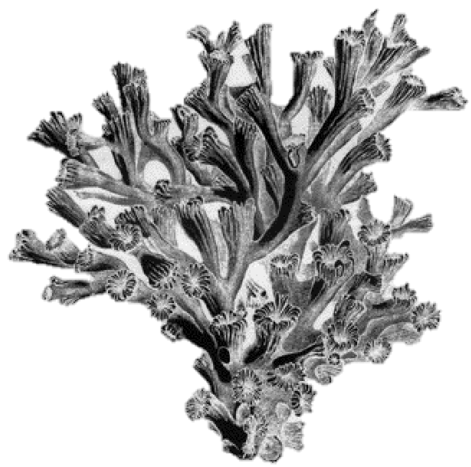
DEEP SEA CORALS AMENDMENT
TO THE ATLANTIC MACKEREL, SQUID, AND BUTTERFISH FISHERY MANAGEMENT PLAN

Measures to Protect Deep Sea Corals from Impacts of Fishing Gear

Public Information Document - **REVISED** as of 5/27/15



Prepared by the Mid-Atlantic Fishery Management Council
in cooperation with NOAA Fisheries

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

1.0 EXECUTIVE SUMMARY

Deep sea corals are fragile and slow-growing organisms that serve an important role in unique and diverse deep sea ecosystems. Given recent and historical findings of deep sea corals off the Mid-Atlantic Coast, the Mid-Atlantic Fishery Management Council (MAFMC or Council) initiated this Amendment in 2012 to consider measures to protect deep sea corals from the impacts of fishing gear. After reviewing initial public comments, the Council developed a range of alternatives and associated analyses. The Council will select from the alternatives described in this document at its June 2015 Council meeting. The Council will consider comments received during public hearings and a written comment period (comment summaries are available on the Council's website at www.mafmc.org). During the selection of alternatives, the Council can also modify the alternatives as long as sufficient information and rationale exists to support the final selected options.

The Council will then recommend the selected alternatives to NOAA Fisheries. Assuming the Council recommends some action alternatives, NOAA Fisheries will then publish a proposed rule along with an Environmental Assessment for public comment. After considering public comments on the proposed rule, NOAA Fisheries will publish a final rule with implementation details.

The purpose of this amendment is "to identify and implement measures that reduce, to the extent practicable, impacts of fishing gear on deep sea corals in the Mid-Atlantic region." The Council recognizes the value of deep sea corals and is exercising its authority under the reauthorized Magnuson-Stevens Act (MSA) to recommend management measures to minimize fishery impacts to deep sea corals in the Mid-Atlantic region. At the same time, the importance and value of commercial fisheries that operate in or near areas of deep sea coral habitat is also recognized by the Council. As such, measures in this amendment will be considered in light of their benefit to corals as well as the cost to commercial fisheries. The information presented in this document is designed to assist the public in commenting on the proposed measures and ultimately to support the Council in achieving an appropriate balance between protecting deep sea corals and minimizing negative economic impacts to fisheries.

Given this approach, this document first provides general background and describes the alternatives. It then describes the environment (including deep sea corals) and the fisheries that may be affected, and concludes with information about how corals and the relevant fisheries may be impacted by the alternatives under consideration.

The range of alternatives includes designations for "deep sea coral zones" in which fishing gear use would be restricted, including potential for both "broad" coral zones and "discrete" coral zones. Broad coral zones would consist of large, less heavily fished areas (especially the deeper broad zones) where measures would limit and prevent the expansion of commercial gear use. Discrete coral zones would consist of smaller areas of known coral presence or highly likely coral habitat. These areas primarily consist of offshore canyons or slope areas along the continental shelf edge.

The range of alternatives proposed in this document is associated with a range of potential impacts, both for deep sea corals and the relevant fisheries (Boxes ES-1 and ES-2). Generally, the more total area that is restricted and the more fishing activity that is restricted, the greater the predicted benefits are for corals. However, as more areas are restricted and more fishing activities are restricted, social and economic impacts to those who fish in these areas is also expected to increase.

Although some combinations of alternatives contained in this document would restrict current fishing activity in areas of high or highly likely coral presence, many of the alternatives, particularly the broad zone alternatives, are primarily precautionary in nature and are intended to protect corals from future expansion of fishing effort. Many deep sea corals exist in areas with some degree of natural protection from fishing gear, i.e., they inhabit areas where little or no fishing effort is currently taking place due to extreme depths or areas of very high seafloor slope. Corals also exist in some areas with hard bottom or structure that fishermen tend to avoid due to the potential for lost or damaged fishing gear. The coral protection zone alternatives proposed in this document would expand protections in and around some of these areas, as well as protect corals from expansion of effort into deeper water or areas of steeper slopes.

Additional alternative sets in this amendment include options to modify the Framework provisions of the Mackerel, Squid, and Butterfish (MSB) Fishery Management Plan (FMP), as well as the option to require use of Vessel Monitoring Systems (VMS) for *Illex* squid vessels. The impacts of these additional alternatives are expected to be primarily administrative in nature (Box ES-3).

Box ES-1. Summary comparison of the differences in Broad Coral Zone Alternatives in this amendment.

Issue	Alternatives	Main Differences in Alternatives
Broad Coral Zone Designation	Alternative 1A (No action/*Status Quo*)	No action. Neutral impacts expected (relative to *status quo*).
	Alternative 1B (Landward Boundary ~ 200 m Depth Contour)	*Size of Designation Area:* Largest (100,372 km^2); greatest number of coral records. *Impacts on Corals:* Designation alone affords some additional benefits/attention via project consultation by NMFS; greatest benefits. *Fishery Economic Impacts:* None (designation alone)
	Alternative 1C (Landward Boundary ~ 300 m Depth Contour)	*Size of Designation Area:* Second Largest (100,165 km^2) *Impacts on Corals:* Designation alone affords some additional benefits/attention via project consultation by NMFS; next to greatest benefits. *Fishery Economic Impacts:* None (designation alone)
	Alternative 1D (Landward Boundary ~ 400 m Depth Contour)	*Size of Designation Area:* Next to Smallest (99,218 km^2) *Impacts on Corals:* Designation alone affords some additional benefits/attention via project consultation by NMFS; next to least benefits. *Fishery Economic Impacts:* None (designation alone)
	Alternative 1E (Landward Boundary ~ 500 m Depth Contour)	*Size of Designation Area:* Smallest (98,444 km^2); smallest number of coral records *Impacts on Corals:* Designation alone affords some additional benefits/attention via project consultation by NMFS; least benefits. *Fishery Economic Impacts:* None (designation alone)

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<table>
<tr><th colspan="3">Box ES-1, continued. Summary comparison of the differences in Broad Coral Zone Alternatives in this amendment.</th></tr>
<tr><th>Issue</th><th>Alternatives</th><th>Main Differences in Alternatives</th></tr>
<tr><td rowspan="6">Broad Coral Zone Restrictions</td><td>Alternative 2A
(No action/Status Quo)</td><td>No action. Neutral impacts expected (relative to status quo).</td></tr>
<tr><td>Alternative 2B
(Prohibit All Bottom-tending Gear)</td><td>Impacts on Corals: Greatest positive impacts on corals by reducing potential for gear impacts the most (when compared to alts. 2C or 2D)
Fishery Economic Impacts: The larger the broad coral zone, the greater the impacts because of the number of historic hauls taken in the areas are greatest; impacts are expected to be greatest under this alternative (when compared to alts. 2C or 2D), because it prohibits the greatest numbers of gears and fisheries in the offshore fishing areas.

<u>Sub-option 2B-1: Exempt red crab fishery</u>
Fishery Economic Impacts: The larger the broad coral zone, the greater the impacts; primary gears impacted include bottom otter trawls, sea scallop dredges, crab pots and traps, lobster pots, and bottom longlines. Impacted species excluding red crab would be: longfin squid, Illex squid, sea scallops, summer flounder, silver hake (whiting), golden tilefish, Jonah crab, scup, and black sea bass.

<u>Sub-option 2B-2: Exempt golden tilefish fishery</u>
Fishery Economic Impacts: Impacts are similar to 2B-1, exempt the red crab fishery would be impacted, and the golden tilefish fishery would not.</td></tr>
<tr><td>Alternative 2C
(Prohibit Mobile Bottom-tending Gear)</td><td>Impacts on Corals: Smaller positive impacts to corals as just some gears are prohibited, although mobile gears are believed to have the greatest negative impact on corals.
Fishery Economic Impacts: Impacts similar to alternative 2B but traps, sink gillnets and bottom longlines would not be impacted.</td></tr>
<tr><td>Alternative 2D
(Require VMS for Vessels in Broad Coral Zones)</td><td>Impacts on Corals: Indirect slight positive impacts likely due to increased ability to enforce gear-restricted coral zones (if gear restriction alternatives are also selected).
Fishery Economic Impacts: Low fishery economic impacts; many vessels operating in these areas are already required to use VMS.</td></tr>
<tr><td>Alternative 2E (Allow transit with gear stowage requirements)</td><td>Impacts on Corals: Indirect slight negative impacts possible due to increased complication of enforcement of gear-restricted coral zones (if gear restriction alternatives are also selected).
Fishery Economic Impacts: Positive fishery economic impacts; vessels would not have to expend time and fuel transiting around gear-restricted areas.</td></tr>
<tr><td>Alternative 2F (Allow transit via change in VMS declaration)</td><td>Impacts on Corals: Indirect slight negative impacts possible due to increased complication of enforcement of gear-restricted coral zones (if gear restriction alternatives are also selected).
Fishery Economic Impacts: Positive fishery economic impacts; vessels would not have to expend time and fuel transiting around gear-restricted areas.</td></tr>
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Box ES-2. Summary comparison of the differences in Discrete Coral Zone Alternatives under consideration in this amendment.		
Issue	**Alternatives**	**Main Differences in Alternatives**
Discrete Coral Zone Designation	Alternative 3A (No action/*Status Quo*)	No action. Neutral impacts expected (relative to *status quo*).
	Alternative 3B (Designation of Discrete Coral Zones)	*Impacts on Corals:* Designation alone affords some additional benefits/attention via potential project consultation by NMFS; Wilmington and Baltimore Canyons have the highest percentages of coral habitat; the Mey-Lindenkohl Slope and Hudson Canyon have the greatest areas of high/very high habitat suitability. *Fishery Economic Impacts:* None (designation alone)
Discrete Coral Zone Restrictions	Alternative 4A (No action/*Status Quo*)	No action. Neutral impacts expected (relative to *status quo*).
	Alternative 4B (Prohibit All Bottom-tending Gear)	*Impacts on Corals:* Greatest positive impacts on corals by reducing potential for gear impacts the most; impacts depend on the canyons selected. Some degree of coral benefits may be offset by effort shifts into non-restricted areas. *Fishery Economic Impacts:* Depends on total number of discrete zones selected and the economic importance of the selected zones. Hudson Canyon, Wilmington Canyon, and Mey-Lindenkohl Slope are the areas associated with the greatest fishery revenues. Some degree of revenue loss is expected to be offset by effort shifts into non-restricted areas.
	Alternative 4C (Prohibit Mobile Bottom-tending Gear)	*Impacts on Corals:* Smaller positive impacts to corals (compared to 4B) as just some gears are prohibited. Depends on the canyons selected (see section 5.0 for Canyon area sizes). *Fishery Economic Impacts:* Smaller fishery impacts as fewer gear types are prohibited.
	Alternative 4D (Allow transit with gear stowage requirements)	*Impacts on Corals:* Indirect slight negative impacts possible due to increased complication of enforcement of gear-restricted coral zones (if gear restriction alternatives are also selected). *Fishery Economic Impacts:* Positive fishery economic impacts; vessels would not have to expend time and fuel transiting around gear-restricted areas.
	Alternative 4E (Allow transit via change in VMS declaration)	*Impacts on Corals:* Indirect slight negative impacts possible due to increased complication of enforcement of gear-restricted coral zones (if gear restriction alternatives are also selected). *Fishery Economic Impacts:* Positive fishery economic impacts; vessels would not have to expend time and fuel transiting around gear-restricted areas.

Box ES-3. Summary comparison of the differences in Framework and Vessel Monitoring Alternatives under consideration in this amendment.		
Issue	**Alternatives**	**Main Differences in Alternatives**
Framework Provisions	Alternative 5A (No action/*Status Quo*)	No action. Neutral impacts expected.
	Alternative 5B (Modify Zone Boundaries via Framework)	Administrative in nature; some time savings; neutral impacts expected; any proposed action will be analyzed through a separate NEPA process.
	Alternative 5C (Modify Management Measure via Framework)	
	Alternative 5D (Modify Add Additional Coral Zones via Framework)	
	Alternative 5E (Implement Special Access Program via Framework)	
Vessel Monitoring Alternatives	Alternative 6A (No action/*Status Quo*)	No action. Neutral impacts expected.
	Alternative 6B (VMS Requirement for *Illex* Squid Moratorium Vessels)	*Impacts on Corals:* No direct impacts on corals; indirect slight positive impacts likely due to increased ability to enforce gear-restricted coral zones. *Fishery Economic Impacts:* Low; few Illex moratorium vessels are not already required to use VMS related to other permits they possess.

2.0 LIST OF ACRONYMS AND ABBREVIATIONS

ACUMEN	Atlantic Canyons Undersea Mapping Expedition
ASMFC	Atlantic States Marine Fisheries Commission (Commission)
BOEM	Bureau of Ocean and Energy Management
CEA	Cumulative Effects Assessment
CFR	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
DMNH	Delaware Museum of Natural History
DOC	Department of Commerce
DSCRTP	Deep Sea Coral Research and Technology Program
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFP	Exempted Fishing Permit
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
FMAT	Fishery Management Action Team
FMP	Fishery Management Plan
FR	Federal Register
GARFO	Greater Atlantic Regional Fisheries Office (formerly Northeast Regional Office/NERO)
GRA	Gear restricted area
GSSA	Garden State Seafood Association
IFQ	Individual Fishing Quota
LAGF	Limited Access General Category
LOA	Letter of Acknowledgement
MAFMC	Mid-Atlantic Fishery Management Council (Council)
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
MSA	Magnuson-Stevens Fishery Conservation and Management Act (as currently amended)
MSB	Mackerel, Squid, and Butterfish
MT	Metric tons
NCCOS	National Centers for Coastal Ocean Science
NEFMC	New England Fishery Management Council
NEFOP	Northeast Fisheries Observer Program
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NGO	Non-governmental organization
NGOM	Northern Gulf of Maine
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA OER	NOAA Office of Exploration and Research
NOS	National Ocean Service
ROV	Remotely Operated Vehicle
TAL	Total Allowable Landings
US	United States
USD	U.S. Dollars
VMS	Vessel Monitoring System
VTR	Vessel Trip Report
WHOI	Woods Hole Oceanographic Institution

3.0 CONTENTS, TABLES, AND FIGURES

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4.0 INTRODUCTION AND BACKGROUND

Deep sea corals are unique, fragile, slow-growing marine organisms that are valued for their function as habitat for many fish and invertebrates, as well as for a variety of ecosystem and cultural services they provide. These corals occupy deep, largely unexplored offshore areas that include the continental shelf break and marine canyons in the Mid-Atlantic, and are considered to be very vulnerable to human activities such as fishing.[1] When commercial fishing gears, such as trawls or pots, contact the sea floor in areas where deep sea corals occur, they become a potential threat to coral ecosystems through scarring, crushing or complete removal of corals. Deep sea corals can live for hundreds or even thousands or years, and damaged or destroyed deep sea corals may take many years to become re-established, if they are able to do so at all (See **Appendix C** for a review of information on fishery gear impacts to deep sea coral).

Deep sea coral habitats are among the most biologically diverse ecosystems in the deep sea, and may increase the resilience of deep water ecosystems to external shocks. Corals provide habitat for many species of fish and invertebrates including nursery grounds, protection, reproduction, and feeding. Additionally, deep sea corals may sequester atmospheric carbon dioxide, and can serve as long-term indicators of climate change by serving as a record for ocean temperature changes. Corals also offer opportunities for pharmaceutical, engineering, and medical research. Finally, deep sea corals have cultural value, including non-use benefits such as existence value.[2] The general public has seen increasing opportunities in recent years to view and appreciate deep sea ecosystems by engaging virtually in deep sea exploration streamed via the internet.

The Mid-Atlantic Fishery Management Council (Council) recognizes the value of deep sea corals and is exercising its authority under the reauthorized Magnuson-Stevens Act (MSA) to recommend management measures to minimize fishery impacts to deep sea corals in the Mid-Atlantic region. This amendment is a regulatory vehicle initiated by the Council to identify and develop fishery management measures that will limit the negative impacts of commercial fishing on deep sea corals. At the same time, the importance and value of commercial fisheries that operate in or near areas of deep sea coral habitat is recognized by the Council. As such, measures in this amendment will be considered in light of their benefit to corals as well as the cost to commercial fisheries. The information presented in this document is designed to assist the public in commenting on the proposed measures and ultimately to support the Council in achieving an appropriate balance between protecting deep sea corals and minimizing negative economic impacts to fisheries.

4.1 PURPOSE AND NEED FOR ACTION

The purpose of this amendment is to identify and implement measures that reduce, to the extent practicable, impacts of fishing gear on deep sea corals in the Mid-Atlantic region. The measures, or some subset of the measures, developed in the amendment are necessary to protect valued deep sea corals and their dependent ecosystem components while also considering the operational needs and long term sustainability of commercial fisheries.

Deep sea corals are fragile and slow-growing organisms that are highly vulnerable to various types of disturbance of the sea floor, including fishing activities. Corals are valued for their habitat, ecosystem,

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[1] E.g., Hourigan 2009 - http://www.int-res.com/articles/theme/m397p333.pdf. Managing fishery impacts on deep-water coral

ecosystems of the USA: emerging best practices. Marine Ecology Progress Series. Vol. 397: 333–340, 2009.

[2] Foley, Naomi S., van Rensburg, Tom M., and Claire W. Armstrong. 2010. The ecological and economic value of cold-water coral ecosystems. *Ocean & Coastal Management* 53:313-326.

cultural, and other values, yet remain largely unprotected from human disturbance in the Mid-Atlantic. Research on commercial fishing gear impacts to deep sea corals indicates that fishing gear can damage corals in variety of ways, including scarring, breaking, smothering, or complete destruction. This amendment contains alternatives that aim to protect corals by restricting fishing in select areas where fishing effort and prime coral habitats overlap, as well as by restricting expansion of effort into less heavily fished areas where corals are known or are highly likely to be present.

4.2 REGULATORY AUTHORITY

The range of alternatives in this document is based on application of discretionary provisions related to deep sea corals contained in the 2007 reauthorization of the MSA.[3] These provisions give the Regional Fishery Management Councils the authority to designate zones where, and periods when, fishing may be restricted in order to protect deep sea corals. Under the authority of the MSA, designated deep sea coral zones may include areas beyond known coral locations, if necessary, to ensure their effectiveness. Management measures applied to deep sea coral zones may include restrictions on the location and timing of fishing activity, allowing fishing for only certain vessel types, and/or complete closure to fishing. The Council seeks to balance the exercise of this authority with the management objectives of the Mackerel, Squid, and Butterfish (MSB) Fishery Management Plan (FMP) and the value of potentially affected commercial fisheries.

4.3 FMP HISTORY AND MANAGEMENT OBJECTIVES

Bottom trawls have been consistently identified as the gear type with the greatest potential to negatively affect deep sea corals. Any measures to protect deep sea corals will, therefore, likely include gear restrictions affecting bottom trawl fisheries, especially those operating near areas identified as prime deep sea coral habitat. Among the Council's management plans, the FMP that directly governs major offshore trawl fisheries operating in areas of likely coral habitat in the Mid-Atlantic is the MSB FMP. As such, measures to protect deep sea corals are being considered through an amendment to this plan. Nevertheless, and as detailed below (Section 4.4) alternatives developed in this amendment are not limited to the activities of the MSB fisheries, and may apply to other federally regulated fishing activities as well.

Management of the MSB fisheries began through the implementation of three separate FMPs (one each for mackerel, squid, and butterfish) in 1978. The plans were merged in 1983. Over time a wide variety of management issues have been addressed including stock rebuilding, habitat conservation, bycatch minimization, and limiting participation in the fisheries. The history of the plan and its amendments can be found at http://www.mafmc.org/fisheries/fmp/msb.

The management goals and objectives, as described in the current FMP are listed below.

1. Enhance the probability of successful (i.e., the historical average) recruitment to the fisheries.
2. Promote the growth of the U.S. commercial fishery, including the fishery for export.
3. Provide the greatest degree of freedom and flexibility to all harvesters of these resources consistent with the attainment of the other objectives of this FMP.
4. Provide marine recreational fishing opportunities, recognizing the contribution of recreational fishing to the national economy.
5. Increase understanding of the conditions of the stocks and fisheries.
6. Minimize harvesting conflicts among U.S. commercial, U.S. recreational, and foreign fishermen.

[3] http://www.nmfs.noaa.gov/msa2007/docs/act_draft.pdf#page=82.

4.4 MANAGEMENT UNIT AND SCOPE OF ALTERNATIVES

The management unit (fish stock definition) for the MSB FMP is all Atlantic mackerel (*Scomber scombrus*), Longfin squid (*Doryteuthis (Amerigo) pealeii*),[4] Illex squid (*Illex illecebrosus*), and butterfish (*Peprilus triacanthus*) under U.S. jurisdiction in the northwest Atlantic, with a core fishery management area from Maine to North Carolina.

Although gear restrictions are being developed within the MSB FMP, the alternatives listed in this document aim to achieve protection of deep sea corals and are not limited to the activities of the MSB fisheries. Management measures developed under the regulatory authority described in Section 4.2 and implemented via this amendment could be applied to any federally regulated fishing activity within the range of the MSB fisheries, including activity or gears that are not used in these fisheries. Management measures developed in this amendment would not apply to any species managed solely by the Atlantic States Marine Fisheries Commission (Commission), such as American lobster, unless the Commission takes complementary action.

The Mid-Atlantic Fishery Management Council, the New England Fishery Management Council (NEFMC), and the South Atlantic Fishery Management Council have signed a Memorandum of Understanding (MOU) identifying areas of consensus and common strategy related to conservation of corals and mitigation of the negative impacts of fishery interactions with corals.[5] As per the terms of the MOU, the Mid-Atlantic Fishery Management Council has agreed to develop alternatives applicable only to areas within the Mid-Atlantic Council region boundary as defined in the current regulations (Figure 1).[6] The NEFMC has agreed to develop management measures applicable within the boundaries of their Council region, and the South Atlantic Fishery Management Council will continue to manage deep sea corals via its Coral, Coral Reef and Live/Hardbottom FMP.

To promote continuity and consistency in regional protection of deep sea corals, the alternatives contained in this document were developed with consideration of consistency in approach to deep sea coral protections to that being considered by the NEFMC. The NEFMC began developing deep sea coral alternatives as part of their Essential Fish Habitat Omnibus Amendment 2, which has since been split into a separate Omnibus Deep Sea Corals Amendment.[7]

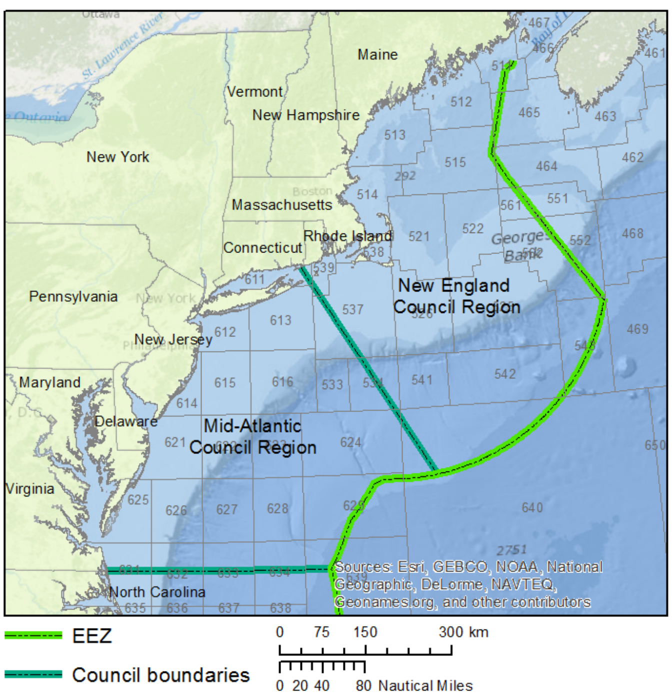

Figure 1: Mid-Atlantic and New England Council regions.

[4] For longfin squid there was a scientific name change from *Loligo pealeii* to *Doryteuthis (Amerigo) pealeii*. To avoid confusion, this document will utilize the common name "longfin squid" wherever possible, but this squid is often referred to as "*Loligo*" by interested parties.

[5] The full Memorandum of Understanding is available on the Council's website, at http://www.mafmc.org/actions/msb/am16.

[6] Council boundaries are defined in the Code of Federal Regulations (CFR), at 50 C.F.R. §§ 600.105(a) and (b), available at http://www.gpo.gov/fdsys/granule/CFR-2001-title50-vol3/CFR-2001-title50-vol3-sec600-105/content-detail.html.

[7] For more information, see http://nefmc.org/habitat/index.html.

5.0 MANAGEMENT ALTERNATIVES[8]

This amendment attempts to achieve the Council's desired deep sea coral protections while considering the social and economic value of potentially affected fisheries. In recognition of the diversity of potential solutions to these two goals, a range of alternative management measures ("alternatives") has been developed so that each alternative's effectiveness and practicability can be considered. This approach also complies with the statutory requirements of the National Environmental Policy Act (NEPA) for a consideration of a "range of alternatives" in evaluating the environmental impacts of federal actions. The range of alternatives is presented below.

Deep Sea Coral Zones

In identifying and developing the alternatives, the general approach is to apply the discretionary provisions of the MSA for designating "deep sea coral zones." Once these zones have been designated, any federally regulated fishing activities within them could then be restricted, and those restrictions could be further modified in the future. Two types of deep sea coral zones are currently envisioned, as described below.

Broad deep sea coral zones would encompass large, mostly unfished and unexplored areas and measures would limit and prevent expansion of commercial gear use where little or no fishing has historically occurred. 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." [9]

Discrete deep sea coral zones would consist of smaller areas of known coral presence or highly likely coral habitat. These areas primarily consist of offshore canyons or slope areas along the continental shelf edge. Fishing activity occurs nearby these areas, and to some extent within them. Therefore, restrictions applied to these areas would mainly reduce or eliminate current fishing activities rather than just prevent their expansion.

These two types of deep sea coral zones could be implemented simultaneously. Depending on the alternatives selected by the Council, different types of zones could have different management measures or the same management measures applied within each type of zone. If both broad and discrete zones

[8] Range of alternatives as modified May 2015 to reflect February 2015 Council motions regarding transit provisions, discrete zone exemptions, and a framework provision to prohibit anchoring in coral zones.

[9] National Oceanic and Atmospheric Administration, Coral Reef Conservation Program. 2010. NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems: Research, Management, and International Cooperation. Silver Spring, MD: NOAA Coral Reef Conservation Program. NOAA Technical Memorandum CRCP 11. 67 pp.

are implemented and management measures differ between the two types, the more restrictive management measures would apply in any areas of overlap.

Six sets of alternatives are presented below:

1) Designation of broad deep sea coral zones,
2) Restrictions within broad zones,
3) Designation of discrete deep sea coral zones,
4) Restrictions within discrete zones,
5) Framework provisions for future refinements to deep sea coral zone measures,
6) Vessel Monitoring System (VMS) requirements.

5.1 BROAD CORAL ZONE DESIGNATION ALTERNATIVES

Except for the no action alternative, all broad zone alternatives would begin with a landward boundary approximating a depth contour and extend into deeper waters to the edge of the EEZ and the MAFMC region boundaries. Because depth contours resulting directly from bathymetry data are very complex with many thousands of vertices, these contours would need to be approximated in order to draw boundary lines on a map that could be entered into navigation systems as a series of coordinates. A proposed methodology for simplifying and approximating depth contour lines is described in the May 2015 Fishery Management Action Team (FMAT) report, available on the Council's website at www.mafmc.org.

Alternative 1A: No Action/*Status Quo*

Under this alternative, no action would be taken to designate a broad deep sea coral zone. This option is equivalent to the *status quo*. Several canyons have been closed for tilefish habitat protection, and as was noted in the analysis for those actions, deep sea corals do receive some protection from those closures. In the Mid-Atlantic region, tilefish gear-restricted areas include part of Norfolk Canyon.

Alternative 1B: Landward boundary approximating 200 meter depth contour

Under this alternative, a broad coral zone would be designated with the landward boundary approximating the 200 meter (109 fathom) depth contour and extending out to the northern and southern boundaries of the MAFMC management region, and to the edge of the EEZ (Figure 2).

Alternative 1C: Landward boundary approximating 300 meter depth contour

Under this alternative, a broad coral zone would be designated with the landward boundary approximating the 300 meter (164 fathom) depth contour and extending out to the northern and southern boundaries of the MAFMC management region, and to the edge of the EEZ (Figure 2).

Alternative 1D: Landward boundary approximating 400 meter depth contour

Under this alternative, a broad coral zone would be designated with the landward boundary approximating the 400 meter (219 fathom) depth contour and extending out to the northern and southern boundaries of the MAFMC management region, and to the edge of the EEZ (Figure 2).

Alternative 1E: Landward boundary approximating 500 meter depth contour

Under this alternative, a broad coral zone would be designated with the landward boundary approximating the 500 meter (273 fathom) depth contour and extending out to the northern and southern boundaries of the MAFMC management region, and to the edge of the EEZ (Figure 2).

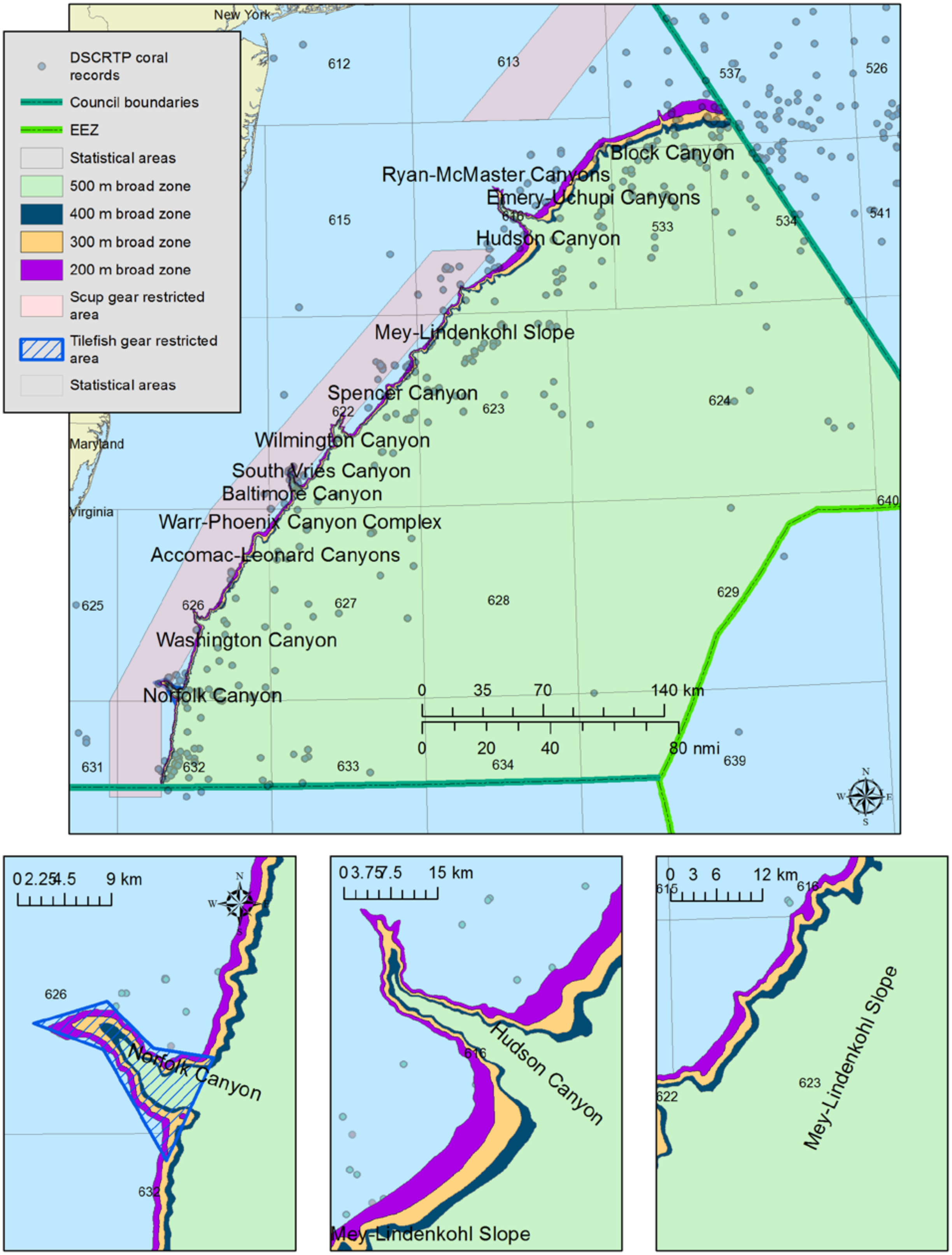

Figure 2: Broad coral zone alternatives.

5.2 RESTRICTIONS WITHIN BROAD CORAL ZONES

Alternative 2A: No Action

Under this alternative, no action would be taken to implement management measures in any designated broad deep sea coral zones. Several canyons have been closed for tilefish habitat protection, and as was noted in the analysis for those actions, deep sea corals do receive some protection from those closures. In the Mid-Atlantic region, tilefish gear-restricted areas include part of Norfolk Canyon.

Alternative 2B: Prohibit all bottom-tending gear

Under this alternative, vessels would be prohibited from using any bottom-tending gear within designated broad coral zones. "Bottom-tending gear" includes any mobile bottom-tending gear (as defined in Alternative 2C below), as well as any stationary or passive gear types that contact the bottom, including bottom longlines, pots and traps[10], and sink or anchored gill nets.

Sub-alternative 2B-1: *Exempt red crab fishery from broad zone restrictions*

If selected in conjunction with Alternative 2B, sub-alternative 2B-1 would exempt the red crab fishery from restrictions on all bottom-tending gear. The red crab fishery currently consists of only a few vessels, which harvest crabs using traps. These vessels focus effort along the center of a narrow range of depth (targeting 350 fathoms or 640 meters; see Section 6.3.7 for a description of the fishery). Thus, any prohibition on all bottom-tending gear within the proposed broad zones, absent an exemption, would impact all fishing activity for red crab within the Mid-Atlantic Council region.

Sub-alternative 2B-2: *Exempt golden tilefish fishery from broad zone restrictions*

If selected in conjunction with Alternative 2B, sub-alternative 2B-2 would exempt the golden tilefish fishery from restrictions on all bottom-tending gear. Golden tilefish are primarily harvested using bottom longlines. Selecting sub-alternative 2B-2 would allow the golden tilefish bottom longline fishery to continue operation within a designated broad zone, but prevent current or future use of stationary or passive bottom-tending gear targeting other species (with the exception of red crab trap gear if sub-alternative 2B-1 above is also selected).

Alternative 2C: Prohibit all mobile bottom-tending gear

Under this alternative, vessels would be prohibited from using any mobile bottom-tending gear within designated broad coral zones. Mobile bottom-tending gear (as defined at 50 C.F.R. §648.200 with respect to the Northeast 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 VMS for vessels within broad coral zones

Under this alternative, vessels would be required to use an approved Vessel Monitoring System (VMS) as a condition for operating within any broad coral zones. This alternative could be selected alone or in combination with any of the gear restriction alternatives above. Currently, VMS is required for vessels issued various types of permits for: Northeast multispecies, monkfish, scallop, herring, surfclam, ocean quahog, mackerel, and longfin squid/butterfish.[11]

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[10] As indicated in section 4.4, alternatives contained in this document would not apply to non-federally managed fisheries, including species managed solely by the Atlantic States Marine Fisheries Commission, such as American lobster.

[11] Current regulations for vessels required to use VMS are detailed at: http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9f5bb83d0dd1bf6af01d7baf383b29c0&r=SUBPART&n=50y12.0.1.1.5.1#se50.12.648_110.

Alternative 2E: Allow for transit with gear stowage requirements

Under this alternative, vessels would be allowed to transit through gear-restricted broad coral areas provided that the gear is not available for immediate use.[12]

Alternative 2F: Allow for transit via change in VMS declaration

Under this alternative, vessels would be allowed to transit through gear-restricted broad coral areas if they submit a VMS declaration specific to transit. This alternative would require NMFS to create a "transit" VMS declaration.

5.3 DISCRETE CORAL ZONE DESIGNATION ALTERNATIVES

Alternative 3A: No Action/*Status Quo*

Under this alternative, no action would be taken to designate discrete deep sea coral zones. This option is equivalent to the *status quo*.

Alternative 3B: Designation of Discrete Coral Zones

Under this alternative, specific submarine canyons and/or slope areas would be designated as discrete coral zones based on observed coral presence or highly likely coral presence indicated by modeled suitable habitat. Proposed discrete zones are listed in Table 1 as sub-options to this alternative (see also: Figure 3). The Council could select any combination of these specific areas to designate as discrete coral zones.

Table 1: Discrete zones proposed under Alternative 3B.

