Amendment 16 to the Atlantic Mackerel, Squid, and Butterfish FMP: Protections for Deep Sea Corals

April 2014 Discussion Document

1.0 Introduction

This document summarizes the most recent range of management alternatives and the results of several initial analyses related to the Mid-Atlantic Fishery Management Council (Council)'s Amendment 16 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (FMP) to protect deep sea corals.

Purpose and Need:
The purpose of this amendment is to minimize the impacts of fishing gear on deep sea corals in the mid-Atlantic. Deep sea corals are fragile and slow-growing, and as such are highly vulnerable to disturbance by fishing gear. Bottom-tending gear poses a particular threat to deep sea coral ecosystems, with the potential to cause negative impacts ranging from scarring and damage to crushing or complete removal. The reauthorized Magnuson-Stevens Act (MSA) contains provisions giving the Regional Fishery Management Councils authority to implement management measures to mitigate fishery impacts to deep sea corals. This amendment is necessary to develop management measures under these provisions that would limit the impact of fishing on deep sea corals.

The range of alternatives in this document is based on application of the discretionary provisions contained in the 2007 reauthorization of the Magnuson-Stevens Act (MSA) giving the Regional Fishery Management Councils authority to designate deep sea coral zones, within which fishing restrictions may be implemented to protect deep sea corals. Such deep sea coral zones may include areas beyond known coral locations, if necessary, to ensure effectiveness. Management measures applied to deep sea coral zones may include restrictions on the location and timing of fishing activity, restrictions limiting fishing to specified vessel types, gear restrictions, and/or zones closed to fishing.

Management measures developed under this authority and implemented via Amendment 16 could be applied to any federally regulated fishing activity within the range of the Atlantic mackerel, squid, and butterfish fishery as described in the FMP (even to activity or gears that are not used in these fisheries). **However, these management measures would not apply to any species managed solely by the Atlantic States Marine Fisheries Commission (such as American lobster) unless the Commission took complementary action.**

2.0 Range of Alternatives

The alternatives below are structured around both "broad" coral zones and "discrete" coral zones:

Broad deep sea coral zones are intended to encompass larger areas where management measures could be applied to "freeze the footprint" of fishing, with the primary intention being to prevent expansion of effort into areas where little or no fishing occurs as a precautionary approach. Options for management measures in such broad zones could include some combination of gear restrictions and/or additional requirements for reporting, monitoring, or authorization. The concept of these broad coral zones is in line with the "freeze the footprint" approach outlined in NOAA's Strategic Plan for Deep Sea Corals:

> "The expansion of fisheries using mobile bottom tending gear beyond current areas has the potential to damage additional deep-sea coral and sponge habitats. Potentially, many undocumented and relatively pristine deep-sea coral and sponge ecosystems may exist in unmapped areas untouched, or relatively untouched, by mobile bottom-tending gear. This objective takes a precautionary approach to "freeze the footprint" of fishing that uses mobile bottom-tending gear in order to protect areas likely to support deep-sea coral or sponge

ecosystems until research surveys demonstrate that proposed fishing will not cause serious or irreversible damage to such ecosystems in those areas. Special emphasis is placed on mobile bottom-tending gear (e.g., bottom trawling), as this gear is the most damaging to these habitats. This objective applies to areas where use of such gear is allowed or might be allowed in the future. If subsequent surveys identify portions of these areas that do not contain deep-sea corals or sponges, NOAA may recommend that suitable areas be opened for fishing using such gear."[1]

Discrete deep sea coral zones would be designated in smaller areas of known coral presence or highly likely (based on habitat suitability analysis) coral presence. These areas primarily include canyons along the shelf/slope break.

These two types of deep sea coral zones could be implemented simultaneously. Different management measures could be applied in each type of zone, allowing the flexibility to protect areas of known deep sea coral presence, while taking a precautionary approach in other areas.

Consistent with this framework, six sets of alternatives are presented below: 1) options for the designation of broad deep sea coral zones, 2) options for management measures to be applied to broad zones, 3) options for designation of discrete deep sea coral zones, 4) options for management measures to be applied to discrete zones, 5) options for framework provisions for deep sea coral zones, and 6) options for vessel monitoring system requirements.

These alternatives represent the range approved at the August 2013 Council meeting in Wilmington, DE including additional alternatives proposed at this meeting.

2.1 Broad Coral Zone Alternatives

Alternative 1A: No Action/*Status Quo*
No action would be taken to designate broad deep sea coral zones. This option is equivalent to the *status quo*.

Alternative 1B: Landward boundary at the 200 meter depth contour
Designation of a broad deep sea coral zone with a landward boundary at the 200 m depth contour and extending out to the edge of the EEZ (Figure 1).

Alternative 1C: Landward boundary at the 300 meter depth contour
Designation of a broad deep sea coral zone with a landward boundary at the 300 m depth contour and extending out to the edge of the EEZ (Figure 1).

Alternative 1D: Landward boundary at the 400 meter depth contour
Designation of a broad deep sea coral zone with a landward boundary at the 400 m depth contour and extending out to the edge of the EEZ (Figure 1).

Alternative 1E: Landward boundary at the 500 meter depth contour
Designation of a broad deep sea coral zone with a landward boundary at the 500 m depth contour and extending out to the edge of the EEZ (Figure 1).

[1] The full Strategic Plan for Deep Sea Coral and Sponge Ecosystems is available at http://coris.noaa.gov/activities/deepsea_coral/.

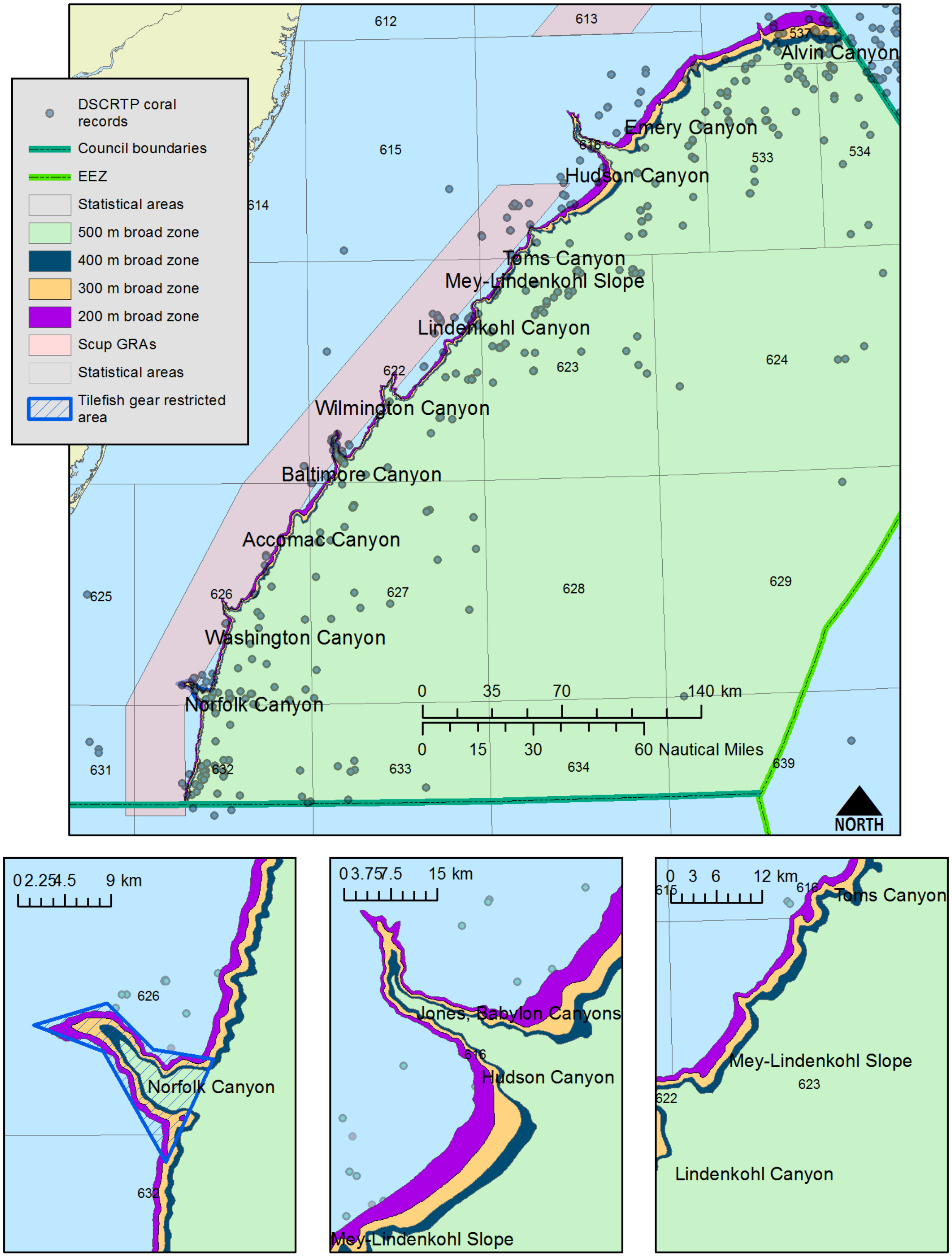

Figure 1: Broad coral zone alternatives.

2.2 Management Measures within Broad Coral Zones

Alternative 2A: No Action

No action would be taken to implement management measures in broad deep sea coral zones.

Alternative 2B: Prohibit all bottom-tending gear

All bottom-tending gear would be prohibited within designated broad coral zones. "All bottom-tending gear" includes all mobile bottom-tending gear (as defined below), as well as stationary gear types that contact the bottom, including bottom longlines, pots and traps, and sink or anchored gill nets.

Alternative 2C: Prohibit mobile bottom-tending gear

All mobile bottom-tending gear would be prohibited within designated broad coral zones. Mobile bottom-tending gear (as defined at 50 C.F.R. §648.200 with respect to the NE multispecies and tilefish fisheries) means gear in contact with the ocean bottom, and towed from a vessel, which is moved through the water during fishing in order to capture fish, and includes otter trawls, beam trawls, hydraulic dredges, non-hydraulic dredges, and seines (with the exception of a purse seine).

Alternative 2D: Require Council review and approval for fishing within broad zones

This option would require specific approval, including a Council review step, to fish within broad deep sea coral zones. This could be accomplished in several ways, including a potential set of categories of permitted fisheries with separate evaluation criteria.

2D-1. Implement special access program (for existing fisheries)

2D-2. Implement exploratory fishing access program (for potential new fisheries)

2D-3. Implement research/experimental access program (for scientific research)

Alternative 2E: Exempt red crab fishery from broad coral zone restrictions

Alternative 2F: Require increased monitoring for vessels fishing in broad zones

2F-1. Require observers for vessels fishing in broad coral zones

2F-2. Require VMS for vessels fishing in broad coral zones

2F-3. Require gear monitoring electronics on board to fish within broad zones (equipment monitoring gear distance from seafloor)

Alternative 2G: Exempt mid-Atlantic golden tilefish fishery from broad zone restrictions

Alternative 2H: Exempt *Illex* and longfin squid fisheries from broad zone restrictions

2.3 Discrete Coral Zone Alternatives

Alternative 3A: No Action/Status Quo

No action would be taken to designate discrete deep sea coral zones. This option is equivalent to the *status quo*. Within the Mid-Atlantic Fishery Management Council region, there are currently no measures in place designed specifically for the protection of deep sea corals.

Note: The specific canyons or areas in each alternative 3B-3D are likely to change. The FMAT plans to review each area based on new information (recent coral findings, habitat suitability model) to group these areas as appropriate.

Alternative 3B: Designation of canyons or slope areas with moderate to high observed coral presence

These areas were assessed as having adequate observations on which to classify these areas as having moderate to high relative coral abundance. To date, these include:

- Mey-Lindenkohl Slope (encompassing several canyons: Mey, Hendrickon, Toms, S. Toms, Berkley, Carteret, Lindenkohl, and the slope area between them. Note that Toms Canyon, Hendrickson Canyon, and Middle Toms Canyon are areas where corals have been observed on recent research cruises.)
- Baltimore Canyon
- Norfolk Canyon
- Block Canyon
- Ryan Canyon

3B-1. Original boundaries

These alternatives reflect the original boundary designations developed by the New England Habitat Plan Development Team. The boundaries at the heads of the canyons approximate the 3-degree slope contour, and the rest of the boundaries encompass areas of highest slope.

3B-2. Modified boundaries

These alternatives reflect the modified boundary designations developed for Norfolk Canyon, Baltimore Canyon, and the Mey-Lindenkohl Slope as the result of the April Deep Sea Corals Alternatives Workshop and follow-up work with industry representatives.

3B-3. Depth-contour based boundaries

The landward boundary designations would be modified for the discrete zones in this category to follow the 200 m, 300 m, 400 m, or 500 m depth contour, until the point at which the depth contour boundary intersects with the original boundaries of the sides of the canyon, and follow the original boundaries on the seaward side.

Alternative 3C: Designation of canyons with inferred coral presence

These canyons were recommended by the Habitat PDT on the basis of habitat suitability inferred for deep sea corals. These canyons include Emery Canyon, Babylon and Jones Canyons, Hudson Canyon, Wilmington Canyon, Accomac Canyon, and Washington Canyon.

Alternative 3D: Designation of canyons with possible coral presence

This alternative was added at the August 2013 Council meeting, and includes canyons with insufficient coral presence data to determine whether or not corals are present. These canyons include McMaster Canyon, Uchupi Canyon, Spencer Canyon, South Wilmington Canyon, North Heyes Canyon, South Vries Canyon, Warr Canyon, Phoenix Canyon, and Leonard Canyon.

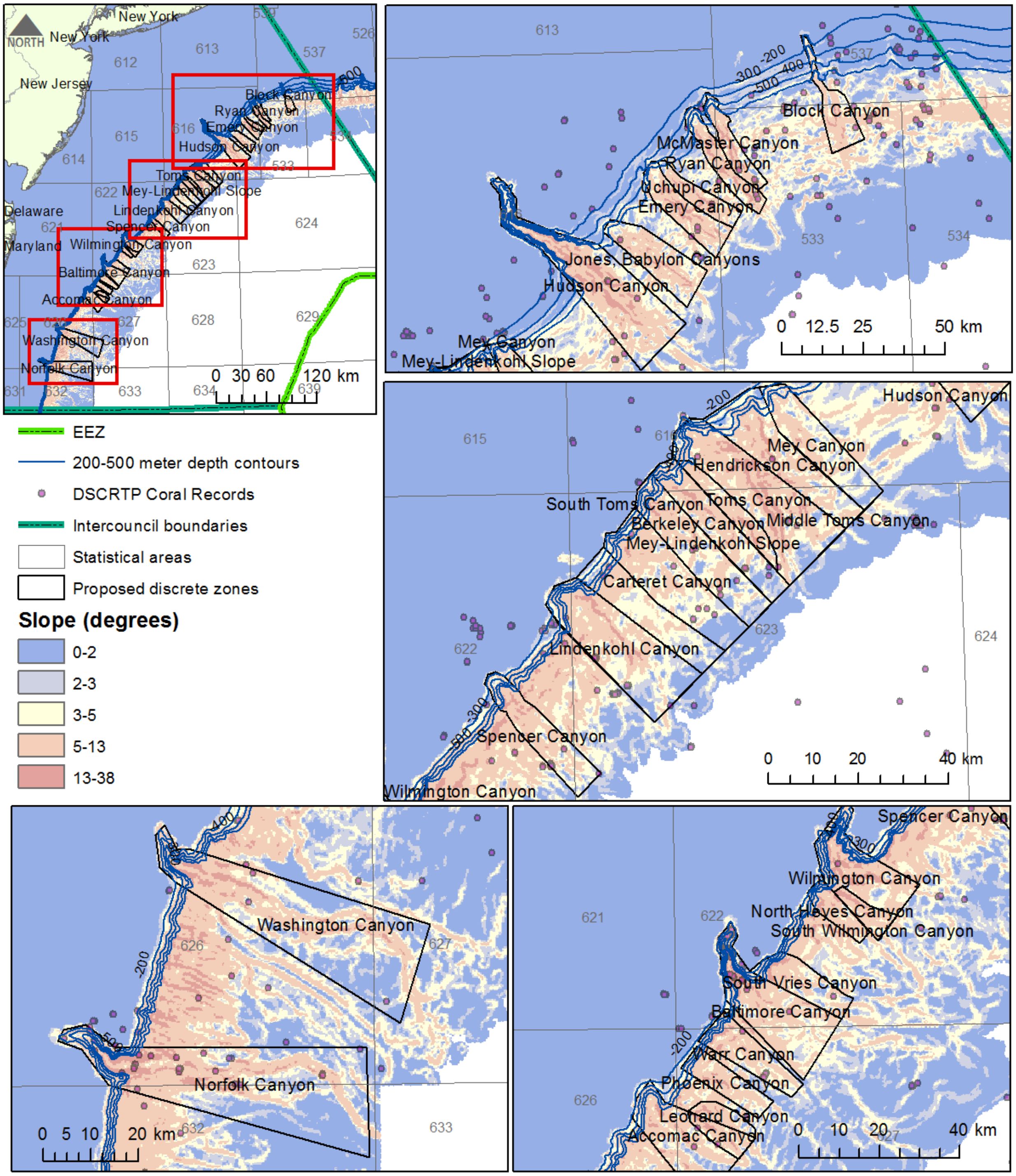

Figure 2: Discrete coral zone alternatives.

