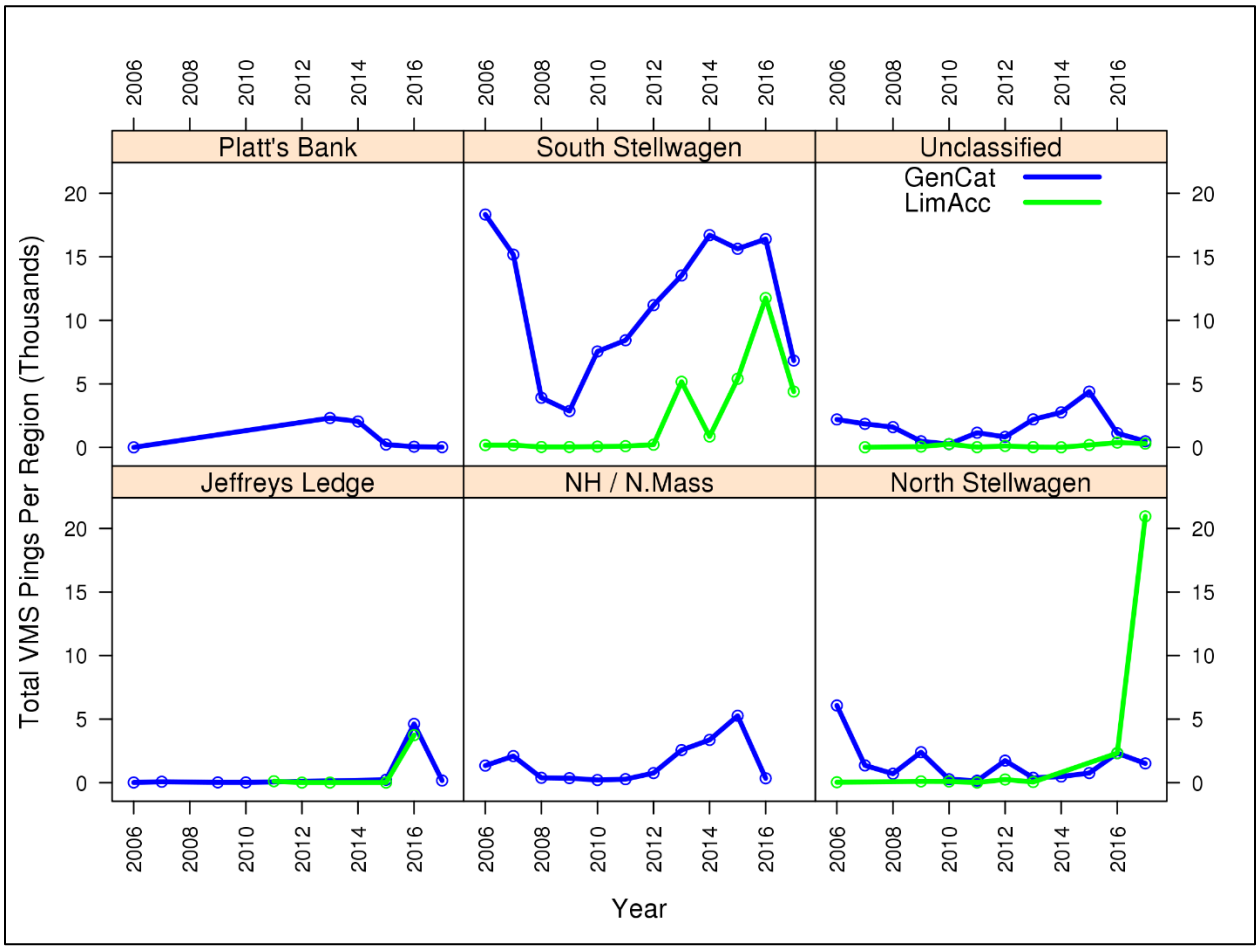


Figure 20 - Limited Access VMS fishing effort on Stellwagen Bank (2014 - 2017)

