Draft Omnibus Deep-Sea Coral Amendment Including a Draft Environmental Assessment

DRAFT: April 10, 2017
For Habitat Committee review on April 14 and Council review on April 18

Prepared by the
New England Fishery Management Council
In consultation with the National Marine Fisheries Service

COVER IMAGES, CLOCKWISE FROM UPPER RIGHT:

A large black coral and two Paramuricea *corals in Oceanographer Canyon. Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.*

Close-up of a sea pen colony at 2,023 meters depth on Retriever Seamount. Sea pens are octocorals and the characteristic eight pinnate tentacles are plainly visible in this image. The dark line running down below the tentacles of each polyp is the pharynx, connecting the mouth to the bag-like digestive cavity. A mysid shrimp ("possum shrimp") is swimming by the colony. Image courtesy of NOAA Okeanos Explorer Program, Our Deepwater Backyard: Exploring Atlantic Canyons and Seamounts.

Cup corals and a sea star a mile underwater in Heezen Canyon. Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.

A Paramuricea *coral in Nygren Canyon which 165 nautical miles southeast of Cape Cod, Massachusetts. Image courtesy of NOAA Okeanos Explorer Program, 2013 Northeast U.S. Canyons Expedition.*

1 Executive summary

1.1 Background and purpose

Deep-sea or cold water corals are attached, benthic animals related to anemones and jellyfish that live in waters at least 50 meters (28 fathoms) deep. They are found in marine habitats worldwide. Offshore New England (see section 6.2), the greatest species richness of corals occurs in the canyons south of Georges Bank, as well as on the surrounding continental slope and seamounts. Corals, primarily soft corals and sea pens, also occur in select locations in the Gulf of Maine, both relatively close to shore and in offshore basins. Deep-sea corals come in a diverse range of sizes, shapes and colors. Some types, including sea pens and soft corals, have a flexible structure, while the stony corals have a hard outer covering. Corals occur in both soft sedimented habitats and in hard bottom areas. Many types require a hard substrate for attachment, but others including the sea pens and some soft corals anchor in fine sediments.

Deep-sea corals are ecologically important (see section 6.4). Deep-sea coral habitats have been noted to have higher associated concentrations of fish than surrounding areas, and are believed to serve as nursery grounds and provide habitat for many species of fish and invertebrates at various life stages, including commercially important fish species (Costello et al. 2005; Auster 2007; Foley et al. 2010). Many invertebrate species are directly associated with deep-sea corals. Recent work in the canyons suggests that some of these relationships are very specific. In coral habitats surveyed in the Gulf of Maine, sponges and anemones often occurred in high density patches amongst the more extensive corals on walls and on steep features without corals. Crustaceans such as shrimp, amphipods, krill, and king crab were commonly associated with coral communities along steep walls, and were seen foraging amongst structure-forming organisms, including corals, on the seafloor. At the Gulf of Maine sites, commercially important species were observed in coral habitats, including Acadian redfish, haddock, pollock, cusk, monkfish, cod, silver hake, Atlantic herring, spiny dogfish, squid, and lobster. The fish were observed searching for and catching prey that were also found among the coral, including shrimp, amphipods, krill, and other small fish. The corals seemed to provide refuge from the strong, tidally generated bottom currents.

Purpose and need for this action: Deep-sea corals are vulnerable to anthropogenic impacts (6.5). In general, deep-sea corals are slow growing and some species have limited dispersal capability. These features, combined with the branching and sometimes brittle structure of some taxa, make them vulnerable to mechanical disturbance, such as from fishing gear. Given the ecological importance and vulnerability of corals, the overarching objective of this amendment is to identify and protect deep-sea corals in the New England region. Although there are uncertainties in terms of the precise extent of overlap between fishing activities and coral habitats, the problem statement approved for this action affirms the Council's desire to balance coral conservation with commercial fishing usage of coral management zones.

> "The Council is utilizing its discretionary authority under section 303(b) in MSA to identify and implement measures that reduce, to the extent practicable, impacts of

> fishing gear on deep-sea corals in New England. This amendment contains alternatives that aim to identify and protect concentrations of corals in select areas and restrict the expansion of fishing effort into areas where corals are likely to be present.
>
> "Deep-sea corals are fragile, slow-growing organisms that play an important role in the marine ecosystem and are vulnerable to various types of disturbance of the seafloor. 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 their costs to commercial fisheries."

Amendment development: The measures under consideration were developed between 2011 and 2017, initially as part of Omnibus Habitat Amendment 2, but split into a separate coral-focused amendment in 2012. The New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and the South Atlantic Fishery Management Council (SAFMC) 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. As per the terms of the MOU, the Council developed the alternatives in this document to be applicable only to areas within the NEFMC region as defined in the current regulations (50 C.F.R. §600.105).

1.2 Alternatives considered

The management alternatives include a range of coral zones (section 4.2) and fishing restriction measures that may be applied within those zones (section 4.3). The No Action alternative (section 4.1) includes management areas that provide some coral conservation benefits, but there are currently no management areas developed under the §303(b) discretionary authority in the New England region. Special access programs as well as alternatives to modify coral conservation measures via framework adjustment are also being considered in this amendment. The measures proposed in this amendment would affect commercial fisheries operating with bottom-tending fishing gear (i.e., bottom trawls, dredges, bottom longlines, sink gillnets, or pots/traps). Management measures developed under the regulatory authority described in section 3.3 and implemented via this amendment would apply based on gear type, and are not limited to fisheries directly managed by NEFMC. Fisheries operating in and around the coral zones are managed by NEFMC, MAFMC, and the Atlantic States Marine Fisheries Commission (ASMFC). Deep-sea coral protection measures were implemented in the Mid-Atlantic region in January 2017. There are many similarities between the NEFMC and MAFMC approaches.

Table 1 - Summary of alternatives considered

<table>
<tr><th colspan="3">4.1 No Action</th></tr>
<tr><th>Management areas</th><th>Fishing gear restrictions</th><th>Notes</th></tr>
<tr><td>Monkfish/Mackerel-Squid-Butterfish closures in Lydonia and Oceanographer Canyons
Tilefish Gear Restricted Areas in Lydonia, Oceanographer, and Veatch Canyons
Northeast Canyons and Seamounts Marine National Monument</td><td>Monkfish/MSB: No fishing by vessels permitted under those plans
Tilefish: no MBTG
Monument: no commercial fishing of any kind; lobster and red crab restrictions not in effect until 2023</td><td>Monkfish closures under joint FMP with MAFMC
MSB and tilefish areas under MAFMC
Monument is a permanent designation by President Obama, not subject to modification by the Councils</td></tr>
<tr><th colspan="3">4.2.1 Broad zones
4.3 Fishing gear restrictions</th></tr>
<tr><th>Management areas</th><th>Fishing gear restrictions</th><th>Notes</th></tr>
<tr><td>Option 1: 300m zone
Option 2: 400m zone
Option 3: 500m zone
Option 4: 600m zone
Option 5: 900m zone</td><td>Option 1: Prohibit BTG
Sub-option A: exempt red crab fishery
Sub-option B: exempt other trap fisheries
Option 2: Prohibit MBTG</td><td>Zone options are mutually exclusive (select one or none)
If a zone is selected, choose either Option 1 or Option 2 gear restrictions. If Option 1, could choose Sub-option A, Sub-option B, Sub-options A and B, or no exemptions.
Alternate boundaries discussed during workshops and other meetings. See separate memo.</td></tr>
<tr><th colspan="3">4.2.2 Discrete zones
4.3 Fishing gear restrictions</th></tr>
<tr><th>Management areas</th><th>Fishing gear restrictions</th><th>Notes</th></tr>
<tr><td>Alvin Canyon
Atlantis Canyon
Nantucket Canyon
Veatch Canyon
Hydrographer Canyon
Dogbody Canyon
Clipper Canyon
Sharpshooter Canyon
Welker Canyon
Heel Tapper Canyon
Oceanographer Canyon
Filebottom Canyon</td><td>Option 1: Prohibit BTG
Sub-option A: exempt red crab fishery
Sub-option B: exempt other trap fisheries
Option 2: Prohibit MBTG</td><td>If a zone is selected, choose either Option 1 or Option 2 gear restrictions. If Option 1, could choose Sub-option A, Sub-option B, Sub-options A and B, or no exemptions.
Canyon zones largely within broad zones, but generally cover additional area in the heads of the canyons, depending on broad zone boundary</td></tr>
</table>

<table>
<tr><td colspan="2">• Chebacco Canyon
• Gilbert Canyon
• Lydonia Canyon
• Powell Canyon
• Munson Canyon
• Nygren Canyon
• Unnamed Canyon
• Heezen Canyon
• Bear Seamount
• Mytilus Seamount
• Physalia Seamount
• Retriever Seamount
• Mount Desert Rock
• Outer Schoodic Ridge
• WJB - 114 Fathom Bump
• WJB - 96 Fathom Bump
• WJB - 118 Fathom Bump
• Central Jordan Basin
• Lindenkohl Knoll</td><td></td><td>• Seamount zones encompassed spatially within broad zones and monument
• Areas can be adopted invididually, but some are analyzed in groups
• Canyon zones could be adopted in addition to a broad zone, if shallower boundaries or different gear restrictions are desired
• Seamount zones could be adopted in addition to a broad zone if different gear restrictions are desired
• Gulf of Maine zones are separate and spatially distinct from one another and from canyon/seamount/broad zones.
• Alternate boundaries for the canyon and Gulf of Maine zones discussed during workshops and other meetings. See separate memo.</td></tr>
<tr><th colspan="4">4.4 Special fishery programs for coral zones</th></tr>
<tr><th colspan="2">Alternatives</th><th colspan="2">Notes</th></tr>
<tr><td colspan="2">• Alternative 1: Special access program fishing
• Alternative 2: Exploratory fishing
• Alternative 3: Research activities</td><td colspan="2">• Could adopt one or more alternatives, in any combination</td></tr>
<tr><th colspan="4">4.5 Framework provisions for coral zones</th></tr>
<tr><th colspan="2">Alternatives</th><th colspan="2">Notes</th></tr>
<tr><td colspan="2">• Alternative 1/No Action: No additional frameworkable coral management measures
• Alternative 2: Add, revise, or remove coral zones
• Alternative 3: Change fishing restrictions
• Alternative 4: Allow changes to special access or exploratory fishing programs</td><td colspan="2">• Could adopt one or more alternatives, in any combination.
• Substantial changes could require an amendment regardless of whether these alternatives are adopted.</td></tr>
</table>

1.3 Impacts of the alternatives on the ecosystem

The alternatives proposed in this amendment are associated with a range of potential impacts to several Valued Ecosystem Components (VECs), including 1) deep-sea corals, 2) managed resources and essential fish habitat, 3) human communities, and 4) protected resources. These impacts are described in Section 7. Depending on the combination of zones and restrictions selected from sections 4.2 and 4.3, the amendment outcomes will be more conservative of coral habitat, with a larger degree of fishing activity displaced, or more conservative of fishing activities, with some types of bottom-tending gear permitted in coral zones, and/or smaller areas of coral habitat protected. Some of the coral habitats in New England occur in very deep water beyond the current distribution of fishing activity. These include the deeper portions of the canyons and slope as well as on the seamounts. Coral habitats in the shallower waters of the canyons and slope, as well as the coral habitats in the Gulf of Maine, overlap with fishing grounds.

No Action alternative (section 4.1):

Broad deep-sea coral zones (section 4.2.1) and associated fishing restrictions (section 4.3):

Discrete deep-sea coral zones (section 4.2.2) and associated fishing restrictions (section 4.3:

Special fishery programs for coral zones (section 4.4): Special fishery programs including special access, exploratory fishing, and requirements that facilitate better tracking of research activities could have negative, neutral, or positive impacts depending on the VEC. Special access and exploratory fishing programs would be carefully designed to manage negative impacts on corals and managed resources, but negative effects of these programs could occur. By extension, socio-cultural impacts on those interested in coral conservation could also be negative. Conversely, such programs would afford flexibility and economic opportunity to fishing community members who take advantage of special access or exploratory fishing programs. Improvements in research tracking as a result of Alternative 4 in this section would likely have indirect positive impacts across a range of VECs.

Framework provisions (section 4.5): Framework adjustments facilitate expedient modifications to certain management measures. This amendment includes alternatives that could edit the list of items in the FMP that could be modified through a framework, to allow for future consideration of deep-sea coral measures through a framework action. In general, the framework alternatives proposed are primarily administrative and intended to simplify and improve the efficiency of future actions related to deep sea coral protections. Thus, they are not expected to result in any direct impacts to any of the VECs. Indirect impacts are possible from some of the alternatives on some VECs if they allow for more efficient responses to immediate conservation concerns for deep sea corals or associated habitats.

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3 Background and purpose

3.1 What are deep-sea corals?

Deep-sea corals, also referred to as cold water corals, can build reef-like structures or occur as thickets, isolated colonies, or solitary individuals, and often are significant components of deep-sea ecosystems, providing habitat (substrate, refugia) for a diversity of other organisms, including many economically important fish and invertebrate species. They are suspension feeders, but unlike most tropical and subtropical corals, do not require sunlight and do not have symbiotic algae (zooxanthellae) to meet their energy needs. Deep corals can be found from near the surface to 6,000 m depth, but most commonly occur between 50-1,000 m on hard substrate (Puglise and Brock 2003), hence their "deep-sea" appellation.

A diversity of coral species live in the northeast region (see section 6.2 for details). The characteristics of these corals vary in terms of their size, shape, and flexibility, growth rates and reproductive strategies, preferred depth range, and habitat associations. Some are relatively common, whereas other types are rare. All coral are vulnerable to fishing gear impacts, but the degrees of susceptibility and the rates of recovery vary, depending both on coral biology and on spatial overlap between corals and fishing grounds, which influences the likelihood of gear interactions. In general, coral species richness is greater at deeper depths (Cairns 2007), but there are concentrations of corals at depths where fishing routinely occurs, for example in the Gulf of Maine.

3.2 Need and purpose for action

This action is needed to reduce potential impacts to corals from fishing activity, as allowed under the Council's discretionary authority. The purpose of this action is to consider area-based management measures for deep-sea corals occurring in the New England region.

The following problem statement was adopted by the Council for this action in April, 2016:

> "The Council is utilizing its discretionary authority under section 303(b) in MSA to identify and implement measures that reduce, to the extent practicable, impacts of fishing gear on deep-sea corals in New England. This amendment contains alternatives that aim to identify and protect concentrations of corals in select areas and restrict the expansion of fishing effort into areas where corals are likely to be present.
>
> "Deep-sea corals are fragile, slow-growing organisms that play an important role in the marine ecosystem and are vulnerable to various types of disturbance of the seafloor. 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 their costs to commercial fisheries."

3.3 Management background and authority

There are multiple provisions in the Magnuson Stevens Fishery Conservation and Management Act (MSA) that can be used to justify coral protection. One is the Essential Fish Habitat (EFH) authority, where corals are considered a component of essential fish habitat, and fishing restrictions are enacted in the context of minimizing, to the extent practicable, the effects of fishing on EFH (see section 305(b)). In the Northeast region, this authority was used in Monkfish FMP Amendment 2 to protect deep-sea corals and associated habitat features in two offshore canyons, Lydonia and Oceanographer, from fishing activity occurring under a monkfish day at sea. Options for minimizing the adverse effects of fishing on EFH include fishing equipment restrictions, time/area closures, and harvest limits (in this case, direct harvest of corals).

In the Northeast Region, coral distributions extend well beyond the bounds of designated EFH. The Section 303(b) discretionary provisions found in the 2007 reauthorization of the MSA (below) provide a second and more flexible mechanism by which Councils may protect deep-sea corals from the effects of fishing.

> Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, may—
>
> (A) designate zones where, and periods when, fishing shall be limited, or shall not be permitted, or shall be permitted only by specified types of fishing vessels or with specified types and quantities of fishing gear;
>
> (B) designate such zones in areas where deep-sea corals are identified under section 408 (this section describes the deep-sea coral research and technology program), to protect deep-sea corals from physical damage from fishing gear or to prevent loss or damage to such fishing gear from interactions with deep-sea corals, after considering long-term sustainable uses of fishery resources in such areas; and
>
> (C) with respect to any closure of an area under this Act that prohibits all fishing, ensure that such closure—
>
> (i) is based on the best scientific information available;
>
> (ii) includes criteria to assess the conservation benefit of the closed area;
>
> (iii) establishes a timetable for review of the closed area's performance that is consistent with the purposes of the closed area; and
>
> (iv) is based on an assessment of the benefits and impacts of the closure, including its size, in relation to other management measures (either alone or in combination with such measures), including the benefits and impacts of limiting access to: users of the area, overall fishing activity, fishery science, and fishery and marine conservation;

In May 2010, the Council received guidance from NMFS NERO regarding implementation of the discretionary provisions. This guidance was updated by the NMFS Office of Habitat Conservation and distributed to all eight regional fishery management councils in June 2014. Both the 2010 and 2014 guidance documents refer to the deep-sea coral research and technology program (DSCRTP) as a conduit for providing information about coral distributions to the Councils. According to the 2014 guidance, when designating deep-sea coral zones, the following parameters and considerations apply:

1. The authority may only be used for deep-sea coral areas identified by the DSCRTP.
2. Deep-sea coral zones may only be designated within the U.S. Exclusive Economic Zone (EEZ) and within the geographical range of a fishery managed under an FMP. A Council may develop protective measures for such zones that apply to any fishing, not just that managed under the applicable FMP. Thus, measures may apply to fishing that is managed under a different federal FMP or to state-regulated fishing that is authorized in the EEZ.[1]
3. A Council should coordinate with potentially affected Councils, state commissions, and states to ensure that it has sufficient information to support the need for its action and to analyze impacts of the action on other fisheries.
4. Long-term sustainable uses of fishery resources in the deep-sea coral areas must be considered. This consideration informs but does not limit the scope of protective measures that a Council may adopt.
5. Deep-sea coral zones and protective measures may be adopted even if there are no vessels currently fishing at or near the areas or there is no indication that current fishing activities are causing physical damage to deep-sea corals.
6. To ensure the effectiveness of protective measures, deep-sea coral zones may include, as necessary, additional areas beyond the exact locations of the deep-sea corals.

The 2014 guidance suggests the following criteria for identification of coral zones. The NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems (NOAA 2010b) provides similar guidance on selection of coral conservation measures.

- The size of the reef or coral aggregation, or density of structure-forming deep-sea corals;
- The occurrence of rare species;
- The importance of the ecological function provided by the deep-sea corals as habitat;
- The extent to which the area is sensitive to human-induced environmental degradation;
- The likelihood of occurrence of deep-sea corals in unsurveyed areas based on the results of coral habitat suitability models or similar methods.

Finally, the 2014 guidance suggests that options for protecting corals from fishing gear damage include but are not limited to:

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[1] This is different from the 2010 guidance from NERO, which indicated that for coral management provisions to apply to fisheries managed under the Atlantic Coastal Cooperative Fisheries Management Act (ACA), either the ASMFC must take complementary action in their FMP, or there must be a Council FMP for the same resource. The relevant example in our region is the offshore component of the American lobster fishery, which is managed by ASMFC.

1. Restrictions on the location where fishing may occur. If a closure to all fishing is being considered, it must comply with requirements at MSA section 303(b)(2)(C),14 which include establishing a timetable for review of the closed area's performance. This review should be conducted in consultation with the DSCRTP. Given the additional requirements and process, a Council may want to consider whether targeted gear restrictions, as opposed to a full fishing closure, would provide sufficient protection.
2. Restrictions on fishing by specified types of vessels or vessels with specified types and quantities of gear. These could include, for example, limits on the use of specified fishing-related equipment, required equipment modifications to minimize interactions with deep-sea coral communities, prohibitions on the use of explosives and chemicals, prohibitions on anchoring or setting equipment, and prohibitions on fishing activities that cause damage to deep-sea corals.
3. Proactive protection by freezing the footprint of current fishing activities of specified types of vessels or vessels with specified types and quantities of gear to protect known or expected locations of deep-sea corals.
4. Limits on the harvest or bycatch of species of deep-sea coral that provide structural habitat for other species, assemblages, or communities.

As noted in the 2014 Office of Habitat Conservation guidance and the NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems, other sections of the MSA may also apply to the protection of deep-sea corals and associated ecosystems:

- MSA section 303(a)(7) requires that an FMP describe and identify EFH for the fishery, minimize to the extent practicable adverse effects caused by fishing, and identify other actions to encourage the conservation and enhancement of the EFH. Federal action agencies must consult with NOAA on activities that may adversely affect EFH, and NOAA provides non-binding conservation recommendations to the agencies through that process. If a deep-sea coral area is EFH (e.g., essential for spawning, breeding, feeding or growth to maturity of fish managed under an FMP), then it must be identified as such and the above requirements apply.
- Section 301(a)(9) requires Councils to include conservation and management measures that, to the extent practicable, minimize bycatch.
- Section 303(b)(12), authorizes Councils to include management measures in FMPs to conserve target and non-target species and habitats.

3.4 Amendment development process

The coral protection zones included in this amendment were initially developed during 2010 and 2011 as part of the Council's Omnibus Essential Fish Habitat Amendment 2 (OHA2). The Council approved a specific range of alternatives for analysis in April 2012. In September 2012, the Council split the coral protection zones areas and associated management measures out of OHA2 into a separate omnibus amendment. The canyon and seamount Habitat Area of Particular Concern designations, which do not restrict fishing activities but rather serve as a focus for future management efforts as well as EFH consultations, were retained within OHA2. The OHA2 HAPC designations and the coral zones in this action have overlapping but not identical locations and boundaries.

The Council took final action on OHA2 in June 2015, including approval of the canyon and seamount HAPCs. OHA2 and its associated Environmental Impact Statement are currently undergoing final development and review, with implementation expected in 2017.

Because Mid-Atlantic and New England-managed fisheries overlap spatially along the shelf break, the two Councils have been coordinating their coral management efforts for years through technical work groups (NEFMC Habitat PDT, MAFMC Coral FMAT) and via the NEFMC Habitat Committee, which currently includes two MAFMC representatives. In June 2013, the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils formalized this coordination via a memorandum of understanding (http://s3.amazonaws.com/nefmc.org/June-2013-Final-DSC-MOU.pdf). Specifically, the purposes of this Memorandum of Understanding (MOU) are:

- To establish a framework for coordination and cooperation toward the protection of deep-sea coral ecosystems; and
- To clarify and explain each Council's role and geographic areas of authority and responsibility with regard to deep-sea coral management.

Under the MOU, each Council develops measures within their respective area of jurisdiction. Inter-council boundaries identifying areas of jurisdiction are specified at 50 CFR §600.105. The boundary between the Mid-Atlantic and New England regions runs diagonally across the shelf from the CT/RI/NY intersection point across Alvin Canyon to the EEZ. Thus, one important outcome of the MOU is that Mid-Atlantic region alternatives initially developed in 2010 are no longer included in the NEFMC coral amendment. Prior to and since signing the MOU, the New England and Mid-Atlantic Councils in particular have been sharing technical information and monitoring policy approaches discussed by the other Council to improve consistency in the policies proposed as well as in the use of scientific information.

In addition, the MOU includes a commitment to develop consistent management approaches when possible, and to engage potentially affected stakeholders regardless of which Council manages their fishery. The MAFMC took final action on their coral amendment, which is Amendment 16 to the Mackerel, Squid, and Butterfish FMP, in June 2015. Many of the coral zones selected by MAFMC were initially developed by NEFMC, although the boundaries were subsequently refined by MAFMC using new sources of data and stakeholder feedback, and some additional areas were added. The management measures (e.g., gear restrictions) selected by MAFMC generally fall within the range initially developed by NEFMC and approved for analysis in 2012. While final NMFS approval and rulemaking is pending, the preferred MAFMC approach is described below to facilitate continuity in management approaches. A proposed rule was published on September 27, 2016 and the final rule went into effect on January 13, 2017.

- MAFMC selected discrete zones in various individual canyons or canyon complexes, specifically Block, Ryan/McMaster, Emery/Uchupi, Jones/Babylon,

Mey-Lindenkohl Slope, Spencer, Wilmington, N. Heyes/S. Wilmington, S. Vries, Baltimore, Warr/Phoenix, Accomac/Leonard, Washington, and Norfolk.
    - The MAFMC adopted boundaries developed during a workshop held during April 2015. The workshop included input from industry members, conservation organizations, and scientists, and participants reviewed updated bathymetric data, habitat suitability model outputs, and the locations of direct coral observations prior to and during the meeting.
- MAFMC selected a broad zone with a landward boundary between 400-500 meters extending to the EEZ.
    - The landward boundary line is comprised of straight segments, with the following constraints: minimum depth of 400 m, maximum depth of 500 m, and consistency with discrete boundaries where possible.
    - The north/south extent encompasses the entire MAFMC area of jurisdiction.
    - The discrete zone boundaries take priority in areas of overlap.
- For both broad and discrete zones, MAFMC's amendment prohibits all bottom tending-gear, with an exemption for the red crab fishery. Prohibition would not apply to the American lobster fishery managed by ASMFC. Transit would be allowed, subject to gear stowage requirements.
- Frameworkable measures would include:
    - Boundaries of coral zones,
    - Management measures within zones, including fishing restrictions, exemptions, monitoring, and anchoring,
    - New discrete coral zones, and
    - Special access programs.
- Finally, MAFMC's amendment implements a VMS requirement for all Illex squid moratorium vessels, whether they are fishing within or outside of coral zones.

4 Management alternatives

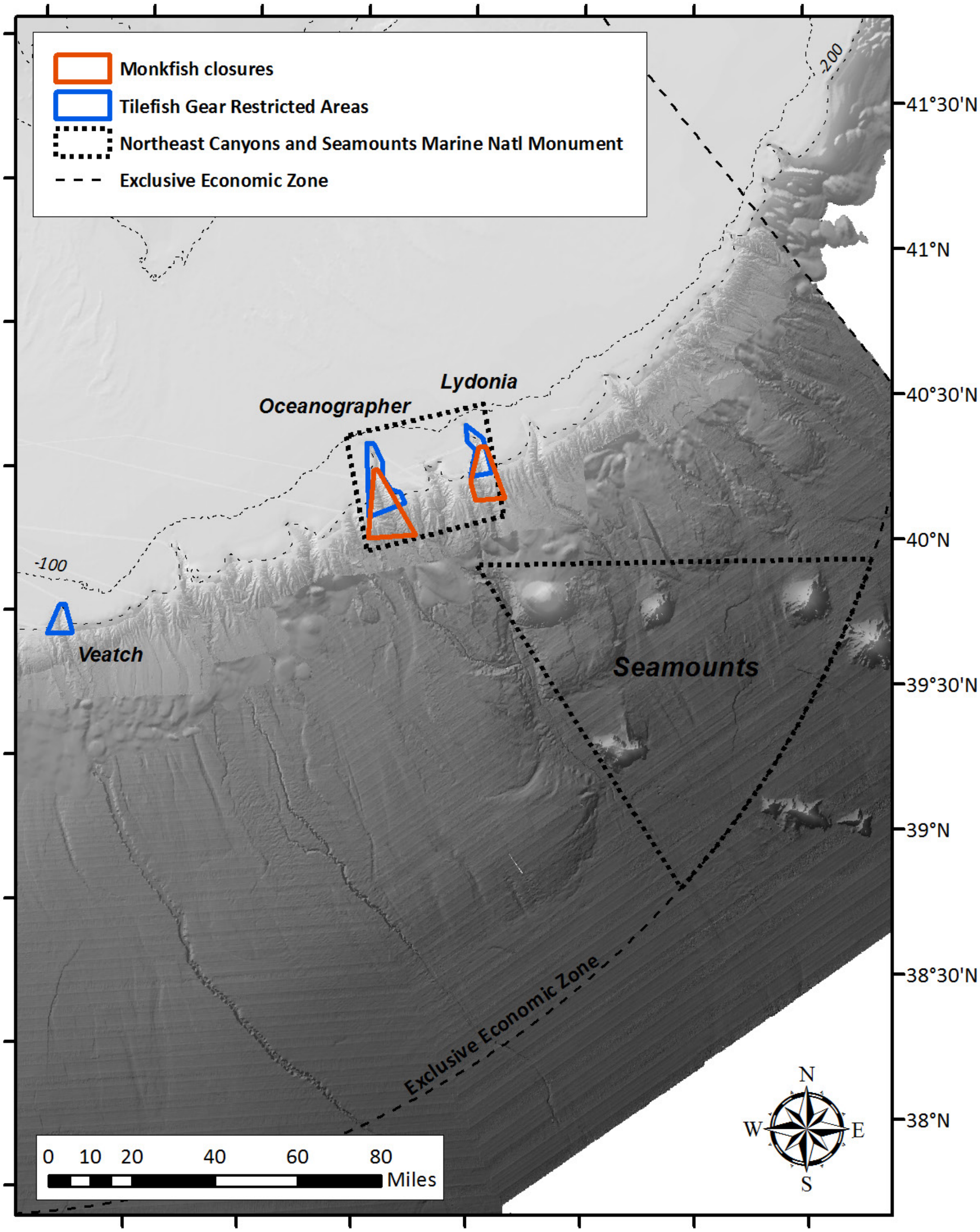
4.1 No Action – existing areas that provide protections for corals

Currently, there are no coral zones designated by the Council under the discretionary authority. However, current area closures offer protection to deep-sea corals in certain locations (Map 1).

- **Monkfish/MSB Areas (Joint New England and Mid-Atlantic Councils)**: Monkfish Amendment 2 (implemented 2005) prohibited fishing with any gear type while on a monkfish Day-at-Sea (DAS) in Lydonia and Oceanographer Canyons. The rationale provided in Monkfish Amendment 2 explicitly references protection of deep-water species and habitat in canyons, including deep-sea corals. These areas were developed via the MSA EFH authority, not using the discretionary coral protection provisions. These same two areas were later adopted as mackerel, squid, and butterfish bottom trawling restricted areas via Amendment 9 to that FMP (2008). Under the MSB FMP, no permitted mackerel, squid, or butterfish vessel may fish in the areas with bottom trawl gear on a year-round basis. Vessels fishing with other gear types or under other permits not covered by these provisions are able to fish in these two areas.
- **Tilefish Areas (Mid-Atlantic Council)**: Amendment 1 to the Tilefish FMP (2009) adopted mobile bottom-tending gear restrictions (Gear Restricted Areas, or GRAs) in Lydonia, Oceanographer, and Veatch Canyons. There is also a GRA in Norfolk Canyon, outside the New England region. These apply to any mobile bottom-tending gears regardless of fishery. Note that the Tilefish GRAs are located towards the heads of the canyons, with the boundaries based on those of the Tilefish Habitat Areas of Particular Concern (HAPC). The HAPCs were designed to protect clay outcrop habitats which occur in the heads of the canyons to roughly 300 m, although they cover deeper water areas along the axis of the canyons as well and would therefore have conservation benefits for deep-sea coral occurring deeper than 300 m. As above, these areas were developed via the MSA EFH authority, not using the discretionary coral protection provisions.
- **Northeast Canyons and Seamounts Marine National Monument:** On September 15, 2016, President Barack Obama designated the Northeast Canyons and Seamounts Marine National Monument, which has two sub-areas. The first encompasses the shelf-slope region from Oceanographer to Lydonia Canyons between about 100 meters and 2,000 meters, and the second encompasses all four seamounts in the EEZ. Sixty days from designation (November 2016), the areas closed to all commercial fishing as well as to energy exploration and development. The lobster and red crab fisheries will have seven years to cease operations within the Monument.

The Lydonia and Oceanographer Canyon monkfish and tilefish areas described above are almost entirely encompassed by the canyon section of the Monument. The Veatch Canyon Tilefish GRA is fully outside the Monument.

Map 1 – No Action alternative – various areas in the New England region that afford protection for deep-sea corals. Depth contours shown are in meters.



4.2 Deep-sea coral zone designations

Two conceptual approaches are considered for the development of coral zones. Both would rely on the discretionary coral protection authority provided in the 2007 MSA reauthorization.

The **'discrete areas'** approach would designate more narrowly defined coral zones based on discrete bathymetric/geological features and groupings of corals. These zones include specific locations in the Gulf of Maine, single canyons, and individual seamounts. The boundaries of the discrete coral zones are based on direct observations of corals and other animals, plus inferences about the likely spatial extent of coral habitats, based on terrain data or habitat suitability models. The discrete coral zones were developed to encompass species that attach to hard substrates, and are relatively large or have other attributes that make them more susceptible to fishing-related impact. While there is abundant soft substrate in the deep ocean, hard substrate areas are much more limited in their distribution. Because hard substrate areas tend to be patchy in their spatial distribution, some soft sediment areas and associated fauna would be included within the discrete zone boundaries, incidental to the primary conservation target.

The **'broad areas'** approach would designate a coral zone along the entire shelf-slope region between the US/Canada EEZ boundary and the New England/Mid-Atlantic Council boundary. Broad zones are generally intended to cover areas beyond the distribution of currently occurring fishing effort, and represent a precautionary approach to management that would prevent the expansion of fishing into additional deep-water habitats. They would encompass coral habitats in the canyons, on the continental slope and on the seamounts. The broad areas do not overlap the coral zones in the Gulf of Maine.

The broad zone alternatives, in addition to encompassing the canyon and seamounts themselves, include additional areas of low-relief mud habitats that harbor other species of corals, including sea pens. Specifically, the white sea pen, *Stylatula elegans*, and the common sea pen, *Pennatula aculeata* possibly have lower susceptibility to fishing disturbance, and are more widely distributed than other types of corals. Other corals fall into the category of lower susceptibility – specifically, the hard coral *Dasmosmilia lymani*. This species was noted as being relatively common, including in shallower depths, is small in size, and is possibly less susceptible to fishing gear impacts. Some larger species such as the bamboo coral *Acanella arbuscula* are also associated with these soft substrates.

Management options for restricting or modifying fishing operations within the deep-sea coral zones include restrictions on mobile bottom-tending gears, restrictions on bottom-tending gears, and authorized exemptions to these restrictions. Different restrictions may be appropriate in broad vs. discrete zones, or among the various discrete zones.

Note that broad areas and discrete areas could be implemented simultaneously. While the individual discrete zones do not overlap one another, the canyon and seamount discrete zones overlap the depth-based broad zone alternatives. In some areas, the landward boundary of the discrete canyon zones is slightly shallower than the landward boundary of the shallowest broad zone, so combining the discrete zones with one of the broad zones would protect additional coral habitats in the heads of the canyons. A combination approach might also be appropriate if different management measures are desired in the discrete vs. broad areas.

To increase flexibility and allow for incorporation of new scientific information, there is an alternative that would allow new coral zones, or new fishing restrictions in designated coral zones, to be implemented via framework action.

4.2.1 Broad deep-sea coral zone designation

This alternative would designate a large area of the shelf-slope and abyssal plain out to the EEZ as a deep-sea coral zone. There are five overlapping and mutually exclusive broad zone options under consideration, and only one may be selected by the Council. Options for fishing restrictions in these zones are described in Section 4.3.

The zones have their landward boundaries along the southern flank of Georges Bank, their seaward boundary at the EEZ, and their western boundary along the New England/Mid-Atlantic intercouncil boundary line. The landward boundary options are simplified versions of 300 m, 400 m, 500 m, 600 m, and 900 m depth contours, with line segments connecting waypoints with specific latitude/longitude coordinates. Map 2 shows the full spatial extent of all five broad zone alternatives. These simplified contours are shown on Map 2-Map 4, are being used for analysis, and would be adopted as specific management area boundaries, should one of these areas be selected.

The Committee discussed 700 meters and 550 meters at their February 24 meeting, with these being the only coral zones in New England, and the shallower boundary having an exemption for two red crab vessels. The workshop in New Bedford discussed a zone with a minimum depth of 550 meters, with an exemption for red crab, and a zone at 900 meters with non exemption for red crab. These depths were acceptable to industry members participating in the workshop but were not supported by conservation NGOs in attendance. The New Bedford workshop discussion was not tied to the concept of these being the only coral zones, i.e. there could potentially be coral zones in the Gulf of Maine. The 600 meter zone as currently defined with a minimum depth of 550 meters would seem to meet the Committee and workshop criteria, but could be further adjusted to simplify the boundary if a strict 650 minimum depth is not necessary.

Rationale: The overall objective of this type of measure would be to prevent the expansion of fishing effort into deepwater coral areas, while limiting impacts on current fishing operations. Progressively deeper broad zones encompass less and less fishing activity.

Method to define broad zone boundaries: The original depth contours were derived from a 25 m resolution digital terrain model. In order to draw straight line approximations at the landward boundaries, a 50 m depth tolerance was allowed on either side. For example, the landward boundary of the 300 m zone has a minimum depth of 250 m and a maximum depth of 350 m. The relationship between the zone boundaries and depth contours is illustrated in Map 3, which shows what these boundaries look like along the western shoulder of Oceanographer Canyon.

The simplified boundary alternatives were derived from the raw depth contours using the simplify line tool in ArcGIS 10.2.2 for Desktop. In many locations along the continental shelf edge, a distance over ground tolerance of 0.5 km achieves the desired +/- 50 m depth tolerance, while significantly simplifying the contour. Thus, a 0.5 km distance over ground tolerance was specified when running the automated line simplify tool. In steeper locations where this tolerance resulted in boundaries outside the +/- 50 m depth tolerance, waypoints were added manually to follow the depth contour. The objective was to minimize the number of waypoints and simplify the boundary as much as possible, given the 50 m depth tolerance around each target contour. Given the shape of the contours along the edge of the shelf, the 300 m zone is a somewhat smoother boundary, with the 400-900 m zones becoming increasingly complex.

The broad zones align generally with the discrete zones (Section 4.1.3) at the heads of the canyons, with some of the discrete canyon zone boundaries approximating the 300 m zone, and others approximating the 400 m zone (Map 4). Four of the discrete canyon zones (Veatch, Hydrographer, Lydonia, Heezen) include areas shallower than 300 meters.

Table 2 – Size and depth of broad coral zones

Area name	Area size, km^2	Target minimum depth, m	Maximum depth, m
300 m broad zone	67,142	300	6000 m (approximate)
400 m broad zone	66,410	400	6000 m (approximate)
500 m broad zone	65,838	500	6000 m (approximate)
600 m broad zone	65,365	600	6000 m (approximate)
900 m broad zone	64,193	900	6000 m (approximate)

4.2.1.1 Option 1: 300 m broad zone

This option would designate a broad coral zone from the US-CAN EEZ boundary to the boundary between the New England and Mid-Atlantic Council regions, with the landward boundary based on the 300 m contour and the seaward boundary at the EEZ.

4.2.1.2 Option 2: 400 m broad zone

This option would designate a broad coral zone from the US-CAN EEZ boundary to the boundary between the New England and Mid-Atlantic Council regions, with the landward boundary at the 400 m contour and the seaward boundary at the EEZ.

4.2.1.3 Option 3: 500 m broad zone

This option would designate a broad coral zone from the US-CAN EEZ boundary to the boundary between the New England and Mid-Atlantic Council regions, with the landward boundary at the 500 m contour and the seaward boundary at the EEZ.

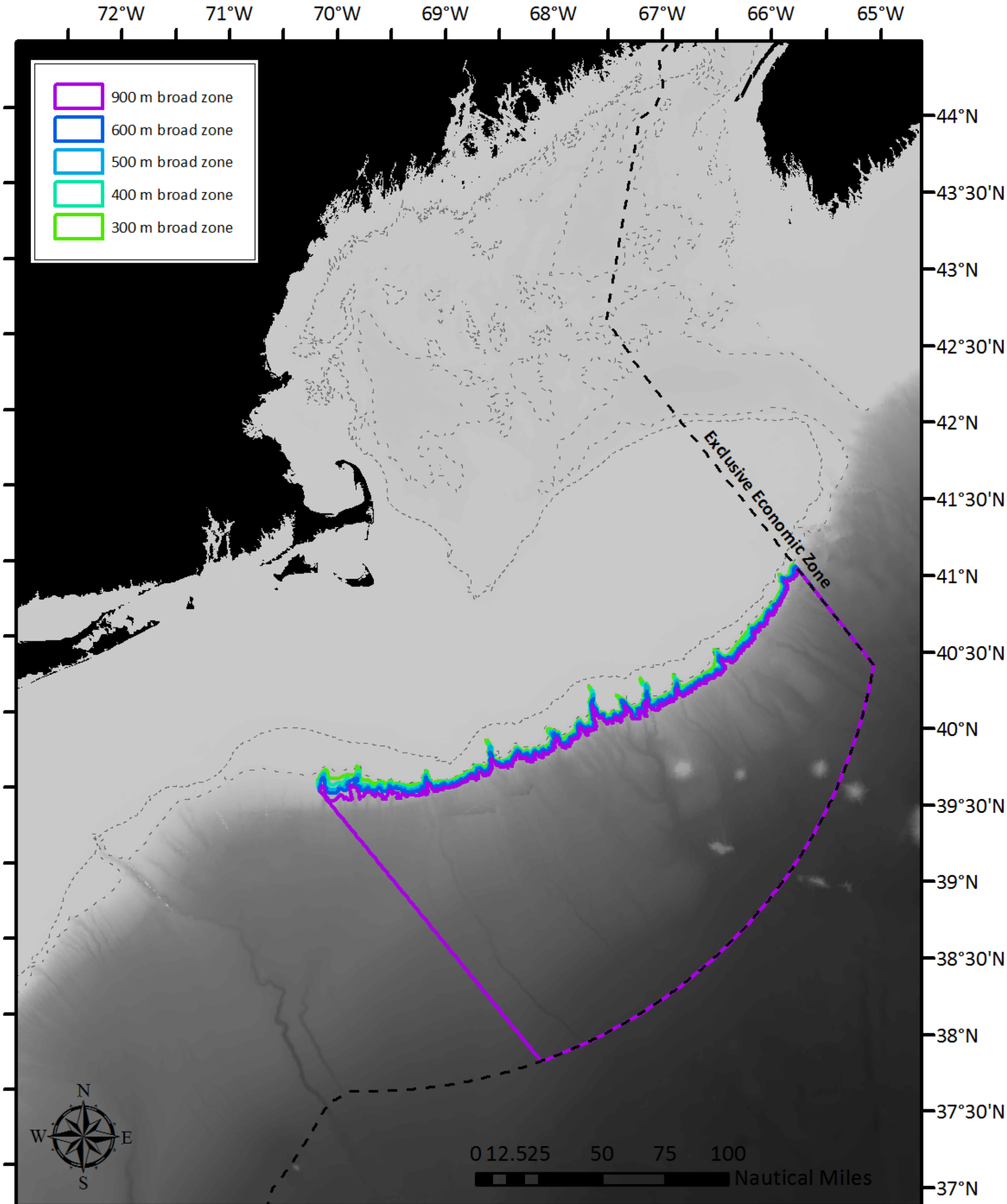
4.2.1.4 Option 4: 600 m broad zone

This option would designate a broad coral zone from the US-CAN EEZ boundary to the boundary between the New England and Mid-Atlantic Council regions, with the landward boundary at the 600 m contour and the seaward boundary at the EEZ.

4.2.1.5 Option 5: 900 m broad zone

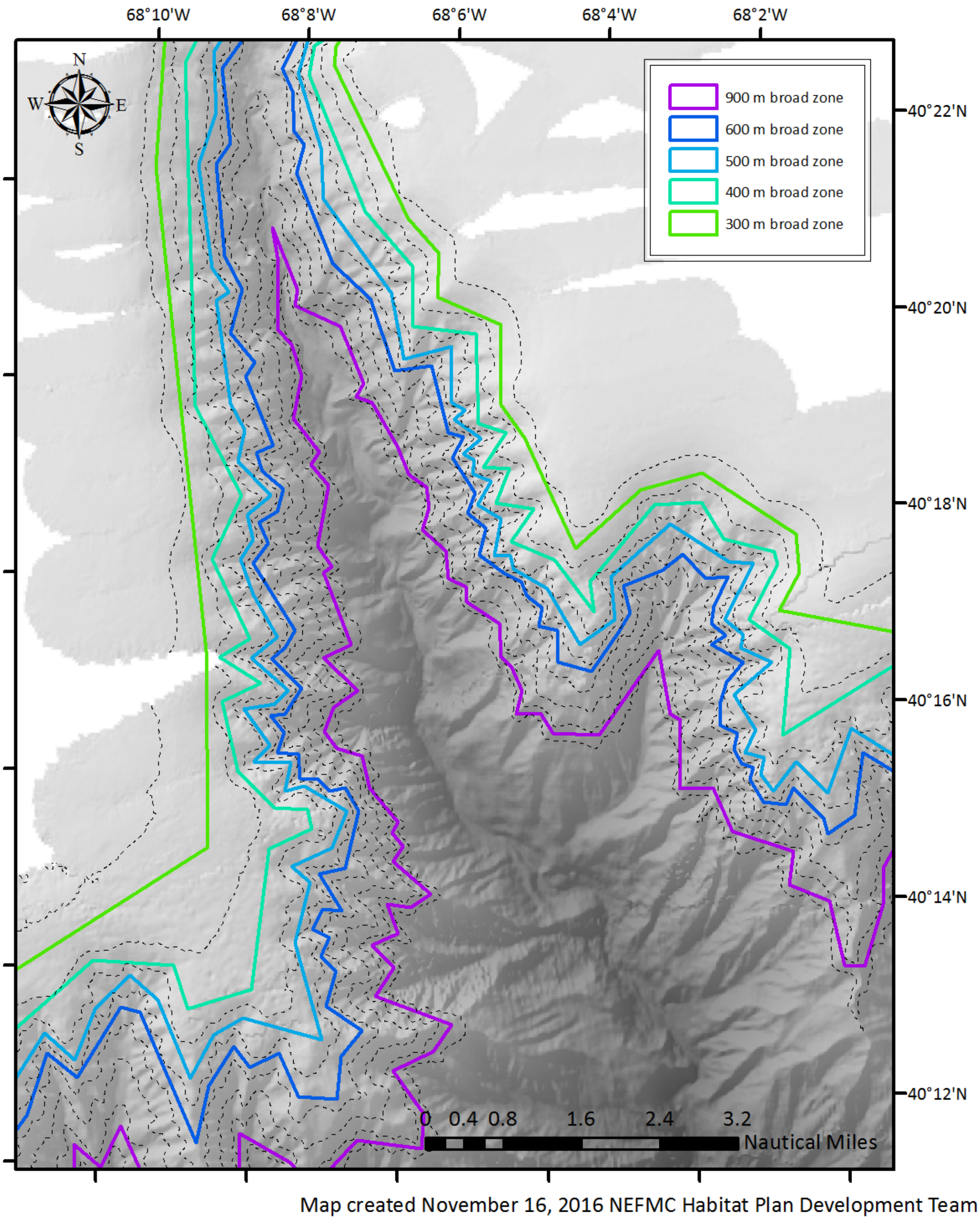
This option would designate a broad coral zone from the US-CAN EEZ boundary to the boundary between the New England and Mid-Atlantic Council regions, with the landward boundary at the 900 m contour and the seaward boundary at the EEZ.

Map 2 – Broad coral protection zones.



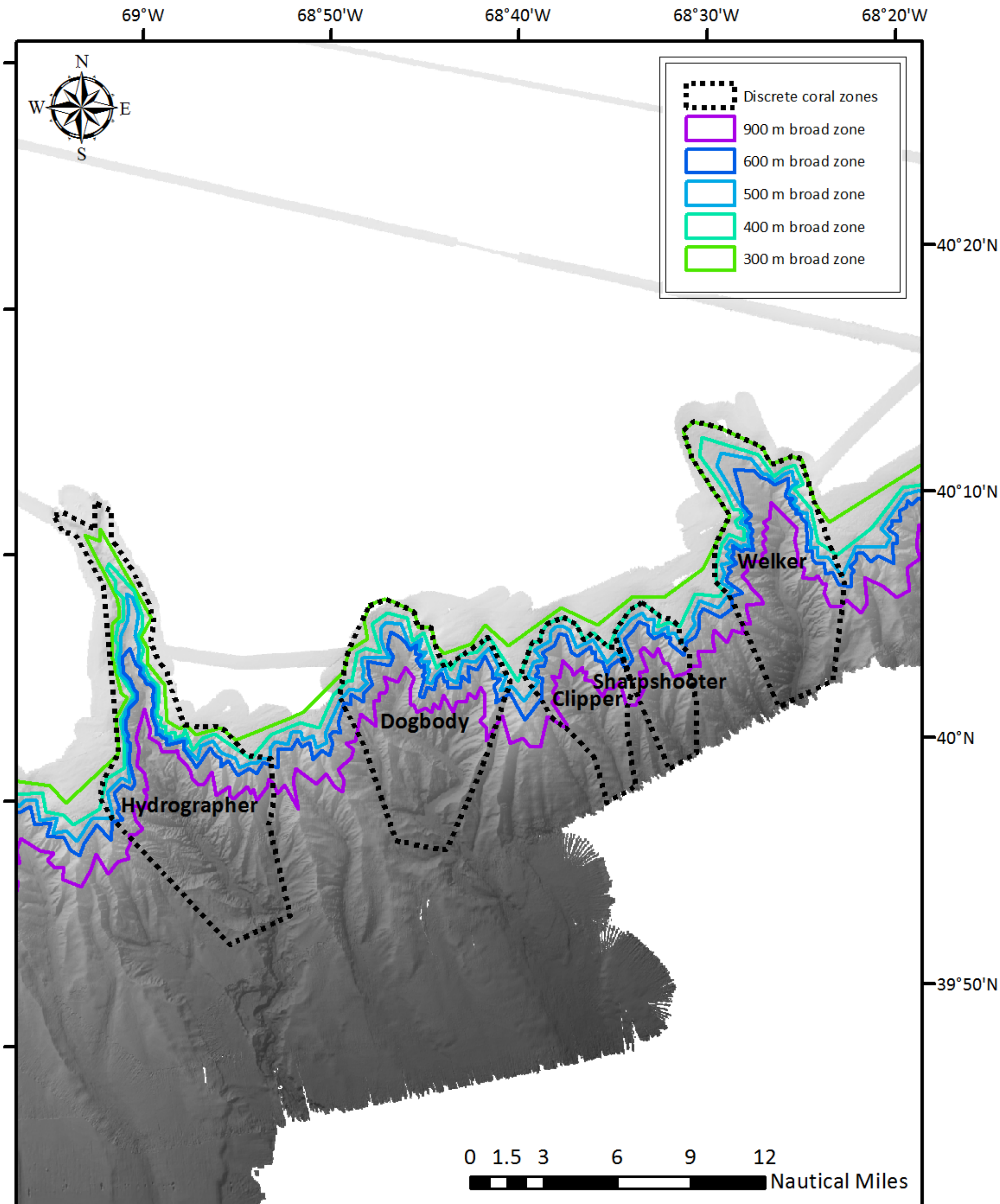
Map created November 16, 2016 NEFMC Habitat Plan Development Team

Map 3 – Broad zones alternatives at the shoulder of Oceanographer Canyon.



Notes: Because the areas are so steeply sloping, the contours are often only 1-2 km apart between the canyons, and even more closely spaced within the canyons. The deeper boundaries are necessarily more complex (more segments and waypoints) than the shallower boundaries. Heavy straight lines indicate the broad zone boundaries. The black dotted lines indicate the adjacent contours (50 meter depth intervals) that serve as upper and lower depth bounds for the broad zones. Grey shading shows the underlying ACUMEN bathymetry surface from which the contours were derived.

Map 4 – Broad zone boundaries with discrete coral zones.



Map created November 16, 2016 NEFMC Habitat Plan Development Team

Notes: Compare Dogbody, and Welker, which follow the 300 meter zone, with Clipper and Sharpshooter, which follow the 400 meter zone. Hydrographer's landward boundary is slightly shallower than 300 meters. Grey shading shows the underlying ACUMEN bathymetry surface from which the contours were derived.

4.2.2 Discrete deep-sea coral zone designations

Discrete deep-sea coral zones overlap individual canyons, seamounts, or other features. These discrete coral zones are intended to encompass known aggregations of corals, as well as steeply sloping habitats likely to have exposed rock outcroppings that provide suitable attachment sites for corals. Because the discrete zones do not overlap one other, any combination of areas could be selected.

The following sources of data were used to develop a list of recommended deep-sea coral zones, and to generate boundaries for those zones. Available data are similar for the different types of zones (canyon, seamount, Gulf of Maine), with variations as noted below. The major data types include information on the presence, abundance, and locations of various types of corals, terrain data such as depth and slope, and model outputs that predict areas where suitable habitats for particular taxonomic groups of corals are likely to occur. It is important to note the linkages between these datasets, which were generally collected or developed in an integrated, iterative fashion, rather than in an independent or stepwise manner. For example, historical coral distribution records combined with terrain and other environmental data were used in the habitat suitability model, and model outputs were in turn used to direct recent field sampling for coral habitats. Interest in coral habitats based on historical data helped drive collection of high resolution bathymetric data, which in turn informed selection of recent dive sites.

Deep-sea coral observations: Deep-sea coral observations from (1) an historical database and (2) recently conducted remotely operated vehicle (ROV) dives, autonomous underwater vehicle (AUV) dives, and camera tows were used as a starting point to identify areas of conservation interest. See section 6.2.1 for details about these data.

Terrain data (bathymetry and slope): Bathymetry and slope are key data for describing seafloor terrain and identifying areas that may contain deep-sea corals, as many taxa have been found in higher abundances attached to vertical rock walls and other steep terrain. Bathymetry datasets are also referred to as digital elevation models, or DEMs. These bathymetric datasets were used to identify area boundaries, and also to calculate minimum, maximum, and mean depths of candidate management areas.

- The primary source of bathymetry data for the canyons comes from a series of Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) on NOAA's research vessels Hassler, Bigelow, and Okeanos Explorer. These mapping expeditions took place from February 2012 through August 2012. Data were collected at 25m resolution.
- For the deepest portions of the canyons, the abyssal plain, and the seamounts, 100 meter resolution multibeam bathymetry data are available. These data were collected as part of a NOAA-initiated collaboration to fill data gaps identified during an inventory of data holdings to support potential claims under the United Nations Convention on the Law of the Sea (UNCLOS). Data are available for download from the University of New Hampshire Center for Coastal and Ocean Mapping Joint Hydrographic Center (http://ccom.unh.edu/theme/law-sea/law-of-the-sea-data/atlantic).

- In the Gulf of Maine, a 10 meter resolution multibeam bathymetric dataset was used for Outer Schoodic Ridge, a 20 meter resolution multibeam bathymetric dataset was used in Western Jordan Basin, and a 1/3 arc-second (about 10 m) bathymetric dataset (the Bar Harbor DEM) was used in the Mount Desert Rock area and surrounds. The Outer Schoodic Ridge and Western Jordan Basin data were collected during a fall 2013 ECOMON cruise aboard the Okeanos Explorer (Auster et al. 2014). The Bar Harbor DEM is described in Friday et al. 2011.
- A lower resolution 250 meter DEM from The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment, which is largely based on the Coastal Relief Model, is available in other areas where higher resolution data do not exist.
- A complete 30 arc-second DEM for the entire region was downloaded from the General Bathymetric Chart of the Oceans website, www.gebco.net. The GEBCO 2014 dataset is based on "quality-controlled ship depth soundings, with interpolations between soundings guided by satellite-derived gravity data". When available, additional data sources such as multibeam or Olex are integrated in particular locations.

Maps in this document show hill-shaded bathymetry, which allows for the shape of the seafloor to be visualized more easily. Hill-shaded surfaces are generated using Geographic Information System (GIS) software, by simulating what the terrain would look like if a light was shone over the surface from a specific angle and elevation. Values of 315° and 35° with a vertical exaggeration of 3x were used for the maps in this document.

Slope is a measure of the rate of change in bathymetry, and slope surfaces can be derived directly from any digital elevation model. Slope surfaces were also generated for other digital elevation models and high slope areas are highlighted on the maps of each discrete coral zone. The canyons generally contain larger areas of very high slope compared with the seamounts or Gulf of Maine areas. For areas where very steep terrain is less prevalent, including the seamounts and Gulf of Maine areas, slopes greater than 10 or 20° are mapped instead of slopes above 30°.

When interpreting bathymetric data, it is important to recognize the potential for artefacts in the data, which appear as a sudden change in depth. These artefacts can occur at seams, where data collected at different times are joined together to form a single coverage. These visible seams are due to small differences in instrument calibration. These abrupt jumps in bathymetry values can cause false slopes at the seams, which are not reflective of features on the seafloor. Though less probable and less severe, such artefacts can also occur at the boundaries between multibeam swaths collected at different times with the same ship and instrument, especially when data are collected across years. Caution is also needed at the edges of multibeam coverage and in the vicinity of holidays (pixels without valid data), where fewer bottom contacts are averaged and higher statistical noise may be present. These are all common and well-known features of multibeam echosounder data. It is widely accepted that expert interpretation is required to avoid considering such areas as true bottom features, and such expert guidance is standard practice in the hydrographic field. Where such artefacts are present in the maps presented below, they are noted on the maps in the text.

Habitat suitability model: Direct observations of corals are only available for a small portion of each area, thus requiring inference about the spatial extent of suitable coral habitats in various locations. A habitat suitability model (Kinlan et al., in review) was developed for the northeast region that predicts areas of lower and higher suitability for various types of corals. The model is described further in section 6.3. The combined high and very high suitability areas for the Gorgonian Alcyonacea and non-gorgonian Alcyonacea combined were used to develop the canyon zones.

4.2.2.1 Canyon coral zones

This alternative would designate coral zones within 20 submarine canyons off the southern boundary of Georges Bank. From west to east, these canyons include Alvin, Atlantis, Nantucket, Veatch, Hydrographer, Dogbody, Clipper, Sharpshooter, Welker, Heel Tapper, Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia, Powell, Munson, Nygren, an unnamed canyon, and Heezen. The canyons that overlap the National Monument are Oceanographer, Filebottom, Chebacco, Gilbert, and Lydonia. Options for fishing restrictions in these zones are described in section 4.3.

Should clarify if the intent is to adopt all canyon zones as a group, once boundary refinements are complete, or if the intent is to adopt each zone separately. The impacts analysis assumes adoption of the canyon zones as a group, but separates results for the groups of canyons that do and do not overlap the Marine National Monument. This will allow the Council to more readily understand the additional impacts of designating new canyons, beyond those impacts already associated with the Monument.

The New Bedford workshop included discussion of the utility of combining discrete and broad zones. If discrete zones are considered, the same depths as the broad zones were acceptable to the fishing industry, 550 meters minimum with red crab exemption, or 900 meters minimum without a red crab exemption. The environmental NGO representatives were concerned about eliminating shallower areas that overlapped the suitability model and encompassed some records of corals.

Rationale: All of these canyons have recent ROV or towed camera dives indicating the presence of coral habitats. Some areas have historical records as well.

Method used to define discrete canyon zone boundaries: Boundaries of these zones are based on the most up to date information on coral observations, high resolution terrain data, and habitat suitability model results. Coral zone boundaries are primarily based on bathymetry and slope, and were designed to encompass the full extent of the canyon feature from the shelf break to the point where the slope begins to flatten out at the edge of continental rise. The 3° slope contour was used to identify the shelf break in previous PDT coral analyses, and this convention is adopted here as well. The 3° slope contour is typically lies somewhere between 200 and 300 meters depth off of New England.

Because the shallow edge of the high resolution ACUMEN bathymetry dataset overlaps these contours, this dataset was not suitable for defining a 3° slope contour. Therefore, the slope contour was developed using the TNC NAMERA[2] DEM. This slope contour roughly approximates the landward coral zone boundary in the shelf incising canyons, and in some of the slope confined canyons as well. The landward boundary of other slope confined canyons begins slightly deeper, which is consistent with the slope and habitat suitability model outputs (more on this below).

Areas of the canyons with high slope (greater than 30°) have been shown to have corals most of the time during recent ROV and towed camera surveys, and corals have been found in areas with very high slope (greater than 36°) during all recent dives. Thus, these high and very high slope areas, which are derived from the ACUMEN bathymetry, were a useful guide for defining the width of the canyon zones (west to east dimension), as well as the seaward boundaries of the zones.

The high and very high habitat suitability outputs for gorgonian Alcyonacea, and non-gorgonian Alcyonacea were also considered when developing canyon zone boundaries. These high and very high suitability model outputs often align well with the high and very high slope areas described above. Similar to the slope outputs, the model results were used to help define the width of the canyon zones, and well as their landward and seaward extents. A buffer of 0.4 nautical miles around the high suitability outputs was generated to roughly reflect the degree of spatial uncertainty in the model results. As appropriate, the zones include these buffer areas as well. The PDT prioritized the high resolution bathymetry and slope data over the model outputs when developing boundaries because these high resolution data are best for accurately bounding the spatial extent of the canyon features. The suitability outputs are a useful guide, but are based on a lower resolution dataset. This diverges slightly from the approach used by the MAFMC FMAT. In the MAFMC coral amendment, the FMAT included high and very high habitat suitability areas, plus the buffer, in their initial canyon zone boundary recommendations, but these areas were ultimately scaled back in the heads of the canyons by the time the boundary development process had concluded after their coral workshop. More tightly focused boundaries at this initial stage will hopefully result in the need for fewer changes as these areas make their way through the Council process.

The locations of historic and recent coral observations generally fall solidly within zones developed using bathymetry, slope, and suitability model results, so while they are confirmatory of the presence of coral habitats in a canyon zone, they are not really a driving factor behind the zone boundaries.

Maps for each canyon shows a draft set of boundaries and the underlying coral distribution, bathymetry, slope, and habitat suitability data layers. The legend below (Figure 1) applies to each of the canyon zone maps that follow. It shows locations of recent ROV and towed camera dives (green triangles, with green line tow paths) and

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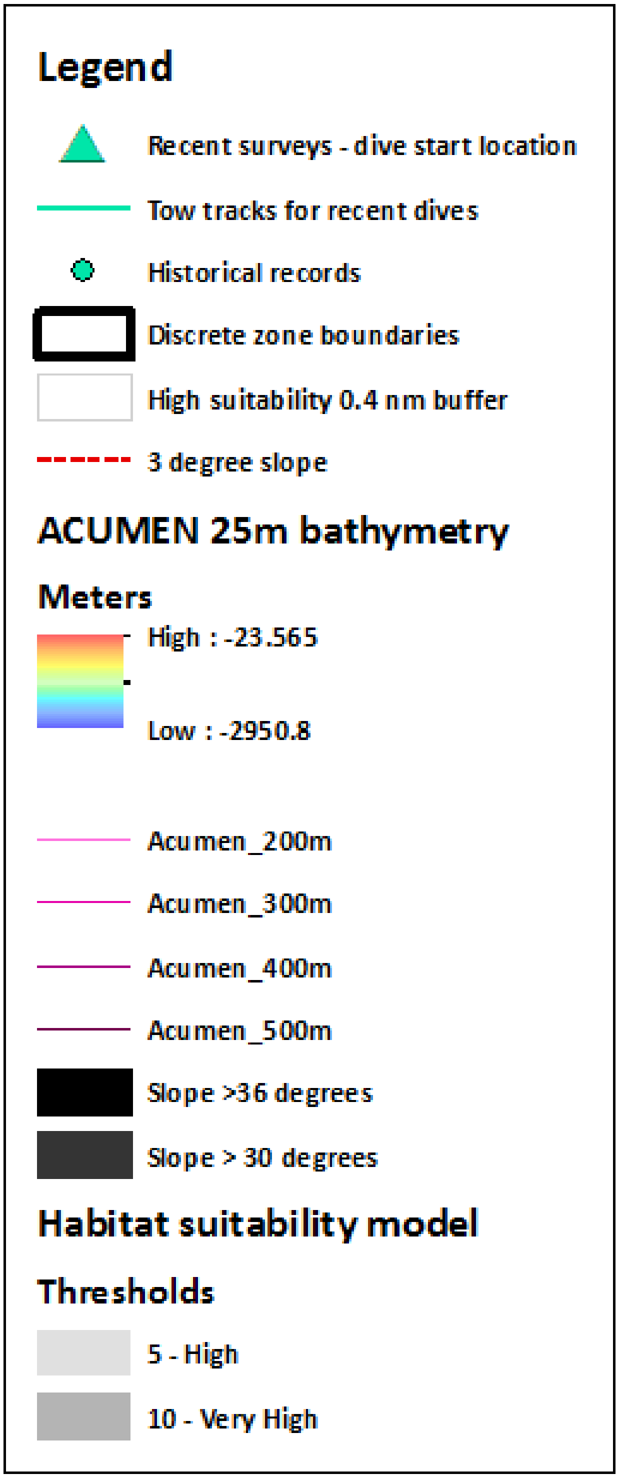
[2] The Nature Conservancy Northwest Atlantic Marine Ecoregional Assessment digital elevation model

coral locations in the historical database (green circles). Coral orders represented in the historical database include stony corals (order Scleractinia); sea pens (order Pennatulacea); soft corals (order Alcyonacea); and black corals (order Antipatharia).

The maps also depict depth, hill-shaded relief (red to blue shading) and contour lines (purple) from the ACUMEN data. Note that the 200m contour is rather incomplete in the ACUMEN data and is not often depicted fully on the maps. The 3° slope contour (red dotted line) is shown on each map as well. Areas of high slope (> 30°) and very high slope (> 36°) are identified in dark grey and black. The hill-shaded relief indicates the shapes of the canyon and helps to indicate the path of the thalweg, or main axis of the canyon. Seams in the bathymetry data and resulting slope artefacts are noted on the maps.

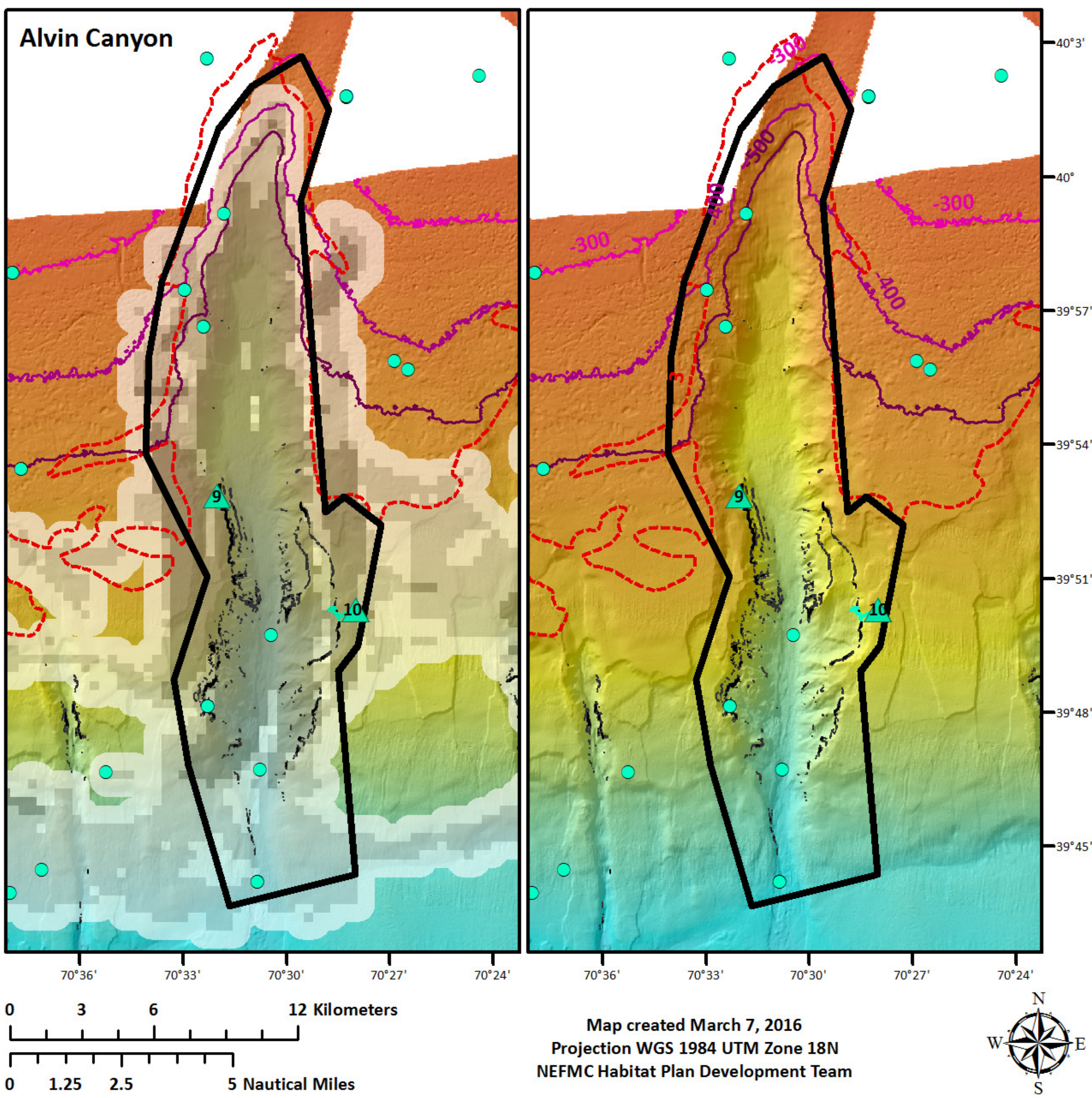
Two sets of maps were prepared for this document, one with the combined gorgonian and non-gorgonian Alcyonacean habitat suitability layers, and one without, because the maps without habitat suitability more clearly show the shapes of the canyons. High and very high habitat suitability areas are shown in transparent grey shading, and a 0.4 nm buffer is shown in white shading.

Figure 1 – Legend for canyon area maps



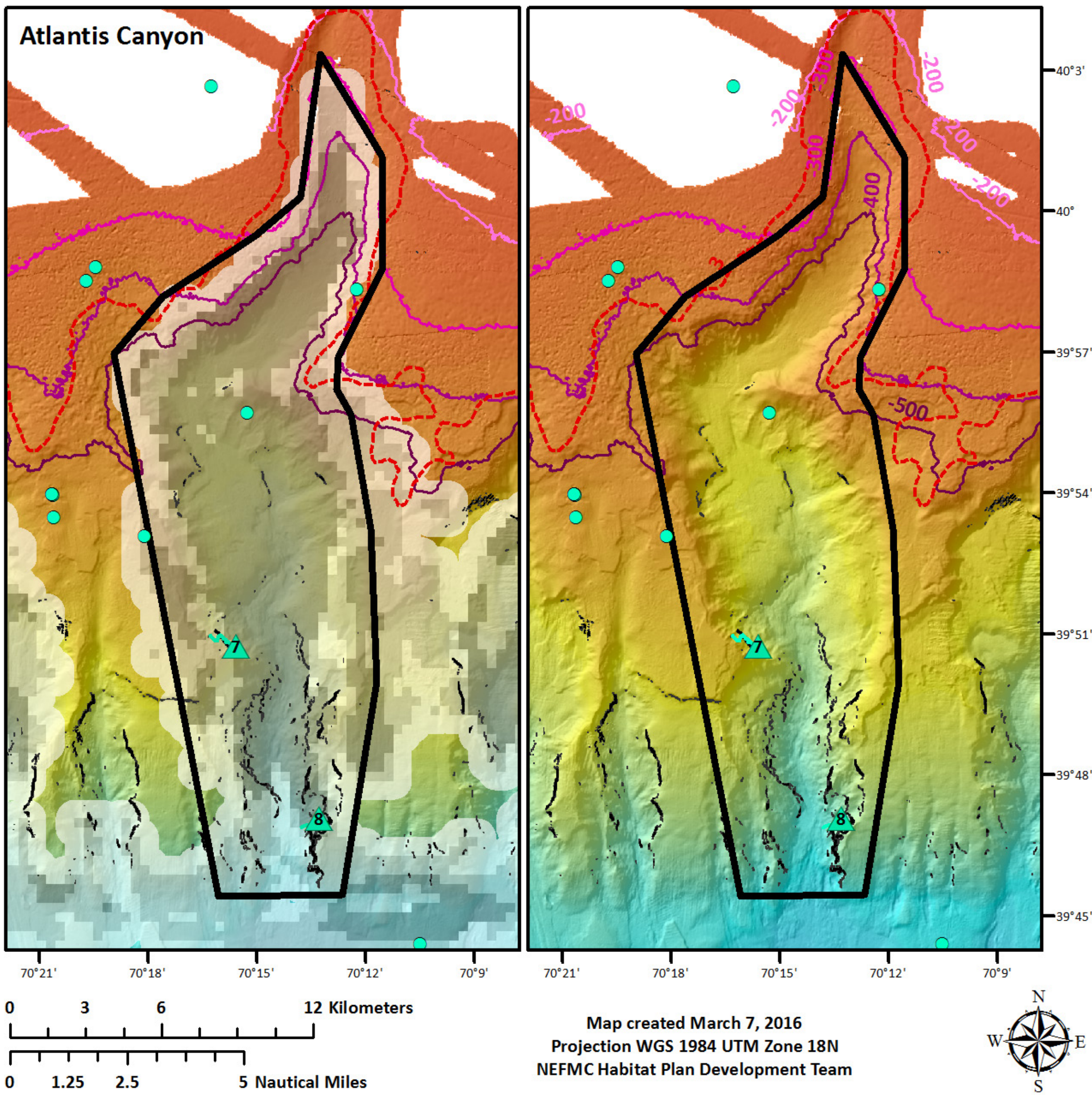
Alvin Canyon incises the continental shelf, encompassing an area of about 200 km^2. The proposed zone follows the 300-meter depth contour at the head of the canyon and aligns closely with the 3° slope contour. The proposed zone encompasses areas of high and very high suitability as well as areas of high slope (greater than 30 degrees), which tend to occur in the deeper portion of the canyon. High suitability areas extend beyond the boundaries of the zone to the east and west, but very high suitability areas are mostly confined to the suggested boundaries. There are no issues with seams in the bathymetric data in this canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 5 – Alvin Canyon discrete zone



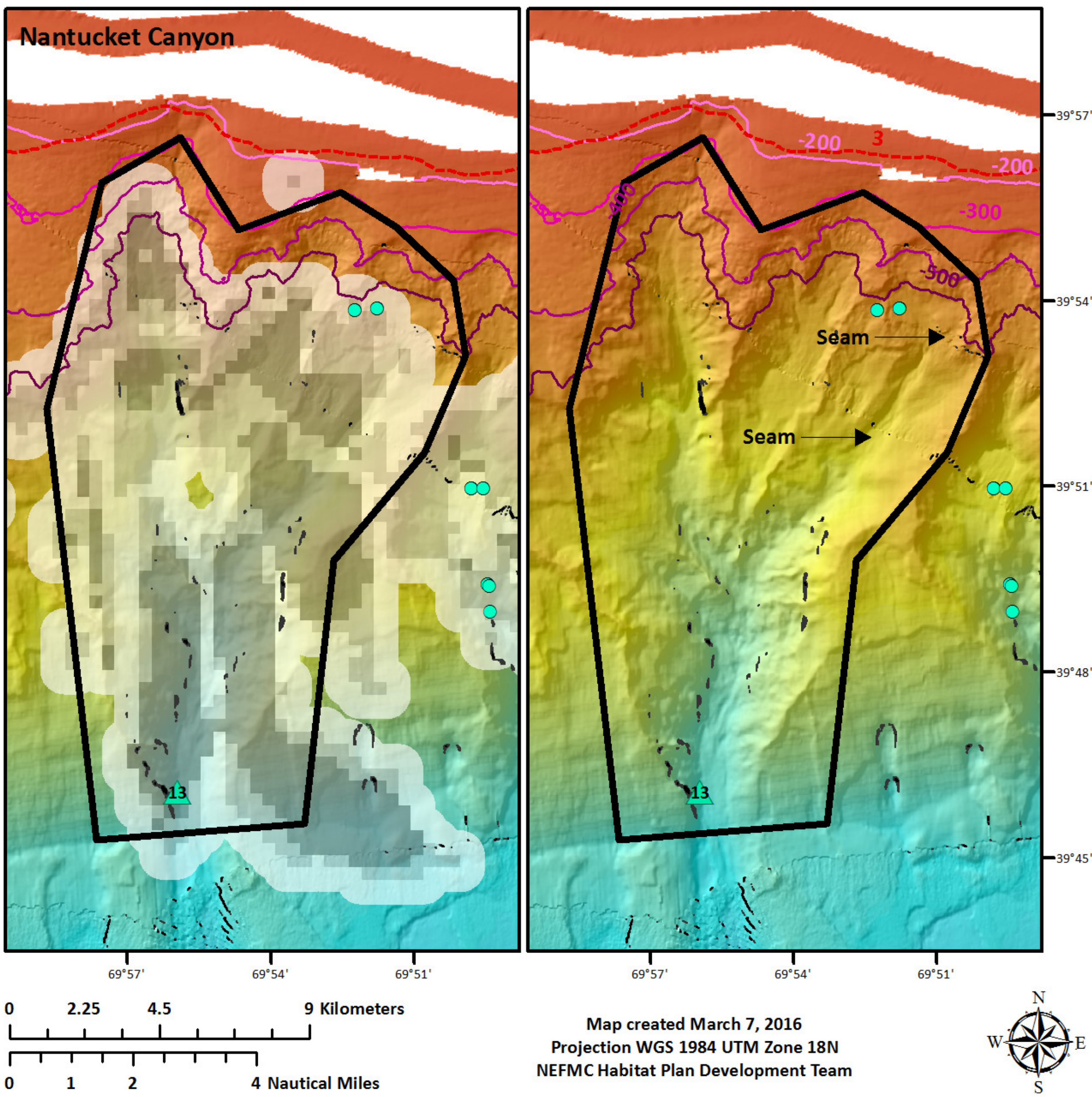
Atlantis Canyon incises the continental shelf break, encompassing an area of about 200 km^2. The proposed zone follows the 300-meter depth contour at the head of the canyon and aligns closely with the 3° slope contour. The proposed zone encompasses areas of high and very high suitability as well as areas of high slope (greater than 30 degrees), which tend to occur in the deeper portion of the canyon. There are smaller canyon-type features to the east and west of the proposed zone. There are no issues with seams in the bathymetric data in this canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 6 – Atlantis Canyon discrete zone



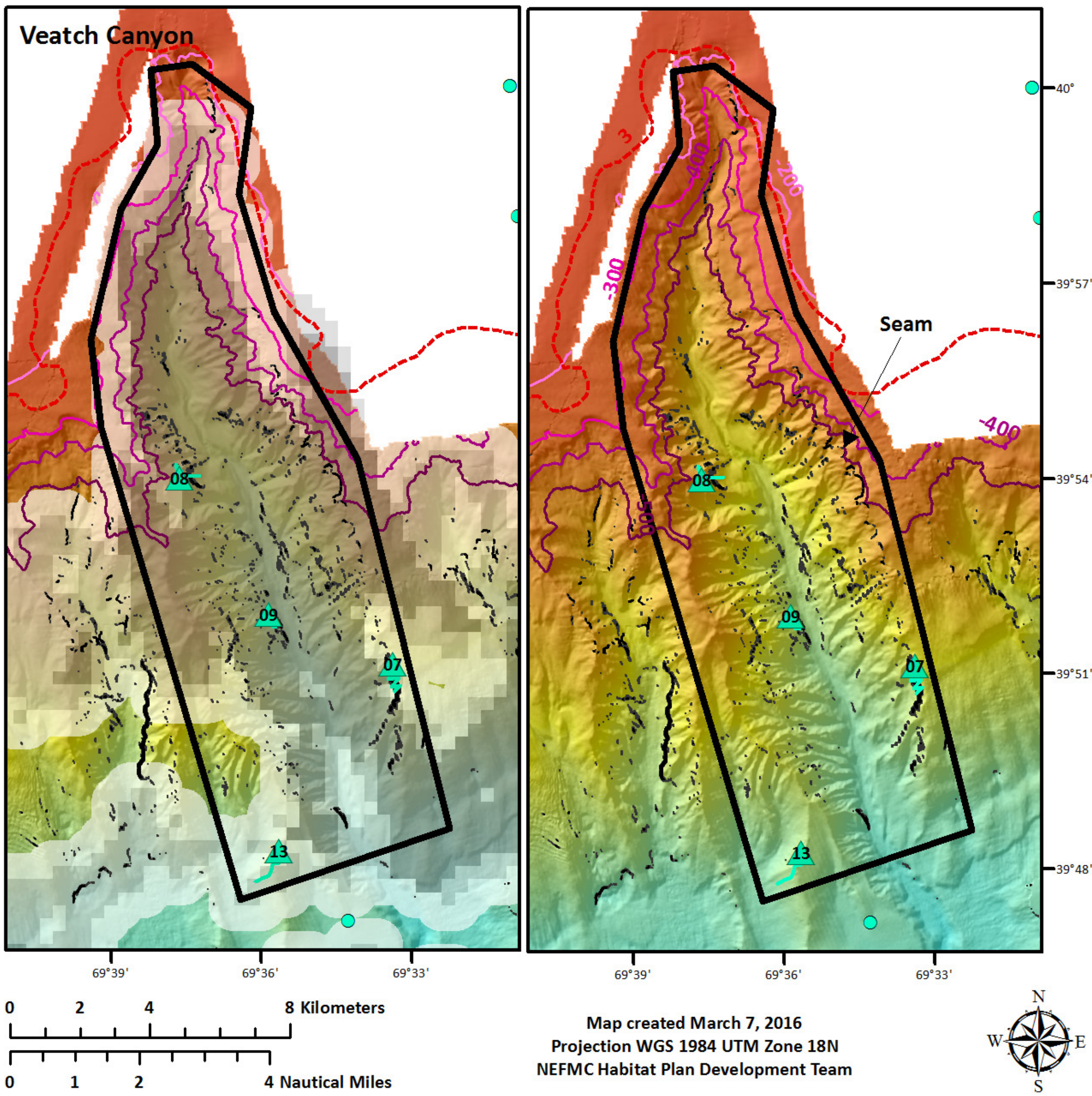
Nantucket Canyon lies seaward of the 3° slope contour, encompassing an area of about 200 km^2. It is a dendritic canyon, with three major branches. Although Harris and Whiteway (2011) classify Nantucket as shelf-incising, there is not a substantial curve in the 3° slope contour at the head of the canyon, such that it could be argued that it is more appropriately classified as slope-confined. The proposed zone roughly follows the 300-meter depth contour at the head of the canyon. It encompasses areas of high and very high suitability as well as areas of high slope (greater than 30 degrees), which tend to occur in the deeper portion of the canyon. There are areas to the east of the proposed zone that indicate high likelihood of coral presence. Some apparent high slope areas in the northeastern portion of the zone appear to be artifacts due to seams in the bathymetry data. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 7 – Nantucket Canyon discrete zone



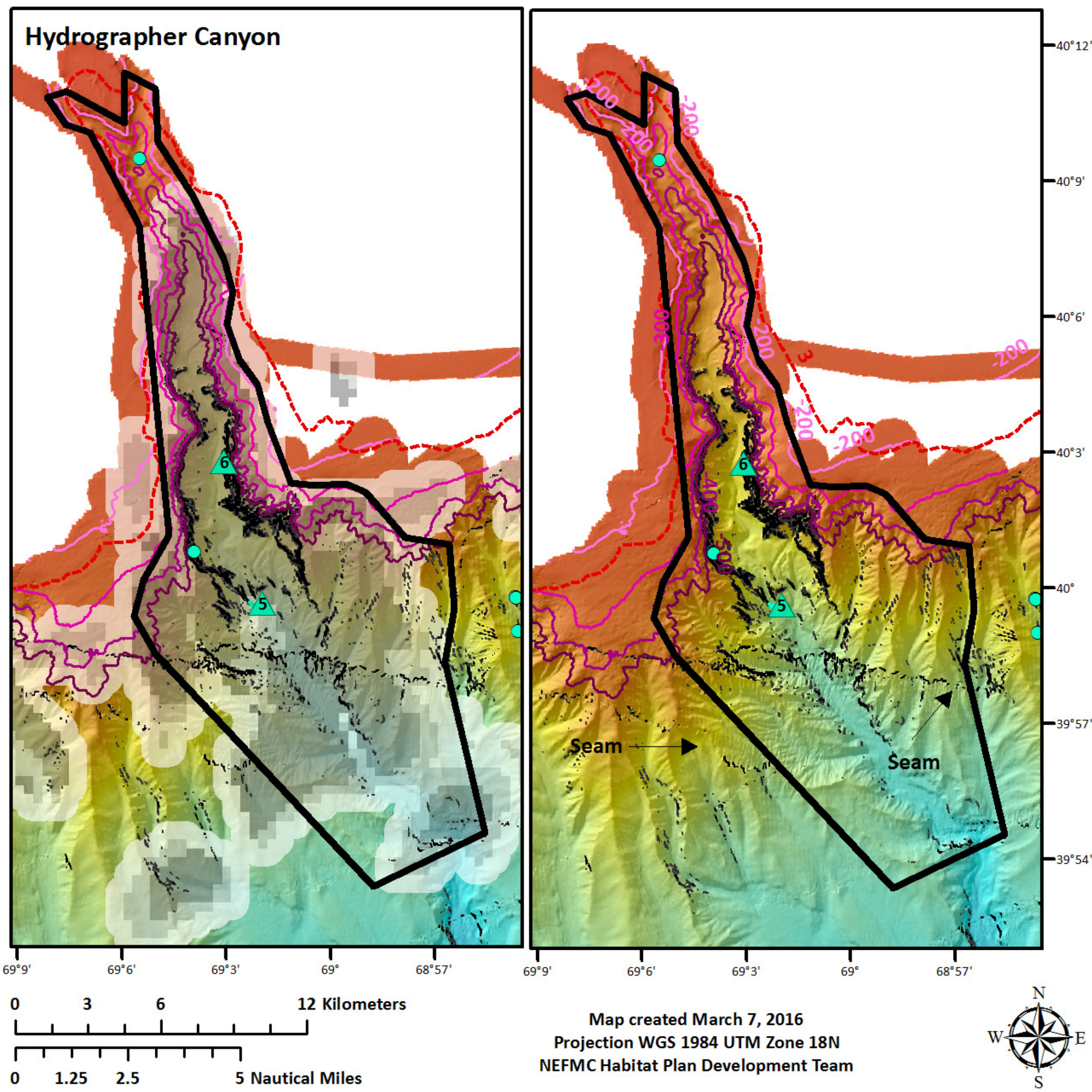
Veatch Canyon incises the continental shelf break. The recommended zone encompasses an area of approximately 125 km^2 and is between 200m and 300m in the head of the canyon. Most of the recommended zone is mapped as very high habitat suitability. High suitability areas extend to the east and west of the boundary, overlapping smaller slope-confined canyons on either side of Veatch. Some apparent high slope areas in the head of the canyon are artifacts due to seams in the bathymetry data. The true high slope areas tend to occur mainly in the deeper portions of the canyon, beyond the shelf break. While there are no historical observations of coral presence in Veatch Canyon area, there have been five recent dives that have documented a range of coral species.

Map 8 – Veatch Canyon discrete zone



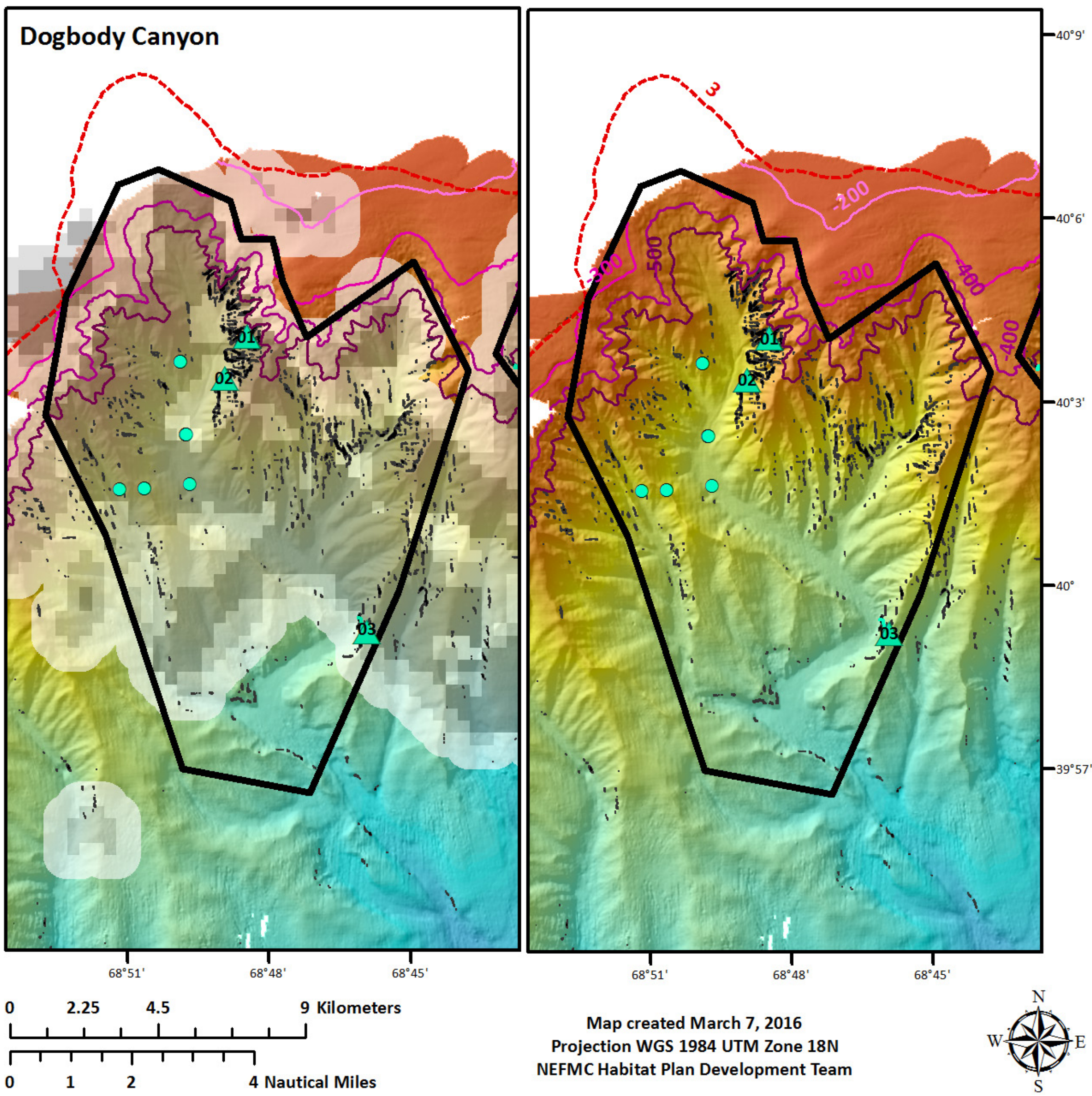
Hydrographer Canyon is a narrow canyon that incises the continental shelf break, encompassing an area of approximately 200 km^2. The proposed zone follows the 200-meter depth contour at the head of the canyon. The areas of high slope (i.e., greater than 30 degrees) are found in the narrow portion of the proposed canyon zone, midway between the mouth and foot of the canyon. The zone also encompasses the high and very high habitat suitability output results. The effect of "seams" in the dataset is also visible on the map, and should be ignored. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 9 – Hydrographer Canyon discrete zone



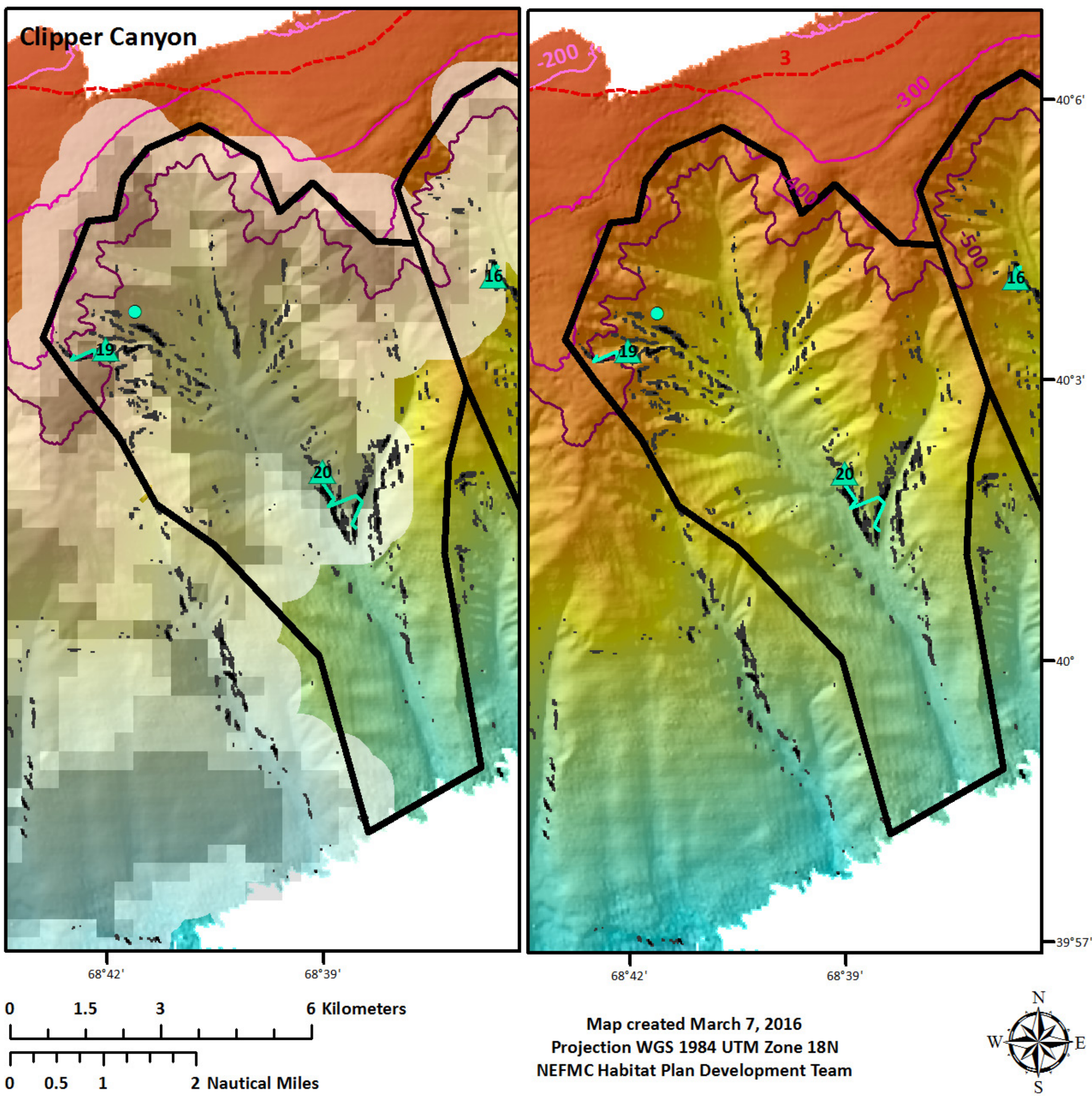
Dogbody Canyon is a dendritic canyon that incises the continental shelf break, encompassing an area of approximately 150 km^2. The proposed zone follows the 300-meter depth contour at the head of the canyon and is seaward of the 3° slope contour. The main thalweg is somewhat sinuous with a smaller branch to the east. Most of the canyon is predicted to have high or very high habitat suitability for soft corals, and both branches include large areas of high slope, in relatively shallow water compared with some of the other canyons. There are no issues with seams in the bathymetric data in this canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 10 – Dogbody Canyon discrete zone



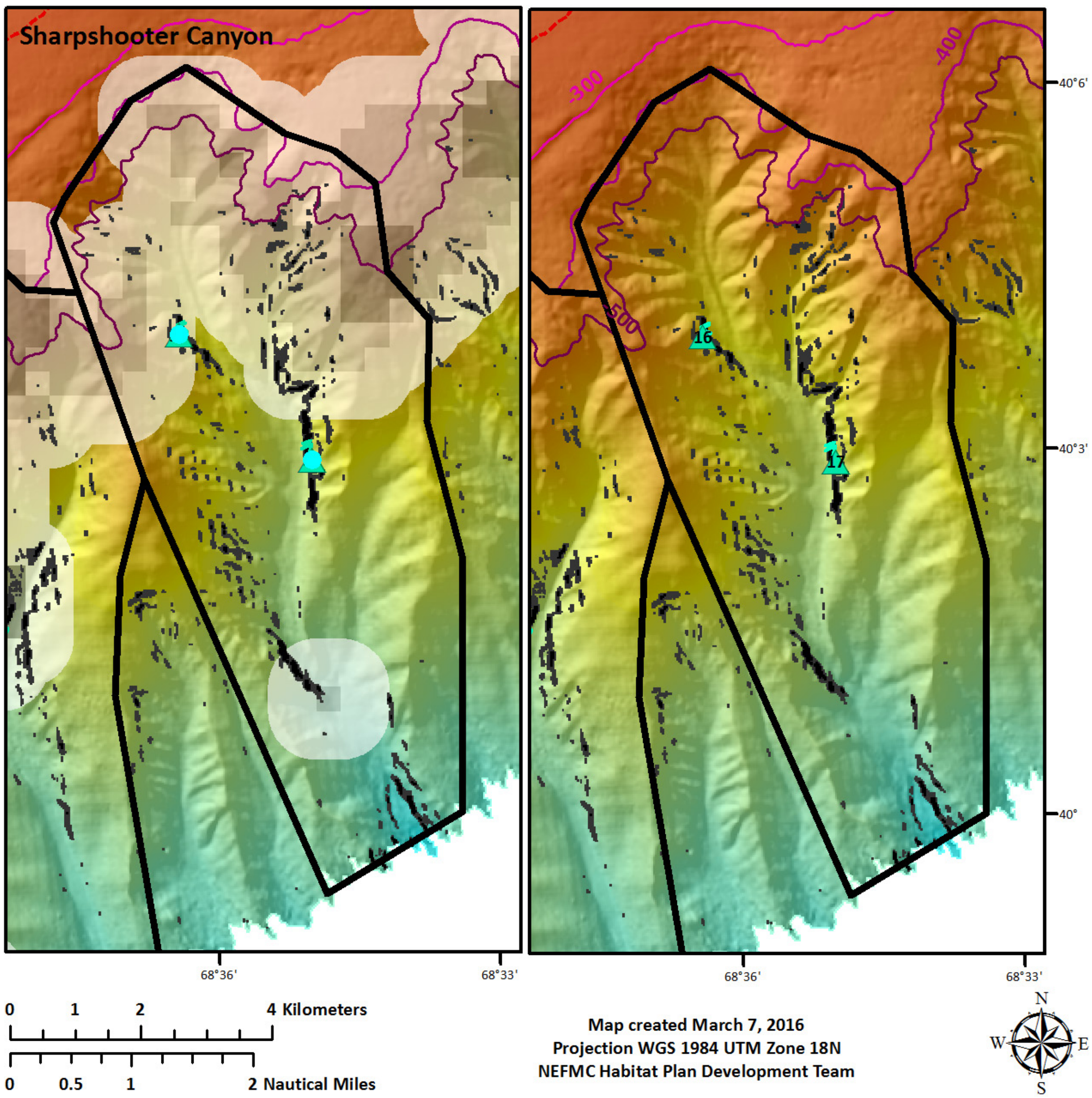
Clipper Canyon is slope-confined, encompassing an area of approximately 50 km^2, which puts it among the smaller canyons off the Northeast continental shelf. The proposed zone follows the 400-meter depth contour at the head of the canyon. Clipper has one main branch and a smaller branch to the east. The habitat suitability model predicts the shallower portions of the zone as suitable coral habitat. The high/very high suitability footprint coincides spatially with areas of high and very high slope. Areas of high slope are found along both branches of the canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 11 – Clipper Canyon discrete zone



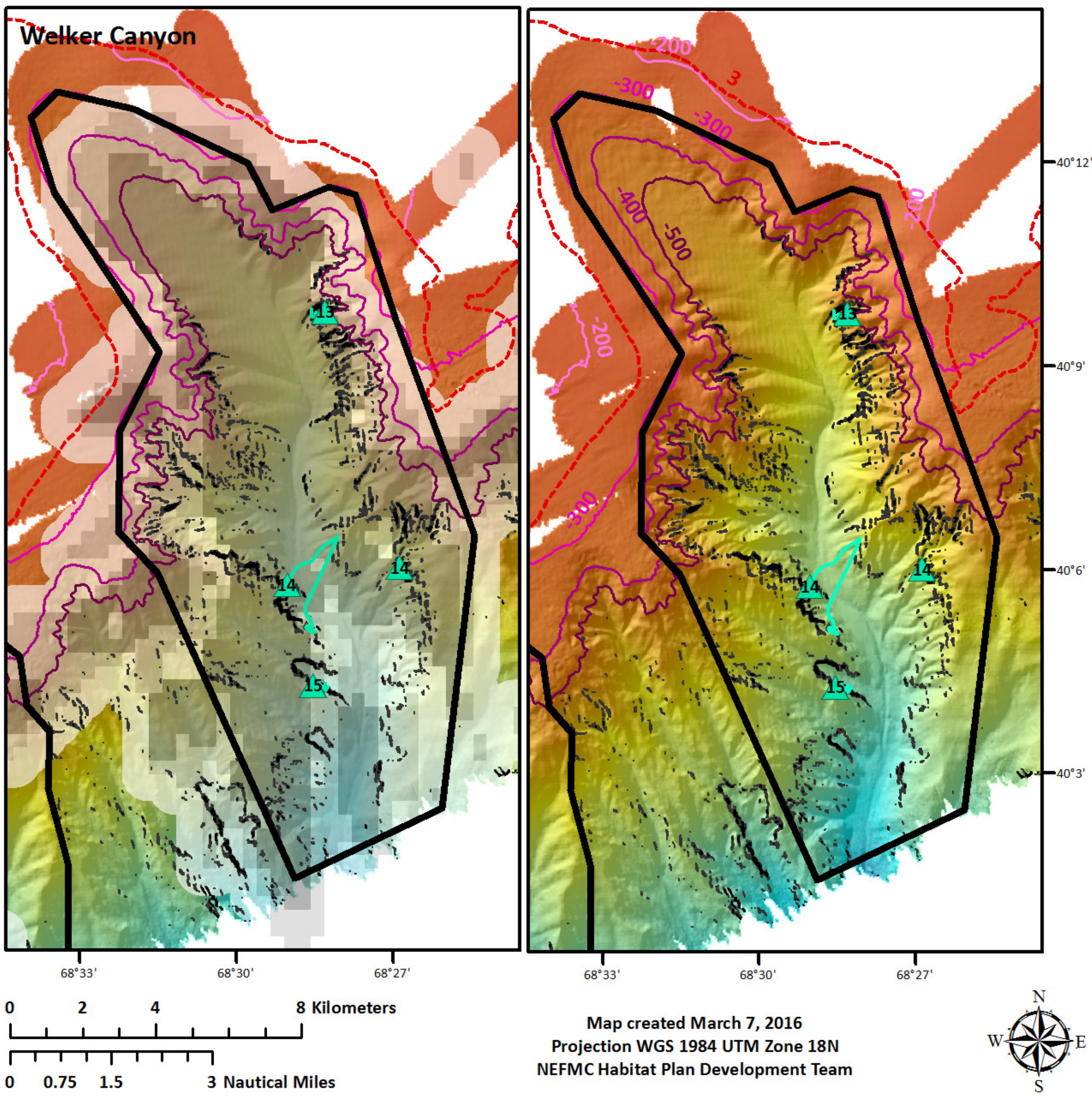
Sharpshooter Canyon is slope-confined, encompassing an area of approximately 50 km^2, which puts it among the smaller canyons off the Northeast continental shelf. The proposed zone follows the 400-meter depth contour at the head of the canyon. Much of the proposed zone was not identified as high and very high habitat suitability based on the model output results. However, the proposed zone follows the shape of the canyon, and includes areas of high slope at various depths. There are no issues with seams in the bathymetric data in this canyon. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 12 – Sharpshooter Canyon discrete zone



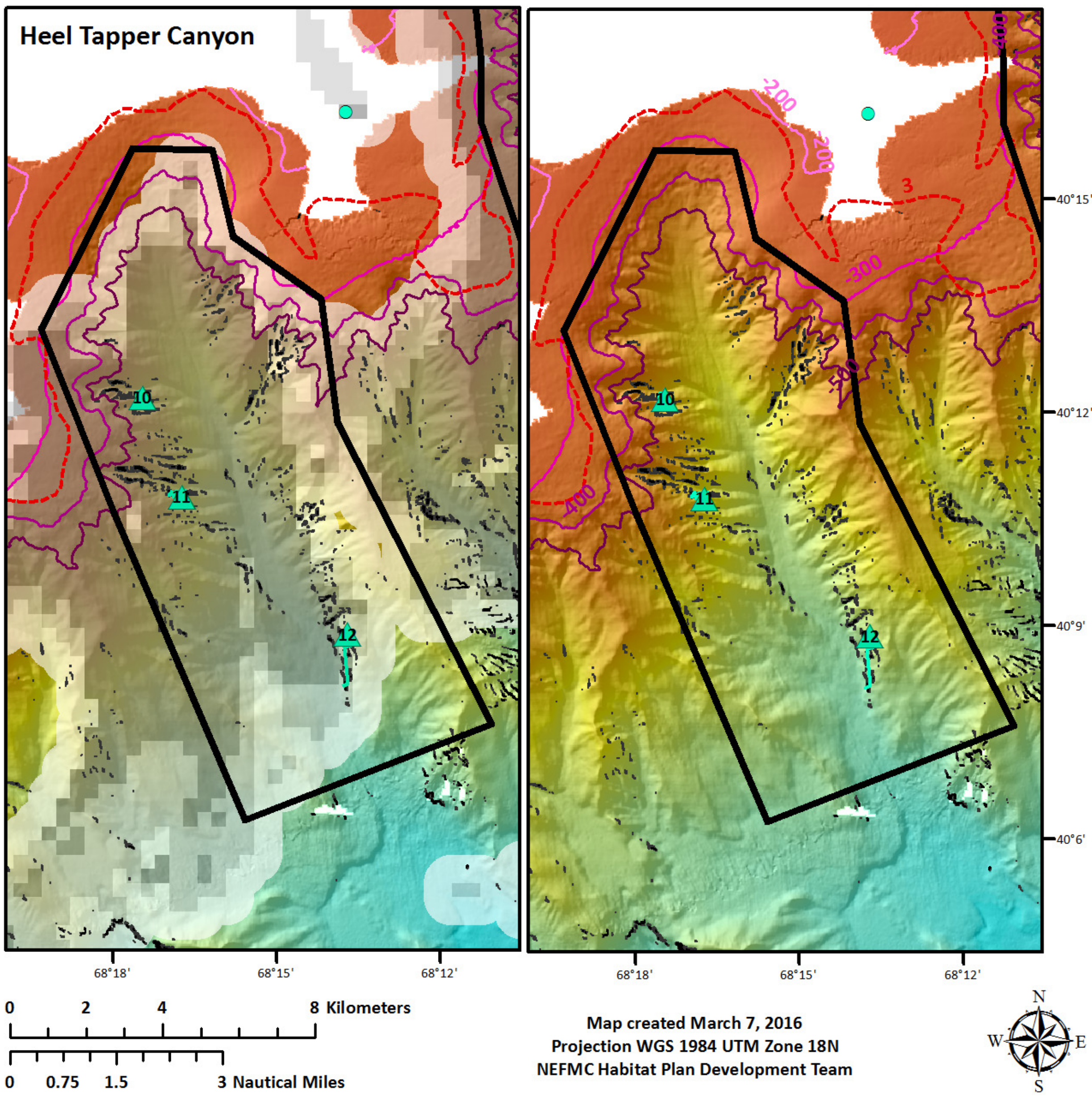
Welker Canyon incises the continental shelf break, encompassing an area of approximately 150 km^2. The proposed zone follows the 300-meter depth contour at the head of the canyon. The head of the canyon is not very steeply sloped, but there are large areas of high slope along both walls. Most of the proposed zone is predicted to be high or very high suitability soft coral habitat, and areas of high slope are found throughout the zone. There are no issues with seams in the bathymetric data in this canyon. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 13 – Welker Canyon discrete zone



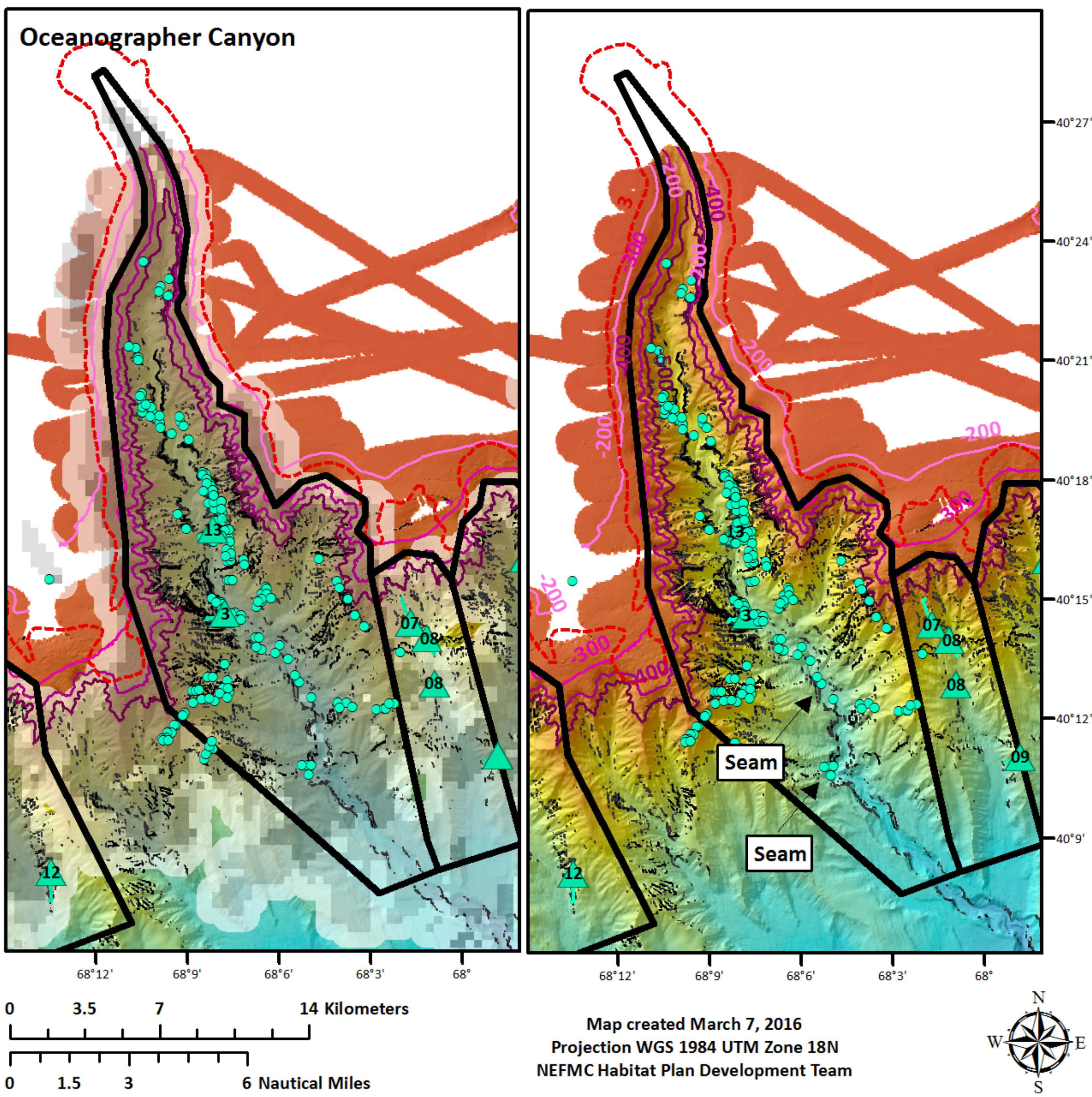
Heel Tapper Canyon incises the continental shelf break, encompassing an area of approximately 100 km^2. The proposed zone follows the 300-meter depth contour at the head of the canyon. The areas of high slope are also encompassed in the proposed zone. The area to the west of the proposed zone includes very high habitat suitability model output; however, higher resolution bathymetric data show that the areas of high slope are located within the proposed discrete coral zone. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 14 – Heel Tapper Canyon discrete zone