2.4 Management Measures within Discrete Coral Zones

Alternative 4A: No Action

Alternative 4B: Prohibit all bottom-tending gear
This option would prohibit use of all bottom-tending gears in discrete deep sea coral zones. "All bottom-tending gear" includes all mobile bottom-tending gear (as defined below), as well as stationary gear types that contact the bottom, including bottom longlines, pots and traps, and sink or anchored gill nets.

Alternative 4C: Prohibit mobile bottom-tending gear
All mobile bottom-tending gear would be prohibited within designated broad coral zones. Mobile bottom-tending gear (as defined at 50 C.F.R. §648.200 with respect to the NE multispecies and tilefish fisheries) means gear in contact with the ocean bottom, and towed from a vessel, which is moved through the water during fishing in order to capture fish, and includes otter trawls, beam trawls, hydraulic dredges, non-hydraulic dredges, and seines (with the exception of a purse seine).

Alternative 4D: Exempt *illex* and longfin squid fisheries from discrete zone restrictions

Alternative 4E: Require gear monitoring electronics on board to fish within discrete zones (equipment monitoring gear distance from seafloor)

2.5 Framework Provisions for Deep Sea Coral Zones and Management Measures

Recently completed survey cruises have discovered deep sea corals in areas where they have previously not been observed. Some of this research is still ongoing and many data products will not be available within the planned timeline for this amendment. Including options for framework provisions in Amendment 16 may allow the Council to modify deep sea coral zones or management measures in response to new information or issues arising after implementation of Amendment 16.

Alternative 5A: No Action

Alternative 5B: Option to modify boundaries for deep sea coral zones
This option would allow the Council to modify the boundaries of deep sea coral zones through a Framework action.

Alternative 5C: Option to modify management measures within zones
This option would allow the Council to modify fishing restrictions and exemptions within deep sea coral zones through a Framework action.

Alternative 5D: Option to add additional discrete coral zones
This option would allow the Council to add discrete coral zones through a Framework action.

2.6 VMS Requirement

Alternative 6A: No Action

Alternative 6B: Require Vessel Monitoring Systems (VMS) for Illex squid moratorium vessels
This option would require use of VMS for all *Illex* squid moratorium vessels.

3.0 Deep Sea Coral Data and Distribution Relative to Proposed Coral Zones

The following analysis describes data sources and records for deep sea corals in the mid-Atlantic, as well as summarized results of a habitat suitability model for deep sea coral habitat in the Northeast region. In combination, this information can be used to evaluate the potential conservation benefits associated with the proposed deep sea coral protection zones and associated fishing restrictions.

3.1 Deep Sea Coral Research and Technology Program Database

Records of deep sea coral observations are maintained in a database by NOAA's Deep Sea Coral Research and Technology Program (DSCRTP). These records include historical and current data from a variety of sources, including peer-reviewed literature, research surveys, museum records, and incidental catch records. It is important to keep in mind that the records contained in this database are mostly **presence-only**. **Many areas have not been adequately surveyed for the presence of deep sea corals.** There is very little absence or abundance information available for deep sea corals, although usable absence data may become available as data is processed from recent research cruises.

Coral presence data from this database was analyzed using ArcGIS software and Microsoft Excel pivot tables to determine how records of known corals overlap with proposed management areas.

The DSCRTP database[2] contains 870 records of deep sea corals within the MAFMC management region. Of these, 635 records are included within proposed broad coral zones (73%; Table 1). There is only one coral record in the database that is contained within a proposed discrete zone that is *not* also encompassed by a broad zone alternative (one observation of *Dasmosmilia lymani*, a stony coral, in Baltimore Canyon).

The coral records within the total area of the proposed zones are composed of sea pens (40%), soft corals/gorgonians (34%), and hard/stony corals (27%). Outside of the proposed zones, there are 236 total records, the majority of which are stony corals or sea pens (Table 3). Within the proposed discrete zones, the areas of highest coral observations are contained within Baltimore Canyon, Norfolk Canyon, and the Mey-Linedenkohl Slope (Table 4). These areas are all included in the areas recommended based on high documented coral presence and suitable habitat.

The data below should be interpreted with caution. As described above, the data are presence-only, and many areas have not been explored for the presence of corals. Furthermore, identifying deep sea coral taxa down to genus and species levels is difficult and problematic, especially through the use of photographs or video alone; also, deep sea coral taxonomy is in a constant state of flux. Additionally, given the nature of this type of data collection, many of the records tend to be spatially clustered and display a possible bias toward records in shallower water given the increased difficulties associated with sampling further offshore. Additionally, this analysis does not include the results of recent survey work, as data from these cruises has not yet been added to the DSCRTP database (however, some information is available; see below for additional discussion of recent research findings).

[2] As of June 10, 2013

Table 1: Deep sea coral presence records within proposed MAFMC broad coral zones, in number (a) and percent (b). Data from DSCRTP database as of June 2013.

a.		**Total records (all types)**	**Soft corals and gorgonians**	**Stony corals**	**Sea pens**
Broad zone (depth contour as landward boundary)	*[Shallower than 200 m]*	*235*	*24*	*118*	*93*
	200 meter broad zone	**635**	**214**	**167**	**255**
	[between 200 m and 300 m]	*40*	*1*	*17*	*23*
	300 meter broad zone	**595**	**213**	**150**	**232**
	[between 300 m and 400 m]	*51*	*10*	*26*	*15*
	400 meter broad zone	**544**	**203**	**124**	**217**
	[between 400 m and 500 m]	*25*	*15*	*4*	*6*
	500 meter broad zone	**519**	**188**	**120**	**211**
	TOTAL MAFMC Region	**870**	**238**	**285**	**348**

b.		**% of total records (all types)**	**% Soft corals and gorgonians**	**% Stony corals**	**% Sea pens**
Broad zone (depth contour as landward boundary)	*[Shallower than 200 m]*	*27%*	*10%*	*38%*	*27%*
	200 meter broad zone	**73%**	**90%**	**62%**	**73%**
	[between 200 m and 300 m]	*5%*	*0%*	*6%*	*7%*
	300 meter broad zone	**68%**	**89%**	**56%**	**67%**
	[between 300 m and 400 m]	*6%*	*4%*	*10%*	*4%*
	400 meter broad zone	**62%**	**85%**	**46%**	**62%**
	[between 400 m and 500 m]	*3%*	*6%*	*5%*	*2%*
	500 meter broad zone	**60%**	**79%**	**40%**	**61%**
	TOTAL MAFMC Region	**100%**	**100%**	**100%**	**100%**

Table 2: Composition of deep sea corals presence records by type within proposed broad and discrete zones. Data from DSCRTP database as of June 2013.

	Broad Zones		**Discrete Zones[a]**	
Coral Type	Number of Records within Broad Zones	% Composition of Broad Zone Records by Coral Type	Number of Records within Discrete Zones	% Composition of Discrete Zone Records by Coral Type
Soft corals and gorgonians	213	33.5%	87	37.5%
Stony corals	167	26.3%	70	32.3%
Sea pens	255	40.2%	75	30.2%
TOTAL	**635**	**100%**	**232**	**100%**

[a] All records within proposed discrete zones are also contained within the shallowest broad zone option (200 m), with the exception of one record of a stony coral in Baltimore Canyon.

Table 3: Deep sea coral presence records NOT within any of the proposed zones. Data from DSCRTP database as of June 2013.

Coral Type	Number of Records OUTSIDE of proposed coral zones	% Composition by Coral Type
Soft corals and gorgonians	23	10%
Stony corals	118	50%
Sea pens	93	40%
TOTAL	**234**	**100%**

Table 4: Deep sea coral presence records by proposed discrete zone. Note that these records reflect varying spatial concentrations of survey effort, and many areas have not been surveyed for corals. This data also does not contain any new records from recent research surveys.

	Coral Type				
Canyon Area	Alcyonacea	Gorgonacea	Pennatulacea	Scleractinia	Total Records
Block Canyon		3			3
McMaster Canyon				3	3
Ryan Canyon		5	5	1	11
Uchupi Canyon	1		3		4
Emery Canyon	1		3	2	6
Jones, Babylon Canyons				1	1
Hudson Canyon	1	1		4	6
Mey-Lindenkohl Slope	9	12	33	12	66
Hendrickson Canyon				1	1
Toms Canyon	4	1		1	6
South Toms Canyon	1	1	9		11
Berkeley Canyon	2	1	1	3	7
Carteret Canyon	1	5	8	5	19
Lindenkohl Canyon		4	15	1	20
Spencer Canyon		2	9	2	13
Wilmington Canyon			2		2
South Vries Canyon	1			1	2
Baltimore Canyon	7	21	1	26	55
Warr Canyon			14		14
Leonard Canyon			1		1
Accomac Canyon	1		3	2	6
Washington Canyon	1	1		4	6
Norfolk Canyon	5	16	5	11	37

2.2 Recent and Planned Research Surveys

Several recent research efforts have resulted in new observations of deep sea corals in the mid-Atlantic. Some of this research is still ongoing, with plans for some work to continue into 2014 and 2015. Although some qualitative results are available, much of the processed/georeferenced data from recent cruises is not yet available. The FMAT is working to incorporate new information into amendment development as soon as it becomes available.

2012 BOEM Surveys

In 2012, research cruises funded by the Bureau of Ocean Energy Management (BOEM) explored mid-Atlantic deepwater hard bottom habitat, focusing on canyon habitats and coral communities. This survey included many dives in Baltimore Canyon using a remotely operated vehicle (ROV), and a few dives in Norfolk Canyon. Deep sea corals were locally abundant in both Baltimore and Norfolk Canyons, and the surveys resulted in the first observations of the species *Lophelia pertusa* in the mid-Atlantic (Figure 3). *L. pertusa* is a structure-forming coral commonly found off the coast of the southeastern U.S., and occasionally observed in New England, but has not previously been observed in the mid-Atlantic. In September 2012, *L. pertusa* was observed in live colonies on steep walls in both Baltimore and Norfolk Canyons, at depths between 381 and 434 m.[3] Several other coral types were observed in both Baltimore and Norfolk Canyons, including dense areas of *Paragorgia, Anthothela, Primnoa*, and *Acanthogorgia* communities (georeferenced data not yet available). Many sightings of lost fishing gear were also recorded in the two canyons, including traps, fishing lines, and nets. Baltimore and Norfolk Canyons are currently included in the range of possible deep sea coral zones under Alternative 3B (recommended based on coral presence).

2012 ACUMEN Surveys

In the summer of 2012, the Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) surveys concluded with a deep-sea coral survey funded by NOAA and the Deep-Sea Coral Research and Technology Program from aboard the NOAA ship *Henry Bigelow*.[4] Areas sampled in the mid-Atlantic included Middle Toms Canyon, the edge of Hendrickson Canyon, the slope area between Toms and Hendrickson Canyons, and Toms Canyon. Using a towed camera system, high-resolution images were taken to collect data on deep-sea coral diversity, abundance, and distribution, as well as ground-truth locations of predicted deep-sea coral habitat (based on habitat suitability model outputs), historical records, and multibeam bathymetry collected by NOAA ships *Okeanos Explorer* and *Ferdinand Hassler*. Deep-sea corals were observed in many locations within the Toms Canyon complex, which is currently included in the range of proposed deep sea coral zones (the Mey-Lindenkohl slope area) under Alternative 3B (recommended based on coral presence). Corals were observed during every tow with fewest coral observations at the head of Toms Canyon and the most coral observations made in Middle Toms Canyon (Table 5). The majority of corals were octocorals, with fewer observations of scleractinians (stony corals) and sea pens. Differences among individual canyons likely reflect differences in depth and substrate type in the area where tows were conducted. These factors are hypothesized to influence coral abundance and distribution.

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[3] Brooke, S., and Ross, S.W. In press. First observations of the cold-water coral *Lophelia pertusa* in mid-Atlantic canyons of the USA. Deep-Sea Res. II. http://dx.doi.org/10.1016/j.dsr2.2013.06.011.

[4] http://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/bigelow/welcome.html.

2013 Deep Sea Coral Research and Technology Program Funded Survey

In the summer of 2013, scientists from NOAA, Woods Hole Oceanographic Institution (WHOI), and the Delaware Museum of Natural History (DMNH) conducted another deep-sea coral survey cruise aboard NOAA ship *Henry Bigelow*. This cruise, a logical follow-on to the successful ACUMEN initiative, utilized the same towed camera system and methodologies as the previous cruise. Only one Mid-Atlantic canyon, Ryan Canyon, was surveyed during this cruise. Five tows were made, covering shallow, mid, and deeper depths within the canyon. Based on data collected from approximately 9,000 bottom images, corals were virtually nonexistent along the shallowest (closest to the canyon head) tow tracks. Corals were significantly more abundant at the deepest tow. Similar to results from the 2012 expedition, in the areas surveyed, the majority of corals observed were octocorals and differences in coral distribution within Ryan Canyon likely reflect differences in depth and substrate type. One camera tow survey, following the 500 m contour, was made in the intercanyon area between Ryan and McMaster canyons. Corals were observed in only one image. Ryan Canyon has now been added to the list of canyons were coral presence and suitable habitat have been documented.

2013 Okeanos Explorer Surveys

In the summer of 2013, the NOAA vessel *Okeanos Explorer* explored mid-Atlantic submarine canyons using an ROV. In the mid-Atlantic, this included work in and around Block Canyon, where deep sea corals were observed in July 2013.[5]

2014 Proposed Fieldwork in the Mid-Atlantic Region

Another deep-sea coral survey to take place in the Spring of 2014 will use a towed camera system aboard NOAA ship *Henry Bigelow* and will focus exclusively on Mid-Atlantic canyons. Scientists from NOAA, WHOI, and DMNH will survey Washington and Wilmington canyons. These canyons were identified as the primary targets by the FMAT and GARFO. Other canyons likely to be explored include, Accomac, Spencer, Lindenkohl, Carteret canyons. NOAA/NMFS Science and Technology Program and NOAA's Deep-Sea Coral Research and Technology Program are funding this cruise.

Discussions are underway with NOAA's Office of Exploration and Research to include 1-2 dives at mid-Atlantic canyons during the *Okeanos Explorer* September 2014 expedition to the seamounts. Results from the *Bigelow* cruise will guide these discussions.

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[5] http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/dailyupdates.html

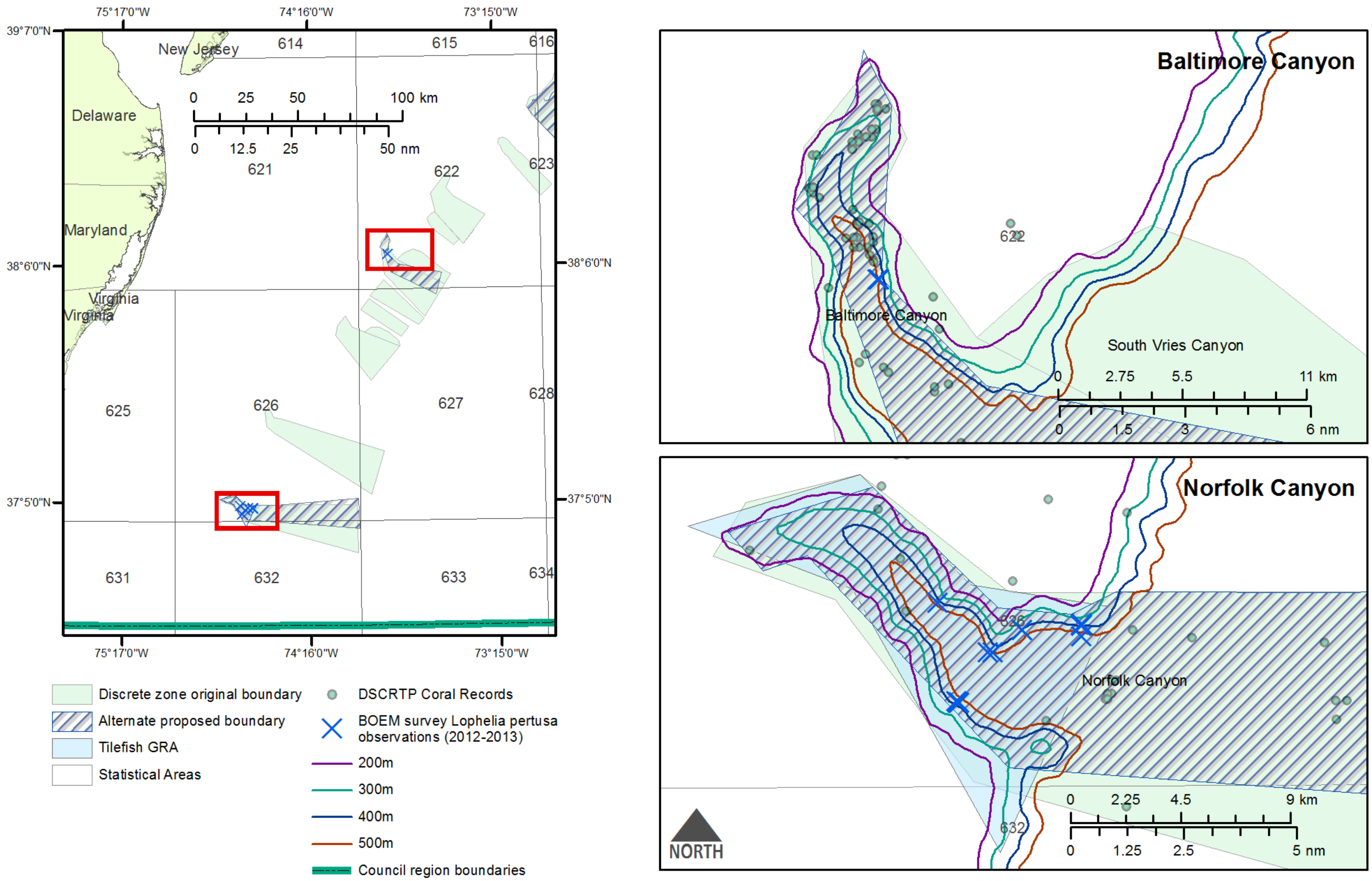

Figure 3: Observations of *Lophelia pertusa* from BOEM cruises in Baltimore and Norfolk Canyons, 2012 and 2013. Source: Brooke and Ross (2013).