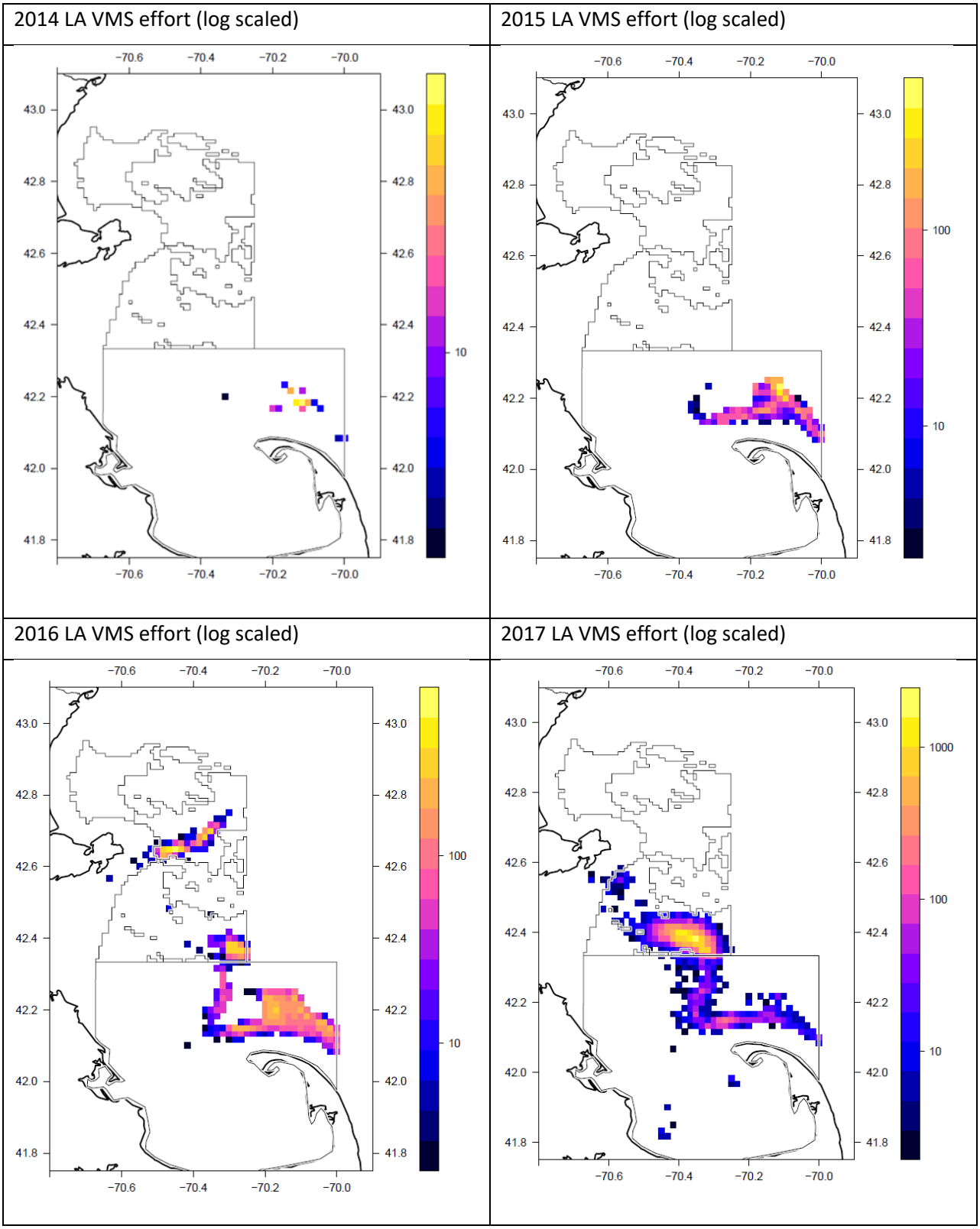
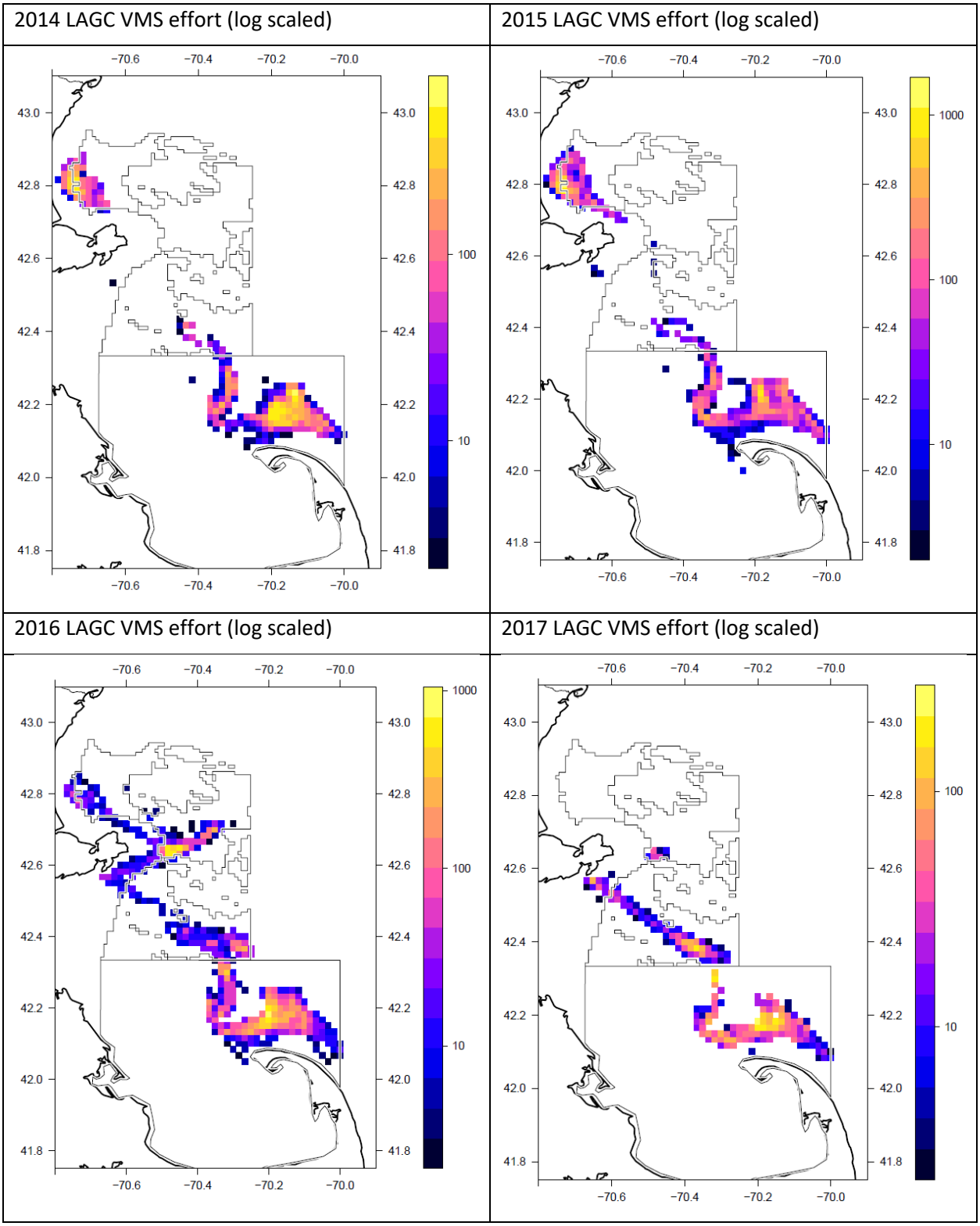


Figure 21 - LAGC VMS fishing effort on Stellwagen Bank (2014 – 2017)

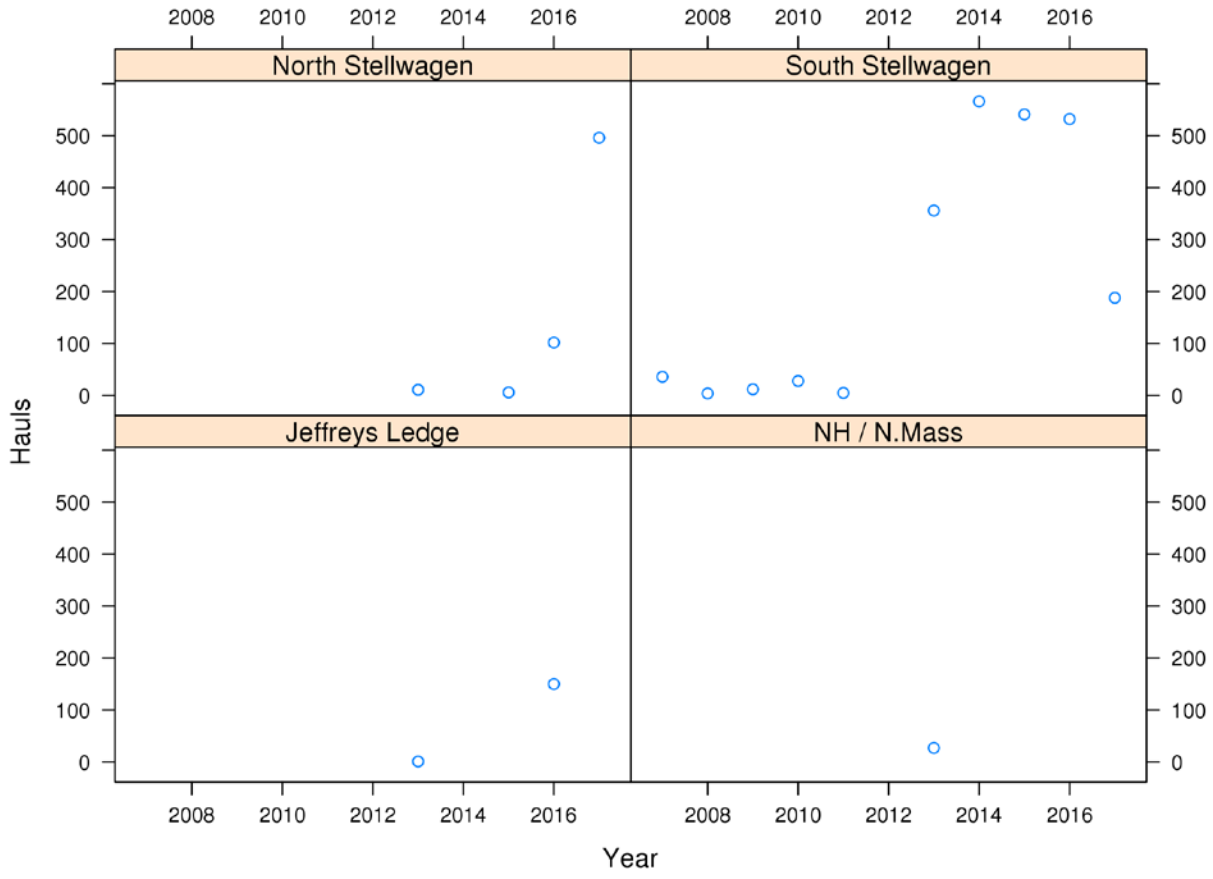


3.2 OBSERVER DATA

At-sea observers are deployed on federally permitted scallop vessels through the Northeast Fisheries Observer Program (NEFOP). In general, observers collect information on catch and bycatch (species, counts, weights), the location of fishing activity, the amount of fishing effort (number of hauls), and gear configurations. Observers are currently deployed on two classes of scallop vessels (Limited Access and Limited Access General Category IFQ permitted vessels).

