New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
John F. Quinn, J.D., Ph.D., *Chairman* | Thomas A. Nies, *Executive Director*

MEMORANDUM

DATE: June 14, 2017

TO: Habitat Committee

FROM: Habitat Plan Development Team

SUBJECT: **Potential new coral zone alternative for canyon/slope region south of Georges Bank; additional technical advice related to final action**

On May 30, 2017, the Habitat Committee passed a motion tasking "the PDT to analyze the compromise alternative proposed during public hearings by the Pew Charitable Trusts, Wild Oceans, Earthjustice, and the Conservation Law Foundation in their May 24 letter." This new coral zone boundary was presented to the Council during each of the public hearings conducted to solicit comments on the Omnibus Deep-Sea Coral Amendment. These hearings were held the week of May 22 in Montauk, Narragansett, New Bedford, Gloucester, Portsmouth, Ellsworth, and via webinar (see separate summary for detailed hearing comments). A method, rationale, and preliminary analysis of the approach was provided by Pew in writing on May 24. An updated version of this analysis was submitted on June 5. The proposal includes both the criteria used to determine the new boundary and specific boundary points that meet the criteria, as developed by Pew et al.

This memo contains a description of this new alternative and preliminary PDT analysis. Within the range of alternatives, the new alternative would likely be listed within §4.2.1 – Broad Deep-Sea Coral Zone Designations, as Option 7. The boundary for Option 7 is not based on a single depth, as is the case with the other broad zone options, but varies according to the occurrence of coral habitats and fishing activity with mobile bottom-tending gears. Detailed criteria for defining the boundary are explained below. The analysis will be developed further in the Environmental Assessment subsequent to the June Council meeting.

This memo also contains responses to questions raised during public comment or by the Habitat Committee and addition technical advice that may help the Council as it prepares to take final action on this amendment.

DESCRIPTION OF OPTION 7

As proposed, this option would designate a single coral zone in the slope/canyon/seamount region south of Georges Bank, with the western boundary along the New England/Mid-Atlantic

inter-council boundary line, the eastern boundary at the Hague Line, and the offshore boundary at the 200 mile limit. This is the same as all other broad zone options. The zone would be closed to mobile bottom-tending gears (MBTG), i.e. fixed bottom tending gears would be permitted, as would gears that are not bottom-tending. The inshore boundary along the shelf break varies in depth, was according to the following criteria:

- *Boundary follows the **550 m** depth contour if:* the area has evidence of MBTG fishing, but no evidence of coral habitat. This provides the mobile bottom fishing industry with an additional buffer beyond what was identified as the deepest current fishing during the New Bedford workshop.

- *Boundary follows the **500 m** depth contour if:* the area has evidence of MBTG fishing and evidence of coral habitat <u>or</u> did not have evidence of MBTG fishing or evidence of coral habitat. This accommodates what the mobile bottom fishing industry identified as the maximum depth of current fishing.

- *Boundary follows the spatial footprint of coral habitat, including areas as shallow as the **300 m** depth contour if:* the area did not have evidence of MBTG fishing, but did have evidence of coral habitat. This was done to protect corals where they are known or highly likely in areas where it is unlikely that fishing would be impacted.

<u>Data sources used to develop Option 7</u>

Coral habitat was assessed based on coral presence records, areas identified as highly likely to be suitable soft coral habitat in a predictive model, or presence of steep slopes (> 30°). These are the exact same approaches used by the PDT and are explained in the coral impacts section below.

Fishing with mobile bottom-tending gears (MBTG) was determined based on visual inspection of VMS and VTR data via the Northeast Ocean Data Portal and Mid-Atlantic Ocean Data Portal. Map services with these data layers can be viewed within any Geographic Information System along other sources of data, including, in this case, draft coral management zones, high resolution depth contours and slope polygons, coral modeling outputs, and coral point data.

Both the Northeast and Mid-Atlantic data portals includes vessel activity based on hourly VMS polls, which are point data. The data were grouped according to VMS declaration code, filtered to remove polls that indicate vessel speeds above 4 knots (5 knots for scallops), with the points (individual polls) interpolated to create a surface representing a gradient of effort in each category. VMS polls were omitted from the dataset altogether if there were fewer than 3 polls in a 1,400 m^2 grid cell. The polls were then interpolated to a 100 m^2 grid, where an individual 100 m^2 grid was turned on if there was a poll within a 1,000 m search radius. The number of polls within the search radius determined the color intensity of the 100 m^2 grid cell. VMS data for monkfish (2011-2014), squid (2014), and multispecies (2011-2014) were examined by Pew during development of the alternative.

The Mid-Atlantic Ocean Data Portal also includes VTR data. VTR maps on the data portal represent the location and intensity of fishing during recent years (2011-2013). To develop the maps, individual points (trip locations) were weighted according to effort metrics such as days out, and number of crew, and then data were smoothed into a continuous surface using kernel

density estimation, with a constant smoothing factor of 10 km (Jim Trimble, Rutgers University, personal communication). Data used by Pew during development of the alternative include bottom trawl < 65 ft., bottom trawl > 65 ft., and dredge, although other gears are available, and gillnet data are referenced in Pew et al.'s June 5 correspondence.

Comparison with Habitat PDT approach

The identification by the Habitat PDT of recent fishing activity relative to the alternatives under consideration – the approach to impacts analysis in the amendment – relies on VTR and VMS data as well, but the datasets are somewhat different than those available on the data portals. The PDT did not use the fishing effort data to draw coral zone boundaries, but rather, relied on the coral data, directions of the Habitat Committee, and depth contours. Fishing effort data were used after the boundaries were drawn to assess how each zone may overlap with recent fishing activity, thus informing the impacts analysis of alternatives.

For the VTR analysis, the Northeast Fisheries Science Center (NEFSC) modeled the likely distribution of effort around a VTR point (trip) based on trip characteristics such as days out, vessel size, etc. Revenues were assigned to trips based on catch information in the VTR, and monthly average prices from dealer data. Most of the revenue is assumed to be generated close to the reported point, with smaller amounts of revenue further away from the reported point. The distances of these circular confidence intervals were developed by comparing fisheries observer data with the reported VTR location for trips with information from both data sets.

The VTR analysis was used to map the spatial distribution of fishing effort, and to summarize revenue by gear or species within a particular coral zone under consideration. Permit and landing port attributes were used to estimate how much revenue an individual permit holder derives from a particular coral zone, or which port communities are associated with fishing activity in a particular zone. More information about this approach is provided in section 7.1.3 of the environmental assessment and in DePiper (2014).

Like VTR data, raw VMS data are also points, but each point represents the location of the vessel at intervals throughout the trip, with many vessel locations representing a single trip. NEFSC has developed models to assign each poll a probability of fishing. These probabilities are largely based on vessel speed estimated at each point, but also incorporate gear and trip information. An 'hours fished' metric is calculated for each point/poll by multiplying the probability that the poll represents fishing with the hours elapsed since the previous poll. Details are provided in section 7.1.3 of the environmental assessment and in Records and Demarest. For a given coral zone option, the PDT selected the VMS points falling within the option, and summed their hours fished. These data are presented by gear type and year.

Overall, the PDT expects that data available through the Portals and data used by the PDT provide similar perspectives on the spatial distribution in fishing effort associated with coral zones. One gap in the VMS data available on the portals is that they are not likely to include information about the whiting fishery, but this fishery should be captured in the VTR data on the Portals, and in both datasets used by the PDT to estimate revenue and hours fished within Option 7, and all other coral zone options.

Habitat PDT evaluation of Option 7 boundary

As noted above, the Option 7 boundary was defined by examining data depicting the spatial distribution of both coral habitats and fishing activity with mobile bottom-tending gears, and applying the decision tree. The PDT has checked whether the proposed boundary line meets the proposed criteria using the fishing effort data on the Portals, as well as the coral model data, point data, slope data, and high resolution depth contours. The depth contours used to draw and assess the boundary were generated from the ACUMEN digital elevation model. The ACUMEN data were collected in 2012, and cover depths between approximately 300 m and 2,200 m, as deep as 3,000 m in small areas.

Based on fishing effort, coral, and depth information, the PDT evaluated the boundary within 37 segments, each representing a canyon or intercanyon area. Where the fishing effort data for the east and west walls of a canyon varied, the canyon was analyzed as two segments.

The results of the PDT's assessment are presented in Table 1. Overall, the criteria were adhered to in most locations. The boundary could better match the criteria if shifted deeper in a few areas. Discrepancies and other comments are noted below:

- Section 11, west shoulder of Hydrographer – suitable habitat for corals indicated, but sparse. No evidence of fishing activity close to canyon. Followed criteria, but boundary could be shifted deeper to follow discrete zone boundary for Hydrographer Canyon, that modeled coral habitat is patchy in this location.

- Section 12, eastern shoulder of Hydrographer Canyon – suitable habitat, and substantial area of high slope, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria.

- Section 13, Hydrographer-Dogbody intercanyon region – suitable habitat for corals indicated, but sparse. VTR evidence of fishing activity just inshore of area. Followed criteria, but boundary could be shifted deeper given limited footprint of suitable habitat and presence of fishing activity nearby.

- Section 14 – Dogbody Canyon, west wall of western tributary – suitable habitat, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria.

- Section 18 – Welker Canyon – suitable habitat, but there is evidence of fishing activity in the head of the canyon. Boundary could be shifted deeper to 500 m in the head of the canyon to better follow criteria.

- Section 25 – Gilbert to Lydonia intercanyon region – suitable habitat, but there is evidence of fishing activity in the head of the canyon. Boundary could be shifted deeper to 500 m in the head of the canyon to better follow criteria. In this location, the shallower boundary may not be a significant issue given that the Option 7 boundary falls within a Tilefish GRA, and within the National Monument.

- Section 26 – Lydonia Canyon – suitable habitat, but there is evidence of fishing activity in the head of the canyon. Boundary could be shifted deeper to 500 m in the head of the canyon to better follow criteria. Shallower boundary is probably not a significant issue in this location, given that the Option 7 boundary falls within a Tilefish GRA, and within the National Monument.

- Section 27 – Lydonia-Powell intercanyon region – suitable habitat, however area is just beyond footprint of fishing as indicated by VTR. Boundary could be shifted deeper if industry indicates that fishing occurs in this region at deeper depths.

- Section 28 – Powell Canyon – suitable habitat, but there is evidence of fishing activity around the head of the canyon. While the boundary is at 500 m in the head of the canyon, it could be shifted deeper along the shoulders of the canyon to better avoid the VTR footprint.

- Section 29 – Powell-Munson intercanyon region – suitable habitat, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria.

- Section 30 – Munson Canyon – suitable habitat, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria.

- Section 31 – Munson-Nygren intercanyon region – suitable habitat, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria

- Section 36 – Heezen Canyon, east wall – suitable habitat, but there does appear to be fishing activity nearby based on VTR data. Boundary could be shifted deeper to 500 m to better follow criteria. The west wall and shoulder of Heezen and the slope area to the west appear to be very heavily fished, relative to other locations along the boundary.