Table 5: Preliminary image survey of NE canyon fauna from TowCam surveys, 2012-2013. Images were captured at 10 second intervals through each dive. Each bottom image was visually screened for hard and soft corals, sponges, and fish fauna. Presence/absence information was logged for each image.

TowCam Dive #	Canyon Location	Date	Launch Lat N	Launch Lon W	Recovery Lat	Recovery Lon	Total No. of Images	No. of Images on bottom	No. images with corals	No. images with sponges	% images with corals	% images with sponges	Nominal Depth (m)
HB1204-01	Toms Canyon SE	7/7/2012	38 56.3823	72 25.7944	38 55.5772	72 25.6275	2556	1734	828	2	47.75	0.12	1802
HB1204-02	Toms Canyon Lower West	7/8/2012	38 57.1788	72 27.2815	38 57.5213	72 27.5442	2749	2067	557	121	26.95	5.85	1736 to 1694
HB1204-03	Toms Canyon Canyon Head	7/8/2012	39 06.2975	72 38.0914	39 05.8721	72 38.1695	1420	1226	11	16	0.90	1.31	553 to 861
HB1204-04	Hendrickson Canyon Lower East Scarp	7/9/2012	38 57.6673	72 26.3203	38 57.5940	72 26.5532	2328	1148	291	264	25.35	23.00	175 to 1705
HB1204-05	Middle Toms Canyon Mid	7/10/2012	38 56.9385	72 35.3163	38 56.8551	72 35.0058	2779	1963	1016	522	51.76	26.59	1337 to 1591
HB1204-06	Toms Canyon Mid-East	7/10/2012	39 01.6231	72 33.2098	39 01.7749	72 33.1740	2036	1781	154	83	8.65	4.66	1115 to 1216
HB1302-001	Ryan Canyon	6/10/2013	39 46.4979	71 41.9049	39 46.3115	71 41.9738	1534	649	0	0	0.00	0.00	599
HB1302-002	Ryan Canyon	6/11/2013	39 43.8514	71 42.6188	39 43.9435	71 41.9149	1424	420	2	0	0.48	0.00	771
HB1302-003	Ryan Canyon	6/12/2013	39 43.8357	71 42.1705	39 43.3885	71 41.3225	3223	2262	48	497	2.12	21.97	992
HB1302-004	Ryan Canyon	6/12/2013	39 42.3582	71 38.6827	39 41.5694	71 38.3807	2766	2079	62	496	2.98	23.86	1135
HB1302-005	Ryan Canyon	6/13/2013	39 34.7145	71 33.3316	39 35.317	71 32.6441	2197	1358	584	9	43.00	0.66	1965
HB1302-006	Ryan-McMaster Inter-canyon area	6/13/2013	39 47.5719	71 42.7850	39 47.3285	71 40.5977	2561	2230	1	52	0.04	2.33	498

2.3 Fishery Independent and Observer Data for Deep Sea Corals

NEFSC Fishery Independent Surveys

The Northeast Fishery Science Center's fishery independent surveys have been assessed for deep sea coral bycatch. Neither the NEFSC's trawl survey nor their scallop survey "catch" deep-sea corals in any meaningful quantities, nor is any catch of corals recorded in any significant quantitative way. For example, prior to the year 2000, bycatch quantity in the Atlantic sea scallop surveys were estimated by cursory visual inspection or "eyeballing" only. Since that time, the survey has gathered more quantitative bycatch information. The bycatch data, referred to as "trash," is divided up into 3 categories: substrate, shell, and other invertebrates, but the log sheets still only record percent composition and total volume (bushels), and methods and accuracy of this quantification may vary. The NEFSC trawl surveys also have a "trash" component – trash being defined as any substrate or non-coded invertebrate species. The trash is loosely described and roughly quantified to the whole liter.

The general lack of deep-sea coral in both of these surveys may be due to the surveys fishing too shallow to encounter the more significant (i.e., larger) deep-sea coral species (e.g., nearly all the scallop surveys fish < 100 m and all are < 140 m) and the possibility that some of these larger corals (e.g., *Paragorgia, Primnoa*) may have been "fished out" in the shallower areas earlier in the 19th and 20th centuries. Nevertheless, the NEFSC is planning to improve their quantification of invertebrate bycatch in their groundfish and scallop surveys, including the identification and enumeration of any deep-sea corals encountered. However, this effort appears to be challenging, with time being the major limiting factor. The surveys are close to a maximum in terms of catch processing time per station, and increasing overall invertebrate bycatch processing would require specific strategies, including increased identification training.

Northeast Fisheries Observer Program

Records of deep sea coral bycatch in the Northeast Fisheries Observer Program (NEFOP) data have historically been sparse and inconsistently recorded, although there has been an attempt to improve this in recent years. In the spring of 2013, NEFOP implemented database and protocol changes related to the documentation of deep sea coral interactions. The NEFOP Program Manual and NEFOP database now include more specific categories of coral, including: soft coral, hard coral, sea pens, and sponges (as opposed to several inconsistent, more generic categories applied in prior years).

A deep sea coral training module was developed based on a completed identification guide (Packer and Drohan 2013, unpublished), and has been successfully incorporated into all current observer certification programs offered at the NEFOP Training Center (including the At-Sea Monitor certification, Industry Funded Scallop Observer certification, and the NE Observer Program certification). This program includes basic coral identification skills, sampling protocols, and how corals interface with the NEFOP Species Verification Program (SVP). In addition to initial general identification, observers are now instructed on proper photographic logging of any deep sea coral bycatch. These photos are to be uploaded for species identification or confirmation by NOAA coral experts. All observer-issued reference materials are now uploaded with the most current Coral ID guide and sampling protocols. Additionally, all NEFOP editing staff have also been trained on the NEFOP Coral Program.

When reviewing observer data for deep sea coral interactions, it is important to keep in mind that the percentage of commercial fishing trips actually covered by observers or the observer program varies depending on the fishery (gear type, fishing area, target species, etc.). Additionally, because the observer program observes thousands of trips every year in dozens of different fisheries, with each fishery having its own regulations for mesh size and configuration, a reported absence of deep-sea coral at a location may simply be a function of the catchability of the gear used. This is also a problem with the NEFSC surveys; it is important to remember that fishing gear is not designed to “catch” deep-sea corals. Some level of gear impacts may be occurring that do not result in corals or coral fragments being retained or entangled in the gear, able to be viewed by an observer.

Records of deep-sea coral bycatch in the Northeast region observer program data were obtained for the years 1994 to 2014. The data contains limited records with limited taxonomic information: there were 65 confirmed coral entries in the database collected from 1994-2014. Most of these records were identified as stony corals, with the remaining records composed primarily of sea pens (Table 6). Historically, observers did not record numbers or density; instead, because fishermen tended to toss the pile over the side, for most of the records, the total weight (in pounds) for deep-sea coral in a given haul was simply estimated. Gear types in these recorded observations included otter trawls, scallop dredges, lobster pots and sink gill nets, at beginning haul depths ranging from 5.5 to 464 meters (3 to 254 fathoms). Estimated or actual weights for the deep-sea coral in a given haul ranged from 0.1 to 100 kg.

Within the Mid-Atlantic Council region, only 11 records of deep sea corals have been reported in the observer data since 1994 (Table 7). Of these, six of were recorded as interactions with gill nets in state waters in the Chesapeake Bay area. Of the remaining 5 records in federal waters, none occur within any of the currently proposed deep sea coral zones (Figure 4).

Table 6: NEFOP records of deep sea interactions in the Northeast region, by coral type and gear type, 1994-2014. NK= not known.

Coral Type and Gear Type	Number of observations	Total weight (kg)
CORAL, SOFT, NK	**2**	**0.7**
TRAWL,OTTER,BOTTOM,FISH	2	0.7
CORAL, STONY, NK	**46**	**562.9**
DREDGE, SCALLOP,SEA	3	10.6
GILL NET, DRIFT-SINK, FISH	1	0.1
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	26	315.2
TRAWL,OTTER,BOTTOM,FISH	16	237
SEA PEN, NK	**17**	**7.8**
GILL NET, DRIFT-SINK, FISH	6	1.8
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	5	1.7
POT/TRAP, LOBSTER OFFSH NK	2	0.6
TRAWL,OTTER,BOTTOM,FISH	4	3.7
Grand Total	**65**	**571.4**

Table 7: NEFOP records of deep sea corals within the Mid-Atlantic Council Region, 1994-2014. NK= not known.

Coral Records by Gear Type	Number of observations	Total weight (kg)
DREDGE, SCALLOP,SEA	**3**	**10.6**
CORAL, STONY, NK	3	10.6
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	**6**	**120**
CORAL, STONY, NK	6	120
TRAWL,OTTER,BOTTOM,FISH	**2**	**100.1**
CORAL, SOFT, NK	1	0.1
CORAL, STONY, NK	1	100
Grand Total	**11**	**230.7**

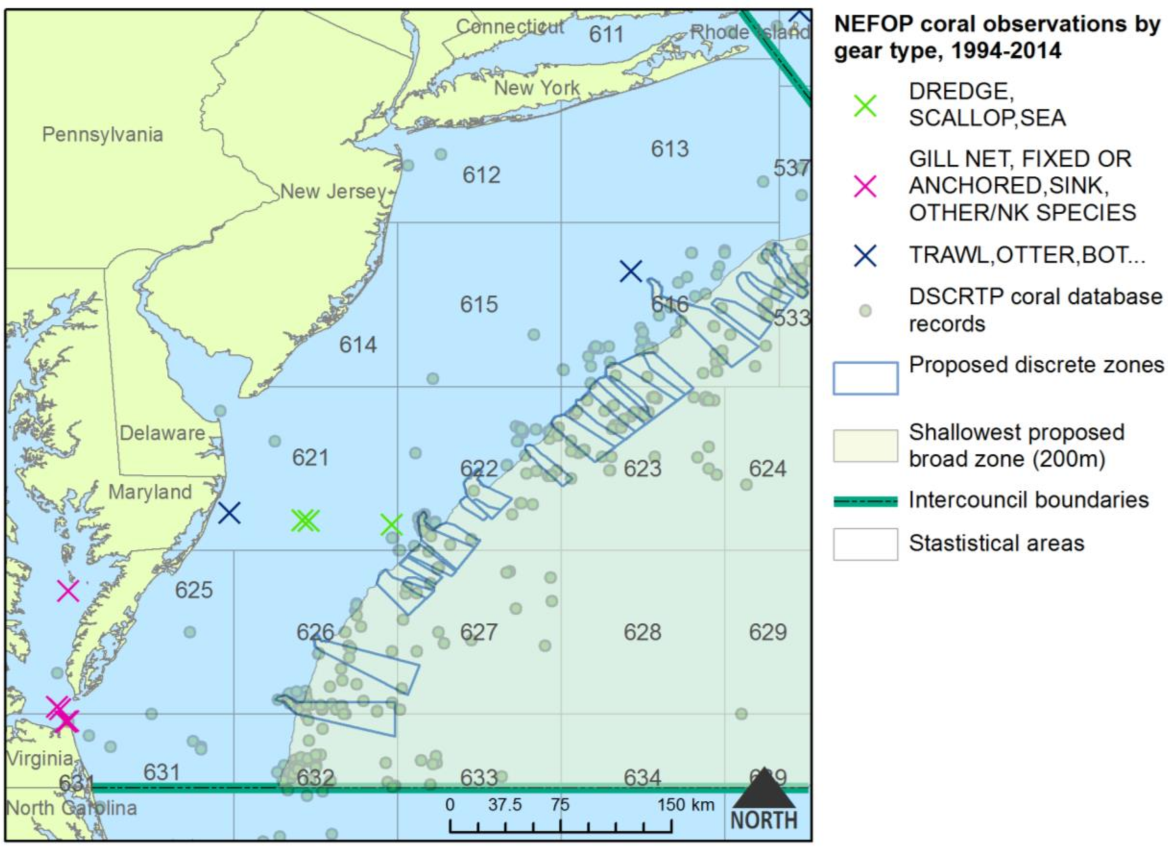

Figure 4: NEFOP records of deep sea corals in the Mid-Atlantic, 1994-2014.

2.4 Deep Sea Coral Habitat Suitability Model

The following summarizes the results of a habitat suitability model for deep sea corals in the Northeast region, developed in partnership between NOAA's National Centers for Coastal Ocean Science (NCCOS) and NOAA Northeast Fisheries Science Center (NEFSC).[6]

This predictive habitat model was developed by relating two types of data: 1) known deep sea coral presence locations (from the Deep Sea Coral Research & Technology Program database), and 2) environmental and geological predictor variables. A variety of environmental inputs were incorporated, including variables for slope, depth, depth change, aspect ratio, rugosity, salinity, oxygen, substrate, temperature, turbidity, and others.

Several of the model outputs are displayed in the maps below, which reflect the predicted likelihood of deep sea coral habitat for a given area. In these maps, the values for predicted likelihood of coral habitat suitability are displayed by the following likelihood categories: very low, low, medium, high, and very high. These outputs can be compared directly across groups of different coral types.[7]

In the Northeast Region, several different taxonomic groups of deep sea corals were modeled (Table 8). Some of these model outputs will be better predictors of coral presence than others, due to different sample sizes of coral records of each type in the DSCRTP database. For example, the model output for Gorgonian Alcyonacea is expected to be the model with the best predictive ability for structure-forming deep sea corals, as it is based on a sizeable number of data points from known structure-forming species. The model for Scleractinians, on the other hand, is based on a smaller number of records of mostly solitary, soft-sediment dwelling cup corals, and is likely to under-predict the likelihood of suitable habitat for this coral type. Future incorporation of recent observations of structure-forming Scleractinians in the mid-Atlantic will improve this model's predictive ability.

In July 2012, the NOAA ship Bigelow visited three "hotspots" predicted by the model, and surveyed the sites using WHOI's TowCam. Data collected during this cruise was used to refine model predictions. The model was qualitatively validated: all camera tow sites that were observed to be hotspots of coral abundance and diversity were also predicted hotspots of habitat suitability based on the regional model.

However, it should be noted that the exact location of deep coral hotspots on the seafloor often depends on fine-scale seabed features (e.g., ridges or ledges of exposed hard substrate) that are smoothed over in this regional-scale model. The current resolution of the model is grid cells of approximately 370 square km (although there are plans to improve model resolution to the 25 km scale within the next several years). These maps should be viewed as representing only the general locations

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[6] Kinlan BP, Poti M, Drohan A, Packer DB, Nizinski M, Dorfman D, Caldow C. 2013. Digital data: Predictive models of deep-sea coral habitat suitability in the U.S. Northeast Atlantic and Mid-Atlantic regions. Downloadable digital data package. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS), Center for Coastal Monitoring and Assessment (CCMA), Biogeography Branch. Released August 2013. Available at: <http://coastalscience.noaa.gov/projects/detail?key=35>. Funding for this research was provided by the National Marine Fisheries Service - Northeast Fisheries Science Center, the NOAA Deep Sea Coral Research and Technology Program, and the National Ocean Service - National Centers for Coastal Ocean Science.

of predicted suitable coral habitat (within approximately 350-750 meters, or approximately two model grid cells). Also, model predictions are of coral presence, and high likelihood of presence will not necessarily correlate with high abundance.

Table 8: Modeled deep sea coral taxonomic groups for habitat suitability model. Groups displayed in maps below are highlighted.