Overall, a limited amount of observer data is available from directed scallop fishing in the Gulf of Maine. This is in part due to less scallop fishing occurring in the Gulf of Maine compared to Georges Bank and the Mid-Atlantic, and also because there is no at-sea observer coverage on directed LAGC scallop trips in the Northern Gulf of Maine Management Area. Figure 22 describes the number of hauls in sub-regions of the Gulf of Maine by year. The majority of available information is specific to Stellwagen Bank.

Figure 22 – Number of observed hauls by year and Gulf of Maine Region



3.2.1 FY2017 Observed LA trips in the NGOM

As previously noted, NEFOP does not currently assign at-sea monitors to LAGC IFQ or LAGC NGOM vessels fishing under a Northern Gulf of Maine (NGOM) management area declaration; however, in FY2017, several LA vessels fishing under DAS management in the NGOM had on-board observers.

The FY2017 NGOM fishery was concentrated on Stellwagen Bank, in shallow water just north of 42° 20' N (i.e. the southern boundary of the NGOM management area). NEFOP assigned at-sea monitors to 18 LA scallop trips that directed effort in this part of the NGOM, resulting in a combined total of 443 observed hauls. Catch and discard data from the observed hauls are shown in Table 4.

Table 4. Summary of kept and discarded catch (lbs) from the 443 observed hauls recorded on LA vessels fishing in the NGOM in FY2017.

COMNAME	LBS	K/D	D/R		COMNAME	LBS	K/D	D/R
DEBRIS, ROCK	209790	DISCARD	ROUND		FLOUNDER, NK	17	DISCARD	ROUND
SCALLOP, SEA	164039	KEPT	DRESSED		COD, ATLANTIC	15	DISCARD	ROUND
SCALLOP, SEA	71432	DISCARD	ROUND		DEBRIS, PLASTIC	13	DISCARD	ROUND
SHELL, SCALLOP	15335	DISCARD	ROUND		OCEAN POUT	10	DISCARD	ROUND
SAND DOLLAR	5227	DISCARD	ROUND		WOLFFISH, ATLANTIC	8	DISCARD	ROUND
FISH, NK	3619	DISCARD	UNKNOWN		SQUID, ATL LONG-FIN	8	DISCARD	ROUND
SHELL, NK	3579	DISCARD	ROUND		FLOUNDER, WINTER (BLACKBACK)	8	KEPT	ROUND
FLOUNDER, WINTER (BLACKBACK)	1729	DISCARD	ROUND		CRAB, HERMIT, NK	6	DISCARD	ROUND
SCULPIN, LONGHORN	1336	DISCARD	ROUND		SKATE, LITTLE/WINTER, NK	4	DISCARD	ROUND
FLOUNDER, YELLOWTAIL	1005	DISCARD	ROUND		HALIBUT, ATLANTIC	4	KEPT	ROUND
FLOUNDER, SAND DAB (WINDOWPANE)	451	DISCARD	ROUND		SEAWEED, NK	4	DISCARD	ROUND
SKATE, LITTLE	403	DISCARD	ROUND		EEL, SAND LANCE, NK	3	DISCARD	ROUND
CRAB, JONAH	249	DISCARD	ROUND		DEBRIS, NK	3	DISCARD	ROUND
SKATE, WINTER (BIG)	113	DISCARD	ROUND		FLOUNDER, AMERICAN PLAICE	3	DISCARD	ROUND
STARFISH, SEASTAR,NK	97	DISCARD	ROUND		ANEMONE, NK	2	DISCARD	ROUND
CRAB, ROCK	90	DISCARD	ROUND		FLOUNDER, WITCH (GREY SOLE)	2	KEPT	ROUND
DEBRIS, FISHING GEAR	53	DISCARD	ROUND		FLOUNDER, SUMMER (FLUKE)	1	DISCARD	ROUND
SPONGE, NK	52	DISCARD	ROUND		QUAHOG, OCEAN (BLACK CLAM)	1	DISCARD	ROUND
MUSSEL, NK	48	DISCARD	ROUND		DEBRIS, METAL	1	DISCARD	ROUND
RAVEN, SEA	46	DISCARD	ROUND		HAKE, SILVER (WHITING)	0.6	DISCARD	ROUND
SNAIL, NK	38	DISCARD	ROUND		HERRING, ATLANTIC	0.6	DISCARD	ROUND
MONKFISH (GOOSEFISH)	29	DISCARD	ROUND		MACKEREL, ATLANTIC	0.3	DISCARD	ROUND
CLAPPER, SCALLOP	26	DISCARD	ROUND		FLOUNDER, WITCH (GREY SOLE)	0.3	DISCARD	ROUND
FISH, NK	25	DISCARD	ROUND		CORAL, SOFT, NK	0.2	DISCARD	ROUND
CLAM, NK	23	DISCARD	ROUND		SEA ROBIN, NORTHERN	0.2	DISCARD	ROUND

At-sea monitors also record measurement data (i.e. shell height, meat weight) of kept and discarded scallops for a minimum of 25% of observed hauls on a LA scallop trip. A total of 32,790 kept scallops were measured from observed LA hauls in the NGOM in FY2017, amounting to 164,039 pounds of observed kept meats.

Figure 23 displays the shell-height distribution of kept scallops from these observed hauls. Kept scallops ranged from approximately 75 mm to 160 mm, though the majority were between 100 mm and 115 mm.

Figure 24 displays the shell-height distribution of discarded scallops and Table 5 summarizes discarded meat weights by discard code. Of the 71,432 lbs of discarded meats, the majority were smaller scallops that did not have as high a market value as larger scallops being caught in the same hauls.

Figure 23 - Recorded shell-heights of kept scallops from observed LA hauls in the NGOM in FY2017

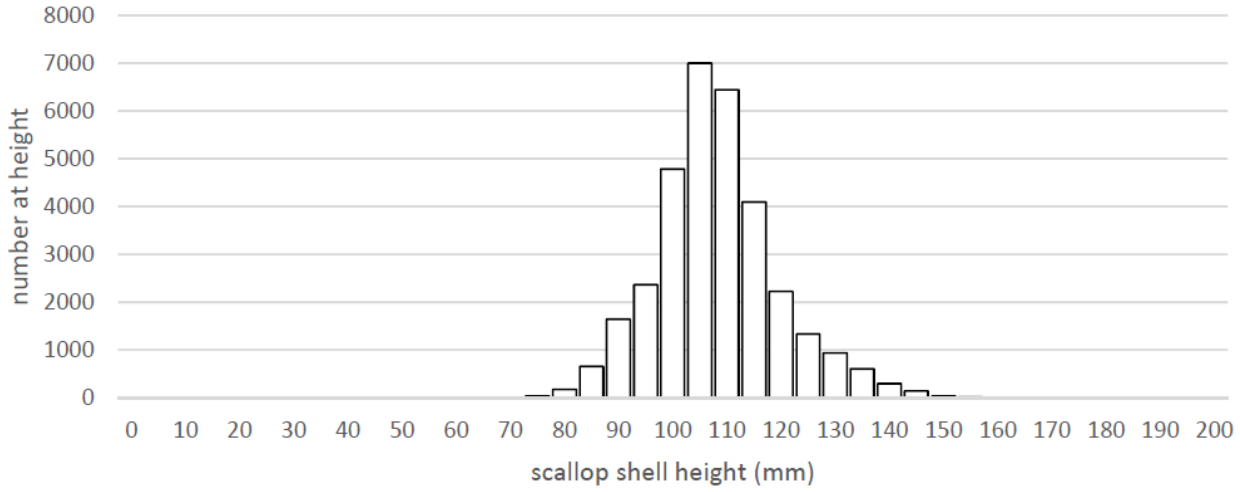


Figure 24 - Recorded shell-heights of kept (white bars) and discarded (black bars) scallops from observed LA hauls in the NGOM in FY2017.