	Canyon or Complex
1	Block Canyon
2	Ryan and McMaster Canyons
3	Emery and Uchupi Canyons
4	Jones and Babylon Canyons
5	Hudson Canyon
6	Mey-Lindenkohl Slope (encompassing several canyons, including Mey, Hendrickon, Toms, South Toms, Berkley, Carteret, and Lindenkohl Canyons, and the slope area between them)
7	Spencer Canyon
8	Wilmington Canyon
9	North Heyes and South Wilmington Canyons
10	South Vries Canyon
11	Baltimore Canyon
12	Warr and Phoenix Canyon Complex
13	Accomac and Leonard Canyons
14	Washington Canyon
15	Norfolk Canyon

Multiple boundary options have been proposed for each discrete zone, as described in sub-alternatives 3B-1 through 3B-5. These options are in chronological order based on when they were developed or refined. The geographic coordinates of discrete zone alternatives are listed in **Appendix B**.

[12] "Not available for immediate use" is defined in the current regulations at: http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9f5bb83d0dd1bf6af01d7baf383b29c0&r=SUBPART&n=50y12.0.1.1.5.1#se50.12.648_12.

Sub-alternative 3B-1: *Advisor-proposed boundaries for three discrete zones (2013)*

Under this sub-alternative, modified discrete zone boundaries are proposed for Norfolk Canyon, Baltimore Canyon, and the Mey-Lindenkohl Slope, as developed by a member of the Council's MSB Advisory Panel following an April 2013 Deep Sea Corals Alternatives workshop.

Sub-alternative 3B-2: *FMAT boundaries (revised 2014)*

These boundaries were developed in 2014 by the FMAT, primarily using a NOAA-developed habitat suitability model for deep sea corals,[13] as well as areas of very high slope (>30 degrees). Recent research has indicated that the coral habitat suitability model has been very successful in predicting coral habitat, and additionally has confirmed that areas of slope greater than 30 degrees almost always contain hardbottom habitat and deep sea corals. Areas of high and very high habitat suitability and areas of high slope were buffered by approximately 0.4 nautical miles to account for spatial uncertainties associated with the current resolution of the habitat model. Specific locations of historical and recent coral observations were also considered when developing boundaries, especially where recent data was available for observations that have not yet been incorporated into the habitat model. The specific criteria for how the FMAT boundaries were developed are further detailed in **Appendix A**.

Sub-alternative 3B-3: *Garden State Seafood Association (GSSA) boundaries (February 2015)*

These boundaries were developed and submitted to the Council during the amendment's public comment period in February 2015 by a group of fishing industry stakeholders, through GSSA.

Sub-alternative 3B-4: *NGO Coalition boundaries (April 2015)*

These boundaries were developed and submitted to the Council by a coalition of NGO representatives and Ecosystems and Ocean Planning AP members, in advance of the Council's April 2015 Deep Sea Corals Workshop.[14]

Sub-alternative 3B-5: *Corals Workshop boundaries (April 2015)*

These boundaries were developed cooperatively by participants at the Council's April 29-30, 2015 Deep Sea Corals Workshop. Participants included the Squid, Mackerel, and Butterfish Advisory Panel, the Ecosystems and Ocean Planning Advisory Panel, members of the Fishery Management Action Team (FMAT), deep sea coral experts, additional fishing industry representatives, and other interested stakeholders. Workshop details and a summary report are available on the Council's website. [15]

[13] Kinlan BP, Poti M, Drohan A, Packer DB, Nizinski M, Dorfman D, Caldow C. 2013. Predictive models of deep-sea coral habitat suitability in the U.S. Northeast Atlantic and Mid-Atlantic regions. Downloadable digital data package. National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS). August 2013. Available at: <http://coastalscience.noaa.gov/projects/detail?key=35>.

[14] A memo describing the group's methodology for these proposed zones can be found at: http://www.mafmc.org/s/NGO-Alternative-Methodology-for-Discrete-Zone-Designation.pdf.

[15] http://www.mafmc.org/workshop/2015/deep-sea-corals.

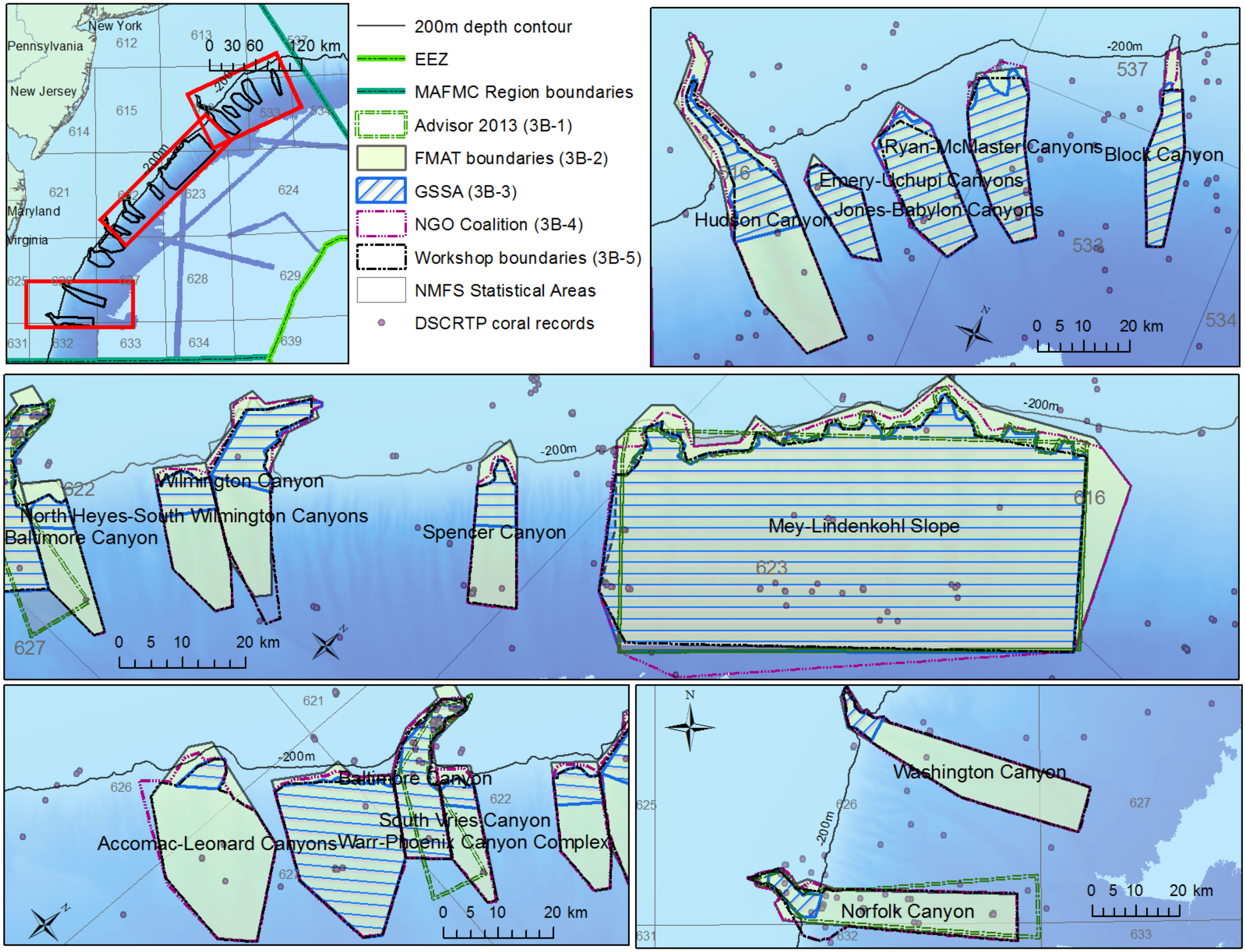

Figure 3: Discrete coral zone alternatives.

5.4 RESTRICTIONS WITHIN DISCRETE CORAL ZONES

Alternative 4A: No Action

Under this alternative, no action would be taken to implement management measures in any potential discrete deep sea coral zones.

Alternative 4B: Prohibit all bottom-tending gear

Under this alternative, vessels would be prohibited from using any bottom-tending gear within designated discrete coral zones. This prohibition could include any or all of the discrete coral zones listed in Table 1. "Bottom-tending gear" includes any mobile bottom-tending gear (as defined in Alternative 4C below), as well as any stationary or passive gear types that contact the bottom, including bottom longlines, pots and traps,[16] and sink or anchored gill nets.

***Sub-alternative 4B-1:** Exempt red crab fishery from discrete zone restrictions*

If selected in conjunction with Alternative 4B, sub-alternative 4B-1 would exempt the red crab fishery from restrictions on all bottom-tending gear in discrete zones. The red crab fishery currently consists of only three active vessels, which harvest crabs using traps. These vessels focus effort along the center of a narrow range of depth (targeting 350 fathoms, or 640 meters). This depth contour runs through all 15 proposed discrete zones. An exemption was proposed given that the operational needs of this fishery (see section 7.X) may make jumping over multiple closed areas prohibitively burdensome for these vessels.

***Sub-alternative 4B-2:** Exempt golden tilefish fishery from discrete zone restrictions*

If selected in conjunction with Alternative 4B, sub-alternative 4B-2 would exempt the golden tilefish fishery from restrictions on all bottom-tending gear in discrete zones. Golden tilefish are primarily harvested using bottom longlines. Selecting sub-alternative 4B-2 would allow the golden tilefish bottom longline fishery to continue operation within designated discrete zones.

Alternative 4C: Prohibit mobile bottom-tending gear

Under this alternative, vessels would be prohibited from using any mobile bottom-tending gear within designated discrete coral zones. This prohibition could include any or all of the discrete coral zones listed in Table 1. Mobile bottom-tending gear (as defined at 50 C.F.R. §648.200 with respect to the Northeast 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: Allow for transit with gear stowage requirements

Under this alternative, vessels would be allowed to transit through gear-restricted discrete areas provided that the gear is not available for immediate use.[17]

Alternative 4E: Allow for transit via change in VMS declaration

Under this alternative, vessels would be allowed to transit through gear-restricted discrete areas if they submit a VMS declaration specific to transit. This alternative would require NMFS to create a "transit" VMS declaration.

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[16] As indicated in section 4.4, alternatives contained in this document would not apply to non-federally managed fisheries, including species managed solely by the Atlantic States Marine Fisheries Commission, such as American lobster.

[17] "Not available for immediate use" is defined in the current regulations at: http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=9f5bb83d0dd1bf6af01d7baf383b29c0&r=SUBPART&n=50y12.0.1.1.5.1#se50.12.648_12.

5.5 FRAMEWORK PROVISIONS TO ALLOW FUTURE MODIFICATIONS TO MANAGEMENT MEASURES

Framework actions facilitate expedient modifications to certain management measures. Framework actions can only modify existing measures and/or those that have been previously considered in an FMP amendment. While amendments may take several years to complete and address a variety of issues, frameworks generally can be completed in 5-8 months and address one or a few issues in a fishery. The MSB FMP contains a list of actions that are able to be taken via framework action. The following alternatives would modify that list to allow framework actions related to the proposed deep sea coral measures in this amendment.

Recently completed research surveys have observed deep sea corals in several submarine canyons within the Mid-Atlantic Council management area. Additional research is planned or ongoing and many data products will not be available within the planned timeline for this amendment. Modifying the framework provisions of the FMP would allow the Council to modify deep sea coral zones or management measures in response to new information or issues arising after implementation of the amendment.

Alternative 5A: No Action

Under this alternative, no changes would be made to the framework provisions of the MSB FMP. Any future modifications to the deep sea coral zones or associated management measures would likely have to be accomplished through an amendment to the FMP.

Alternative 5B: Option to modify coral zone boundaries via framework action

This alternative would give the Council the option to modify the boundaries of deep sea coral zones through a framework action.

Alternative 5C: Option to modify management measures within zones via framework action

This alternative would give the Council the option to modify fishing restrictions, exemptions, monitoring requirements, and other management measures within deep sea coral zones through a framework action. This would also include the ability to add a prohibition on anchoring (as discussed at the February 2015 Council meeting).

Alternative 5D: Option to add additional discrete coral zones via framework action

This alternative would allow the Council to add discrete coral zones through a framework action.

Alternative 5E: Option to implement special access program via framework action

This alternative would give the Council the option to design and implement a special access program for commercial fishery operations in deep sea coral zones through a framework action.

5.6 VESSEL MONITORING ALTERNATIVES

Alternative 6A: No Action

Under this alternative, no changes would be made to the VMS requirements for *Illex* squid moratorium vessels.

Alternative 6B: Vessel Monitoring Systems (VMS) requirement for *Illex* squid moratorium vessels

This option would require use of VMS for all *Illex* squid moratorium vessels (regardless of whether fishing activity is occurring within or outside of any potential deep sea coral zones).

5.7 CONSIDERED BUT REJECTED FROM FURTHER ANALYSIS

The following section contains options that were previously included in the range of alternatives, but have been removed from further consideration at this time.

1. Require Council review and approval for fishing within broad zones

- ***Sub-alternative:*** Implement special access program (for existing fisheries)
- ***Sub-alternative:*** Implement exploratory fishing access program (for potential new fisheries)
- ***Sub-alternative:*** Implement research/experimental access program (for scientific research)

The Fishery Management Action Team (FMAT) recommended moving this alternative set to considered but rejected primarily due to existing exemption and access programs that would serve essentially the same purpose as these proposed alternatives. Specifically, Exempted Fishing Permits (EFPs) issued through the Greater Atlantic Regional Fisheries Office (GARFO) would cover many of the intended activities described under the sub-alternatives above. An EFP is a permit that authorizes a fishing vessel to conduct fishing activities that would be otherwise prohibited under the regulations at 50 CFR part 648 or part 697. Generally, EFPs are issued for activities in support of fisheries-related research, including seafood product development and/or market research, compensation fishing, and the collection of fish for public display. **Exploratory fishing** as described in the sub-alternative above would be covered by the existing EFP program.

For a **special access** program within any potential broad zones, if the Council wishes to permit special access for any fishing activities, it is possible that such a system could be designed. However, the Council would need to give specific direction as to how such a system would operate, including who would be eligible, the types of fishing and species to be harvested. Because this alternative would need further development to be included in the amendment, the FMAT recommends moving this sub-alternative to "considered but rejected." However, a Council special access program could be considered at a later date via a framework action, provided that Alternative 5E, the option to implement a special access program via framework action, is selected by the Council.

For the purposes of **scientific research**, a statutory exemption is provided within the MSA, meaning scientific research activities are exempt from any and all MSA regulations. A Letter of Acknowledgement (LOA) can be obtained from the Regional Office that acknowledges certain activities as scientific research conducted from a scientific research vessel. An LOA is not required for scientific research, but serves as a convenience to the researcher and to law enforcement entities. To be considered a scientific research vessel, a vessel must be conducting scientific research activity under the direction of a foreign government agency, a U.S. government agency, a U.S. state or territorial agency, university or other accredited educational institution, international treaty organization, or scientific institution.

More information about EFPs, LOAs, and other exempted activity summarized above is available at: http://www.nero.noaa.gov/permits/forms/EFPLOAEEAPossessionLOAGuidance.pdf.

2. Require observers on vessels fishing in broad coral zones

The FMAT recommended moving this alternative to "considered but rejected" due to ongoing efforts to resolve issues related to observer coverage funding and industry cost-sharing. Specifically, an Omnibus Observer Coverage Funding Amendment is currently being developed jointly between the Mid-Atlantic and New England Councils, and is directly related to proposed requirements like the one under this alternative. The Omnibus amendment was initiated following NMFS's partial disapproval of both Amendment 5 to the Atlantic Herring FMP and Amendment 14 to the MSB FMP, which contained recommendations for 100 percent observer coverage for certain vessels and provisions for cost-sharing with industry participants. There is no current legal mechanism that allows NMFS and the fishing industry to share observer costs, and budget uncertainties have prevented NMFS from being able to commit to funding for increased observer coverage for particular fisheries. Without a clear and viable funding source for this requirement, this alternative is not practical at this time. Once the Omnibus Observer Coverage Funding Amendment is completed, the Council could address observer coverage requirements within broad coral zones through a future framework action (provided that Alternative 5C to modify management measures within coral zones via Framework is selected by the Council).

3. Require gear monitoring electronics on board to fish within broad or discrete zones (equipment monitoring gear distance from seafloor)

This alternative was proposed at the August 2013 Council meeting, and would require vessels operating in broad or discrete zones to have gear monitoring electronics on board that are able to read the distance from the seafloor at which the vessel's gear is operating. The FMAT recommended that this alternative be moved to "considered but rejected" due to the need for further development, including clarification on how such a requirement would work and the specific purpose it would serve. Specifically, whether this alternative would serve as a tool for enforcement purposes, or simply as a tool for the vessel operator's knowledge (i.e., to facilitate avoiding bottom contact). More information is needed on how these systems would operate in the context of the proposed measures in this amendment, and the potential benefits to requiring them on board, including any potential intersection with enforcement.

The FMAT recognizes that this proposed alternative is at least partially related to concerns regarding vessel movement in and around zones when fishing gear is not fully deployed. The FMAT also recognizes the need for more information and development of measures to address these issues. Specifically, there is a need to consider vessel needs for deployment and haulback of gear (which for squid trawl vessels often extends significantly behind the vessel). Squid trawlers target specific high productivity areas in and around the heads of the canyons, near the continental shelf-slope break. If any of the proposed coral zones are implemented, future fishing activity near these zones would likely occur very near the coral zone boundaries, posing a potential problem for vessels when positioning for gear deployment or haulback, or drifting into closed areas during these processes. Additionally, there is a need to consider potential allowances and associated restrictions for transit through any potential coral zones (for example, transit allowances for vessels with stowed gear, etc.). <u>The Council is soliciting feedback and suggestions from the public and the Council's advisors on these issues during the public hearing process.</u>

4. Exempt *Illex* and longfin squid fisheries from broad zone restrictions AND
5. Exempt *Illex* and longfin squid fisheries from discrete zone restrictions

The FMAT recommended that the alternatives exempting the *Illex* and longfin squid fisheries from both broad and discrete zone be moved to "considered but rejected." If the Council wishes to avoid negative economic impacts to the squid fisheries, the FMAT believes that there is a sufficient range of options within the document that would allow this to occur, including the "no action" option under each alternative set as well as the option to designate the deepest depth-based broad zone (500m). For analysis purposes under the National Environmental Policy Act

(NEPA), when the above exemption alternatives are included in any set of alternatives taken in combination, the result is essentially a *status quo* situation in terms of impacts to the affected environment. Thus, these exemption alternatives would appear to be contrary to the "purpose and need" of the amendment if they would result in a lack of meaningful action in combination with other alternatives.

6. Depth-contour based boundaries for discrete coral zones

Under this alternative, the landward boundary designations of the discrete coral zones would follow one of the following depth contours: 200 m, 300 m, 400 m, or 500 m. The boundary would follow the 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. The FMAT recommended that these options be moved to "considered but rejected" for several reasons. The discrete zones are intended to encompass areas of coral presence and highly likely coral habitat, and therefore the revised discrete zone boundaries were drawn based on the best available scientific information about coral presence and suitable habitat. In the course of re-drawing the boundaries, the FMAT attempted to align any landward boundaries with one of the proposed depth contours. The FMAT found that the vast majority of proposed depth-contour based boundaries did not meet or approximate the criteria for drawing the boundaries based on coral presence and habitat suitability (see Appendix A). Given the differences across canyon and slope areas, there was additionally no consistent depth contour across proposed areas which would approximate areas of high coral habitat suitability. Finally, analysis of all proposed depth-contour based boundaries in combination with the model-based boundaries and additional advisor proposed boundaries would mean analyzing five to seven different sets of boundaries for each area. This would overly complicate any cumulative effects analysis given the need to analyze all alternatives in combination with each other alternative, and delay amendment development.

6.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The affected environment consists of those resources expected to experience environmental impacts if the actions under consideration in this amendment are implemented. The actions being considered are generally expected to reduce commercial fishing effort below current levels for some offshore fisheries that operate within or near potentially designated coral zones. However, some of this effort is likely to be displaced to areas outside any implemented coral zones. From this perspective, the affected environment consists of those physical, biological, and human components of the environment that are or will be meaningfully connected to commercial fishing operations in those zones. These environmental components are described below.

6.1 PHYSICAL ENVIRONMENT

The managed resources inhabit the Northeast U.S. Shelf Ecosystem, which has been described as including the area from the Gulf of Maine south to Cape Hatteras, extending from the coast seaward to the edge of the continental shelf, including the slope sea offshore to the Gulf Stream. The continental slope includes the area east of the shelf, out to a depth of 2000 m. Four distinct sub-regions comprise the NOAA Fisheries Northeast Region: the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and the continental slope. The areas of interest in this action include the Mid-Atlantic Bight and the continental slope. The Mid-Atlantic Bight is comprised of the sandy, relatively flat, gently sloping continental shelf from southern New England to Cape Hatteras, NC. The continental slope begins at the continental shelf break and continues eastward with increasing depth until it becomes the continental rise.

The continental shelf slopes gently from shore out to between 100 and 200 km offshore where it transforms to the slope at the shelf break (100-200 m water depth), continuing eastward with increasing depth until it becomes the continental rise, and finally the abyssal plain. The width of the slope varies from 10-50 km, with an average gradient of 3-6°; however, local gradients can be nearly vertical. The base of the slope is defined by a marked decrease in seafloor gradient where the continental rise begins. The slope is cut by at least 70 large canyons between Georges Bank and Cape Hatteras and numerous smaller canyons and gullies, many of which may feed into the larger canyon systems.

On the slope, silty sand, silt, and clay predominate. A "mud line" occurs on the slope at a depth of 250-300 m, below which fine silt and clay-size particles predominate. Localized coarse sediments and rock outcrops are found in and near canyon walls, and occasional boulders occur on the slope because of glacial rafting. Sand pockets may also be formed because of downslope movements.

Submarine canyons are not spaced evenly along the slope, but tend to decrease in areas of increasing slope gradient. Canyons are typically "v" shaped in cross section and often have steep walls and outcroppings of bedrock and clay. The canyons are continuous from the canyon heads to the base of the continental slope. Some canyons end at the base of the slope, but others continue as channels onto the continental rise. Larger and more deeply incised canyons are generally significantly older than smaller ones, and there is evidence that some older canyons have experienced several episodes of filling and re-excavation.

Canyons can alter the physical processes in the surrounding slope waters. Fluctuations in the velocities of the surface and internal tides can be large near the heads of the canyons, leading to enhanced mixing and sediment transport in the area.

More information on the physical properties of the Northeast U.S. Shelf Ecosystem and the submarine canyon environments relevant to this action can be found in the NOAA Technical Memo "Characterization of the Fishing Practices and Marine Benthic Ecosystems of the Northeast U.S. Shelf, and an Evaluation of the Potential Effects of Fishing on Essential Fish Habitat" (Stevenson et al. 2004, available at: http://www.nefsc.noaa.gov/publications/tm/tm181/.)

6.2 BIOLOGICAL ENVIRONMENT

6.2.1 Description of the Managed Resource

Atlantic mackerel is a semi-pelagic/semi-demersal (may be found near the bottom or higher in the water column) schooling fish species primarily distributed between Labrador (Newfoundland, Canada) and North Carolina. Additional life history information is detailed in the Essential Fish Habitat (EFH) document for the species, located at: http://www.nefsc.noaa.gov/nefsc/habitat/efh/. The status of Atlantic mackerel is unknown with respect to being overfished or not, and unknown with respect to experiencing overfishing or not. Recent results from the Northeast Fisheries Science Center (NEFSC) Spring Trawl survey (the spring survey catches the most mackerel) are highly variable, and are graphed in the "NEFSC Biological Update" that is created as part of the annual quota setting process. These are available at: http://www.mafmc.org/ssc-meeting-documents/ (see May 2014 Meeting Materials).

Atlantic butterfish is a semi-pelagic/semi-demersal schooling fish species primarily distributed between Nova Scotia, Canada and Florida. Additional life history information is detailed in the EFH document for the species, located at: http://www.nefsc.noaa.gov/nefsc/habitat/efh/. The status of butterfish is not overfished (above target biomass) with no overfishing occurring according to a recently accepted assessment (NEFSC 2014, available at: http://nefsc.noaa.gov/publications/crd/crd1403/).

Longfin squid is a semi-pelagic/semi-demersal schooling cephalopod species primarily distributed between Georges Bank and Cape Hatteras, NC. Additional life history information is detailed in the EFH document for the species, located at: http://www.nefsc.noaa.gov/nefsc/habitat/efh/. Based on a new biomass reference point from a 2010 stock assessment, the longfin squid stock was not overfished in 2009, but overfishing status was not determined because no overfishing threshold was recommended (though the assessment did describe the stock as "lightly exploited'). The assessment documents are available at: http://www.nefsc.noaa.gov/saw/reports.html. Recent results from the NEFSC Trawl surveys are highly variable, and are graphed in the "NEFSC Biological Update" that is created as part of the annual quota setting process. These are available at: http://www.mafmc.org/ssc-meeting-documents/ (see May 2014 Meeting Materials).

***Illex* squid** is a semi-pelagic/semi-demersal schooling cephalopod species distributed between Newfoundland and the Florida Straits. Additional life history information is detailed in the EFH document for the species, located at: http://www.nefsc.noaa.gov/nefsc/habitat/efh/. The status of *Illex* is unknown with respect to being overfished or not, and unknown with respect to experiencing overfishing or not. Recent results from the NEFSC Trawl surveys are highly variable, and are graphed in the "NEFSC Biological Update" that is created as part of the annual quota setting process. These are available at: http://www.mafmc.org/ssc-meeting-documents/ (see May 2014 Meeting Materials).

6.2.2 Deep Sea Corals

Deep sea corals, or cold water corals, are generally defined as corals occurring at ocean depths below 50 meters. Deep sea corals are unlike shallow water corals in that they do not possess the symbiotic photosynthetic algae known as zooxanthellae, which produce food for corals found in shallow waters. Deep sea corals exist mainly in areas where photosynthesis cannot occur due to lack of light, and so instead they must obtain food from their environment. Several types of deep sea corals are found in U.S. waters of the northwestern Atlantic Ocean. The major orders of deep sea corals found in the Mid-Atlantic region include stony corals (Scleractinians), sea pens (Pennatulaceans), true soft corals and gorgonians (Alcyonaceans and Gorgonaceans), and black corals (Antipatharians). Types of deep sea corals observed to date in the Mid-Atlantic range from small, solitary corals to larger colonies including complex structure-forming corals. Deep sea corals, in particular types that form complex structures, provide habitat for many species of fishes and invertebrates.

Deep Sea Coral Distribution and Abundance Data

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. 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.

Several recent (2012-2014) research efforts have resulted in new observations of deep sea corals in the Mid-Atlantic. Although general locations of observations and some qualitative and quantitative survey results are available, some data are available only in preliminary form, and some data still being processed. Detailed reports of coral diversity and abundance are not yet available for all recent surveys, though preliminary observation data and dive locations have been considered where possible. New information has been incorporated into the range of alternatives to the extent possible. Available findings from these surveys, relative to proposed coral zones, are described in Section 7.1.2.

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 meaningfully 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 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 relevant areas earlier in the 19^{th} and 20^{th} 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.

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 NEFOP 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; 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 or scientists on the NEFSC trawl surveys. Deep sea coral records from the NEFSC Fishery Independent Surveys, relative to proposed coral zones, are described in Section 7.

6.3 HUMAN COMMUNITIES AND ECONOMIC ENVIRONMENT

This section describes the socio-economic importance of the MSB fisheries, as well as the importance of several other fisheries that may be impacted by measures proposed in this action (see section 7 for more information on how these fisheries were identified). Information was compiled from various FMPs and associated documents to describe the human and economic environments of each fishery, and data presented for each fishery may vary based on the information source. The fisheries described below include the managed fisheries (MSB), as well as summer flounder/scup/black sea bass, golden tilefish, red crab, silver hake (whiting), and scallops. These are the fisheries that the analysis in section 7 suggested may be impacted by this action. (While a very small percentage of the scallop-dredge revenues may be impacted, this fishery is included given the high value of the scallop fishery.)

Recent Amendments to the MSB FMP contain additional information about the MSB fisheries, especially demographic information on ports that land MSB species. See Amendments 11 and 14 at http://www.mafmc.org/msb/ for more information or visit NMFS' communities page at: http://www.nefsc.noaa.gov/read/socialsci/community_profiles/. In general, the MSB fisheries saw high foreign landings in the 1970s followed by a domestication of the fishery, and domestic landings have been lower than the foreign landings. Detailed information on historical landings is available in the briefing materials for the most recent SSC meeting on MSB, at http://www.mafmc.org/ssc-meetings/2014/may-7-8-2014.

6.3.1 Atlantic Mackerel

US commercial landings of mackerel increased steadily from roughly 3,000 metric tons (mt) in the early 1980s to greater than 31,000 mt by 1990. US mackerel landings declined to relatively low levels 1992-2000 before increasing in the early 2000s. The most recent years have seen a significant drop-off in harvest.

Nominal ex-vessel price has generally varied between about $200-$700 per mt, but when inflation is taken into account, erosion is observed in the ex-vessel per-pound value of mackerel from 1982-2010. The 2011 and 2012 prices increased substantially (near $700/mt), which is likely at least partially related to the low levels of mackerel landed. The 2013 ex-vessel prices were about $436/mt. Total ex-vessel value tracks both price and the quantity of fish landed (see Council's Advisory Panel Fishery Information

Document at http://www.mafmc.org/ssc-meetings/2013/april-may). Landings in 2013 totaled 4,372 mt and generated $1.9 million in ex-vessel revenues.

The mackerel fishery became a limited access fishery in 2013, except for open-access incidental catch permits. The current numbers of permits are 32 Tier 1 permits, 24 Tier 2 permits, and 90 Tier 3 permits.

Table 2: 2013 vessel dependence on mackerel (revenue-based).

Dependence on Mackerel	Number of Vessels in Each Dependency Category
1%-5%	23
5%-25%	13
25%-50%	4
More than 50%	5

Source: Unpublished NMFS dealer reports. Not at state level due to data confidentiality issues.

Table 3: Recent mackerel landings by gear type (mt).

Year	Gill Nets	Bottom Trawl	Single Mid-Water Trawl	Pair Mid-Water Trawl	Trap/Pots/ Pound Nets/Weir	Other/ Unknown
2011	27	327	69	72	5	30
2012	4	3,059	576	1,488	24	181
2013	6	965	166	2,338	15	883

Source: Unpublished NMFS dealer reports.

Because of data confidentiality issues, details for port revenues from mackerel cannot be provided. Ports that had at least $100,000 in ex-vessel revenues from mackerel over 2011-2013 (combined) included (from more mackerel dollars to less): North Kingstown, RI; Gloucester, MA; New Bedford, MA; Cape May, NJ; Portland, ME, and Point Judith, RI. (*Source: Unpublished NMFS dealer reports.)* Additional information on this fishery can be found in the specifications' Environmental Assessment, available at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/November/14msb2015174specspr.html.

6.3.2 *Illex* Squid

Landings of *Illex* squid are heavily influenced by year-to-year availability and world-market activity. Nominal ex-vessel price has increased from $200-$500 per metric ton in the 1980s to $600-$1,000 per mt in recent years. In inflation adjusted dollars, prices have varied from $600-$1,000 per mt without trend. 2013 ex-vessel prices were about $610/mt. Total ex-vessel value tracks both price and the quantity of fish landed (see Council's Advisory Panel Fishery Information Document at http://www.mafmc.org/ssc-meetings/2013/april-may for details). Landings in 2013 totaled 3,835 mt and generated $2.3 million in ex-vessel revenues.

The *Illex* fishery is a limited access fishery with 74 current permits except for open access incidental permits. As long as the fishery is open there is no trip limit for moratorium permits - open access incidental permits have a 20,000 pound per trip limit. Only a few vessels accounted for most *Illex* landings in 2013. Landings are usually provided by state but since there are few dealers that buy *Illex*, confidentiality rules do not allow precise descriptions. However, it can be reported that most *Illex* landings occur in New Jersey and Rhode Island.

Table 4: 2013 Vessel dependence on *Illex* squid (revenue-based).

Dependence on *Illex*	Number of Vessels in Each Dependency Category
1%-5%	9
5%-25%	5
25%-50%	2
More than 50%	0

Table 5: Recent *Illex* landings by gear type (mt).

Year	Bottom Trawl	Mid-Water Trawl	Other/ Unknown
2011	18,192	486	118
2012	11,390	319	0
2013	3,597	5	190

Source: Unpublished NMFS dealer reports.

Because of data confidentiality issues, details for port revenues from mackerel cannot be provided. Ports that had at least $100,000 in ex-vessel revenues from *Illex* over 2011-2013 (combined) included (from more mackerel dollars to less): North Kingstown, RI; May, NJ; Hampton, VA; and Wanchese, NC. (*Source: Unpublished NMFS dealer reports.)*

Table 6. Recent numbers of active dealers.

Year	Number of dealers buying at least $10,000 *Illex*	Number of dealers buying at least $100,000 *Illex*
2011	2	3
2012	2	2
2013	2	3

Source: Unpublished NMFS dealer reports.

Additional information on this fishery can be found in the specifications' Environmental Assessment at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/November/14msb2015174specspr.html.

6.3.3 Longfin Squid

The development and expansion of the US squid fishery occurred relatively slowly as the US industry did not develop the appropriate technology to catch and process squid in offshore waters until the 1980's. Price has increased fairly steadily since 1982 to $2,365/mt in 2013, even taking inflation into account (see Fishery Information Document at http://www.mafmc.org/ssc-meetings/2013/april-may for details). Landings in 2013 totaled 10,940 mt and generated $25.9 million in ex-vessel revenues.

Table 7: 2013 Vessel dependence on Longfin squid (revenue-based).

Dependence on Longfin	Number of Vessels in Each Dependency Category
1%-5%	49
5%-25%	68
25%-50%	35
More than 50%	31

Table 8: Recent Longfin landings by gear type (mt).

Year	Bottom Trawl	Unknown	Mid-Water Trawl	Dredge	Trap/Pots/ Pound Nets/Weir	Other
2011	8,051	1,319	91	54	13	26
2012	10,879	1,621	99	131	48	40
2013	9,890	990	19	184	1	5

Source: Unpublished NMFS dealer reports.

Table 9. Recent numbers of active dealers.

Year	Number of dealers buying at least $10,000 Longfin	Number of dealers buying at least $100,000 Longfin	Number of dealers buying at least $1,000,000 Longfin
2011	21	22	6
2012	20	25	8
2013	20	18	6

Source: Unpublished NMFS dealer reports.

Table 10. Recent Longfin squid ex-vessel revenues by port for all ports with at least $200,000 Longfin squid ex-vessel sales combined over last three years. CI = Confidential Information.

YEAR	POINT JUDITH, RI	MONTAUK, NY	CAPE MAY, NJ	HAMPTON BAYS, NY	NORTH KINGSTOWN, RI	NEW BEDFORD, MA	NEW LONDON, CT
2011	$8,206,277	$3,792,870	$2,932,800	$2,643,944	$2,321,291	$1,128,010	$141,030
2012	$10,661,735	$4,739,505	$3,666,660	$3,080,859	$1,837,346	$1,195,242	$998,311
2013	$9,842,003	$3,250,471	$4,390,149	$2,234,447	$3,251,086	$848,885	$725,914
YEAR	**BARNSTABLE, MA**	**STONINGTON, CT**	**POINT LOOKOUT, NY**	**BELFORD, NJ**	**WOODS HOLE, MA**	**POINT PLEASANT, NJ**	**SHINNECOCK, NY**
2011	$331,584	$360,612	$488,106	CI	CI	CI	CI
2012	$1,100,494	$689,303	$537,550	CI	CI	CI	CI
2013	$71,755	$403,915	$161,679	CI	CI	CI	CI
YEAR	**NEWPORT, RI**	**HAMPTON, VA**	**FALMOUTH, MA**	**EAST LYME, CT**			
2011	CI	CI	CI	CI			
2012	CI	CI	CI	CI			
2013	CI	CI	CI	CI			

Source: Unpublished NMFS dealer reports.

Additional information on this fishery can be found in the specifications' Environmental Assessment at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/November/14msb2015174specspr.html.

6.3.4 Butterfish

During the period 1965-1976, US Atlantic butterfish landings averaged 2,051 mt. From 1977-1987, average US landings doubled to 5,252 mt, with a historical peak of slightly less than 12,000 mt landed in 1984. Since then US landings have declined sharply. Low abundance and reductions in Japanese demand for butterfish probably had a negative effect on butterfish landings in the 1990s-early 2000s but regulations kept butterfish catches low from 2005-2012. Price (nominal) has increased fitfully since 1982 to about $1481/mt in 2013, but taking inflation into account erodes most of that price increase (see Fishery Information Document at http://www.mafmc.org/ssc-meetings/2013/april-may for details). Landings in 2013 totaled 1074 mt and generated $1.6 million in ex-vessel revenues.

Table 11: 2013 vessel dependence on butterfish (revenue-based).

Dependence on Butterfish	Number of Vessels in Each Dependency Category
1%-5%	108
5%-25%	19
25%-50%	0
More than 50%	0

Table 12: Recent butterfish landings by gear type (mt).

Year	Bottom Trawl	Dredge	Unknown/ Other
2011	452	27	185
2012	456	20	163
20130	940	14	137

Table 13. Recent numbers of active dealers.

Year	Number of dealers buying at least $10,000 butterfish	Number of dealers buying at least $50,000 butterfish
2011	16	7
2012	13	6
2013	17	7

Source: Unpublished NMFS dealer reports.