Table 1 – PDT evaluation of Option 7 boundary based on coral data, fishing effort data on data portals, and ACUMEN depth contours

#	Location	Corals present?	Overlaps MBTG fishing effort?	Depth of boundary (m)
1	Alvin Canyon	Yes	Yes	500
2	Alvin-Atlantis intercanyon	No (small areas of suitable habitat)	Yes	500-550
3	Atlantis Canyon west wall	Yes	Yes	550
4	Atlantis Canyon east wall	Yes	No	500
5	Atlantis-Nantucket intercanyon	No (small areas of suitable habitat)	Yes	500-550
6	Nantucket Canyon	Yes	Yes	500-550

#	Location	Corals present?	Overlaps MBTG fishing effort?	Depth of boundary (m)
7	Nantucket-Veatch intercanyon	Yes	No	500-550
8	Veatch Canyon west wall	Yes	No	500
9	Veatch Canyon east wall	Yes	No	300 (note this is within the existing Tilefish GRA closed to MBTG)
10	Veatch-Hydrographer intercanyon area	Yes	No	500 (some areas 550)
11	Hydrographer Canyon, western shoulder	Yes, but sparse	No	300
12	Hydrographer Canyon	Yes, with substantial area of high slope	Yes	300
13	Hydrographer-Dogbody intercanyon	Yes, but sparse	No	300
14	Dogbody Canyon, west wall of western tributary	Yes	Yes	300
15	Dogbody Canyon, east wall of western tributary, eastern tributary	Yes	No	Varies, 400-550 to follow suitability model outputs
16	Clipper and Sharpshooter Canyons	Yes	No	350-500
17	Sharpshooter-Welker intercanyon	Yes	No	350-550 to follow suitability model outputs
18	Welker	Yes	Yes, at head of canyon	350-550 to follow suitability model outputs
19	Welker-Heel Tapper intercanyon	Yes	No	350-550 to follow suitability model outputs
20	Heel Tapper Canyon	Yes	No	300-400 to follow suitability model outputs
21	Heel Tapper to Oceanographer intercanyon	Yes	No	300-500 to follow suitability model outputs
22	Oceanographer Canyon	Yes	Yes, at head of canyon	300-350 (canyon is within the existing Tilefish GRA closed to MBTG, and within the National Monument)
23	Filebottom Canyon and Chebacco Canyon	Yes	No	400-500 (canyons is within the National Monument)
24	Gilbert Canyon	Yes	No	300 (canyons is within the National Monument)
25	Gilbert to Lydonia intercanyon	Yes	Yes	300-500 (canyons is within the National Monument)

#	Location	Corals present?	Overlaps MBTG fishing effort?	Depth of boundary (m)
26	Lydonia Canyon	Yes	Yes	300 (canyon is within the existing Tilefish GRA closed to MBTG, and within the National Monument)
27	Lydonia-Powell intercanyon	Yes	Uncertain – just outside VTR footprint	300-350
28	Powell Canyon	Yes	Yes	500 in head, to 350 at shoulders
29	Powell-Munson intercanyon	Yes	Yes	300-350 to follow suitability model outputs
30	Munson Canyon	Yes	Yes	300 to follow suitability model outputs
31	Munson-Nygren intercanyon	Yes	Yes	300-500 to follow suitability model outputs
32	Nygren Canyon	Yes	Yes	500
33	Nygren-unnamed intercanyon and unnamed canyon	Yes	Yes	500
34	Unnamed-Heezen intercanyon area	Yes	Yes	500-550
35	Heezen, west wall	Yes	Yes	500
36	Heezen, east wall	Yes	Yes	300
37	Heezen to EEZ	Yes	No	400-500 (depth contours uncertain here), to follow suitability model outputs

IMPACTS OF OPTION 7 ON DEEP-SEA CORALS

Consistent with other broad zones and the discrete canyon zones analyzed in the environmental assessment, Option 7 was evaluated in terms of the extent of overlap with coral database records, modeled habitat suitability for soft corals, and areas of slopes greater than 30°. These datasets are described in the environmental assessment, within Section 7.1.1 “Impacts analysis methods for deep-sea corals”, and Sections 6.2 and 6.3 “Coral species of the New England region” and “Deep-sea coral habitat suitability model”.

Briefly, the coral database includes geo-referenced records from the late 1800s to present of all types of deep-sea corals: soft corals, sea pens, stony corals, and black corals. There are 704 records in the New England region between a depth of 100 m south of Georges Bank and the EEZ boundary. As noted in the environmental assessment, these data are not evenly distributed across the region, but rather are concentrated in specific areas of scientific study. Nonetheless, as a comparative metric, the number of records per zone is useful for understanding how different areas compare, particularly as the broad zones are generally nested, with Options 2-6 being nested subsets of the 300 m zone, Option 1.

The coral suitability model analysis pools three different soft coral model outputs together, and looks for areas estimated to be highly or very highly likely to contain habitats suitable for all types of soft corals combined, non-gorgonian soft corals only, or gorgonian soft corals only. While the broad zones extend to the outer edge of the Exclusive Economic Zone, the footprint of the suitability analysis described here is restricted to slope/canyon region south of Georges Bank: between 100 m depth, just shallower than the shelf break, and somewhere between 2,000-2,200 m depth, the spatial extent of the NOAA Coastal Relief Model in the NEFMC region. Thus, the suitability percentage for each zone option can be understood as the fraction of likely soft coral habitat in the slope/canyon region within that zone. The total area of the NEFMC slope/canyon region is 21,629 km^2, approximately 23% of which (4,973 km^2) is likely to be suitable habitat for soft corals, based on the model results.

Finally, the high slope area is based on the ACUMEN bathymetry data. Slope is the rate of change in depth between two adjacent 25 m x 25 m grid cells, calculated in degrees. During 2013-2015 coral dives with ROVs and towed cameras, corals were almost always observed in locations with a slope of 30° or greater. Thus, the location of high slope habitats is a reliable indicator of the presence of deep-sea corals. The total area of very high slope is much smaller than the area of predicted suitable habitat. Within the NEFMC region, the ACUMEN data set covers 12,132 km^2, only 164 km^2 of which has a slope greater than 30° (1.4% high slope).

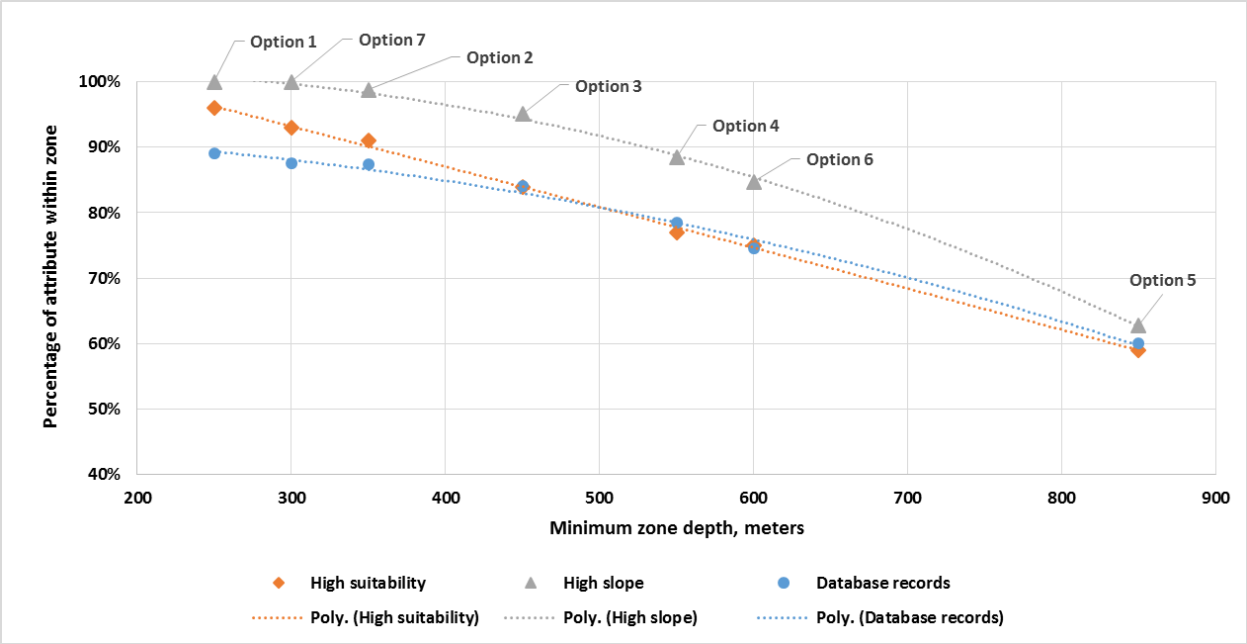
In terms of coral habitat encompassed, Option 7 falls between the 300 m zone (Option 1) and the 400 m zone (Options 2). Option 7 includes 616 out of 704 coral presence records (88%), 4,458 km^2 out of 4,973 km^2 of seafloor likely to be suitable habitat for soft corals (93%), and 164 km^2 (100%) of the known high slope habitat. By contrast, the preferred alternative (Option 6) includes 525 (75%) of the coral records, 3,587 km^2 (75%) of the modeled suitable habitat, and 139 km^2 (85%) of the high slope area. These values, as well as the values for Options 1-5, are summarized in Table 2 and

Figure 1. Overall, Option 7 would protect more coral habitat than Options 3, 4, 5, or 6 (preferred), and protect similar amounts of coral habitat compared to Options 1 and 2.

Table 2 – Coral metrics summary for broad zone options 1-7. Options 6 and 7 are in bold font.

Min. depth	Option#	# Coral records in zone	% Coral records on continental margin	Area highly likely to be suitable habitat for soft corals in zone, km²	% High suitability habitat on continental margin	Area of high slope in zone, km²	% High slope on continental margin
250	Option 1	627	89%	4582	96%	164	100%
300	**Option 7**	**616**	**88%**	**4458**	**93%**	**164**	**100%**
350	Option 2	615	87%	4354	91%	162	99%
450	Option 3	592	84%	4042	84%	156	95%
550	Option 4	553	79%	3700	77%	145	88%
600	**Option 6**	**525**	**75%**	**3587**	**75%**	**139**	**85%**
850	Option 5	422	60%	2821	59%	103	63%

Figure 1 – Percentage of database records, high likelihood suitable soft coral habitat, and high slope habitat by broad zone option.



IMPACTS OF OPTION 7 ON HUMAN COMMUNITIES

Fishery impacts

The PDT analyzed the fishery impact of boundary line as proposed, rather than drawing a line based on the proposed criteria. Although the data presented in most of the figures and tables below includes all bottom tending gear, the discussion of fishery impacts focuses on mobile bottom-tending gear (MBTG), given Option 7 as proposed would restrict only those gears.

Summary: VMS coverage for MBTG trips with VTR locations overlapping the Option 7 area is high (Table 4), and can generally be used to assess the spatial extent of fishing within the region. The VMS analysis suggests very low levels of overlap by MBTG with Option 7, and suggests that the VTR analysis (Figure 2, Figure 3) is overestimating exposure. The same can be said for the Preferred Alternative (Option 6), suggesting that the estimates should provide valid relative estimates of overlap across these alternatives (Option 7 has more recent MBTG revenue and effort attributed to it than Option 6). Notably, many of the top 20 exposed owners in the 2013-2015 VTR data have no VMS data in the years covered by the PDT's analysis (as the VMS dataset used by the PDT goes through 2012 only, a direct match for the same time period cannot be established). Trips by these permits are predominantly (i.e., greater than 70% of revenue) landing silver hake, inshore longfin squid, and butterfish. Thus, although individuals with VMS coverage have much lower VMS exposure estimates when compared to VTR estimates, there seems to be a systematic under-representation for the most highly exposed owners in the VMS, concentrated on fishing for species known to occur along the shelf break, which adds some additional uncertainty to the analysis. Nevertheless, Option 7, when applied to only MBTG, is expected to have neutral to very slightly negative impacts to fishermen.

