New England Fishery Management Council
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MEETING SUMMARY
Habitat Plan Development Team

Radisson Airport Hotel, 2081 Post Rd., Warwick, RI
December 4, 2015

The Habitat Plan Development Team met to discuss updated data available to support the Omnibus Deep-Sea Coral Amendment.

Plan Development Team members present: Michelle Bachman (Chair), Maria Jacob, Kiley Dancy, David Stevenson, David Packer, Peter Auster, Page Valentine, Carl Wilson (via GoToMeeting)

Other participants: Matt Poti, NOAA National Ocean Service Biogeography Branch, Martha Nizinski, NOAA/NMFS Systematics Laboratory

Audience: Greg Ardini, Anne Hawkins, Beth Casoni, Grant Moore, David Borden, Meaghan Lapp, Brad Sewell, one other in-person attendee. Via GoToMeeting: Alison Verkade, Joyce Rowley, Erica Fuller, Heidi Henninger, Travis Ford, Meredith Mendelson.

Main outcomes of meeting: The PDT reviewed habitat suitability model, canyon/slope/seamount and Gulf of Maine coral distributions, and Mid-Atlantic Fishery Management Council boundary development approaches. As next steps, the PDT agreed to (1) continue to gather and organize data sources to support this amendment, (2) review the list of discrete zones under consideration and make updated recommendations to the Committee, including revised boundaries for existing proposals as needed, (3) develop simplified broad zone boundary recommendations for the Habitat Committee, and (4) continue to review fishing effort information to identify potentially affected user groups. These issues will be further discussed on Tuesday, December 15.

Agenda item #1: Introductions

The chair asked PDT members, invited participants, and audience members to introduce themselves. There was not a detailed discussion of coral management alternatives during this agenda item.

Agenda item #2: Presentation on predictive modeling of deep-sea coral habitat suitability in the U.S. New England and Mid-Atlantic (Matt Poti)

The PDT received a presentation from Matt Poti (NOAA National Ocean Service Biogeography Branch) on the coral habitat suitability model and its use in management. A number of authors collaborated on model development including PDT member Dave Packer, and a primary publication is in preparation, undergoing final edits prior to resubmission. These same model outputs were used by the MAFMC to support development of coral zones in their region.

The model uses historical coral presence data (i.e., pre-2012 and the recent exploratory surveys) combined with environmental data to predict the likelihood that suitable habitat occurs in a particular location. The model domain is the entire northeast region, including both the New England and Mid-Atlantic areas, and results are reported on a 370 m grid, which was selected based on the resolution of the underlying bathymetry data, and is appropriate given that older coral presence records have positional uncertainty. Deep-sea coral database has presence data for the overwhelming majority of records, so the model is presence only (vs. presence/absence or relative abundance). The model was developed using a maximum entropy approach, which is appropriate when absence information is not available. The model identifies significant predictor variables (Appendix 1, predictor variables retained in final model runs) and their relationships with coral distribution for each taxonomic grouping (Appendix 2 coral groups). The outputs do reflect sampling bias in the underlying coral presence data, but the domain is fairly data-rich. Only one coral record per taxonomic group was used per grid cell, and older records were dropped when there were multiple records in a grid. In areas of the region with fewer coral records, model outputs should still be predictive assuming that the ecological setting is similar to the areas where there are more coral records (i.e. model outputs are applicable to Gulf of Maine despite fewer coral presence records in the version of the database used in the model; more GOM data exist now, see agenda item #3).

A large number of predictor variables were considered. These included variables describing seafloor terrain, including depth, slope, curvature (slope of slope), and rugosity, which is a measure of surface area to total area. These topographic variables were analyzed at multiple spatial scales to highlight large scale and finer features. Climatologic variables including bottom dissolved oxygen, temperature, and chlorophyll were also used. Bottom DO was taken from the World Ocean Database (https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html) and NEFSC data. For some climatologic variables, seasonal data were used, while annual averages were used for others. In general the maximum and minimum values are most predictive. Highly correlated predictor variables were removed to arrive at a set of 64 predictors. The final model (selection process described below) uses 22 predictor variables, out of a total of 64 variables (Appendix 1). For each predictor variable, response curves are generated to help users understand how that variable relates to coral distributions.