Table 14: Recent butterfish ex-vessel revenues by port for all ports with at least $100,000 butterfish ex-vessel sales combined over last three years. CI = Confidential Information.

YEAR	POINT JUDITH, RI	MONTAUK, NY	NORTH KINGSTOWN, RI	NEW BEDFORD, MA	HAMPTON BAYS, NY	STONINGTON, CT	AMAGANSETT, NY
2011	373,268	281,011	31,224	58,929	47,095	CI	49,144
2012	302,847	231,844	27,466	75,764	59,724		35,268
2013	376,089	300,094	536,403	67,917	39,704		22,090

Source: Unpublished NMFS dealer reports.

Additional information on this fishery can be found in the specifications' Environmental Assessment at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/November/14msb2015174specspr.html.

6.3.5 Summer Flounder, Scup, and Black Sea Bass

Otter trawls are utilized in the commercial fisheries for all three species. In addition, floating traps and pots/traps are used to capture scup and black sea bass, respectively. Information on commercial landings and economic value is provided below. Additional information on these fisheries can be found on the Council website at: http://www.mafmc.org.

Table 15: Landings (million lb) and revenues (millions of US dollars) for summer flounder, scup, and black sea bass, 2008-2013.

	Summer Flounder		Scup		Black Sea Bass	
	Landings	Ex-vessel value	Landings	Ex-vessel value	Landings	Ex-vessel value
2008	9.21	21.89	5.22	5.81	1.93	5.62
2009	11.05	21.05	8.20	6.27	1.17	3.52
2010	13.55	27.44	10.73	7.11	1.75	5.34
2011	16.57	29.86	15.03	8.23	1.69	5.40
2012	12.91	30.23	14.88	10.43	1.72	5.75
2013	12.49	29.17	17.87	9.79	2.26	7.36

Source: Unpublished NMFS dealer reports.

The ex-vessel value of summer flounder landings in 2013 was approximately $29.2 million resulting from commercial landings of 12.5 million lb, with an average ex-vessel price estimated at $2.33/lb. Based on VTR data for 2013, the bulk of the summer flounder landings were taken by bottom otter trawls (97 percent), followed by bottom scallop trawls (1 percent), with other gear types (e.g. hand lines, scallop dredges, sink gill nets) each accounting for 1 percent or less of landings. In Federal waters, commercial fishermen holding a moratorium permit may fish for summer flounder. Permit data for 2013 indicates that 824 vessels held commercial permits for summer flounder. Top ports of landing in 2013 included Newport News, VA (2.20 mil lb), Hampton, VA (1.92 mil lb), and Pt. Judith, RI (1.92 mil lb).

Commercial scup landings were approximately 17.9 million lb (from ME to Cape Hatteras, NC) and valued at $9.80 million in 2011 ($0.55/lb). Based on VTR data for 2013, the bulk of scup landings were taken by bottom otter trawls (97 percent), followed by pots and traps (~1.3 percent). In Federal waters, commercial fishermen holding a moratorium permit may fish for scup. Permit data indicate that 697 vessels held commercial permits for scup in 2013. The top ports of landing for scup in 2013 included Point Judith, RI (6.19 mil lb), Montauk, NY (3.38 mil lb), and Cape May, NJ (0.91 mil lb).

Commercial black sea bass landings were approximately 1.74 million lb (from ME to Cape Hatteras, NC) and valued at $5.7 million in 2012 ($3.30/lb). Based on VTR data for 2013, the majority of black sea bass landings were reported to be taken by bottom otter trawls (61 percent), followed by pots and traps (26 percent), offshore lobster pots (7 percent), and hand lines (5 percent). Other gear types each accounted for less than 1 percent of landings. In Federal waters, commercial fishermen holding a moratorium permit may fish for black sea bass. Permit data for 2013 indicate that 736 vessels held commercial permits for black sea bass. Top ports of landing for black sea bass in 2013 included Ocean City, MD (0.22 mil lb), Pt. Pleasant, NJ (0.21 mil lb), and Cape May, NJ (0.19 mil lb).

Additional information on this fishery can be found in the specifications' Environmental Assessment at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/March/14sfsbsb20142015specspr.html.

6.3.6 Golden Tilefish

A detailed description of the social and economic aspects of the fishery for tilefish was presented in Amendment 1 to the FMP (2009; available at http://www.mafmc.org/fmp/pdf/Tilefish_Amend_1_Vol_1.pdf). Montauk, NY and Barnegat Light, NJ continue to be the ports with the most landings.

Commercial tilefish ex-vessel revenues have ranged from $2.5 to $5.5 million for the 1999 through 2013 period (calendar year). The mean price for tilefish (adjusted) has ranged from $1.03/lb in 2004 to $3.27/lb in 2013. The 2009 through 2013 coastwide average ex-vessel price per pound for all market categories combined was $2.98, $3.31 for extra large, $3.71 for large, $2.86 for medium, $2.21 for kittens, $1.92 for small-kittens; $1.83 for small, and $3.29 for unclassified.

Over 56 percent of the landings for 2013 were caught in statistical area 537, which includes Atlantis and Block Canyons. Statistical area 616, which includes Hudson Canyon, had 36 percent of the landings.

The ports and communities that are dependent on tilefish are fully described in Amendment 1 to the FMP available at: http://www.mafmc.org/fmp/pdf/Tilefish_Amend_1_Vol_1.pdf). Additional information on "Community Profiles for the Northeast U.S. Fisheries" can be found at http://www.nefsc.noaa.gov/read/socialsci/community_profiles/.

Table 16: Top ports of landing (in lb) for golden tilefish, based on NMFS 2012 - 2013 dealer data. Since this table includes only the "top ports," it may not include all of the landings for the year. (Note: values in parenthesis correspond to IFQ vessels). C=Confidential.

Port	2012		2013	
	Landings	# Vessels	Landings	# Vessels
MONTAUK, NY	1,193,294 (1,188,394)	17 (4)	1,183,535 (1,179,437))	14 (4)
BARNEGAT LIGHT/LONG BEACH, NJ	397,610 (396,054)	12 (9)	357,360 (355,845)	8 (6)
HAMPTON BAYS, NY	213,948 (C)	3 (C)	250,941 (C)	4 (C)
POINT JUDITH, RI	7,789 (0)	48 (0)	13,868 (0)	53 (0)

Source: Unpublished NMFS dealer reports.

Table 17: Dealer dependence on tilefish, 2009-2013.

Number of Dealers	Relative Dependence on Tilefish
82	<5%
3	5%-10%
2	10% - 25%
3	25% - 50%
1	50% - 75%
1	90%+

Source: Unpublished NMFS dealer reports.

Additional information on this fishery can be found in the specifications' Environmental Assessment at http://www.greateratlantic.fisheries.noaa.gov/regs/2014/September/14tilefish20152017specspr.html.

6.3.7 Red Crab[18]

The red crab fishery is managed by the New England Fishery Management Council, and currently consists of five vessels with limited access permits, three of which are currently active (two active full-time vessels and one active part-time vessel). The fishery operates from Cape Hatteras to the US-Canadian border. The vessels use conical mesh traps, set about 150 feet apart with 150 traps on each line. Each vessel fishes 600 traps, and haul each line daily. Traps are set along the 350 fathom (640 meter) depth contour. This depth is targeted because red crabs segregate by sex and depth, and take of female crabs is prohibited. Targeting this depth allows for male-only harvest. Vessels move north or

[18] Unless otherwise noted, information is from 2013 Red Crab Specifications, available at http://www.nefmc.org/management-plans/red-crab, and Pers. Comm. with Jon Williams (red crab fishery).

south fishing along this contour several times per year, resulting in a relatively even distribution of reported landings (Figure 4).

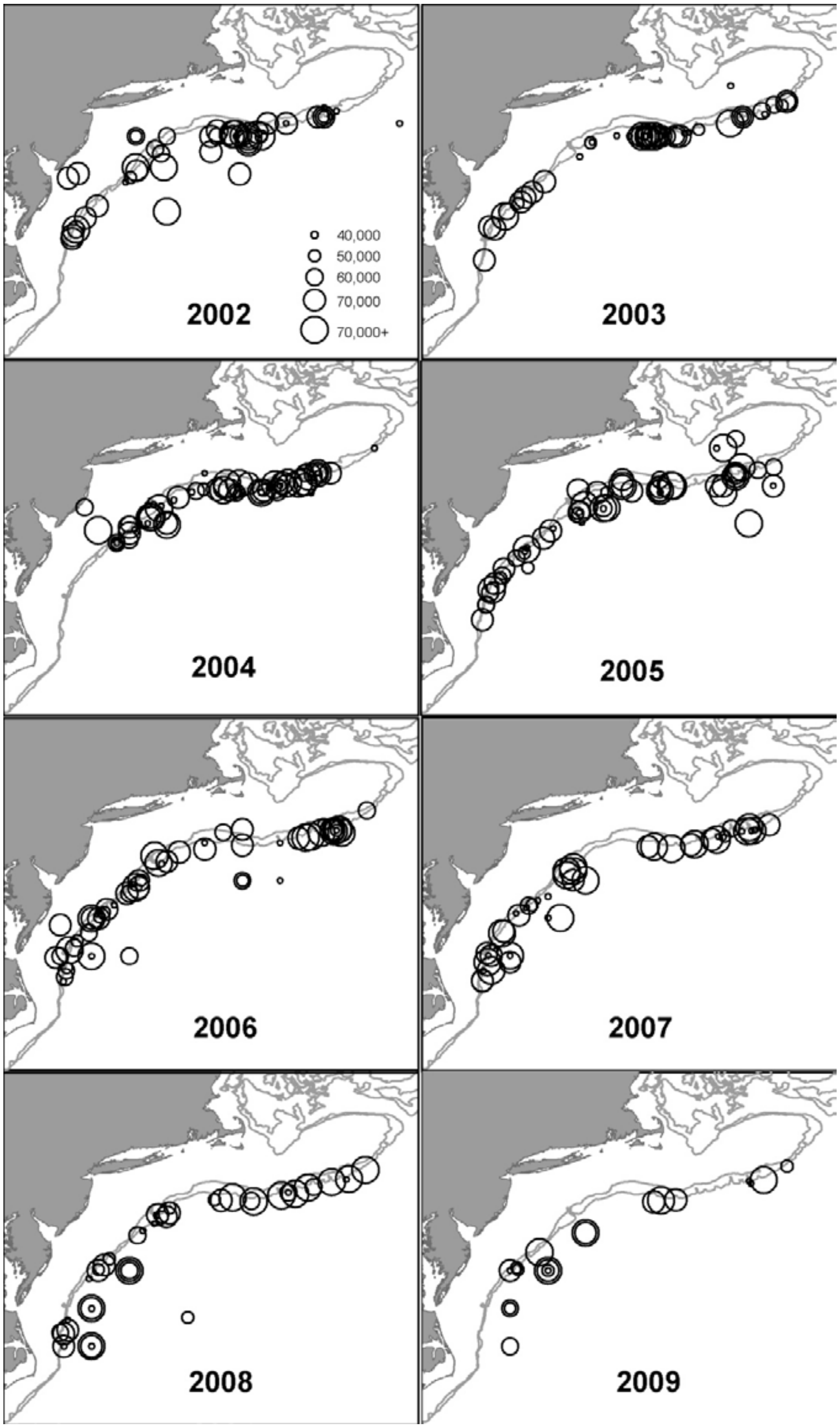

Figure 4: Locations of reported red crab trips, 2002-2009 (partial). Note some reported trip locations overlap and some reported trip locations are obviously incorrect.[19]

The fishery is a small, market-driven fishery, and landings are very closely tied to market demand. As a result, the landings have been lower than the Total Allowable Landings recently. Almost all red crab landings occur in New Bedford, MA. The few boats with limited access permits in the red crab fishery have overlapping ownership and operate as a voluntary cooperative. The cooperative relationship fosters a strong incentive to harvest red crab in a way that maximizes profits for the fleet as a whole. It is understood that primarily the current market conditions, not the landings limit, constrain the catch of red crab.

Since implementation of the FMP, four vessels have harvested the total red crab landings. Although this is a small fishery in terms of the number of vessels that participate, the individuals that are involved in this fishery have a very high dependence on the red crab resource. The handful of vessels that received limited access permits were surveyed during the development of the FMP, and the majority of harvesters reported that revenues from the red crab fishery make up the vast majority of their annual income. Since implementation of the FMP, vessel owners still report red crab as the primary fishery that supports their annual income. The figure and table below describe landings and revenues for red crab.

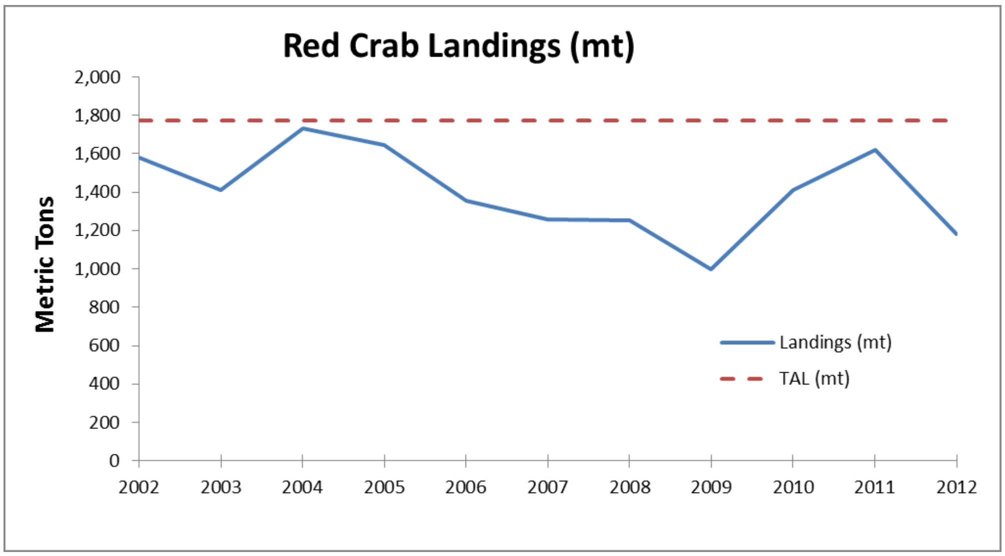

Figure 5. Red Crab Landings 2002-2012.

[19] Figure from Red Crab Amendment 3, available at: http://www.nefmc.org/library/amendment-3-4.

Table 18. Red crab price per pound, inflation adjusted price (based on 2010 dollars), Vessel Trip Report (VTR) landings in pounds and estimated revenue, fishing years 2002-2012.

Fishing year	Price per Pound	* Inflation Adjusted Price	** VTR Reported Landings	*** Revenue
2002	$0.86	$1.04	3,484,283	$3,623,654
2003	$0.85	$1.00	3,111,953	$3,111,953
2004	$0.94	$1.08	3,815,415	$4,120,648
2005	$0.90	$1.00	3,631,754	$3,631,754
2006	$0.90	$0.97	2,984,084	$2,894,561
2007	$0.92	$0.96	2,777,723	$2,666,614
2008	$1.01	$1.03	2,763,519	$2,846,425
2009	$0.96	$0.97	2,202,021	$2,135,960
2010	$0.97	$0.97	3,111,892	$3,018,535
2011	$0.97	$0.95	3,575,278	$3,396,514
2012	$1.00	$0.97	2,602,352	$2,524,281
Average	$0.93	$0.99	3,096,389	$3,065,425

* The consumer price index (CPI) used to convert nominal dollars to 2010 equivalent dollars is from the Bureau of Economic Analysis Table 1.1.9 (www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1).
** Landings data is from VTRs, which do not exactly match dealer data.
*** Revenue is estimated based on VTR reported landings and prices calculated from dealer data.

6.3.8 Silver Hake (Whiting)[20]

Prior to 1960, the commercial exploitation of silver hake in the Northwest Atlantic was exclusively by U.S. fleets. Distant water fleets reached the banks of the Scotian Shelf by the late 1950s, and by 1961, scouting/research vessels from the former USSR were fishing on Georges Bank. By 1962, factory freezer fleets (ranging from 500 to 1,000 GRT) intensively exploited the whiting and red hake stocks on the Scotian Shelf and on Georges Bank. Led by the former USSR, the distant water fleet landed an increasingly larger share of silver hake catch from the Gulf of Maine, Georges Bank, and northern Mid-Atlantic waters. In 1962, the distant water fleet landed 41,900 tons of silver hake (43% of the total silver hake landings), but that number had increased to 299,200 tons (85% of the total silver hake landings) in 1965. That year marked the year of the highest total commercial silver hake landings, 351,000 tons. Unable to sustain such high rates of fishing, the abundance of silver hake off the U.S. Atlantic coast began to decline. As a result, total commercial catches decreased significantly after 1965 and reached a 20-year low of 55,000 tons in 1970. U.S. recreational landings also dropped after 1965 to about half the levels of previous years.

After 1970, catches of silver hake by the distant water fleet in U.S. waters increased again, especially in southern New England and the Mid-Atlantic. Between 1971 and 1977, distant water fleet landings from the southern stock averaged 75,000 tons annually and accounted for 90% of the total harvest from the southern stock. The size and efficiency of distant water fleet factory ships also increased, many ranging between 1,000 and 3,000 GRT. In 1973, the International Commission for the Northwest Atlantic Fisheries established temporal and spatial restrictions that reduced the distant water fleet to small "windows" of opportunity to fish for U.S. silver hake. These windows restricted the distant water fleet to the continental slope of Georges Bank and the Mid-Atlantic. As effort control regulations increased, foreign fleets gradually left most areas of Georges Bank.

[20] Taken from http://s3.amazonaws.com/nefmc.org/SAFE-Report-for-Fishing-Year-2013.pdf.

Although foreign fishing had ceased on Georges Bank by about 1980 and in the Mid-Atlantic by about 1986, the U.S. groundfish fleet's technologies and fishing practices began to advance, and between 1976 and 1986, fishing effort (number of days) increased by nearly 100% in the Gulf of Maine, 57% on Georges Bank, and 82% in southern New England (Anthony, 1990). Such increases in effort, although directed primarily towards principal groundfish species (cod, haddock, yellowtail flounder), were accompanied by a 72% decline in silver hake biomass. In turn, U.S. East Coast landings of silver hake began to decline, dropping to 16,100 tons in 1981. Since that time, landings have remained relatively stable, but at much lower levels in comparison to earlier years. U.S. East Coast silver hake catches are taken almost exclusively by otter trawls, either as bycatch from other fisheries or through directed fisheries targeting a variety of sizes of silver hake. The figures below describe silver hake landings, and vessel dependence on silver hake.

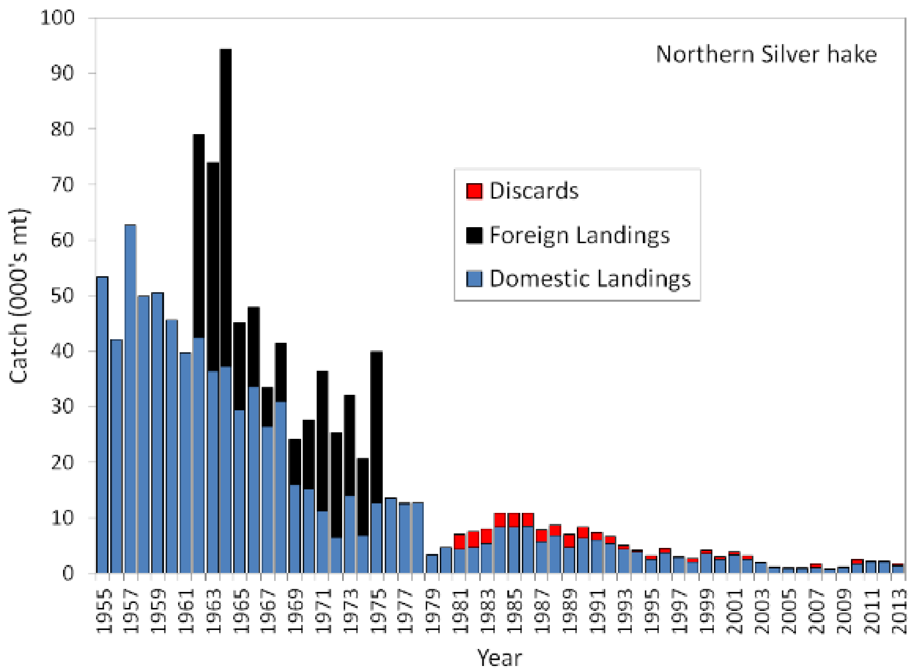

Figure 6. Northern Silver Hake Catch.

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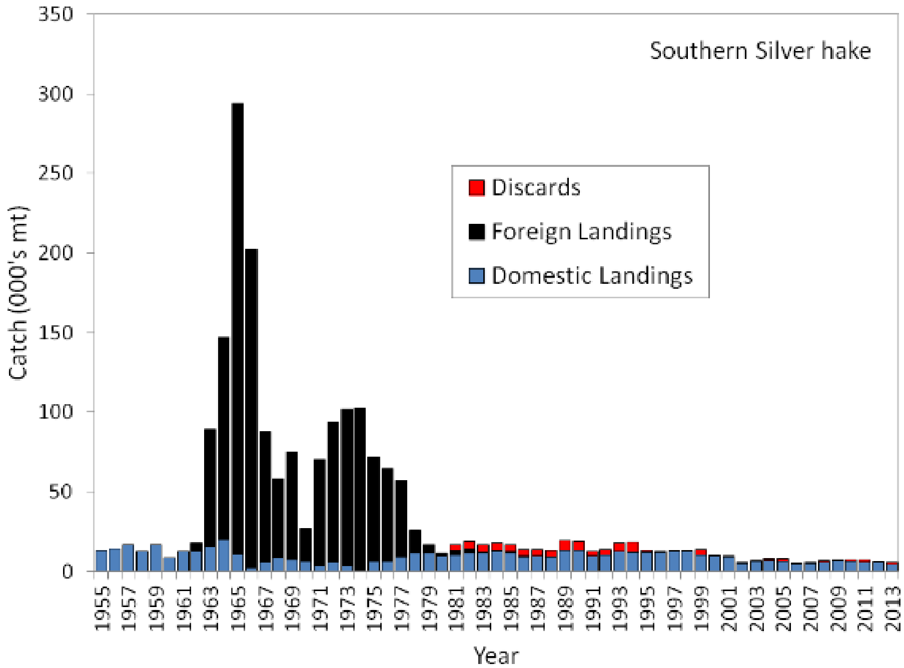

Figure 7. Southern Silver Hake Catch.

Table 19. Silver hake landings and revenues.

Year	Silver hake landings (mt)	Silver hake revenue ($)
1996	16,181	13,567,329
1997	15,565	15,045,264
1998	14,867	13,259,078
1999	14,020	14,243,589
2000	12,362	11,644,431
2001	12,908	13,211,153
2002	7,938	7,410,730
2003	8,643	9,326,001
2004	8,163	10,006,343
2005	6,902	8,493,180
2006	5,153	6,727,695
2007	6,217	7,880,472
2008	5,915	8,035,894
2009	7,441	8,602,262
2010	8,014	10,951,987

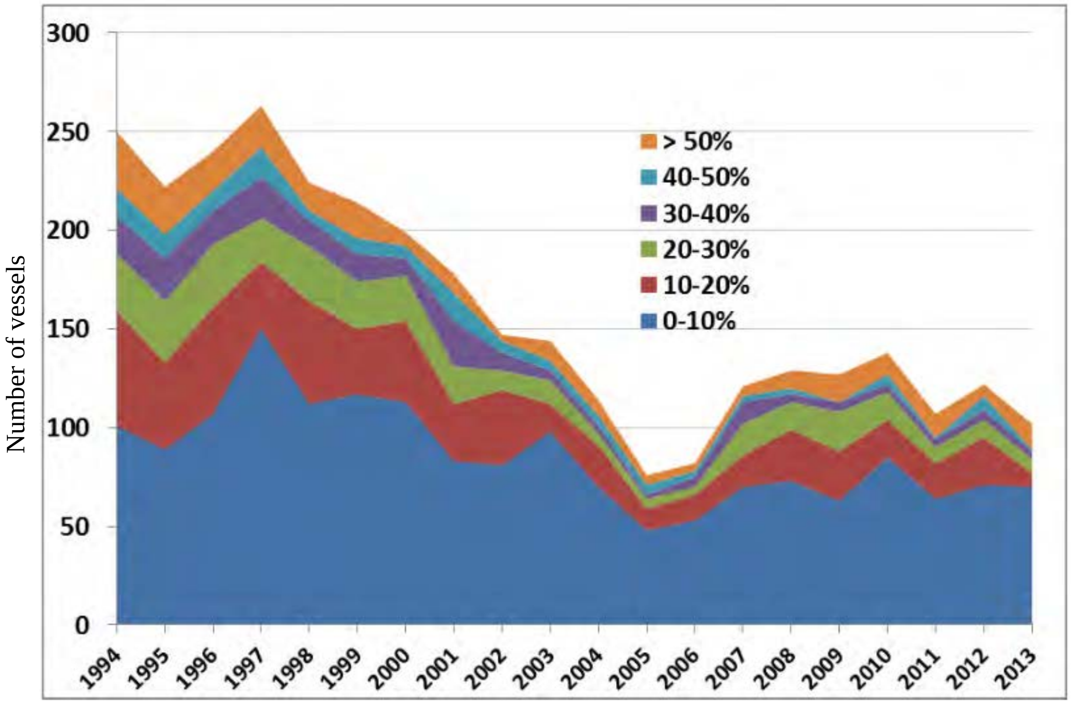

Figure 8. Total number of vessels, by dependence on small mesh (hake) multispecies fishery.

6.3.9 Sea Scallops[21]

In the fishing years 2003-2011, the landings from the northeast sea scallop fishery stayed above 50 million pounds, surpassing the levels observed historically. The recovery of the scallop resource and consequent increase in landings and revenues was striking given that average scallop landings per year were below 16 million pounds during the 1994-1998 fishing years, less than one-third of the present level of landings. Recent landings and revenues are described in the figures below.

The limited access scallop fishery consists of 347 vessels. It is primarily full-time, with 250 full-time dredge, 52 full-time small dredge vessels and 11 full-time net boats. Since 2001, there has been considerable growth in fishing effort and landings by vessels with general category permits, primarily as a result of resource recovery and higher scallop prices. Most limited access category effort is from vessels using scallop dredges, including small dredges. The number of vessels using scallop trawl gear has decreased continuously and has been at 11 full-time trawl vessels since 2006. In comparison, there has been an increase in the numbers of full-time and part-time small dredge vessels after 2002. About 80% of the scallop pounds are landed by full-time dredge and about 13% landed by full-time small dredge vessels since the 2007 fishing year. Both full-time and part-time limited access vessels had a high dependence on scallops as a source of their income. Full-time limited access vessels had a high dependence on scallops as a source of their income and the majority of the full-time vessels (94%) derived more than 90% of their revenue from the scallop fishery in 2011. Comparatively, part-time limited access vessels were less dependent on the scallop fishery in 2011, with only 37% of part-time vessels earning more than 90% of their revenue from scallops.

Amendment 11 implemented a limited entry program for the general category fishery reducing the number of general category permits after 2007. In 2011, there were 288 LAGC IFQ permits, 103

[21] Taken from Framework 25, available at http://www.nefmc.org/management-plans/scallops

Northern Gulf of Maine (NGOM) and 279 incidental catch permits in the fishery totaling 670 permits. Although not all vessels with general category permits were active in the years preceding 2008, the number of vessels (and owners) that hold a limited access general category permit under the Amendment 11 regulations are less than the number of general category vessels that were active prior to 2008. Most general category effort is, and has been, from vessels using scallop dredge and other trawl gear. The percentages of scallop landings show that landings made with a scallop dredge in 2012 continue to be the highest compared to other general category gear types. General category permit holders (IFQ and NGOM) are less dependent on scallops compared to vessels with limited access permits. In 2011, less than half (43%) of IFQ permitted vessels earned greater than 50% of their revenue from scallops. Among active NGOM permitted vessels (that did not also have a limited access permit), 88% had no landings with scallops in 2011. Scallops still comprise the largest proportion of the revenue for IFQ general category vessels, accounting for 38.6% of these vessels revenue. Scallops still comprise the largest proportion of the revenue for IFQ general category vessels, accounting for 38.6% of these vessels revenue. For NGOM vessels (that did not also have a limited access permit) scallop landings accounted for less than 1% of revenue in 2011.

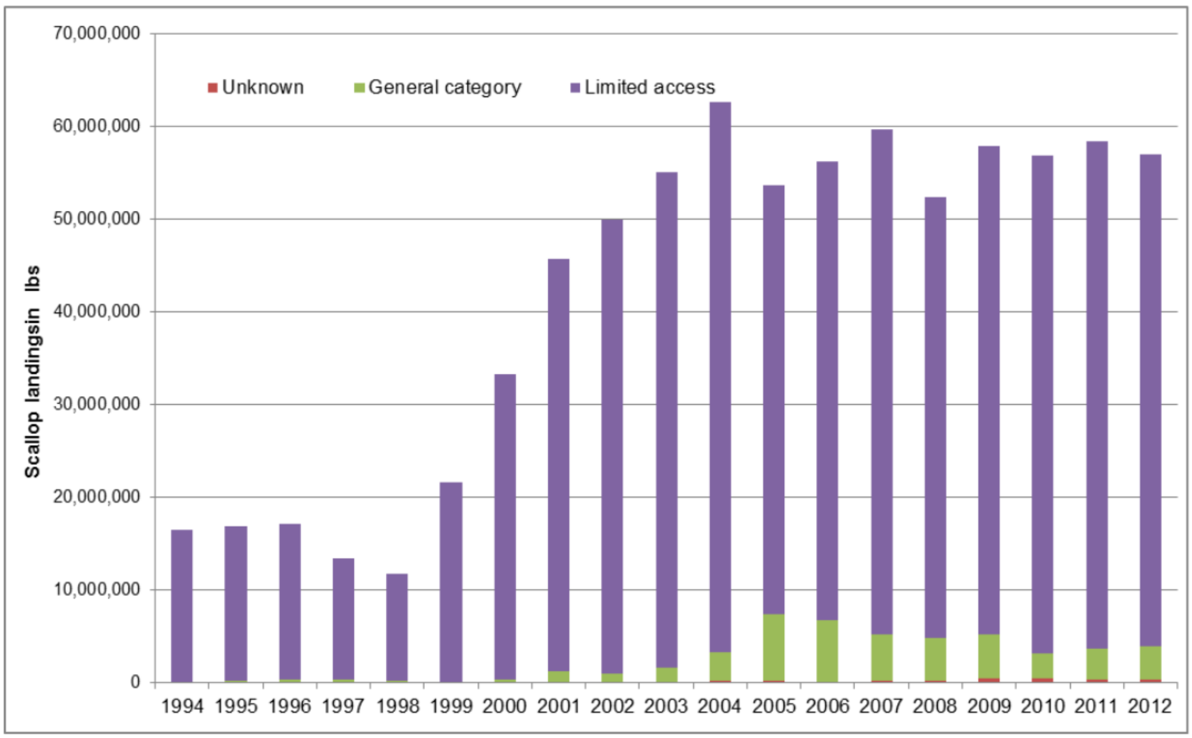

Figure 9. Scallop landings by permit category and fishing year (in lb., dealer data).

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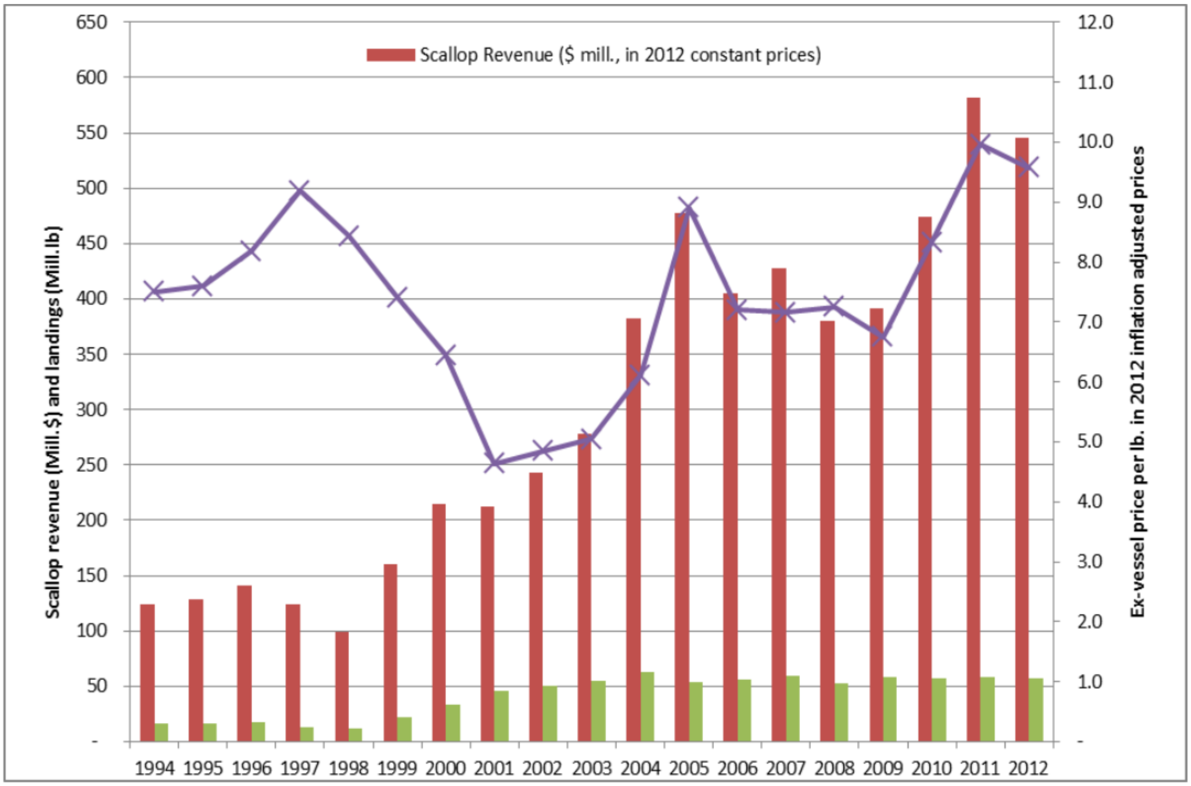

Figure 10. Trends in total scallop revenues (left bar, left axis), landings (right bar, left axis) and ex-vessel price (line, right axis) by fishing year (including limited access and general category fisheries, revenues and prices are expressed in 2011 constant prices.

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7.0 IMPACTS OF THE ALTERNATIVES

7.1 DEEP SEA CORALS IN THE MID-ATLANTIC

Impacts to deep sea corals were analyzed by mapping and quantifying available data for coral presence and suitable habitat relative to all proposed coral zones (broad and discrete). The sections below describe this analysis relative to several data sources for deep sea corals and their habitat, including historical records, observations from recent research surveys, Northeast Fisheries Observer Program (NEFOP) records, and modeled deep sea coral habitat.

7.1.1 Deep Sea Coral Research and Technology Program (DSCRTP) Records

Coral presence data from NOAA's Deep Sea Coral Research and Technology Program database were analyzed using ArcGIS software and Microsoft Excel to determine how records of known corals overlap with proposed management areas. The DSCRTP database[22] 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 20). 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). Within the proposed discrete zones, the areas of highest coral observations are contained within Baltimore Canyon, Norfolk Canyon, and the Mey-Linedenkohl Slope (Table 23).

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 (26%). Outside of the proposed zones, there are 232 total records, the majority of which are stony corals or sea pens (Table 22). However, the data below should be interpreted with caution. The data presented for coral records are presence-only, as little absence or abundance information is available. Many areas in the mid-Atlantic have not been explored for the presence of corals, thus, a lack of historical records does not necessarily indicate a lack of deep sea corals. Although each record is associated with a set of geographic coordinates, some historical records have uncertainties associated with their exact position. 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, and deep sea coral taxonomy is constantly evolving. Additionally, given the nature of this type of data collection, many of the records tend to be spatially clustered and may display a bias toward areas that have been more heavily sampled. This analysis does not include the results of recent survey work, as data from these cruises have not yet been added to the DSCRTP database (however, some information is available; see Section 7.1.2 for additional discussion of recent research findings).

[22] As of June 10, 2013.

Table 20: 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 21: 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%	82	35.6%
Stony corals	167	26.3%	64	27.8%
Sea pens	255	40.2%	84	36.5%
TOTAL	**635**	**100%**	**230**	**100%**

[a] Based on FMAT (2014) boundaries. All records within proposed discrete zones are also contained within the shallowest broad zone option (200 m), with the exception of two records in Norfolk Canyon (one sea pen and one stony coral).

Table 22: Deep sea coral presence records within the Mid-Atlantic region but 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	% by Coral Type
Soft corals and gorgonians	23	10%
Stony corals	117	50%
Sea pens	92	40%
TOTAL	**232**	**100%**

Table 23: Deep sea coral historical presence records by proposed discrete zone (based on 2014 FMAT boundaries). 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 (2012-2013).