Region	Group	Description	Notes
Northeast U.S.	1	**Order Alcyonacea**	**Soft Corals and Gorgonians**
Northeast U.S.	1a	**Gorgonian Alcyonacea** (Suborders Calcaxonia, Holaxonia, Scleraxonia)	Gorgonians *Expected to be the current best predictor of habitat for structure-forming deep sea corals.
Northeast U.S.	1b	**Non-Gorgonian Alcyonacea** (Suborders Alcyoniina, Stolonifera)	Soft corals
Northeast U.S.	2	**Order Scleractinia**	**Stony corals**
Northeast U.S.	2a	Family Caryophylliidae	
Northeast U.S.	2b	Family Flabellidae	
Northeast U.S.	3	**Order Pennatulacea**	**Sea pens**
Northeast U.S.	3a	Suborder Sessiliflorae	
Northeast U.S.	3b	Suborder Subsessiliflorae	
Northeast U.S.	All	**Average, all types**	**Average of all above**

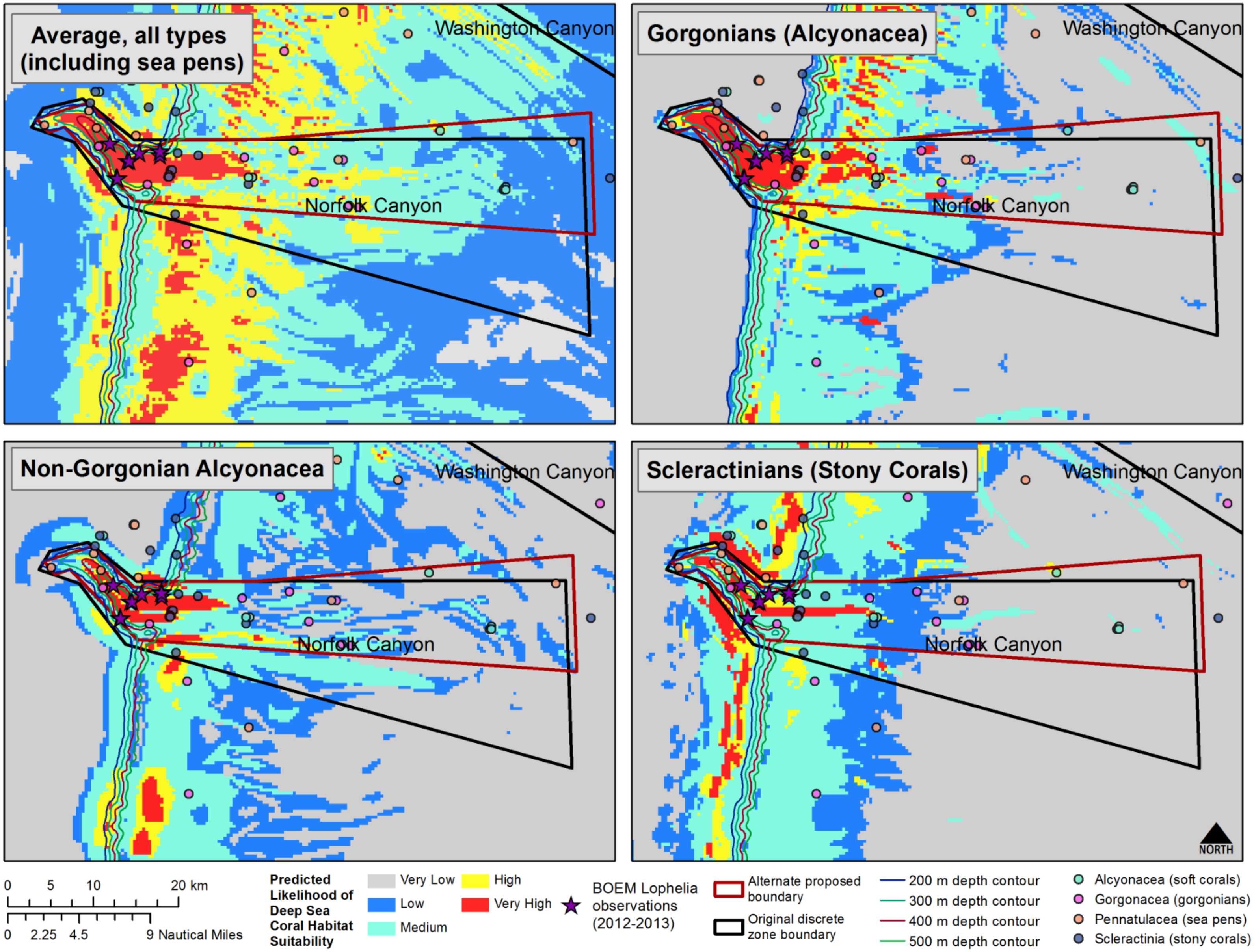

Figure 5: Model-predicted likelihood of deep sea coral habitat suitability for Norfolk Canyon. Source: Kinlan et al. 2013.; NCCOS/NEFSC.

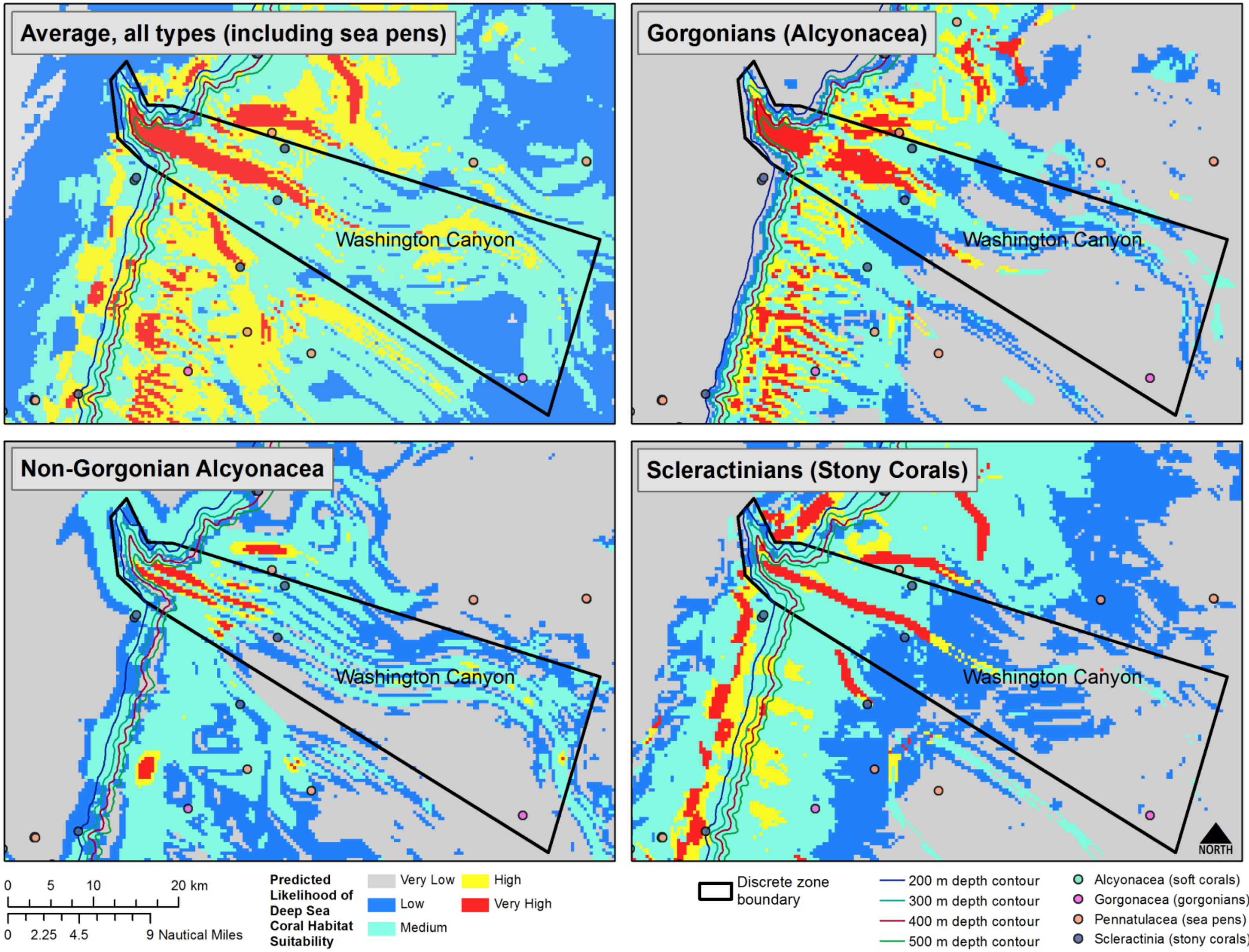

Figure 6: Model-predicted likelihood of deep sea coral habitat suitability for Washington Canyon. Source: Kinlan et al. 2013.

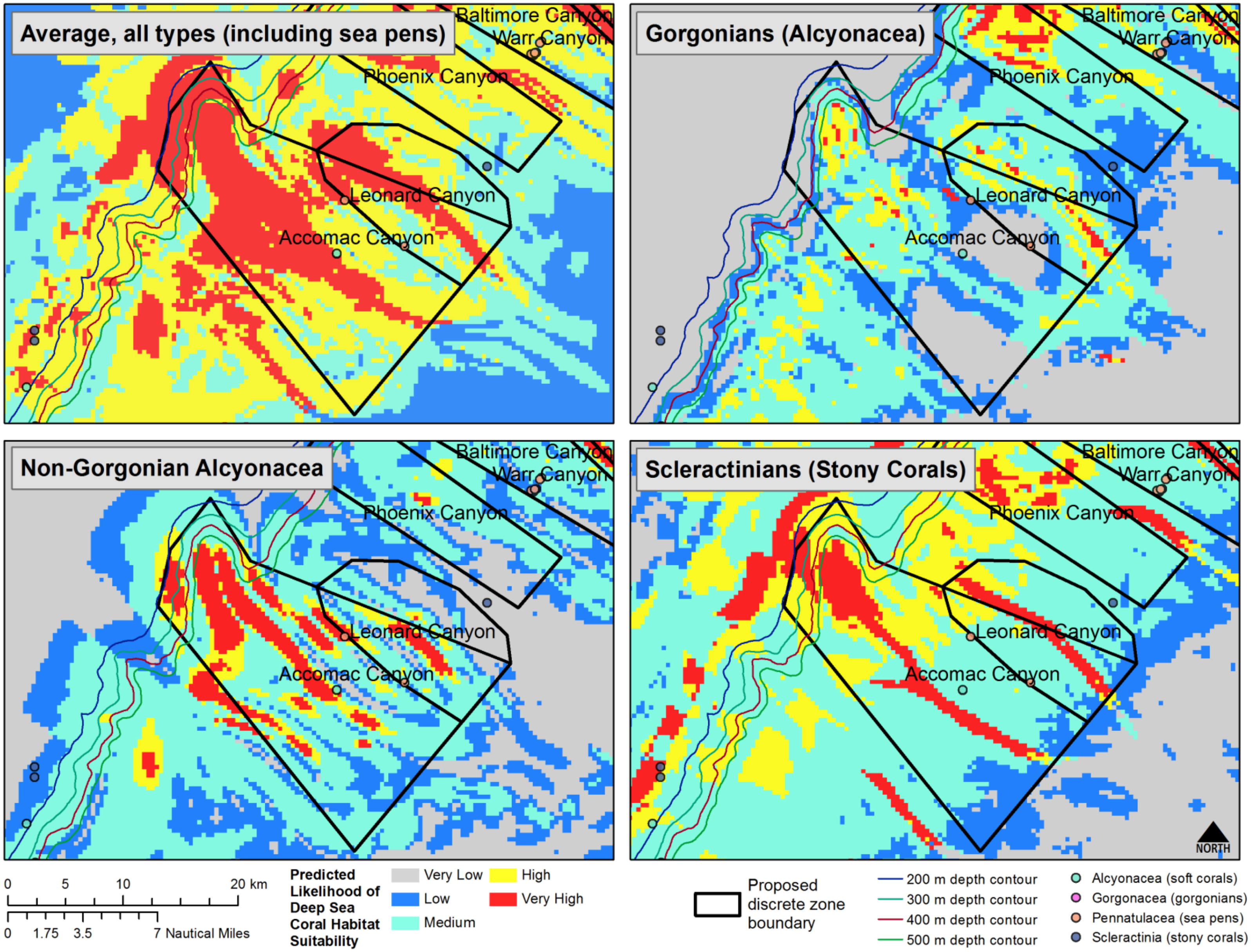

Figure 7: Model-predicted likelihood of deep sea coral habitat suitability for Accomac and Leonard Canyons. Source: Kinlan et al. 2013.

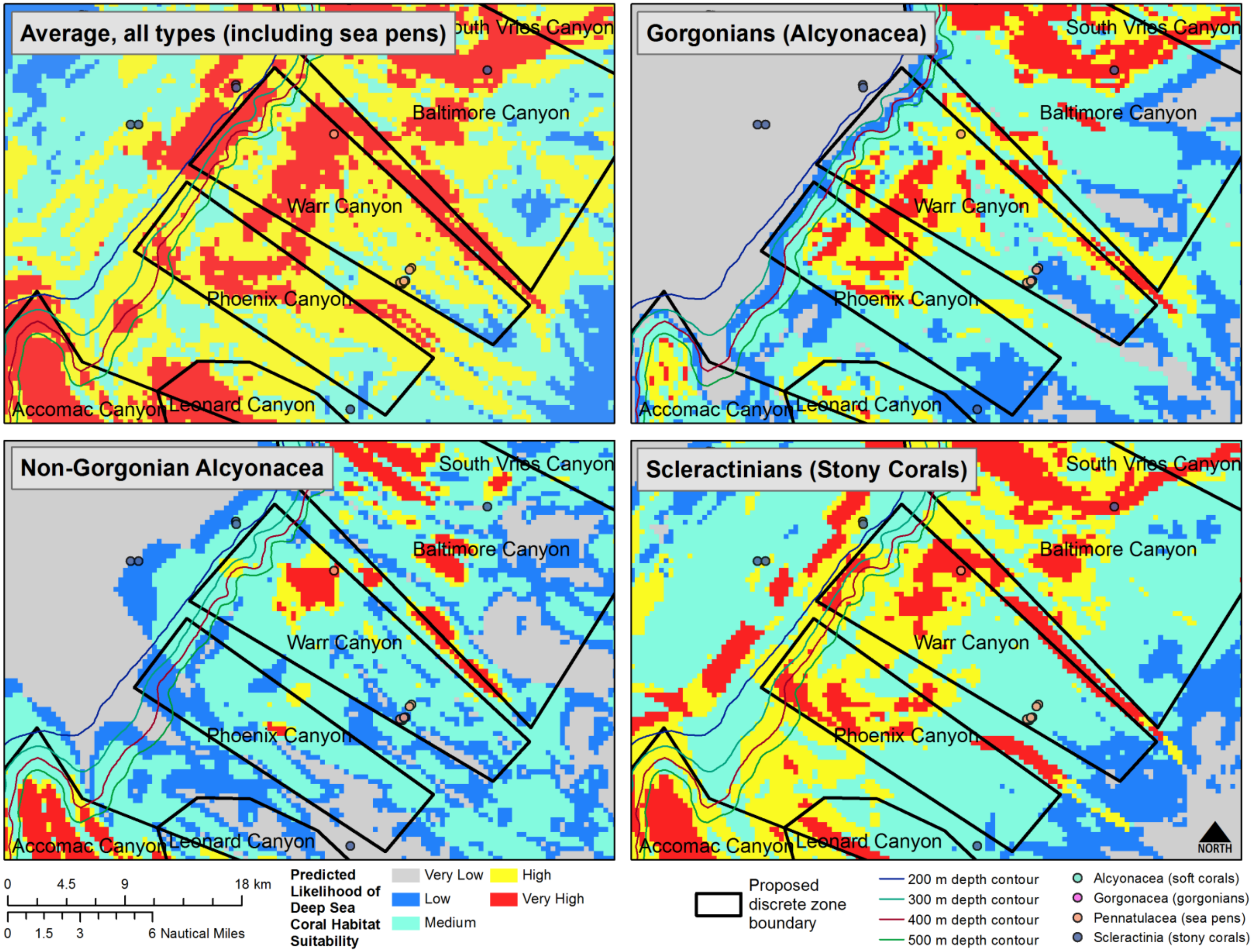

Figure 8: Model-predicted likelihood of deep sea coral habitat suitability for Phoenix and Warr Canyons. Source: Kinlan et al. 2013.