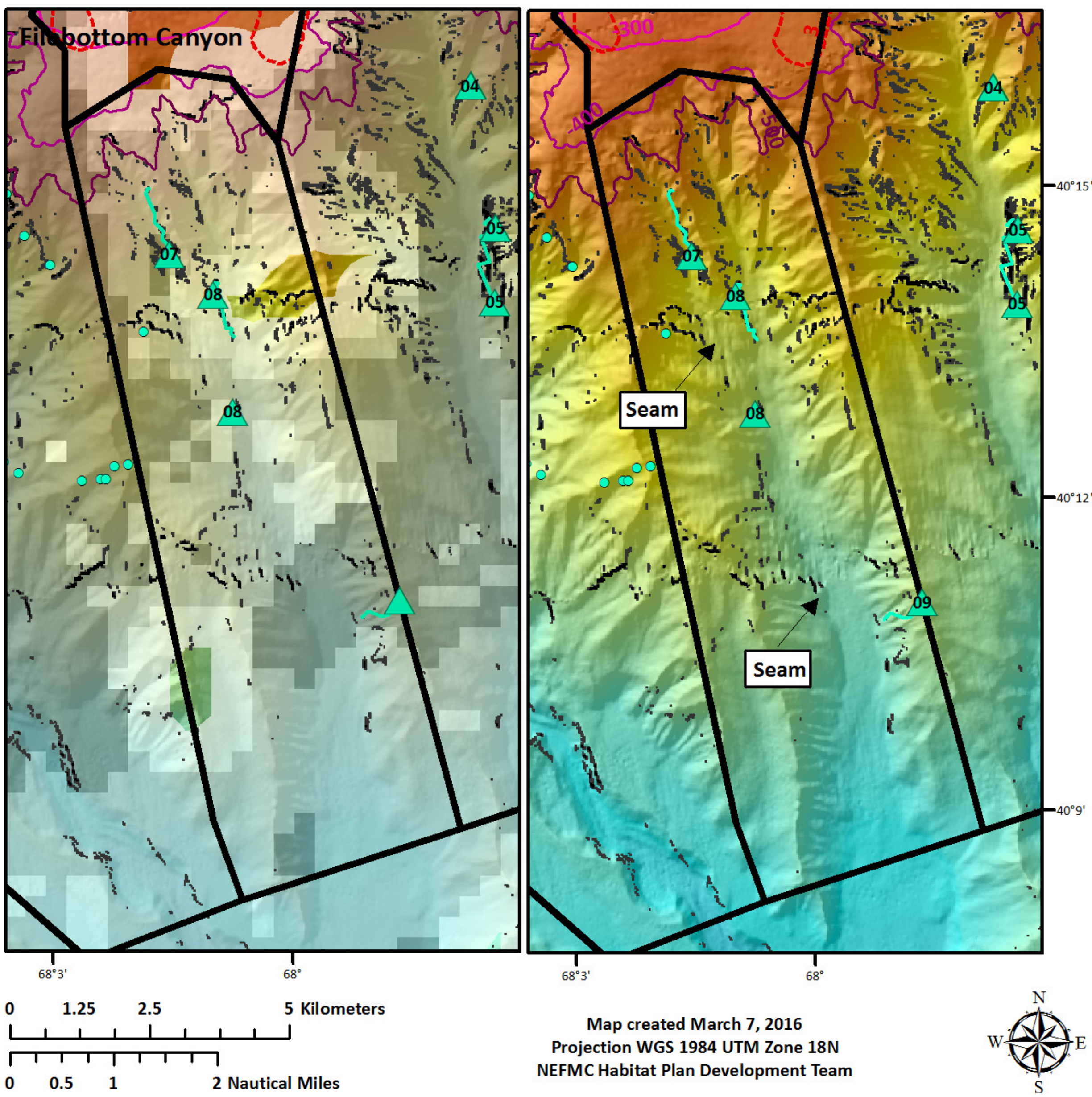
Oceanographer Canyon incises the continental shelf break, encompassing an area of over 200 km². It is the largest of the proposed canyon zones. The proposed zone follows the 300-meter depth contour at the head of the canyon and the boundary is largely within the 3° slope contour. Oceanographer has a clear main axis with a smaller branch on the eastern side. The areas of high slope and the areas predicted to have high/very high habitat suitability for soft corals are encompassed in the proposed zone. There are a few areas of seams in the bathymetry data that lead to high slope artefacts, but these are difficult to discern amidst the large areas of high slope. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 15 – Oceanographer Canyon discrete zone



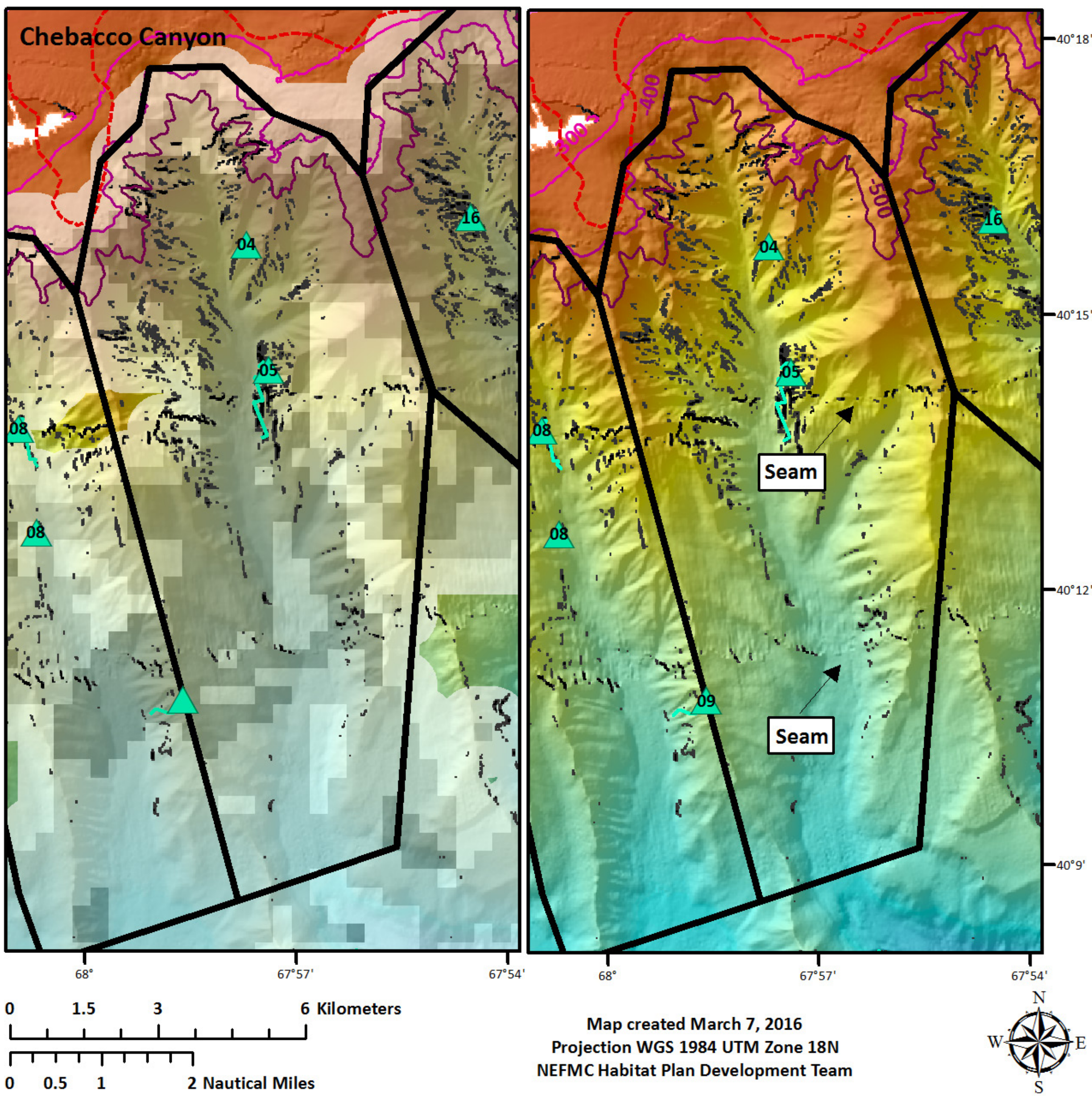
Filebottom Canyon is slope-confined, encompassing an area of approximately 50 km^2. It is immediately adjacent to Oceanographer Canyon to the west and Chebacco Canyon to the east. The proposed zone follows the 300-meter depth contour at the head of the canyon. There are fewer areas of high slope compared with some other canyons, and some of the high slope areas shown on the map are artefacts resulting from seams in the data. Much of the zone is predicted to have suitable habitat for corals, although there is less overlap with the very high suitability layer compared with some of the other coral zones proposed. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 16 – Filebottom Canyon discrete zone



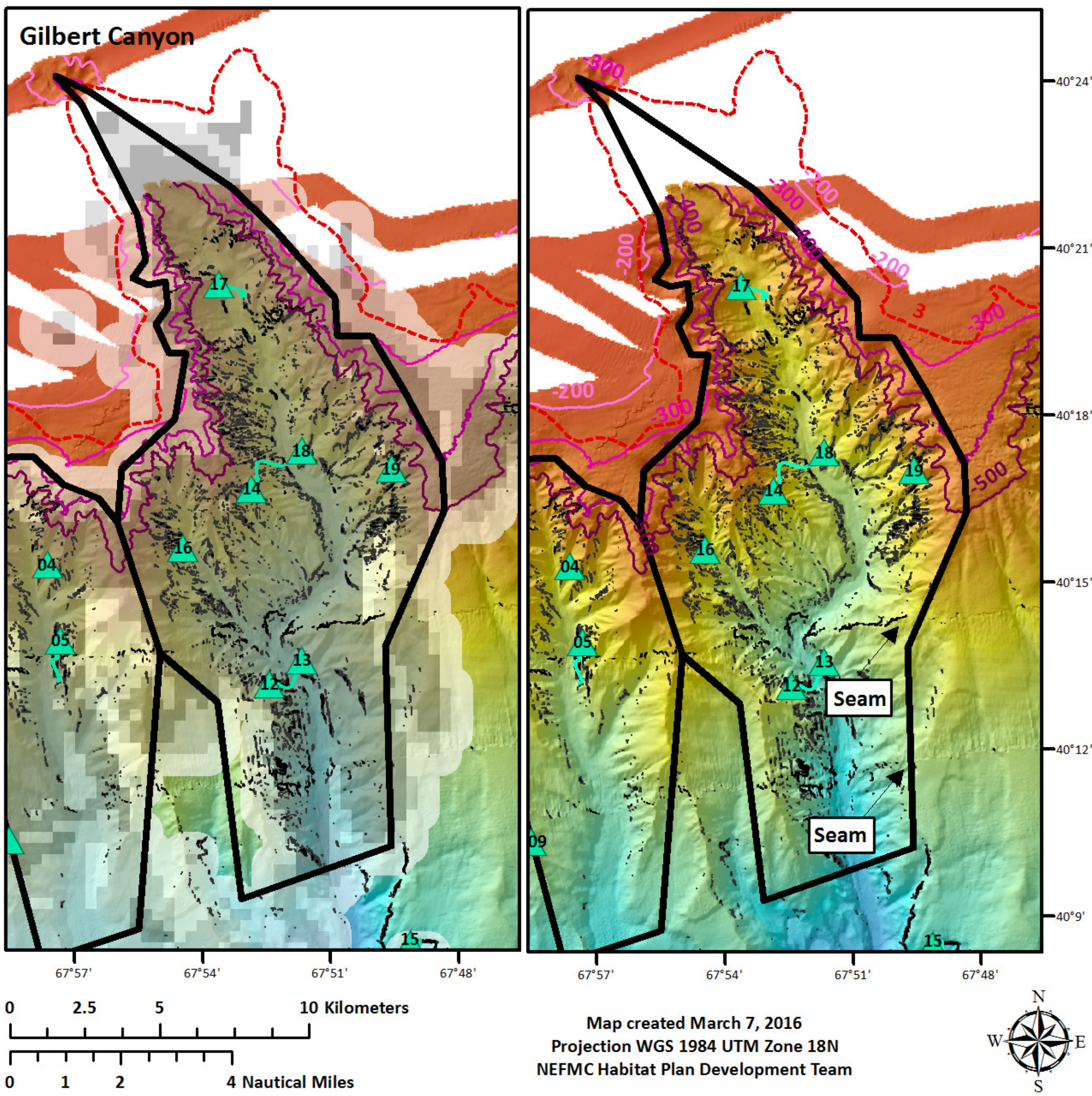
Chebacco Canyon is slope-confined, encompassing an area of approximately 100 km^2. It is larger and steeper than nearby Filebottom. The proposed zone follows the 400-meter depth contour at the head of the canyon. Some of the high slope areas shown on the map are artefacts resulting from seams in the data. Much of the zone is high or very high predicted habitat suitability for soft corals. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 17 – Chebacco Canyon discrete zone



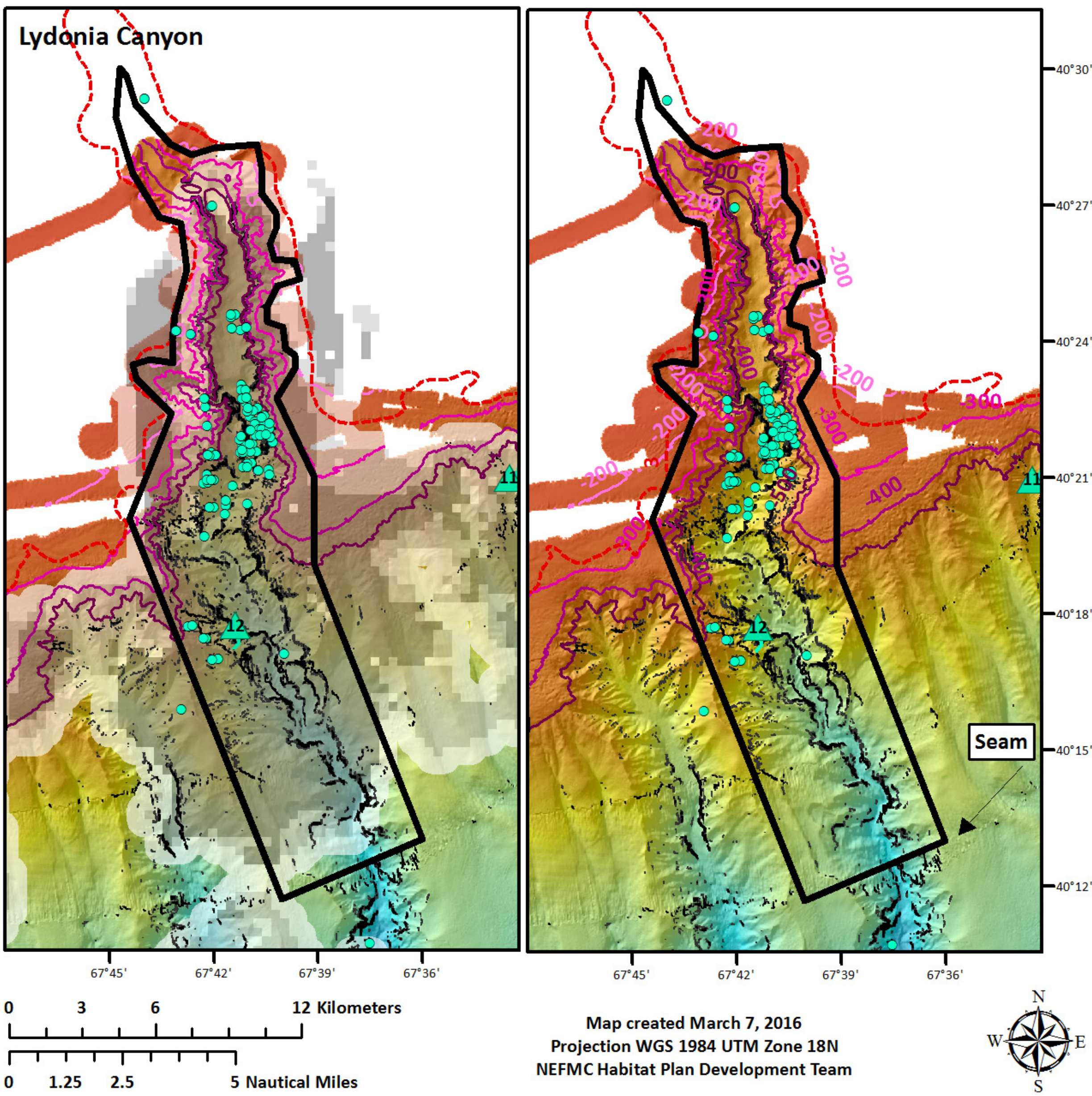
Gilbert Canyon incises the continental shelf break, and has two major branches. The main thalweg is located to the east, and there is another limb to the west. The recommended zone encompasses an area of approximately 175 km^2, following the 300-meter depth contour at the mouth of the canyon. The recommended zone is mapped mostly as very high suitability habitat. There are substantial high slope (greater than 30 degrees) areas encompassed within the proposed zone. A few high slope artefacts are observed due to seams in the bathymetry but these are somewhat difficult to discern on the map. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 18 – Gilbert Canyon discrete zone



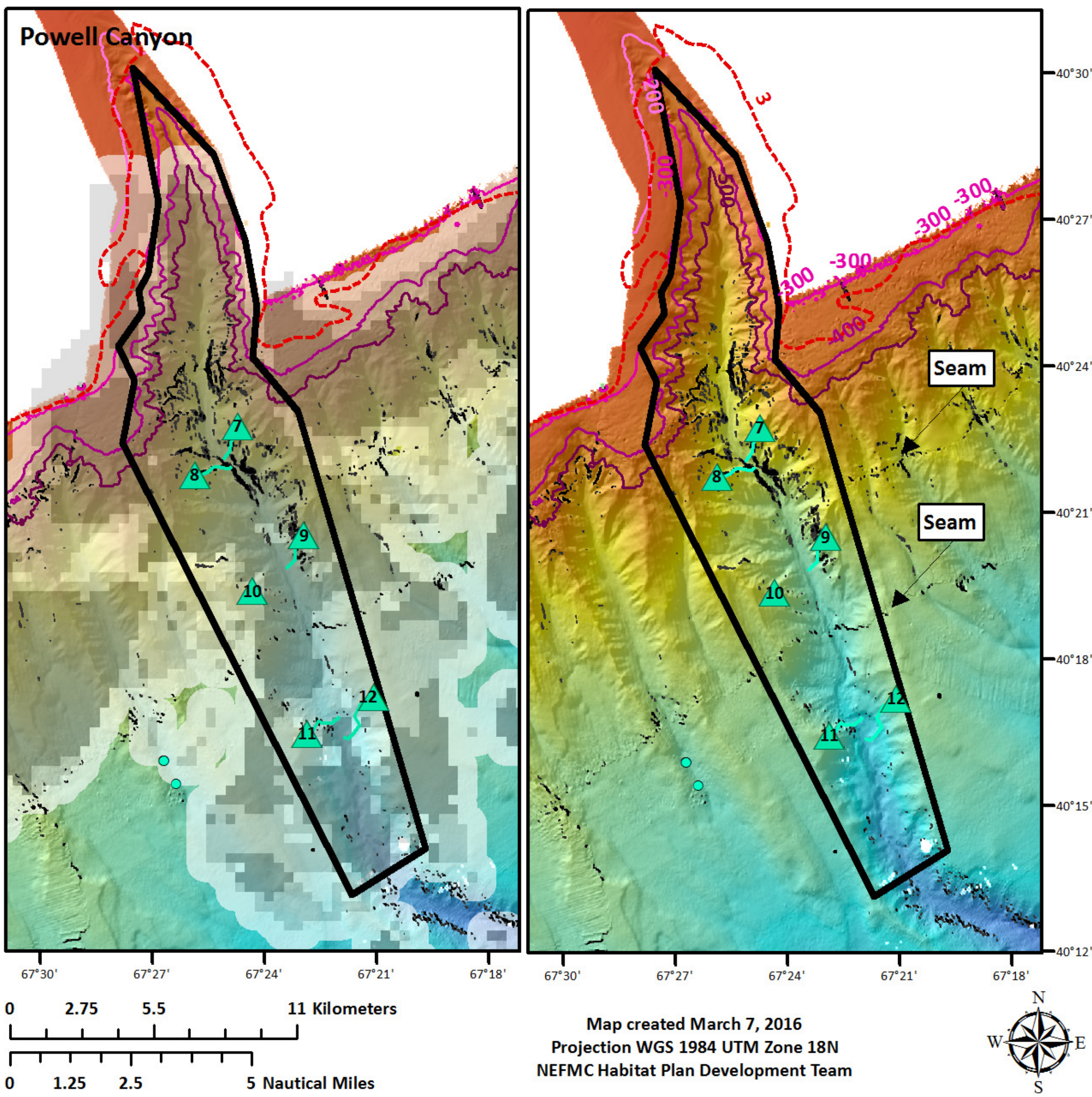
Lydonia Canyon incises the continental shelf break, encompassing an area of over 200 km^2, second in size only to Oceanographer Canyon. The proposed zone follows the 200-meter depth contour at the head of the canyon. Based on the ACUMEN bathymetric data, the proposed zone has a depth range of 142 to 2,249 meters below sea level. Much of the zone is predicted to be highly or very highly suitable habitat for soft corals. In addition, there are areas to the west and east of the boundary which are also predicted to be suitable coral habitat. However, most of the areas of high slope are encompassed within the proposed zone, including within the head of the canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 19 – Lydonia Canyon discrete zone



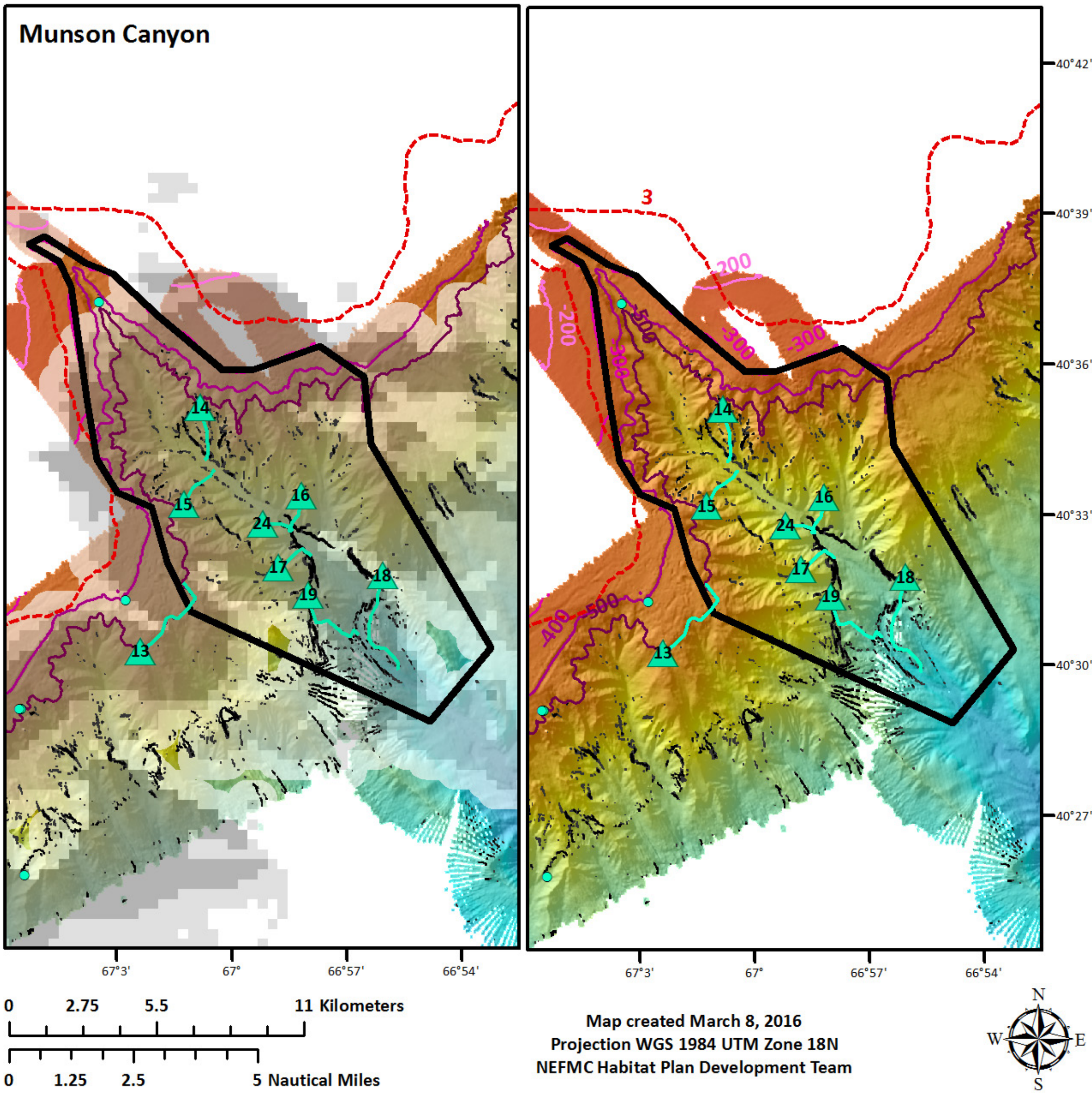
Powell Canyon incises the continental shelf break, encompassing an area of approximately 200 km^2. The proposed boundary follows the 300-meter depth contour along the head of the canyon. The areas predicted to have a high likelihood of coral presence based on the habitat suitability model are also encompassed in the zone, along with the areas identified as high slope areas. The areas of high slope are concentrated just beyond the shelf break and in the deepest parts of the canyon. There is an east-west seam in the data in the middle of the zone. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 20 – Powell Canyon discrete zone



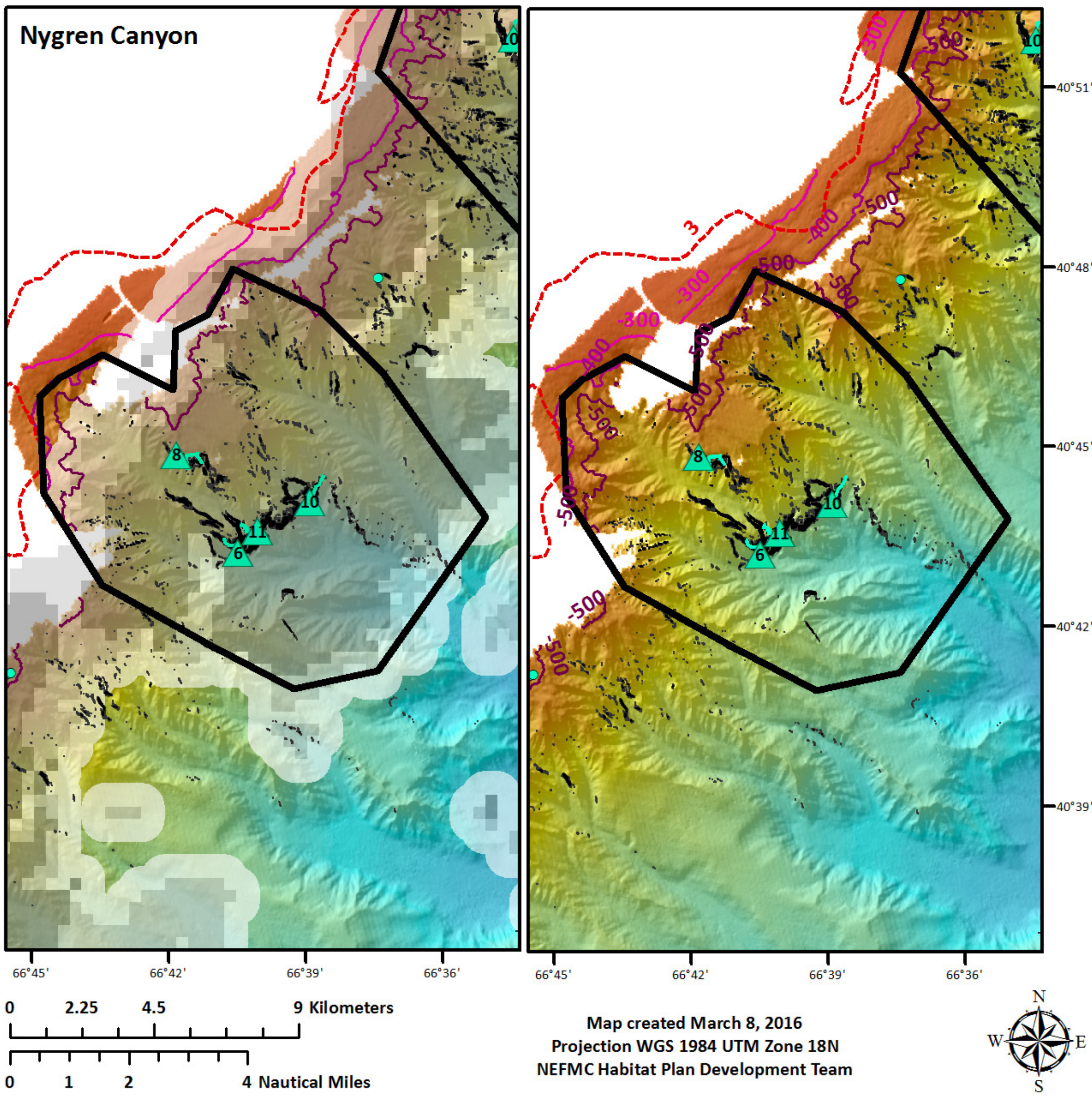
Munson Canyon incises the continental shelf break, encompassing an area of approximately 100 km^2. The proposed boundary follows the 300-meter depth contour along the head of the canyon. Munson has one main branch and a smaller branch to the east. Most of the canyon is identified as having high and very high likelihood of coral presence based on the habitat suitability model. Areas of high slope can be found throughout the zone, except in the shallowest portion of the canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 21 – Munson Canyon discrete zone



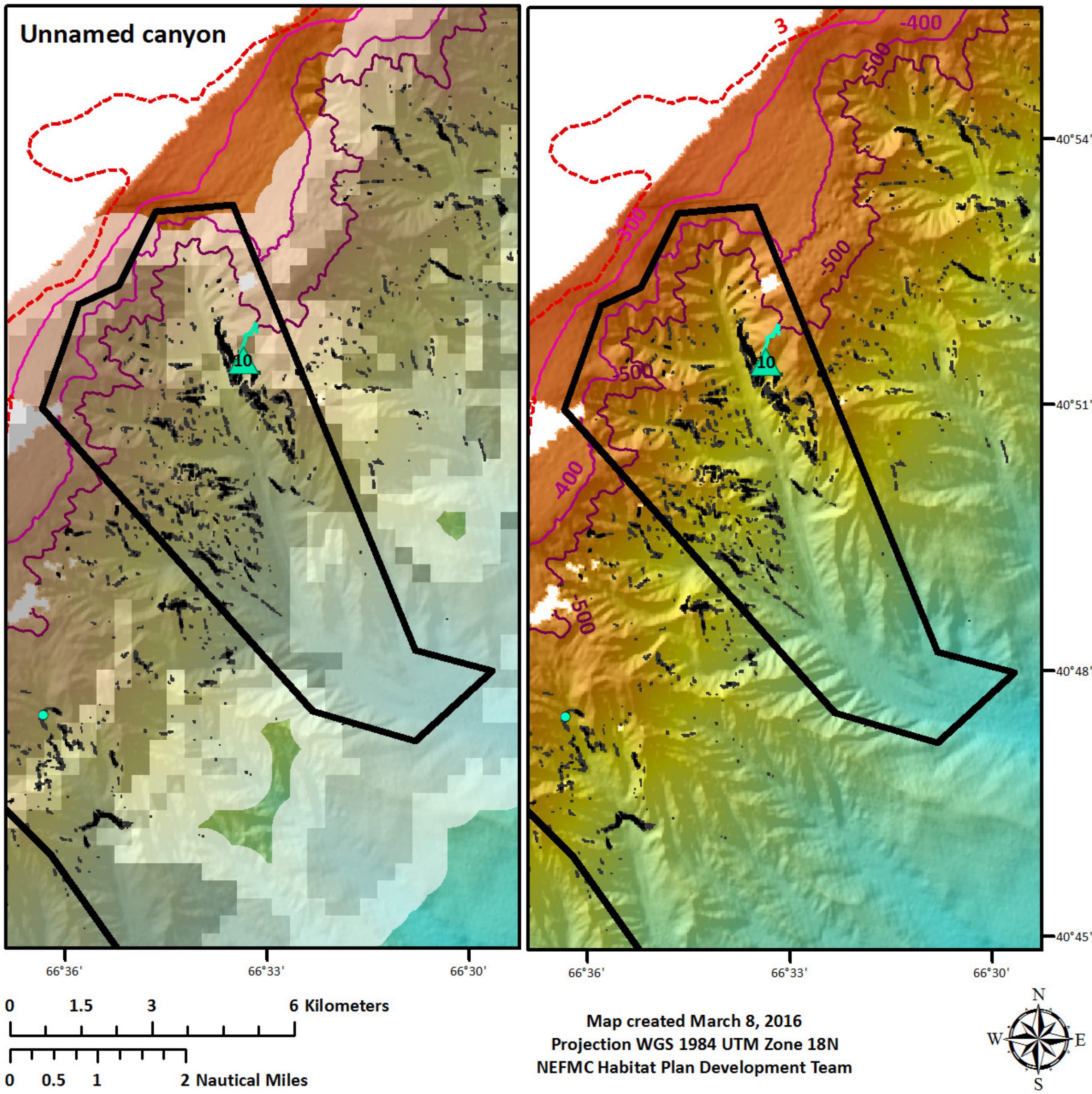
Nygren Canyon is a dendritic, slope-confined canyon that encompasses an area of approximately 100 km^2. The recommended zone follows the 400-meter depth contour along the head of the canyon. Most of the canyon is identified as having high and very high likelihood of coral presence based on the habitat suitability model. Areas of high slope are concentrated in the middle of the proposed zone, but can be found on all major branches of the canyon. The very high suitability areas coincide with the very high slopes. Both the landward and seaward depths of the recommended zone were developed to correspond with the habitat suitability results. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 22 – Nygren Canyon discrete zone



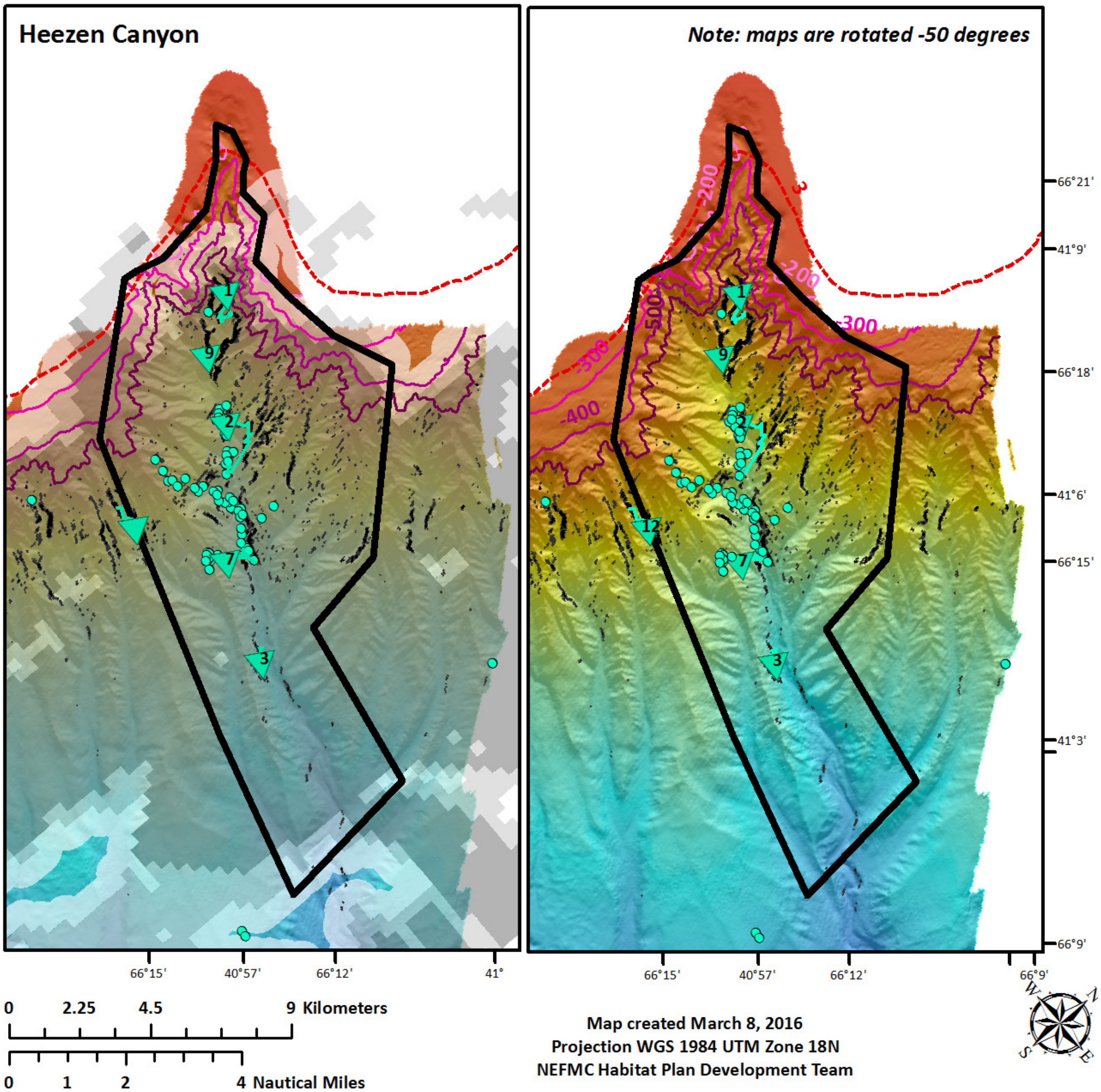
This **unnamed, slope-confined canyon** is relatively small, encompassing an area of approximately 50 km^2. The recommended zone follows the 400-meter contour along the head of the canyon. Most of the canyon is identified as having high or very high likelihood of coral presence based on the habitat suitability model. Areas of high slope can be found throughout the zone, and generally coincide with areas of very high habitat suitability. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 23 – Discrete zone in unnamed canyon located between Heezen and Nygren Canyons



Heezen Canyon incises the continental shelf break, encompassing an area of approximately 125 km^2. The proposed zone follows the 200-meter contour at the head of the canyon. Most of the recommended zone is identified as having high and very high likelihood of coral presence based on the habitat suitability model. Areas of high slope can be found throughout the zone, except in the shallowest and deepest portion of the canyon. Corals have been documented in both the historical and recent data (see section 6.2.3.1 for details).

Map 24 – Heezen Canyon discrete zone



4.2.2.2 Seamount coral zones

This alternative would designate coral zones around the four seamounts within the U.S. EEZ. All of the seamounts combined are shown on Map 38. Options for fishing restrictionsin these zones are described in section 4.3.

All four of the discrete seamount zones are fully encompassed within the Northeast Canyons and Seamounts Marine National Monument and are also fully contained within each of the broad zone alternatives. The seamount zones were developed during 2011-2012, in conjunction with the original set of broad zones and discrete canyon and Gulf of Maine zones. The concept behind designating the seamount zones in conjunction with a broad zone was that the Council might adopt more comprehensive fishing restrictions within the seamount zones as compared to the larger surrounding broad zones. The monument, designated in September 2016, has fishing restrictions that are more comprehensive than what the Council is considering in these areas. Given the monument, the bottom-tending gear restrictions imposed by the Council would have no additional conservation benefit. The only difference is that under the monument designation, restrictions on red crab and lobster pots do not take effect until 2023, and Council regulations prohibiting these gears from fishing on the seamounts could take effect sooner, potentially during 2018. As a practical matter, even prior to monument designation, fishing was not known to occur on the seamounts.

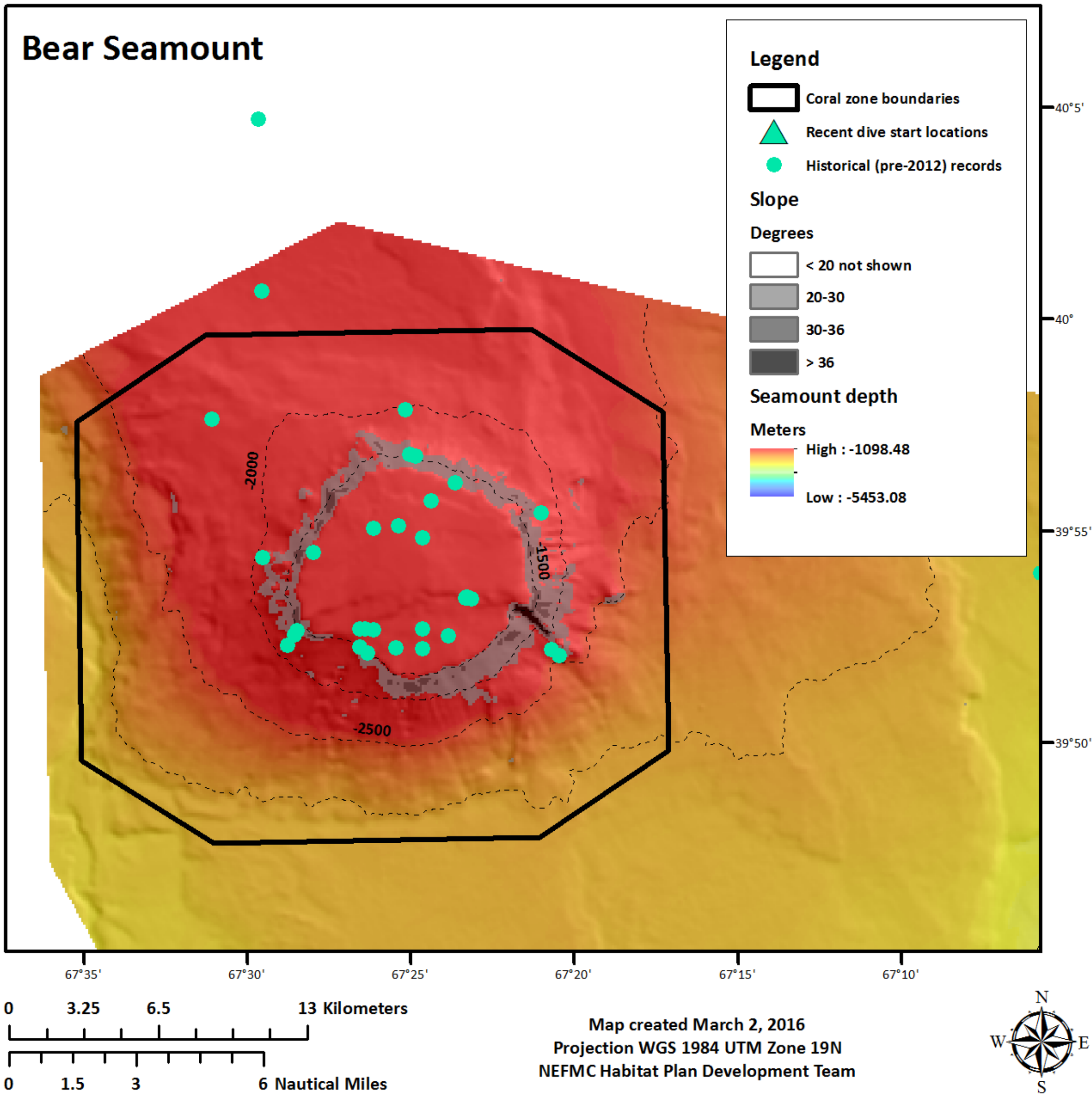
Clarify if the intent is to selet all seamount zones as a group, or individually. The impacts analysis assumes adoption of the seamount zones as a group.

Rationale: Deep-sea corals are known to occur on the seamounts on the basis of ROV and AUV surveys (see section 6.2.3.2 for details).

Method used to define discrete seamount zone boundaries: The four seamounts vary in size, depth range, and slope. The seamount bathymetry data are lower resolution than the canyon data (100 meter vs. 25 meter), but nonetheless provide a clear indication of the spatial extent of each seamount. The boundaries were drawn based on these bathymetry data and are intended to encompass the full extent of each seamount. Areas of high slope are also shown on the maps. In general, there are fewer areas of slope greater than 30° than in the canyons, so areas with slopes greater than 20° are shown. Overall, the seamount zones are somewhat larger than the canyon zones, ranging from approximately 200-500 km^2. Contours are shown in 500 meter intervals. Note that while the depth color shading uses the same coloration as the canyon maps, it is on a different scale.

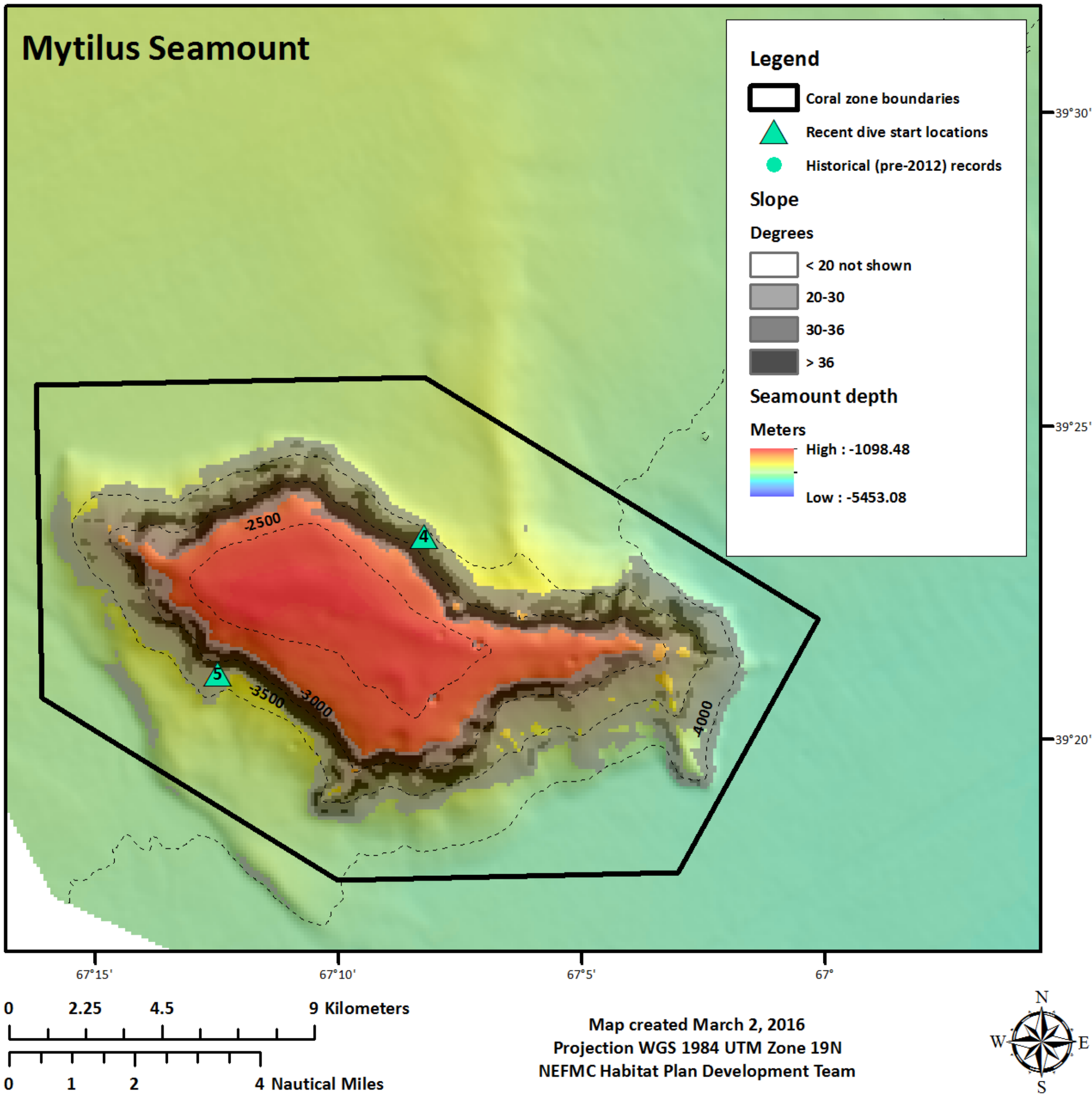
Bear is the largest of the New England seamounts. The summit is approximately 1,100m below sea level, and the base of the seamount is at over 3,000m. While it was not visited during recent (2012-2015) cruises, all four groups of corals (soft, stony, sea pens, and black corals) had been previously documented in the area.

Map 25 – Bear Seamount coral zone boundary



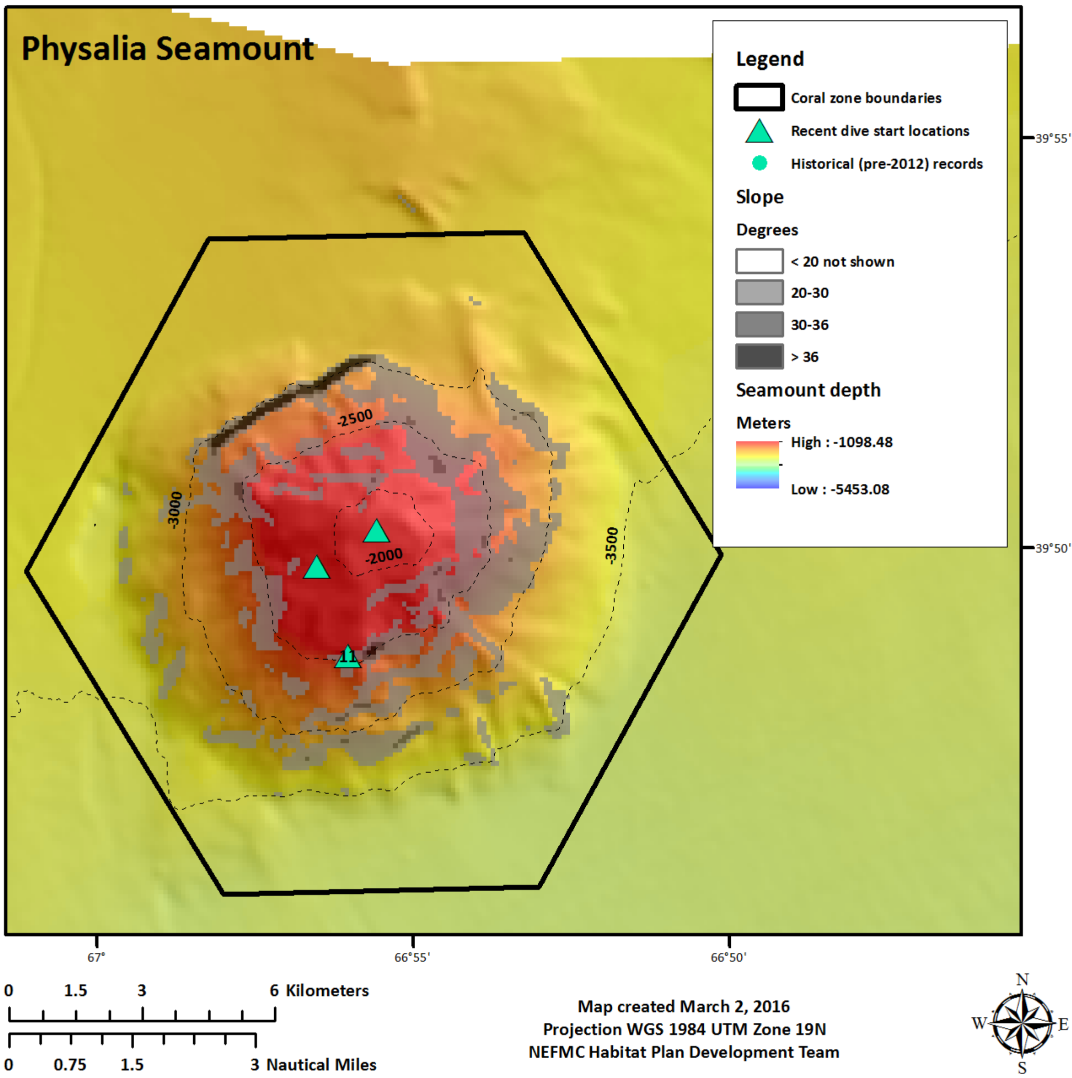
Mytilus is the deepest of the four seamounts, with a minimum depth of 2,396m and a maximum depth within the proposed coral zone boundary of 4,183m. Corals have been documented in recent data only (see section 6.2.3.1 for details).

Map 26 – Mytilus Seamount coral zone boundary



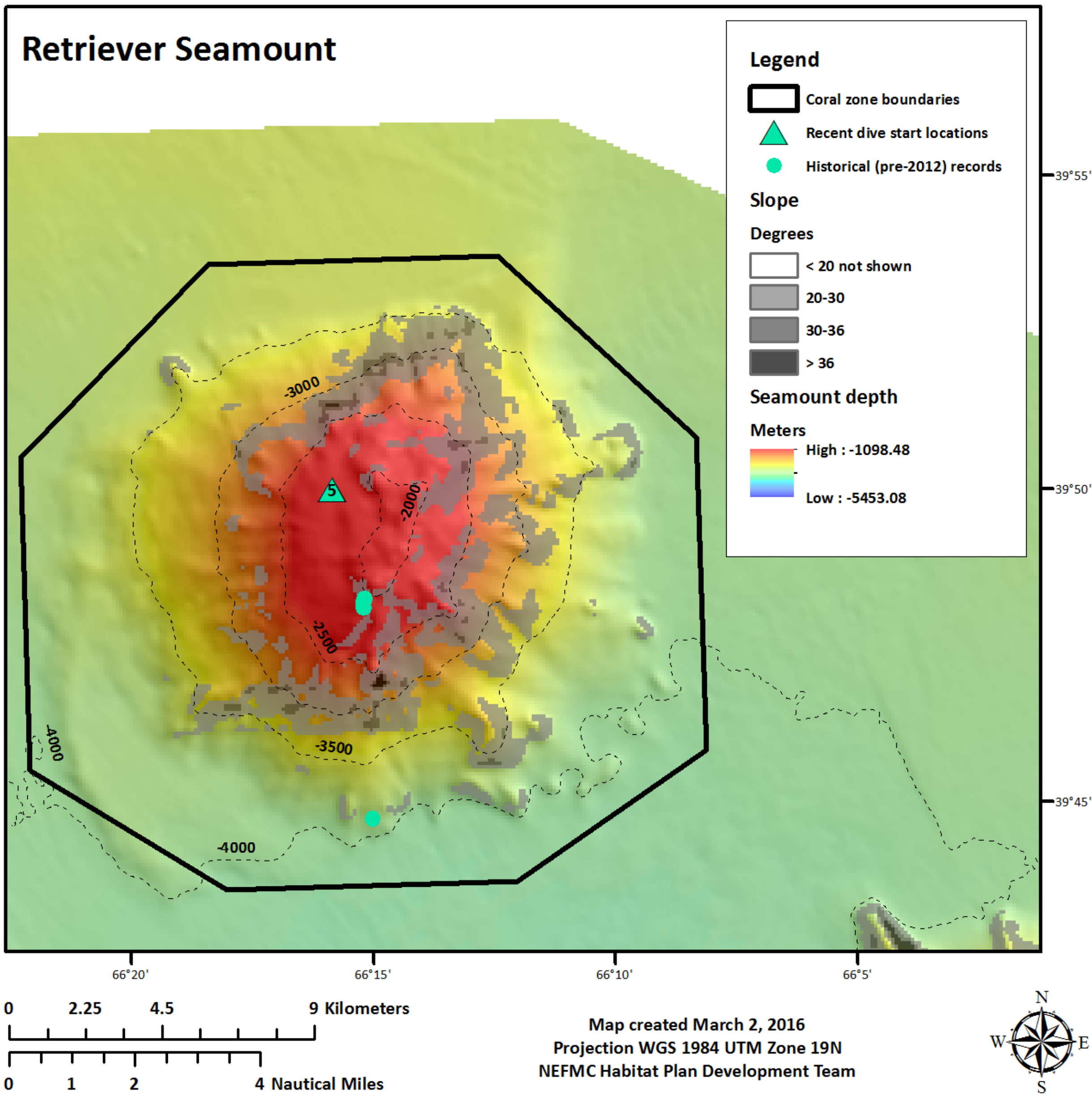
Physalia and Retriever seamounts have similar minimum and maximum depths. The summit of Physalia is at approximately 1,900m, and the deepest part of the proposed zone is at over 3,700m. Physalia was surveyed for the first time in 2012 using AUV technology (Kilgour et al. 2014), and was also observed during a 2014 Okeanos Explorer cruise (see section 6.2.3.2 for details).

Map 27 – Physalia Seamount coral zone boundary



The summit of **Retriever Seamount** is at approximately 1900m, and the deepest part of the proposed zone is at depths of over 4,000m. Corals have been documented in recent data only (see section 6.2.3.2 for details).

Map 28 – Retriever Seamount coral zone boundary



4.2.2.3 Gulf of Maine coral zones

Deep-sea corals have been known to occur in the Gulf of Maine since the 19th century (Watling and Auster 2005), but targeted camera surveys to assess coral distribution have been conducted only in the last fifteen years, with most of this type of survey activity occurring since 2013. Recent activities include both towed camera and ROV dives in various locations throughout the Gulf (see Auster et al. 2014, Auster et al. 2014 for details on 2013 and 2014 cruises). Coral habitats observed during 2002, 2003, and 2013-2015 surveys were classified as either low density corals or coral gardens. A density of 0.1 colonies per m^2 is the threshold that the International Council for the Exploration of the Sea (ICES) used to define coral garden habitat (ICES 2007). Coral habitats in some areas of the Gulf of Maine exceed the coral garden threshold density (see sections below for details), although coral management zones are recommended in areas with both classifications. The recommended zones are Outer Schoodic Ridge, Mount Desert Rock, three sites in Western Jordan Basin, one site in Central Jordan Basin, and Lindenkohl Knoll, which is in Georges Basin. All sites with multiple dive observations, specifically Outer Schoodic Ridge, Mount Desert Rock, the 114 Bump site in Western Jordan Basin, Central Jordan Basin, and Lindenkohl Knoll, had at least one dive where coral garden habitats were found.

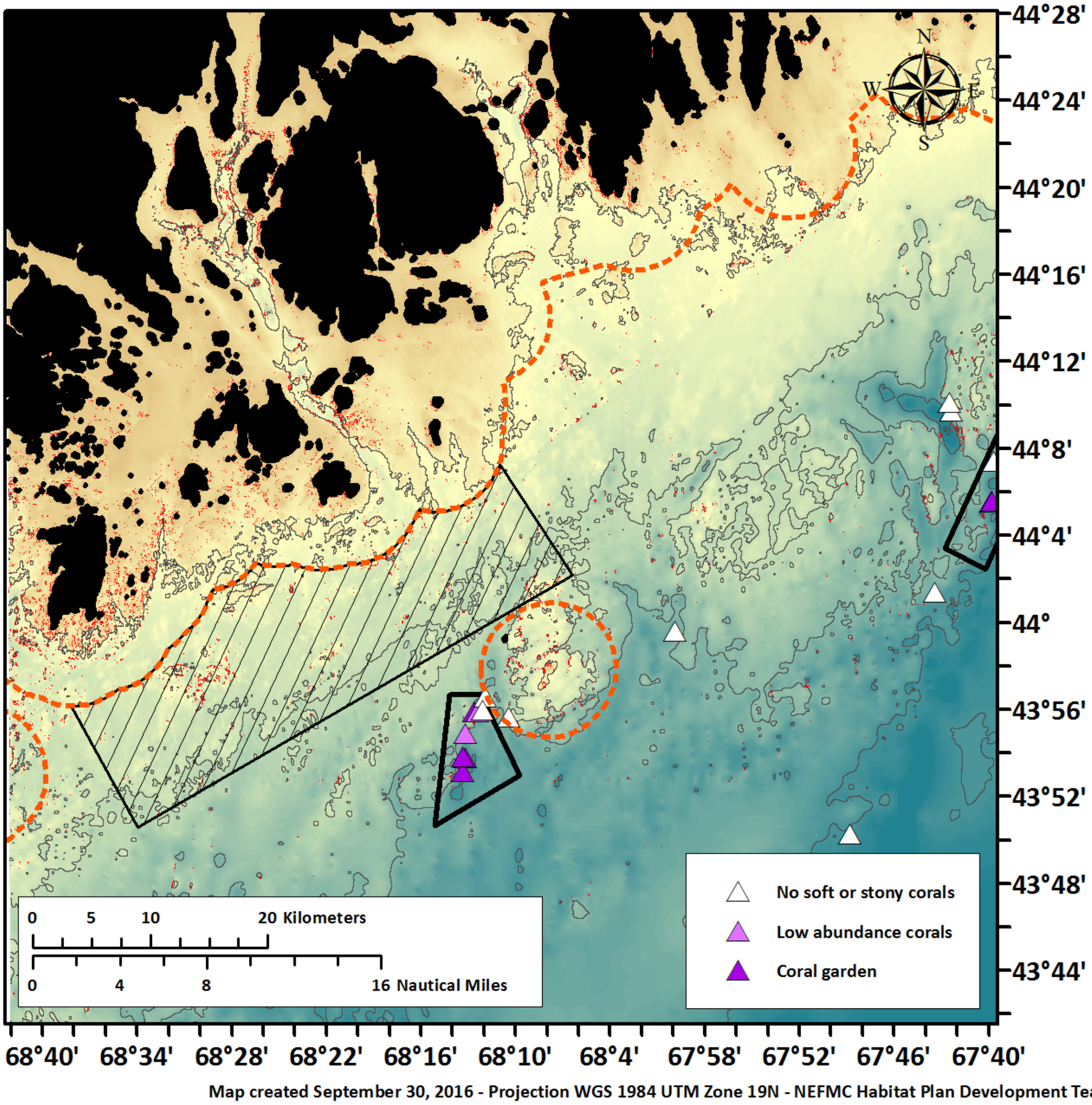
In general, the boundaries of the recommended coral zones were developed to encompass dive sites where corals were positively identified. Other recently collected data that inform the delineation of coral zones include high resolution multibeam bathymetry in the Outer Schoodic Ridge and Western Jordan Basin regions. Because the spatial extent of high resolution bathymetric data is limited, it is not possible to delineate zone boundaries based on full spatial extent of specific terrain features, as is the case with the canyon and seamount sites. However, the bathymetric data confirm the presence of similar terrain at sampled locations and nearby unsampled locations, such that suitable habitat can be inferred beyond the dive sites.

4.2.2.3.1 Mount Desert Rock

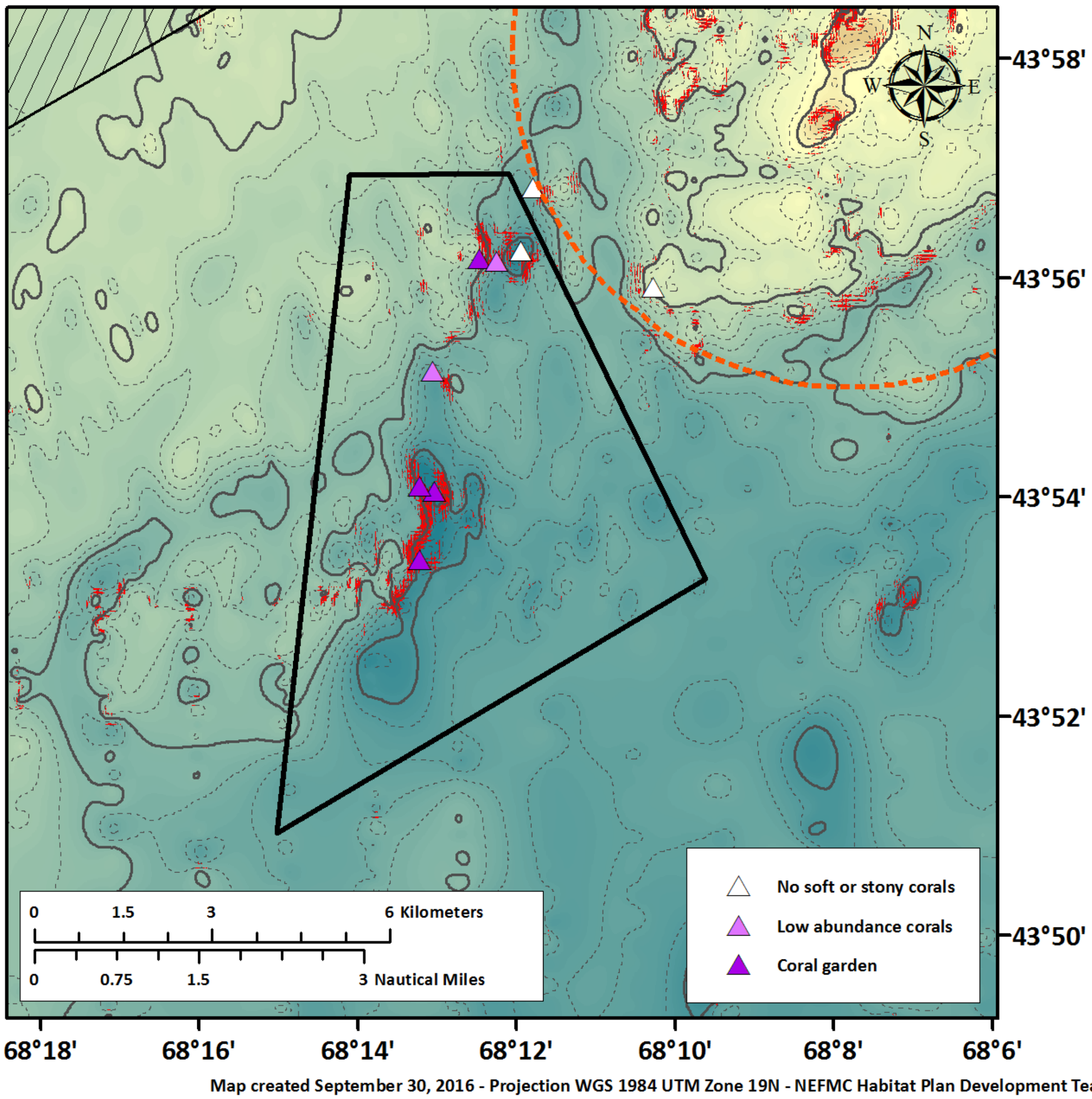
This alternative would designate a coral zone southwest of Mount Desert Rock, a small, rocky island off the eastern Maine coast, about 20 nm south of Mount Desert Island (Map 29). The proposed coral zone lies just outside state waters, and has depths ranging from approximately 100m to 200m (Map 30). The coral zone encompasses an area of approximately 47 km^2/18 mi^2. Options for fishing restrictions in this zone are described in Section 4.3.

Rationale: Corals have been documented in both the historical and recent data (see section 6.2.3.3 for details).

Map 29 – Regional siting of Mount Desert Rock Coral Zone (heavy black outline). The hatched area is the Eastern Maine Habitat Management Area adopted via Omnibus EFH Amendment 2 as a mobile bottom-tending gear closure. State waters are outlined in orange.



Map 30 – Mount Desert Rock Coral Zone, including recent dive locations and relative abundance of corals. Contours are in 10 m intervals with 50 m intervals highlighted.

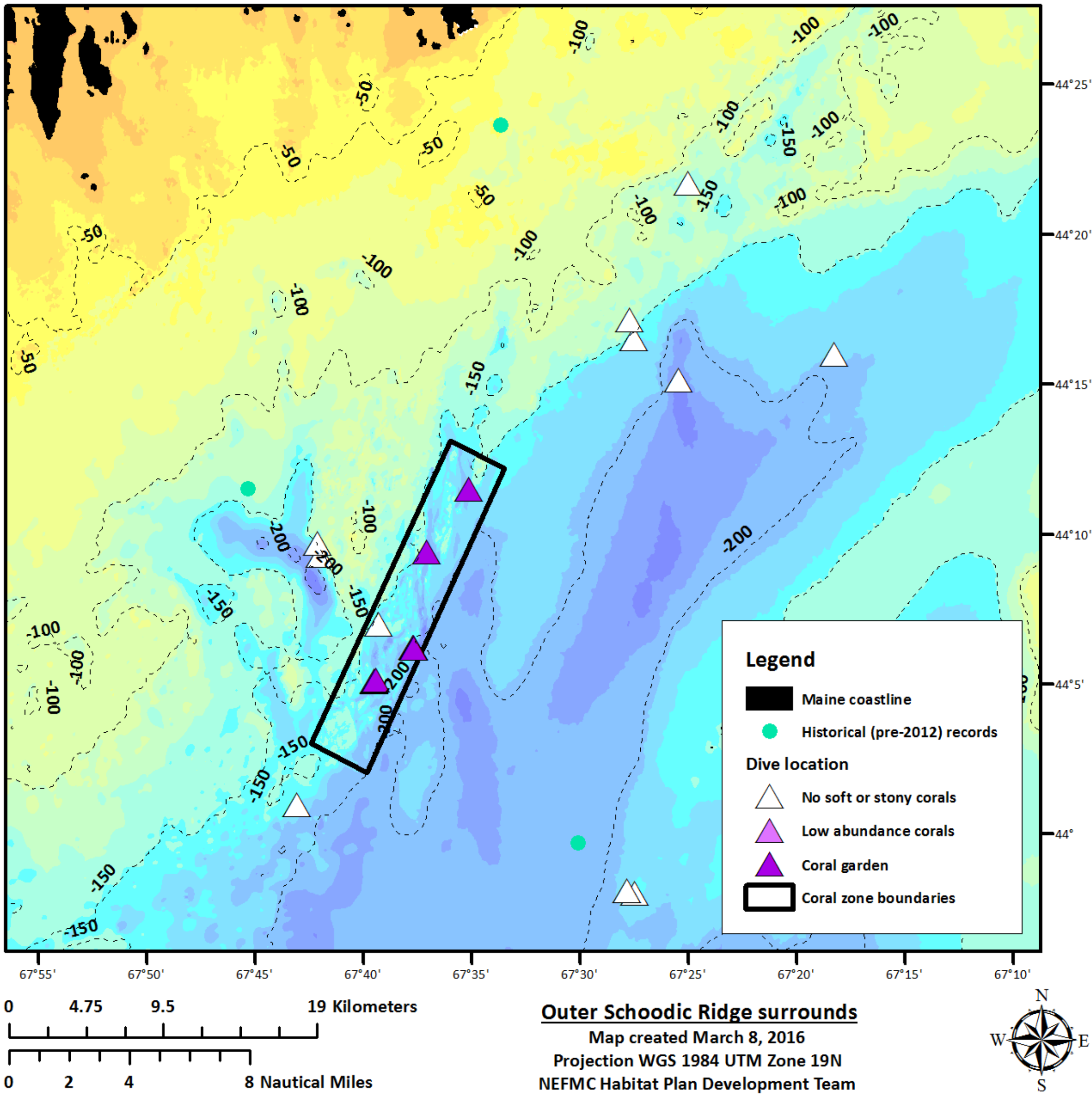


4.2.2.3.2 Outer Schoodic Ridge

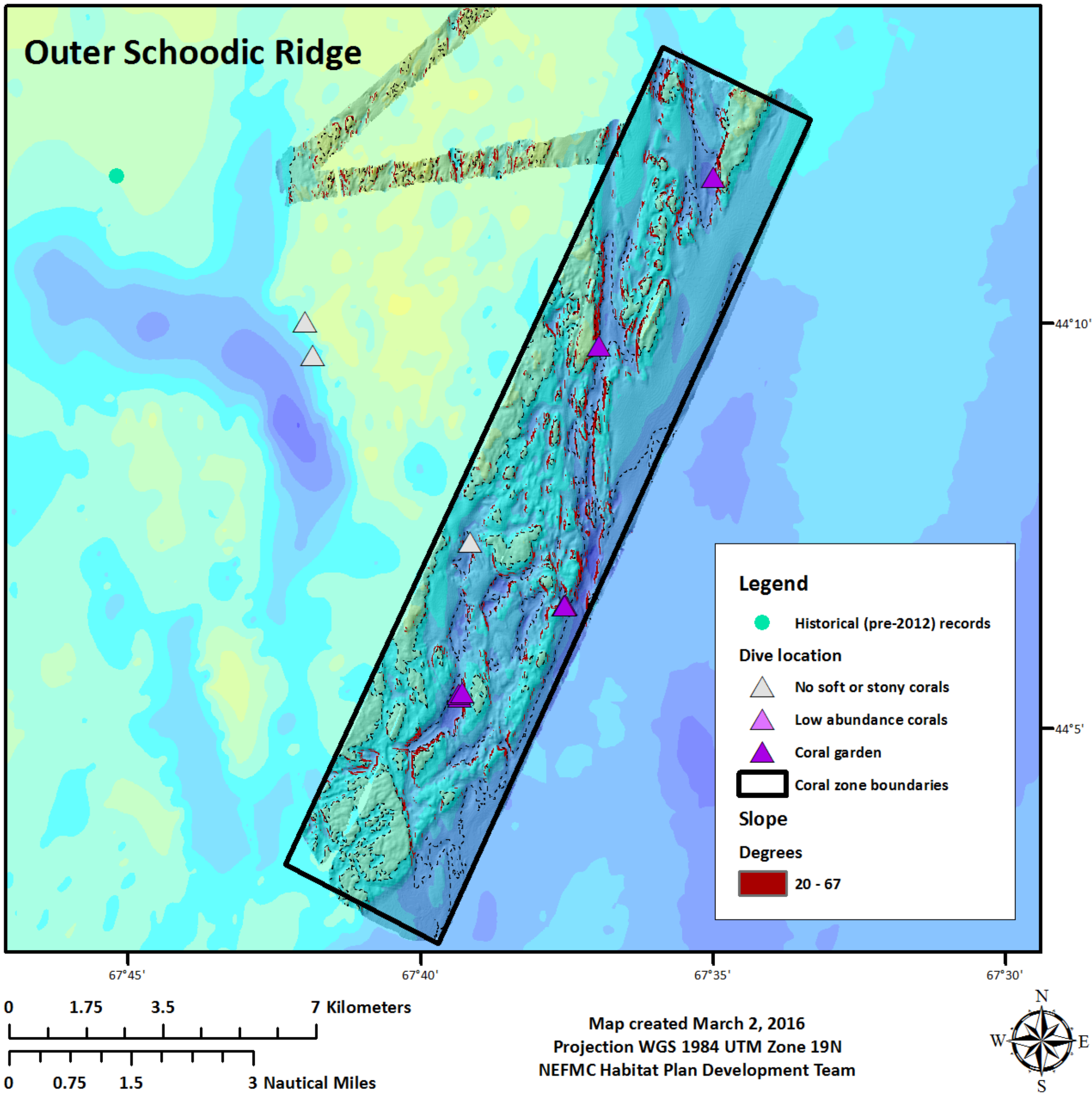
This alternative would designate a coral zone on the Outer Schoodic Ridge, roughly 25 nm southeast of Mt. Desert Island (Map 31), within Statistical Area 511 and Maine Lobster Management Zone A. The coral zone encompasses a portion of the ridge that has been recently mapped with multibeam and surveyed using ROV. Recent high resolution bathymetric mapping details the complex, slot canyon terrain in the area. These data indicate that depths in the recommended zone range from 104m to 248m, with a mean depth of 174m. The coral zone is approximately 79 km^2/31 mi^2. Options for fishing restrictions in this zone are described in Section 4.3.4.

Rationale: Corals have been documented in both the historical and recent data (see section 6.2.3.3 for details). Corals at this location were studied during eight ROV dives and two camera tows during 2013, 2014, and 2015. Steeply sloped features that are likely to provide suitable attachment sites for corals are found in the vicinity of the dive sites, throughout the area with high resolution bathymetry data. Based on the presence of steep terrain, the entire footprint of this dataset, aside from a small amount of data to the west of the area in shallower waters, is recommended as a coral zone. It is possible that there are additional corals outside the recommended zone boundaries, but corals were not observed during dives at similar depths nearby (Map 31).

Map 31 – Area surrounding the Outer Schoodic Ridge Coral Zone. Contours are at 50 meter intervals. Relative coral densities during recent dives are shown in purple shading.



Map 32 – Outer Schoodic Ridge Coral Zone and high resolution bathymetry. Areas of high slope are shown in red. Relative coral densities during recent dives (triangles) are shown in purple shading.



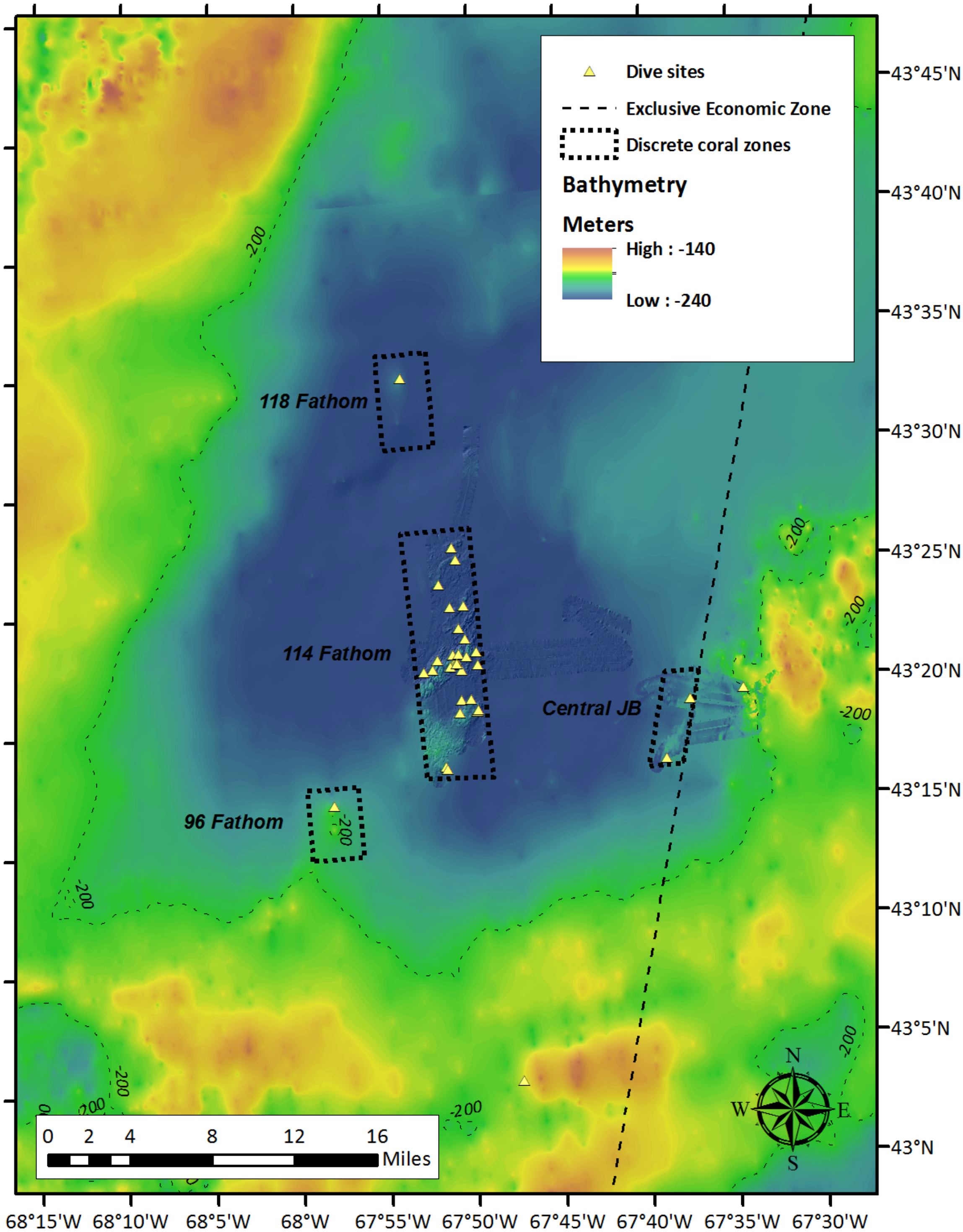
4.2.2.3.3 Jordan Basin

This alternative would designate four coral zones in Jordan Basin, which would be selected as a group. Jordan Basin straddles the EEZ boundary, has depths ranging from approximately 175 to 250 meters. Deep-sea corals have been observed on shallower rocky features within the basin, which are named for their charted depths: 98 Fathom Bump (179m), 114 Fathom Bump (208m), and 118 Fathom Bump (216m). A site in Central Jordan Basin encompasses depths of approximately 220m to 235m. All four sites are shown on Map 33. They areas range in size: Central Jordan Basin 19 km^2/7 mi^2, 96 Fathom Bump 23 km^2/9 mi^2, 118 Fathom Bump 39 km^2/12 mi^2, 114 Fathom Bump 103 km^2/40 mi^2. The 114 Fathom Bump and its immediate surrounds is the best mapped of these four sites, and has the greatest number of dives (Map 34). According to the high resolution multibeam bathymetry, depths in the recommended zone range from 208m to 276m, with a mean depth of 240m.

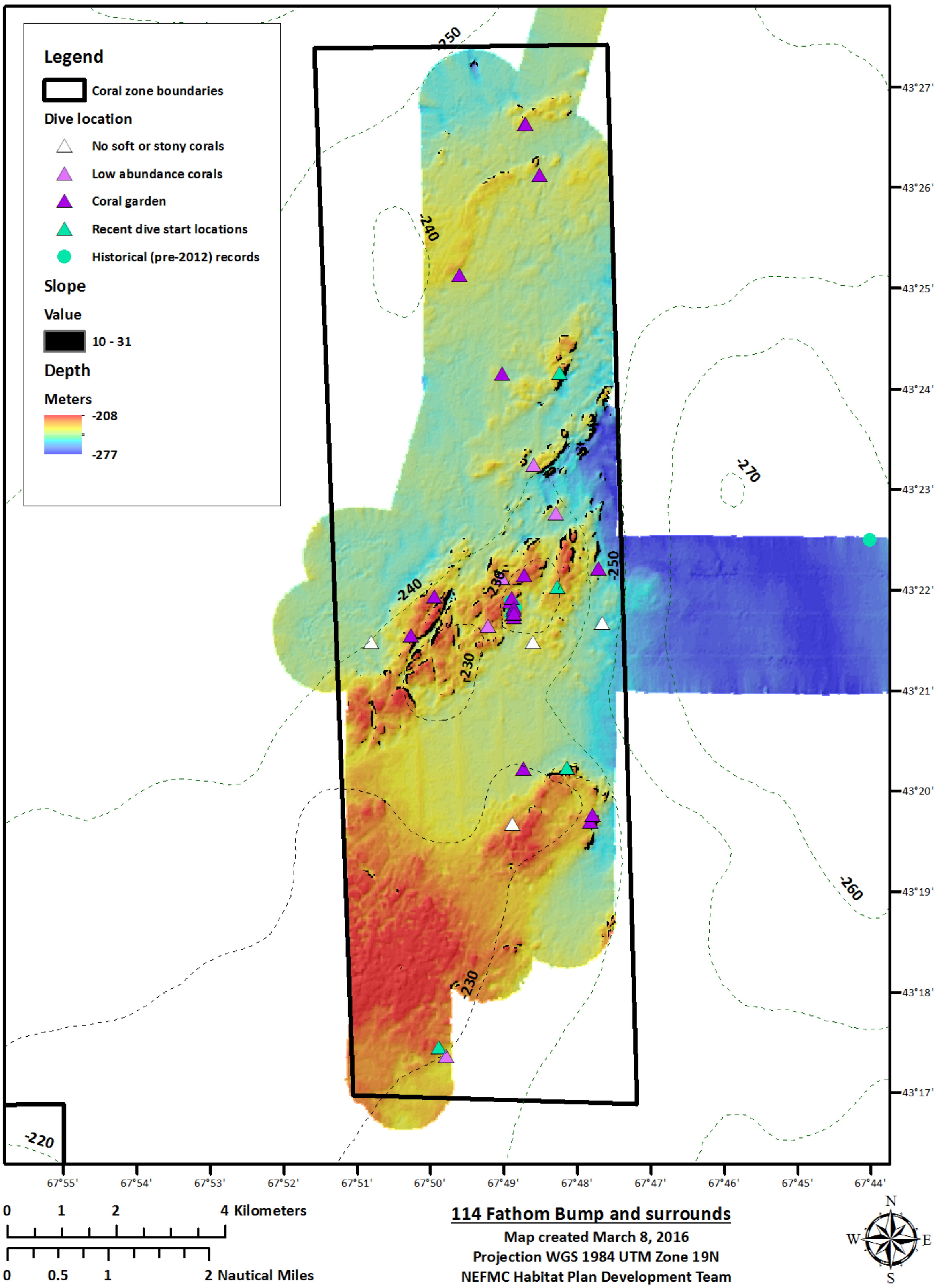
Options for fishing restrictions in this zone are described in Section 4.3.

Rationale: This zone would protect coral habitats in Jordan Basin from the impacts of fishing gear.

Map 33 – Discrete coral zones in Jordan Basin.



Map 34 – Larger scale image of the high resolution bathymetry at the 114 Fathom Bump zone. This map uses a different color scale than the previous map of the Western/Central Jordan Basin region.

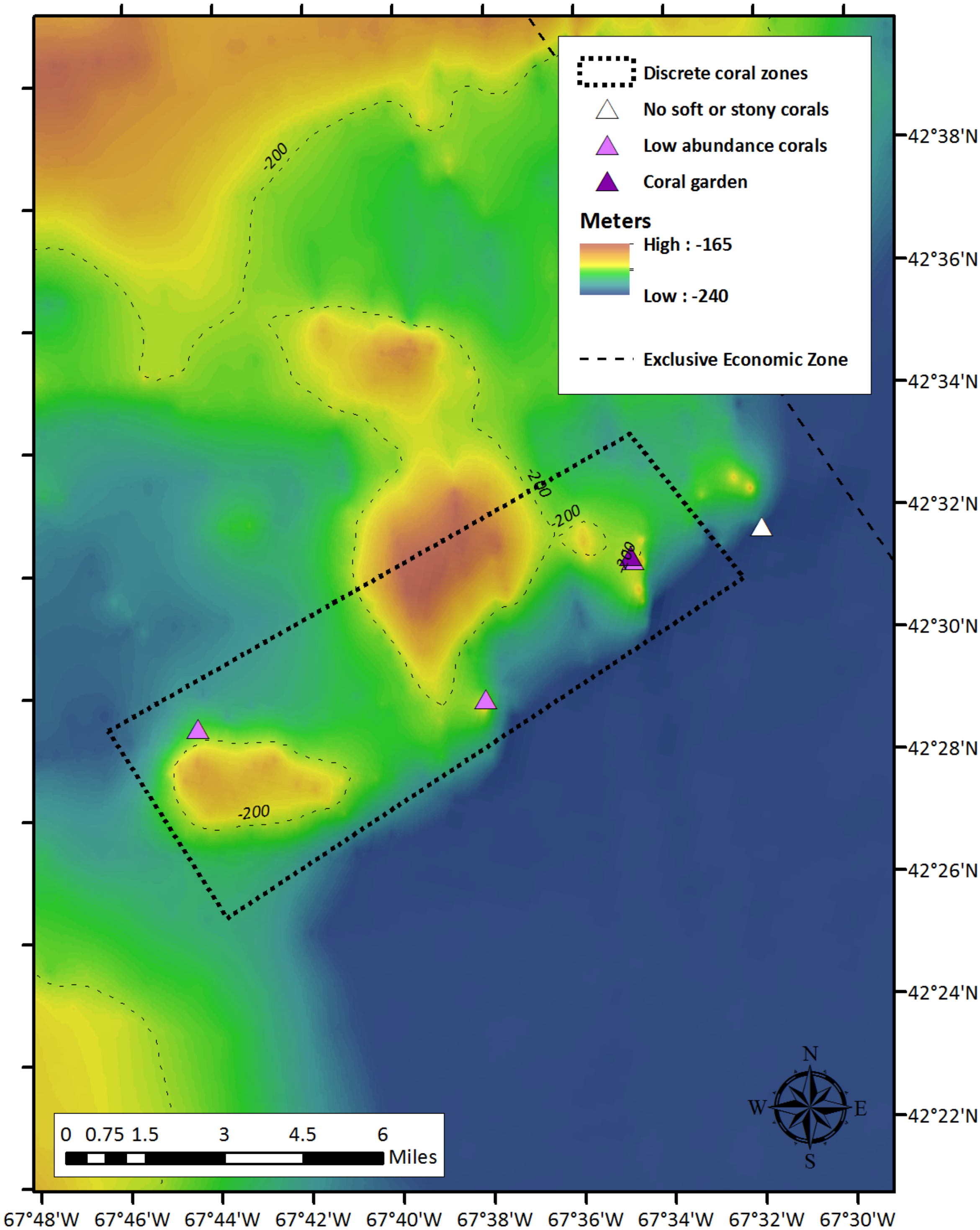


4.2.2.3.4 Lindenkohl Knoll

This alternative would designate a coral zone at Lindenkohl Knoll within Georges Basin, which is just north of Georges Bank, and includes the deepest waters in the Gulf of Maine (approximately 200 fa, over 360 m). Lindenkohl Knoll is a somewhat shallower feature on the western side of Georges Basin, roughly 25 miles north of the northern edge of Georges Bank. The eastern boundary of the Lindenkohl Knoll Coral Zone is just over two nautical miles from the Hague Line. The recommended zone is approximately 114 km^2 (44 mi^2) and has depths ranging from approximately 165m to 255m. Corals have been documented in recent data only (see section 6.2.3.3 for details). Options for fishing restrictions in this zone are described in Section 4.3.

Rationale: This zone would protect coral habitats at Lindenkohl Knoll from the impacts of fishing gear.

Map 35 – Recommended Lindenkohl Knoll coral zone.



4.3 Fishing restriction options for coral zones

The following range of fishing restriction alternatives are under consideration within the coral zones described above. Different measures could be used in broad vs. discrete zones, or in different discrete zones, depending on the fisheries that occur there and the degree of precaution desired. Note that broad and discrete zones could be used in combination, with different types of measure applied in each.

4.3.1 Option 1. Prohibit bottom-tending gears

This option would prohibit the use of bottom-tending fishing gears in deep-sea coral zones, but would allow the use of gears that do not contact the seabed. Restricted gear types would include bottom-tending otter trawls, bottom-tending beam trawls, hydraulic dredges, non-hydraulic dredges, bottom-tending seines, bottom-tending longlines, sink or anchored gillnets, and pots and traps. This list is intended to be comprehensive, but some of these gears may not be active in the coral zones currently. Pots and traps could be exempted from this restriction by adopting one or both of the sub-options listed below in combination with this alternative.

Vessels may transit the coral zones provided bottom-tending trawl nets are out of the water and stowed on the reel and any other fishing gear that is prohibited in these areas is onboard, out of the water, and not deployed. Fishing gear would not be required to meet the definition of “not available for immediate use” in 50 CFR § 648.2. These transit provisions are consistent with those adopted by the Mid-Atlantic Fishery Management Council for their coral zones, which went into effect on January 13, 2017.

4.3.1.1 Sub-option A: Exempt the red crab fishery from coral zone restrictions

This sub-option would exempt the red crab trap fishery from bottom-tending gear restrictions. This exemption would be limited to vessels fishing under a limited access red crab permit (Category B or C).

4.3.1.2 Sub-option B: Exempt other trap fisheries from coral zone restrictions

This sub-option would exempt vessels in all other pot and trap fisheries from coral zone restrictions. This exemption would cover vessels fishing for lobster and Jonah crab with federal waters lobster permits, as well as any other vessels fishing with traps or pots.

4.3.2 Option 2. Prohibit use of mobile bottom-tending gears

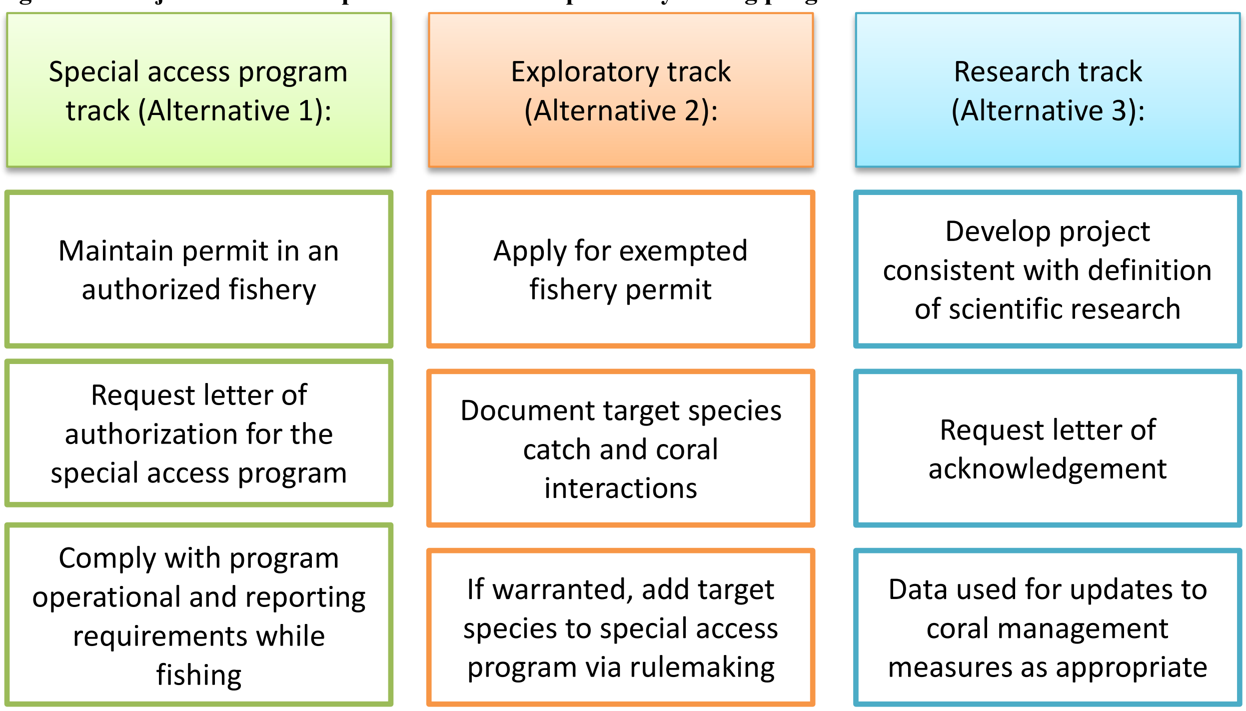
This option would prohibit the use of mobile bottom-tending fishing gears in deep-sea coral zones, but would allow the use of fixed gears and any gears that do not contact the seabed. Restricted gear types would include bottom-tending otter trawls, bottom-tending beam trawls, hydraulic dredges, non-hydraulic dredges, and bottom-tending seines. This list is intended to be comprehensive, but some of these gears may not be active in the coral zones currently.

Vessels may transit the coral zones provided bottom-tending trawl nets are out of the water and stowed on the reel and any other fishing gear that is prohibited in these areas is onboard, out of the water, and not deployed. Fishing gear would not be required to meet the definition of “not available for immediate use” in 50 CFR § 648.2. As above, these transit provisions are consistent with those adopted by the Mid-Atlantic Fishery Management Council.

4.4 Special fishery programs for coral zones

The alternatives in this section would create programs to allow special access fishing, exploratory fishing, and/or research activities within coral zones (comparison in Figure 2). The concepts in these alternatives come from existing special access programs in the groundfish, scallop, and herring fisheries, the exempted fishing permit process, and the Northwest Atlantic Fishery Organization exploratory fishing program. One or more of the action alternatives could be selected, in any combination, or Alternative 1/No Action.

Figure 2 – Major elements of special access and exploratory fishing programs within coral zones



4.4.1 Alternative 1/No Action: No special programs for access, exploratory fishing, or research tracking requirements

Under Alterantive 1/No Action, the Council would not develop any new programs for special access or exploratory fishing, and would not request that researchers ask for a letter of acknowledgement.

4.4.2 Alternative 2. Special access program fishing

This alternative would implement a special access program within some or all of the deep-sea coral zones. The objectives of the program would be as follows:

(1) To allow for continued fishery access to some or all coral areas
(2) To ensure that such fishing does not conflict with coral conservation objectives

This program would generate sufficient data to understand fishing distributions in coral zones, as well as interactions between fishing and corals. The intention here is to specify in detail the possible the operational requirements for a vessel that wishes to fish within a coral zone.

The main distinction between this program and a categorical exemption from gear restrictions for the red crab fishery (section 4.3.1.1) or other trap fisheries (section 4.3.1.2) is that this program could have additional reporting requirements and/or spatial restrictions, while fisheries under categorical exemption would operate under current restrictions with no additional reporting requirements.

Which vessels? A program to allow fishing activities in specified deep-sea coral zones could potentially apply to any vessel that is restricted from operating in a particular coral zone according to the measures selected in section 4.3 (fishing restrictions for coral zones). This could include vessels fishing with any type of bottom tending gear, or only those fishing with mobile bottom-tending gear, depending on the alternative selected. Alternatively, the Council could restrict participation in special access programs to vessels participating in specific fisheries, based on permit type.

Which areas? The Council would need to determine where special access program fishing would be allowed. Such activities could be authorized in all designated coral zones, or only in certain coral zones. Areas authorized for a special access fishery could vary by fishery to include only those areas fished currently or in the recent past. Sub-areas of broad zones might also be appropriate.

Operational requirements: When fishing in an exempted/special access fishing program in a coral area, vessel operators could be subject to additional requirements. These might include:

1. *Gear requirements:* The Council may wish to specify gear restrictions that are different from what is currently authorized under the various FMPs in order to better protect corals from fishing impacts. This could include limits on rollers or rockhoppers, for example.
2. *Seasonal requirements:* This is an element of some existing special access programs and is listed for completeness, but would probably not be necessary here. Corals are almost certain to be equally vulnerable to fishing impacts year round.
3. *Total amount of effort or target species landings:* The Council could specify the number of trips allowed for each vessel authorized in the special access program in order to limit the total amount of fishing that could occur in coral areas. Or, the Council could consider exemptions from certain fishery regulations when operating in coral zones. For example, trip limits might be counterproductive to conservation objectives if discarding occurs and additional bottom time is therefore required to land the same amount of the target species. Ensuring coral protection should remain the focus though. In the case of corals, effort limitation might not be a useful tool because the impact/recovery relationship is such that

the initial impact is most damaging, such that any effort occurring in locations with lots of corals could be problematic from a conservation standpoint. This underscores the importance of only allowing special access fishing to occur in locations where interactions between that type of fishing and the coral types known or thought to occur would be minimal to begin with.

4. *Move-along provision if any corals are caught:* This type of provision would require the vessel to stop fishing if corals are encountered and move to a new location. The Council could specify a zero or non-zero threshold of coral bycatch that would trigger a move-along clause. While the Northwest Atlantic Fisheries Organization (NAFO) has advanced the use of such approaches, these types of thresholds are difficult to develop because coral catch rates vary by coral species, gear and area (Auster et al. 2010). Whether the threshold is zero or non-zero, this type of provision would require the vessel operator to be able to identify corals in the catch.
5. *Coral retention requirement:* Would require any corals caught to be retained and brought back to shore for analysis, to determine the species caught.
6. *Reporting requirements:*
   a. For vessels that are equipped with one as a requirement of a fishery they participate in, use of a vessel monitoring system with half-hourly polling
   b. Enhanced documentation of fishing location and catch. For each tow of mobile gear or set of fixed gear:
      i. Start and end location and depth of all tows
      ii. Catch weights by species, including target and non-target fishes and invertebrates identified to the lowest taxonomic level possible
      iii. Alternatively, use an observer.
   c. File fishing vessel trip reports as usual.

Letter of authorization: A special access program would likely require a letter of authorization. The fishing that would occur under the letters of authorization typically needs to meet a range of requirements. These types of information could be included in the request:

1. Vessel identifying information and point of contact
2. Must be filed by the application deadline. A deadline would need to be specified so that vessel owners would know how far in advance they need to request a letter of authorization. In the case of research-related exempted fishery permits, the project proponents are asked to apply 60 days before the permit is to be used. Requests could be submitted on a rolling basis, similar to research-related applications, or only within a certain window each year. If the latter option is selected, the deadline could be 60 days before the start of a particular fishing year, or the deadline might be the same for all fisheries (e.g., November 1 to take effect January 1 of the following year).
3. Target and incidental species expected to be harvested and discarded:
   a. For species regulated under a federal FMP, it is assumed all size limits, possession limits, and trip limits would still apply. The vessel would need to have a permit to fish under that FMP and comply with any limitations

associated with the category of permit held, unless the special access program rules are different.

b. For non-target/incidental species including corals and protected species, the application would need to specify a list of species that might be encountered and how catch of those species would be monitored and documented.

4. The vessel would need to be in good standing at the time the request is made. This means no open violations, must be current with reporting requirements, etc.
5. A description of any fishing gear to be used would be required. This would include roller gear or other sweep attachments on trawl vessels, number and size of traps in a string, type of line connecting traps in a string, etc. All gear would need to comply with existing regulations for use outside of coral areas.

4.4.3 Alternative 3. Exploratory fishing

This alternative would implement an exploratory fishing program within some or all of the deep-sea coral zones. The objectives of an exploratory program would be as follows:

(1) To allow for exploration of the feasibility (technological, economic) of new fisheries
(2) To collect data that indicate whether the new fishery conflicts with coral conservation objectives

Steps in the exploratory fishing process would be as follows:

1. Apply for an exempted fishing permit and letter of authorization to conduct research/exploratory fishing
2. Document feasibility of the fishery including evidence that the fishery does not compromise coral conservation objectives
3. Longer term, as appropriate, add the target species to the list of special access program species via rulemaking

Which vessels? Presumably, any vessel could apply for an exploratory fishing permit, whether they were currently permitted to operate in regional fisheries or not.

Which areas? As above, the Council would need to determine where exploratory fishing activity would be allowed. Such activities could be authorized in all designated coral zones, or only in certain types of coral zones. For example, distinctions might be made between whether or not exempted/exploratory fishing is authorized in broad zones, discrete zones based on coral data and habitat suitability, and/or discrete zones based on habitat suitability only.

Operational requirements: When fishing under an exploratory fishing permit in a coral area, vessel operators could be subject to requirements, similar to those for special access fisheries, above. The Regional Administrator would have the discretion to grant exempted permits as he or she saw fit, but the Council could provide guidance as to the types of activities that they would consider appropriate.

1. Gear requirements
2. Seasonal requirements (again, probably not necessary)
3. Total amount of effort permitted
4. Move-along provision if any corals are caught
5. Coral retention requirement
6. Reporting requirements:
    a. Vessel monitoring system if equipped
    b. Scientific personnel or NEFOP observer
    c. Enhanced documentation of fishing location and catch. For each tow of mobile gear or set of fixed gear:
        i. Start and end location and depth of all tows
        ii. Catch weights by species, including target and non-target fishes and invertebrates identified to the lowest taxonomic level possible

Permit requirements: An application for an exempted fishing permit to conduct market research/exploration could include the following elements. Additional details about these elements are provided above in the special access program section. The Regional Administrator would maintain final discretion regarding the approval of exempted fishing permits. Table 4 contains additional information about exempted fishing permits and other types of research documents. While exploratory fishing activities would not constitute scientific research, some of the requirements of an exempted fishing permit application are appropriate to an exploratory fishing program within deep-sea coral zones.

1. Vessel identifying information and point of contact.
2. Must be filed by the application deadline.
3. Target and incidental species expected to be harvested and discarded:
    a. Species regulated under a federal FMP
    b. Non-target/incidental species including corals and protected species
    c. For target exploratory species not regulated under a federal FMP, the application would need to summarize all available information about the distribution of the species, provide a brief rationale as to why the species is of exploratory fishing interest, and whether or not the species would be retained for sale.
4. The vessel would need to be in good standing
5. A description of any fishing gear to be used

4.4.4 Alternative 4. Research activities

This alternative would request that individuals and organizations seek a letter of acknowledgement when conducting scientific research (see definition below) in coral zones, acknowledging that such letters are not required. A letter of acknowledgement would be useful to help NMFS and the Council keep track of research activities that may be occurring in coral zones, the results of which could benefit future management decisions. Letters of acknowledgement are distinct from letters of authorization.

Presently, four types of documents are issued by the Northeast Regional Office to vessels participating in scientific research projects: an exempted fishing permit, a temporary possession permit, an exempted educational activity authorization, and/or a letter of acknowledgement (Table 4). This alternative would not change requirements for exempted fishing permits, temporary possession permits, or exempted educational activity authorizations.

Table 3 – Types of research documents issued by NERO.

Exempted Fishing Permit: Authorizes a fishing vessel of the United States to conduct fishing activities that would be otherwise prohibited under the regulations at 50 CFR part 648 or part 697. Generally 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. Anyone that intends to engage in an activity that does not meet the definition of scientific research but that would be otherwise prohibited under these regulations is required to obtain an EFP prior to commencing the activity.
Temporary Possession Permit: Temporary Possession Permits authorize a federally permitted fishing vessel that is accompanied by an eligible research technician to temporarily retain fish that are not compliant with applicable fishing regulations for the purpose of collecting catch data. Example regulations include minimum fish sizes, species under quota closures, and fish possession limits. All non-compliant fish are returned to the sea as soon as practicable following data collection.
Exempted Educational Activity Authorization: An EEAA is a permit issued to accredited educational institutions that authorize, for educational purposes, the target or incidental harvest of species managed under an FMP or fishery regulations that would otherwise be prohibited.
Letter of Acknowledgement: An LOA is a letter that acknowledges certain activities as scientific research conducted from a scientific research vessel. Scientific research activities are activities that would meet the definition of fishing under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), but for the statutory exemption provided for scientific research. Such activities are exempt from any and all regulations promulgated under the Magnuson-Stevens Act, provided they continue to meet the definition of scientific research activities conducted from a scientific research vessel. Although the LOA is not required for scientific research, obtaining an LOA serves as a convenience to the researcher, the vessel(s), NMFS, the NOAA Office of Law Enforcement, and the U.S. Coast Guard, to establish that the activity is indeed exempt from the provisions of the Magnuson-Stevens Act.
To meet the definition of a scientific research vessel, the vessel must be conducting a scientific research activity and be under the direction of an appropriate group (e.g., a government agency, university or accredited educational institution, etc.).
Scientific research activity includes, but is not limited to sampling, collecting, observing, or surveying the fish or fishery resources within the EEZ. Research topics include taxonomy, biology, physiology, behavior, disease, aging, growth, mortality, migration, recruitment, distribution, abundance, ecology, stock structure, bycatch or other collateral effects of fishing, conservation engineering, and catch estimation of fish species considered to be a component of the fishery resources.

Summarized from Research Documentation: Exempted Fishing Permits, Temporary Possession Permits, Exempted Educational Activity Authorizations, and Letters of Acknowledgement. Updated 23 November 2010, available at http://www.nero.noaa.gov/permits/.

4.5 Framework provisions for deep-sea coral zones

These options would allow the measures adopted via this amendment to be changed via framework adjustment versus fishery management amendment. This would not preclude the Council from determining, or NMFS from recommending, that an amendment is a more appropriate vehicle for consideration of the change. In some cases, an amendment might be more appropriate, particularly if the impacts of an action are likely to be substantial. Note that the decision about whether an environmental assessment vs. environmental impact statement is prepared is separate from the decision to pursue a framework or an amendment. Either Alternative 1/No Action, or one or more of the action alternatives 2-4 could be selected.

4.5.1 Alternative 1/No Action

Under Alternative 1, there would be no change to framework adjustment provisions of the FMPs regarding deep-sea coral management measures.

4.5.2 Alternative 2. Add, revise, or remove coral zones via framework adjustment

Alternative 2 would allow coral zones to be added, revised, or removed via framework adjustment.

4.5.3 Alternative 3. Change fishing restrictions in coral zones via framework adjustment

Alternative 3 would allow the Council to change the types of fishing gears restricted within deep-sea coral zones via framework.

4.5.4 Alternative 4. Allow changes to special access or exploratory fishing programs via framework adjustment

Alternative 4 would allow changes to special access or exploratory fishing programs (e.g., permit and observer requirements, move-along provisions) via framework adjustment.

5 Considered and rejected alternatives

In June 2015, the MAFMC approved coral management zones for their region through Amendment 16 to the Atlantic Mackerel/Squid/Butterfish FMP. The provisions of the amendment went into effect on January 13, 2017. Earlier versions of the NEFMC alternatives, developed prior to intiation of the MAFMC amendment, included areas with the MAFMC region. The NEFMC coral zone alternatives were modified to remove areas south of the NEFMC/MAFMC boundary, including the Mey-Lindenkohl slope, Baltimore Canyon, Norfolk Canyon, Emery Canyon, Hudson Canyon, Toms Canyon, Lindenkohl Canyon, Wilmington Canyon, Accomac Canyon, and Washington Canyon.

A broad coral zone with a landward boundary based on the 200 m depth contour was considered by the Habitat Committee and rejected, due to concerns about potential fishery impacts of a zone extending into these relatively shallower depths.

Larger discrete coral zones in the Gulf of Maine were not recommended for further analysis at the April 6, 2012 Committee meeting:

- An expanded version of the Mt Desert Rock zone that extended into similar depths and habitats, and also included some shallower areas within state waters
- Larger areas combining areas 1 and 2 and areas 3 and 4 in Western Jordan Basin, that would have encompassed a wider range of deeper and shallower habitat types

The PDT evaluated the following additional canyon and slope areas as possible discrete coral zones, but did not recommend zones in these areas to the Habitat Committee. The Committee concurred with the PDT's assessment and did not ask for further analysis of these options at their February 23, 2012 meeting. Note that some of these canyons are in the mid-Atlantic region, and were later evaluated by the MAFMC and their coral FMAT. Some were later reconsiderd by the PDT given additional coral exploratory survey data.

- Slope near U.S. – Canadian border
- Slope between Veatch and Hydrographer Canyons
- Slope west of Alvin and Atlantis Canyons
- Slope area between Baltimore and Accomac canyons
- Canyons not recommended based on GIS analysis: Chebacco, Filebottom, Sharpshooter, Dogbody, Shallop, Nantucket, Atlantis, Block, McMaster, Ryan Canyon, Uchupi, and Spencer Canyons
- Canyons not recommended, did not incise shelf enough to conduct GIS analysis: Clipper, South Wilmington, North Heys, South Vries, Warr, Phoenix, and Leonard Canyons

6 Description of the affected environment

The purpose of this section is to provide background information that will inform analysis of impacts of the alternatives proposed in this amendment. Topics covered include:

- Physical setting, including geology and physical oceanography relevant to deep-sea coral and fishery distributions
- Background information on deep-sea corals, including species richness, geographic distribution, distribution of suitable habitats, associated species and ecological interactions, and vulnerability to impacts
- Essential fish habitat occurring within coral zones
- Managed resources, fisheries, and associated human communities
- Protected resources such as marine mammals, turtles, and any other Endangered Species Act-listed species occurring in or around coral zones

6.1 Physical setting

These two sections describe the oceanographic and geological features of the Gulf of Maine, continental slope, canyons, and seamounts.