The model selection process relied on AUC and AIC combined with informed judgement of the analysts to identify a parsimonious suite of predictor variables. The model was fit to 70 percent of the coral data points for each taxa, and validated with the remaining 30 percent of the dataset that was withheld. The model fit was evaluated using the area under the AU curve, and the gain, i.e. how well do the outputs fit the test data. For single variable response curves, peak suitability for each predictor variable is the highest point on the response curve. Multivariate response curves were also generated that indicate response to one varying predictor while others are held at their mean values.

The basic suitability outputs are generated on 0 to 1 scale, but they are not probabilities and cannot be compared across taxonomic groupings. The model does not predict abundance, density, or diversity, rather, it is indicating the likelihood of finding corals of a particular type in a particular area. Thresholded outputs were developed to allow comparisons between taxonomic groupings (these were the outputs used by MAFMC).

When using the results, it is important to consider the underlying data quality and resolution. The model grid resolution was selected to accommodate the positional uncertainty associated with the underlying coral data, but the canyon areas in particular have complex terrain such that the model outputs should be considered a somewhat coarse predictor of suitable habitat. In addition, the taxonomic resolution is also fairly coarse, to the order or sub-order level, and there is considerable diversity of coral species within each of these groupings. In the historical database, most of the structure forming corals are in the order Alcyonacea, so these outputs are the most useful. Most of the scleractinians (hard or stony corals) found in the historical database were two small cup coral species – not really structure forming – so the results for hard corals will reflect these species. Structure forming stony corals were found in the recent surveys, mostly at deeper depths. Similarly, most of the sea pen records in the historical database are for two species.

Model development occurred primarily during 2012, and results were used to guide sampling in the recent 2012-2015 fieldwork. Locations with varying levels of predicted suitability were visited with cameras and remotely operated vehicles to ground truth the results.

Dr. Valentine asked whether the depth values associated with the coral records had been compared to depths from modern bathymetric charts, and Matt responded that yes, they had made these comparisons and eliminated some records. The PDT also discussed reproductive strategies of various coral taxa. Some species have very heavy, yolky, eggs and larvae, which would have limited ability to disperse away from the parent colonies, while the gametes of other species might disperse more widely. These strategies have implications for variations in coral diversity, connectivity, and potential for recovery in adjacent habitats (see population genetics papers). It does appear that that groups of canyons, seamounts, and slope regions support dissimilar coral communities, although data are continue to be evaluated in detail (see agenda item #3).

Agenda Item #3: Deep-sea coral research cruises to the New England canyons (Martha Nizinski)

Martha Nizinski described recent fieldwork in the canyon, slope, and seamount areas off Georges Bank and southern New England, and in the Gulf of Maine. These surveys (see Appendix 3, recent coral surveys) were completed during 2012-2015 using towed camera systems (WHOI TowCam, ISIS 2) and ROVs (Deep Discoverer, Kraken 2, ROPOS) aboard the research vessels Henry B. Bigelow, Connecticut, and Okeanos Explorer. The habitat suitability model was used to help select sampling areas, including both high and low suitability locations as noted above.