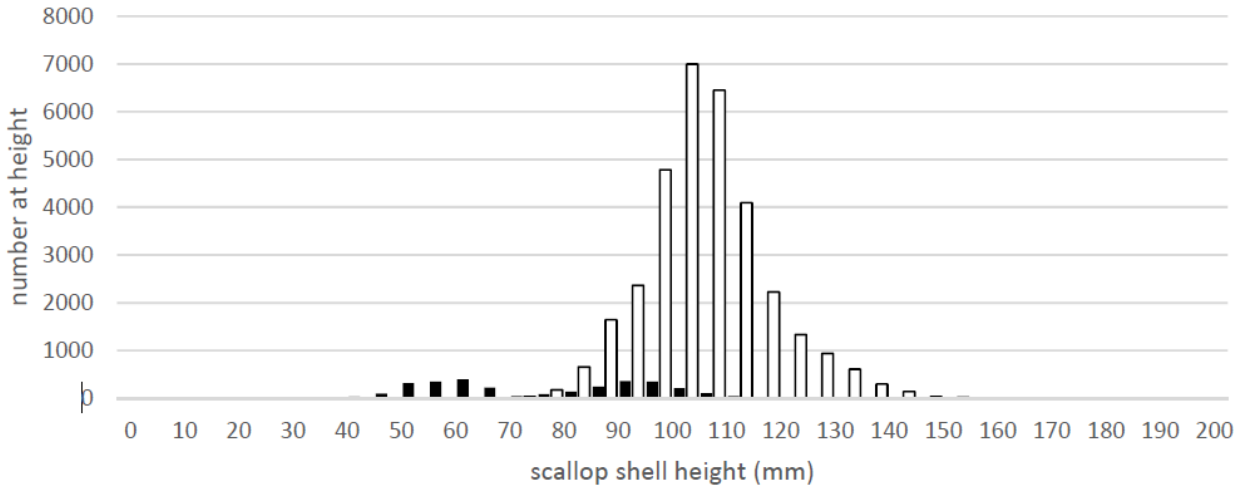


Table 5. Discarded scallop meats (in pounds) by discard code from observed NGOM LA hauls in FY2017.

Discard Code	scallop meats (lbs)
NO MARKET, TOO SMALL	38,050
POOR QUALITY, GEAR DAMAGE	16,226
DISCARDED, OTHER	17,156
Total	71,432

3.3 LANDINGS DATA

3.3.1 State Waters Landings Data

Scallop removals from the Gulf of Maine come from separate state and federal water fisheries. The largest state waters fishery in the region takes place in Maine, where landings exceeded three million pounds in the early 1980's (Figure 26). Recent landings have increased from around 100,000 lbs in 2008 and 2009 to nearly 800,000 pounds in 2017 (Figure 25).

Figure 25 - State of Maine state waters scallop landings (2008 - 2017) and average price per pound

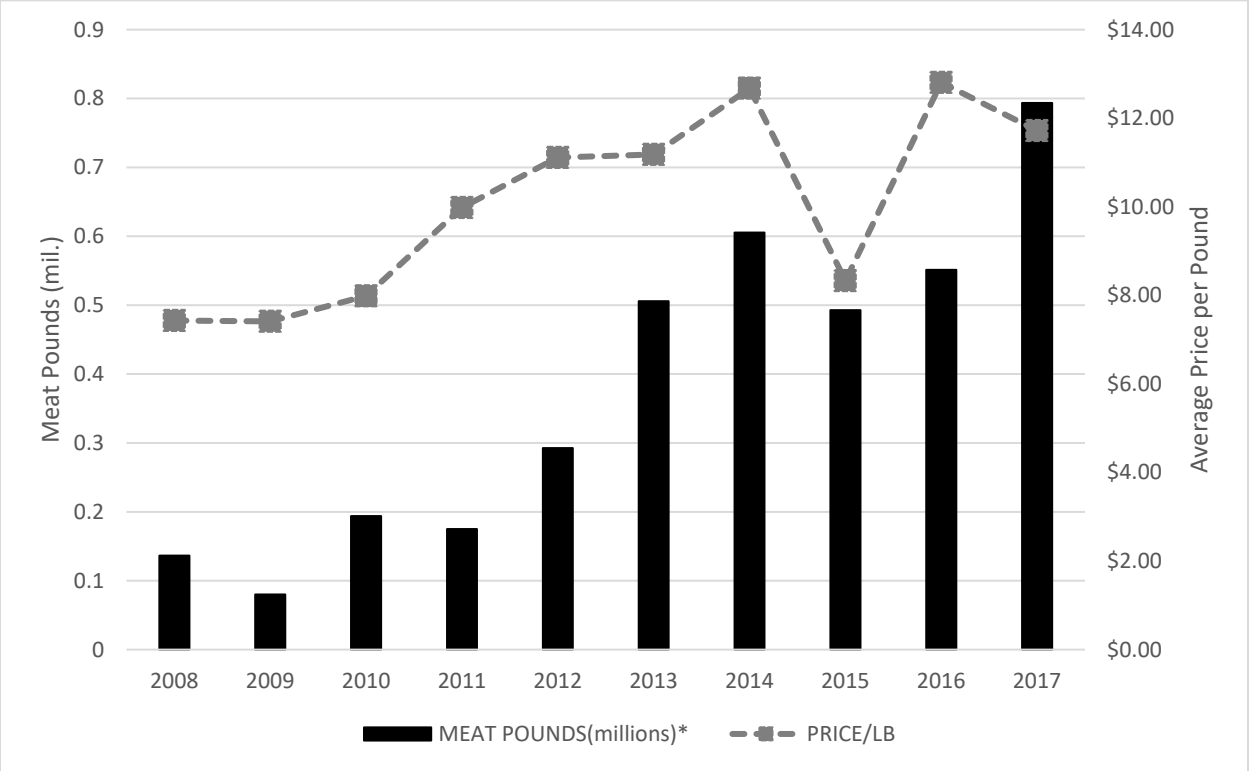
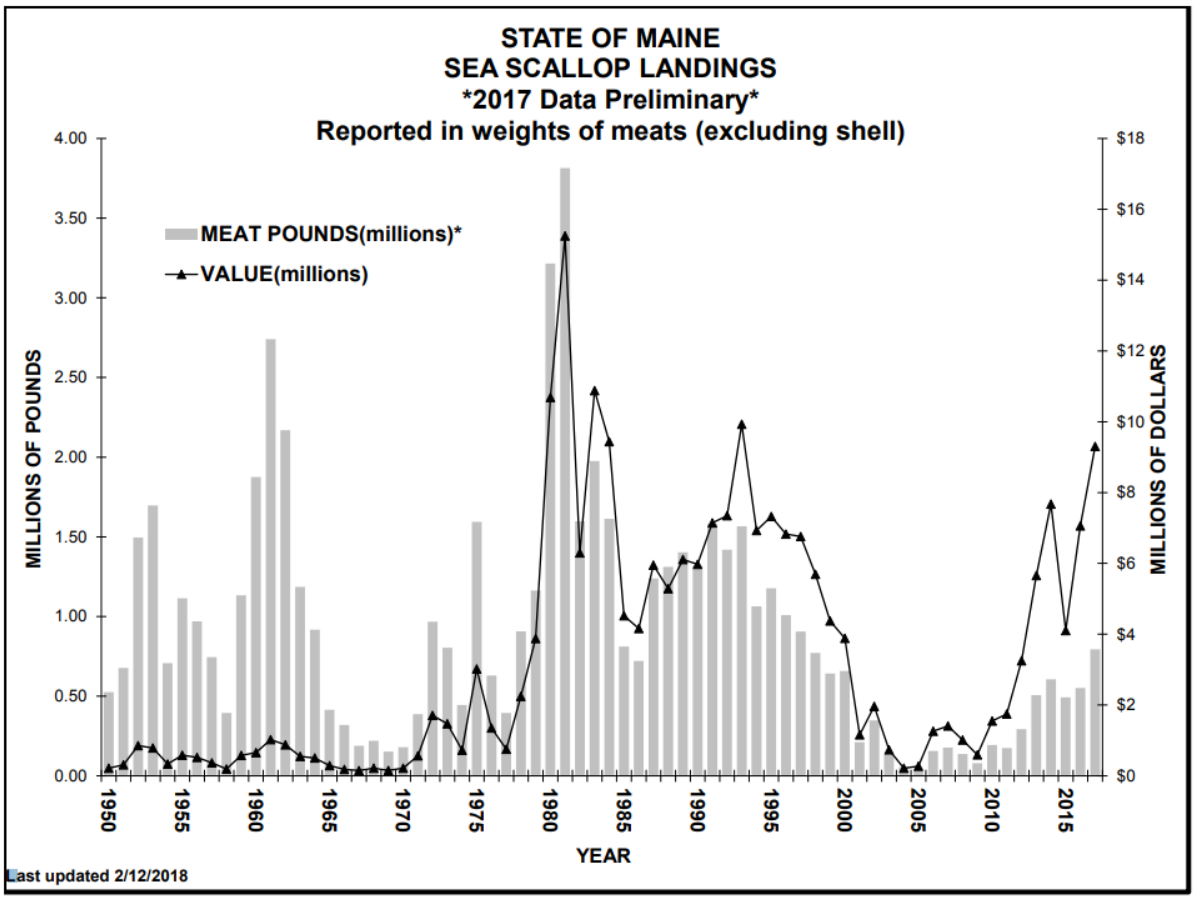