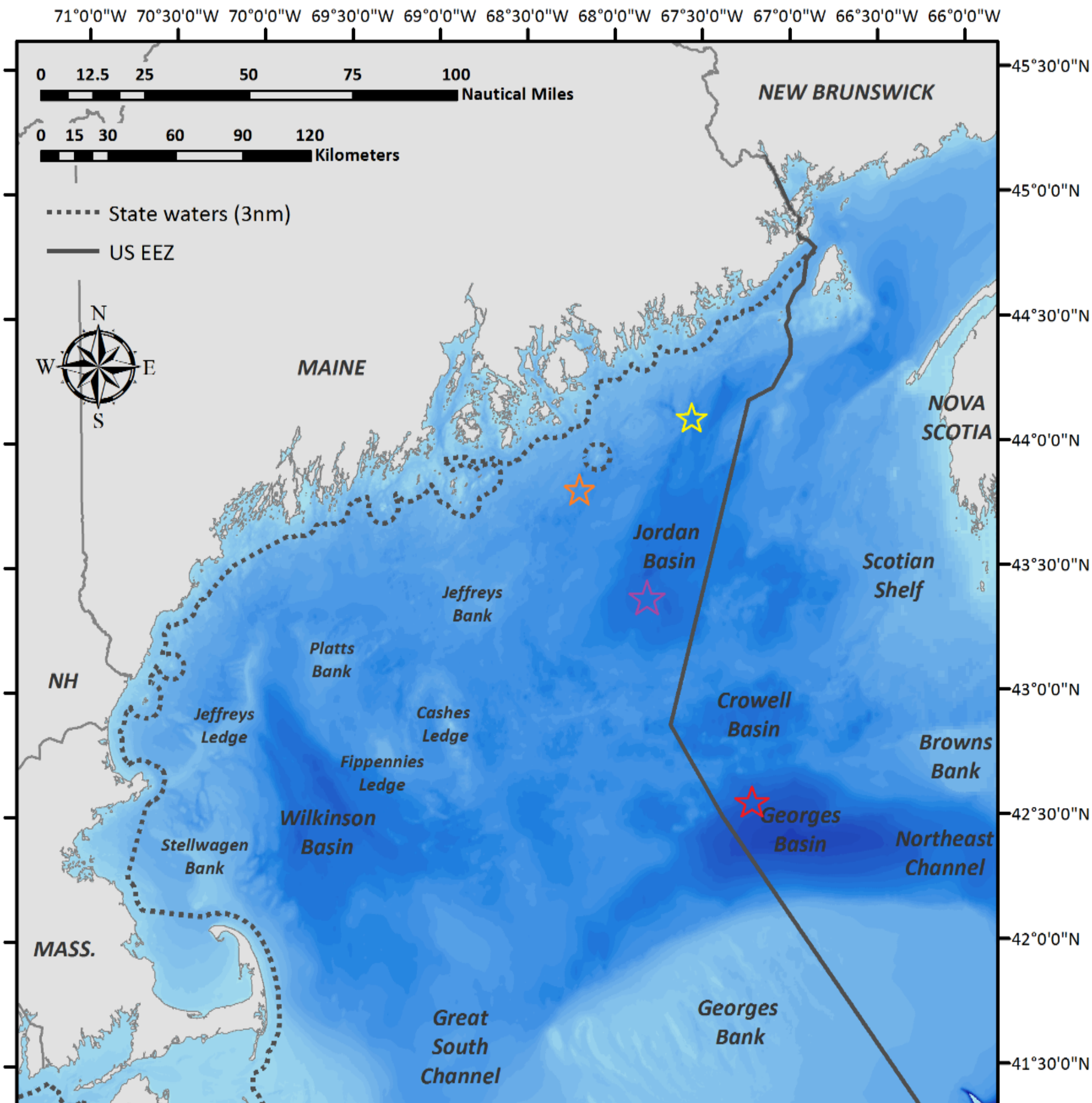
6.1.1 Gulf of Maine

The Gulf of Maine is an enclosed coastal sea, bounded on the east by Browns Bank, on the north by the Nova Scotian Shelf, on the west by the New England states, and on the south by Cape Cod and Georges Bank. The Gulf of Maine is glacially derived, and is characterized by a system of deep basins, moraines and rocky protrusions with limited access to the open ocean (Map 36). This geomorphology influences complex oceanographic processes that in turn produce a rich biological community.

The Gulf of Maine's geologic features, when coupled with vertical variations in water properties, result in a great diversity of habitat types. There are 21 distinct basins separated by ridges, banks, and swells. The three largest basins are Wilkinson, Georges, and Jordan. Corals are found in all three basins, although to date observations in Wilkinson Basin are limited to sea pens only. Depths in the basins exceed 250 m, with a maximum depth of over 350 m in Georges Basin which is just north of Georges Bank. The Northeast Channel between Georges Bank and Browns Bank leads into Georges Basin, and is one of the primary avenues for exchange of water between the Gulf of Maine and the North Atlantic Ocean.

In addition to the basins, other locations in the Gulf of Maine containing deep-sea coral habitats include rocky areas south of Mt. Desert Island and the Outer Schoodic Ridge, which runs southwest to northeast approximately 20 nm offshore the eastern Maine coast.

Map 36 – Major features of the Gulf of Maine.



Locations with coral management alternatives are indicated with stars (yellow – Outer Schoodic Ridge, orange – Mt. Desert Rock, purple – western Jordan Basin, red – Georges Basin). Lindenkohl Knoll is west of the Hague Line.

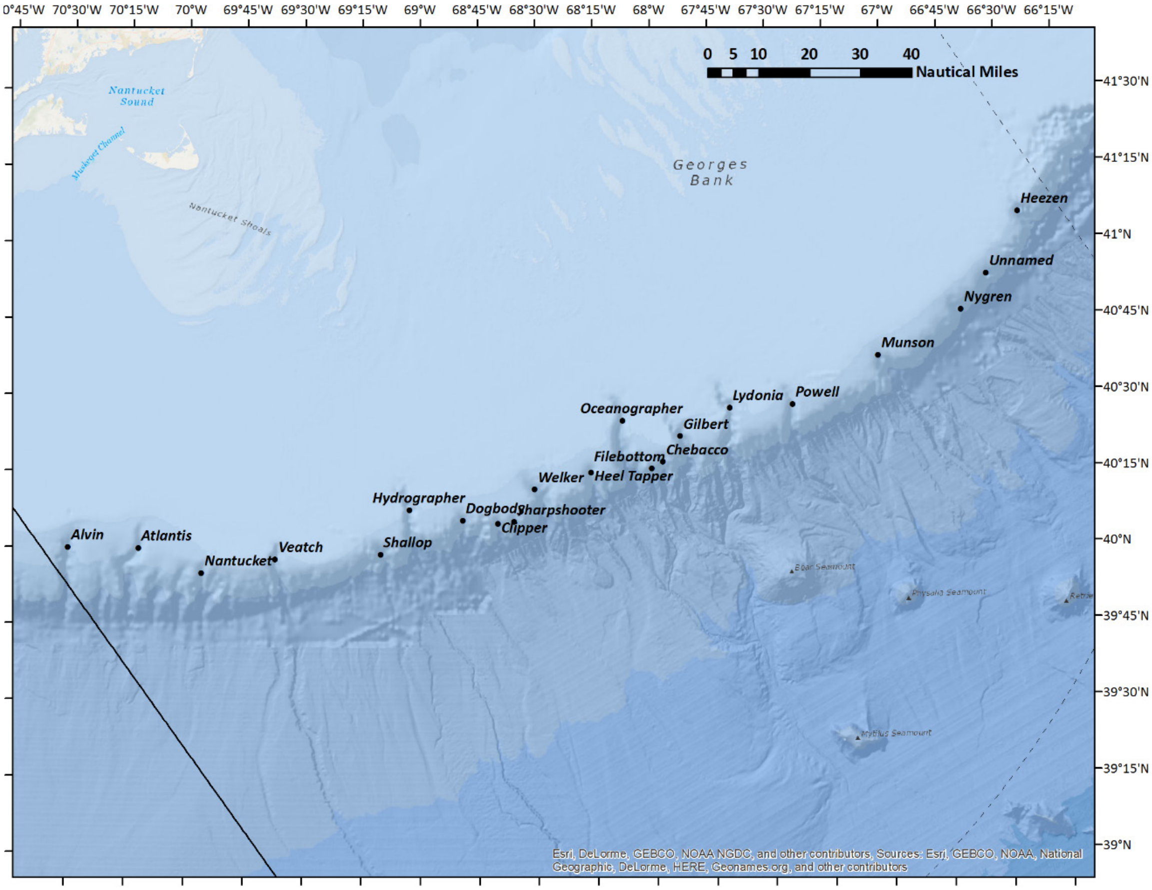
6.1.2 Continental slope, canyons, and seamounts

The continental slope extends from the continental shelf break, at depths between 60-200 m, eastward to a depth of 2,000 m. 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 morphology of the present continental slope appears largely to be a result of sedimentary processes that occurred during the Pleistocene, including, 1) slope upbuilding and progradation by deltaic sedimentation principally during sea-level low stands; 2) canyon cutting by sediment mass movements during and following sea-level low stands; and 3) sediment slumping. This video includes a three dimensional visualization of the shelf/slope region and shows some of the coral habitats found in the canyons and on the seamounts: http://www.whoi.edu/visualWHOI/deep-water-corals-in-the-northeast-canyons.

Sediments become progressively finer with increasing depth and distance from land, although in some areas submarine canyons channel coarser sediments onto the continental slope and rise. 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. Gravity induced downslope movement is the dominant sedimentary process on the slope, and includes slumps, slides, debris flows, and turbidity currents, in order from thick cohesive movement to relatively nonviscous flow. Slumps may involve localized, short, down-slope movements by blocks of sediment. However, turbidity currents can transport sediments thousands of kilometers.

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. Map 37 shows the canyons in the New England region. Submarine canyons are not spaced evenly along the slope, but tend to decrease in areas of increasing slope gradient. Canyons form by erosion of the sediments and sedimentary rocks of the continental margin. They can be classed as high or low relief. Canyons with high relief that are deeply eroded into the continental margin may be U-shaped or V-shaped.

Map 37 – Canyons of the New England region.



Note that a discrete zone is not recommended in Shallop Canyon as there are no historical or recent observations of corals.

Erosion by glaciers produces U-shaped canyons. These include canyons in Canadian waters in the glacially-eroded Northeast Channel that separates Georges Bank and the Scotian Shelf, but these areas are not under consideration for management in this action. Erosion by rivers, mass wasting, and turbidity currents produces V-shaped canyons. These include the canyons on the southern margin of Georges Bank. These canyons did not experience direct glacial erosion because the glaciers terminated on the bank's northern margin. These V-shaped canyons contain the following sediment types:

- Gravel in canyons that was transported by floating ice
- Outcropping rocks exposed on canyon walls
- Rock rubble on canyon walls and floor from rock falls
- Stiff Pleistocene clay exposed on canyon walls; burrowed by crabs and fish to form "pueblo villages"; burrowed clay can collapse to form rubble on canyon walls and floors
- Veneer of modern sediment partly covering canyon walls
- Modern sediment covering canyon floors
- Modern sand transported onto the canyon floor from the shelf can be formed into bedforms by strong tidal currents in some canyons

Canyons shallowly eroded into the continental margin are produced by erosion/mass wasting events such as slumping or landslides. These types of shallow canyons are found on the shelf edge and upper slope of the southern margin of Georges Bank. Shallow canyons are less likely than deep canyons to have a well-defined canyon axis and floor, and because their walls are not steep, they are less likely than deep canyons to have outcropping rocks. They may contain the following sediment types:

- Gravel in canyons that was transported by floating ice
- Veneer of modern sediment covering canyon walls

Inter-canyon areas on the southern margin of Georges Bank are gently sloping seabed between canyons on the continental slope. They are characterized by both erosional (mass wasting) and depositional processes. Sediment types include:

- Gravel that was transported by floating ice
- Modern sediment

The continental shelf edge (shelf-slope break) represents a transition from a gently sloping shelf (1-2°) to a somewhat steeper continental slope (3-6°), and from coarser-grained shelf sediment to finer-grained upper slope sediment. Sediment types include:

- Modern sediment
- Gravel that was transported by floating ice
- Pebble gravel substrate in areas where sandy sediment has been eroded.

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. Shepard et al. (1979) concluded that the strong turbidity currents initiated in study canyons were responsible for enough sediment erosion and transport to maintain and modify those canyons. Since surface and internal tides are ubiquitous over the continental shelf and slope, it can be anticipated that these fluctuations are important for sedimentation processes in other canyons as well. In Lydonia Canyon, Butman et al. (1982) found that the dominant source of low frequency current variability was related to passage of warm core Gulf Stream rings rather than the atmospheric events that predominate on the shelf.

The water masses of the Atlantic continental slope and rise are essentially the same as those of the North American Basin. Worthington (1976) divided the water column of the slope into three vertical layers: deepwater (colder than 4°C), the thermocline (4 - 17°C), and surface water (warmer than 17°C). In the North American Basin, deepwater accounts for two-thirds of all the water, the thermocline for about one-quarter, and surface water the remainder. In the slope water north of Cape Hatteras, the only warm water occurs in the Gulf Stream and in seasonally influenced summer waters. The principal cold water mass in the region is the North Atlantic Deep Water. North Atlantic Deep Water is comprised of a mixture of five sources: Antarctic Bottom Water, Labrador Sea Water, Mediterranean Water, Denmark Strait Overflow Water, and Iceland-Scotland Overflow Water. The thermocline represents a straightforward water mass compared with either the deepwater or the surface water. Nearly 90% of all thermocline water comes from the water mass called the Western North Atlantic Water. This water mass is slightly less saline northeast of Cape Hatteras due to the influx of southward flowing Labrador Coastal Water. Seasonal variability in slope waters penetrates only the upper 200 m of the water column.

In the winter months, cold temperatures and storm activity create a well-mixed layer down to about 100-150 m, but summer warming creates a seasonal thermocline overlain by a surface layer of low density water. The seasonal thermocline, in combination with reduced storm activity in the summer, inhibits vertical mixing and reduces the upward transfer of nutrients into the photic zone.

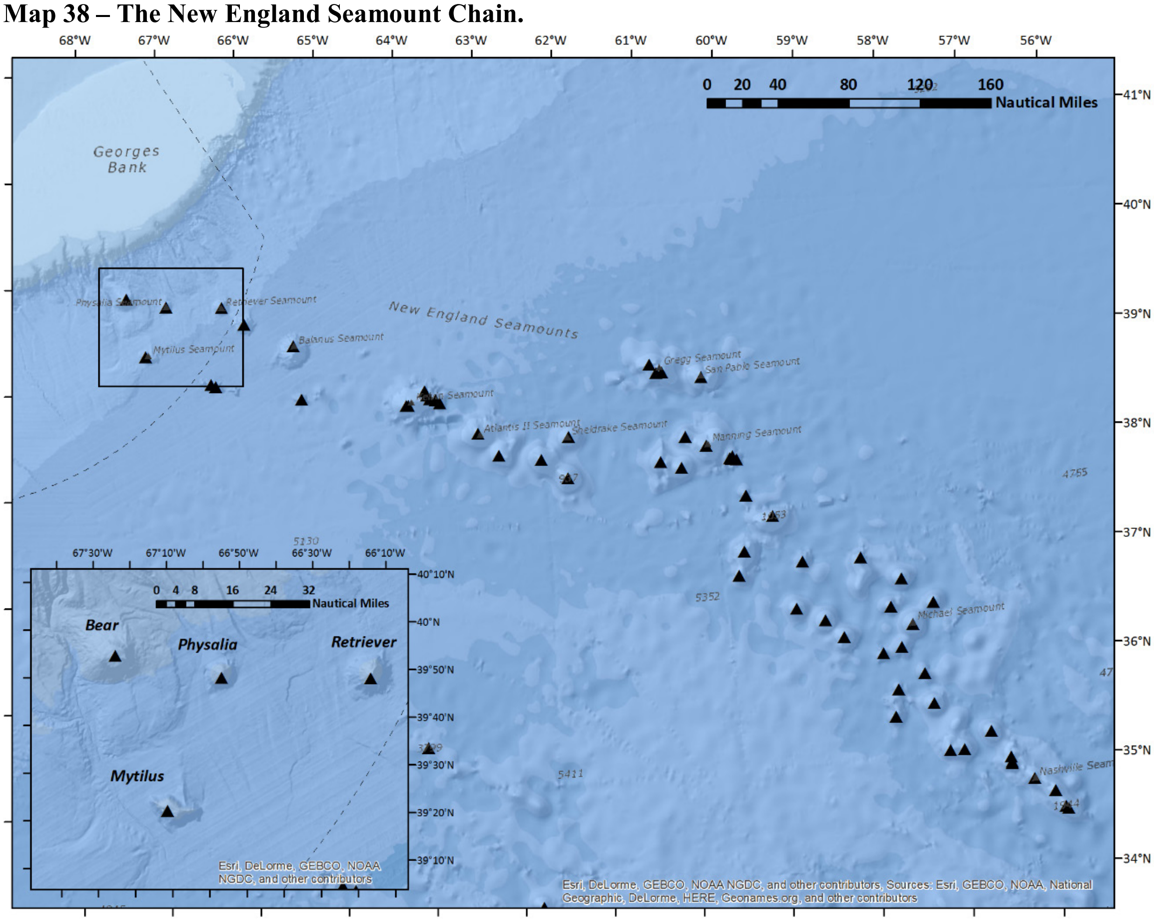
Two currents found on the slope, the Gulf Stream and Western Boundary Undercurrent, together represent one of the strongest low frequency horizontal flow systems in the world. Both currents have an important influence on slope waters. Warm and cold core rings that spin off the Gulf Stream are a persistent and ubiquitous feature of the northwest Atlantic Ocean. The Western Boundary Undercurrent flows to the southwest along the lower slope and continental rise in a stream about 50 km wide. The boundary current is associated with the spread of North Atlantic Deep Water, and it forms part of the generally westward flow found in slope water. North of Cape Hatteras, it crosses under the Gulf Stream in a manner not yet completely understood.

Shelf and slope waters of the northeast region are intermittently affected by the Gulf Stream. The Gulf Stream begins in the Gulf of Mexico and flows northeastward at an approximate rate of 1 m/s (2 knots), transporting warm waters north along the eastern coast of the United States, and then east towards the British Isles. Conditions and flow of the Gulf Stream are highly variable on time scales ranging from days to seasons. Intrusions from the Gulf Stream constitute the principal source of variability in slope waters off the northeastern shelf.

The location of the Gulf Stream's shoreward, western boundary is variable because of meanders and eddies. Gulf Stream eddies are formed when extended meanders enclose a parcel of seawater and pinch off. These eddies can be cyclonic, meaning they rotate counterclockwise and have a cold core formed by enclosed slope water (cold core ring), or anticyclonic, meaning they rotate clockwise and have a warm core of Sargasso Sea water (warm core ring). The rings are shaped like a funnel, wider at the top and narrower at the bottom, and can have depths of over 2,000 m. They range in size from approximately 150 - 230 km in diameter. There are 35% more rings and meanders near Georges Bank than in the Mid-Atlantic region. A net transfer of water on and off the shelf may result from the interaction of rings and shelf waters. These warm or cold core rings maintain their identity for several months until they are reabsorbed by the Gulf Stream. The rings and the Gulf Stream itself have a great influence over oceanographic conditions all along the continental shelf.

Seamounts are topographic rises of the seabed that are typically conical in shape, with circular, elliptical, or elongate bases (Yesson et al. 2011). They vary in terms of elevation above the seafloor, with larger features have a relief of over 1,000 m above the adjacent seabed. Large seamounts are often volcanic in origin. Using a criterion of at least 1,000 m height above the seafloor, Yesson et al. (2011) identified over 33,000 seamounts globally based on an analysis of 30 arc-second bathymetry data. The New England seamount chain (Map 38) includes four seamounts within the U.S. EEZ, and additional seamounts further east. Yesson et al. classified seamounts with summits shallower than 1,500 meters as middle-depth seamounts, noting that these features can interact with zooplankton that migrate diurnally in the water column (the deep scattering layer). Bear Seamount falls into this category. Mytilus, Physalia, and Retreiver Seamounts are classified as deep seamounts, as they are below the influence of the deep-scattering layer.

Map 38 – The New England Seamount Chain.



The four seamounts within the U.S. EEZ are shown in the inset. Seamount locations (triangles) are from a global seamount identification study (Yesson et al. 2011).

6.2 Coral species of the New England region

This section describes the data sources used to characterize the coral fauna of New England, lists coral types and known species found in the region, and summarizes the species richness in particular locations, based on sampling conducted to date.

6.2.1 Data sources

Sources of information on coral species richness and distribution in New England include historical (pre-2012) physical and visual samples, as well as recent (2013-2015) visual exploratory surveys conducted with remoted operated vehicles and towed camera systems.

6.2.1.1 Historical records (2012 and earlier)

The primary sources of historical deep-sea coral records and observations in this region are discussed and referenced in Packer et al. (2007). These include geo-referenced presence records and non-geo-referenced presence records (i.e., “observations”). There is also a small amount of deep-sea coral density or abundance data. The Northeast deep-sea coral database, based largely on historical geo-referenced presence records from the late 1800s to the present, was updated between 2007 and 2013 by incorporating taxonomic changes and adding additional presence records gleaned from museum collection databases and other data mining activities. Museum records were obtained from the Smithsonian Institution’s National Museum of Natural History collection, which includes records of coral taxa collected from various research surveys, 1873 through the present, and from other collections. Other records were added based on the NOAA-Ocean Explorer 2003 *Mountains in the Sea* expeditions to the New England Seamounts. Additional records of sea pens (especially *Pennatula aculeata*) collected between 1956 and 1984 were compiled from various sources (e.g., Langton et al. 1990). Records of new species of soft corals, mostly from Bear and Retriever seamounts, with some from the submarine canyons off New England, were obtained from recently published literature (Cairns et al. 2007, Thoma et al. 2009, Pante and Watling 2011, Watling et al. 2011). New records of antipatharians (black corals) were also obtained from recently published seamount literature (Thoma et al. 2009). The major coral datasets covered by this database are summarized in Table 5.

Although the historical database has been thoroughly vetted, it should be viewed with caution as only presence data are shown (i.e., there is no absence data). Unlike NOAA’s fish-focused trawl surveys, the various coral surveys tend to be of limited spatial extent, and the regional coverage of coral-related investigations is rather patchy. Also, some specimens in the historical database were not identified very specifically, i.e., to the family, genus, or species level. Despite these caveats, the more recent records, particularly those collected via submersible that document corals in situ, are useful indicators of coral presence.

Table 4 – Deep-sea coral data sources for the Northeast Region

Dataset	Citation
Deichmann, 1936	Deichmann, Elisabeth, 1936, The Alcyonaria of the western part of the Atlantic Ocean: Memoirs of the Museum of Comparative Zoology at Harvard College, v. 53, 317 p.

Dataset	Citation
Hecker et al., 1980, 1983	These reports were prepared for Minerals Management Service in the early 1980s. Several canyons and slope areas were surveyed via submersible and towed camera sled. Hecker, B., Blechschmidt, G., and Gibson, P. 1980. Epifaunal zonation and community structure in three mid- and north Atlantic canyons—final report for the canyon assessment study in the mid- and north Atlantic areas of the U.S. outer continental shelf: U.S. Department of the Interior, Bureau of Land Management Monograph, 139 p. Hecker, B., et al. 1983. Final Report – Canyon and Slope Processes Study. Prepared for U.S. Department of the Interior, Minerals Management Service. Contains three volumes: Vol. I, Executive Summary; Vol. II, Physical Processes; and Vol. III, Biological Processes.
NEFSC HUDMAP	Records from 2001, 2002, and 2004 video samples taken near the head of Hudson Canyon between 100-200 m depth. Corals sampled include the sea pen *Stylatula elegans* and the stony coral *Dasmosmilia lymani*.
NEFSC Sea Pens	Records of sea pens compiled from various sources, including submersible surveys, trawl surveys, and towed camera surveys. Data collected between 1956 and 1984.
NES CR Dives	These data summarize dives locations of samples collected during NOAA Ocean Explorer "Mountains in the Sea" cruises to the New England seamounts during 2003 and 2004.
Smithsonian National Museum of Natural History	Records off all coral types from various research vessel surveys conducted from 1873 through present. Surveys conducted in GOM as well as along shelf/slope break on Georges Bank and in Mid-Atlantic Bight.
Theroux and Wigley	Theroux, Roger B. and Wigley, Roland L., 1998, Quantitative composition and distribution of the macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States. NOAA Technical Report NMFS 140**:** 240.
US Fish Commission	Records for *Dasmosmilia lymani* off NJ/VA; collected in the 1880s
VIMS for BLM/MMS	Mostly *Dasmosmilia lymani* records; fewer records of *Stylatula elegans*; records from mid-late 1970s; collected for Minerals Management Service by Virginia Institute of Marine Science
Watling et al, 2003	Watling, L., Auster, P.J., Babb, I., Skinder, C., and Hecker, B., 2003, A geographic database of deepwater alcyonaceans of the northeastern U.S. continental shelf and slope: Groton, National Undersea Research Center, University of Connecticut, Version 1.0 CD-ROM.
Yale University Peabody Museum Collection	Yale University Peabody Museum Collection, Yale Invertebrate Zoology—Online Catalog: accessed July 2007. Current url is: http://collections.peabody.yale.edu/search/Search/Advanced?collection=Invertebrate%20Zoology

6.2.1.2 Recent exploratory surveys (2013-2015)

Recent survey work includes towed camera, remotely operated vehicle (ROV), and autonomous underwater vehicle (AUV) dives conducted from 2012 to 2015 (Table 6). Although these recent dives cover many additional areas, and are a much more comprehensive inventory of coral habitats compared with the historical database, many locations remain lightly sampled, and have not been visited repeatedly over time as is the case with continental shelf trawl or dredge surveys. Results from the recent 2012-2105 surveys will be added to the historical database in time (although likely not until after this amendment is completed), and will include data on relative abundance.

Table 5 – Recent deep-sea coral oriented cruises within the New England region

Year	Cruise Dates	Cruise Number	Research Vessel	Gear	Tows (#)[a]	Locations
2012	5-6 Oct		*Scarlett Isabella*	REMUS 6000 AUV	2	Physalia Seamount
2012	7-17 Jul	HB1204	*Bigelow*	TowCam	11	Veatch Canyon (3), Gilbert Canyon (8)
2013	11-24 Jul	ISIS2_2013	*Connecticut*	ISIS2	40	Western Jordan Basin (18), Blue Hill Bay (3), Monhegan (5), Schoodic Ridges (9), Sommes Sound (4), test tow of tethering system
2013	9-23 Jun	HB1302	*Bigelow*	TowCam	16	Powell Canyon (6), Munson Canyon (7), minor Canyon between Powell and Munson (2), Munson-Powell intercanyon area (1)
2013	8-25 Jul	EX1304L1	*Okeanos*	D2	12	Alvin Canyon (2), Atlantis Canyon (2), Hydrographer Canyon (2), NE Seep2 (1), NE Seep3 (1), USGS Hazard 2 (1), USGS Hazard 4 (1), NE Seep (1), Veatch Seeps (1)
2013	31 Jul-16 Aug	EX1304L2	*Okeanos*	D2	14	Heezen Canyon (2), Lydonia Canyon (1), Lydonia-Powell intercanyon area (1), Mytilus Seamount (2), Nygren Canyon (2), Nygren-Heezen intercanyon (1), Oceanographer Canyon (2), Minor canyon next to Shallop Canyon (1), Welker Canyon (1), USGS Hazard 5 (1)
2014	23 Jul-6 Aug	K2_2014	*Connecticut*	Kraken2	21	Outer Schoodic Ridge (8), western and central Jordan Basin (11), Stellwagen Bank (1), Wilkinson Basin (1)
2014	18 Jun-1 Jul	HB1402	*Bigelow*	ROPOS	7	Nygren Canyon (2), Heezen Canyon (3), minor Canyon btw Nygren and Heezen (1), Jordan Basin (1)
2014	23 Sep-6 Oct	EX1404L3	*Okeanos*	D2	4	Nantucket Canyon (1), Physalia Seamount (1), Retriever Seamount (1), unnamed canyon east of Veatch (1)
2015	1-10 Jul	ISIS2_2015	*Connecticut*	ISIS2	26	Outer Schoodic Ridge (4), Mount Desert Rock (4), Georges Basin and Lindenkohl Knoll (9), West Wilkinson Basin (5), Stellwagen Bank (1), Chandler Bay (3)
2015	27 Jul-7 Aug	HB1504	*Bigelow*	TowCam	23	Dogbody Canyon (3), Chebacco Canyon (5 – dives 4 and 5 repeated), Heel Tapper (3), Filebottom Canyon (4 – dive 8 repeated), Sharpshooter Canyon (2), Welker Canyon (4 – dive 15 repeated), Clipper Canyon (2)

Year	Cruise Dates	Cruise Number	Research Vessel	Gear	Tows (#)[a]	Locations
[a] Number of tows in New England locations only; some cruises included tows in the Mid-Atlantic region or in Canadian waters.						

All of these survey technologies are capable of collecting visual samples, and many of the survey gears were able to collect physical specimens as well. Different survey gears have distinct capabilities and advantages (Kilgour et al 2012) and are used for various reasons in different settings. For example, AUVs have fewer support vessel needs than ROVs, may be easier to deploy and retrieve, and can be used to survey a larger area more quickly. While ROVs, towed camera sleds, and manned submersibles require additional vessel support and move more slowly than AUVs, they can be used to study areas at a very fine spatial scale and collect physical samples. With the exception of the 2012 cruise on Physalia Seamount, which used AUV technology, all of the recent cruises used either towed camera systems or ROVs. Because so much data are gathered during each dive, detailed analyses of many of these dives are still in progress, but high level classifications of geological and biological habitats are presently available to inform management decisions.

These recent surveys have greatly expanded our knowledge of coral species richness and distribution in both the New England and Mid-Atlantic. While some abundance data are collected during these efforts, these surveys should be considered exploratory, and are different in their design from surveys used to assess populations and generate biomass estimates. Despite the relatively large number of cruises and dives conducted, many areas of the canyons, seamounts, and Gulf of Maine remain unexplored. Thus, survey results, combined with terrain data and suitability model outputs, are the best way to understand the likely distribution of corals in the region.

Dive locations were often selected by identifying topographic features of interest on maps generated from high-resolution multibeam or side-scan sonar data. In order to guide survey efforts and better understand the seafloor terrain in the canyons, the Atlantic Canyons Undersea Mapping Expeditions (ACUMEN) program was developed to generate integrated, coherent digital terrain model for the Atlantic shelf/slope region. Between February and August 2012, *RV Ferdinand R. Hassler* and *RV Okeanos Explorer* collected high-resolution bathymetry data that was quickly processed into mapping products. The data from this project are used throughout this amendment in mapping and analysis.

The 2012 ACUMEN field efforts finished with a July survey aboard the *FSV Henry B. Bigelow* (HB1204). The goals of the Bigelow mission were to survey and ground-truth known or suspected deep-sea coral habitats associated with the submarine canyons off the edge of the Northeastern U.S continental shelf/slope, and included (1) characterizing benthic habitats and identifying areas where deep-sea corals and sponges were present; (2) initial ground-truthing of areas predicted to be coral "hotspots" based on data and outputs provided from the deep-sea coral habitat suitability model; (3) ground-truthing newly collected high resolution (25-50 m) continental slope bathymetric maps created from the multibeam data collected during the ACUMEN cruises; and, (4) ground-truthing historical deep-sea coral records. Using the Woods Hole Oceanographic Institution's (WHOI) towed camera system (TowCam), three main canyon areas were targeted, including Veatch and Gilbert Canyons off New England and the rim of an un-named canyon northeast of Veatch. Gilbert Canyon in particular was identified as a deep-sea coral "hotspot" by the habitat suitability model; all three main canyon areas were either under-explored or unknown with regards to deep-sea coral and sponge occurrences. During the 2012 Bigelow mission, there were 18 TowCam tows and over 38,600 high resolution photos taken at 10 second intervals during the dives, along with concurrent sampling of environmental data (e.g., depth, temperature, salinity) to characterize benthic and deep-sea coral/sponge habitats. Each bottom image was visually screened for corals, sponges, and fish fauna, and presence/absence information was logged for each image.

These initial survey efforts were an important precursor to the 2013-2015 NOAA Deep Sea Coral Research and Technology Program (DSCRTP) Northeast fieldwork initiative. The overall purpose of the initiative was to locate, survey, and characterize deep-sea coral and sponge communities in this region. The work was guided by the Northeast Fieldwork Planning Team and implemented by NOAA scientists in collaboration with other NOAA line offices, other government agencies (including the Canadian Department of Fisheries and Oceans), and researchers from academic institutions. The major objectives included:

- Assisting resource managers by characterizing the deep-sea coral and sponge ecosystems and determining the distribution, abundance, and diversity of deep-sea corals/sponges in select areas of the continental slope, including the submarine canyons, the seamounts within the EEZ, and select areas of the Gulf of Maine where major structure forming corals/sponges may or were known to exist. Establishing the spatial extent of corals/sponges in these areas, their scales of patchiness, and correlation with substrate features.
- Collecting specimens, where possible, for taxonomic analyses, age and growth studies, genetic analyses, and reproduction studies.
- Using the deep-sea coral/sponge survey and distribution data to refine the next iterations of the Northeast's deep-sea coral habitat suitability model; conversely, the model would assist in choosing survey sites and thus be continuously "field tested" and ground-truthed.
- Continuing collaborative work with other NOAA line offices (Oceanic and Atmospheric Research, Office of Exploration and Research; National Ocean Service, Office of Coast Survey) to obtain high resolution multibeam maps and data of the Northeast shelf, slope, and seamounts where corals/sponges are known to or may occur.
- Assisting the NEFSC groundfish and shellfish surveys and the Northeast Fisheries Observer Program in better identifying and quantifying their deep-sea coral and sponge bycatch.

By combining DSCRTP resources with other partners within and outside of NOAA, leveraging funding, and employing a wide range of research tools, the initiative advanced deep-sea coral science and management through three major fieldwork projects.

1. Surveys and exploration of coral/sponge habitats in submarine canyons, slope areas, and seamounts off New England and the Mid-Atlantic.
2. Characterizations of seafloor communities in the U.S. and Canadian transboundary Gulf of Maine region and on the U.S. and Canadian continental margin.
3. Surveys of northern Gulf of Maine (U.S.) habitat areas for deep-sea corals and sponges.

Surveys off New England and the Mid-Atlantic occurred every summer from 2013-2015, targeting areas in and around submarine canyons and on Mytilus seamount. Using the NOAA *FSV Henry B. Bigelow* with the towed camera system TowCam, scientists collected still images from all major and some minor canyons not previously surveyed by the other recent expeditions. Cruise HB1302 (2013) covered Munson and Powell Canyons off New England. Cruise HB1404 surveyed mid-Atlantic areas only. During Cruise HB1504, seven New England minor canyons were surveyed; most had not been previously explored.

Also during 2013, 31 ROV dives (494-3271 m) over two cruises were conducted from the NOAA *RV Okeanos Explorer* (Cruise EX1304, Legs 1 and 2). A variety of broad-scale habitat features, including 11 canyons in the New England and Mid-Atlantic regions (Heezen, Nygren, Lydonia, Oceanographer, Welker, Hydrographer, Atlantis, Alvin, Block, two un-named canyons), open areas on the continental slope and intercanyon areas, Mytilus Seamount, and three cold seeps (1053–1484 m) were surveyed. The ROV transects ranged from 300 to 2200 m in length. During September and October 2014, the NOAA *RV Okeanos Explorer* returned to the region and surveyed two seamounts off New England and several canyons off both New England and the Mid-Atlantic (Cruise EX1404, "Our Deepwater Backyard"). Sixteen *ROV Deep Discoverer* dives were conducted during EX1404, and high-resolution multibeam sonar data covering 36,200 km^2 of seafloor was collected. Full descriptions of the dives can be found at: http://oceanexplorer.noaa.gov/okeanos/explorations/ex1404/welcome.html. The areas surveyed off New England included Physalia and Retriever Seamounts (see seamount section below), Nantucket Canyon, and an un-named, minor canyon east of Veatch Canyon.

NOAA scientists collaborated with Canadian academic partners and Canada's Department of Fisheries and Oceans to characterize coral communities in the transboundary Gulf of Maine region and along the continental margin south of Georges Bank in 2014. This international collaboration and information sharing enabled the U.S. and Canadian science teams, each with limited resources, to establish a better understanding of shared waters in the Gulf of Maine and along the continental margin and slope. Using the Canadian *ROV ROPOS* aboard *FSV Henry B. Bigelow*, the project team collected videos, photos, and coral samples from Nygren and Heezen canyons and a minor canyon between the two in U.S. waters; Corsair Canyon and the Northeast Channel Coral Conservation Area in Canada; and both sides of the international boundary in Central Jordan Basin, Gulf of Maine. Initial analyses of the videos and images show diverse and abundant corals in Nygren and Heezen Canyons. Given the significant deep-sea coral discoveries documented by *ROV Deep Discoverer* in 2013, the objective here was to increase both geographic and bathymetric coverage within the two canyons.

In the Gulf of Maine, the information needed to assess the status of corals has been lacking or incomplete. Therefore, the goals of 2013-15 Gulf of Maine exploratory surveys, undertaken in partnership with the Universities of Connecticut and Maine, included:

- Delineating the spatial extent of deep-sea coral habitats at depths around 200 m in and around the proposed management areas;
- Characterizing deep-sea coral community structure and composition, including the abundance, density, size and size classes of coral;
- Documenting fauna found near or associated with the coral and their habitats, especially commercially important/federally managed fish and shellfish species;
- Collecting specimens for taxonomy, reproductive analyses, aging/growth, and genetics;
- Documenting anthropogenic impacts to these habitats;
- Using the survey results to directly inform the NEFMC deep-sea coral management alternatives process.

Previous deep-sea coral exploratory surveys and seafloor mapping in the Gulf of Maine guided the selection of survey sites in 2013. Initial deep-sea coral surveys using ROVs in 2002 and 2003 documented a limited number of locations in Western Jordan Basin and around Mount Desert Rock, with dense coral garden communities at around 200 m (Auster 2005, Watling and Auster 2005). Deep-sea corals were found on rocks, boulders, ridges and walls extending above the surrounding fine-grained sediments. During a cruise aboard the NOAA *RV Ronald H. Brown* during 2005, preliminary multibeam bottom sonar data was collected in Western Jordan Basin and revealed that hard bottom in the immediate area around one of the sites surveyed for corals in 2002-2003 (known as “114 Bump”) was more spatially extensive than previously suspected, thus implying more potential deep-sea coral habitat.

In 2013-2015, two different camera platforms on the RV Connecticut were used to assess the presence and composition of coral communities in the Gulf of Maine: the towed camera sled ISIS 2 (2013, 2015) and ROV Kraken 2 (2014); both systems had hi-definition still and video cameras, and the ROV could collect specimens. For the 2013 survey, using a bathymetric map created from the 2005 multibeam bottom sonar data and a detailed bathymetric chart of the Jordan Basin-Mount Desert Rock-Schoodic Ridge regions (Fisheries and Oceans Canada LC 4011), areas of steep topographies in depth ranges where corals were expected to occur (around 200 m) were selected for exploration. Thirty-five ISIS 2 camera tows were conducted in four areas: Western

Jordan Basin, near Mount Desert Rock, on Outer Schoodic Ridge, and off Monhegan Island.

High quality multibeam data were collected in the region after the initial 2013 survey. Maps of the two primary survey areas, Western Jordan Basin and Outer Schoodic Ridge, were produced during a collaborative effort with the Ecosystem Monitoring group of the NEFSC and NOAA's Office of Exploration and Research during the fall 2013 ecosystem monitoring cruise aboard the NOAA *RV Okeanos Explorer*. A map of a Central Jordan Basin dive site, next to the U.S.-Canada boundary, was also produced during the June 2014 joint U.S.-Canadian deep-sea coral cruise on the *FSV Bigelow*. Selection of ROV dive locations in 2014 was based on topographic features shown in these detailed maps. Based on these data, 18 ROV dives in 2014 re-explored areas in Western Jordan Basin and Outer Schoodic Ridge, along with one dive in Central Jordan Basin near and north of the U.S./Canadian dive site. The ROV also collected specimens.

For 2015, merged bathymetric data (combined regional hydrographic survey data and site specific multibeam coverages) for the larger Gulf of Maine region at a finer scale then available on bathymetric charts, along with resultant slope maps, facilitated exploration in areas beyond existing multibeam in Western Jordan Basin and Outer Schoodic Ridge regions. An area was also surveyed on the northern edge of Georges Bank, down into Georges Basin, where corals had been previously seen during a 1995 submersible survey of seafloor geology.

Detailed analyses of video and still images to determine coral and sponge distributions in relation to geology, associated species, and coral size structure are ongoing. The 2014 *ROV Kraken 2* dives in Outer Schoodic Ridge and western and central Jordan Basin collected specimens of coral and other invertebrates for studies on deep-sea coral reproduction, population genetics, aging and growth, and taxonomy.

6.2.2 Species richness

As determined from the historical record and from recent explorations, deep-sea corals in the northwest Atlantic are a diverse assortment of two Anthozoan subclasses. The subclass Hexacorallia (Zoantharia) includes the hard or stony corals (order Scleractinia) and the black corals (order Antipatharia), and the subclass Octocorallia (Alcyonaria or octocorals) includes the true soft corals and gorgonians (order Alcyonacea) as well as the sea pens (order Pennatulacea). Some taxonomists have assigned the gorgonians to a separate order, Gorgonacea, but they are often combined, and that convention is adopted in this document (Bayer 1981, Daly et al. 2007; McFadden et al 2010). “Octocorals” is an umbrella term for the true soft corals, gorgonians, and sea pens, but is avoided here because the soft corals and gorgonians are generally distinct from the sea pens in terms of their habitat preferences, morphology, and their susceptibility to fishing gear impacts. Coral taxonomy is an active field of research, and continues to evolve as additional voucher specimens are collected and genetic analyses allow for discrimination between morphotypes.

The following four sections describe the species richness of corals in New England, grouped by taxonomic order. Some of these species are only recently known to occur in the region because of the recent exploratory surveys, while others are documented in the various historical datasets. Note that in the tables below, the genus and species names are listed in italics. The abbreviation 'sp.' indicates that the listed coral belongs to the genus noted, but that the species is uncertain; "spp." indicates it may be one of several species. Names following the species and genus refer to the author who first identified the species. When this name is in parentheses, the species name has been changed since the original identification. A question mark preceding the genus or species name indicates that the identification at this taxonomic level although uncertain, is probable. Species that thus far have only been found or described from the Mid-Atlantic region are not included in these tables.

6.2.2.1 True soft corals and gorgonians (Order Alcyonacea)

Along with the sea pens, which belong to a different taxonomic order and are discussed separately below, true soft corals and gorgonians are members of the subclass Octocorallia. The octocorals have polyps that are are subdivided into eight mesenteries, or spaces, each of which gives rise to a tentacle (Watling et al. 2011). Combining true soft corals and gorgonians together, eleven families are represented in New England: Acanthogorgiidae, Alcyoniidae, Anthothelidae, Chrysogorgiidae, Clavulariidae, Corallidae, Isididae, Nephtheidae, Paragorgiidae, Plexauridae, and Primnoidae. All of the species in these families are colonial (Watling et al. 2011). Table 7 lists true soft corals and gorgonians found in the New England region, by family affiliation. A more detailed version of this table that shows species in both the New England and Mid-Atlantic regions is found in Packer et al. (in review).

These corals exhibit a variety of forms. True soft corals in the family Clavulariidae grow from ribbon-like stolons, while those in the families Alcyoniidae and Nephtheidae are fleshy, and lack an axial skeleton. Many of their relatives are found in shallow reef environments. True soft corals in the families Anthothelidae, Corallidae, and Paragorgiidae have an axial skeleton composed of sclerites. Gorgonian corals in the families Acanthogorgiidae, and Plexauridae have a fan-like shape, with an organic central axis that has varying amounts of calcareous material, while those in the families Chrysogorgiidae, Isididae (bamboo corals), and Primnoidae are also fan-shaped, but have a solid axis comprised of large amounts of calcareous material.

Watling and Auster (2005) noted two distinct distributional patterns for alcyonaceans. Most are deepwater species that occur at depths > 500 m; these include corals in the genera *Acanthogorgia*, *Acanella*, *Anthomastus, Anthothela*, *Clavularia, Lepidisis*, *Radicipes*, and *Swiftia*. Others occur throughout shelf waters to the upper continental slope and include *Paragorgia arborea*, *Primnoa resedaeformis*, and species in the genus *Paramuricea*.

Table 6 – True soft corals and gorgonians (Order Alcyonacea) of the New England region.

Family	Species	References
Acanthogorgiidae	*Acanthogorgia armata* Verrill, 1878	Hecker and Blechschmidt 1980; Hecker et al. 1980; Opresko 1980; Malahoff et al. 1982; Watling and Auster 2005; Watling et al. 2011; Auster et al. 2013, 2014; Quattrini et al. 2015
Alcyoniidae	*Alcyonium digitatum* Linné, 1758	Watling and Auster 2005, Watling et al. 2011
	Anthomastus agassizii Verrill, 1922	Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Opresko 1980; Valentine et al. 1980; Maciolek et al. 1987a; Hecker 1990; Moore et al. 2003; Watling and Auster 2005, Watling et al. 2011
	Anthomastus grandiflorus Verrill, 1878	Hecker and Blechschmidt 1980; Hecker et al. 1980; Opresko 1980; Watling and Auster 2005, Watling et al. 2011
	Anthomastus (sp.?)	Quattrini et al. 2015
Anthothelidae	*Anthothela grandiflora* (Sars, 1856)	Hecker et al. 1980; Opresko 1980; Watling and Auster 2005
Chrysogorgiidae	*Chrysogorgia tricaulis* Pante and Watling, 2011	Thoma et al. 2009, Pante and Watling 2011
	Chrysogorgia sp.	Quattrini et al. 2015
	Metallogorgia melanotrichos (Wright and Studer, 1889)	Mosher and Watling 2009; Thoma et al. 2009; Watling et al. 2011; Quattrini et al. 2015
	Iridogorgia pourtalesii Verrill, 1883	Watling and Auster 2005
	Radicipes gracilis (Verrill, 1884)	Moore et al. 2004; Watling and Auster 2005; Thoma et al. 2009
Clavulariidae	Stoloniferan sp. 1 (yellow) [Family Clavulariidae?]	Quattrini et al. 2015
	Stoloniferan sp. 2 (white) [Family Clavulariidae?]	Quattrini et al. 2015
	Clavularia modesta (Verrill, 1874)	Watling and Auster 2005
	Clavularia rudis (Verrill, 1922)	Hecker and Blechschmidt 1980; Hecker et al. 1980; Opresko 1980; Watling and Auster 2005
Coralliidae	*Corallium ?bathyrubrum* Simpson and Watling 2010	Quattrini et al. 2015
	?Hericorallium Gray 1867	Quattrini et al. 2015

Family	Species	References
Isididae	*Acanella arbuscula* (Johnson, 1862)	Hecker and Blechschmidt 1980; Hecker et al 1980; Opresko 1980; Maciolek et al. 1987a, b; Hecker 1990; Theroux and Wigley 1998; Watling and Auster 2005; Thoma et al 2009
	Keratoisis grayi Wright, 1869	Watling and Auster 2005; Bear Seamount: Moore et al. 2004; Deep Atlantic Stepping Stones Science Team/IFE/URI/NOAA
	Keratoisis sp. 1	Quattrini et al. 2015
	Keratoisis sp. 2	Quattrini et al. 2015
	Keratoisis sp. 3	Quattrini et al. 2015
	Keratoisis sp. 4	Quattrini et al. 2015
	Keratoisis sp. 5	Quattrini et al. 2015
	Keratoisis spp.	Quattrini et al. 2015
	Lepidisis caryophyllia Verrill, 1883	Moore et al. 2003; Watling and Auster 2005
	Lepidisis sp. 1	Quattrini et al. 2015
	Lepidisis sp. 2	Quattrini et al. 2015
	?Eknomisis Watling and France, 2011	Quattrini et al. 2015
	Keratoisidinae (unbranched)	Quattrini et al. 2015
	Isidella Gray 1857	Quattrini et al. 2015
	Jasonisis Alderslade and McFadden, 2012	Quattrini et al. 2015
	Isididae unknown 1	Quattrini et al. 2015
Nephtheidae	*Duva* [= *Capnella*] *florida* (Rathke, 1806)	Hecker and Blechschmidt 1980; Hecker et al. 1980; Opresko 1980; Maciolek et al. 1987a; Hecker 1990; Watling and Auster 2005; Watling et al. 2011
	Capnella glomerata (Verrill, 1869)	Hecker et al. 1980; Opresko 1980; Watling and Auster 2005
	Gersemia fruticosa (Sars, 1860)	Hecker and Blechschmidt 1980; Opresko 1980; Watling and Auster 2005
	Gersemia rubriformis (Ehrenberg, 1934)	Watling and Auster 2005
	Nephtheidae Unidentified sp. 1	Quattrini et al. 2015
Paragorgiidae	*Paragorgia arborea* (Linné, 1758)	Wigley 1968; Hecker and Blechschmidt 1980; Hecker et al. 1980; Opresko 1980; Theroux and Grosslein 1987; Theroux and Wigley 1998; Moore et al. 2003; Watling and Auster 2005
	Paragorgia ?johnsoni Gray, 1862	Quattrini et al. 2015
	Paragorgia sp.	Quattrini et al. 2015

Family	Species	References
	Paragorgia/Sibogagorgia sp. 1	Quattrini et al. 2015
Plexauridae	*Paramuricea grandis* Verrill, 1883	Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Opresko 1980; Valentine et al. 1980; Watling and Auster 2005; Thoma et al 2009
	Paramuricea placomus (Linné, 1758)	Watling and Auster 2005
	Paramuricea n. sp.	Watling and Auster 2005
	Paramuricea spp.	Quattrini et al. 2015
	Paramuricea/Placogorgia sp. 1	Quattrini et al. 2015
	Swiftia casta (Verrill, 1883)	Moore et al. 2003; Watling and Auster 2005
	Swiftia ?pallida Madsen, 1970	Quattrini et al. 2015
	Plexauridae Unidentified sp. 1	Quattrini et al. 2015
	Narella laxa Deichmann, 1936	Watling and Auster 2005
Primnoidae	*Primnoa resedaeformis* Gunnerus, 1763)	Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Opresko 1980; Valentine et al. 1980; Theroux and Grosslein 1987; Theroux and Wigley 1998; Moore et al. 2003; Cairns and Bayer 2005; Watling and Auster 2005; Heikoop et al. 2002
	Thouarella grasshoffi Cairns, 2006	Watling and Auster 2005 = *Thouarella* n. sp.; Cairns 2006, 2007
	Parastenella atlantica Cairns, 2007	Cairns 2007, Watling et al. 2011
	Calyptrophora antilla Bayer, 2001	Cairns 2007, Watling et al. 2011
	Paranarella watlingi Cairns, 2007	Cairns 2007, Watling et al. 2011, Quattrini et al. 2015
	Convexella ?jungerseni (Madsen, 1944)	Quattrini et al. 2015
	Primnodidae Unidentified sp. 1	Quattrini et al. 2015

6.2.2.2 Sea pens (Order Pennatulacea)

Like the true soft corals and gorgonians, sea pens are also members of the subclass Octocorallia. Unlike their octocoral cousins which have some representatives in shallow reefs, almost all sea pens are deepwater species. Generally the sea pens are associated with soft sediments, and each colony is anchored to the seabed with a fleshy peduncle, or foot. In New England, the most widespread species occur on the continental shelf and include the common sea pen *Pennatula aculeata* (Family Pennatulidae) and the white sea pen *Stylatula elegans* (family Virgulariidae). *P. aculeata* is common in the Gulf of Maine (Langton et al. 1990), and there are numerous records of *Pennatula* sp. on the outer continental shelf as far south as the Carolinas (Theroux and Wigley 1998). *S. elegans* is abundant on the Mid-Atlantic coast outer shelf (Theroux and Wigley 1998). Eight additional families are represented in New England: Anthoptilidae, Funiculinidae, Halipteridae, Kophobelemnidae, Ombellulidae, Protoptilidae, Renillidae, and Scleroptilidae.

Table 8 lists the sea pens that have been documented in New England waters. Some of these identifications are at the genus or even family level only. A more detailed version of this table that applies to both the New England and Mid-Atlantic regions is provided in Packer et al. (in review). Older records of sea pens are drawn from Smithsonian Institution collections and the Wigley and Theroux benthic database (Packer et al. 2007). Nearly all materials from the former source were collected either by the U.S. Fish Commission (1881-1887) or for the Bureau of Land Management (BLM) by the Virginia Institute of Marine Sciences (1975-1977) and Battelle (1983-1986). These latter collections heavily favor the continental slope fauna. The Wigley and Theroux collections (1955-1974) were made as part of a regional survey of all benthic species (Theroux and Wigley 1998), heavily favoring the continental shelf fauna.

Table 7 – Sea pens (Order Pennatulacea) of the New England region.

Family	Species	References
Anthoptilidae	*Anthoptilum grandiflorum*	US NMNH collection, OBIS; Hecker and Blechschmidt 1980; Opresko 1980, Quattrini et al. 2015
	Anthoptilum murrayi	US NMNH collection, OBIS
	Anthoptilum sp. 1	Quattrini et al. 2015
	Anthoptilum sp. 2	Quattrini et al. 2015
Funiculinidae	*Funinculina armata* Verrill, 1879	US NMNH collection
Halipteridae	*Halipteris (=Balticina) finmarchica* (Sars, 1851)	US NMNH collection as *Balticina*; Hecker and Blechschmidt 1980 and Opresko 1980 as *Balticina*; Quattrini et al. 2015
	?Halipteris Kölliker, 1880	Quattrini et al. 2015
Kophobelemnidae	*Kophobelemnon stelliferum*	US NMNH collection, OBIS; Hecker et al. 1980, 1983; Opresko 1980; Maciolek et al. 1987b
	Kophobelemnon scabrum	US NMNH collection
	Kophobelemnon tenue [may not be a valid species]	US NMNH collection
	Kophobelemnon sp. 1	Quattrini et al. 2015
	Kophobelemnon sp. 2	Quattrini et al. 2015
Ombellulidae (or Umbellulidae)	*Ombellula guntheri* Kölliker, 1880	US NMNH collection
	Ombellula lindahlii Kölliker, 1880	US NMNH collection, OBIS
	Umbellula (= Ombellula) Gray, 1870	Quattrini et al. 2015
Pennatulidae	*Pennatula aculeata*	US NMNH collection, OBIS. Hecker et al. 1980, 1983; Hecker and Blechschmidt 1980; Opresko 1980; Moore et al. 2004
	Pennatula grandis	US NMNH collection, OBIS; Hecker et al. 1983

	Pennatula borealis	US NMNH collection, OBIS
	Pennatula sp.	Quattrini et al. 2015
Protoptilidae	*Distichoptilum gracile*	US NMNH collection, OBIS; Hecker et al 1980, 1983; Opresko 1980; Maciolek et al. 1987a; Hecker 1990; Quattrini et al. 2015
	Protoptilum aberrans	US NMNH collection
	Protoptilum carpenteri	US NMNH collection, OBIS
Scleroptilidae	*Scleroptilum gracile*	US NMNH collection
Scleroptilidae	*Scleroptilum grandiflorum*	US NMNH collection, OBIS
Virgulariidae	*Stylatula elegans*	US NMNH collection, OBIS; Hecker et al. 1980, 1983; Opresko 1980; Pierdomenico et al. 2015

6.2.2.3 Hard (stony) corals (Order Scleractinia)

Hard or stony corals are in the subclass, Hexacorallia, and as their subclass name would suggest, the stony corals have a six part division, rather than eight like the octocorals (Pechenik 2000). Stony corals (and hexacorallians generally) commonly exhibit solitary body forms, although many are colonial as well (Pechenik 2000). As their common name indicates, these species have substantial hard exoskeletons made from calcium carbonate (sclero is Greek for hard, Pechenik 2000). Some stony corals form reefs or mounds over time, as new colonies overgrow old ones (Pechenik 2000). These reef builders are referred to as the hermatypic corals (Pechenik 2000). Most of the stony corals in New England are non-reef building or ahermatypic (e.g., solitary stony corals such as *Desmophyllum dianthus*), although *Lophelia pertusa* and *Solenosmilia variabilis* are notable exceptions. *L. pertusa* was only recently found in New England waters, but is more commonly known from the Southeastern U.S and Canada, as well as the eastern North Atlantic and elsewhere in the world. The carbonate skeletons of stony corals are sensitive to changes in ocean chemistry. Assessing the resilience of these species to more acid and warmer waters is an active field of research.

Table 9 lists stony corals found in the New England region. Families with representatives in New England include the Caryophillidae, Dendrophylliidae, Flabellidae, Fungiacyathidae, and Rhizangiidae. A more detailed version of this table that applies to both the New England and Mid-Atlantic regions is provided in Packer et al. (in review).

Table 8 – Hard (stony) corals (Order Scleractinia) of the New England region

Family	Species	References
Caryophillidae	*Caryophyllia ambrosia ambrosia* Alcock, 1898	Cairns and Chapman 2001; Moore et al. 2003
	Caryophyllia ambrosia caribbeana Cairns, 1979	Cairns and Chapman 2001
	Dasmosmilia lymani (Pourtales, 1871)	Hecker 1980; Hecker et al. 1983; Maciolek et al. 1987a; Hecker 1990; Cairns and Chapman 2001
	Deltocyathus italicus (Michelotti, 1838)	Cairns and Chapman 2001
	Desmophyllum dianthus	Hecker 1980; Hecker and Blechschmidt 1980; Hecker et al.

Family	Species	References
	(Esper, 1794)	1980, 1983; Malahoff et al. 1982; Cairns and Chapman 2001; Moore et al. 2003; Quattrini et al. 2015
	Lophelia pertusa (L, 1758)	Hecker 1980; Hecker and Blechschmidt 1980; Hecker et al. 1980; Cairns and Chapman 2001; Moore et al. 2003; Quattrini et al. 2015
	Solenosmilia variabilis Duncan, 1873	Hecker 1980; Hecker et al. 1983; Cairns and Chapman 2001; Moore et al. 2004; Quattrini et al. 2015
	Vaughanella margaritata (Jourdan, 1895)	Cairns and Chapman 2001; Moore et al. 2003
Dendrophylliidae	*Enallopsammia profunda* (Pourtales, 1867)	Cairns and Chapman 2001
	Enallopsammia rostrata (Pourtales, 1878)	Cairns and Chapman 2001; Moore et al. 2004
Flabellidae	*Flabellum alabastrum* Moseley, 1873	Hecker 1980; Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Maciolek et al. 1987a; Cairns and Chapman 2001; Moore et al. 2003, 2004
	Flabellum angulare Moseley, 1876	Hecker 1980; Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Cairns and Chapman 2001; Moore et al. 2003
	Flabellum macandrewi Gray, 1849	Hecker 1980; Hecker and Blechschmidt 1980; Hecker et al. 1980, 1983; Cairns and Chapman 2001; Moore et al. 2003
	Javania cailleti (Duch. and Mich., 1864)	Hecker 1980; Hecker et al. 1983; Cairns and Chapman 2001; Quattrini et al. 2015
Fungiacyathidae	*Fungiacyathus fragilis* Sars, 1872	Cairns and Chapman 2001
Rhizangiidae	*Astrangia poculata* (Ellis and Solander, 1786)	Theroux and Wigley 1998; Cairns and Chapman 2001

6.2.2.4 Black corals (Order Antipatharia)

Like the stony corals, black corals are also members of the subclass Hexacorallia. The black corals, however, are almost all deepwater species, occurring well below 50 m, often with increasing abundance with depth, perhaps to avoid competition with other coral types (Wagner et al. 2012). Black corals are very slow growing and long lived, and while they do not form reefs (ahermatypic), over time some can form dense aggregations or beds, and are therefore important habitat engineers for other invertebrate taxa (Wagner et al. 2012). In other parts of the world, black corals are culturally important, and may by harvested for medicinal purposes, or for making decorative objects such as jewelry (Wagner et al. 2012).

All black corals are colonial, but they have a wide array of body forms, from long, whip shapes to branching structures that may be bushy, feathery, fan like, or shaped like a bottle brush (Wagner et al. 2012). The majority of black corals attach to hard substrates by means of a basal plate, but a small number of species are adapted to anchor in soft sediments (Wagner et al. 2012). They are referred to as black corals because their underlying skeleton is brown to black, although this skeleton is covered by a layer of soft tissue, to which the polyps are attached (Wagner et al. 2012). The outer soft tissues come in a rainbow of colors.

Many of the black coral species occurring in New England, including all of the records in the canyons, are known from recent exploratory surveys conducted since 2013. Most are members of the family Schizopathidae, and are identified to the genus level only. A single Leiopathid species is known from Bear Seamount. This lack of taxonomic specificity is not surprising, as black corals are one of the less well studied coral types, and reference specimens are often lacking (Wagner et al. 2012). Prior to these recent explorations, black corals were thought to occur only on the seamounts, but now they are known to be more widespread. A more detailed version of this table that applies to both the New England and Mid-Atlantic regions is provided in Packer et al. (in review).

Table 9 – Black corals (Order Antipatharia) of the New England region.

Family	Species	References
Leiopathidae	*Leiopathes sp.*	Brugler 2005, Smithsonian Institution
Schizopathidae	*Bathypathes* sp.	Thoma et al. 2009
	Bathypathes sp. 1	Quattrini et al. 2015
	Bathypathes sp. 2	Quattrini et al. 2015
	Parantipathes sp.	Thoma et al. 2009
	Parantipathes sp. 1	Quattrini et al. 2015
	Parantipathes sp. 2 (branched)	Quattrini et al. 2015
	Telopathes magna MacIssac and Best, 2013	Quattrini et al. 2015
	Stauropathes sp. 1	Quattrini et al. 2015
	Unidentified *Schizopathidae* sp. 1	Quattrini et al. 2015

6.2.3 Geographic distribution

The following three sections describe the geographic distribution of corals in New England, based on both historical records and recent exploratory surveys.

6.2.3.1 Canyons and slope

Deep-sea corals are generally more densely distributed and diverse in the canyons than on the adjacent slope. Some species, such as those restricted to hard substrates, are generally found only in the canyons, while other species that frequently occur on soft substrates, such as *Acanella arbuscula*, are found both in canyons and on the slope. The canyons, particularly the larger ones, have hard substrates along most of their axes and walls that support many deep-sea corals. The slope south of Georges Bank is mostly soft substrate, supporting mainly stony corals on the upper slope and sea pens deeper than about 1500 m, with some exceptions.

The recent exploratory surveys provide a wealth of new information on the distribution of corals in the canyons. While much of the analysis of the recent cruises remains ongoing, the results of the 2013 Okeanos Explorer survey EX1304 have been published (Quattrini et al. 2015). At least 58 taxa of deep-sea corals were noted, and at least 24 of these had not been documented in this region previously. The type of broad-scale habitat feature and high habitat heterogeneity in this region was an important factor that influenced coral assemblages. Quattrini et al. (2015) found no significant differences between deep-sea coral assemblages between continental shelf-breaching canyons vs. canyons confined to the continental slope, but did find lower diversity and different faunal assemblages at cold seeps and soft-bottom open slope sites. The canyons often had large patches of deep-sea coral habitat, which also included bivalves, anemones, and sponges. Stony (e.g., *Desmophyllum*, *Solenosmilia, Lophelia*) and soft corals were often abundant on long stretches of canyon walls and under and around overhangs. Coral communities were uncommon on the open slope, except on the channel floor of Veatch Canyon where sea pens and bamboo corals in soft sediments were frequently observed. Corals and sponges were also observed on boulders and outcrops in some open slope and intercanyon areas. At Veatch seeps and on the canyon wall adjacent to the seep community in Nygren Canyon, soft corals and stony cup corals (*Desmophyllum*) were found attached to authigenic (locally generated) carbonates.

Quattrini et al. (2015) found that depth was a significant factor influencing the coral assemblages. Although species richness did not change significantly with depth over the range explored by the surveys (494-3,271 m), species composition changed at approximately 1,600-1,700m. Species composition in the canyons and other areas with hard substrates were significantly dissimilar across this depth boundary. Stony corals and the soft corals *Anthothela* spp., *Keratoisis* sp. 1, and *Paragorgia arborea* occurred at depths < 1,700m, whereas chrysogorgiids and sea pens were more common at depths >1,700m. Overall, depth, habitat, salinity and dissolved oxygen explained 71% of the total variation observed in coral assemblage structure (Quattrini et al. 2015). Coral types observed in individual canyons are described below.

There are 11 historical records that fall within **Alvin Canyon**, including observations of stony corals, sea pens, and soft corals. The two observations just outside the recommended zone boundary are a cup coral (*Dasmosmilia lymani*), which is type of hard coral, and the soft coral *Duva florida*. Both were older records from 1883 such that the exact location of these records is somewhat uncertain. There were two 2013 dives in the Alvin Canyon area at depths ranging from 846 to 927m (Cruise EX1304L1, dives 9 and 10)[3]. Both the east and west walls were surveyed. The dives traversed a range of soft sediment and rock wall/overhang habitats, and corals were observed during both dives, especially in rocky areas.

There are two historical observations that fall within **Atlantis Canyon**, one stony coral and one sea pen. There were two 2013 dives in Atlantis Canyon (Cruise EX1304L1, dives 7 and 8), at depths ranging from 885 to 1,794m below sea level. Both the east and west walls were surveyed. Corals were observed during both dives. Dive 7 found colonial

[3] Do not have detailed logs for these dives.

stony corals, soft corals, and black corals, plus cup corals, which are a solitary type of stony coral. Diverse types of stony, soft, and black corals were also found on Dive 8, in addition to sea pens.

There are seven historical coral observations within **Nantucket Canyon**, including observations of stony corals. During 2014, Cruise EX1404L3 Dive 13 visited the southwestern canyon wall at the mouth (1,600-1,900m). Corals observed on a debris field at 1,875 m include the soft corals *Acanthogorgia* and *Anthomastus* and small *Distichoptilum* sea pens. The sea pen *Umbellula* was seen at 1,870m. At 1,861m, tall whip-like sea pens had large *Asteronyx* brittle stars clinging to them. At the base of the wall (~1,825m) *Paramuricea* sea fans (with associated *Ophiocreas* brittlestars) were noted. On the wall face were the soft corals *Anthomastus* and *Paramuricea* and the black coral *Bathypathes*. Overall, the wall was sparsely colonized. Other corals observed include bamboo corals (soft corals) *Keratoisis* (1,783m) *Lepidisis, Acanella,* and *Isidella*; the soft corals *Anthomastus* and *Clavularia* stoloniferous coral; *Parantipathes* black coral; and stony cup corals. *Paramuricea* sea fans and *Pennatula* sea pens were seen growing on the flat cap of the outcrop. *Chrysogorgia* soft coral colonies appeared at 1,750m, some with a shrimp associate. *Eknomisis* bamboo coral were seen, as well as different morphs of hexactinellid or glass sponges.

While there are no historical observations of coral presence in **Veatch Canyon**, there have been five recent dives. There were three TowCam dives in Veatch Canyon in 2012 during cruise HB1204. During Dive 8, only stony and soft corals were observed, and in a smaller percentage of the collected images compared with the other two dives. Dives 7 and 9, which were in deeper parts of the canyon, had larger percentages of images with corals, and stony, soft, and black corals and sea pens were observed. Overall, between 570-750m, the canyon has mostly sedimented habitats, with some draped chalky rocks. Between 1,050-1,250m there are hard bottom walls dominated by the soft coral *Acanthogorgia* and the stony corals *Solenosmilia* and *Desmophyllum*, all sparsely distributed. Between 1,290-1,424m, the seafloor is dominated by chalky rock bottom intermingled with flat, fully sedimented areas. On the hard substrate (rocks and walls) there is a diverse coral fauna, including the soft corals *Parmuricea*, *Anthomastus*, *Paragorgia*, *Swiftia*, *Clavularia*, *Acanthagorgia,* and bamboo corals; the stony coral *Desmophyllum*; and the black coral *Parantipathes*. On soft sediments at this deeper depth range, cerianthid anemones and the soft coral *Anthomastus* were noted. Overall, black coral abundance increased with depth, and none were observed between 569-751m. Stony and soft coral abundances were also low at the shallowest depths, and greatest at intermediate and deepest depths based on the percentages noted in the images; the highest abundances of stony coral were observed on vertical walls. Sea pen abundance was low throughout.

Cruise EX1404 (2014) explored a small mid-canyon cliff and the main canyon walls in an unnamed, narrow **minor canyon east of Veatch Canyon** ("Okeanos Canyon"). Large debris boulders at the base of the cliff had a surprising density of corals, including the soft corals *Anthomastus*, *Paramuricea*, and *Swiftia,* and stony cup corals. Stony cup corals and the colonial *Solenosmilla* corals, black corals (?*Bathypathes*), bamboo coral

(*Keratoisis*), and sponges were seen on the wall. Ascending the wall to about 1,395m, there were many patches of stony cup corals (*Desmophyllum*) and *Solenosmilia* colonies, the black coral *Parantipathes*, and the soft corals *Clavularia* and *Acanthogorgia*. At 1,385m, *Keratoisis* bamboo coral and *Paragorgia ?johnsoni* were observed. Other corals observed during the dive included the sea pens ?*Distichoptilum* and the black corals *Bathypathes* and *Telopathes*.

There are two historical observations of coral presence within **Hydrographer Canyon**, both soft corals. There have been two recent coral cruise tows in Hydrographer Canyon (Cruise EX1304L1, dives 5 and 6), where both the east and west walls of the canyon were surveyed. Dive 5 (1,299-1,418m) found stony, soft, and black corals of various species, including some smaller colonies noted as new recruits. Dive 6 (610-907m) found soft and stony corals, including *Lophelia pertusa*, which is a reef building species.

Dogbody Canyon has eight historical observations of soft corals. In 2015 (cruise HB1504), tow 1 (558-675 m) found sponges, but corals were uncommon. Tow 2 (894-1,014m) found abundant and diverse stony (*Desmophyllum*), soft (*Thouarella*, *Paramuricea*, *Acanthogorgia*, *Swiftia*) and black (*Telopathes*?) corals. During tow 3 (1,461-1,620m), corals were rare with low diversity, and only soft (*Paramuricea*, *Radicipes*?) corals were observed.

Clipper Canyon had one historical observation of soft coral presence. In 2015 (cruise HB1504), sightings of corals were sparse, with soft corals seen during both tow 19 (495-571m, *Paragorgia*) and tow 20 (1,216-1,455m, *Paramuricea*).

During cruise HB1504 (2015), Tows 16 and 17 were conducted in **Sharpshooter Canyon**, in two of the larger contiguous areas of high slope. No corals were noted during the shallow tow 16 (800-901); but the deeper tow, 17 (1,144-1,168m), found stony corals (*Solenosmilia*) and soft corals (*Paramuricea*).

Welker Canyon had no historical records of coral presence. On dive 14 of Cruise EX1304L2 (1,377-1,445m), a wide diversity of corals were observed, including at least 17 species in all four major groupings. Three tows during cruise HB1504 (2015) surveyed the walls of the canyon. Tow 13 (559-778m) found stony corals (*Solenosmilia, Desmophyllum*) and soft corals (*Acanthogorgia, Paragorgia*); tow 14 (851-1,156m) found stony corals (*Solenosmilia*), soft corals (*Paramuricea, Thouarella*), and black corals (*Telopathes, Bathypathes*?); and tow 15 (1,480-1,650m) found soft corals (*Paramuricea, Anthomastus*) and black corals (*Parantipathes, Bathypathes*?).

There are no historical observations of coral presence in **Heel Tapper Canyon**. However, there have been recent ROV dives in the area, which include three tows in 2015 (Cruise HB1504). These three ROV dives at depths ranging from 666 to 1,444m observed soft corals (*Thourella*, *Paramuricea*, and *Acanella*).

There are a relatively large number of historical observations (150+) within **Oceanographer Canyon**, including observations of soft corals and stony corals. Some additional areas to the west of the proposed zone have historical observations as well. In addition, there have been two recent dives within the proposed zone (cruise EX1304L2. Both the eastern and western walls were surveyed. Dive 3 (983-1,239m) and Dive 13 (1,102-1,248m) both encountered diverse habitat types and at least 16 species of stony, soft, and black corals. The colonial stony coral *Lophelia* was observed during Dive 3.

Filebottom Canyon had one historical record of soft corals. There were a total of four tows there during the cruise HB1504 (2015). Tow 7 (664-887 m) and Tow 8 (1,029-1,077m) recorded stony corals (*Solenosmilia, Desmophyllum*) and soft corals (*Paramuricea*, *Primnoa*?). Heel Tapper Canyon had no historical observations. Three tows ranging from 666-1,444m found soft corals (*Thouarella*, *Paramuricea*, *Acanella*).

Chebacco Canyon has no historical coral records. During cruise HB1504 (2015), there were two tows on the east wall. Tow 4 (801-875 m) found stony corals (*Solenosmilia, Desmophyllum*) and Tow 5 (1133-1356 m) found soft corals (*Paramuricea, Swiftia, Acanthogorgia, Clavularia,* bamboo), stony corals (*Solenosmilia*), and black corals (*Parantipathes*?). The deepest tow (6, 1,909-2,061m) found soft corals (*Paramuricea*).

Gilbert Canyon is a hotspot of coral abundance and diversity. The tows during cruise HB1204 (2012) covered various locations throughout the canyon including an area near the head and on multiple walls and tributaries. All of the tows found soft corals, with the percentage of images with soft corals ranging from 2% to 54%. Other coral types were found in the canyon as well, including black corals, stony corals, and sea pens. Two tows of the eight revealed markedly high coral abundance and diversity. These tows were on the western wall between 1,370-1,679m and in the canyon head between 640-820m. The western canyon slopes had the greatest abundance and diversity of corals, with the hard bottom hosting solitary stony corals and a few colonial stony corals (*Solenosmilia*), mostly on rocky outcrops. Soft coral diversity (*Paramuricea*, *Acanella*, *Paragorgia*, etc.) was high in this canyon due to the diversity of habitats. Sea pen abundance was also high in the canyon. Soft corals in the head of the canyon (640-820m) were highly abundant but dominated by a single type of coral (likely *Acanella*). Black corals (possibly *Plumapathes* and *Parantipathes*), were also noted.

There are 105 historical observations of coral presence in **Lydonia Canyon**, including observations of soft corals, sea pens, and stony corals, making it one of the best studied locations prior to the recent exploratory surveys. There has also been one recent ROV dive within the proposed zone during cruise EX1304L2, dive 12; 1,135-1,239m. A large number of species (at least 15) from all four coral groups were observed during the dive.

There were six tows in **Powell Canyon** during cruise HB1302 (2013). Tows 7 (753-1,306m) and 8 (905-1,340m) had high abundances and diversities of corals, while tow 9 (1,302-1,630m) had abundant corals, and often with areas of high localized abundances, with some areas having widely dispersed corals or none at all. The remaining three deeper tows (1,292-2,053m) had low abundances/low diversities of corals. Examples of species observed included the stony corals *Solenosmilia* and *Desmophyllum*; the soft corals *Paramuricea, Acanthogorgia, Anthomastus, Paragorgia, Primnoa, Radicipes*, *Thourella*, *Swiftia*, *Acanella*, *Chrysogorgia*, and bamboo corals; the black corals *Parantipathes, Bathypathes*, and ?*Telepathes*; and sea pens. In addition to these efforts within Powell Canyon, one tow surveyed a relatively shallow inter-canyon area (482-508m) between Munson and Powell. In this intercanyon area, corals were rare, with low diversity, and only the soft coral *Acanthogorgia* was noted. Two tows surveyed a minor canyon between Munson and Powell (927-1,273m). On these tows, corals were common, diverse, and widely distributed, with some areas of high localized abundance or no corals at all. Stony corals found included *Solenosmilia* and *Desmophyllum*; soft corals included *Paramuricea, Anthomastus, Swiftia*, and bamboo corals; black corals included *Parantipathes*.

In **Munson Canyon**, seven TowCam tows were completed during cruise HB1302 (2013). In tows 14 (535-1,040m), 16 (983-1,346m), 17 (935-1,455m), 18 (1,330-1,941m) and 24 (1,084-1,472m), corals were abundant, often with areas of high localized abundance. Other areas had widely dispersed corals or none at all. Tow 19 (1,283-1,855m) had fewer corals overall, while Tow15 (550-1,089m) had a low abundance and diversity of corals present. Examples of species observed included the stony corals *Solenosmilia* and *Desmophyllum*; the soft corals *Paramuricea, Acanthogorgia, Anthothela, Anthomastus, Paragorgia, Primnoa, Radicipes*, and bamboo corals; the black coral *Parantipathes,* and sea pens.

Relative to Munson Canyon, coral diversity in **Nygren Canyon** was higher, with few species occurring at locally high abundance as observed during the collaborative 2014 U.S./Canadian cruise. One notable exception was a vertical wall covered with colonies of the stony coral *Solenosmilia variabilis*. Bamboo corals, *Paramuricea* sp. and the stony coral *Desmophyllum dianthus* were numerically dominant species. Sponges were diverse and abundant in Nygren Canyon. These 2014 observations were consistent with dives conducted during leg 2 of the 2013 *RV Okeanos Explorer* Cruise EX1304. Dive 6 (1,310-1,590m) traversed a diverse range of habitats, including soft sediments, a cold seep, and exposed rock faces. Corals found included soft corals (at least 17 species), black corals (three species), stony corals (three to four species), and sea pens (three species). Dive 8 (678-914m) traversed a shallower area of the canyon, with sediments ranging from soft sediment with large boulders to rugged steep terrain with sediment-draped rock. A diverse coral fauna was observed during this dive, as well as a diversity of fishes and other fauna.

There are no historical observations of coral presence in the **unamed canyon between Nygren and Heezen**. There was a 2013 ROV dive in the canyon (Okeanos Explorer Cruise EX1304 leg 2, dive 10, 497-824m). The dive track transited diverse habitat types and geological features, including soft sediments over rocky ledges, sediment with coral rubble, and a steeply sloping wall. The wall ledges harbored various coral types, including stony corals (solitary cup corals and colonial species) and soft corals. At the top of the slope the dive concluded on a sediment field with scattered rocks, colonized by attached organisms including soft corals (*Acanthogorgia*).

There are 67 historical records within **Heezen Canyon**, including observations of stony corals, soft corals, and sea pens. Two dives were completed in the area during cruise EX1304, leg 2. Dive 7 (1,615-1,723m), traversed varied habitat types along the southwestern flank of the canyon. Various coral taxa were found, including soft corals (*Paramuricea*, *Acanella*, *Clavularia*, and *Radicipes*), stony corals (the colonial *Solenosmilia*), black corals (*Stichopathes*), and sea pens (*Umbellela*). Dive 9 (703-926m), was in a shallower portion of the canyon along the southwestern wall. Vertical rock faces traversed during the dive were inhabited by enormous soft coral (*Paragorgia*, *Primnoa*, and *Paramuricea*) colonies. Other coral taxa were also observed during the dive. In contrast to Nygren Canyon, the 2014 U.S./Canadian cruise suggested that Heezen Canyon had lower diversity of corals, but several species were locally abundant. For example, vertical canyon walls were populated with numerous, large colonies of the bubblegum coral *Paragorgia arborea* interspersed with *Primnoa resedaeformis* and *Paramuricea* sp. at depths of 569-668 m (Dive 1). In addition, true soft corals (Neptheidae) were commonly observed on the wall of Heezen Canyon. At deeper depths (1,046-1,133 m), the soft coral *Anthomastus* sp. was more abundant, often found co-occurring with the hard corals *D. dianthus* and *S. variabilis* and the soft coral *Anthothela grandiflora*.

6.2.3.2 Seamounts

The summit of **Bear Seamount** is approximately 1,100m below sea level, and the base of the seamount is at over 3,000m. Bear is the largest of the New England seamounts, and while it was not visited during recent (2012-2015) cruises, all four groups of corals (soft, stony, sea pens, and black corals) had been previously documented in the area.

Mytilus is the deepest of the four seamounts, with a minimum depth of approximately 2,400m and a maximum depth of over 4,000m. Mytilus Seamount was surveyed during cruise EX1304 leg 2, dives 4 and 5. Dive 4 documented a diverse array of soft corals as well as two species of black coral. Sea pens, soft corals, and black corals were noted during Dive 5. A diversity of sponges was observed during both dives.

In October 2012, AUVs were used to investigate deep-sea coral presence distribution on **Physalia Seamount** (summit depth approximately 1,880m), a previously unexplored member of the New England Seamount chain (Kilgour et al 2014). The AUVs collected 2,956 color seafloor images as well as 120 kHz (low-frequency) and 420 kHz (high-frequency) sidescan sonar. Vehicle altitude of 8-10 m was necessary to maintain speeds of 3-4 kts and maximize area of coverage to locate coral aggregations. The presence of octocorals were confirmed from the images; sea pens were found in flat, soft sediments, but most other octocorals were found at either the ecotone of soft sediment and hard bottom, or on hard bottom features such as walls, ledges, and gravel/bedrock pavement (Kilgour et al. 2014).

Retriever Seamount was surveyed during 2013. Retriever Seamount is the farthest-offshore seamount within the US EEZ. It reaches depths of approximately 2,000m, is 7km in diameter, and has three main summits. The seamount harbors a diverse assemblage of taxa, including soft and especially black corals, and numerous hexactinellid (glass) sponges and demosponges. The corals observed (below 2,600m) were significantly different from those at other sites. Differences in species composition between Mytilus Seamount and other sites were primarily due to the presence/absence of numerous species. *Chrysogorgia* spp., *Convexella*? *jungerseni*, *Corallium*? *bathyrubrum*, *Paranarella*? *watlingi*, and *Paragorgia*/*Sibogagorgia* sp. 1 were observed on Mytilus Seamount, while *Acanthogorgia* spp., *Anthothela* spp., *Clavularia*? *rudis*, *P. arborea*, and *Paramuricea* spp. were not seen on Mytilus Seamount, but occurred at other sites. No stony corals were observed here; Quattrini et al. (2015) suggest that the deeper depths (2,600 to 3,200m) are beyond the stony corals' bathymetric limits.

Cruise EX1404 (2014) returned to both Retriever and Physalia seamounts. The ROV dive on Physalia Seamount took place on the upper flanks and ascended a steep slope on the southern side of the seamount (maximum depth 2,589m). Corals were observed in low abundance and diversity, with the soft coral *Chrysogorgia* sp. and sea pen *Anthoptilum* sp. being seen most commonly; the latter were seen in typical sea pen habitats embedded in soft sediments but also on hard substrates. The occasional bamboo coral *Lepidisis* sp. was seen. Other corals include black corals *Telopathes* and *Bathypathes*, the soft coral *Anthomastus*, and stony cup coral. On Retriever, the ROV was deployed to a depth of 2,142m and settled on a fairly monotonous sandy slope. Many sea pens colonies were seen in sedimented areas, with ?*Anthoptilum* sp. more common than *Pennatula* sp., as well as stony cup corals *Caryophyllia* sp. Soft coral *Metallogorgia melanotrichos* colonies were very abundant on a rock outcrop, and several "sub-adult" colonies were observed, suggesting different bouts of recruitment to the area. The orientation of many of the coral colonies clearly pointed to a downslope current. Other corals observed on the outcrop included the soft corals *Corallium* ?*bathyrubrum* and *C.* ?*niobe*, *Paramuricea* sp., *Iridogorgia splendens* (at least one with shrimp associate) and *I. magnispiralis*, *Candidella imbricata* and an unidentified Primnoidae, bamboo corals *Lepidisis* sp. and *Acanella* sp., and the black corals *Parantipathes*, *Stauropathes*, and *Bathypathes*.

6.2.3.3 Gulf of Maine

Deep-sea corals in the Gulf of Maine have been reported since the 19th century, both as fisheries bycatch and from naturalist surveys. At one time corals may have been considered common on hard bottoms in the region, but their current distribution appears to be more restricted. Presently, substantial concentrations of deep-sea corals are now confined to small areas where the bottom topography makes them mostly inaccessible to fishing gear (Auster 2005; Watling and Auster 2005; Cogswell et al. 2009, Auster et al. 2013).

Similar to the canyons and seamounts, recent survey work has added substantially to our knowledge of coral diversity and distribution in the Gulf of Maine. These surveys revealed extensive coral at around 200-250m depth in the primary survey areas, which included western and central Jordan Basin, Mount Desert Rock, Outer Schoodic Ridge, and Lindenkohl Knoll in Georges Basin (Auster et al. 2013, 2014; Packer et al., unpublished data). At all sites, structure-forming corals on hard substrate were predominantly gorgonian soft corals, in particular *Primnoa resedaeformis* and *Paragorgia arborea*, although scarce numbers of tiny, stony cup corals were seen on some dives, and sea pens were also observed. The sea pen *Pennatula aculeata*, which is common in the Gulf of Maine, was found in dense patches in the mud and gravel/mud habitats adjacent to hard-bottom habitats. The highest densities of sea pens were observed in the Mount Desert Rock region.

During these surveys, coral occurrences were classified as either coral present (sparse to medium density) or coral garden (high density patches). Coral gardens are areas where soft corals are among the dominant fauna and occur at densities higher than surrounding patches (Bullimore et al. 2013). Here, we adopt the threshold of 0.1 colonies/m^2 used by ICES (2007) to define coral garden habitat. Dense and extensive coral gardens were seen in Jordan Basin, at the Outer Schoodic Ridge site, and near Mount Desert Rock, especially in areas of high vertical relief.

Both low density coral habitats and coral garden habitats have been observed within the proposed **Mt. Desert Rock** coral zone, with the coral garden sites aligning with high slope areas. Six dives with corals and one nearby dive without corals have been conducted in the proposed zone since 2002, specifically dive 224 during 2002, dive 235 during 2003, tows 24 and 32 during 2013, and tows 10 and 11 in 2015. The 2013 and 2015 tows were all completed with the ISIS 2 towed camera system. The 2015 tows exhibited dense soft coral communities. Fine-grained sediment areas encountered during Tow 11 exhibited very high densities of sea pens.

Structure forming corals within the **Outer Schoodic Ridge** zone are mostly soft corals, although some smaller stony corals are also present. Outer Schoodic Ridge has topography reminiscent of narrow slot canyons on land (e.g., western U.S., in southern Utah). Based on the 2013 images (Auster et al. 2013), these steep areas had some of the highest coral densities found in the Gulf of Maine, with about 16-39 colonies/m^2, well above the threshold of 0.1 colonies/m^2. In some locations, *P. resedaeformis* colonies were so densely packed it was impossible to identify and count individual colonies. Some colonies may have been as large as one meter in size. All but one of the Outer Schoodic Ridge dives within the proposed coral zone found corals at coral garden densities, with sea pens and sponges found at the remaining dive site in the coral zone. Nearby dives outside the zone did not have coral. Common species at the Outer Schoodic Ridge dive sites include *Primnoa resedaeformis*, along with *Paramuricea placomus* and *Acanthogorgia* cf. *armata.* Areas outside these very steep rock faces with scattered gravels and smaller rock outcrops support lower densities of corals, primarily *P. placomus*, co-occurring with other structure-forming species such as burrowing cerianthid anemones, and sponges, as well as sea pens (*Pennatula aculeata*).

Generally, the dense corals on the steep vertical walls and cliffs of Outer Schoodic Ridge and Mount Desert Rock were primarily *Primnoa resedaeformis*, with lower abundances of *Paramuricea placomus. P. placomus* exhibits two color morphs in this region, yellow and purple. The proximity of extremely high densities of large sized, structure-forming gorgonians *P. resedaeformis* and *P. placomus* so close to shore and their association with commercially important fish and shellfish increases the potential role of these habitats to function as EFH (e.g., Auster 2005). Of note during the recent Gulf of Maine cruises were the first observations of the white coral *Anthothela* (*?grandiflora*) in the relatively shallow waters of the Gulf of Maine. Two colonies were seen at Outer Schoodic Ridge (e.g., Dive 13 in 2014) around 200m. This species has been observed off the Northeast Channel along the continental margin at depths below 1,400m (Cogswell et al. 2009).

Unlike the more inshore sites, where *P. resedaeformis* dominates, the major coral species found in the offshore basins was *P. placomus,* with lower abundances of *P. resedaeformis* and *Acanthogorgia cf. armata*. Similar to Outer Schoodic Ridge, coral garden habitats on 114 Fathom Bump in **Jordan Basin** exhibited the highest soft coral densities on steep rock walls. Both pink and white forms of *Paragorgia arborea* were noted at 114 Bump during a 2003 survey but they are the same species. Lower density coral habitats were observed at the nearby 96 Fathom Bump and 118 Fathom Bump sites, which have been surveyed with only a single dive each. Two dives have been completed in the central portion of Jordan Basin, and both have documented coral presence. Lower density coral habitats were found at the northern dive site, and higher density coral habitats at the southern site visited during the 2015 U.S./Canadian cruise. The southern site would be classified as a coral garden. In areas of high abundance in central Jordan Basin, corals were often a mix of the soft corals *Paramuricea placomus*, *Primnoa resedaeformis* and *Acanthogorgia* cf. *armata*. High abundances of sea pens and anemones were also observed. Based on multivariate analyses of eight 2013 transects in Jordan Basin with coral garden habitat (Martin 2015), temperature, depth, sediment type, rock outcrop, and topographic rise were primary factors that correlated with coral distributions.

Georges Basin also contains coral communities, found at **Lindenkohl Knoll.** Corals at Lindenkohl Knoll were generally patchier, less dense, and occurred in lower relief environments than in other Gulf of Maine sites. Specifically, four 2015 camera tows found corals at both coral garden densities of greater than one colony per meter squared (one tow) and lower densities (three tows). The soft coral *Paramuricea* was the most commonly occurring species. One dive located just east of the proposed coral zone did not document any corals.

6.3 Deep-sea coral habitat suitability model

Habitat suitability modeling examines the associations between the presence and/or absence of organisms and their relevant environmental or habitat variables. Because of the prohibitive costs and logistical difficulties of surveying the deep-sea, geo-referenced deep-sea coral location data are often limited, patchy, and mostly presence-only. As noted in the previous section, coral data in the New England region, in particular those data collected prior to 2012-2015 fieldwork, are no exception to these general rules. Predictive habitat modeling for deep-sea corals has therefore become a cost effective tool to identify potential locations of deep-sea corals and other benthic species, and aid managers in determining deep-sea coral management zones (Leverette and Metaxes 2005; Bryan and Metaxas 2007; Davies et al. 2008; Tittensor et al. 2009; Davies and Guinotte, 2011; Guinotte and Davies 2012; Yesson et al. 2012; Vierod et al. 2013).

NOAA's National Ocean Service (NOS) National Centers for Coastal Ocean Science (NCCOS), in partnership with the Northeast Fisheries Science Center (NEFSC), developed a deep-sea coral predictive habitat model for the Northeast region (Kinlan et al. 2013; Kinlan et al., in review). The spatial domain of the model is based on the footprint of the coastal relief digital elevation model, and thus includes the continental shelf and canyons in New England and the Mid-Atlantic, but not the seamounts. Results are reported on a 370m grid, which was selected based on the resolution of the underlying bathymetry data, and is appropriate given that older coral presence records have some positional uncertainty.

A machine-learning technique called Maximum Entropy modeling, or MaxEnt, was used to predict suitability of unexplored habitats based on locations and environmental characteristics of known deep-sea coral presence (Guinotte et al. 2016). The MaxEnt method was selected, because it has performed well in previous deep-sea coral predictive habitat modeling studies using presence-only data, and outperformed other types of habitat suitability models, such as environmental niche factor analysis, in cross-validation studies (Tittensor et al. 2009, Davies and Guinotte 2011, Guinotte and Davies 2012, Yesson et al. 2012).

The MaxEnt model was run with selected predictor (environmental) variables and presence data for three groups of deep-sea corals in the Northeast historical (pre-2012) database (true soft corals and gorgonians, stony corals, and sea pens; **Error! Not a valid bookmark self-reference.**). Black coral data were insufficient to include in the model. Data included were: 1) coral presence records, 2) NOAA Coastal Relief Model bathymetry (NOAA 2011), and 3) environmental predictors (seafloor terrain statistics; physical, chemical, and biological oceanographic data, and sediment/substrate information). Only one coral record per taxonomic group was used per grid cell, and older records were dropped when there were multiple records in a grid.

In areas of the region with fewer coral records, model outputs should still be predictive assuming that the ecological setting is similar to the areas where there are more coral records. However, the Gulf of Maine high suitability areas do not align well with the distribution of coral habitats determined from remotely operated vehicle and towed camera data. The discrepancy in the Gulf of Maine could be the result of lower resolution terrain data in the Gulf of Maine, so the steep slopes where structuring-forming coral species tend to occur are not adequately resolved. Therefore, the PDT determined that the suitability model results are not a useful metric in the Gulf of Maine.

Table 10 – Coral taxonomy used in the habitat suitability model

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

Habitat suitability maps and model evaluation methods predicted suitable habitat in the vicinity of known deep-sea coral presence locations, as well as in some areas without recorded presences. 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 historical database. The combined output for the three Alcyonacean models (all Alcyonaceans, gorgonians only, and true soft corals only) is the model with the best predictive ability for structure-forming deep-sea corals, as it is based on a sizeable number of data points from known structure-forming species. The model for scleractinians, on the other hand, is based on a smaller number of records of mostly solitary, soft-sediment dwelling cup corals (e.g., *Dasmosmilia* and *Desmophyllum*), and is likely to under-predict the likelihood of suitable habitat for this coral type. While numerous sea pens are documented in the historical database, most were records from the continental shelf and are either *Pennatula aculeata* from New England/Gulf of Maine or *Stylatula elegans* from the Mid-Atlantic; these animals occur in soft bottoms and are not considered to be structure-forming. Future incorporation of recent data for structure-forming scleractinians and black corals in the Northeast region will improve this model's predictive ability for these coral groups.

A large number of predictor variables were considered. These included variables describing seafloor terrain, including depth, slope, curvature (slope of slope), and rugosity, which is a measure of surface area to total area. These topographic variables were analyzed at multiple spatial scales to highlight large scale and finer features. Climatologic variables including bottom dissolved oxygen, temperature, and chlorophyll were also used. Bottom dissolved oxygen was taken from the World Ocean Database (https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html) and NEFSC data. For some climatologic variables, seasonal data were used, while annual averages were used for others. In general, the maximum and minimum values are most predictive. Highly correlated predictor variables were removed to arrive at a set of 64 predictors. The final model (selection process described below) uses 22 predictor variables, out of a total of 64 variables (Table 12). For each predictor variable, response curves were generated to help users understand how that variable relates to coral distributions.

The model selection process relied on more formal selection criteria (area under the receiver operating characteristic curve, or AUC, and Akaike's Information Criteria, or AIC) combined with informed judgement of the analysts to identify a parsimonious suite of predictor variables. The model was fit to 70 percent of the coral data points for each taxa, and validated with the remaining 30 percent of the dataset. For single variable response curves, peak suitability for each predictor variable is the highest point on the response curve. Multivariate response curves were also generated that indicate response to one varying predictor while others are held at their mean values.

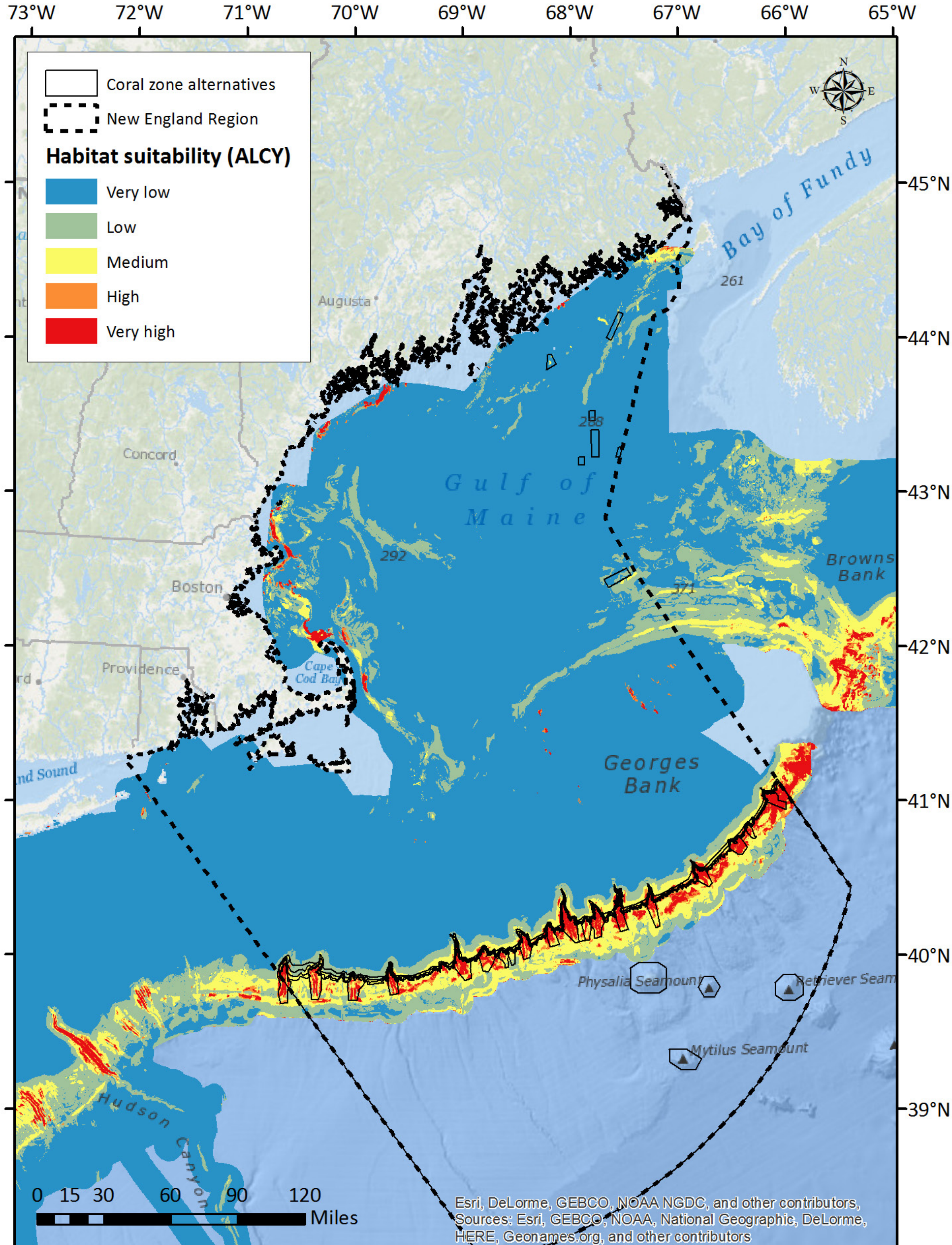
When using the results, it is important to consider the underlying data quality and resolution. As noted above, the model grid resolution was selected to accommodate the positional uncertainty associated with the underlying coral data, but the canyon areas in particular have complex terrain at this spatial scale, such that the model outputs should be considered a somewhat coarse predictor of suitable habitat. In addition, the taxonomic resolution is also fairly coarse, to the order or sub-order level, and there is considerable diversity of coral species within each of these groupings. The model does not predict abundance, density, or diversity, rather, it is indicating the likelihood of finding corals of a particular type in a particular area. The basic suitability outputs are generated on 0 to 1 scale, but they are not probabilities and cannot be compared across taxonomic groupings. Thresholded outputs were developed to allow comparisons between taxonomic groupings. The following likelihood categories were used: very low, low, medium, high, and very high. High and very high likelihood categories were combined to support impacts analysis (see section 7.1.1.2).

Table 11 – Predictor variables retained in coral habitat suitability model.

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

Table 2 in Kinlan, B.P., M. Poti, A.F. Drohan, D.B. Packer, D.S. Dorfman, and M.S. Nizinski (in review). Predictive Modeling of Suitable Habitat for Deep-Sea Corals Offshore of the Northeast United States.

Map 39 – Habitat suitability model outputs for Alcyonacean corals.



Data from Kinlan et al. 2013.

The deep-sea coral habitat suitability model was qualitatively validated during later visual surveys, including the 2014 *RV Okeanos Explorer* canyon and seamount cruise. All sites observed to be hotspots of coral abundance and diversity (e.g., Gilbert Canyon) were predicted hotspots based on the regional model. Each model validation attempt indicated that the habitat suitability model performs well in predicting areas of likely deep-sea coral habitat, as well as predicting areas where corals are unlikely to occur. However, the exact location of deep-sea coral hotspots 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. In addition, model predictions are of the likelihood of coral presence, and high likelihood of presence will not necessarily correlate with high abundance. There are plans to improve the model by increasing resolution to 25 m^2, as well as incorporate more recent coral observations.

6.4 Deep-sea coral associates and ecological interactions

Deep-sea coral habitats have been noted to have higher associated concentrations of fish than surrounding areas, and are believed to serve as nursery grounds and provide habitat for many species of fish and invertebrates at various life stages, including commercially important fish species (Costello et al. 2005; Auster 2007; Foley et al. 2010). There is recent evidence that deep-sea corals play an important role in the early life history of some fish and shark species, providing nursery grounds and habitat for protection, reproduction, and feeding (Costello et al. 2015; Armstrong et al. 2014). Numerous types of fish have been noted to co-occur with three-dimensional deep-sea coral habitat, including, for example, redfish (*Sebastes sp.*), rabbit fish (*Chimaera monstrosa*), cusk (*Brosme brosme*), cod (*Gadhus morhua*), morid cods (*Laemonema sp.*), slimeheads (e.g., *Hoplostethus sp.*), American anglerfish (*Lophius americanus*), cusk eels (e.g., *Benthocometes robustus*), cutthroat eels (e.g., *Dysommina rugosa*), and various deep water sharks (see Costello et al. 2005; Auster 2007; Henry et al. 2013; Ross et al. 2015). Fish associating with corals and other three-dimension habitat types may be seeking cover from predators, and/or sites for enhanced capture of prey (Costello et al. 2005; Auster 2007).

Many invertebrate species are directly associated with deep-sea corals. Brittle stars, sea stars, and feathery crinoids live directly on coral colonies, and smaller animals burrow into coral skeletons (Foley et al. 2010). Recent studies in the Northeast U.S. highlight relationships of symbionts and their octocoral hosts at deep-sea coral habitats on the seamounts (Watling et al. 2011). In an extreme case of host fidelity, Mosher and Watling (2009) showed that the ophiuroid *Ophiocreas oedipus* was found only on the gorgonian *Metallogorgia melanotrichos*. *O. oedipus* is an obligate associate of *M. melanotrichos*, with young brittle stars settling on young corals and the two species then remain together for life. The brittle star may receive some refuge and feeding benefits from the coral, but the coral's relationship to the brittle star appears to be neutral. Within the EEZ, these two species were collected from Bear Seamount at 1,491 and 1,559m. Another ophiuroid, *Asteroschema clavigera*, has a close relationship with *Paramurecia* sp. and *Paragorgia* sp. on both the seamounts and continental slope (Cho and Shank 2010; this was also noted in images from the 2012 Bigelow/TowCam canyon cruise). The shrimp *Bathypalaemonella serratipalma* as well as the egg cases of an unknown octopus were found on *Chrysogorgia tricaulis* on the seamounts (Pante and Watling 2011). Additionally, older colonies of *Acanella arbuscula* collected from the seamounts were host to a scale worm (Watling et al. 2011). See Watling et al. (2011) for reviews and lists of known invertebrate symbionts and their octocoral hosts worldwide.

During the *RV Okeanos Explorer* 2013 slope/canyon/seamount surveys, Quattrini et al. (2015) noted that the presence of certain deep-sea coral species may influence crustacean assemblage patterns. For example, the squat lobster *Uroptychus* sp. was only observed on the black coral *Parantipathes* sp. In contrast, the squat lobster *Munidopsis* spp. utilized a variety of different coral species as habitat, particularly those with structurally complex morphologies. Other observations suggesting associations between deep-sea corals and other invertebrates are documented in the dive logs from recent exploratory surveys.

A cause and effect relationship between coral/sponge presence and fish populations is hard to determine, and our understanding of relationships between deep-sea corals and fishes is speculative (e.g., Baker et al. 2012), particularly in seamount habitats (Auster 2007). Nevertheless, it has been shown, for example, that false boarfish, *Neocyttus helgae*, were associated with basalt habitats featuring gorgonian corals and sponges (on both nearly horizontal basalt sheets and steep cliffs) on Bear and other seamounts (Moore et al. 2008). Dead coral on seamounts could also be habitat for juveniles of deep-sea fish, but observations have been limited (Moore and Auster 2009).

There is also some new information from the recent exploratory surveys regarding the functional role deep-sea corals play in fish life history and ecology. As part of the BOEM Southern Mid-Atlantic Canyon Surveys 2012-2013, Baltimore and Norfolk canyons were surveyed to determine demersal fish distributions and habitat associations, including the influence of deep-sea corals and sponges (Ross et al. 2015). Although it was determined that deep-sea coral and sponge presence did not statistically influence fish assemblages in the two canyons, deep-sea coral and sponges did increase habitat complexity, which is an important factor governing the distribution of deep-sea fishes (Ross et al. 2015), and some of the fishes were closely associated with the corals. Quattrini et al. (2015) found that deep-sea coral species richness was an important variable in explaining demersal fish assemblage structure. They speculated that the corals may increase fish diversity because the fish use the corals as habitat, among other reasons.

In all areas surveyed in the Gulf of Maine, sponges (e.g., *Polymastia*, *Iophon, Phakellia/Axinella*) and anemones (e.g., *Urticina*) often occurred in high density patches amongst the more extensive corals on walls and on steep features without corals. Crustaceans such as shrimp, amphipods, krill (*Meganyctiphanes norvegica*), and king crab (*Lithodes maja*) were commonly associated with coral communities along steep walls, and were seen foraging amongst structure-forming organisms, including corals, on the seafloor. In mud and gravel-mud habitats adjacent to hard-bottom habitats, other structure forming and non-structure forming attached and mobile invertebrates were found including brachiopods, attached anemones, the large burrowing anemone (*Cerianthus borealis*), sponges, sea stars, and the ubiquitous and abundant brittle stars.

At the Gulf of Maine sites, commercially important fish and shellfish species were observed in coral habitats, including Acadian redfish (juveniles, adults, and pregnant females), haddock, pollock, cusk, monkfish, cod, silver hake, Atlantic herring, spiny dogfish, squid, and lobster. The fish were observed searching for and catching prey that were also found among the coral, including shrimp, amphipods, krill, and other small fish. The corals seemed to provide refuge from the strong, tidally generated bottom currents.

Baillon et al. (2012) collected sea pens as trawl bycatch during routine multispecies research surveys, and found convincing evidence that several species of sea pens, including *Pennatula aculeata, Anthoptilum grandiflorum*, *Pennatula grandis*, and *Halipteris finmarchica*, are being directly utilized as shelter by fish larvae, mainly by those of redfish (*Sebastes* spp.). *Anthoptilum grandiflorum* appeared to be of particular importance to redfish larvae in that study.

Although Baillon et al. collected sea pens from the Laurentian Channel and southern Grand Banks, because the same species of redfish and sea pens co-occur in the Gulf of Maine, researchers hypothesized that similar associations could be occurring in New England. To test this hypothesis, speciments of the sea pen *P. aculeata* were collected via ROV from different sites during the 2014 Gulf of Maine coral cruise; the specimens were examined for fish larvae, and none were found. *P. aculeata* were then collected as bycatch from the 2015 NEFSC Gulf of Maine northern shrimp survey aboard the *RV Gloria Michelle*. Eight stations on the shrimp survey generated sea pen bycatch and 186 individual *P. aculeata* were subsequently examined in the laboratory. Redfish larvae were found on *P. aculeata* at four stations, either adhering to the exterior of the colony, or entrapped within the arms or polyps (Dean et al. 2016).

Because both these sea pens and those collected by Baillon et al. were trawl survey bycatch, this introduces the possibility that fish larvae were extruded by viviparous ripe and running redfish during capture, and then the larvae then subsequently adhered to the sea pens. Baillon et al. (2012) reported the presence of adult redfish in all but one of their hauls; however, they found no correlation between the number of adult redfish and yield of fish larvae per sea pen colony. For this Gulf of Maine study, it was observed that there were instances of redfish extruding larvae in the checker on deck, but at other times adult redfish were noted in the catch but were not spawning. Thus, while these results confirm some general co-occurrence and possible association between these two species in the Gulf of Maine, the strength of the relationship cannot be determined without taking the state of the co-occurring redfish in the trawls into account.

In June 2016, a two-day cruise aboard the *RV Gloria Michelle* resampled some of the previous stations where a positive association had been found between redfish larvae and *P. aculeata*, only this time a small beam trawl was used as the sampling gear, with the hope that it would only capture sea pens without adult redfish, thus eliminating the potential cross contamination described above. Over 1,400 sea pens were collected over two days of beam trawling at depths around 150-180 m over soft bottoms. No larval redfish were found associated with the sea pens, but that may be because ~80 to 85% of the sea pens collected were quite small, < 25-50 mm total length (adults are upwards of 200-250 mm), suggesting a recent recruitment event. These younger, smaller sea pens are probably too small to be used as nursery habitat. Very few of the larger sea pens were captured, and those that were caught were generally tangled in the chain rather than caught in the net, suggesting that the beam trawl may not have dug deep enough into the sediment to dislodge the animals. Thus, the role of *P. aculeata* as possible nursery habitat for larval redfish in the Gulf of Maine remains uncertain. Collection of sea pens will continue to future examine this possible relationship.

Despite inconclusive results in the northwest Atlantic, deep-sea corals appear to be an important component of redfish habitat in other locations. In Norway, Foley et al. (2010) applied a production function approach to estimate the link between deep-sea corals and redfish (*Sebastes* spp.). Both the carrying capacity and growth rate of the redfish were found to be functions of deep-sea coral habitat and thus they concluded that deep-sea corals can be considered as essential fish habitat; they also estimate a facultative relationship between deep-sea coral and *Sebastes* stocks.

In addition to these direct interactions with other organisms, deep-sea corals support ecosystem processes. Given the contribution of anthropogenic carbon dioxide (CO_2) to global climate change, the deep-sea may provide ecosystem services in the form of CO_2 sequestration, thus removing CO_2 from the atmosphere (Foley et al. 2010), though this idea has become more controversial recently (Armstrong et al. 2014). Deep-sea corals have also been shown to have high microbial diversity, even among different colonies of the same species separated over a short distance (Gray et al. 2011). Microorganisms associated with corals may provide other ecosystem functions in addition to cycling carbon, such as fixing nitrogen, chelating iron, producing protective antibiotics, and other beneficial activities (Gray et al. 2011). Deep-sea corals have also offered opportunities for pharmaceutical and engineering research. Some species have been used in clinical trials for cancer research or bone grafting (Foley et al. 2010).

6.5 Coral vulnerability to fishing impacts

The biological characteristics of deep-sea corals influence their vulnerability to physical disturbance. While deep-sea corals are threatened by various human activities, fishing with bottom-tending gears, particularly bottom trawls, has impacted coral habitats worldwide. The studies and reviews summarized below have assessed the impacts of commercial fishing on deep-sea corals and coral reefs, addressing a range of gear types as well as study locations. While other activities such as mining or energy exploration can threaten deep-sea corals, fishing restircitons are within the purview of the Council and are the subject of this action. This section concludes with a summary of the data on recent interactions between corals and fishing gears in New England.

6.5.1 Coral vulnerability and recovery potential

Deep-sea corals tend to be sensitive to physical disturbance given that they are sessile, fragile, and extend above the seafloor in a manner that makes interactions with fishing gear more likely. The ability of deep-sea corals to recover from injury, their rates of growth, and their ability to reproduce and colonize new sites is directly related to their resilience in the face of direct impacts from fishing or other mechanical disturbance, as well as their resilience to longer-term environmental change, specifically warming and increasingly acidic waters. This section describes these biological characteristics.

When bottom-tending gear interacts physically with corals, mechanical impacts can include removal of entire colonies, branches, or polyps, fracture, abrasion, crushing and/or burial. Severe mechanical impacts could cause immediate mortality. Sub-lethal effects might result from wounds in the tissue and possible microbial infection (Fosså et al. 2002), or from increased predation (Malecha and Stone 2009). Bottom trawling can also suspend sediments, which can impact coral feeding and may suppress growth and recovery of colonies. Because black coral polyps do not retract, these species are particularly sensitive to physical abrasion from sediments (Wagner et al. 2012). On the other hand, some types of scleractinian corals appear to be able to shed sediment, and may be able to cope with sediment suspension (Fosså et al. 2002; Clark et al. 2015). Sediment layer disturbance can also alter the physical or chemical composition of the sediment, particularly in the more stable waters of the deep-sea (Clark et al. 2015), potentially impacting suitable habitat for corals.