	Coral Type (Order)				
Canyon or Complex	**Alcyonacea**	**Gorgonacea**	**Pennatulacea**	**Scleractinia**	**Total Records**
Block Canyon					**0**
Ryan-McMaster Canyons		5	7	4	**16**
Emery-Uchupi Canyons	1		3	2	**6**
Jones-Babylon Canyons				1	**1**
Hudson Canyon	1	1		3	**5**
Mey-Lindenkohl Slope	9	13	40	12	**74**
Spencer Canyon		1	9	2	**12**
Wilmington Canyon			2		**2**
North Heyes-South Wilmington Canyons					**0**
South Vries Canyon	1			1	**2**
Baltimore Canyon	7	21	1	25	**54**
Warr-Phoenix Canyon Complex			14		**14**
Accomac-Leonard Canyons	1		3	2	**6**
Washington Canyon				1	**1**
Norfolk Canyon	5	16	5	11	**37**
Grand Total	**25**	**57**	**84**	**64**	**230**

7.1.2 Coral Observations from Recent Research

As noted previously, deep sea corals have recently been observed within the boundaries of several proposed discrete coral zones, including Block Canyon, Ryan and McMaster Canyons, the Mey-Lindenkohl Slope, Spencer Canyon, Wilmington Canyon, Baltimore Canyon, Phoenix Canyon, Accomac and Leonard Canyons, Washington Canyon, and Norfolk Canyon (Table 24). Although general survey locations and some qualitative and preliminary quantitative results are available, some processed and/or georeferenced data from recent cruises are not yet available. However, new information has been incorporated into the evaluation of alternatives to the extent possible. Findings from each survey relative to proposed coral zones are briefly described below.

Table 24: Summary of recent (2012-2014) research expeditions in proposed discrete areas.

Expedition Identifier	Name	Date	Survey Type	Vessel	Proposed Discrete Areas Surveyed
BOEM	Atlantic Deepwater Canyons Expedition	Aug.-Sept. 2012	ROV	Nancy Foster	Baltimore Canyon, Norfolk Canyon
HB1204	Deep Sea Coral Survey	July 2012	Towed Camera	Henry Bigelow	Mey-Lindenkohl Slope *(Middle Toms Canyon, Toms-Hendrickson inter-canyon Area, Toms Canyon, edge of Hendrickson Canyon)*
HB1302	Deep Sea Coral Survey	June 2013	Towed Camera	Henry Bigelow	Ryan Canyon
EX1304	Okeanos Explorer Northeast Canyons Expedition	Jul.-Aug. 2013	ROV	Okeanos Explorer	Block Canyon and surrounding areas
HB1404	Deep Sea Coral Survey	Aug. 2014	Towed Camera	Henry Bigelow	Mey-Lindenkohl Slope *(Lindenkohl Canyon, Toms Canyon, Carteret Canyon),* Washington Canyon, Accomac Canyon, Leonard Canyon, Wilmington Canyon, Spencer Canyon
EX1404	Okeanos Explorer Our Deepwater Backyard Expedition	Sept.-Oct. 2014	ROV	Okeanos Explorer	Mey-Lindenkohl Slope *(Lindenkohl Canyon, Hendrickson Canyon),* Washington Canyon, Norfolk Canyon, Phoenix Canyon, McMaster Canyon, Ryan Canyon

2012 BOEM Survey

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 11). *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.[23] Several other coral types were observed in both Baltimore and Norfolk Canyons, including dense areas of *Paragorgia*, *Anthothela*, *Primnoa*, and *Acanthogorgia* communities (general locations shown in figure below; precise georeferenced coral locations not yet available). 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 discrete zones under Alternative 3B.

[23] 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.

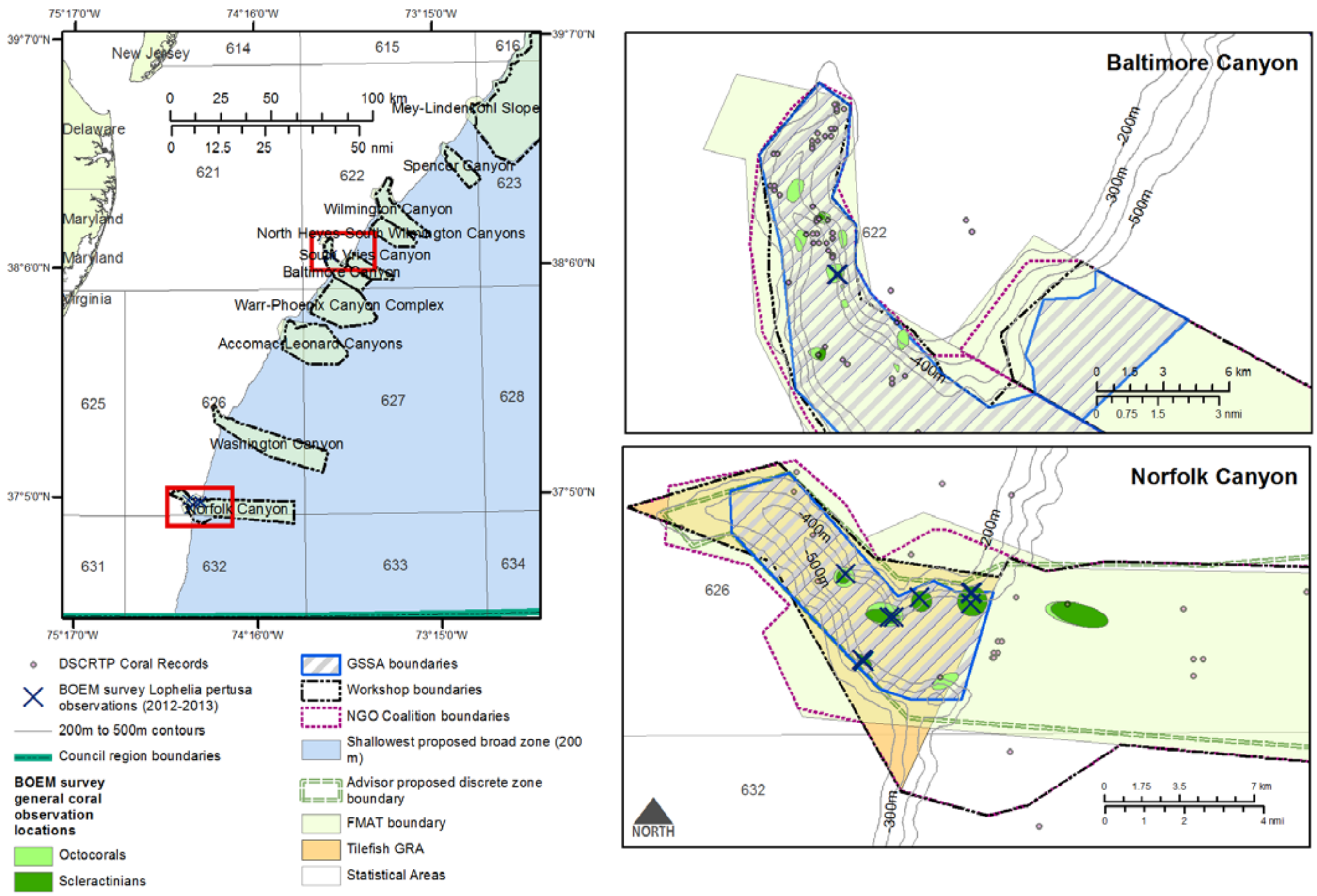

Figure 11: Observations of *Lophelia pertusa* from BOEM cruises in Baltimore and Norfolk Canyons, 2012 and 2013. Source: Brooke and Ross (2013).

2012 ACUMEN Survey

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*.[24] 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. 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 25). The majority of corals were octocorals, with fewer observations of stony corals and sea pens. Differences among individual canyons

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

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.

2013 Deep Sea Coral Research and Technology Program 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 much more abundant at the deepest tow (Table 25). 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 inter-canyon area between Ryan and McMaster canyon, where corals were observed in only one image.

2013-2014 Northeast Canyons and Seamounts Okeanos Explorer Expeditions

In the summer of 2013, the NOAA vessel *Okeanos Explorer* explored northeast 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 of 2013. This ROV dive began at approximately 1,870 meters depth and transitioned upslope, where numerous coral colonies were observed on the faces and tops of large hard features. Cup corals were also observed on the underside of ledges. The dominant species was *Acanella sp*., a type of bamboo coral that commonly occurs on both soft and hard substrates.[25]

Another *Okeanos Explorer* expedition was conducted in September and October of 2014.[26] This expedition included ROV dives in Lindenkohl and Hendrickson Canyons (within the Mey-Lindenkohl Slope proposed discrete zone), as well as in Washington, Norfolk, Phoenix, McMaster, and Ryan Canyons. In Washington Canyon, scientists observed colonies of deep sea including *Anthothela* and both white and pink bubblegum corals. In Norfolk Canyon, several colonies of octocorals (including *Acanthagorgia*, *Anthothela*, and bubble gum corals), were observed in addition to many species of fish and invertebrates, including monkfish, red crab, and several schools of squid. In Phoenix Canyon, the dive began at about 1,135 meters depth, and many large rocks and outcrops encrusted with corals were observed, as well as several species of squid, skate, and flounder. High densities of cup corals under ledges were also observed. In Hendrickson Canyon, the ROV began at about 1,670 meters and observed abundant cup corals during this dive, generally located under frequent overhangs and outcrops. Also noted were octocorals, black corals, stony corals, sea pens, and several species of fish. In McMaster canyon, octocorals were observed in high density, as well as groups of cup corals. Similar to Hendrickson Canyon, large groups of corals were observed living under overhangs and outcrops along the steep canyon walls. In Ryan Canyon, human debris was observed, in addition to shrimp, fish, eels, hake, dogfish, some cup corals, and coral rubble. Diversity of corals along the transect in Ryan Canyon was low. Photos, videos, logs, and maps from these dives are publicly available at: http://oceanexplorer.noaa.gov/okeanos/explorations/ex1404/welcome.html.

[25] http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/dailyupdates.html
[26] http://oceanexplorer.noaa.gov/okeanos/explorations/ex1404/welcome.html.

2014 Towed Camera Survey

A research survey aboard the *Henry Bigelow* using towed cameras took place in August 2014. Researchers surveyed portions of Lindenkohl, Toms, and Carteret Canyons (within the Mey-Lindenkohl Slope proposed discrete zone), as well as areas in Washington Canyon, Accomac and Leonard Canyons, Wilmington Canyon, and Spencer Canyon. Deep sea corals were observed in a number of analyzed images in all of these canyons (Table 26). These camera surveys were also used to further ground truth NOAA's coral habitat suitability model. Scientists noted that the abundance, distribution, and diversity of deep sea corals varied between and within canyons, exhibiting different trends correlating with different geological characteristics.

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Table 25: 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	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	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	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	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	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	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	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	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	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	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	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	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	2230	1	52	0.04	2.33	498

Table 26: Preliminary image survey of NE canyon fauna from TowCam surveys, 2014. Images were captured at 10 second intervals. Each bottom image was visually screened for hard and soft corals, sponges, and fish. Presence/absence information was logged for each image.

TowCam Dive #	Canyon Location	Date	Launch Lat N	Launch Lon W	Recovery Lat	Recovery Lon	Depth range (m)	No. of bottom images	No. images w/ corals	No. images w/ sponges	% images w/corals	% images w/ sponges
HB1404- 01	Washington Canyon	8/6/2014	37 25.087	74 24.824	37 247125	74 24.4262	491-874	1680	70	74	4.17	4.40
HB1404- 02	Washington Canyon	8/7/2014	37 22.5827	74 17.2213	37 22.5846	74 17.2227	DIVE ABORTED	x	x	x	x	x
HB1404- 03	Washington Canyon	8/7/2014	37 22.5858	74 17.2234	37 22.7155	74 17.3077	DIVE ABORTED	x	x	x	x	x
HB1404- 04	Washington Canyon	8/7/2014	37 22.5815	74 17.2256	37 22.5437	74 17.8913	1126-1294	1004	81	47	8.07	4.68
HB1404- 05	Washington Canyon	8/8/2014	37 18.6327	74 13.0820	37 18.7444	74 12.4163	1515-1637	748	745	94	99.60	12.57
HB1404- 06	Accomac Canyon	8/8/2014	37 49.5832	74 03.0897	37 49.4621	74 03.3781	497-825	424	66	227	15.57	53.54
HB1404- 07	Leonard Canyon	8/8/2014	37 49.5877	73 55.7825	37 49.4592	73 55.4191	1167-1235	446	43	43	9.64	9.64
HB1404- 08	Leonard Canyon	8/9/2014	37 47.5576	73 55.4035	37 47. 5836	73 54.7282	1348-1522	707	574	118	81.19	16.69
HB1404- 09	Wilmington Canyon	8/9/2014	38 26.2101	73 32.5511	38 25.6822	73 31.8554	370-540	1321	401	1149	30.36	86.98
HB1404- 10	Wilmington Canyon	8/10/2014	38 19.9080	73 26.4575	38 19.2323	73 25.4968	1130-1492	1156	124	226	10.73	19.55
HB1404- 11	Wilmington Canyon	8/10/2014	38 22.7823	73 30.3828	38 22.6162	73 30.8392	640-818	700	0	0	0.00	0.00
HB1404- 12	Wilmington Canyon	8/10/2014	38 21.2480	73 26.7960	38 20.6120	73 26.5101	574-1031	1362	4	303	0.29	22.25
HB1404- 13	Wilmington Canyon	8/11/2014	38 17.1090	73 24.7006	38 17.5566	73 24.0859	1466-1610	932	737	35	79.08	3.76
HB1404- 14	Wilmington Canyon	8/11/2014	38 19.2628	73 30.9987	38 19.3828	73 31.4621	661-847	671	1	88	0.15	13.11
HB1404- 15	Spencer Canyon	8/12/2014	38 36.7995	73 07.9232	38 36.6291	73 7.7906	526-700	796	0	162	0.00	20.35
HB1404- 16	Spencer Canyon	8/12/2014	38 35.7369	73 08.8504	38 35.0430	73 09.0364	757-1020	659	286	410	43.40	62.22
HB1404- 17	Spencer Canyon	8/12/2014	38 34.4928	73 07.2639	38 34.1771	73 07.1344	1035-1313	1117	122	470	10.92	42.08
HB1404- 18	Spencer Canyon	8/13/2014	38 33.9234	73 06.3917	38 33.9026	73 04.8420	DIVE ABORTED			x	x	x
HB1404- 19	Spencer Canyon	8/13/2014	38 33.6988	73 06.1232	38 33.3535	73 05.9664	1302-1522	472	268	180	56.78	38.14
HB1404- 20	Spencer Canyon, very deep	8/13/2014	38 29.5745	73 04.1680	38 29.5526	73 03.9679	2002-2121	440	0	52	0.00	11.82
HB1404- 21	Lindenkohl Canyon, Shallow	8/14/2014	38 47.6467	73 01.2698	38 47.7220	73 00.8393	546-664	390	13	0	3.33	0.00
HB1404- 22	Lindenkohl Canyon, Mid	8/14/2014	38 46.1905	72 56.5147	38 45.9626	72 56.6090	945-1139	576	288	345	50.00	59.90
HB1404- 23	Lindenkohl Canyon, Deep	8/14/2014	38 44.0860	72 53.6111	38 43.9139	72 53.5711	1527-1607	238	206	35	86.55	14.71
HB1404- 24	Lindenkohl Canyon, Very deep	8/14/2014	38 42.0646	72 50.8507	38 41.9557	72 50.8198	1762-1946	390	215	110	55.13	28.21
HB1404- 25	Carteret Canyon, Deep	8/14/2014	38 50.9024	72 45.6454	38 50.7350	72 45.5056	1373-1478	309	105	107	33.98	34.63
HB1404- 26	Carteret Canyon, Very Deep	8/15/2014	38 48.6365	72 43.8868	38 48.5267	72 43.9589	1651-1724	288	144	17	50.00	5.90
HB1404- 27	Carteret Canyon, Mid	8/15/2014	38 51.2950	72 47.1788	38 51.3254	72 47.2947	1200-1286	382	33	95	8.64	24.87
HB1404- 28	Carteret Canyon, Shallow	8/15/2014	38 53.7168	72 51.3923	38 53.4874	72 51.3237	627-823	909	0	55	0.00	6.05

7.1.3 Northeast Fisheries Observer Program Records

Records of deep-sea coral bycatch in the Northeast Fisheries Observer Program (NEFOP) 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 27). Historically, observers did not record numbers or density; instead, corals tended to be discarded and the total weight 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 28). 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 12).

Table 27: 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 28: 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**

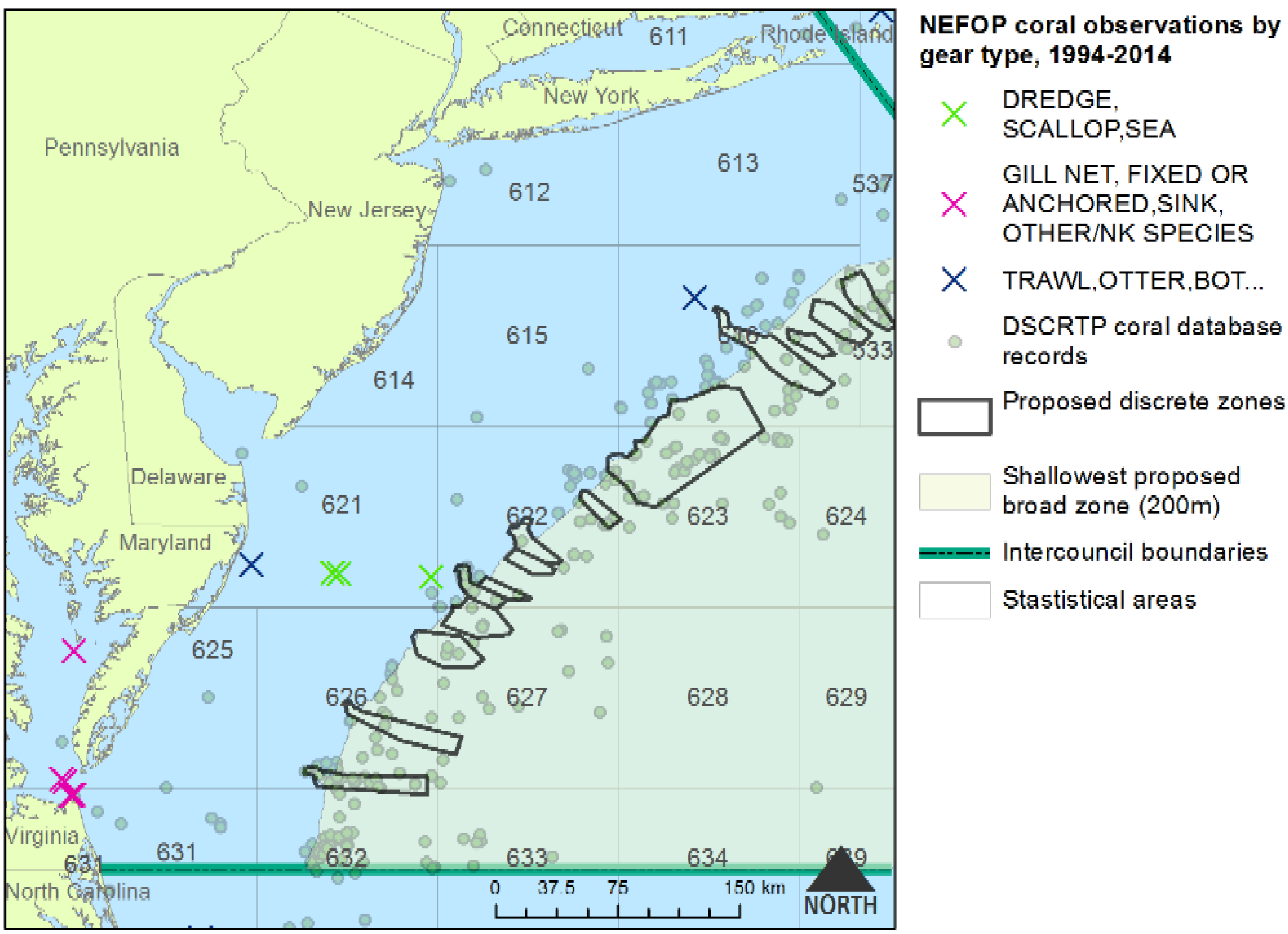

Figure 12: NEFOP records of deep sea corals in the Mid-Atlantic, 1994-2014.

7.1.4 Deep Sea Coral Habitat Suitability Model

A main limitation of point data for deep sea coral observations is that this data is mostly presence-only, and many areas have not been surveyed for the presence of deep sea corals. Surveying deep offshore habitats using Remotely Operated Vehicles (ROVs) or towed cameras is expensive and often logistically difficult. However, existing coral observation data, together with associated environmental data, are useful for developing models that can predict deep sea coral habitat based on known coral locations. 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).[27] 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 variables were incorporated, including slope, depth, depth change, rugosity, salinity, oxygen, substrate, temperature, turbidity, and others.

In the Northeast Region, several different taxonomic groups of deep sea corals were modeled. Some of these model outputs are better predictors of coral presence than others, due to different sample sizes of coral records of each type in the DSCRTP database. The model output for Gorgonian and Alcyonacean corals 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. Therefore, the model outputs for Gorgonian and Alcyonacean corals were used to evaluate the habitat suitability of each proposed discrete zone (Figures 13-21; Table 29). Model outputs are displayed in the figures below, and 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.

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. The model was further validated during the August 2014 towed camera surveys previously described. Each attempt has indicated that this habitat suitability model performs well in predicting areas of likely deep sea coral habitat, as well as predicting areas where corals are unlikely to be found.

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 m^2 (although there are plans to improve the model by increasing resolution to 25 m^2 within the next several years, as well as incorporate more recent coral observations). These maps should be viewed as representing only the general locations of predicted suitable coral habitat (within approximately 350-750 meters, or approximately two model grid cells). This is the primary reason why proposed FMAT discrete zone boundaries were buffered by 0.4 nautical miles (approximately 741 meters). Also, model predictions are of coral presence, and high likelihood of presence will not necessarily correlate with high abundance.

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[27] 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.

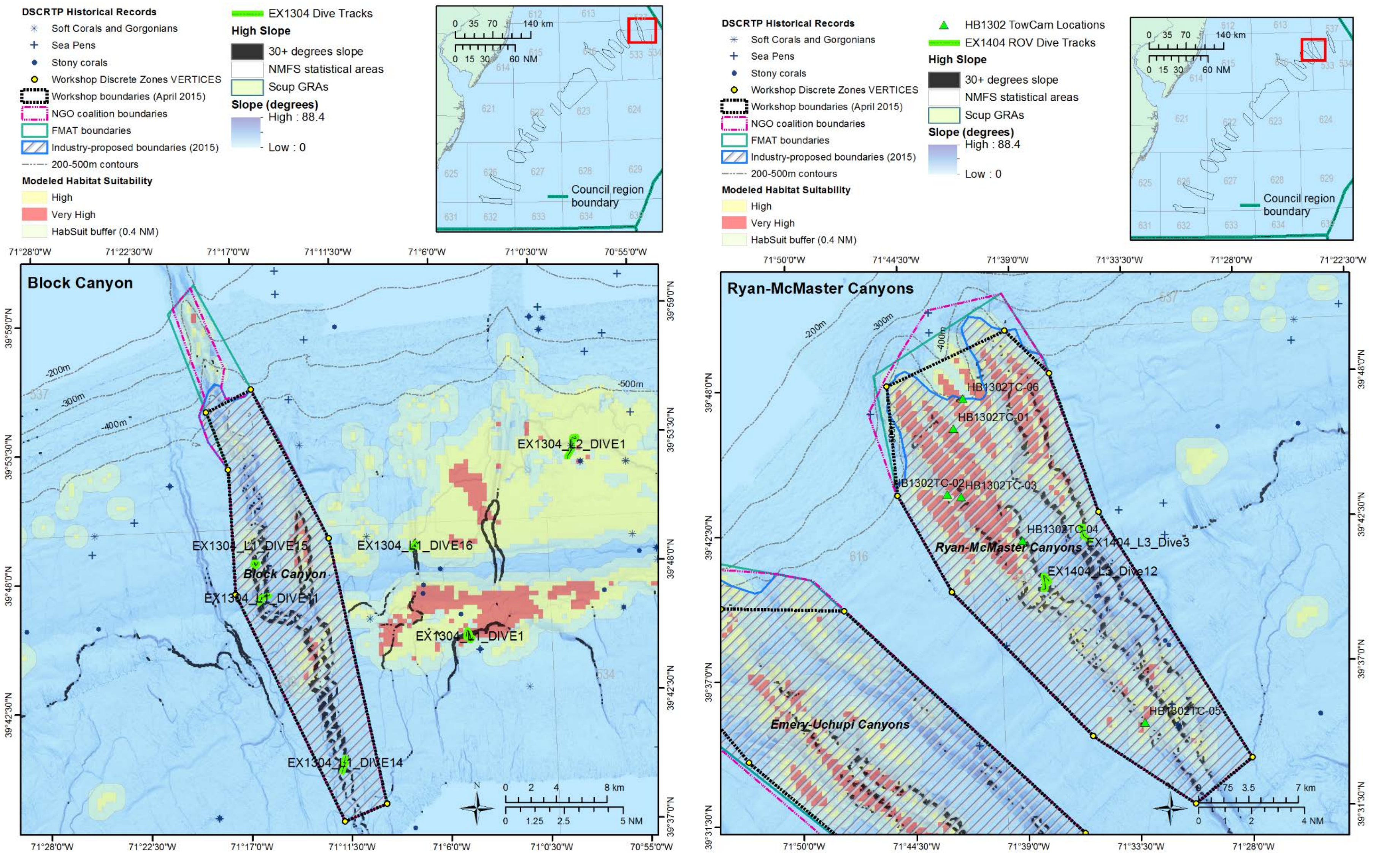

Figure 13: Block Canyon and Ryan-McMaster Canyons, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

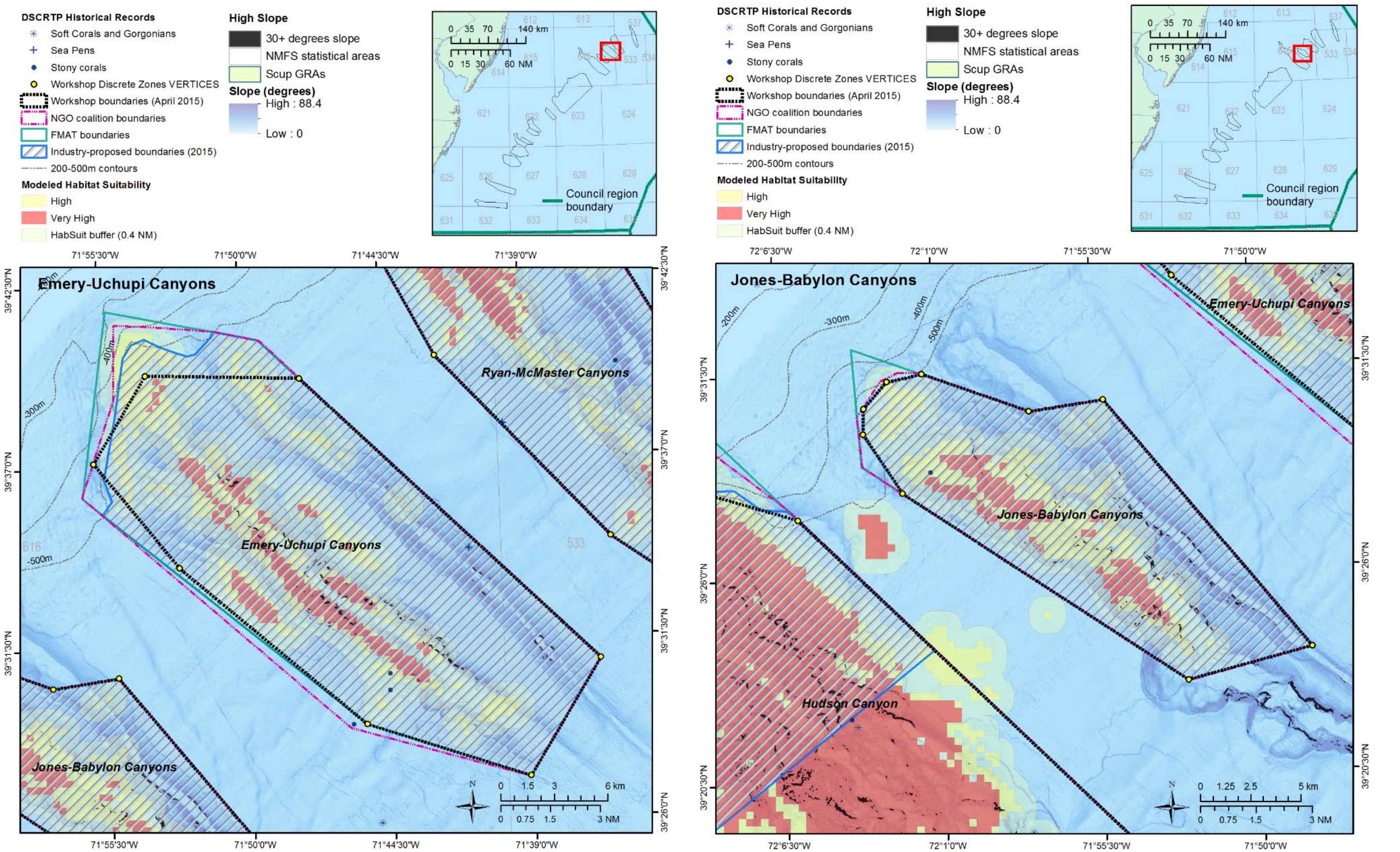

Figure 14: Emery-Uchupi Canyons and Jones-Babylon Canyons, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

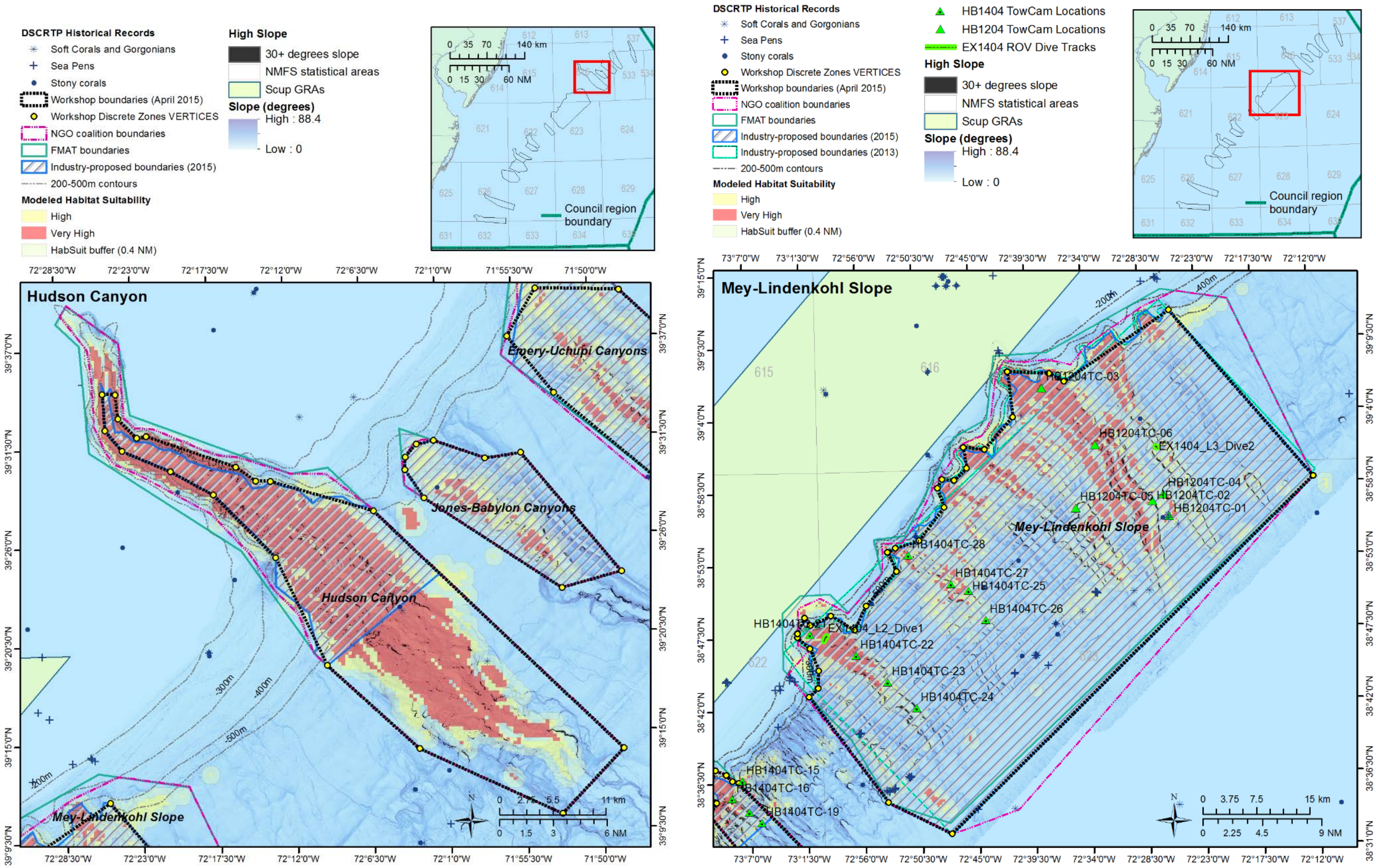

Figure 15: Hudson Canyon and the Mey-Lindenkohl Slope, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

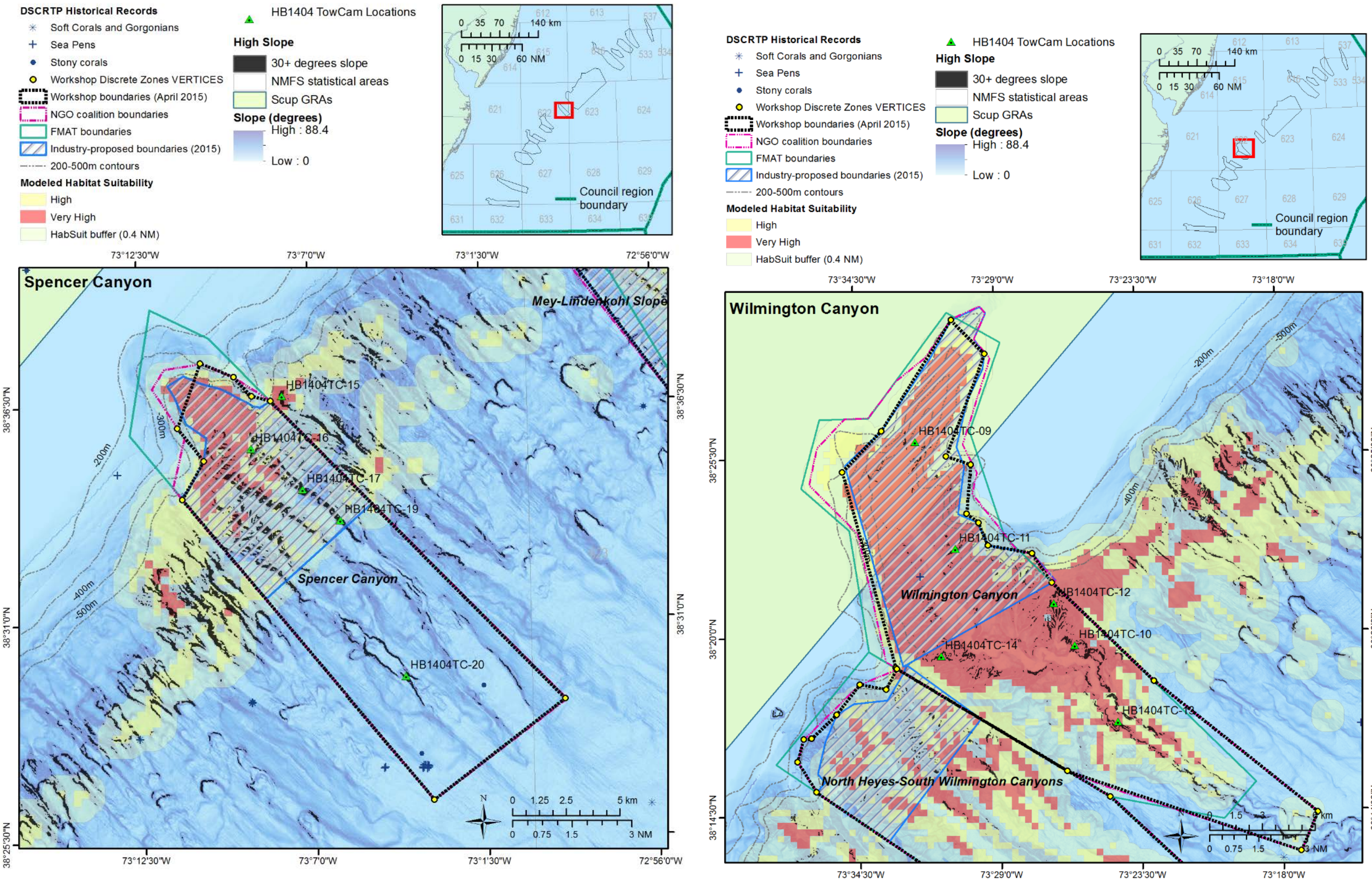

Figure 16: Spencer Canyon and Wilmington Canyon, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