Figure 26 – State of Maine Sea Scallop Landings



3.3.2 Landings Data – Federal Fishery

3.3.2.1 Federal Dealer Landings from Northern Gulf of Maine Management Area

The majority of federal waters in the Gulf of Maine region are bounded by the Northern Gulf of Maine scallop management area, which is the found north of 42º 20' N and within the boundaries of the Gulf of Maine Scallop Dredge Exemption Area.

This area was created by the New England Fishery Management Council in 2008 to allow vessels that did not qualify for an LAGC IFQ permit the ability to fish at a conservative level (NEFMC, 2008). When fishing in the NGOM management area, LAGC vessels (i.e. LAGC IFQ, LAGC NGOM) adhere to a 200-pound possession limit and may fish until the annual Total Allowable Catch (TAC) limit is met and the area is closed by NMFS. Until the 2018 fishing year, LA vessels could operate in the NGOM under DAS management until the LAGC TAC was met and the management area was closed to all federally permitted scallop vessels. In 2018, the Council modified harvest controls in the NGOM so that an overall TAC was split between LAGC and LA components, and the LA share was dedicated to research compensation fishing (NEFMC, 2018). The following sub-sections are based on information reported in Framework 29 to the Scallop FMP (NEFMC 2018), and briefly summarize NGOM landings from fishing years 2008 to 2016 (Section 3.3.2.1.1) and in fishing year 2017 (Section 3.3.2.1.2).

3.3.2.1.1 NGOM Landings, 2008 to 2016

Before FY2013, combined annual landings by LAGC IFQ and LAGC NGOM vessels filled a small portion of the NGOM TAC, in several years landing less than 20% (Table 6). A strong year class of scallops on Platts Bank in FY2013 was followed by an increased LAGC NGOM fishing effort in this area through FY2014. LAGC IFQ vessels have typically focused effort to the southern portion of the management area, namely east and southeast of Cape Ann. IFQ landings nearly doubled between FY2014 and FY2015, with LAGC IFQ vessels working on aggregations of scallops located in Ipswich Bay and to the east and southeast of Cape Ann. FY 2015 marked the first year that the NGOM TAC was reached (overage of approximately 2,500 lbs). In FY2016, the NGOM TAC was exceeded by approximately 21,000 lbs.

From FY2008-FY2015, all NGOM landings came from the LAGC IFQ and LAGC NGOM fleets, during which time landings did not exceed the TAC (70,000 lbs) (Table 7). FY2016 marked a high point in landings by all permit types fishing in NGOM since the area was established in 2008, collectively totaling over 381,000 lbs (Table 7); LA vessels fishing under DAS management in the NGOM harvested roughly 293,000 lbs while approximately 89,000 lbs were landed by LAGC IFQ and LAGC NGOM vessels.

Table 6. Combined annual landings and percent of the NGOM TAC used in the management area.

FY	NGOM & IFQ Landings	TAC	Percent of TAC used
2008	9,936	70,000	14%
2009	15,534	70,000	22%
2010	8,639	70,000	12%
2011	6,908	70,000	10%
2012	7,440	70,000	11%
2013	55,450	70,000	79%
2014	57,842	70,000	83%
2015	72,546	70,000	104%
2016	89,083	67,454	132%

Table 7. Total landings attributed to the NGOM Management Area by permit type.

	Landings by Permit Category			Total NGOM Landings	NGOM closure date, (days open)
FY	**LAGC IFQ**	**LAGC NGOM**	**LA**		
2009	0	5,793	0	5,793	n/a, (entire FY year)
2010	4,762	3,877	0	8,639	n/a, (entire FY year)
2011	6,092	816	0	6,908	n/a, (entire FY year)
2012	894	6,546	0	7,440	n/a, (entire FY year)
2013	8,907	46,543	0	55,450	n/a, (entire FY year)
2014	11,521	46,321	0	57,842	n/a, (entire FY year)
2015	26,395	46,151	0	72,546	n/a, (entire FY year)
2016	26,484	62,599	292,517	381,600	May 13, (74 days)

3.3.2.1.2 NGOM Landings, 2017

FY2017 fishing by both LA and LAGC components was heavily concentrated along the southern boundary of the NGOM management area on Stellwagen Bank. VMS daily catch reports indicated 67 Limited Access vessels fished within the management area along with 38 LAGC vessels; the upper limit of total FY2017 removals from the NGOM was estimated to be roughly 1.6 million lbs. (Table 8). The NGOM management area was closed to all federally permitted scallop vessels effective at 12:01 AM on March 23rd, 2017. Upon closure, LA vessels were prohibited from fishing within the NGOM, but could continue fishing outside of the management area using open-area DAS.

Table 8. The number of active permits and estimated landings by Limited Access and LAGC vessels operating in the NGOM in FY2017.