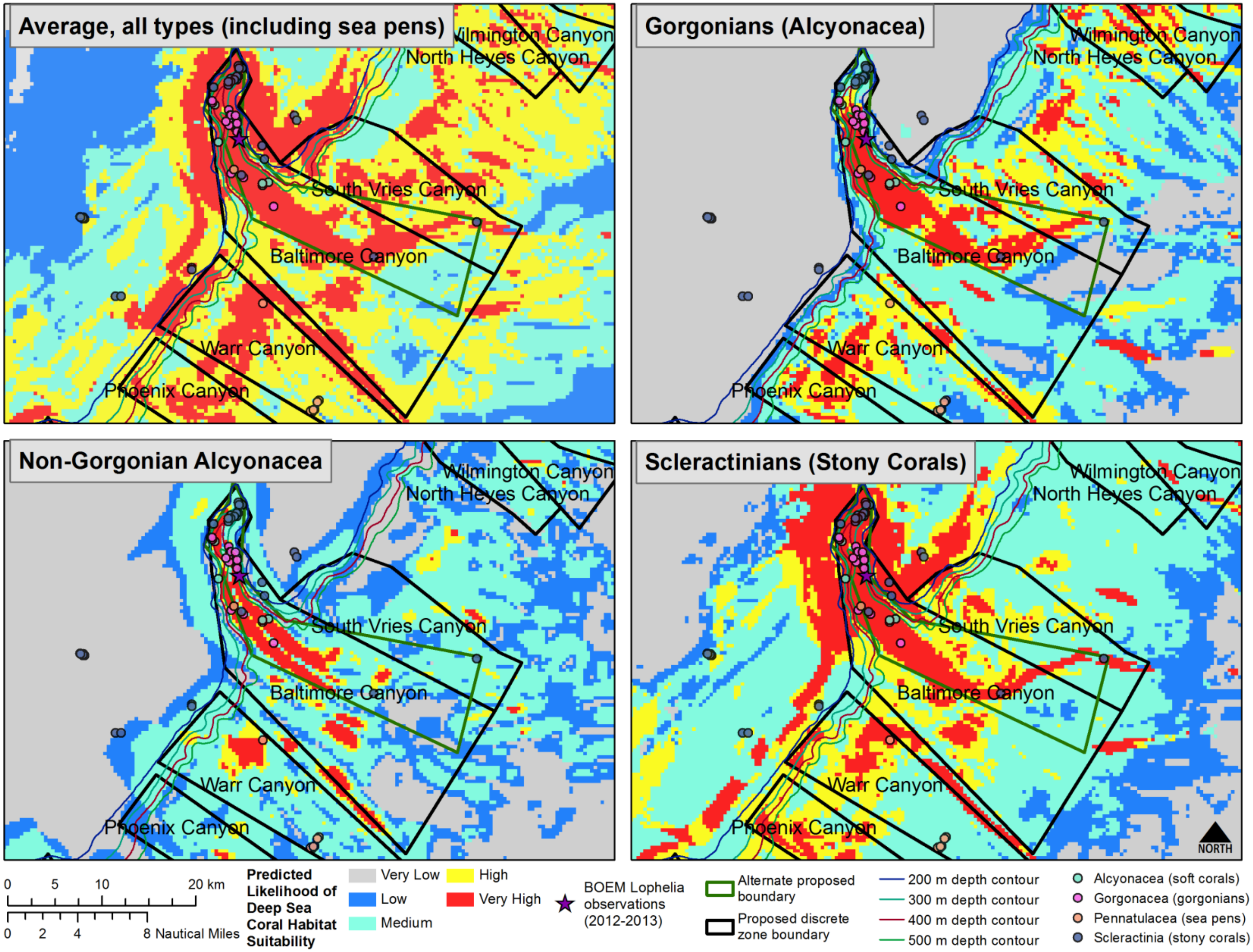

Figure 9:Model-predicted likelihood of deep sea coral habitat suitability for Baltimore and South Vries Canyons. Source: Kinlan et al. 2013.

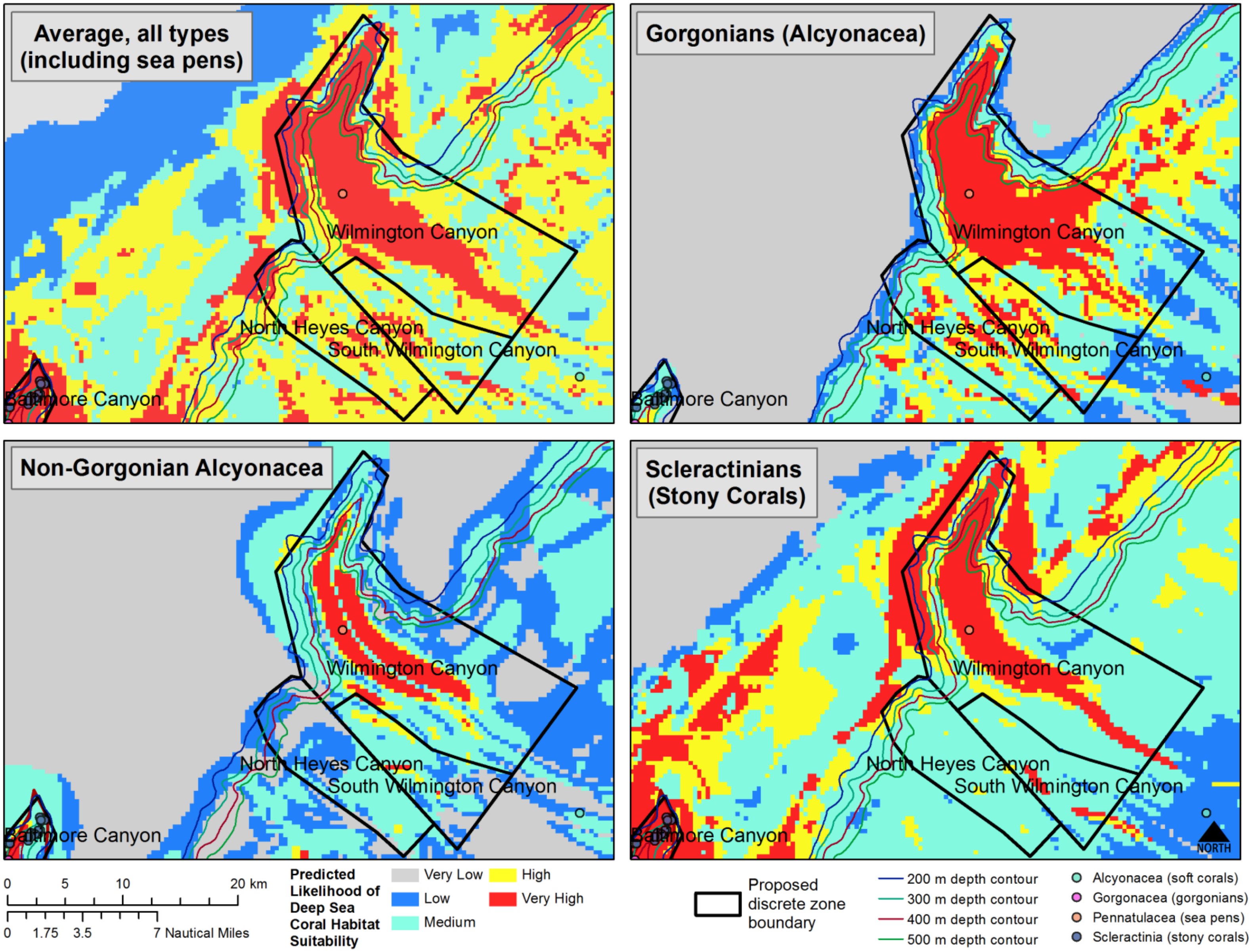

Figure 10: Model-predicted likelihood of deep sea coral habitat suitability for North Heyes, South Wilmington, and Wilmington Canyons. Source: Kinlan et al. 2013.

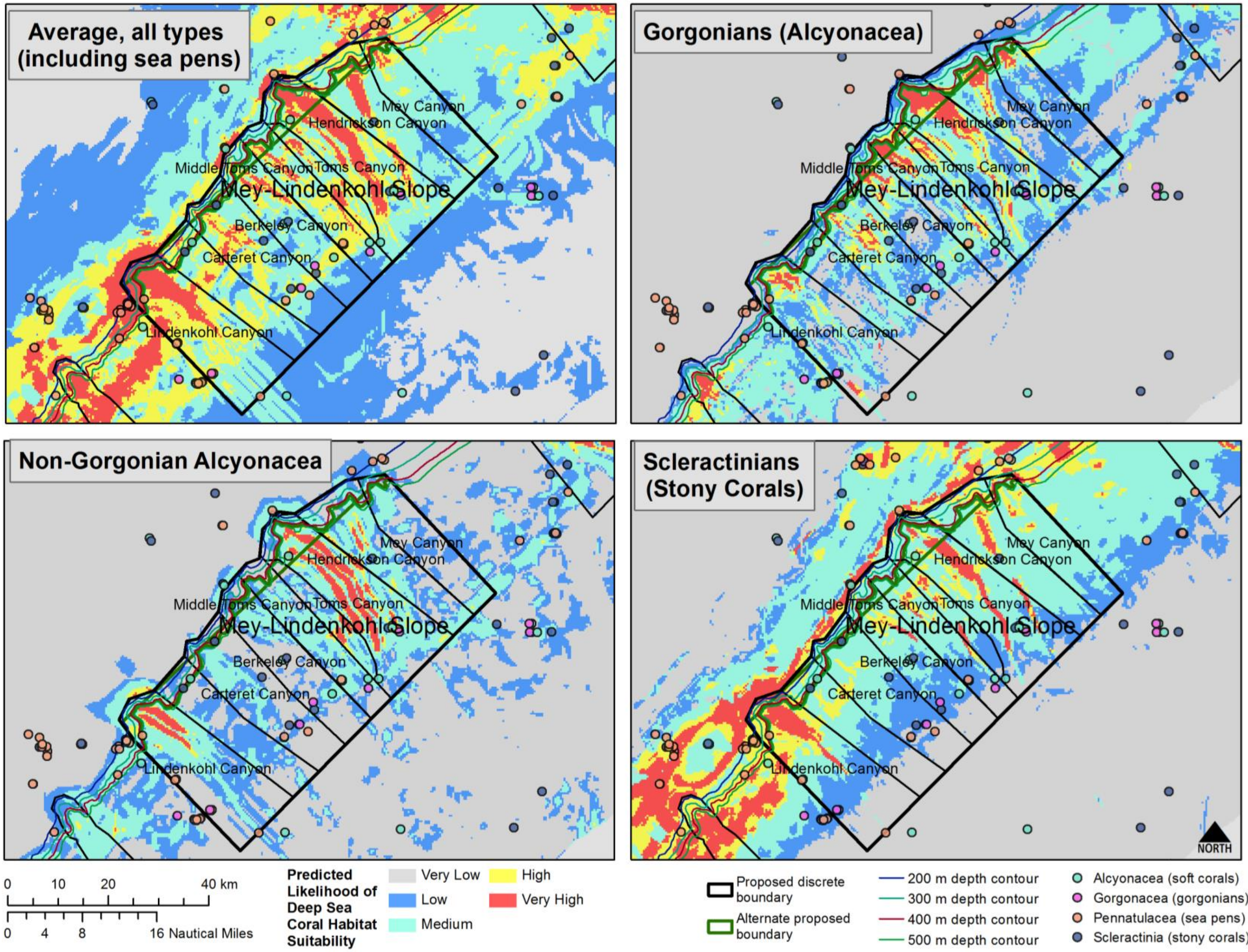

Figure 11: Model-predicted likelihood of deep sea coral habitat suitability for Mey-Lindenkohl Slope, and canyons within, including Lindenkohl, Carteret, Berkeley, Middle Toms, Toms, Hendrickson, and Mey Canyons. Source: Kinlan et al. 2013.

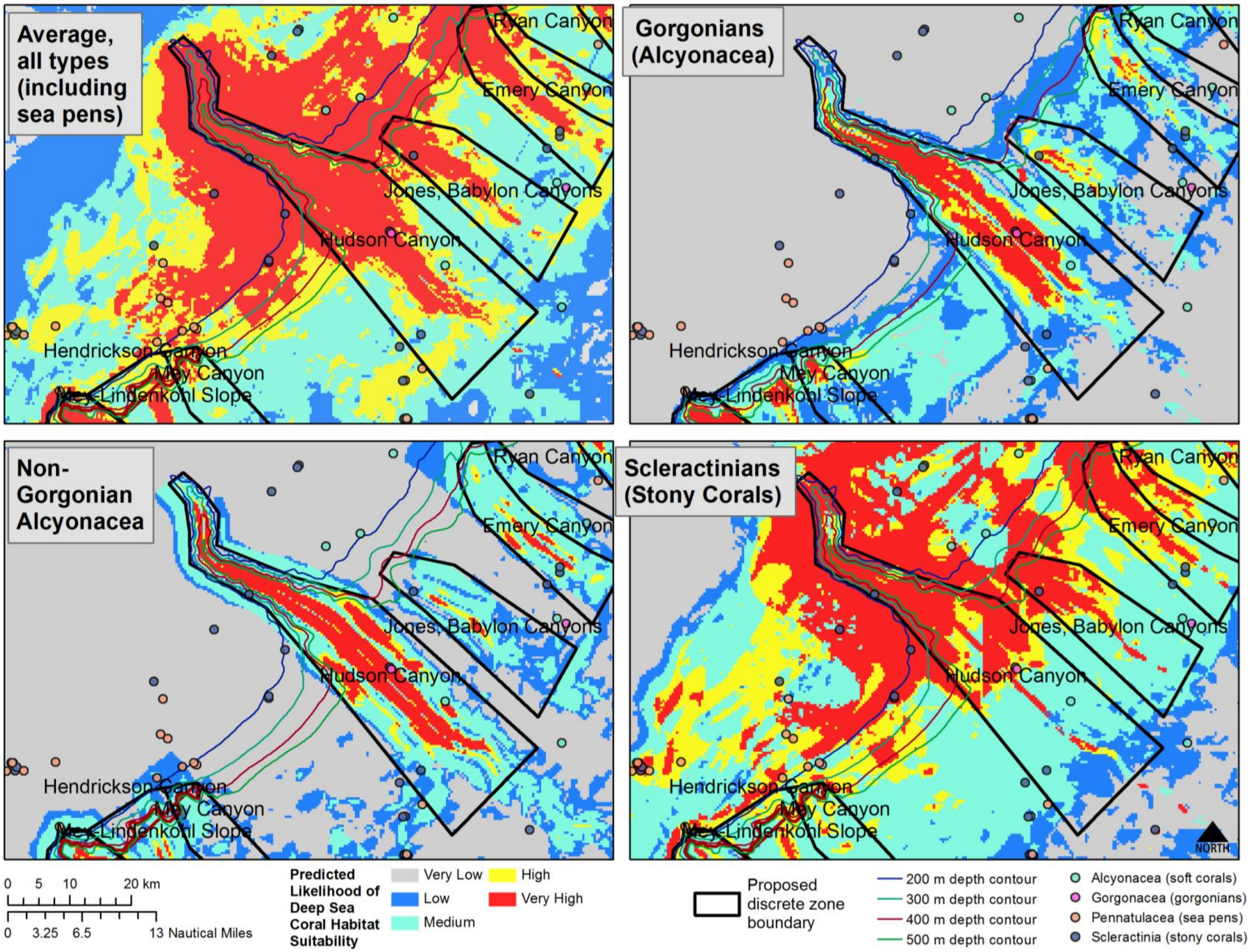

Figure 12: Model-predicted likelihood of deep sea coral habitat suitability for Hudson and Babylon/Jones Canyons. Source: Kinlan et al. 2013.

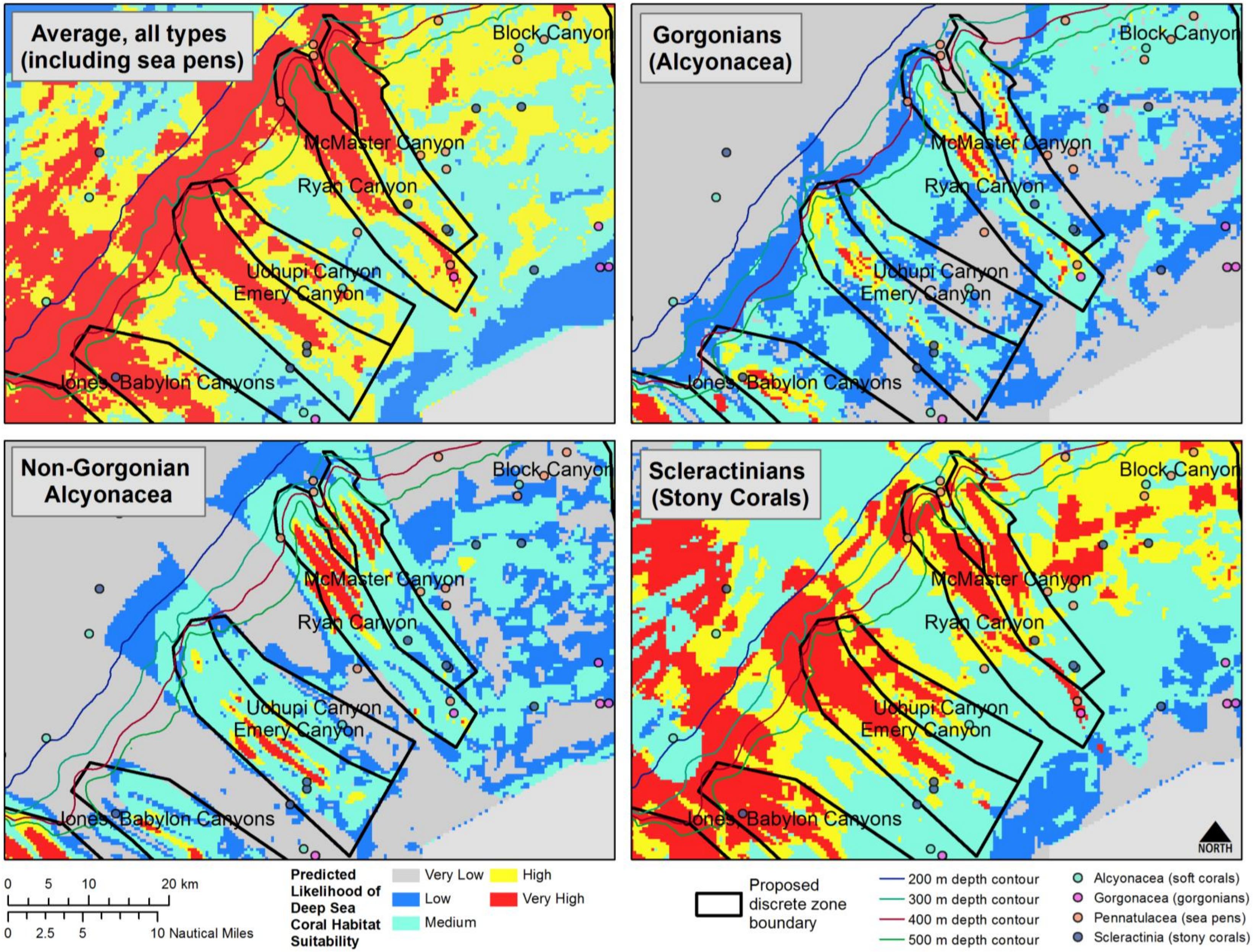

Figure 13: Model-predicted likelihood of deep sea coral habitat suitability for Emery, Uchupi, Ryan, and McMaster Canyons. Source: Kinlan et al. 2013.