The effects of mechanical disturbance and trauma to the soft coral *Gersemia rubiformis* (collected from the Bay of Fundy) were examined in a lab setting (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, with observations recorded four days and then one week after disturbance. 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. The mortality rate of the juveniles was 100%, however, and none of these daughter colonies survived past the polyp stage. Upon further testing, it was determined that these colonies were sexually derived, and since the individual colonies had been separated for the experiment, it is assumed that the corals were brooding when collected, as they were not visibly fertile prior when the experiment commenced. However, the control group did not have any daughter colonies during the experiment, and only after experimental crushing did daughter colonies appear. The authors guessed that the reason for daughter colony development and subsequent mortality was the expulsion of premature larvae, due to stress placed on the coral and the need to allocate resources to repair damaged tissue. While adult *G. rubiformis* were able to withstand the mechanical rolling and crushing, such physical disturbance could have negative long-term effects on the fitness of impacted corals, if they are less likely to produce surviving offspring during periods of tissue repair (Henry et al. 2003).

The approximate growth rates of different deep-sea corals have been calculated in several studies. Off Atlantic Canada, Risk et al. (2002) examined the growth rates for *Primnoa* *resedaeformis*. The corals were found at approximately 200-600m and were dated to 2,600-2,920y ± 50-60y using ^{14}C dating techniques. Using the dated age and size of the colony (~0.5-0.75m tall) the average radial growth at the base of the coral was found to be 0.44 mm/y and tip extension growth rates were around 1.5-2.5 mm per year (Risk et al. 2002). Another study of *P. resedaeformis* and *Paragorgia arborea* (Mortensen and Buhl-Mortensen 2005) found that 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 61y (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.

Deep-sea 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-sea 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. 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) found *Fungiacyathus marenzelleri* collected from the Northeast Atlantic at 2,200m to be gonochoric, with an approximately 1:1 sex ratio. The mean diameter of oocytes did not vary significantly from month to month and all levels of sperm development were noted in the collection. The coral was thus considered a quasi-continuous reproducer. 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).

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 1,100-1,300m), *C. cornuformis* (from 435-2,000m), and *C. seguenzae* (from 960-1,900m) were all found to be cyclical hermaphrodites. 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 200-2,750 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).

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, time-intensive process.

6.5.2 Gear interaction studies

Research on gear impacts to deep-sea corals specifically within the New England Council region is extremely limited; thus, studies reviewed here include a range of different study locations worldwide. While the study sites cover a variety of locations, the impacts of commercial fishing on the local corals and seafloor are virtually identical throughout the literature. The conclusions drawn by these studies are that commercial fishing gear can damage or destroy deep-sea corals and associated fauna. Trawling, specifically, is very detrimental to coral. Several studies have concluded that deep-sea 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). Disturbances to deep-sea corals range from scarring left by fishing gear to complete destruction of coral and stripping of the seafloor to underlying rock or sediment. The substrates of areas heavily fished with bottom-tending gear have been observed stripped to bare rock or reduced to coral rubble and sand, whereas unfished and lightly fished areas typically do not see such degradation (Grehan et al. 2005).

Most of the relevant research has involved study sites that were 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 allows for determination of 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, have also been utilized by several studies in 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 research areas, as well as providing information about to the history of fishing and practices in the area (Fosså et al. 2002).

Potential gear impacts to corals depend on many factors, such as the configuration and weight of the gear, towing speed, sediment type, the strength of tides and currents, and the frequency of disturbance (Jones 1992; Clark et al. 2015). It should be noted that in many studies reviewed, there was frequently a lack of adequate descriptions of the gear used, so generalizations should be made with caution. 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. Nevertheless, general conclusions were similar among various studies using different configurations of gear.

Passive or static gear types, such as pots, traps, or longlines, have been demonstrated to impact localized area of corals, though they have not been observed to be as destructive as bottom trawls and dredges. Several studies have described passive gear interactions with benthic habitat, commonly in the form of observed entanglements of coral with fishing gear (Fosså et al. 2002, Ross et al. 2015). Despite these gears having a smaller footprint than a trawl, in certain conditions, these gear types may drag across the seafloor, potentially entangling corals or stirring up sediments (Clark et al. 2015). Longline impacts on corals and sponges have been observed where corals have been broken by longline weights or by the mainline cutting through them during fishing or hauling. A Canadian report (DFO 2010) concluded that traps can crush and entangle sponges and corals and cited a number of factors that can affect their habitat impacts, including the type of bottom, their weight, size, and construction material, the type of rope (floatline or sinkline), retrieval methods and weather conditions, soak time, the number of traps on a string, and the use of anchors.

In Alaska, Heifetz et al. (2009) and Stone (2006) conducted studies in commercially fished areas in the Aleutian Islands using a ROV and a research submersible, and Krieger (2001) made direct observations inside and outside the paths of two research trawl paths in the Gulf of Alaska from a submersible. Stone found that disturbance attributable to longline gear was observed on 76% of transects, but was very localized, occurring on only 5% of the observed seafloor. Damage attributed to trawling, on the other hand, was observed in 28% of transects, but affected about 33% of the observed seafloor, indicating a relatively greater impact of trawls. Overall, 22 of the 25 transects showed disturbance to the seafloor and about 39% of the total observed area showed signs of disturbance.

The second study in this region (Heifetz et al. 2009) was conducted over a broader area and greater depth range and provided additional evidence of trawling impacts, as indicated by uniform parallel striations in the seafloor, seen on several dives. The proportion of damaged corals was significantly lower in areas with little or no bottom trawl fishing than in areas with medium and high intensity bottom trawling activity. There was also a general tendency for coral damage to be greater in areas fished with crab pots, fish pots, and longlines, but due to high variability, there were no statistically significant differences in the proportion of damaged corals between the fished and unfished areas. Both studies observed that the most damage done to corals occurred at depths where commercial fishing intensity was the highest (100-200 m), with higher population densities occurring at 200-300 m. All damage deeper than 700 m was attributed to longlines and pots, since those were the only two gear types used at those depths.

Observations made by Krieger (2001) in the Gulf of Alaska revealed severe impacts to *Primnoa* spp. along two paths of a research trawl. At one site in an un-fished area, a 30 minute trawl tow (2.72 km) had removed a metric ton of coral colonies seven years before the in situ observations were made. The path of the net was identified by displaced boulders, broken corals, and pieces of net twine. Thirty-one coral colonies were observed over a distance of 0.68 km. Almost all of the branches were removed from 5 of 13 large colonies and 80% of the polyps were missing from two smaller colonies. Damage was attributed primarily to corals that were attached to boulders that had become entangled in the net, causing the boulders to tip or be moved. Large patches of bare rock on boulders showed where the trawl had removed entire colonies. No damage was observed outside the trawl path, including areas within 10 m of the net path that had been swept by the net bridles. No young colonies were seen in the trawl path, indicating that corals had not recolonized the bottom during the seven year time period.

In a more recent study in the eastern Gulf of Alaska, Stone et al. (2014) attributed most of the damage to red tree corals (*Primnoa pacifica*) to fishing gear rather than predation. Study sites were located in an area that was closed to trawling in 1998 where large catches of red tree corals have been observed as bycatch in groundfish surveys. The area was virtually untrawled for ten years prior to the closure. Small longline fisheries still occur in or near the study sites. At one site, 90.7% of the observed damage was attributed to fishing gear. A total of 24 derelict longlines were seen at the two study sites on 13 of 19 transects. Damaged corals and sponges were observed in the immediate vicinity of all derelict longlines and anchor drag furrows were seen in soft sediment areas. Larger colonies were much more susceptible to damage at both sites.

Studies conducted in the Northeast Atlantic Ocean have reached similar conclusions to those conducted in the Aleutian Islands. Fosså et al. (2002) found that damage to *Lophelia pertusa* reefs off Norway was most severe at shallower depths where commercial fishing primarily took place. The various study sites 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. 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%.

Hall-Spencer et al. (2002), in a study focused on the West Ireland continental shelf break, 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*. Similar findings were observed at a site off the northern coast of Ireland (Wheeler et al. 2005). 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.

Althaus et al. (2009) and Koslow et al. (2001) conducted studies on seamounts in Tasmania. Areas that had never been trawled, or were lightly fished (determined via trip logs), were dominated by the stony coral *Solenosmilia variabilis*, making up 89-99% of coral cover in never trawled areas (Althaus et al. 2009) as well as seamounts peaking below 1,400m (Koslow et al. 2001). These studies 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 five to ten years earlier, showed coral in approximately 21% of 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.

While several studies reported that much of the coral on fishing grounds was damaged or destroyed, there were areas that avoided contact. The surviving coral in fished areas was often located on undesirable fishing terrain, or at depths not targeted by fishermen. Corals growing on steep slopes have a natural protection from commercial fishing gear, as a slope greater than about 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 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 fishing-related damage to corals on mounds having slopes greater than 20 degrees. Here, the terrain is too steep to trawl and the corals were naturally protected from the gear and relatively undamaged. 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 five 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.

6.5.3 Fishing gear interactions with corals in the New England region

Overall, the fishery independent trawl surveys are not particularly useful in terms of characterizing the distribution of corals in the region. Several years ago, the NEFSC's fishery independent survey and Northeast Fishery Observer Program (NEFOP) databases were searched for coral bycatch records (Packer at al. 2007). Historically, observers aboard NEFSC research vessels and commercial fishing vessels loosely described and quantified any substrate (rock, shell, etc.) or non-coded invertebrate species that were retained in the gear and were not trained to recognize corals. Although this bycatch information could possibly be useful as presence/absence data, since deep-sea corals are not the focus of the bottom trawl surveys, these data should be used with caution (John Galbraith, NOAA Fisheries Service, NEFSC, Woods Hole Laboratory, Woods Hole, MA, pers. comm.).

Outside of the Gulf of Maine, the general lack of deep-sea coral in both the NEFSC spring/fall groundfish trawl and scallop dredge surveys may be a function of the surveys fishing in waters shallower than where the larger deep-sea coral species are likely to occur (e.g., nearly all the scallop surveys fish < 100 m and all are < 140 m).

Alternatively, these larger corals (e.g., *Paragorgia*, *Primnoa*) may have already been “fished out” in the survey areas during the 19th and 20th centuries (Packer et al. 2007). Anecdotal accounts from the period before the groundfish survey began (1950’s or early 60's) reference an area on Georges Bank called "The Trees" where large corals existed in shallower water before being eventually cleared out, supposedly by foreign trawling vessels. In Canadian waters near the Northeast Channel, but within the survey region, there is a deep-sea coral protection area that is closed to fishing. John Galbraith (NEFSC, pers. comm.) stated that this was the only area he could remember where any amount of coral was encountered during the survey.

The fishery dependent deep-sea coral bycatch data collected by observers aboard commercial fishing vessels used to suffer many of the same problems (i.e., coral catches were poorly characterized). A small NEFOP database of coral bycatch collected form 1994-2009 was examined and showed to only include 39 confirmed coral entries (Packer et al. 2007). Two of these entries were labeled *Astrangia* (a genus of stony coral) and 10 additional entries were labeled as "stony corals." Basic information about the haul (gear type, year, month, depth, and geographic coordinates) was included. Gear used included otter trawls, scallop dredges, and gill nets, at depths from 5.5-253 m (depths were taken at the beginning of a trawl). Estimated or actual weights for the coral in a given haul ranged from 0.05-22.7 kg. No specimens or photographs were included.

In 2013, the NEFOP training curriculum and associated sampling protocols were significantly upgraded to improve deep-sea coral bycatch identification, retention, enumeration, and documentation (Lewandowski et al. 2016). This included the development of a Northeast deep-sea coral identification guide for the onboard observers, and standardized recording, sampling, and preservation procedures. Since the new protocols were implemented, although deep-sea coral bycatch is still low, the number of recorded and verified samples has increased, and photographic records and samples are being stored using the NEFOP Species Verification Program (Lewandowski et al. 2016). Specimens collected at sea were recently examined and classified by Northeast deep-sea coral experts, and several species of structure-forming soft corals and sea pens were identified. Improved NEFOP fishery dependent deep-sea coral bycatch data will lead to a better understanding of fisheries and deep-sea coral interactions and impacts, and guide conservation efforts of deep-sea corals habitats in the Northeast.

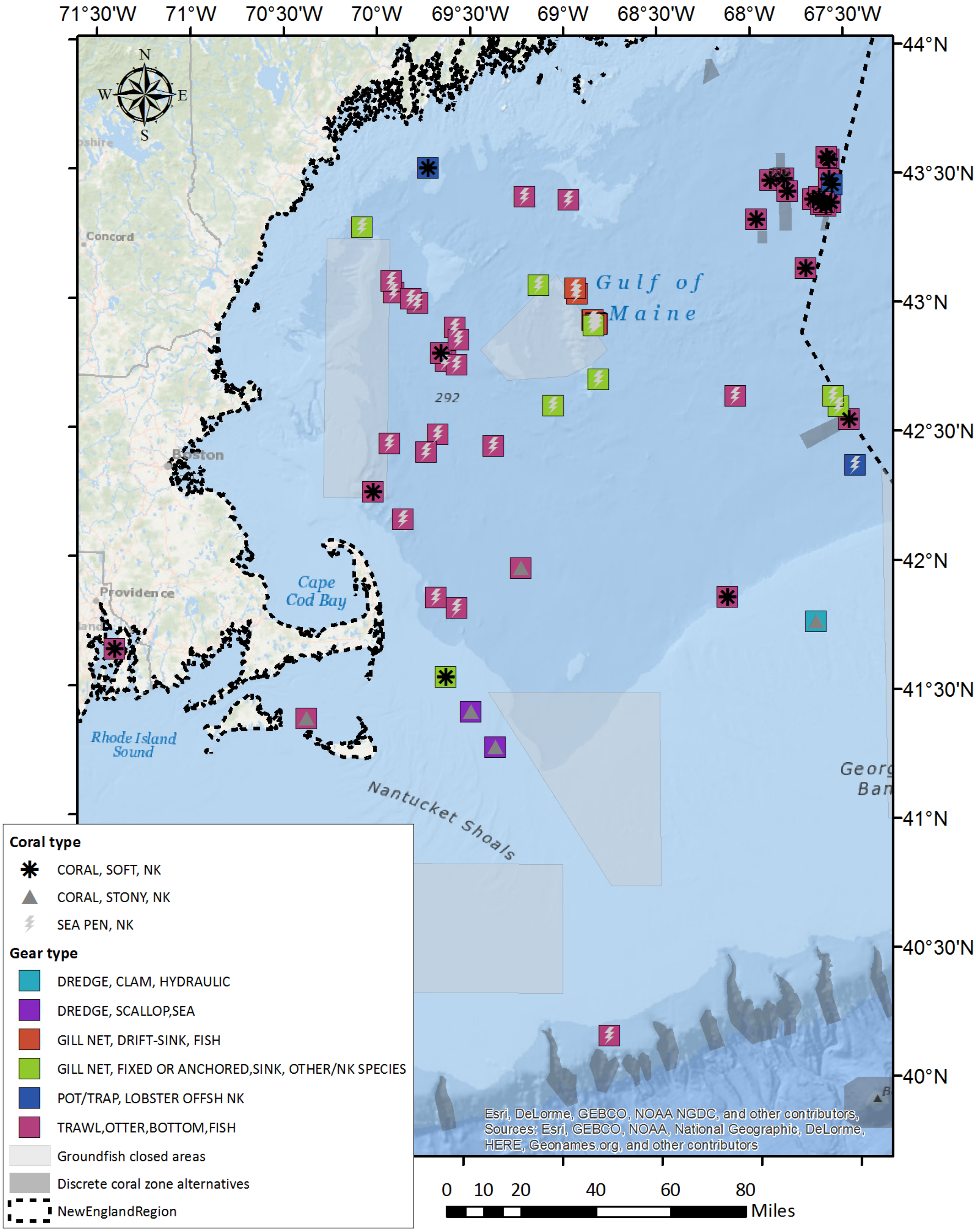
Since 2013, the NEFOP program has documented coral catches during 63 hauls occurring within the New England Fishery Management Council region (Map 40). Just over half (N=36) were identified as sea pens, 22 were identified as soft corals, and five were identified as stony corals. Just under half of the 63 records (N=28) have been identified to species. Documented taxa include the sea pens *Pennatula aculeata* and *Halipteris finmarchica*, the soft corals *Paramuricea placomus* and *Primnoa resedaeformis*, and one record of the stony coral *Astrangia poculata*. With a small number of exceptions, these catch records are concentrated in the Gulf of Maine. Catches occur in a variety of gears, mainly bottom trawl (N=40), and gillnet (N=17), but also pot/trap, sea scallop dredge, and clam dredge. The three dredge records were in shallow waters on Georges Bank and in the Great South Channel and captured stony corals.

The spatial patterns of coral bycatch by species are consistent with known distributions of corals in the Gulf of Maine. There are relatively large number of observed catches of sea pens in Wilkson Basin and surrounding Cashes Ledge. The catches in Wilkinson Basin (N=15) were taken with bottom trawls targeting plaice, pollock, and other unspecified groundfish. The catches around Cashes (N=13) were taken with gillnets, targeting pollock and other unspecified groundfish.

A relatively large number of the catch records (N=15) occur in Jordan Basin, and all of these records are of soft corals, including *P. placomus* and *P. resedaeformis*, which are the most common soft coral taxa in the Gulf of Maine. With the exception of a single lobster trap record, the Jordan Basin catches occurred in bottom trawls targeting species such as white hake, plaice, and other unspecified groundfish. Assuming straight line tow paths between haul start and end positions, it is possible that a few of these catches occurred within proposed coral management zones, but most appear to be outside them as the tow paths do not intersect the proposed management areas. Four of the observed catches (three sea pen, one soft coral) occurred in Georges Basin, but outside the Lindenkohl Knoll zone. The remaining 16 records were scattered throughout the region, roughly half in the Gulf of Maine and half outside it.

It is not possible to extrapolate from these data to estimate the annual number of interactions between fishing gear and deep-sea corals. The percentage of fishing effort that is observed ranges from around 10-40%, depending on the fishery, and a grand average may be somewhere around 10%. Observer coverage rates by gear type and fishery are designed to estimate bycatch of specific managed resources, and are not intended to accurately assess bycatch rates of corals. However, given the large number of observed fishing events, and the low number of documented interactions, it is probably fair to say that a relatively small number of trips interact with deep-sea corals.

Map 40 – Observed fishery interactions with deep-sea corals in the New England region, 2013-present. Data from the Northeast Fishery Observer Program.



In addition to these observed catches, evidence of fishing gear damage has been noted in recent camera surveys. Areas exhibiting direct impacts from fishing activities were observed at sites in the Gulf of Maine in Western and Central Jordan Basin, Outer Schoodic Ridge, and Georges Basin. In steep areas, paths or tracks, consistent with the setting or recovery of trap gear, were denuded of corals and associated fauna. The peaks of some ridges and nearly horizontal sections of wider rock outcrops were also denuded. Tracks observed here were consistent with impacts from mobile fishing gear. Some coral patches exhibited damage in the form of live colonies with disjunct size class structure, suggesting past impacts. In areas such as Georges Basin, colonies of *Paramuricea placomus* and associated species were often small and virtually all occurred in physical refuges such as cracks and crevices of outcrops and along the sediment-rock interface of large cobbles and boulders. Of note is that the sea star *Hippasteria phrygiana* was observed eating or preying on *P. resedaeformis* colonies at the Outer Schoodic Ridge site. These were seen on living coral colonies that had been detached from rock walls and were laying on the seafloor, possibly due to fishing activity, as one was seen next to an abandoned fishing net. Opportunistic predation by *H. phrygiana* has also been noted in Alaska on *Primnoa pacifica* that had been injured or detached by fishing gear (Stone et al. 2015). This may indicate that coral damaged by fishing gear interactions are at an increased risk of predation by sea stars, thus further reducing the chances that a coral colony will recover from gear-related injuries and impacts.

In 2011, NMFS granted the Maine Department of Marine Resources an exempted fishing permit for redfish to conduct a baseline catch and bycatch evaluation in and around Wilkinson Basin in the central Gulf of Maine. Redfish are currently harvested in this area, but many smaller individuals escape from the 6.5 in mesh nets currently in use. The experimental fishing used nets with smaller, 4.5 in mesh liners in the cod end and targeted schools of redfish that congregate on "bumps" or pinnacles that occur in the normally deep, muddy areas in the central Gulf of Maine. Since redfish seek shelter near structure-forming organisms such as deep-sea corals and sponges, as well as boulder reefs (Packer et al. 2007), concerns were raised by NMFS that the smaller mesh nets would increase the probability of increased bycatch of deep-sea corals. NMFS determined that the project could have an adverse effect on EFH, particularly on any deep-sea corals found there. Therefore, they requested that deep-sea coral bycatch be carefully monitored to enhance the understanding of deep-sea coral distribution in the Gulf of Maine and the potential effects of an expanded redfish fishery on deep-sea corals. However, by the end of the project the only coral bycatch was that of a single specimen of the common sea pen, *Pennatula aculeata*, which is ubiquitous in muddy areas of the Gulf of Maine.

6.6 Essential Fish Habitat

EFH designations (updated in Omnibus Habitat Amendment 2) include both a map representation (spatial coverage) and qualitative text description of preferred habitat attributes. The designations reflect the distribution of essential habitats occupied by a particular species and lifestage, and can be used to indicate which coral zones may provide conservation benefits for particular managed species.

The analysis in this section uses the same approach as the EFH overlap analysis completed for OHA2 (see Volume 2 of the FEIS for updated designations, and Volume 4, Section 3 for more detailed methods). Most of the juvenile and adult EFH map representations were developed by conditioning relative abundance survey data binned into ten minute squares by preferred depth and temperature ranges. Although two different catch rate thresholds (75% and 90%) were used to make the maps, and survey catchability varies by species, it is reasonable to compare the degree of overlap across species and lifestages when assessing the benefits of different areas and alternatives.

Some of the juvenile and adult designations do not follow this method and cannot really be compared with designations that do use the abundance/habitat considerations approach. Atlantic wolffish EFH includes all waters north of 41° N in the Gulf of Maine and on Georges Bank, as limited by the habitat types outlined in the text description. EFH for wolffish is based on very broadly defined geographic range information so spatial overlap with the proposed management areas or alternatives is not especially meaningful. Similarly, sea scallop EFH uses a species range (100% presence in all surveys) approach in the map representation, so areas where positive survey catches are relatively uncommon are still mapped as EFH. However, scallop EFH is limited to depths shallower than 110 meters, which removes many areas with positive but infrequent catches.

The coral zone management measures focus on bottom-tending gear restrictions, so this analysis is restricted to species and lifestages that are benthic versus pelagic (Table 13). Benthic lifestages that are in close association with the seabed are most likely to benefit from measures that protect seabed habitats. In general, egg and larval lifestages are typically pelagic, and juvenile and adult lifestages are benthic, but there are a few species with benthic eggs and larvae. For species where more than one lifestage is combined into a single designation (e.g. Atlantic halibut), if any of the lifestages are benthic, the designation was included in the analysis. Some Council-managed species are not listed on the overlap tables. Specifically, clearnose skate occur south of the proposed management areas, and Atlantic salmon EFH is designated in specific rivers and associated coastal waters to a distance of 3 nm, and therefore has no overlap with any coral zones, which are in federal waters only.

Table 12 – Benthic vs. pelagic habitat use by species and lifestage

Benthic eggs:	Benthic larvae:	Benthic juveniles:	Benthic adults:
Atlantic salmon, Atlantic wolffish, ocean pout, red crab (attached to adults), sea scallop, winter flounder, Atlantic herring. EFH is not designated for skate eggs, but skate egg cases are benthic. Deep-sea red crab eggs are benthic because they are attached to adult female crabs.	Atlantic salmon, Atlantic wolffish, sea scallop after settlement (spat)	Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic salmon, Atlantic wolffish, barndoor skate, clearnose skate, monkfish, haddock, little skate, ocean pout, offshore hake, pollock, red crab, red hake, rosette skate, sea scallop, silver hake, smooth skate, thorny skate, white hake after settlement, windowpane flounder, winter flounder, winter skate, witch flounder, yellowtail flounder, deep-sea red crab	Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, spawning Atlantic herring, spawning Atlantic salmon, Atlantic wolffish, barndoor skate, clearnose skate, monkfish, haddock, little skate, ocean pout, offshore hake, pollock, red crab, red hake, rosette skate, sea scallop, silver hake, smooth skate, thorny skate, white hake, windowpane flounder, winter flounder, winter skate, witch flounder, yellowtail flounder, deep-sea red crab
Pelagic/surface eggs:	**Pelagic/surface larvae:**	**Pelagic juveniles:**	**Pelagic adults:**
American plaice, Atlantic cod, Atlantic halibut, monkfish, haddock, offshore hake, pollock, red hake, silver hake, white hake, windowpane flounder, witch flounder, yellowtail flounder	Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic herring, Atlantic wolffish, monkfish, haddock, offshore hake, pollock, red crab, red hake, sea scallop prior to settlement, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, yellowtail flounder, deep-sea red crab	Atlantic herring, white hake prior to settlement, offshore hake	Atlantic herring, Atlantic salmon, offshore hake

Certain species managed by the Council occur in deeper waters of the continental slope. Because the continental slope is not generally sampled in the trawl survey, the portions of the EFH designation maps that overlap the slope are generally based on depth ranges from the literature, rather than relative abundance data. These depth ranges are summarized in Table 14.

Table 13 - NEFMC-managed species with deep-water distribution

Species	Depth (m)	Location	References	Maximum depth determined by PDT
Atlantic halibut (*Hippoglossus hippoglossus*) juveniles/adults	a) 37-550 b) 200-750 c) typically 100-700, max 720-900	a) Virginia to Greenland b) Iceland Slope c) Virginia to Labrador	a) Moore et al. 2003 b) Haedrich and Merrett 1998 c) Cargnelli et al. 1999	700 (juvs/adults)
Barndoor skate (*Dipturus laevis*) juveniles/adults	0-750	Cape Hatteras to Grand Banks	Moore et al. 2003	750 (juvs/adults)
Monkfish (*Lophius americanus*) juveniles/adults	a) 0-948 b) max 744-839 c) very few >823	a) Florida to Gulf of St. Lawrence b) SNE Slope c) GB/SNE Slope	a) Moore et al. 2003 b) Kvilhaug and Smolowitz 1996 c) Balcom 1997	1000 (juvs/adults)
Offshore hake (*Merluccius albidus*) juveniles/adults	a) 80-1170 (mostly 160-640) b) 200-750	a) Northern Brazil to Le Have Bank b) SNE Slope	a) Moore et al. 2003 b) Haedrich and Merrett 1988	750 (juvs/adults)
Deep-sea red crab (*Chaceon quinquedens*) juveniles/adults	a) 200-599 b) 360-540; max 915-932 c) 274-1463 (juvs mostly d) 503-1280, adults mostly 320-914)	a) Continental Slope MAB thru GOM b) Continental Slope- Sable Island to Corsair Canyon c) SNE Slope d) Continental Slope (between 38° and 41°30 min N)	a) Wahle 2005 b) Stone and Bailey 1980 c) Kvilhaug and Smolowitz 1996 d) Wigley et al. 1975	1300 on slope (juvs) 900 on slope (adults) 2000 on seamounts (juvs/adults)
Redfish (*Sebastes* sp.) juveniles/adults	a) 200-592 b) 200-750 c) max 768-786 (mostly 490-616)	a) Virginia to Labrador/Greenland Slope b) Newfoundland; Iceland Slope c) GB/SNE Slope	a) Moore et al. 2003 b) Haedrich and Merrett 1988 c) Balcom 1997	600 (juvs/adults)
Red hake (*Urophycis chuss*) juveniles/adults	a) 37-792 b) 200-750	a) North Carolina to Southern Newfoundland b) SNE Slope	a) Moore et al. 2003 b) Haedrich and Merrett 1988	750 (adults)
Smooth skate (*Malacoraja senta*) juveniles/adults	46-956	North Carolina to southern Grand Banks	Moore et al. 2003	900 (juvs/adults)
Thorny skate (*Amblyraja radiata*) juveniles/adults	18-996	South Carolina to Greenland	Moore et al. 2003	900 (juvs/adults)
White hake (*Urophycis tenuis*)	0-1000	North Carolina to Labrador	Moore et al, 2003	900 (adults)

Species	Depth (m)	Location	References	Maximum depth determined by PDT
juveniles/adults				
Witch flounder (*Glyptocephalus cynoglossus*) juveniles/adults	a) 18-1570 (mostly 45-366) b) max 635	a) North Carolina to Greenland b) GB/SNE Slope	a) Moore et al. 2003 b) Balcom 1997	1500 (juvs/adults)

The table below identifies various levels of spatial overlap between the map representations for each species and lifestage and the corresponding habitat management area boundaries. Overlaps were assessed visually using Geographic Information System software and are coded as follows. The numeric scores were used to generate a comparison metric across areas. 'High' and 'full' were given the same numeric score because the differences between these two categories were typically minor, and in many cases the difference between high and full resulted from small areas eliminated from the map based on a depth contour-based clipping of the spatial coverage.

Overlap	Score	Definition
None	0	No spatial overlap
Slight	1	Overlap of less than 25% of the coral zone(s)
Moderate	2	Overlap of greater than 25% but less than 75% of the coral zone(s)
High	3	Overlap of greater than 75% of the coral zone(s)

At the bottom of each table, some summary statistics are provided. First, the numeric scores were added across all designations listed in the table to provide a metric representing both the number of designations represented and the degree of overlap for those designations. This "total score" metric ranges from a low value of 2 to a high value of 68, out of a possible score of 141, which would represent a score of 3 for all 47 benthic lifestages. Next, a "species count" metric is provided, which indicates the number of species that have at least one benthic lifestage designated in a coral zone or group of zones. Twenty six species total are included on the tables (clearnose skate and Atlantic salmon are excluded). The "designation count" metric indicates the number of individual benthic designations overlapping the area.

Table 14 - Degree of overlap between designated EFH and coral zones, Gulf of Maine

Species and lifestage	Outer Schoodic Ridge	Mt Desert Rock	Jordan Basin	Lindenkohl Knoll
Acadian redfish juvenile	3	3	1	2
Acadian redfish adult	2	1	3	3
American plaice juvenile	1	2	0	0
American plaice adult	3	3	3	0
Atlantic cod juvenile	0	1	1	1
Atlantic cod adult	1	1	0	0
Atlantic halibut - all stages	1	1	0	0
Atlantic wolffish - all stages	3	3	3	3
Haddock juvenile	1	1	0	0

Species and lifestage	Outer Schoodic Ridge	Mt Desert Rock	Jordan Basin	Lindenkohl Knoll
Haddock adult	2	2	0	0
Ocean pout egg	0	0	0	0
Ocean pout juvenile	0	0	0	0
Ocean pout adult	1	0	0	0
Pollock juvenile	3	3	0	1
Pollock adult	2	0	3	3
White hake juvenile	3	3	3	3
White hake adult	3	3	3	3
Windowpane flounder juvenile	1	0	0	0
Windowpane flounder adult	1	0	0	0
Winter flounder egg	1	0	0	0
Winter flounder larvae and adult	1	0	0	0
Winter flounder juvenile	1	0	0	0
Witch flounder juvenile	3	3	3	3
Witch flounder adult	3	3	3	3
Yellowtail flounder juvenile	0	3	0	0
Yellowtail flounder adult	1	3	0	0
Red hake egg, larvae, and juvenile	1	0	0	0
Red hake adult	3	3	3	3
Silver hake juvenile	3	3	3	3
Silver hake adult	3	3	3	3
Offshore hake juvenile and adult	0	0	0	0
Monkfish juvenile	2	3	2	3
Monkfish adult	2	3	3	3
Smooth skate juvenile	3	3	3	3
Smooth skate adult	0	3	2	2
Thorny skate juvenile	3	3	3	1
Thorny skate adult	3	3	3	3
Barndoor skate – juv/adu	0	0	0	0
Little skate juvenile	1	0	0	0
Little skate adult	0	0	0	0
Winter skate juvenile	1	0	0	0
Winter skate adult	1	0	0	0
Rosette skate juvenile and adult	0	0	0	0
Atlantic sea scallop - all	1	0	0	0
Atlantic herring egg	0	0	0	0
Deep-sea red crab larvae and juvenile	0	0	0	0
Deep-sea red crab adult	0	0	0	0
Total score (out of 141)	**68**	**66**	**51**	**49**
Count of species (out of 26)	**21**	**15**	**12**	**11**
Count of designations (out of 47)	**35**	**26**	**19**	**19**

Table 15 - Degree of overlap between designated EFH and coral zones overlapping the canyons, continental slope, and seamounts.

Species and lifestage	Slope depth range, m	Canyon (MNM)	Canyon (not MNM)	Sea-mount	300 m	400 m	500 m	600 m	900 m
Acadian redfish juv	400-600	1	1	0	1	1	1	0	0

Acadian redfish adult	400-600	1	1	0	1	1	1	0	0
American plaice juv	None	0	0	0	0	0	0	0	0
American plaice adult	None	0	0	0	0	0	0	0	0
Atlantic cod juvenile	None	0	0	0	0	0	0	0	0
Atlantic cod adult	None	0	0	0	0	0	0	0	0
Atlantic halibut - all	400-700	1	1	0	1	1	1	1	0
Atlantic wolffish - all	None	0	0	0	0	0	0	0	0
Haddock juvenile	None	0	0	0	0	0	0	0	0
Haddock adult	None	0	0	0	0	0	0	0	0
Ocean pout egg	None	0	0	0	0	0	0	0	0
Ocean pout juvenile	None	0	0	0	0	0	0	0	0
Ocean pout adult	None	0	0	0	0	0	0	0	0
Pollock juvenile	None	0	0	0	0	0	0	0	0
Pollock adult	None	0	0	0	0	0	0	0	0
White hake juvenile	None	1	1	0	0	0	0	0	0
White hake adult	400-900	2	2	0	1	1	1	1	0
Windowpane juvenile	None	0	0	0	0	0	0	0	0
Windowpane adult	None	0	0	0	0	0	0	0	0
Winter flounder egg	None	0	0	0	0	0	0	0	0
Winter fl larvae/adult	None	0	0	0	0	0	0	0	0
Winter flounder juv	None	0	0	0	0	0	0	0	0
Witch fl juvenile	400-1500	3	3	0	1	1	1	1	1
Witch flounder adult	400-1500	3	3	0	1	1	1	1	1
Yellowtail fl juvenile	None	0	0	0	0	0	0	0	0
Yellowtail fl adult	None	0	0	0	0	0	0	0	0
Red hake e/l/j	None	0	0	0	0	0	0	0	0
Red hake adult	400-750	2	2	0	1	1	1	1	0
Silver hake juvenile	None	0	0	0	0	0	0	0	0
Silver hake adult	None	1	1	0	1	0	0	0	0
Offshore hake juvenile and adult	400-750	2	2	0	1	1	1	1	0
Monkfish juvenile	400-1000	2	2	0	1	1	1	1	1
Monkfish adult	400-1000	2	2	0	1	1	1	1	1
Smooth skate juv	400-900	2	2	0	1	1	1	1	0
Smooth skate adult	400-900	2	2	0	1	1	1	1	0
Thorny skate juvenile	400-900	2	2	0	1	1	1	1	0
Thorny skate adult	400-900	2	2	0	1	1	1	1	0
Barndoor skate j/a	400-750	2	2	0	1	1	1	1	0
Little skate juvenile	None	0	0	0	0	0	0	0	0
Little skate adult	None	0	0	0	0	0	0	0	0
Winter skate juvenile	None	0	0	0	0	0	0	0	0
Winter skate adult	None	0	0	0	0	0	0	0	0

Rosette skate j/a	None	0	1	0	1	0	0	0	0
Sea scallop all	None	0	0	0	0	0	0	0	0
Atlantic herring egg	None	0	0	0	0	0	0	0	0
Red crab lar/juv	400-1300	3	3	1	1	1	1	1	1
Red crab adult	400-900	2	2	1	1	1	1	1	1
Total score (out of 141)		**36**	**37**	**2**	**19**	**17**	**17**	**15**	**6**
Count of species (out of 26)		**12**	**13**	**1**	**13**	**11**	**11**	**10**	**3**
Count of designations (out of 47)		**19**	**20**	**2**	**19**	**17**	**17**	**15**	**6**

Adult red crab EFH is designated to 2000m on the seamounts.

Overall, EFH designations for the largest number of species overlap the inshore Gulf of Maine zones, with moderate numbers of designations overalapping the offshore Gulf of Maine zones, and lower EFH overlap in the canyon and seamount zones. The greater number and degree of overlapping designations in inshore areas is consistent with the findings of Omnibus Habitat Amendment 2, where inshore habitat management areas tended to have a greater diversity of EFH designations present. In general, the species associated with the coral zones are generally those that occur in deeper water, for example pollock, white hake, witch flounder, and monkfish, as well as some skates and of course deep-sea red crab in the canyon, seamount, and broad zones.

6.7 Managed resources and fisheries

The managed resources described here are those that may be impacted by the coral zone alternatives under consideration, whose fisheries use bottom-tending gear in areas overlapping the alternatives. The resources of interest were identified through the economic analysis of recent vessel trips that overlap the deep-sea coral zones under consideration. The potentially impacted fisheries are also described. Some of these resources and fisheries occur exclusively in areas overlapping the Gulf of Maine or deep-sea coral zones, while others occur in both (Table 17).

Table 16 – General distribution of managed resources and their fisheries relative to coral zone alternatives under consideration

Fishery and species	Managed by	Canyon and seamount zones	Gulf of Maine zones
Northeast multispecies, large mesh	NEFMC	GB haddock, white hake	GOM cod, GOM haddock, American plaice, witch flounder, white hake, GOM winter flounder, pollock, Acadian redfish
Northeast multispecies, small mesh	NEFMC	Silver and offshore hake along shelf break, particularly in eastern canyons	Silver and red hake occur in these areas, but the fishery is precluded.
Longfin squid, butterfish	MAFMC	Longfin squid and butterfish along shelf break	No overlap noted
Monkfish	NEFMC, MAFMC	Along the shelf break in	Offshore zones (Jordan Basin,

		western canyons	Lindenkohl)
Golden tilefish	MAFMC	Along shelf break in western canyons	No overlap noted
Deep-sea red crab	NEFMC	Along shelf break in all canyons	No overlap noted
Lobster	ASMFC	Along shelf break in all canyons	Fishery overlaps all zones; distinct fisheries inshore vs. offshore
Jonah crab	ASMFC	All shelf break particularly in western canyons	No overlap noted

6.7.1 Northeast Multispecies

There are 13 species managed under the Northeast Multispecies Fishery Management Plan (FMP) as large mesh (groundfish) species, based on fish size and type of gear used to harvest the fish: American plaice, Atlantic cod, Atlantic halibut, Atlantic wolffish, haddock, pollock, redfish, ocean pout, yellowtail flounder, white hake, windowpane flounder, winter flounder, and witch flounder. Several large mesh species are managed as two or more stocks based on geographic region. Three species — offshore hake, red hake, and silver hake (whiting) — are managed under a separate small mesh multispecies FMP (per Amendment 12).

6.7.1.1 Large mesh (groundfish) multispecies

Groundfish stocks have been managed under the Magnuson-Stevens Act (MSA) beginning with the adoption of a groundfish plan for cod, haddock, and yellowtail flounder in 1977. This plan first relied on hard quotas, but the quota system ended in 1982 with the adoption of the Interim Groundfish Plan, which controlled fishing mortality with minimum fish sizes and codend mesh regulations. The Northeast Multispecies FMP replaced this plan in 1986, initially continuing to control fishing mortality with gear restrictions and minimum mesh size, and used biological targets based on a percentage of maximum spawning potential. The FMP has had many revisions in subsequent years. Since 2010, the vast majority of the fishery has been managed with a catch share program, in which self-selected groups of commercial fishermen (i.e., sectors) are allocated a portion of the available catch.

The groundfish fishery has recently targeted the following stocks within the areas that overlap with the coral management zones under consideration:

- Canyon and seamount zones: GB haddock, white hake
- Gulf of Maine zones: GOM haddock, GOM cod, American plaice, witch flounder, white hake, GOM winter flounder, pollock, and Acadian redfish.

Framework 55 to the Northeast Multispecies FMP summarizes the status of all groundfish stocks and the groundfish fishery (NEFMC, 2016). Of the nine stocks with fisheries that potentially overlap the alternatives under consideration, two are considered overfished and overfishing is occurring (Table 18).

Table 17 – Status of selected Northeast groundfish stocks for FY2015. Source: NEFMC 2016.

	Previous Assessment		2015 Assessments	
Stock	Overfishing?	Overfished?	Overfishing?	Overfished?
Gulf of Maine cod	Yes	Yes	Yes	Yes
Georges Bank haddock	No	No	No	No
Gulf of Maine haddock	No	No	No	No
American plaice	No	No	No	No
Witch flounder	Yes	Yes	Yes	Yes
Gulf of Maine winter flounder	No	Unknown	No	Unknown
Acadian redfish	No	No	No	No
White hake	No	No	No	No
Pollock	No	No	No	No

The overall trend since the start of sector management through 2013 has been a decline in groundfish landings (42.3M lbs in FY2013), revenue ($58.7M in FY2013), the number of vessels with a limited access groundfish permit (1,119 in FY2013), and the number of vessels with revenue from at least one groundfish trip (316 in FY2013). The groundfish fishery has had a diverse fleet of vessels sizes and gear types. Over the years, as vessels entered and exited the fishery, the typical characteristics defining the fleet changed as well. The decline in active vessels has occurred across all vessel size categories. Since FY2009, the 30’ to < 50’ vessel size category, which has the largest number of active groundfish vessels, experienced a 38% decline (305 - 159 active vessels). The <30’ vessel size category, containing the least number of active groundfish vessels, experienced the largest (50%) reduction since FY2009 (34 - 17 vessels). The vessels in the largest (≥75’) vessel size category experienced the least reduction (30%) since FY2009 (Murphy et al 2013).

6.7.1.2 Small mesh multispecies

The silver, red, and offshore hake trawl fishery, commonly referred to as the “whiting” fishery, and is managed by the NEFMC under the Small Mesh Multispecies FMP. Silver hake is the primary target species. There is little to no separation of silver and offshore species in the market, and both are generally sold under the name "whiting."

Silver hake (*Merluccius bilinearis*) occur throughout the Gulf of Maine and in moderate to deeper depths on Georges Bank and in the Mid-Atlantic Bight. In the NEFSC trawl survey, larger and older fish are found further north and in deeper waters, and smaller younger fish are found in relatively shallow waters. Depth appears to be a more important determinant of silver hake distribution than temperature (NEFSC 2006). The 2013 assessment update concluded that both the northern and southern stocks were found to be not overfished and overfishing was not occurring (NEFMC 2013).

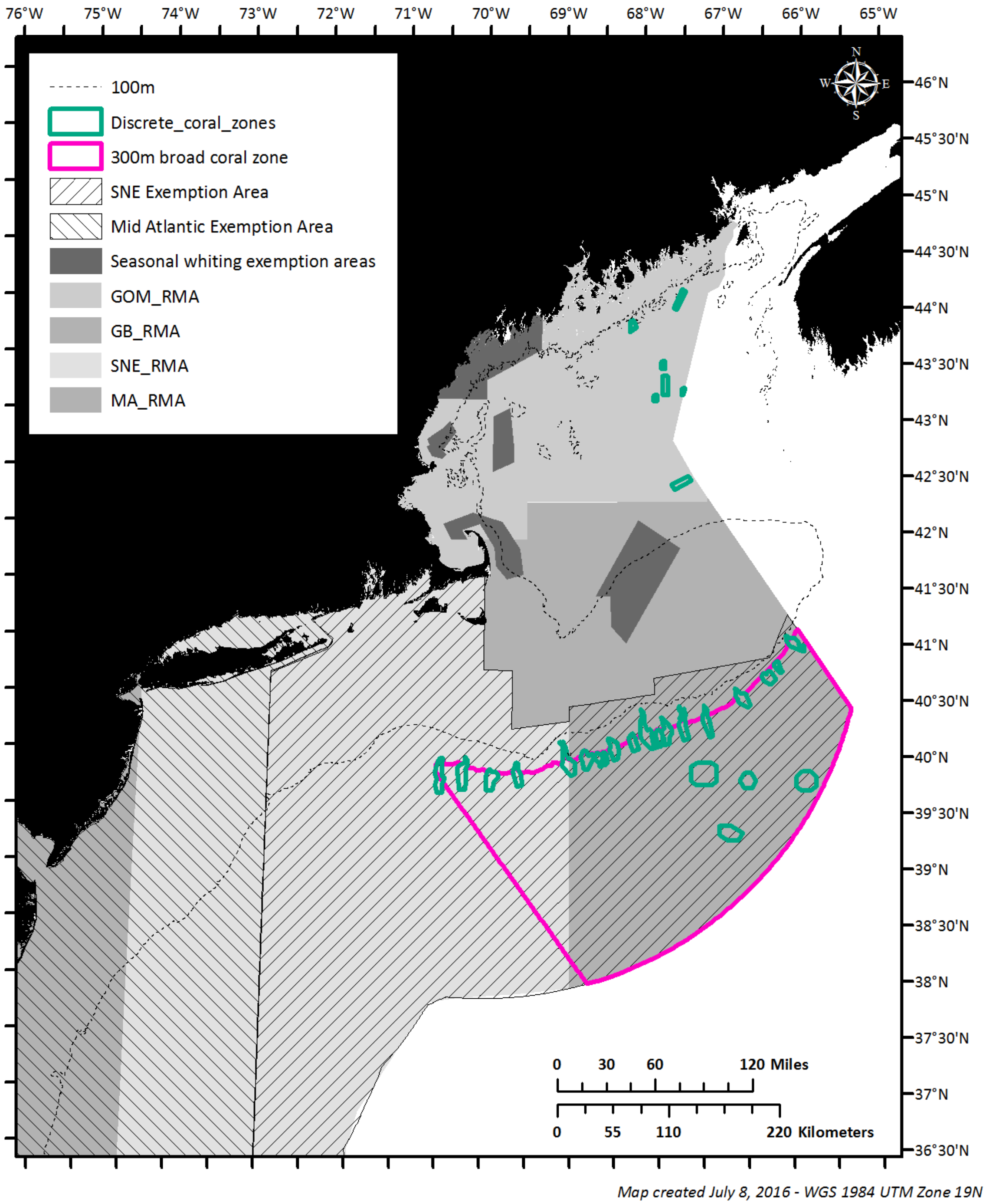
Red hake (*Urophycis chuss*) occur throughout the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic Bight. They occur at a wide range of depths throughout the year, the juveniles in particular making seasonal migrations to follow preferred temperature ranges. I the Mid-Atlantic Bight, the juveniles move into deeper waters in the fall, while on Georges Bank, they are found in shallower waters in fall and nearly absent in the spring, when they occur mostly on the northern edge. Overall, juveniles have a shallower distribution in the NEFSC trawl surveys, 0-30 m in spring and 40-80 m in fall, while adults occur between 60-300 m in spring, and 50-160 m in the fall. The 2015 assessment update concluded that both northern and southern stocks of red hake were not overfished and overfishing was not occurring. Northern red hake had previously experienced overfishing (NEFMC 2015).

Offshore hake (*Merluccius albidus*) occur along the shelf/slope break. Their distribution in the Northeast U.S. extends from the southeastern flank of Georges Bank to Cape Hatteras. At night, juveniles and adults occur in the water column. During the day, both occur in mud, mud/sand, and sand habitats. As their common name implies, offshore hake have the deepest distribution of any of the hake species managed by NEFMC. There is little information available on the reproductive biology of offshore hake. Spawning appears to occur over a protracted period or even continually throughout the year from the Scotian Shelf through the Mid-Atlantic Bight. Offshore hake feed on pelagic invertebrates, e.g. euphausiids and other shrimps, and pelagic fish, including conspecifics. There is no accepted assessment of offshore hake.

Fishery. The whiting fishery is managed under the Northeast Multispecies FMP via a series of exemptions to the regulations for large mesh stocks, including a 6.5 inch codend mesh size requirement that limits catch of undersized groundfish. This exemption requires that a fishery should routinely catch under 5% of regulated multispecies (i.e., large mesh species and ocean pout). The whiting fishery also has possession limits and area restrictions on small-mesh use. Seasonally, the whiting fishery can operate within spatially-discrete exemption areas within the Gulf of Maine and Georges Bank regulated mesh areas (RMAs). Year-round, the fishery can also operate throughout the southern portion of the Georges Bank RMA, as well as throughout the Southern New England and Mid-Atlantic RMAs. The deep-sea canyons and slope are part of the Southern New England/Southern GB exemption area. The Gulf of Maine coral zones are outside the discrete exemption areas and therefore are not accessible to the whiting fishery.

Landings and revenues of silver hake in the northern and southern area have been increasing since 2006. Landings of northern silver hake have been over 1,000 mt per year ($1.2 – 2.3M annual revenue). Landings of southern silver hake have been higher, between 2,600 mt to 13,000 mt er year ($7.6 – 15.5M annual revenue). Most of the high landings trips targeting whiting are made by vessels fishing along the Mid-Atlantic continental shelf edge and along the southern edge and eastern portion of Georges Bank. Almost all trips landing over 12.7 mt and targeting whiting occurred in the Southern New England Exemption Area. Other trips targeting whiting are more broadly distributed along the Southern New England shelf edge and within statistical area 537. There is an increasing trend of trips targeting whiting in the southern stock area and landing closer to 13.6 mt per trip.

Map 41 – Deep-sea coral zones and whiting exemption areas.



6.7.2 Longfin inshore squid and butterfish

Longfin inshore squid (*Loligo pealeii*) is distributed primarily in continental shelf waters located between Newfoundland and the Gulf of Venezuela (Cohen 1976; Roper et al. 1984). In the northwest Atlantic Ocean, longfin squid are most abundant in the waters between Georges Bank and Cape Hatteras, where the species is commercially exploited. The stock area extends from the Gulf of Maine to Cape Hatteras. Distribution varies seasonally. North of Cape Hatteras, squid migrate offshore during late autumn to overwinter in warmer waters along the shelf edge and slope, and then return inshore during the spring where they remain until late autumn (Jacobson 2005). The species lives for about nine months, grows rapidly, and spawns year-round with peaks during late spring and autumn. Individuals hatched in summer grow more rapidly than those hatched in winter and males grow faster and attain larger sizes than females (Brodziak & Macy III 1996). At the latest assessment in 2011, overfishing was not occurring, and the overfished status could not be determined, as there is no biomass reference point (NEFSC 2011a).

Butterfish *(Peprilus tricanthus)* is a semi-pelagic/semi-demersal schooling fish, primarily distributed between Nova Scotia and Florida, but are most abundant between the Gulf of Maine and Cape Hatteras. Butterfish are fast-growing, short-lived, pelagic fishes that form loose schools, often near the surface. They winter near the edge of the continental shelf in the Middle Atlantic Bight and migrate inshore in the spring into southern New England and Gulf of Maine waters. During the summer, butterfish occur over the entire mid-Atlantic shelf from sheltered bays and estuaries out to about 200 m. In late fall, butterfish move southward and offshore in response to falling water temperatures (Cross et al. 1999, and references therein). At the latest assessment in 2014, butterfish was not overfished and overfishing was not occurring (NEFSC 2014). Butterfish are also managed as a single stock. The most recent assessment in 2010 questioned the 2004 reference points, and while it was agreed that overfishing was unlikely to be occurring, the overfished status of butterfish was classified as unknown. A benchmark assessment of the stock is ongoing.

Fishery. Longfin squid and butterfish have been managed by the MAFMC under the Atlantic Mackerel, Squid, and Butterfish FMP since 1983. The domestic longfin fishery occurs primarily in Southern New England and Mid-Atlantic waters, but some fishing also occurs along the edge of Georges Bank. Fishing effort reflects seasonal longfin distribution, and effort is generally directed offshore during October through April and inshore during May through September. The fishery is dominated by small-mesh otter trawlers, but near-shore pound net and fish trap fisheries occur during spring and summer. Since 1984, annual offshore landings have generally been three-fold greater than inshore landings. Management measures for the *L. pealeii* stock include annual TACs, which have been partitioned into seasonal quotas since 2000 (trimesters in 2000 and quarterly thereafter), a moratorium on fishery permits, and a minimum codend mesh size of 1 7/8 inches.

The directed longfin squid fishery is managed via trimester quota allocations and the directed fishery is closed when 90% of the trimester quota allocations or 9% of the total domestic harvest is projected to be landed. There is also a cap on butterfish discards in the longfin squid fishery that is allocated by trimester, and closes the longfin squid fishery to directed harvest once it has been exceeded. Finally, butterfish is managed using a phased system. The system triggers butterfish possession limit reductions at different points to ensure quota is available for directed harvest throughout the fishing year. During closures of the directed longfin squid or butterfish fisheries, incidental catch fisheries for these species are permitted.

Although 1.5 percent of butterfish landed from 2007-2011 were reported as caught with gillnets, and trace amounts of these species were reported as caught with a variety of fishing gears, more than 98 percent of reported landings of all four species during this period were caught with otter trawls (midwater and bottom). Management measures implemented under the FMP restrict only the commercial fishing sectors, although there is a recreational fishery for Atlantic mackerel. Fishing for Atlantic mackerel occurs year-round, although most fishing activity occurs from January through April. Butterfish are landed year-round, with no apparent seasonality.

Butterfish had been landed domestically since the late 1800s, and in the 1960s and 1970s there was a substantial increase in catch, mostly by foreign vessels. After extended jurisdiction was implemented, domestic landings expanded but then declined in the 1990s due to lower abundance and market conditions. As of January 2013, a limited domestic fishery has been reestablished, although landings have been low so far. In general discards represent a significant fraction of the catch.

6.7.3 Monkfish

Juvenile and adult monkfish (*Lophius americanus*, i.e., “goosefish”) are common in mud habitats and occur in U.S. waters from the Hague Line to Cape Hatteras, North Carolina, in depths of at least 900 m. Monkfish undergo seasonal onshore-offshore migrations, which may relate to spawning or possibly to food availability. Female monkfish begin to mature at age 4 with 50% of females maturing by age 5 (~17 in [43 cm]). Males generally mature at slightly younger ages and smaller sizes (50% maturity at age 4.2 or 14 in [36 cm]). Spawning takes place from spring through early autumn. It progresses from south to north, with most spawning occurring during the spring and early summer. Females lay a buoyant egg raft or veil that can be as large as 39 ft (12 m) long and 5 ft (1.5 m) wide, and only a few mm thick. The larvae hatch after 1 - 3 weeks, depending on water temperature. The larvae and juveniles spend several months in a pelagic phase before settling to a benthic existence at a size of ~3 in (8 cm; NEFSC 2011).

The Monkfish FMP defines two management areas for monkfish (northern and southern), divided roughly by an east-west line bisecting Georges Bank. As of 2013 data, monkfish in both management areas are not overfished and overfishing is not occurring (NEFSC 2013c), although the 2013 stock assessment emphasized a high degree of uncertainty: “due to cumulative effects of under-reported landings, unknown discards during the 1980s, uncertainty in survey indices, and incomplete understanding of key biological parameters such as age and growth, longevity, natural mortality and stock structure contributing to retrospective patterns primarily in the northern management area.” (NEFSC 2013c).

Since 1999, the monkfish fishery has been jointly managed by the NEFMC and MAFMC in two management units, a Northern Management Area in the Gulf of Maine, the Great South Channel, and most of Georges Bank, and a Southern Management Area covering the southwest part of Georges Bank, Southern New England, and Mid-Atlantic waters. Monkfish have a large, bony head and are harvested for their livers and the tender meat in their tails. During the early 1990s, fishermen and dealers in the monkfish fishery approached both Councils with concerns about the increasing amount of small fish being landed, the increasing frequency of gear conflicts between monkfish vessels and those in other fisheries, and the expanding directed trawl fishery. Since the implementation of the FMP, vessels are more commonly landing large, whole monkfish for export to Asian markets.

The Northern Management Area monkfish fishery is closely integrated with the northeast multispecies fishery, and is primarily a trawl fishery, while the Southern Management Area fishery is primarily a gillnet fishery targeting monkfish almost exclusively. These differences have resulted in some differences in management measures, such as trip limits and DAS allocations, between the two areas.

The fishery is primarily managed through the issuance of limited access permits, as well as days-at-sea (DAS) allocations, landing limits, and gear restrictions that differ in each fishery management area. Limited access monkfish vessels having a limited access groundfish permit are also required to comply with applicable Multispecies DAS and sector provisions or common pool regulations, depending on the vessel's enrollment for a given fishing year. Mesh size regulations for trawls and gillnets are set to prevent the fishery from targeting small monkfish and catching groundfish when not on a Multispecies DAS. As a measure to reduce habitat impacts, regulations promulgated under Monkfish Amendment 2 require trawl vessels in the SFMA to use nets with roller gear with a diameter no larger than 6-inches[4]. Vessels in the western Gulf of Maine may not use roller gear with a diameter larger than 12-inches.

Monkfish are harvested primarily with bottom trawls and gillnets. Scallop dredges also catch monkfish, but in much smaller amounts. No other gear types account for more than trace landings of monkfish, and there is no recreational component to this fishery. Revenues have generally increased since the mid-1980s, peaking in 1999 and 2000, before declining through 2010. Vessels using trawls typically target monkfish along the continental shelf edge, next to canyons and in deeper water than vessels fishing with gillnets.

Landings for both areas combined have generally decreased since 1999, with a peak in 2003 (26, 353 mt), and have been under 10,000 mt since 2009. Revenue was just under $20M in 2014. In 2014, there were 637 monkfish limited access permits, of which 282 were Category C permits holding limited access permits in either the multispecies (52%) or scallop (59%) fisheries, and 264 were Category D permits, primarily (98%) holding limited access multispecies permits (NEFMC 2016a).

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[4] See Section 4.1.8.1 in Monkfish Amendment 2, http://www.nefmc.org/monk/planamen/final_planamen2.html)

6.7.4 Golden tilefish

The golden tilefish (*Lopholatilus chamaeleonticeps*) is the largest and longest lived of all the tilefish species, and in U.S. waters ranges from Georges Bank to Key West, Florida, and throughout the Gulf of Mexico. In the SNE/MA area, golden tilefish generally occur at depths of 76-366m along the outer continental shelf and are most abundant in depths of 100-240m. Temperature may also constrain their range, as they are most abundant near the 15° C isotherm. Although golden tilefish occupies a variety of habitats, it is somewhat unique in that it creates and modies existing vertical burrows in the sediment as its dominant habitat in U.S. waters. The most recent stock assessment, SAW 58, determined that tilefish is not overfished and overfishing is not occurring (NEFSC 2014).

The MAFMC has managed golden tilefish fishery within the Tilefish FMP since 2001. for the fishery that occurs north of the Virginia/North Carolina border. An original intent was to address the overfished status of the species (the stock was considered rebuilt in 2014). Amendment 1 to the Tilefish FMP, implemented in 2009, adopted an IFQ program, initially with 13 quota holders, based primarily on historical participation in the fishery. Since then, the IFQ fishery has been allocated 95% of the annual quota. The open access incidental fishery, under a 500lb. trip limit, is allocated the remainder. (MAFMC 2016).

During 2001-2015, golden tilefish landings have averaged 1.9 million pounds, ranging from 1.3 (2015) to 2.5 (2004) million pounds. Based on dealer data from 2011 through 2015, the bulk of the golden tilefish landings are taken by longline gear (98%) followed by bottom trawl gear (~1%). No other gear had any significant commercial landings. Minimal catches were also recorded for hand line and gillnets (MAFMC 2016). There is a minimal recreational fishery for this species, with less than 8,300 lb. landed annually for the last 30 years. In 2015, just 4% of landings were from Statistical Area 526 and 525 on Georges Bank, with all other landings from areas to the west and south (MAFMC 2016).

6.7.5 Deep-sea red crab

Deep-sea red crab is a data poor stock. Red crab inhabit deep water, are rarely caught in the trawl survey, and there is little information about their life history. In U.S. waters, deep-sea red crab (*Chaceon quinquidens*) occurs in the Gulf of Maine, along the continental slope from Georges Bank to the Gulf of Mexico, and on the seamounts. The stock status for deep-sea red crab is unknown.

There is limited information about red crab spawning locations and times. Erdman et al. (1991) suggested that the egg brooding period may be about nine months, at least for the Gulf of Mexico population, and larvae are hatched in the early spring there. There is no evidence of any restricted seasonality in spawning activity in any geographic region of the population, although a mid-winter peak is suggested as larval releases are reported to extend from January to June (Wigley et al. 1975; Haefner 1977; Lux et al. 1982; Erdman et al. 1991; Biesiot and Perry 1995).

Based on laboratory observations, larvae probably consume zooplankton. Juveniles and adults are opportunistic feeders. Post-larval, benthic red crabs eat a wide variety of infaunal and epifaunal benthic invertebrates (e.g. bivalves) that they find in the silty sediment or pick off the seabed surface. Smaller red crabs eat sponges, hydroids, mollusks (gastropods and scaphopods), small polychaetes and crustaceans, and possibly tunicates. Larger crabs eat similar small benthic fauna and larger prey, such as demersal and mid-water fish (*Nezumia* and myctophids), squid, and the relatively large, epibenthic, quill worm (*Hyalinoecia artifex*). They can also scavenge deadfalls (e.g., trawl discards) of fish and squid, as they are readily caught in traps with these as bait and eat them when held in aquaria.

Only male red crabs are landed in the trap fishery, which is managed via the Atlantic Deep-Sea Red Crab FMP, implemented in 2002. The species is managed as a single stock, and red crabs in the Gulf of Maine are not included in reference point, biomass, or management calculations. Additional details are provided in the 2008 Data Poor Stocks Working Group Report (NEFSC 2009), which found that as of 2008, the stock status was unknown.

The NEFMC has managed the deep-sea red crab fishery under a FMP since 2002. In 1999, members of the red crab fishing industry requested that the Council development a FMP to prevent overfishing of the red crab resource and address a threat of overcapitalization of the red crab fishery. There had been a small, directed fishery off the coast of New England and in the Mid-Atlantic since the early 1970s. Though the size and intensity of this fishery has fluctuated, it has remained small relative to more prominent fisheries (e.g., groundfish, sea scallops, and lobster).

The FMP established a limited access permit program for qualifying vessels with documented history in the fishery, days-at-sea limits, trip limits, gear restrictions, and at-sea processing limits. The directed, limited access red crab fishery is a male-only fishery. In 2011, Amendment 3 implemented Annual Catch Limits (i.e., the fishery is closed when the quota is reached) and accountability measures and revised the management measures by eliminating DAS and the vessel trip limit. Although there is an open access permit category, and 1,295 such permits were issued in 2016 (NMFS, 2016), the small possession limit (500 pounds per trip) has kept this fishery component very small. The directed fishery is limited to using parlor-less crab pots, and is considered to have little, if any, incidental catch of other species. There is no known recreational fishery for deep-sea red crab.

The catch limit has been stable since 2002 at 1,775 mt and landings have fluctuated between about 1,000-1,700 during this time. The red crab fishery is a small, market-driven fishery, and landings are very closely tied to market demand. When landings are low, it is often because the demand for red crabs has decreased and the fleet has targeted other more profitable species. Catch is attributed to three regions: Georges Bank/Southern New England, New Jersey, and Delmarva. The GB/SNE area encompsses the area the canyon and/or seamount deep-sea coral zone areas considered in this action. Through 2007, the largest proportion of landings was attributed to the GB/SNE area.

Since 2013, had the largest proportion has been attributed to New Jersey (NEMFC 2016b).

Since at least 2014, limited access red crab permits have been issued to six vessels. Fishery revenue since 2002 has averaged $3.0M per year (NEFMC 2016b). The fishery occurrs out of New Bedford, MA, where a red crab processing plant has been in operations since 2009 (NEFMC 2011; www.atlanticredcrab.com).

6.7.6 American lobster

American lobsters (*Homarus americanus*) are benthic crustaceans found in U.S. waters from Maine to New Jersey inshore and Maine to North Carolina offshore. Lobsters tend to be solitary, territorial, and exhibit a relatively small home range of 5-10 square kilometers, although large mature lobsters living in offshore areas may migrate inshore seasonally to reproduce, and southern inshore lobsters may move to deeper areas to seek cooler temperatures on a seasonal or permanent basis.

The 2009 lobster stock assessment assumed three distinct stocks, Gulf of Maine, Georges Bank, and Southern New England. However, the 2015 lobster stock assessment combined the Gulf of Maine and Georges Bank stocks to more effectively model recruitment size compositions and seasonal variations in the location of large females (ASMFC 2015). The 2015 lobster stock assessment concluded that the SNE stock is depleted (at record low levels), while the GOM/GB stock is at record abundance. While the assessment concluded that neither the GOM/GB stock nor the SNE stock is experiencing overfishing, the overfishing determination for SNE may be misleading and unreliable, because the methods used to estimate fishing mortality are not designed for such low biomass situations (ASMFC 2015).

The lobster fishery is one of the top fisheries on the U.S. Atlantic coast (>$461M total revenue in 2013). It is managed by the Atlantic States Marine Fisheries Commission in state waters (0-3 nm from shore) and by NMFS in federal waters (3-200 mi from shore). The fishery occurs within the three stock units: Gulf of Maine, Georges Bank, and Southern New England, each with an inshore and offshore component. The management areas most relevant to this action are Area 1 (inshore Gulf of Maine) and Area 3 (offshore Gulf of Maine, Georges Bank, and Mid-Atlantic Bight to the EEZ). Map 42 shows the overlap between the lobster management areas and coral zones.

The fishery is managed using minimum and maximum lobster sizes; limits on the number and configuration of traps; possession prohibitions on egg-bearing females and v-notched lobsters, lobster meat, or lobster parts; prohibitions on spearing lobsters; and limits on non-trap landings. Between 1981 and 2013, 96% of all lobster was harvested using traps (ASMFC 2015).

The Gulf of Maine stock supports the largest portion of the fishery (average of 79% of the U.S. landings between 1981 and 2013; over 90% since 2009; 95% in 2013). The fishery is prosecuted mainly with small, 22-42' vessels that conduct day trips within about 12 miles of shore. Some larger vessels fish offshore in the Gulf of Maine. Maine vessels account for most of the fishing effort, and the number of traps fished increased substantially between 1993 and 2002, and has remained at over 3.5 million since then. Trap effort in New Hampshire and Massachusetts is much smaller than in Maine. Since 1989, effort in New Hampshire has increased and Gulf of Maine effort in Massachusetts has declined.

For Georges Bank, the offshore fishery dominates, however, inshore Georges Bank catch from statistical area 521 has increased in recent years. On Georges Bank, most of the effort is on multi-day trips taken using larger, 55-75' vessels. There is day trip fishery in the Outer Cape Cod area. According to the 2009 stock assessment, the number of traps fishing on Georges Bank is "not well characterized, due to a lack of mandatory reporting, and/or a lack of appropriate resolution in the reporting system" (ASMFC 2009, p 42). Data from Massachusetts, which constitutes a large fraction of the Georges Bank fishery, indicate that the number of traps remained relatively stable between 1994 and 2007.

In Southern New England, the offshore fishery has dominated total catch since the late 1990s, due to dramatic declines in the catch from inshore SNE (attributed to waters increasingly exceeding the lobster thermal stress threshold of 20° C). Southern New England has been the second largest fishery (average of 22% of the U.S. landings between 1981 and 2001), but recent declines in SNE landings (≤9% since 2002) make this component more on par with the Georges Bank fishery (5% from 1981 to 2013). In Southern New England, there is a nearshore, small vessel day boat fleet as well as an offshore fleet that takes multi-day trips to the canyons along the edge of the continental shelf.

An average of 11,396 vessels were issued commercial lobster permits each year between 2009 and 2013, including permits issued by each state (n=7) from Maine to New Jersey for fishing in their respective state waters (73%) and by NMFS (27%) for the federal fishery (Table 19). The State of Maine is the jurisdiction that has issued the largest number of permits (45%). Vessels with Federal lobster permits in 2013 had homeports in 15 states, 48% from Maine and 28% from Massachusetts (NMFS 2016).

Table 18 – Commercial lobster licenses issued by jurisdiction, 2009-2013

Year	ME	NH	MA	RI	CT	NY	NJ	NMFS	Total
2009	5,376	365	1,314	979	220	375	109	3,176	11,914
2010	5,226	347	1,278	948	206	360	109	3,141	11,615
2011	5,155	333	1,245	922	180	344	109	3,119	11,407
2012	5,079	334	1,214	905	161	334	109	3,003	11,139
2013	4,979	322	1,188	874	142	326	109	2,963	10,903
Average	**5,163**	**340**	**1,248**	**926**	**182**	**348**	**109**	**3,080**	**11,396**
Source: ASMFC (2015a).									

Lobster landings have generally increased over time, from about 5,000 mt in the 1920s to an average of about 59,000 mt between 2009 and 2013 (Table 20). Given that the Gulf of Maine supports the largest portion of the fishery and Maine is the state with the most permitted vessels, it follows that Maine has the largest portion of landings, about 83% between 2009 and 2013 (ASMFC 2015a).

Table 19 – Total lobster landings (mt) by state, 2009-2013. Source ASMFC 2015.

	ME	NH	MA	RI	CT	NY	NJ + south	Total
2009	36,828	1,354	5,929	1,289	187	331	388	**46,306**
2010	43,654	1,654	6,094	1,328	201	369	366	**53,666**
2011	47,590	1,777	6,333	1,249	90	156	341	**57,536**
2012	57,446	1,905	6,753	1,219	110	125	450	**68,008**
2013	57,797	1,729	6,894	978	58	112	359	**67,927**
Average	**48,663**	**1,684**	**6,401**	**1,213**	**129**	**219**	**381**	**58,689**
Source: ASMFC (2015a).								

In 2016, the ASMFC sent mail surveys to 97 commercial lobster permit holders with a trap allocation in Area 3. Of the 34 permit holders who returned surveys, 19 had fished in the areas the canyon and/or seamount deep-sea coral zone areas considered in this action (Whitmore, 2016).

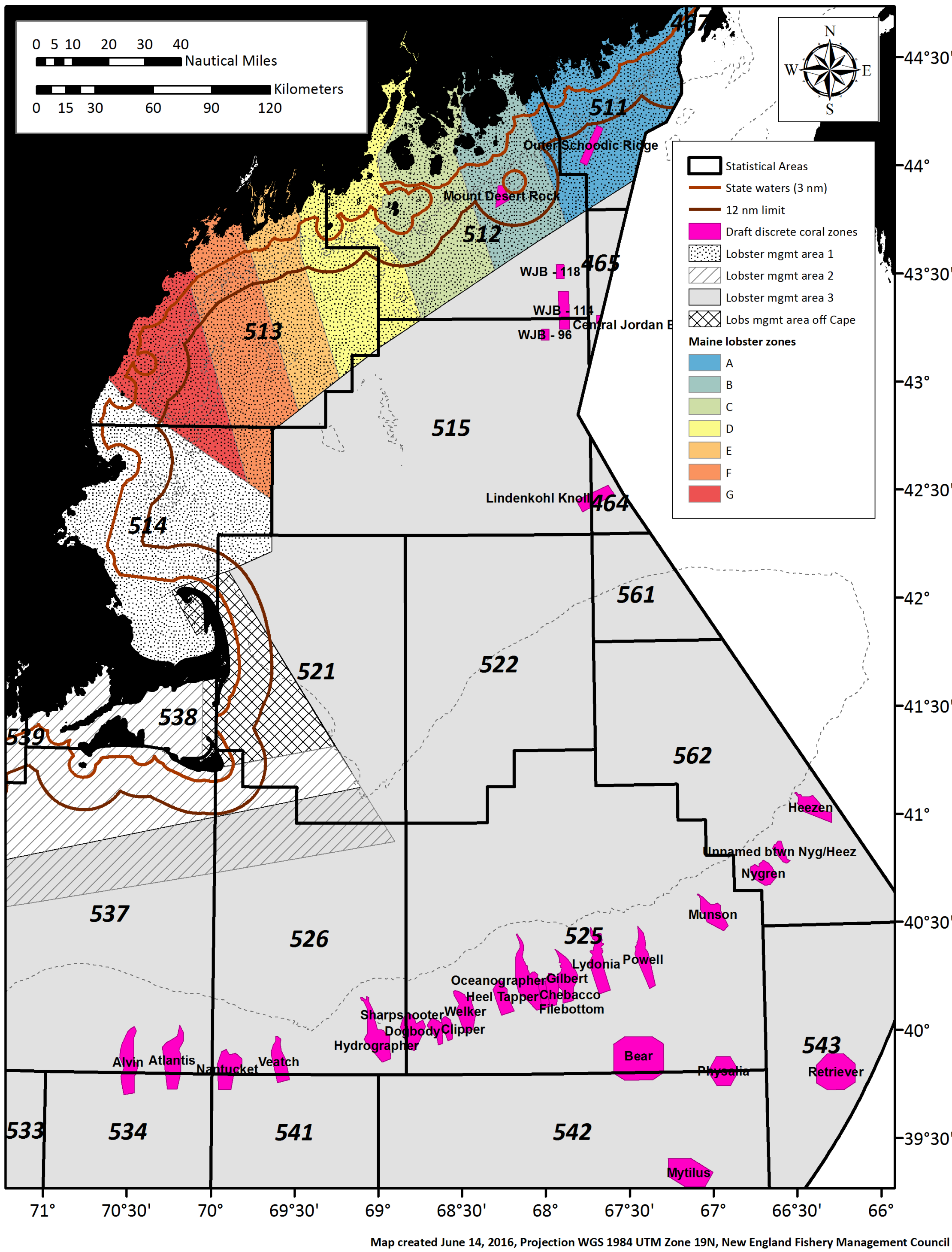
6.7.7 Jonah crab

Jonah crab (*Cancer borealis*) are distributed in the waters of the Northwest Atlantic Ocean primarily from Newfoundland, Canada to Florida. The Jonah crab life cycle is poorly understood; what is known is largely compiled from a patchwork of studies that have both targeted and incidentally documented the species. Female crabs (and likely some males) move inshore during the late spring and summer. Motivations for this migration are unknown, but could be due to maturation, spawning, and molting. It is also widely accepted that migrating crab move back offshore in the fall and winter. Due to the lack of a widespread and well-developed aging method for crustaceans, the age, growth, and maturity of Jonah crab is poorly described. The status of the Jonah crab resource is unknown, as no range-wide stock assessment has been conducted (ASMFC 2015b).

The ASMFC instituted a Jonah crab FMP in 2015, prompted by the American Lobster Board's concern for potential impacts to the status of the Jonah crab resource given the recent and rapid increase in landings. Jonah crab has long been lobster fishery bycatch, but in recent years, there has been increasing targeted fishing pressure and growing market demand for crab. Over time, a mixed crustacean fishery has emerged that can target both lobster or crab or both at different times of year.

Commercial Jonah crab landings were 2-3M lbs. throughout the 1990s, but steadily rose to over 17M lbs. in 2014. A similar increase occurred in the value of fishery, as ex-vessel values grew from about $1.5M in the 1990s to about $12.7M in 2013. Landings in 2014 predominately came from Massachusetts (70%), followed by Rhode Island (24%). The practice of declawing the Jonah crab while fishing lobster traps and pots occurs in the mid-Atlantic and constitutes less than 1% of the total Jonah crab fishery. The magnitude of recreational landings is unknown, but is likely minimal (ASMFC 2015b).

Map 42 – Overlap between coral management zones and lobster management areas. The broad zones (not shown) are within management area 3.



6.7.8 Other species and fisheries

Other species and their associated fisheries overlap, or at least appear to overlap, with the deep-sea coral zones (Table 21). In some cases (sea scallop and summer flounder) this apparent overlap may be the result of spatially imprecise vessel trip report data.

Table 20 – Other species and fisheries that overlap deep-sea coral zones

Species	Fishery and gear
Atlantic sea scallop	Atlantic sea scallop; generally dredge but some bottom trawl
Atlantic mackerel	Mackerel/Squid/Butterfish; generally midwater trawl, also bottom trawl
Summer flounder (fluke)	Summer flounder/scup/black seabass; generally bottom trawls, handlines and gillnets are also used
Hagfish	Hagfish pot fishery (no federal FMP)

Scallops are not generally known to occur at commercial abundance in waters deeper than 110 meters. Thus, it is unlikely that there is truly a substantial degree of overlap between the scallop fishery and deep-sea coral zones.

None of the statistical areas overlapping the coral zones had more than 1,000 mt mackerel catch between 2012 and 2014 (MAFMC 2016).

Summer flounder catches are concentrated in southern New England and the Mid-Atlantic (MAFMC). The only statistical area overlapping the coral zones is 537. This area accounted for about 24% of summer flounder catch reported in VTRs during 2014 (MAFMC 2016). Essential fish habitat for adult summer flounder is designated to 500 feet (about 150 m), which is generally shallower than the coral zones.

Hagfish are harvested almost exclusively in specialized pots and are exported to Asia. They are used for both leather and food. As there is no federal FMP, reporting via vessel trip reports is not required unless the vessel carries other federal permits, so data are likely incomplete. The Council considered initiating a hagfish FMP in the early 2000s, and a detailed report was prepared by staff characterizing the fishery and what was known about the species' biology. No plan was developed. At that time, the New England hagfish fishery, which began in the inshore Gulf of Maine in the early 1990s, appeared to be shifting offshore. Jordan Basin was noted as a fishing ground. Table 22 suumarizes recent hagfish landings in the New England fishery.

Table 21 –Recent landings in the New England hagfish fishery.

Year	States where hagfish were landed	Metric Tons	Pounds	$	$ VTR data, New England region only
1993	ME, MA	477.1	1,051,896	316,769	*Not calculated*
1994	ME, MA	1,105.2	2,436,574	691,449	*Not calculated*
1995	MA	1,421.4	3,133,716	865,459	*Not calculated*
1996	ME, MA	1,959.2	4,319,182	1,209,541	*Not calculated*
1997	ME, NH	422.1	930,455	235,866	*Not calculated*
1998	ME, MA	1,447.6	3,191,277	909,262	*Not calculated*
1999	ME, MA	2,382.1	5,251,648	1,423,799	*Not calculated*
2000	ME, MA	3,085.2	6,801,556	1,886,160	*Not calculated*

Year	States where hagfish were landed	Metric Tons	Pounds	$	$ VTR data, New England region only
2001	CT	0.0	70	10	*Not calculated*
2002	MA	1,360.8	2,999,949	1,059,066	*Not calculated*
2003	-	0.0	0	0	*Not calculated*
2004	-	0.0	0	0	*Not calculated*
2005	-	0.0	0	0	*Not calculated*
2006	MA	383.4	845,138	359,664	*Not calculated*
2008	ME, MA	1,058.1	2,332,676	1,312,253	*Not calculated*
2009	-	0.0	0	0	*Not calculated*
2010	ME	299.0	659,097	469,089	738,380
2011	-	0	0	0	578,512
2012	ME	629.0	1,386,656	1,282,294	641,594
2013	MA	596.4	1,314,897	1,426,918	1,644,365
2014	-	0.0	0	0	1,883,553
2015	MA	571.6	1,260,167	1,286,518	1,747,895

Data are almost certainly incomplete given the lack of mandatory reporting or perhaps due to confidentiality requirements. Source: NMFS Annual Commercial Landings Statistics.

6.8 Human Communities

This section describes the human communities that could be affected by the alternatives under consideration in this amendment.

6.8.1 Fishing Communities

This amendment considers and evaluates the impact management alternatives may have on people's economy, way of life, traditions, and community. These social and economic impacts may come from changes in fishery flexibility, opportunity, stability, certainty, safety, and/or other factors. While individuals alone could experience these impacts, it is likely that community impacts would also occur.

The alternatives under consideration could affect fishing communities throughout the Northeast. Consideration of the social impacts on these communities from proposed fishery regulations is required as part of the National Environmental Policy Act (NEPA) of 1969 and the Magnuson Stevens Fishery Conservation and Management Act (Magnuson Stevens Act) of 1976. A "fishing community" is defined in the Magnuson-Stevens Act, as amended in 1996, as "a community which is substantially dependent on or substantially engaged in the harvesting or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community" (16 U.S.C. § 1802(17)). For detailed descriptions of the affected human communities and fisheries affected by the Omnibus Amendment refer to the respective FMPs available from the New England and Mid-Atlantic Fishery Managment Councils and the Atlantic States Marine Fisheries Commission.

Given the geographic scope of this action, and the fact that it will influence fishing with various gear types, these alternatives will impact numerous fishing communities. Identifying specific communities that will be impacted is can be difficult and uncertain.

In part this reflects challenges with the confidential nature of the information used to narrow the focus to individual communities in the analysis of fishing dependence. Data must be presented so that proprietary information such as landings or revenue cannot be attributed to an individual vessel or a small group of vessels. This is particularly difficult when presenting information on small ports and communities that may only have a small number of vessels, such that information can easily be attributed to a particular vessel or individual.

The communities that are likely to experience significant impacts from the alternatives under consideration include those that support fishing that would be prohibited by this action (e.g., excluded from certain coral zones). The specific communities of interest were identified through the economic analysis of recent vessel trips that overlap the deep-sea coral zones under consideration. It is important to note that this is not an exhaustive list of communities that could be impacted. It is necessary to consider the impacts of the proposed alternatives across all communities, particularly those identified as communities of interest in their respective FMPs.

Community characteristics are described in other publications. Brief snapshots of the Human Communities and Fisheries of the Northeast with the most recent data available for key indicators for Northeastern fishing communities related to dependence on fisheries and other economic and demographic characteristics can be found at http://www.nefsc.noaa.gov/read/socialsci/communitySnapshots.php. More detailed profiles providing in-depth information regarding the historic, demographic, cultural, and economic context for understanding a community's involvement in fishing can be found at http://www.nefsc.noaa.gov/read/socialsci/communityProfiles.html.

The communities likely to be most impacted by the alternatives under consideration are identified below using two approaches:

1. Communities were identified using the VTR analysis of recent (2010-2015) trips that overlap the deep-sea coral zones under consideration (Section 7.1.3). The analysis uses fishing trips reported through VTRs that used bottom-tending fishing gear. However, there are known uncertainties with this analysis (e.g., only a portion of the lobster fishery operates with a federal VTR requirement). The impacts analysis (Section 0) contain tables identifying landings revenue from fishing with federal permits using bottom-tending fishing gear within the specific areas under consideration during 2010-2015 – as estimated by the VTR analysis. Landings are reported by states and the top ten ports, as constrained by data confidentiality requirements.
2. MEDMR asked the Maine Lobstermen's Association (MLA) for input on the communities potentially impacted by the Mt. Desert Rock and Outer Schoodic Ridge alternatives.

Based on the VTR analysis, between 2010 and 2015, there were at least 90 communities that landed species with bottom-tending fishing gear from the areas under consideration in this action. These communities occur between Maine and North Carolina. Of those communities, 20 are identified as being within the top 10 landing ports for a given alternative (and meeting the data confidentiality requirement; Table 23). In addition, the MLA identified eight additional ports that are likely important to lobstermen fishing in the vacinity of the Mt. Desert Rock and Outer Schoodic Ridge zones. A subset of these ports is described below.

Table 22 - Key fishing communities identified through the VTR analysis and by the MLA

State	Port
Maine	Jonesport, Beals Island, Addison[a], Birch Harbor[b], Milbridge[a], Stueben[a], Corea[b], Winter Harbor[a], Bar Harbor[b], Bass Harbor[b], Isleford[b], Southwest Harbor[a], Swans Island[b], Oceanville[b], Stonington[a], Northwest Harbor[b], Vinalhaven, Port Clyde, Portland
New Hampshire	Portsmouth
Massachusetts	Gloucester, New Bedford, Sandwich, Boston
Rhode Island	Newport, Pt. Judith, Tiverton
New York	Montauk
Virginia	Newport News
[a] Port identified by VTR analysis and MLA. [b] Port identified by MLA only.	

Stueben, ME. Stuben is a fishing community in Washington County, Maine, with a population of 1,131, as of 2010 (U.S. Census 2017b). In 2011-2015, about 21% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Stueben; the poverty rate was about 25%; and the population was 91% white, non-Hispanic (U.S. Census 2017a).

In 2015, Stueben was the homeport and primary landing port identified for 26 federal fishing permits (GARFO 2017). Total landings in Stuben were valued at $9.9M, 2% of the state-wide total ($591M). American lobster accounted for $9.4M (94%) of the 2015 landings in Stueben, landed by 66 vessels and sold to 11 dealers. All other species landed are confidential (Table 24; ACCSP, 2017).

Table 23 - Top five species landed by value in Stueben ME, 2015

Species	Revenue ($)	Vessels	Dealers
American lobster	$9.4M	66	11
Note: Data for four of the five top species landed are confidential. *Source:* ACCSP, as of March 2017.			

Stonington, ME. Stonington is a fishing community in Hancock County, Maine, with a population of 1,043, as of 2010 (U.S. Census 2017b). In 2011-2015, about 33% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Stonington; the poverty rate was about 15%; and the population was 97% white, non-Hispanic (U.S. Census 2017a).

In 2015, Stonington was the homeport and primary landing port identified for 89 and 90 federal fishing permits, respectively (GARFO 2017). Total landings in Stonington were valued at $64M, 11% of the state-wide total ($591M). American lobster accounted for

$62M (97%) of the 2015 landings in Stonington, landed by 372 vessels and sold to 10 dealers (Table 25; ACCSP, 2017).

Table 24 - Top five species landed by value in Stonington ME, 2015

Species	Revenue ($)	Vessels	Dealers
American lobster	$62M	372	10
Sea scallop	$0.44M	35	9
Atlantic halibut	$0.23M	39	5
Atlantic rock crab	$0.034M	33	5
Note: Data for one of the five top species landed are confidential. *Source:* ACCSP, as of March 2017.			

Portland, ME. Portland is a fishing community in Cumberland County, Maine, with a population of 66,194, as of 2010 (U.S. Census 2017b). In 2011-2015, about 0.5% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Portland; the poverty rate was about 20%; and the population was 83% white, non-Hispanic (U.S. Census 2017a).

In 2015, Portland was the homeport and primary landing port identified for 69 and 95 federal fishing permits, respectively (GARFO 2017). Total landings in Portland were valued at $35M, 6% of the state-wide total ($591M). American lobster accounted for $17M (49%) of the 2015 landings in Portland, landed by 218 vessels and sold to 21 dealers (Table 26; ACCSP, 2017).

Table 25 - Top five species landed by value in Portland ME, 2015

Species	Revenue ($)	Vessels	Dealers
American lobster	$62M	372	10
Atlantic herring	$8.1M	8	50
Pollock	$1.9M	32	5
White hake	$0.89M	27	3
Goosefish (monkfish)	$0.58M	27	4
Source: ACCSP, as of March 2017.			

New Hampshire ports. The principal ports of New Hampshire include Newington, Portsmouth, Rye, Hampton, and Seabrook, in Rockingham County. These towns, collectively, have a population of 50,953, as of 2010 (U.S. Census 2017b). In 2011-2015, about 0.8% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in these towns; the poverty rate was about 4-12%; and the population was 92% white, non-Hispanic (U.S. Census 2017a).

In 2015, ports in New Hampshire were the homeport and primary landing port identified for 160 and 162 federal fishing permits, respectively (GARFO 2017). The value of commercial fishery landings in New Hampshire was $28M in 2015 (ACCSP, 2017).

Gloucester, MA. Gloucester is a fishing community in Essex County, Massachusetts, with a population of 28,789, as of 2010 (U.S. Census 2017b). In 2011-2015, about 1% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Gloucester; the poverty rate was about 9%; and the population was 94% white, non-Hispanic (U.S. Census 2017a).

In 2015, Gloucester was the homeport and primary landing port identified for 214 and 232 federal fishing permits, respectively (GARFO 2017). Total landings in Gloucester were valued at $44M, 8% of the state-wide total ($524M). American lobster accounted for $16M (36%) of the 2015 landings in Gloucester, landed by 199 vessels and sold to 24 dealers (Table 27; ACCSP, 2017).

Table 26 - Top five species landed by value in Gloucester MA, 2015

Species	Revenue ($)	Vessels	Dealers
American lobster	$16M	199	24
Atlantic herring	$5.3M	9	25
Haddock	$3.8M	70	13
Goosefish (monkfish)	$2.5M	70	9
Acadian redfish	$2.5M	55	12
Source: ACCSP, as of March 2017.			

New Bedford, MA. New Bedford is a fishing community in Bristol County, Massachusetts, with a population of 95,072, as of 2010 (U.S. Census 2017b). In 2011-2015, about 2% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in New Bedford; the poverty rate was about 23%; and the population was 66% white, non-Hispanic (U.S. Census 2017a).

In 2015, New Bedford was the homeport and primary landing port identified for 220 and 242 federal fishing permits, respectively (GARFO 2017). Total landings in New Bedford were valued at $322M, 62% of the state-wide total ($524M). Sea scallops accounted for $245M (76%) of the 2015 landings in New Bedford, landed by 275 vessels and sold to 28 dealers (Table 28; ACCSP, 2017).

Table 27 - Top five species landed by value in New Bedford MA, 2015

Species	Revenue ($)	Vessels	Dealers
Sea scallop	$245M	275	28
Atlantic surfclam	$12M	18	11
American lobster	$8.3M	103	22
Haddock	$6.4M	50	9
Winter flounder	$5.7M	57	8
Source: ACCSP, as of March 2017.			

Newport, RI. Newport is a fishing community in Newport County, RhodeIsland, with a population of 24,672, as of 2010 (U.S. Census 2017b). In 2011-2015, about 0.2% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Newport; the poverty rate was about 10%; and the population was 86% white, non-Hispanic (U.S. Census 2017a).

In 2015, Newport was the homeport and primary landing port identified for 30 and 33 federal fishing permits, respectively (GARFO 2017). Total landings in Newport were valued at $7.5M, 9% of the state-wide total ($82M). American lobster accounted for $4.6M (61%) of the 2015 landings in Newport, landed by 29 vessels and sold to 10 dealers (Table 29; ACCSP, 2017).

Table 28 - Top five species landed by value in Newport, RI 2015

Species	Revenue ($)	Vessels	Dealers
American lobster	$4.6M	29	10
Jonah crab	$1.5M	19	10
Goosefish (monkfish)	$0.27M	10	6
Summer flounder	$0.21M	32	9
Winter skate	$0.16M	8	4
Source: ACCSP, as of March 2017.			

Point Judith, RI. Point Judith is a fishing community within the town of Narragansett in Washington County, Rhode Island. Narragansett has a population of 15,868, as of 2010 (U.S. Census 2017b). In 2011-2015, about 2% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Narragansett; the poverty rate was about 16%; and the population was 95% white, non-Hispanic (U.S. Census 2017a).

In 2015, Point Judith was the homeport and primary landing port identified for 112 and 138 federal fishing permits, respectively (GARFO 2017). Total landings in Point Judith were valued at $46M, 56% of the state-wide total ($82M). Inshore longfin squid accounted for $13M (29%) of the 2015 landings in Point Judith, landed by 98 vessels and sold to 17 dealers (Table 30; ACCSP, 2017).

Table 29 - Top five species landed by value in Point Judith, RI 2015

Species	Revenue ($)	Vessels	Dealers
Inshore longfin squid	$13M	98	17
American lobster	$7.0M	109	14
Sea scallop	$5.5M	36	14
Summer flounder	$5.3M	326	20
Scup	$3.6M	254	21
Source: ACCSP, as of March 2017.			

Montauk, NY. Montauk is a fishing community within the town of East Hampton in Suffolk County, New York. As of 2010, Montauk had a population of 3,326 (U.S. Census 2017b). In 2011-2015, about 3% of the civilian employed population aged 16 years and over worked in agriculture, forestry, fishing and hunting in Montauk; the poverty rate was about 13%; and the population was 83% white, non-Hispanic (U.S. Census 2017a).

In 2015, Montauk was the homeport and primary landing port identified for 128 and 144 federal fishing permits, respectively (GARFO 2017). Total landings in Montauk were valued at $16M, 31% of the state-wide total ($51M). Inshore longfin squid accounted for $3.5M (22%) of the 2015 landings in Montauk, landed by 50 vessels and sold to 21 dealers (Table 30; ACCSP, 2017).

Table 30 - Top five species landed by value in Montauk, NY 2015

Species	Revenue ($)	Vessels	Dealers
Inshore longfin squid	$3.5M	50	21
Tilefish	$3.2M	7	10
Scup	$2.6M	117	18
Summer flounder	$1.7M	98	23
Silver hake	$1.3M	37	15
Source: ACCSP, as of March 2017.			

6.8.2 Other Affected Communities

In addition to participants in potentially affected fisheries, there are other human communities that have an interest in the alternatives under consideration. During amendment development, the Council has received a number of public comments from a diverse array of interested parties. There is a strong interest in the conservation goals of this amendment from stakeholders beyond those in the fishing communities described in the sections above. Specifically, the conservation community (e.g., environmental NGOs, agencies, or individuals focused on marine conservation) are expected to experience indirect positive impacts from the protection of deep-sea corals. These stakeholders are interested in preserving the integrity of marine ecosystems and the ecosystem services they provide, as well as the non-use or existence value of deep-sea corals. Additional indirect benefits to human communities interested in deep-sea corals may include increased public and conservation interest, academic interest, and funding for monitoring and research on these ecosystems. The general public has had increasing opportunities in recent years to view and appreciate deep-sea communities by engaging virtually in deep-sea exploration streamed via the internet.

6.9 Protected resources

Numerous protected species inhabit the environment within the jurisdiction of the New England Fishery Management Council. These species are under NMFS jurisdiction and are afforded protection under the Endangered Species Act of 1973 (ESA) and/or the Marine Mammal Protection Act of 1972 (MMPA). Table 32 lists the species, protected either by the ESA, the MMPA, or both, that may be found in the areas utilized by Council fisheries. Table 32 also includes several candidate fish species, as identified under the ESA. The following sections summarize the best available information on protected species occurrence and distribution in the areas utilized by Council fisheries. The following sites are good sources of information on protected species distributions in New England:

- http://seamap.env.duke.edu/
- http://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/maps/index.html
- http://www.nefsc.noaa.gov/psb/surveys/
- http://www.nmfs.noaa.gov/pr/sars/region.htm
- http://marinecadastre.gov/

As protected resources occur in the areas used by Council fisheries, protected species are at risk of interacting with fishing gears that are present in these areas. Changes to spatial management via designation of deep-sea coral zones may influence expected interaction rates. This section includes information on gear interaction risks.

Table 31 – Species and/or critical habitat protected under the ESA and/or MMPA that occur in the affected environment of the Deep-Sea Coral Amendment.

Species	Status	MMPA strategic stock?	Potentially affected by action?[5]
Cetaceans			
North Atlantic right whale (*Eubalaena glacialis*)	Endangered	Yes	
Humpback whale, West Indies DPS (*Megaptera novaeangliae*)	Protected (MMPA)	Yes	
Fin whale (*Balaenoptera physalus*)	Endangered (ESA)	Yes	
Sei whale (*Balaenoptera borealis*)	Endangered (ESA)	Yes	
Blue whale (*Balaenoptera musculus*)	Endangered (ESA)	Yes	
Sperm whale (*Physeter macrocephalus*	Endangered (ESA)	Yes	
Minke whale (*Balaenoptera acutorostrata*)	Protected (MMPA)	No	
Pilot whale (*Globicephala spp.*)[6]	Protected (MMPA)	No	
Risso's dolphin (*Grampus griseus*)	Protected (MMPA)	No	
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Protected (MMPA)	No	
Short beaked common dolphin (*Delphinus delphis*)	Protected (MMPA)	No	
Bottlenose dolphin (*Tursiops truncatus*)[7]	Protected (MMPA)	Yes	
Harbor porpoise (*Phocoena phocoena*)	Protected (MMPA)	Yes	
Pygmy sperm whale (*Kogia breviceps*)	Protected (MMPA)	No	
Dwarf sperm whale (*Kogia sima*)	Protected (MMPA)	No	
Striped dolphin (*Stenella coeruleoalba*)	Protected (MMPA)	No	
Atlantic spotted dolphin (*Stenella frontalis*)	Protected (MMPA)	No	
Beaked whales (*Ziphius and Mesoplodon spp*)[8]	Protected (MMPA)	No	
Pinnipeds			
Harbor seal (*Phoca vitulina*)	Protected (MMPA)	No	
Gray seal (*Halichoerus grypus*)	Protected (MMPA)	No	

[5] The determination for whether a species may be affected by a Council fishery is based on whether there has been confirmed interactions with gear types primarily used in that fishery (see Waring et al. 2014; Waring et al. 2015; NMFS 2012a; NMFS 2013; NMFS 2014a; NMFS 2015a; NMFS NEFSC FSB 2015; 79 FR 77919 (December 29, 2014)).
[6] There are 2 species of pilot whales: short finned (*G. melas melas*) and long finned (*G. macrorhynchus*). Due to the difficulties in identifying the species at sea, they are often just referred to as *Globicephala* spp.
[7] This includes the Western North Atlantic Offshore, Northern Migratory Coastal, and Southern Migratory Coastal Stocks of Bottlenose Dolphins.
[8] There are multiple species of beaked whales in the Northwest Atlantic. They include the Cuvier's (*Ziphius cavirostris*), Blainville's (*Mesoplodon densirostris*), Gervais' (*Mesoplodon europaeus*), Sowerbys' (*Mesoplodon bidens*), and Trues' (*Mesoplodon mirus*) beaked whales. Species of *Mesoplodon*; however, are difficult to identify at sea, and therefore, much of the available characterization for beaked whales is to the genus level only.

Species	**Status**	**MMPA strategic stock?**	**Potentially affected by action?[5]**
Harp seal (*Phoca groenlandicus*)	Protected (MMPA)	No	
Hooded seal (*Cystophora cristata*)	Protected (MMPA)	No	
Turtles			
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered (ESA)	n/a	
Kemp's ridley sea turtle (*Lepidochelys kempii*)	Endangered (ESA)	n/a	
Green sea turtle (*Chelonia mydas*), North Atlantic DPS	Threatened (ESA)	n/a	
Loggerhead sea turtle (*Caretta caretta*), Northwest Atlantic DPS	Threatened (ESA)	n/a	
Hawksbill sea turtle (*Eretmochelys imbricate*)	Endangered (ESA)	n/a	
Fishesn/a			
Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered (ESA)	n/a	
Atlantic salmon (*Salmo salar*)	Endangered (ESA)	n/a	
Atlantic sturgeon (*Acipenser oxyrinchus*), Gulf of Maine DPS	Threatened (ESA)	n/a	
Atlantic sturgeon (*Acipenser oxyrinchus*), New York Bight DPS, Chesapeake Bay DPS, Carolina DPS & South Atlantic DPS	Endangered (ESA)	n/a	
Thorny skate (*Amblyraja radiata*)	Candidate (ESA)	n/a	
Cusk (*Brosme brosme)*	Candidate (ESA)	n/a	
Critical habitat			
North Atlantic Right Whale Critical Habitat[9]	Protected (ESA)	n/a	
Northwest Atlantic DPS of Loggerhead Sea Turtle Critical Habitat	Protected (ESA)	n/a	

Shaded species prefer continental shelf edge/slope waters (i.e., >200 meters), although incursions into continental shelf waters do occur seasonally or sporadically during periods of high prey abundance.

Cusk and thorny skate (included in Table 32) are NMFS "candidate species" under the ESA. Candidate species are those petitioned species for which NMFS has determined that listing may be warranted under the ESA and those species for which NMFS has initiated an ESA status review through an announcement in the *Federal Register*. If a species is proposed for listing, the conference provisions under Section 7 of the ESA apply (see 50 CFR 402.10); however, candidate species receive no substantive or procedural protection under the ESA. As a result these species will not be discussed further in this and the following sections. Additional information on cusk and thorny skate can be found at http://www.nmfs.noaa.gov/pr/species/esa/candidate.htm.

6.9.1 Species and Critical Habitat not likely to be affected

To be completed prior to final action.

[9] Designation expanded on January 27, 2016 (81 FR 4837)

6.9.2 Occurrence and distribution of species potentially affected

To be completed prior to final action.

6.9.3 Fishing gear interactions with protected resources

To be completed prior to final action.

7 Environmental impacts of the alternatives

This section describes the potential positive and negative impacts associated with the management alternatives considered in this amendment. These analyses are organized by alternative and then by valued ecosystem component (VEC) to facilitate a comprehensive understanding of the costs and benefits of any particular coral zone or set of zones.

Similar coral zone alternatives are grouped together for analysis when this grouping is consistent with how decisions might be made about the zones. Specifically, four sets of areas that are grouped for analysis are the no action areas, canyon coral zones, seamount coral zones, and Jordan Basin coral zones. In some cases, data are presented at the individual zone level, for example depth statistics or number of coral records in Alvin vs. Atlantis Canyons. Other data, for example revenues by species or gear, are pooled within each of the four groupings. Because five of the 20 canyons analyzed fall entirely within the Northeast Canyons and Seamounts Marine National Monument, the canyon revenue data are divided into two sub-groups to more clearly discriminate between locations that would be newly managed via the coral amendment, vs. locations that are currently managed as part of the Monument.

While the alternatives sections of this document describe coral zones and measures for coral zones in separate sections, the impacts analyses link these two decisions and their associated potential impacts. Potential impacts of designating coral zones independent of applying fishing restrictions in those zones are described under the deep-sea coral VEC. For example, even in the absence of fishing restrictions, coral zones might have indirect conservation benefits as they would educate the public about the existence of corals in a particular location.

7.1 Impacts analysis methods by VEC

The following sections summarize the methods used in the impacts analyses. For a given VEC, these methods are generally similar across the various groupings of alternatives.

7.1.1 Deep-sea corals

This portion of the analysis evaluates the potential impacts that a particular zone of group of zones might have on deep-sea corals. Various metrics are used to assess the potential impacts of each alternative on deep-sea corals. These include information about coral presence, species richness, and relative abundance, area of high/very high coral habitat suitability, seafloor terrain data including depth and occurrence of steep slopes, and likelihood of gear interactions.

Because only a small area of each zone has been directly observed, general habitat charateristics of each zone are also summarized. These include water depth, area of modeled high or very high coral habitat suitability, and area of high slope calculated from a digital elevation model. The habitat suitability and slope data are provided as total values, and also as percentages of the zone area. The habitat suitability model is described in section 6.3.

7.1.1.1 Coral presence

All zones under consideration in this amendment have corals documented during recent camera surveys, and some of the zones have historical records of coral presence as well. Additional background on the historical and recent data is in sections 6.2.1.1 and 6.2.1.2, respectively. Detailed coral information by zone is summarized in section 6.2.3.

Overlaps between each coral zone and pre-2012 coral presence data are summarized in Table 33. These data should be viewed as indicators of both coral presence and survey effort. The occurrence of corals in some areas of New England has been well documented for years, for example within Lydonia, Oceanographer, and Heezen Canyons, the Bear and Retriever Seamount zones, and the largest zone in Jordan Basin, 114 fathom bump. Many of the zones under consideration in this amendment do not have any pre-2012 records, and recent exploratory surveys represent the first time they were surveyed for corals.

Between 2012 and 2015, exploratory surveys using remotely operated vehicles, autonomous underwater vehicles, and towed camera systems were deployed throughout the region to collect data on coral distribution and species richness. Coral observations during these dives are described very briefly in Table 34. Site selection during these surveys was frequently guided by high resolution bathymetric data and the coral habitat suitability model. Additional recent dives not described here overlap with the broad zones but are outside the discrete zones.

Table 32 – Number of historical (pre-2012) records of coral presence in each zone

No action (Tilefish, Monkfish-MSB, Monument)						
Area name	***None***	***Soft corals***	***Sea pens***	***Hard corals***	***Black corals***	***Total***
Tilefish closures		159	3	16	0	178
Monkfish-MSB		249	2	26	0	277
Monument		307	7	31	7	352
Broad zones						
Zone name	***None***	***Soft corals***	***Sea pens***	***Hard corals***	***Black corals***	***Total***
300m		452	85	82	8	627
400m		445	81	81	8	615
500m		434	77	73	8	592
600m		410	73	62	8	553
900m		290	72	52	8	422
Canyons						
Zone name	***None***	***Soft corals***	***Sea pens***	***Hard corals***	***Black corals***	***Total***
Alvin		2	5	4		11
Atlantis			1	1		2
Nantucket				7		7
Veatch	X					0
Hydrographer		2				2
Dogbody		8				8
Clipper		1				1
Sharpshooter	X					0
Welker	X					0
Heel Tapper	X					0

Oceanographer		149		18		167
Filebottom		1				1
Chebacco	X					0
Gilbert	X					0
Lydonia		92	4	7		103
Powell	X					0
Munson		1				1
Nygren	X					0
Unnamed Canyon	X					0
Heezen		42	12	13		67
Seamounts						
Zone name	***None***	***Soft corals***	***Sea pens***	***Hard corals***	***Black corals***	***Total***
Bear		32	1	5	6	44
Mytilus	X					1
Physalia	X					0
Retriever		12			1	13
Gulf of Maine						
Zone name	***None***	***Soft corals***	***Sea pens***	***Hard corals***	***Black corals***	***Total***
Mount Desert Rock		2				2
Outer Schoodic Ridge	X					0
Western Jordan Basin - 114 Fathom Bump		11				11
Western Jordan Basin - 96 Fathom Bump		1				1
Western Jordan Basin - 118 Fathom Bump		2				2
Central Jordan Basin	X					0
Lindenkohl Knoll	X					0

Table 33 – Recent exploratory survey dives in discrete deep-sea coral zones.

Canyons	
Zone name	***Dive notes***
Alvin Canyon	Okeanos Explorer 2013, Cruise EX1304L1, dives 9 and 10, depths ranging from 846 to 927 meters below sea level. East and west walls; dives traversed a range of soft sediment and rock wall/overhang habitats. Corals observed on both dives, especially in rocky areas.
Atlantis Canyon	Okeanos Explorer 2013, Cruise EX1304L1, dives 7 and 8, depths ranging from 885 to 1,794 meters below sea level. East and west walls. Corals were observed during both dives. Dive 7: colonial stony corals, soft corals, and black corals, plus cup corals, which are a solitary type of stony coral. Dive 8: stony, soft, and black corals; sea pens.
Nantucket Canyon	Okeanos Explorer 2014, Cruise EX1404. Southwestern canyon wall at the mouth (1600-1900m). Stony, soft, and black corals; sea pens.

Veatch Canyon	Three *TowCam* dives from the S/V Bigelow during cruise HB1204 (2012). Dive 8: stony and soft corals. Deeper dives 7 and 9: stony, soft, and black corals; sea pens.
Hydrographer Canyon	Okeanos Explorer 2013, Cruise EX1304L1, dives 5 and 6. East and west walls. Dive 5 (1299-1418m): stony, soft, and black corals. Dive 6 (610-907m): soft and stony corals.
Dogbody Canyon	Three *TowCam* dives from the S/V Bigelow during Cruise HB1504 (2015). Tow 1 (558-675 m) found sponges, but corals were uncommon. Tow 2 (894-1014 m) found abundant and diverse stony, soft, and black corals. Tow 3 (1461-1620), soft corals only.
Clipper Canyon	Two *TowCam* dives from the S/V Bigelow during Cruise HB1504 (2015). Soft corals on both dives.
Sharpshooter Canyon	Two *TowCam* dives during Cruise HB1504 (2015). Tows 16 and 17 in two of the larger contiguous areas of high slope. No corals were noted during the shallow tow 16 (800-901); tow 17 (1144-1168 m) found stony and soft corals.
Welker Canyon	Okeanos Explorer 2013, Cruise EX1304L2 (dive 14, 1,377-1,445m). Diversity of stony, soft, and black corals; sea pens. Three tows during cruise HB1504 (2015) surveyed the walls of the canyon. Tow 13 (559-778 m) found stony and soft corals; tow 14 (851-1156 m) found stony, soft, and black corals; tow 15 (1480-1650 m) found soft and black corals.
Heel Tapper Canyon	Three *TowCam* dives from the S/V Bigelow during Cruise HB1504 (2015). Depths ranging from 666 to 1,444 meters, soft corals observed.
Oceanographer Canyon	Okeanos Explorer Cruise EX1304L2, dives 3 and 13. Eastern and western walls were surveyed. Dive 3 (983-1,239m) and Dive 13 (1,102-1,248m) encountered at least 16 species of stony, soft, and black corals.
Filebottom Canyon	Three *TowCam* dives during Cruise HB1504 (2015). Tow 7 (664-887 m) and Tow 8 (1029-1077 m) recorded stony and soft corals. Tow 9 also found corals.
Chebacco Canyon	Two tows during cruise HB1504 (2015), on the east wall. Tow 4 (801-875 m) found stony corals and Tow 5 (1133-1356 m) found soft, stony, and black corals.
Gilbert Canyon	Seven tows during cruise HB1204 (2012) covered various locations throughout the canyon including an area near the head and on multiple walls and tributaries. All tows found soft corals, with the percentage of images with soft corals ranging from 2% to 54%. Other coral types were found in the canyon as well, including black corals, stony corals, and sea pens. Two tows had very high coral abundance and diversity (western wall between 1370-1679 m and in the canyon head between 640-820 m).
Lydonia Canyon	One recent ROV dive within the proposed zone, onboard the *RV Okeanos Explorer*, cruise EX1304L2, dive 12; 1,135-1,239 m. A large number of species (at least 15) from all four coral groups were observed.
Powell Canyon	Six tows during cruise HB1302 (2013). Tows 7 (753-1306 m) and 8 (905-1340 m) had high abundances and diversities of corals, while tow 9 (1302-1630 m) had abundant corals, and often with areas of high localized abundances, with some areas having widely dispersed corals or none at all. The remaining three deeper tows (1292-2053 m) have low abundances/low diversities of corals. Stony, soft, and black corals, as well as sea pens.
Munson Canyon	Seven *TowCam* tows during cruise HB1302 (2013). In tows 14 (535-1040 m), 16 (983-1346 m), 17 (935-1455 m), 18 (1330-1941 m) and 24 (1084-1472 m), corals were locally abundant, with some areas having widely dispersed corals or none at all. Tow 19 (1283-1855 m) had fewer corals overall, while Tow15 (550-1089 m) had a low abundance and diversity of corals present. Stony, soft, and black corals, as well as sea pens.
Nygren Canyon	Two tows during Cruise EX1304L2 (2013) and two during HB1402 (2014). Stony,

	soft, and black corals, as well as sea pens. Higher species richness than dives in Munson Canyon.
Unamed canyon between Nygren and Heezen	One ROV dive during Okeanos Explorer Cruise EX1304 leg 2, dive 10, 497-824m. Stony and soft corals.
Heezen Canyon	Two dives during the 2013 Okeanos Explorer Cruise EX1304L2. Dive 7 (1615-1723m): stony, soft, and black corals, as well as sea pens. Dive 9 (703-926m): very large soft coral colonies, plus other coral types.
Seamounts	
Zone name	***Dive notes***
Bear Seamount	Not visited during recent (2012-2015) cruises.
Mytilus Seamount	Two dives during the 2013 Okeanos Explorer cruise EX1304L2. Dive 4: soft and black corals. Sea pens, soft corals, and black corals were noted during Dive 5.
Physalia Seamount	2012 AUV dives (Kilgour et al 2014) collected 2956 color seafloor images. Soft corals and sea pens. Single dive during Okeanos Explore Cruise EX1404 (2014). Corals observed in low abundance and diversity, including soft, stony, and black corals, as well as sea pens.
Retriever Seamount	Single dive during Okeanos Explorer Cruise EX1404 (2014). Sea pens, soft corals, black corals.
Gulf of Maine	
Zone name	***Dive notes***
Mount Desert Rock	Four dives during 2013 and 2015 (earlier dives as well). Soft corals, primarily gorgonians, sometimes at very high densities; sea pens locally abundant in soft sediments. One of four recent dives without corals, but corals found near that site in 2002 and 2003.
Outer Schoodic Ridge	Ten dives during 2013, 2014, and 2015. Soft corals, primarily gorgonians, sometimes at very high densities, and sea pens.
Western and central Jordan Basin	Twenty eight dives during 2013 and 2014. Soft corals, primarily gorgonians, sometimes at high densities; sea pens sparse to medium density.
Lindenkohl Knoll	Four dives during 2015. Soft corals, primarily gorgonians; sea pens. Generally low to medium density except for one site with high density soft corals.

