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MEMORANDUM

DATE: January 5, 2018

TO: Habitat Committee

FROM: Habitat Plan Development Team

SUBJECT: **Revised coral zone alternative for canyon/slope region south of Georges Bank**

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 coral zone boundary (referred to as Option 7) had been presented to the Council during each of the public hearings conducted to solicit comments on the Omnibus Deep-Sea Coral Amendment during the week of May 22. 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 by Pew on June 5. The proposal included both the criteria used to determine the boundary and specific boundary points that meet the criteria. Per the Habitat Committee's instruction, the PDT drafted a memo dated June 14, 2017 evaluating the alternative.

On June 22, 2017 the Council passed a motion "committing the following to the Habitat Committee for further analysis and consideration so that it can be brought back to the Council for a final decision as soon as the analyses are complete":

- Option 6 (boundary of 600 m minimum depth) as a broad coral protection zone. The use of all bottom tending gear will be prohibited within the zone (Section 4.3, Option 1). The use of pot gear for red crab (Section 4.3, Sub-Option A) shall be exempt from these restrictions.
- In addition, Option 7, a broad zone management area (Section 4.2.1), as revised consistent with the June 14, 2017 PDT Memorandum recommendations (pp. 4-5). This area will be closed to all mobile bottom-tending gear (Section 4.3, Option 2).

This memo describes updates made to Option 7 by the PDT, and provides an analysis of the impacts of the option as a closure to mobile bottom-tending gears. This memo also summarizes the additional impacts of designating Option 6 as a closure to all bottom tending gears except red crab pots.

What is Option 7? How was it revised from the original version?

Option 7 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. Option 7 specifically 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. Other broad zones include options to designate them as closures to just mobile bottom-tending gears, or to all bottom-tending gears, with sub-options to exempt red crab traps or other types of traps (e.g., lobster traps). The Council motion from June indicates that Options 6 and 7 might be designated in combination. The methods used to define Option 6 are summarized in the Environmental Assessment.

Boundary criteria

The inshore boundary along the shelf break varies in depth, according to the following criteria (these remain as proposed by Pew and others in May):

- *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 or 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.

Data sources used to develop Option 7

Coral data

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°). This is the same approach as has been used by the PDT throughout the development of the amendment.

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, 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. Option 7 falls between some of the other zones as the depth of the boundary varies depending on the data. Locations of relatively recent camera transects and remotely operated vehicle dives were also considered when drawing the boundary.

The coral suitability 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 is restricted to the slope/canyon region south of Georges Bank: between 100 m depth, just shallower than the shelf break, to 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 remotely operated vehicles and towed cameras, corals were almost always observed where the slope was 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).

Fishing effort data

The May 2017 Option 7 boundary was based on vessel monitoring system (VMS) and vessel trip report (VTR) maps available on the Northeast and Mid-Atlantic ocean data portals. For the June 14 memo, the PDT evaluated the May 2017 Option 7 boundary in sections, each representing a canyon or intercanyon area. This evaluation was based on the data portal maps used by Pew et al. to develop the alternative. At the time, the PDT made a handful of suggestions that might be used to adjust the coordinates of the boundary line.

For this update, fishing with mobile bottom-tending gears (MBTG) was determined based on visual inspection of VMS data, using new spatial data sets developed by the PDT during summer and fall 2017. These data were used to redraw the boundary during December 2017. Because the focus of this option is on mobile bottom-tending gears, and trawls are the only gears used at coral habitat depths, the boundary was developed using bottom trawl VMS data. As described in the Environmental Assessment, bottom trawl vessels have high rates of VMS coverage. Two data types were used, model-based data from 2005-2012, and speed-filtered data from 2010-2016.

The foundation for the model-based maps was a database of VMS polls from 2005-2012. The data were assembled by Chad Demarest and David Records at the Northeast Fisheries Science Center and their methods are summarized in a draft working paper (Records and Demarest 2013). A similar approach was recently published (Muench et al 2017). Each poll was matched with a trip-level VTR to identify gear and catch, and then matched to at sea fisheries observer data from the Northeast Fisheries Observer Program to estimate the probability that a particular poll represented fishing activity. The observer data identifies fishing events at the haul or set level, and includes haul start and end times that can be used to flag an individual VMS poll as fishing or non-fishing. Because observer data are not collected on all trips, generalized additive modeling was used to estimate fishing vs. non-fishing during unobserved trips. The time elapsed between adjacent polls, which is directly calculated from the VMS data, was multiplied by the probability of fishing at each poll location to generate a probability-weighted hours fished value for each point. Data were sorted into métiers and separate models were generated for each of two métiers and each year. Specifically, the bottom trawl and squid trawl métiers were used.

A second speed-filtered VMS dataset was developed for 2010-2016 by selecting all trawl gear VTR trips that landed a range of species known to be caught in bottom trawls along the shelf break, and then matching those trips to their VMS polls. The species included were butterfish, silver hake, offshore hake, unclassified hake, red hake, longfin squid, *Illex* squid, summer flounder, scup, black seabass, and monkfish. The VTR data were filtered by this list of species to reduce the number of trips and polls in the dataset, because VMS datasets can be very large files. Data were provided to the PDT by Mike Palmer, Northeast Fisheries Science Center.

Once the VMS polls (points) were collected, the data were converted to heatmaps using point density methods in Arc GIS 10.5[1]. Annual files for each dataset and year were imported into ArcMap 10.5, and points were plotted using the Display XY Data function and assuming a WGS 1984 geographic coordinate system. Data were projected into WGS 1984 Zone 19N. For the model-based data, polls representing a probability of fishing below 0.20 were then removed from each annual dataset. The speed-filtered data were used as provided as they were already filtered to exclude polls unlikely to represent fishing.

Individual polls were interpolated using the Point Density tool (Spatial Analyst).[2] The resulting point density raster data were natural log transformed (Ln tool, Spatial Analyst), and standardized.[3] All data sets were categorized in the same way, < -1 std dev, -1-0 std dev, 0-1 std dev, 1-2 std dev, > 2 std dev, permanently reclassified into these five categories (Reclassify tool, Spatial Analyst), and then converted to vector (polygon) data (Raster to Polygon tool, Conversion toolbox).

Reclassified raster data were used for developing map products. The vector data were used to assess confidentiality.[4] Confidentiality criteria were easily met for all data sets and years, even

[1] The approach was adapted from December 2015 methods used by the Northeast Regional Ocean Council to map VMS data (Rachel Shmookler, RPS Applied Science Associates).

[2] For the model-based data sets, the following settings were used: population field = hours fished, output cell = 100 m, neighborhood = 1000 m, and area units = square kilometers. This approach places a greater weighting on polls with higher hours fished values. For the speed filtered data, the settings were the same except that the population field was left blank, and all points were weighted equally. As specified here, the tool assesses the number (and for the model-based data, also the value) of VMS points within 1000 m radius circular neighborhood, and assigns a density based on this assessment to 100 m grid cells.

[3] Using the Raster Calculator tool (Spatial Analyst), each transformed data set was standardized by subtracting the mean and dividing by the standard deviation. These values were read from the ln transformed data sets.

[4] To do this, the vector data were joined to the original point and each point was assigned a standard deviation class from 1-5. The point data were then examined to ensure that at least three unique permit numbers were represented for each class. This ensures that the different colors represented in the maps are non-confidential.

when selecting just the subset of points falling along the shelf break in the New England region only.

Evaluate data with respect to boundary and edit points

The next step was to evaluate the initial boundary provided during May 2017 with respect to the coral and fishing effort data. This was done is a standardized fashion to improve objectivity. Buffers were drawn around the draft boundary to indicate the distance 2 km from the boundary, and 5 km from the boundary (Buffer tool, Analysis toolbox). Within 2 km was assessed as being in close proximity of the boundary, within 5 km was assessed as being in proximity of the boundary, and beyond 5 km was assessed as being distant from the boundary. The shelf break was broken into 24 locations (canyons, groupings of adjacent canyons, or sections of the intercanyon slope). VMS data were grouped into low density (< -1 or -1-0 std dev), dense (0-1, 1-2 std dev), or very dense (> 2 std dev).

For each VMS dataset (data type/year combination), the heat map was evaluated visually to determine if there were no polls within 5 km of the boundary, if there were only low-density polls within 5 km of the boundary, if there were dense or very dense polls within 5 km of the boundary, or if there were dense or very dense polls within 2 km of the boundary. These findings were scored as follows:

Code	Description
x	*No data for that dataset and year*
1	No VMS polls near boundary
2	Only low density of polls near boundary (low is defined as <-1 std deviations or -1-0 std deviations from mean density). Near is within 5 km.
3	Dense, but inshore of the boundary (dense is defined as 0-1 or 1-2 standard deviations from mean density). Inshore of is within 2-5 km.
4	Very dense, but inshore of the boundary (very dense is defined as >2 standard deviations from mean density). Inshore of is 2-5 km.
5	Dense, and tight to the boundary (dense is defined as 0-1 or 1-2 standard deviations from mean density). Tight is within 2 km of boundary.
6	Very dense, and tight to the boundary (very dense is defined as > 2 standard deviations from the mean density). Tight is within 2 km of boundary.