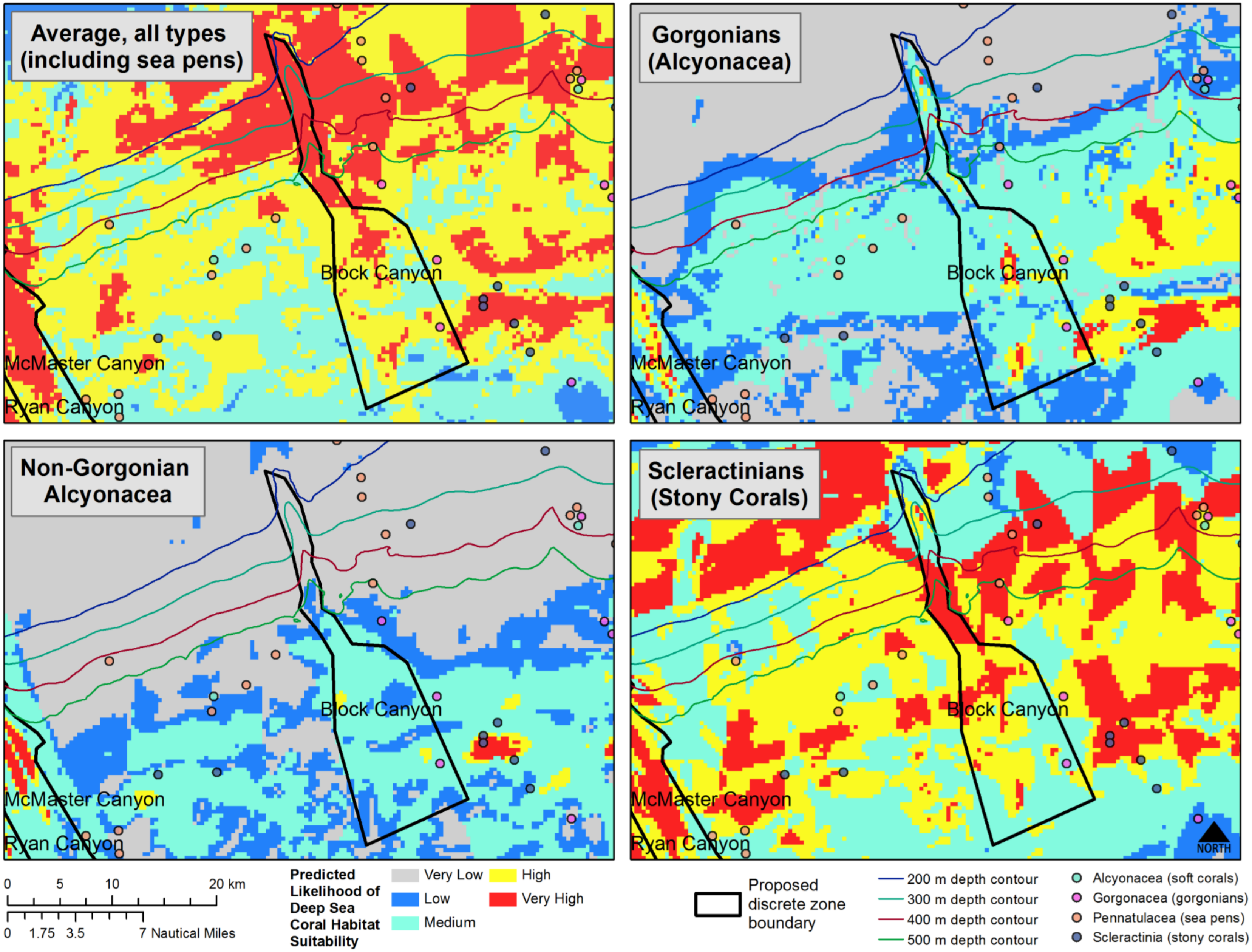

Figure 14: Model-predicted likelihood of deep sea coral habitat suitability for Block Canyon. Source: Kinlan et al. 2013.

Table 9: Percent of canyon area in each likelihood class for habitat suitability; all coral types (average).

	Predicted likelihood of habitat suitability for ALL TYPES					
Canyon	**Very Low**	**Low**	**Medium**	**High**	**Very High**	**Total canyon Area (km^2)**
Block Canyon	0%	1%	25%	47%	27%	195
McMaster Canyon	0%	0%	19%	35%	45%	156
Ryan Canyon	0%	0%	12%	36%	52%	194
Uchupi Canyon	0%	2%	29%	50%	19%	149
Emery Canyon	0%	1%	22%	44%	33%	400
Jones, Babylon Canyons	0%	4%	41%	26%	29%	325
Hudson Canyon	0%	1%	25%	20%	54%	871
Mey-Lindenkohl Slope *(Original)*	0%	13%	46%	29%	13%	2728
Mey-Lindenkohl Slope *(Alternate; Straight line)*	0%	14%	46%	28%	12%	2445
Mey-Lindenkohl Slope *(Alternate; Depth-based)*	0%	14%	46%	28%	12%	2460
Mey Canyon	0%	18%	64%	15%	3%	241
Hendrickson Canyon	0%	9%	60%	21%	10%	316
Toms Canyon	0%	3%	42%	31%	24%	577
Middle Toms Canyon	0%	1%	46%	41%	12%	104
South Toms Canyon	0%	10%	45%	38%	7%	236
Berkeley Canyon	0%	21%	49%	23%	6%	302
Carteret Canyon	0%	20%	48%	27%	5%	355
Lindenkohl Canyon	0%	9%	30%	36%	25%	447
Spencer Canyon	0%	7%	24%	42%	27%	205
Wilmington Canyon	0%	0%	24%	35%	40%	377
South Wilmington Canyon	0%	0%	37%	52%	12%	73
North Heyes Canyon	0%	0%	26%	58%	16%	94
South Vries Canyon	0%	1%	21%	46%	32%	175
Baltimore Canyon *(Original)*	0%	3%	25%	35%	36%	431
Baltimore Canyon *(Alternate)*	0%	1%	21%	25%	52%	221
Warr Canyon	0%	3%	14%	52%	30%	189
Phoenix Canyon	0%	1%	21%	60%	19%	145
Leonard Canyon	0%	0%	30%	36%	33%	137
Accomac Canyon	0%	0%	18%	37%	45%	402
Washington Canyon	0%	20%	60%	13%	7%	816
Norfolk Canyon *(Original)*	3%	34%	39%	15%	8%	894
Norfolk Canyon *(Alternate)*	0%	27%	45%	16%	11%	598

Table 10: Percent of canyon area in each likelihood class for habitat suitability of Gorgonians (Alcyonacea).

	Predicted likelihood of habitat suitability for GORGONIAN ALCYONACEANS					
Canyon	**Very Low**	**Low**	**Medium**	**High**	**Very High**	**Total canyon Area (km^2)**
Block Canyon	5%	14%	68%	9%	4%	195
McMaster Canyon	19%	22%	47%	9%	3%	156
Ryan Canyon	10%	18%	51%	16%	5%	194
Uchupi Canyon	40%	29%	27%	4%	0%	149
Emery Canyon	25%	28%	36%	9%	1%	400
Jones, Babylon Canyons	36%	20%	32%	9%	3%	325
Hudson Canyon	16%	16%	30%	11%	27%	871
Mey-Lindenkohl Slope	19%	27%	39%	9%	6%	2728
Mey-Lindenkohl Slope *(Alternate; Straight line)*	20%	28%	39%	8%	5%	2445
Mey-Lindenkohl Slope *(Alternate; Depth-based)*	19%	27%	38%	9%	7%	2460
Mey Canyon	14%	50%	29%	3%	3%	241
Hendrickson Canyon	12%	35%	38%	8%	6%	316
Toms Canyon	4%	23%	46%	15%	13%	577
Middle Toms Canyon	3%	19%	54%	16%	8%	104
South Toms Canyon	12%	17%	48%	12%	11%	236
Berkeley Canyon	24%	23%	40%	8%	5%	302
Carteret Canyon	17%	24%	45%	10%	4%	355
Lindenkohl Canyon	35%	24%	31%	7%	3%	447
Spencer Canyon	25%	17%	45%	5%	8%	205
Wilmington Canyon	2%	8%	31%	18%	40%	377
South Wilmington Canyon	1%	9%	42%	35%	14%	73
North Heyes Canyon	1%	9%	50%	25%	15%	94
South Vries Canyon	12%	12%	36%	30%	10%	175
Baltimore Canyon	12%	13%	41%	10%	24%	431
Baltimore Canyon *(Alternate)*	13%	7%	23%	16%	41%	221
Warr Canyon	7%	15%	39%	29%	10%	189
Phoenix Canyon	1%	19%	52%	18%	9%	145
Leonard Canyon	8%	19%	52%	18%	3%	137
Accomac Canyon	31%	20%	37%	11%	2%	402
Washington Canyon	51%	19%	19%	4%	7%	816
Norfolk Canyon	58%	8%	19%	6%	9%	894
Norfolk Canyon *(Alternate)*	55%	8%	17%	7%	12%	598

4.0 Fishery Effort Relative to Proposed Coral Zones

4.1 Northeast Fisheries Observer Program Data

Bottom Trawl Gear

Observer data from the Northeast Fisheries Observer Program (NEFOP) were obtained for bottom trawl gear for years 2000 through 2013, and subset to contain records within the MAFMC region only. Records with incomplete geographic coordinates were unable to be plotted and were removed (about 2% of trips; 4% of hauls). Within the MAFMC management region, there were 25,073 observed hauls (on 3,967 trips) using bottom trawl gear within this time period (Table 11; Figure 15).

Observer hauls were analyzed relative to proposed broad zone alternatives in an attempt to discern which fisheries are prosecuted beyond certain depth contours. Although observer overage varies by fishery and by year, aggregating the data over many years can reveal patterns in fishing effort with a higher degree of spatial accuracy than can be obtained using VTR data.

Tables 12-15 show the number of bottom trawl hauls intersecting each of the proposed broad coral zones, with associated number of trips and the average depth taken at the start of each haul. Note that the depth information is meant to provide an approximation of the depth at which these fisheries are prosecuted, but may not provide a complete picture (especially for longer hauls), given that it is based on haul start location.

Hauls were analyzed by selecting those *intersecting* each broad zone, and not for those *completely within* the broad zone, thus, many records are duplicated across Tables 12-15 if they intersect more than one broad zone alternative. In the vicinity of the proposed coral zones, bottom trawl effort is concentrated along the continental shelf and shelf break, and at the heads of canyons (Figure 15). For observed bottom trawl hauls over this time period, 14% intersect the 200 meter broad zone, 6% intersect the 300 meter broad zone, 0.03% intersect the 400 meter broad zone, and 0.01% intersect the 500 m broad zone.

Table 11: All NEFOP observed bottom trawl hauls and trips, by gear type, within the Mid-Atlantic Council region from 2000-2013.

Gear Type	Number of trips	Number of hauls	Average Haul Start Depth
TRAWL,OTTER,BOTTOM,FISH	3,959	24,985	86 m (47 ftm)
TRAWL,OTTER,BOTTOM,SCALLOP	2	20	51 m (28 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	6	68	340 m (186 ftm)
Total	**3,967**	**25,073**	**87 m (48 ftm)**

Table 12: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by gear type and target species, intersecting the 200 meter broad zone alternative, 2000-2013.

200 meter broad zone			
Gear Type; Target Species	**Number of trips**	**Number of hauls**	**Average Haul Start Depth**
TRAWL,OTTER,BOTTOM,FISH	**637**	**3,414**	**199 m (109 ftm)**
DORY, BUCKLER (JOHN)	--	4	233 (128 ftm)
FLOUNDER, SUMMER (FLUKE)	--	67	109 m (60 ftm)
GROUNDFISH, NK	--	18	262 m (143 ftm)
HAKE, RED (LING)	--	1	256 m (140 ftm)
HAKE, SILVER (WHITING)	--	245	279 m (152 ftm)
MACKEREL, ATLANTIC	--	2	118 m (65 ftm)
MACKEREL, CHUB	--	2	134 m (73 ftm)
MONKFISH (GOOSEFISH)	--	449	267 m (146 ftm)
SCUP	--	32	133 m (73 ftm)
SEA BASS, BLACK	--	20	100 m (55 ftm)
SKATE, LITTLE	--	2	51 m (28 ftm)
SQUID, ATL LONG-FIN	--	1,257	163 m (89 ftm)
SQUID, NK	--	23	152 m (83 ftm)
SQUID, SHORT-FIN	--	1,248	199 m (109 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	46	362 m (198 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**6**	**67**	**343 m (188 ftm)**
HAKE, SILVER (WHITING)	--	15	338 m (185 ftm)
MONKFISH (GOOSEFISH)	--	3	316 m (173 ftm)
SHRIMP, PANDALID (NORTHERN)	--	9	353 m (193 ftm)
SHRIMP, ROYAL RED	--	31	344 m (188 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	9	350 m (191 ftm)
Grand Total	**643**	**3,481**	**202 m (110 ftm)**

Table 13: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by gear type and target species, intersecting the 300 meter broad zone alternative, 2000-2013.

300 meter broad zone			
Gear Type; Target Species	**Number of trips**	**Number of hauls**	**Average Haul Start Depth**
TRAWL,OTTER,BOTTOM,FISH	**432**	**1,486**	**217 m (119 ftm)**
DORY, BUCKLER (JOHN)	--	1	227 m (124 ftm)
FLOUNDER, SUMMER (FLUKE)	--	31	101 m (55 ftm)
GROUNDFISH, NK	--	7	289 m (158 ftm)
HAKE, SILVER (WHITING)	--	121	323 m (177 ftm)
MACKEREL, CHUB	--	1	144 m (79 ftm)
MONKFISH (GOOSEFISH)	--	172	323 m (176 ftm)
SCUP	--	11	126 m (69 ftm)
SEA BASS, BLACK	--	13	91 m (50 ftm)
SKATE, LITTLE	--	1	51 m (28 ftm)
SQUID, ATL LONG-FIN	--	441	162 m (88 ftm)
SQUID, NK	--	5	147 m (81 ftm)
SQUID, SHORT-FIN	--	640	207 m (113 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	42	371 m (203 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**6**	**67**	**343 m (188 ftm)**
HAKE, SILVER (WHITING)	--	15	338 m (185 ftm)
MONKFISH (GOOSEFISH)	--	3	316 m (173 ftm)
SHRIMP, PANDALID (NORTHERN)	--	9	353 m (193 ftm)
SHRIMP, ROYAL RED	--	31	344 m (188 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	9	350 m (191 ftm)
Grand Total	**438**	**1,553**	**222 m (122 ftm)**

Table 14: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by gear type and target species, intersecting the 400 meter broad zone alternative, 2000-2013.

400 meter broad zone			
Gear Type; Target Species	**Number of trips**	**Number of hauls**	**Average Haul Start Depth**
TRAWL,OTTER,BOTTOM,FISH	**272**	**627**	**221 m (121 ftm)**
FLOUNDER, SUMMER (FLUKE)	--	19	91 m (50 ftm)
HAKE, SILVER (WHITING)	--	63	348 m (190 ftm)
MONKFISH (GOOSEFISH)	--	56	378 m (207 ftm)
SCUP	--	7	126 m (69 ftm)
SEA BASS, BLACK	--	10	86 m (47 ftm)
SQUID, ATL LONG-FIN	--	166	158 m (86 ftm)
SQUID, NK	--	1	106 m (58 ftm)
SQUID, SHORT-FIN	--	291	208 m (113 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	14	395 m (216 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**5**	**13**	**357 m (195 ftm)**
HAKE, SILVER (WHITING)	--	3	343 m (188 ftm)
SHRIMP, PANDALID (NORTHERN)	--	3	397 m (217 ftm)
SHRIMP, ROYAL RED	--	5	345 m (189 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	2	348 m (191 ftm)
Grand Total	**277**	**640**	**225 m (123 ftm)**

Table 15: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by gear type and target species, intersecting the 500 meter broad zone alternative, 2000-2013.