VTR analysis: Vessel Trip Report data were used to estimate recent (2010-2015) fishing activity within the Option 7 coral zone. With the exception of lobster trap gear, revenue results were unscaled (consistent with the analysis of the other broad zone options)[1]. Because a large number of lobster vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded (method explained in draft Environmental Assessment). Maps of revenue by gear type and species are in Section 13 of the draft Environmental Assessment.

Revenue: Table 3 compares average species revenue between Option 7 and the current Preferred Alternative, including the percentage increase in exposure associated with Option 7. The top ten species landed, by value (Figure 3), are consistent with those in the 300-900 m broad zones (section 7.3.3, environmental assessment). When only MBTG is considered, lobster, red crab and Jonah crab are replaced with yellowtail flounder, *Illex* squid, and Atlantic mackerel to round out the top ten list.

Annual MBTG revenue attributed to Option 7 averages 14% higher than the preferred alternative (Table 3). This revenue is dominated by bottom trawl (averaging 67% of estimated revenue), followed by scallop gear and clam dredge (averaging 31% of estimated revenue), with a much

[1] Vessels in the federal waters lobster fishery are only required to submit VTRs if they carry another federal permit, so a relatively small percentage of offshore (Area 3) vessels are not captured in the VTR dataset. Thus, lobster revenues attributed to Area 3 coral zones were scaled up to account for the gap between total landings in the VTR and total landings in the Area 3 fishery, considering all catch regardless of association with trip reports.

lower value generated by separator and Ruhle trawls (averaging 2% of estimated revenue). Given prevailing knowledge on scallop depth distributions, and spatial imprecision of bottom trawl VTR reports, there is a strong likelihood that the VTR derived revenue estimate is high, and VMS data is used below to further assess effort distribution. As the same can be said for the Preferred Alternative, the estimates should provide valid relative estimates of exposure across these alternatives, though the magnitude is expected to be imprecise.

Figure 4 and Figure 5 present the proportion of an owner's revenue overlapping Option 7 for all bottom tending gear and MBTG only, respectively. Although the majority of individuals have relatively low exposure to Option 7, the data suggests there are a small number of individuals generating the bulk of their revenue from the area, whether all gears or just MBTG are considered. This is consistent with the findings for other broad zones.

VTR vs. VMS comparison: Between 2010 and 2015, based on the VTR data, an average of 764 bottom trawl trips fished within the vicinity of Option 7, making it the dominant MBTG[2]. Scallop and clam dredge trips follow (180 trips), and Separator & Ruhle Trawl is substantially lower (averaging 56 trips). Permit numbers (i.e., number of vessels overlapping the area) across gear types follow similar patterns, though there is substantial interannual variability in both trips and permits.

The percent of these VTR-based trips with VMS data in 2010 – 2012 is high (bottom trawl ~ 87% - 94%; scallop & clam dredge ~ 90 – 97%; separator & Ruhle trawl ~ 71 – 84%) (Table 4). Of covered trips (i.e., trips with a match in the VMS and VTR datasets), the VMS data suggest only 10% of bottom trawl and 64% of scallop and clam dredge trips report VMS polls within Option 7. Similarly, 23% of bottom trawl and 68% of scallop and clam permit holders identified in the VTR have VMS polls falling within Option 7. Probability-weighted fishing effort expended by both LA and GC scallop vessels in the region averages very close to zero, and bottom trawl effort is also very low, when compared to the gear's total fishing effort (Table 5).

Figure 6 and Figure 7, respectively, show the percentage of a permit's overall effort and MBTG effort estimated to fall within Option 7. Although the exposure, in terms of all bottom-tending gear (Figure 6), is similar to the owner-revenue estimates in Figure 4, the MBTG estimates (Figure 7) are substantially different, with the VMS presenting very low exposure when compared to the VTR (Figure 5). As summarized earlier in this memo, of note is that 13 of the top 20 exposed owners in 2013, 11 of the top 20 in 2014, and 8 of the top 20 in 2015 have no VMS data in years previous to 2013. Trips by these permits are predominantly (>70% of revenue) landing silver hake, inshore longfin squid, and butterfish. Thus, although individuals with VMS coverage have much lower VMS exposure estimates when compared to VTR estimates, there does seem to be a systematic under-representation for the most highly exposed owners in the VMS, and the exposure is concentrated on fishing for species known to occur along the shelf break, which adds some additional uncertainty to the analysis.

ASMFC survey: The Environmental Assessment includes a discussion of the ASFMC survey of Area 3 lobster permit holders, which estimated that 33% of lobster effort and 28% of revenue in

[2] A trip was considering to be in the vicinity if any portion of its estimated footprint fell within the zone. It was not required that the actual point location from the VTR fall within the zone.

the offshore component of Area 3 in 2014 and 2015 was derived from fishing at depths below 300 m. Additionally, it was estimated that the 300-400 m depth interval may have the highest density of fishing activity for the offshore fishery (Sections 7.1.3.2 and 7.3.3.1). Since Option 7 would not restrict lobster fishing, the survey results are more pertinent to other options under consideration. However, it should be noted that a MBTG restriction may allow for the expansion of the lobster fishery into previously trawled areas. Although Option 7 was designed to be outside the current footprint of the trawl fisheries, the VTR and VMS data suggest that there may be some overlap.

NEFMC workshops: The Environmental Assessment includes a discussion of the industry input provided during the NEFMC coral workshops (Section 7.3.3.1). Workshop participants agreed that due to the distribution of target species, the MBTG fishery is active out to depths of about 500 m, the lobster fishery to 550 m, and the red crab fishery to 800 m. However, vessels tending fixed gear could be located in deeper waters, due to the length of fixed gear end lines necessary for fishing these depths, slope steepness or ocean conditions. Mobile gear fishing vessels could also be located in deeper waters while setting out or hauling back gear. A coral scientist indicated that a reason why exploratory dives do not occur shallower than about 490 m is due to the potential for interaction with fishing vessels. With this input in mind, Option 7 may have little overlap with the MBTG fisheries, despite overlap in the VTR data, as it was developed by combining these stated depths with information about the occurrence of fishing activity in specific locations. In areas where fishing with mobile bottom-tending gears was not indicated, the boundary is shallower than the 500 m depth suggested at the workshop as the maximum depth fished by mobile bottom-tending gear. See Table 1 for a detailed evaluation of the boundary.

Restricted Gear Areas I-IV: The Environmental Assessment includes a discussion of the Restricted Gear Areas I-IV on the southwestern flank of Georges Bank. These areas were established with input from both mobile and fixed gear fishermen and are intended to reduce gear conflicts as lobster vessels move their traps to follow the seasonal migration of lobsters (deeper waters in winter, shallower in summer). The seaward areas (I and II) prohibit trawl gear in winter and trap gear in summer, and the landward areas (III and IV) the reverse, prohibiting trawl gear in summer and trap gear in winter.

The Option 7 coral zone is deeper than the Restricted Gear Areas, except for the eastern side of Veatch Canyon and at the head of Hydrographer Canyon. Veatch Canyon also is within the Tilefish Gear Restricted Area, so it is already closed to mobile bottom tending gear. Option 7 would have additional fishery impacts only within Hydrographer Canyon. Where mobile bottom-tending gear would be prohibited by Option 7, the available area for the summer trawl fishery in Area I narrows. The area available for the winter trawl fishery (Area IV, inshore of Area I) would likely not be impacted by Option 7.

Figure 2 - Revenue by gear type attributed to Option 7 coral zone, 2010-2015 – ALL GEARS.

Note: Option 7 would only restrict Mobile Bottom Tending Gear, which includes only Bottom Trawl, Other Gear, Scallop Gear & Clam Dredge, and Separator & Ruhle Trawl in the figure.

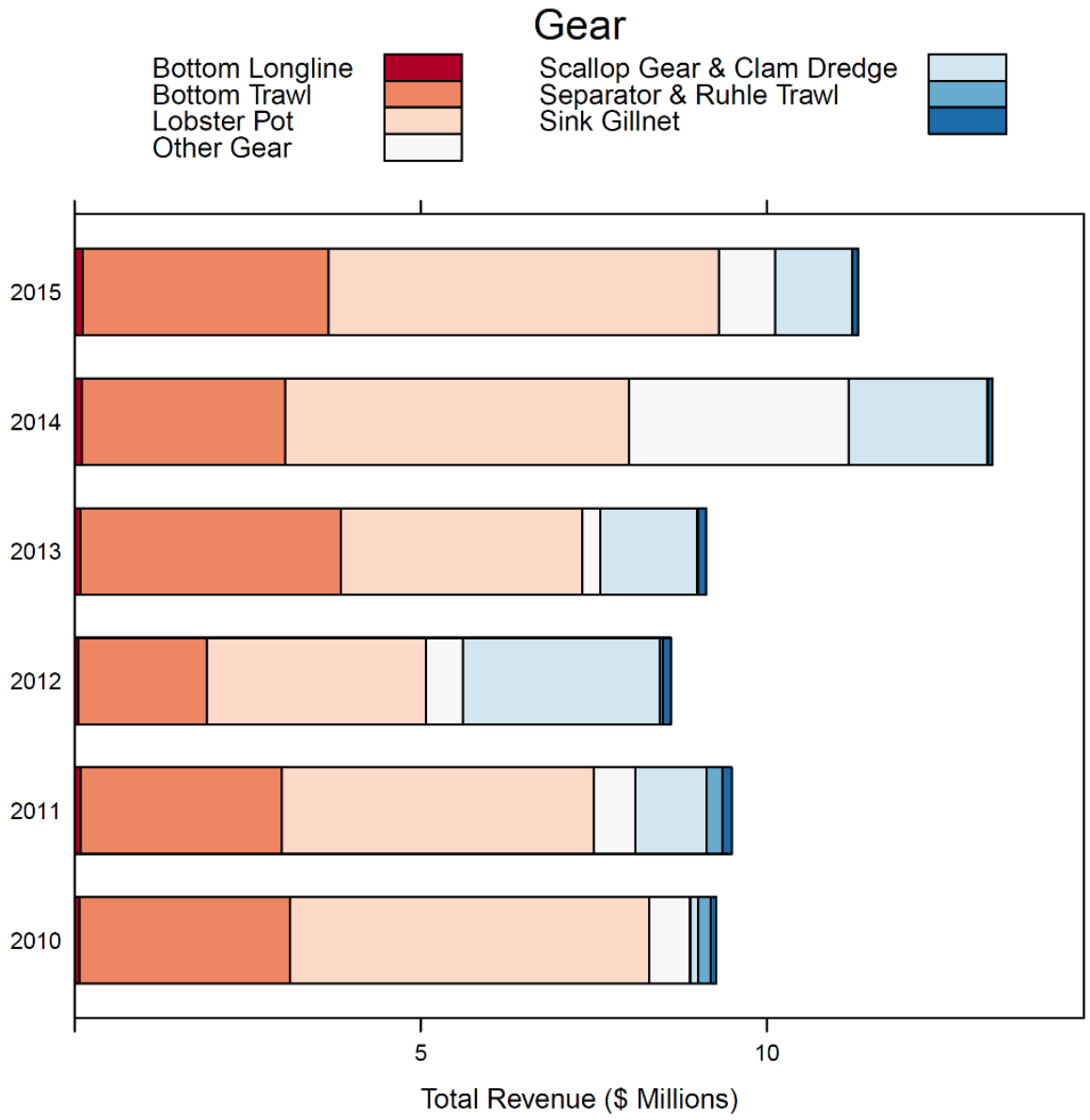


Figure 3 – Revenue by species (top 10) attributed to Option 7 coral zone, 2010-2015 – ALL GEARS.