- WHOI's TowCam system was used on four cruises aboard the R/V Bigelow. It takes an image every ten seconds and allows for real-time image review. The vessel travels at 0.25 knots during sampling. The 46 tows generated over 85,000 high-resolution photos and review of these data are ongoing (plan is to review all images). Sampling occurs at varied depths, shallow (500-900m), mid-depth (900-1300m), deep (1300-1700m), and very deep (below 2,000m).
- NOAA Office of Exploration and Research cruises aboard the R/V Okeanos Explorer used the ROV Deep Discoverer (D2) during a two-leg 2013 cruise and an additional cruise in 2014. Eight canyons, multiple slope areas, and one seamount were surveyed in 2013. Results were recently published in the peer-reviewed literature. Frame grabs can be taken from the video collected during these dives to generate georeferenced data points of coral abundance.
- The Canadian ROV ROPOS was used to survey some of the easternmost canyons as well as Jordan Basin during 2014. Video, still images, and coral samples were collected.
- Finally, three cruises aboard the R/V Connecticut were conducted during 2013, 2014, and 2015 using the ISIS2 towed camera system and Kraken 2 ROV (these are described in more detail under agenda item #4).

In general, the canyon expeditions provided the opportunity to collect contemporary image data to document coral presence/absence, diversity and abundance in the canyons. Using the model outputs to guide sampling effectively ground-truthed and validated the model. The sampling approach during many of the canyon dives was to begin at the edge of the canyon in lower relief areas and the move down the wall of the canyon during the dive. This was to insure that areas predicted to be coral hotspots as well as those areas predicted to have low likelihood of coral presence were surveyed. Corals were found in all canyons, but at varying levels of diversity and relative abundance. Many of the corals were observed in the 900-1700m depth range. Each canyon seems to have its own biological and geological signature.

Oceanographic data are also collected during these cruises, and coral samples were collected with some of the gears (ROPOS, Kraken 2) for taxonomic confirmation and genetic analyses. High-resolution multibeam (25 m) data has been collected for all canyons. Cruise summaries will be collected for the next PDT meeting. Martha noted that there were times when the dive sites were selected to avoid fixed fishery gear. A lobster industry member present (Grant Moore) indicated that there is some year round fishing activity in the canyons but that lobster trapping occurs at depths of approximately 240 fathoms (440m) or shallower. Few lobsters were seen in survey still images or videos. Mr. Moore indicated that canyon-tagged lobsters have been capture on Georges Bank indicating movement of lobsters out of the canyons.

Agenda Item #4: Recent deep-sea coral surveys in the Gulf of Maine (Peter Auster, Dave Packer)

In the Gulf of Maine there are known high density coral habitats in Western Jordan Basin, near Mt. Desert Rock, on the Outer Schoodic Ridges, and in Georges Basin, specifically on

Lindenkohl Knoll. Survey areas were selected based on historical information of where the corals existed, and anecdotal information from the fishing industry, with an initial focus on steep/high relief habitats. Sampling during these cruises was iterative, based initially on areas with steep terrain in nautical charts. Additional multibeam data collected contemporaneously with the coral dives indicated other potential coral habitats. There were some areas in the Gulf of Maine where no corals were observed and they were identified in the habitat suitability model as high density areas. One possible explanation is that slope data used in the model might not match the slope where the dive actual was conducted. Another is that fishing impacts may have removed any corals present. For example, at one of the sites where corals were predicted, sector scanning sonar revealed a high density of trawl doors marks in the seafloor. Some dive sites were revisited during multiple years and corals were consistently found at those sites, indicating community persistence at least over a decade plus.

Data were collected using the Kraken 2 ROV and the ISIS 2 towed camera system, which is flown above the seafloor using dynamic positioning of the ship and variation in tether length based on real time video. The two systems use forward and down-facing high definition video and still cameras and collect CTD information; the Kraken 2 ROV also collected specimens. Coral samples were collected for taxonomy, genetics, age, growth, and reproduction studies.

Additional analyses are forthcoming, but at the present time each dive site has been classified as corals absent, corals present but sparse to medium density, and high density coral garden, using the ICES definition for coral garden (0.1 colony/m^2). In the Gulf of Maine, there are many coral habitats above this threshold, which are therefore considered coral gardens. An overall observation was that between the 1970s and present there were something like 3,000 dives conducted in the Northwest Atlantic (Gulf of Maine and on Georges Bank) by the National Undersea Research Program, which makes these areas fairly well sampled, and yet many of these coral garden areas were not known until these recent surveys, suggesting a degree of spatial rarity.