500 meter broad zone			
Gear Type; Target Species	**Number of trips**	**Number of hauls**	**Average Haul Start Depth**
TRAWL,OTTER,BOTTOM,FISH	**170**	**299**	**192 m (105 ftm)**
FLOUNDER, SUMMER (FLUKE)	--	13	81 m (44 ftm)
HAKE, SILVER (WHITING)	--	12	341 m (186 ftm)
MONKFISH (GOOSEFISH)	--	9	338 m (185 ftm)
SCUP	--	6	123 m (67 ftm)
SEA BASS, BLACK	--	10	86 m (47 ftm)
SQUID, ATL LONG-FIN	--	95	157 m (86 ftm)
SQUID, NK	--	1	106 m (58 ftm)
SQUID, SHORT-FIN	--	153	212 m (116 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**1**	**1**	**349 m (191 ftm)**
SHRIMP, ROYAL RED	--	1	349 m (191 ftm)
Grand Total	**171**	**300**	**192 m (105 ftm)**

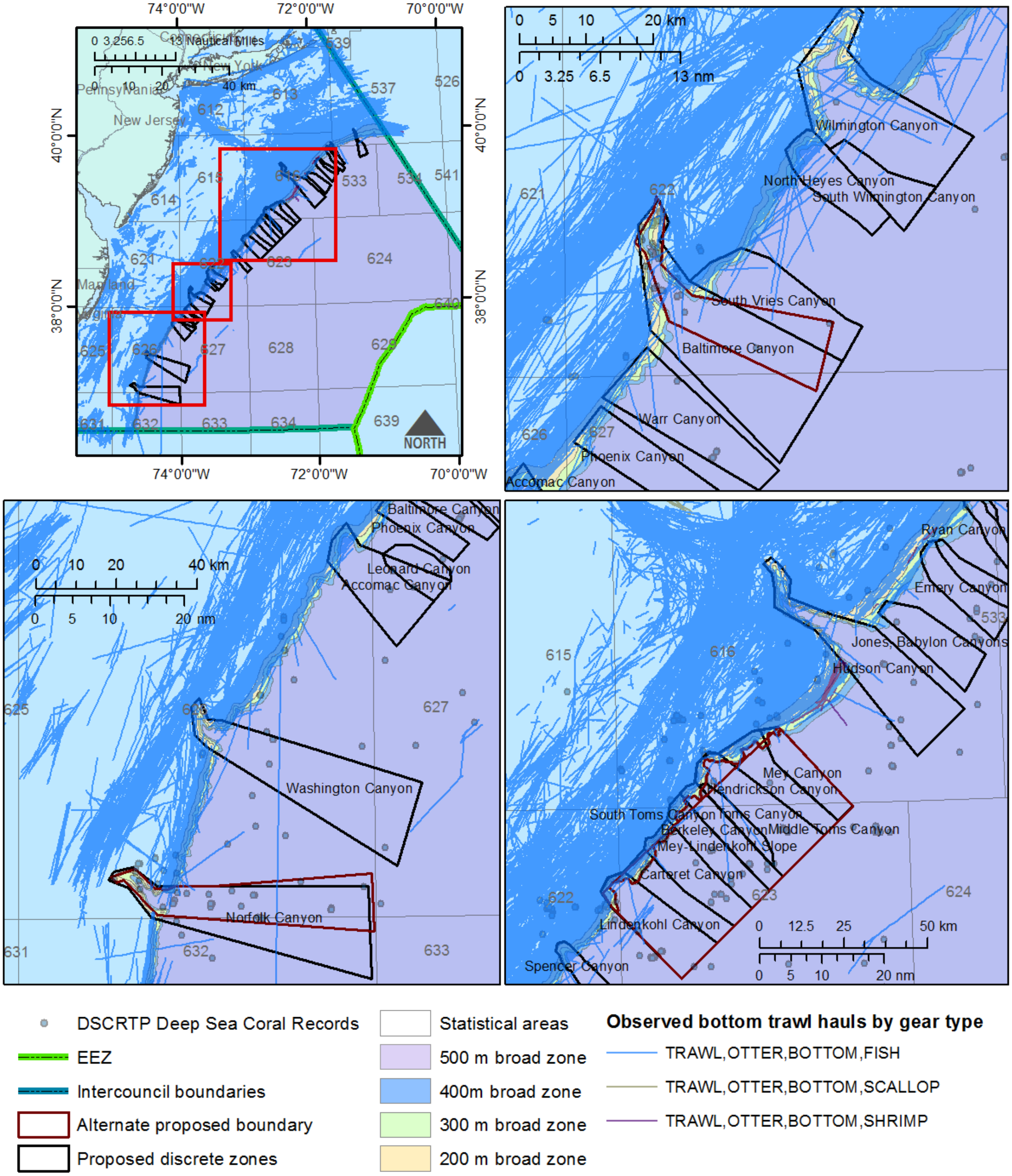

Figure 15: NEFOP observed bottom trawl hauls in the mid-Atlantic region by gear type, 2000-2013.

Gillnet Gear

Observer data indicate that in the Northeast Region from 2000-2013, there were 63,494 observed hauls (on 14,160 trips) using gillnet gear. Geographic coordinates for gillnet set location were present for only about 33% of the records in the database; therefore, haul coordinates were analyzed. Records with incomplete geographic location for haul were removed (6% of hauls; 4% of trips).

Within the MAFMC region, there were 13,928 observed hauls using gillnet gear, on 3,432 trips (Table 16a). Of these observed hauls, only six intersected any of the proposed coral zones (0.0004%). All six of these were hauls targeting monkfish using sink gillnets in 2004. These hauls occurred on two trips northeast of Block Canyon along the 300 meter depth contour (Figure 16).

The vast majority of observed gillnet effort since 2000 has occurred in waters significantly shallower than the depths of any of the proposed coral zones in the mid-Atlantic (Table 16). Only about 0.006% of observed gillnet trips and 0.005% of observed gillnet hauls occurred deeper than 75 fathoms (137 meters), according to haul depth information recorded in the observer data.

Table 16: NEFOP Observer records of gillnet gear a) in the MAFMC region and b) intersecting proposed coral zones, 2000-2013.

a) Within MAFMC Region

Gear Type	Trips	Hauls	Average Haul Depth
GILL NET, ANCHORED-FLOATING, FISH	32	135	10 m (5 fathoms)
GILL NET, DRIFT-FLOATING, FISH	197	621	20 m (11 fathoms)
GILL NET, DRIFT-SINK, FISH	496	2,045	8 m (15 fathoms)
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	2,707	11,127	12 m (22 fathoms)
Total	**3,432**	**13,928**	**11 m (21 fathoms)**

b) Within proposed coral zones

Gear Type	Trips	Hauls	Average Haul Depth
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	2	6	282 m (154 fathoms)
Total	**2**	**6**	**282 m (154 fathoms)**

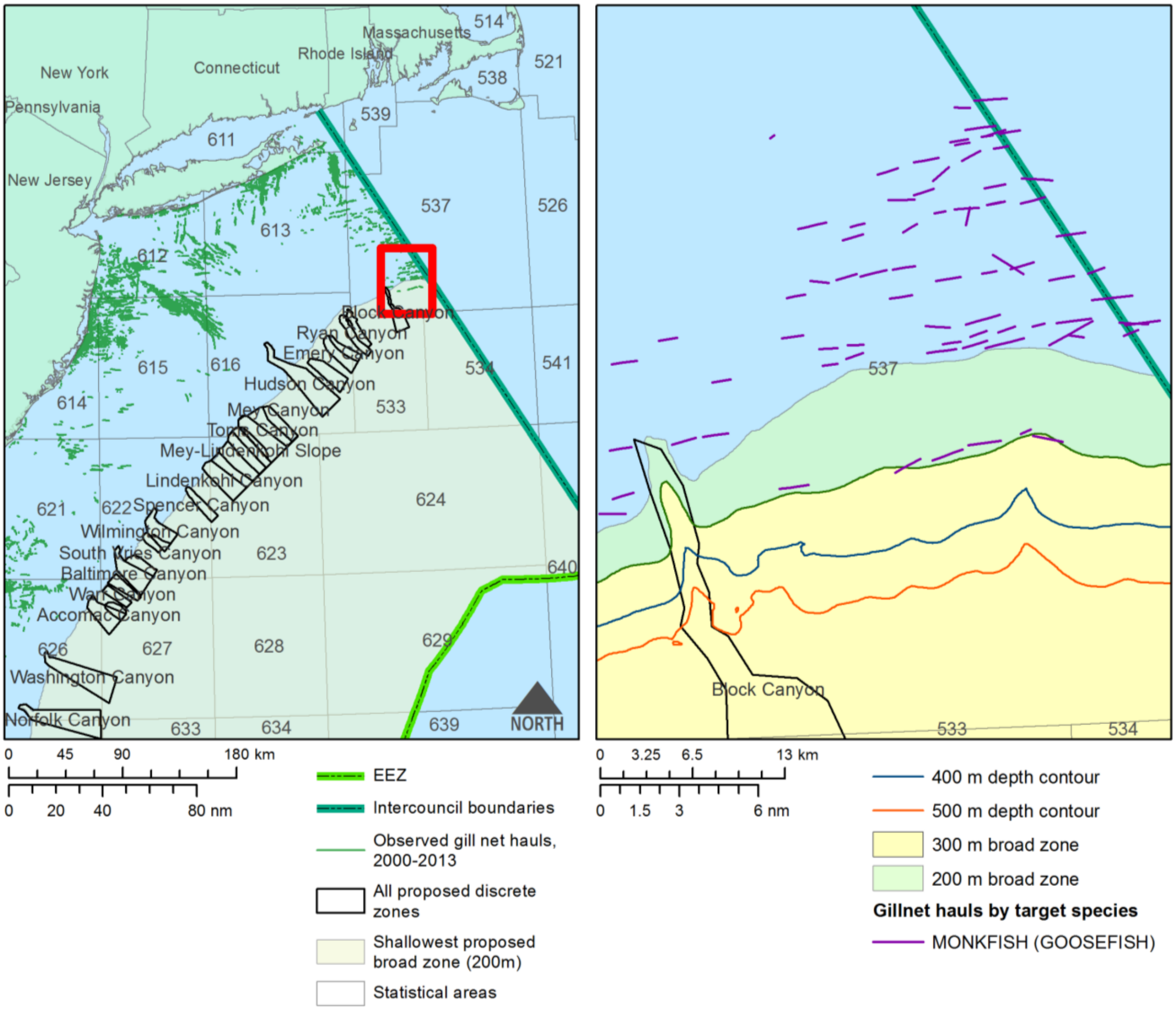

Figure 16: NEFOP observer hauls for gillnet gear in the mid-Atlantic, 2000-2013, and area of intersection with proposed MAFMC broad coral zones.

Bottom Longline Gear

For years 2000-2013, a total of 885 trips and 4,791 hauls using bottom longline gear were recorded for the Northeast Region in the NEFOP database. The majority of these records occurred within the management region of the New England Fishery Management Council, and primarily targeted Atlantic cod, haddock, and other groundfish. Records with missing or incomplete geographic coordinates were unable to be plotted and were removed (about 1% of trips; 8% of hauls).

Within the MAFMC region, a total of 130 hauls using bottom longline gear were recorded in the observer data for 2000-2013. All of these records indicated tilefish as the target species, and occurred in northern areas of the MAFMC management region between 2004 and 2008 (Table 16; Figure 17).

In total, the proposed coral zones are intersected by most of these observed longline trips occurring within the MAFMC region (92%), but only about half of the hauls (53%). At the 300 meter broad zone, the number of observed trips within proposed zones drops to 4. Only one trip extends into the 400 meter and 500 meter broad zones (Figure 17). This would suggest that longline effort in these areas tends to be concentrated around the 200 meter depth contour or shallower at the heads of the canyons; however, given the limited sample size for this dataset, other fishery effort data should be consulted.

Table 17: NEFOP Observer data records of hauls using bottom longline gear from 2000-2013 a) in the MAFMC region, and b) within proposed coral zones.

a) Within MAFMC Region

Gear Type, Target Species	Trips	Hauls	Average Haul Depth
LONGLINE, BOTTOM			
TILEFISH, GOLDEN	10	98	180 m (99 ftm)
TILEFISH, NOT KNOWN	3	32	166 m (91 ftm)
Grand Total	**13**	**130**	**177 m (97 ftm)**

b) Within proposed coral zones

Gear Type, Target Species	Trips	Hauls	Average Haul Depth
LONGLINE, BOTTOM			
TILEFISH, GOLDEN	10	54	205 m (112 ftm)
TILEFISH, NOT KNOWN	2	15	195 m (106 ftm)
Grand Total	**12**	**69**	**203 m (111 ftm)**

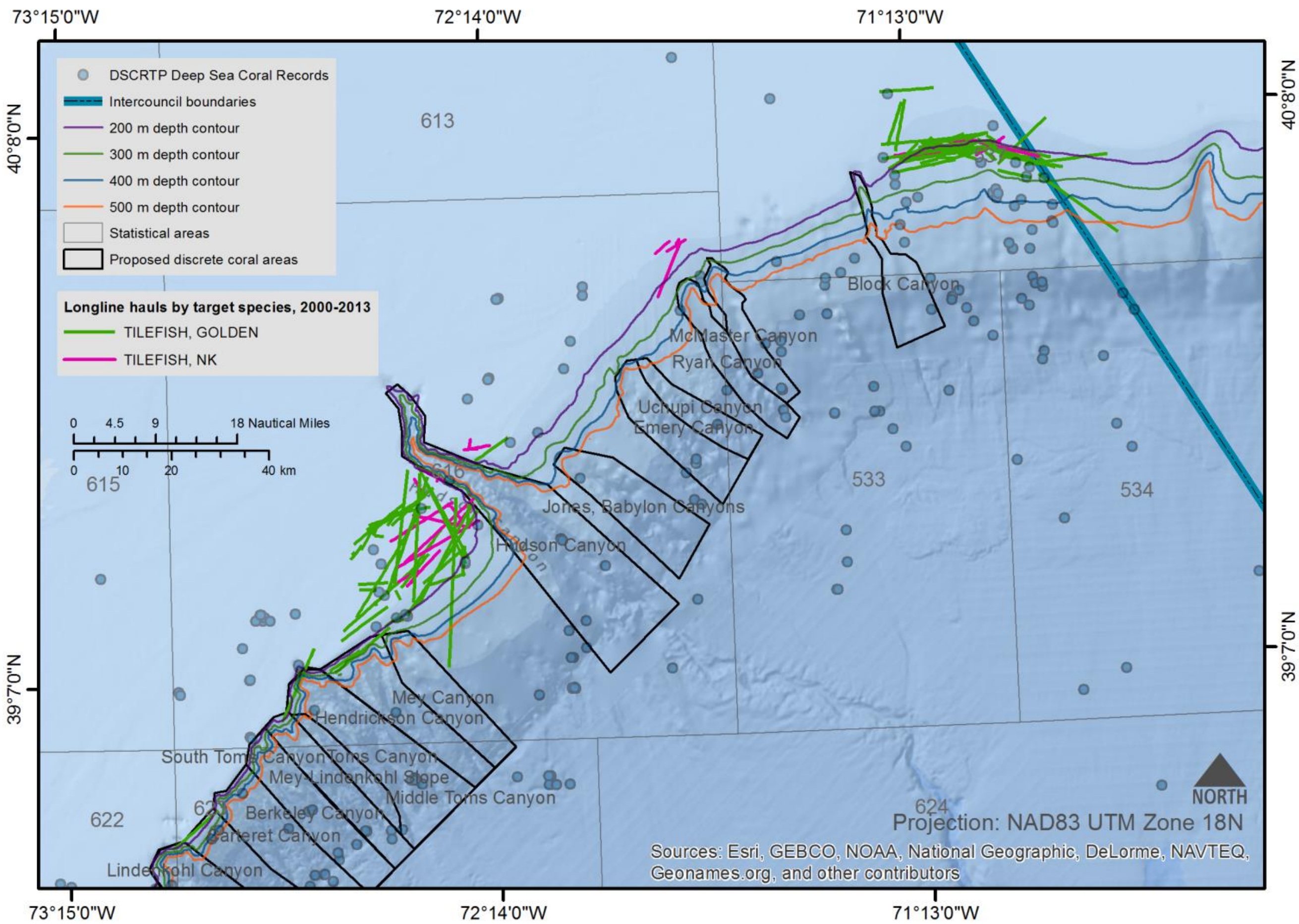

Figure 17: Observed bottom longline hauls in the MAFMC region, 2000-2013.

4.2 VTR and VMS Data

In addition to observer data, the FMAT plans to assess fishing effort relative to proposed coral zones using Vessel Trip Report (VTR) and Vessel Monitoring System (VMS) data, primarily using two products from the Northeast Fisheries Science Center. These include:

1) A VTR-based revenue mapping model that takes into account uncertainty around reported VTR points. This model can be used to identify areas important to specific fishing communities, species, gears, and seasons to establish a baseline of commercial fishing effort.

2) A VMS-based fishery effort model. This is a statistical model that predicts the probability that a vessel is fishing or not at a given VMS poll, with an associated confidence interval. From this data, effort density maps can be created which can be compared to the proposed coral zone alternatives.

At the time of this writing, these products are being finalized and are not yet available in their entirety to the FMAT for analyses. The FMAT is working with Science Center staff to use these products as they become available (expected to be within the month of April 2014).