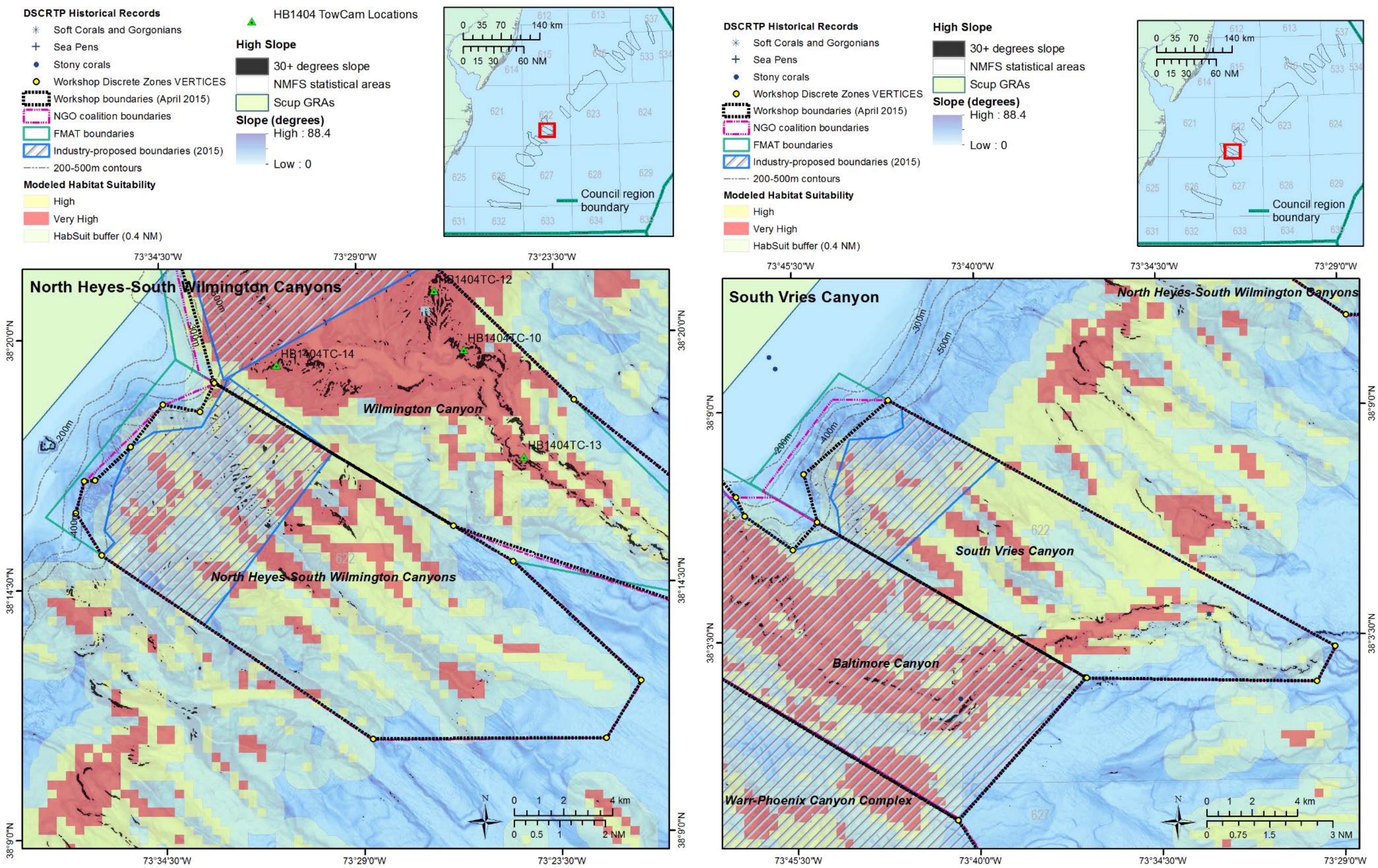

Figure 17: North Heyes-South Wilmington Canyons and South Vries Canyon, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

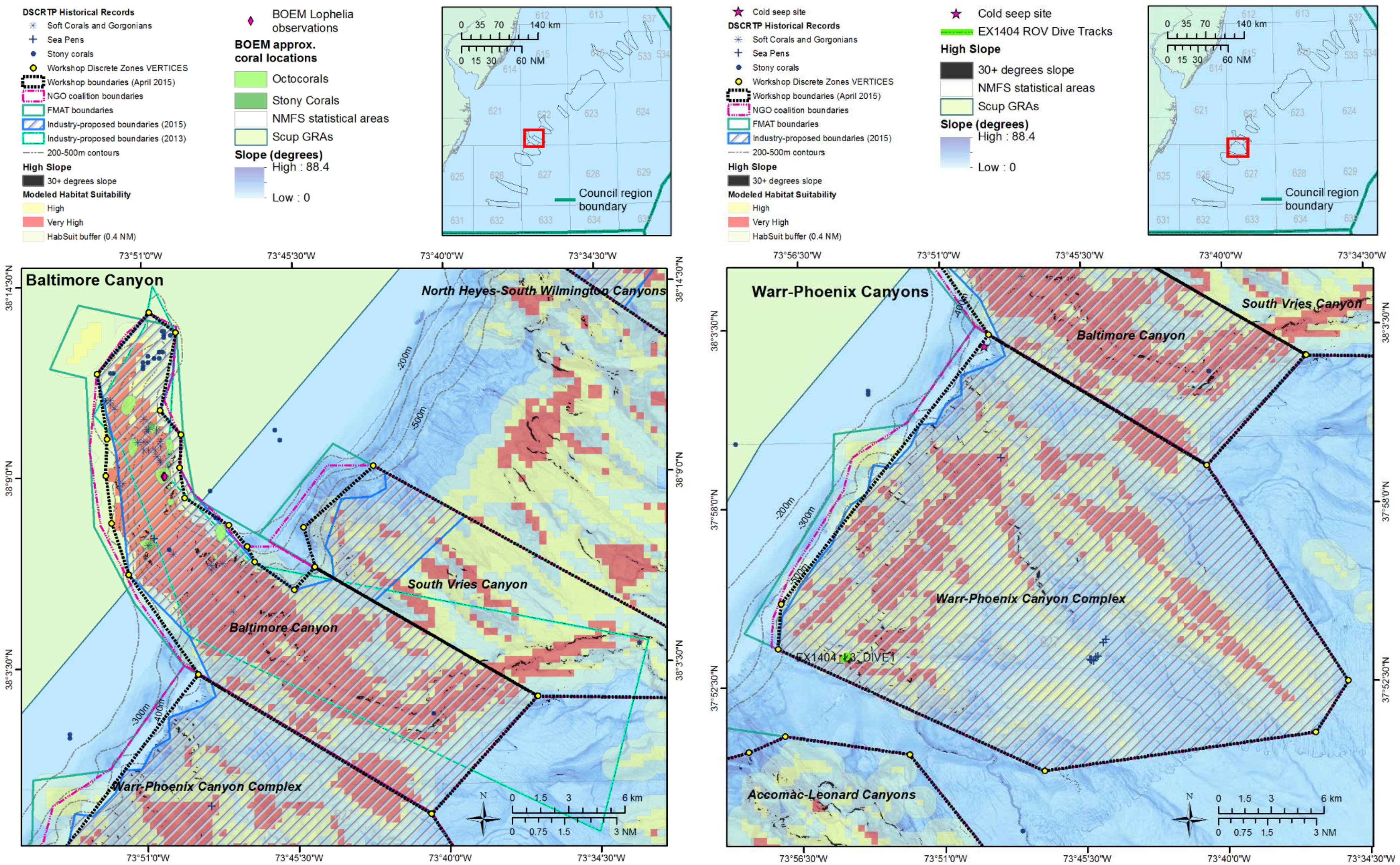

Figure 18: Baltimore Canyon and Warr-Phoenix Canyons, showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

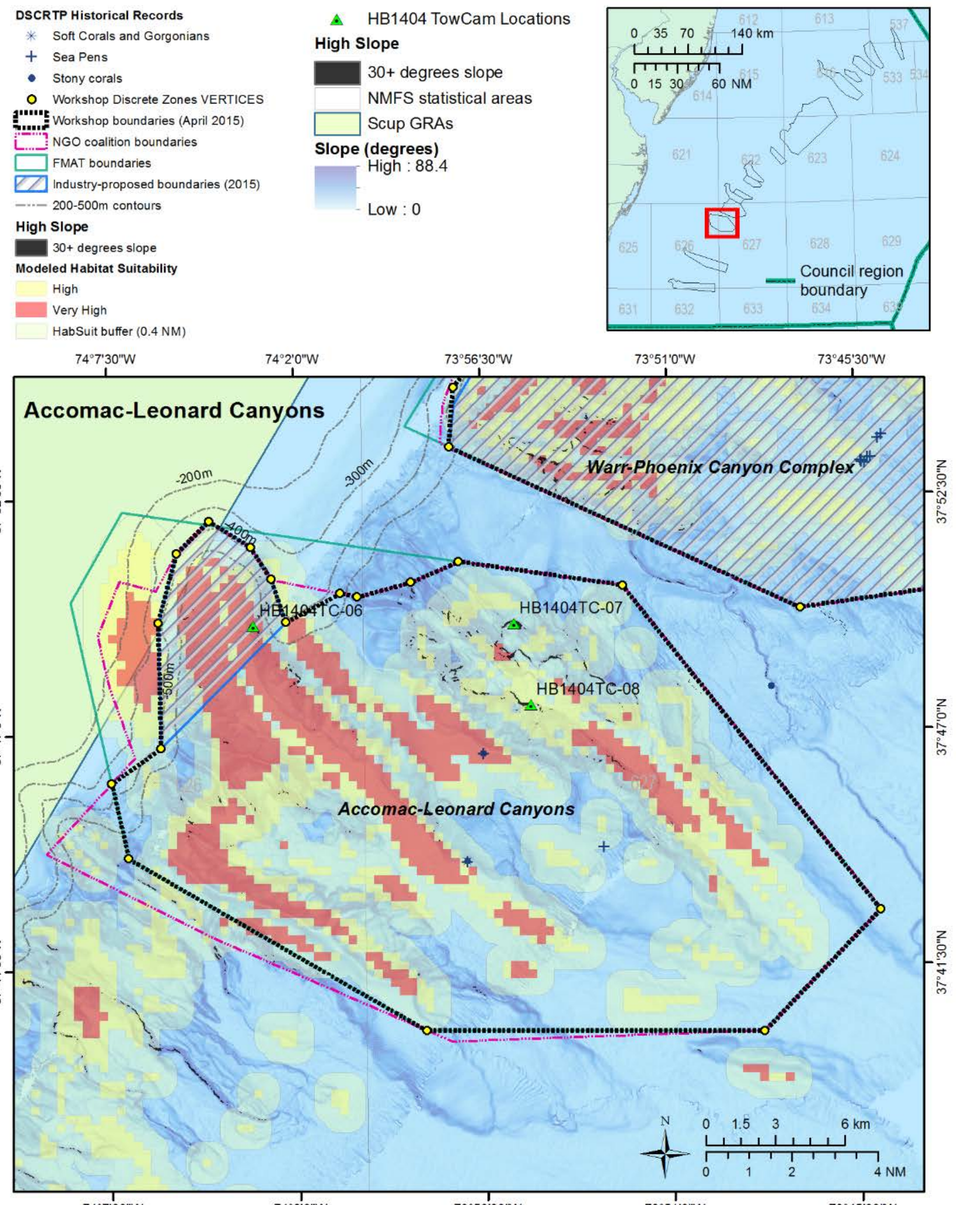

Figure 19: Accomac and Leonard Canyons showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

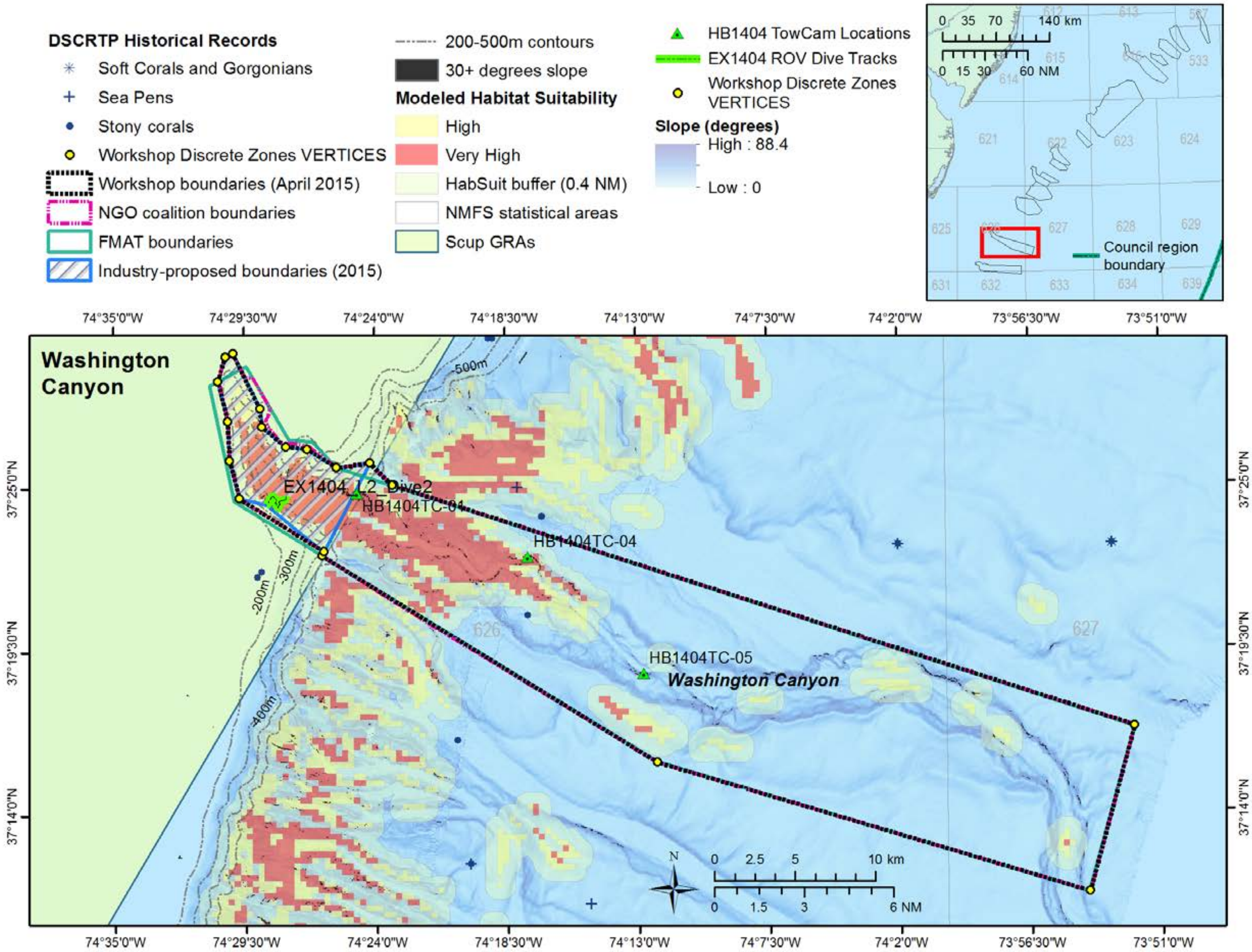

Figure 20: Washington Canyon showing areas of high slope, modeled deep sea coral habitat suitability, and discrete zone boundaries.

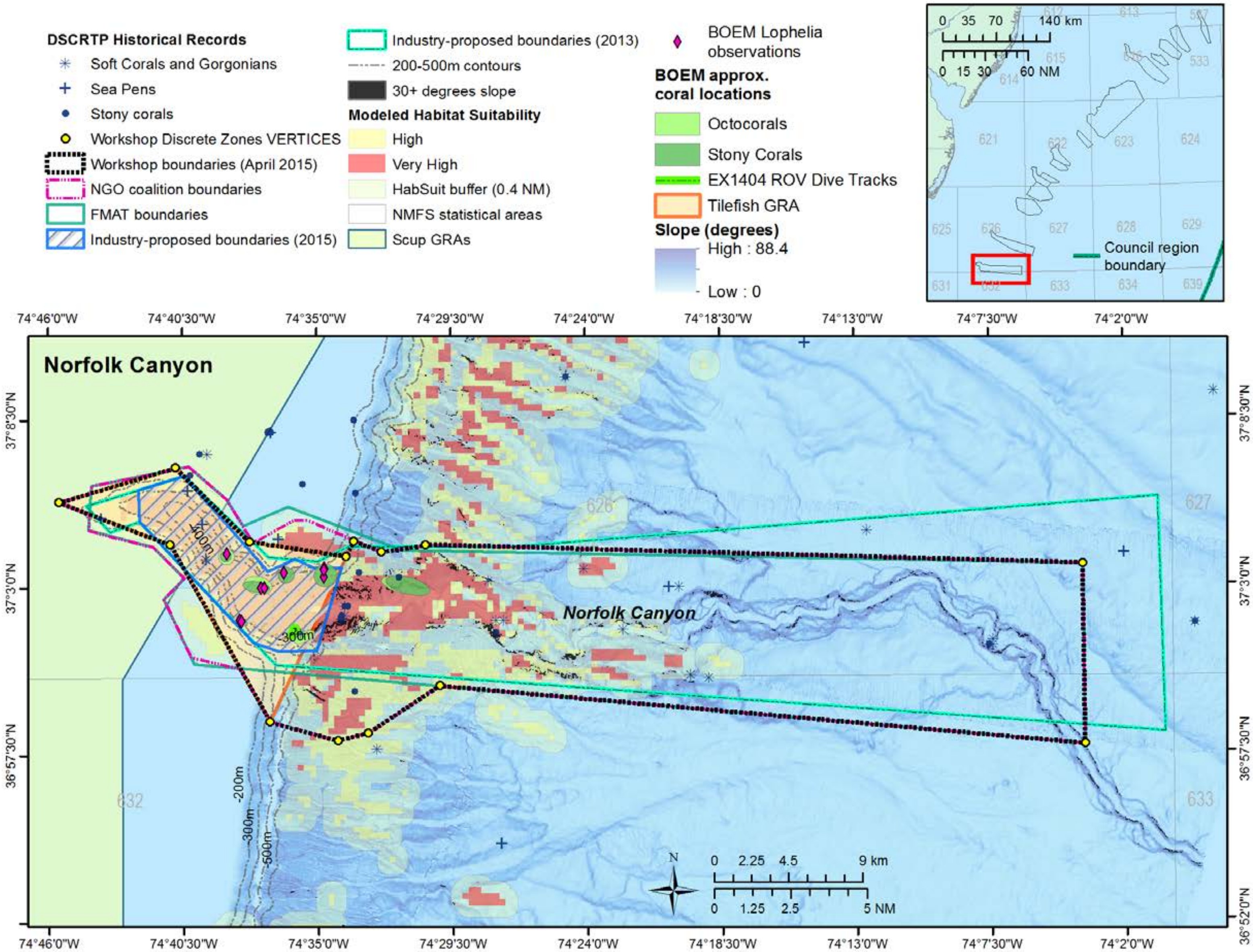

Figure 21: Norfolk Canyon areas of high slope, deep sea coral habitat suitability, and discrete zone boundaries.

7.2 Impacts to Deep Sea Corals

In general terms, deep sea corals are expected to benefit from any alternative that reduces the likelihood of damage by commercial fishing gear. However, many corals growing on steep slopes are likely to have a degree of natural protection from some commercial fishing gear, as very steep slopes cannot be trawled. Areas of higher three-dimensional complexity tend to be avoided by fishermen for fear of damage and loss of their gear. In other areas, fishing may be occurring in or near areas of deep sea coral habitats. Thus, the exact nature of potential impacts to corals are difficult to define, but it should be noted that many of the proposed measures are precautionary in nature and are designed to protect corals from future expansion of fishing effort. Given its small overall scope and the small physical footprint of gear contact with the seafloor, it is believed that the red crab fishery may currently have a small impact on corals. As such, an exemption from the broad zones is being considered for the red crab fishery.

Under the status-quo, one would expect some ongoing negative impacts to deep water corals and any potential expansion of effort into new deep water areas would be unconstrained and could increase impacts. Evidence of gear impacts to deep water corals in the Mid-Atlantic is sparse and generally limited to occasional observations of fishing gear during remote vehicle coral surveys and coral observations in the limited NEFOP data described above. However, trawling's detrimental impact on deep water corals is well documented.[28] **Appendix C** provides a review of information on the vulnerability of deep sea corals to fishing gear impacts.

As shown above, for areas where the presence of deep sea corals is likely but not proven, the presence of modeled deep sea coral habitat provides the best measure for inferring deep sea coral occurrence. Deep sea research dives have, however, validated that coral is likely to be found in areas predicted to have suitable habitat by the model. Therefore, for any of the coral zones defined in the alternatives, the total area of likely deep sea coral habitat serves as a measure of the importance of the zone for deep sea corals. The impacts of the alternatives can be assessed as the protection afforded to corals by eliminating or reducing access to those areas by vessels using bottom tending fishing gear.

Table 29 displays each boundary option for proposed canyon areas, with total area of modeled high/very high suitable habitat (the left side of the "Habitat Suitability" columns). This area represents the total area of modeled "high" or "very high" habitat suitability within each boundary. The adjacent percentage column represents the percent of modeled high and very high habitat suitability divided by the total area of the boundary option.

While slope is a variable included in the habitat suitability model, areas of high slope (>30 degrees) are also believed to be an important indicator of coral habitat, so the amount of high slope areas in the potential coral zones is also provided in the table below. These follow the same initial trend as modeled habitat suitability, with the Mey-Lindenkohl Slope and Hudson Canyon areas having the greatest areas of high slope, but also identify some canyons as potentially having more or less coral than suggested by the suitability model. For example, based on high slope areas, the Norfolk and Spencer Canyon areas may have relatively more coral habitat than suggested by the suitability model.

As discussed in the economic impacts section, if some canyon areas are closed, it would be expected that effort would shift near/around canyons that remain open to some degree. This reduces both the positive biological and negative fishery socio-economic impacts of canyon closures.

As can be seen in the maps above for the canyons, the 500 m broad zone would cover most of the high/very high suitability areas. The exceptions are the heads of longer canyons that incise the shelf/slope break (e.g.

[28]For example, see references in Hourigan 2014, p. 128 in Interrelationships Between Corals and Fisheries, Ed. Stephen Bortone.

Hudson, Baltimore, Washington, and Norfolk), where high/very high suitability areas extend into the shallower heads of the canyons (400m/300m). Based on the outputs of the habitat suitability model in the Mid-Atlantic Region, the 200m broad zone would protect nearly 100% of areas predicted as having a high or very high likelihood of coral habitat suitability, the 300m broad zone would protect 99% of high/very high likelihood areas, the 400m broad zone would protect 97% of high/very high likelihood areas, and the 500m broad zone would protect 93% of high/very high likelihood areas.

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Table 29: Summary of analysis across proposed discrete zones under alternative 3B for coral observations, habitat suitability, and areas of high slope. Note: recent fieldwork observations are not included in the DSCRTP historical database.

		Coral Observations		Habitat Suitability		Slope	
Canyon or Complex	Total area (km^2)	Historical Coral Records (all)	Encompasses recent fieldwork?	Total Area of High/Very High Habitat Suitability	Percent High/Very High Habitat Suitability	Total area of slope >30 degrees (km^2)	Percent area of slope >30 degrees
Block Canyon							
FMAT boundaries (3B-2)	231.6	0	Some, not all	19.2	8.3%	7.7	3.3%
GSSA boundaries (3B-3)	206.9	0	Some, not all	17.4	8.4%	7.7	3.7%
NGO boundaries (3B-4)	222	0	Some, not all	19.2	8.4%	7.7	3.5%
Workshop boundaries (3B-5)	200.6	0	Some, not all	17.4	8.7%	7.7	3.8%
Ryan and McMaster Canyons							
FMAT boundaries (3B-2)	390.3	16	Yes	121.0	31.0%	6.3	1.6%
GSSA boundaries (3B-3)	356.1	16	Yes	115.0	32.3%	6.3	1.8%
NGO boundaries (3B-4)	400.4	20	Yes	145.5	36.3%	6.3	1.6%
Workshop boundaries (3B-5)	365.2	16	Yes	143.8	39.4%	6.3	1.7%
Emery and Uchupi Canyons							
FMAT boundaries (3B-2)	369.2	6	NA	80.6	21.8%	2.1	0.6%
GSSA boundaries (3B-3)	349.2	6	NA	78.3	22.4%	2.1	0.6%
NGO boundaries (3B-4)	370.6	7	NA	86.5	23.3%	2.1	0.6%
Workshop boundaries (3B-5)	323.5	6	NA	77.3	23.9%	2.1	0.7%
Jones and Babylon Canyons							
FMAT boundaries (3B-2)	166.1	1	NA	46.8	28.2%	1.6	1.0%
GSSA boundaries (3B-3)	159.5	1	NA	46.8	29.3%	1.6	1.0%
NGO boundaries (3B-4)	162.4	1	NA	53.3	32.8%	1.6	1.0%
Workshop boundaries (3B-5)	159.4	1	NA	53.2	33.4%	1.6	1.0%
Hudson Canyon							
FMAT boundaries (3B-2)	770.8	5	NA	445.4	57.8%	12.7	1.7%
GSSA boundaries (3B-3)	237.2	0	NA	210.7	88.8%	6.3	2.6%
NGO boundaries (3B-4)	718.7	5	NA	543.4	75.6%	12.7	1.8%
Workshop boundaries (3B-5)	606.5	3	NA	492.7	81.2%	12.0	2.0%

Table 29 (continued):

		Coral Observations		Habitat Suitability		Slope	
Canyon or Complex	**Total area (km^2)**	**Historical Coral Records (all)**	**Encompasses recent fieldwork?**	**Total Area of High/Very High Habitat Suitability**	**Percent High/Very High Habitat Suitability**	**Total area of slope >30 degrees (km^2)**	**Percent area of slope >30 degrees**
Mey-Lindenkohl Slope							
2013 Advisor boundaries: Depth-based landward boundary approximating 250 ftm/457m (3B-1)	2445.3	62	Yes	503.9	20.6%	49.0	2.0%
2014 Advisor boundaries: Straight line landward boundary (3B-1)	2458.8	65	Some, not all	443.5	18.0%	48.5	2.0%
FMAT boundaries (3B-2)	2818.2	74	Yes	550.5	19.5%	50.2	1.8%
GSSA boundaries (3B-3)	2500.9	73	Yes	496.6	19.9%	50.1	2.0%
NGO boundaries (3B-4)	2934.5	76	Yes	635.6	21.7%	50.5	1.7%
Workshop boundaries (3B-5)	2495	69	Yes	575.1	23.0%	50.1	2.0%
Spencer Canyon							
FMAT boundaries (3B-2)	163.3	12	Yes	28.4	17.4%	8.3	5.1%
GSSA boundaries (3B-3)	50	0	Yes	25.7	51.4%	6.1	12.3%
NGO boundaries (3B-4)	149.1	12	Yes	29.7	19.9%	8.3	5.6%
Workshop boundaries (3B-5)	142.5	12	Yes	27.2	19.1%	8.3	5.8%
Wilmington Canyon							0.0%
FMAT boundaries (3B-2)	268.1	2	Yes	180.9	67.5%	6.2	2.3%
GSSA boundaries (3B-3)	103.9	2	Some, not all	90.9	87.5%	1.5	1.4%
NGO boundaries (3B-4)	270.7	2	Yes	208.3	77.0%	6.6	2.4%
Workshop boundaries (3B-5)	242.6	2	Yes	202.3	83.4%	6.6	2.7%
North Heyes and South Wilmington Canyon							0.0%
FMAT boundaries (3B-2)	183.4	0	NA	74.6	40.7%	1.4	0.8%
GSSA boundaries (3B-3)	50.6	0	NA	27.1	53.6%	0.8	1.6%
NGO boundaries (3B-4)	176.8	0	NA	76.2	43.1%	1.4	0.8%
Workshop boundaries (3B-5)	174.5	0	NA	76.1	43.6%	1.4	0.8%

Table 29 (continued):

Canyon or Complex	Total area (km^2)	Coral Observations: Historical Coral Records (all)	Coral Observations: Encompasses recent fieldwork?	Habitat Suitability: Total Area of High/Very High Habitat Suitability	Habitat Suitability: Percent High/Very High Habitat Suitability	Slope: Total area of slope >30 degrees (km^2)	Slope: Percent area of slope >30 degrees
South Vries Canyon							0.0%
FMAT boundaries (3B-2)	142.6	2	NA	61.4	43.1%	1.1	0.8%
GSSA boundaries (3B-3)	27.6	0	NA	11.7	42.4%	0.1	0.4%
NGO boundaries (3B-4)	138.1	2	NA	61.4	44.5%	1.1	0.8%
Workshop boundaries (3B-5)	129.2	2	NA	61.5	47.6%	1.1	0.8%
Baltimore Canyon							
2013 Advisor boundaries (3B-1)	220.7	50	Some, not all	130.6	59.2%	3.2	1.5%
FMAT boundaries (3B-2)	231	54	Yes	141.1	61.1%	3.4	1.5%
GSSA boundaries (3B-3)	189.7	53	Yes	135.3	71.3%	3.3	1.7%
NGO boundaries (3B-4)	211.3	54	Yes	160.7	76.1%	3.3	1.6%
Workshop boundaries (3B-5)	197.6	54	Yes	160.5	81.2%	3.3	1.7%
Warr and Phoenix Canyons							
FMAT boundaries (3B-2)	511.6	14	Yes	207.0	40.5%	2.5	0.5%
GSSA boundaries (3B-3)	475.5	14	Yes	203.5	42.8%	2.4	0.5%
NGO boundaries (3B-4)	501.9	14	Yes	223.5	44.5%	2.5	0.5%
Workshop boundaries (3B-5)	480.9	14	Yes	220.4	45.8%	2.5	0.5%
Accomac and Leonard Canyons							
FMAT boundaries (3B-2)	538.2	6	Yes	200.6	37.3%	1.6	0.3%
GSSA boundaries (3B-3)	30.9	0	Some, not all	19.2	62.1%	0.1	0.5%
NGO boundaries (3B-4)	528.7	6	Yes	220.2	41.6%	1.7	0.3%
Workshop boundaries (3B-5)	486.2	6	Yes	202.4	41.6%	1.6	0.3%
Washington Canyon							
FMAT boundaries (3B-2)	554.1	1	Yes	98.1	14.7%	3.3	0.6%
GSSA boundaries (3B-3)	43.3	0	Some, not all	25.7	59.4%	0.8	1.9%
NGO boundaries (3B-4)	550.4	1	Yes	118.2	21.5%	3.3	0.6%
Workshop boundaries (3B-5)	546.8	1	Yes	117.9	21.6%	3.3	0.6%

Table 29 (continued):

		Coral Observations		Habitat Suitability		Slope	
Canyon or Complex	Total area (km^2)	Historical Coral Records (all)	Encompasses recent fieldwork?	Total Area of High/Very High Habitat Suitability	Percent High/Very High Habitat Suitability	Total area of slope >30 degrees (km^2)	Percent area of slope >30 degrees
Norfolk Canyon							
2013 Advisor boundaries (3B-1)	598.4	37	Yes	132.4	22.1%	11.9	2.0%
FMAT boundaries (3B-2)	543.7	37	Yes	145.9	26.8%	12.1	2.2%
GSSA boundaries (3B-3)	57	7	Some, not all	48.8	85.5%	3.9	6.9%
NGO boundaries (3B-4)	576.3	38	Yes	190.8	33.1%	12.4	2.1%
Workshop boundaries (3B-5)	548.7	35	Yes	181.3	33.0%	12.3	2.2%

7.2 FISHERY EFFORT AND ECONOMIC IMPACTS

Impacts to fishing effort and thus also economic impacts were analyzed by mapping and quantifying recent fishing effort relative to all proposed coral zones (broad and discrete). Several data sources are available to analyze past effort. None of the sources are complete, and their strengths and weaknesses are discussed below.

7.2.1 VTR Revenue Mapping Model

Economic impacts of proposed coral zones were analyzed using a Vessel Trip Report (VTR)-based revenue mapping model produced by the Northeast Fisheries Science Center. A Technical Memo outlining the methodology behind this model is forthcoming from the NEFSC, and an overview is provided here.

Federally permitted vessels are required to submit a VTR for each trip, the requirements of which include indicating a general fishing location as a set of geographic coordinates. These self-reported coordinates do not precisely indicate the location of fishing effort, given that only one point is provided regardless of trip length or distance covered during the trip. In the absence of spatially explicit fishery effort data for many fisheries, this model allows for more robust analysis using VTR data by taking into account some of the uncertainties around each reported point. Using observer data, for which precise locations are available, the model was developed to derive probability distributions for actual fishing locations, around a provided VTR point. Other variables likely to impact the precision of a given VTR point, such as trip length, vessel size, and fishery, were also incorporated into the model. This model allows for generation of maps that predict the spatial footprint of fishing. Price information from dealer reports was used to transform VTR catches into revenues. Trip information was used to incorporate information about revenue generated from each trip, resulting in a model that can produce maps of revenue generated for a given set of specified parameters such as gear type, species, or port of landing. The revenue-mapping model covers the years 2007-2012, and can be used to identify areas important to specific fishing communities, species, gears, and seasons to establish a baseline of commercial fishing effort.

For this analysis, first, gear and species combinations likely to be impacted by the proposed measures were identified. VTR-point data were used to identify the primary gear-species combinations that occur within proposed broad and discrete zones. The primary gear types reported within the proposed coral zones (broad and discrete combined) include bottom otter trawls, sea scallop dredges, crab pots and traps, lobster pots, and bottom longlines. The primary species caught include longfin squid, *Illex* squid, sea scallops, deepsea red crab, American lobster, summer flounder, silver hake (whiting), golden tilefish, Jonah crab, scup, and black sea bass.

Of these gear-species combinations, American lobster and Jonah crab were not included in further analysis due to the nature of the regulatory authority under which the alternatives in this document are proposed. Management measures applied under the discretionary provisions of the MSA to designate deep sea coral zones would be applicable to Federally-managed fisheries only, meaning they would not impact lobster pots, since lobster is managed solely by the Atlantic States Marine Fisheries Commission (i.e., not jointly managed with NMFS or the Councils). Jonah crabs are caught as bycatch within the lobster pot fishery, and generally retained for sale.

Thus the primary gear-species combinations identified for further analysis in the revenue-mapping model included:

1. Bottom otter trawl – Squid (*Illex* and longfin)
2. Bottom otter trawl – Hake

3. Bottom otter trawl – Summer flounder, scup, and black sea bass (BOT – FLUKE)
4. Pots/Traps – Red crab
5. Bottom longline – Golden tilefish
6. Dredge – Sea scallops

The data in Tables 30 and 31 are also illustrated in revenue intensity maps shown in Figures 22-27 and both are a direct product of the VTR model. The data reveal spatial concentrations of effort that provide additional context for the estimates in the tables. When interpreting the maps, the appropriate interpretation is that most revenues would be contained by the areas of intense color, but it would not be correct to interpret the model as saying high effort definitely occurred in all areas of intense color.

This model does have important caveats. The probability distributions generated from each reported VTR point create a likelihood of actual fishing locations in all directions from a given point, and do not take into account any specific directionality that may be associated with specific fishing methods or specific locations. For example, the model does not take into account fishing behavior along depth contours or other specific habitat features. The model-estimated distribution of fishing effort would tend to be expanded beyond the shelf break or into the middle of canyons to deeper areas that are not actually fished. As such, the model likely overstates effort and revenue dependence in those deeper areas, suggesting that the values (i.e. contributions to overall revenue) in Tables 32 and 33 are overestimates. The model should still illustrate the approximate relative value among potential closure areas and facilitate approximate relative comparisons.

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Table 30: VTR model-estimated revenue (USD) by proposed discrete zone, shown as a percentage of coastwide revenues for each species-gear combination, 2007-2012, Maine through North Carolina. BOT = bottom otter trawl; BLL = bottom longline; DRG = dredge.

DISCRETE ZONE	AREA (km^2)	BOT-SQUID	DRG-SCALL	BOT-FLUKE	POT-RCRAB	LL-TILE	BOT-HAKE	Total	Mobile gears only (trawl/ dredge)
Mey-Lindenkohl Slope	2,818	2.14%	0.19%	1.17%	3.47%	1.65%	0.32%	0.42%	0.39%
Hudson Canyon	770	1.27%	0.04%	0.56%	1.13%	3.50%	1.20%	0.22%	0.18%
Wilmington Canyon	268	1.64%	0.08%	0.17%	0.77%	0.13%	0.02%	0.21%	0.20%
Baltimore Canyon	231	0.73%	0.05%	0.16%	0.80%	0.02%	0.01%	0.11%	0.11%
Warr & Phoenix Canyon Complex	512	0.62%	0.05%	0.10%	0.98%	0.03%	0.01%	0.10%	0.09%
Accomac & Leonard Canyons	539	0.33%	0.05%	0.10%	0.87%	0.02%	0.01%	0.08%	0.07%
North Heyes & South Wilmington Canyon	183	0.53%	0.03%	0.06%	0.42%	0.02%	0.01%	0.07%	0.07%
Washington Canyon	554	0.22%	0.05%	0.10%	0.64%	0.00%	0.00%	0.07%	0.06%
Spencer Canyon	163	0.46%	0.02%	0.09%	0.24%	0.01%	0.00%	0.06%	0.06%
South Vries Canyon	143	0.36%	0.02%	0.04%	0.28%	0.01%	0.00%	0.05%	0.05%
Norfolk Canyon*	544	0.34%	0.01%	0.03%	0.88%	0.01%	0.00%	0.04%	0.04%
Ryan & McMaster Canyons	390	0.13%	0.00%	0.18%	0.30%	0.22%	0.34%	0.03%	0.03%
Emery & Uchupi Canyons	369	0.12%	0.00%	0.14%	0.33%	0.32%	0.23%	0.03%	0.02%
Jones & Babylon Canyons	166	0.08%	0.01%	0.06%	0.17%	0.44%	0.12%	0.02%	0.02%
Block Canyon	231	0.06%	0.00%	0.10%	0.13%	0.14%	0.22%	0.02%	0.01%
All Discrete Zones	**7,881**	9.00%	0.60%	3.06%	11.43%	6.51%	2.48%	1.50%	1.40%
Coastwide		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

*Norfolk Canyon revenue estimates for trawl and dredge fisheries were adjusted to exclude the Norfolk Canyon Tilefish GRA, which is closed to mobile bottom-tending gear.