Component	Active permits	scallop landings (lb)
LA	67	1,578,020
LAGC	38	47,437
Grand Total	105	1,625,457

3.3.2.2 Vessel Trip Report Landings Data

Federally permited vessels are required to report catch from each trip on vessel trip reports (VTRs). Vessels report the statistial reporting area they fished in, as well as the amout of kept catch by species. Figure 28 highlights statistical reporting areas in the Gulf of Maine. Figure 27 depicts estimated scallop landings from four areas in the Gulf of Maine by limited access (LA) and general cateogry (LAGC) vessels fom 1996 – 2017. The majority of the scallop removals over the past 20 years have come from statistical reporting area 514, which covers several important scallop grounds in the Gulf of Maine (Stellwagen Bank, Jeffreys Ledge, Ipswich Bay). This statisitcal reporting area is also bisected by the Nothern Gulf of Maine Management Area at 42°40'N latitude, meaning that harvest in this statistical area is regulated differently north and south of NGOM boundary line. Statistical reporting area 511 generally covers grounds in Eastern Maine, such as Machias/Seal Island, while 512 covers the Mid-Coast of Maine and federal waters south of Penobscot Bay. Area 513 covers Platts Bank, as well as inshore areas off of New Hanpshire and southern Maine. VTR data suggests that areas 511, 512, and 513 have supported both Limited Access and Limited Access Genenal Category fishing between 1996 and 2017.

Statistical reporting area 515 is considered part of the Gulf of Maine and covers Fippennies Ledge, which supported scallop effort in the mid-1980s to early 1990s; however, SRA 515 was excluded from this analysis because: 1) scallop fishing in this area generally pre-dated the use of VTRs and, 2) the majority of scallop habitat in SRA 515 (i.e. Fippennies Ledge, parts of Cashes Ledge), has been subject to a permananent groundfish mortality closure since 1998.

Figure 27 - VTR landings from Gulf of Maine statistical reporting areas (1996 - 2017) by fishery component.

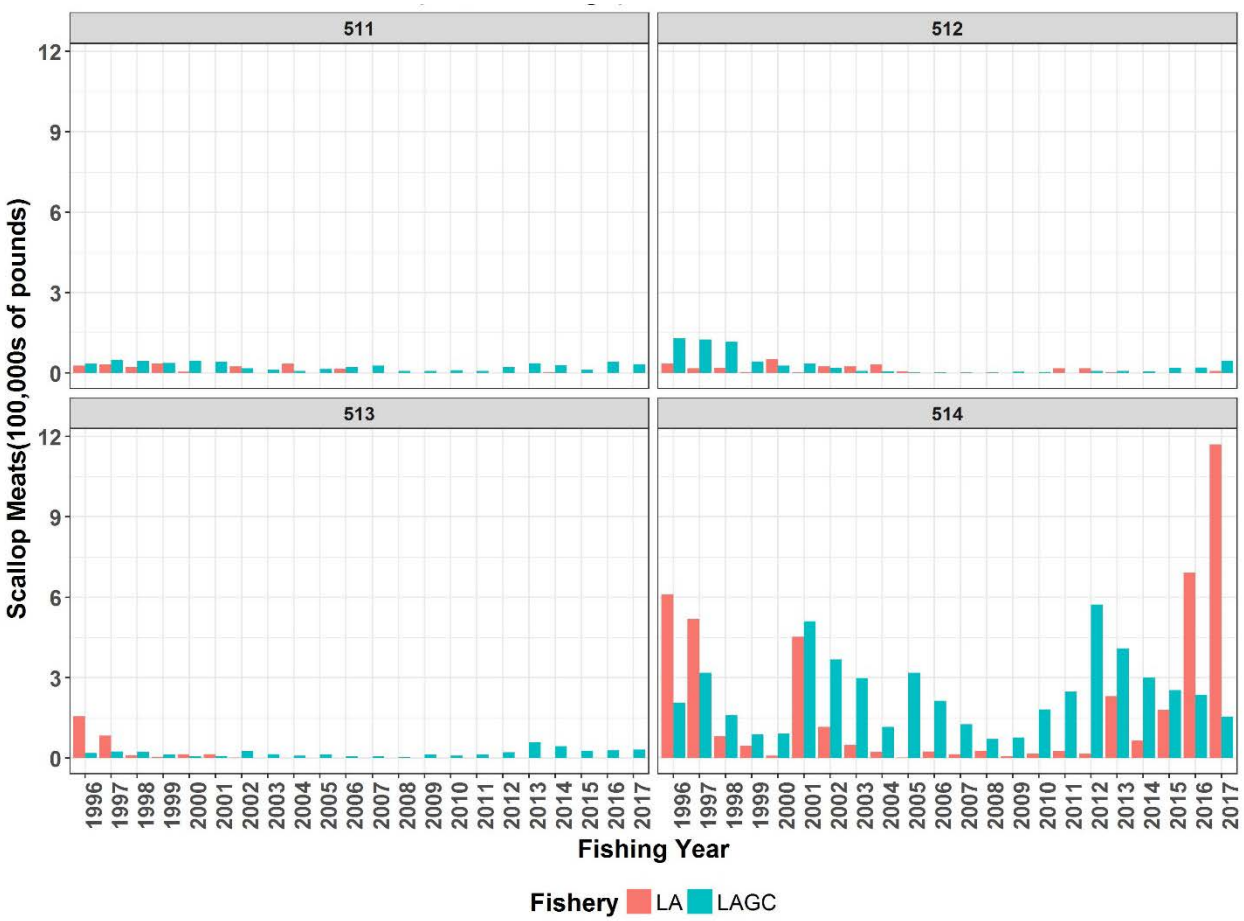
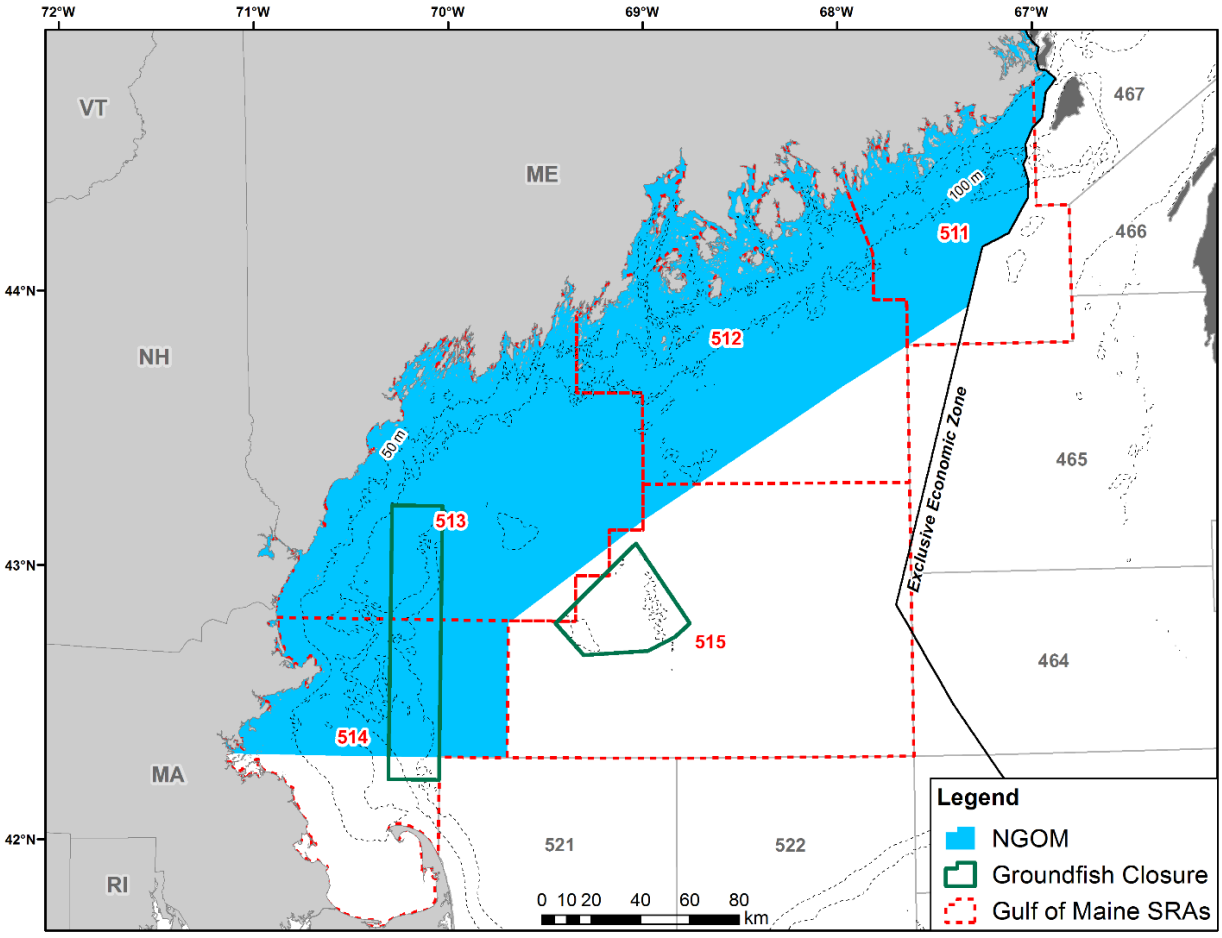