5.0 Vulnerability of Corals to Fishing Gear Impacts

The following is a review of research studies concerned with the impacts of commercial fishing on deepwater corals and coral reefs. This review was completed by the New England Fishery Management Council's Habitat Plan Development Team for their document "Deep Sea Corals of the Northeast Region: Species, Habitats and Proposed Coral Zones, and Vulnerability to Fishing Impacts.".[8]

The literature describing impacts of fishing on deepwater corals addresses several gear types as well as study locations. While the studies sites cover a variety of locations globally, the impacts of commercial fishing on the local corals and seafloor are virtually identical throughout the literature. The disturbances seen ranged from scarring left by trawl gear, to complete destruction of coral and stripping of the seafloor to underlying rock. The surviving coral in fished areas was often located on undesirable fishing terrain, or at depths not targeted by fishermen.

The conclusions drawn by these studies are that commercial fishing gear damages deep-sea corals. Trawling, specifically, is very detrimental to coral and the seafloor. The level of damage between trawled and untrawled sites is large enough to conclude that fishing has a negative impact on both the corals and the associated fauna. The substrates of heavily fished areas have been stripped to bare rock or reduced to coral rubble and sand, whereas unfished and lightly fished areas did not see such degradation (Grehan et al 2005). Passive gear, such as pots or longlines, while still affecting localized area of corals, were not as destructive as trawl gear. Coral mortality is markedly increased due to corals being crushed, buried and wounded by gear as it is dragged over the bottom (Fosså et al 2002). The degree of disturbance to the coral and seafloor ranges from lightly disturbed areas of overturned cobble with attached, living, coral, to complete stripping of the seafloor (Stone 2006).

The deep water reefs attract fauna and promote areas of high diversity in an otherwise low diversity area. Fishermen have reported that as the damage to the reefs increase, areas that were once fertile fishing grounds have seen fewer successful fishing trips (Fosså et al 2002). The fauna associated with corals are primarily “removed” along with the destruction of the coral substrate.

While much of the coral on fishing grounds was damaged or destroyed, there were areas that avoided contact. As stated previously, corals growing on steep slopes have a natural protection from commercial fishing gear as a slope >20 degrees cannot be trawled. Areas of higher three-dimensional complexity were also relatively untouched, as these were avoided by the fishermen for fear of damage and loss of their gear.

The studies have concluded that deep water corals are especially fragile and the greatest disturbance and destruction occurs at depths targeted by commercial fishing (Heifetz et al 2009, Hall-Spencer et al 2002). Bottom contact gear is especially detrimental and there is a correlation between the highest rates of coral damage and the depths targeted by that industry in particular. Slow growth rates and reproductive processes that are so easily disrupted result in a timely recovery period of disturbed areas.

5.1 Study methods

Each of the study sites was observed using some form of photographic or continuous video transects. Several studies mapped the area using sidescan sonar (Wheeler et al 2005, Fosså et al 2002) or multibeam sonar in conjunction with a deep camera system (Althaus et al 2009, Grehan et al 2005). This technique allowed them to determine the damage caused by dragging gear over the seafloor.

The logs of fishing trips, reports from fishermen, and other literature on fishing activities at each of the areas, were utilized by a number of the studies from each of the different regions (Althaus et al 2009, Koslow et al

[8] Available at: http://nefmc.org/habitat/index.html

2001, Heifetz et al 2009, Fosså et al 2002, Cryer et al 2002). Anecdotal reports acted as a guide to further research areas, as well as providing information about to the history of fishing and practices in the area (Fosså et al 2002).

Samples were examined in three of the studies to determine the associated fauna in the area of the corals, as well as to assess the bycatch in commercial fisheries. One study (Cryer et al 2002) used previously collected and stored samples from other research trips to determine fauna of the area. Another (Hall-Spencer et al 2002) collected samples while accompanying two French trawlers on a fishing trip to examine commercial bycatch. A third study (Koslow et al 2001) used dredge, drop line with hooks, and traps to sample benthic, as well as motile, fauna associated with the corals.

5.2 Gear types evaluated

In reviewing the research there was frequently a lack of adequate gear descriptions being examined by each study, however, three papers gave a general description of what gears are commonly employed in each of the fisheries, as well as the gear used for research. While gear descriptions can be found via other sources, the variety of gear types as well as techniques used to fish them leaves much to be inferred when the only description provided by the researcher is that a “trawl” was used. A few studies were successful at providing gear descriptions, but the dimensions of gear size can vary and a universal description and size should not be assumed for all fishing effort with each gear type. It appears that the gear could be lumped into categories, based on door size and net width for the example of trawls, however larger boats are most likely going to pull larger gear, in theory causing more damage.

The best attempt at describing the gear associated with fishing impacts provided typical gear set up and use for deep water fishing using long-lines, gill nets, traps, and trawls. It stated that for long-lines 85 hooks were typically set 3m apart on a line, and 100-120 lines were often set out (averaging 8000-9600 hooks on 28-35km of line). Gill nets in the industry were 50m long x 12m high. These were worked in stings of 700 nets. Trawls were usually fitted with rockhopper gear and held open by otter boards weighing around 1000kg each, set at a distance of 60-70m apart. The trawls are then towed for about 4 hours at a around 5-8km/h (Grehan et al 2005).

There was only one study (Cryer et al 2002) that gave a short description of the gear in use, observing that the trawl doors were set at about 40m apart, but when towing (at 5.0-5.4 km/h) the net had an effective width of around 25m. It also mentioned the use of a “Florida Flyer” net (85mm mesh and 35mm mesh) set up between “Bison” doors being used in the trawl. This at least provides a starting point for researching further descriptions of the gear used during the study.

The gear used by two 38m commercial trawlers in another study (Hall-Spencer et al 2002) was briefly described, stating that both boats used trawls with rockhopper gear and 900kg otter boards, with the boards set at approximately 22m apart. The speed was the same 4.5-5.5 km/h towing speed that appeared to be the general towing speed mentioned for fishing, or camera-towed research.

5.3 Study Sites and Findings

The research area of the studies can be broken down into larger regions. Three of the studies took place in the southern Pacific Ocean. Two of these (Althaus et al 2009, Koslow et al 2001) focused on seamounts south of Tasmania while the other (Cryer et al 2002) examined the Bay of Plenty on the north shore of New Zealand.

On the Tasmanian seamounts, areas that had never been trawled, or were lightly fished (determined via trip logs), were dominated by the coral Solenosmilia variabilis, making up 89-99% of coral cover in never trawled areas (Althaus et al 2009) as well as seamounts peaking below 1400m (Koslow et al 2001). It was found that active trawling at sites removed most, or all, of the coral and associated substrate, leaving bare rock in heavily trawled areas, and coral rubble and sand at the lower limits of fishing activity (Koslow et al 2001). This was supported by photographic transects by Althaus et al (2009) showing coral in less than 2% of trawled areas. "Trawling ceased" areas, where trawling had effectively stopped 5-10 years earlier, showed coral in approximately 21% of the transects. This study also found a higher abundance of the faster growing hydroids colonizing cleared areas, smaller corals and octocorals, as well as noting whip-like chrysogorgiid corals which were flexible and could presumably bend and pass under the trawls.

Two studies (Heifetz et al 2009, Stone 2006) were focused in the northern Pacific Ocean around the Aleutian Islands. In these studies, longline gear was observed on 76% of transects, but were found to only result in 5% of the disturbed area. Trawling, on the other hand, was only seen at 28% of the transects, but disturbed 32.7% of the observed seafloor, indicating a relatively greater impact of trawls. Overall, 22 of the 25 transects showed disturbance to the seafloor (approximately 39% disturbance) (Stone 2006). This was supported by the second study in this region (Heifetz et al 2009) with evidence of trawling, indicated by uniform parallel striations in the seafloor, seen on several dives. Damage caused by traps was not statistically significant between the fished and unfished areas at this site. Both studies observed that the most damage done to corals and the seafloor occurred at depths where commercial fishing intensity was the highest (100-200m), with higher population densities occurring at 200-300m.

Four studies took place in the north-eastern Atlantic Ocean. Two examined the corals on raised carbonate mounds off the western (Grehan et al 2005) and northern coasts (Wheeler et al 2005) of Ireland. The third (Hall-Spencer et al 2002) focused on the West Ireland continental shelf break, and the last study (Fosså et al 2002) dealt with deep water reefs in Norwegian waters.

The observations made off the coasts of Ireland and Norway were both similar to, and supported, findings at the Aleutian Islands. Damage at the reefs (*Lophelia pertusa*) of Norway was most severe at shallower depths where commercial fishing primarily took place. The continental shelf, at approximately 200-400m (below the highest levels of fishing), had the highest abundance of corals. These corals were intact and developed, whereas the shallower sites contained crushed coral and coral rubble, where damages were estimated at 30-50%. Accounts from local fishermen claim this is due to the fact that often the gear, chains, and otter doors of trawlers were used to crush and clear the seafloor prior to the start of fishing (Fosså et al 2002).

Another study (Hall-Spencer et al 2002) found scars from trawl doors (indicated by parallel marks or furrows on the sea floor) that were up to 4km long, as well as coral rubble on trawled areas. Locations lacking observable trawl scars contain living, unbroken, L. pertusa. These findings were observed at the site off the northern coast of Ireland (Wheeler et al 2005) as well. Trawl marks were located on side scan sonar records, and video showed parallel marks left by trawl doors, as well as the net and ground line gear, on the seafloor. The amount of dead coral and coral rubble increased at sites that were obviously trawled.

The various study sites of Fosså et al (2002) presented a range of disturbance due to fishing. While the deeper water corals were intact and living at one site, almost all corals were crushed or dead at another. A third demonstrated multiple stages of coral degradation, from living to dead and crushed, as well as the base aggregate the reefs often form and grow on being crushed and spread out. The percent of damage to the area was correlated with the number of reports by the fishermen of fishing activity, bycatch, and corals in the area; ranging from 5-52% damaged. More of these reports from an area indicated a larger coral community at that location, and with that, higher proportions of the area were found to be damaged.

Hall-Spencer et al (2002) also noted that fishermen avoided uneven ground due to the loss of time and money from resulting gear upkeep of tangled and damaged gear. Areas of large coral bycatch were avoided in the future, as known trouble areas for the fishermen. Because of this only 5 of the 229 trawls in the study contained large amounts of coral bycatch. Thus, the areas where corals were present and undamaged tended to have a higher topographic complexity of the seafloor.

The effect of seafloor topography on fishing and the resulting impact on corals was observed in a study site west of Ireland (Grehan et al 2005). While evidence of active trawling was seen, indicated by trawl scars in mud and non-coral habitat, there was no damage to corals on the mounds observed caused by fishing. This was due to the fact that the slope of the mounds where coral growth occurred was greater than 20 degrees. This makes the terrain is too steep to trawl and the corals were naturally protected from the gear and relatively undamaged.

One of the studies (Mortensen and Buhl-Mortensen 2004) examined the distribution of corals in the Northeast Channel in the Gulf of Maine. This site could be similar to the sites off of Ireland and Norway, however because of the distance and somewhat different environmental factors it was considered a separate region. This study was concerned with the distribution of corals relative to the benthic habitat. It found that the corals were located on the shelf break and along valleys. This habitat was subject to daily tidal water movement into and out of the Gulf of Maine, aiding in the regulation of temperature, salinity, and food supply. Similar water movement is found on seamounts and shelf breaks, as currents flow over the change in topography, providing the corals with a regulated area in which to grow (Thiem et al 2006; Pires et al 2009).

5.4 Coral growth and recovery potential

The approximate growth rates of deepwater corals have been calculated in several studies on different species of corals. Oculina reefs occur in waters off the east coast of Florida. By observing these corals at 6m and at 80m it was found that the corals found at the deepwater (80m) site grew relatively more quickly (16.1 mm/yr) than the same corals at the 6m site (11.3 mm/yr). When transplanted from 6m to 80m the coral polyps lost their zooxanthellae and fed off the food supply provided by the colder deep currents containing more nutrients (Reed 2002).

Two studies done off Atlantic Canada worked at finding the growth rates for *Primnoa resedaeformis*. The corals were found at approximately 200-600m and were dated to 2600-2920 years old ± 50-60 years using C14 dating techniques. Using the dated age and size of the colony (~0.5-0.75m in height) the average radial growth at the base of the coral was found to be 0.44 mm/yr and tip extension growth rates were around 1.5-2.5 mm/yr (Risk et al 2002), slower than the estimated rate found for Oculina reefs.

The difference in growth rates calculated in these studies can potentially be explained by the other study working with *P. resedaeformis*, as well as *Paragorgia arborea*. The height of colonies ranged from 5-180cm for *P. arborea* (averaging 57cm) and 5-80cm for *P. resedaeformis* (averaging 29.5cm). The maximum age of samples collected was 61 years (found by counting annual growth rings under a dissecting microscope and x-ray examination). It estimated that the rate of growth for the first 30 years was around 1.8-2.2 cm/yr. After the coral began to age (>30 years), growth slowed to 0.3-0.7 cm/yr. This shows that initially the coral grows at a speed concurrent with the first study, and then dramatically slows to only a few millimeters a year, suggested by the second study (Mortensen and Buhl-Mortensen 2005). With a growth rate of, at most, a centimeter or two year, the complete destruction and clearing of the seafloor of corals can result in very long recovery time for both the coral, and associated fauna.

Deep water coral reproduction is a subject that has not been the topic of research until recently. While the physiology of reproduction in corals has been studied, little is known about the process of timing involved and the survival of resulting offspring. Studies have, however, shown that many of the deep water corals have separate sexes (Brooke and Stone 2007; Roberts et al 2006; Waller et al 2002; Waller et al 2005). Brooke and Stone (2007) collected samples of corals (Stylaster, Errinopora, Distichopora, Cyclohelia, and Crypthelia) around the Aleutian Islands and discovered that the collection held a mix of females containing mature eggs, developing embryos, and planulae, males producing spermatozoa, and organisms with no reproductive material. As was pointed out the gametes within the collection were not synchronized which indicates that reproduction is either continuous, or prolonged during a certain season of the year (Brook and Stone 2007).

Waller et al (2002) also found *Fungiacyathus marenzelleri* (collected from the Northeast Atlantic at 2200m) to be gonochoric, with a sex ratio of near 1:1. The fecundity of *F. marenzelleri* was calculated to be 2892 ± 44.4 oocytes per polyp. The mean diameter of oocytes did not vary significantly from month to month and all levels of sperm development were noted. The coral was thus considered quasi-continuous reproducers, with gametogenesis for spermacysts and oocytes occurring continuously as in Brooke and Stone (2007). An interesting finding of the study was that while *F. marenzelleri* has separate sexes, it can also undergo asexual reproduction and budding was present during the study. However, this was limited to no more than one bud found on any individual and no more than two individuals were found to bud at the same time (Waller et al 2002), not nearly the kind of reproductive rate to sustain a population in highly disturbed areas.

Fecundity and reproductive traits for three other corals collected in the Northeast Atlantic were also determined in a study by Waller et al (2005). *Caryophyllia ambrosia* (collected from 1100-1300m), C. cornuformis (from 435-2000m), and *C. seguenzae* (from 960-1900m) were all found to be cyclical hermaphroditic. The corals possessed both sexes but only one sex was dominant at a time, corals transitioning between sexes were seen in the study and labeled as "intermediates". The fecundity of the corals was calculated at 200-2750 oocytes per polyp for *C. ambrosia*, 52-940 oocytes per polyp for *C. seguenzae* and no data due to insufficient samples of *C. cornuformis*. As with the other studies there was no significant difference in the average number of oocytes per month and continuous reproduction is assumed for both C. ambrosia and *C. cornuformis* (Waller et al 2005).

The effects of mechanical disturbance and trauma to the soft coral *Gersemia rubiformis* (collected from the Bay of Fundy) was examined in a lab setting by Henry et al (2003). In the study, eight colonies of soft coral, four control and four experimental, were set up in separate aquariums to determine damage and recovery rate of the organisms. The experimental colonies were rolled over and crushed every two weeks to simulate bottom contact trawling. Four days and one week after disturbance observations were recorded. It was found that crushing the corals caused retraction of the entire colony. Damaged tissue was repaired and healed between 18 and 21 days. The effect the crushing had on coral reproduction was surprising to the researchers.

Thirteen days after the initial disturbance daughter colonies were seen forming at the base of the corals, and by the end of the experiment 100% of the corals had daughter colonies at one point during the study. The mortality rate of the juveniles was 100%, however, and no colonies survived past the polyp stage. Upon testing it was determined that these colonies were sexually derived, and since they had been separated for the experiment it is assumed that the corals were brooding when collected, as they were not visibly fertile prior to the experiment. It should be noted that the control group did not have any daughter colonies during the experiment, and only after (when they were experimentally also crushed) did daughter colonies appear. It is thought that the reason for this was the expulsion of premature planulae (resulting in their ultimate death) due to stress placed on the coral and the need to allocate resources to repair damaged tissue. While adult *G. rubiformis* was able to withstand the mechanical rolling and crushing, the increased mortality of offspring due to ejecting premature planulae may have increased long term effects as the corals are repeatedly disturbed and not able to produce surviving offspring (Henry et al 2003).

While the physiology of these corals has been recently studied, more research is needed to determine the ability of corals to recolonize disturbed areas. Brooke and Stone (2007) concluded that a lightly impacted area would be able to recover via colony growth alone. However, heavily impacted areas, where the seafloor has been scoured and stripped of cover would require coral larvae to be dispersed via currents and settle the area again, which could be a slow, timely process.

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