This scoring gives priority to distance from the boundary, rather than density. Evidence of coral habitat was also summarized in the table. The results are presented at the end of this document.

Boundaries were reconsidered for each location, and in some cases drawn at different depths for the east or west walls of individual canyons according to the location of dense or very dense VMS polls. In many cases, a boundary of around 500 m was maintained from the May 2017 approach, since there was both evidence of coral habitat and evidence of fishing within 5 km of the boundary. In general, dense VMS polls were in closest proximity to the zone boundary along the edges of canyons, and dense VMS polls were often beyond 2 km or even beyond 5 km from the zone boundary in intercanyon areas. Once the boundary was redrawn, the 2k and 5k buffers were redrawn and the scoring was reassessed for each area/dataset combination with respect to the updated buffers. These final scores are shown in the table at the end of this memorandum.

In certain areas, the updated boundary was more than 2 km from the boundary for all, or nearly all, datasets and years. These included Dogbody/Clipper Canyons, Sharpshooter/Welker Canyons, Heel Tapper Canyon, Lydonia to Powell intercanyon, Powell to Munson intercanyon (except 2009 model-based bottom trawl), and Munson to Nygren intercanyon (except 2009 model-based bottom trawl). These areas are shown in greens and yellow on the summary table.

In contrast, in a few areas, there were very high-density areas of VMS polls within 2 km of the boundary. This included the Veatch to Hydrographer intercanyon area (model-based squid trawl, during 2009 only), and Heezen Canyon (model-based squid trawl 2007, speed-filtered trawl 2015-2016). In Heezen canyon, except during 2005, at least one dataset showed dense (0-1 or 1-2 std dev) VMS polls within 2 km of the boundary during each year. This suggests that fishing occurs close to the edge of Heezen Canyon very consistently over the period examined. Alvin and Atlantis Canyons showed similar results, with fishing consistently occurring within 2 km of the 500 m (approximate depth) boundary in all years examined, except for Atlantis Canyon during 2012. These areas are colored orange and red on the summary table.

Near Nygren Canyon and east towards Heezen Canyon, very dense areas of VMS polls occurred within 5 km of the boundary in the speed-filtered dataset, very consistently. The model-based bottom trawl dataset showed dense VMS polls closer to the boundary. Squid trawl data were more variable on a year to year basis for these areas.

Impacts of Option 7 on deep-sea corals

Consistent with other broad zones and the discrete canyon zones analyzed in the Environmental Assessment, the revised version of 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 above, as well as within 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".

The different broad zones vary in size, as follows (Table 1):

Table 1 – Broad zone sizes

Option #	Size, km^2
Option 1 (300 m)	67,142
Option 2 (400 m)	66,410
Option 7 May 2017	**66,320**
Option 7 Dec 2017	**66,164**
Option 3 (500 m)	65,838
Option 4 (600 m)	65,365
Option 6 (600 m minimum depth)	65,147
Option 5 (900 m)	64,192

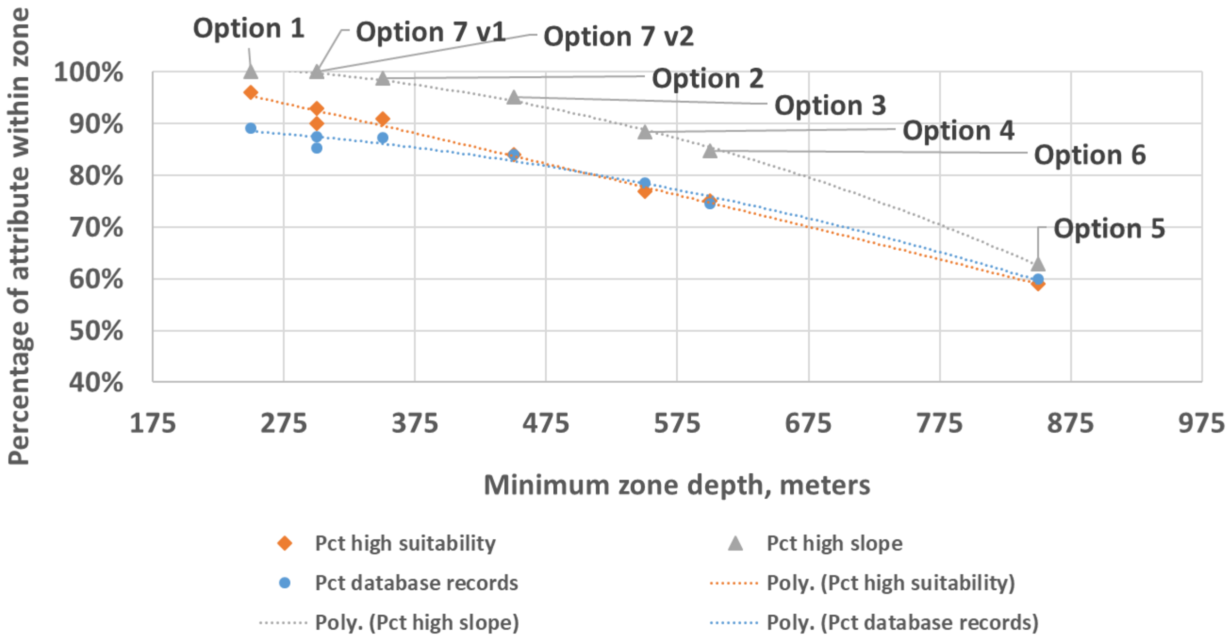
In terms of coral habitat encompassed, Option 7 as modified during December 2017 falls between the 300 m zone (Option 1) and the 500 m zone (Option 3). The original version of Option 7 was between Option 1 and Option 2, the 400 m zone. Option 7 as modified includes

601 out of 704 coral presence records (85%), 4,320 km^2 out of 4,973 km^2 of seafloor likely to be suitable habitat for soft corals (90%), and 164 km^2 (100%) of the known high slope habitat. By contrast, 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 4, 5, or 6, and protect similar amounts of coral habitat compared to Options 1, 2, and 3. Because the modified version of Option 7 was drawn to avoid areas of trawl gear fishing activity indicated by VMS data, it is unsurprising that 100% of the very high slope areas are encompassed, which is the same as the original May version of Option 7, as well as Option 1, the 300 m zone. Habitat suitability and coral records percentages are slightly lower than Option 1, Option 2, or the May version of Option 7, which is reasonable to expect as the modified version of Option 7 is smaller.

Table 2 – Coral metrics summary for broad zone options 1-7 (includes May and December versions of Option 7).

Min. depth	Option#	# Coral records in zone	% Coral records on continental margin	Area highly likely to be suitable habitat for soft corals in zone, km^2	% High suitability habitat on continental margin	Area of high slope in zone, km^2	% High slope on continental margin
250	Option 1 "300 m zone"	627	89%	4,582	96%	164	100%
300	**Option 7, May 2017**	**616**	**88%**	**4,458**	**93%**	**164**	**100%**
350	Option 2 "400 m zone"	615	87%	4,354	91%	162	99%
300	**Option 7, Dec 2017**	**601**	**85%**	**4,320**	**90%**	**164**	**100%**
450	Option 3 "500 m zone"	592	84%	4,042	84%	156	95%
550	Option 4 "600 m zone"	553	79%	3,700	77%	145	88%
600	Option 6 "600 m minimum zone"	525	75%	3,587	75%	139	85%
850	Option 5 "900 m zone"	422	60%	2,821	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 and combination of Options 6 and 7 on human communities

<u>Fishery impacts</u>

This analysis is of Option 7 as revised, including a prohibition on mobile bottom-tending gear (MBTG), and fixed gear use within Option 6. The two pieces of information can be combined to assess the potential impacts of the combined approach suggested at the June 2017 Council meeting.

VMS coverage for MBTG trips with VTR locations overlapping the Option 7 area is high (Table 4), and can 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 4) overestimates exposure. The same can be said for Option 6, suggesting that the estimates should provide valid relative estimates of overlap across these alternatives. As expected because it encompasses additional area, Option 7 has more 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 to tabulate hours fished goes through 2012 only, a direct match for the same time period cannot be established). Trips by these permits are predominantly (i.e., ~65% 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 data evaluated here, concentrated on fishing for species known to occur along the shelf break. This adds uncertainty to the analysis. Nevertheless, Option 7, when applied to only MBTG, is expected to have ***neutral to slightly negative impacts*** to fishermen. Selecting Option 6 in combination with Option 7 is expected to add slightly to the impacts, primarily due to the additional impacts on the lobster and Jonah crab pot fishery. For both alternatives, the impacts accrue primarily to a very small number of individuals.

VTR analysis: Vessel Trip Report data (DePiper 2014) were used to estimate recent (2010-2015) fishing activity within the Option 7 coral zone. Revenue results were unscaled (consistent with the analysis of the other broad zone options)[5]. Maps of revenue by gear type and species are in Section 13 of the draft Environmental Assessment.

Revenue: The top ten species by landed value for the revised Option 7 and the current Preferred Alternative (Option 6; Table 3, Figure 2), are consistent with those of the other broad zones (Options 1-5; Section 7.3.3, environmental assessment), excepting the addition of Atlantic Mackerel and removal of Skates for Option 7.