Figure 28. Statistical reporting areas (SRAs) in the Gulf of Maine relative to the NGOM management area and groundfish closures.



4.0 METHODS FOR DEVELOPING CATCH ADVICE

The current configuration of the Scallop Area Management Simulator (SAMS) provides forecasts for 21 sub-areas on Georges Bank and Mid-Atlantic, but does not cover portions of the Gulf of Maine. Since 2008, other methods for developing catch advice have been used to facilitate harvest of the resource in the Northern Gulf of Maine Management area, while harvest in areas of the Gulf of Maine south of 42°20 counts against fishery wide allocations. While some directed scallop fishing occurs in the Gulf of Maine, harvest from federal waters in this region have historically been a small proportion of total fishery removals. Table 9 describes the ways catch advice has been developed for the NGOM since 2008. Section 4.1 describes the methods used to develop catch advice for the NGOM in 2018.

Table 9 - Methods used to develop catch advice for Northern Gulf of Maine Management Area (2008 - 2018)

Method for developing catch advice for NGOM	Fishing Year(s) used
Historic Catch (TAC set at 70,000 lbs)	2008 – 2016
Simple exploitation of 2016 dredge survey estimates	2017
Forward projecting model using 2017 optical survey data	2018

4.1 2018 CATCH ADVICE - PROJECTION MODELING

A projection was used to develop catch advice for the Northern Gulf of Maine Management Area for the first time for the 2018 fishing year. For the 2018 exploitable biomass estimates, 2017 survey shell heights were projected forward 9 months for both Stellwagen (Figure 29) and southern Jeffreys Ledge (Figure 30) using growth parameters L_∞= 134.7, K = 0.433, and M = 0.16. Projections were made using shell height to meat weight parameter estimates from the 2016 UMaine/Maine DMR survey of Stellwagen Bank. 2018 exploitable biomass was estimated at approximately 360 mt on Stellwagen Bank and approximately 101 mt on southern Jeffreys Ledge, translating to a combined exploitable biomass of approximately 461 mt.

The 2018 catch advice for the NGOM management area was calculated based on the projected 2018 exploitable biomass of southern Jeffreys Ledge and Stellwagen because these are the parts of the NGOM management area that were expected to be fished in 2018. In light of this, and acknowledging that this approach does not include biomass from other parts of the NGOM, the 2018 TAC was estimated at a conservative level using a fishing mortality target (F_{target}) of 0.18, which is less than 70% of the F_{MSY} reference point used for Georges Bank (F_{MSY} = 0.3) in SARC 59. Table 10 shows the TAC calculation for southern Jeffreys at varying fishing mortality targets. Table 11 shows the TAC calculation for Stellwagen Bank at varying fishing mortality targets. The combined 2018 TAC calculation (both southern Jeffreys and Stellwagen) is shown in Table 12.

Figure 29. Observed shell heights on Stellwagen Bank in 2017 and projected shell heights for April 2018.

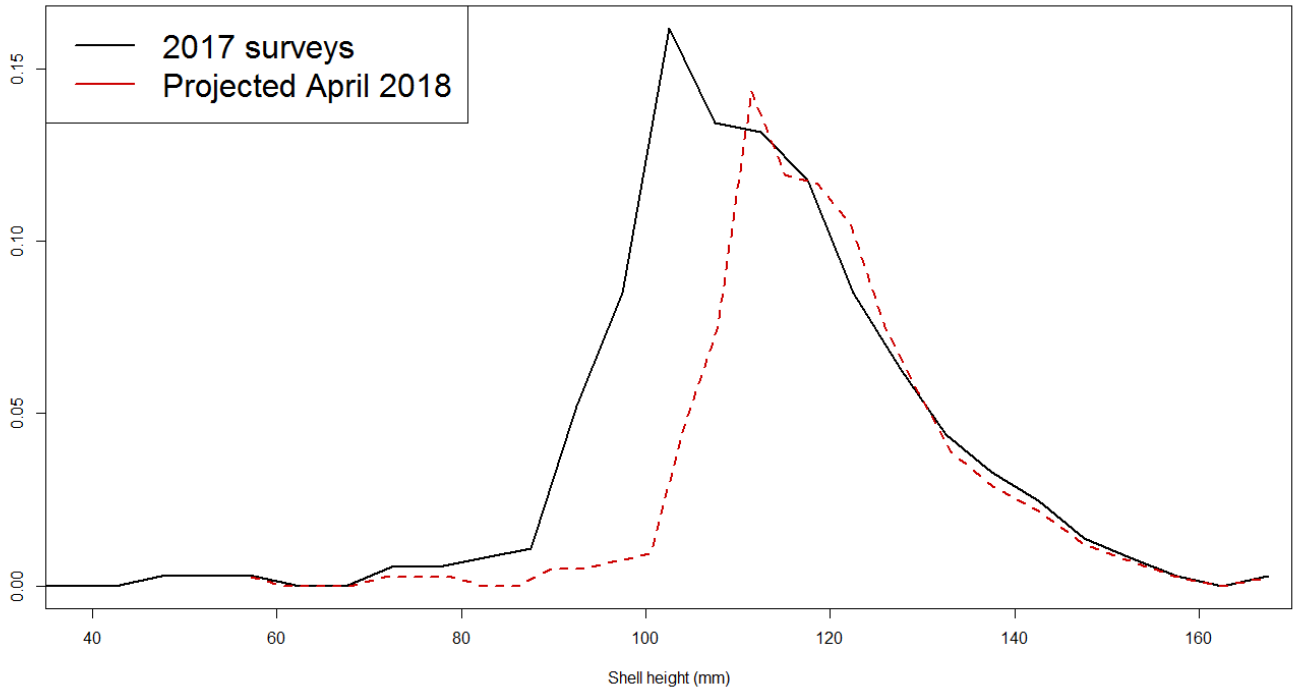


Figure 30. Observed shell heights on southern Jeffreys in 2017 and projected shell heights for April 2018.