7.1.1.2 Habitat suitability for deep-sea corals

Many locations are likely to have habitat types suitable for colonization by deep-sea corals, but have not yet been sampled due to the time and cost associated with conducting deep-sea research with remotely operated vehicles, towed camera systems, or other sampling gears. Instead of relying on sampled locations only to determine the species distribution, habitat suitability models can be used to predict a species occurrence. Habitat suitability models use a combination of environmental conditions to identify locations that are more likely to support a species than other locations. As described in Section 6.3, NOAA developed a habitat suitability model for deep-sea corals by relating deep-sea coral presence locations (through 2012) and environmental and geological predictor variables (such as slope, depth, depth change, rugosity, salinity, oxygen, substrate, temperature, turbidity, and others). The spatial resolution of the model is somewhat coarse, and is best applied to analyses at broader scales (hundreds of meters to a few kilometers).

The habitat suitability of several different taxonomic groups of deep sea corals were modeled, including soft corals (Alcyonaceans), stony corals (Scleractinians), and sea pens (Pennatulacea). Data did not exist to model black corals (Antipatharia). The model outputs for soft corals are based on a sizeable number of data points from known structure-forming species, so confidence in the model is high. In contrast, the outputs for stony corals are based on many fewer records and model confidence is low. Sea pens are not the direct conservation focus of the amendment. Therefore, the soft coral modeling is the focus here. Three separate soft coral model runs (Alcyonacean, Gorgonian Alcyonacean, and Non-gorgonian Alcyonacean) were combined to represent the broadest spatial extent of area suitable for soft corals. Although they do have different distributions by depth and sediment type, soft corals, sea pens, stony corals, and black corals are known to co-exist, giving us some confidence that management measures that align well with the soft coral model provide protection for other taxonomic groups.

The model outputs indicate the likelihood that a particular location is suitable habitat for a particular coral group. High and very high likelihoods for the three soft coral groupings are the focus on this analysis. These high and very high likelihood areas are concentrated along the edge of the continental shelf south of Georges Bank, and to a lesser extent in coastal areas of the Gulf of Maine. The ROV and towed camera data generally validate the model outputs in the canyons and on the slope, but given the resolution of the terrain data used in the model, the PDT determined that the suitability model results are not a useful metric in the Gulf of Maine (see section 6.3). Therefore, this analysis focuses on the continental margin only (grey shaded area on **Map 43**). The total area of habitat suitable for deep-sea corals along the continental margin deeper than 100 meters is 4,793 km^2 (red shaded areas on **Map 43**). In terms of evaluating the management alternatives, the question is to what extent the management alternatives proposed in this amendment overlap with areas predicted to be suitable for corals.

The alternatives vary in size, and in the amount of suitable habitat along the continental margin they encompass (Table 35). Both data points are accounted for in order to determine the percentage of suitable habitat covered by an alternative, and to calculate how efficiently the areas in the alternative overlap with suitable habitats. These results are explored further in the impacts anlaysis for each alternative (sections 7.2.1, 7.3.1, etc.).

Map 43 – High suitability habitat for deep sea corals (red), canyon zones (blue), and broad zones (black outline).

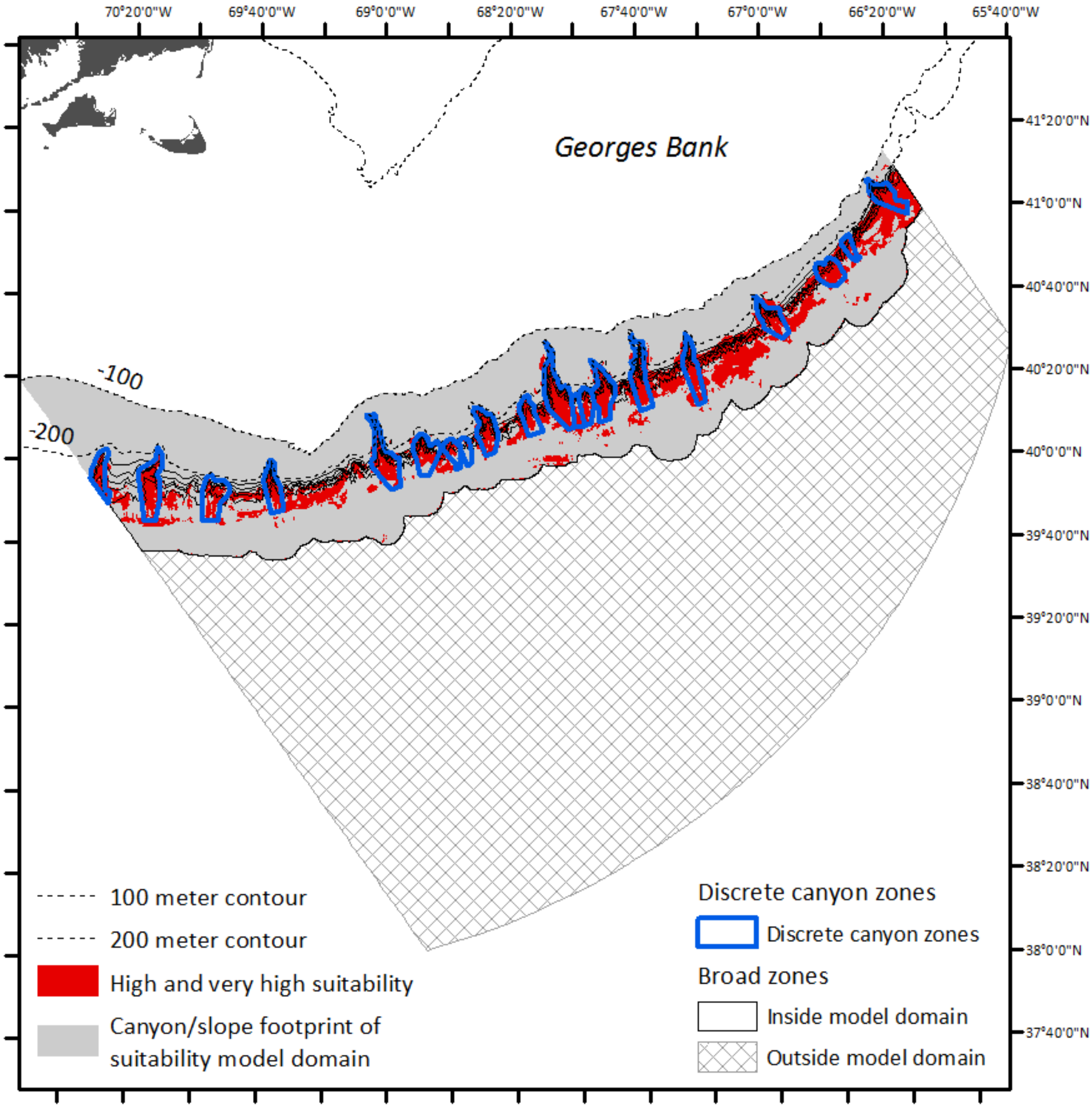


Table 34 – Suitable habitat for deep-sea corals by management area. Analysis considers portions of management areas within the suitability model domain only.

Management Area	Total size of coral zone (km²)[1]	Area of suitable habitat covered by coral zone (km²)	Proportion of suitable habitat covered by coral zone (%)[2]	Efficiency index[3]
Tilefish GRAs (No Action)	371	241	5%	65%
Monkfish-Mackerel/Squid/Butterfish Closures (No Action)	426	396	8%	93%
Northeast Canyons and Seamounts Marine National Monument (No Action)	2,354	886	18%	38%
Canyons (all 20 combined)	2,651	2,050	43%	77%
>300	13,097	4,582	96%	35%
>400	12,366	4,354	91%	35%
>500	11,794	4,042	84%	34%
>600	11,320	3,700	77%	33%
>900	10,148	2,821	59%	28%

[1] Considering just the area within the suitability model domain.
[2] This is calculated by dividing the area of suitable habitat covered by the management area by the total amount of suitable habitat modeled, which is 4,793 km². This only considers the portion of the model domain beyond 100 meters south of Georges Bank.
[3] This index represents how efficiently the coral zone covers highly suitable habitat. It is the area of suitable habitat covered by the coral zone over the total size of the coral zone, again just considering the portion of the zones within the suitability model domain.

7.1.1.3 Bathymetry and slope

Table 36 provides descriptive statistics for the water depth within various coral zones. The data source for these calculations is a global, digital elevation model, the General Bathymetric Chart of the Oceans (GEBCO). This elevation model was used because it fully overlaps all of the coral zones, whereas some higher resolution data sources only partially overlap the areas. The grid resolution of these data is 30 arc seconds, and thus the cell size of the GEBCO digital elevation model varies by latitude. At 40° N, this translates to a distance of just under a kilometer (approximately 925 meters). This resolution is somewhat coarse relative to the dimensions of various coral zones considered in this amendment, so the results in the table should be considered as rough approximations of true depth. The landward boundaries of the broad zones and canyon zones in particular were developed using a higher resolution dataset, ACUMEN, that covers just the slope region (see Map 44).

Values shown in the table include minimum depth, maximum depth, and depth range, as well as median, mean, and standard deviation. The results of this analysis are self-explanatory. The broad zones include the deepest depths as they encompass large areas of the continental rise and abyssal plain, but have fairly shallow minimum depths. The same depth is reported as the minimum for both the 300 and 400 meter zones owing to the coarse resolution of the depth model relative to the close spacing of the depth contours at the shelf break. Very deep waters are also encompassed by the seamount zones, but these zones have minimum depths below 1,000 meters. The depth range for the seamounts indicates their height above the seabed, approximately 2 kilometers. The canyon zones have minimum depths according to this model of between roughly 150-400 meters. Again, the minimum depths shown here should be viewed cautiously, given the steepness of the shelf break and the resolution of these depth data, but the slope-confined, smaller canyons such as Clipper, Sharpshooter, Filebottom, and Chebacco, have deeper minimum depths. On average, depth in the canyons is approximately 1 kilometer, which suggests that they are deep habitats despite having their heads in shallower water where they cross the shelf break. The Gulf of Maine zones are the shallowest, and have the narrowest depth range. The four Jordan Basin zones are generally deeper and have smaller depth ranges than the coastal and Lindenkohl zones.

Steeply sloped areas of the seafloor tend to contain deep-sea corals. Slope is a significant predictor variable in the habitat suitability model. In addition, locations with high slope (greater than 30°, and especially slopes over 36°) almost always contain corals when observed with remotely operated vehicles or towed cameras. These high-slope habitats tend to contain outcropping rocks, which provide attachment sites for various species of soft, stony, and black corals.

The best slope data available for the continental slope and canyons was compiled during a series of 2012 cruises, the Atlantic Canyons Undersea Mapping Expeditions. The compiled data are referred to as ACUMEN, and are 25 meter spatial resolution, which is a substantial improvement over the previously available digital elevation model. The footprint of the ACUMEN data in New England (Map 44) roughly approximates the slope and canyons between 300-2,000 meters, and covers a total area of approximately 12,811 km^2. Considering the intersection between the New England region and the area covered by the ACUMEN data, 164 km^2 has a slope greater than 30 degrees. The 20 discrete canyon zones cover 3,029 km^2, just 24% of the ACUMEN footprint, but contain 108 km^2 (66%) of the high slope area. This means that the canyons identified as discrete zones have steeper terrain than the ACUMEN region overall, which is not surprising. A smaller area of the ACUMEN domain, 45 km^2, is very high slope (greater than 36°). Most of this area, 29 km^2 or 64%, overlaps the discrete canyon zones.

Map 45 shows where high slope areas occur within Oceanographer Canyon. The ACUMEN bathymetry and slope datasets are not without artefacts, and in locations where datasets from individual cruises were stitched together, false areas of high slope can be seen. However, the majority of the areas mapped as high and very high slope are expected to represent truly steep areas of the seafloor. The overlap between high slope and management area is summarized in Table 37.

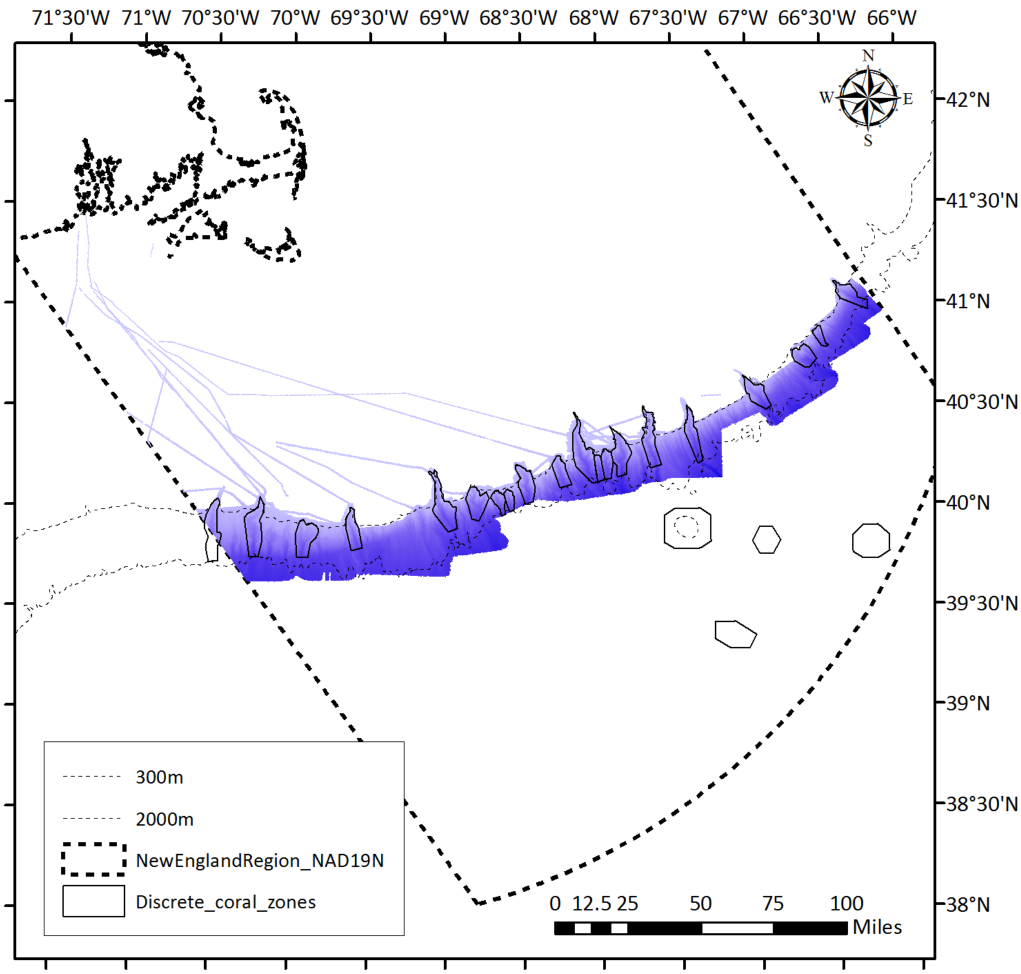
Future work: Add violin plots of depth by zone.

Table 35 – Depth statistics for deep-sea coral zones. Data source: General Bathymetric Chart of the Oceans (GEBCO) 30 arc second digital elevation model.

No Action management areas						
Zone name	***Shallow/ min***	***Deep/ max***	***Range***	***Median***	***Mean***	***Standard deviation***
Tilefish GRAs						
Monkfish-MSB						
Monument						
Broad zones						
Zone name	***Shallow/ min***	***Deep/ max***	***Range***	***Median***	***Mean***	***Standard deviation***
300m	-191	-4,434	4,243	-3,131	-2,997.5	954.58
400m	-191	-4,434	4,243	-3,140	-3,022.7	921.01
500m	-248	-4,434	4,186	-3,151	-3,045.6	892.94
600m	-390	-4,434	4,044	-3,162	-3,068.1	867.78
Canyons						
Zone name	***Shallow/ min***	***Deep/ max***	***Range***	***Median***	***Mean***	***Standard deviation***
Alvin	-307	-1,955	1,648	-936	-1,022.8	472.73
Atlantis	-315	-1,998	1,683	-914	-968.8	426.35
Nantucket	-330	-1,935	1,605	-945	-999.9	422.08
Veatch	-230	-1,792	1,562	-844	-913.9	439.02
Hydrographer	-141	-1,949	1,808	-1,001	-991.8	521.02
Dogbody	-322	-1,835	1,513	-1,043	-1,059.9	415.07
Clipper	-440	-1,801	1,361	-979	-1,038.2	386.91
Sharpshooter	-441	-1,884	1,443	-1,082	-1,092.7	413.90
Welker	-290	-2,083	1,793	-881	-966.7	475.23
Heel Tapper	-321	-1,765	1,444	-1,009	-1,003.5	409.86
Oceanographer	-280	-2,026	1,746	-904	-999.7	498.57
Filebottom	-413	-1,965	1,552	-1,407	-1,340.1	442.83
Chebacco	-403	-1,925	1,522	-1,192	-1,182.4	436.72
Gilbert	-199	-2,094	1,895	-969	-1,035.8	480.87
Lydonia	-156	-1,960	1,804	-761	-859.0	492.65
Powell	-271	-2,146	1,875	-1203	-1,177.5	544.89
Munson	-202	-2,000	1798	-998	-1,006.1	445.86
Nygren	-344	-1,774	1430	-1108	-1,105.7	447.10
Unnamed canyon between Nygren and Heezen	-392	-1,573	1,181	-940	-932.3	348.83
Heezen	-151	-2,084	1,933	-909	-1,034.2	537.90
Seamounts						
Zone name	***Shallow/ min***	***Deep/ max***	***Range***	***Median***	***Mean***	***Standard deviation***
Bear	-1,088	-3,204	2,116	-2,255	-2,225.3	533.58

Mytilus	-2,382	-4,190	1,808	-3,653	-3,429.7	532.20
Physalia	-1,902	-3,691	1,789	-3,200	-3,054.2	405.60
Retriever	-1,946	-4,048	2,102	-3,561	-3,338.9	552.77
Gulf of Maine						
Zone name	***Shallow/ min***	***Deep/ max***	***Range***	***Median***	***Mean***	***Standard deviation***
Mount Desert Rock	-106	-203	97	-169	-162.4	22.50
Outer Schoodic Ridge	-144	-211	67	-172	-172.3	15.93
Western Jordan Basin - 114 Fathom Bump	-213	-251	38	-241	-237.7	7.80
Western Jordan Basin - 96 Fathom Bump	-188	-222	34	-209	-209.2	7.32
Western Jordan Basin - 118 Fathom Bump	-221	-265	44	-242	-244.2	9.32
Central Jordan Basin	-215	-232	17	-226	-225.3	4.21
Lindenkohl Knoll	-165	-256	91	-210	-209.8	16.89

Map 44 – Spatial extent of high-resolution ACUMEN bathymetry data south of Georges Bank (blue shading). The heavy dotted outline shows the spatial extent of the New England region, and the light dotted lines show the 300 and 2,000 m contours. Canyon coral zones are shown in solid black outline.



Map created November 7, 2016, NEFMC Habitat Plan Development Team

Map 45 – High slope areas in Oceanographer Canyon. Lighter to darker colors indicate progressively steeper slopes up to 30 degrees. Green shows slopes between 30-36 degrees, and pink shows slopes greater than 36 degrees.

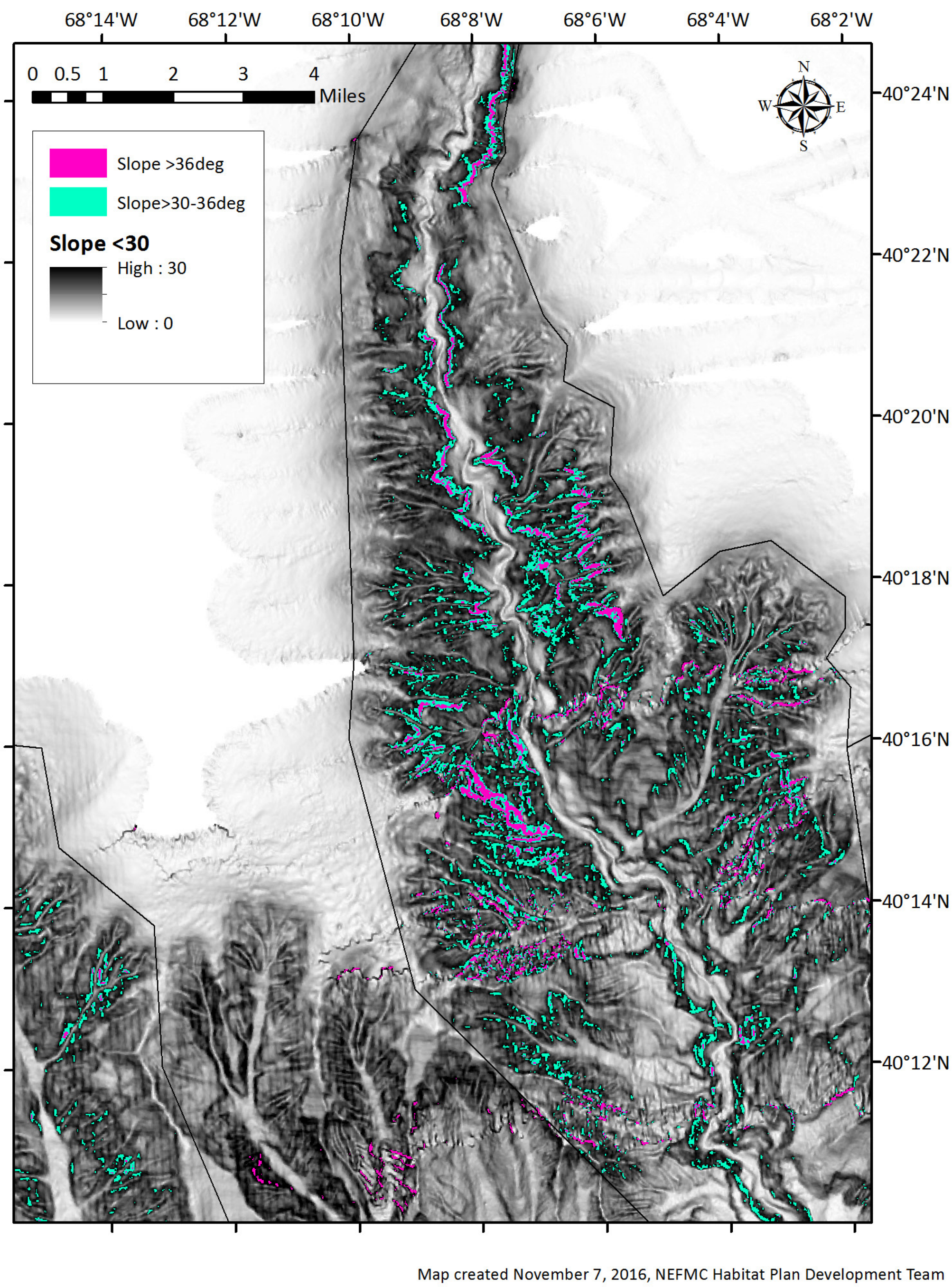


Table 36 – Area of high slope by management area. Analysis considers portions of management areas within the ACUMEN footprint only.

Management Area	Area of slope > 30° (km^2)[1]	Proportion of suitable high slope covered by management area (%)[2]
Tilefish GRAs (No Action)	15	9%
Monkfish-Mackerel/Squid/Butterfish Closures (No Action)	28	17%
Northeast Canyons and Seamounts Marine National Monument (No Action)	54	33%
Canyons (all 20 combined)	108	65%
>300	164	99%
>400	162	98%
>500	156	95%
>600	145	88%
>900	103	62%

[1] Considering just the area overlapping the ACUMEN data set.

[2] This is calculated by dividing the area of high slope covered by the management area by the total amount of high slope, which is 164 km^2.

7.1.1.4 Likelihood of interactions between corals and fishing activity

These coral and coral habitat data are then considered in the context of fishing effort and potential fishing gear effects to estimate the magnitude of impacts a zone might have on deep-sea corals. Each of the gear restriction options is discussed separately, from most to least restrictive, including:

- All bottom-tending gears,
- All bottom-tending gears, red crab traps allowed,
- All bottom tending gears, except traps of any type allowed,
- All mobile bottom-tending gears,
- No gear restrictions, zone designation only.

In general, the coral zones are presently accessible to various fishing gear types, so the impacts analysis considered what the potential effects would be of excluding gears that are allowed under current management. In a small number of cases, the coral zones proposed are currently closed to fishing. This is mainly the case in areas overlapping the Northeast Canyons and Seamounts Marine National Monument, which encompasses the five canyon zones from Oceanographer Canyon to Lydonia Canyon, and all four seamount zones. In these locations, the impacts of coral zone restrictions are considered as additions to any existing restrictions. Mobile bottom-tending gears are currently excluded in portions of Veatch Canyon due to a Tilefish Gear Restricted Area, but the GRA does not fully overlap the coral zone.

It is difficult to assess the magnitude of spatial overlap between fishing effort and coral habitats with any degree of precision, given the current state of knowledge of coral and fishing distributions. The Northeast Fishery Observer Program has documented bycatch of corals in fishing gear, but at-sea observer sampling schemes are designed to estimate catch and bycatch rates of target species and stocks of concern, with coral bycatch as an incidental element of their data collection. Thus, these data cannot be used to estimate coral bycatch rates.

7.1.2 Managed species and essential fish habitat

In addition to deep-sea corals, various managed species occupy the coral zones. These species may benefit from gear restrictions that minimize impacts to habitats within the zones. In particular, seafloor habitats provide shelter and feeding opportunities for managed species. The magnitude of any benefits will depend on the degree of overlap with each species' distribution and the extent to which the species use habitat features vulnerable to impacts from fishing gears. The degree of overlap between essential fish habitat designations and each zone or group of zones is one metric for estimating the benefits that may be generated. These overlaps are explored in section 6.6 and discussed in the impacts analysis by zone or group of zones in order to estimate potential impacts on managed resources.

7.1.3 Human communities

The analysis of impacts on human communities characterizes the magnitude and extent of the economic and social impacts likely to result from the alternatives under consideration. National Standard 8 requires the Council to consider the importance of fishery resources to affected communities and provide those communities with continuing access to fishery resources, but it does not allow the Council to compromise the conservation objectives of the management measures. Thus, continued overall access to fishery resources is a consideration, but not a guarantee that fishermen will be able to use a particular gear type, harvest a particular species of fish, fish in a particular area, or fish during a certain time of the year.

A fundamental difficulty exists in forecasting economic and social change relative to fishery management alternatives when communities or other societal groups are constantly evolving in response to numerous external factors, such as market conditions, technology, alternate uses of waterfront, and tourism. Certainly, management regulations influence the direction and magnitude of economic and social change, but attribution is difficult with the tools and data available. While this analysis focuses generally on the economic and social impacts of the proposed fishing regulations, external factors may also influence change, both positive and negative, in the affected communities. In many cases, these factors contribute to a community's vulnerability and ability to adapt to new or different fishing regulations.

7.1.3.1 Confidentiality requirements

MSA section 402(b), 16 U.S.C. 1881a(b) states that no information gathered in compliance with the Act can be disclosed, unless aggregated to a level that obfuscates the identity of individual submitters. The economic analysis in this amendment is thus aggregated to at least three reporting units, to preserve confidentiality. Any data with less than three reporting units is censored to comply with this federal law. Jonah and red crab data are pooled given the low number of individuals that harvest red crab and resultant confidentiality concerns. Additional standards are applied to reporting the fishing activity of particular states, regions, or fishing communities. To report landings revenue to a specific geographic location, GARFO requires that the landings must be attributed to at least three fishing permit numbers and the landings must be sold to three dealer numbers. However, the dealers do not necessarily have to be located in the same specific geographic location. ACCSP requires that non-confidential data for a geographic location must include three dealers, three commercial fishermen, and three vessels.

7.1.3.2 Approach to fishery impact analysis

The fishery impact analysis in this action, in general, uses recent gross revenue generated from within an alternative area or group of areas to estimate the exposure of fishing vessels, owners, and communities to closing the area(s) to specific fisheries or gear types, as a proxy for the cost of closure. A few approaches have been used here to identify the fishery effort that may be impacted, each with their own caveats and limitations, but together, they provide a general sense of recent fishing effort and indicate the relative importance of specific areas to particular fisheries and gear types. In general, fisheries or gear types that operate within a coral zone alternative area that would be restricted are expected to be negatively affected by any alternative that reduces access to those areas. The magnitude of impact would depend on which areas would close and to which fisheries or gear types, and how vessel operators could respond to area closures by redirecting fishing effort elsewhere.

There are numerous caveats associated with revenue estimates. Redistribution of effort into other locations may mitigate negative effects, but alternative fishing choices are difficult to predict. Relocation may be challenging if other locations are already crowded with gear (e.g., the lobster pot fishery, which can be territorial in nature), or if it is difficult to catch the target species outside the coral zones (e.g., the deep-sea red crab fishery, where the target species distribution is restricted to very deep water). If effort can be redistributed outside coral zones, net losses to displaced fishermen will be dependent on changes in efficiency and costs of fishing in alternate fishing grounds. The impacts analysis explores, qualitatively, possible alternative fishing location choices, based on current distributions of effort.

While a relatively small fraction of revenue in a particular fishery may come from a particular coral zone, the revenue may be concentrated amongst a small number of individuals and/or communities. In general, revenue information is presented at an aggregate level across a management area or areas, but individual level effects are also explored. Owner revenue data derived from VTR and permit effort data derived from VMS indicate the percentage of annual revenue and effort affected by a zone or group of zones at each respective level of fishing entity, across all fishing activity within a zone or group of zones. In general, these percentages are very low, but there are outliers suggesting that for some individuals, these areas may be very important fishing grounds.

Impacts may extend beyond the boundaries of coral zones as well. When deploying and fish their nets, mobile gear fishermen account for bathymetry, current, wind, and area restrictions. These factors may prevent them from fishing efficiently just outside a coral management area. For example, squid vessels typically 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 – as they prepare to trawl along an adjacent shelf. Preventing vessels from being within an area with gear deployed would mean that they may not be able to fish the non-restricted shelf areas immediately adjacent to a closed area.

Of course, the full impacts of area management ripple through the economy, with effects on fuel, bait, and ice suppliers, and other service providers. Additionally, after the first point of sale, a host of other related industries, including seafood retailers, restaurants, transportation firms, all of their suppliers, and ultimately the consumers that frequent these establishments are also impacted by area management decisions. Because the primary focus in this document is on ex-vessel revenues, the information provided should be considered a partial analysis which abstracts away from the broader societal impacts one would calculate under optimal circumstances.

VTR analysis: Vessel trip reports (VTR) are a primary source of data used here to understand fishing location, revenue, days absent, and number of vessels that might be affected by a particular alternative. VTRs are required for all vessels fishing with a federal permit, unless the only federal permit is lobster. For a trip where VTR is required, the vessel must submit a VTR for each gear type used and/or statistical area is fished in. Each VTR includes a single point location for where fishing occurred relative to that VTR. Previous studies indicate that this self-reporting underreports switches in gear type and statistical area (Palmer and Wigley 2007, 2009). Furthermore, and perhaps more importantly, given that commercial fishing trips can be quite long, a single spatial point is unlikely to adequately represent the actual footprint of fishing. Because of this, a statistical approach (DePiper 2014) was used to better represent the footprint of fishing. This analysis was developed for the Omnibus Habitat Amendment (NEFMC 2017, Volume 4) and also used to analyze the impacts of the Mid-Atlantic Coral Amendment (MAFMC 2016). The approach is briefly summarized here.

A model was developed that compares the single, self-reported, VTR point locations, with more detailed haul-by-haul position data on the subset of VTR trips that were observed (DePiper 2014). On trips that carry an at-sea observer, the true spatial extent of fishing activity can be determined from haul-by haul data. With this model, revenue, days absent, and other trip attributes can be distributed in concentric rings around the VTR point, proportional to the modeled probability of fishing. The size of the rings varies with trip characteristics such as gear type and number of days absent. For example, week-long bottom trawl trips have a larger footprint than scallop dredge day trips. Once every trip in the VTR database is spatially assigned using this approach, the resulting dataset can be queried and presented according to year, gear type, species caught, a particular geographic area (e.g., the coral zones under consideration in this amendment). Since VTRs do not include fish prices or revenue, the landed values associated with a particular trip were estimated using average monthly prices for the species from the dealer database, and all values are adjusted to January 2015 dollars for comparability across years.

For this analysis, the data are reported by calendar year (2010-2015), gear type, species, and management area. Pelagic species and gear types were excluded from the analysis, because restrictions on pelagic gears are not included in the alternatives under consideration (Section 4.3). Data are summarized by gear type to help analyze gear-specific measures. Summaries by species are provided to help distinguish particular fisheries that may use the same gear. For example, whiting (silver hake) and longfin squid are both harvested with bottom trawls, and lobster, Jonah crab, and deep-sea red crab are all captured in traps.

Caveats: The estimates of revenue, days fished, or landings within a particular management area are not exact. There are a few possible reasons for a discrepancy between true revenue/effort in a coral zone (which is of course unknown) and the estimates shown here. Despite the following caveats, the VTR data can characterize fishing effort and the relative importance of specific areas in terms of revenue generated, species targeted, and number of participants, and are the most comprehensive data from which to assess fishing location.

1. For some fishing modes, there are limited haul-by-haul location data to develop a reliable effort/revenue distribution model. For example, the lobster fishery has a low at-sea sampling rate, and available data indicate that VTRs can be highly imprecise. Since lobster and bottom trawl trips were statistically indistinguishable, in terms of the distance between VTR points and observed hauls, the same statistical approach is used for these gear types to estimate fishing location around a particular VTR point. The maps included in this document are helpful for understanding the spatial uncertainties associated with VTR data.

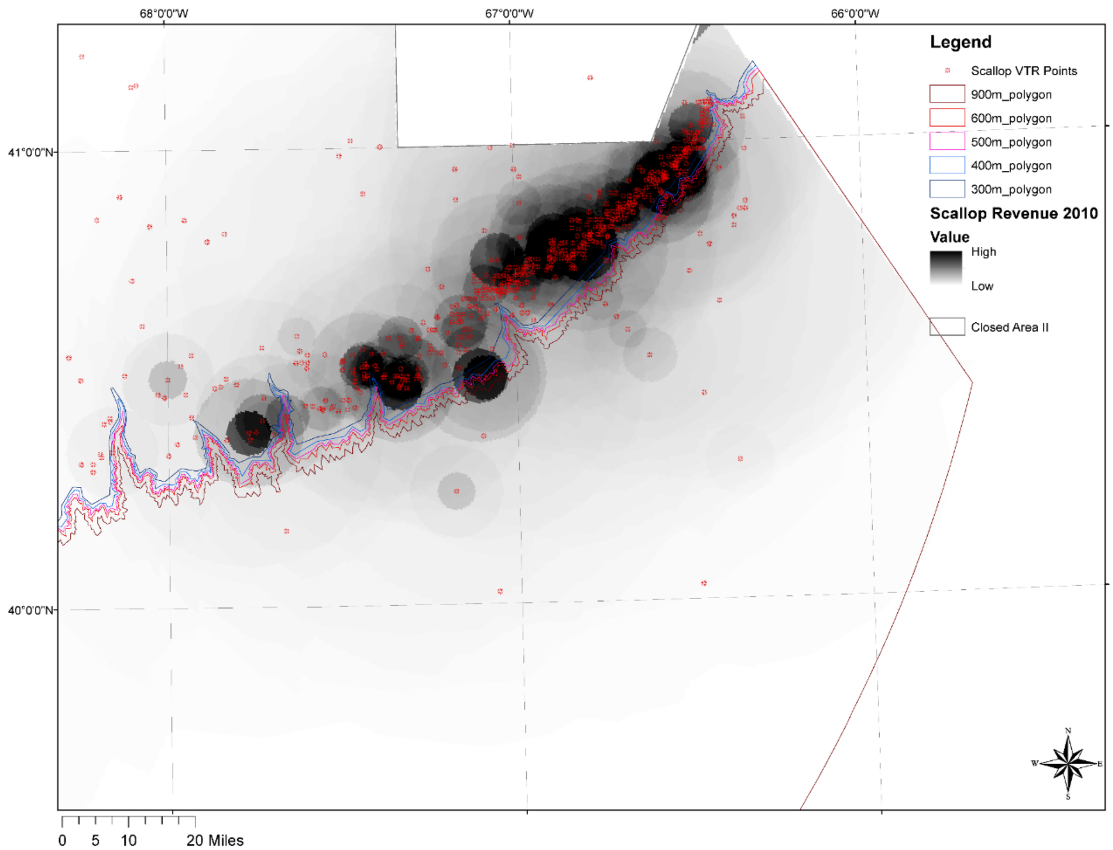
2. Even for fisheries that are relatively well observed, the spatial imprecision of VTR points can lead to the assignment of revenue in unlikely locations (see Map 46). For example, because scallops command a high price per pound relative to other species, revenue from just a handful of trips with erroneous point locations may bias the results.

3. Some types of fishing are known to occur within a particular depth range, so modelling a circular distribution of fishing effort around a VTR point attributes fishing to unlikely locations. For example, in the squid fishery along the continental slope, observer data (haul-by-haul) indicate that tows run along the slope in narrow bands. The modeled confidence interval sizes are large relative to the distance between depth contours on the continental slope, such that revenue/effort is inferred in water deeper than is almost certainly fished.

4. Because VTRs are required for all vessels fishing under a federal permit, unless the only federal permit is lobster, only a portion of the lobster fishery is captured in the VTR data. Thus, VTR data underrepresent lobster revenue/effort. In

Lobster Management Area 3, which overlaps the canyons and the offshore Gulf of Maine, the majority of lobster vessels are required to submit VTRs, whereas inshore, just 6% of vessels with federal lobster permits submit VTRs.

Map 46 – Comparison between scallop VTR point locations, revenue heat map, and coral zones.



Note: **deepwater points beyond the broad zone boundaries result in the attribution of revenue to even the 900 meter zone, which is unrealistic for sea scallops.**

Scaling of offshore lobster VTR revenue data. With the exception of lobster trap gear, all revenue data were taken directly from the VTR analysis. To account for caveat #4 above, the VTR analysis scales VTR-reported lobster revenue in the offshore areas (i.e., not Mt. Desert Rock and Outer Schoodic Ridge). An ASMFC technical committee estimate was used to determine the upper bound of landings from LCMA 3. Specifically, total annual landings for the years 2010-2012 at the statistical area level were summed across the statistical areas overlapping LCMA 3[10] (data for individual statistical areas and years beyond 2012 were not provided to the PDT). Next, total VTR-based landings for LCMA 3 were estimated using spatial analysis of the confidence interval data (using LCMA 3

[10] Statistical areas that overlap LCMA 3: 464, 465, 522, 523, 524, 525, 526, 533, 534, 537, 541, 542, 543, 561, 562, 616, 622, 623, 624, 626, 627, 632.

boundaries, rather than the overlapping statistical areas). The difference between the higher ASMFC estimate and the lower VTR estimate was divided by the total VTR estimate to determine the percentage by which the VTR data needed to be increased. The difference was an average of 24.20% across 2010-2012. This percentage was used to scale up lobster revenue estimates in all coral zones located within LCMA 3, for all years (2010-2015) covered in this analysis. This 24.20% increase was applied to all catches of lobster in lobster pot gear. Lobster catches in trawls or other gear types were not adjusted. Permit and trip data were not adjusted, only revenue, because upper bounds (i.e., ASMFC data) for the number of trips and active permits were not available.

Scaling of inshore lobster VTR revenue data. Inshore lobster VTR data have not been scaled, due to the general agreement that VTR provides insufficient coverage to adequately represent the spatial distribution of lobster fishing in state waters (Section 7.6.3).

Trips and permits by gear type. Another approach to estimating extent of fishing effort relative to the areas considered is number of trips and permits by gear type attributed to recent fishing in each area. The trip estimate is simply a count of the number of trips that overlap the management areas (including partial overlap). The permit estimate reflects the number of individual permits, by gear type, whose activity overlaps the areas. This roughly approximates the number of vessels that might be affected by a given alternative, although it does not consider the probability associated with this overlap. To this extent it can be considered an upper bound on the number of trips and permits which might be exposed to the action under development.

Revenue by species. Because some fishing gear is used to catch multiple species in distinct fisheries, revenue at the species level was also estimated for each group of management areas. Data are provided for the top ten species that generate revenue attributed to the areas.

Percent owner revenue. To help determine the importance of the areas under consideration to the fishery, the contribution of the fishing attributed to the areas to a vessel owner's annual revenue (in all areas fished) was calculated. The analysis included just the owners with vessel activity attributed to an area. Thus, the percent owner revenue data indicate the importance of an area to potentially affected owners. These percentages were pooled across all gear types and species and were calculated for the most recent three years, 2013 - 2015. Boxplots indicate the range of the percentages (e.g., the median value indicated with a dark vertical bar, outliers indicated with open circles).

ASMFC survey: To better characterize offshore lobster and Jonah crab fishery effort, the Atlantic States Marine Fisheries Commission, at the NEFMC's request, collected data on lobster fishing activity in and around the canyons along the southern margin of Georges Bank. ASMFC conducted a voluntary mail survey of all Lobster Management Area 3 permit holders (Whitmore et al. 2016). Because only a portion of permit holders responded, estimates of fishing activity (e.g., revenue, number of vessels fishing in the canyons) are not a census of Area 3 lobster fishing activity. Further, the survey results cannot be independently verified using the VTR or observer databases, because only a portion of the respondents submit VTRs, few lobster or Jonah crab trips are observed, and some survey questions do not match up with VTR data. Regardless, the survey helps to paint a more complete picture of the offshore lobster and Jonah crab fishery when combined with the VTR-based analysis.

MEDMR data: The majority of Lobster Management Area 1 vessels do not hold other federal permits, such that the VTR dataset underestimates fishing activity in two of the coral zones, Mount Desert Rock and Outer Schoodic Ridge. To better characterize inshore Gulf of Maine lobster fishery effort, the State of Maine has contributed data via the Maine Department of Marine Resources (MEDMR). The MEDMR harvester report data are not a census of lobster fishing activity, as they are submitted by approximately 10% of lobster permit holders, those chosen for a lobster logbook (10% of each liscence class in each zone). Lobster permit holders with a VTR requirement, through participation in another fishery, do not also have to submit harvester reports. Combined with dealer data (incl. all landings from a trip for each license that is assigned to zone by port of transaction), and assuming representativeness of the harvester reports, the data can help describe fishing effort by season, depth, and distance from shore in and around these two coral zones.

VTR vs. VMS comparison: For some fisheries/permit types, Vessel Monitoring System (VMS) data provide a more refined spatial dataset than VTR or observer data. VMS data are used as available for a complementary analysis of fishing effort. Records and Demarest (2013) developed a logit model to determine a probability of fishing based on trip characteristics (e.g., vessel size, primary gear used on trip) and VMS poll (e.g., imputed vessel speed, depth fished, depth change, distance to known fishing hotspots). This model can then be used to assess the probability-weighted effort associated with each VMS poll. This approach classifies a trip based on the primary gear/landed fish combination, and is thus not a full census of trips which could be attributed to each FMP. However, this classification avoids double-counting of effort.

7.1.3.3 Approach to fishing community impact analysis

The fishing communities that are potentially impacted by the management alternatives are identified and discussed. There are, however data limitations and data confidentiality standards that constrain the extent of the analysis in this document. The fishing communities most likely to be impacted, at least in the near-term, include those that have been the homeport or landing port to fishing vessels active in the areas included in the management alternatives.

Communities at the port of landing and city of vessel registration could be impacted by the alternatives under consideration. Potential impacts related to the port of landing include a loss of landings and revenue that can affect the fisheries infrastructure in the community. The city where the permit is registered is generally where the permit holder resides. Impacts to these communities may be widespread beyond fisheries related aspects of the communities. Permits are often registered in different cities than the ports where the vessels land, so the number of vessels cannot be added across community type as this may result in double counting vessels.

This analysis identifies the states, regions, and fishing communities that would likely be impacted by the alternatives under consideration, based on the VTR analysis, which identifies recent (2010-2015) fishing activity in the coral zone areas under consideration in this action. For each area, the data provided include:

- Landings revenue by state attributed to the coral areas.
- Within certain states, landings revenue by region attributed to the coral areas.
- Landings revenue by the top ten ports with landings attributed to the coral areas.
- Number of the fishing permits with landings revenue attributed to the coral areas.

The VTR data analysis includes the fishing activity by vessels with federal fishing permits that submit VTRs, but this analysis may underrepresent the lobster fishery and has many caveats that may impact the accuracy of the data. The number of permits (i.e., vessels) impacted is included for a general representation of the impact to each community. It is important to remember that a single vessel can land in multiple ports, so each vessel may be included in more than one community at the port level.

In addition to the ports explicitly identified, other ports are impacted but cannot be detailed due to data confidentiality. Background information on several communities is in Section 6.8.1 and is also available at:
http://nefsc.noaa.gov/read/socialsci/communitySnapshots.php

It is unlikely that this action would affect all identified communities to the same extent. The communities that are more dependent on fishing with the affected gear types would likely have more impacts than those that participate in a range of fisheries and gear types. Even among communities with similar dependence, there are likely to be different impacts since some alternatives have localized impacts. Additionally, the general level of vulnerability and resilience of a community will determine the magnitude of the impact. Social Vulnerability Indicators of each community are listed in the Affected Environment. These indices correspond to different components of social vulnerabilities that may affect communities. More information is available in Jepson and Colburn (2013) and at: http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index.

7.1.3.4 Approach to sociocultural impact analysis

The social impact factors outlined below can be used to describe the potentially impacted fisheries, its sociocultural and community context and its participants. These factors or variables are considered relative to the management alternatives and used as a basis for comparison between alternatives. Use of these kinds of factors in social impact assessment is based on NMFS guidance (NMFS 2007) and other texts (e.g., Burdge 1998). Longitudinal data describing these social factors region-wide and in comparable terms is limited. While this analysis does not quantify the impacts of the management alternatives relative to the social impact factors, qualitative discussion of the potential changes to the factors characterizes the likely direction and magnitude of the impacts. The factors fit into five categories:

- *Size and Demographic Characteristics* of the fishery-related work force residing in the area; these determine demographic, income, and employment effects in relation to the work force as a whole, by community and region.
- *Attitudes, Beliefs, and Values* of fishermen, fishery-related workers, other stakeholders and their communities; these are central to understanding behavior of fishermen on the fishing grounds and in their communities.
- Effects of proposed actions on *Social Structure and Organization*; that is, changes in the fishery's ability to provide necessary social support and services to families and communities.
- *Non-Economic Social Aspects* of the proposed action or policy; these include life-style issues, health and safety issues, and the non-consumptive and recreational uses of living marine resources and their habitats.
- *Historical Dependence on and Participation* in the fishery by fishermen and communities, reflected in the structure of fishing practices, income distribution and rights (NMFS 2007).

Longitudinal data describing these social factors region-wide and in comparable terms are limited, though the new surveys currently being implemented will begin to alleviate this. The academic literature provides multiple lists of potential social variables, but such lists should not be considered "exhaustive" or "a checklist" (e.g., IOCGP, 2003; Burdge, 2004).

The analysis evaluates the effects management alternatives may have on people's way of life, traditions, and communities. These social impacts may be driven by changes in fishery flexibility, opportunity, stability, certainty, safety, and/or other factors. While the social impacts of some measures under consideration could be experienced solely by one community group or another, it is more likely that impacts will be experienced across communities, fisheries, gear sectors, and vessel size classes.

While some management measures tend to produce certain types of social impacts it is not always possible to predict precise effects. There is also a wide variation in the acceptance of area closures among stakeholders based on the intended goals (e.g., reduce bycatch, protect spawning aggregations or habitats) of a possible closure (e.g., Pita et al. 2010). The difficulty in defining the social impacts of closed areas is inextricably tied to their variability and how they are perceived by stakeholders (Pomeroy et al. 2007). The *Attitudes, Beliefs, and Values* of those members of the public who are concerned with ocean conservation need to be acknowledged as well. Management measures that are perceived to contribute to conservation of resources are generally expected to have indirect, positive impacts for those stakeholders.

Also changes to the human environment often occur in small, incremental amounts and the character of a particular impact can be hidden by the gradual nature with which it occurs. As such, there is high uncertainty in the relative strengths of the impacts.

Therefore, the discussion of social impacts for alternatives indicates the likely directional impacts of specific measures (e.g., positive, negative, or neutral). The analysis is generally qualitative in nature, because of the limitations of determining effects over the large geographic areas under consideration and across many fisheries.

7.1.3.5 General impacts of area closures on human communities

Area closures can have numerous social impacts across various fisheries and communities. For areas subject to new closures, as considered in this action, the most direct impacts would be on the vessels currently fishing in the areas subject to closures. Fishermen would be forced to modify where and how they fish (or cease fishing if no suitable fishing ground remains available), having a negative impact on the *Historical Dependence on and Participation* and the *Size and Demographic Characteristics* of the affected fisheries, because of a probable reduction in fishing opportunity, revenue, and employment. Negative social impacts would be expected in the *Non-economic Social Aspects* of the fishery, as fishermen would have less flexibility in choosing where to fish.

The ability to adapt to closed areas is highly variable and largely dependent on the physical location of the closed areas. Less mobile fishermen may bear a heavier burden, as they are less able to easily switch harvest areas (out of closed areas, or into reopened areas). Smaller vessels will be less able to adapt to closures of areas near shore as their range is limited and they cannot easily target offshore areas. Any change in fishing behavior that attempts to employ a more mobile fishing strategy will have additional social costs, such as disruptions to family and community life as well as increasing the likelihood of safety risks. Increased risk can result when fishermen spend longer periods at sea to minimize steam time to and from fishing grounds, operate with fewer crew, and fish in poor weather conditions. Fishermen severely impacted by the new closed areas may leave fishing entirely or at least seek temporary opportunities in another fishery or gear type that is less affected by the management alternatives. Both possibilities would cause a change in the *Size and Demographics* of the different fisheries. The short-term impacts on markets, processing capability, and other infrastructure during the period of adjustment to the new closures may be such that shoreside resources may be impaired.

Shifting effort into areas that remain open may cause vessel crowding and gear conflicts, which are important concerns for many stakeholders. If an area is closed to some but not all fishing gears (e.g., closed to bottom trawls, but not to traps), fishermen that may remain active within a given area may experience indirect positive benefits via reduced gear conflicts – though fishermen active outside the area may have negative impacts due to crowding.

The public could be negatively impacted by decreases in seafood availability, which could occur due to area exclusions. The magnitude and sign of the net consumer benefit depends on the exact relationship between changes in quantities and prices, as well as substitutes for the species under consideration. Lee and Thunberg (2013) provide an example of how these relationships, and their corresponding welfare changes, can be estimated. However, without an estimate of the changes in landings directly due to area management, these models are inoperable. Even if specific estimates of changes in landings were available, models estimating consumer welfare do not currently exist for the full suite of impacted species.

There is also the potential for positive social impacts derived from new closures. Typically, the intent of a closure relates to the potential for future, long-term benefits on the improvement of ecosystem services or fish stocks. These benefits are difficult to analyze, because of the uncertainty associated with the magnitude of the benefit, how these benefits would be distributed among fishing communities, and the timing of these impacts.

7.1.3.6 Non-use value of corals

The tradeoffs between use and non-use values derived from the deep-sea coral areas under consideration in this action are central to Council decision-making. The alternatives are considered in light of their expected benefits to corals and their potential short- and long-term costs to commercial fisheries and fishing communities.

As a rare species, deep-sea corals have cultural value to society, including non-use values. *Existence value* is the utility gained from knowledge that these corals exist and will continue to exist into the future (Foley et al. 2010; Spurgeon, 1992). People derive satisfaction from knowing future generations would be able to experience this existence (i.e., bequest value). Thus, protection of deep-sea corals provides positive benefits to society, though these benefits are extremely hard to quantify. *Option value* is the utility gained from preserving a resource today for potential future use. It can also be argued coral reefs and their associated organisms have an *intrinsic value,* that they have a right to exist without any specific utility for mankind. These non-use values value may increase with the quality or uniqueness of a particular coral reef (Spurgeon, 1992).

Non-use values are difficult to measure, as they will always have a degree of subjectivity. Wallmo and Edwards (2008) found broad differences in how people value conservation associated with area management in New England. The values differ not only across individuals, in that they can be positive and negative, but also vary across allowable activities within conservation areas. Values such as these can thus only be estimated with very carefully crafted instruments that are specific to the circumstances under consideration, and even then are subject to hypothetical bias, in that the respondents understand and act upon the incentive to either overstate or understate their actual valuations (Wallmo and Edwards 2008, List and Gallet 2001, Harrison and Rutstrom 2008).

7.1.4 Protected resources

The spatial management alternatives considered in this amendment could change fishing behavior (e.g., gear use), which may influence the potential for regional fisheries to interact with protected resoruces. The management measures currently in place for the fisheries operating in New England all limit the overall amount of fishing effort, mainly through annual catch limits on target stocks, but also through permit and trap limits in the case of the lobster and crab fisheries. Given these existing limits, the changes proposed in this amendment are not expected to increase fishing effort overall, but fishing locations could change due to gear restrictions in coral zones.

Protected species interaction risks are broadly related to the total amount of gear in the water, soak or tow time, and co-occurrence with protected species. Generally speaking, if shifts in effort result in more gear being present for a longer period of time in areas of higher protected species co-occurrence, this is likely to result in increased interaction risks. While fishermen may fish and set gear in different locations following the implementation of coral zones, these changes do not necessarily equate to increased protected species interactions. Risk could decrease if activity shifts away from areas with relatively higher interaction rates.

7.2 Impacts of No Action (existing areas and fishing restrictions that provide protection for corals)

The No Action alternative (Section 4.1) includes two closures with the same boundaries in both the Monkfish and Mackerel/Squid/Butterfish (MSB) FMPs, three closures in the Tilefish FMP, and the recently designated Northeast Canyons and Seamounts Marine National Monument. The monkfish and MSB closures in Oceanographer and Lydonia canyons are closed to vessels using days at sea in those fisheries. The tilefish gear restricted areas are in shallower parts of Oceanographer, Lydonia, and Veatch Canyons. These areas are closed to mobile bottom-tendings gear. The Monument areas were closed to all commercial fishing on November 15, 2016. Closure to red crab and lobster trap fisheries will not take effect until seven years from the date of designation (i.e., 2023).

For this impacts analysis, the No Action closures have been group as follows:

- Monkfish/MSB/Tilefish Areas
- Northeast Canyons and Seamounts Marine National Monument

Because the fishery management closures and Monument overlap, the impacts described here cannot simply be added together.

7.2.1 Impacts on deep-sea corals

Generally, the No Action management areas, which overlap with one another in Lydonia and Oceanographer Canyons, have positive impacts on deep-sea corals. All of the designated areas include records of deep-sea corals from recent dives (Table 34) as well as earlier sampling (Table 33). Of all the management areas under consideration, the existing monkfish-mackerel/squid/butterfish closures are the most efficient 93% (Table 35) at encompassing areas predicted to be high suitability habitat for soft corals, and have the largest percent area of high slope (7%, Table 37). The Tilefish Gear Restricted Areas and the Northeast Canyons and Seamounts Marine National Monument (Monument) extend into shallower areas as compared to the monkfish habitat closures in Lydonia and Oceanographer Canyons (Table 36), and therefore are less efficient at encompassing predicted soft coral habitats and areas of high slope. However, oweing to the relatively large size of the monument, the No Action areas in combination include over 18% of the predicted suitable soft coral habitat on the continental margin (considering just the New England region, Table 35), and 33% of the high slope areas (Table 37).

Given the relatively shallow extent of the Tilefish GRAs and Monument which extends into depths fished by various gear types, the No Action areas do have a material effect on the distribution of bottom-tending gears. The Tilefish GRAs restrict all mobile bottom-tending gear, and the Monument includes broader restrictions, eventually to encompass the lobster and red-crab trap fisheries. The sections on human community impacts discuss the likelihood of effort displacement vs. overall reductions. Given that the No Action management areas in combination encompass just six of the twenty canyons along the New England continental margin, the expectation is that at least some of the effort from these areas is being prosecuted in similar depths in other locations within the canyons and on the slope. Thus, if none of the action alternatives are adopted, the No Action areas will afford fairly comprehensive protections for the corals in these six canyons (Veatch, Oceanographer, Filebottom, Chebacco, Gilbert, and Lydonia), but could lead to increased effort in other locations.

7.2.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.2.3 Impacts on human communities

Under No Action, the fishing restrictions associated with the Northeast Canyons and Seamounts National Monument would remain in place. The Monument has been closed to all commercial fishing since November 2016, with the exception of the lobster and red crab fisheries, which have seven years to cease operations within the Monument.

The impacts of No Action on human communities are expected to be low negative. For the fisheries constrained by the Monkfish/MSB/Tilefish areas and the National Monument (current or future), the impacts are expected to be negative. With the Monument implementation, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.2.3.1 Fishery impacts

Estimates of recent fishing activity within the No Action areas. Due to data limitations, it is impossible to know the true amount of fishing activity that has occured within the No Action areas. Thus, multiple approaches are used to estimate fishing activity, and thus characterize the potential fishery impacts of No Action.

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the No Action areas. Note that the No Action Monkfish/MSB/Tilefish areas were in effect during the time period encompassed by this analysis, but the National Monument was implemented after the time period evaluated. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2).

Total revenue. From 2010-2015, an annual average of $0.5M dollars of fishing revenue is attributed to the area of the Monkfish/MSB/Tilefish areas, with higher than average values in 2014 and 2015 (Figure 3). Figure 3 is a good example of the spatial imprecision of VTR data, as all of these areas were closed to bottom trawl gear during 2010-2015, but about $100K annual revenue is attributed to this gear type. The area of the National Monument (Figure 4), which is larger and encompasses most of the Monkfish/MSB/Tilefish areas, has a more revenue attributed to it, about $1M per year, except in 2015 when dredge revenues were substantially higher. The National Monument boundaries also extend into shallower waters. During 2010-2015, there was a substantial scallop dredge fishery on the southeastern part of Georges Bank, close to the National Monument boundary.

Revenue by gear type. Revenue in the Monkfish/MSB/Tilefish areas is primarily attributed to bottom trawls, lobster pots, other pots, and scallop/clam dredges combined (Figure 3); separator and Ruhle trawls, and sink gillnet revenues are minor. In the National Monument, revenue is primarily attributed to bottom trawl, lobster pot, and scallop/clam dredges, with smaller contributions from separator and Ruhle trawls (Figure 4). Maps of revenue by gear type and species are in section 13, beginning on page 338.

Trips and permits by gear type. Similar to revenue by gear type, bottom trawl and lobster pot effort are the dominant gear types used on trips attributed to the Monkfish/MSB/Tilefish areas (Figure 5) and National Monument (Figure 6), but scallop and clam dredge effort is deemphasized relative to revenue to the high revenue per trip in those fisheries. Unlike with revenue, where more revenue is attributed to the larger National Monument, the total number of trips is similar between the two No Action zones (Figure 5 and Figure 6). In reality, the Monkfish/MSB/Tilefish areas likely overlaps more trips than the National Monument, because there is a tilefish gear restricted area in Veatch Canyon, outside of the Monument. This Veatch Canyon tilefish gear restricted area thus pulls in fishing activity from that part of the shelf/slope break, whereas the Monument is centered on Lydonia and Oceanographer canyons only, combined with the seamount areas, which are assumed to be unfished.

For the permits (i.e., vessels) with 2010-2015 fishing attributed to either the Monkfish/MSB/Tilefish areas (Figure 7) or the National Monument (Figure 8), bottom trawl gear is the most common gear type, though there is a decline through time, from ~120-50 vessels fishing with bottom trawls in each area. Around 25 lobster vessels are fished in the vicinity of these areas, again, with slightly more permits being fished around the Monkfish/MSB/Tilefish areas (including Veatch Canyon). Vessels with scallop and clam permits also report fishing in and around the areas. As noted above, larger numbers of permits report activity near the National Monument than in the

Monkfish/MSB/Tilefish areas, likely because the Monument extends into shallower waters. There are also a small number of permits that report using separator or Ruhle trawls in each of the areas, and some permits reporting the use of gillnet gear in the Monkfish/MSB/Tilefish areas only. This reflects the concentration of gillnet effort in offshore RI and southeastern MA, but not further to the east where the Monument is located.

Revenue by species. Lobster, crabs, and scallops are the highest value species of the top 10 species with landings attributed to the Monkfish/MSB/Tilefish areas (Figure 9), although an increase in revenue from butterfish is evident in 2012-2015. Longfin squid, a small mesh trawl species managed under the same FMP as butterfish, is consistently in the top ten, but more variable from year to year. Silver hake, another small mesh trawl species, is also a consistent contributor to revenues in these areas. Other trawl-caught resources include flounders, mackerel, and haddock. There have been recent increases in effort in the Jonah crab fishery, and a spike in red crab revenue generated from the area occurred in 2014. Revenues in the Jonah crab fishery are likely to remain above historic levels for the foreseeable future (Megan Ware, ASMFC, personal communication). Revenue from sea scallops is particularly prominent in 2015.

The results for the National Monument (Figure 10) are similar in terms of the top 10 species by revenue, but emphasize sea scallop revenues relative to the Monkfish/MSB/Tilefish areas, and the highest overall revenue (over $1M vs. < $600,000 annually). Again, this is likely the result of the Monument's larger size overall, and its extension into shallower areas of the continental shelf.

Percent owner revenue. For both the Monkfish/MSB/Tilefish areas (Figure 11) and the National Monument (Figure 12), the percent revenue exposed of owners fishing within these regions is typically in the single digit percentages, but higher for some individuals, with some outlier owners generating as much as 5-10% of their revenue in these areas. This indicates that most of the potentially affected owners generate only a small fraction of their annual revenue from these areas, but a few owners derive a larger fraction of their annual revenue from the area.

VTR vs. VMS comparison. For both the Monkfish/MSB/Tilefish areas and the National Monument, the percent of VTR trips with Vessel Monitoring System (VMS) data is high for scallop dredge, bottom trawl, and Separator and Ruhle trawl trips (Table 38). For these trips, the VMS analysis represents fishing effort at a much more refined scale, and covers the vast majority of trips in the region. The same cannot be said for lobster pot and other gears, whose low level of coverage indicates likely problems when extrapolating the VMS results more broadly. Bottom longline and gillnet data have not yet been processed. It is unclear whether this same level of overlap between VMS and VTR trips exists prior to 2010, given the fact that VMS coverage has not been consistent across time.

In general, the more refined analysis, using VMS polling data, indicate that only 15-35% of permits attributed by the VTR analysis to fishing in the No Action management areas had VMS points falling within the regions of interest, for gears with good coverage (Table 39). It should be noted that the majority of VMS transponders are programmed to send spatial coordinates once an hour. Given that bottom trawl vessels in the region tend to fish at a speed of 2-5 knots, while scallop dredges fish at 2-7 knots (Palmer and Wigley, 2007), there is potential for this point analysis to underestimate the actual numbers of fishermen fishing within a relatively small region such as the Monkfish/MSB/Tilefish areas. Although less of an issue with the larger National Monument, the VMS data indicate a mismatch between the size of the management areas under consideration and the spatial precision of the data available to assess the impacts of the areas.

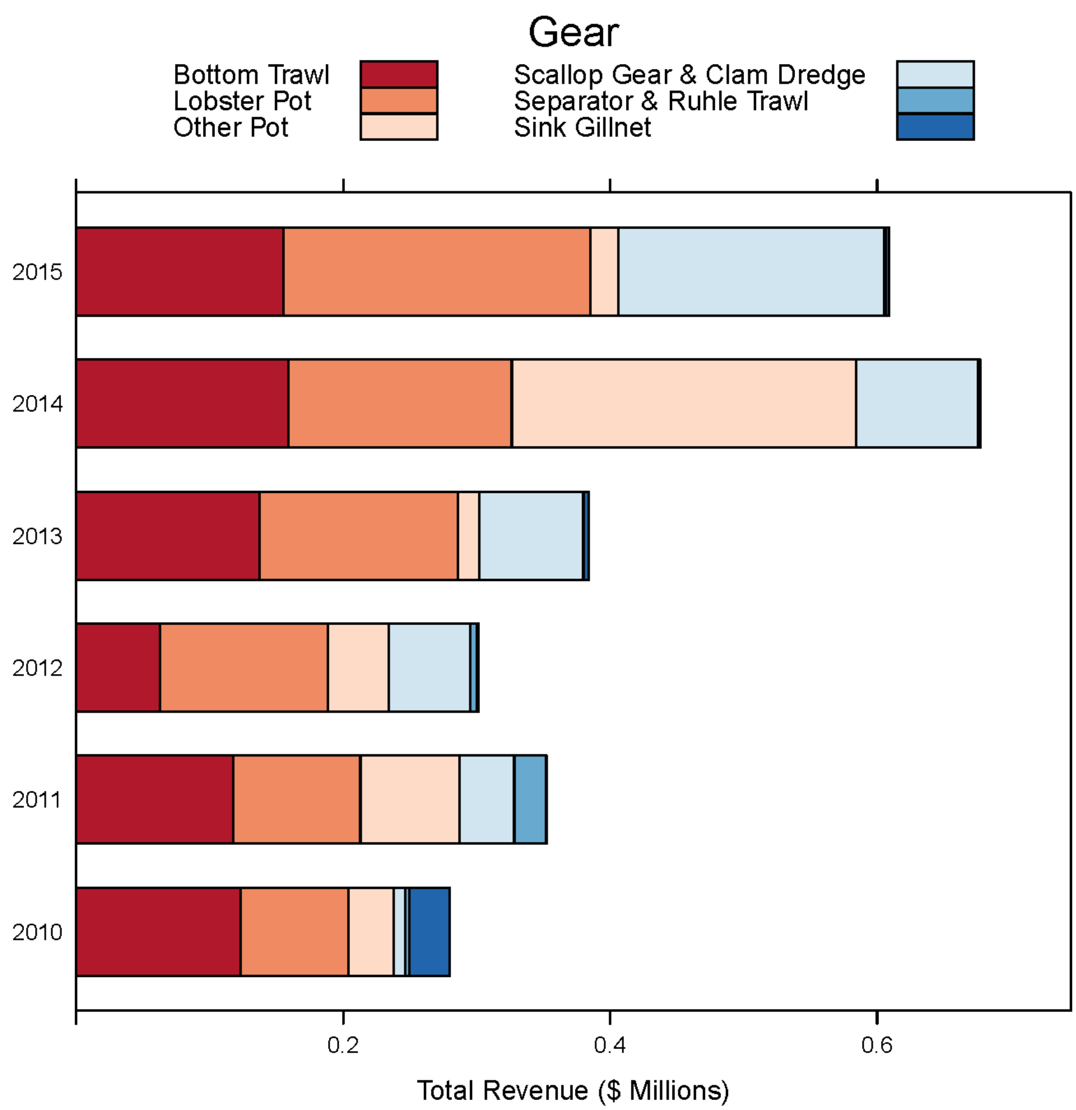
About 15% of VTR trips identified to be fishing within the Monkfish/MSB/Tilefish areas have VMS points falling within those regions, and the probability-weighted hours fished indicates a relatively small amount of effort is being expended in these regions by bottom trawl, squid trawl, and in particular scallop dredges. This is intuitive, because these areas are currently closed to these gears. The larger National Monument encompasses substantially more effort by bottom and squid trawls, although there is substantial inter-annual fluctuation. About 25% of trips identified in the VTR analysis as having fished in the National Monument between 2010 and 2012 have corresponding VMS polls falling within the same region. Although the magnitude differs substantially, the interannual trends are generally consistent between the VTR and VMS analyses for trips and permits in the No Action areas.

In addition, the relative magnitude of effort estimated between the Monkfish/MSB/Tilefish areas and the National Monument are very similar between the VTR and VMS analysis. For 2010 to 2012, the ratio of revenue (VTR) and hours fished (VMS) in the Monkfish/MSB/Tilefish areas to the revenue/hours fished in the National Monument ranges from 14-20% in the VTR and 9-20% in the VMS, for trawls. This indicates that although the magnitude of effort estimated by the VTR is uninformative, it is adequate as a relative measure of fishing across these two regions and this gear type. The scallop dredge ratios conform less across the two analyses, with the VMS analysis indicating no real concentration of fishing effort in either of these two areas using this gear. This is expected given the depths at which sea scallops generally fish in commercial abundance, i.e., below 110 m.

Figure 13 and Figure 14 provide the distribution of a permit's overall probability-weighted VMS effort falling within the Monkfish/MSB/Tilefish areas and the National Monument. Although this would be expected to differ at least slightly from the percentage of owner revenue generated in each of these regions (Figure 11, Figure 12), due to the fact that multiple permits can belong to the same ownership group, there is substantial concurrence between the two metrics. In particular, both metrics indicate that t vast majority of individuals fishing within the Monkfish/MSB/Tilefish areas expend less than 1% of effort and generate less than 1% of total revenue in this region. For a similar majority, less than 5% of effort expended and total revenue generated is calculated to fall within waters of the National Monument.

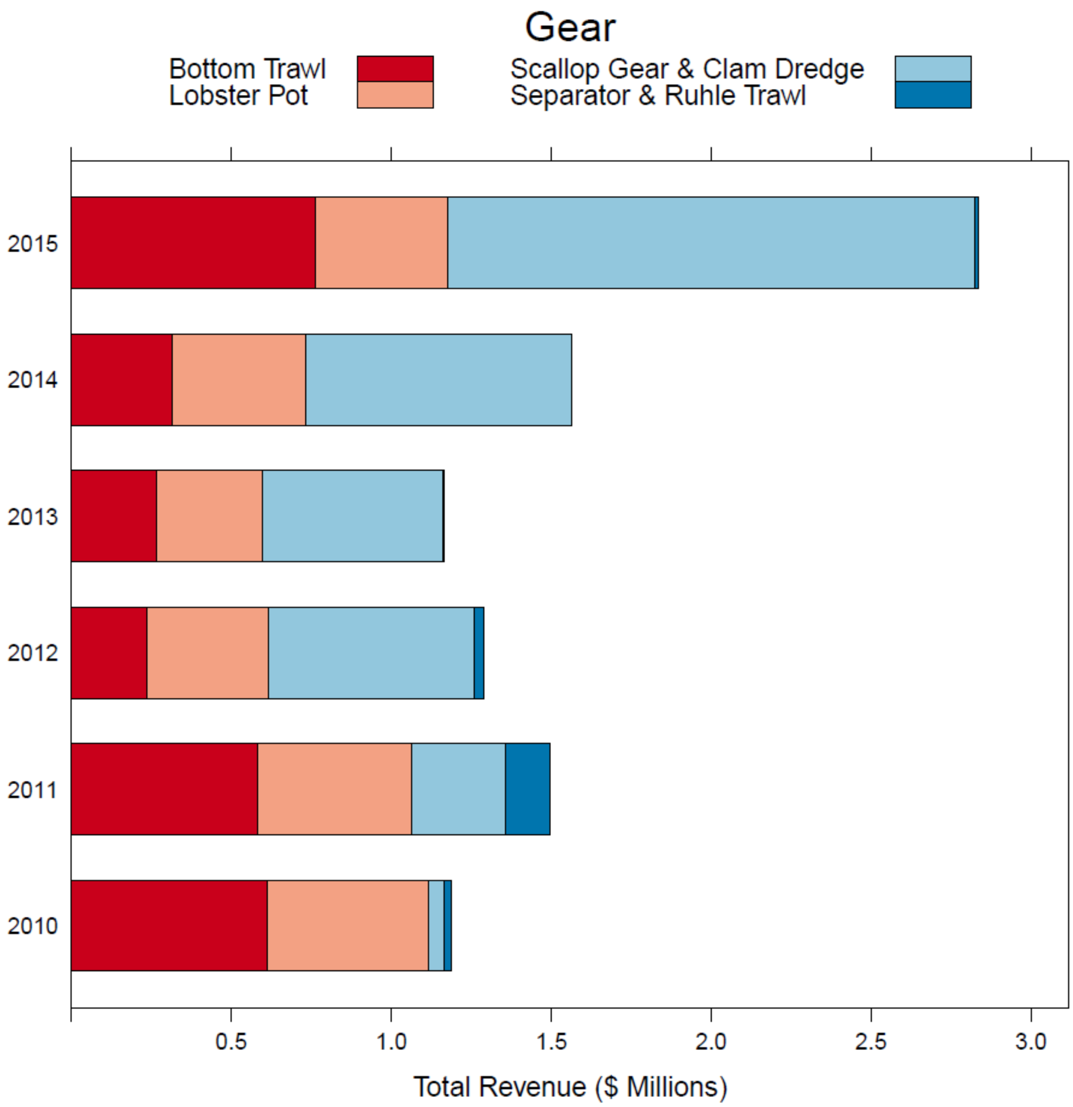
Given the high VMS coverage for bottom trawl, scallop dredge, and separator and Ruhle trawls in this region, for these gears the estimates of fishing activity exposed are better assessed through VMS rather than VTR. Conversely, given the low coverage of lobster pot fishing in the region, the VMS provides a lower bound, while VTR provides an upper bound, on the uncertainty regarding the trips and permits historically fishing within the Monkfish/MSB/Tilefish areas and the National Monument. For sink gillnets and clam dredges, only the VTR analysis is currently available. Although the high uncertainty regarding these estimates might upon first blush seem problematic, the percentage of revenue and effort, assessed at the owner and permit level respectively, consistently indicate a low level of fishing activity for the vast majority of individuals estimated to utilize these waters. However, a very small number of individuals seem to be using these areas more intensively.

Figure 3 – Revenue by gear type attributed to the No Action Monkfish/MSB/Tilefish areas within Veatch, Oceanographer, and Lydonia Canyons, 2010-2015.



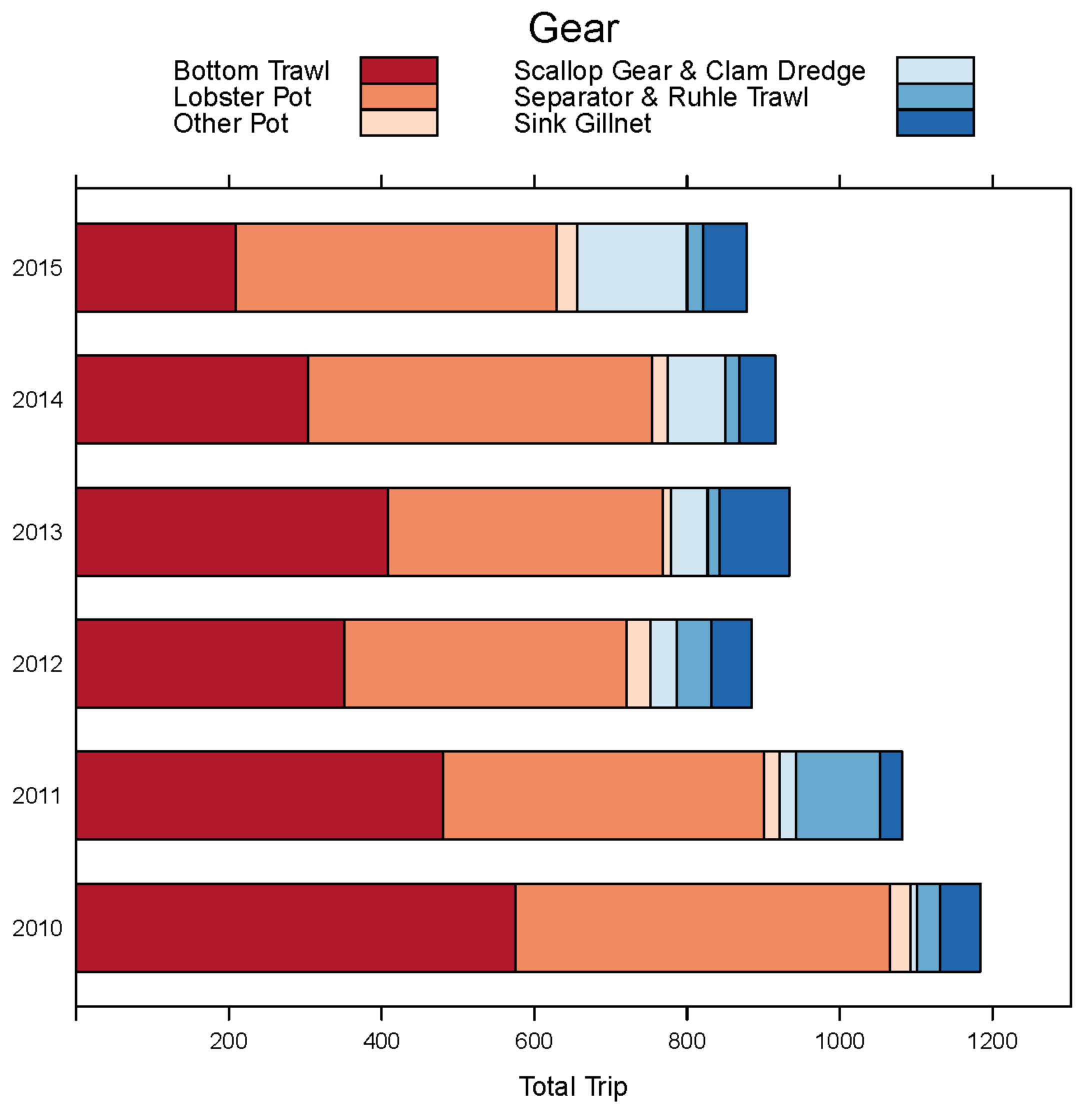
Source: **VTR analysis.**

Figure 4 – Revenue by gear type attributed to the Northeast Canyons and Seamounts Marine National Monument, 2010-2015.



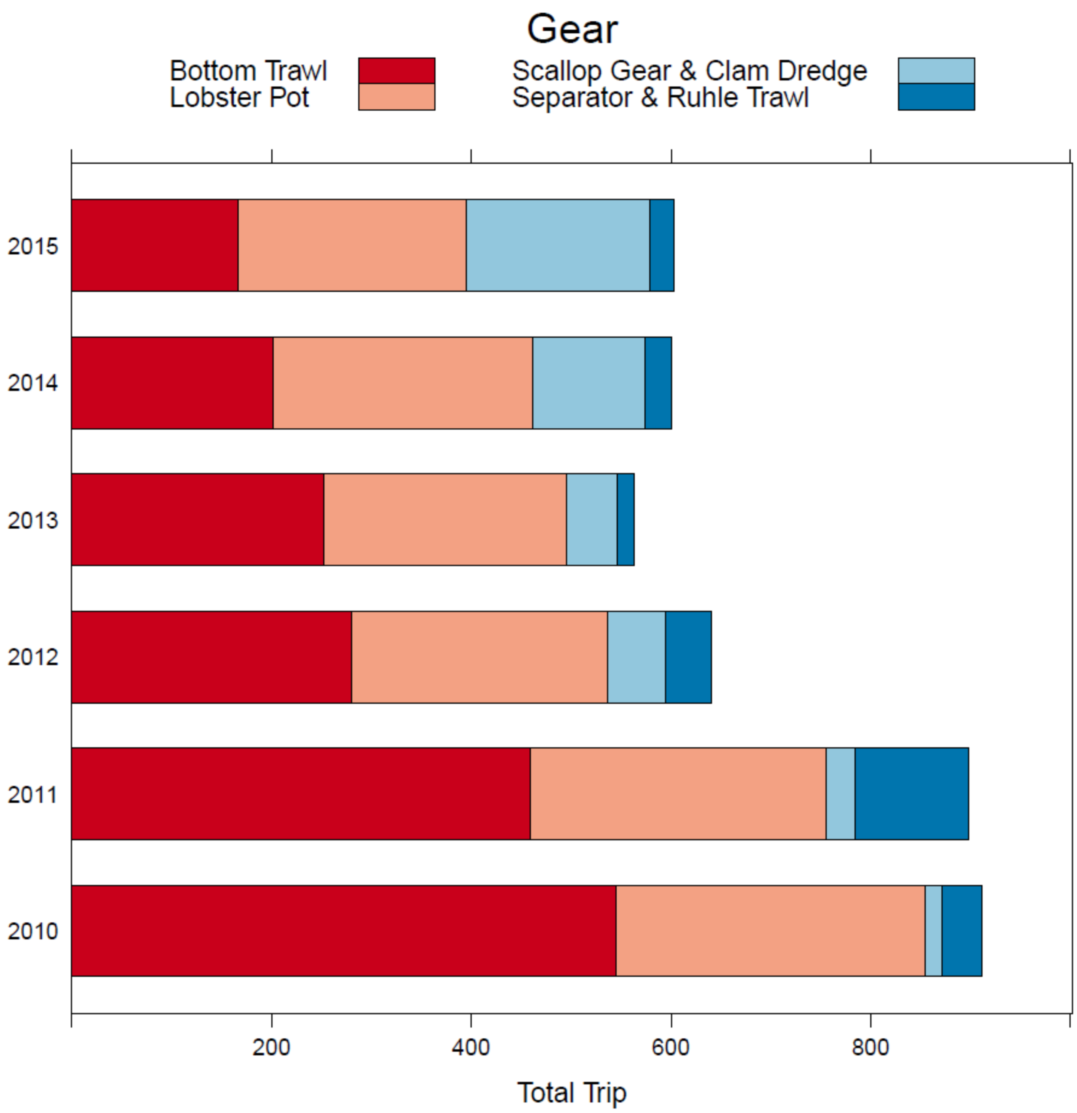
Source: **VTR analysis.**

Figure 5 – Trips by gear type attributed to the No Action Monkfish/MSB/Tilefish areas within Veatch, Oceanographer, and Lydonia Canyons, 2010-2015.



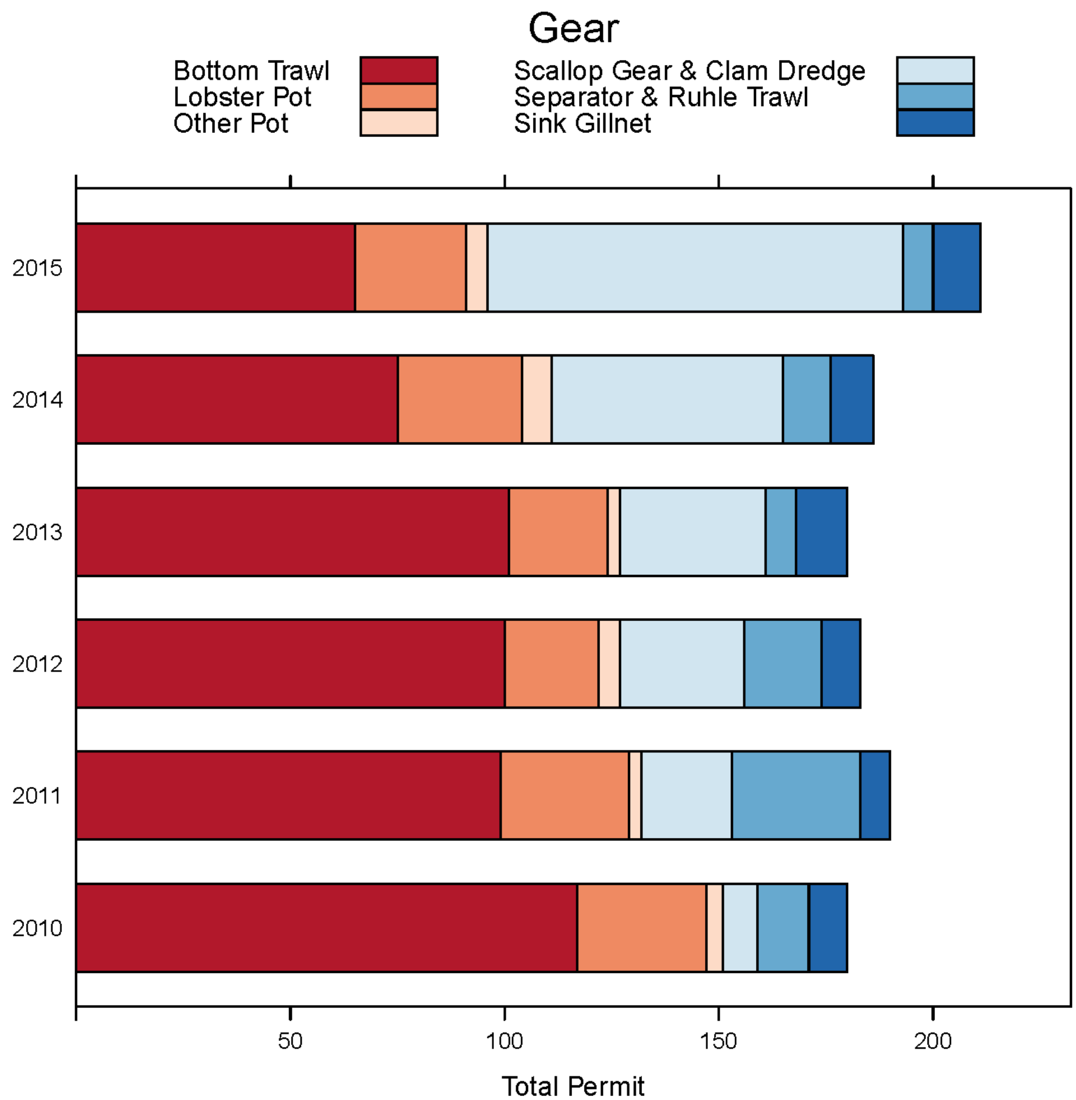
Source: **VTR analysis.**

Figure 6 – Trips by gear type attributed to the Northeast Canyons and Seamounts Marine National Monument, 2010-2015.



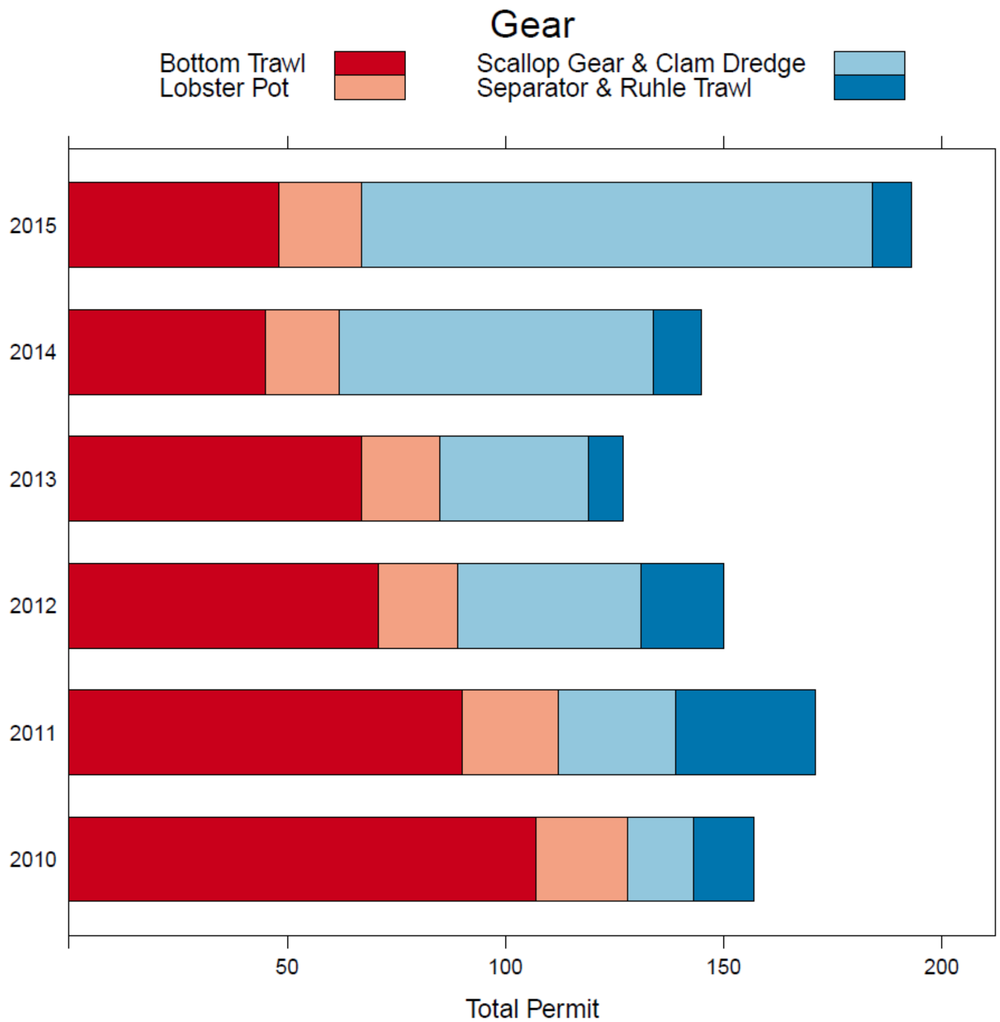
Source: **VTR analysis.**

Figure 7 – Permits by gear type attributed to the No Action Monkfish/MSB/Tilefish areas within Veatch, Oceanographer, and Lydonia Canyons, 2010-2015.



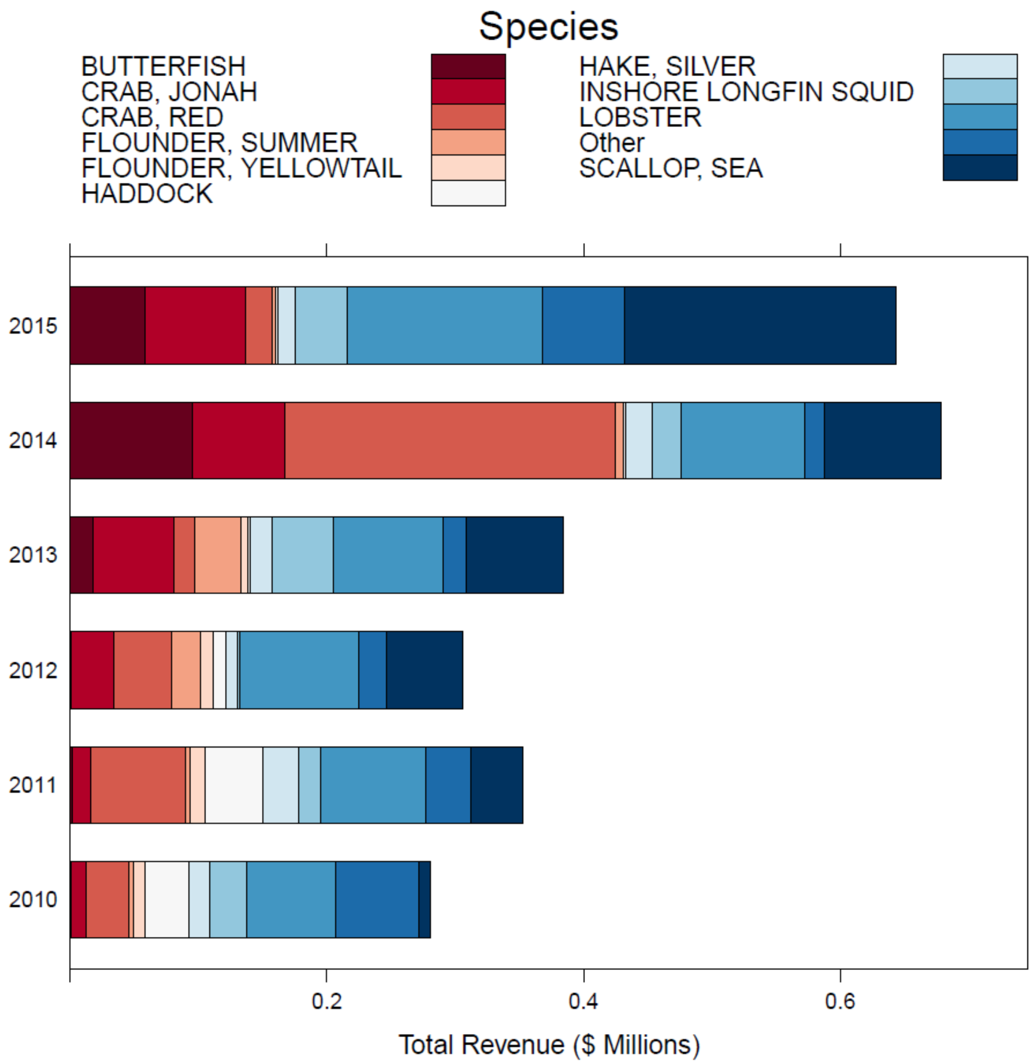
Source: **VTR analysis.**

Figure 8 – Permits by gear type attributed to the Northeast Canyons and Seamounts Marine National Monument, 2010-2015.



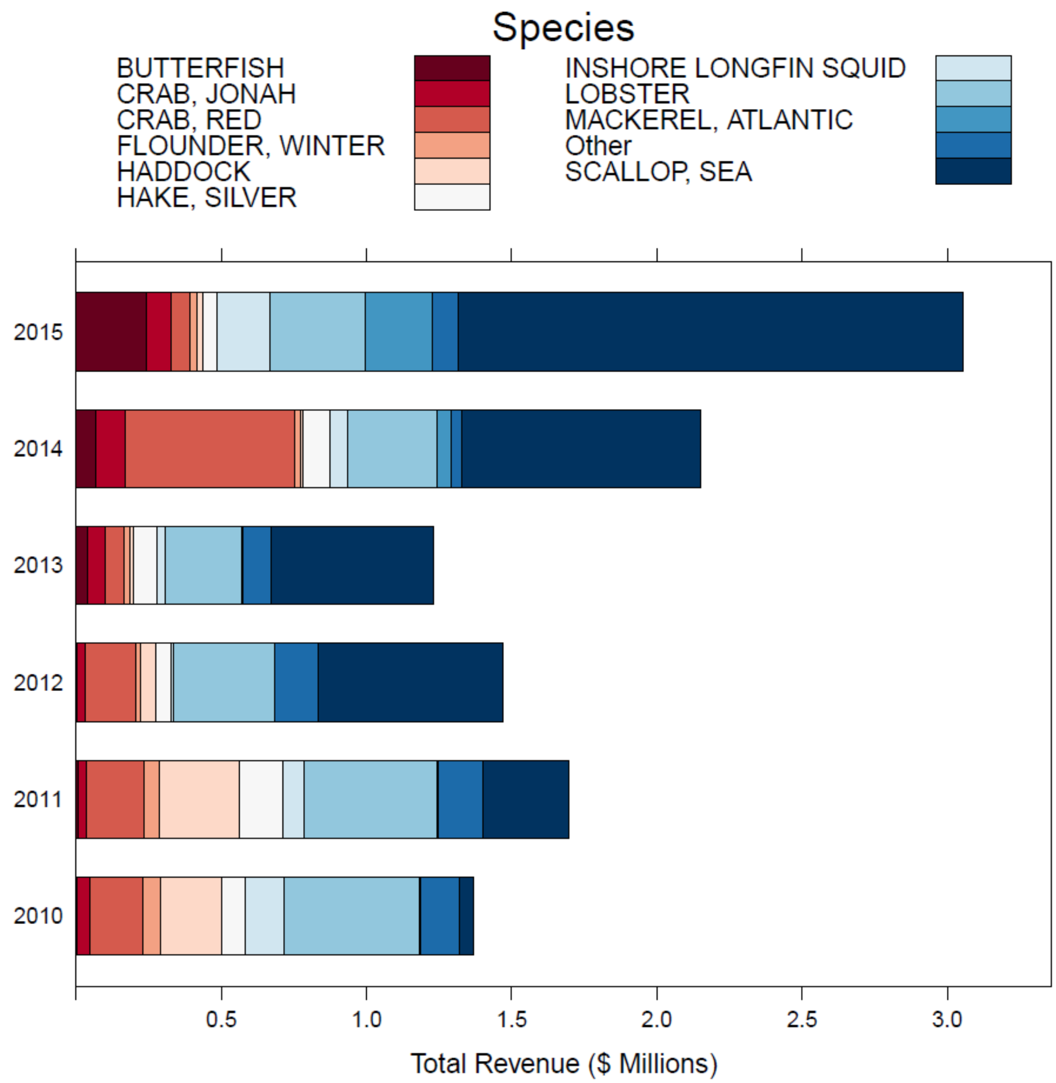
Source: **VTR analysis.**

Figure 9 – Revenue by species (top 10) attributed to the No Action Monkfish/MSB/Tilefish areas within Veatch, Oceanographer, and Lydonia Canyons, 2010-2015.



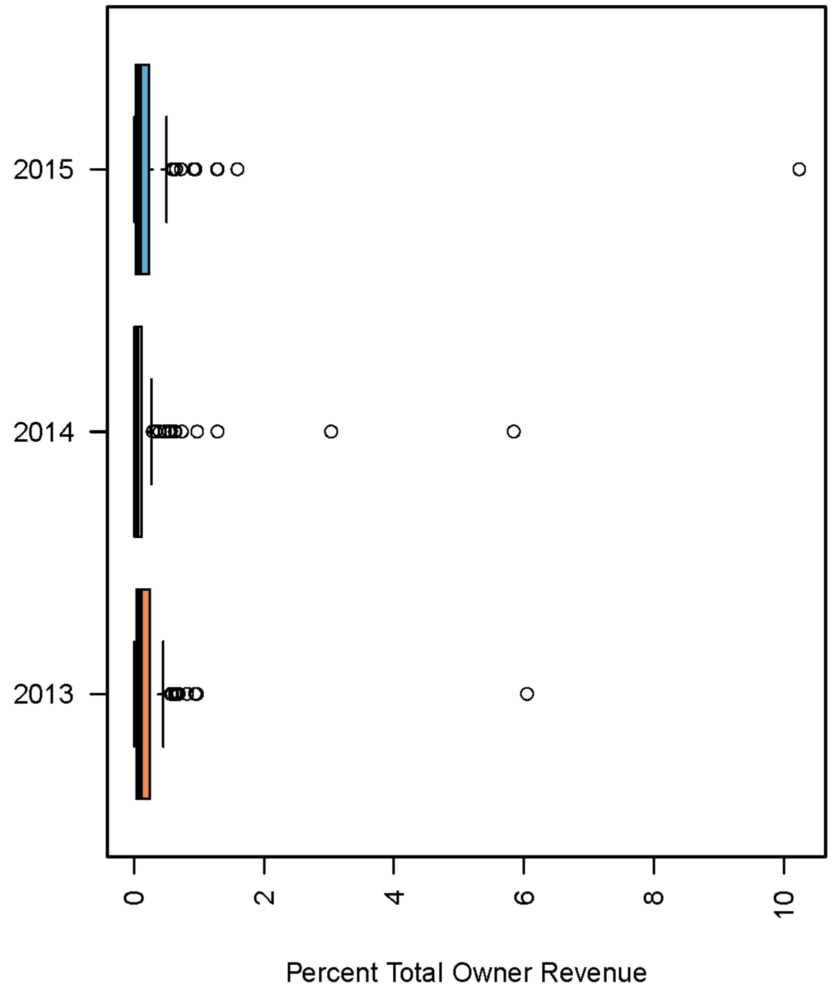
Source: **VTR analysis.**

Figure 10 – Revenue by species (top 10) attributed to the Northeast Canyons and Seamounts Marine National Monument, 2010-2015.



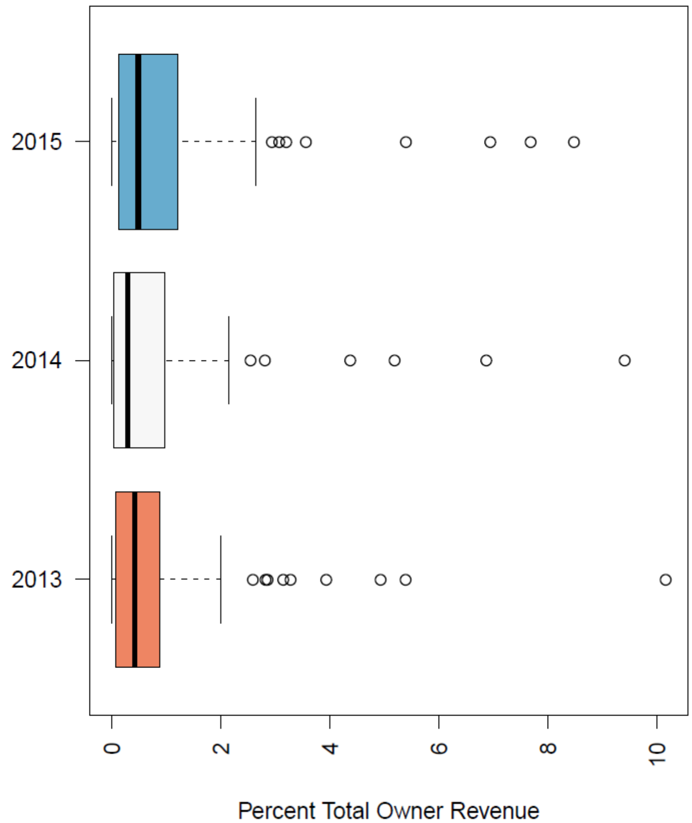
Source: **VTR analysis.**

Figure 11 – Percent of total owner revenue attributed to the No Action Monkfish/MSB/tilefish areas, 2013-2015.



Source: **VTR analysis.**

Figure 12 – Percent of total owner revenue attributed to the Northeast Canyons and Seamounts Marine National Monument, 2013-2015.



Source: **VTR analysis.**

Table 37 – Percentage of VTR trips overlapping the No Action management areas that have VMS coverage, by gear type.

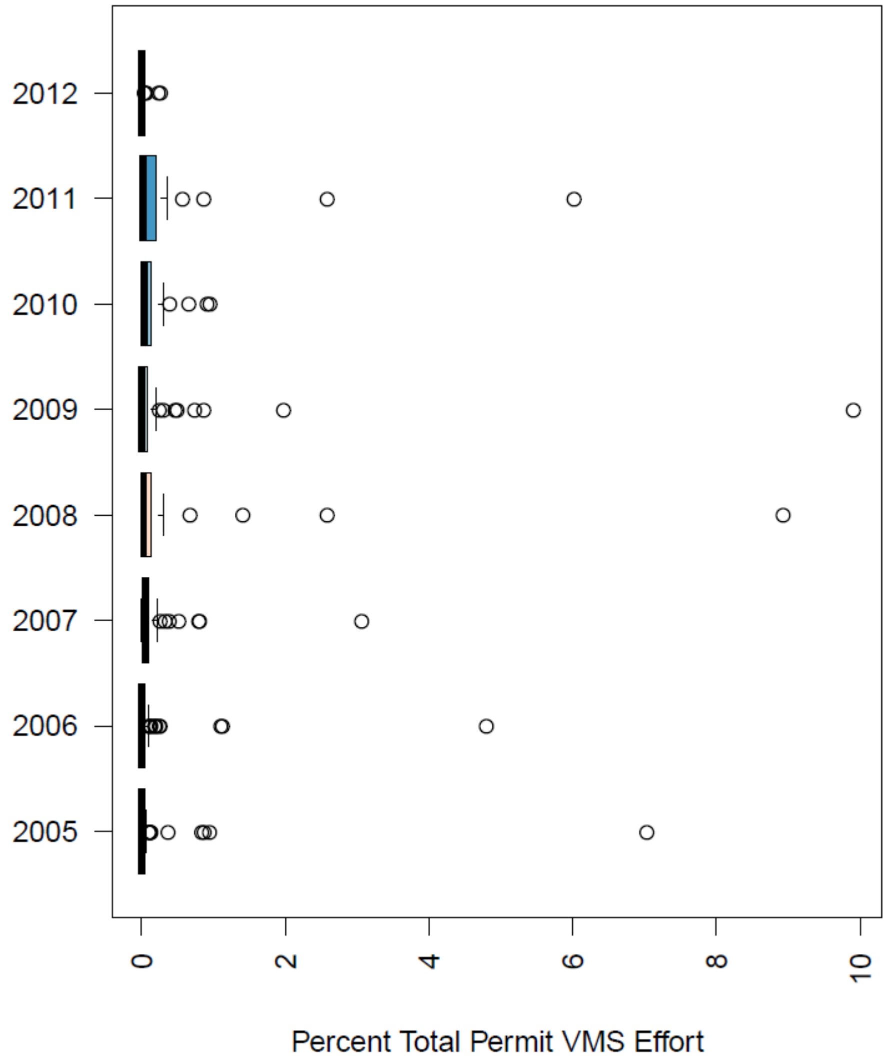
		No Action Monkfish Tilefish Areas			National Monument		
Gear	Year	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage
Bottom Trawl	2010	575	539	94%	545	513	94%
Bottom Trawl	2011	481	430	89%	459	411	90%
Bottom Trawl	2012	351	296	84%	280	235	84%
Lobster Pot	2010	491	76	15%	309	49	16%
Lobster Pot	2011	420	28	7%	296	9	3%
Lobster Pot	2012	370	0	0%	257	1	0%
Scallop Gear & Clam Dredge	2010	8	8	100%	17	16	94%
Scallop Gear & Clam Dredge	2011	22	20	91%	30	28	93%
Scallop Gear & Clam Dredge	2012	35	35	100%	57	57	100%
Separator & Ruhle Trawl	2010	30	24	80%	40	30	75%
Separator & Ruhle Trawl	2011	110	92	84%	113	94	83%
Separator & Ruhle Trawl	2012	45	32	71%	46	33	72%

Table 38 – VMS-derived estimates of effort (hours fished, permits, and trips) within the No Action management areas, by gear category

		No Action Monkfish Tilefish Areas			National Monument		
Gear	Year	Hours Fished	Permits	Trips	Hours Fished	Permits	Trips
Bottom Trawl	2005	19.32	20	39	614.52	50	149
Bottom Trawl	2006	48.51	25	44	373.21	49	101
Bottom Trawl	2007	57.70	46	71	756.01	55	127
Bottom Trawl	2008	23.41	23	61	433.21	31	103
Bottom Trawl	2009	22.14	19	70	256.56	36	137
Bottom Trawl	2010	40.54	33	85	243.10	37	132
Bottom Trawl	2011	51.33	18	53	305.25	22	91
Bottom Trawl	2012	7.99	11	41	105.40	17	73
Squid Trawl	2005	16.26	33	60	210.59	34	62
Squid Trawl	2006	27.19	32	70	32.41	23	41
Squid Trawl	2007	37.71	39	87	580.87	38	102
Squid Trawl	2008	8.02	8	13	3.84	5	5
Squid Trawl	2009	26.59	8	16	1.87	4	4
Squid Trawl	2010	9.46	10	21	187.75	10	17
Squid Trawl	2011	15.29	12	22	22.42	13	13
Squid Trawl	2012	1.71	6	7	2.71	3	3
Raised Footrope	2006	-	1	-	-	1	-
Trap	2005	1.83	3	5	13.76	3	5
Trap	2006	31.88	3	40	-	2	-
Trap	2007	22.53	3	28	-	2	-
Trap	2008	18.17	3	11	-	2	-
Trap	2009	10.11	3	17	-	1	-
Trap	2010	-	1	-	0.00	0	0
Trap	2011	-	2	-	-	2	-
GC Scallop	2006	-	1	-	-	1	-
GC Scallop	2009	0.00	0	0	-	1	-
GC Scallop	2011	0.00	0	0	-	1	-
GC Scallop	2012	-	1	-	-	1	-
LA Scallop	2005	0.16	25	28	0.20	9	10
LA Scallop	2006	0.18	28	35	1.34	28	40
LA Scallop	2007	0.00	0	0	1.05	3	3
LA Scallop	2008	0.00	0	0	-	1	-
LA Scallop	2009	0.22	12	12	0.56	13	13
LA Scallop	2011	0.73	8	9	0.73	7	7
LA Scallop	2012	0.09	9	9	0.14	9	9

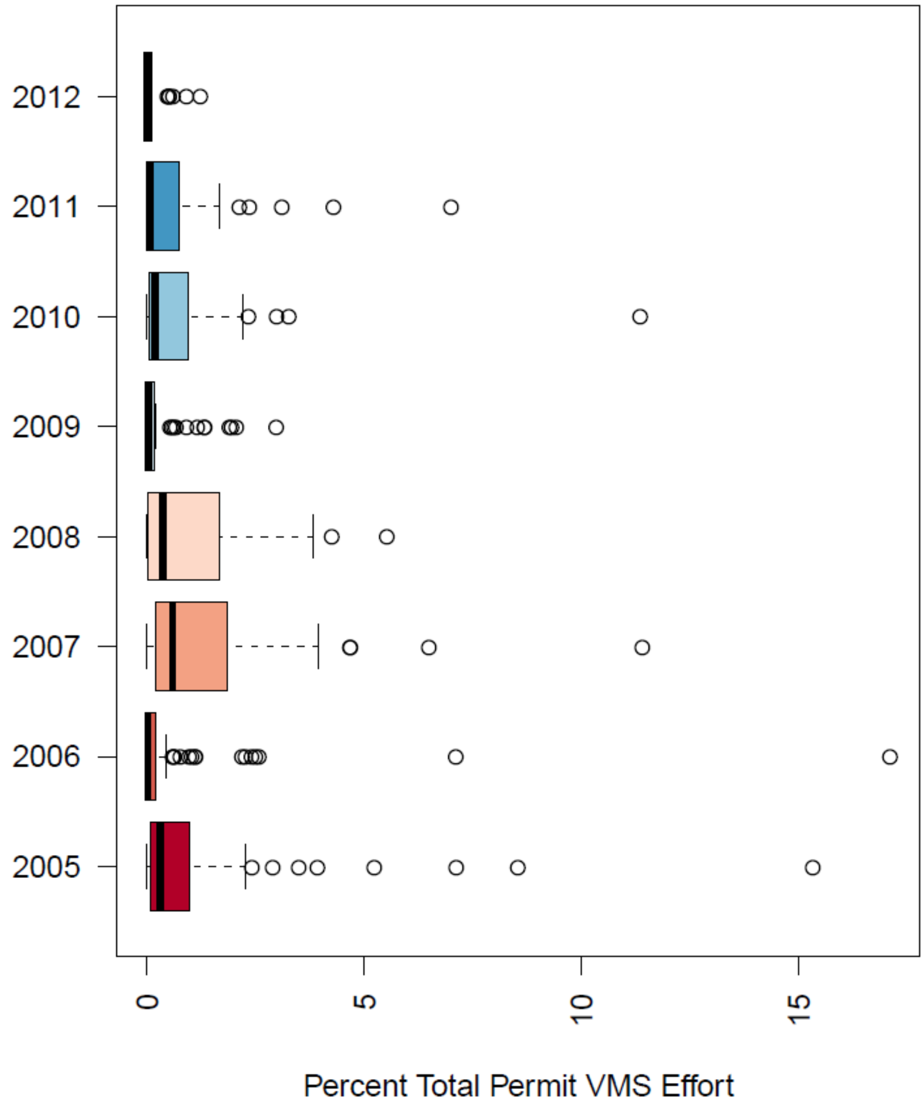
Note: LA and GC refer to limited access and limited access general category scallop gears, respectively.

Figure 13 - Percent of total annual permit fishing activity attributed to the No Action Monkfish/MSB/tilefish areas between 2005 and 2012, as derived from VMS



Source: VMS

Figure 14 - Percent of total annual permit fishing activity attributed to the Northeast Canyons and Seamounts Marine National Monument between 2005 and 2012, as derived from VMS



Source: VMS

7.2.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 40 and Table 41, the revenue by state, region, and port attributed (using the VTR analysis) to recent fishing within the No Action coral zones.

No Action Monkfish/MSB/Tilefish Areas. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be active within the No Action Monkfish/MSB/Tilefish Areas are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, Virginia, and other states (Table 40). The VTR analysis attributes recent (2010-2015) landings revenue to 45 ports, and 57% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith are among the top ten landing ports, and 28% of the revenue is attributed to other ports, indicating that these areas may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the No Action Monkfish/MSB/Tilefish Areas is about 0.05% and 0.19% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are minor fractions, certain individual permit holders could have as much as 10% of their revenue attributed to fishing from these areas (Figure 11, p. 207).