Note: Option 7 would only restrict Mobile Bottom Tending Gear. If fixed gears were excluded from this analysis, this would replace the crustaceans in the figure with Yellowtail flounder, *Illex* squid, and Atlantic Mackerel to encompass the top 10 species.

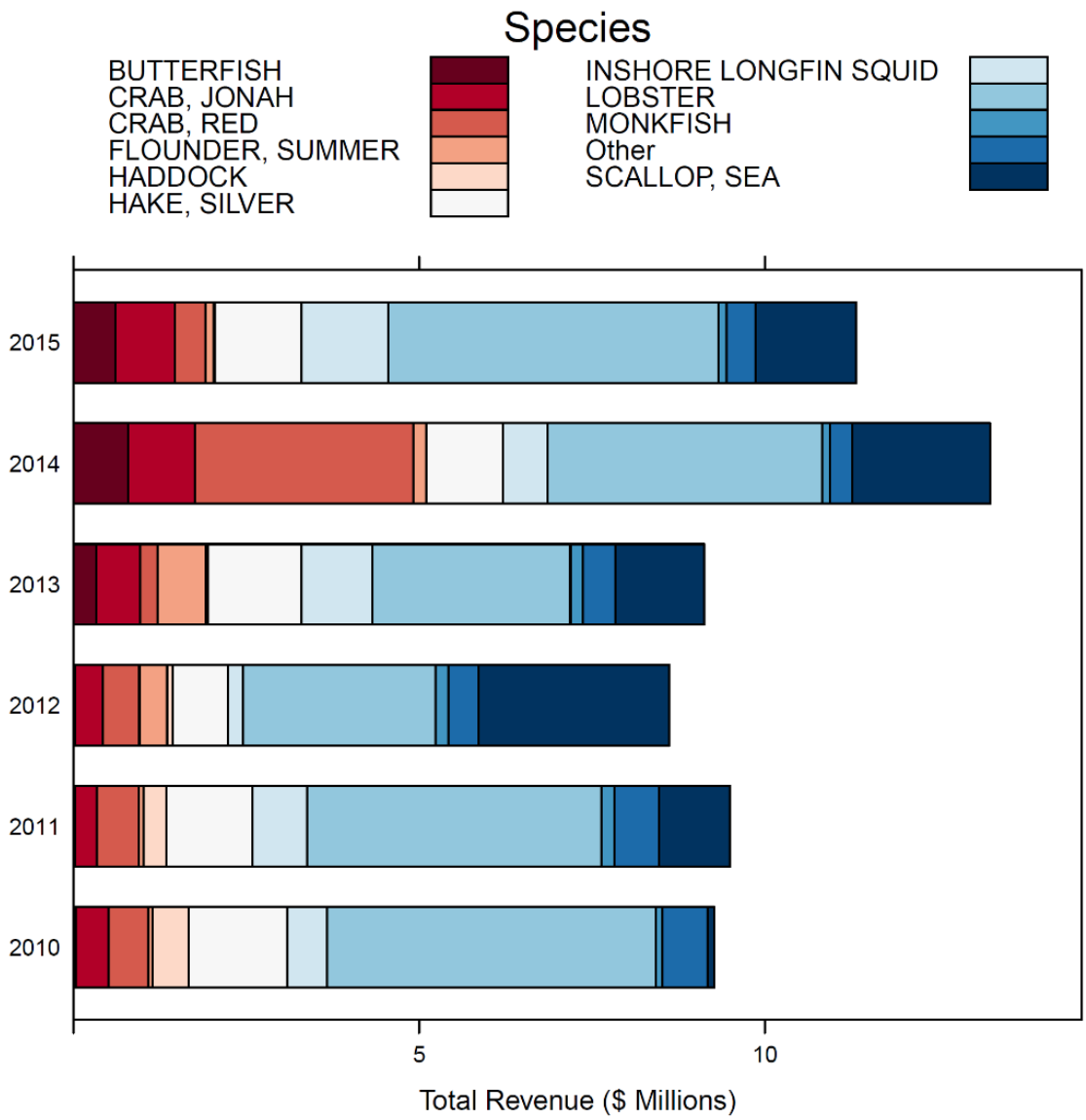


Figure 4 – Percent of vessel owner revenue attributed to the Option 7 coral zone, 2013-2015 – ALL GEARS. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

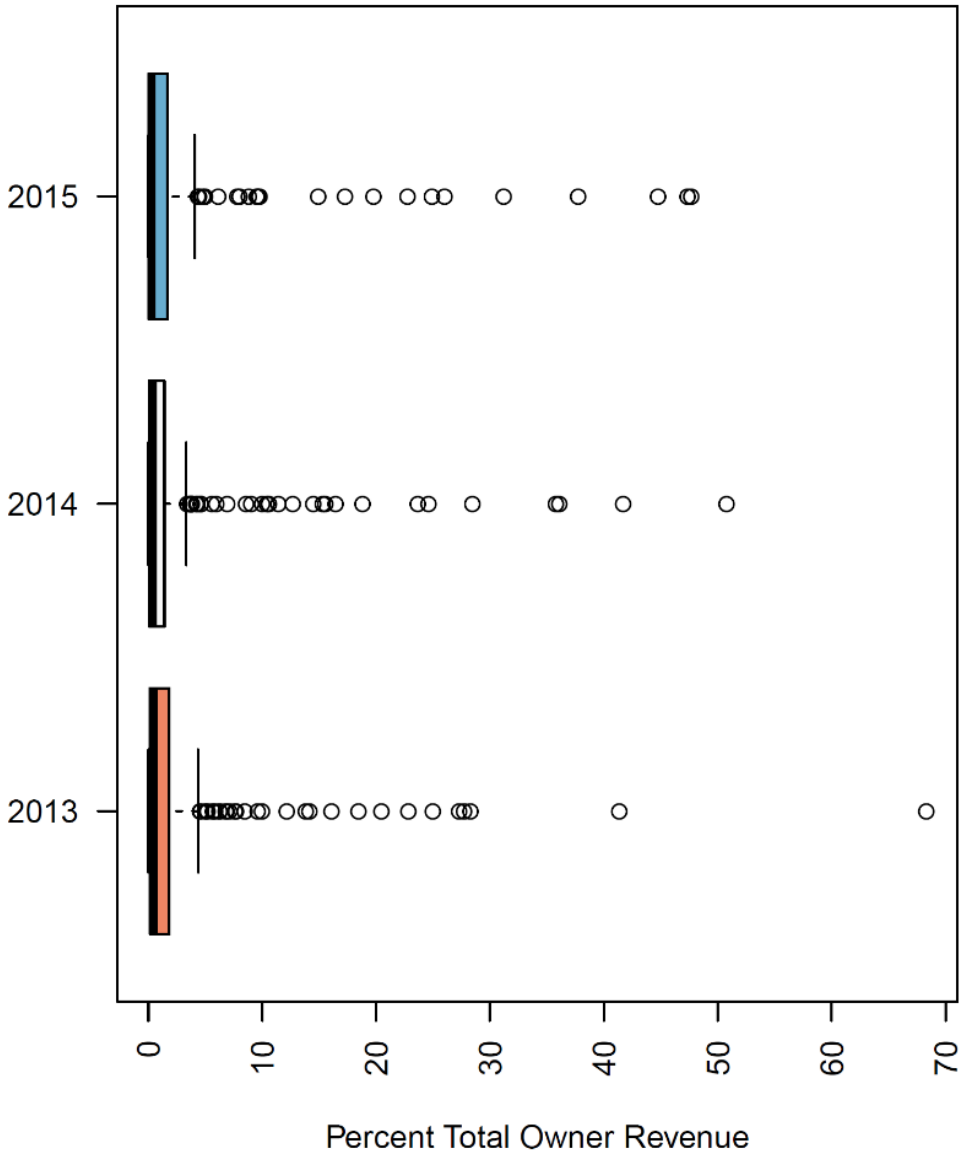


Figure 5 – Percent of vessel owner revenue attributed to the Option 7 coral zone, 2013-2015 - MBTG ONLY. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

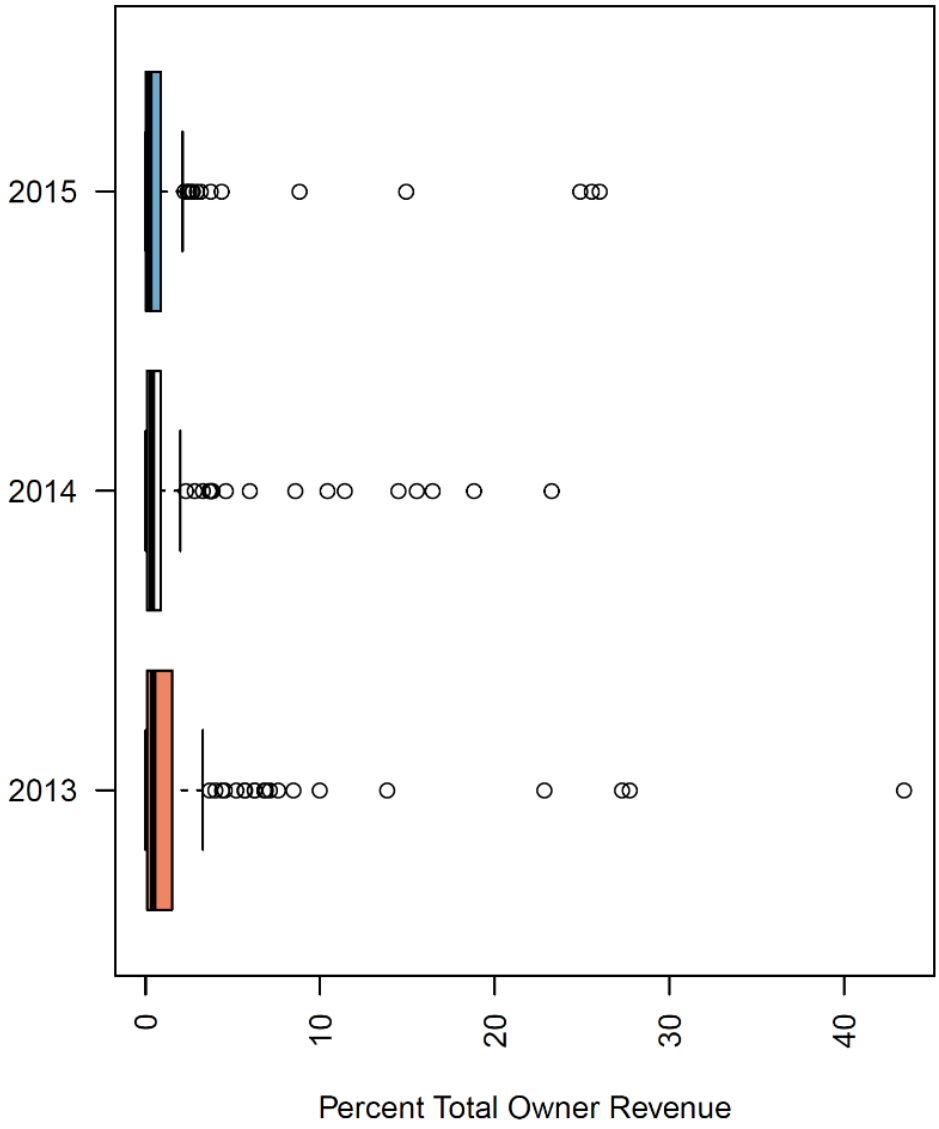


Figure 6 – Percent of total annual permit fishing activity attributed to the Option 7 coral zone, 2005-2012, as derived from VMS – ALL GEARS. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