Table 31: VTR model-estimated cumulative revenue (USD) by proposed broad zone, shown as a percentage of coastwide revenues for each species-gear combination, 2007-2012, Maine through North Carolina. BOT = bottom otter trawl; BLL = bottom longline; DRG = dredge. Note that percentages are not additive given the significant overlap in area across all broad zones.

BROAD ZONE	APPROX. AREA (km^2)	BOT-SQUID	DRG-SCALL	BOT-FLUKE	POT-RCRAB	LL-TILE	BOT-HAKE	Total	Mobile gears only (trawl/ dredge)
200 Broad Zone	101,372	24.56%	1.25%	7.44%	42.15%	16.83%	7.80%	3.80%	3.47%
300 Broad Zone	100,165	22.13%	1.12%	6.35%	40.31%	12.31%	6.10%	3.37%	3.09%
400 Broad Zone	99,218	20.29%	1.03%	5.62%	38.63%	10.07%	4.84%	3.07%	2.81%
500 Broad Zone	98,444	19.06%	0.97%	5.14%	37.29%	8.83%	4.07%	2.86%	2.62%

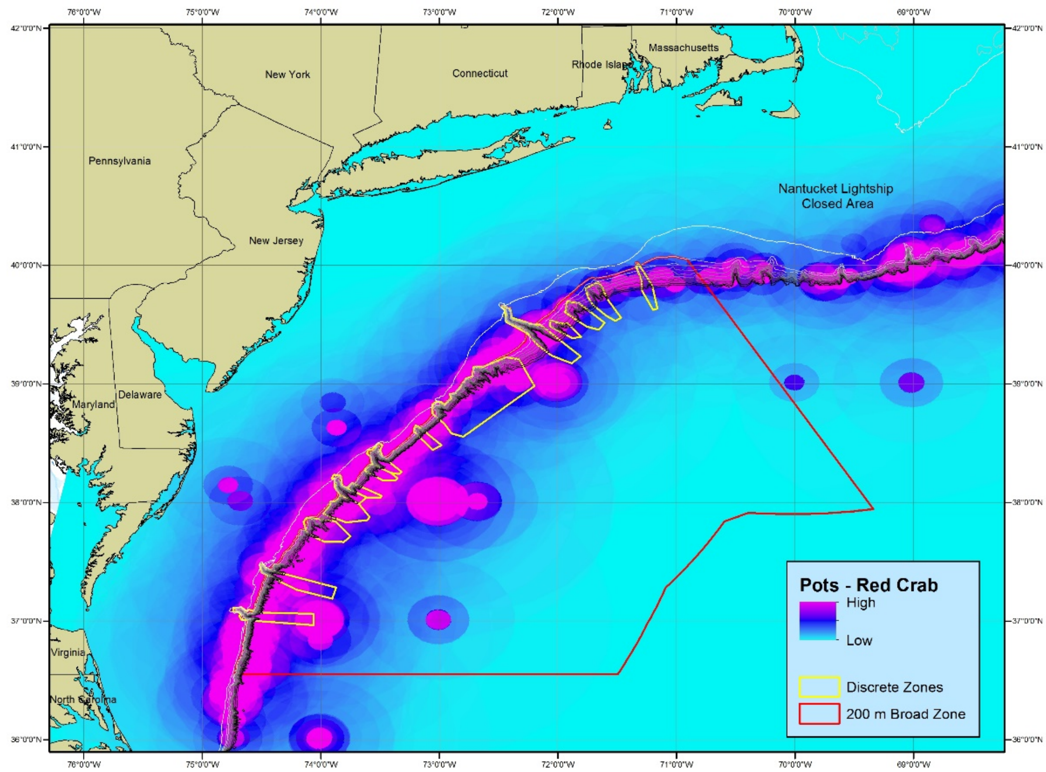

Figure 22: Areas of high cumulative estimated revenue (USD) for red crab caught using pots, 2007-2012, Maine through Virginia.

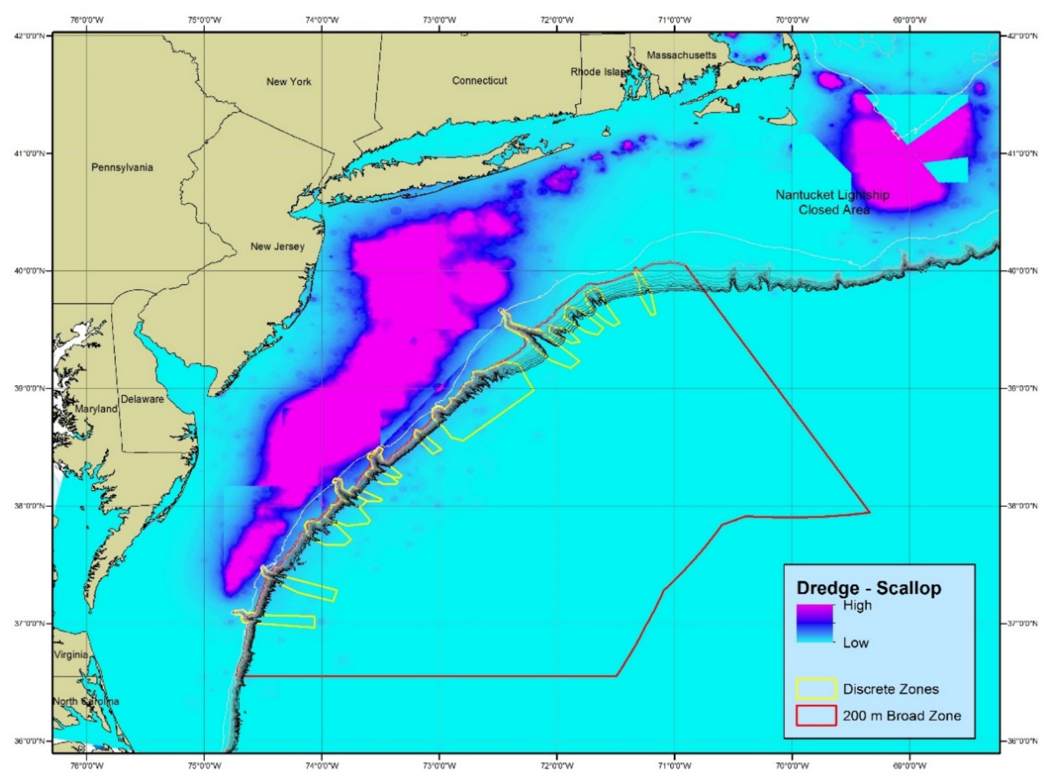

Figure 23: Areas of high cumulative estimated revenue (USD) for scallops caught using dredge gear, 2007-2012, Maine through Virginia.

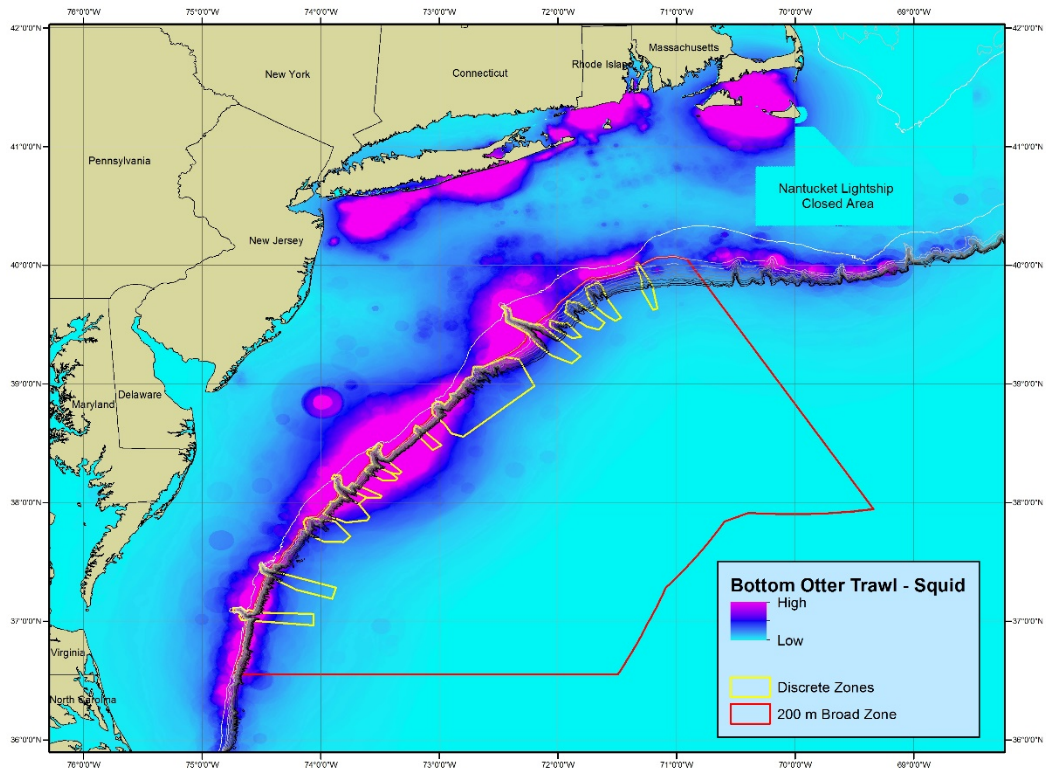

Figure 24: Areas of high cumulative estimated revenue (USD) for *Illex* and longfin squid caught using bottom otter trawls, 2007-2012, Maine through Virginia.

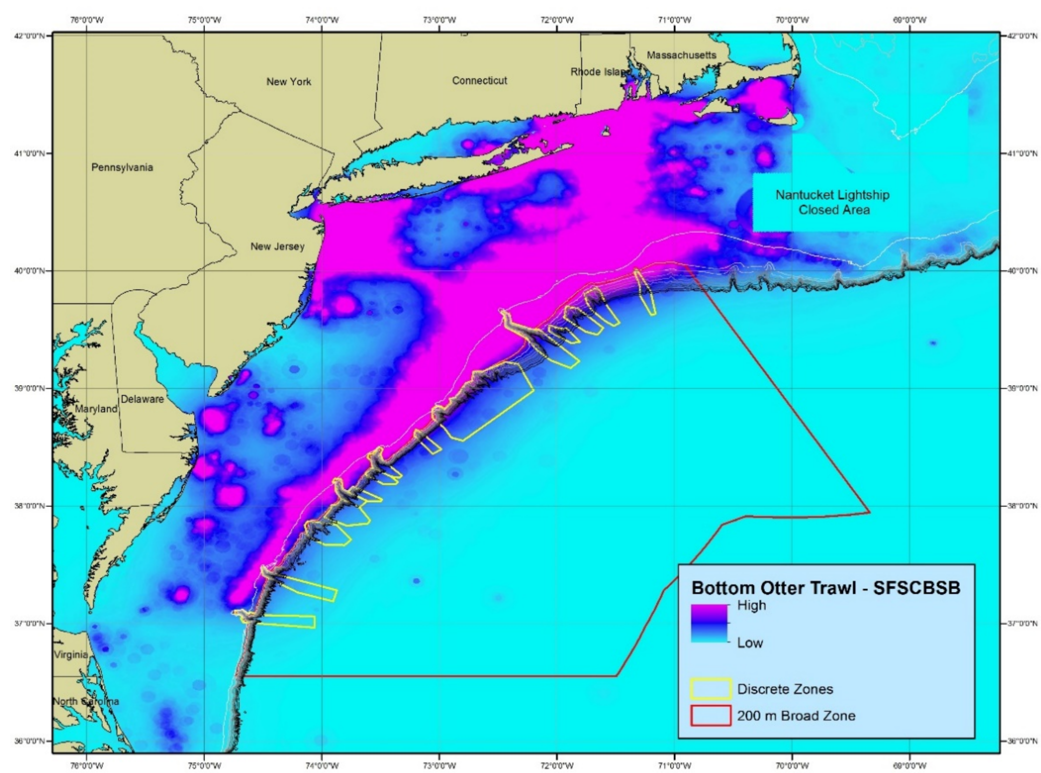

Figure 25: Areas of high cumulative estimated revenue (USD) for summer flounder, scup, and black sea bass caught using bottom otter trawl gear, 2007-2012, Maine through Virginia.

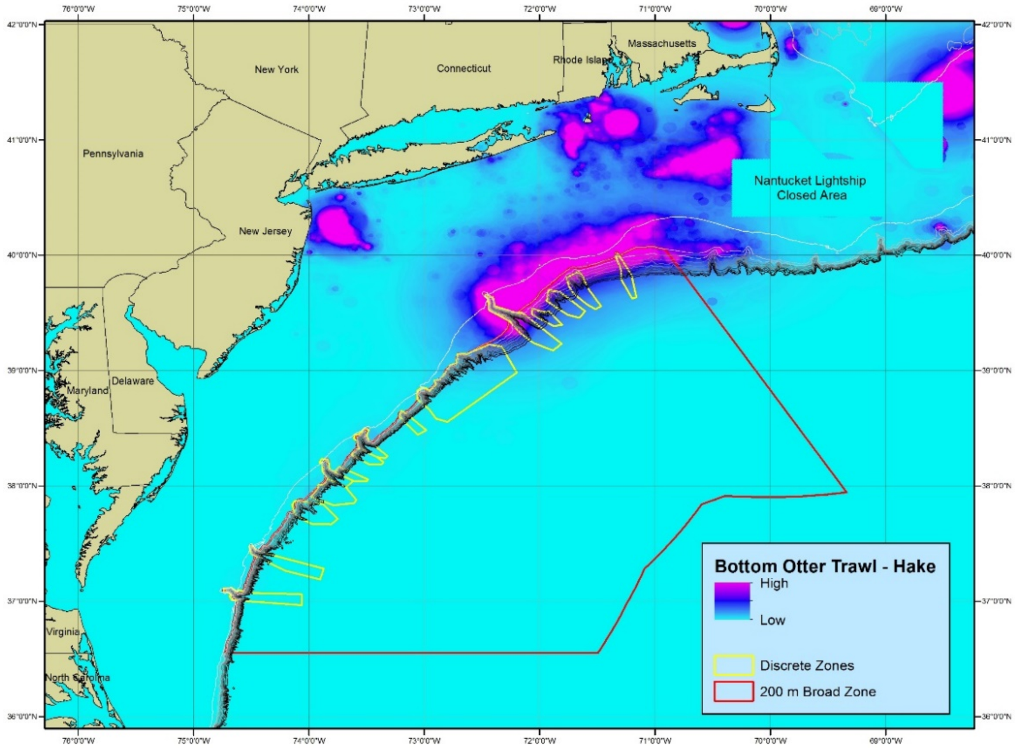

Figure 26: Areas of high cumulative estimated revenue (USD) for silver hake (whiting) caught using bottom otter trawl gear, 2007-2012, Maine through Virginia.

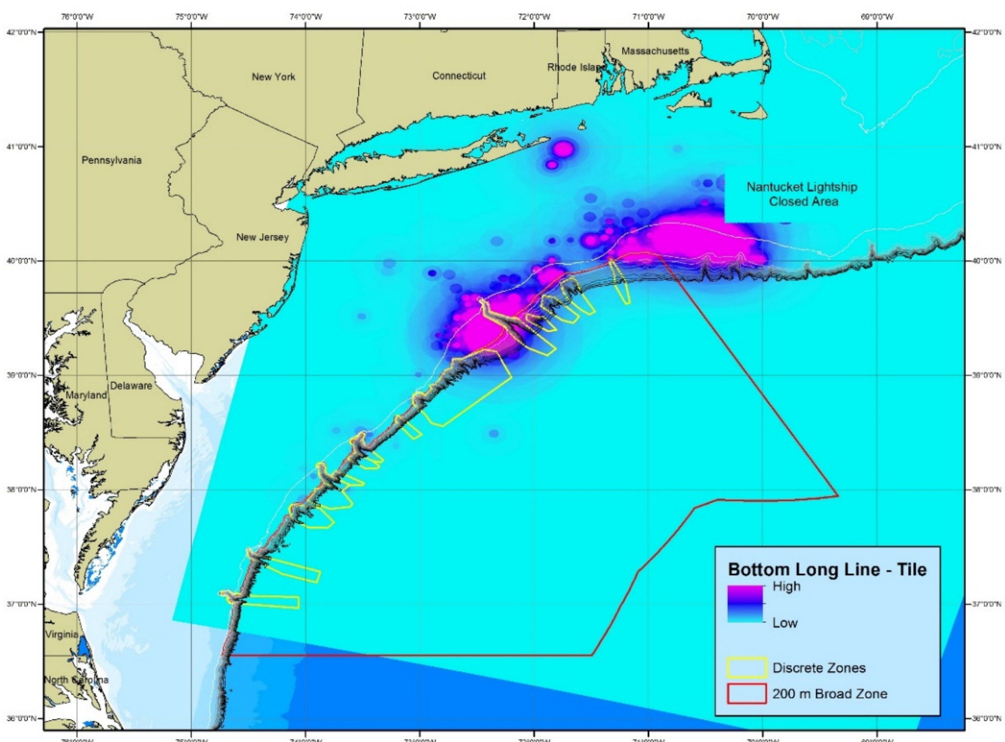

Figure 27: Areas of high cumulative estimated revenue (USD) for golden tilefish caught using bottom longline gear, 2007-2012, Maine through Virginia.

Because of the limitations of the VTR revenue-mapping model, raw VTR catch data and observer data were also analyzed to provide additional information on how fishing activity might be impacted by the proposed coral zones. For both of these additional investigations, a broader range of years was also used, 2000-2013.

7.2.2 VTR Point Data

An analysis of VTR point data, based on reported locations, was conducted to support for the model results. However, additional years were considered (2000-2013), and only catch data were used (i.e., they were not transformed into revenues as was done for the model). Additionally, the summer flounder/scup/black sea bass group was broken up into a summer flounder/black sea bass group and scup alone due to the lower value of scup. Unlike the above model, this analysis focused on the reported point location alone rather than spreading the effort around the point based on other information.

The initial dataset was all Northeast VTR reports for the gears described in the table below. Not all VTR reports include location information that can be mapped, so records lacking this information were removed. As discussed above, the VTR location information is approximate for a trip overall, but likely gives an approximate indication of whether areas are important for fishing, especially when considered over a range of years. The following table reports the percentage of catches that did have location information that could be mapped.

Table 32. Percent of VTR catch data with associated location information, 2000-2013.

Fishery	Percent of Catch Mappable
1. Bottom otter trawl – Squid (*Illex* and longfin)	94%
2. Bottom otter trawl – Hake	93%
3a. Bottom otter trawl – Summer flounder and black sea bass	93%
3b. Bottom otter trawl – Scup	95%
4. Pots/Traps – Red crab	87%
5. Bottom longline – Golden tilefish	92%
6. Dredge – Sea scallops	95%

Catches were analyzed with ArcGIS to determine the amounts of catch (totaled over all years) that are associated with the various areas being considered in this amendment. The table below describes the results. The percentages in the table are only of the total available to be mapped. So for example, from the 94% of all VTR squid catches (pounds) that could be mapped, 1.3% of those trips reported locations on their VTRs deeper than 500m (i.e. in the 500m broad zone), and those 1.3% of trips accounted for 15% of reported VTR catches. Since each trip only is associated with one general latitude/longitude point, these values are not necessarily the catches that actually occurred in the area, but should indicate relative importance of the various areas if the VTR locations are generally reported near where fishing actually occurred.

Table 33. Fishing activity in potential coral zones based on Vessel Trip Report (VTR) point data, 2000-2013.

Area	1. Bottom otter trawl – Squid (*Illex* and longfin)		2. Bottom otter trawl – Hake		3a. Bottom otter trawl – Summer flounder and black sea bass		3b. Bottom otter trawl – Scup		4. Pots/Traps – Red crab		5. Bottom longline – Golden tilefish		6. Dredge – Sea scallops	
*The catch percents assume that all of the catch from a given trip occurred in the area encompassed by the reported VTR location	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*	% of Trips in Area	% of Catch from Area*
All Areas Not Under Consideration	93.4%	44.5%	93.7%	88.1%	97.7%	93.8%	98.3%	92.7%	36.9%	21.9%	75.8%	78.1%	99.3%	99.0%
500m broad zone	1.3%	15.0%	0.6%	0.7%	0.5%	1.7%	0.3%	1.3%	29.8%	42.6%	2.8%	2.5%	0.3%	0.6%
400m broad zone (includes deeper zones)	1.7%	19.9%	1.1%	1.8%	0.6%	2.0%	0.4%	1.7%	31.3%	43.7%	3.1%	2.8%	0.4%	0.6%
300m broad zone (includes deeper zones)	3.0%	30.5%	2.6%	5.6%	1.0%	2.8%	0.6%	2.3%	33.2%	44.7%	9.3%	8.6%	0.4%	0.7%
200m broad zone (includes deeper zones)	4.7%	40.7%	4.6%	9.5%	1.6%	3.8%	1.0%	3.7%	35.2%	44.9%	16.5%	15.2%	0.4%	0.7%
Baltimore Canyon (Industry)	0.0%	0.5%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	1.9%	1.7%	0.1%	0.0%	0.0%	0.0%
Mey-Lindenkohl Slope-Depth (Industry)	0.1%	0.6%	0.1%	0.1%	0.1%	0.3%	0.1%	0.5%	3.6%	5.5%	0.4%	0.2%	0.0%	0.1%
Mey-Lindenkohl Slope-Straight (Industry)	0.2%	1.2%	0.1%	0.1%	0.1%	0.4%	0.1%	0.7%	3.0%	4.6%	0.4%	0.2%	0.0%	0.1%
Norfolk Canyon (Industry)	0.1%	1.2%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	1.5%	0.5%	0.1%	0.0%	0.0%	0.0%
Accomac & Leonard Canyons	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	1.3%	0.0%	0.0%	0.0%	0.0%
Baltimore Canyon	0.1%	1.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	2.1%	1.7%	0.0%	0.0%	0.0%	0.0%
Block Canyon	0.1%	0.1%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Emery & Uchupi Canyons	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.6%	0.7%	0.0%	0.0%	0.0%	0.0%
Hudson Canyon	0.7%	1.1%	1.0%	1.3%	0.2%	0.2%	0.2%	1.0%	2.0%	3.2%	5.3%	5.1%	0.0%	0.0%
Jones & Babylon Canyons	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	1.4%	0.4%	0.5%	0.0%	0.0%
Mey-Lindenkohl Slope	0.3%	2.2%	0.2%	0.2%	0.1%	0.5%	0.2%	1.2%	3.6%	5.5%	0.6%	0.4%	0.0%	0.1%
Norfolk Canyon	0.1%	1.5%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	1.6%	0.7%	0.1%	0.0%	0.0%	0.0%
North Heyes & South Wilmington Canyon	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%
Ryan & McMaster Canyons	0.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%
South Vries Canyon	0.1%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Spencer Canyon	0.0%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%
Warr & Phoenix Canyon Complex	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.7%	0.0%	0.0%	0.0%	0.0%
Washington Canyon	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	2.5%	0.9%	0.3%	0.2%	0.0%	0.0%
Wilmington Canyon	0.1%	1.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	1.0%	1.6%	0.0%	0.0%	0.0%	0.0%

7.2.3 Northeast Fisheries Observer Program Data (NEFOP)

Observer data from NEFOP were obtained for bottom trawl, bottom longline, and sink/anchored gillnet gear types for years 2000 through 2013 for the Mid-Atlantic region. Records with incomplete geographic coordinates were removed. Observed hauls were analyzed relative to proposed broad zones. While coverage of trips is much lower with the observer data compared to the Vessel Trip Report (VTR) data, the observer data generally provides very precise location data for each tow/set. Observer coverage also varies by fishery and by year, however, aggregating the data over many years likely reveals relative patterns in fishing effort. Accordingly, NEFOP data was used to consider effort across the potential coral zones.

Observed Bottom Trawl Effort

Within the Mid-Atlantic management region, there were 25,073 total observed hauls (on 3,967 trips) using bottom trawl gear within this time period (Table 34; Figure 28). Tables 35-38 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. 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 many records are duplicated across Tables 35-38 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 28). For observed bottom trawl hauls over this time period, 14% intersect the 200 meter broad zone, 6% intersect the 300 meter broad zone, 3% intersect the 400 meter broad zone, and 1% intersect the 500 m broad zone. Tables are also provided that describe how many hauls intersect the discrete zones, and Figure 28 overlays the haul track data on a map with the proposed coral zones.

Table 34: 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**	**Average: 87 m (48 ftm)**

Table 35: 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. Records removed for species observed on less than 5 hauls.

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)**
SQUID, ATL LONG-FIN	--	1,257	163 m (89 ftm)
SQUID, SHORT-FIN	--	1,248	199 m (109 ftm)
MONKFISH (GOOSEFISH)	--	449	267 m (146 ftm)
HAKE, SILVER (WHITING)	--	245	279 m (152 ftm)
FLOUNDER, SUMMER (FLUKE)	--	67	109 m (60 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	46	362 m (198 ftm)
SCUP	--	32	133 m (73 ftm)
SQUID, NK	--	23	152 m (83 ftm)
SEA BASS, BLACK	--	20	100 m (55 ftm)
GROUNDFISH, NK	--	18	262 m (143 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**6**	**67**	**343 m (188 ftm)**
SHRIMP, ROYAL RED	--	31	344 m (188 ftm)
HAKE, SILVER (WHITING)	--	15	338 m (185 ftm)
SHRIMP, PANDALID (NORTHERN)	--	9	353 m (193 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	9	350 m (191 ftm)
Grand Total	**643**	**3,481**	**Average: 202 m (110 ftm)**

Table 36: 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. Records removed for species observed on less than 5 hauls.

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)**
SQUID, SHORT-FIN	--	640	207 m (113 ftm)
SQUID, ATL LONG-FIN	--	441	162 m (88 ftm)
MONKFISH (GOOSEFISH)	--	172	323 m (176 ftm)
HAKE, SILVER (WHITING)	--	121	323 m (177 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	42	371 m (203 ftm)
FLOUNDER, SUMMER (FLUKE)	--	31	101 m (55 ftm)
SEA BASS, BLACK	--	13	91 m (50 ftm)
SCUP	--	11	126 m (69 ftm)
GROUNDFISH, NK	--	7	289 m (158 ftm)
SQUID, NK	--	5	147 m (81 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**6**	**67**	**343 m (188 ftm)**
SHRIMP, ROYAL RED	--	31	344 m (188 ftm)
HAKE, SILVER (WHITING)	--	15	338 m (185 ftm)
SHRIMP, PANDALID (NORTHERN)	--	9	353 m (193 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	9	350 m (191 ftm)
Grand Total	**438**	**1,553**	**Average: 222 m (122 ftm)**

Table 37: 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. Records removed for species observed on less than 5 hauls.

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)**
SQUID, SHORT-FIN	--	291	208 m (113 ftm)
SQUID, ATL LONG-FIN	--	166	158 m (86 ftm)
HAKE, SILVER (WHITING)	--	63	348 m (190 ftm)
MONKFISH (GOOSEFISH)	--	56	378 m (207 ftm)
FLOUNDER, SUMMER (FLUKE)	--	19	91 m (50 ftm)
WHITING, BLACK (HAKE, OFFSHORE)	--	14	395 m (216 ftm)
SEA BASS, BLACK	--	10	86 m (47 ftm)
SCUP	--	7	126 m (69 ftm)
TRAWL,OTTER,BOTTOM,SHRIMP	**5**	**13**	**357 m (195 ftm)**
SHRIMP, ROYAL RED	--	5	345 m (189 ftm)
Grand Total	**277**	**640**	**Average: 225 m (123 ftm)**

Table 38: 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**	**Average: 192 m (105 ftm)**

Table 39: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by target species, intersecting the discrete zones under alternative 3B.

Bottom Otter Trawl				
Canyon or Complex TARGET SPECIES	**Trips**	**Hauls**	**Avg. Haul Start Depth**	
			meters	**fathoms**
Block Canyon	**26**	**51**	**329.7**	**180.3**
GROUNDFISH, NK	--	3	249.9	136.7
HAKE, SILVER (WHITING)	--	14	360.9	197.4
MONKFISH (GOOSEFISH)	--	33	327.5	179.1
SQUID, ATL LONG-FIN	--	1	206.7	113.0
Ryan-McMaster Canyons	**8**	**13**	**261.9**	**143.2**
HAKE, SILVER (WHITING)	--	4	334.7	183.0
MONKFISH (GOOSEFISH)	--	5	303.6	166.0
SQUID, ATL LONG-FIN	--	4	137.2	75.0
Emery-Uchupi Canyons	**6**	**12**	**365.2**	**199.7**
HAKE, SILVER (WHITING)	--	7	368.1	201.3
MONKFISH (GOOSEFISH)	--	2	299.9	164.0
WHITING, BLACK (HAKE, OFFSHORE)	--	3	401.7	219.7
Jones-Babylon Canyons	**4**	**6**	**390.8**	**213.7**
HAKE, SILVER (WHITING)	--	4	388.6	212.5
WHITING, BLACK (HAKE, OFFSHORE)	--	2	395.0	216.0
Hudson Canyon	**197**	**488**	**154.1**	**84.3**
DORY, BUCKLER (JOHN)	--	1	135.3	74.0
FLOUNDER, SUMMER (FLUKE)	--	15	119.4	65.3
HAKE, RED (LING)	--	1	40.2	22.0
HAKE, SILVER (WHITING)	--	41	214.0	117.0
MONKFISH (GOOSEFISH)	--	2	138.1	75.5
SCUP	--	21	127.8	69.9
SEA BASS, BLACK	--	3	134.1	73.3
SHRIMP, ROYAL RED	--	12	356.3	194.8
SQUID, ATL LONG-FIN	--	373	137.0	74.9
SQUID, NK	--	2	139.9	76.5
SQUID, SHORT-FIN	--	5	186.2	101.8
WHITING, BLACK (HAKE, OFFSHORE)	--	12	376.0	205.6
Mey-Lindenkohl Slope	**172**	**571**	**153.2**	**83.8**
FLOUNDER, SUMMER (FLUKE)	--	66	109.8	60.0
HAKE, SILVER (WHITING)	--	14	246.2	134.6
SCUP	--	13	113.8	62.2
SEA BASS, BLACK	--	14	105.9	57.9
SHRIMP, ROYAL RED	--	1	365.8	200.0
SQUID, ATL LONG-FIN	--	349	141.7	77.5
SQUID, NK	--	8	151.1	82.6
SQUID, SHORT-FIN	--	104	212.7	116.3
WHITING, BLACK (HAKE, OFFSHORE)	--	2	343.8	188.0

Table 39, continued:

Spencer Canyon	**91**	**248**	**169.9**	**92.9**
FLOUNDER, SUMMER (FLUKE)	--	1	118.9	65.0
SCUP	--	4	134.9	73.8
SQUID, ATL LONG-FIN	--	119	156.8	85.7
SQUID, NK	--	6	133.8	73.2
SQUID, SHORT-FIN	--	118	186.5	102.0
Wilmington Canyon	**112**	**215**	**156.8**	**85.8**
FLOUNDER, SUMMER (FLUKE)	--	15	86.6	47.3
MACKEREL, ATLANTIC	--	1	76.8	42.0
SCUP	--	4	107.9	59.0
SEA BASS, BLACK	--	5	99.1	54.2
SQUID, ATL LONG-FIN	--	108	154.3	84.4
SQUID, NK	--	1	168.2	92.0
SQUID, SHORT-FIN	--	81	180.1	98.5
North Heyes-South Wilmington Canyons	**33**	**49**	**183.2**	**100.2**
SQUID, ATL LONG-FIN	--	15	173.6	94.9
SQUID, SHORT-FIN	--	34	187.4	102.5
South Vries Canyon	**58**	**121**	**183.4**	**100.3**
SQUID, ATL LONG-FIN	--	41	169.4	92.6
SQUID, SHORT-FIN	--	80	190.5	104.2
Baltimore Canyon	**117**	**267**	**150.3**	**82.2**
FLOUNDER, SUMMER (FLUKE)	--	80	81.3	44.5
SEA BASS, BLACK	--	13	89.0	48.7
SQUID, ATL LONG-FIN	--	89	152.6	83.4
SQUID, SHORT-FIN	--	85	222.4	121.6
Warr-Phoenix Canyon Complex	**30**	**72**	**185.8**	**101.6**
SQUID, ATL LONG-FIN	--	43	176.2	96.3
SQUID, SHORT-FIN	--	29	200.1	109.4
Accomac-Leonard Canyons	**37**	**87**	**168.6**	**92.2**
FLOUNDER, SUMMER (FLUKE)	--	5	66.2	36.2
SQUID, ATL LONG-FIN	--	40	161.7	88.4
SQUID, SHORT-FIN	--	42	187.4	102.5
Washington Canyon	**47**	**93**	**150.3**	**82.2**
FLOUNDER, SUMMER (FLUKE)	--	19	93.1	50.9
SCUP	--	1	107.9	59.0
SEA BASS, BLACK	--	11	104.9	57.4
SQUID, ATL LONG-FIN	--	27	143.5	78.5
SQUID, SHORT-FIN	--	35	202.1	110.5
Norfolk Canyon	**50**	**178**	**193.1**	**105.6**
CROAKER, ATLANTIC	--	1	20.1	11.0
FLOUNDER, SUMMER (FLUKE)	--	2	77.7	42.5
SQUID, ATL LONG-FIN	--	49	174.7	95.5
SQUID, SHORT-FIN	--	126	203.5	111.3

Table 40: NEFOP observed bottom trawl hauls, trips, and average haul start depth, by target species, intersecting the advisor-proposed discrete zones under sub-alternative 3B-1.

Bottom Otter Trawl				
Canyon or Complex	**Trips**	**Hauls**	**Avg. Haul Start Depth**	
			meters	**Fathoms**
Baltimore Canyon	**34**	**45**	**192**	**105**
FLOUNDER, SUMMER (FLUKE)	--	8	77	42
SEA BASS, BLACK	--	1	106	58
SQUID, ATL LONG-FIN	--	12	153	83
SQUID, SHORT-FIN	--	24	254	139
Mey-Lindenkohl Slope (Depth-based)*	**24**	**30**	**182**	**99**
FLOUNDER, SUMMER (FLUKE)	--	2	131	72
HAKE, SILVER (WHITING)	--	2	221	121
SCUP	--	1	57	31
SQUID, ATL LONG-FIN	--	16	135	74
SQUID, SHORT-FIN	--	9	281	154
Mey-Lindenkohl Slope Straight*	**69**	**151**	**179**	**98**
FLOUNDER, SUMMER (FLUKE)	--	8	125	69
HAKE, SILVER (WHITING)	--	1	132	72
SCUP	--	4	113	62
SEA BASS, BLACK	--	1	90	49
SQUID, ATL LONG-FIN	--	83	156	85
SQUID, SHORT-FIN	--	54	229	125
Norfolk Canyon	**36**	**86**	**209**	**114**
CROAKER, ATLANTIC	--	1	20	11
FLOUNDER, SUMMER (FLUKE)	--	2	59	32
SQUID, ATL LONG-FIN	--	20	186	102
SQUID, SHORT-FIN	--	63	224	122

*Differences in hauls and trips in the depth-based vs. straight line option for advisor-proposed boundaries of Mey-Lindenkohl are largely due to a very small area in the western corner of the proposed area, where the straight-line boundary extends slightly into an area where the depth-based boundary does not.