Table 39 – Landings revenue to states, regions, and top ports attributed to fishing within the No Action Monkfish/MSB/Tilefish Areas, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits 2010-2015[a]
	Total $	Average $	
Massachusetts	$1,500K	$300K	301
New Bedford	$1,332K	$266K	253
Sandwich	$109K	$22K	3
Gloucester	$31K	$6K	25
Other (n=13)	$28K	$6K	57
Rhode Island	$879K	$176K	70
Newport	$399K	$80K	9
Point Judith	$183K	$37K	61
Other (n=4)	$297K	$59K	12
New York	$73K	$15K	12
Montauk	$72K	$14K	10
Virginia	$60K	$12K	55
Newport News	$26K	$5K	29
Other (n=3)	$34K	$7K	33
New Jersey	$27K	$5K	14
Connecticut	$14K	$3K	10
North Carolina	$4K	$1K	27
Other state(s)[b]	$87K	$17K	15
Total	**$2,645K**	**$529K**	**411**

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

National Monument. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be active within the Northeast Canyons and Seamounts Marine National Monument are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New Jersey, New York, and other states (Table 41). The VTR analysis attributes recent landings revenue to 35 ports, and

73% of this revenue to ports in Massachusetts. New Bedford, Point Judith, and Sandwich are among the top ten landing ports, and 24% of the revenue is attributed other ports, indicating that the areas near the Monument may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the National Monument is about 0.21% and 0.35% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are minor fractions, certain individual permit holders could have as much as 10% of their revenue attributed to fishing from these areas (Figure 12, p.41).

Table 40 – Landings revenue to states, regions, and top ports attributed to fishing within the National Monument, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$6,760K	$1,352K	285
New Bedford	$5,987K	$1,197K	248
Sandwich	$485K	$97K	3
Gloucester	$173K	$35K	22
Other (n=11)	$115K	23	41
Rhode Island	$1,653K	$331K	44
Point Judith	$536K	$107K	38
Newport	$344K	$69K	6
Other (n=3)	$773K	$155K	5
New Jersey	$242K	$48K	7
New York	$211K	$42K	6
Montauk	$210K	$42K	5
Connecticut	$80K	$16K	6
Virginia	$64K	$13K	30
Other state(s)[b]	$266K	$53K	16
Total	**$9,275K**	**$1,855K**	**353**

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

7.2.3.3 Sociocultural impacts

The sociocultural impacts associated with maintaining the No Action areas are expected to be negative for fishermen and fishing communities, as it would maintain the status quo. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. In the case of red crab, the vessels track the migration of this species along the continental shelf break, so the future Monument closure will likely decline participation in that fishery. No Action may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.2.4 Impacts on protected resources

To be completed prior to final action.

7.3 Impacts of broad deep-sea coral zones and associated fishing restrictions

This alternative (section 4.2.1) would designate a large area of the shelf-slope and abyssal plain out to the EEZ as a deep-sea coral zone. There are five overlapping and mutually exclusive broad zone options under consideration, and only one may be selected by the Council. The options have their seaward boundary at the EEZ and their western boundary along the New England/Mid-Atlantic intercouncil boundary line. The landward boundaries are simplified versions of depth contours along the southern margin of Georges Bank, drawn by simplifying a depth contour derived from a 25 m spatial resolution bathymetry dataset, and are constrained to the depth contours 50 m shallower and deeper than the target depth. Broad zone landward boundary options are as follows:

- Option 1: 300 m
- Option 2: 400 m
- Option 3: 500 m
- Option 4: 600 m
- Option 5: 900 m

Potential fishing restriction measures for coral zones are described in Section 4.3. They include:

- Option 1: Prohibit bottom-tending gears
    - Sub-option A: Exempt the red crab fishery
    - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

7.3.1 Impacts on deep-sea corals

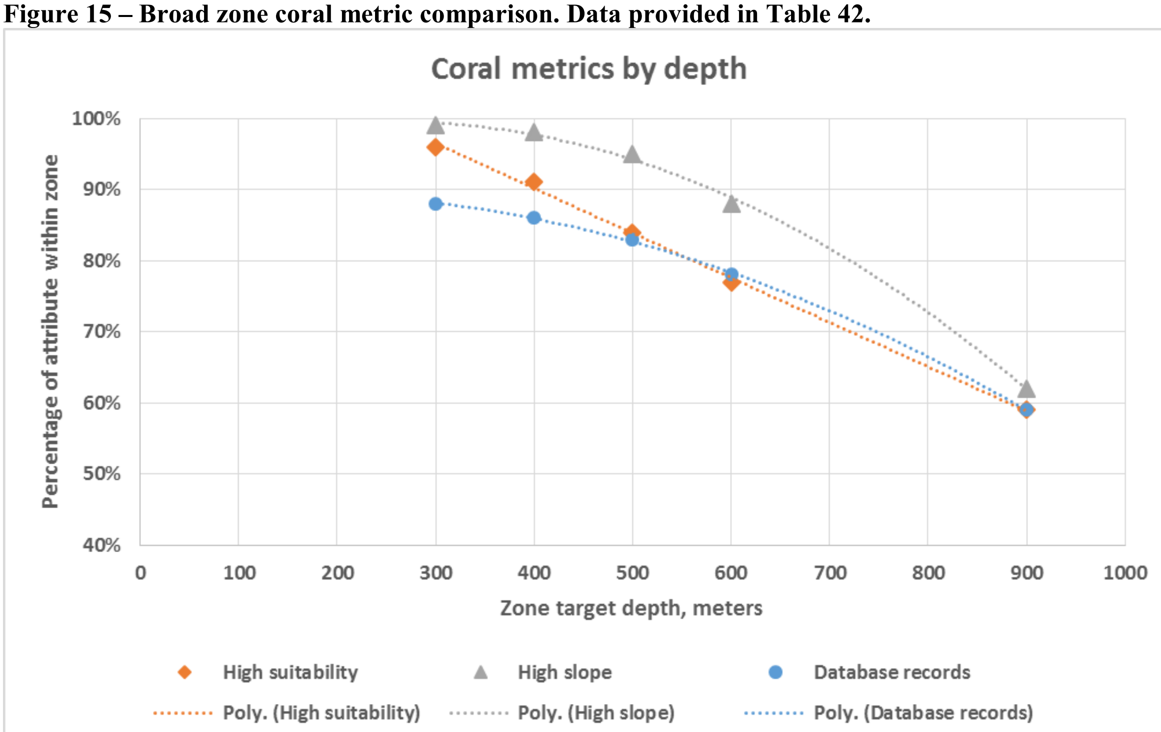
The broad zone options are extensive, covering the entire continental margin and the seamounts out to the EEZ boundary. Thus, the areas would provide comprehensive protection for coral habitats occurring throughout the New England portion of the continental margin, within the depths covered by each zone. The zones are nested, with the 900 meter zone a subset of the 600 meter zone, which is in turn a subset of the 500 meter zone, and so on. The data on coral distributions (Table 33), soft coral habitat suitability (Table 35), and area of high slope (Table 37) suggest that the positive impacts of the zone options on corals increase from the 900 meter to the 300 meter zone. These attributes are summarized below:

Table 41 – Summary of coral attributes for the broad zone options. See Table 33, Table 35, and Table 37 for additional details.

Broad zone option	Coral records (pre-2012 database). Number and percentage of continental margin observations.[1]	Percent of high suitability habitat encompassed	Percent of high slope habitat encompassed
>300	627 (88%)	96%	99%
>400	615 (86%)	91%	98%
>500	592 (83%)	84%	95%
>600	553 (78%)	77%	88%
>900	422 (59%)	59%	62%

[1] **There are roughly 1100 records in this database for the entire New England region, around 700 of which are beyond 100 meters on the continental margin south of Georges Bank.**

Figure 15 – Broad zone coral metric comparison. Data provided in Table 42.



Generally, all of the broad zone alternatives would have positive impacts on corals, increasing with the size and shallowness of the zones and the extent of gear restrictions. The 900 meter zone, for example, encompasses roughly 60% of the high slope habitat, high suitability habitat, and historical database records from the continental margin, while the 300 meter zone encompasses 99% of the high slope habitat and 96% of the high suitability habitat, and many of the coral database records (88%). The other depth options are intermediate to these. The 600 meter zone, which has a boundary that falls between the 550 meter and 650 meter contours, encompasses 88% of the high slope habitat, 77% of the high suitability habitat, and 78% of the coral records along the continental margin.

When comparing across zones, the question becomes what is gained or lost by selecting shallower or deeper depths? In addition to less coverage of high slope habitat and other suitable habitats for soft corals at the deeper broad zone sites, dive transects conducted between the 600 m and 900 m zones confirm the presence of coral habitats in shallower areas. The remaining dive sites within the canyons occurred within the 900 m zone. More details about the observations during these dives are provided in section 6.2.3.1. The dive locations are mapped in the section describing canyon alternatives (section 4.2.2.1).

- Veatch Canyon – Cruise HB1204 (2012), Dive 8 occurred in the area between 600 m and 900 m zones. During this dive, only stony and soft corals were observed, and in a smaller percentage of the collected images compared with the other two dives in the canyon.
- Hydrographer Canyon – Cruise EX1304L1 (2013), Dive 6 occurred in the area between the 600 m and 900 m zones. During this dive, soft and stony corals were observed, including the stony coral *Lophelia pertusa*, which is relatively uncommon in New Engalnd.
- Dogbody Canyon – Cruise HB1504 (2015), Dive 1 occurred in the area between the 600 m and 900 m zones. Corals occurred but were uncommon at this site.
- Clipper Canyon – Cruise HB1504 (2015), Dive 19 occurred in the area between the 500 m and 600 m zones. Corals were sparsely distributed, but could be locally abundant where found.
- Sharpshooter Canyon – Cruise HB1504 (2015), Dive 16 occurred between the 600 m and 900 m zones, but no corals were observed.
- Welker Canyon – Cruise HB1504 (2015), Dive 13 occurred between the 600 m and 900 m zones. Corals were sparsely distributed, but could be locally abundant where found.
- Heel Tapper Canyon – Cruise HB1504 (2015), Dives 10 and 11 occurred beween the 600 m and 900 m zones. At the shallower of the two dives, corals were sparse although locally abundant, and at the deeper site just shoal of the 900 m boundary, corals were abundant.
- Oceanographer Canyon – A number of soft coral records collected with the submersible Alvin occur between the 600 m and 900 m zones
- Filebottom Canyon – Cruise HB1504 (2015), Dive 7 occurred between the 600 m and 900 m zones. Corals were common and locally abundant.
- Chebacco Canyon – Cruise HB1504 (2015), Dive 4 occurred between the 600 m and 900 m zones. Corals were uncommon.
- Gilbert Canyon – Cruise HB1204 (2012), Dive 19, Dive 17 and a portion of Dive 14 occurred between the 600 m and 900 m zones. Corals were uncommon at Dives 14 and 19, but were common at the shallower Dive 17.
- Lydonia Canyon – Similar to Oceanographer, submersible collections indicated that soft corals occur in the area between the 600 m and 900 m zones.
- Munson Canyon – Cruise HB1302 (2013), Dives 14 and 15 occurred on the east and west walls, respectively. Corals occurred along both transects, and were abundant at the east wall site, but not the west wall site.
- Nygren Canyon – Cruise EX1304L2 (2013), Dive 8 occurred between the 600 m and 900 m zones. Corals were present and there was a high diversity of fishes.

- Unamed Canyon – Cruise EX1304L2 (2013), Dive 10 occurred between the 500 m and 900 m zones. Corals occurred along the dive transect, including large colonies of *L. pertusa*.
- Heezen Canyon – Cruise EX1304L2 (2013), Dive 9 occurred between the 600 m and 900 m zones, at deeper depths, and corals were observed, including some very large colonies. During Cruise HB1402 (2014), at the Dive 1 site (depths of 569-668 m), vertical canyon walls were populated with numerous, large colonies of soft corals.

The extent to which these corals zones would be more precautionary, vs. displacing existing fishing activity that could be currently impacting coral habitats, depends on the zone. Based on the feedback provided during the workshops, there are no or very limited fishing activities currently occurring in the 900 m zone, and only red crab fishing occurring within the 600 meter zone. The red crab fishery is broad in geographic scope but limited in size (number of traps), so impacts to corals of continuing this fishery within any of the broad zone alternative would likely be low negative, and impacts of restricting this fishery would be slightly positive.

Additional types of effort including lobster trapping, trawling, and some gillnet and longline fishing occur within the 500 m, 400 m, and 300 m zones. Workshop participants suggested that deeper than 500 meters (within the 500 m but not the 600 m zone), only lobster trapping occurs regularly. All four gear types are used shallower than 500 meters, and would be displaced to an increasing extent by the 500 m, 400 m, and 300 m zones. This effort displacement would occur along the entire continental margin of New England, considering the spatial extent of these zones. Thus, designation of shallower broad zones at 300 m, 400 m, or 500 m would have positive impacts on coral habitats occurring with the zones. As these zone boundaries increase in depth, coral habitat protected decreases.

7.3.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.3.3 Impacts on human communities

Under this alternative, a broad coral zone would be established along the southern margin of Georges Bank, with five depth options and options for which gear types would be precluded from the zone. This alternative would be additive to No Action (Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the broad coral zones on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. Option 1 (300m zone) would be substantially more constraining than Option 5 (900m zone). These negative impacts would be additive to the negative fishery impacts of No Action. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.3.3.1 Fishery impacts

Relative to the No Action areas, the broad zones encompass a greater fraction of the continental slope and canyon region south of Georges Bank. Due to data limitations, it is impossible to know the true amount of fishing activity that has occurred within the broad zone areas. Thus, multiple approaches are used to estimate fishing activity, and thus characterize the potential fishery impacts of this alternative.

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the broad zone areas. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2).

As expected, the broad zones encompass a larger number of gear types and species, and encompass additional revenue. As for the No Action areas, bottom trawl, lobster pot, other gear, and scallop/clam dredge gears are the major revenue generators in these areas. Longline gear is also represented in the broad zone data and encompasses enough vessels that confidentiality concerns do not preclude reporting, as with the No Action zones. The 'other gear' category shows a spike in 2014, which is due to increased revenue from red crabs.

Total revenue. Total annual revenue estimates are about $10-15M for the 300 meter zone, depending on the year (Figure 16).

Revenue by gear type. The majority of the revenue is attributed to lobster pot gear. While most of the value is likely due to lobster, this lobster pot revenue also includes other species such as Jonah crab landed with lobster pots. In the 300 meter zone, lobster gear revenue is $5-7M per year, followed by bottom trawl revenue (around $4-5M per year). The relative proportions are similar across the five broad zones, with total revenue declining from the 300 meter zone to the 900 meter zone. In the 300 meter zone, scallop gear and clam dredges contribute approximately $2-3M in revenue during most years. These values decline slightly in as the zones become progressively deeper. Neither of these species occur at any abundance at the water depths found in any of the broad zones (minimum of 250 meters for the 300 meter zone). Thus, the revenues attributed are expected to be generated in shallower waters, but attributed to the broad zones due to spatial imprecision in the VTR data. There is also uncertainty in the depth contours in a few locations, in particular just west of the EEZ boundary, but the imprecision in the VTR data is likely the more important reason for the inference of dredge revenues in the broad zones. Maps of revenue by gear type and species are in section 0, beginning on page 338.

Trips and permits by gear type. Figure 21-Figure 25 (trips) and Figure 26-Figure 30 (permits) indicate the amount of fishing activity and vessels overlapping the broad zones. As for the revenue data, bottom trawl and lobster trap are the major gear types with overlap. In terms of number of trips, the two gear types are similar, but the lobster trips are attributed to fewer unique permits. About 50 lobster trap permits per year overlap the broad zones, and compared with about 100 bottom trawl permits per year during 2014 and 2015.

A few hundred trips per years taken with scallop gear, clam dredge, and sink gillnet overlap the broad zones. These overlaps may be due to a small portion of the estimated footprint of the trip overlapping with the coral zones. Separator and Ruhle trawls, bottom longlines, and other gears have smaller degrees of overlap. Since 2012, the number of scallop permits with inferred revenues in the broad coral zones is around 200 permits annually. This indicates that a substantial fraction of the fishery (which currently has around 350 full-time-equivalent permits) operates in the vicinity of the coral zones.

Revenue by species. Figure 31-Figure 35 break down the estimated revenues in each zone by species. The largest revenue estimates are associated with lobster, crab (Jonah and red), silver hake, longfin squid, and sea scallop. Other species include butterfish, summer flounder, haddock, and monkfish. All species show some interannual variation. Revenue from butterfish are only notable during the years 2013-2015, and as noted previously, there was a spike in crab revenue during 2014, which can be attributed to red crab. While total revenue across all species declines from the 300 meter to the 900 meter zones, the relative proportions by species are similar. This finding is consistent with the revenue by gear type analysis.

Percent owner revenue: Across all five broad zones, median percent annual revenue at the owner level hovers around zero. However, there are outliers, regardless of zone depth, whose inferred percent annual revenue values are between 5-10%; over 60% in a few cases. Again, while the large revenues attributed to even the 900 meter broad zone indicate clearly that the VTR data are spatially imprecise, these large percentages do indicate that, at the owner level, there are some fishing businesses that focus a significant fraction or even a majority of their annual effort in the vicinity of the coral zones.

VTR vs. VMS comparison. Two tables were prepared to compare between VTR and VMS data:

- Table 43 – Percentage of VTR trips overlapping the broad and discrete coral zones south of Georges Bank that have VMS coverage, by gear type.
- Table 44 – VMS estimates of effort (total hours fished, trips, and permits) within the broad and discrete coral zones south of Georges Bank, by gear category.

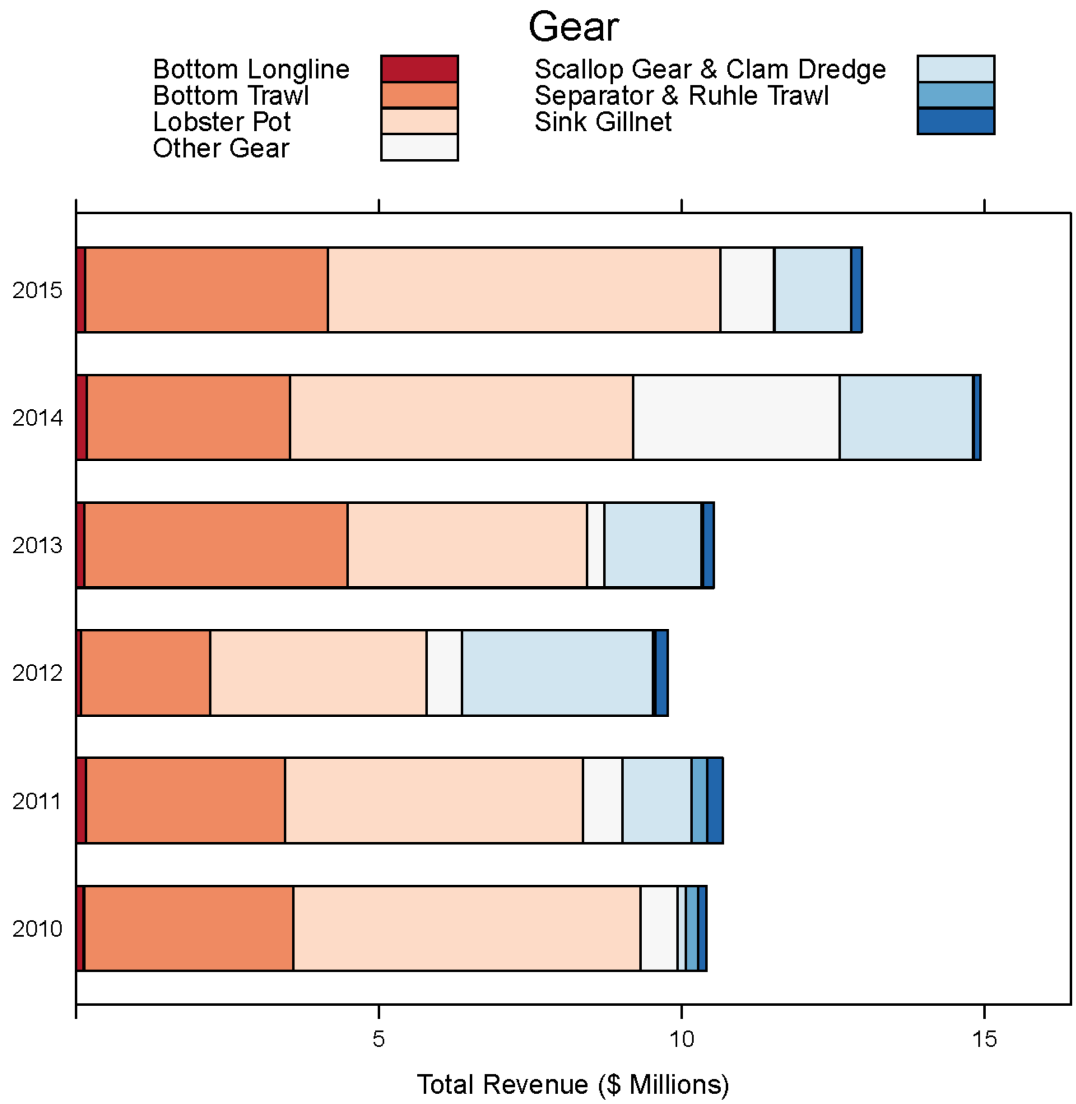
These tables includes data for all discrete canyons in combination in the last column. In general, VMS coverage is good for trawls and dredges, and poor for traps and other gears (Table 43). For bottom trawls, the VMS data suggest a much steeper decline, in terms of hours fished, when compared with the decline shown in the VTR. This is very likely due to the spatial imprecision of the VTR, which does not support differentiating areas with boundaries so close together. VMS estimates of scallop dredge hours fished are very low in all broad zones, despite relatively substantial revenue estimates in the VTR data. Given the complete VMS coverage in the scallop fishery, this suggests that the broad coral zones are not actually important scallop grounds, but rather, lie adjacent to fishing grounds in shallower water on Georges Bank. Pot/trap effort also shows a fairly steep decline across the 300-900 meter zones in the VMS data, but sample sizes are fairly small, so it is difficult to ascertain whether these results apply more broadly across all fishermen using traps, including those whose vessels do not have VMS polling.

Figure 41 through Figure 45 present the percentage of a permit's VMS-derived effort calculated to occur within each broad zone. Given the high VMS coverage for bottom trawl, scallop & clam dredge, and separator and Ruhle trawls in this region, the estimates of fishing activity exposed for these gears are better assessed through VMS rather than VTR. Due to the low coverage of lobster pot fishing in the region, the VMS provides a lower bound, while VTR provides an upper bound, on the uncertainty regarding the trips and permits historically fishing within the broad zones under consideration. For sink gillnets and bottom longline, only the VTR analysis is currently available.

Some differences between these results and those presented in Figure 36 through Figure 40 would be expected, given the latter are calculated at the owner group level, which can include multiple permits. For the 300 m broad zone, the VTR analysis indicates that the vast majority of owner groups have less than 5 percent of their revenue exposed to this alternative between 2013 and 2015, although some owners are exposed at a much higher level. A comparison with the VMS analysis of permit-level effort exposed to the management action seems to indicate a somewhat lower level of dependence on this region for 2005 – 2012, except 2008 which is more consistent with the VTR. Given the difference in time periods between the two metrics, it is unclear whether the difference is due to the fact that the VMS analysis only covers a sub-sample of the VTR (and potentially misses the individuals most intensively exploiting the region), or whether temporal shifts in exploitation are driving the results (with 2013 –2015 more akin to 2008 than other years in the analysis). Both analyses consistently indicate some small number of individuals highly exposed to this management alternative.

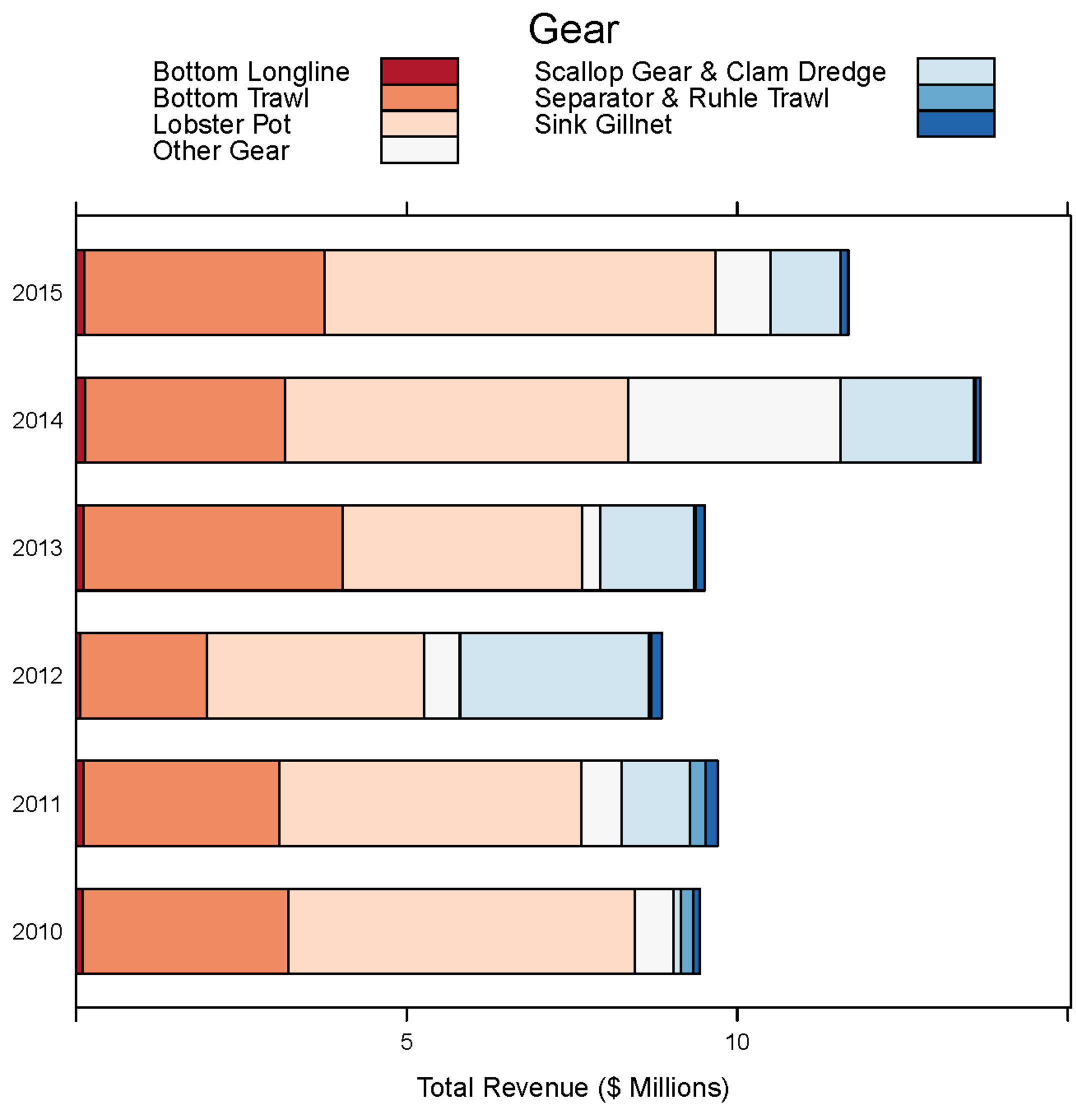
For the other broad zones under consideration, the VMS analysis indicates a much steeper decline in exposure across depth contours than the VTR. As previously stated, this result is driven primarily by the spatial imprecision of VTR data. However, the low coverage of lobster pot trips in the VMS analysis is a source of substantial uncertainty in regards to the overall exposure metric as derived from this dataset. Given the analysis presented by the ASMFC Lobster Technical Committee, there is some lobster pot effort expected, particularly between the 300m and 500 m broad zones. Nevertheless, the vast majority of impacts to the fishing industry would be expected to be mitigated by selection of the 600 m and 900 m broad zone alternatives.

Figure 16 – Revenue by gear type attributed to the 300 m broad coral zone, 2010-2015.



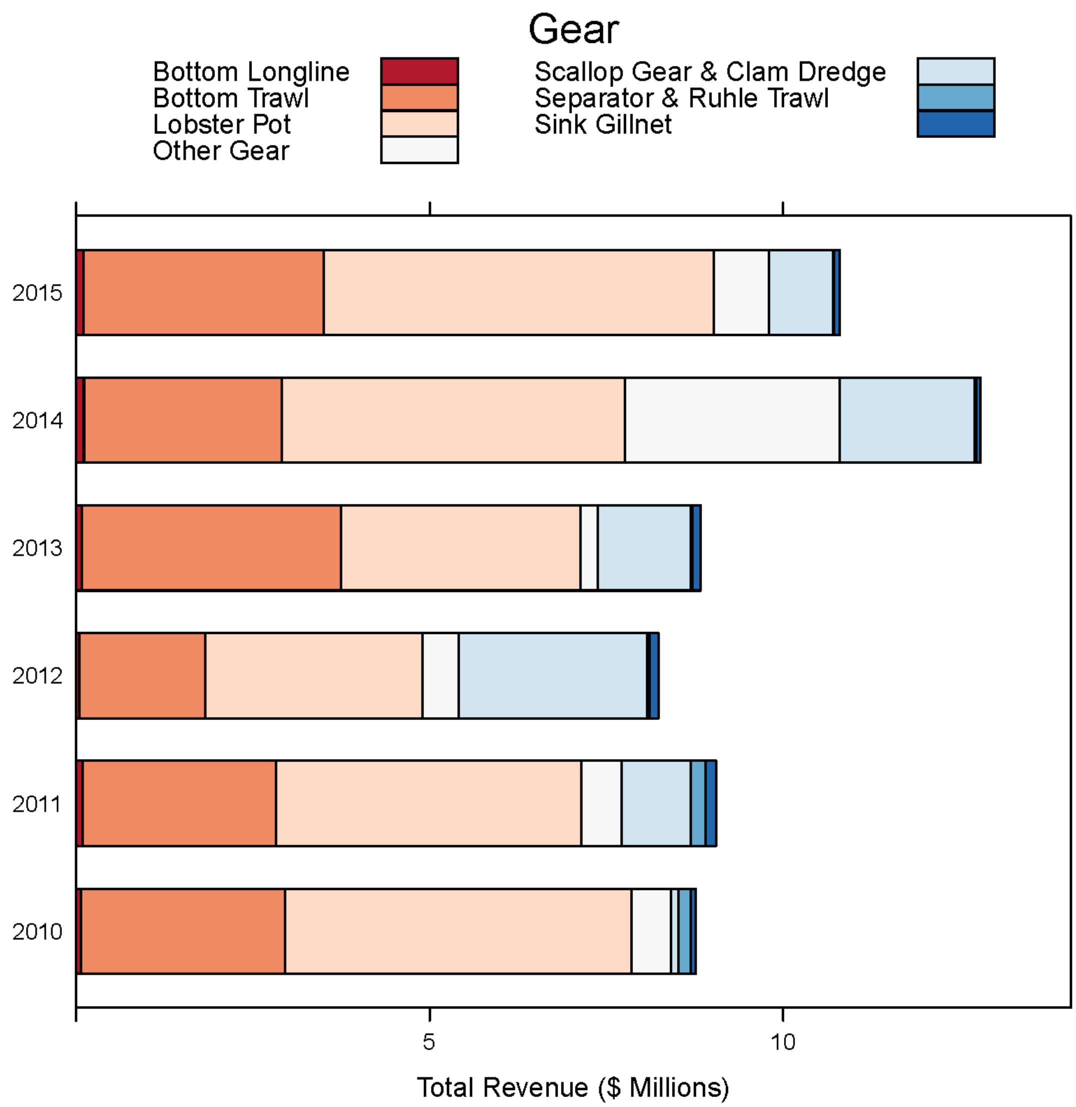
Source: **VTR analysis.**

Figure 17 – Revenue by gear type attributed to the 400 m broad coral zone, 2010-2015.



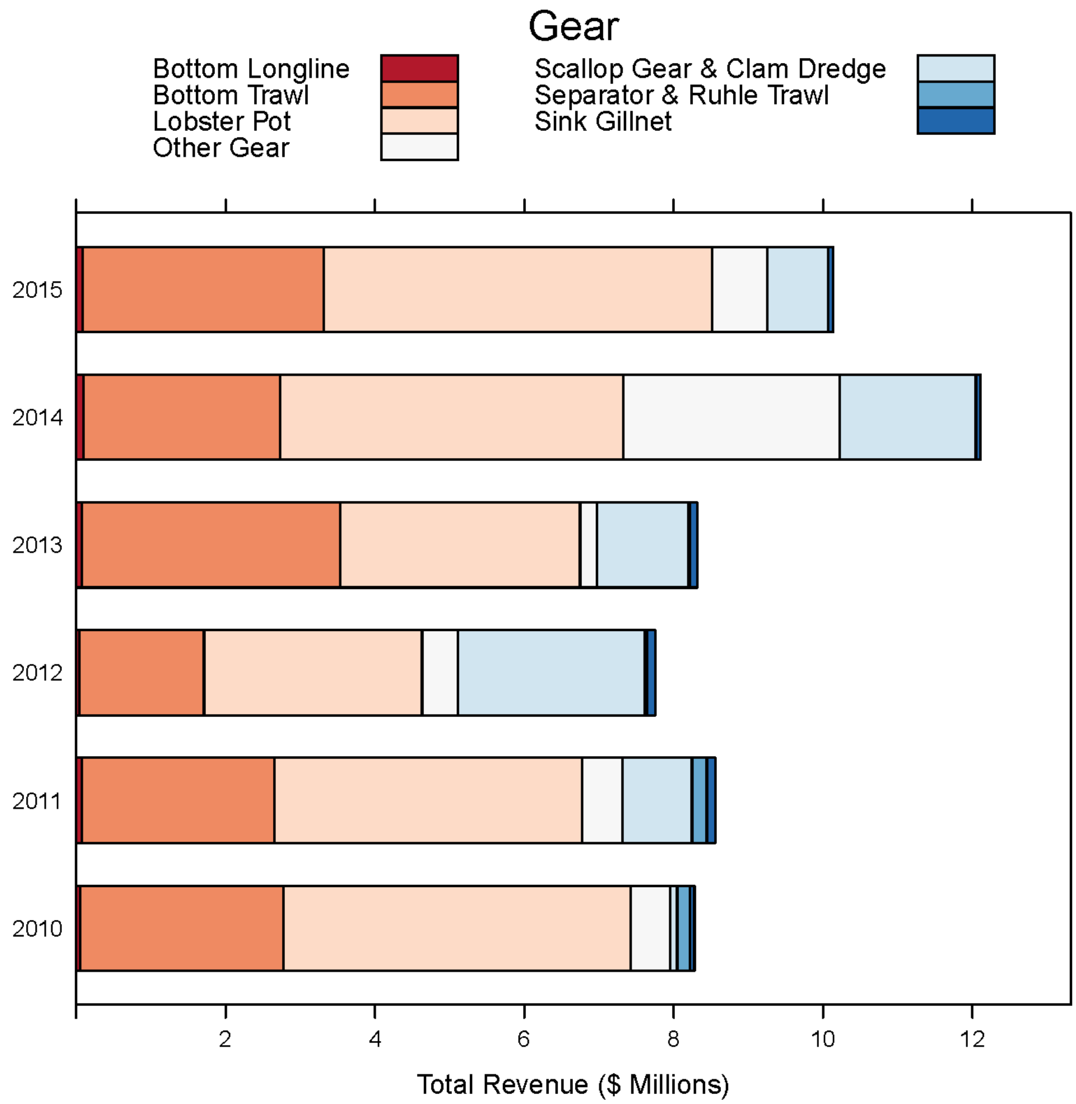
Source: **VTR analysis.**

Figure 18 – Revenue by gear type attributed to the 500 m broad coral zone, 2010-2015.



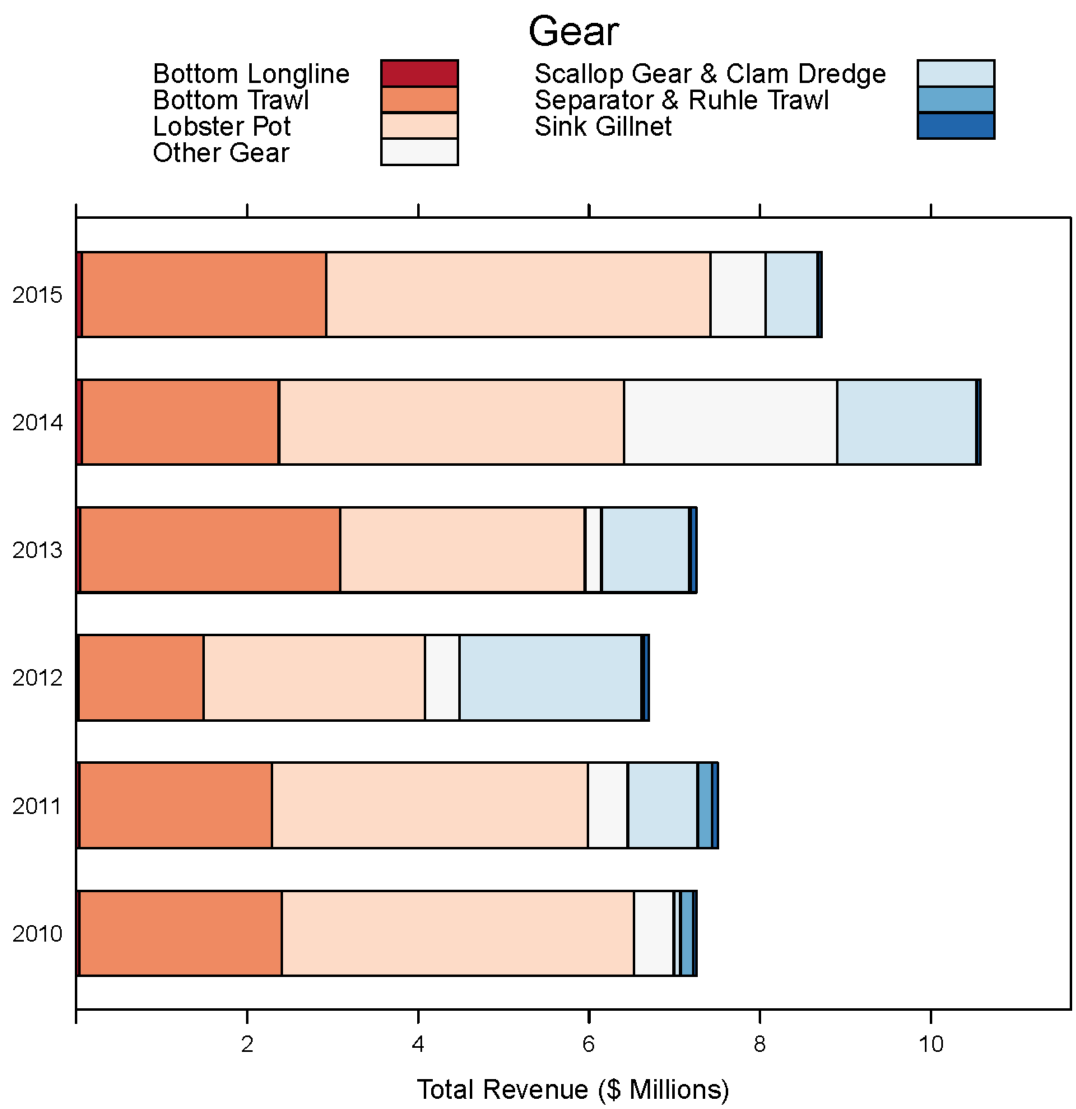
Source: **VTR analysis.**

Figure 19 – Revenue by gear type attributed to the 600 m broad coral zone, 2010-2015.



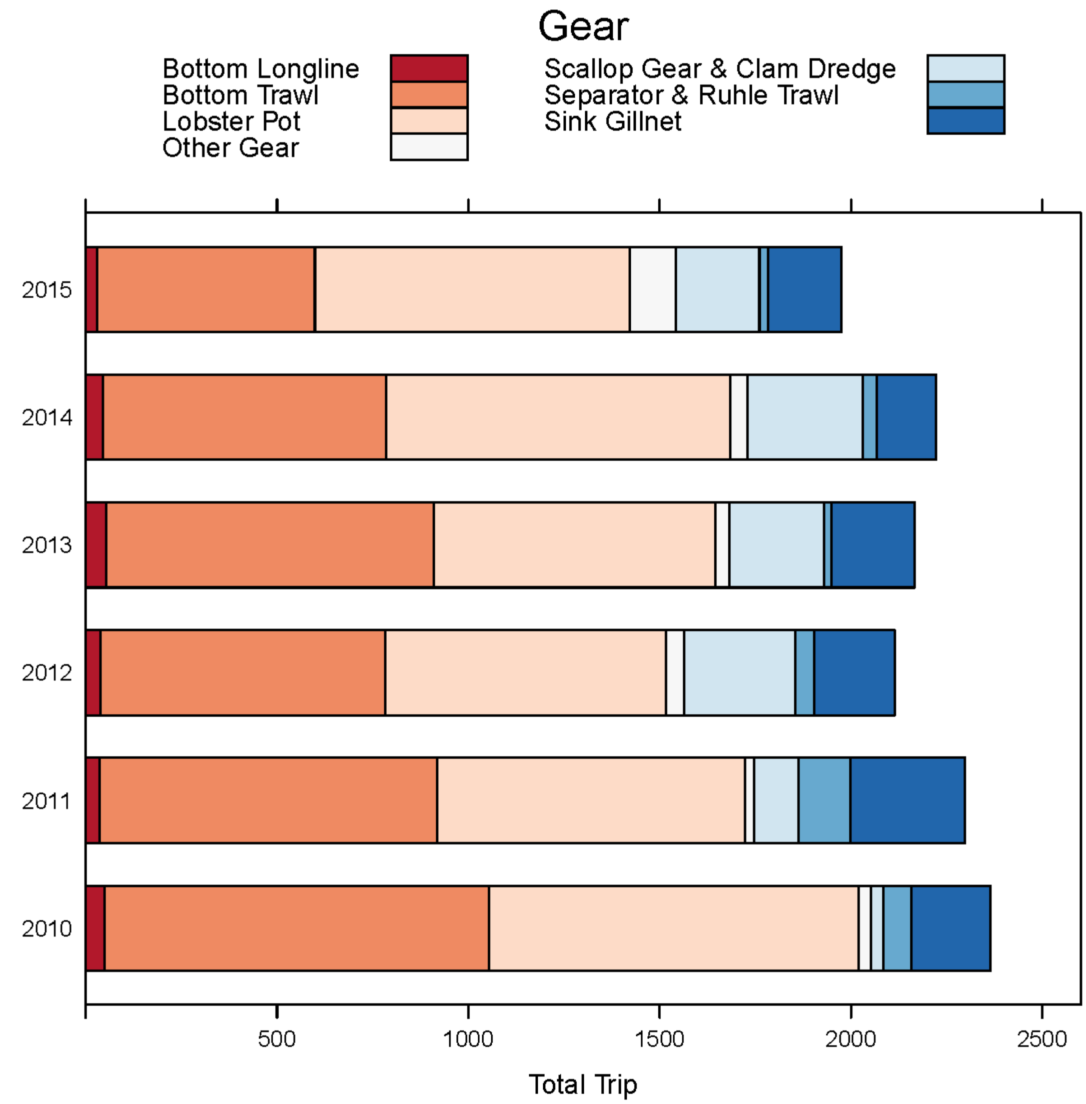
Source: **VTR analysis.**

Figure 20 – Revenue by gear type attributed to the 900 m broad coral zone, 2010-2015.



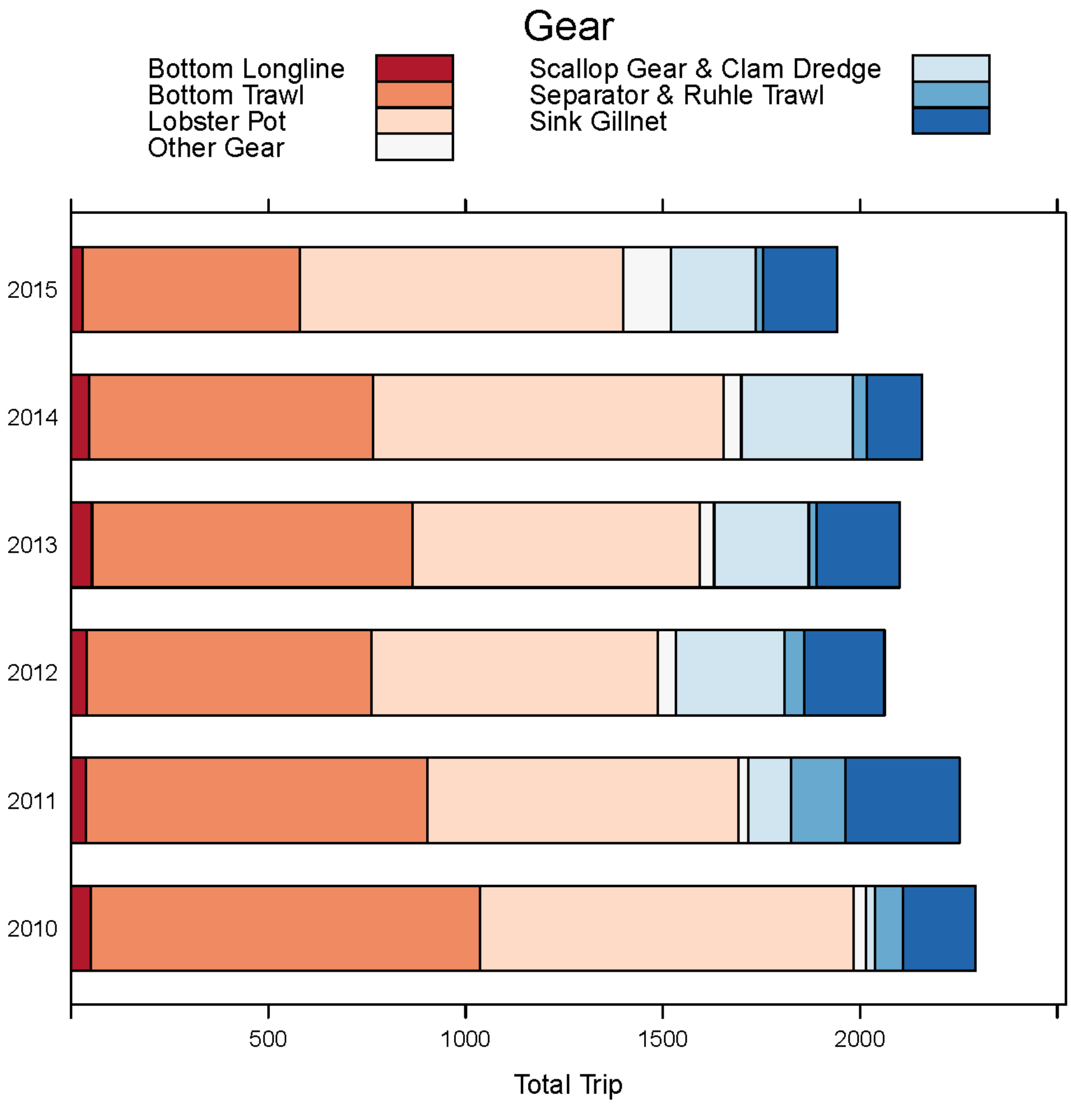
Source: **VTR analysis.**

Figure 21 – Trips by gear type attributed to the 300 m broad coral zone, 2010-2015.



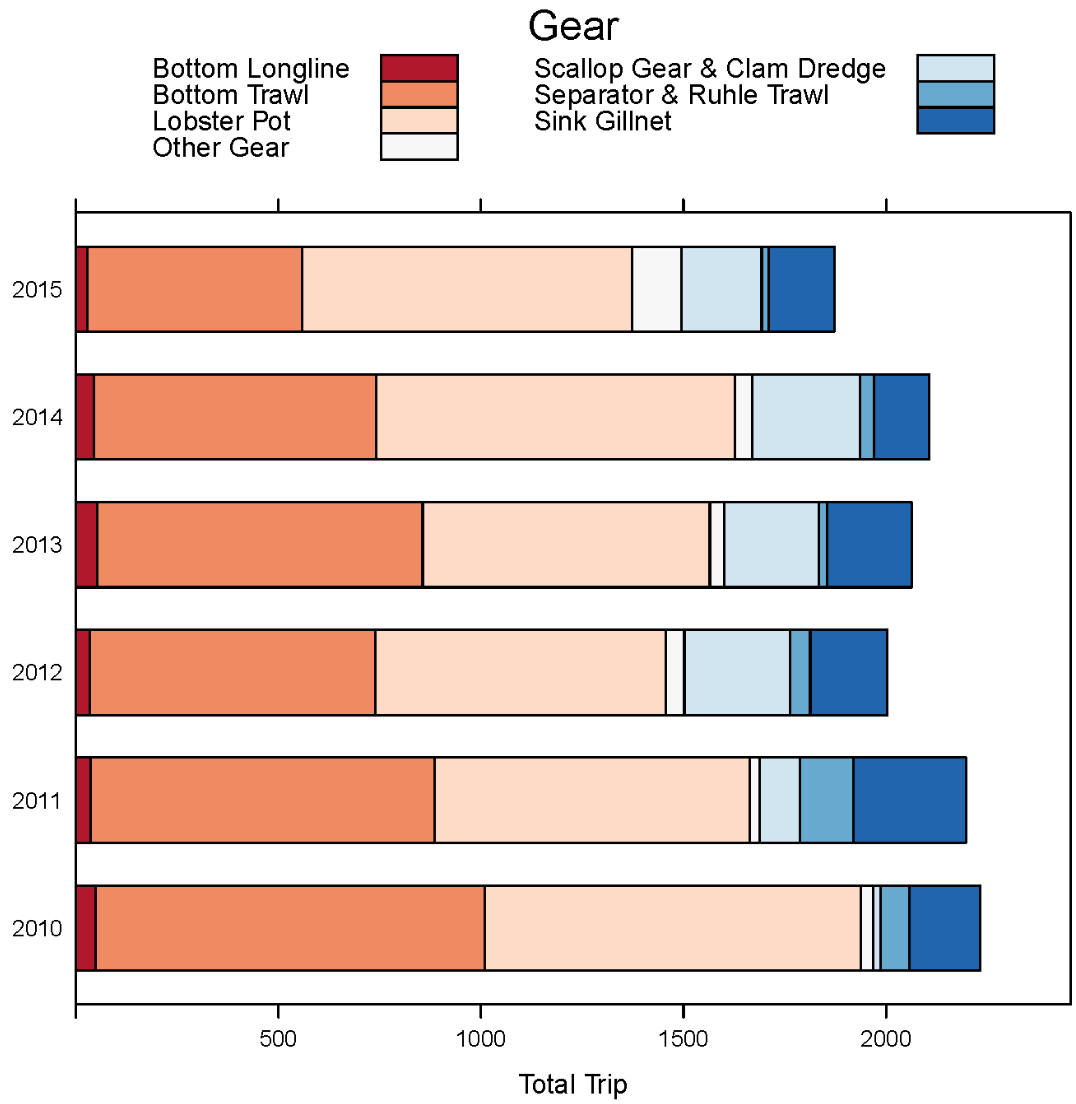
Source: **VTR analysis.**

Figure 22 – Trips by gear type attributed to the 400 m broad coral zone, 2010-2015.



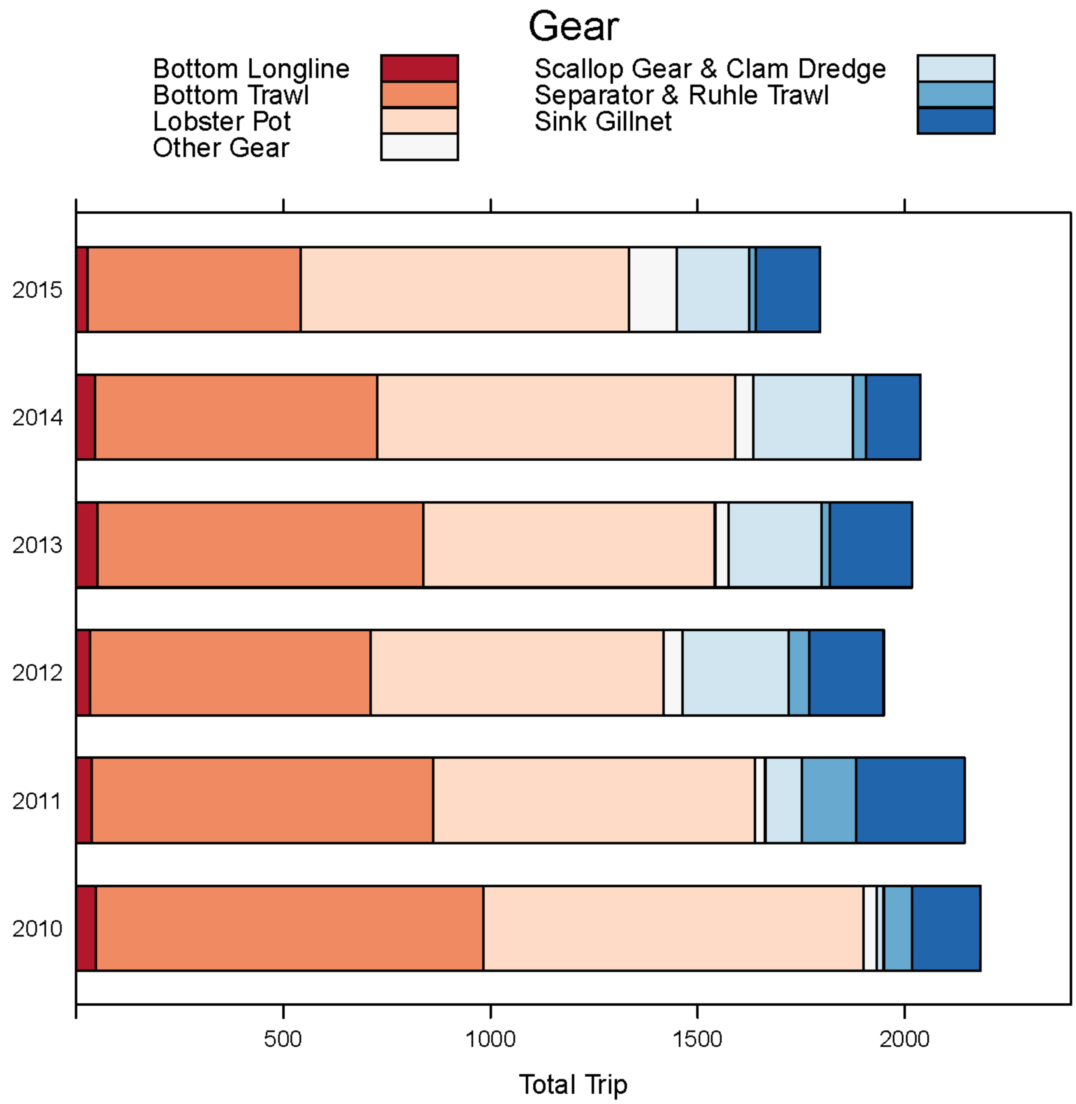
Source: **VTR analysis.**

Figure 23 – Trips by gear type attributed to the 500 m broad coral zone, 2010-2015.



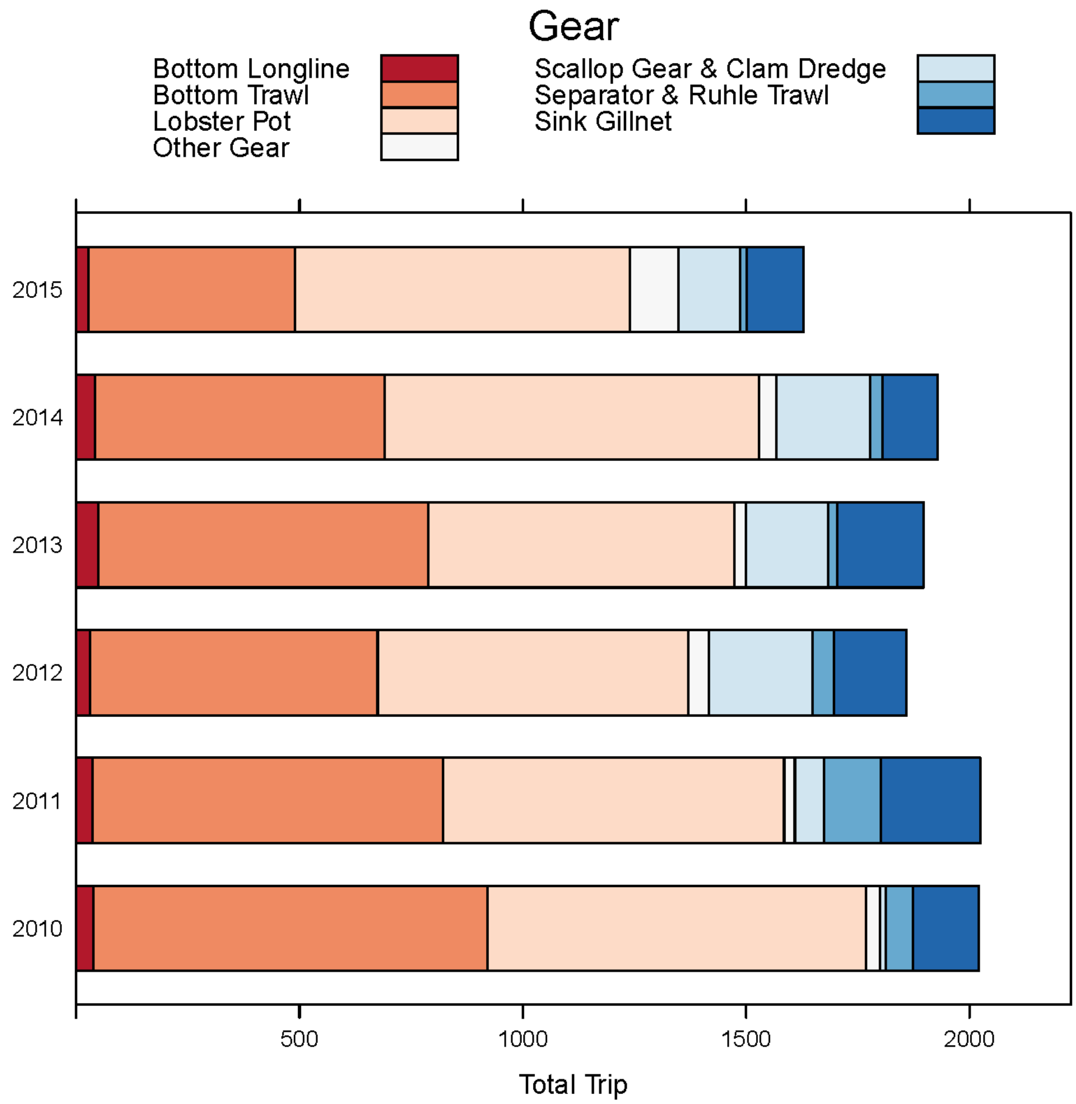
Source: **VTR analysis.**

Figure 24 – Trips by gear type attributed to the 600 m broad coral zone, 2010-2015.



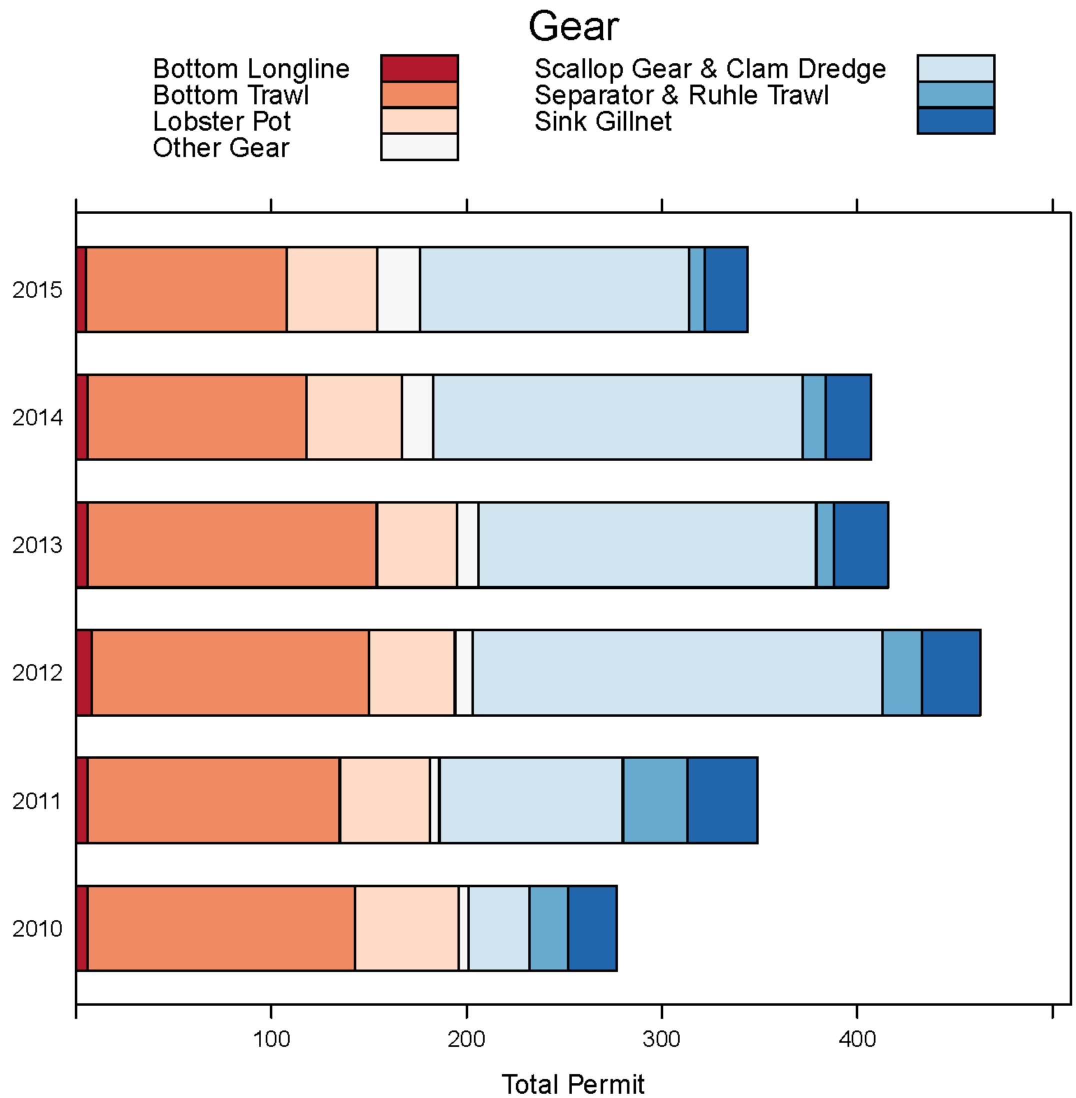
Source: **VTR analysis.**

Figure 25 – Trips by gear type attributed to the 900 m broad coral zone, 2010-2015.



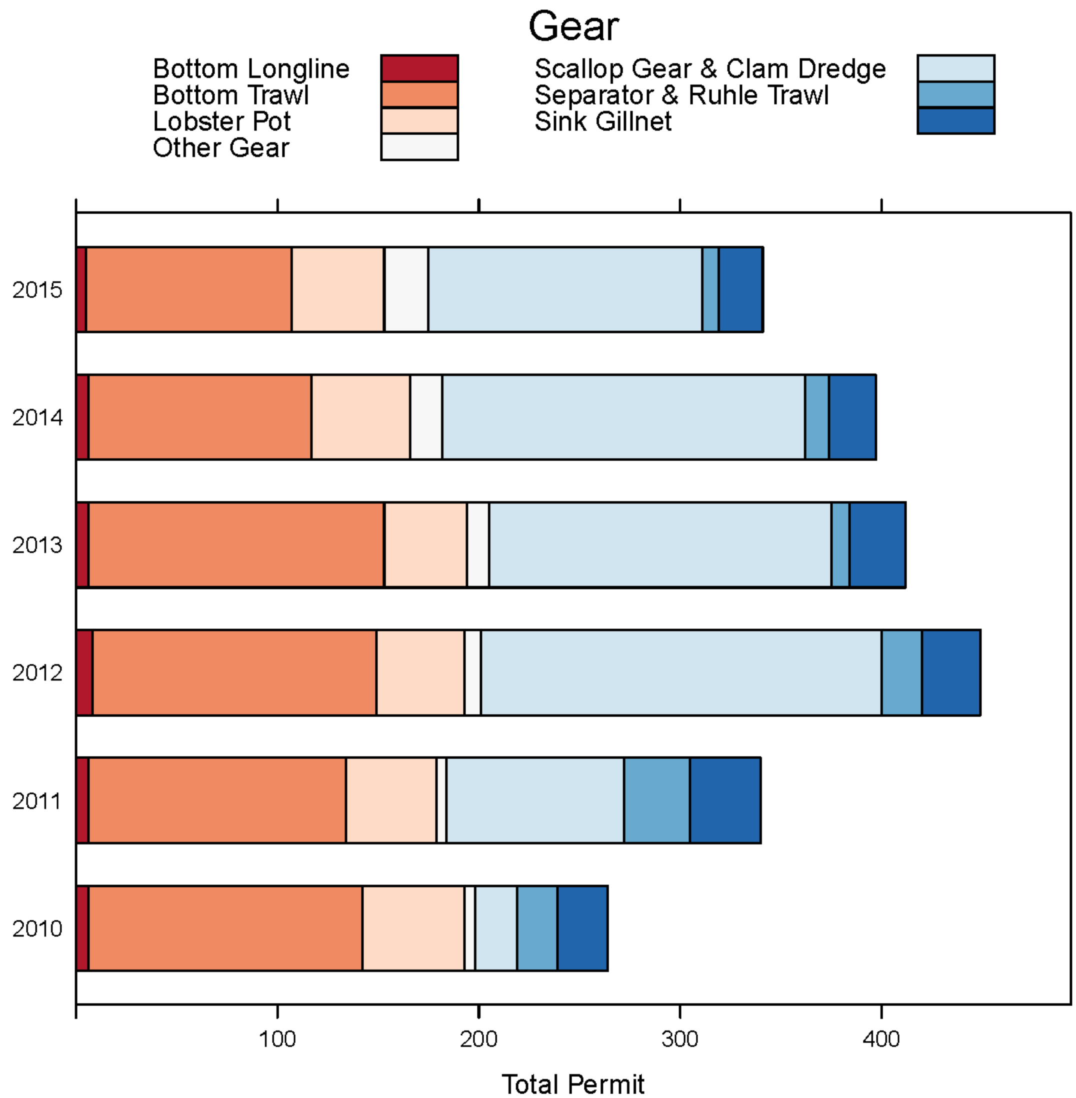
Source: **VTR analysis.**

Figure 26 – Permits by gear type attributed to the 300 m broad coral zone, 2010-2015.



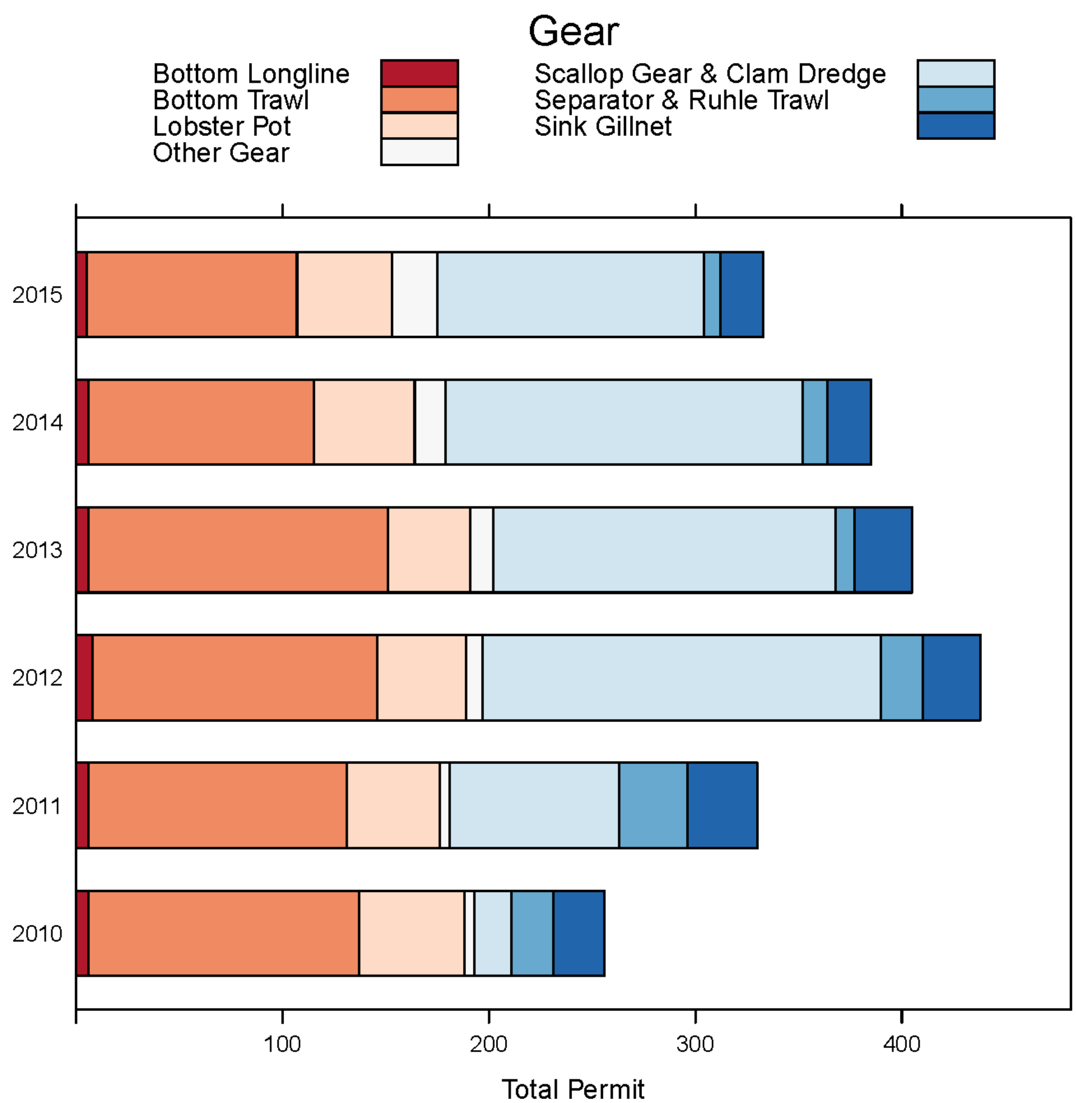
Source: **VTR analysis.**

Figure 27 – Permits by gear type attributed to the 400 m broad coral zone, 2010-2015.



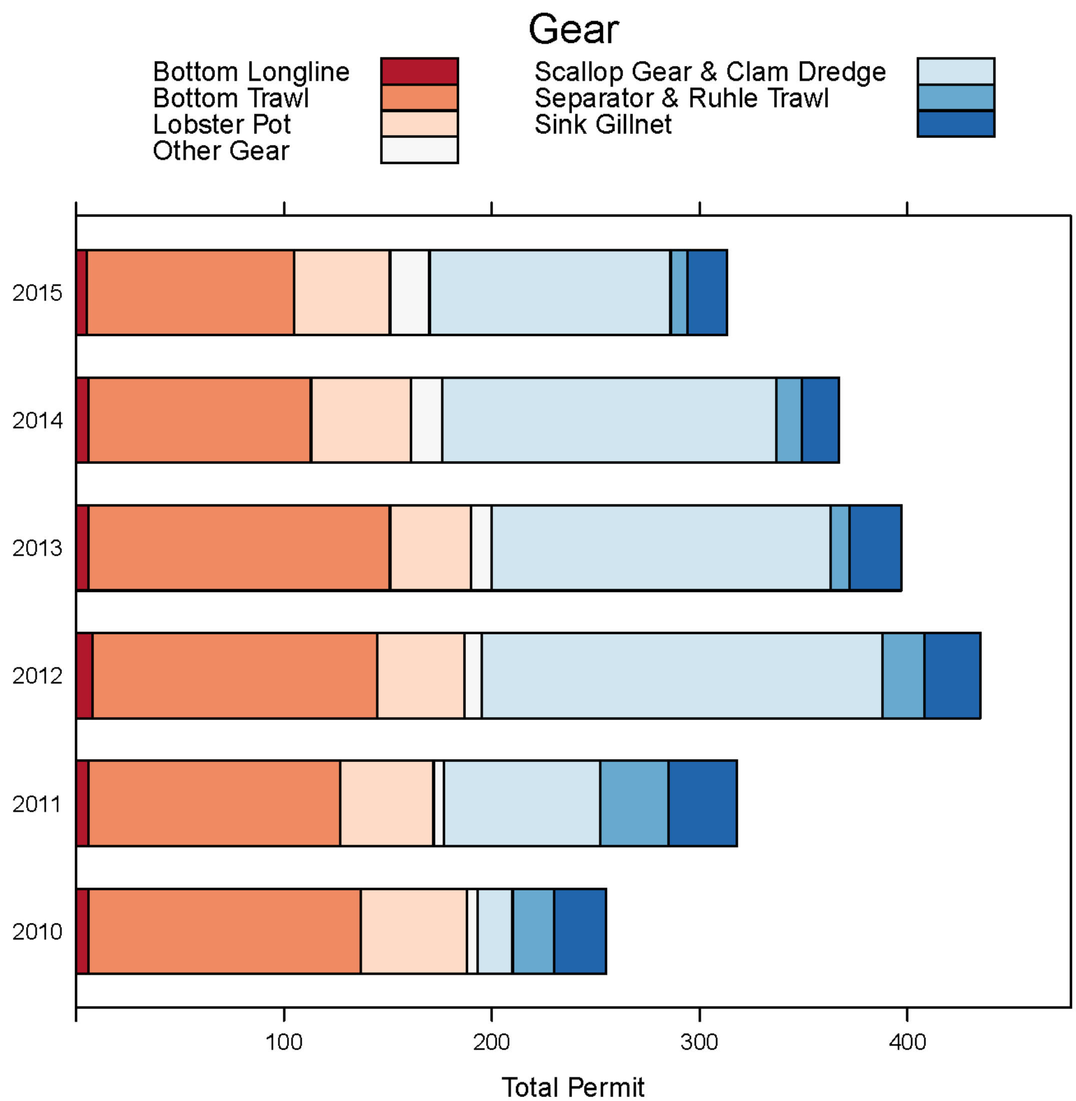
Source: **VTR analysis.**

Figure 28 – Permits by gear type attributed to the 500 m broad coral zone, 2010-2015.



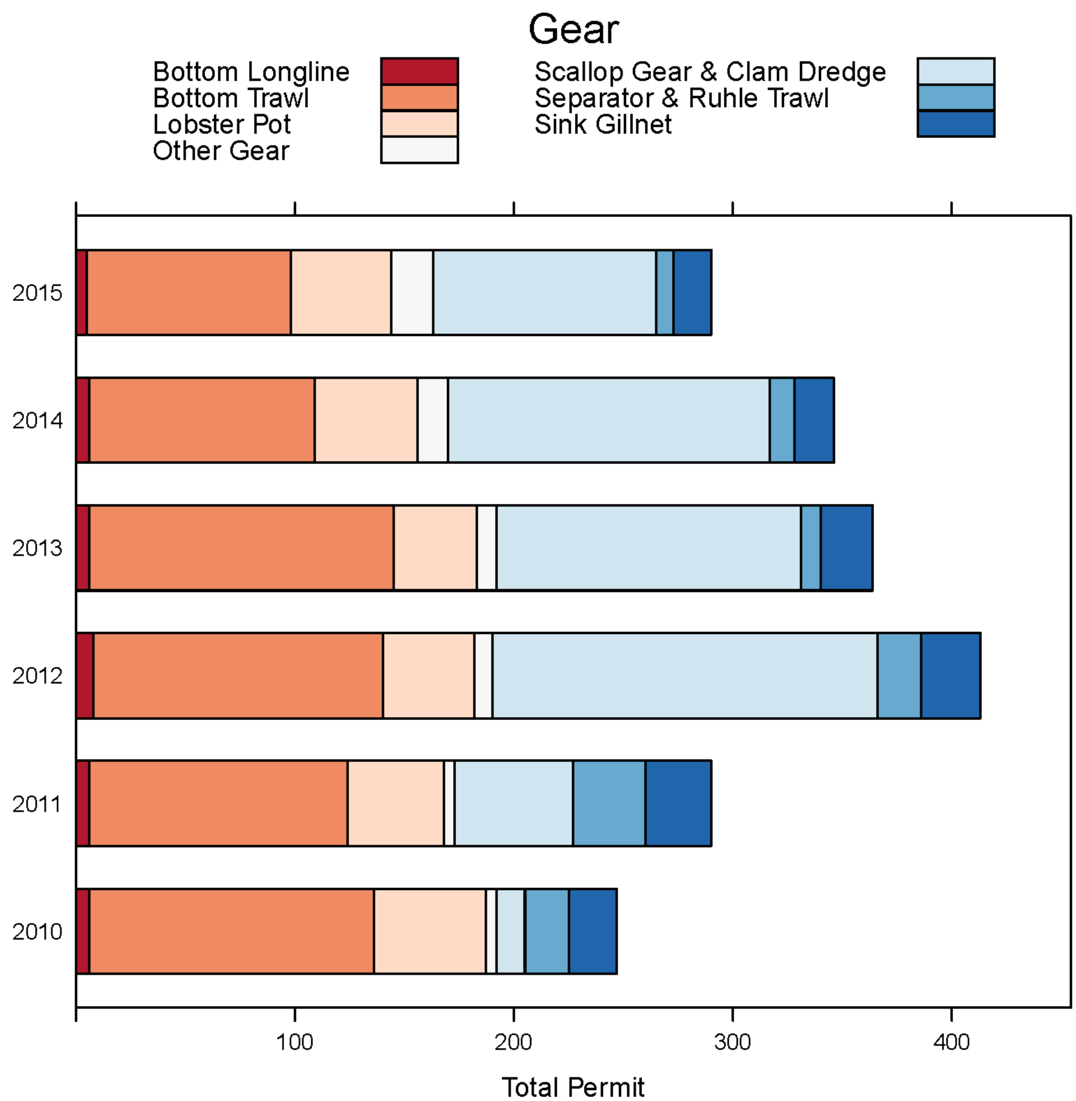
Source: **VTR analysis.**

Figure 29 – Permits by gear type attributed to the 600 m broad coral zone, 2010-2015.



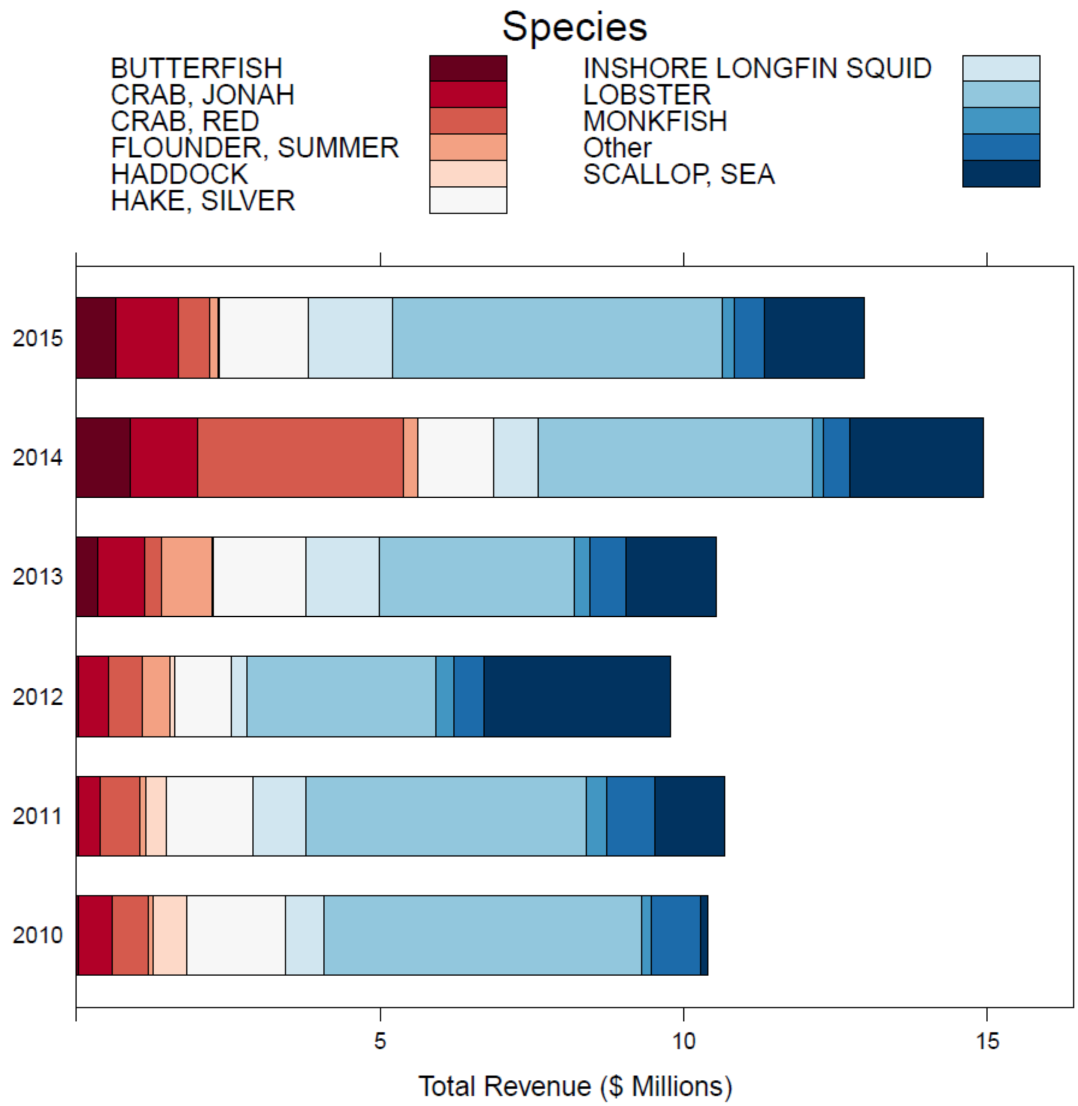
Source: **VTR analysis.**

Figure 30 – Permits by gear type attributed to the 900 m broad coral zone, 2010-2015.



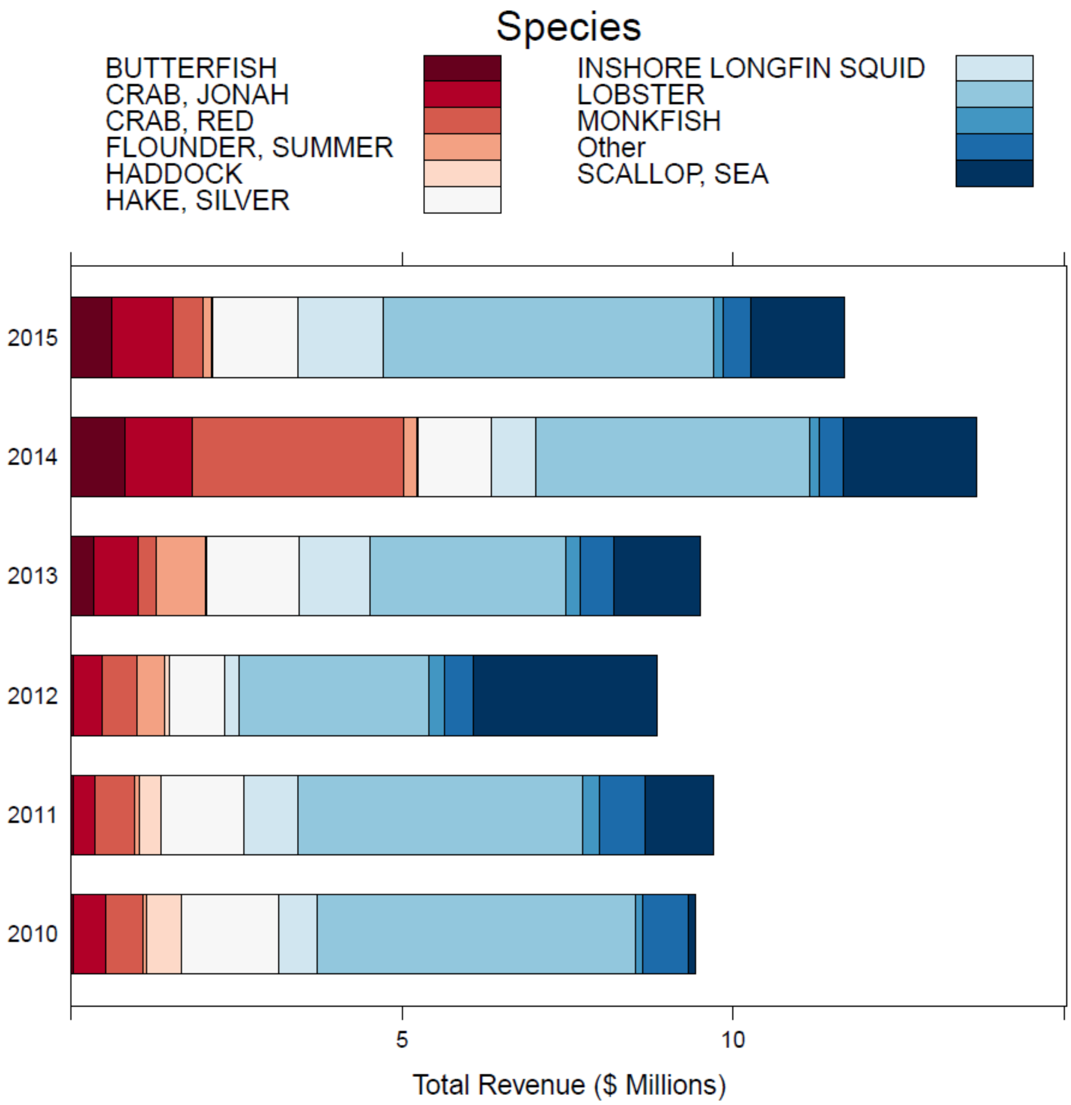
Source: **VTR analysis.**

Figure 31 – Revenue by species (top 10) attributed to the 300 m broad coral zone, 2010-2015.



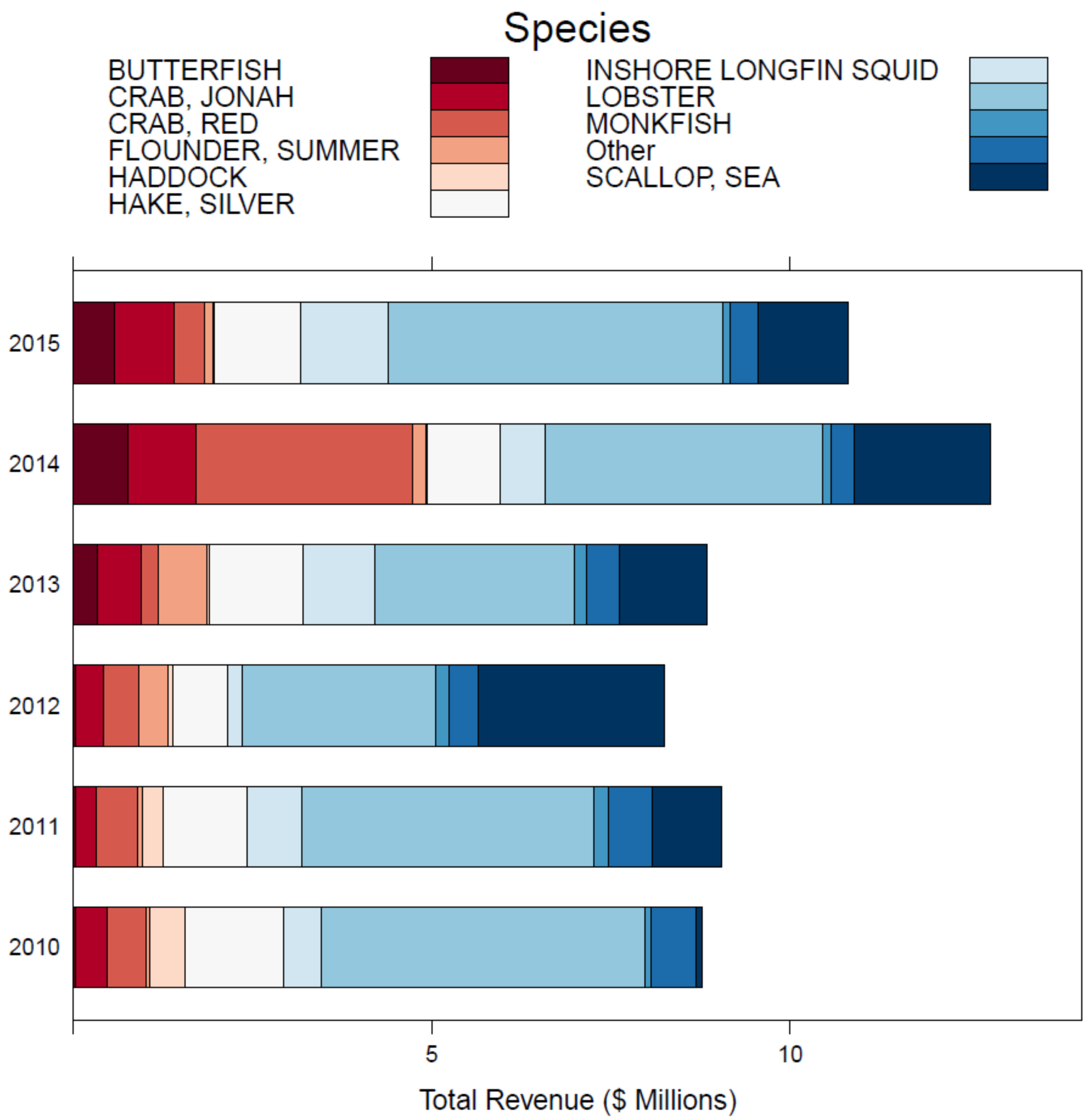
Source: **VTR analysis.**

Figure 32 – Revenue by species (top 10) attributed to the 400 m broad coral zone, 2010-2015.



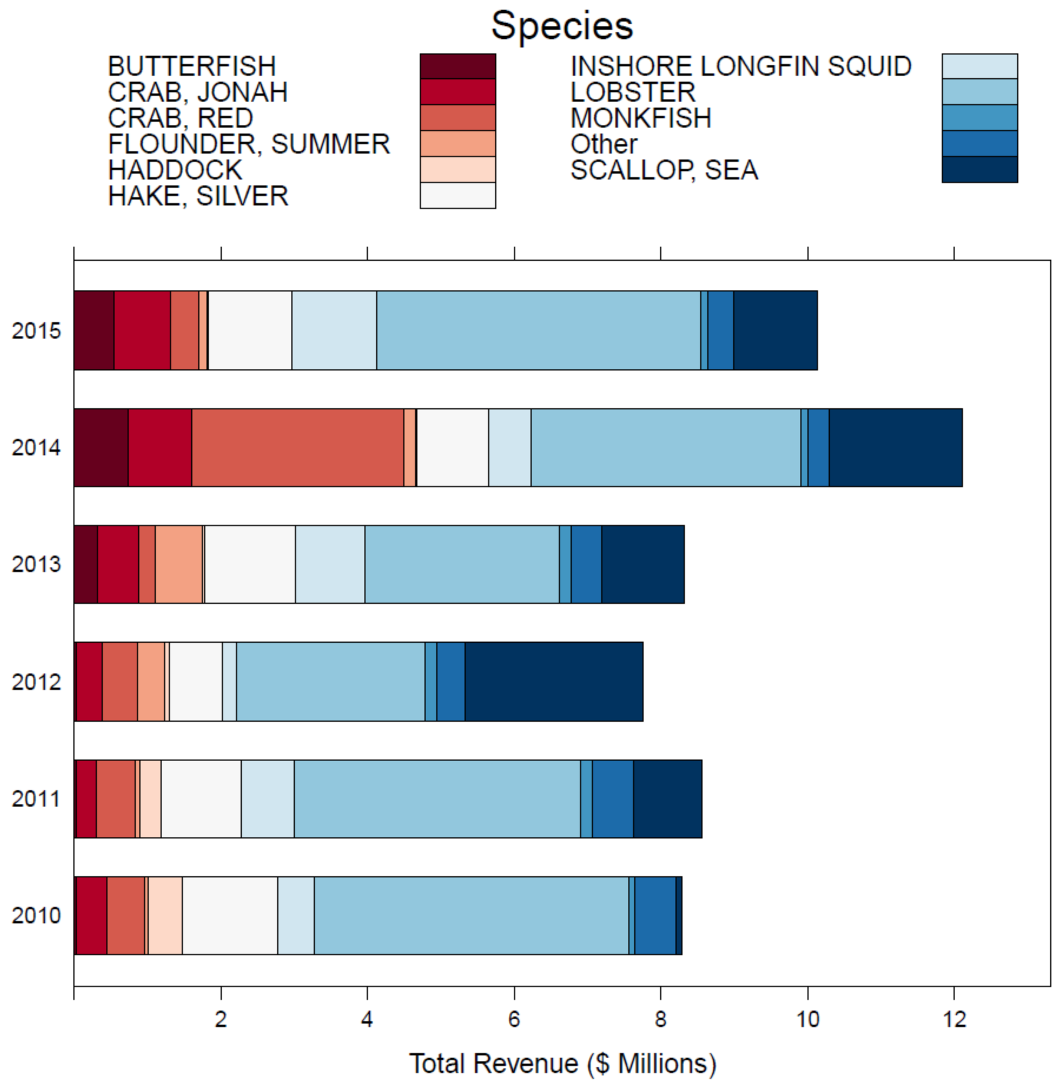
Source: **VTR analysis.**

Figure 33 – Revenue by species (top 10) attributed to the 500 m broad coral zone, 2010-2015.



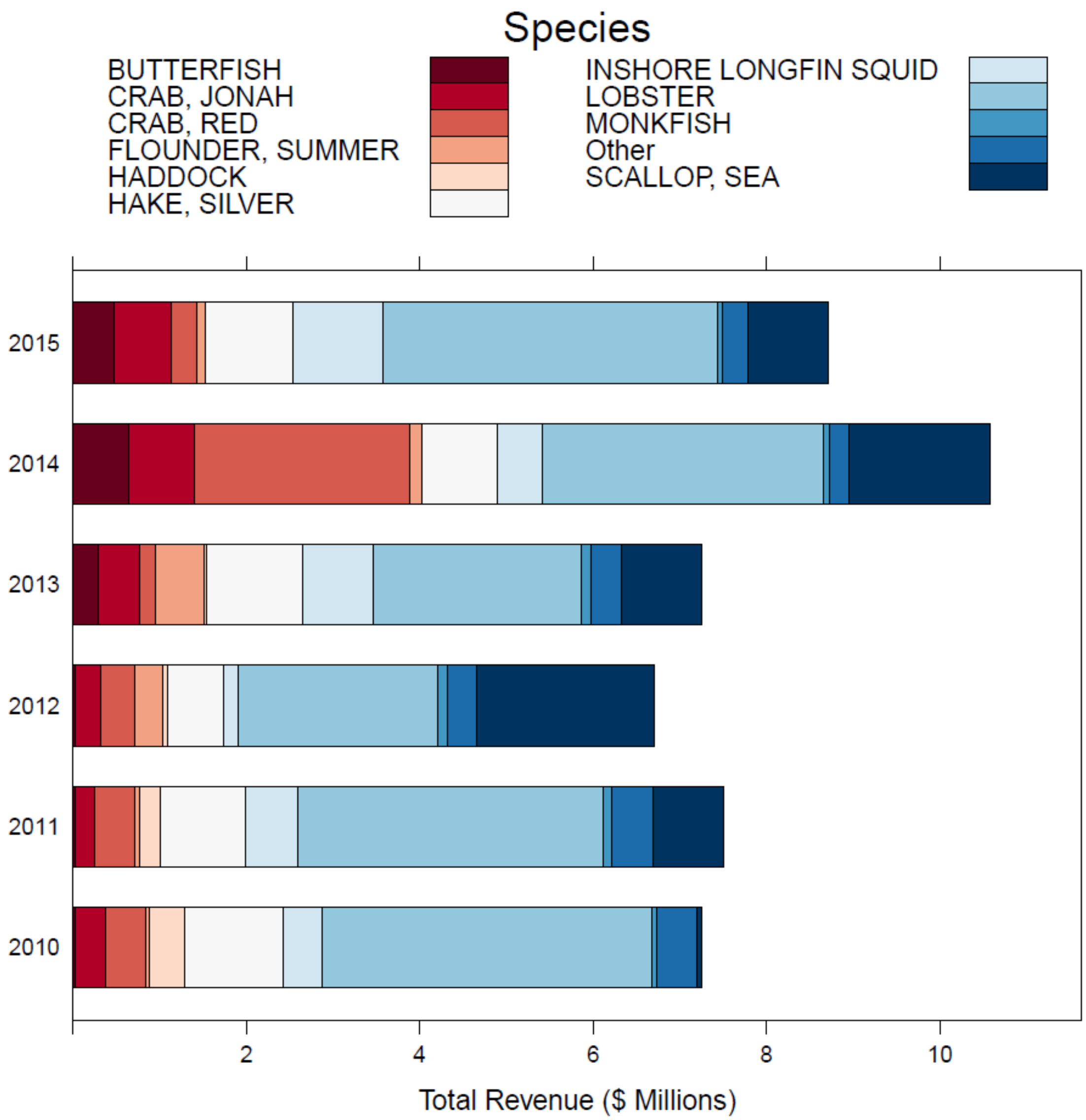
Source: **VTR analysis.**

Figure 34 – Revenue by species (top 10) attributed to the 600 m broad zone, 2010-2015.



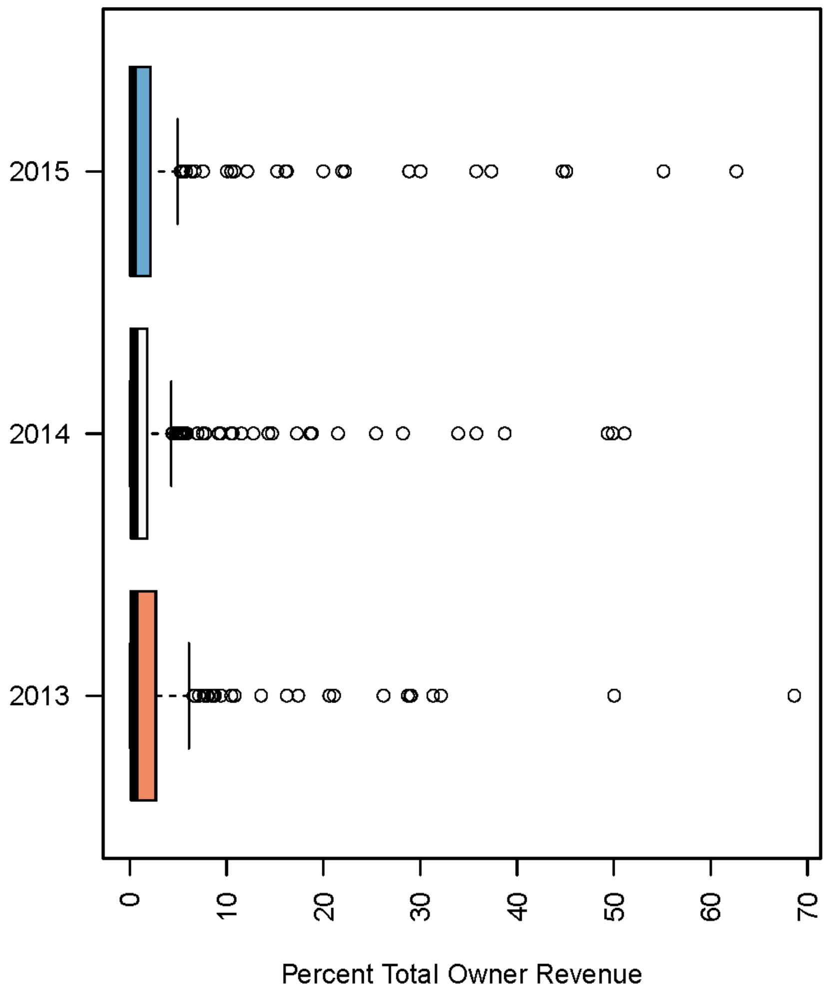
Source: **VTR analysis.**

Figure 35 – Revenue by species (top 10) attributed to the 900 m broad zone, 2010-2015.



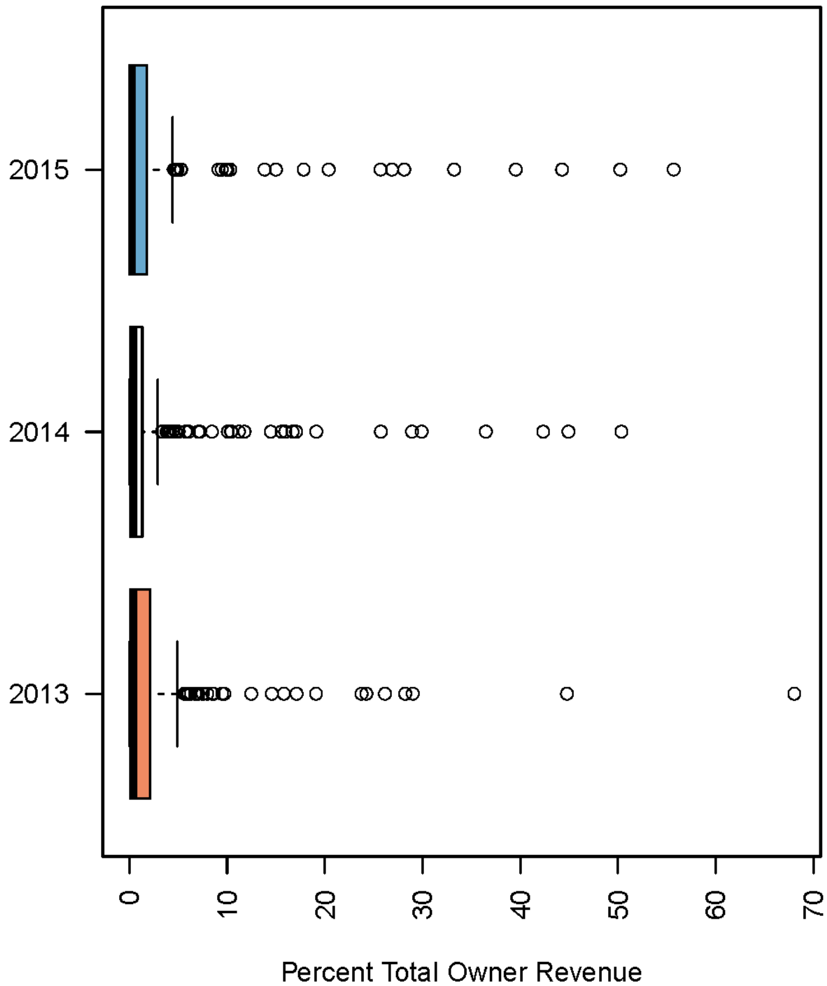
Source: **VTR analysis.**

Figure 36 – Percent of total owner revenue attributed to the 300 m broad coral zone, 2013-2015.



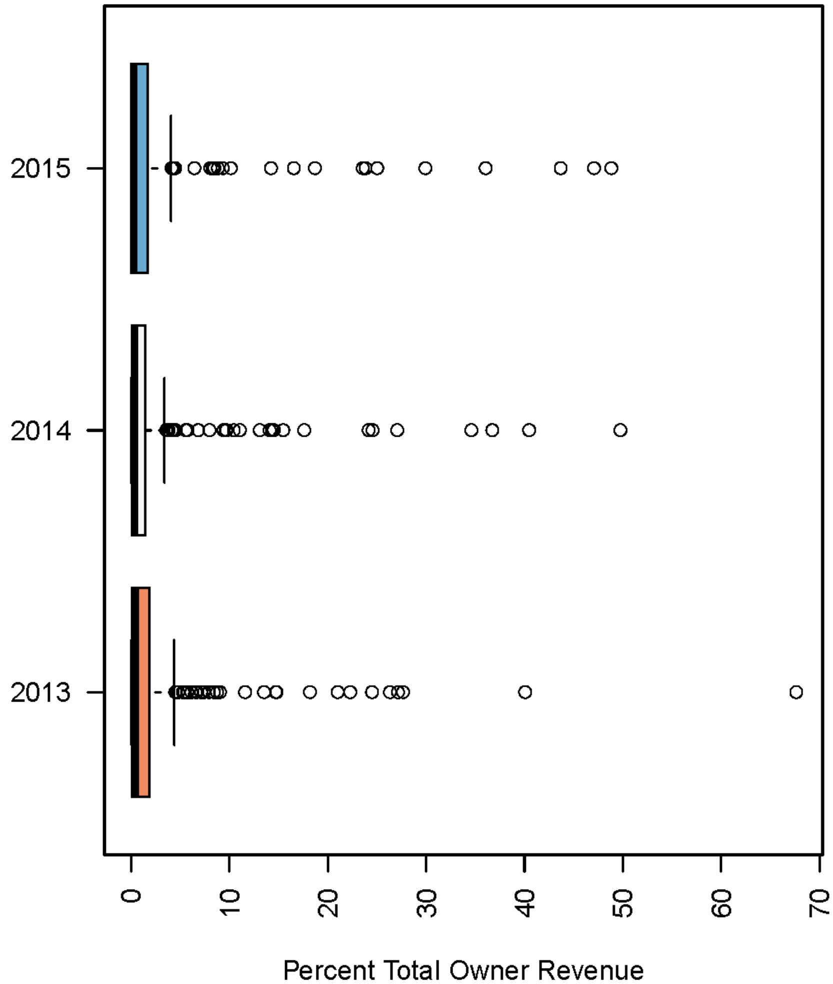
Source: **VTR analysis.**

Figure 37 – Percent of total owner revenue attributed to the 400 m broad coral zone, 2013-2015.



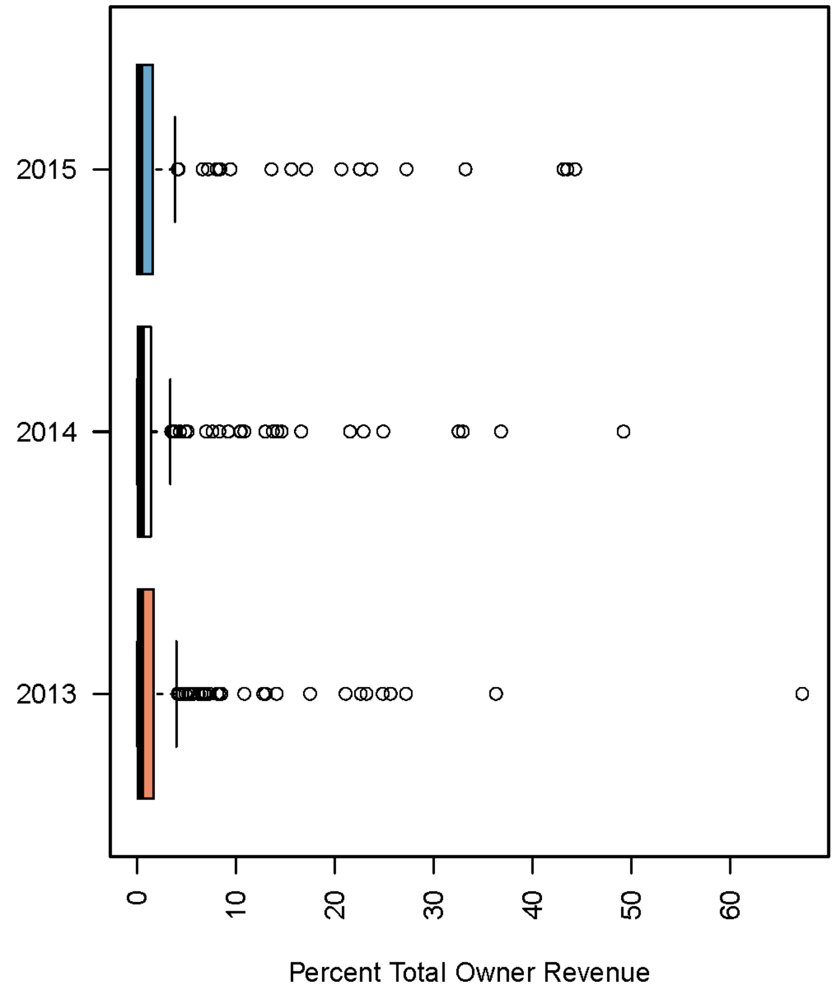
Source: **VTR analysis.**

Figure 38 – Percent of total owner revenue attributed to the 500 m broad coral zone, 2013-2015.



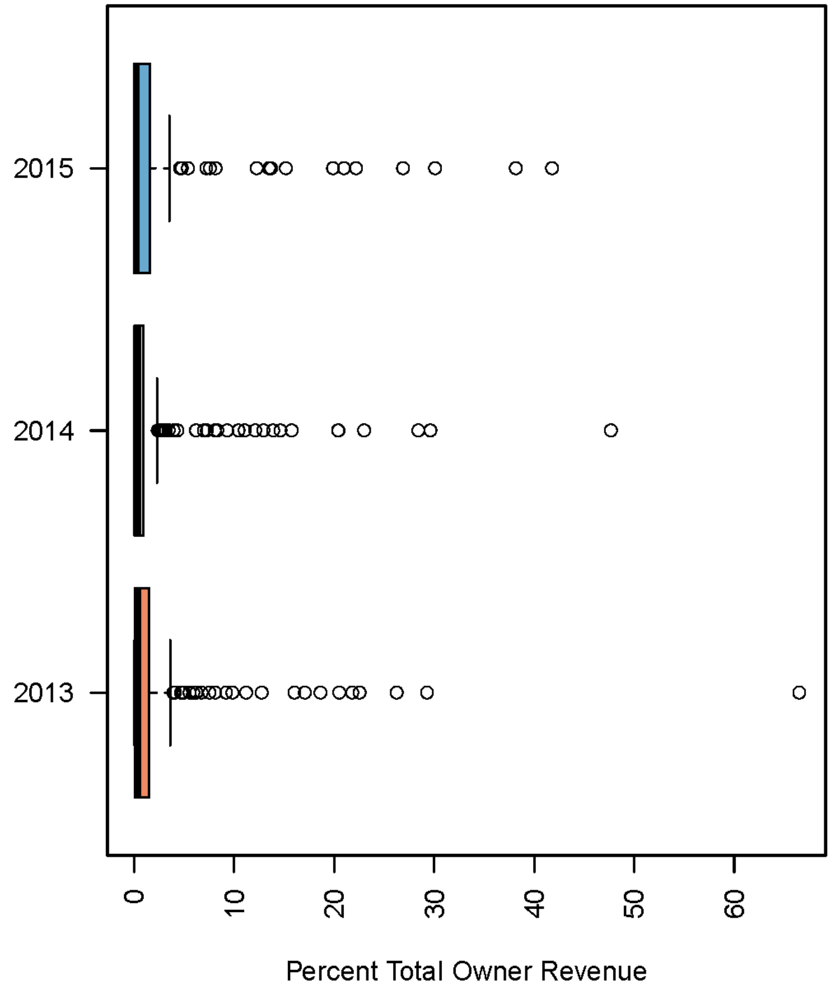
Source: **VTR analysis.**

Figure 39 – Percent of total owner revenue attributed to the 600 m broad coral zone, 2013-2015.



Source: **VTR analysis.**

Figure 40 – Percent of total owner revenue attributed to the 900 m broad coral zone, 2013-2015.