Annual MBTG revenue attributed to Option 7 averages 12% higher than Option 6 (Table 3). This revenue is dominated by bottom trawl (67% of estimated revenue), followed by scallop gear and clam dredge (31% of estimated revenue), with minor revenue attributed to separator and Ruhle trawls (2% of estimated revenue). Given prevailing knowledge of scallop depth distributions, and spatial imprecision of bottom trawl VTRs, 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 Option 6, the estimates should provide valid relative estimates of exposure across these alternatives, though the magnitude is expected to be imprecise.

Although most vessel owners with MBTG revenue attributed to the Option 7 have had a low proportion of their revenue derived from this area, there are a small number of individuals generating a substantial proportion of their revenue (10-45%) from the area (Figure 6). 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 840 bottom trawl trips fished within the vicinity of Option 7, making it the dominant MBTG[6]. Scallop and clam dredge trips follow (128 trips), and Separator & Ruhle Trawl is substantially lower (averaging 85 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 trips with a match in the VMS and VTR datasets, the VMS data indicates only 11% of bottom

[5] 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.
[6] 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.

trawl trips and 30% of permit holders have polls within the bounds of Option 7. Although the VMS indicates that at least 23% of the scallop and clam dredge trips and 25% of permits identified in the VTR report VMS polls within Option 7, the probability-weighted fishing effort expended by both LA and GC scallop vessels in the region averages very close to zero. Bottom trawl effort is also very low, when compared to the gear's total fishing effort (Table 5).

Figure 8 shows 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 is similar to the owner-revenue estimates (Figure 6), the MBTG estimates (Figure 8) are substantially different, with the VMS presenting very low exposure relative to the VTR (Figure 6). As summarized earlier in this memo, of note is that 19 of the top 20 exposed owners in 2013, 10 of the top 20 in 2014, and 7 of the top 20 in 2015 have no VMS data in those years. Trips by these permits are predominantly (~65% 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 uncertainty to the analysis.

Additional impacts of Option 6: Figure 3 and Figure 5 indicate that most of the additional impacts of Option 6 reside in the pot fishery, predominantly landing lobster and Jonah crab. Figure 7 highlights that the additional exposure of individuals to Option 6 is higher, as a percentage of total owner revenue, than for Option 7. Given the relatively high level of specialization expected for these fleet components, lobster fishermen are likely different individuals than those fishing for squid and butterfish. Thus, additive impacts are unlikely within an ownership entity between the two alternatives. Instead, combining the two options increases the number of entities potentially impacted. VMS coverage for the lobster pot fishery is low, with only 8 – 15% coverage between 2010 and 2012 (Table 4), so analysis of Option 6 with VMS data was not conducted. Nevertheless, the impacts of Options 6 and 7 combined are expected to be ***low negative***, but accrue primarily to a small number of individuals.

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 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 lobster fishery (Sections 7.1.3.2 and 7.3.3.1). Although Option 7 would not restrict lobster fishing, 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 could be located in deeper waters than where their gear is fishing, due to the length of fixed gear end lines or mobile gear tow wire necessary for fishing these depths, slope steepness or ocean conditions. 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 actual overlap with the MBTG fisheries, despite overlap in the VTR and VMS 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 MBTG was not indicated, the Option 7 boundary is shallower than the maximum depth fished by MBTG (500 m), as suggested at the workshops.

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 small sections of the zone in certain locations that overlap with areas I and II. These areas of overlap are in the heads of Veatch, Hydrographer, Dogbody, and Clipper Canyons, as well as small areas between Veatch and Hydrographer Canyon. Veatch Canyon is within the Tilefish Gear Restricted Area, so it is already closed to mobile bottom tending gear. Option 7 would have additional fishery impacts within the other areas. Where mobile bottom-tending gear would be prohibited by Option 7, the available area for the summer trawl fishery in Area I narrows. The areas available for the winter trawl fishery (Areas III and IV) would not be impacted by Option 7.

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 revised Option 7 coral zone are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, Virginia and other states. Presented here are estimates of recent state and port participation in fisheries attributed to the Option 7 (updated) coral zone.

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 6).

The average revenue for 2010-2015 attributed to fishing with MBTG within the revised Option 7 boundary is $4.4M. This is virtually the same as the original Option 7 boundary, $4.5M. Again, these figures are likely overestimates and include $1.3M from scallop fishing.

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

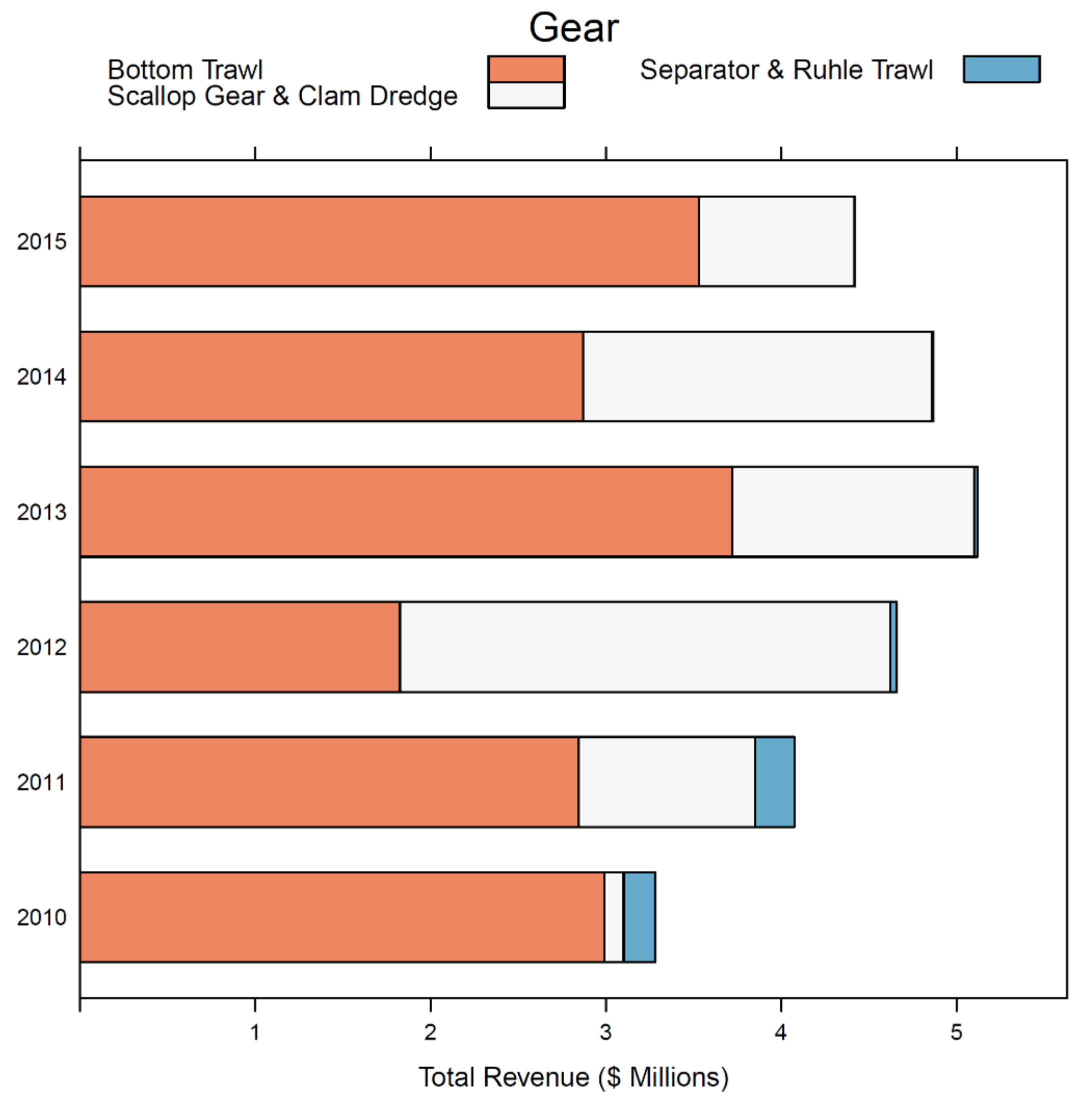


Figure 3 – Revenue by gear type attributed to Option 6 coral zone, 2010-2015 – All non-mobile BTG excluding Red Crab.