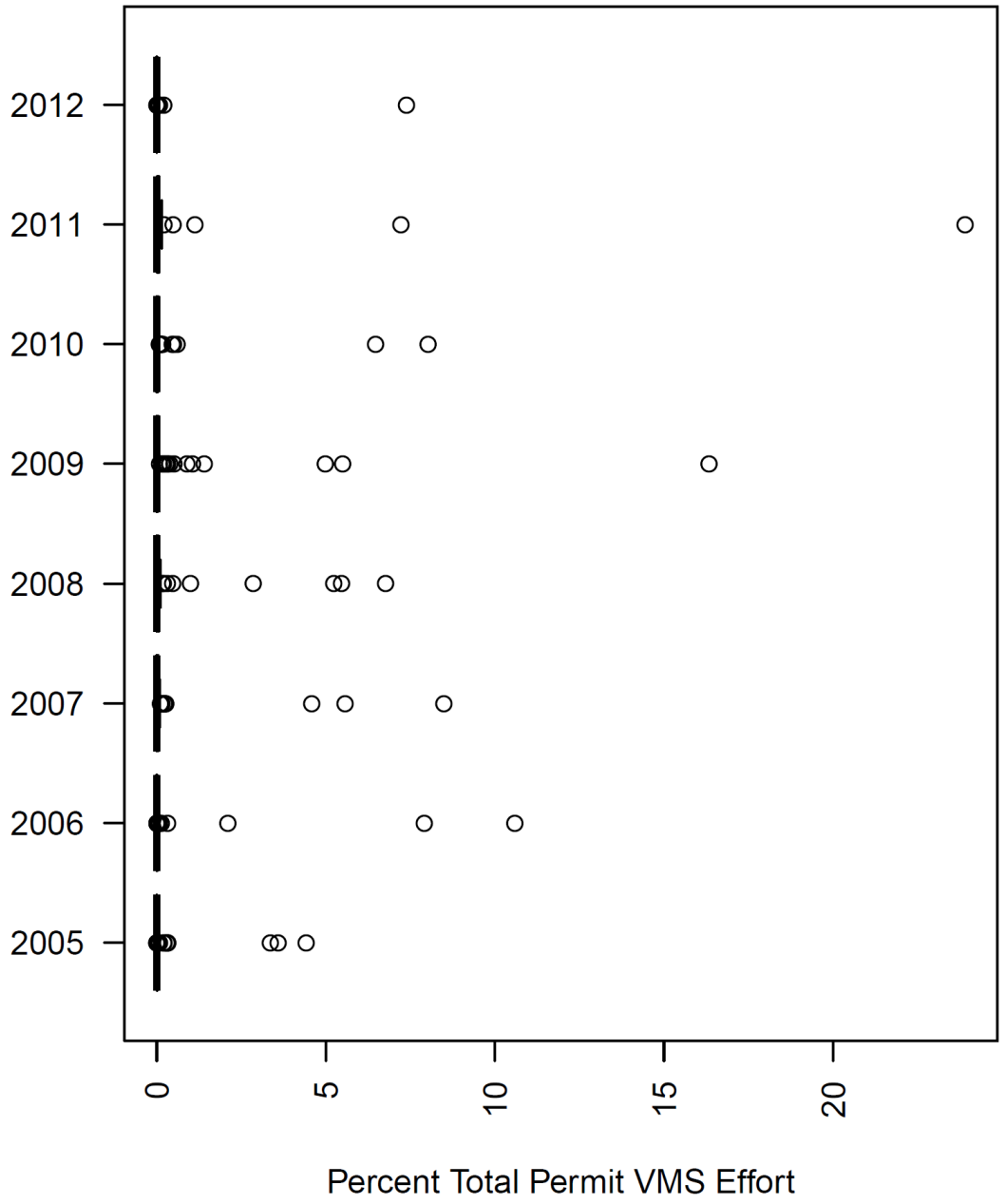


Figure 7 – Percent of total annual permit fishing activity attributed to the Option 7 coral zone, 2005-2012, as derived from VMS - MBTG ONLY. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

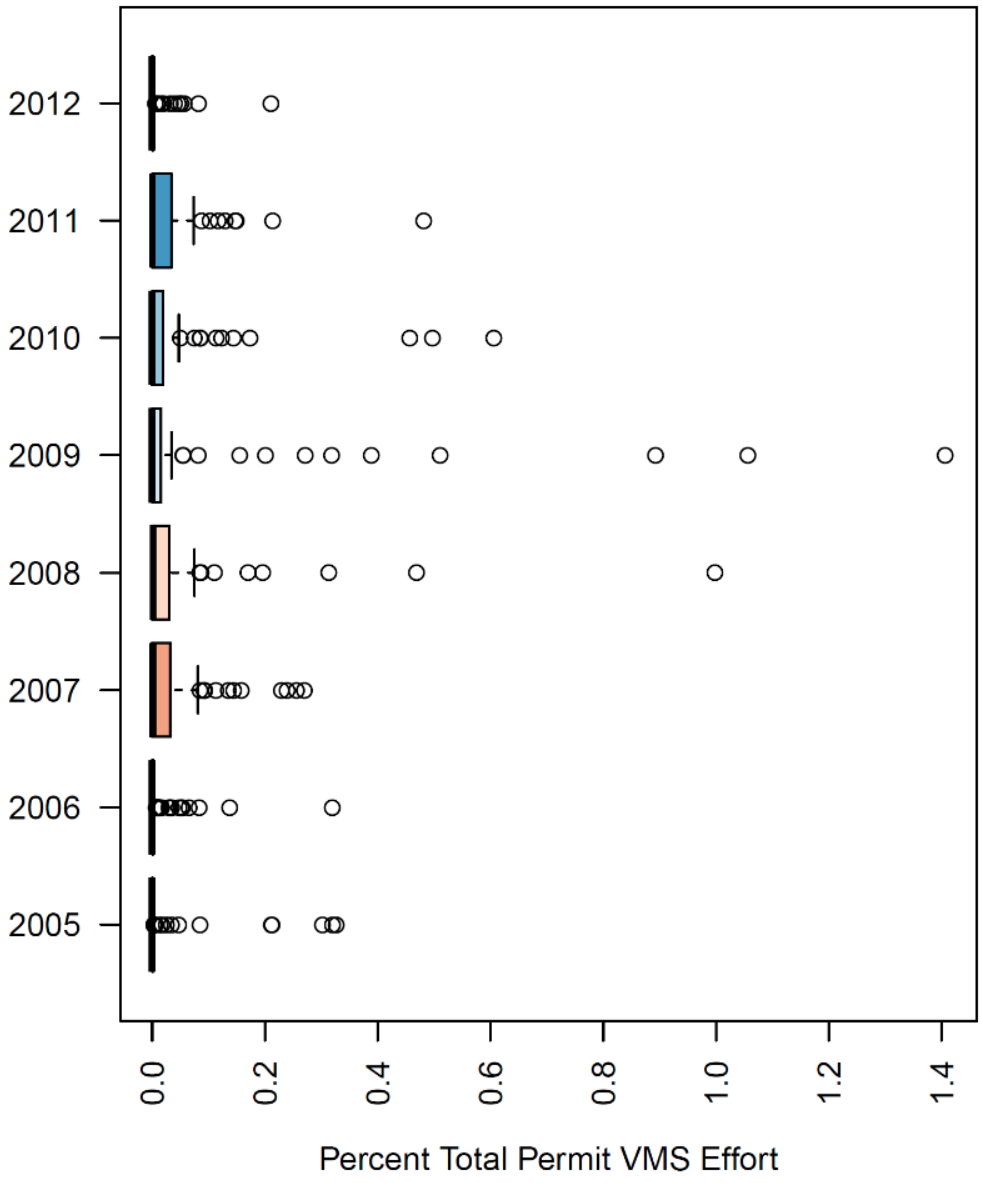


Table 3 – From the VTR analysis, percent difference in species mean revenue ($ millions) between the current Preferred Alternative (Option 6) and Option 7. This table includes data for all gears, but species harvested with MBTG are flagged.

		Mean Revenue		
	MBTG	Preferred Alternative	Alternative 7	Difference
CRAB, JONAH	N	0.53	0.61	14%
CRAB, RED	N	0.82	0.93	13%
LOBSTER	N	3.54	3.90	10%
Other	49%	0.42	0.49	16%
MONKFISH	40%	0.12	0.15	21%
Non-MBTG Total		**5.17**	**5.78**	**12%**
BUTTERFISH	Y	0.27	0.30	11%
FLOUNDER, SUMMER	Y	0.23	0.26	11%
HADDOCK	Y	0.14	0.16	16%
HAKE, SILVER	Y	1.06	1.20	13%
INSHORE LONGFIN SQUID	Y	0.67	0.75	12%
MONKFISH	Y	0.12	0.15	21%
SCALLOP, SEA	Y	1.22	1.44	18%
MBTG Total		**3.98**	**4.55**	**14%**

Table 4 – Percentage of VTR trips, by gear type, attributed to the Option 7 coral zone south of Georges Bank, that have VMS coverage 2010-2012.