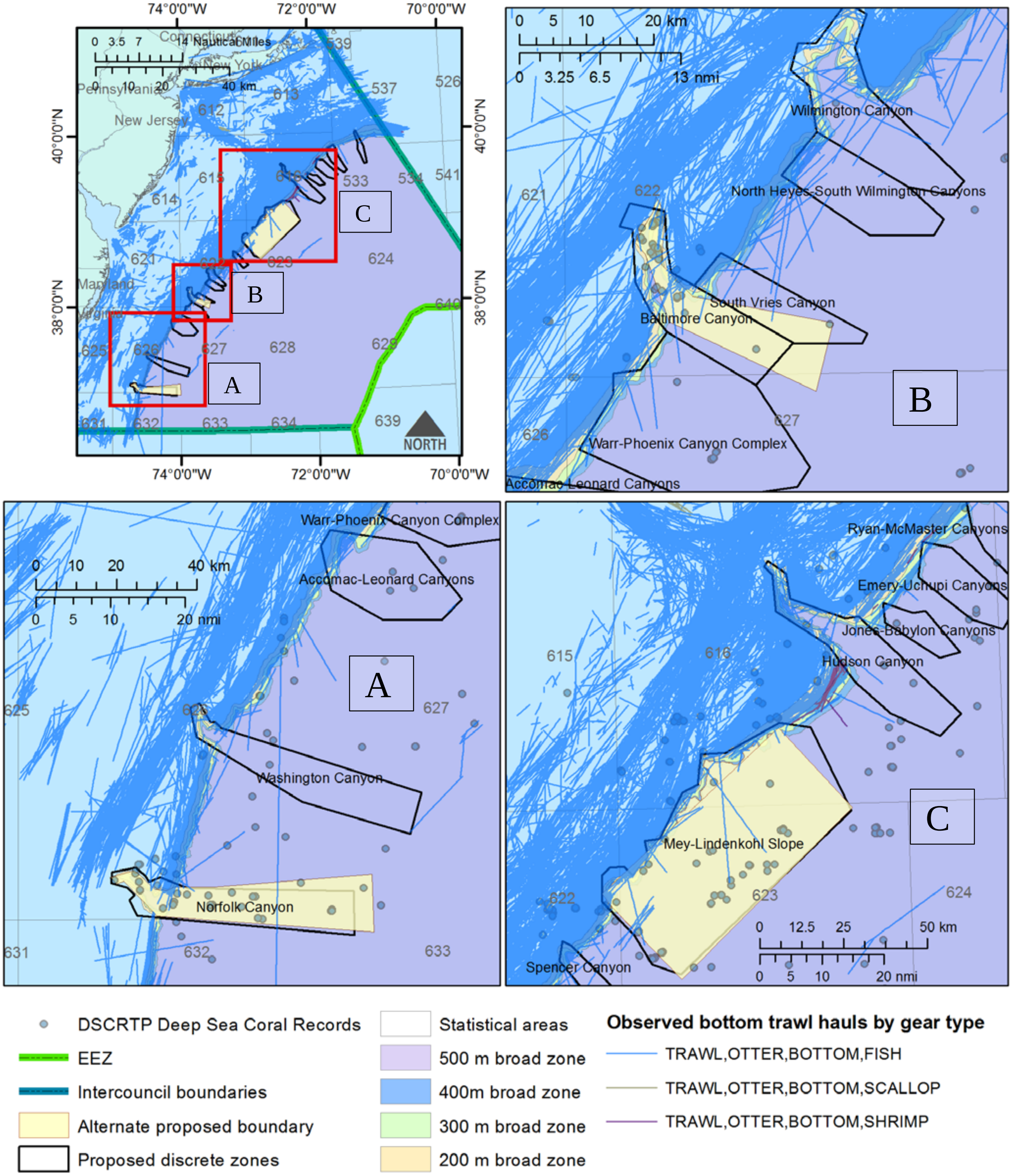

Figure 28: NEFOP observed bottom trawl hauls in the Mid-Atlantic region by gear type, 2000-2013.

Observed Gillnet Effort

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 Mid-Atlantic region, there were 13,928 observed hauls using gillnet gear, on 3,432 trips (Table 41a). Of these observed hauls, only six intersected any of the proposed coral zones (a small fraction of one percent). 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 29). No observed gillnet hauls during this time period intersected any of the proposed discrete zones.

The vast majority of observed gillnet effort since 2000 has occurred in waters much shallower than the depths of any of the proposed coral zones in the Mid-Atlantic (Table 41). Only about 0.6% of observed gillnet trips and 0.5% of observed gillnet hauls occurred deeper than 75 fathoms (137 meters) in the Mid-Atlantic region, according to haul depth information recorded in the observer data.

Table 41: 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 Start Depth
GILL NET, ANCHORED-FLOATING, FISH	32	135	10 m (5 ftm)
GILL NET, DRIFT-FLOATING, FISH	197	621	20 m (11 ftm)
GILL NET, DRIFT-SINK, FISH	496	2,045	8 m (15 ftm)
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	2,707	11,127	12 m (22 ftm)
Total	**3,432**	**13,928**	**11 m (21 ftm)**

b) Within proposed coral zones

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

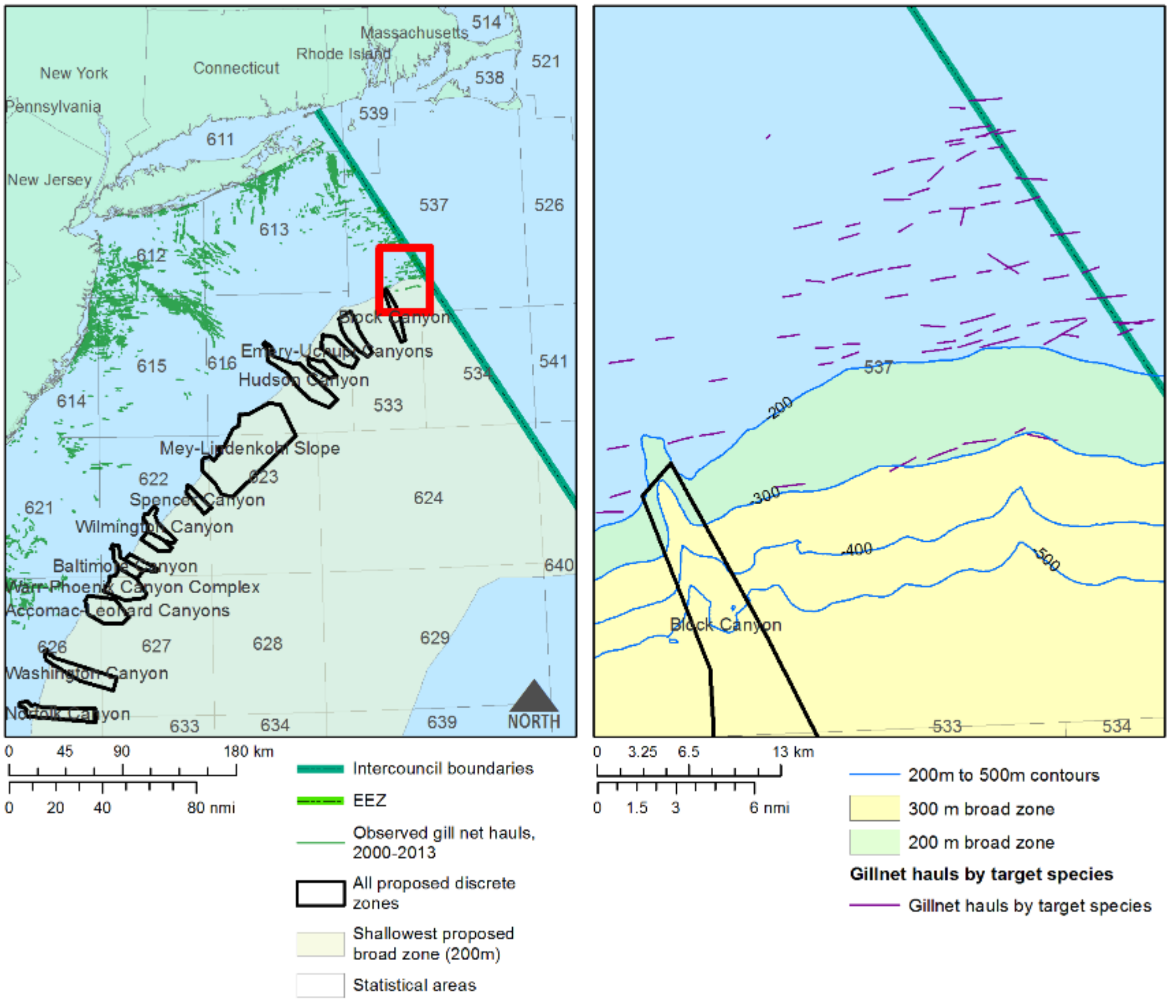

Figure 29: NEFOP observer hauls for gillnet gear in the Mid-Atlantic, 2000-2013, and area of intersection with proposed MAFMC broad coral zones.

Observed Bottom Longline Effort

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 NEFMC, 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 42; Figure 30).

In total, the proposed coral zones are intersected by most of these observed longline trips occurring within the MAFMC region (92%), and 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 30). 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 canyon.

Table 42: NEFOP Observer data records of hauls using bottom longline gear from 2000-2013 a) in the MAFMC region, and b) within proposed broad coral zones.

a) Within MAFMC Region

Gear Type, Target Species	Trips	Hauls	Average Haul Start 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 broad coral zones

Broad Zone, Target Species	Trips	Hauls	Average Haul Start Depth
200 Meter Broad Zone	**12**	**69**	**203 m (111 ftm)**
TILEFISH, GOLDEN		54	205 m (112 ftm)
TILEFISH, NOT KNOWN		15	195 m (106 ftm)
300 Meter Broad Zone		**5**	**229 m (125 ftm)**
TILEFISH, GOLDEN		4	193 m (106 ftm)
TILEFISH, NOT KNOWN		1	375 m (205 ftm)
400 Meter Broad Zone		**2**	**144 m (79 ftm)**
TILEFISH, GOLDEN		2	144 m (79 ftm)
500 Meter Broad Zone		**1**	**146 m (80 ftm)**
TILEFISH, GOLDEN		1	146 m (80 ftm)

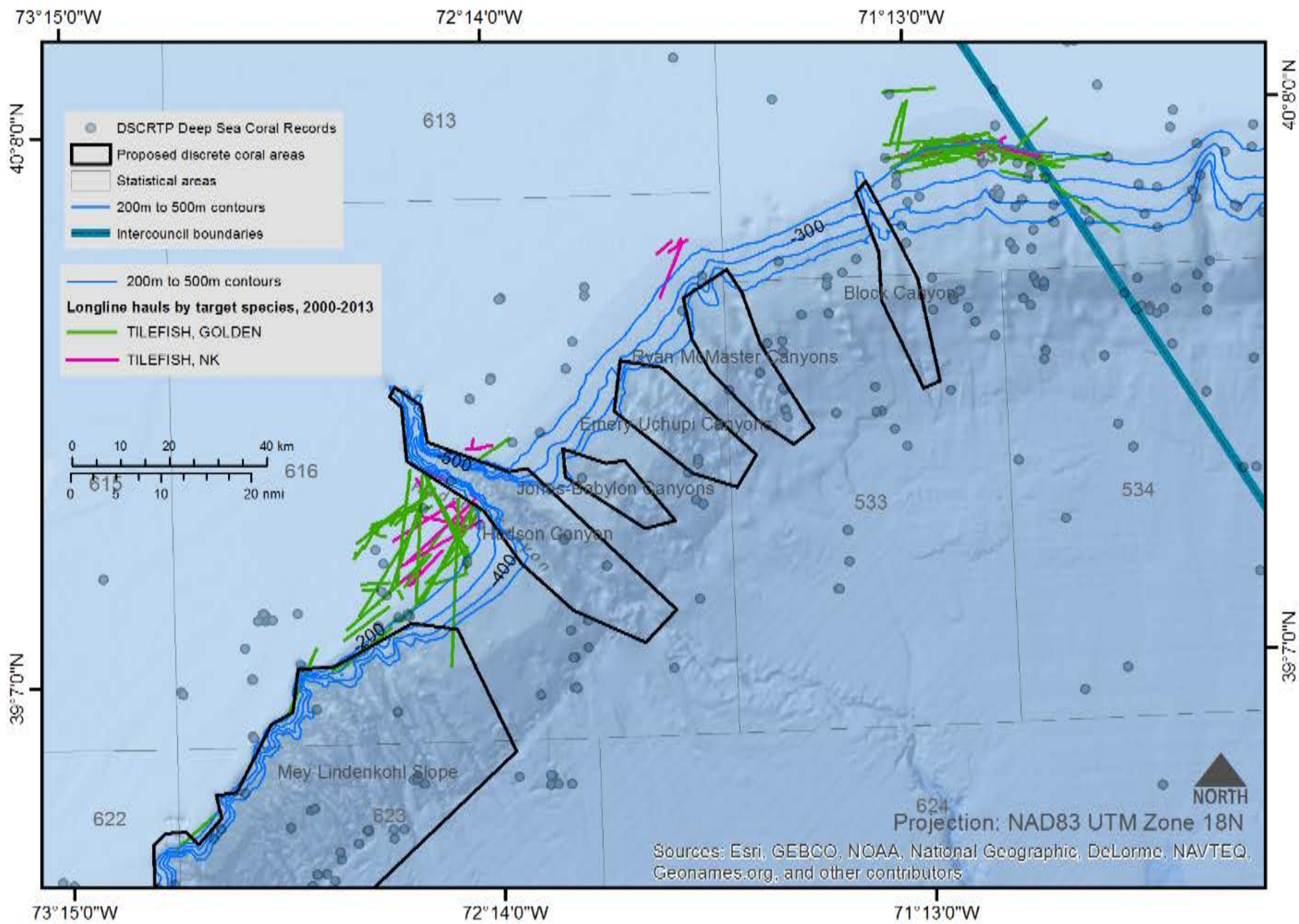

Figure 30: Observed bottom longline hauls in the MAFMC region, 2000-2013.

7.2.4 Summary of Economic Impacts

In general terms, fisheries that operate in offshore areas are expected to be negatively affected by any alternative that reduces access to those fishing areas. Of the fisheries that operate in the area, the squid and red crab fisheries are most likely to be affected. The potential for revenue losses at gross fleet-wide levels should be proportionate to the relative reduction in areas that can be fished, though the exact losses would depend on which areas are closed and how vessels respond to area closures, given that participants would be expected to relocate harvest effort into areas that remain open to some degree. Net losses are then dependent on the degree of reduced efficiencies, i.e., if lower catches are made in the remaining areas and/or if it costs more to fish in those areas. Many of the fisheries operate in specific environments and locations, such as in specific areas near/around canyons that are known for being highly productive. Thus, alternative locations may be limited depending on the measures selected by the Council. However, in general, effort would be expected to shift near/around other areas/canyons not impacted by the proposed measures. This effect would reduce both the negative socio-economic impacts to commercial fishermen and the protections to corals from closing particular areas.

Alternatively, socio-economic effects may be increased because of how fishermen deploy and fish their nets to account for bottom contours, current, wind, and area restrictions, which may prevent them from fishing a greater area than is mapped. For example, if they cannot have gear in the water (but not in contact with the bottom) while their vessel is above a canyon during net deployment and/or retrieval, they may not be able to fish the non-restricted shelf areas immediately adjacent to the closed areas. They also report that these areas are sometimes the most productive areas. While it is not possible to quantify the exact impacts relative to this fishing behavior, it would suggest that fishery impacts may be greater than is otherwise apparent because the effective closed area would be bigger than the mapped closed area.

7.4 SYNTHESIS OF CORAL AND ECONOMIC IMPACTS

The information provided in the above sections reflects the best scientific information on the distribution of deep sea coral and coral habitat. For the discrete zones, the measure of coral presence in individual canyon areas is quantitatively expressed as the area of high/very high coral habitat suitability within each canyon. This allows for a ranking of the canyons relative to their potential value if closed. The broad zones include portions of all of the discrete zones/canyons - their protective value and economic impacts diminish as the defining depth contours increase in depth.

The relative values of the discrete zones provided in Tables 29 (total coral habitat area) and 32 and 33 (ex-vessel revenue) are illustrated in Figure 31. Note that when the canyons are ranked by descending coral habitat area, the decline in percent revenue corresponds fairly well. Exceptions include Spencer Canyon, which is important economically, for its size, but comprises the second lowest coral habitat position, and Norfolk Canyon which has a high coral habitat rank, but a low economic value, largely due to the fact that a Tilefish GRA currently closes part of Norfolk Canyon to mobile bottom-tending gear, which was accounted for in revenue estimates.

This figure can be used to rank individual discrete zones - areas that result in higher coral protection relative to fishery revenues potentially have a higher rank given that more coral would be protected while impacting relatively less fishery revenue. However, results should be interpreted with caution, as there are uncertainties associated with both the habitat model and the revenue mapping model. In addition, effort redistribution by commercial fishermen as a reaction to any closed area may partially reduce the expected impacts.

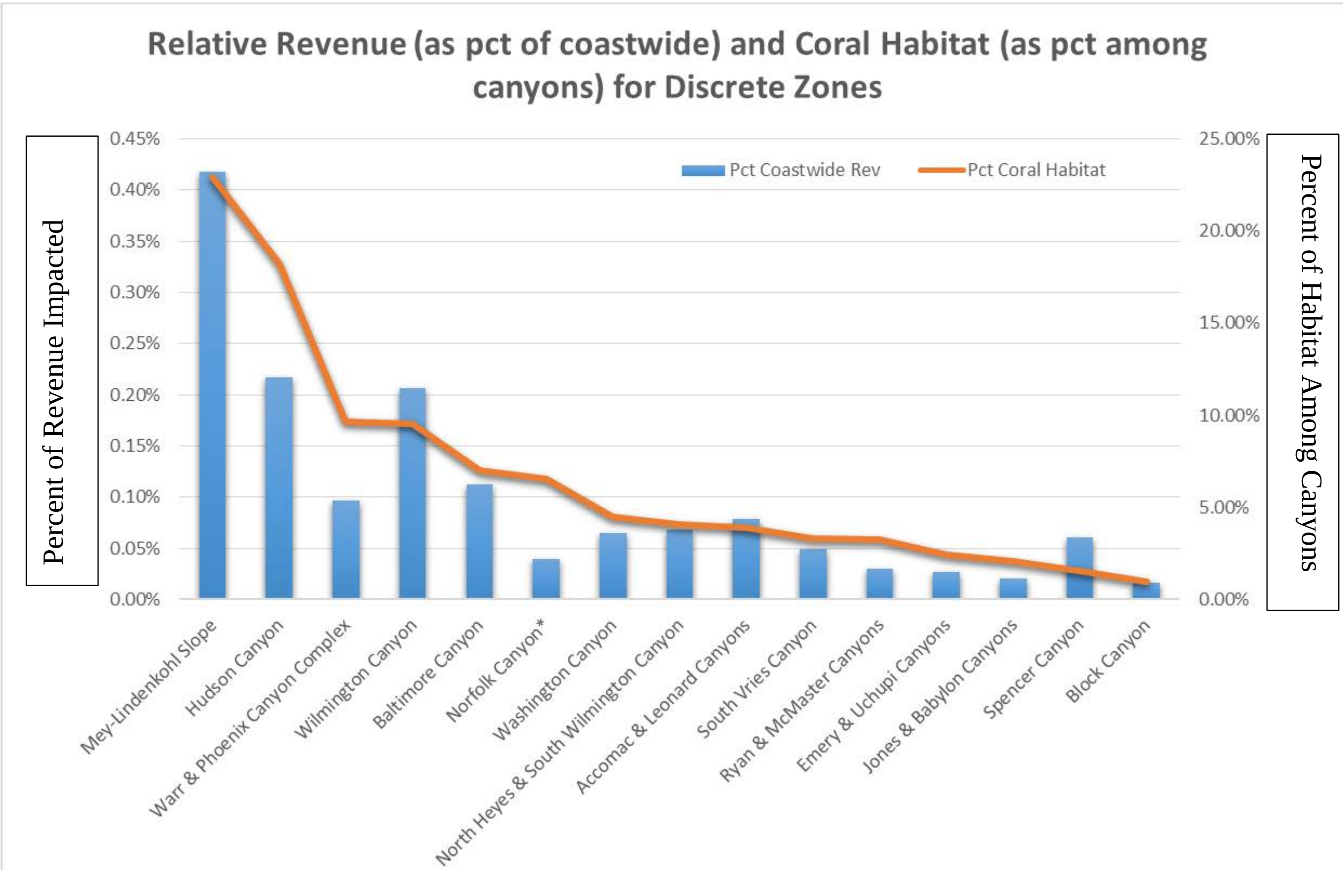

Figure 31: Ranked discrete zones as percentage of coastwide revenue (all gears, species) and coral habitat. *Note: Norfolk Canyon revenue estimates for trawl and dredge fisheries were adjusted to exclude the Norfolk Canyon Tilefish GRA, which is closed to mobile bottom-tending gear.

APPENDIX A: Criteria for FMAT discrete coral zone boundaries

The Council's Deep Sea Corals FMAT met in April 2014 to discuss revisions to the original discrete zone boundaries based on new scientific information. Original boundaries were developed by the NEFMC Habitat Plan Development Team (PDT) during development of the NEFMC's Omnibus Habitat Amendment 2 (prior to splitting deep sea coral alternatives into a separate omnibus amendment).

The FMAT reviewed the boundaries relative to new information available from a deep sea coral habitat suitability model, new high resolution bathymetry data, and recent observations of corals from research surveys. The following criteria were developed by the FMAT and used to guide the re-drawing of boundaries:

1. Identify the major geomorphological features of each canyon or slope area (major axes; overall shape) within the current range of alternatives, based on examination of high resolution slope, bathymetry and other data describing canyon features and morphology.
2. Encompass areas of high and very high habitat suitability[1] from the deep sea coral habitat suitability model outputs for Alcyonacean corals (gorgonian and non-gorgonian combined), 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[2], within approximately 0.4 nautical miles (2 habitat suitability 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 hardbottom 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 sub-options.

[1] "High" and "very high" likelihood classes for habitat suitability were taken directly from thresholded versions of the model output provided by NOAA/NCCOS model developers.

[2] Slope data derived from ACUMEN 25m resolution multibeam data.

APPENDIX B: Coordinates for discrete zone alternatives

Table B1: Number of vertices associated with each boundary option for each discrete zones.

	Advisor 2013 (3B-1)	FMAT 2014 (3B-2)	GSSA 2015 (3B-3)	NGO 2015 (3B-4)	Workshop 2015 (3B-5)
Block Canyon	-	9	17	17	8
Ryan_McMaster Canyons	-	10	47	12	10
Emery_Uchupi Canyons	-	7	18	10	8
Jones_Babylon Canyons	-	7	10	10	10
Hudson Canyon	-	14	49	27	19
Mey-Lindenkohl Slope	6[1]	19	105	32	31
Spencer Canyon	-	6	17	10	10
Wilmington Canyon	-	13	19	27	17
North Heyes and South Wilmington Canyons	-	7	12	10	13
South Vries Canyon	-	6	10	7	7
Baltimore Canyon	11	12	21	20	20
Warr_Phoenix Canyons	-	10	25	12	8
Accomac_Leonard Canyons	-	8	8	19	18
Washington Canyon	-	14	17	22	19
Norfolk Canyon	13	10	13	24	15

[1] Straight-line version only shown.

Table B2: Geographic coordinates of discrete zone options under Alternative 3B for each boundary option (degrees minutes seconds).

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Block Canyon	--	1. 39°47'16'', -72°42'37''	1. 39°53'49'', -72°41'27''	1. 39°38'5'', -72°50'28''	1. 39°55'5'', -72°41'23''
		2. 39°52'36'', -72°42'30''	2. 39°54'55'', -72°40'60''	2. 39°37'23'', -72°48'9''	2. 39°55'60'', -72°43'56''
		3. 39°59'19'', -72°39'30''	3. 39°56'2'', -72°41'36''	3. 39°47'15'', -72°42'36''	3. 39°49'30'', -72°47'53''
		4. 40°0'32'', -72°40'58''	4. 39°56'16'', -72°41'56''	4. 39°52'36'', -72°42'29''	4. 39°38'6'', -72°50'30''
		5. 39°53'46'', -72°45'23''	5. 39°56'10'', -72°42'15''	5. 39°53'49'', -72°41'27''	5. 39°37'24'', -72°48'8''
		6. 39°49'30'', -72°47'53''	6. 39°55'38'', -72°42'31''	6. 39°54'55'', -72°41'0''	6. 39°47'16'', -72°42'37''
		7. 39°38'6'', -72°50'30''	7. 39°55'34'', -72°42'37''	7. 39°55'37'', -72°41'23''	7. 39°52'36'', -72°42'30''
		8. 39°37'24'', -72°48'8''	8. 39°55'33'', -72°42'58''	8. 39°59'33'', -72°39'46''	8. 39°55'5'', -72°41'23''
		9. 39°47'16'', -72°42'37''	9. 39°55'43'', -72°43'35''	9. 40°0'24'', -72°40'49''	
			10. 39°55'60'', -72°43'56''	10. 39°56'55'', -72°42'30''	
			11. 39°53'46'', -72°45'23''	11. 39°56'6'', -72°42'17''	
			12. 39°49'28'', -72°47'55''	12. 39°55'38'', -72°42'31''	
			13. 39°38'6'', -72°50'30''	13. 39°55'43'', -72°43'35''	
			14. 39°37'24'', -72°48'8''	14. 39°55'60'', -72°43'56''	
			15. 39°47'15'', -72°42'36''	15. 39°53'23'', -72°45'37''	
			16. 39°52'36'', -72°42'30''	16. 39°49'28'', -72°47'55''	
			17. 39°53'49'', -72°41'27''	17. 39°38'5'', -72°50'28''	
Ryan-McMaster Canyons	--	1. 39°51'23'', -72°20'35''	1. 39°44'15'', -72°15'5''	1. 39°33'25'', -72°32'7''	1. 39°48'0'', -72°14'48''
		2. 39°48'45'', -72°22'38''	2. 39°44'15'', -72°15'10''	2. 39°31'45'', -72°29'14''	2. 39°49'58'', -72°20'43''
		3. 39°42'58'', -72°24'59''	3. 39°44'30'', -72°15'32''	3. 39°34'27'', -72°24'18''	3. 39°48'17'', -72°22'49''
		4. 39°33'26'', -72°32'5''	4. 39°45'10'', -72°15'38''	4. 39°40'3'', -72°17'41''	4. 39°42'58'', -72°24'59''
		5. 39°31'45'', -72°29'14''	5. 39°46'16'', -72°15'23''	5. 39°43'55'', -72°15'4''	5. 39°33'26'', -72°32'5''
		6. 39°34'28'', -72°24'19''	6. 39°47'3'', -72°14'47''	6. 39°46'59'', -72°13'52''	6. 39°31'45'', -72°29'14''
		7. 39°40'7'', -72°17'39''	7. 39°47'36'', -72°14'51''	7. 39°48'24'', -72°14'49''	7. 39°34'28'', -72°24'19''
		8. 39°43'51'', -72°15'9''	8. 39°48'0'', -72°14'48''	8. 39°50'51'', -72°16'55''	8. 39°40'7'', -72°17'39''
		9. 39°48'26'', -72°14'10''	9. 39°48'16'', -72°15'14''	9. 39°51'22'', -72°20'37''	9. 39°43'51'', -72°15'9''
		10. 39°51'23'', -72°20'35''	10. 39°48'24'', -72°15'16''	10. 39°48'51'', -72°22'31''	10. 39°48'0'', -72°14'48''
			11. 39°48'33'', -72°15'42''	11. 39°42'49'', -72°25'3''	
			12. 39°48'19'', -72°16'17''	12. 39°33'25'', -72°32'7''	
			13. 39°48'8'', -72°16'30''		
			14. 39°47'48'', -72°16'55''		
			15. 39°47'32'', -72°17'27''		

Ryan-McMaster Canyons (cont.)	16. 39°47'26'', -72°17'45'' 17. 39°47'35'', -72°18'2'' 18. 39°47'28'', -72°18'31'' 19. 39°47'26'', -72°19'2'' 20. 39°47'23'', -72°19'23'' 21. 39°47'26'', -72°19'31'' 22. 39°47'38'', -72°19'43'' 23. 39°48'5'', -72°19'30'' 24. 39°48'51'', -72°19'19'' 25. 39°49'12'', -72°19'3'' 26. 39°49'26'', -72°18'51'' 27. 39°49'53'', -72°18'40'' 28. 39°50'8'', -72°18'35'' 29. 39°50'32'', -72°18'57'' 30. 39°50'31'', -72°19'8'' 31. 39°50'29'', -72°19'33'' 32. 39°50'10'', -72°20'0'' 33. 39°50'8'', -72°20'4'' 34. 39°49'58'', -72°20'43'' 35. 39°50'1'', -72°21'14'' 36. 39°49'22'', -72°21'33'' 37. 39°49'17'', -72°21'35'' 38. 39°49'10'', -72°21'51'' 39. 39°49'0'', -72°22'27'' 40. 39°48'45'', -72°22'38'' 41. 39°42'58'', -72°24'59'' 42. 39°33'26'', -72°32'5'' 43. 39°31'46'', -72°29'14'' 44. 39°34'27'', -72°24'21'' 45. 39°40'8'', -72°17'37'' 46. 39°43'52'', -72°15'9'' 47. 39°44'15'', -72°15'5''

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Emery-Uchupi Canyons	---	1. 39°36'6'', -72°3'40'' 2. 39°41'45'', -72°4'47'' 3. 39°40'45'', -72°10'44'' 4. 39°30'47'', -72°23'46'' 5. 39°27'15'', -72°20'52'' 6. 39°28'60'', -72°14'32'' 7. 39°36'6'', -72°3'40''	1. 39°35'36'', -72°4'26'' 2. 39°35'59'', -72°4'49'' 3. 39°36'39'', -72°4'32'' 4. 39°38'30'', -72°5'2'' 5. 39°40'20'', -72°5'26'' 6. 39°40'44'', -72°5'46'' 7. 39°40'53'', -72°6'18'' 8. 39°40'40'', -72°6'50'' 9. 39°40'29'', -72°7'24'' 10. 39°40'20'', -72°7'58'' 11. 39°40'24'', -72°8'16'' 12. 39°40'52'', -72°8'53'' 13. 39°41'4'', -72°8'60'' 14. 39°40'45'', -72°10'44'' 15. 39°30'48'', -72°23'46'' 16. 39°27'15'', -72°20'52'' 17. 39°28'60'', -72°14'32'' 18. 39°35'36'', -72°4'26''	1. 39°30'47'', -72°23'45'' 2. 39°27'15'', -72°20'52'' 3. 39°28'54'', -72°13'53'' 4. 39°36'8'', -72°3'39'' 5. 39°39'3'', -72°4'60'' 6. 39°41'20'', -72°5'7'' 7. 39°41'14'', -72°6'53'' 8. 39°41'3'', -72°9'2'' 9. 39°40'44'', -72°10'49'' 10. 39°30'47'', -72°23'45''	1. 39°37'9'', -72°4'9'' 2. 39°39'46'', -72°6'18'' 3. 39°39'33'', -72°12'19'' 4. 39°30'47'', -72°23'46'' 5. 39°27'15'', -72°20'52'' 6. 39°28'60'', -72°14'32'' 7. 39°33'55'', -72°7'24'' 8. 39°37'9'', -72°4'9''
Jones-Babylon Canyons	--	1. 39°29'1'', -73°56'24'' 2. 39°32'11'', -73°56'9'' 3. 39°30'22'', -72°2'17'' 4. 39°30'37'', -72°4'52'' 5. 39°23'48'', -72°11'51'' 6. 39°22'60'', -72°7'31'' 7. 39°29'1'', -73°56'24''	1. 39°28'15'', -73°57'49'' 2. 39°29'53'', -73°56'29'' 3. 39°30'34'', -73°56'32'' 4. 39°31'17'', -73°57'22'' 5. 39°31'28'', -73°58'36'' 6. 39°30'22'', -72°2'17'' 7. 39°30'37'', -72°4'52'' 8. 39°23'48'', -72°11'51'' 9. 39°22'60'', -72°7'31'' 10. 39°28'15'', -73°57'49''	1. 39°31'31'', -73°57'45'' 2. 39°31'29'', -73°58'32'' 3. 39°30'23'', -72°2'16'' 4. 39°30'38'', -72°4'53'' 5. 39°23'48'', -72°11'52'' 6. 39°22'60'', -72°7'34'' 7. 39°29'1'', -73°56'25'' 8. 39°30'21'', -73°56'17'' 9. 39°31'18'', -73°57'9'' 10. 39°31'31'', -73°57'45''	1. 39°28'16'', -73°57'48'' 2. 39°29'53'', -73°56'29'' 3. 39°30'34'', -73°56'32'' 4. 39°31'17'', -73°57'22'' 5. 39°31'28'', -73°58'36'' 6. 39°30'22'', -72°2'17'' 7. 39°30'37'', -72°4'52'' 8. 39°23'48'', -72°11'51'' 9. 39°22'60'', -72°7'31'' 10. 39°28'16'', -73°57'48''

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Hudson Canyon (cont.)	---	1. 39°19'37", -73°49'43" 2. 39°25'36", -73°44'31" 3. 39°31'18", -73°33'45" 4. 39°37'16", -73°33'14" 5. 39°38'32", -73°31'34" 6. 39°39'33", -73°32'23" 7. 39°37'25", -73°36'5" 8. 39°33'22", -73°36'46" 9. 39°29'50", -73°48'15" 10. 39°30'7", -73°50'56" 11. 39°13'56", -72°11'34" 12. 39°10'23", -72°7'2" 13. 39°14'16", -73°56'55" 14. 39°19'37", -73°49'43"	1. 39°19'50", -73°49'30" 2. 39°20'2", -73°49'45" 3. 39°22'3", -73°49'14" 4. 39°23'36", -73°46'56" 5. 39°25'10", -73°46'58" 6. 39°26'27", -73°45'35" 7. 39°28'3", -73°43'34" 8. 39°28'48", -73°42'37" 9. 39°30'10", -73°39'35" 10. 39°30'23", -73°39'6" 11. 39°30'52", -73°37'29" 12. 39°31'23", -73°36'9" 13. 39°31'57", -73°35'29" 14. 39°32'10", -73°35'21" 15. 39°32'33", -73°34'56" 16. 39°34'11", -73°34'51" 17. 39°35'11", -73°34'45" 18. 39°34'32", -73°35'3" 19. 39°34'53", -73°35'26" 20. 39°34'34", -73°35'36" 21. 39°34'23", -73°35'16" 22. 39°32'24", -73°35'41" 23. 39°32'29", -73°36'8" 24. 39°32'6", -73°36'41" 25. 39°31'52", -73°37'7" 26. 39°31'51", -73°37'53" 27. 39°31'45", -73°38'17" 28. 39°31'32", -73°38'43" 29. 39°31'22", -73°39'9" 30. 39°31'25", -73°39'32" 31. 39°30'59", -73°40'39" 32. 39°30'45", -73°40'50" 33. 39°30'13", -73°42'39"	1. 39°37'21", -73°36'6" 2. 39°33'13", -73°36'20" 3. 39°32'38", -73°37'7" 4. 39°32'34", -73°38'24" 5. 39°31'2", -73°42'49" 6. 39°30'49", -73°44'35" 7. 39°29'51", -73°48'14" 8. 39°29'48", -73°50'45" 9. 39°27'55", -73°53'48" 10. 39°13'55", -72°11'36" 11. 39°10'24", -72°7'1" 12. 39°14'14", -73°56'59" 13. 39°19'4", -73°50'27" 14. 39°19'49", -73°49'30" 15. 39°22'0", -73°48'30" 16. 39°23'23", -73°46'49" 17. 39°25'27", -73°45'5" 18. 39°27'49", -73°42'19" 19. 39°30'2", -73°37'19" 20. 39°30'40", -73°35'31" 21. 39°31'19", -73°34'57" 22. 39°32'46", -73°34'10" 23. 39°35'24", -73°34'2" 24. 39°37'4", -73°33'48" 25. 39°38'58", -73°31'54" 26. 39°39'34", -73°32'24" 27. 39°37'21", -73°36'6"	1. 39°25'10", -73°46'58" 2. 39°28'48", -73°42'37" 3. 39°30'10", -73°39'35" 4. 39°31'23", -73°36'9" 5. 39°32'33", -73°34'56" 6. 39°34'34", -73°34'49" 7. 39°34'32", -73°35'46" 8. 39°33'10", -73°35'54" 9. 39°32'4", -73°37'13" 10. 39°32'10", -73°37'55" 11. 39°30'18", -73°44'18" 12. 39°29'29", -73°45'42" 13. 39°29'27", -73°46'45" 14. 39°27'37", -73°54'8" 15. 39°13'56", -72°11'34" 16. 39°10'23", -72°7'2" 17. 39°14'16", -73°56'55" 18. 39°19'5", -73°50'27" 19. 39°25'10", -73°46'58"

Hudson Canyon (cont.)			34. 39°30'1'', -73°44'5''		
			35. 39°29'50'', -73°44'47''		
			36. 39°29'6'', -73°45'28''		
			37. 39°29'9'', -73°46'13''		
			38. 39°29'27'', -73°46'45''		
			39. 39°29'6'', -73°47'48''		
			40. 39°29'1'', -73°48'37''		
			41. 39°28'10'', -73°49'45''		
			42. 39°28'26'', -73°50'12''		
			43. 39°28'29'', -73°50'40''		
			44. 39°28'29'', -73°51'57''		
			45. 39°27'57'', -73°52'51''		
			46. 39°27'53'', -73°53'47''		
			47. 39°24'1'', -73°58'44''		
			48. 39°19'4'', -73°50'27''		
			49. 39°19'50'', -73°49'30''		