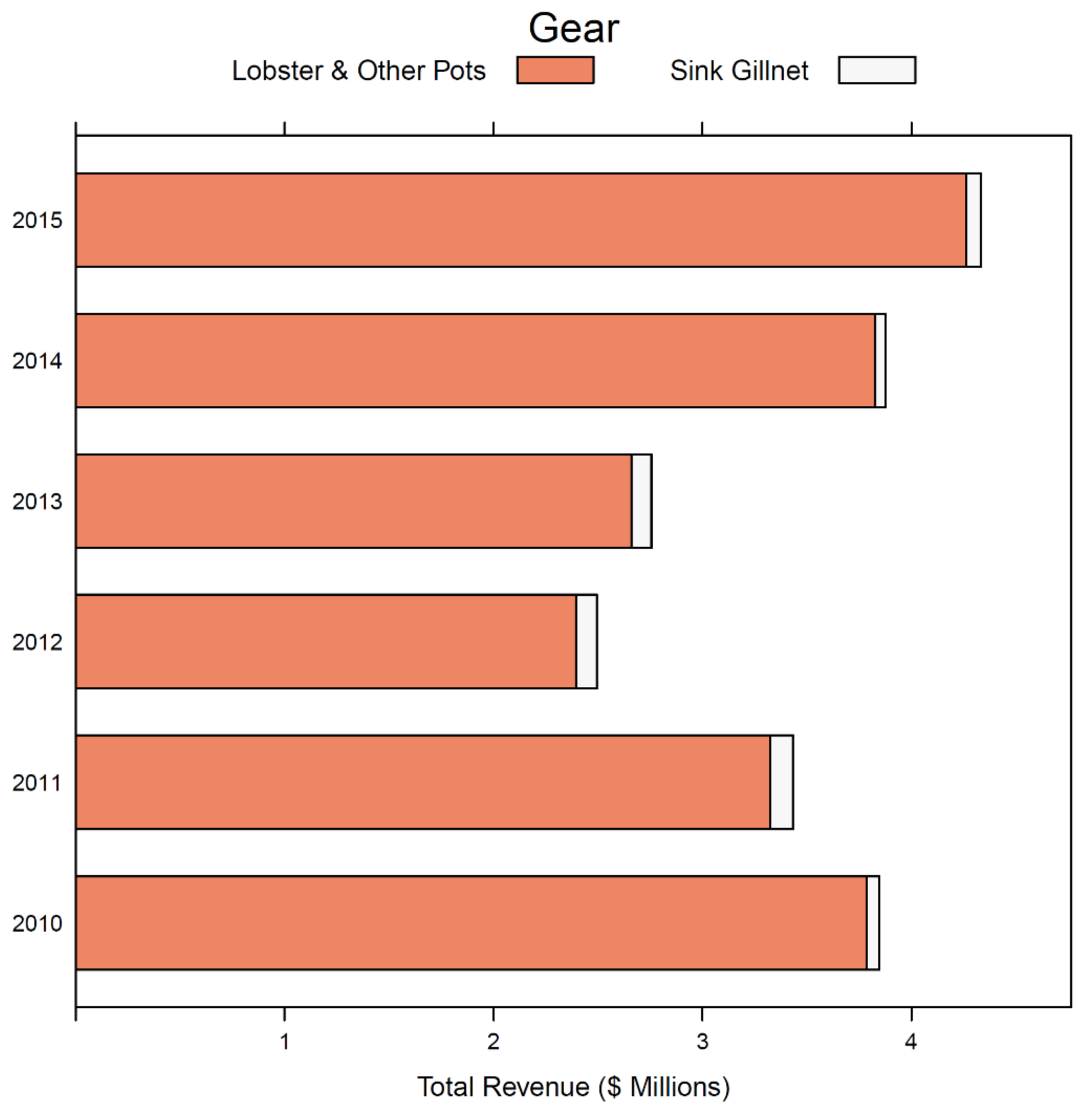


Figure 4 – Revenue by species (top 10) attributed to Option 7 coral zone, 2010-2015 – MBTG ONLY.

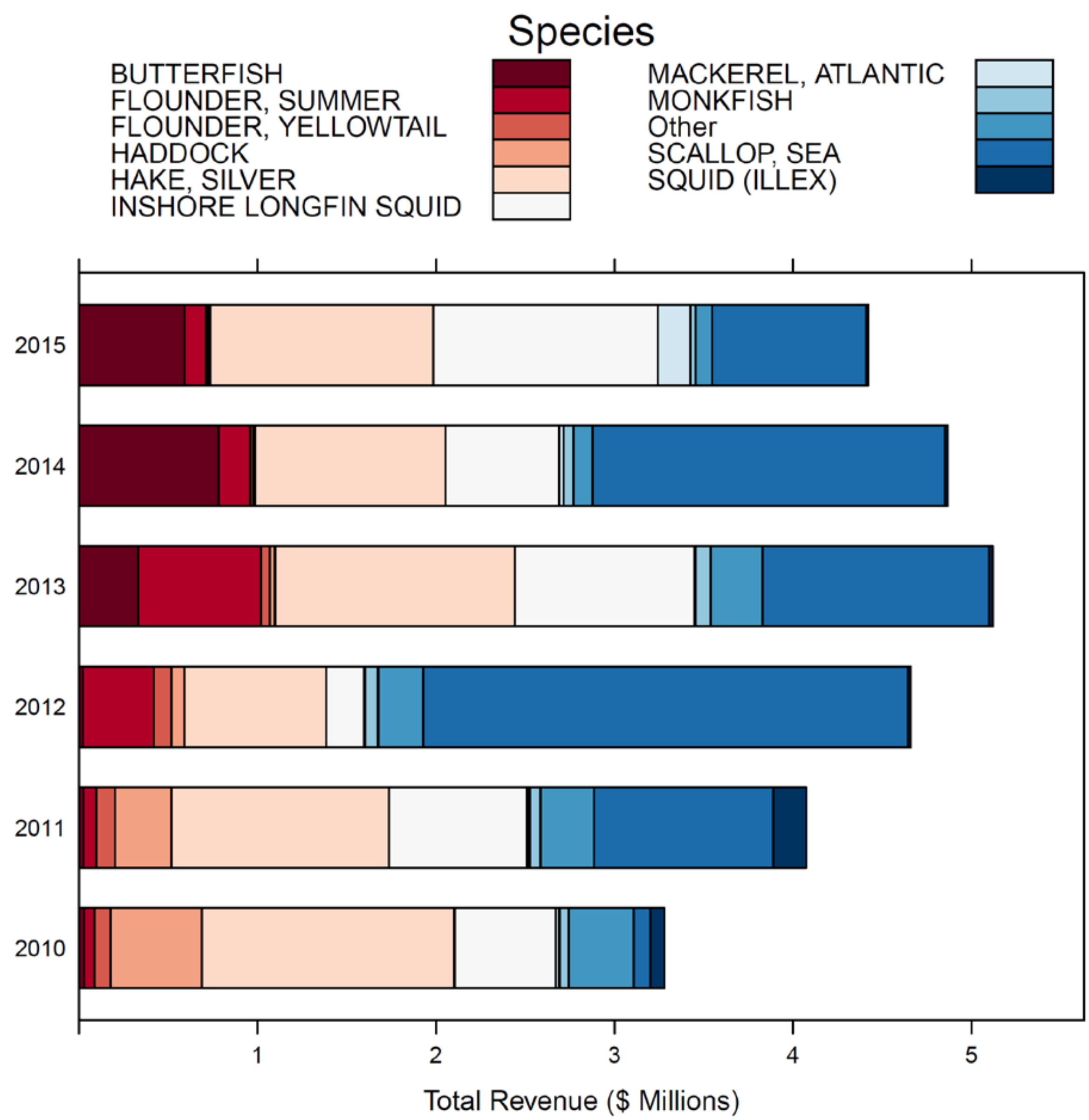


Figure 5 – Revenue by species (top 10) attributed to Option 6 coral zone, 2010-2015 – All non-mobile BTG except Red Crab.