Source: **VTR analysis.**

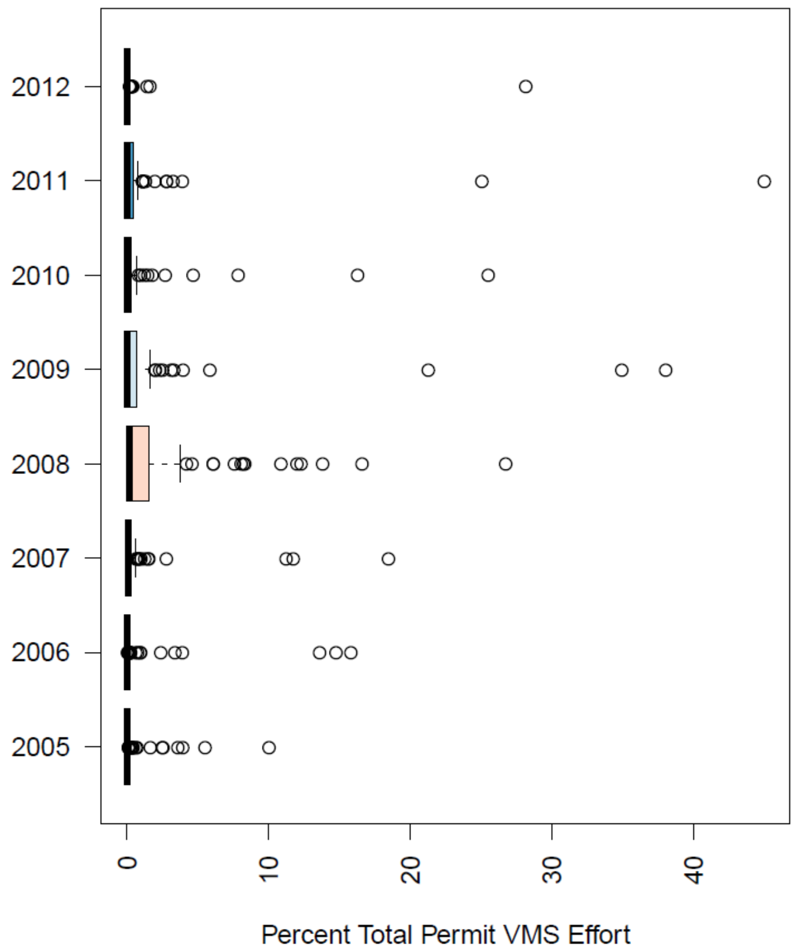
Table 42 – Percentage of VTR trips overlapping the broad and discrete coral zones south of Georges Bank that have VMS coverage, by gear type.

		300m			400 m			500 m			600 m			900 m			Discrete Canyons		
Gear	Year	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage
Bottom Trawl	2010	1005	946	94%	987	928	94%	961	903	94%	935	880	94%	882	832	94%	1004	945	94%
Bottom Trawl	2011	881	794	90%	867	785	91%	848	768	91%	824	747	91%	784	710	91%	863	779	90%
Bottom Trawl	2012	744	644	87%	723	626	87%	704	612	87%	678	589	87%	644	563	87%	731	632	86%
Lobster Pot	2010	965	144	15%	947	139	15%	928	137	15%	918	137	15%	847	127	15%	948	143	15%
Lobster Pot	2011	805	73	9%	788	72	9%	779	71	9%	778	71	9%	764	65	9%	787	70	9%
Lobster Pot	2012	734	58	8%	725	58	8%	717	55	8%	707	55	8%	696	55	8%	734	58	8%
Other Gear	2010	32	0	0%	32	0	0%	32	0	0%	32	0	0%	32	0	0%	50	0	0%
Other Gear	2011	24	0	0%	24	0	0%	24	0	0%	24	0	0%	24	0	0%	37	0	0%
Other Gear	2012	47	0	0%	46	0	0%	46	0	0%	46	0	0%	46	0	0%	39	0	0%
Scallop Gear & Clam Dredge	2010	32	30	94%	22	20	91%	18	16	89%	17	15	88%	13	11	85%	37	35	95%
Scallop Gear & Clam Dredge	2011	116	112	97%	110	106	96%	99	95	96%	89	85	96%	65	62	95%	119	115	97%
Scallop Gear & Clam Dredge	2012	291	282	97%	276	268	97%	262	254	97%	256	248	97%	232	224	97%	293	285	97%
Separator & Ruhle Trawl	2010	73	55	75%	72	54	75%	71	53	75%	69	51	74%	60	46	77%	73	55	75%
Separator & Ruhle Trawl	2011	136	115	85%	136	115	85%	133	112	84%	131	111	85%	127	107	84%	130	110	85%
Separator & Ruhle Trawl	2012	49	35	71%	49	35	71%	49	35	71%	49	35	71%	48	34	71%	47	33	70%

Table 43 – VMS estimates of effort (total hours fished, trips, and permits) within the broad and discrete coral zones south of Georges Bank, by gear category.

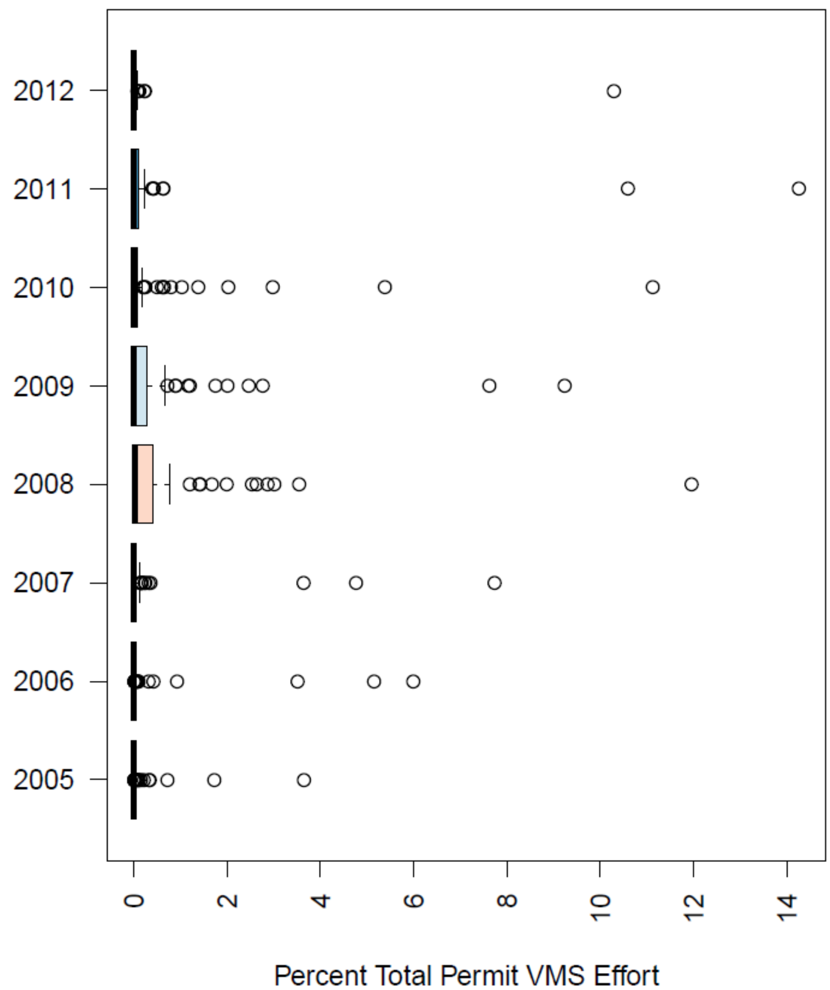
		300m			400 m			500 m			600 m			900 m			Discrete Canyons		
Gear	Year	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits	Hours Fished	Trips	Permits
Bottom Trawl	2005	218.63	54	27	26.23	32	22	7.74	18	16	1.85	12	10	0.17	4	4	42.63	48	26
Bottom Trawl	2006	184.01	66	32	33.60	44	24	6.75	35	21	0.75	18	15	0.00	5	4	39.98	67	35
Bottom Trawl	2007	258.02	128	54	24.94	61	35	12.86	36	23	9.13	20	14	5.37	11	9	91.23	135	60
Bottom Trawl	2008	1442.01	143	52	249.90	101	40	22.89	61	30	4.43	30	19	0.80	12	8	334.46	136	51
Bottom Trawl	2009	489.07	118	37	222.19	90	35	26.19	56	26	12.89	32	18	6.07	14	9	119.03	124	37
Bottom Trawl	2010	391.78	137	43	180.78	95	34	32.04	64	27	21.98	52	23	12.86	17	7	121.07	138	45
Bottom Trawl	2011	379.99	91	33	70.28	66	28	20.40	43	20	12.70	32	15	7.49	11	6	91.90	85	32
Bottom Trawl	2012	114.18	85	38	24.12	61	34	7.31	46	27	5.44	35	22	2.10	15	11	34.19	74	34
Squid Trawl	2005	11.50	59	30	4.44	40	22	3.01	33	19	1.44	24	17	0.26	7	9	10.15	59	29
Squid Trawl	2006	40.33	96	42	5.90	73	35	2.89	52	28	1.71	37	23	0.56	11	18	15.60	87	39
Squid Trawl	2007	40.61	123	43	21.16	94	38	11.14	68	31	6.34	51	26	3.27	16	28	38.63	121	43
Squid Trawl	2008	8.27	16	11	2.18	14	10	0.26	12	9	0.16	12	9	0.02	4	5	4.26	17	11
Squid Trawl	2009	43.92	25	8	15.64	24	7	7.80	19	5	3.05	17	5	0.88	5	15	22.74	25	8
Squid Trawl	2010	11.98	30	11	2.74	23	10	0.89	18	8	0.20	13	7	0.02	3	4	12.34	29	9
Squid Trawl	2011	35.59	23	10	8.19	21	10	5.41	19	10	2.63	15	7	0.12	7	9	11.90	23	10
Squid Trawl	2012	5.45	12	10	2.47	10	8	0.51	8	7	0.32	4	4	0.06	3	3	1.84	12	10
Pot/Trap	2005	11.11	5	3	3.84	5	3	2.13	5	3	-	-	2	-	-	1	8.10	5	3
Pot/Trap	2006	319.91	81	6	104.47	69	4	30.63	61	4	18.26	51	4	4.36	32	3	177.81	93	5
Pot/Trap	2007	337.25	75	3	130.95	66	3	46.65	62	3	24.61	51	3	7.33	36	3	160.98	86	4
Pot/Trap	2008	350.63	57	5	140.42	49	5	49.60	44	5	31.85	37	3	12.04	26	3	132.67	65	5
Pot/Trap	2009	275.17	50	5	85.65	39	4	30.72	30	3	20.24	28	3	-	-	2	98.49	63	5
Pot/Trap	2010	307.01	62	4	125.77	56	4	44.03	51	3	-	-	2	-	-	2	117.68	83	5
Pot/Trap	2011	260.73	44	4	98.56	37	3	32.57	29	3	19.18	27	3	-	-	2	88.84	56	5
Pot/Trap	2012	216.55	36	3	-	-	1	-	-	1	-	-	1	-	-	1	62.24	42	3
GC Scallop	2006	-	-	1	-	-	1	-	-	1	-	-	1	0.00	0	0	-	-	1
GC Scallop	2011	-	-	1	-	-	1	-	-	1	-	-	1	-	1	-	-	-	1
GC Scallop	2012	-	-	1	-	-	1	-	-	1	-	-	1	0.00	0	0	-	-	1
LA Scallop	2005	0.06	77	58	0.05	71	57	0.04	53	64	0.03	51	62	0.01	49	60	0.08	67	51
LA Scallop	2006	0.47	151	68	0.14	138	65	0.07	63	131	0.04	60	121	0.02	57	106	0.23	142	68
LA Scallop	2007	0.02	26	23	0.01	25	23	0.00	19	20	0.00	15	16	0.00	9	10	0.01	27	24
LA Scallop	2008	0.04	17	16	0.00	17	16	0.00	14	15	0.00	11	12	0.00	6	7	0.00	17	16
LA Scallop	2009	5.13	31	29	0.94	30	28	0.36	27	29	0.06	27	28	0.01	25	26	2.39	30	28
LA Scallop	2010	0.41	37	35	0.18	35	33	0.04	28	28	0.01	25	25	0.00	16	16	0.08	34	32
LA Scallop	2011	0.19	27	20	0.04	26	19	0.03	19	23	0.02	18	21	0.00	13	13	0.27	28	21
LA Scallop	2012	0.56	39	31	0.46	34	28	0.44	27	32	0.02	25	29	0.01	21	23	0.33	36	29

Figure 41 – Percent of total annual permit fishing activity attributed to the 300 m Broadzone between 2005 and 2012, as derived from VMS



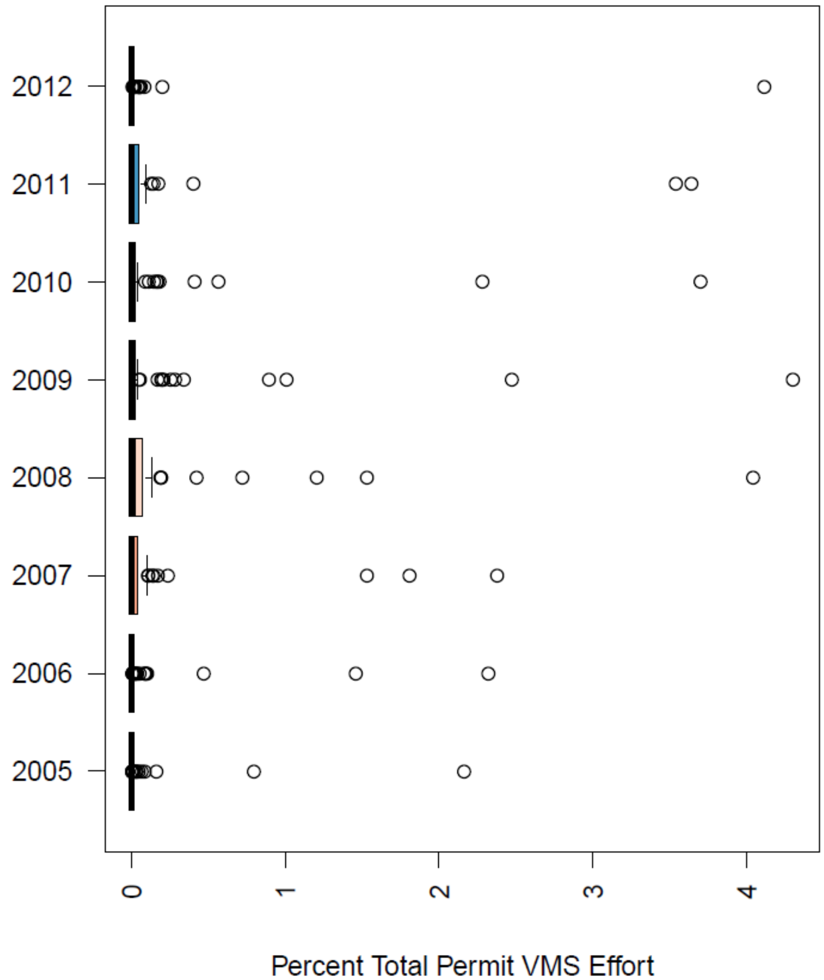
Source: VMS analysis

Figure 42 - Percent of total annual permit fishing activity attributed to the 400 m Broadzone between 2005 and 2012, as derived from VMS



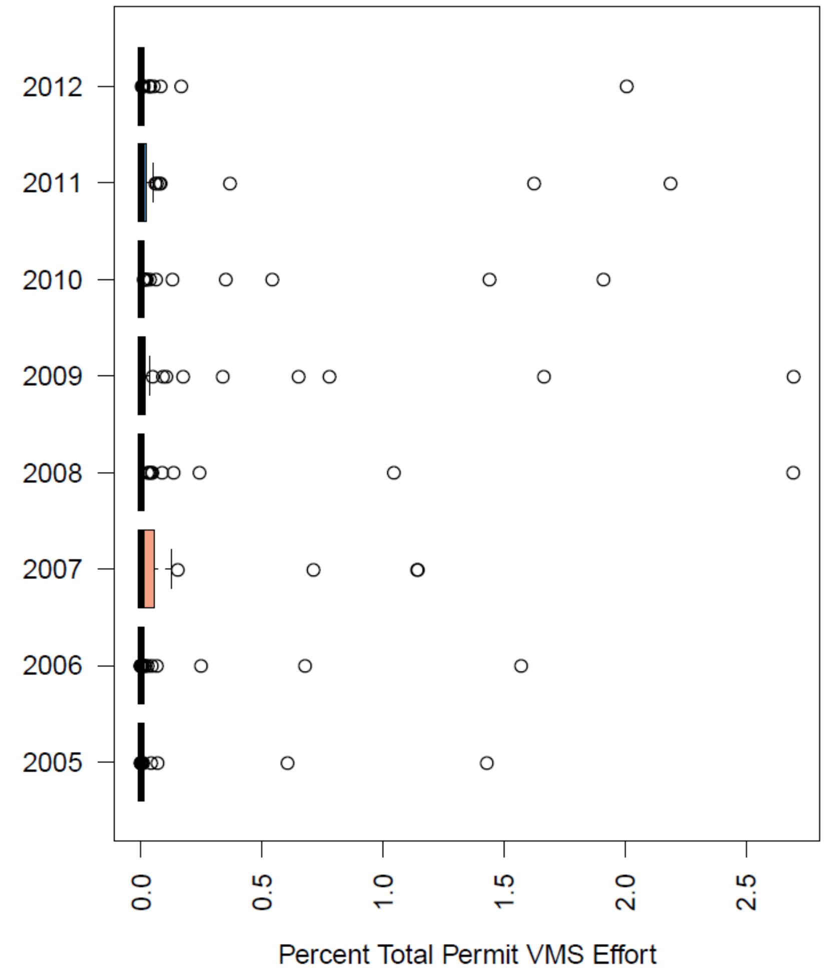
Source: VMS analysis

Figure 43 - Percent of total annual permit fishing activity attributed to the 500 m Broadzone between 2005 and 2012, as derived from VMS



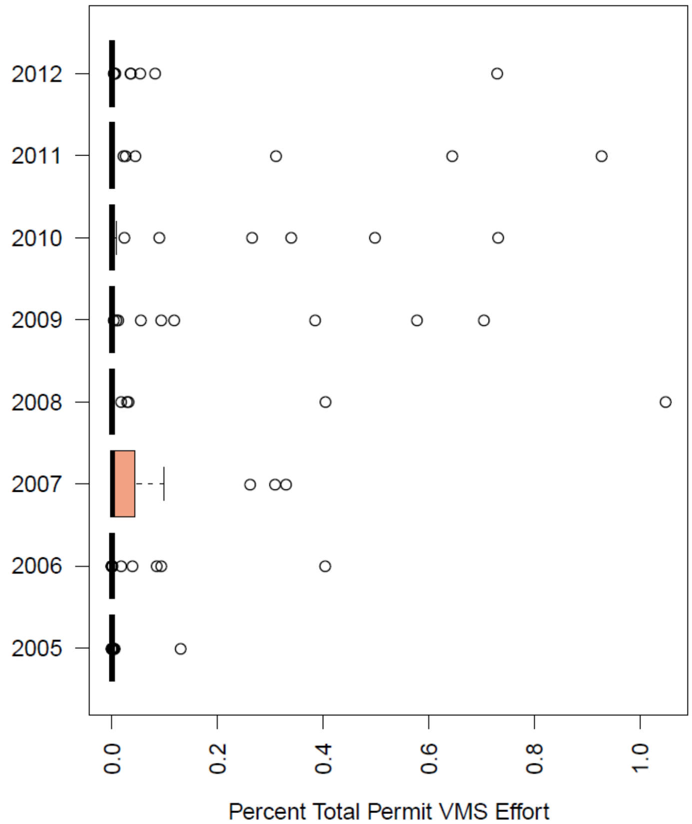
Source: VMS analysis

Figure 44- Percent of total annual permit fishing activity attributed to the 600 m Broadzone between 2005 and 2012, as derived from VMS



Source: VMS analysis

Figure 45 - Percent of total annual permit fishing activity attributed to the 900 m Broadzone between 2005 and 2012, as derived from VMS



Source: VMS analysis

7.3.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 45The revenue attributed to Massachusets and Rhode Island from the 300m Broad Zone is about 1.3% and 4.0% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 36, p. 242).

Table 45 to Table 49, the revenue attributed (using the VTR analysis) to recent fishing within the coral broad zone alternatives.

300m Broad Zone. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the 300m Broad Zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states. The revenue attributed to Massachusets and Rhode

Island from the 300m Broad Zone is about 1.3% and 4.0% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 35, p. 241).

The VTR analysis attributes recent landings revenue to 58 ports, and 60% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and 37% of the revenue is attributed to other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the 300m Broad Zone is about 1.3% and 4.0% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 36, p. 241).

Table 44 - Landings revenue to states, regions, and top ports attributed to fishing within the 300 m Broad Zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$41.3M	$8.3M	477
North of Cape	$1.7M	$0.3M	52
Gloucester	$1.6M	$0.3M	36
Other (n=4)	$0.1M	$0.0M	23
Cape & Islands	$8.5M	$1.7M	50
South of Cape	$31.1M	$6.2M	420
New Bedford	$30.6M	6.1M	394
Other (n=3)	$0.5M	$0.1M	34
Rhode Island	$19.0M	$3.8M	118
Newport	$9.3M	$1.9M	19
Point Judith	$4.1M	$0.8M	96
Tiverton	$1.5M	$0.3M	3
Other (n=4)	$4.1M	$0.8M	17
New York	$2.7M	$0.5M	31
Montauk	$2.5M	$0.5M	26
Other (n=5)	$0.2M	$0.0M	7
Virginia	$1.8M	$0.4M	110
Connecticut	$1.3M	$0.3M	25
New Jersey	$1.2M	$0.2M	58
North Carolina	$0.2M	$0.0M	48
Maine	$0.0M	$0.0M	3
Other[b]	$1.7M	$0.3M	13
Total	**$69.3M**	**$13.9M**	**665**

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

400m Broad Zone. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the 400m Broad Zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states (Figure 45). The VTR analysis attributes recent landings revenue to 57 ports, and 59% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and 36% of the revenue is attributed other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the 400m Broad Zone is about 1.1% and 3.7% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 37, p. 242).

Table 45 - Landings revenue to states, regions, and top ports attributed to fishing within the 400 m Broad Zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$37.4M	$7.5M	472
North of Cape	$1.6M	$0.3M	50
Gloucester	$1.5M	$0.3M	36
Other (n=4)	$0.1M	$0.0M	23
Cape & Islands	$7.6M	$1.5M	52
South of Cape	$28.2M	$5.6M	406
New Bedford	$27.9M	$5.6M	385
Other (n=3)	$0.3M	$0.0M	33
Rhode Island	$17.5M	$3.5M	117
Newport	$8.9M	$1.7M	19
Point Judith	$3.6M	$0.7M	94
Other (n=5)	$5.0M	$1.1M	20
New York	$2.3M	$0.5M	31
Montauk	$2.1M	$0.4M	26
Other (n=5)	$0.2M	$0.1M	7
Virginia	$1.6M	$0.3M	107
Connecticut	$1.1M	$0.2M	23
New Jersey	$1.1M	$0.2M	57
North Carolina	$0.2M	$0.0M	47
Maine	$0.0M	$0.0M	3
Other[b]	$1.6M	$0.3M	13

Total	$62.9M	$12.7M	658
Notes: Ports listed are the top 10 ports by landing revenue that are non-confidential. [a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states. [b] Includes confidential state(s). *Source:* VTR data analysis.			

500m Broad Zone. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the 500m Broad Zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states (Table 47). The VTR analysis attributes recent landings revenue to 55 ports, and 59% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and 35% of the revenue is attributed other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the 500m Broad Zone is about 1.1% and 3.5% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 38, p. 243).

Table 46 - Landings revenue to states, regions, and top ports attributed to fishing within the 500 m Broad Zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$34.8M	$7.0M	464
North of Cape	$1.5M	$0.3M	51
Gloucester	$1.4M	$0.3M	36
Other (n=4)	$0.1M	$0.0M	20
Cape & Islands	$7.1M	$1.4M	47
South of Cape	$26.3M	$5.3M	402
New Bedford	$26.0M	$5.2M	383
Other (n=3)	$0.3M	$0.1M	31
Rhode Island	$16.4M	$3.3M	114
Newport	$8.5M	$1.7M	19
Point Judith	$3.3M	$0.7M	91
Other (n=5)	$4.6M	$0.9M	16
New York	$2.0M	$0.4M	31
Montauk	$1.8M	$0.4M	26
Other (n=5)	$0.2M	$0.0M	9
Virginia	$1.5M	$0.3M	105
Connecticut	$1.1M	$0.2M	22
New Jersey	$1.0M	$0.2M	54
North Carolina	$0.2M	$0.0M	47
Other[b]	$1.5M	$0.3M	15

Total	$58.5M	$11.7M	647
Notes: Ports listed are the top 10 ports by landing revenue that are non-confidential. [a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states. [b] Includes confidential state(s). *Source:* VTR data analysis.			

600m Broad Zone. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the 600m Broad Zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states (Table 48). The VTR analysis attributes recent landings revenue to 56 ports, and 59% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and 35% of the revenue is attributed other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusetts and Rhode Island from the 600m Broad Zone is about 1.0% and 3.3% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 39).

Table 47 - Landings revenue to states, regions, and top ports attributed to fishing within the 600 m Broad Zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$32.8M	$6.6M	461
North of Cape	$1.4M	$0.3M	48
Gloucester	$1.3M	$0.3M	34
Other (n=4)	$0.1M	$0.0M	19
Cape & Islands	$6.6M	$1.3M	46
South of Cape	$24.8M	$4.5M	402
New Bedford	$24.4M	$4.9M	400
Other (n=3)	$0.4M	$0.1M	30
Rhode Island	$15.6M	$3.1M	112
Newport	$8.2M	$1.6M	19
Point Judith	$3.0M	$0.6M	90
Other (n=4)	$4.4M	$0.9M	14
New York	$1.8M	$0.4M	31
Montauk	$1.7M	$0.3M	26
Other (n=5)	$0.1M	$0.1M	7
Virginia	$1.4M	$0.3M	104
Connecticut	$1.0M	$0.2M	22
New Jersey	$1.0M	$0.2M	51
North Carolina	$0.2M	$0.0M	46
Other[b]	$1.4M	$0.3M	15
Total	**$55.1M**	**$11.0M**	**643**

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

900m Broad Zone. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the 900m Broad Zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New York, and other states (Table 49). The VTR analysis attributes recent landings revenue to 52 ports, and 59% of this revenue to ports in Massachusetts. New Bedford, Newport, and Point Judith, are among the top ten landing ports, and 34% of the revenue is attributed other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the 900m Broad Zone is about 0.87% and 2.9% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 70% of their revenue attributed to fishing from this area (Figure 40, p. 245).

Table 48 - Landings revenue to states, regions, and top ports attributed to fishing within the 900 m Broad Zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$28.4M	$5.7M	445
North of Cape	$1.2M	$0.2M	48
Gloucester	$1.2M	$0.2M	34
Other (n=2)	$0.0M	$0.0M	17
Cape & Islands	$5.7M	$1.1M	47
South of Cape	$21.4M	$4.3M	386
New Bedford	$21.2M	$4.2M	364
Other (n=3)	$0.2M	$0.1M	27
Rhode Island	$13.9M	$2.8M	108
Newport	$7.7M	$1.5M	16
Point Judith	$2.6M	$0.5M	88
Other (n=4)	$3.6M	$0.8M	12
New York	$1.5M	$0.3M	30
Montauk	$1.4M	$0.3M	24
Other (n=5)	$0.1M	$0.0M	7
Virginia	$1.2M	$0.2M	102
Connecticut	$0.8M	$0.2M	19
New Jersey	$0.8M	$0.2M	48
North Carolina	$0.1M	$0.0M	45
Other[b]	$1.2M	$0.2M	15
Total	**$48.0M**	**$9.6M**	**627**

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

7.3.3.3 Sociocultural impacts

The sociocultural impacts associated with establishing a broad coral zone are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.3.4 Impacts on protected resources

To be completed prior to final action.

7.4 Impacts of canyon coral zones and associated fishing restrictions

This alternative would designate coral zones within 20 submarine canyons off the southern boundary of Georges Bank. From west to east, these canyons are: Alvin, Atlantis, Nantucket, Veatch, Hydrographer, Dogbody, Clipper, Sharpshooter, Welker, Heel Tapper, Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia, Powell, Munson, Nygren, an unnamed canyon, and Heezen.

Potential fishing restriction measures for coral zones are described in Section 4.3. They include:

- Option 1: Prohibit bottom-tending gears
    - Sub-option A: Exempt the red crab fishery
    - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

The canyons are placed into two groups for analysis:

- "Discrete Monument Canyons" - canyons that overlap the National Monument (Oceanographer, Filebottom, Chebacco, Gilbert, and Lydonia), and
- "Discrete Non-Monument Canyons" - canyons that do not overlap (remaining 15 canyons).

This grouping is because once the National Monument is fully implemented for trap fisheries (in 2023), Monument fishing restrictions will exceed those that might be associated with the coral zones. Coral zone designations and fishing restrictions in the canyons that do not overlap the monument would have a more immediate effect on any fisheries that operate in those locations.

7.4.1 Impacts on deep-sea corals

The types of coral data available for the canyons are the same as for the broad zones. The canyons encompass known coral habitats, as determined by recent and older coral occurrence records (Table 34 and Table 33), as well as areas of high slope and modeled suitable habitat (Table 37 and Table 35). In general, the canyon zones are a subset of the 300 m broad zone, although in some of the canyons the minimum depth is deeper, around 400 m, and in a few cases the discrete zones are shallower, approaching 200 m (Table 36). As expected, in aggregate, the canyons protect a smaller area of coral habitat (as indicated by the suitability model and slope data, relative to all of the broad zones being considered. This is not surprising as suitable habitat occurs outside the canyons on the slope, and considering just the suitability model footprint, the canyon zones cover much less area (2,651 km^2 vs. 10,148-13,097 km^2 for the broad zones). Combining the size of the zones with the suitable habitat area, the suitable habitat efficiency index (last column in Table 35), is much higher for the discrete canyons than the broad zones (77% as compared to 35% for the 300 m and 400 m broad zones, down to 28% for the 900 m broad zone).

One area where the canyons perform better than the broad zones is that the canyons encompass a slightly larger area of high slope than the deepest broad zone at 900 m (108 km^2 or 65% of the high slope rea, vs. 102 km^2 or 62%). In terms of comparing the canyon zones to the deeper (600 m, and especially 900 m) broad zones, the recent dives and tows highlighted in the broad zone impacts section (7.3.1) are relevant here as well, as they all occurred within the canyons.

Generally, the discrete canyon zones would have a positive impact on deep-sea corals. A relatively straightforward conclusion is that designating the canyon zones alone would have fewer positive impacts as compared to designating a broad zone at either 300 m or 400 m. This is because the discrete canyons are generally a subset of those two zones, and designating just the canyons would not afford protection for coral habitats on the continental slope. Assessing tradeoffs between the canyon zones and the deeper broad zones (500 m, 600 m, and 900 m) is less straightforward. As noted above, the canyon zones encompass less coral habitat than the much larger broad zones, regardless of broad zone depth. But, high suitability habitats, including areas of high slope, tend to be concentrated in the canyons, and coral habitats in the shallower portions of the canyons would not be protected through the designation of a deeper broad zone.

7.4.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.4.3 Impacts on human communities

Under this alternative, coral zones would be established within 20 distinct canyons along the southern margin of Georges Bank, with options for which gear types would be precluded from the zones. This alternative would be additive to No Action (Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the canyon coral zones on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. These negative impacts would be additive to the negative fishery impacts of No Action, as fishing in 15 additional canyons would be restricted. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.4.3.1 Fishery impacts

Relative to the broad zones, the discrete canyon zones encompass a much smaller area, only the twenty largest canyons vs. the entire shelf/slope region to the EEZ. Generally, the discrete canyon zones are a subset of the 300 meter broad zone, although they do extend into shallower waters in a few of the largest canyons. Due to data limitations, it is impossible to know the true amount of fishing activity that has occured within the canyons. Thus, multiple approaches are used to estimate fishing activity, and thus characterize the potential fishery impacts of this alternative.

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the canyon areas. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2). The canyons were grouped into Monument (5 canyons) and non-Monument (15 canyons), because fishing restrictions associated with canyons overlapping the Monument would duplicate monument restrictions, and those for other canyons outside the monument would generally be new restrictions, with the exception of Veatch Canyon, which already has a tilefish management area closed to mobile bottom-tending gear.

Because the canyons cover the same east-west extent along the shelf break as the broad zones, the mix of species and gear types are similar, and are more diverse than those attributed to the No Action areas. Bottom trawl, lobster pot, other gear, and scallop/clam dredge gears are the major revenue generators in these areas. Longline gear is also represented. The 'other gear' category shows a spike in 2014, which is most likely due to increased revenue from red crabs, which are fished primarily in the western portion of the area.

Total revenue. Total revenue attributed to the non-Monument canyons is \$2-2.5M annually (Figure 46), and annual revenue attributed to the Monument canyons is between \$200-400K (Figure 47).

Revenue by gear type. In the 15 non-Monument canyons, bottom trawl and lobster pot are again the primary revenue generators, except for relatively high scallop gear/clam dredge revenue in 2012, and other gear revenue in 2014. In the Monument canyons, lobster pots and bottom trawls are the major sources of revenue, with other gear and scallop gear/clam dredge important in 2014 and 2012/2015, respectively. Maps of revenue by gear type and species are in section 13, beginning on page 338.

Trips and permits by gear type. Figure 48 and Figure 49 (trips) and Figure 50 and Figure 51 (permits) indicate the amount of fishing activity and vessels overlapping the non-Monument and Monument canyons. As with the broad zones, similar numbers of lobster pot and bottom trawl trips overlap the areas. In the non-Monument canyons, the overlap is up to around 1,000 trips per year per gear type. The number of trips decreases to between 200-300 trips per year for each of the two gear types in the canyons that overlap the Monument. Given the spatial resolution of the VTR analysis, there is certainly overlap between the two datasets, i.e., unique trips may be included in each one. Unlike the revenue data, where scallop gear/clam dredge data constitute a large fraction of total revenue during some years, the trip metric deemphasizes these gears. This makes sense considering that scallops are a high value species.

The total numbers of permits associated with the non-Monument canyons are similar to those associated with the broad zones, which is intuitive as the areas overlap. Fishing effort associated with fewer numbers and types of permits overlaps the Monument canyons, and no overlap with gillnet, longline, separator, or Ruhle trawl was noted. In most years, it appears that a large fraction of the scallop fleet (100-200 scallop or clam permits, out of around 350 scallop permits) fishes near the non-Monument discrete zones. As noted previously, it is unlikely that this effort is actually occurring within the canyon zones, as they are uniformly deeper than the depths at which scallops typically occur.

Revenue by species. Figure 52 and Figure 53 break down the estimated revenues in each zone by species, for the top ten species harvested from each area. The mix of species in the non-Monument canyons in particular is similar to those harvested in and around the broad zones, although total revenue is less. The two sets of areas have most top ten species in common, including butterfish, Jonah/red crab, silver hake, longfin squid, lobster, and sea scallop. In the non-Monument canyons, summer flounder, golden tilefish and monkfish fall into the top ten, and in the canyons within the Monument yellowtail flounder, haddock, and Atlantic mackerel fall into the top ten. Some of these species are not known to occur in particularly deep water, so their association with the canyon zones is questionable. These include scallops, as mentioned previously, plus the three flounders and butterfish.

Percent owner revenue. Across both sets of zones for the three years studied, median percent annual revenue at the owner level hovers around zero (Figure 54 and Figure 55). However, there are outliers whose inferred percent annual revenue values are between 2-25% for the non-Monument canyons, and 0.5-2.5% for the Monument-overlapping canyons. These outliers indicate that at the owner level, there are some fishing businesses that focus their effort on fishing in and around the canyons.

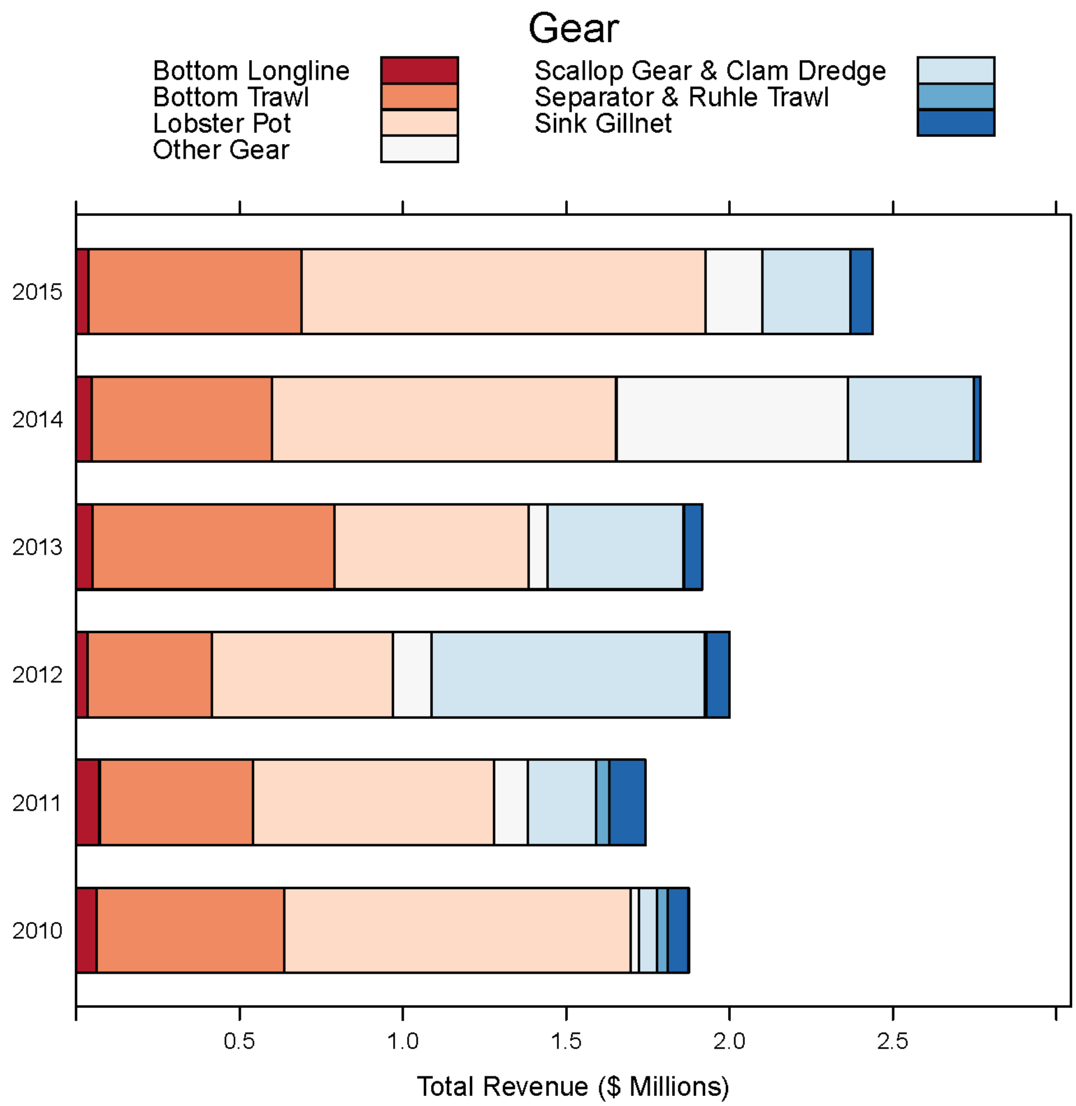
VTR vs. VMS comparison. Two tables were prepared to compare between VTR and VMS data:

- Table 43 – Percentage of VTR trips overlapping the broad and discrete coral zones south of Georges Bank that have VMS coverage, by gear type.
- Table 44 – VMS estimates of effort (total hours fished, trips, and permits) within the broad and discrete coral zones south of Georges Bank, by gear category.

These tables combine effort estimates for all 20 canyons. In general, VMS coverage is good for trawls and dredges, and poor for traps and other gears (Table 43). Given the high VMS coverage for bottom trawl, scallop & clam dredge, and separator and Ruhle trawls in this region, the estimates of fishing activity exposed for these gears are better assessed through VMS rather than VTR. Total hours fished in scallop dredge gear is very low, suggesting that the canyons are not important scallop fishing grounds. Due to the low coverage of lobster pot fishing in the region, the VMS provides a lower bound, while VTR provides an upper bound, on the uncertainty regarding the trips and permits historically fishing within the discrete canyons south of Georges Bank. For sink gillnets and bottom longline, only the VTR analysis is currently available.

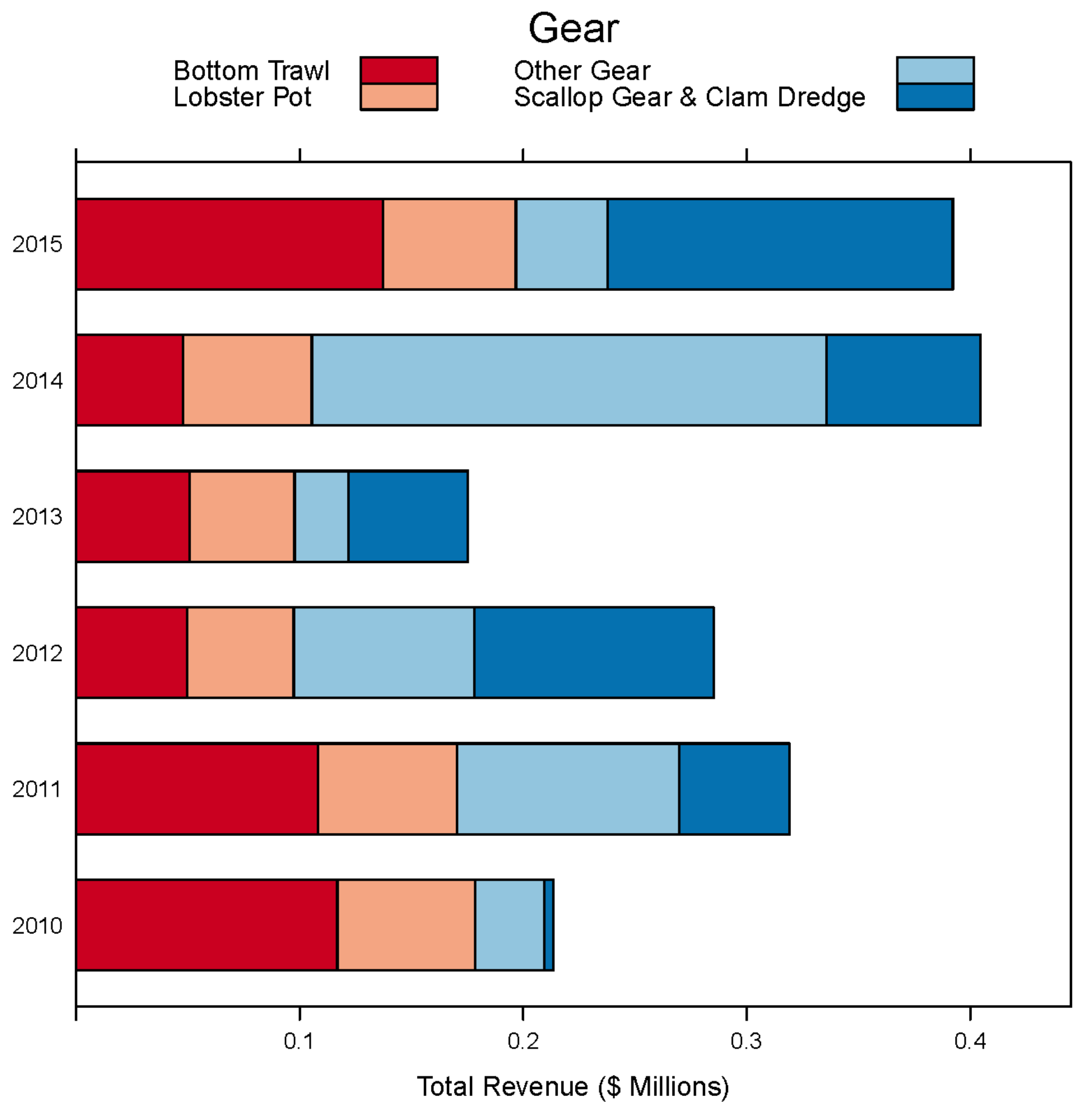
Figure 56 presents the VMS-derived effort calculated to have fallen within the discrete canyons off of Georges Bank, as a percentage of the total effort for each permit calculated to be fishing in the region. Some differences between these results and those presented in Figure 54 and Figure 55 would be expected, given the latter are calculated at the owner group level, which can include multiple permits. Nevertheless there is substantial agreement between the estimates, with the vast majority of the ownership groups and permits estimated to have only a small amount of their total activity (~1% and < 1% respectively) within the discrete canyons off Georges Bank. Further, both the VTR and VMS estimates suggest 20 – 25% as the upper bound on the entities with the highest exposure to the proposed canyon management areas. Thus, although the majority of individuals fishing within the Georges Bank discrete coral zones would be expected to undergo only slightly negative impacts of this alternative, there are a small number of individuals for which the impacts would be much more negative.

Figure 46 – Revenue by gear type attributed to the discrete non-Monument canyons (Alvin-Heel Tapper, Powell-Heezen), 2010-2015.



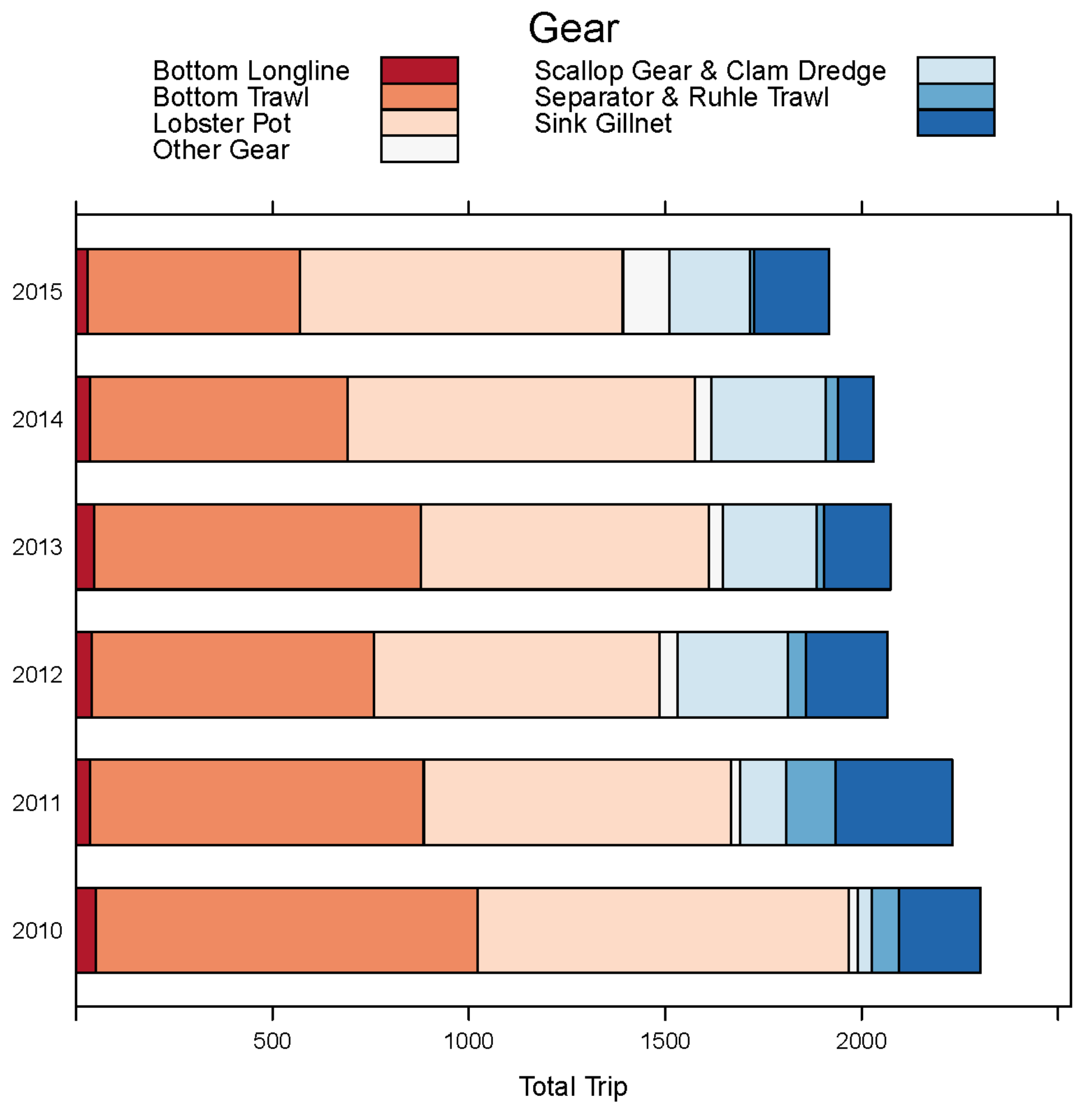
Source: **VTR analysis.**

Figure 47 – Revenue by gear type attributed to the discrete Monument canyons (Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia), 2010-2015.



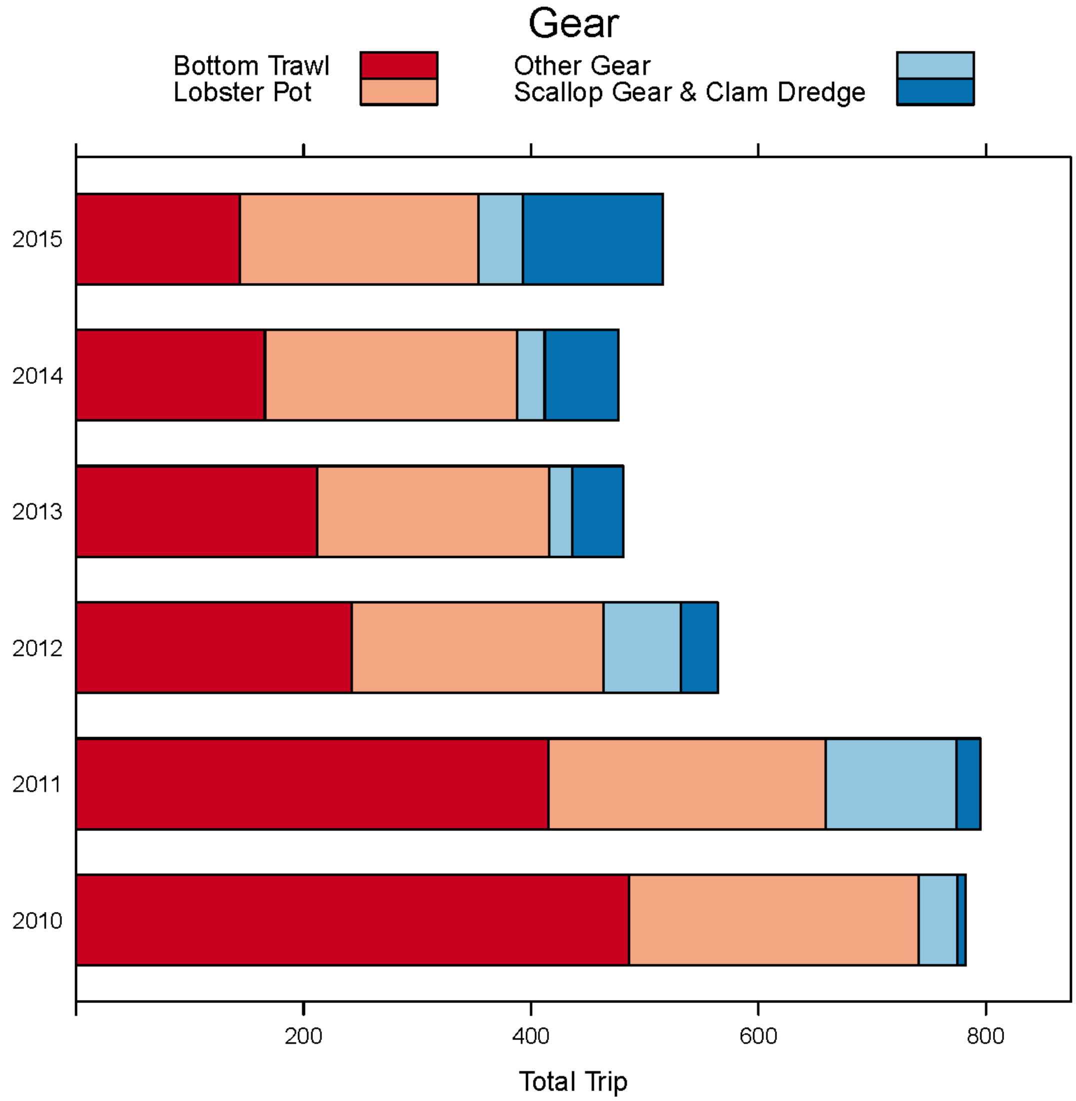
Source: **VTR analysis.**

Figure 48 – Trips by gear type attributed to the discrete non-Monument canyons (Alvin-Heel Tapper, Powell-Heezen), 2010-2015.



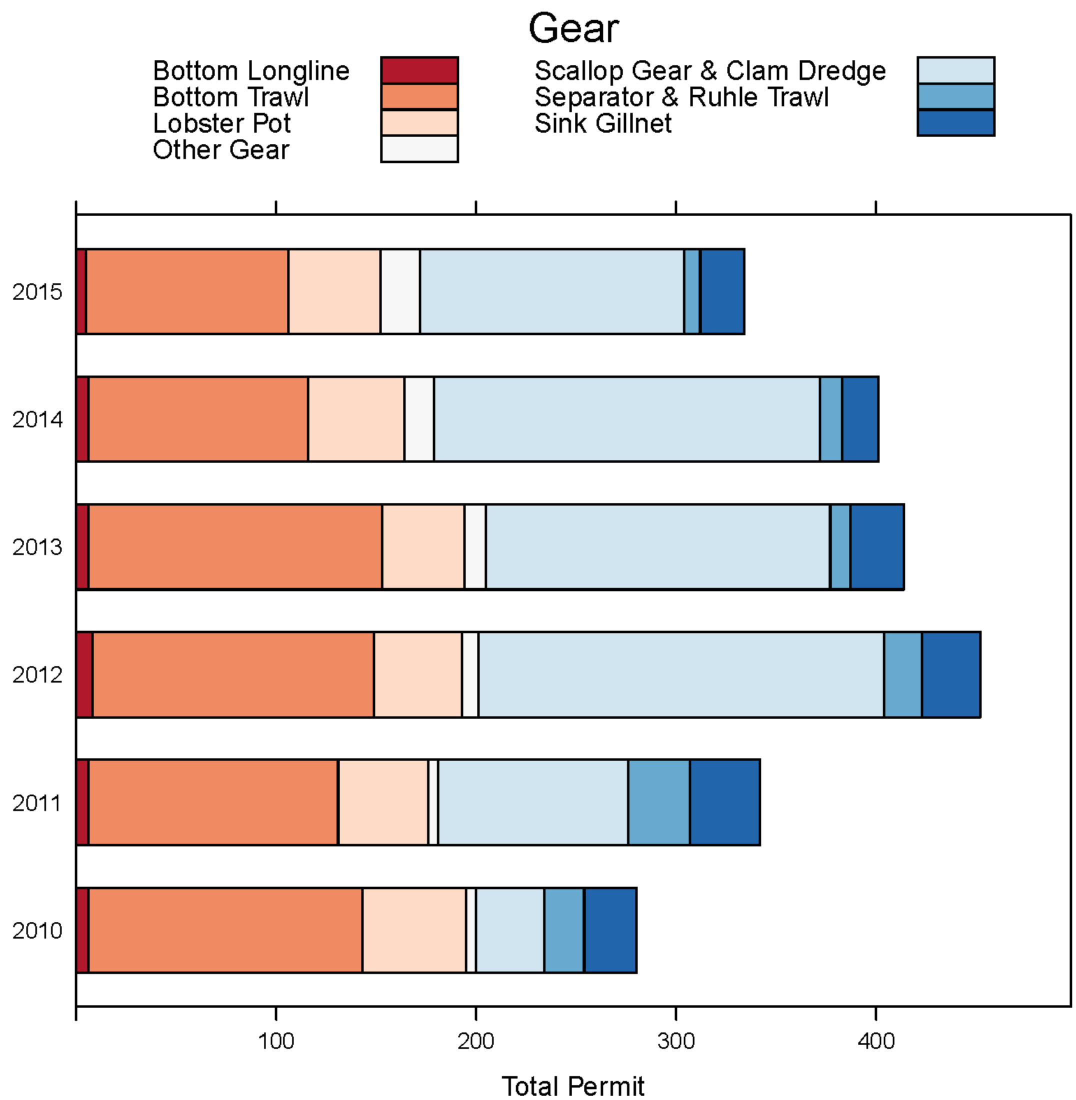
Source: **VTR analysis.**

Figure 49 – Trips by gear type attributed to the discrete Monument canyons (Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia), 2010-2015.



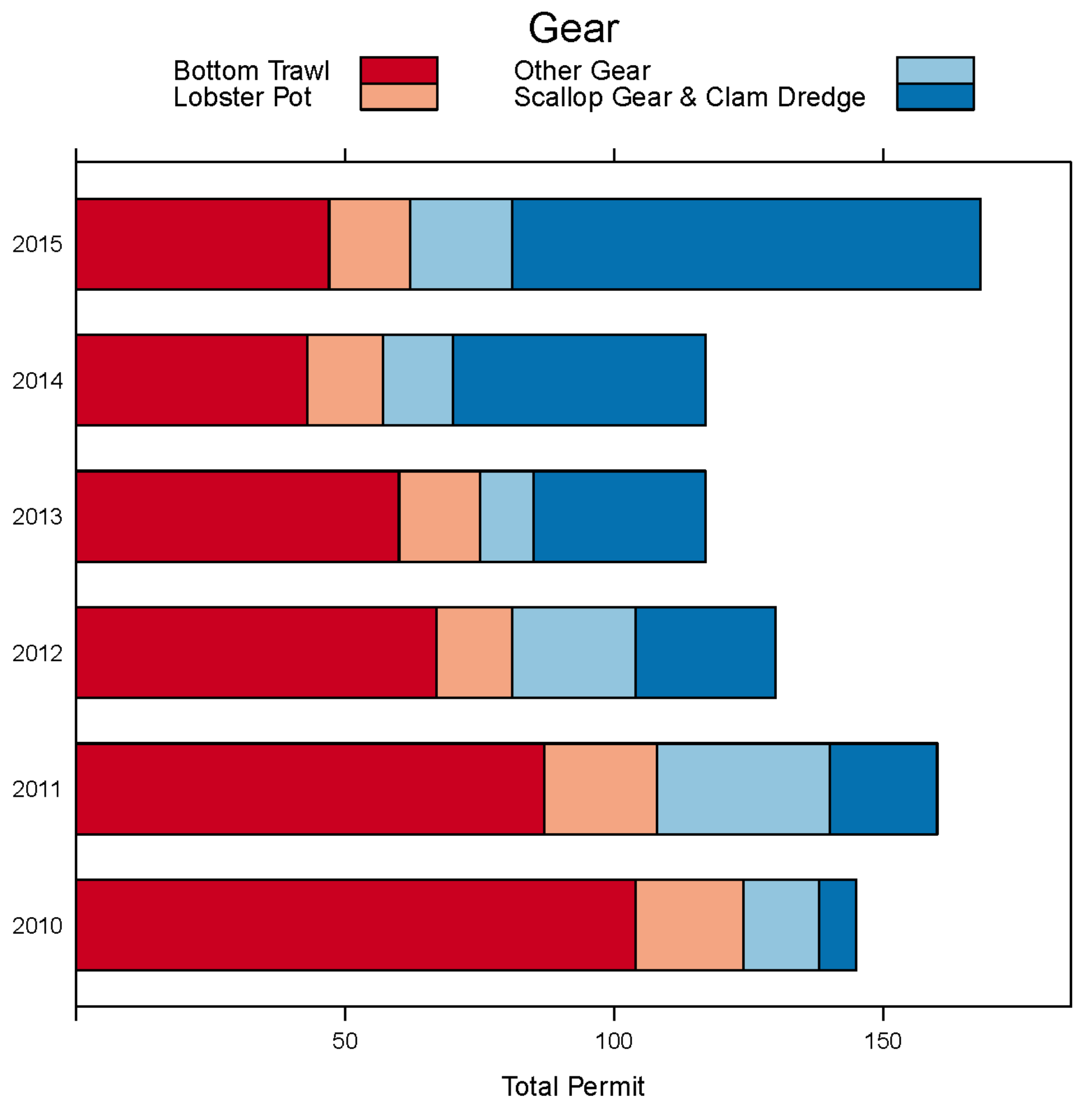
Source: **VTR analysis.**

Figure 50 – Permits by gear type attributed to the discrete non-Monument canyons (Alvin-Heel Tapper, Powell-Heezen), 2010-2015.



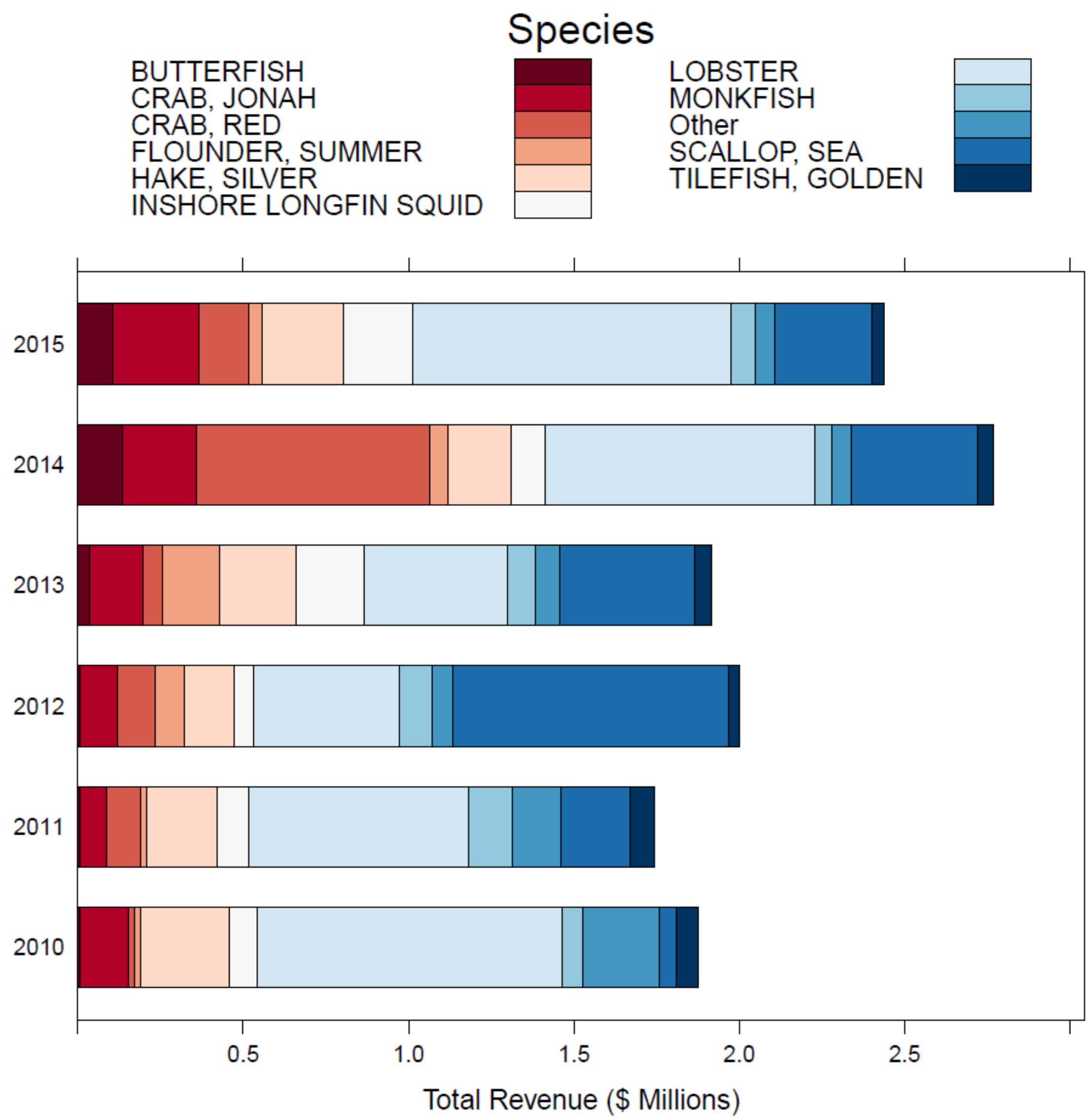
Source: **VTR analysis.**

Figure 51 – Permits by gear type attributed to the discrete Monument canyons (Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia), 2010-2015.



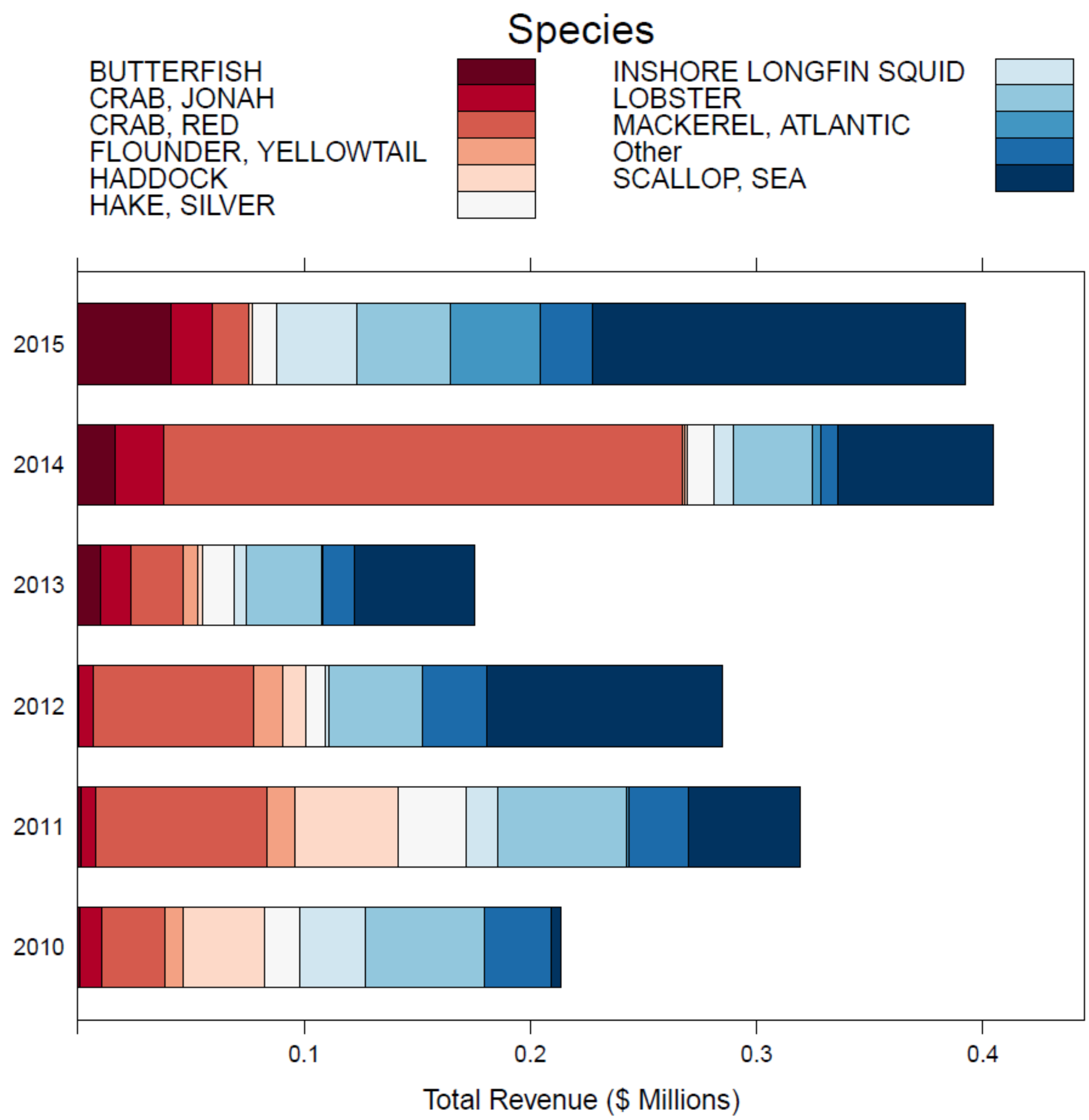
Source: **VTR analysis.**

Figure 52 – Revenue by species (top 10) attributed to the discrete non-Monument canyons (Alvin-Heel Tapper, Powell-Heezen), 2010-2015.



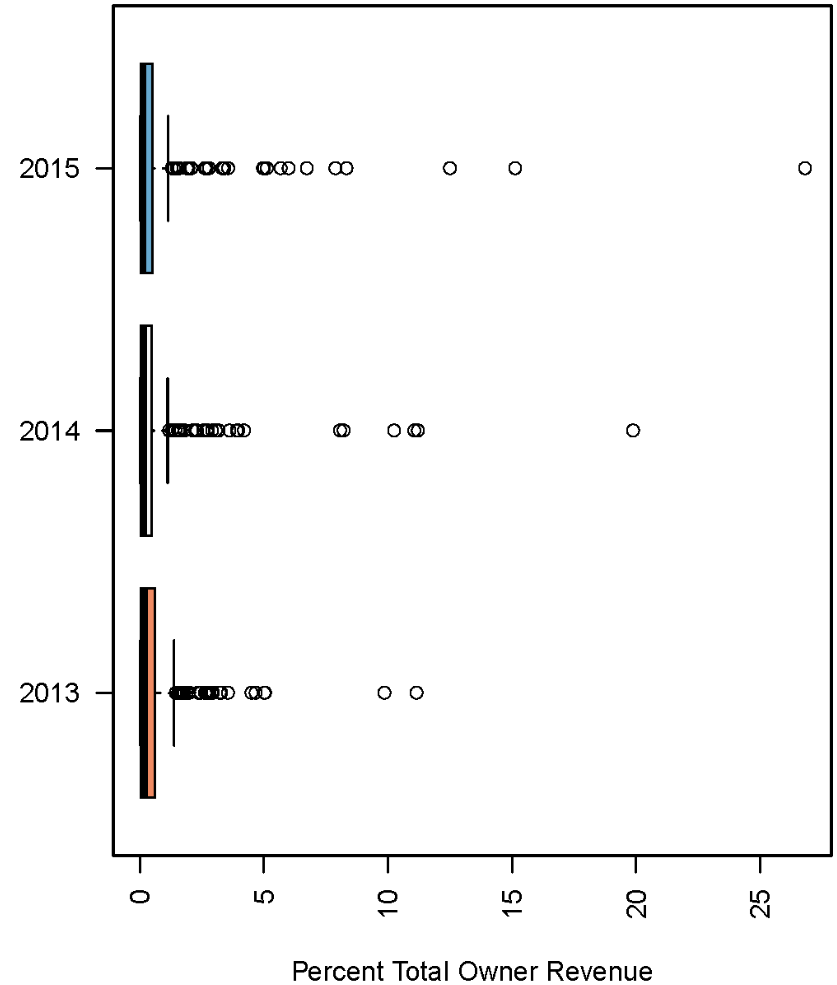
Source: **VTR analysis.**

Figure 53 – Revenue by species (top 10) attributed to the discrete Monument canyons (Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia), 2010-2015.



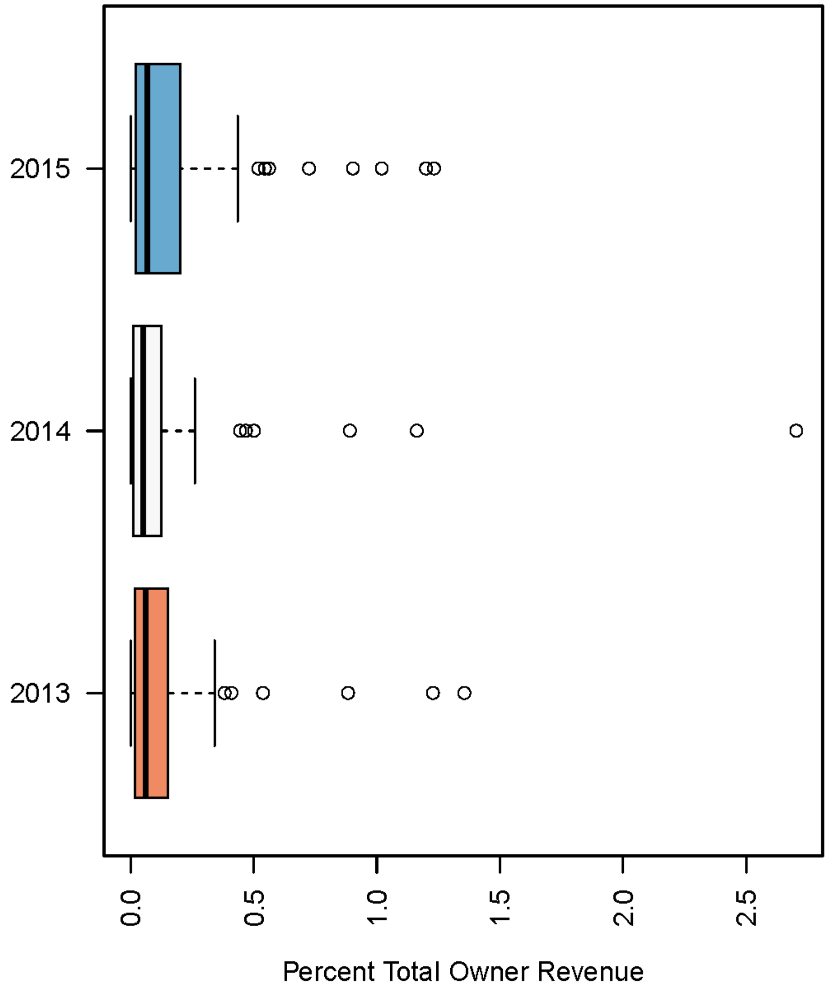
Source: **VTR analysis.**

Figure 54 – Percent of total owner revenue attributed to the discrete non-Monument canyons (Alvin-Heel Tapper, Powell-Heezen), 2013-2015.



Source: **VTR analysis.**

Figure 55 – Percent of total owner revenue attributed to the discrete Monument canyons (Oceanographer, Filebottom, Chebacco, Gilbert, Lydonia), 2013-2015.

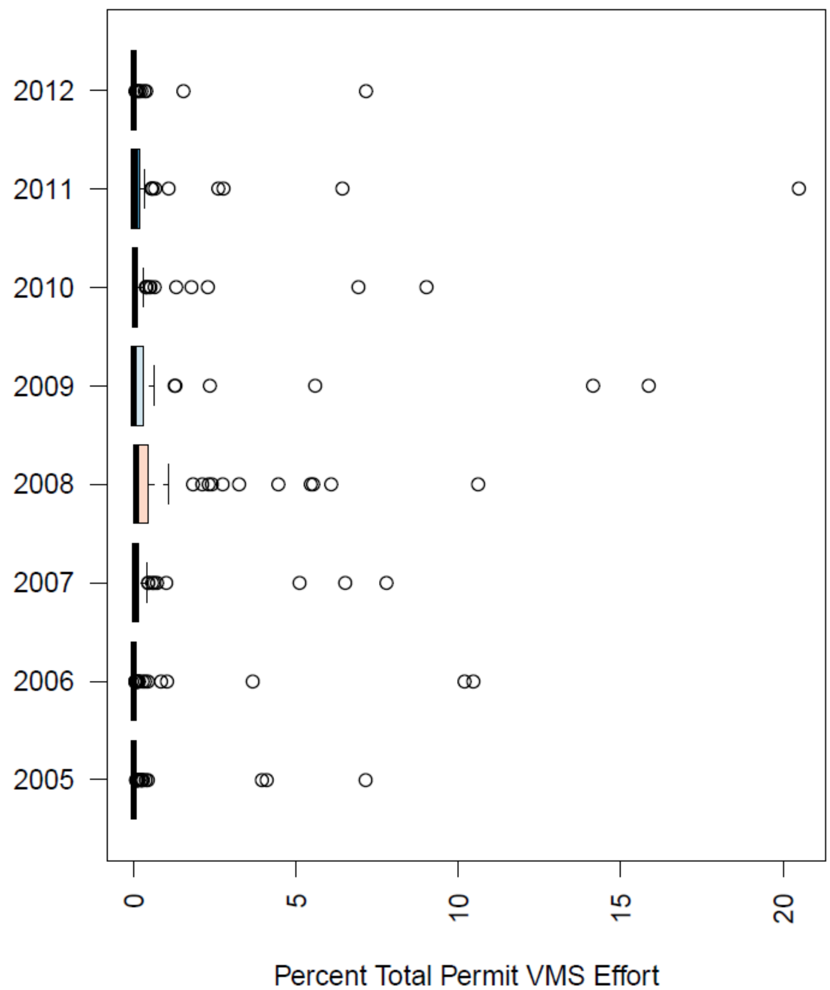


Source: **VTR analysis.**

Table 49 - Percentage of VTR trips overlapping the discrete canyon coral zones south of Georges Bank that have VMS coverage, by gear type.

		Monument Canyons			Non-Monument Canyons		
Gear	Year	VTR Trips	VMS Trips	Coverage	VTR Trips	VMS Trips	Coverage
Bottom Trawl	2010	486	457	94%	973	914	94%
Bottom Trawl	2011	415	371	89%	849	765	90%
Bottom Trawl	2012	242	200	83%	720	621	86%
Lobster Pot	2010	255	37	15%	944	140	15%
Lobster Pot	2011	244	8	3%	782	70	9%
Lobster Pot	2012	222	0	0%	726	58	8%
Other Gear	2010	34	24	71%	23	0	0%
Other Gear	2011	115	83	72%	24	0	0%
Other Gear	2012	68	29	43%	46	0	0%
Scallop Gear & Clam Dredge	2010	7	7	100%	35	34	97%
Scallop Gear & Clam Dredge	2011	21	19	90%	116	113	97%
Scallop Gear & Clam Dredge	2012	32	32	100%	281	273	97%
Bottom Longline	2010	-	-	-	50	0	0%
Bottom Longline	2011	-	-	-	36	0	0%
Bottom Longline	2012	-	-	-	39	0	0%
Separator & Ruhle Trawl	2010	-	-	-	70	52	74%
Separator & Ruhle Trawl	2011	-	-	-	127	107	84%
Separator & Ruhle Trawl	2012	-	-	-	47	33	70%
Sink Gillnet	2010	-	-	-	207	0	0%
Sink Gillnet	2011	-	-	-	297	0	0%
Sink Gillnet	2012	-	-	-	207	0	0%

Figure 56 - Percent of total annual permit fishing activity attributed to the offshore discrete canyons between 2005 and 2012, as derived from VMS.



7.4.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 51 and Table 51, the revenue attributed (using the VTR analsyis) to recent fishing within the canyon coral zone alternatives. The revenue attributed to Massachusets and Rhode Island from the Discrete Non-Monument Canyons is about 0.25% and 0.60% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 25% of their revenue attributed to fishing from this area (Figure 48, p. 271).

Discrete Monument Canyons. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Discrete Monument Canyons (included within No Action) are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New Jersey, and other states (Table 51). The VTR analysis attributes recent landings revenue to 29 ports, and 67% of this revenue to ports in Massachusetts. New Bedford, Sandwich, and Point Judith are among the top ten landing ports, and 31% of the revenue is attributed to other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the Discrete Monument Canyons is about 0.04% and 0.07% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 3% of their revenue attributed to fishing from this area (Figure 55).

Table 50 - Landings revenue to states, regions, and top ports attributed to fishing within the canyon coral zones overlapping the National Monument, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$1,198K	$240K	248
New Bedford	$1,032K	$206K	216
Sandwich	$112K	$22K	3
Gloucester	$35K	$7K	20
Other (n=8)	$19K	$4K	29
Rhode Island	$341K	$68K	42
Point Judith	$100K	$20K	37
Newport	$84K	$17K	5
Other (n=2)	$157K	$31K	4
New Jersey	$99K	$20K	6
New York	$48K	$10K	5
Montauk	$48K	$10K	5
Connecticut	$13K	$3K	6
Virginia	$12K	$2K	26
Other[b]	$78K	$16K	15
Total	**$1,790K**	**$358K**	**312**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
Source: VTR data analysis.

Discrete Non-Monument Canyons. Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Discrete Non-Monument Canyons (additive to No Action) are primarily located in Massachusetts, with lesser activity attributed to ports in Rhode Island, New Jersey, and other states (Table 52). The revenue attributed to Massachusets and Rhode Island from the Discrete Non-Monument Canyons is about 0.25% and 0.60% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 25% of their revenue attributed to fishing from this area (Figure 48, p. 271).

The VTR analysis attributes recent landings revenue to 59 ports, and 65% of this revenue to ports in Massachusetts. New Bedford, Point Judith, and Newport are among the top ten landing ports, and 39% of the revenue is attributed other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Massachusets and Rhode Island from the Discrete Non-Monument Canyons is about 0.25% and 0.60% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 25% of their revenue attributed to fishing from this area (Figure 54).

Table 51 – Landings revenue to states, regions, and top ports attributed to fishing within the canyon coral zones not overlapping the National Monument, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$8,230K	$1,646K	470
North of Cape			50
Gloucester	$250K	$50K	36
Other	$13K	$2K	
Cape Cod & Islands			52
Sandwich	$305K	$61K	5
Other	$1,433K	$287K	
South of Cape			405
New Bedford	$6,074K	$1,215K	385
Other	$6,229K	$31K	
Rhode Island	$2,862K	$572K	118
Point Judith	$867K	$173K	96
Newport	$867K	$173K	17
Tiverton	$569K	$114K	3
Other	$559K	$112K	
New York	$670K	$134K	31
Montauk	$611K	$122K	26
Virginia	$363K	$73K	107
Connecticut	$234K	$47K	25
New Jersey	$202K	$40K	60
North Carolina	$49K	$10K	47
Other[b]	$127K	$25K	15
Total	**$12,738K**	**$2,548K**	**661**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
Source: VTR data analysis.

7.4.3.3 Sociocultural impacts

The sociocultural impacts associated with establishing the canyon zones are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.4.4 Impacts on protected resources

To be completed prior to final action.

7.5 Impacts of seamount coral zones and associated fishing restrictions

This alternative would designate coral zones for the four seamounts within the U.S. EEZ: Bear, Retriever, Physalia, and Mytilus (section 4.2.2.2). The seamount zones do not overlap one another, but all of these discrete seamount zones are fully encompassed within the Northeast Canyons and Seamounts Marine National Monument and are fully contained within each broad zone (see discussion in section 4.2.2.2). Individual alternatives could be selected independently from one another, but it is assumed the zones would be adopted as a group.

Potential fishing restriction measures for coral zones are described in section 4.3. They include:

- Option 1: Prohibit bottom-tending gears
  - Sub-option A: Exempt the red crab fishery
  - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

7.5.1 Impacts on deep-sea corals

Corals have been recorded on the seamounts in both older and recent data (Table 33 and Table 34). All four types of corals are known to occur within the management zones. The seamounts are not within the footprint of the habitat suitability model. Because fishing is not known to occur on the seamounts at present, and considering the restrictions associated with the overlapping monument designation, designating discrete seamount zones would have neutral to slightly positive impacts. Seamount zone designations would represent a precautionary approach that would serve to highlight the fact that coral habitats occur at these sites. Increased awareness of seamount habitats through the Council process could have indirect positive impacts, perhaps by encouraging additional scientific study at the sites.

7.5.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.5.3 Impacts on human communities

Under this alternative, coral zones would be established around four seamounts, with options for which gear types would be precluded from the zones. The zones are within the National Monument (already included under No Action) and could be selected in combination with other alternatives under consideration.

The impacts of the seamount zones are expected to be negligible, but neutral relative to No Action. Some fishing activity is attributed to the seamount zones, but this is likely due to imprecise VTR reporting. No fishing with mobile or fixed bottom-tending gears is known to occur over the seamounts.

As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.5.3.1 Fishery impacts

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the seamount coral zones. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2). Some fishing activity is attributed to the seamount zones, but this is likely due to imprecise VTR reporting, as discussed below.

Total revenue. Annual revenue by fishing attributed to the seamount coral zones ranges from $30K-65K (Figure 51). Given the relativly large size of the seamount area, this level of revenue suggests the area is not a major center of fishing activity. This is consistent with the prevailing wisdom that to seamounts' distance from shore and surrounding depth make them less than ideal fishing locations.

Revenue by gear type. Revenue is attributed to bottom trawl, lobster pots, and other gears, though the other gears are not broken out individually due to data confidentiality restrictions. Maps of revenue by gear type and species are in section 13, beginning on page 338.

Trips and permits by gear type. About 100-250 trips per year partially overlap the seamount zones (Figure 58). Most of these are taken with lobster pot gear. Figure 59 shows the number of permits associated with these trips, and indicate a larger number of bottom trawl vessels fishing in the vicinity of the zones, vs. a smaller number of lobster trap vessels. Given the low revenue estimates from these trips and the large area of the seamounts themselves, this is additional evidence that estimated fishing activity is likely due to imprecision in the VTR as opposed to fishing itself.

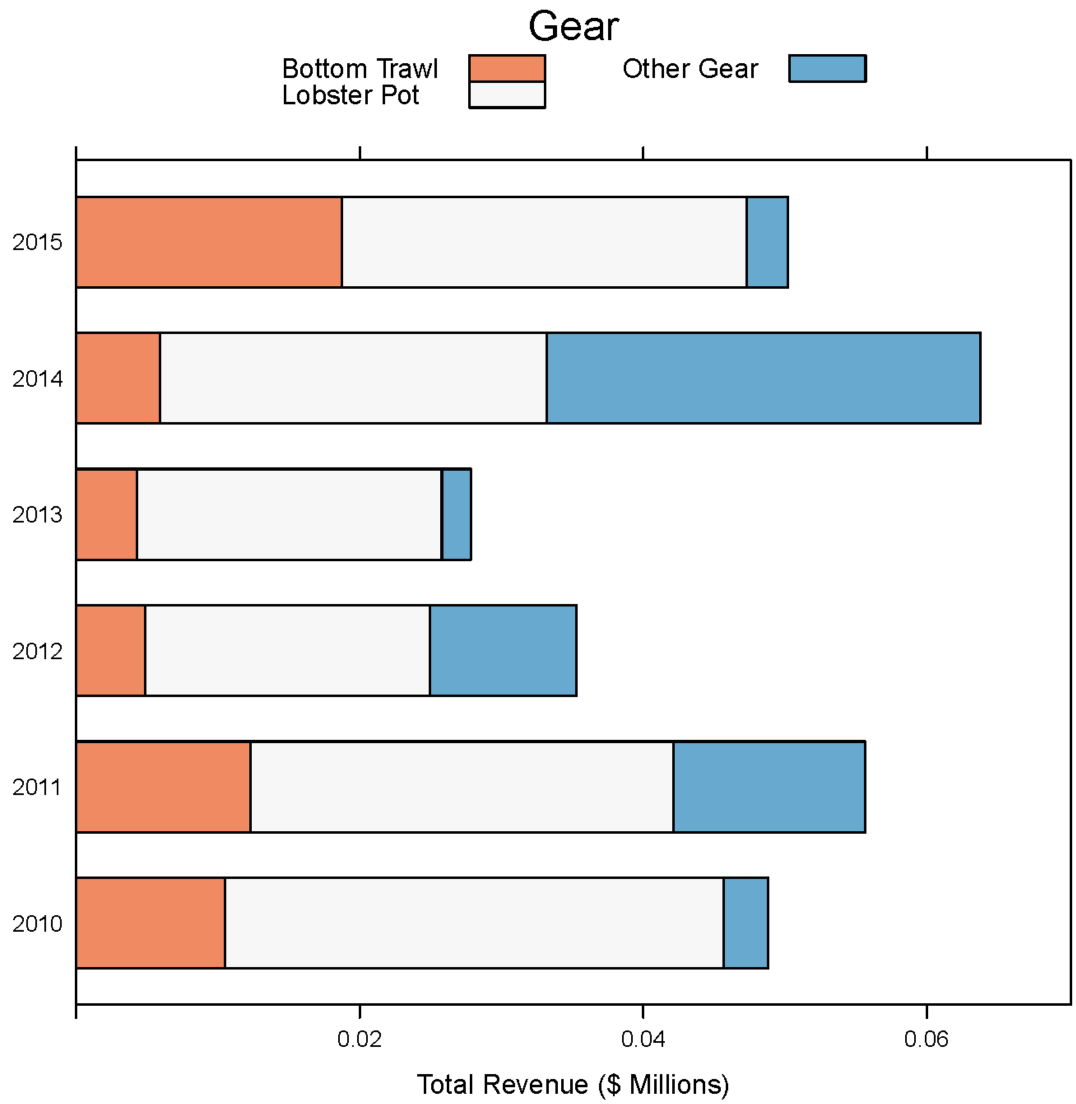
Revenue by species. The mix of species caught during the trips inferred to the seamount zones are the same as those associated with the canyon zones and the broad zones (Figure 60). This is unsurprising. Assuming fishing does not, in fact, occur on the seamounts, revenue inferred to the seamount zones comes from two sources. Either, the trips actually occurred in shallower areas, but were reported as occurring on the seamounts, or, small fractions of revenue associated with trips centered in shallower waters are attributed to the seamount areas. Both of these possibilities are evident in the revenue maps in section 13.

Percent owner revenue. Consistent with the interpretation that the seamounts are adjacent to active fishing grounds, and the revenue associated with them is likely due to inaccurate VTR locations or spatial imprecision in VTR data, the percent annual owner revenues associated with these trips are very small, approaching zero ().

Comparison of VTR and VMS.

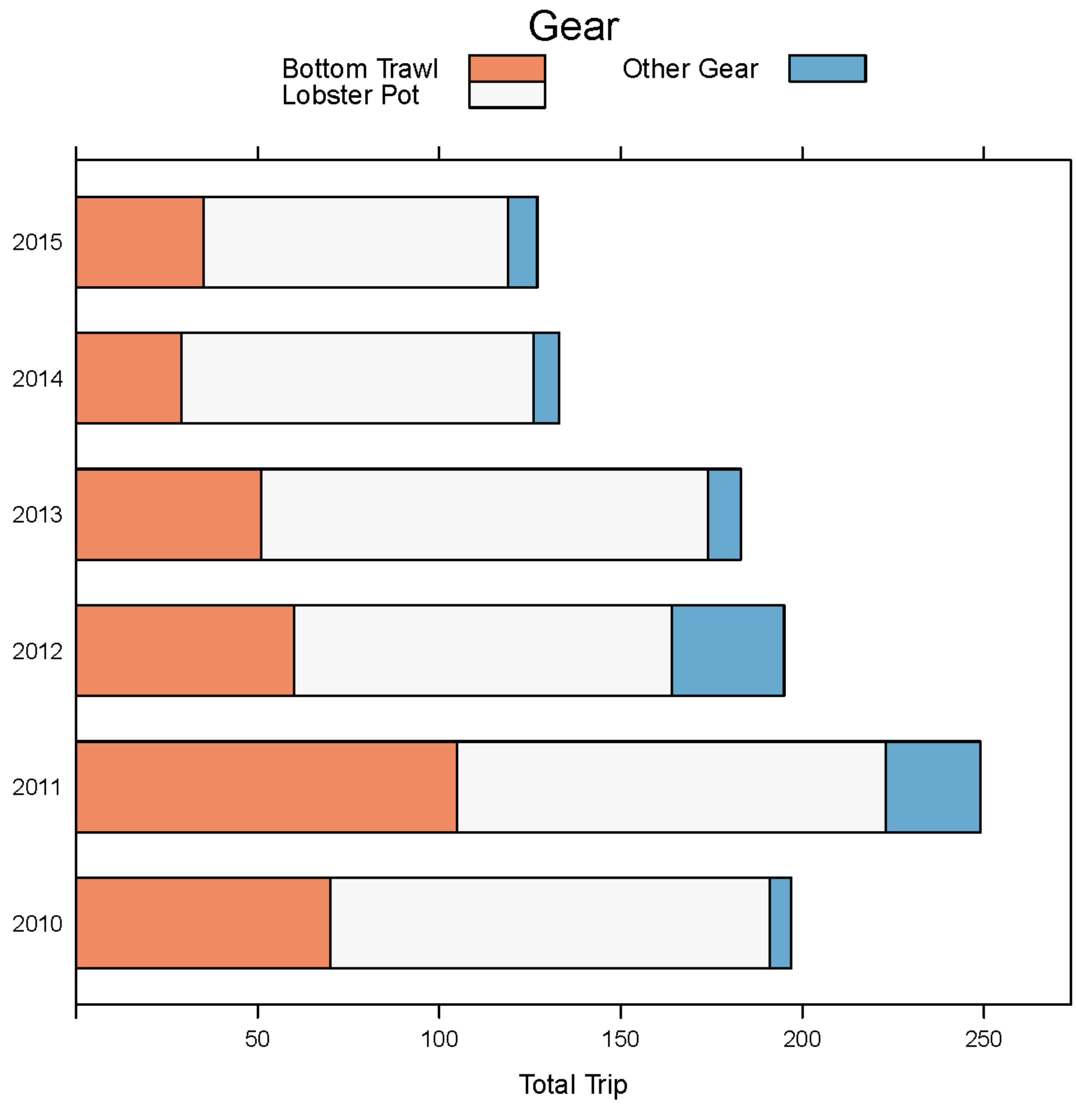
The VMS coverage is high enough for bottom trawl trips that this data is preferred to VTR in assessing trip activity within the seamount area under consideration. There are no VMS points that fall within this seamount region, indicating that no bottom trawl effort is expected to have occurred within the seamounts between 2005 and 2012. The VMS coverage of lobster pot and other gear is low enough to be unclear whether the data is representative of the larger fleet. For this reason, the VMS activity derived from VMS can be viewed as a lower bound, and VTR an upper bound, for these gear. At an ownership group, then, the upper bound is less than 1.5% of revenue generated, with the vast majority of ownership groups expected to have less than 0.2% of revenue potentially displaced by the seamounts alternative. The lower bound across all entities would be 0%, given that no VMS-derived effort has been estimated to fall within the seamounts region between 2005 and 2012.

Figure 57 – Revenue by gear type attributed to the four seamount coral zones, 2010-2015.



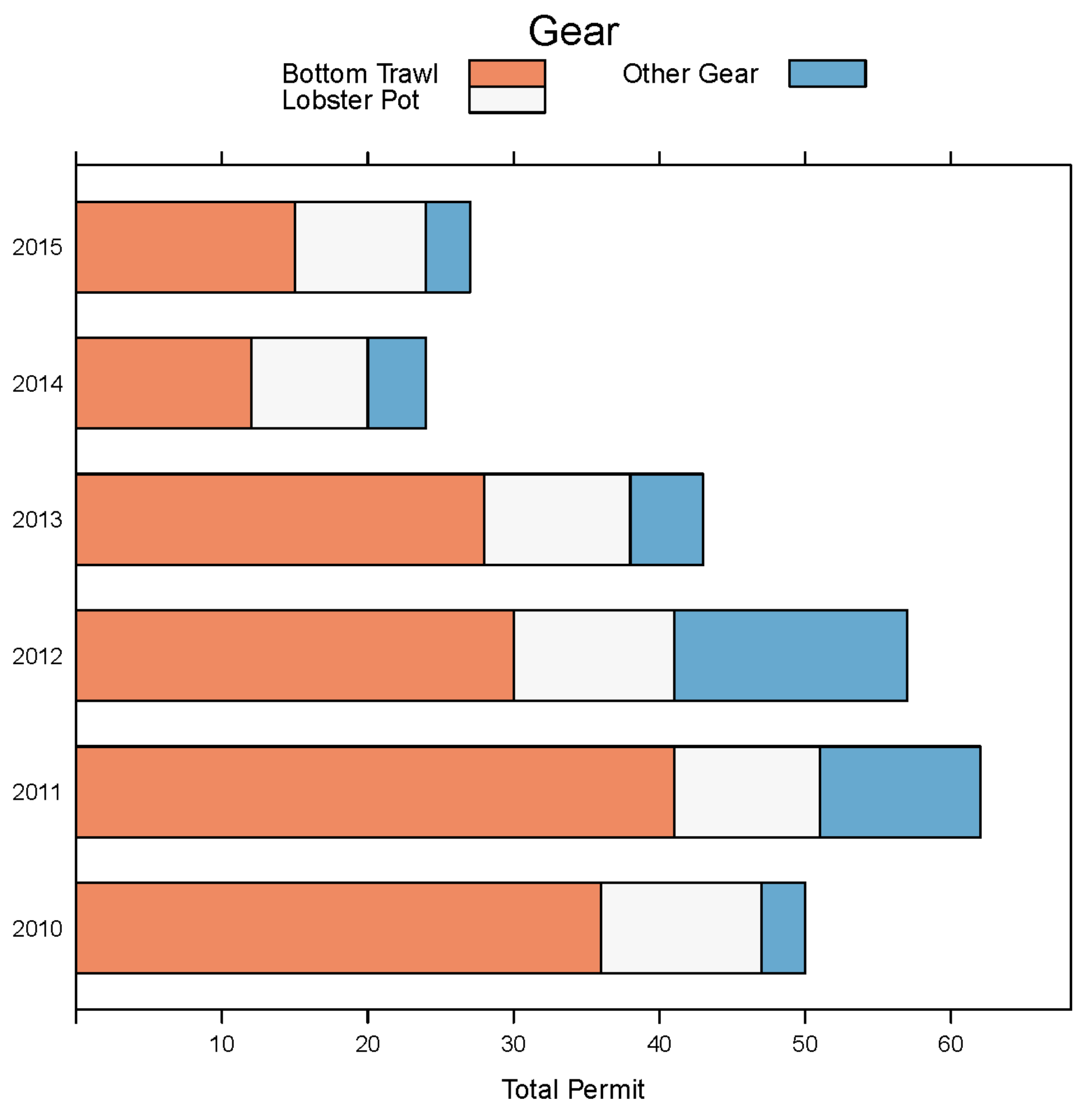
Source: **VTR analysis.**

Figure 58 – Trips by gear type attributed to the four seamount coral zones, 2010-2015.



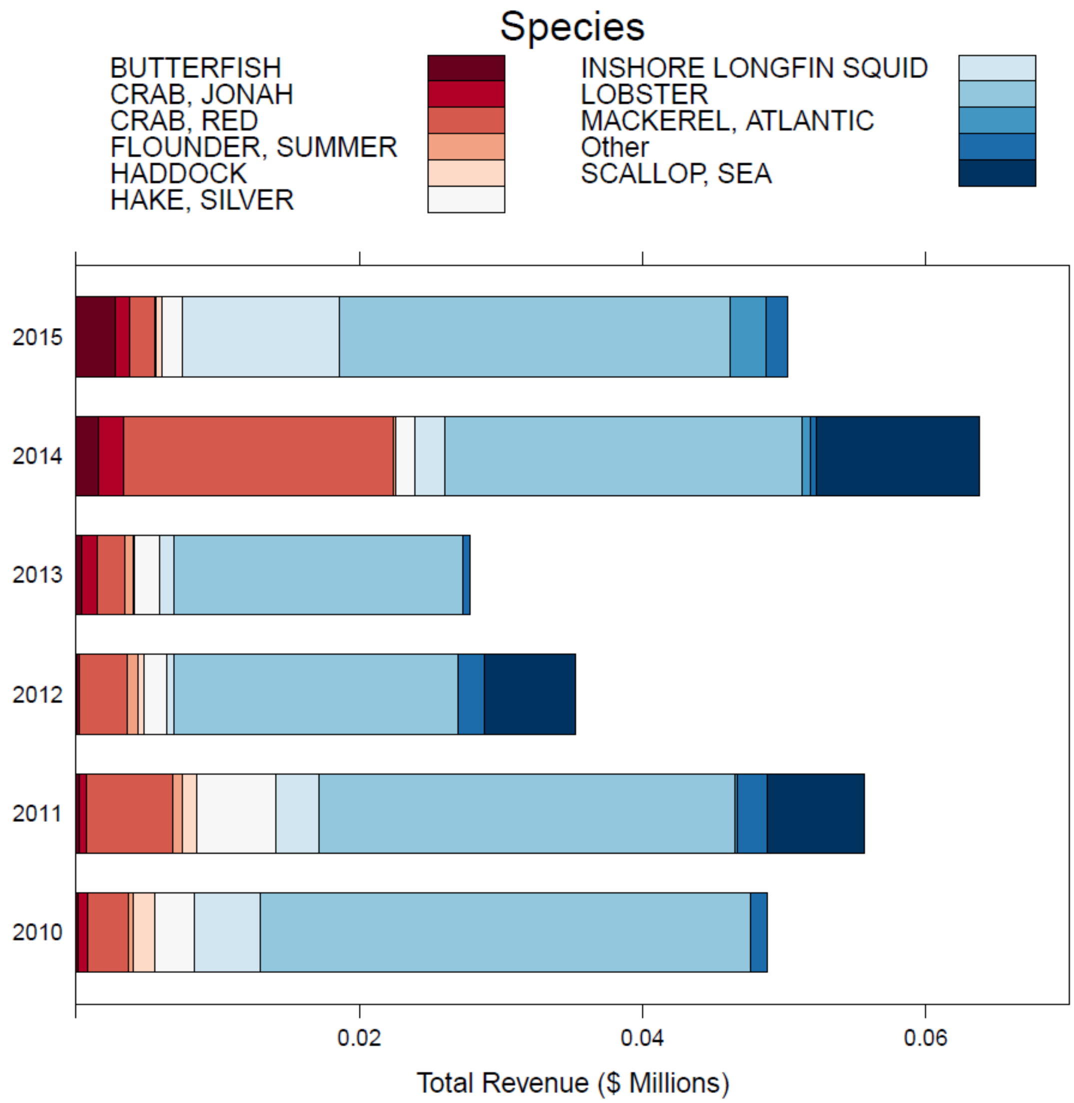
Source: **VTR analysis.**

Figure 59 – Permits by gear type attributed to the four seamount coral zones, 2010-2015.



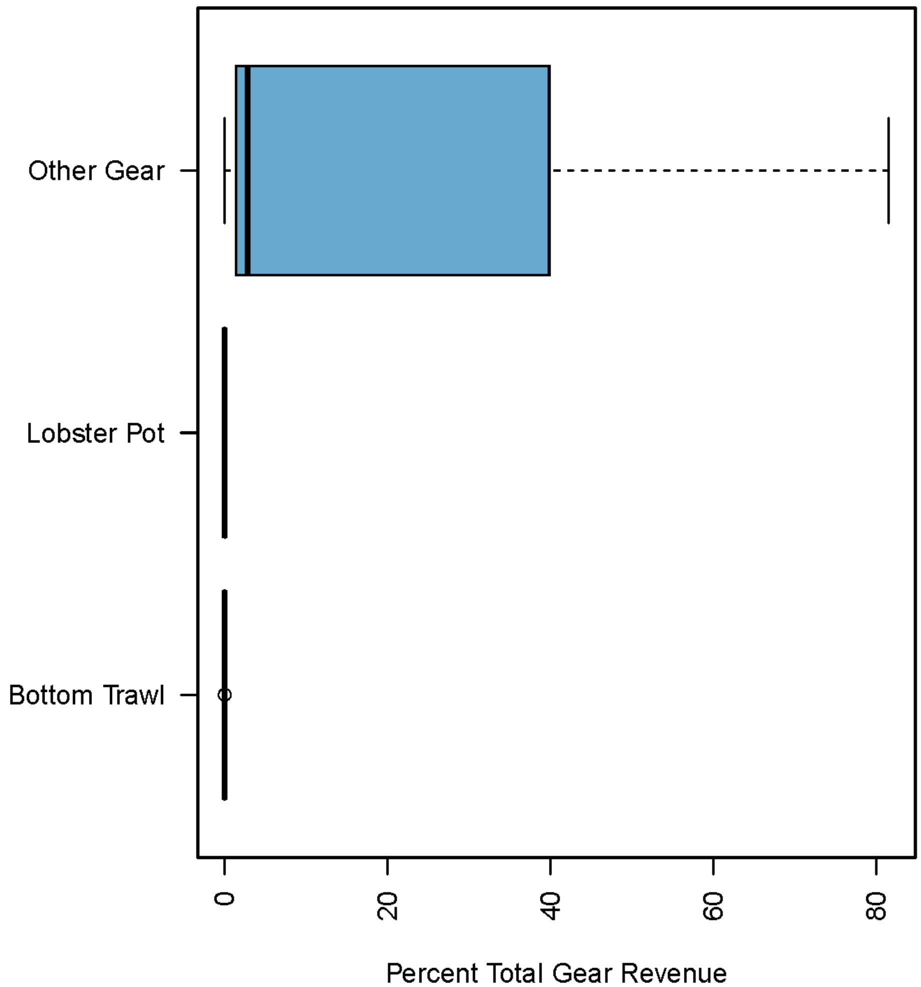
Source: **VTR analysis.**

Figure 60 – Revenue by species (top 10) attributed to the four seamount coral zones, 2010-2015.



Source: **VTR analysis.**

Figure 61 – Percent of total owner revenue attributed to the seamount coral zones, 2013-2015.



***Source:* VTR analysis.**

Table 52 – Percentage of VTR trips overlapping the Seamounts south of Georges Bank that have VMS coverage, by gear type.

Gear	Year	Zone	VTR Trips	VMS Trips	Coverage
Bottom Trawl	2010	Offshore Seamounts	70	67	96%
Bottom Trawl	2011	Offshore Seamounts	105	91	87%
Bottom Trawl	2012	Offshore Seamounts	60	49	82%
Lobster Pot	2010	Offshore Seamounts	121	0	0%
Lobster Pot	2011	Offshore Seamounts	118	0	0%
Lobster Pot	2012	Offshore Seamounts	104	1	1%
Other Gear	2010	Offshore Seamounts	6	0	0%
Other Gear	2011	Offshore Seamounts	26	14	54%
Other Gear	2012	Offshore Seamounts	31	7	23%

7.5.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 52, the revenue attributed (using the VTR analysis) to recent fishing within the seamount coral zone alternatives.

Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the seamount coral zone alternatives are primarily located in Rhode Island and Massachusetts, with lesser activity attributed to ports in other states (Table 52), some fishing activity is attributed to the seamount zones, but this is likely due to imprecise VTR reporting. The VTR analysis attributes recent landings revenue to 22 ports, and 48% of this revenue to ports in Rhode Island. Newport, New Bedford, and Gloucester are among the top ten landing ports, and 29% of the revenue is attributed to other ports, indicating that this zone may be particularly relevant for those three communities.

The revenue attributed to Rhode Island and Massachusets from the seamount coral zones is about 0.03% and 0.003% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 1% of their revenue attributed to fishing from this area.

Table 53 - Landings revenue to states, regions, and top ports attributed to fishing within the seamount coral zones, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Rhode Island	$135K	$27K	27
Newport	$106K	$21K	4
Point Judith	$9K	$2K	22
Other (n=2)	$20K	$4K	4
Massachusetts	$102K	$20K	69

New Bedford	$82K	$16K	56
Gloucester	$13K	$3K	7
Other (n=4)	$7K	$1K	6
New Jersey	$9K	$2K	5
New York	$7K	$1K	5
Montauk	$7K	$1K	5
Connecticut	$3K	$1K	3
Virginia	$1K	$0K	5
Other[b]	$24K	$5K	9
Total	**$282K**	**$56K**	**110**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
Source: VTR data analysis.

7.5.3.3 Sociocultural impacts

The sociocultural impacts associated with establishing the seamount zones are expected to be negligible for fishermen and fishing communities, and neutral relative to No Action. No (or very little) fishing effort is currently ocurring in the seamount zones, though this alternative would prevent the expansion of fisheries or the development of new fisheries in these areas. Deep-sea corals have cultural value to society, so affording them protection from future fisheries has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.5.4 Impacts on protected resources

To be completed prior to final action.

7.6 Impacts of the Mount Desert Rock coral zone and associated fishing restrictions

This alternative would designate a coral zone just outside state waters, southwest of Mount Desert Rock (section 4.2.2.3.1). Potential fishing restriction measures for coral zones are described in section 4.3. Restrictions relevant to this coral zone include:

- Option 1: Prohibit bottom-tending gears
  - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

The red crab fishery exemption is not discussed in the following sections because that fishery is not prosecuted in the Gulf of Maine.

7.6.1 Impacts on deep-sea corals

Deep-sea corals are known to occur within the Mt. Desert Rock zone based on recent survey work (see Table 34 and section 6.2.3.3). Lobster is the dominant fishing activity at the site (see section 7.6.3 below), so the degree to which coral zone designation has a positive impact on corals depends on the fishing restriction measures selected. If a mobile bottom-tending gear restriction is adopted in the zone, it would have indirect, slightly positive impacts on coral habitats. While there would be limited if any reductions in direct impacts of gear on corals, designation of the site would highlight the importance of the area and might encourage additional research. In addition, the designation would prevent mobile bottom-tending gear use in the area in the future, should patterns of effort change. The same impacts would be expected if the Council adopts a restriction on all bottom-tending gears, but exempts trap fisheries.

If the Mt. Desert Rock zone was adopted as a coral zone closed to all bottom-tending gears, without a trap fishery exemption, the lobster fishery would be excluded from the zone and the likelihood of interactions between lobster gear and corals would be reduced. It is difficult to assess the rate of those interactions, and the extent to which any interactions have negative impacts on corals, given presently available information. While trap gears could crush or remove coral colonies, such effects have not been demonstrated to occur within our region, as relevant gear impacts research is not available (see section 6.5.2). However, there are observed interactions between trap gear and corals in the Gulf of Maine (see section 6.5.3). We cannot use these observations to estimate coral bycatch rates in the lobster trap fishery or any fishery. Overall, designation of this zone as a closure to all bottom tending gears would be expected to have positive impacts on deep-sea corals, but the magnitude of these impacts is difficult to determine.

7.6.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.6.3 Impacts on human communities

Under this alternative, a coral zone would be established just southwest of Mt. Desert Rock, with options for which gear types would be precluded from the zone. This alternative would be additive to No Action (i.e. Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the Mt. Desert Rock zone on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. These negative impacts would be additive to the negative fishery impacts of No Action, though the No Action areas do not overlap Mt. Desert Rock and the directly impacted fishermen may be distinct. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.6.3.1 Fishery impacts

The Mt. Desert Rock zone is located in federal waters between 3-12 nautical miles from shore within the Maine Lobster Management Zones B. The zone is in Federal Lobster Management Area 1 (Map 42), thus, a federal permit is required to fish in the zone. Fishing activity in this coral zone has been clearly dominated by the lobster fishery, whereas the fisheries in deeper zones considered (e.g., canyon/slope region) have been more diverse. Due to data limitations, it is impossible to know the true amount of fishing activity that has occurred within the Mt. Desert Rock coral zone. Thus, multiple approaches are used to estimate fishing activity and characterize the potential fishery impacts of the alternatives under consideration.

ME DMR data. Maine DMR, via the Habitat Plan Development Team, provided data on fishing trips, permits fished, value, and landings by Lobster Management Zone, including the proportion attributed to federally permitted vessels (Table 55). Dealer and port data were used to estimate 2015 lobster revenue for Lobster Management Zones A, B, and C. Harvester reports from 2011-2014 were then used to ascribe that zone's revenue to three distances from shore (0-3, 3-12, 12+ nm; Map 49).

The Mt. Desert Rock coral zone is 46.8 km^2, 3.1% of the area of Zone B that is 3-12 nm from shore. Based on the MEDMR data, the total 2015 lobster harvest estimated for Zone B, 3-12 miles from shore, was 3.6M lbs. (Map 47), harvested in 4,382 trips (Map 48) and valued at $15M (Map 48). Simply concluding that the revenue from the area of the Mt. Desert Rock coral zone is 3.1% of $15M ($0.47M) is not appropriate, given that the distribution of lobster fishing is unknown within both the management and coral zones. Lobstermen have indicated that both the Mt. Desert Rock and Outer Schoodic Ridge coral zones are two to four times more productive than surrounding sites (ASMFC 2017). Assuming that $15M is an accurate estimate of total revenue generated in Zone B between 3-12 miles from shore, and that the majority of this revenue is generated in the 96.7% of Zone B outside the coral zone, 2015 revenue from the Mt. Desert Rock coral zone only is certainly well below $15M. If the area within the zone is in fact two to four times more productive than other parts of zone B, this would suggest that during 2015, revenue from the coral zone was in the range of $1-2M.

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent fishing activity reported with VTR within the Mt. Desert Rock coral zone. However, only a very small percentage of federally permitted lobster vessels report their activity via VTR. The MEDMR data indicate that VTR data account for only 9% of the lobster revenue, 7% of trips, and 6% of permits active in Zone B. Simply concluding that the results of the VTR analysis constitute 6-9% of the total revenue and effort from the area of the Mt. Desert Rock coral zone is not appropriate, given that the distribution of lobster fishing is unknown within both the management and coral zones, and there is no information to suggest that vessels submitting VTRs are a representative subset of the fishery. However, the VTR results are almost certainly an underestimate of revenue, trips, and permits associated with the Mt. Desert Rock zone, and thus should be seen as a manner to assess relative exposure of fisheries in the region, as opposed to estimating impacts themselves.