Gulf of Maine coral habitats include diverse fish and invertebrate species in addition to corals, for example Acadian redfish, pandalid shrimp, silver hake, haddock, cod, cusk, pollock, monkfish, lobster, sponges, anemones, brachiopods, and others. Acadian redfish larvae are known to associate with sea pens (*Pennatula aculeata*), and were documented living within sea pen fronds in Canadian trawl surveys (Baillon et. al 2012). Sea pens were sampled during the surveys but have not yet been analyzed. Principle components analysis is being used to investigate environmental factors that are related to coral density, and to examine associations with other biota in the community.

Some of the areas with high density coral habitats have a mud drape on hard surfaces. Corals also settled in some gravel-type areas. Invertebrate larva appear to burrow down through the mud drape to the hard substrate. This is not uncommon in other areas of the Gulf of Maine. Dr. Valentine commented that it would be interesting to quantify how deep the mud can be that will still allow coral larvae to burrow and attach, because they do not attach to the mud. In theory, there are likely some thick mud drapes that do not provide suitable habitat for corals that require hard substrates for attachment. Sponge larvae also burrow into the mud.

There was evidence of fishing activity in some of the images.

Agenda item #5: Review fishing effort data (Bachman)

This item was skipped due to lack of time.

Agenda Item #6: Mid-Atlantic Fishery Management Council coral management alternatives and boundary development (Kiley Dancy)

Kiley Dancy, who coordinated the Mid-Atlantic Fishery Management Council's coral amendment and chaired the coral amendment Fishery Management Action Team or FMAT, summarized their approach to defining deep-sea coral zones, as well as the management measures proposed for the areas. The MAFMC took final action on the coral amendment in June 2015.

The MAFMC proposed a combination of broad and discrete zones, prohibiting all bottom tending gear in both types of zones, with exemptions for the red crab fishery. In the discrete zones, the MAFMC agreed that the red crab exemption would be in place for at least two years, but then might be reconsidered after that time.

To develop coral zone boundaries, the MAFMC used high resolution bathymetry data, high and very high slope polygons derived from the bathymetric data, the habitat suitability model outputs, and coral location data. Coral location data included older presence/absence records from previous surveys as well as dive locations from recent (2012 and later) cruises.

Broad zone boundaries

The MAFMC reviewed broad zone alternatives with depth-contour boundaries during final action, and ultimately selected broad zone landward boundary that is a simplified line at approximately 450 meters, with a minimum depth of 400 meters and a maximum depth of 500 meters. Discrete zone boundaries were used along areas of overlap between the discrete and broad zones. Ms. Dancy described in detail the approach taken to develop this boundary subsequent to final Council action. Briefly, this involved using a detailed 450m contour as a starting point, and then using the simplify line tool in ArcGIS. She commented that at least some industry members involved in the MAFMC process would have preferred to have specific, simplified boundary lines to consider during development of the amendment, rather than deferring the details of boundary development until after final action. She suggested that it might be helpful for NEFMC to consider specific simplified boundaries during amendment development. Ms. Bachman recommended that perhaps some partial boundaries could be generated that approximate the NEFMC's current range of alternatives (landward boundary of 300, 400, 500m), and put before the Habitat Committee at their next meeting. Developing partial boundaries would be less time consuming initially. With concurrence from the Committee about the general approach, the PDT could then develop simplified boundaries over the entire extent from Heezen Canyon to Alvin Canyon.

Discrete zone boundaries

Similar to the original NEFMC approach, the goal of the MAFMC when developing discrete zone boundaries was to identify the extent of specific topographic features, i.e. where does a particular canyon begin and end. Boundary criteria are detailed in a handout provided to the PDT (Appendix 4, discrete zone boundary criteria used by MAFMC). It was noted that the FMAT used the Alcyonacea outputs from the suitability model.