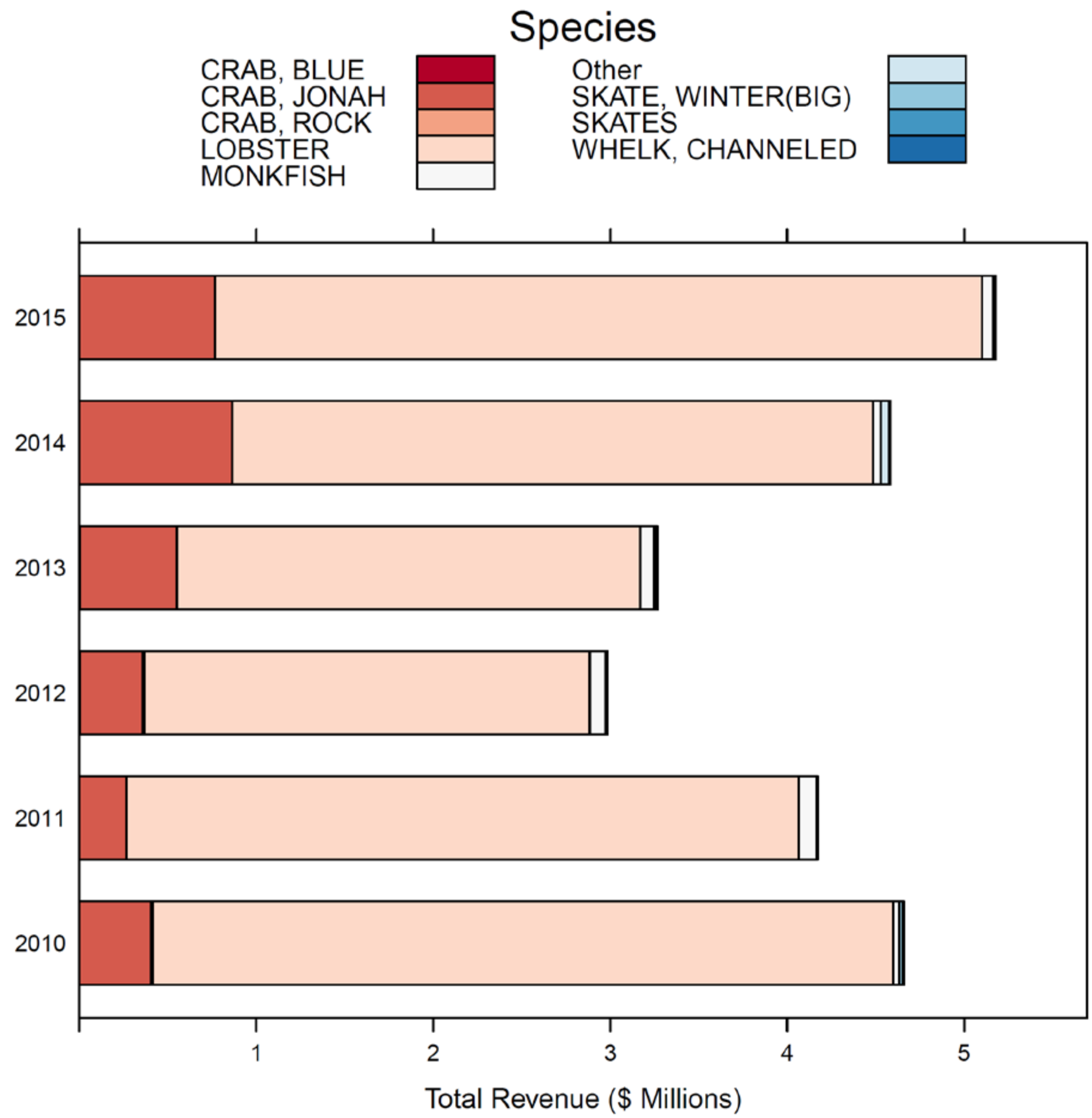


Figure 6 – Percent of vessel owner revenue attributed to the Option 7 coral zone, 2014-2015 - MBTG ONLY. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

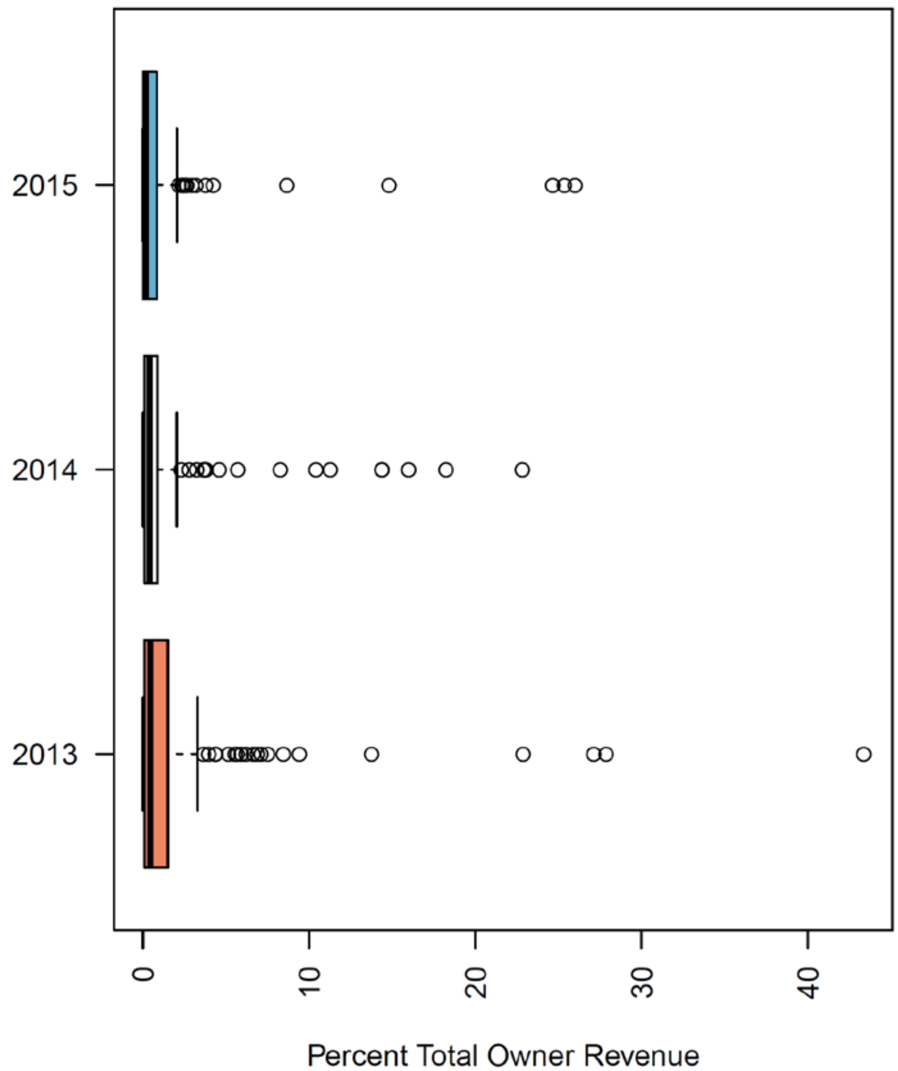


Figure 7 – Percent of vessel owner revenue attributed to the Option 6 coral zone, 2014-2015 - all non-mobile BTG except Red Crab. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

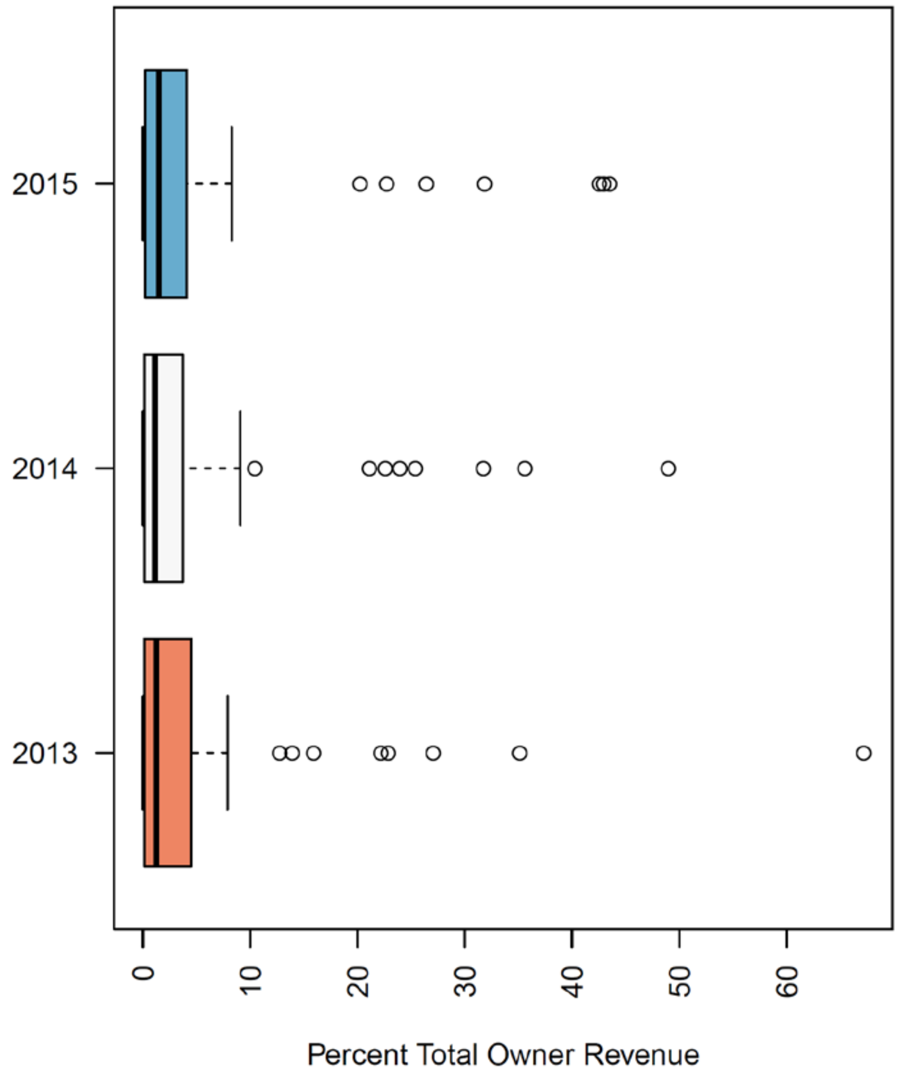


Figure 8 – Percent of total annual permit fishing activity attributed to the Option 7 coral zone, 2005-2012, as derived from VMS - MBTG ONLY. Outliers (dots) to the right of the boxplot whiskers are more than 1.5 times the 75th percentile value.