Gear	Year	Zone	Permits	VTR Trips	VMS Trips	Coverage
Bottom Longline	2010	Alternative 7	6	48	0	0%
Bottom Longline	2011	Alternative 7	6	37	0	0%
Bottom Longline	2012	Alternative 7	8	35	0	0%
Bottom Trawl	2010	Alternative 7	133	972	914	94%
Bottom Trawl	2011	Alternative 7	124	849	769	91%
Bottom Trawl	2012	Alternative 7	138	711	619	87%
Lobster Pot	2010	Alternative 7	52	931	140	15%
Lobster Pot	2011	Alternative 7	45	782	71	9%
Lobster Pot	2012	Alternative 7	44	726	55	8%
Other Gear	2010	Alternative 7	5	32	0	0%
Other Gear	2011	Alternative 7	5	24	0	0%
Other Gear	2012	Alternative 7	9	47	0	0%
Scallop Gear & Clam Dredge	2010	Alternative 7	19	20	18	90%
Scallop Gear & Clam Dredge	2011	Alternative 7	80	98	94	96%
Scallop Gear & Clam Dredge	2012	Alternative 7	194	268	260	97%
Separator & Ruhle Trawl	2010	Alternative 7	20	72	54	75%
Separator & Ruhle Trawl	2011	Alternative 7	33	135	114	84%
Separator & Ruhle Trawl	2012	Alternative 7	20	49	35	71%
Sink Gillnet	2010	Alternative 7	25	172	0	0%
Sink Gillnet	2011	Alternative 7	35	277	0	0%
Sink Gillnet	2012	Alternative 7	28	190	0	0%

Table 5 - VMS estimates of effort (total hours fished, trips, and permits) within the Option 7 coral zone south of Georges Bank, by gear type. As suggested in the previous table, most of these gears have very high coverage rates in VMS, except for lobster traps. VMS data for gillnet and longline are not available.

Zone	Gear	Year	Hours Fished	Permits	Trips
Alternative 7	Bottom Trawl	2005	29.14	18	30
Alternative 7	Bottom Trawl	2006	9.62	22	39
Alternative 7	Bottom Trawl	2007	18.28	29	55
Alternative 7	Bottom Trawl	2008	37.84	32	73
Alternative 7	Bottom Trawl	2009	58.83	30	77
Alternative 7	Bottom Trawl	2010	40.65	32	87
Alternative 7	Bottom Trawl	2011	25.83	21	56
Alternative 7	Bottom Trawl	2012	7.83	28	56
Alternative 7	GC Scallop	2006	-	1	-
Alternative 7	GC Scallop	2011	-	1	-
Alternative 7	GC Scallop	2012	-	1	-
Alternative 7	LA Scallop	2005	0.05	52	63
Alternative 7	LA Scallop	2006	0.08	64	132
Alternative 7	LA Scallop	2007	0.00	20	21
Alternative 7	LA Scallop	2008	0.00	14	15
Alternative 7	LA Scallop	2009	0.27	27	29
Alternative 7	LA Scallop	2010	0.05	28	28
Alternative 7	LA Scallop	2011	0.12	19	23
Alternative 7	LA Scallop	2012	0.35	27	32
Alternative 7	Squid Trawl	2005	3.06	22	39
Alternative 7	Squid Trawl	2006	5.56	32	64
Alternative 7	Squid Trawl	2007	17.67	37	92
Alternative 7	Squid Trawl	2008	1.11	9	13
Alternative 7	Squid Trawl	2009	7.88	6	22
Alternative 7	Squid Trawl	2010	1.99	8	18
Alternative 7	Squid Trawl	2011	7.61	10	19
Alternative 7	Squid Trawl	2012	0.81	7	8
Alternative 7	Pot/Trap	2005	5.50	3	5
Alternative 7	Pot/Trap	2006	143.84	4	70
Alternative 7	Pot/Trap	2007	147.41	3	68
Alternative 7	Pot/Trap	2008	130.33	5	51
Alternative 7	Pot/Trap	2009	86.88	5	37
Alternative 7	Pot/Trap	2010	96.11	4	54
Alternative 7	Pot/Trap	2011	77.32	4	35
Alternative 7	Pot/Trap	2012	-	1	-

Fishing community impacts

Although the VTR analysis has some degree of error (the VMS comparison suggests that the VTR results are an overestimate), it suggests that the fishing communities that could be impacted by the Option 7 coral zone are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states. Presented here are estimates of recent state and port participation in fisheries attributed to the Option 7 coral zone. Though Option 7 would restrict only MBTG (Table 7), results for all bottom tending gears are included (Table 6) to be consistent with the impacts analysis in the Environmental Assessment.

ALL GEARS: The VTR analysis attributes recent landings revenue from all bottom tending gears to 55 ports, and 60% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and only 27% of the revenue is attributed to other ports, indicating that this zone may be particularly relevant for those three communities. The revenue attributed to Massachusetts and Rhode Island from Option 7 is about 1.1% and 3.5% of all revenue, respectively, for these states during 2010-2015 (ACCSP data, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 4).

Table 6 - Landings revenue to states, regions, and top ports attributed to fishing within the Option 7 coral zone, 2010-2015 – ALL BOTTOM TENDING GEARS

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Maine	$0.0M	$0.0M	3
Massachusetts	$36.6M	$6.1M	466
North of Cape	$1.6M	$0.3M	49
Gloucester	$1.5M	$0.3M	36
Other (n=4)	$0.1M	$0.0M	21
Cape & Islands	$7.4M	$1.2M	46
South of Cape	$27.7M	$4.6M	399
New Bedford	$27.3M	$4.6M	383
Other (n=3)	$0.4M	$0.0M	31
Rhode Island	$16.8M	$2.8M	114
Newport	$8.7M	$1.4M	19
Point Judith	$3.4M	$0.6M	91
Other (n=4)	$5.3M	$0.8M	16
Connecticut	$1.1M	$0.2M	22
New York	$2.1M	$0.3M	31
Montauk	$1.9M	$0.3M	26
Other (n=5)	$0.2M	$0.0M	7
New Jersey	$1.1M	$0.2M	53
Virginia	$1.5M	$0.3M	105
North Carolina	$0.2M	$0.0M	46
Other[b]	$1.7M	$0.3M	13
Total	**$61.1M**	**$10.2M**	**627**

Notes: Ports listed are the top 10 ports by landing revenue that are non-confidential.
[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
Source: VTR analysis.

MBTG ONLY: The VTR analysis attributes recent MBTG landings revenue to 44 ports, and 60% of this revenue to ports in Massachusetts. New Bedford, Point Judith, and Montauk are among the top ten landing ports, and 30% of the revenue is attributed to other ports, indicating that this zone may be particularly relevant for those three communities. The revenue attributed to Massachusetts and Rhode Island from the Option 7 zone is about 0.5% and 1.2% of all revenue, respectively, for these states during 2010-2015 (ACCSP data, 2017). Though these are small fractions, certain individual permit holders could have as much as 40% of their revenue attributed to fishing from this area (Figure 5).

Table 7 - Landings revenue to states, regions, and top ports attributed to fishing within Option 7, 2010-2015 – MBTG ONLY

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$16.0M	$2.7M	383
North of Cape	$0.4M	$0.1M	41
Cape & Islands	$0.0M	$0.0M	18
South of Cape	$15.5M	$2.6M	348
New Bedford	$15.4M	$2.6M	337
Other (n=3)	$0.1M	$0.0M	14
Rhode Island	$5.7M	$1.0M	80
Point Judith	$2.1M	$0.3M	72
Other (n=4)	$3.6M	$0.7M	12
Connecticut	$1.1M	$0.2M	20
New London	$0.6M	$0.1M	2
Stonington	$0.5M	$0.1M	18
New York	$1.3M	$0.2M	19
Montauk	$1.3M	$0.2M	14
Other (n=4)	$0.0M	$0.0M	5
New Jersey	$1.0M	$0.2M	47
Cape May	$0.5M	$0.1M	28
Other (n=2)	$0.5M	$0.1M	19
Virginia	$1.5M	$0.3M	105
Newport News	$0.7M	$0.1M	48
Other (n=3)	$0.8M	$0.2M	65
North Carolina	$0.2M	$0.0M	46
Other[b]	$0.0M	$0.0M	4
Total	**$26.8M**	**$4.5M**	**509**

Notes: Ports listed are the top 10 ports by landing revenue that are non-confidential.
[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
Source: VTR analysis.

OTHER ISSUES

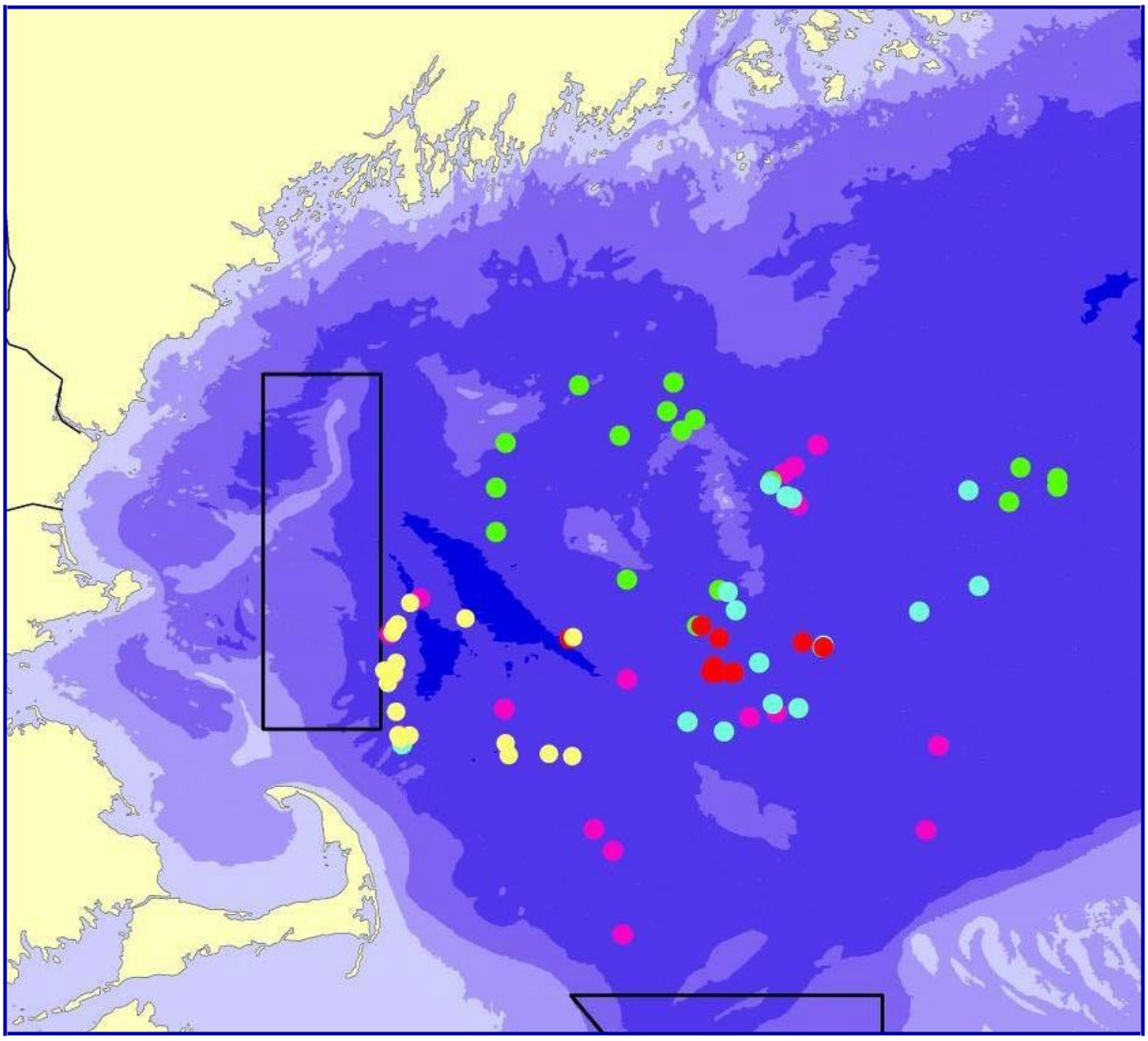
Utility of REDNET report

Through the public comment period, it was suggested that the REDNET project may have valuable information to inform the development of the coral amendment. REDNET was a collaborative research project with many partners including the Maine Department of Marine Resources, the Massachusetts Division of Marine Fisheries, UMass Dartmouth School for Marine Science and Technology, and several redfish fishermen. REDNET has several components designed to increase commercial landings of redfish and the viability of the fishery (Kanwit et al, 2013).