The PDT discussed the coral boundary development workshop conducted in April 2015. During 2014 boundary development, industry recommended boundaries had been provided for some canyons. Immediately preceding the workshop, both the fishing industry via Garden State Seafood Associates and a coalition of non-governmental environmental organizations provided their own boundary recommendations to the Council. The workshop served to reconcile these two sets of boundaries with the FMAT boundaries. The boundary recommendations that emerged from the workshop were adopted by the Council.

The PDT also discussed NOAA guidance to the Councils on use of the discretionary provisions. The MAFMC relied on a 2010 NMFS guidance memo that explicitly indicates that the discretionary provisions should not be used to regulate the lobster fishery. More recent 2014 guidance issued by the Office of Habitat Conservation does not draw a distinction between state-managed fisheries operating in the EEZ and federally managed fisheries. The MAFMC amendment does not propose any restrictions on the lobster fishery.

Agenda Item #7: Next steps and follow up items

- Look for most complete sets of high resolution bathymetric data (Bachman, with help from Matt Poti)
- The PDT discussed the original criteria for discrete zones (corals present and suitable habitat inferred vs. areas where corals had not been documented, but suitable habitat was inferred). It seems that these are still useful criteria in a general sense, but suitable habitat can now be inferred based on model outputs and high resolution multibeam, rather than the criteria used in 2012 (canyon relief at the shelf break). The PDT agreed that the list of discrete zones needs to be reconsidered given recently collected data and model results.
    - Goal is to generate an initial list of zones to add on 12/15/15 – i.e. Atlantis Canyon, Outer Schoodic Ridge, possibly others. (Jacob to work on inventory of available information)
    - Also PDT will work on updating or developing boundaries using MAFMC approach as a starting point (Bachman to develop 1-2 examples for 12/15)
- PDT will draft some simplified boundaries for broad zones (Bachman, with guidance from Dancy)
- PDT will continue to investigate fisheries potentially affected by coral zones (Bachman, DePiper)
- PDT will assemble coral records, including:
    - Identify appropriate version of historical coral presence database to use in analyses (Bachman, Packer)

    - Develop spatial data sets of tow locations for recent cruises in canyon, seamount, slope areas (Bachman, Packer, with help from Martha Nizinski). Note: already have GOM data
    - Gather spatial data/tow locations for earlier ROV dives with Alvin, Hercules, etc. (Auster)
- The PDT discussed where cold seeps fit into the deep-sea coral discussion and will continue to look into this issue.
- Industry members noted that they thought that it would be useful to be able to view WinPlot charts during any workshop or boundary development meetings. The PDT will investigate this possibility and follow up with industry as needed (Bachman).
- A seamount fishery development project was mentioned (PIs M. Vecchione, M. Fogarty, J. Moore) as well as NEFSC cruises to Bear Seamount. The PDT will look into these.

The meeting adjourned at approximately 5:00pm.

Appendix 1 – Predictor variables retained in coral habitat suitability model. Table 2 in Kinlan, B.P., M. Poti, A.F. Drohan, D.B. Packer, D.S. Dorfman, and M.S. Nizinski (in review). Predictive Modeling of Suitable Habitat for Deep-Sea Corals Offshore of the Northeast United States.