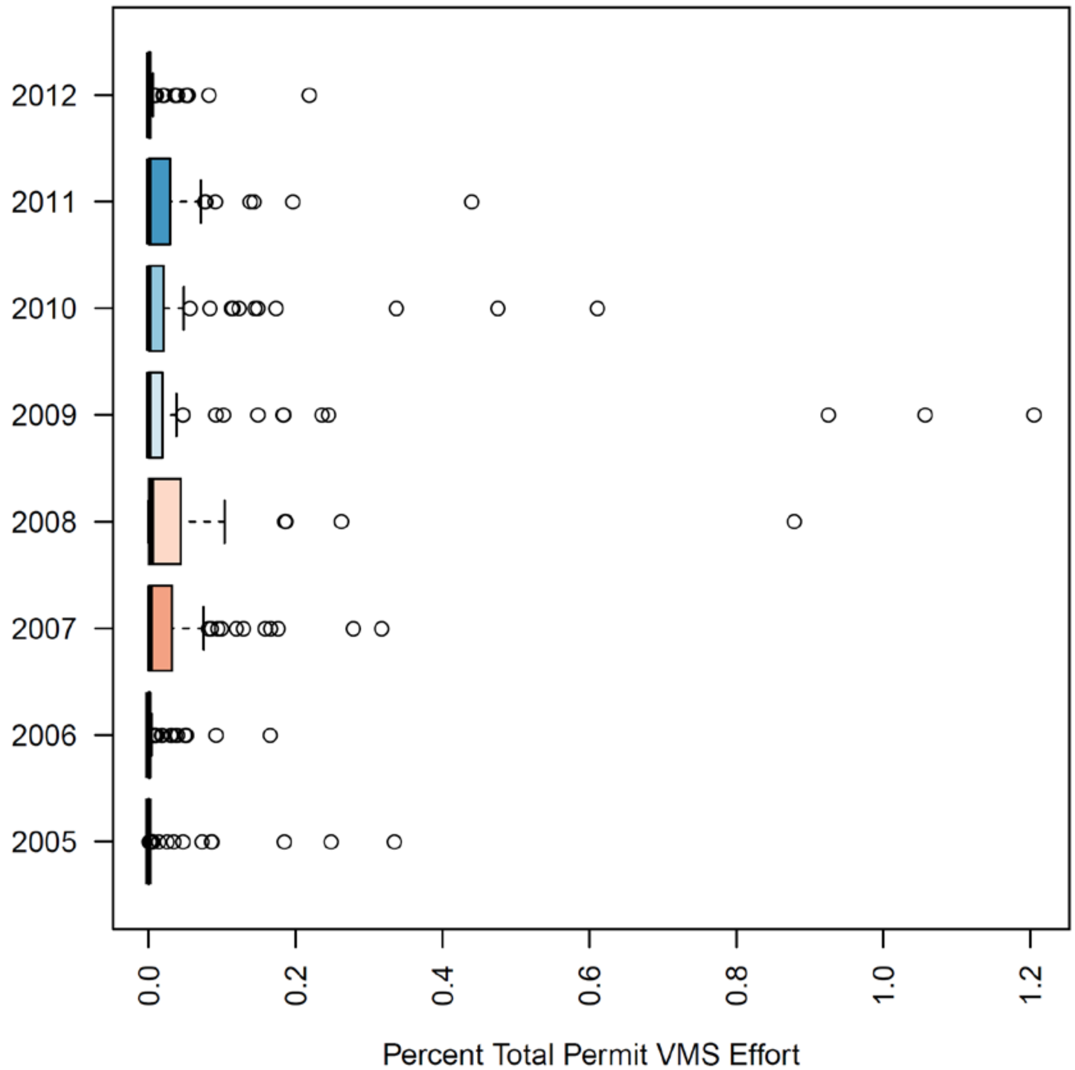


Table 3 – From the VTR analysis, the average annual revenue ($M) and percent difference in revenue between the current Preferred Alternative (Option 6) and Option 7, 2010-2015 - MBTG only.

Species	Prefered Alternative	Option 7	Percentage Increase
BUTTERFISH	0.3	0.3	9%
FLOUNDER, SUMMER	0.2	0.3	9%
FLOUNDER, YELLOWTAIL	0.1	0.1	14%
HADDOCK	0.1	0.2	14%
HAKE, SILVER	1.1	1.2	11%
INSHORE LONGFIN SQUID	0.7	0.7	10%
MONKFISH	0.1	0.1	16%
Other	0.2	0.2	11%
SCALLOP, SEA	1.1	1.3	15%
SKATES	0.0	Not Top 10	
SQUID (ILLEX)	0.1	0.1	9%
MACKEREL, ATLANTIC	Not Top 10	0.0	

Table 4 – Percentage of VTR trips, by gear type (per Alternative exemptions), attributed to the Option 7 and Option 6 coral zones south of Georges Bank that have VMS coverage, 2010-2012.

			Broad Zone Option 7			Broad Zone Option 6 (preferred)			
Gear	Year	Permits	VTR Trips	VMS Trips	Coverage	Permits	VTR Trips	VMS Trips	Coverage
Bottom Trawl	2010	132	968	910	94%	131	927	872	94%
Bottom Trawl	2011	124	848	768	91%	121	816	739	91%
Bottom Trawl	2012	138	706	614	87%	135	670	581	87%
Scallop Gear & Clam Dredge	2010	19	20	18	90%	17	17	15	88%
Scallop Gear & Clam Dredge	2011	82	100	96	96%	74	88	84	95%
Scallop Gear & Clam Dredge	2012	194	265	257	97%	193	256	248	97%
Separator & Ruhle Trawl	2010	20	71	53	75%	20	69	51	74%
Separator & Ruhle Trawl	2011	33	135	114	84%	33	131	111	85%
Separator & Ruhle Trawl	2012	20	49	35	71%	20	49	35	71%
Bottom Longline	2010	NA	NA	NA	NA	6	47	0	0%
Bottom Longline	2011	NA	NA	NA	NA	6	37	0	0%
Bottom Longline	2012	NA	NA	NA	NA	8	32	0	0%
Lobster Pot	2010	NA	NA	NA	NA	51	918	137	15%
Lobster Pot	2011	NA	NA	NA	NA	45	778	71	9%
Lobster Pot	2012	NA	NA	NA	NA	42	707	55	8%
Sink Gillnet	2010	NA	NA	NA	NA	24	163	0	0%
Sink Gillnet	2011	NA	NA	NA	NA	33	262	0	0%
Sink Gillnet	2012	NA	NA	NA	NA	27	180	0	0%
Other Gear	2010	NA	NA	NA	NA	3	13	0	0%
Other Gear	2011	NA	NA	NA	NA	3	5	0	0%
Other Gear	2012	NA	NA	NA	NA	7	17	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 (per Alternative exemptions).

		Broad Zone Alternative 7			Broad Zone Alternative 6		
Gear	Year	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits
Bottom Trawl	2005	18.88	27	19	1.84	11	9
Bottom Trawl	2006	6.74	37	21	0.48	13	11
Bottom Trawl	2007	16.41	48	26	8.78	18	12
Bottom Trawl	2008	34.85	68	32	3.88	30	19
Bottom Trawl	2009	45.03	70	29	10.25	24	16
Bottom Trawl	2010	41.48	87	31	20.57	47	19
Bottom Trawl	2011	23.62	54	20	12.31	28	14
Bottom Trawl	2012	8.74	58	30	5.29	28	18
GC Scallop	2005	NA	NA	0	NA	NA	0
GC Scallop	2006	ND	ND	1	ND	ND	1
GC Scallop	2007	NA	NA	0	NA	NA	0
GC Scallop	2008	NA	NA	0	NA	NA	0
GC Scallop	2009	NA	NA	0	NA	NA	0
GC Scallop	2010	NA	NA	0	NA	NA	0
GC Scallop	2011	ND	ND	1	ND	ND	1
GC Scallop	2012	ND	ND	1	ND	ND	1
LA Scallop	2005	0.04	64	53	0.03	61	50
LA Scallop	2006	0.06	131	64	0.03	118	59
LA Scallop	2007	0.00	19	18	0.00	14	13
LA Scallop	2008	0.00	14	13	0.00	10	9
LA Scallop	2009	0.30	28	27	0.17	28	27
LA Scallop	2010	0.03	29	28	0.01	23	23
LA Scallop	2011	0.03	24	19	0.01	21	18
LA Scallop	2012	0.28	31	26	0.02	28	24
Squid Trawl	2005	3.03	35	20	1.44	21	15
Squid Trawl	2006	4.06	60	29	1.27	33	21
Squid Trawl	2007	16.34	90	37	5.73	45	22
Squid Trawl	2008	0.28	13	9	0.14	11	8
Squid Trawl	2009	7.75	22	6	2.74	17	5
Squid Trawl	2010	1.67	19	9	0.20	13	7
Squid Trawl	2011	5.37	19	10	2.09	15	7
Squid Trawl	2012	0.53	8	6	0.18	4	4
Pot/Trap	2005	NA	NA	NA	ND	ND	2
Pot/Trap	2006	NA	NA	NA	15.83	47	4
Pot/Trap	2007	NA	NA	NA	20.32	47	3
Pot/Trap	2008	NA	NA	NA	27.50	34	3
Pot/Trap	2009	NA	NA	NA	17.70	28	3
Pot/Trap	2010	NA	NA	NA	ND	ND	2
Pot/Trap	2011	NA	NA	NA	16.45	25	3
Pot/Trap	2012	NA	NA	NA	ND	ND	1

Table 6 - Landings revenue to states, regions, and top ports attributed to fishing within Option 7 (updated), 2010-2015 – MBTG ONLY

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	**Average $**	
Massachusetts	$15.7M	$2.6M	381
North of Cape	$0.4M	$0.1M	38
Cape & Islands	$0.0M	$0.0M	17
South of Cape	$15.2M	$2.5M	347
New Bedford	$15.1M	$2.6M	337
Other (n=3)	$0.1M	$0.0M	14
Rhode Island	$5.7M	$1.0M	80
Point Judith	$2.0M	$0.3M	72
Other (n=4)	$3.6M	$0.7M	12
Connecticut	$1.1M	$0.2M	20
New London	$0.6M	$0.1M	4
Stonington	$0.5M	$0.1M	18
New York	$1.3M	$0.2M	18
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	27
Other (n=2)	$0.5M	$0.1M	20
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	**$26.4M**	**$4.4M**	**508**

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 – likely and overestimate of revenue.