Canyon or Complex	**Advisor 2013 (3B-1)**	**FMAT (3B-2)**	**GSSA (3B-3)**	**NGO (3B-4)**	**Workshop (3B-5)**
Mey-Lindenkohl Slope (cont.)	1. 38°46'27'', -74°56'19''	1. 39°13'22'', -73°33'48''	1. 38°42'60'', -74°58'45''	1. 38°34'44'', -73°6'25''	1. 38°42'60'', -74°58'45''
	2. 39°12'33'', -73°33'37''	2. 39°12'31'', -73°40'18''	2. 38°43'40'', -74°59'39''	2. 38°44'46'', -74°56'45''	2. 38°43'40'', -74°59'39''
	3. 38°59'22'', -73°48'26''	3. 38°58'51'', -73°48'13''	3. 38°44'35'', -74°59'45''	3. 38°46'39'', -74°58'54''	3. 38°45'0'', -74°59'44''
	4. 38°32'20'', -73°12'19''	4. 38°33'13'', -73°12'8''	4. 38°45'0'', -74°59'44''	4. 38°46'56'', -74°57'46''	4. 38°46'40'', -74°58'56''
	5. 38°44'28'', -74°58'5''	5. 38°34'49'', -73°6'17''	5. 38°44'42'', -74°59'10''	5. 38°49'35'', -74°57'47''	5. 38°47'33'', -74°57'46''
	6. 38°46'27'', -74°56'19''	6. 38°39'39'', -73°2'46''	6. 38°46'6'', -74°58'51''	6. 38°49'52'', -74°58'10''	6. 38°47'50'', -74°57'45''
	(Straight-line option)	7. 38°45'9'', -74°56'17''	7. 38°46'9'', -74°59'7''	7. 38°50'28'', -74°59'60''	7. 38°49'2'', -74°58'28''
		8. 38°49'25'', -74°56'19''	8. 38°46'38'', -74°59'41''	8. 38°49'17'', -73°2'37''	8. 38°48'27'', -74°58'60''
		9. 38°50'42'', -74°58'3''	9. 38°47'33'', -74°57'23''	9. 38°52'20'', -73°6'6''	9. 38°49'9'', -73°1'1''
		10. 38°50'47'', -73°0'57''	10. 38°47'50'', -74°57'45''	10. 38°54'32'', -73°6'8''	10. 38°48'2'', -73°3'18''
		11. 38°49'23'', -73°2'44''	11. 38°48'44'', -74°58'21''	11. 38°54'35'', -73°8'5''	11. 38°49'51'', -73°4'28''
		12. 38°52'15'', -73°6'1''	12. 38°49'2'', -74°58'28''	12. 38°56'2'', -73°9'33''	12. 38°52'24'', -73°7'30''
		13. 38°54'51'', -73°5'21''	13. 38°48'33'', -74°58'50''	13. 38°58'59'', -73°11'26''	13. 38°53'52'', -73°6'39''
		14. 38°55'6'', -73°8'20''	14. 38°48'32'', -74°59'9''	14. 39°0'56'', -73°13'17''	14. 38°54'10'', -73°7'25''
		15. 39°2'31'', -73°13'22''	15. 38°48'22'', -74°59'38''	15. 39°1'23'', -73°13'20''	15. 38°54'42'', -73°9'44''
		16. 39°3'48'', -73°16'34''	16. 38°48'40'', -74°59'46''	16. 39°1'60'', -73°14'11''	16. 38°57'12'', -73°12'16''
		17. 39°8'35'', -73°17'24''	17. 38°48'40'', -73°0'25''	17. 39°2'36'', -73°16'7''	17. 38°58'39'', -73°11'39''

Mey-Lindenkohl Slope (cont.)	18. 39°8'46", -73°22'35"	18. 38°49'21", -73°0'41"	18. 39°3'42", -73°16'60"	18. 38°59'18", -73°12'8"
	19. 39°13'22", -73°33'48"	19. 38°49'2", -73°1'11"	19. 39°7'17", -73°17'38"	19. 38°59'13", -73°13'18"
		20. 38°48'58", -73°1'37"	20. 39°8'12", -73°18'26"	20. 39°0'8", -73°14'32"
		21. 38°48'56", -73°2'1"	21. 39°8'4", -73°19'60"	21. 39°1'41", -73°14'16"
		22. 38°48'30", -73°2'15"	22. 39°8'15", -73°22'29"	22. 39°1'29", -73°16'20"
		23. 38°47'47", -73°2'12"	23. 39°7'48", -73°24'57"	23. 39°3'54", -73°19'10"
		24. 38°48'5", -73°3'50"	24. 39°9'8", -73°26'21"	24. 39°7'21", -73°18'44"
		25. 38°49'51", -73°4'28"	25. 39°10'23", -73°28'43"	25. 39°7'10", -73°22'47"
		26. 38°50'5", -73°4'58"	26. 39°12'4", -73°31'59"	26. 39°6'31", -73°24'13"
		27. 38°50'45", -73°5'20"	27. 39°13'11", -73°35'14"	27. 39°11'44", -73°34'36"
		28. 38°52'24", -73°7'30"	28. 39°12'32", -73°40'18"	28. 38°58'51", -73°48'13"
		29. 38°53'23", -73°7'46"	29. 38°58'53", -73°48'13"	29. 38°32'23", -73°12'19"
		30. 38°53'39", -73°7'12"	30. 38°34'6", -73°18'47"	30. 38°34'53", -73°6'13"
		31. 38°53'52", -73°6'39"	31. 38°32'24", -73°12'27"	31. 38°42'60", -74°58'45"
		32. 38°53'57", -73°7'8"	32. 38°34'44", -73°6'25"	
		33. 38°54'10", -73°7'25"		
		34. 38°54'15", -73°7'50"		
		35. 38°54'12", -73°8'16"		
		36. 38°54'29", -73°8'17"		
		37. 38°54'23", -73°8'38"		
		38. 38°54'32", -73°8'48"		
		39. 38°54'27", -73°9'2"		
		40. 38°54'42", -73°9'44"		
		41. 38°54'54", -73°9'41"		
		42. 38°55'2", -73°9'17"		
		43. 38°55'13", -73°9'28"		
		44. 38°55'22", -73°9'30"		
		45. 38°55'36", -73°9'8"		
		46. 38°55'44", -73°9'6"		
		47. 38°55'44", -73°9'29"		
		48. 38°55'51", -73°9'36"		
		49. 38°55'57", -73°9'35"		
		50. 38°55'49", -73°10'22"		
		51. 38°56'22", -73°11'19"		

Mey-Lindenkohl Slope (cont.)	52. 38°57'5'', -73°11'30'' 53. 38°57'12'', -73°12'16'' 54. 38°58'5'', -73°12'21'' 55. 38°58'34'', -73°11'49'' 56. 38°58'49'', -73°12'6'' 57. 38°59'9'', -73°12'19'' 58. 38°59'13'', -73°13'18'' 59. 39°0'8'', -73°14'32'' 60. 39°0'36'', -73°14'29'' 61. 39°1'12'', -73°13'58'' 62. 39°1'37'', -73°14'21'' 63. 39°1'26'', -73°14'44'' 64. 39°1'18'', -73°15'26'' 65. 39°1'22'', -73°16'25'' 66. 39°0'50'', -73°17'3'' 67. 39°1'8'', -73°17'17'' 68. 39°2'11'', -73°17'29'' 69. 39°2'22'', -73°17'20'' 70. 39°3'22'', -73°18'7'' 71. 39°3'20'', -73°18'57'' 72. 39°3'54'', -73°19'10'' 73. 39°5'6'', -73°18'50'' 74. 39°6'1'', -73°19'38'' 75. 39°6'56'', -73°18'27'' 76. 39°7'21'', -73°18'44'' 77. 39°7'7'', -73°19'23'' 78. 39°7'17'', -73°19'50'' 79. 39°7'1'', -73°20'15'' 80. 39°6'32'', -73°21'23'' 81. 39°6'39'', -73°21'53'' 82. 39°7'25'', -73°21'54'' 83. 39°7'16'', -73°22'47'' 84. 39°6'58'', -73°23'25'' 85. 39°6'31'', -73°24'13''

Mey-Lindenkohl Slope (cont.)	86. 39°7'47'', -73°26'27'' 87. 39°9'6'', -73°26'20'' 88. 39°8'60'', -73°27'12'' 89. 39°9'55'', -73°28'22'' 90. 39°10'16'', -73°28'57'' 91. 39°9'38'', -73°29'18'' 92. 39°9'22'', -73°29'59'' 93. 39°9'26'', -73°30'42'' 94. 39°10'8'', -73°31'49'' 95. 39°10'43'', -73°31'49'' 96. 39°11'20'', -73°31'32'' 97. 39°11'47'', -73°32'29'' 98. 39°11'15'', -73°33'1'' 99. 39°10'54'', -73°33'45'' 100. 39°11'47'', -73°34'7'' 101. 39°11'44'', -73°34'36'' 102. 38°58'51'', -73°48'13'' 103. 38°32'23'', -73°12'19'' 104. 38°34'53'', -73°6'13'' 105. 38°42'60'', -74°58'45''

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Spencer Canyon	---	1. 38°38'12'', -74°49'47'' 2. 38°28'57'', -73°1'2'' 3. 38°26'27'', -74°56'46'' 4. 38°35'47'', -74°47'12'' 5. 38°38'57'', -74°47'55'' 6. 38°38'12'', -74°49'47''	1. 38°34'12'', -74°48'48'' 2. 38°34'20'', -74°49'2'' 3. 38°35'6'', -74°49'34'' 4. 38°35'41'', -74°49'40'' 5. 38°36'3'', -74°49'2'' 6. 38°36'44'', -74°48'40'' 7. 38°37'0'', -74°48'27'' 8. 38°37'16'', -74°48'58'' 9. 38°37'4'', -74°49'32'' 10. 38°36'56'', -74°50'9'' 11. 38°36'33'', -74°51'0'' 12. 38°36'28'', -74°51'12'' 13. 38°36'26'', -74°51'25'' 14. 38°36'35'', -74°51'45'' 15. 38°33'58'', -74°54'57'' 16. 38°31'36'', -74°51'29'' 17. 38°34'12'', -74°48'48''	1. 38°28'56'', -73°1'5'' 2. 38°26'27'', -74°56'46'' 3. 38°34'25'', -74°48'34'' 4. 38°35'40'', -74°48'58'' 5. 38°36'56'', -74°47'56'' 6. 38°37'26'', -74°48'22'' 7. 38°37'34'', -74°49'31'' 8. 38°37'14'', -74°50'34'' 9. 38°36'34'', -74°51'48'' 10. 38°28'56'', -73°1'5''	1. 38°34'8'', -74°48'52'' 2. 38°35'6'', -74°49'34'' 3. 38°35'57'', -74°48'45'' 4. 38°37'34'', -74°49'31'' 5. 38°37'13'', -74°50'35'' 6. 38°36'44'', -74°51'9'' 7. 38°36'35'', -74°51'45'' 8. 38°28'57'', -73°1'2'' 9. 38°26'27'', -74°56'46'' 10. 38°34'8'', -74°48'52''
Wilmington Canyon	---	1. 38°19'33'', -74°25'56'' 2. 38°23'16'', -74°25'14'' 3. 38°24'35'', -74°23'23'' 4. 38°26'42'', -74°24'8'' 5. 38°26'43'', -74°26'3'' 6. 38°29'57'', -74°29'10'' 7. 38°28'60'', -74°31'15'' 8. 38°26'17'', -74°30'0'' 9. 38°23'2'', -74°31'19'' 10. 38°15'23'', -74°40'58'' 11. 38°14'16'', -74°39'42'' 12. 38°14'59'', -74°35'16'' 13. 38°19'33'', -74°25'56''	1. 38°29'43'', -74°29'21'' 2. 38°30'6'', -74°30'28'' 3. 38°29'55'', -74°30'41'' 4. 38°29'7'', -74°30'13'' 5. 38°28'39'', -74°30'38'' 6. 38°28'11'', -74°30'32'' 7. 38°27'14'', -74°29'56'' 8. 38°25'48'', -74°29'28'' 9. 38°25'12'', -74°29'47'' 10. 38°23'44'', -74°29'30'' 11. 38°23'28'', -74°30'15'' 12. 38°22'46'', -74°30'40'' 13. 38°22'30'', -74°32'22'' 14. 38°21'39'', -74°33'17'' 15. 38°19'5'', -74°27'16'' 16. 38°25'17'', -74°25'6''	1. 38°21'35'', -74°33'8'' 2. 38°18'31'', -74°37'3'' 3. 38°14'25'', -74°43'22'' 4. 38°13'14'', -74°42'41'' 5. 38°15'16'', -74°35'12'' 6. 38°15'47'', -74°33'37'' 7. 38°17'3'', -74°31'1'' 8. 38°19'14'', -74°26'35'' 9. 38°23'11'', -74°25'34'' 10. 38°24'42'', -74°23'42'' 11. 38°25'49'', -74°24'1'' 12. 38°26'42'', -74°25'8'' 13. 38°26'44'', -74°26'3'' 14. 38°27'54'', -74°27'12'' 15. 38°28'35'', -74°28'19'' 16. 38°29'46'', -74°29'23''	1. 38°29'43'', -74°29'21'' 2. 38°28'39'', -74°30'38'' 3. 38°25'31'', -74°29'4'' 4. 38°25'16'', -74°30'2'' 5. 38°23'45'', -74°29'50'' 6. 38°23'28'', -74°30'18'' 7. 38°22'46'', -74°30'40'' 8. 38°22'30'', -74°32'22'' 9. 38°21'35'', -74°33'8'' 10. 38°18'31'', -74°37'3'' 11. 38°14'25'', -74°43'22'' 12. 38°13'14'', -74°42'41'' 13. 38°15'47'', -74°33'37'' 14. 38°19'3'', -74°26'59'' 15. 38°25'5'', -74°25'0'' 16. 38°26'19'', -74°26'33''

Canyon or Complex	**Advisor 2013 (3B-1)**	**FMAT (3B-2)**	**GSSA (3B-3)**	**NGO (3B-4)**	**Workshop (3B-5)**
Wilmington Canyon (cont.)			17. 38°26'19'', -74°26'33'' 18. 38°28'33'', -74°28'30'' 19. 38°29'43'', -74°29'21''	17. 38°30'8'', -74°30'28'' 18. 38°29'54'', -74°30'41'' 19. 38°29'7'', -74°30'13'' 20. 38°28'33'', -74°30'51'' 21. 38°25'54'', -74°29'43'' 22. 38°25'1'', -74°30'15'' 23. 38°24'23'', -74°30'3'' 24. 38°22'35'', -74°31'50'' 25. 38°22'30'', -74°32'21'' 26. 38°21'39'', -74°33'17'' 27. 38°21'35'', -74°33'8''	17. 38°29'43'', -74°29'21''
North Heyes-South Wilmington Canyons	---	1. 38°19'32'', -74°25'56'' 2. 38°14'59'', -74°35'16'' 3. 38°12'19'', -74°38'47'' 4. 38°11'4'', -74°37'48'' 5. 38°11'7'', -74°31'17'' 6. 38°16'7'', -74°22'15'' 7. 38°19'32'', -74°25'56''	1. 38°19'8'', -74°27'23'' 2. 38°17'26'', -74°30'16'' 3. 38°13'42'', -74°26'38'' 4. 38°15'14'', -74°23'47'' 5. 38°15'32'', -74°24'9'' 6. 38°15'49'', -74°23'52'' 7. 38°16'48'', -74°24'10'' 8. 38°17'38'', -74°24'39'' 9. 38°17'57'', -74°25'18'' 10. 38°18'3'', -74°26'38'' 11. 38°18'54'', -74°27'18'' 12. 38°19'8'', -74°27'23''	1. 38°11'3'', -74°37'47'' 2. 38°11'6'', -74°31'18'' 3. 38°15'15'', -74°23'49'' 4. 38°16'12'', -74°23'5'' 5. 38°16'53'', -74°23'20'' 6. 38°18'32'', -74°25'33'' 7. 38°19'0'', -74°27'2'' 8. 38°14'55'', -74°35'22'' 9. 38°12'19'', -74°38'49'' 10. 38°11'3'', -74°37'47''	1. 38°14'59'', -74°35'16'' 2. 38°12'19'', -74°38'47'' 3. 38°11'4'', -74°37'48'' 4. 38°11'7'', -74°31'17'' 5. 38°15'15'', -74°23'48'' 6. 38°16'11'', -74°23'5'' 7. 38°16'53'', -74°23'20'' 8. 38°16'54'', -74°23'39'' 9. 38°17'38'', -74°24'39'' 10. 38°18'33'', -74°25'34'' 11. 38°18'23'', -74°26'36'' 12. 38°19'0'', -74°27'1'' 13. 38°14'59'', -74°35'16''

Canyon or Complex	**Advisor 2013 (3B-1)**	**FMAT (3B-2)**	**GSSA (3B-3)**	**NGO (3B-4)**	**Workshop (3B-5)**
South Vries Canyon	---	1. 38°7'18'', -74°13'10'' 2. 38°9'54'', -74°15'55'' 3. 38°3'13'', -74°30'47'' 4. 38°2'23'', -74°30'13'' 5. 38°2'33'', -74°23'16'' 6. 38°7'18'', -74°13'10''	1. 38°6'0'', -74°15'53'' 2. 38°6'38'', -74°15'49'' 3. 38°6'56'', -74°15'36'' 4. 38°8'19'', -74°16'12'' 5. 38°8'22'', -74°17'16'' 6. 38°8'35'', -74°17'49'' 7. 38°9'4'', -74°17'48'' 8. 38°7'46'', -74°20'42'' 9. 38°5'20'', -74°17'19'' 10. 38°6'0'', -74°15'53''	1. 38°3'12'', -74°30'48'' 2. 38°2'23'', -74°30'14'' 3. 38°2'32'', -74°23'17'' 4. 38°7'6'', -74°13'34'' 5. 38°9'16'', -74°15'42'' 6. 38°9'14'', -74°17'23'' 7. 38°3'12'', -74°30'48''	1. 38°6'21'', -74°15'12'' 2. 38°7'30'', -74°14'48'' 3. 38°9'14'', -74°17'23'' 4. 38°3'13'', -74°30'47'' 5. 38°2'23'', -74°30'13'' 6. 38°2'33'', -74°23'16'' 7. 38°6'21'', -74°15'12''
Baltimore Canyon	1. 38°9'2'', -74°9'51'' 2. 38°6'26'', -74°12'59'' 3. 38°4'7'', -74°27'19'' 4. 37°58'37'', -74°25'27'' 5. 38°4'24'', -74°10'36'' 6. 38°9'54'', -74°8'12'' 7. 38°10'48'', -74°7'12'' 8. 38°13'21'', -74°9'6'' 9. 38°14'30'', -74°9'24'' 10. 38°13'9'', -74°10'14'' 11. 38°9'2'', -74°9'51''	1. 38°7'35'', -74°7'10'' 2. 38°11'52'', -74°6'55'' 3. 38°12'8'', -74°5'38'' 4. 38°13'58'', -74°6'41'' 5. 38°13'20'', -74°10'15'' 6. 38°10'21'', -74°10'27'' 7. 38°8'23'', -74°10'50'' 8. 38°2'33'', -74°23'14'' 9. 37°59'11'', -74°19'20'' 10. 38°3'33'', -74°10'22'' 11. 38°5'22'', -74°8'36'' 12. 38°7'35'', -74°7'10''	1. 38°4'24'', -74°10'35'' 2. 38°6'12'', -74°8'25'' 3. 38°9'40'', -74°8'1'' 4. 38°11'59'', -74°7'21'' 5. 38°13'44'', -74°9'16'' 6. 38°13'9'', -74°10'14'' 7. 38°11'57'', -74°10'6'' 8. 38°10'55'', -74°9'38'' 9. 38°10'12'', -74°10'22'' 10. 38°9'15'', -74°10'19'' 11. 38°8'34'', -74°10'45'' 12. 38°7'31'', -74°11'53'' 13. 38°7'31'', -74°11'52'' 14. 38°7'5'', -74°12'25'' 15. 38°6'32'', -74°12'59'' 16. 38°5'41'', -74°14'27'' 17. 38°6'0'', -74°15'53'' 18. 38°2'33'', -74°23'16'' 19. 37°59'13'', -74°19'21'' 20. 38°3'4'', -74°11'22'' 21. 38°4'24'', -74°10'35''	1. 38°7'52'', -74°11'42'' 2. 38°6'58'', -74°12'32'' 3. 38°6'57'', -74°13'53'' 4. 38°6'0'', -74°15'53'' 5. 38°2'33'', -74°23'15'' 6. 37°59'12'', -74°19'20'' 7. 38°3'34'', -74°10'23'' 8. 38°5'31'', -74°8'42'' 9. 38°7'37'', -74°7'24'' 10. 38°9'43'', -74°7'2'' 11. 38°11'60'', -74°7'21'' 12. 38°13'10'', -74°8'27'' 13. 38°13'44'', -74°9'16'' 14. 38°13'19'', -74°10'15'' 15. 38°11'60'', -74°10'7'' 16. 38°11'12'', -74°9'47'' 17. 38°10'12'', -74°10'21'' 18. 38°9'16'', -74°10'20'' 19. 38°8'30'', -74°10'48'' 20. 38°7'52'', -74°11'42''	1. 38°6'12'', -74°8'25'' 2. 38°7'40'', -74°7'48'' 3. 38°9'3'', -74°7'36'' 4. 38°10'6'', -74°7'41'' 5. 38°11'59'', -74°7'21'' 6. 38°13'44'', -74°9'16'' 7. 38°13'9'', -74°10'14'' 8. 38°10'55'', -74°9'38'' 9. 38°10'12'', -74°10'22'' 10. 38°9'15'', -74°10'19'' 11. 38°8'23'', -74°10'30'' 12. 38°7'35'', -74°12'5'' 13. 38°6'58'', -74°12'45'' 14. 38°6'31'', -74°13'0'' 15. 38°5'41'', -74°14'27'' 16. 38°6'21'', -74°15'11'' 17. 38°2'33'', -74°23'14'' 18. 37°59'11'', -74°19'20'' 19. 38°3'17'', -74°10'54'' 20. 38°6'12'', -74°8'25''

Canyon or Complex	**Advisor 2013 (3B-1)**	**FMAT (3B-2)**	**GSSA (3B-3)**	**NGO (3B-4)**	**Workshop (3B-5)**
Warr-Phoenix Canyon Complex	---	1. 37°59'11'', -74°19'20''	1. 37°53'41'', -74°2'36''	1. 37°50'54'', -74°23'25''	1. 37°53'41'', -74°2'36''
		2. 37°52'30'', -74°24'43''	2. 37°54'41'', -74°2'45''	2. 37°49'50'', -74°12'53''	2. 37°55'4'', -74°2'44''
		3. 37°50'55'', -74°23'25''	3. 37°55'39'', -74°3'30''	3. 37°53'46'', -74°2'19''	3. 38°3'17'', -74°10'54''
		4. 37°49'50'', -74°12'53''	4. 37°56'23'', -74°4'9''	4. 37°54'39'', -74°2'25''	4. 37°59'11'', -74°19'20''
		5. 37°54'10'', -74°1'16''	5. 37°56'56'', -74°4'44''	5. 37°55'57'', -74°3'3''	5. 37°52'30'', -74°24'43''
		6. 37°58'33'', -74°4'47''	6. 37°57'23'', -74°4'58''	6. 37°58'33'', -74°5'12''	6. 37°50'55'', -74°23'25''
		7. 38°0'18'', -74°4'50''	7. 37°57'53'', -74°5'17''	7. 37°59'33'', -74°5'33''	7. 37°49'50'', -74°12'53''
		8. 38°0'34'', -74°7'39''	8. 37°58'8'', -74°5'30''	8. 38°0'38'', -74°7'42''	8. 37°53'41'', -74°2'36''
		9. 38°3'33'', -74°10'22''	9. 37°58'27'', -74°6'6''	9. 38°3'34'', -74°10'24''	
		10. 37°59'11'', -74°19'20''	10. 37°59'19'', -74°6'21''	10. 37°59'12'', -74°19'22''	
			11. 37°59'14'', -74°7'1''	11. 37°52'31'', -74°24'42''	
			12. 37°59'55'', -74°7'50''	12. 37°50'54'', -74°23'25''	
			13. 38°0'34'', -74°8'12''		
			14. 38°0'34'', -74°8'48''		
			15. 38°1'11'', -74°9'13''		
			16. 38°1'27'', -74°9'50''		
			17. 38°2'3'', -74°9'49''		
			18. 38°2'23'', -74°10'60''		
			19. 38°2'39'', -74°11'32''		
			20. 38°3'4'', -74°11'22''		
			21. 37°59'11'', -74°19'20''		
			22. 37°52'30'', -74°24'43''		
			23. 37°50'56'', -74°23'26''		
			24. 37°49'50'', -74°12'53''		
			25. 37°53'41'', -74°2'36''		

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Accomac-Leonard Canyons	---	1. 37°50'7'', -75°51'23'' 2. 37°52'13'', -75°52'56'' 3. 37°50'24'', -74°7'39'' 4. 37°42'46'', -74°15'8'' 5. 37°39'58'', -74°11'40'' 6. 37°40'3'', -74°1'45'' 7. 37°44'8'', -75°53'2'' 8. 37°50'7'', -75°51'23''	1. 37°49'37'', -75°57'43'' 2. 37°46'42'', -75°54'1'' 3. 37°49'37'', -75°53'58'' 4. 37°51'15'', -75°54'31'' 5. 37°51'59'', -75°55'29'' 6. 37°51'22'', -75°56'42'' 7. 37°50'38'', -75°57'19'' 8. 37°49'37'', -75°57'43''	1. 37°51'22'', -75°56'43'' 2. 37°50'36'', -75°57'19'' 3. 37°50'12'', -75°59'50'' 4. 37°50'31'', -74°1'24'' 5. 37°51'0'', -74°2'50'' 6. 37°50'24'', -74°7'40'' 7. 37°42'47'', -74°15'10'' 8. 37°39'58'', -74°11'41'' 9. 37°39'47'', -74°2'32'' 10. 37°42'17'', -75°55'27'' 11. 37°44'14'', -75°50'38'' 12. 37°46'28'', -75°53'15'' 13. 37°48'5'', -75°52'32'' 14. 37°49'17'', -75°52'11'' 15. 37°50'36'', -75°52'50'' 16. 37°50'23'', -75°53'54'' 17. 37°51'14'', -75°54'32'' 18. 37°51'59'', -75°55'30'' 19. 37°51'22'', -75°56'43''	1. 37°49'37'', -75°57'43'' 2. 37°50'16'', -75°59'20'' 3. 37°50'12'', -75°59'50'' 4. 37°50'31'', -74°1'24'' 5. 37°50'60'', -74°2'50'' 6. 37°50'24'', -74°7'39'' 7. 37°42'46'', -74°15'8'' 8. 37°39'58'', -74°11'41'' 9. 37°40'3'', -74°1'45'' 10. 37°44'8'', -75°53'2'' 11. 37°45'53'', -75°52'33'' 12. 37°46'42'', -75°54'1'' 13. 37°49'37'', -75°53'58'' 14. 37°51'15'', -75°54'31'' 15. 37°51'59'', -75°55'29'' 16. 37°51'22'', -75°56'42'' 17. 37°50'38'', -75°57'19'' 18. 37°49'37'', -75°57'43''

Canyon or Complex	Advisor 2013 (3B-1)	FMAT (3B-2)	GSSA (3B-3)	NGO (3B-4)	Workshop (3B-5)
Washington Canyon	---	1. 37°29'6'', -75°30'35'' 2. 37°26'38'', -75°32'23'' 3. 37°26'34'', -75°33'22'' 4. 37°25'42'', -75°34'22'' 5. 37°16'48'', -74°7'53'' 6. 37°11'15'', -74°5'54'' 7. 37°15'44'', -75°47'47'' 8. 37°24'34'', -75°30'3'' 9. 37°28'27'', -75°29'3'' 10. 37°29'6'', -75°30'35''	1. 37°22'51'', -75°33'50'' 2. 37°23'45'', -75°32'28'' 3. 37°24'26'', -75°31'26'' 4. 37°24'40'', -75°30'17'' 5. 37°25'56'', -75°29'52'' 6. 37°27'15'', -75°29'48'' 7. 37°28'36'', -75°29'24'' 8. 37°29'26'', -75°29'43'' 9. 37°29'32'', -75°30'3'' 10. 37°28'6'', -75°30'55'' 11. 37°27'41'', -75°31'12'' 12. 37°27'4'', -75°31'14'' 13. 37°26'23'', -75°32'15'' 14. 37°26'18'', -75°33'8'' 15. 37°25'42'', -75°34'22'' 16. 37°25'50'', -75°35'47'' 17. 37°22'51'', -75°33'50''	1. 37°26'26'', -75°33'12'' 2. 37°25'42'', -75°34'22'' 3. 37°25'50'', -75°35'47'' 4. 37°25'5'', -75°36'43'' 5. 37°16'49'', -74°7'52'' 6. 37°11'16'', -74°5'57'' 7. 37°15'44'', -75°47'48'' 8. 37°20'45'', -75°37'38'' 9. 37°22'44'', -75°33'45'' 10. 37°22'52'', -75°33'50'' 11. 37°24'41'', -75°30'18'' 12. 37°25'56'', -75°29'52'' 13. 37°27'15'', -75°29'48'' 14. 37°28'36'', -75°29'24'' 15. 37°29'26'', -75°29'43'' 16. 37°29'32'', -75°30'3'' 17. 37°28'43'', -75°30'32'' 18. 37°28'42'', -75°30'52'' 19. 37°27'39'', -75°31'39'' 20. 37°27'14'', -75°31'22'' 21. 37°26'34'', -75°32'2'' 22. 37°26'26'', -75°33'12''	1. 37°22'52'', -75°33'50'' 2. 37°24'40'', -75°30'17'' 3. 37°25'56'', -75°29'52'' 4. 37°27'15'', -75°29'48'' 5. 37°28'36'', -75°29'24'' 6. 37°29'26'', -75°29'43'' 7. 37°29'32'', -75°30'3'' 8. 37°27'41'', -75°31'11'' 9. 37°27'4'', -75°31'14'' 10. 37°26'23'', -75°32'15'' 11. 37°26'18'', -75°33'8'' 12. 37°25'42'', -75°34'22'' 13. 37°25'50'', -75°35'47'' 14. 37°25'5'', -75°36'43'' 15. 37°16'49'', -74°7'52'' 16. 37°11'16'', -74°5'57'' 17. 37°15'44'', -75°47'48'' 18. 37°22'44'', -75°33'45'' 19. 37°22'52'', -75°33'50''

Canyon or Complex	**Advisor 2013 (3B-1)**	**FMAT (3B-2)**	**GSSA (3B-3)**	**NGO (3B-4)**	**Workshop (3B-5)**
	1. 37°4'0'', -75°22'59''	1. 37°6'22'', -75°15'45''	1. 37°3'39'', -75°25'58''	1. 37°7'0'', -75°19'44''	1. 37°4'31'', -75°26'30''
	2. 37°3'52'', -75°24'60''	2. 37°6'59'', -75°19'43''	2. 37°0'56'', -75°24'57''	2. 37°5'54'', -75°21'19''	2. 37°4'10'', -75°27'38''
	3. 37°4'22'', -75°26'15''	3. 37°5'54'', -75°21'18''	3. 37°0'56'', -75°23'24''	3. 37°4'30'', -75°22'22''	3. 37°4'24'', -75°29'25''
	4. 37°4'19'', -75°32'53''	4. 37°5'2'', -75°21'57''	4. 37°1'12'', -75°22'23''	4. 37°5'13'', -75°24'2''	4. 37°3'39'', -75°56'20''
	5. 37°5'52'', -75°59'25''	5. 37°5'40'', -75°23'48''	5. 37°5'11'', -75°17'43''	5. 37°5'12'', -75°24'36''	5. 36°57'45'', -75°56'23''
	6. 36°58'9'', -75°59'39''	6. 37°4'14'', -75°28'27''	6. 37°5'30'', -75°17'42''	6. 37°4'10'', -75°27'38''	6. 36°59'46'', -75°29'60''
	7. 37°0'29'', -75°23'16''	7. 37°3'39'', -75°56'19''	7. 37°6'14'', -75°17'40''	7. 37°4'24'', -75°29'25''	7. 36°58'14'', -75°27'3''
	8. 37°2'48'', -75°20'32''	8. 36°57'45'', -75°56'22''	8. 37°6'41'', -75°19'33''	8. 37°3'39'', -75°56'20''	8. 36°57'59'', -75°25'49''
	9. 37°5'11'', -75°17'43''	9. 37°0'31'', -75°19'57''	9. 37°4'39'', -75°21'47''	9. 36°57'45'', -75°56'23''	9. 36°58'37'', -75°23'2''
	10. 37°4'50'', -75°16'31''	10. 37°2'38'', -75°18'42''	10. 37°3'33'', -75°22'58''	10. 36°59'46'', -75°29'60''	10. 37°4'26'', -75°18'58''
	11. 37°5'42'', -75°15'32''	11. 37°3'19'', -75°19'33''	11. 37°3'57'', -75°24'5''	11. 36°58'14'', -75°27'3''	11. 37°5'50'', -75°14'26''
Norfolk Canyon	12. 37°6'41'', -75°19'33''	12. 37°4'21'', -75°18'17''	12. 37°3'39'', -75°24'50''	12. 36°57'59'', -75°25'49''	12. 37°6'58'', -75°19'12''
	13. 37°4'0'', -75°22'59''	13. 37°4'56'', -75°15'37''	13. 37°3'39'', -75°25'58''	13. 36°58'38'', -75°23'2''	13. 37°4'31'', -75°22'14''
		14. 37°6'22'', -75°15'45''		14. 37°0'23'', -75°21'48''	14. 37°4'1'', -75°26'10''
				15. 37°0'44'', -75°19'49''	15. 37°4'31'', -75°26'30''
				16. 37°2'38'', -75°18'42''	
				17. 37°3'20'', -75°19'32''	
				18. 37°4'21'', -75°18'17''	
				19. 37°4'55'', -75°15'39''	
				20. 37°5'27'', -75°15'40''	
				21. 37°5'50'', -75°14'26''	
				22. 37°6'8'', -75°15'45''	
				23. 37°6'22'', -75°15'46''	
				24. 37°7'0'', -75°19'44''	

APPENDIX C: 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.".[32]

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.

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 2001, Heifetz et al 2009, Fosså et al 2002, Cryer et al 2002). Anecdotal reports acted as a guide to further

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

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.

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.

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).

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.

5. Literature Review References

Althaus, F., A. Williams, et al. (2009). "Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting." Marine Ecology Progress Series 397: 279-294.

Brooke, S. and R. Stone (2007). "Reproduction of deep-water Hydrocorals (family Stylasteridae) from the Aleutian Islands, Alaska." Bulletin of Marine Science 81(3): 519-532.

Cryer, M., B. Hartill, et al. (2002). "Modification of marine benthos by trawling: Toward a generalization for the deep ocean?" Ecological Applications 12(6): 1824-1839.

Fosså, J. H., P. B. Mortensen, et al. (2002). "The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts." Hydrobiologia 471: 1-12.

Grehan, A. J., V. Unnithan, et al. (2005). Fishing impacts on Irish deepwater coral reefs: Making a case for coral conservation. Benthic Habitats and the Effects of Fishing: American Fisheries Society Symposium 41. P. W. Barnes and J. P. Thomas: 819-832pp.

Hall-Spencer, J., V. Allain, et al. (2002). "Trawling damage to Northeast Atlantic ancient coral reefs." Proceedings of the Royal Society of London, Series B: Biological Sciences 269(1490): 507-511.

Heifetz, J., R. P. Stone, et al. (2009). "Damage and disturbance to coral and sponge habitat of the Aleutian Archipelago." Marine Ecology Progress Series 397: 295-303.

Henry, L.-A., E. L. R. Kenchington, et al. (2003). "Effects of mechanical experimental disturbance on aspects of colony responses, reproduction, and regeneration in the cold-water octocoral *Gersemia rubiformis*." Canadian Journal of Zoology/Revue Canadienne de Zoologie 81: 1691-1701.

Koslow, J. A., K. Gowlett-Holmes, et al. (2001). "Seamount benthic macrofauna off southern Tasmania: Community structure and impacts of trawling." Marine Ecology Progress Series 213: 111-125.

Mortensen, P. B. and L. Buhl-Mortensen (2004). "Distribution of deep-water gorgonian corals in relation to benthic habitat features in the Northeast Channel (Atlantic Canada)." Marine Biology 144(6): 1223-1238.

Pires, D. O., C. B. Castro, et al. (2009). "Reproductive biology of the deep-sea pennatulacean *Anthoptilum murrayi* (Cnidaria, Octocorallia)." Marine Ecology Progress Series 397: 103-112.

Reed, J. K. (2002). "Deep-water Oculina coral reefs of Florida: biology, impacts, and management." Hydrobiologia 471: 43-55.

Risk, M. J., J. M. Heikoop, et al. (2002). "Lifespans and growth patterns of two deep-sea corals: *Primnoa resedaeformis* and *Desmophyllum cristagalli*." Hydrobiologia 471(1-3): 125-131.

Roberts, J. M., A. J. Wheeler, et al. (2006). "Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems." Science 312(5773): 543-547.

Stone, R. P. (2006). "Coral habitat in the Aleutian Islands of Alaska: depth distribution, finescale species association, and fisheries interactions." Coral Reefs 25(2): 229-238.

Theim, Ø., E. Ravagnan, et al. (2006). "Food supply mechanisms for cold-water corals along a continental shelf edge." Journal of Marine Systems 60: 207-219.

Waller, R. G., P. A. Tyler, et al. (2002). "Reproductive ecology of the deep-sea scleratinian coral *Fungiacyathus marenzelleri* (Vaughan, 1906) in the Northeast Atlantic Ocean." Coral Reefs 21(4): 325-331.

Waller, R. G., P. A. Tyler, et al. (2005). "Sexual reproduction in three hermaphroditic deep-sea *Caryophyllia* species (Anthozoa: Scleractinia) from the NE Atlantic Ocean." Coral Reefs 24(4): 594-602.

Wheeler, A. J. B., B.J., D. S. M. Billett, et al. (2005). The impact of demersal trawling on Northeast Atlantic deepwater coral habitats: the case of the Darwin Mounds, United Kingdom. Benthic Habitats and the Effects of Fishing. American Fisheries Society Symposium 41. P. W. Barnes and J. P. Thomas. Bethesda, MD, American Fisheries Society: 807-817pp.