Predictor Variable	Code	Category
Aspect (derived at 1500 m scale)	asp1500m	Geomorphology
Aspect (derived at 5 km scale)	asp5km	Geomorphology
Depth	bathy	Geomorphology
Bathymetric Position Index (BPI) / Slope Index (derived at 20 km scale)	bpislp20km	Geomorphology
Predicted Mean Annual Bottom Salinity	bsalann	Oceanography
Predicted Mean Annual Bottom Temperature	btempann	Oceanography
Mean Annual Surface Chlorophyll-a	chlann	Oceanography
Predicted Mean Annual Bottom Dissolved Oxygen	doann	Oceanography
Predicted Surficial Sediment Percent Gravel	gravel	Substrate
Predicted Surficial Sediment Mean Grain Size	meanphi	Substrate
Plan Curvature / Slope Index (derived at 1500 m scale)	plcurslp1500m	Geomorphology
Plan Curvature / Slope Index (derived at 5 km scale)	plcurslp5km	Geomorphology
Profile Curvature / Slope Index (derived at 1500 m scale)	prcurslp1500m	Geomorphology
Profile Curvature / Slope Index (derived at 5 km scale)	prcurslp5km	Geomorphology
Rugosity (derived at 370 m scale)	rug370m	Geomorphology
Rugosity (derived at 1500 m scale)	rug1500m	Geomorphology
Predicted Surficial Sediment Percent Sand	sand	Geomorphology
Slope (derived at 370 m scale)	slp370m	Geomorphology
Slope (derived at 5 km scale)	slp5km	Geomorphology
Slope of Slope (derived at 1500 m scale)	slpslp1500m	Geomorphology
Slope of Slope (derived at 5 km scale)	slpslp5km	Geomorphology
Mean Annual Turbidity	turann	Oceanography

Appendix 2 – Coral taxonomy used in the habitat suitability model

Region	Group	Description	Code name
Northeast U.S.	1	Order Alcyonacea	ALCY
Northeast U.S.	1a	Gorgonian Alcyonacea (Suborders Calcaxonia, Holaxonia, Scleraxonia)	ALCY-GORG
Northeast U.S.	1b	Non-Gorgonian Alcyonacea (Suborders Alcyoniina, Stolonifera)	ALCY-NONGORG
Northeast U.S.	2	Order Scleractinia	SCLER
Northeast U.S.	2a	Family Caryophylliidae	SCLER-CARYO
Northeast U.S.	2b	Family Flabellidae	SCLER-FLAB
Northeast U.S.	3	Order Pennatulacea	PENN
Northeast U.S.	3a	Suborder Sessiliflorae	PENN-SESS
Northeast U.S.	3b	Suborder Subsessiliflorae	PENN-SUBSESS

Appendix 3 – Recent coral surveys in the New England region (courtesy of M. Nizinski)

Year	Cruise Dates	Cruise Number	Vessel	Gear	# tows	Location	PI
2012	7-17 July	HB1204	Bigelow	TowCam	3	Veatch	Nizinski
2013	7-17 July	HB1204	Bigelow	TowCam	8	Gilbert	Nizinski
2014	7-17 July	HB1204	Bigelow	TowCam	1	Unnamed canyon	Nizinski
2013	11-24 July		Connecticut	ISIS2	40	Western Jordan Basin, Mount Desert Rock-Outer Schoodic Ridges, Blue Hill Bay, Sommes Sound, near Monhegan Island	Auster/Packer
2013	9-23 June	HB1302	Bigelow	TowCam	6	Powell	Nizinski
2013	9-23 June	HB1302	Bigelow	TowCam	7	Munson	Nizinski
2013	9-23 June	HB1302	Bigelow	TowCam	2	Minor Canyon btw Powell and Munson	Nizinski
2013	9-23 June	HB1302	Bigelow	TowCam	1	Intercanyon area	Nizinski
2013	8-25 July	EX1304L1	Okeanos	D2	1	USGS Hazard 4	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	1	NE Seep3	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	1	NE Seep2	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	2	Hydrographer	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	2	Atlantis	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	1	USGS Hazard 2	Quattrini/Roark
2013	8-25 July	EX1304L1	Okeanos	D2	1	NE Seep	Quattrini/Roark
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	2	Nygren	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	2	Heezen	Demopoulos/Nizinski