References

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

Muench, A., G. S. DePiper and C. Demarest (2017). On the precision of predicting fishing location using data from the Vessel Monitoring System (VMS). Canadian Journal of Fisheries and Aquatic Sciences.

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.

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Alvin Canyon	Model-based bottom trawl	5	5	5	5	5	5	5	5	x	x	x	x	Keep at 500 m. Simplified version of earlier proposal. Continuous areas of high/very high suitable habitat to 450-500m; high slope areas and recent observations deeper. Model based bottom trawl and speed-filtered trawl VMS polls are dense, and tight to the boundary. Squid trawl, also dense, but generally inshore of the boundary.
	Model-based squid trawl	3	3	3	2	5	2	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	5	5	5	5	5	5	5	
Alvin to Atlantis intercanyon	Model-based bottom trawl	3	3	3	3	3	5	3	3	x	x	x	x	Deepen to 550 compared to earlier proposal, given limited coral habitat. Coral model, slope, and observations: no high/very high suitability shallower than 550 m. Model-based bottom trawl dense, but inshore of boundary. Model-based squid trawl: dense to very dense in 2005-2007, but more than 5k from boundary. Speed-filtered bottom trawl: dense, tight to boundary.
	Model-based squid trawl	1	2	3	1	2	2	1	1	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	3	3	2	3	5	5	5	
Atlantis Canyon	Model-based bottom trawl	5	5	5	5	5	5	5	3	x	x	x	x	Keep at 500 m. Simplified version of earlier proposal. Coral model, slope, and observations: continuous areas of high/very high suitable habitat to 450-500m (or shallower); high slope areas and recent observations deeper. Model-based bottom trawl: dense, tight to boundary, 2008 higher density values. Model-based squid trawl: very dense, generally inshore of boundary, tight on eastern wall. Speed-filtered bottom trawl: tight to boundary on western wall.
	Model-based squid trawl	3	4	3	5	5	5	5	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	5	2	5	5	5	5	
Atlantis to Nantucket intercanyon	Model-based bottom trawl	3	3	3	5	5	5	5	2	x	x	x	x	Deepen to 550 given limited coral habitat. Simplified version of earlier proposal. Coral model, slope, and observations: sparse areas of high/very high suitability habitat, high slope areas and recent observations deeper. Model-based bottom trawl: dense, either inshore or tight to boundary depending on year. Model-based squid trawl: very dense some years, but inshore of boundary. Speed-filtered bottom trawl: dense areas well inshore of boundary, some high density areas within 2 km of boundary during a single year (2013).
	Model-based squid trawl	4	4	4	3	3	3	3	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	3	2	5	3	3	2	
Nantucket Canyon	Model-based bottom trawl	3	3	3	5	5	3	3	2	x	x	x	x	Keep between 500 and 550 given fishing effort along boundary and patchy areas of suitable habitat. Simplified version of earlier proposal. Coral model, slope, and observations: patchy areas of high/very high suitability habitat, high slope areas and recent observations deeper. Model-based bottom trawl: deepest in 2008. Model-based squid trawl: very dense some years, but inshore of boundary. Speed-filtered bottom trawl: generally inshore of boundary; 2013 unusual.
	Model-based squid trawl	4	4	4	5	5	3	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	3	2	5	3	3	2	

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Nantucket to Veatch intercanyon	Model-based bottom trawl	3	3	3	5	5	3	2	1	x	x	x	x	Keep at 500 m contour; splits difference between fishing effort and coral model. Simplified version of earlier proposal. Coral model, slope, and observations: patchy areas of high/very high suitability habitat, high slope areas and recent observations deeper. Model-based bottom trawl: highest densities 2007, 2008, 2010. Model-based squid trawl: very dense, but inshore of boundary. Speed-filtered bottom trawl: generally inshore of boundary; 2013 unusual.
	Model-based squid trawl	3	3	3	3	3	3	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	2	5	2	3	2	
Veatch Canyon	Model-based bottom trawl	3	3	5	5	2	5	3	2	x	x	x	x	Tricky boundary on the east wall - many high slope areas along side high density of VMS polls. Encompass high slope areas in head - does not overlap dense or very dense VMS polls in any dataset. Deeper boundary on east wall vs. earlier proposal. Coral model, slope, and observations: continuous areas of high/very high suitable habitat to 450-500m. Model-based bottom trawl: highest densities 2007, 2008, 2010. Model-based squid trawl: dense, but inshore of boundary. Fishing along both east and west walls. Speed-filtered bottom trawl: highest densities 2013, 2015, 2016.
	Model-based squid trawl	4	5	5	5	5	2	5	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	2	5	3	5	3	
Veatch to Hydrographer intercanyon 1	Model-based bottom trawl	3	3	3	5	3	3	5	2	x	x	x	x	Keep at 500 m to balance coral habitat and fishing effort. Simplified version of earlier proposal. Coral model, slope, and observations: high/very high suitability habitat patchy, numerous areas of high slope. Model-based bottom trawl: inshore of areas 2005, 2006, 2007, 2010; deeper in 2008. Model-based squid trawl: very dense, but generally inshore of boundary. Speed-filtered bottom trawl: dense but inshore of boundary in 2013-2016.
	Model-based squid trawl	4	5	4	5	6	3	5	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	1	4	3	3	3	
Veatch to Hydrographer intercanyon 2	Model-based bottom trawl	2	3	3	5	2	3	2	1	x	x	x	x	Keep at 500 m to balance coral habitat and fishing effort. Simplified version of earlier proposal. Coral model, slope, and observations: high/very high suitability habitat patchy, some areas of high slope. Model-based bottom trawl: dense but inshore of boundary in 2006, 2007. Model-based squid trawl: very dense in two years, but inshore of boundary. Generally low density. Speed-filtered bottom trawl: dense but inshore of boundary in 2013-2016.
	Model-based squid trawl	4	5	3	3	3	3	5	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	1	1	1	3	3	2	2	

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Hydrographer Canyon	Model-based bottom trawl	2	5	5	3	2	3	1	1	x	x	x	x	Move boundary to be closer to coral model output along shoulders of canyon; keep depth of 500 m in head of canyon closer to VMS polls. Avoid specific areas of dense or very dense VMS polls in all datasets. Slightly deeper than earlier proposal. Coral model, slope, and observations: continuous areas of high/very high suitability habitat to 300 m, large areas of high slope. Model-based bottom trawl: dense but inshore of boundary in 2006, 2007. Model-based squid trawl: dense, tight to boundary on western wall in two years. Otherwise low density. Speed-filtered bottom trawl Closer to canyon walls 2014.
	Model-based squid trawl	3	5	5	5	2	5	5	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	5	1	2	3	5	5	2	
Dogbody and Clipper Canyons	Model-based bottom trawl	1	3	3	1	3	3	2	1	x	x	x	x	Can go shallower than 500 along east tributary of Dogbody and Clipper - keep boundary tighter to 500 along west tributary of Dogbody. Large area of high slope where fishing effort is closest to canyon. VMS polls are > 2km from boundary. Similar to earlier boundary, but simplified somewhat. Coral model, slope, and observations: Patchy areas of high/very high suitability habitat; areas of high slope just below 600 m. Model-based bottom trawl: Variable - effort is closer to Dogbody than Clipper. Model-based squid trawl: Dense in 2007, but 2-5 km away; otherwise low density. Speed-filtered bottom trawl: Generally low density and not close to boundary.
	Model-based squid trawl	2	3	4	2	1	2	1	1	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	1	2	3	2	2	
Sharpshooter and Welker Canyons	Model-based bottom trawl	2	3	3	2	3	3	3	3	x	x	x	x	Go shallower in west shoulder of Welker, Sharpshooter; keep at 500 m in head of Welker. Only area of close proximity to dense or very dense VMS polls is head of Welker along western wall. Similar to earlier boundary, but simplified somewhat. Coral model, slope, and observations: Patchy areas of high/very high suitability habitat; areas of high slope just below 600 m. Model-based bottom trawl: Density varies; just over 2 km from head of Welker in densest years. Model-based squid trawl: Dense in 2007 but 2-5km away; otherwise low density. Speed-filtered bottom trawl: Density varies; around 2 km from head of Welker in densest years
	Model-based squid trawl	2	2	3	2	1	2	2	1	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	3	3	3	3	3	3	
Heel Tapper Canyon	Model-based bottom trawl	3	3	3	2	3	3	3	2	x	x	x	x	Track shape of canyon more so than coral model outputs. Keep slightly shallower than 500 m. No dense or very dense areas of VMS data within 2 km of boundary. Deeper than earlier proposal. Coral model, slope, and observations: Consistent but not fully continuous areas of high and very high suitability, moderate areas of high slope. Model-based bottom trawl: Dense but inshore of boundary during 2005-2006, 2009-2011. Model-based squid trawl: Dense, but inshore of boundary. Speed-filtered bottom trawl: Dense but inshore of boundary during 2011, 2013-2015.
	Model-based squid trawl	2	3	3	1	2	3	1	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	3	3	2	3	2	3	2	