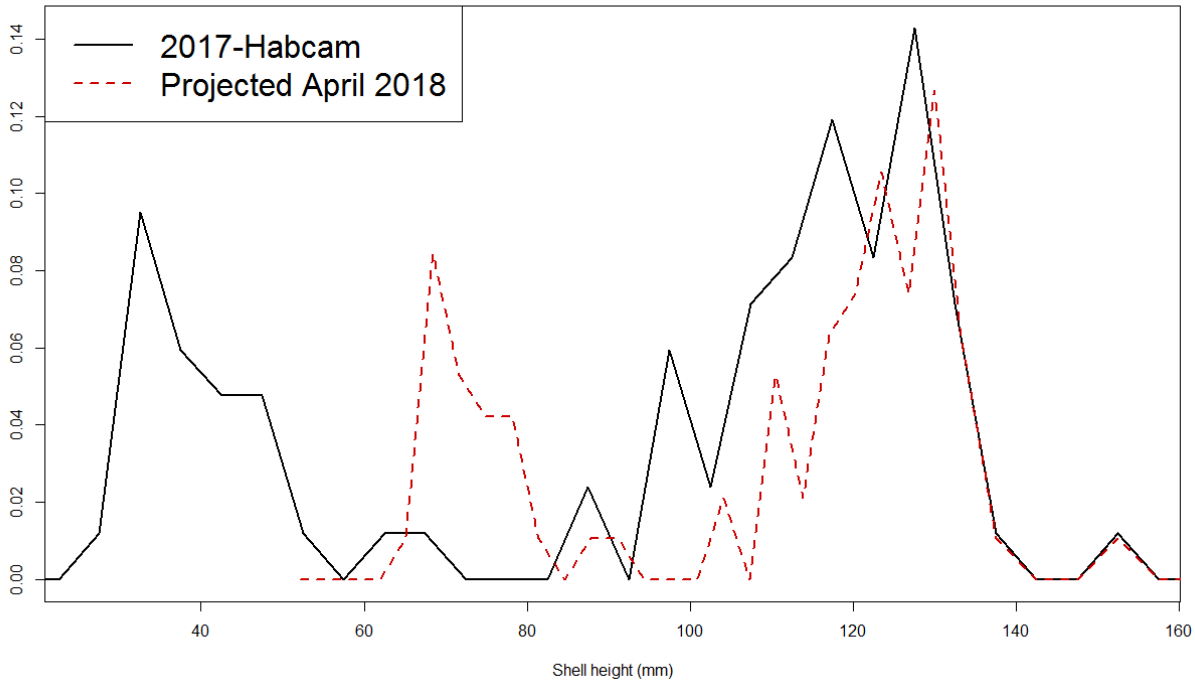


Table 10. Estimated TAC for southern Jeffreys Ledge in 2018 at varying fishing mortality target levels, based on projected exploitable biomass of 101 mt.

F_{target}	TAC (mt)	TAC (thousand lbs)
0.15	15.2	33.5
0.18	18.2	40.2
0.2	20.2	40.6

Table 11. Estimated TAC for Stellwagen Bank in 2018 at varying fishing mortality target levels, based on projected exploitable biomass of 360 mt.

F_{target}	TAC (mt)	TAC (thousand lbs)
0.15	54	119
0.18	64.8	142.9
0.2	72	158.7

Table 12. Estimated TAC for the NGOM in 2018 at varying fishing mortality target levels, based on combined projected exploitable biomass from southern Jeffreys Ledge and Stellwagen Bank.

F_{target}	TAC (mt)	TAC (thousand lbs)
0.15	69.2	152.6
0.18	83	183
0.2	90.2	198.9

4.2 POTENTIAL METHODS FOR DEVELOPING CATCH ADVICE AND DATA NEEDS

4.2.1 Estimating Yield-Per-Recruit, CASA, and Reference Points

The SAW 65 workgroup attempted to estimate yield-per-recruit for the Gulf of Maine using the stochastic yield model (SYM) that is used to develop reference points for Georges Bank and the Mid-Atlantic. Shell-height meat-weight data from UMaine/Maine DMR trawl surveys were used in the SYM model, however the model was determined to be unstable.

Expanding the CASA model to the GOM region would require estimates of abundance, biomass, growth, natural mortality, incidental and discard mortality, as well as landings. Additional biological and life-history information from animals in the Gulf of Maine is needed to estimate yield-per-recruit in this region, and to develop reference points for status determination.

4.2.2 Expanding Scallop Area Management Simulator (SAMS) Model

The SAMS model (forecasting) used to develop catch advice for Georges Bank and the Mid-Atlantic could be expanded to cover portions of the Gulf of Maine. The SAMS model could be used to develop catch advice for areas inside and outside of the Northern Gulf of Maine Management Area. The SAW workgroup recommended this approach when sufficient data is available.

Adding portions of the GOM into the SAMS model requires estimating a "starting" biomass for the current year that can be projected forward. When the model is run, it is typically initialized using the most recent survey data. For example, survey results from 2017 were used to initialize the model for 2018 projections. As the SAMS model can be used to make multi-year projections, catch advice could be made for two or three years using the model, depending on the availability/ frequency of survey information.

The additional data needed to expand the SAMS model are similar to the data needs of the CASA model and include sub-regional shell-height meat-weight relationships and growth, estimates of natural mortality, fishing mortality, and recruitment. If this data is not available for the Gulf of Maine, it may be reasonable to use data from Georges Bank to develop catch advice in the SAMS model for the Gulf of Maine.

4.2.3 Other methods for developing catch advice

The Gulf of Maine is outside of the federal shellfish survey strata, and there is not a dedicated federal survey of resource in this region. The majority of recent dedicated scallop survey work in the Gulf of Maine has been supported through research from the Scallop Research Set-Aside program, or through industry support.

As noted above, the distribution of the scallop resource in the Gulf of Maine is generally patchy, with the majority of animals in federal waters occurring on offshore ledges and banks. Over the past ten years the federal fishery has operated in spatially discrete areas such as Platts Bank, Jeffreys Ledge, Stellwagen Bank, and Ipswich Bay following periodic recruitment in these areas. Landings in the federal scallop fishery from the Gulf of Maine generally ~2% or less of total fishery landings.

The distribution of animals in the region, infrequency of surveys, and lack of key biological information means that existing models used to evaluate the status of the scallop resource (CASA, SYM) and forecast for catch advice (SAMS) cannot currently be applied to the entire Gulf of Maine region. Given the unique characteristics of this region relative to the rest of the resource, other methods of setting catch advice could be considered that require less fishery independent information or draw upon fishery dependent data streams. For example, fishery monitoring programs could be developed or expanded to support catch setting. Depletion modeling could be considered for developing or supporting catch advice in discrete areas of the Gulf of Maine.

5.0 LIST OF ACROYNMS

CASA	Catch-at-Size Analysis
CFF	Coonamessett Farm Foundation
GB	Georges Bank
GOM	Gulf of Maine
LA	Limited Access
LAGC	Limited Access General Category
MA	Mid-Atlantic
MA DMF	Massachusetts Division of Marine Fisheries
ME DMR	Maine Deprartment of Marine Resouces
NEFSC	Northeast Fisheries Science Center
NGOM	Northern Gulf of Maine Management Area
NMFS	National Marine Fisheries Service
SAMS	Scallop Area Management Simulator
SMAST	School for Marine Science and Technology
SYM	Stochastic yield model
TAC	Total Allowable Catch
VMS	Vessel Monitoring System
VTR	Vessel Trip Report
YPR	Yield-per-recruit

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