Year	Cruise Dates	Cruise Number	Vessel	Gear	# tows	Location	PI
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	Lydonia	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	2	Oceanographer	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	USGS Hazard1	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	Welker	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	2	Mytilus Seamount	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	Intercanyon area	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	Minor Canyon next to Shallop	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	Intercanyon area	Demopoulos/Nizinski
2013	31 July-16 Aug	EX1304L2	Okeanos	D2	1	USGS Hazard5	Demopoulos/Nizinski
2014	23 Jul - 6 Aug		Connecticut	Kraken2	21	Outer Schoodic Ridge, western and central Jordan Basin	Auster/Packer
2014	18 Jun-1 Jul	HB1402	Bigelow	ROPOS	2	Nygren	Nizinski
2014	18 Jun-1 Jul	HB1402	Bigelow	ROPOS	3	Heezen	Nizinski
2014	18 Jun-1 Jul	HB1402	Bigelow	ROPOS	1	Minor Canyon btw Nyg and Heez	Nizinski
2014	18 Jun-1 Jul	HB1402	Bigelow	ROPOS	1	Jordan Basin	Nizinski
2014			Okeanos	D2	1	Nantucket Canyon	France
2014			Okeanos	D2	1	Physallia Seamount	France
2014			Okeanos	D2	1	Retriever	France
2014			Okeanos	D2	1	East of Veatch	France
2015	1-10 Jul		Connecticut	ISIS2	26	Outer Schoodic Ridge, Mount Desert Rock, Georges Basin, Lindenkohl Knoll, West Wilkinson, Stellwagen gravel	Auster/Packer
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	3	Dogbody	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	3	Chebacco	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	3	Heel Tapper	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	3	Filebottom	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	2	Sharpshooter	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	3	Welker	Nizinski
2015	27 Jul-7 Aug	HB1504	Bigelow	TowCam	2	Clipper	Nizinski

Appendix 4 – Boundary criteria used by MAFMC FMAT for discrete coral zones (revised 5/19/2014)

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1. Identify the major features of each canyon or slope area within the current range of alternatives, based on examination of high resolution slope and other data describing canyon features and morphology.
2. Encompass areas of high and very high habitat suitability from the deep sea coral habitat suitability model outputs for Alcyonacean corals (gorgonian and non-gorgonian combined, thresholded), within the geographic range of each proposed canyon or slope area. Note: the Alcyonacean model output is expected to be the best predictor of habitat suitability for structure-forming corals.
3. For each proposed canyon or slope area, encompass areas of slope greater than 30 degrees, with emphasis on areas of slope greater than 36 degrees (from ACUMEN 25m multibeam data), within approximately 0.4 nautical miles (2 model grid cells) of high or very high suitable habitat. Note: during 2012-2013 TowCam and Okeanos Explorer cruises, areas of slope >=36 degrees contained exposed hard bottom almost 100% of the time, and areas of slope >=30 degrees often contained hard bottom habitat.
4. Draw boundaries to approximate a buffer of 0.4 nautical miles (2 model grid cells) from target areas of high slope and areas of high habitat suitability (as described in steps 2 and 3 above).
5. Incorporate available data for coral observations from 2012-2013 fieldwork in Baltimore Canyon, Norfolk Canyon, Toms Canyon complex, Block Canyon, and Ryan Canyon. Ensure that boundaries encompass areas where corals were observed within the proposed canyons, if location data is available. Note: These observations have not yet been incorporated into the habitat suitability model or the DSCRTP coral database.
6. Identify additional areas of conservation interest based on database (historical) records of deep sea corals, with an emphasis on records of Alcyonaceans (soft corals and gorgonians) and Scleractinians (stony corals), particularly larger and/or structure-forming (including colonial) coral types.
7. For adjacent canyons or slope areas with identified conservation areas of interest, identify whether such adjacent areas should be collapsed into a single area. Eliminate overlap between proposed discrete zone boundaries. Simplify boundary lines where possible.
8. Identify whether these coral data-based boundaries conflict with any of the industry-proposed boundaries, and where there are major discrepancies, consider two sub-options.