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Oceanographer Canyon	Model-based bottom trawl	5	5	5	3	3	5	5	3	x	x	x	x	Oceanographer is very steep. There are dense and very dense VMS polls within 2 km of west wall, but not within boundary as drawn. Boundary is drawn close to coral model output footprint and discrete zone boundary, at around 300 m. VMS polls are further from boundary along east wall. Deeper than earlier proposal in head of canyon, otherwise similar. Coral model, slope, and observations: Very steep, continuous areas of high suitability. Large areas of high slope. Model-based bottom trawl: West wall but not along east wall. Model-based squid trawl: Dense but inshore on east wall during 2007; otherwise low density. Speed-filtered bottom trawl: Dense along west wall 2011, 2015.
	Model-based squid trawl	2	5	5	2	2	5	2	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	5	2	5	3	5	1	
Filebottom, Chebacco, and Gilbert Canyons	Model-based bottom trawl	2	2	5	5	3	5	5	1	x	x	x	x	Keep tight to 500 m contour along west wall of Gilbert where there are dense VMS polls near boundary, otherwise simplify and make boundary shallower to track coral data and discrete zone boundaries. Similar to earlier proposal in Filebottom and Chebacco, deeper in Gilbert. Shallower east of Gilbert. Coral model, slope, and observations: Patchy areas of suitable habitat in Filebottom and Chebacco Canyons, continuous in Gilbert. Abundant areas of high slope. Model-based bottom trawl: Dense but inshore of boundary 2007, 2011. Model-based squid trawl: Dense, but inshore of boundary. Closer to Gilbert than other canyons. Speed-filtered bottom trawl: Densest 2011. Hard to tell if activity in other years represents fishing or not. Very scattered polls.
	Model-based squid trawl	2	2	5	2	1	3	2	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	5	1	2	2	2	3	
Lydonia Canyon	Model-based bottom trawl	3	5	5	3	5	5	5	3	x	x	x	x	Lydonia is also very steep, with shallow high slope areas. Move boundary inside of original discrete zone boundary, but to between 300-450 m. Not a close proximity to VMS polls except near head of canyon, along east wall. Steep areas outside 500 m. Interpretation of VMS complicated by existing closures. Simplified earlier boundary, deeper in some areas and shallower in others. Coral model, slope, and observations: Continuous areas of high/very high suitability habitat to 300 m, large areas of high slope. Model-based bottom trawl: Dense along west wall most years, also along east wall in 2011. Model-based squid trawl: Very dense in 2007, 2010, but inshore. East and west walls. Speed-filtered bottom trawl: Dense during 2010, 2011, 2015.
	Model-based squid trawl	5	3	5	2	2	5	3	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	5	5	2	3	3	3	3	

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Lydonia to Powell intercanyon	Model-based bottom trawl	2	2	2	2	3	3	3	2	x	x	x	x	Make intercanyon a shallower boundary between 300-400 m to encompass model outputs. All dense VMS polls are more than 2 km from boundary. Shallower than earlier boundary, and simplified. Coral model, slope, and observations: Consistent but not continuous areas of high and very high suitability. Limited areas of high slope. Model-based bottom trawl: Consistent dense polls but relatively far away ~5 km. Model-based squid trawl: Very dense in some years, but not within 5 km. Speed-filtered bottom trawl: Consistent dense polls but more than 5 km from boundary.
	Model-based squid trawl	2	2	3	2	2	3	2	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	2	2	2	3	3	
Powell Canyon	Model-based bottom trawl	3	3	3	5	5	5	5	3	x	x	x	x	Keep at 500 m, which captures high and very high suitability habitat fairly well. Limited VMS polls within 2 km of boundary - could go a little shallower if desired. No change from earlier boundary. Coral model, slope, and observations: Continuous areas of high and very high suitability habitat; high slope areas slightly deeper into canyon. Model-based bottom trawl: Variable proximity to boundary, dense along eastern wall. Model-based squid trawl: Tighter to boundary on eastern wall, still outside 2 km. Speed-filtered bottom trawl: Variable proximity to boundary, dense along eastern wall; two very high density years.
	Model-based squid trawl	4	3	4	2	2	5	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	5	4	3	3	3	4	3	
Powell to Munson intercanyon	Model-based bottom trawl	3	3	3	3	5	3	3	2	x	x	x	x	Run between 300 and 450 m and straighten out. Dense VMS polls are not within 2 km of boundary except in 2009 model-based bottom trawl data set. Shallower than earlier boundary, and simplified. Coral model, slope, and observations: Near continuous areas of high and very high suitability habitat between these two canyons, moderate areas of high slope. Model-based bottom trawl: Dense, but inshore of boundary, consistent spatial patterns. Model-based squid trawl: Inshore of boundary. Speed-filtered bottom trawl: Dense, but inshore of boundary; 2011 anomalously high density.
	Model-based squid trawl	3	3	3	3	1	3	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	3	3	3	2	3	3	2	
Munson Canyon	Model-based bottom trawl	5	3	5	5	5	5	3	3	x	x	x	x	Keep at 500 m. Need to draw boundary shallower than coral dive sites at around 600 m. West wall site corals but low abundance, east wall site corals at high abundance. Dense VMS polls are tighter on east wall. Slightly deeper along west wall vs. earlier boundary. Coral model, slope, and observations: Continuous areas of high and very high suitability habitat throughout canyon, areas of high slope as well. Model-based bottom trawl: Tighter to canyon during 2005, 2008-2009. Model-based squid trawl: Very dense, but inshore of boundary by about 3 km. Speed-filtered bottom trawl: Higher density in three years, but not especially tight to walls.
	Model-based squid trawl	2	3	4	3	1	3	2	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	3	3	3	2	5	3	3	

Area	Data set	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Notes
Munson to Nygren intercanyon	Model-based bottom trawl	2	2	3	3	5	3	2	2	x	x	x	x	Run between 450 and 500 m and straighten out. Dense VMS polls are generally more than 2 km from boundary. Simplified version of earlier boundary. Coral model, slope, and observations: Consistent but not continuous areas of high and very high suitability. Limited areas of high slope. Model-based bottom trawl: Consistent pattern but varying density and distance from boundary. Model-based squid trawl: Very dense but more than 5 km from boundary. Speed-filtered bottom trawl: Consistent pattern but varying density and distance from boundary.
	Model-based squid trawl	1	2	2	1	1	1	1	1	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	2	2	2	1	3	2	3	
Nygren Canyon and unnamed canyon	Model-based bottom trawl	3	3	5	5	5	5	5	5	x	x	x	x	Keep at 500 m in canyon heads, go slightly shallower between canyons. Generally simpler and slightly shallower than earlier boundary. Coral model, slope, and observations: Consistent but not continuous areas of high and very high suitability. Large areas of high slope particularly in unnamed canyon. Model-based bottom trawl: Tighter to boundary in later years, denser 2011, 2012. Model-based squid trawl: Very dense, but inshore of boundary. Polls run parallel to boundary. Speed-filtered bottom trawl: Very high density, but inshore of boundary.
	Model-based squid trawl	2	4	4	3	2	3	3	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	3	4	4	4	4	4	4	
Unnamed to Heezen intercanyon	Model-based bottom trawl	3	3	5	5	5	5	5	5	x	x	x	x	Cut straight across between 300 m and 450 m. Generally simpler and slightly shallower than earlier boundary. Coral model, slope, and observations: Near continuous areas of high and very high suitability habitat between these two canyons, moderate areas of high slope. Model-based bottom trawl: Deeper 2006-2008. Model-based squid trawl: V. dense, but inshore. Steep contours between std deviations. Speed-filtered bottom trawl: Very stable patterns of activity, and dense VMS polls, but inshore of boundary by 2-3 km.
	Model-based squid trawl	2	4	4	2	2	3	3	2	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	4	4	3	4	4	4	4	
Heezen Canyon to EEZ	Model-based bottom trawl	2	5	5	5	5	5	5	5	x	x	x	x	Keep at 500 m to balance coral habitat and fishing effort. Tricky area given high density VMS polls especially along east wall combined with indicators of coral habitat. Simplified version of earlier boundary. Coral model, slope, and observations: Continuous areas of high and very high suitability habitat; large areas of high slope and relatively shallow coral observations on east wall. Model-based bottom trawl: Along western edge only. Model-based squid trawl: Very dense along both edges of canyon, fairly tight to boundary. Speed-filtered bottom trawl: Mostly along western edge of canyon.
	Model-based squid trawl	2	3	6	1	2	3	3	3	x	x	x	x	
	Speed-filtered bottom trawl	x	x	x	x	x	4	5	5	5	5	6	6	