The Habitat PDT examined the final report: *Component 2 – Baseline Catch and Bycatch Evaluation* and had some email communications with the project leaders to understand the locations and catch composition of the exploratory fishing tows, which occurred in 2011 and 2012. Of the 85 tows, there was just one instance where coral was caught, a sea pen from within Wilkinson Basin (at approximately 69º52'W, 42º32'N). On Figure 8, the location is likely one of the yellow dots just east of the Western Gulf of Maine Closed Area. From a visual inspection of the tow locations, it is unlikely that any of the tows made during REDNET Component 2 overlap a coral zone included in the range of alternatives for the Deep-Sea Coral Amendment. The coral zones in Jordan Basin are generally north of the northern boundary of the Western Gulf of Maine Closed Area, and the Lindenkohl zone is further east than the mapped area.

While the REDNET report provides interesting background about traditional redfish fishing grounds, and a detailed assessment of bycatch in other areas, its utility in the impacts analysis of the Deep-Sea Coral Amendment is limited.

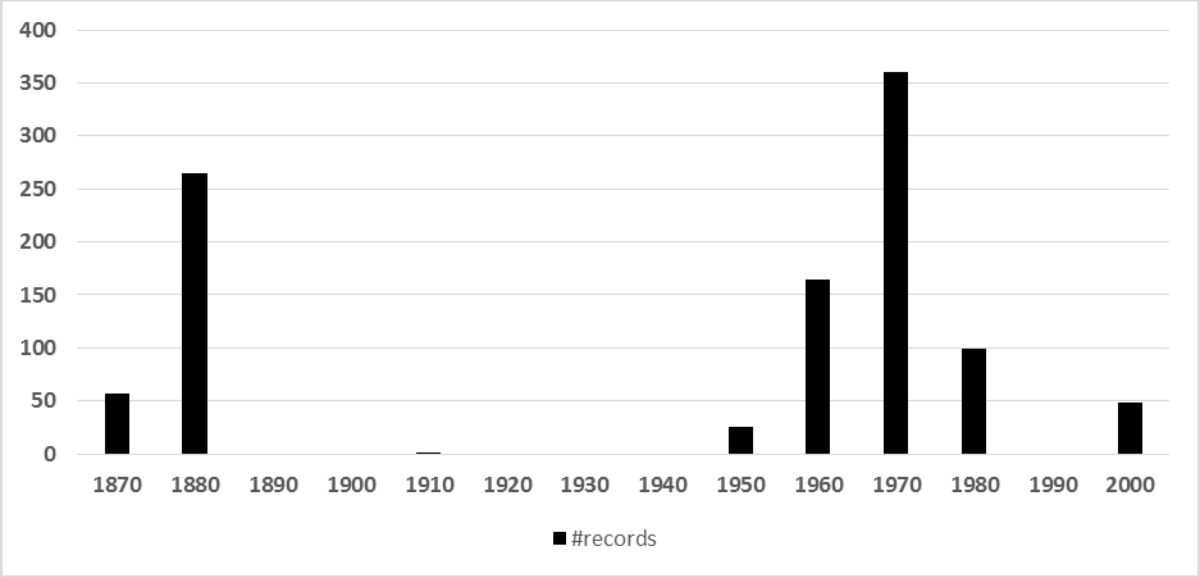
Figure 8 - Tow locations in the Gulf of Maine by month (June: purple; July: green; September: blue; December: red; February: yellow). The black rectangle is the Western Gulf of Maine Closed Area; a portion of Closed Area I is shown in the southern extent of the map. *Source:* Kanwit et al. (2013).



Age of coral records

The Deep-Sea Coral Research and Technology Program (DSCRTP database includes records of varying ages. There are approximately 1,000 records of deep-sea corals and sponges in the New England region, which mostly overlap the canyon/slope region south of Georges Bank. Additional records are located in the Gulf of Maine and on Georges Bank. In terms of the age of these records, around half were collected since 1970, around 200 records date from the 1950s and 1960s, and the remaining ~300 records were collected prior to 1950; most of these from the 1880s (Figure 9).

Figure 9 – Deep-Sea Coral Research and Technology Program database records of coral and sponge occurrence in the New England Region, by collection decade. The 2000s only includes data through 2005. Recent 2013-present data from ROV and towed camera cruises are not part of this dataset but are described separately in the coral amendment.



Offshore Gulf of Maine coral zones

There are key differences between the three coral zones within Jordan Basin and between the sites at Jordan Basin and Lindenkohl Knoll that are important to highlight and may be obscured by the current analysis in the EA. Currently, the coral zones comprising Option 2 at Jordan Basin must be selected as a group. However, the corals at one Jordan Basin site in particular, 114 fathom bump, have important and distinct features, as described below, which the Council could consider protecting – rather than the current preferred alternative of the Habitat Committee (No Action in the offshore Gulf of Maine). As a reminder, in April 2017, the Council recommended that if any management were to be considered for the offshore Gulf of Maine zones, just a MBTG restriction is preferred, such that the gillnet and lobster fisheries would be allowed to continue, and bottom trawling could be restricted.

Coral density, size, and survey effort: Some of the sub-areas within the offshore Gulf of Maine sites are very well studied, others less so. The zones identified at 118 Fathom Bump, 96 Fathom Bump, Central Jordan Basin, and Lindenkohl Knoll have just one to four survey tows each. The Option 2 sub-areas for Central Jordan Basin and Lindenkohl break the larger areas down into

smaller ones that have only one to two tows each. By contrast, the 114 Fathom Bump site in Jordan Basin has much more extensive sampling effort, particularly in the area immediately surrounding the actual 114 fathom feature for which the site was named. There are 29 tows or dives within the Option 1 114 Fathom Bump site, 12 on top of the feature that includes the 114 fathom bump (Figure 10). Four of the 29 dives did not find coral habitats, five found lower density coral habitats, and the remaining 20 indicated coral habitats at high (coral garden) density. Of the 12 sites on top of the 114 bump feature itself, 10 had coral gardens and two had lower density coral habitats.

Coral zone identification approach: The Habitat Committee has questioned how extensive an area of coral habitat can be inferred from the dive information. Both remotely operated vehicles and towed camera systems, but especially ROVs, cover a relatively small area and collect very detailed data. The PDT used information about seafloor terrain to help define appropriate management area boundaries based on these dive sites. The zone boundaries were drawn to include adjacent areas of similar depth and steepness where corals habitats were likely to occur. Throughout the Gulf of Maine, coral habitats appear to be concentrated on steeper features, and structure-forming soft corals are often not observed at adjacent low-relief sites. The PDT examined dive tracks available for ROV and towed camera work at the 114 Fathom Bump site. As an example, the 2013 dive tracks at 114 Fathom Bump cover distances ranging from 0.1-0.6 km per dive. Assessments of low density vs. coral garden habitats were made at the scale of the entire dive. Thus, a 0.3 km dive track marked as a coral garden suggests that coral garden habitats were typical along the dive track.

Coral habitat condition and evidence of fishing impacts: Both the condition of coral habitats and evidence of fishing gear impacts varies between dive sites. At the coral zone scale, the Lindenkohl Knoll zone has smaller coral colonies, and colonies tend to occur in depressions or crevices. Gear marks, assumed to be associated with trawls, are relatively common at Lindenkohl (Figure 11), and in some locations in Jordan Basin (see Figure 14 in Auster et al. 2014). This evidence is consistent with the public narrative that Lindenkohl is heavily fished. This narrative is corroborated by 2011-2014 VMS maps from the Northeast Ocean Data Portal, which indicate high density of VMS polls at vessel speeds < 4 knots over Lindenkohl Knoll (Figure 11). Similar densities of VMS polls also occur at the Jordan Basin 96 fathom bump site, which has also been described as an important fishing ground (Figure 11). By contrast, the coral at the 114 fathom bump site are larger, and more widespread (not restricted to crevices, Figure 13). Gear marks appear to be rare at the 114 fathom bump dive sites. Overall, the PDT's assessment is that, based on both coral habitat condition and evidence of fishing effort and fishery impacts, the 114 fathom bump site may be a good conservation priority, should the Council wish to select a subset of the Option 2 coral zones for management.

Coral genetic diversity: Public comments referenced recent research that suggests corals in the Gulf of Maine are genetically distinct. Coykendall et al. (2016) examined genetic markers on *Primnoa resedaeformis* samples from Outer Schoodic Ridge, western and eastern Jordan Basin, the Northeast Channel, Newfoundland, Baltimore Canyon, Norfolk Canyon, and an eastern North Atlantic site. They found that corals at Outer Schoodic Ridge and Western Jordan Basin were similar to one another, and distinct from other sites. Other locations also exhibited distinct genetic signatures. This suggests metapopulation dynamics for the species in the western North

Atlantic. In the face of temperature or acidity increases, this genetic diversity may help the species adapt.

Figure 10 – Seafloor terrain, coral dive observations, and tow tracks at the 114 fathom bump site. The red dotted outline indicates the feature that includes 114 fathom bump.

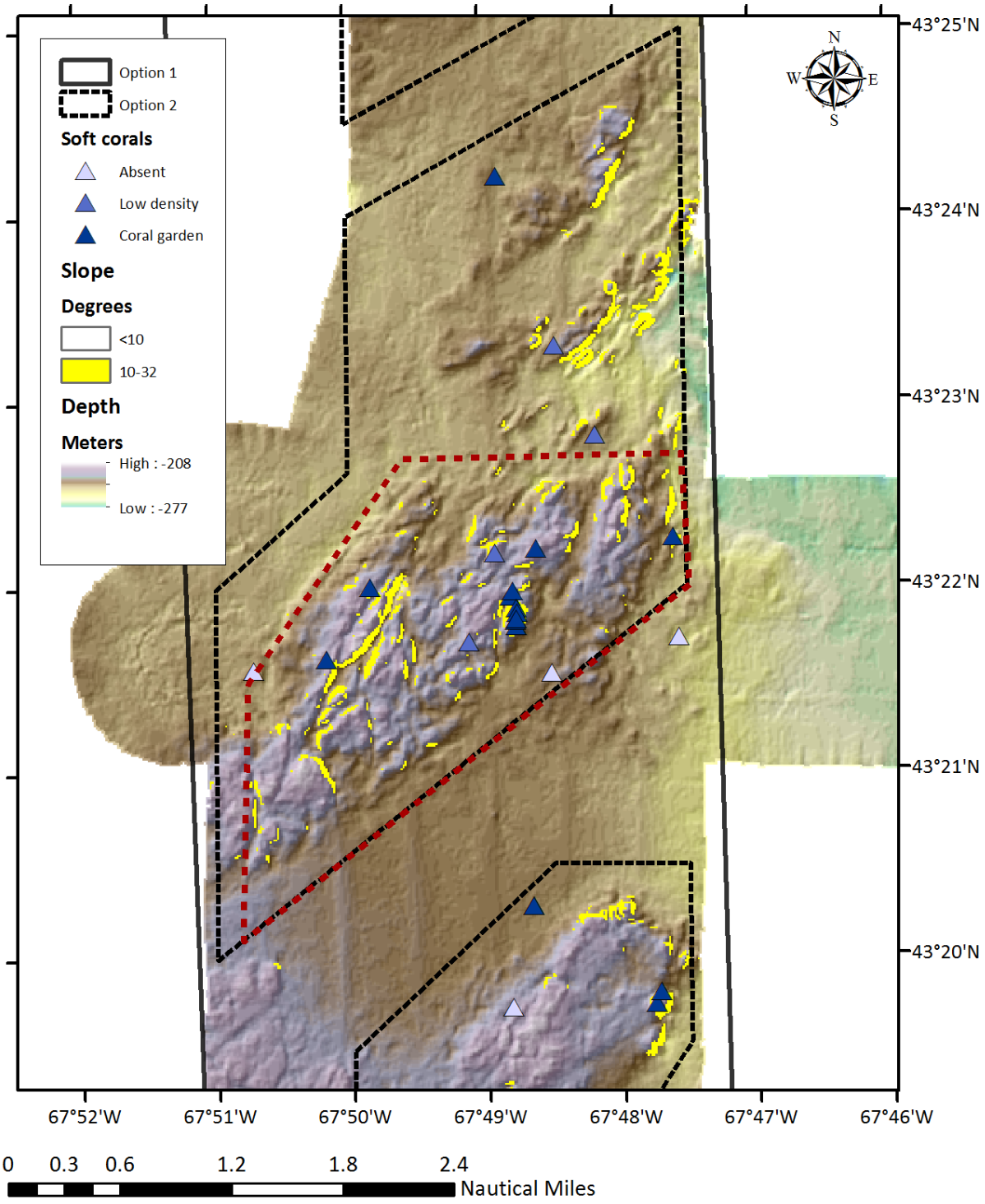


Figure 11 – Typical images from Lindenkohl Knoll, showing colony size and distribution, and evidence of gear marks

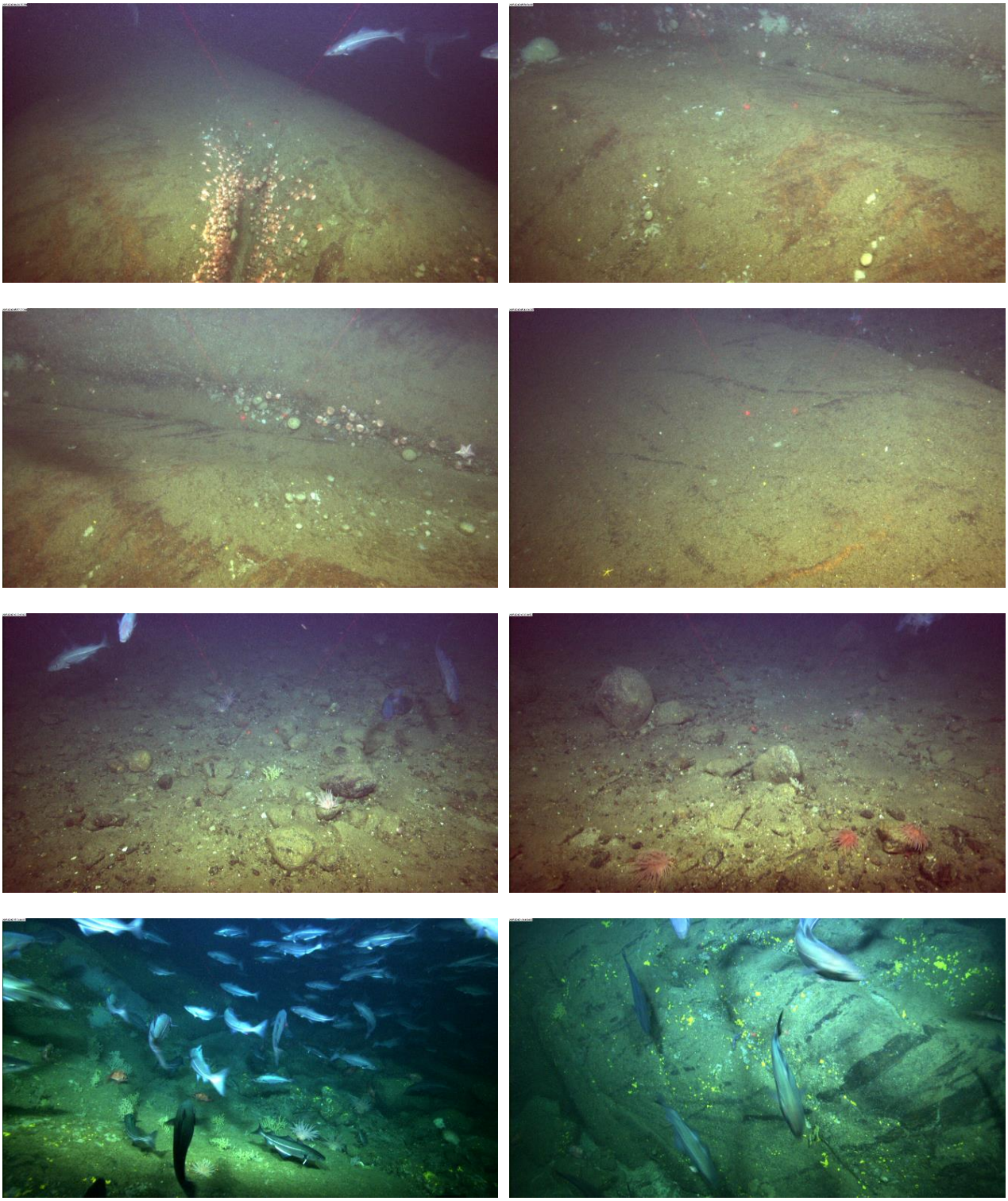


Figure 12 - Offshore GOM coral zones and 2011-2014 bottom trawl VMS data. VMS data from Northeast Ocean Data Portal.

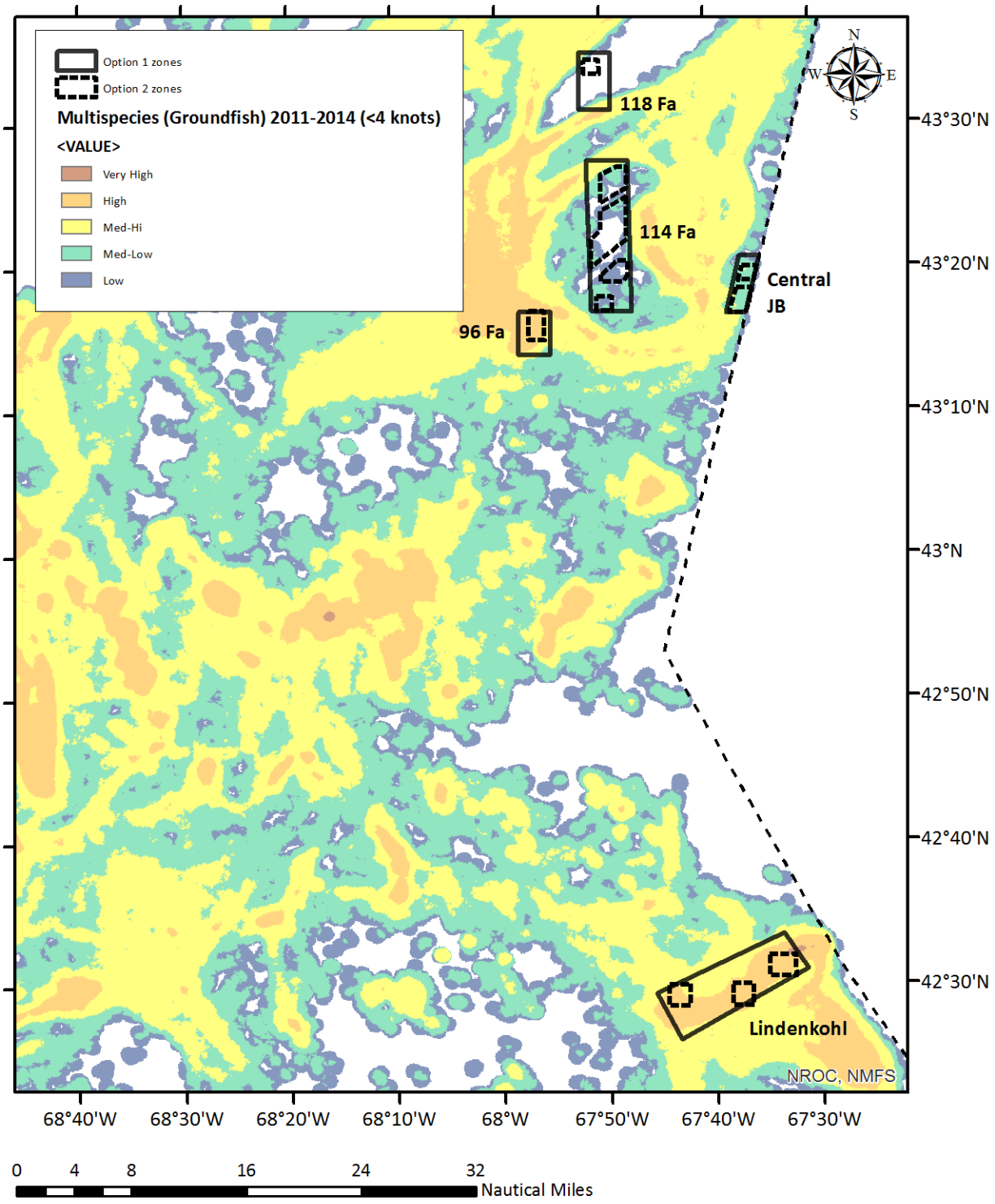


Figure 13 - Typical images from 114 fathom bump, showing colony size and distribution

REFERENCES

Auster, P.J., Packer, D., Waller, R., et al. (2014). Imaging Surveys of Select Areas in the Northern Gulf of Maine for Deep-sea Corals and Sponges during 2013-2014. Report to the New England Fishery Management Council - 1 December 2014. 23p.

Coykendall, D.K., Herrera, S., Nizinski, M.S., et al (2016). Contrasting (?) patterns of population genetic connectivity in octocorals from the northern Atlantic Ocean. 6th International Symposium on Deep-Sea Corals, September 11-16 2016, Boston, MA.

DePiper, G. S. (2014). Statistically assessing the precision of self-reported VTR fishing locations. NOAA Technical Memorandum NMFS-NE-229. 16p.

Kanwit, K., M. Pol, P. He (2013). REDNET - A Network to Redevelop a Sustainable Redfish (*Sebastes fasciatus*) Trawl Fishery in the Gulf of Maine, Component 2 – Baseline Catch and Bycatch Evaluation Final Report. January 23, 2013. 33p.

Records, D. and C. Demarest (2013). Producing high resolution spatial estimates of fishing effort using a VMS-based statistical model (draft working paper). Woods Hole, MA, Northeast Fisheries Science Center: 35p.