For 2010-2015, annual revenue by fishing with VTR attributed to the Mt. Desert Rock zone ranges from $80K-180K **(**Figure 62).Figure 55). As described above, this revenue is expected to be an underestimate of revenue generated by the lobster fishery in the vicinity of Mt. Desert Rock. Nevertheless, lobster pots would be expected to be the dominant gear employed within the region. Trips and permits affected are also dominated by the lobster pot fishery, and lobster generates the vast majority of the value generated from effort within the Mt. Desert Rock zone. Thus, although expected to be an underestimate, the VTR data paint a consistent picture, in that the lobster fishery constitutes the vast majority of fishery exposure to the Mt. Desert Rock zone.

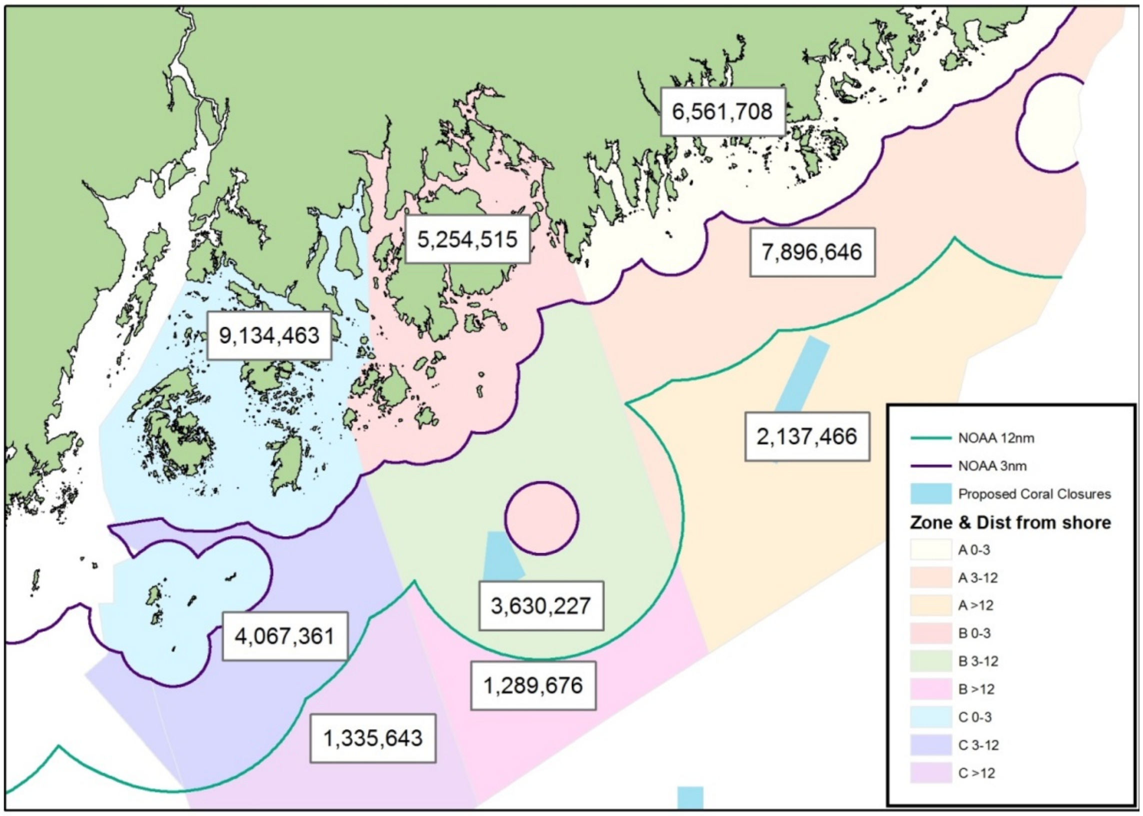
Summary of revenue estimates. It is impossible to know the true amount of revenue generated within the Mt. Desert Rock coral zone. The MEDMR data attribute $15M in 2015 lobster landings to Zone B, 3-12 nm from shore, so this is likely more than the upper bound of what was harvested within the Mt. Desert Rock coral zone..

Table 54 – Number of lobster permits, number of trips, revenue, and landings (lb) by permit type and Maine Management Area (A, B, and C only), 2015.

Permit numbers						
Zone	Federal No VTR	Federal w VTR	State Only	Total	Federal	% federal
A	271	28	664	963	299	31%
B	161	10	408	579	171	30%
C	160	10	604	774	170	22%
Trips						
Zone	Federal No VTR	Federal w VTR	State Only	Total	Federal	% federal
A	21,702	2,357	29,539	53,598	24,059	45%
B	13,098	991	17,933	32,022	14,089	44%
C	17,283	950	35,927	54,160	18,233	34%
Value						
Zone	Federal No VTR	Federal w VTR	State Only	Total	Federal	% federal
A	60,261,907	6,039,883	33,316,457	99,618,247	66,301,790	67%
B	39,009,830	3,671,325	28,076,911	70,758,066	42,681,155	60%
C	55,979,051	3,791,784	66,224,717	125,995,552	59,770,835	47%
Landings						
Zone	Federal No VTR	Federal w VTR	State Only	Total	Federal	% federal
A	15,054,051	1,543,886	9,056,975	25,654,912	16,597,937	65%
B	9,327,846	874,674	6,740,661	16,943,181	10,202,520	60%
C	13,631,809	910,528	17,079,316	31,621,653	14,542,337	46%

***Note:* In the last two columns, federal and % federal combine VTR and non-VTR permits.**
***Source:* Maine dealer data.**

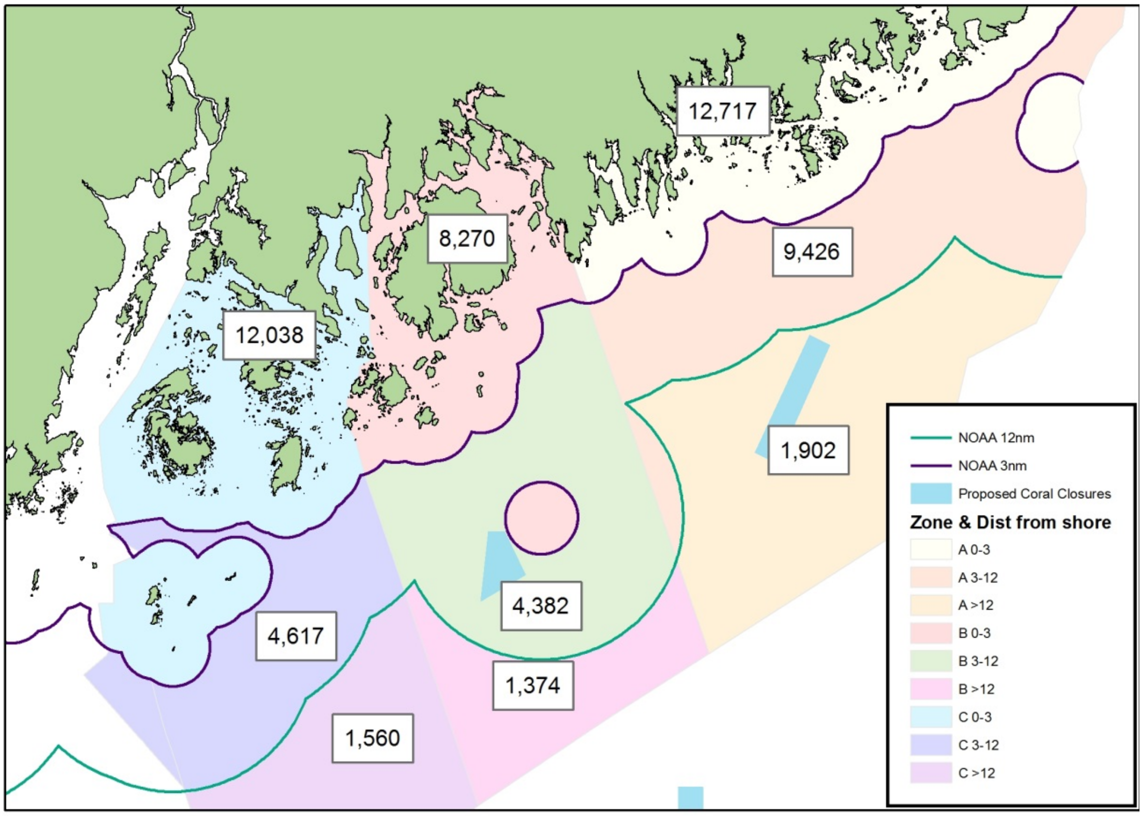
Map 47 – 2015 lobster landings (lbs.) by federal permit holders by distance from shore in Maine Lobster Management Zones A, B, and C.



Note: **Total landings in each management zone was distributed among the distance from shore bands based on the 2011-2014 Maine Harvester Logbooks and the trip locations reported on federal VTRs. Average 2011-2014 percentages for each zone and distance from shore are shown below.**

	0-3 nm	3-12 nm	12+ nm
Zone A	39.53%	47.58%	12.88%
Zone B	51.50%	35.58%	12.66%
Zone C	62.81%	27.97%	13.42%

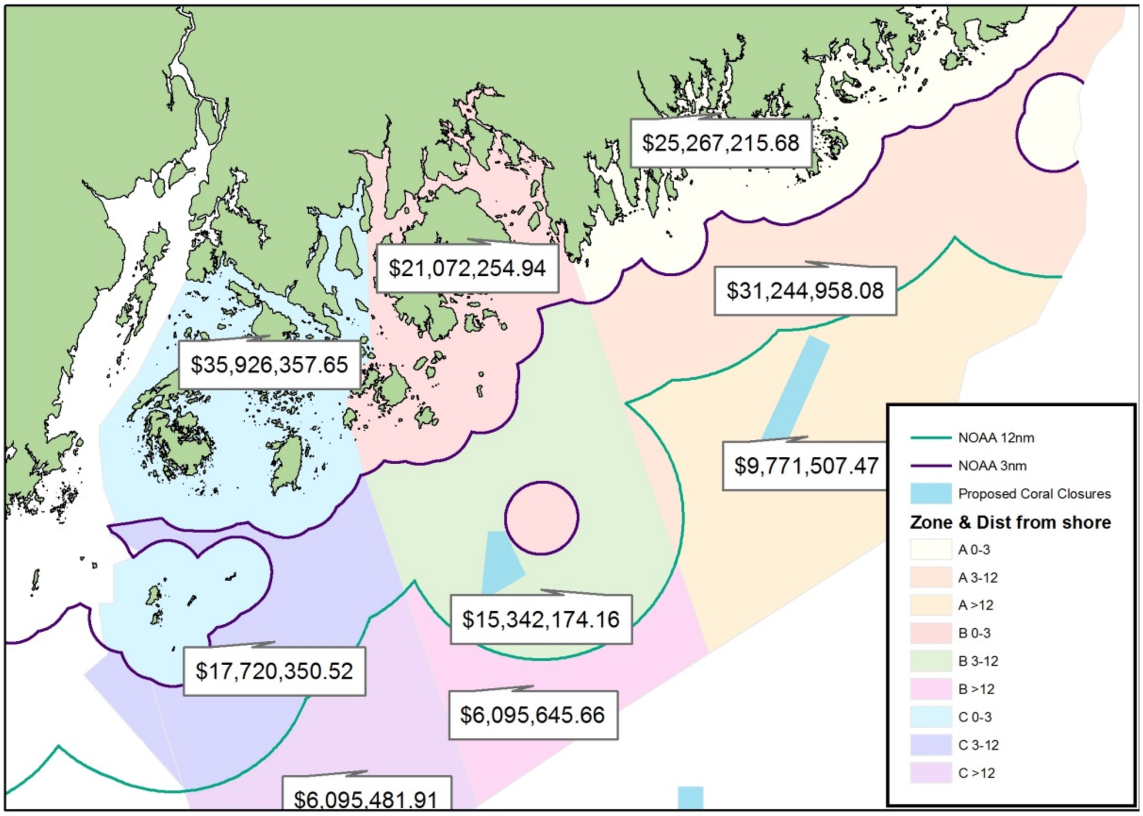
Map 48 – Number of 2015 lobster trips taken by federal permit holders by distance from shore in Maine Lobster Management Zones A, B, and C.



Note: **Total number of trips in each management zone was distributed among the distance from shore bands based on the 2011-2014 Maine Harvester Logbooks and the trip locations reported on federal VTRs. Average 2011-2014 percentages for each zone and distance from shore are shown below.**

	0-3 nm	3-12 nm	12+ nm
Zone A	52.86%	39.18%	7.91%
Zone B	58.69%	31.10%	9.76%
Zone C	66.02%	25.32%	9.18%

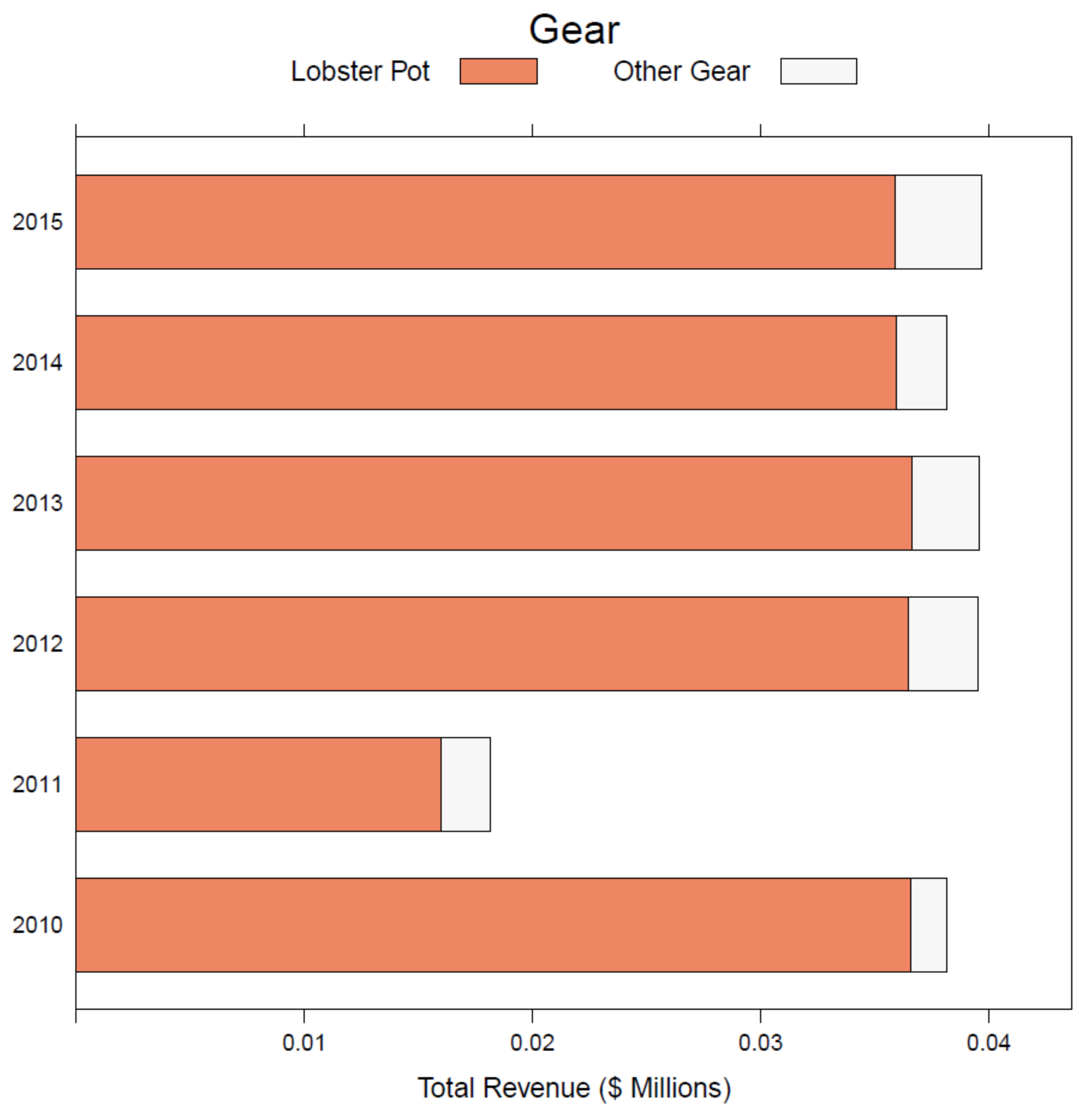
Map 49 – Distribution of 2015 lobster revenue for federal permit holders by distance from shore in Maine Lobster Management Zones A, B, and C.



Note: **Total revenue in each management zone was distributed among the distance from shore bands based on the 2011-2014 Maine Harvester Logbooks and the trip locations reported on federal VTRs. Average 2011-2014 percentages for each zone and distance from shore are shown below.**

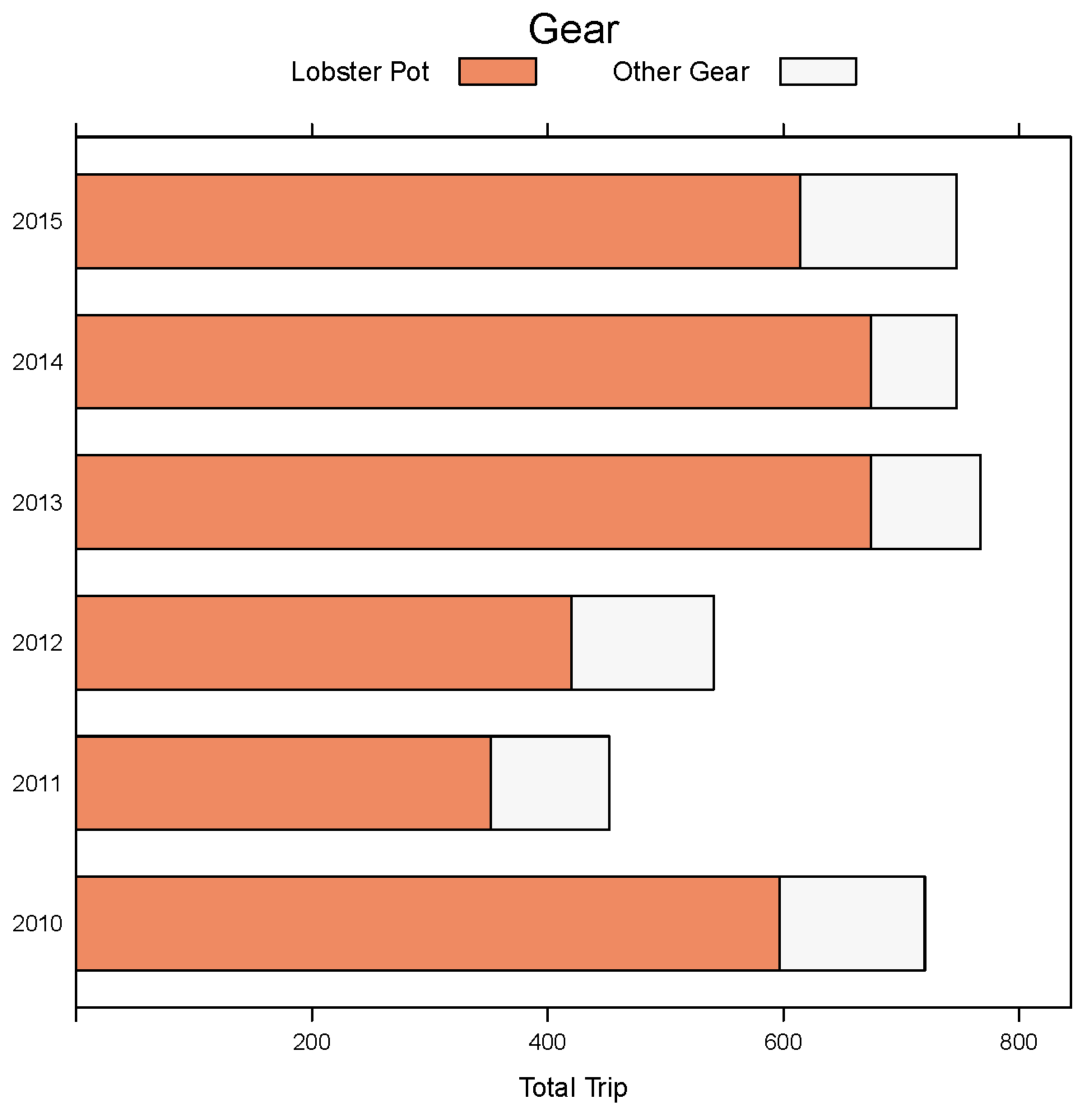
	0-3 nm	3-12 nm	12+ nm
Zone A	38.11%	47.13%	14.74%
Zone B	49.37%	35.95%	14.28%
Zone C	60.11%	29.65%	10.20%

Figure 62 – Revenue by gear type attributed to the Mt. Desert Rock coral zone, 2010-2015.



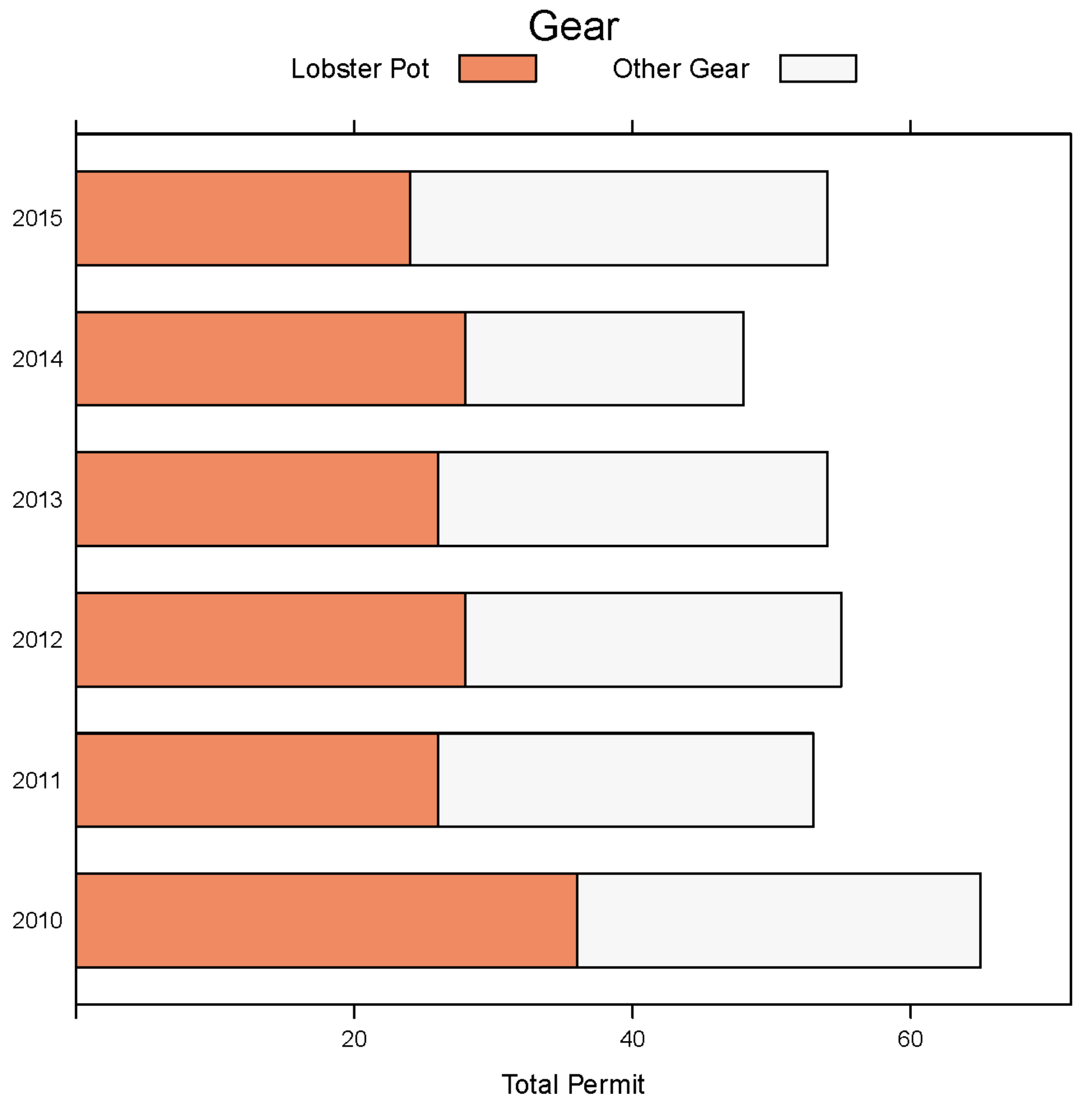
***Source*: VTR analysis.**

Figure 63 – Trips by gear type attributed to the Mt. Desert Rock coral zone, 2010-2015.



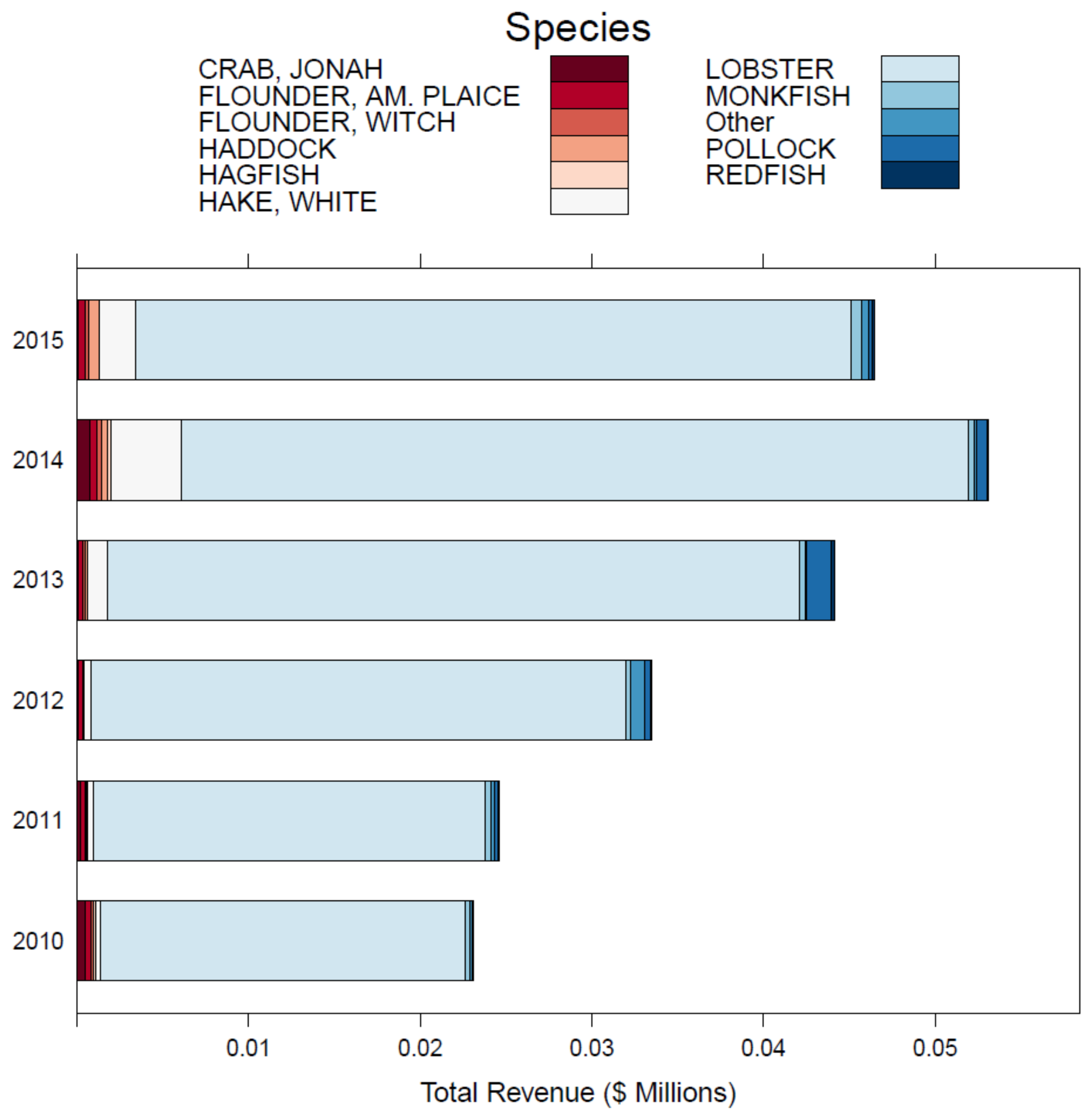
***Source*: VTR analysis.**

Figure 64 – Permits by gear type attributed to the Mt. Desert Rock coral zone, 2010-2015.



***Source*: VTR analysis.**

Figure 65 – Revenue by species (top 10) attributed to the Mt. Desert Rock coral zone, 2010-2015.



***Source*: VTR analysis.**

7.6.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 56, the revenue attributed (using the VTR analysis) to recent fishing within the Mt. Desert Rock coral zone.

Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Mt. Desert Rock alternative are primarily located in Maine, with a small amount of activity attributed to ports in New Hampshire, Massachusetts, and Rhode Island (Table 56). The VTR analysis attributes recent landings (using VTR) revenue to 30 ports, and 88% of this revenue to ports in Maine. Stonington and Winter Harbor, in eastern Maine, are among the top ten landing ports, yet 59% of the Maine revenue is attributed to other ports in that state, indicating that the fishermen and communities that may be impacted are more broadly distributed. The input of the Maine Lobstermen's Association indicates such, that the area near the Mt. Desert Rock coral zone is also important to lobstermen landing in ports such as Oceanville, Bass Harbor, Bar Harbor, Islesford, Northeast Harbor, and Swans Island.

Based on the VTR analysis, the revenue from VTR trips is minor from the Mt. Desert Rock coral zone relative to the total revenue for these states, during 2010-2015 (ACCSP, 2017). Since the majority of Lobster Management Area 1 vessels do not hold other federal permits, the VTR dataset is known to substantially underestimate fishing activity in the Mt. Desert Rock coral zone, so this area is likely far more important to the states, ports, and individuals than what is reported here.

Table 55 - Landings revenue to states, regions, and top ports attributed to fishing with VTR within the Mt. Desert Rock coral zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Maine	$187K	$37K	73
Stonington	$59K	$12K	9
Winter Harbor	$18K	$4K	3
Other	$110K	$22K	
New Hampshire	$13K	$3K	10
Massachusetts	$13K	$3K	43
Gloucester	$9K	$2K	23
New Bedford	$2K	$0.5K	8
Other	$2K	$0.5K	
Rhode Island	$0.3K	$0.1K	3
Total	**$213K**	**$43K**	**117**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
"Eastern" = ports from Lubec to Verona Island
"Mid-Coast" = ports from Stockton Springs to Brunswick
"Southern" = ports from Freeport to Kittery
Source: VTR data analysis.

7.6.3.3 Sociocultural impacts

The sociocultural impacts associated with the Mt. Desert Rock coral zone are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.6.4 Impacts on protected resources

To be completed prior to final action.

7.7 Impacts of the Outer Schoodic Ridge coral zone and associated fishing restrictions

This alternative would designate a coral zone on the Outer Schoodic Ridge, roughly 25 nm southeast of Mt. Desert Island, within NMFS Statistical Area 511 and Maine Lobster Management Zone A (section 4.2.2.3.2). The coral zone encompasses a portion of the Ridge that has been recently mapped with multibeam and surveyed using ROV. Potential fishing restriction measures for coral zones are described in section 4.3. Restrictions relevant to this coral zone include:

- Option 1: Prohibit bottom-tending gears
    - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

The red crab fishery exemption is not discussed in the following sections, because that fishery is not prosecuted in the Gulf of Maine.

7.7.1 Impacts on deep-sea corals

Deep-sea corals are known to occur within the Outer Schoodic Ridge zone based on recent survey work (see Table 34 and section 6.2.3.3). Lobster is the dominant fishing activity at the site (see section 7.7.3 below), so the degree to which coral zone designation has a positive impact on corals depends on the fishing restriction measures selected. If a mobile bottom-tending gear restriction is adopted in the zone, it would have indirect, slightly positive impacts on coral habitats. While there would be limited if any reductions in direct impacts of gear on corals, designation of the site would highlight the importance of the area and might encourage additional research. In addition, the designation would prevent mobile bottom-tending gear use in the area in the future, should patterns of effort change. The same impacts would be expected if the Council adopts a restriction on all bottom-tending gears, but exempts trap fisheries.

If the Outer Schoodic Ridge zone was adopted as a coral zone closed to all bottom-tending gears, without a trap fishery exemption, the lobster fishery would be excluded from the zone and the likelihood of interactions between lobster gear and corals would be reduced. It is difficult to assess the rate of those interactions, and the extent to which any interactions have negative impacts on corals, given presently available information. While trap gears could crush or remove coral colonies, such effects have not been demonstrated to occur within our region, as relevant gear impacts research is not available (see section 6.5.2). However, there are observed interactions between trap gear and corals in the Gulf of Maine (see section 6.5.3). We cannot use these observations to estimate coral bycatch rates in the lobster trap fishery or any fishery. Overall, designation of this zone as a closure to all bottom tending gears would be expected to have positive impacts on deep-sea corals, but the magnitude of these impacts is difficult to determine.

7.7.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.7.3 Impacts on human communities

Under this alternative, a coral zone would be established on the Outer Schoodic Ridge, with options for which gear types would be precluded from the zone. This alternative would be additive to No Action (Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the Outer Schoodic Ridge zone on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. These negative impacts would be additive to the negative fishery impacts of No Action, though the No Action areas do not overlap Outer Schoodic Ridge and the directly impacted fishermen may be distinct. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.7.3.1 Fishery impacts

The Outer Schoodic Ridge zone is located in federal waters between 3-12 nautical miles from shore within the Maine Lobster Management Zones A. The zone is in Federal Lobster Management Area 1 (Map 42), thus, a federal permit is required to fish in the zone. Fishing activity in this zone has been clearly dominated by the lobster fishery, whereas the fisheries in deeper zones considered (e.g., canyon/slope region) have been more diverse. Due to data limitations, it is impossible to know the true amount of fishing activity that has occured within the Outer Schoodic Ridge coral zone. Thus, multiple approaches are used to estimate fishing activity, and thus characterize the potential fishery impacts of the alternatives under consideration.

ME DMR data. Maine DMR, via the Habitat Plan Development Team, provided data on fishing trips, permits fished, value, and landings by Lobster Management Zone, including the proportion attributed to federally permitted vessels (Table 55). Dealer and port data were used to estimate 2015 lobster revenue for Lobster Management Zones A, B, and C. Harvester reports from 2011-2014 were then used to ascribe that zone's revenue to three distances from shore (0-3, 3-12, 12+ nm; Map 49).

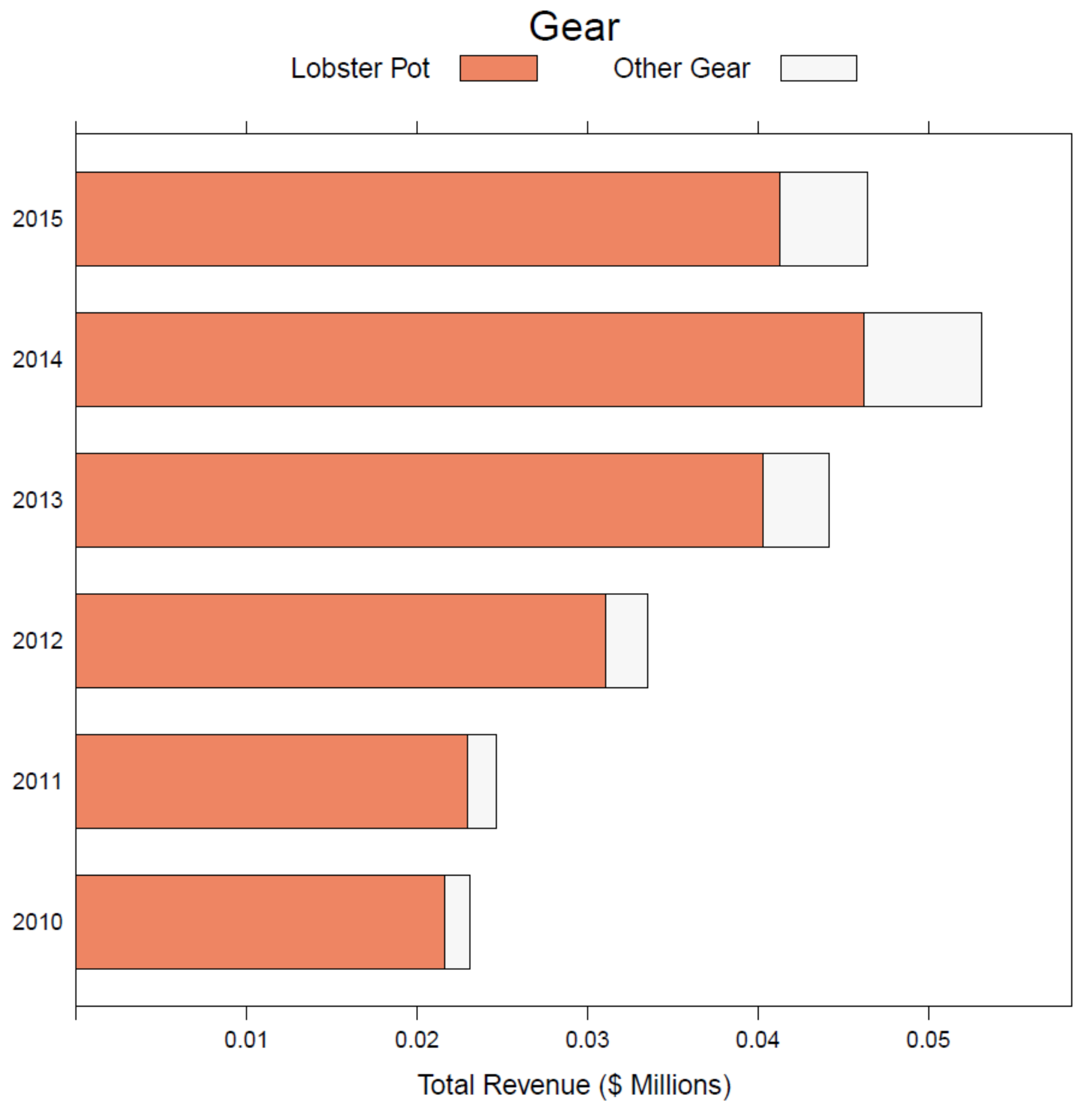
The Outer Schoodic Ridge zone is 79 km^2, or 4.0% of Zone A, 12+ miles from shore. Based on the MEDMR data, the total 2015 lobster harvest estimated for Zone A, 12+ miles from shore, was 2.1M lbs. (Map 47), harvested in 1,902 trips (Map 48) and valued at $9.8M (Map 49). Simply concluding that the revenue from the area of the Outer Schoodic Ridge coral zone is 4.0% of $9.8M ($0.39M) is not appropriate, given that the distribution of lobster fishing is unknown within both the management and coral zones. However, $9.8M would likely be greater than the maximum of 2015 revenue from the Outer Schoodic Ridge coral zone.

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent fishing activity reported with VTR within the Outer Schoodic Ridge coral zone. However, only a very small percentage of federally permitted lobster vessels report their activity via VTR. The MEDMR data indicate that VTR data do not account for 91% of the lobster revenue, 90% of trips, and 91% of permits active in Zone A. Simply concluding that the results of the VTR analysis constitute 9-10% of the total revenue and effort from the area of the Outer Schoodic Ridge coral zone is not appropriate, given that the distribution of lobster fishing is unknown within both the management and coral zones. However, the VTR results are likely a minimum.

Total revenue. For 2010-2015, annual revenue by fishing with VTR attributed to the Outer Schoodic Ridge zone ranges from $20K-50K (Figure 59). Although expected to be an underestimate of potentially displaced revenue, the VTR analysis makes clear that lobster pots are to dominant gear, and lobster is the dominant species, for fishing activity around the Outer Schoodic Ridge coral zone.

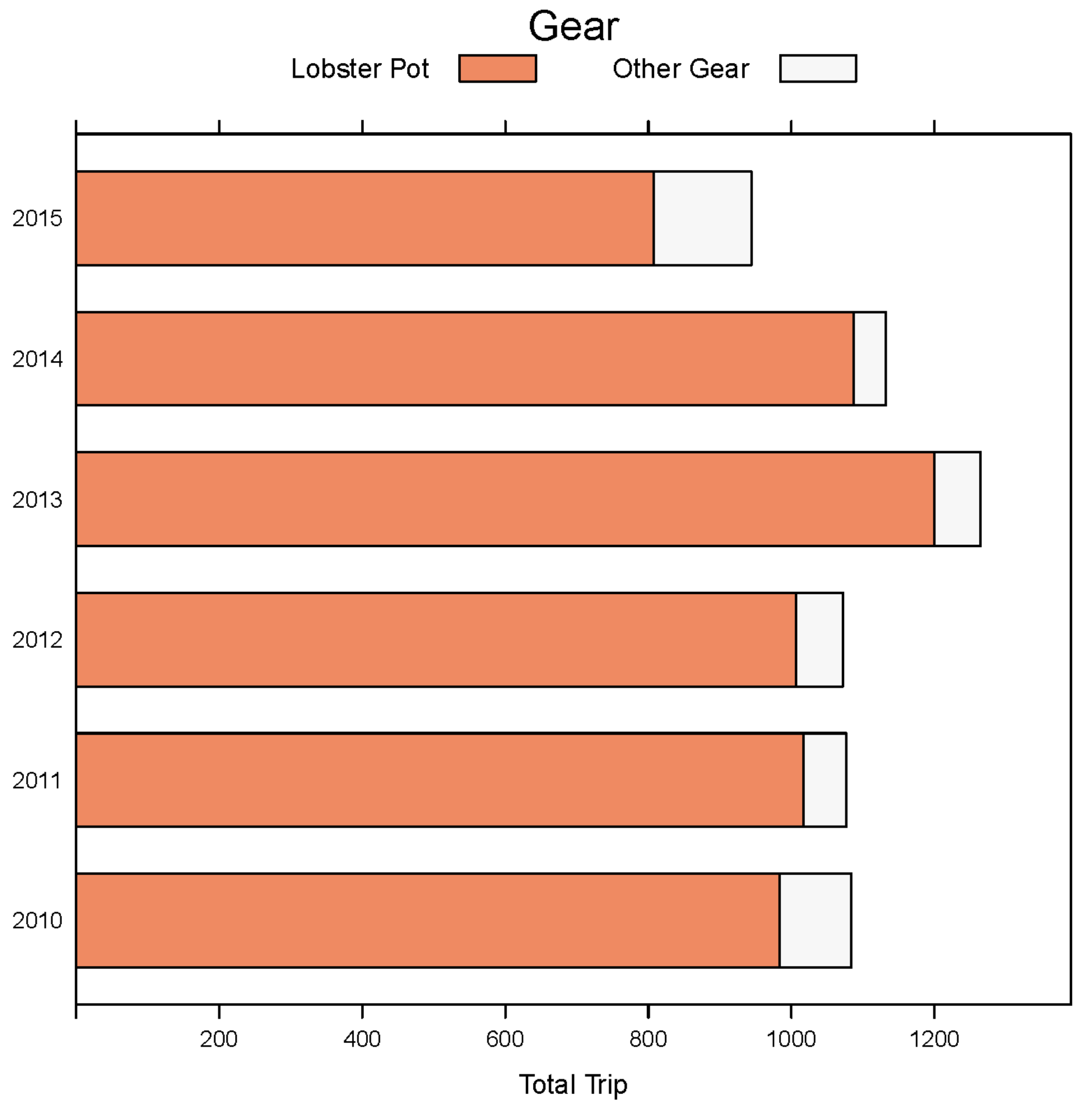
Summary of revenue estimates. It is impossible to know the true amount of revenue generated within the Outer Schoodic Ridge coral zone. The MEDMR data attribute $9.8M in 2015 lobster landings to Zone A, 12+ nm from shore; this is likely more than the upper bound of what was harvested within the Outer Schoodic Ridge coral zone.

Figure 66 – Revenue by gear type attributed to the Outer Schoodic Ridge coral zone, 2010-2015.



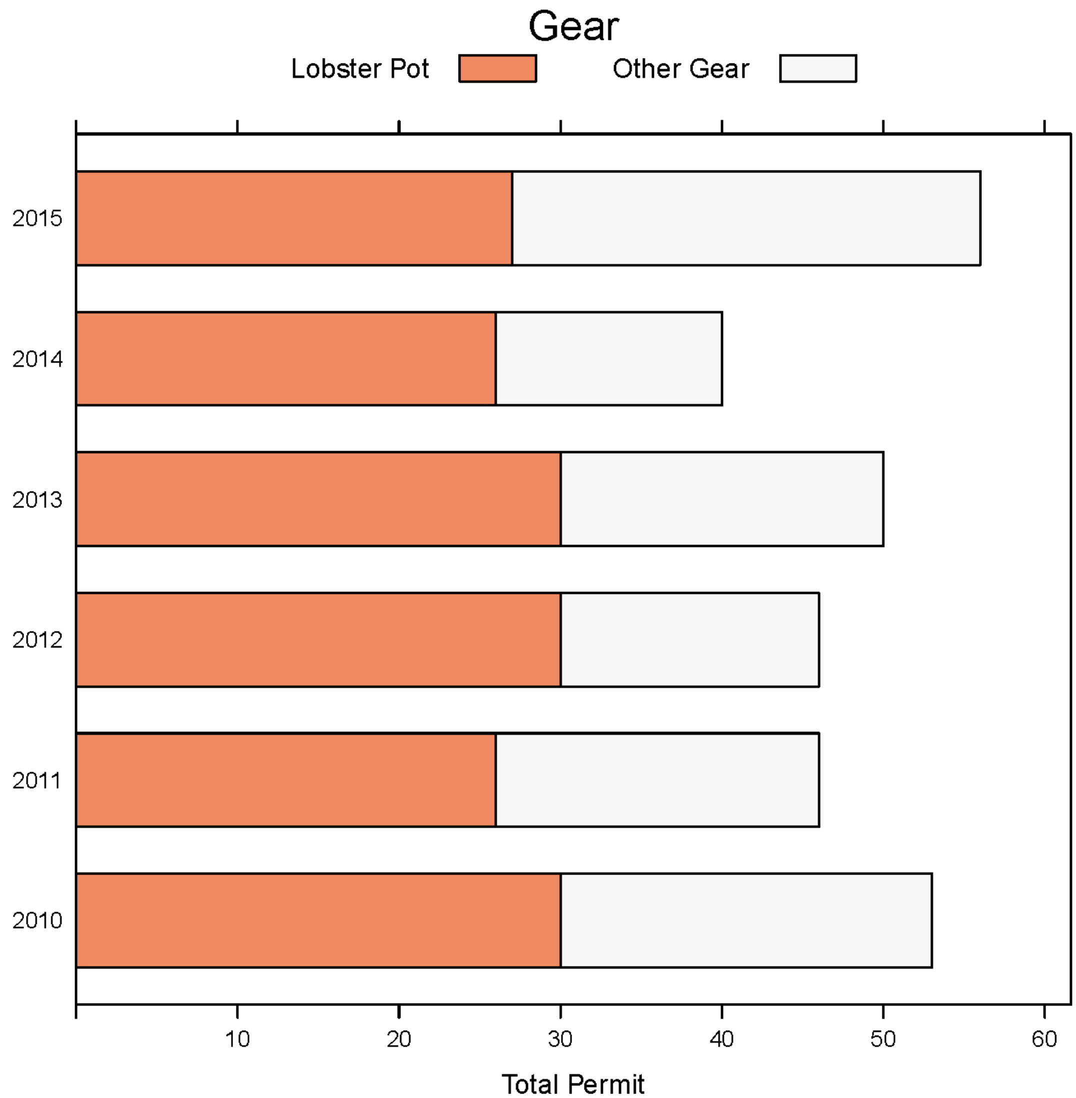
Source: **VTR analysis.**

Figure 67 – Trips by gear type attributed to the Outer Schoodic Ridge coral zone, 2010-2015.



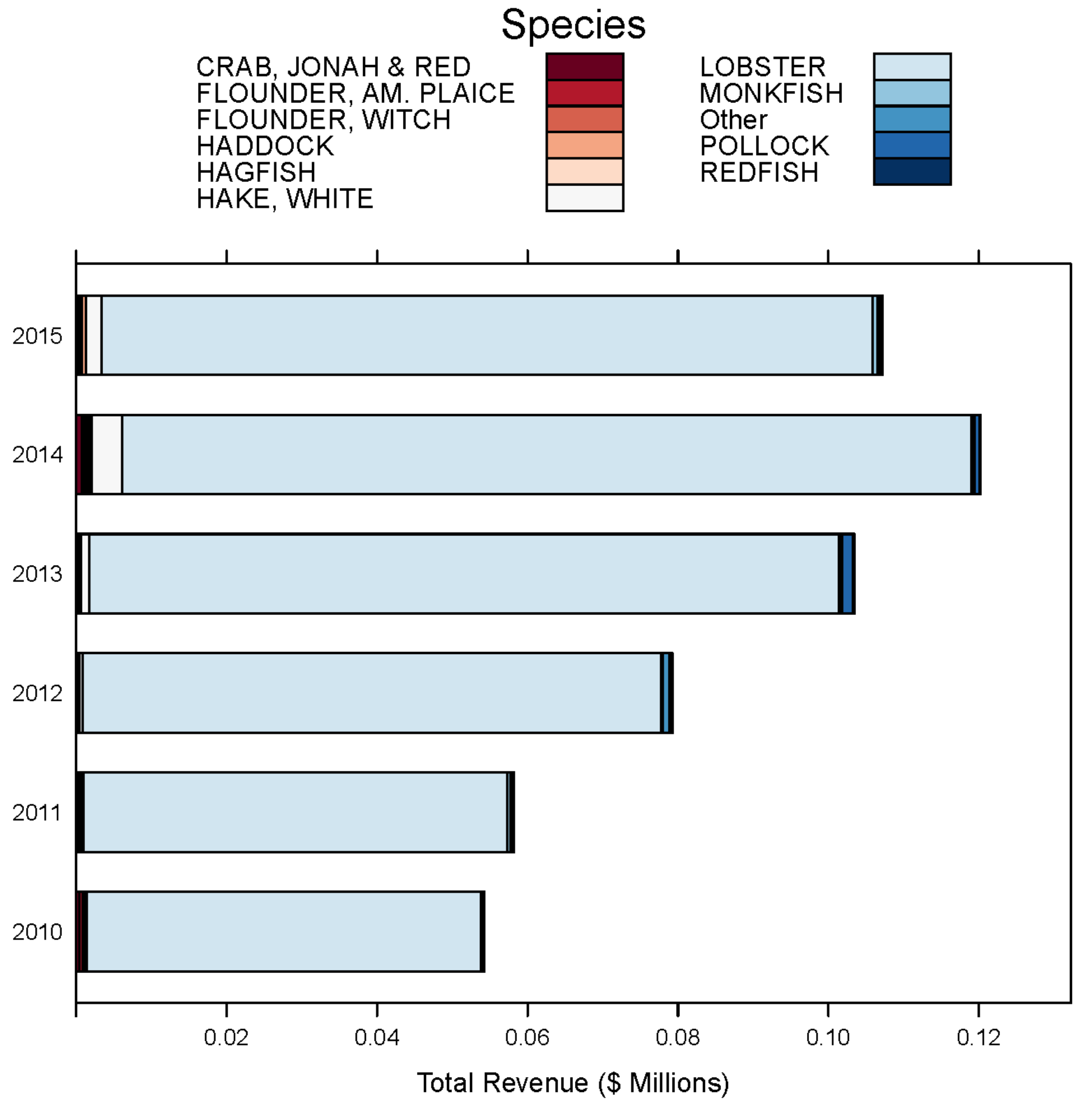
Source: **VTR analysis.**

Figure 68 – Permits by gear type attributed to the Outer Schoodic Ridge coral zone, 2010-2015.



Source: **VTR analysis.**

Figure 69 – Revenue by species (top 10) attributed to the Outer Schoodic Ridge coral zone, 2010-2015.



Source: **VTR analysis.**

7.7.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 57, the revenue attributed (using the VTR analysis) to recent fishing within the Outer Schoodic Ridge coral zone.

Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Outer Schoodic Ridge alternative are primarily located in Maine, with a small amount of activity attributed to ports in New Hampshire, Massachusetts, and other states (Table 57). The VTR analysis attributes recent landings revenue to 27 ports, and 76% of this revenue to ports in eastern Maine. Stueben, Milbridge, Jonesport, Beals Island, and Addison, in eastern Maine, are among the top ten landing ports, and just 3% of the revenue is attributed to other ports in that region, indicating that the communities that may be impacted may be fairly concentrated. However, the input of the Maine Lobstermen's Association is that the area near the Outer Schoodic Ridge coral zone is also important to lobstermen landing in ports such as Winter Harbor, Birch Harbor, Corea, and potentially Bar Harbor. The MLA also indicates that fishermen from Jonesport and Beals Island may be less likely to fish near the Outer Schoodic Ridge (MEDMR, pers. comm., 2017).

Based on the VTR analysis, the revenue attributed to Maine and New Hampshire from the Outer Schoodic Ridge coral zone is about 0.006% and 0.02% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Since the majority of Lobster Management Area 1 vessels do not hold other federal permits, the VTR dataset is known to underestimate fishing activity in the Outer Schoodic Ridge coral zone, so this area is likely more important to the states, ports, and individuals than these data would suggest.

Table 56 - Landings revenue to states, regions, and top ports attributed to fishing with VTR within the Outer Schoodic Ridge coral zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Maine	$172K	$34K	74
Eastern	$170K	$34K	54
Stueben	$77K	$15K	4
Milbridge	$56K	$11K	4
Jonesport	$24K	$5K	26
Beals Island	$4K	$1K	8
Addison	$2K	$0K	3
Other (n=10)	$7K	$2K	19
Mid-Coast	$1K	$0K	7
Southern	$2K	$0K	15
New Hampshire	$33K	$7K	9
Massachusetts	$20K	$4K	37
Gloucester	$12K	$2K	20
New Bedford	$2K	$0K	7
Other[b]	$0K	$0K	2
Total	**$225K**	**$45K**	**112**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
"Eastern" = ports from Lubec to Verona Island
"Mid-Coast" = ports from Stockton Springs to Brunswick
"Southern" = ports from Freeport to Kittery
Source: VTR data analysis.

7.7.3.3 Sociocultural impacts

The sociocultural impacts associated with the Outer Schoodic Ridge coral zone are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.7.4 Impacts on protected resources

To be completed prior to final action.

7.8 Impacts of the Jordan Basin coral zone and associated fishing restrictions

This alternative would designate four coral zones in Jordan Basin (section 4.2.2.3.3). Three are in the western part of the Basin and are named for their charted depths: 98 Fathom Bump (179m), 114 Fathom Bump (208m), and 118 Fathom Bump (216m). The fourth site is in Central Jordan Basin. Potential fishing restriction measures for coral zones are described in section 4.3. Restrictions relevant to this coral zone include:

- Option 1: Prohibit bottom-tending gears
    - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

Impacts of the red crab fishery exemption are not assessed for this alternative, because that fishery is not prosecuted in the Gulf of Maine.

7.8.1 Impacts on deep-sea corals

Deep-sea corals are known to occur within the Jordan Basin coral zones based on recent survey work (see Table 34 and section 6.2.3.3). A small number of older soft coral records are also available for these sites (see Table 33). Lobster is an important fishing activity at the site, although trawling and gillnetting also occur (see section 7.8.3 below). The degree to which coral zone designation has a positive impact on corals depends on the fishing restriction measures selected.

A mobile bottom-tending gear restriction in the Jordan Basin zones would have positive impacts on coral habitats. The same impacts would be expected if the Council adopts a restriction on all bottom-tending gears, but exempts trap fisheries. The magnitude of the positive impact is difficult to determine. Either approach would reduce the likelihood of interactions between trawls and gillnets and deep-sea corals that might damage or remove coral colonies. It is difficult to assess the rate of interactions between these gears and corals using presently available data. There is a substantial body of evidence suggesting that trawl gears negatively impact corals, but fixed gear effects are not well studied (see see section 6.5.2). Trawl bycatch of corals does occur in Jordan Basin (see section 6.5.3), but bycatch rates cannot be determined from these data, which are fairly limited.

If the Jordan Basin zones are adopted closures to all bottom-tending gears, without a trap fishery exemption, the lobster fishery would be excluded from the zone and the likelihood of interactions between lobster gear and corals would be reduced. It is difficult to assess the rate of those interactions, and the extent to which any interactions have negative impacts on corals, given presently available information. While trap gears could crush or remove coral colonies, such effects have not been demonstrated to occur within our region, as relevant gear impacts research is not available (see section 6.5.2). However, there are observed interactions between trap gear and corals in the Gulf of Maine (see section 6.5.3). We cannot use these observations to estimate coral bycatch rates in the lobster trap fishery or any fishery. Overall, designation of this zone as a closure to all bottom tending gears would be expected to have positive impacts on deep-sea corals, but the magnitude of these impacts is difficult to determine.

7.8.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.8.3 Impacts on human communities

Under this alternative, four coral zones would be established in Jordan Basin, with options for which gear types would be precluded from the zone. This alternative would be additive to No Action (Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the Jordan Basin zones on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. These negative impacts would be additive to the negative fishery impacts of No Action, though the No Action areas do not overlap Jordan Basin and the directly impacted fishermen may be distinct. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006), such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.8.3.1 Fishery impacts

VTR analysis. Using the approach described in Section 7.1.3.2, Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the Jordan Basin coral zones. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2).

Total revenue. Between 2010 and 2015, revenue attributed to the four Jordan Basin zones combined ranged between $0.10-0.17M (Figure 70).

Revenue by gear type: Revenue is primarily attributed to fishing with lobster pot gear (Figure 70). Smaller amounts of sink gillnet revenue are also noted for the area. There is a generally increasing trend in revenues over time combining all three gear types. Lobster revenues in lobster pot gear were scaled according to the LCMA 3 methods. Maps of revenue by gear type and species are in section 0, beginning on page 338. Note that lobster pot and lobster species revenues on these figures reflect the base VTR data and are not scaled to match the figures.

Trips and permits by gear type: The number of trips overlapping the four Jordan Basin zones ranges from about 350-700 per year, with more trips associated with lobster and other types of pots than with trawls (Figure 71). These trips were associated with about 60-70 permits Figure 72, including roughly 20 lobster and other pot permits and the remainder bottom trawls and gillnets. The lobster trip and permit data are not expanded like the revenue data, so the estimates for this gear could be low. Revenues were increased by about 26%, but this percentage might not be appropriate for trips and permits.

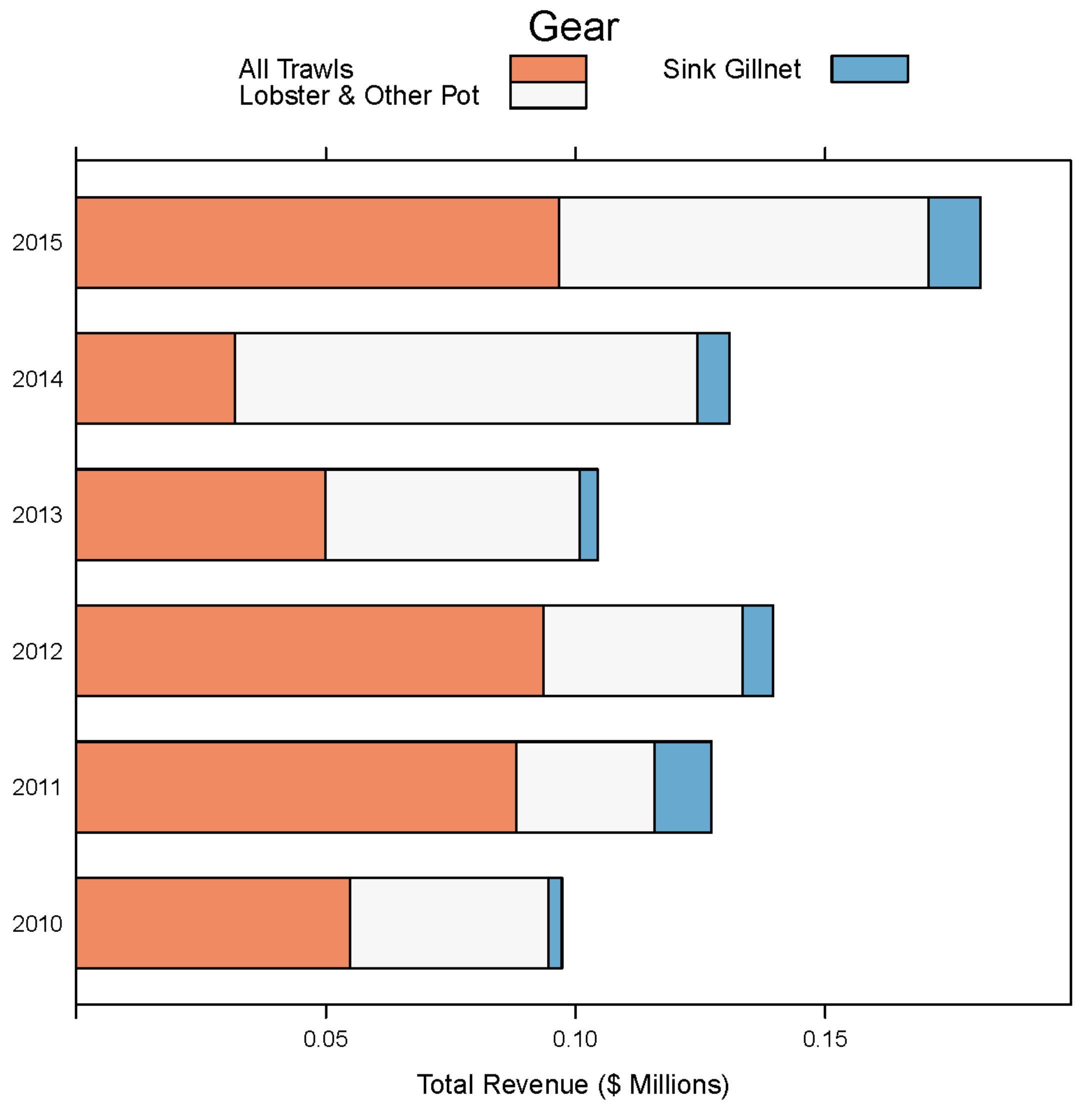
Revenue by species: Unlike in the inshore areas where revenues are almost entirely associated with lobster, a substantial fraction of the revenues in the Jordan Basin zones are generated from groundfish (Figure 73). Monkfish and hagfish are also in the top ten species list. Groundfish species include cod, American plaice, witch flounder, haddock, white hake, pollock, and redfish, with plaice, white hake, pollock, and redfish contributing most of the revenue.

Percent owner revenue: The percent of owner revenue harvested in the Jordan Basin zones is very low, similar to other coral zones (Figure 74). Percentages for most owners are below 0.5%, with a few outliers approaching 2%.

VTR-VMS analysis comparison: Table 58 indicates that only bottom trawl has adequate VMS coverage to provide an analysis likely to be representative of the fishing effort in the vicinity of Jordan Basin. For bottom trawl, the VMS analysis is preferred to the VTR in regards to assessing fishing effort in this region. However, for all other gear VTR represents the only available estimates of fishing activity in the vicinity of Jordan Basin.

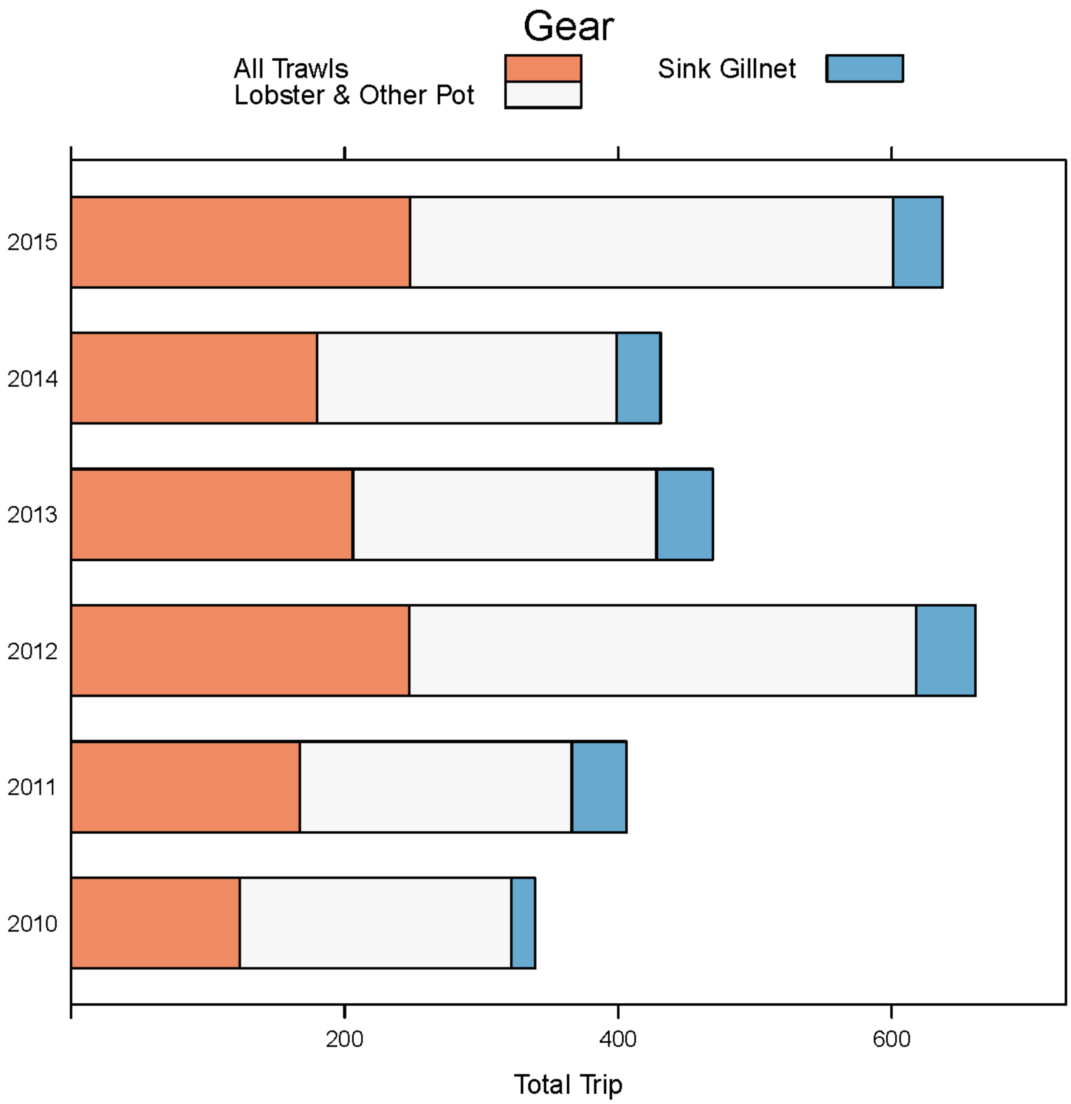
Table 59 indicates that only 25 – 40% of bottom-trawl permits and 15 – 35% of trips identified in the VTR analysis have VMS points indicating activity in the Jordan Basin. The percentage of annual permit-level revenue estimated to fall within the Jordan Basin zone (Figure 75) indicates that most permit-holders fish within this region only sparingly, with less than 1% of VMS-derived effort estimates falling within this region. This is consistent with the VTR-derived estimates of ownership revenue generated from the area (Figure 67). However, Figure 75 also indicates that there are a small number of permits who exert up to 6% of their total effort in the area, which is slightly higher than the upper bound of the percent of owner revenue detailed in Figure 74, based on VTR data. These results likely indicate a mismatch between the spatial precision of the VTR data and the size of the areas being considered within the Jordan Basin coral zone alternative.

Figure 70 – Revenue by gear type attributed to the four Jordan Basin coral zones, 2010-2015.



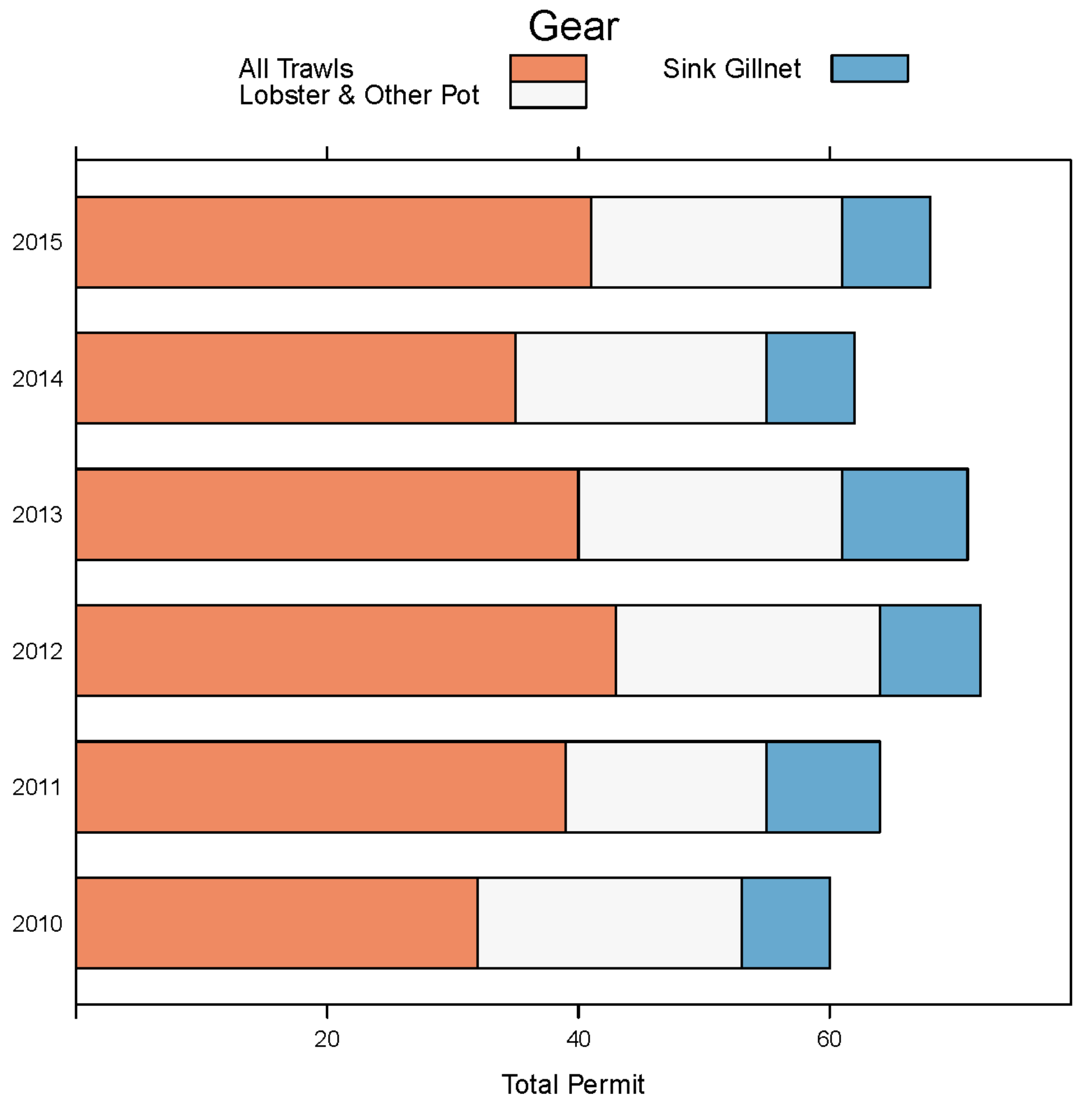
Source: **VTR analysis.**

Figure 71 – Trips by gear type attributed to the four Jordan Basin coral zones, 2010-2015.



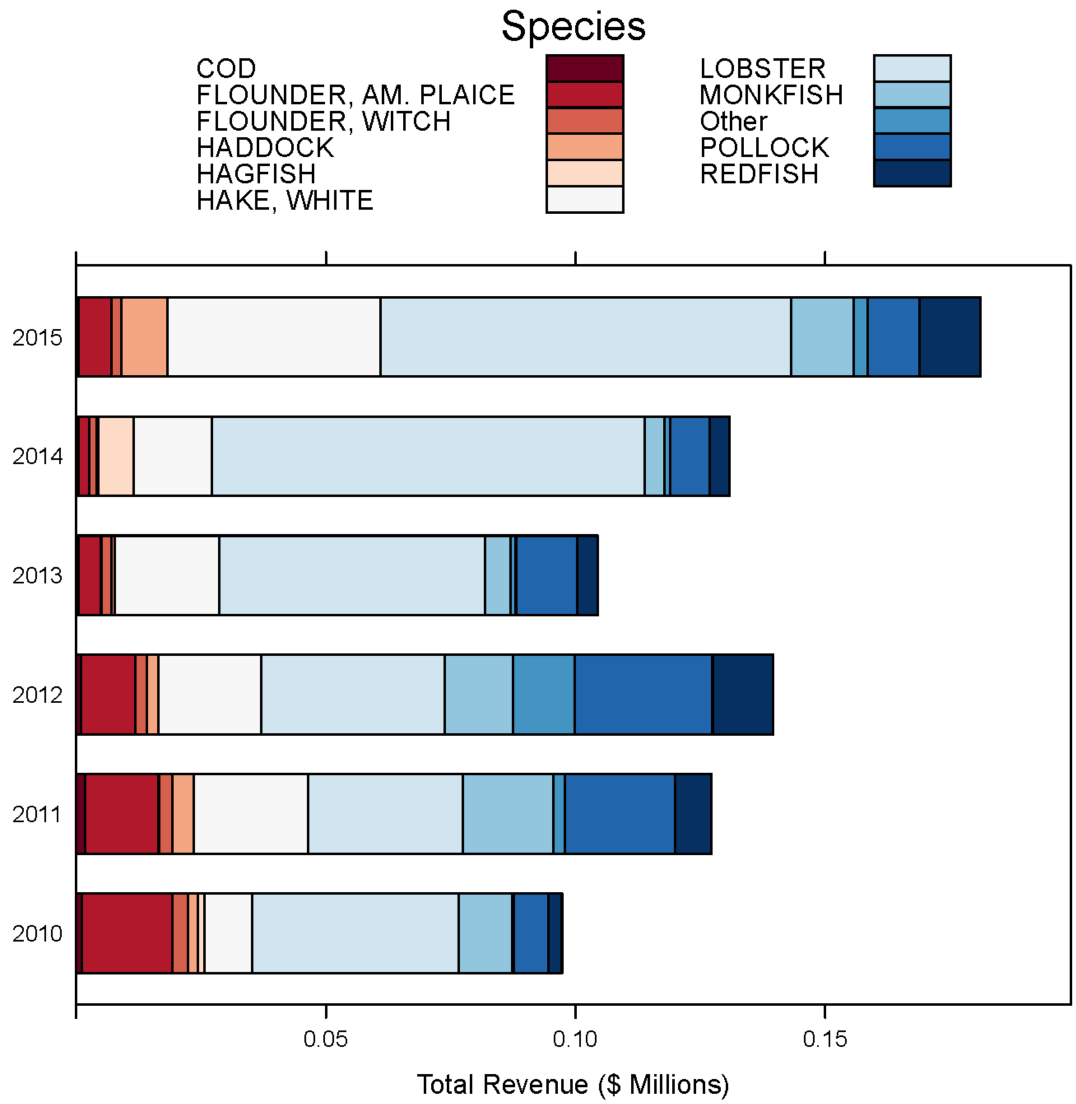
Source: **VTR analysis.**

Figure 72 – Permits by gear type attributed to the four Jordan Basin coral zones, 2010-2015.



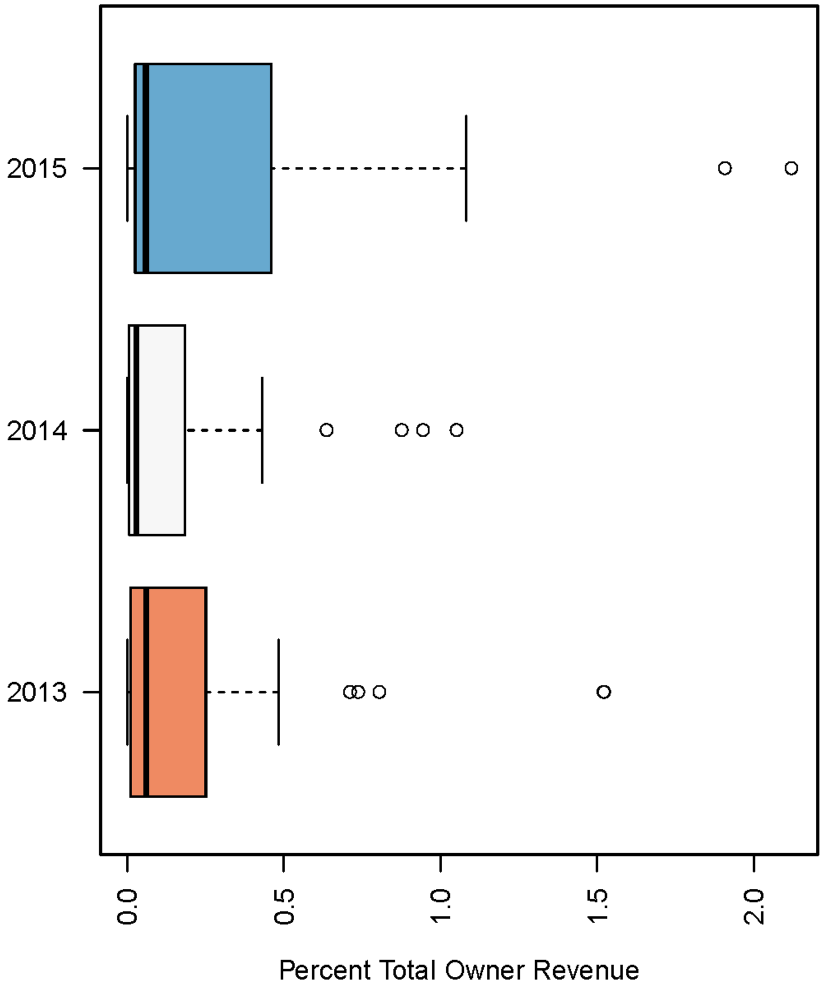
Source: **VTR analysis.**

Figure 73 – Revenue by species (top 10) attributed to the four Jordan Basin coral zones, 2010-2015.



Source: **VTR analysis.**

Figure 74 – Percent of total owner revenue attributed to the four Jordan Basin coral zones, 2013-2015.



Source: **VTR analysis.**

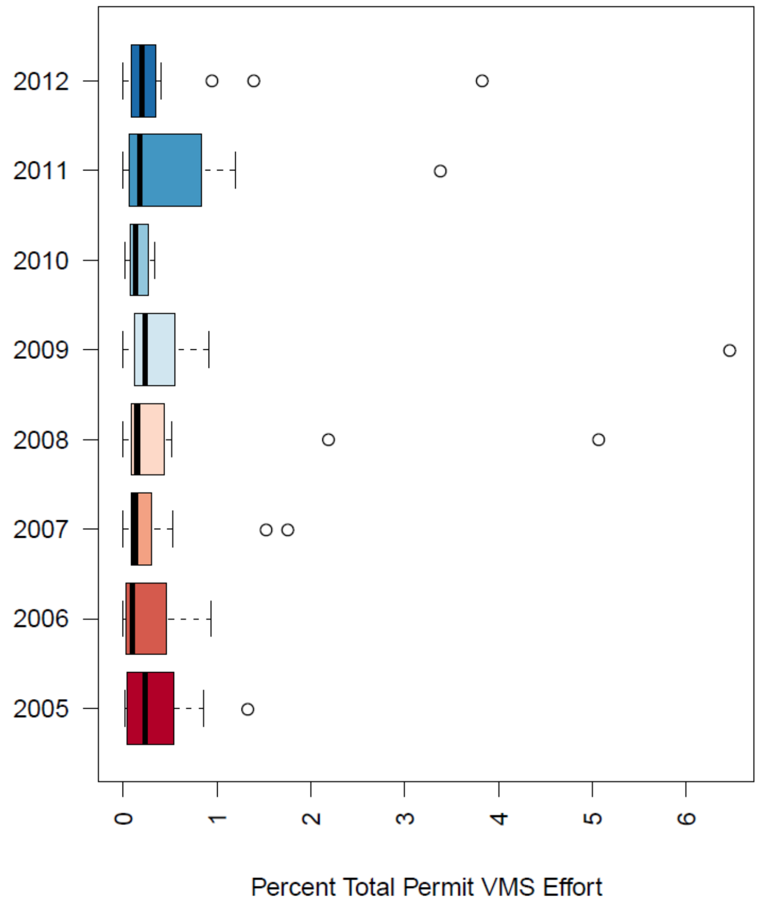
Table 57 - VMS coverage for VTR trips estimated to be fishing within the vicinity of the four Jordan Basin zones.

Zone	Year	Gear	VTR Trips	VMS Trips	Coverage
Jordan Basin	2010	All Trawls	123	108	88%
Jordan Basin	2011	All Trawls	167	138	83%
Jordan Basin	2012	All Trawls	247	207	84%
Jordan Basin	2010	Lobster & Other Pot	199	8	4%
Jordan Basin	2011	Lobster & Other Pot	199	0	0%
Jordan Basin	2012	Lobster & Other Pot	371	2	1%
Jordan Basin	2010	Sink Gillnet	17	0	0%
Jordan Basin	2011	Sink Gillnet	40	0	0%
Jordan Basin	2012	Sink Gillnet	43	0	0%

Table 58 – VMS derived estimates of effort within the Jordan Basin zones.

Zone	Gear	Year	Hours Fished	Permits	Trips
Jordan Basin	otter	2005	113.96	16	50
Jordan Basin	otter	2006	104.10	19	55
Jordan Basin	otter	2007	136.23	18	65
Jordan Basin	otter	2008	58.88	12	42
Jordan Basin	otter	2009	114.55	17	60
Jordan Basin	otter	2010	25.42	8	19
Jordan Basin	otter	2011	226.51	16	59
Jordan Basin	otter	2012	201.79	15	63
Jordan Basin	sca-la	2005	NA	1	NA
Jordan Basin	sca-la	2007	NA	1	NA
Jordan Basin	trap	2005	NA	1	NA
Jordan Basin	trap	2006	NA	1	NA
Jordan Basin	trap	2008	NA	1	NA
Jordan Basin	trap	2009	NA	1	NA

Figure 75 - VMS-derived effort estimated to fall within the Jordan Basin zone, as a percent of all of a permit's annual effort.



Source: VMS analysis

7.8.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 60, the revenue attributed (using the VTR analsyis) to recent fishing within the Jordan Basin zone alternative.

Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Jordan Basin zone alternative are primarily located in Massachusetts, with lesser activity attributed to ports in New Hampshire, Maine, and Rhode Island (Table 60). The VTR analysis attributes recent landings revenue to 27 ports, and 52% of this revenue to ports in Massachusets. Gloucester, Portland, and New Bedford are among the top ten landing ports, and 49% of the revenue is attributed to other ports, indicating that, revenue from this zone may also be important to fishermen landing in other ports.

The revenue attributed to Massachusetts and New Hampshire from the Jordan Basin coral zone is about 0.01% and 0.19% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 2% of their revenue attributed to fishing from this area (Figure 74).

Table 59 - Landings revenue to states, regions, and top ports attributed to fishing within the Jordan Basin coral zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
Massachusetts	$408K	$82K	77
Gloucester	$304K	$61K	41
New Bedford	$31K	$6K	25
Other (n=2)	$73K	$15K	22
New Hampshire	$269K	$54K	16
Portsmouth	$8K	$2K	9
Maine	$85K	$17K	58
Portland	$67K	$13K	31
Port Clyde	$9K	$2K	7
Stonington	$3K	$1K	3
Other (n=16)	$6K	$1K	22
Rhode Island	$18K	$4K	4
Total	**$780K**	**$156K**	**133**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
"Eastern" = ports from Lubec to Verona Island
"Mid-Coast" = ports from Stockton Springs to Brunswick
"Southern" = ports from Freeport to Kittery
Source: VTR data analysis.

7.8.3.3 Sociocultural impacts

The sociocultural impacts associated with the Jordan Basin coral zones are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.8.4 Impacts on protected resources

To be completed prior to final action.

7.9 Impacts of the Lindenkohl Knoll coral zone and associated fishing restrictions

This alternative would designate a coral zone at Lindenkohl Knoll, on the western edge of Georges Basin, just north of Georges Bank (section 4.2.2.3.4). Potential fishing restriction measures for coral zones are described in section 4.3. Restrictions relevant to this coral zone include:

- Option 1: Prohibit bottom-tending gears
  - Sub-option B: Exempt other trap fisheries
- Option 2: Prohibit mobile bottom-tending gears

The red crab fishery exemption is not discussed in the following sections, because that fishery is not prosecuted in the Gulf of Maine.

7.9.1 Impacts on deep-sea corals

Deep-sea corals are known to occur at Lindenkohl Knoll based on recent survey work (see Table 34 and section 6.2.3.3). Lobster is an important fishing activity at the site, although trawling and gillnetting also occur (see section 7.8.3 below). The degree to which coral zone designation has a positive impact on corals depends on the fishing restriction measures selected.

A mobile bottom-tending gear restriction at Lindenkohl Knoll would have positive impacts on coral habitats. The same impacts would be expected if the Council adopts a restriction on all bottom-tending gears, but exempts trap fisheries. The magnitude of the positive impact is difficult to determine. Either approach would reduce the likelihood of interactions between trawls and gillnets and deep-sea corals that might damage or remove coral colonies. It is difficult to assess the rate of interactions between these gears and corals using presently available data. There is a substantial body of evidence suggesting that trawl gears negatively impact corals, but fixed gear effects are not well studied (see see section 6.5.2). Trawl and gillnet bycatch of corals does occur in and around the site (see section 6.5.3), but bycatch rates cannot be determined from these data, which are limited.

If the Lindenkohl Knoll zone is adopted as a closure to all bottom-tending gears, without a trap fishery exemption, the lobster fishery would be excluded from the zone and the likelihood of interactions between lobster gear and corals would be reduced. It is difficult to assess the rate of those interactions, and the extent to which any interactions have negative impacts on corals, given presently available information. While trap gears could crush or remove coral colonies, such effects have not been demonstrated to occur within our region, as relevant gear impacts research is not available (see section 6.5.2). However, there are observed interactions between trap gear and corals in the Gulf of Maine (see section 6.5.3). We cannot use these observations to estimate coral bycatch rates in the lobster trap fishery or any fishery. Overall, designation of this zone as a closure to all bottom tending gears would be expected to have positive impacts on deep-sea corals, but the magnitude of these impacts is difficult to determine.

7.9.2 Impacts on managed species and essential fish habitats

To be completed prior to final action. See section 6.4 for background.

7.9.3 Impacts on human communities

Under this alternative, a coral zone would be established on Lindenkohl Knoll, with options for which gear types would be precluded from the zone. This alternative would be additive to No Action (Monkfish/MSB/Tilefish areas and the National Monument would remain in place) and could be selected in combination with other alternatives under consideration.

The impacts of the Lindenkohl Knoll zone on human communities are expected to be low negative in general, but negative for the fisheries and communities that would be constrained, to the degree that fisheries are constrained. These negative impacts would be additive to the negative fishery impacts of No Action, though the No Action areas do not overlap Lindenkohl Knoll and the directly impacted fishermen may be distinct. As with No Action, it is difficult to determine if fishermen would be precluded from fishing or be able to shift effort to other areas. The lobster fishery is particularly territorial (Acheson 1987; 2006) , such that efforts to shift effort to areas remaining open may be difficult for those displaced by the closures. To the degree that these closures provide habitat for fishery species, there may be long-term benefits to fisheries and society, but these are difficult to project.

7.9.3.1 Fishery impacts

VTR analysis. Using the approach described in Section 7.1.3.2., Vessel Trip Report (VTR) data were used to estimate recent (2010-2015) fishing activity within the seamount coral zones. With the exception of lobster trap gear, all revenue data for this area were taken directly from the VTR analysis. For lobster traps, because a relatively large number of vessel operators are not required to submit VTRs (their vessels do not carry other federal permits), total lobster revenue was expanded to account for this lack of mandatory reporting (method explained in Section 7.1.3.2).

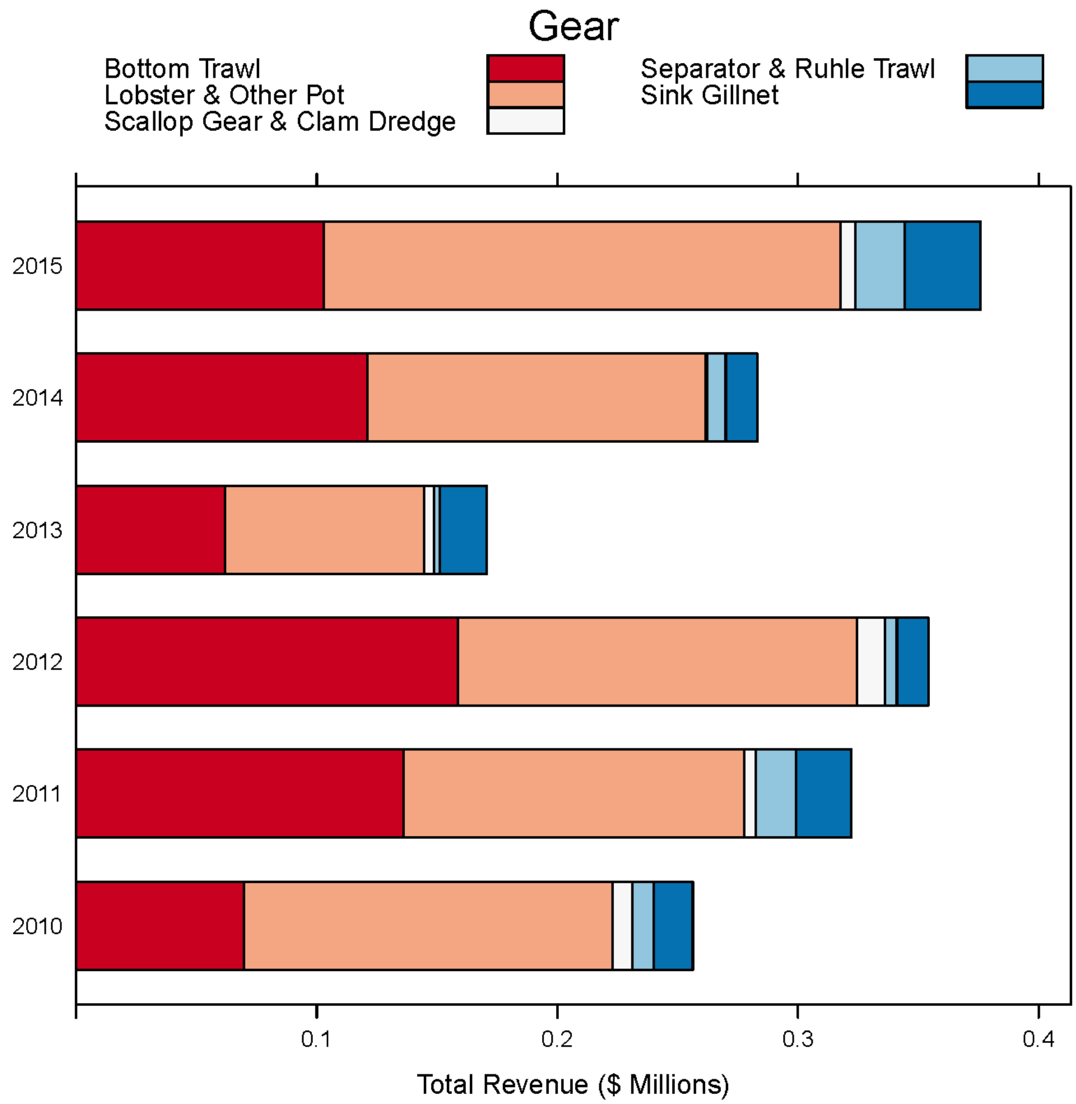
Revenue by gear type: In general the gear types generating revenue at the Lindenkohl Knoll zone are the same as those in Jordan Basin (Figure 76). Small amounts of scallop gear and clam dredge revenue are encompassed within the area. Given the depth of the water at Lindenkohl it is unlikely that these gears operate in the area, but Georges Basin is located just north of Georges Bank, where both gear types are commonly employed to target sea scallops and surfclams. Spatial imprecision in the VTR data is likely what is causing these revenues to be inferred to the Lindenkohl zone. Separator and Ruhle trawls and well as sink gillnet are also indicated as generating revenue at the site. The actual likelihood of overlap with these gears will be investigated further using other data sources such as observer and VMS. Across all years included in the analysis, lobster pots are the number one source of revenue. Lobster revenue in lobster pot gear was expanded using the Area 3 approach outlined in the No Action alternative section. Maps of revenue by gear type and species are in section 0, beginning on page 338. Note that lobster pot and lobster species revenues on these figures reflect the base VTR data and are not scaled to match the figures.

Trips and permits by gear type: Revenues associated with roughly 800-1,000 trips per year overlap the Lindenkohl Knoll zone (Figure 77). These overlaps may be for part of the trip only, with some or even most of the revenue from the trip inferred to areas outside the coral zone. Between 100 and 150 permits are associated with these trips, with over half the permits on bottom trawl vessels (Figure 78). Between 10 and 20 lobster permits are associated with the 200 to 300 lobster pot trips taken each year in and around the Lindenkohl zone. The lobster trip and permit data are not expanded like the revenue data, so these could be underestimates. Revenues were increased by about 26%, but this percentage might not be appropriate for trips and permits.

Revenue by species: The top ten revenue generating species are similar to those identified at the Jordan Basin zones (Figure 79). Revenues are dominated by lobster (roughly $150K estimated in most years, more during 2015), and in some years pollock revenues are sizeable (up to $100K). Other groundfish stocks as well as monkfish and sea scallops contribute minor amounts of revenue. Shallower water species including winter flounder and sea scallops may not actually be landed within the zone; this will be evaluated further with other sources of data.

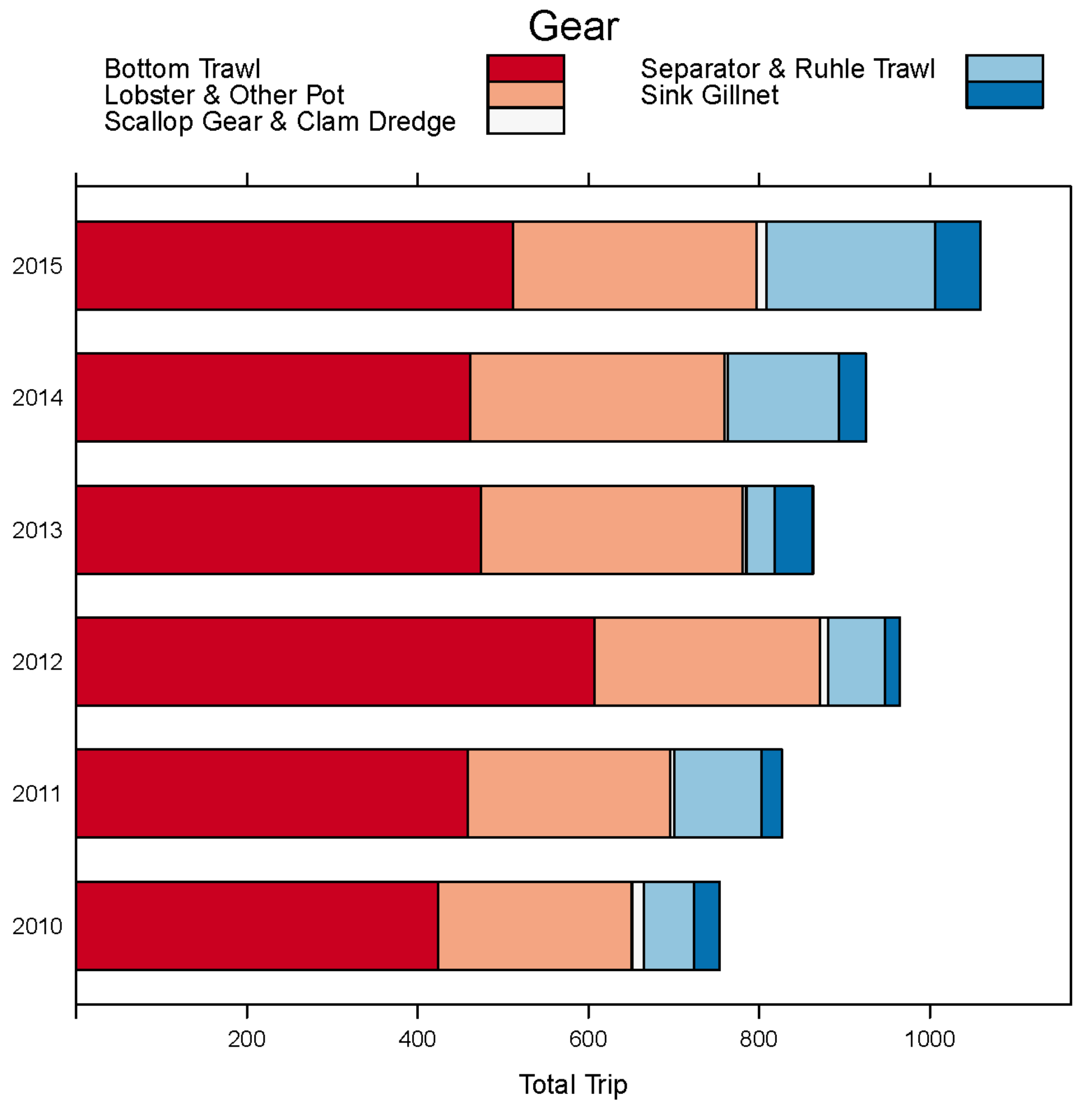
Percent owner revenue: For the owners that have revenue attributed to the Lindenkohl Knoll zone, the zone's contribution to their coastwide annual revenue is generally under 0.5% (Figure 80). A few outlier owners are estimatd to generate a larger percentage of annual revenue, to a maximum of about 2.5%, in the zone.

Figure 76 – Revenue by gear type attributed to the Lindenkohl Knoll coral zone, 2010-2015.



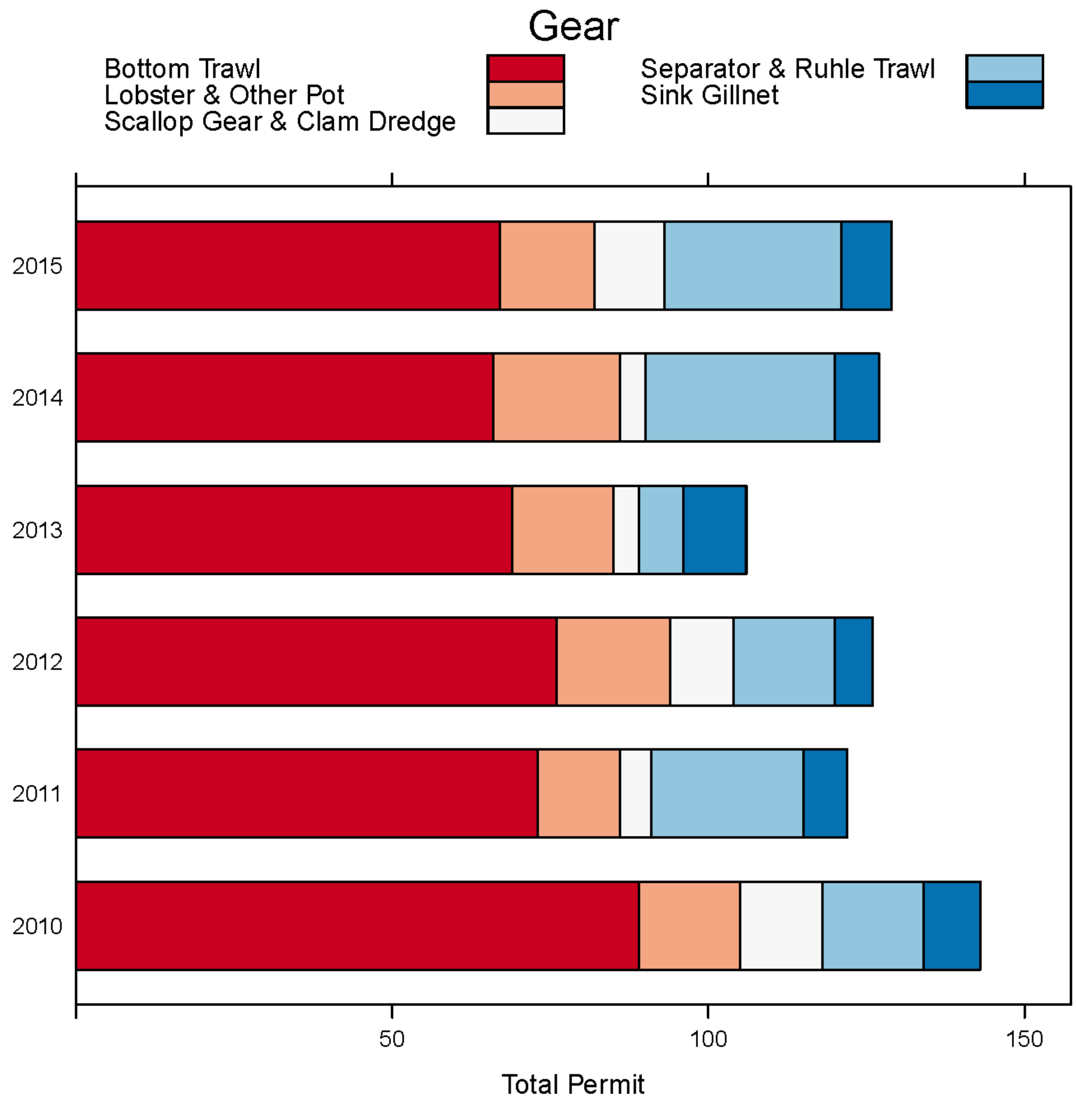
Source: **VTR analysis.**

Figure 77 – Trips by gear type attributed to the Lindenkohl Knoll coral zone, 2010-2015.



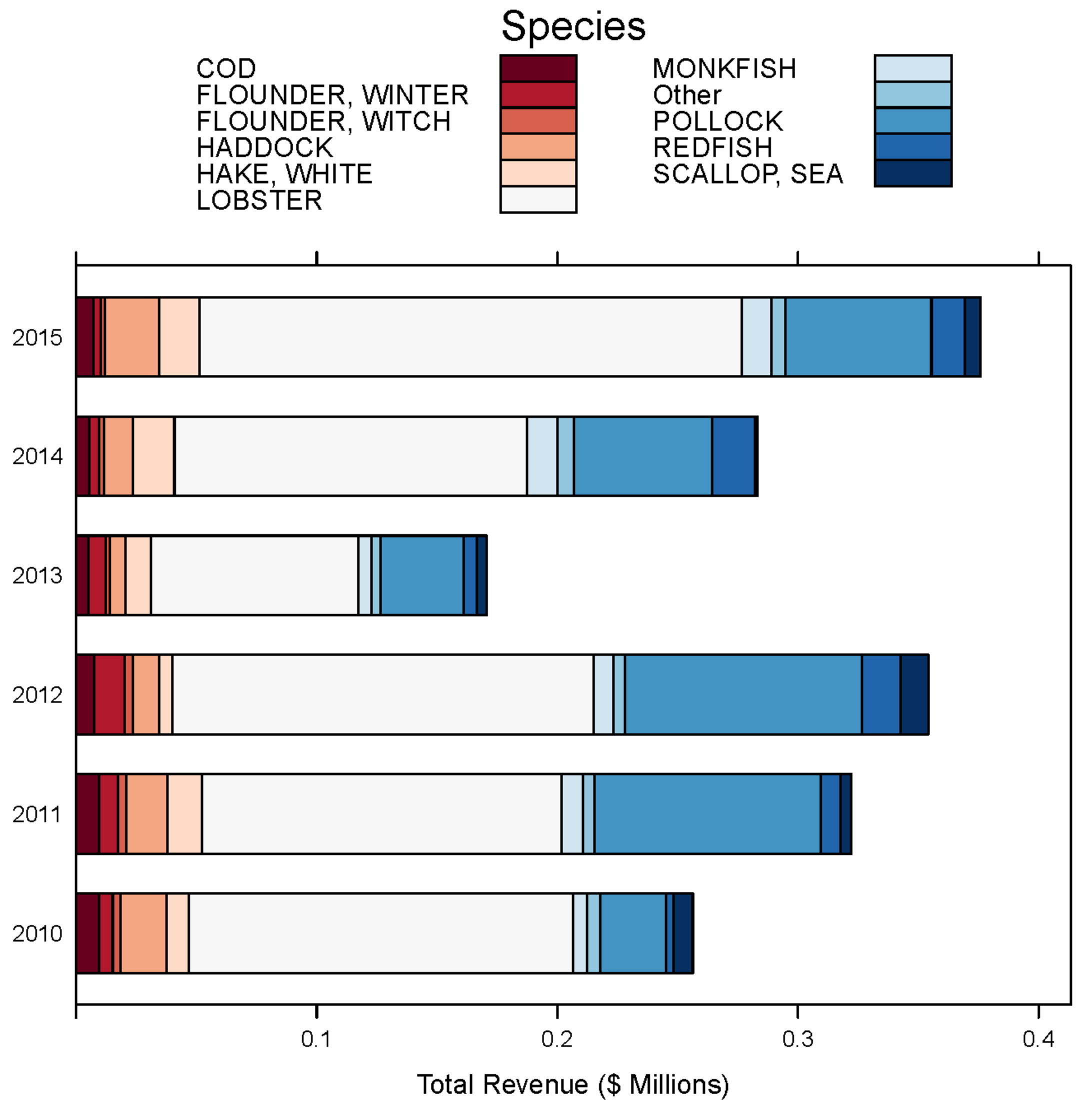
Source: **VTR analysis.**

Figure 78 – Permits by gear type attributed to the Lindenkohl Knoll coral zone, 2010-2015.



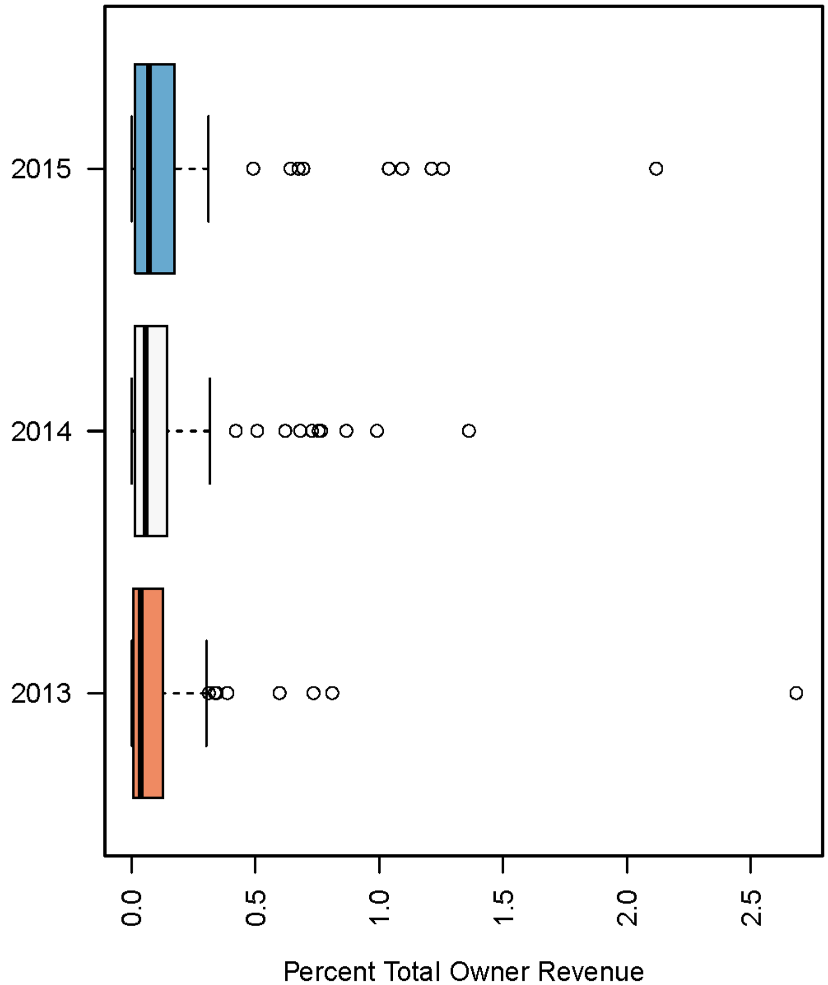
Source: **VTR analysis.**

Figure 79 – Revenue by species (top 10) attributed to the Lindenkohl Knoll coral zone, 2010-2015.



Source: **VTR analysis.**

Figure 80 – Percent of total owner revenue attributed to the Lindenkohl Knoll coral zone, 2013-2015.



***Source:* VTR analysis.**

7.9.3.2 Fishing community impacts

General community impacts of the alternatives under consideration are described in Section 7.1.3, which also describes the method, caveats, and data confidentiality standard used to develop Table 61, the revenue by state, region, or port attributed (using the VTR analysis) to recent fishing within the Lindenkohl Knoll zone alternative.

Although the VTR analysis has some degree of error, it suggests that the fishing communities that may be impacted by the Lindenkohl Knoll zone alternative are primarily located in New Hampshire and Massachusetts, with lesser activity attributed to ports in Maine, Rhode Island, and other states (Table 61). The VTR analysis attributes recent landings revenue to 17 ports, and 49% of this revenue to ports in New Hampshire. Gloucester, New Bedford, and Portland are among the top ten landing ports, and 54% of the revenue is attributed to other ports, indicating that, revenue from this zone may also be important to fishermen landing in other ports.

The revenue attributed to New Hampshire and Massachusetts from the Lindenkohl Knoll coral zone is about 0.62% and 0.02% of all revenue, respectively, for these states during 2010-2015 (ACCSP, 2017). Though these are small fractions, certain individual permit holders could have as much as 3 of their revenue attributed to fishing from this area (Figure 80, p. 323).

Table 60 - Landings revenue to states, regions, and top ports attributed to fishing within the Lindenkohl Knoll coral zone, 2010-2015

State/Region/Port	Landings Revenue 2010-2015		Total Permits, 2010-2015[a]
	Total $	Average $	
New Hampshire	$870K	$174K	16
Portsmouth	$31K	$6K	9
Massachusetts	$750K	$150K	160
Gloucester	$399K	$80K	50
New Bedford	$278K	$56K	108
Boston	$70K	$14K	20
Other (n=5)	$3K	$0K	17
Maine	$132K	$26K	25
Portland	$132K	$26K	24
Rhode Island	$9K	$2K	19
Newport	$8K	$2K	3
Point Judith	$2K	$0K	15
Other[b]	$1K	$0K	2
Total	**$1,762K**	**$352K**	**195**

[a] Totals may not equal the sum of the parts, because permits can land in multiple ports/states.
[b] Includes confidential state(s).
"Eastern" = ports from Lubec to Verona Island
"Mid-Coast" = ports from Stockton Springs to Brunswick
"Southern" = ports from Freeport to Kittery
Source: VTR data analysis.

7.9.3.3 Sociocultural impacts

The sociocultural impacts associated with the Lindenkohl Knoll coral zones are expected to be negative for fishermen and fishing communities, and negative relative to No Action. With effort shifts, conflicts within or between fisheries would have a negative impact on the *Non-Economic Social* aspects and the *Attitudes, Beliefs, and Values* of fishery participants. Establishing the zone may change the *Social Structure and Organization* of communities as well as *Historical Dependence on and Participation* in the fishery by individuals and communities. Deep-sea corals have cultural value to society, so affording them protection has positive impacts on the *Attitudes, Beliefs, and Values* of stakeholders towards management.

7.9.4 Impacts on protected resources

To be completed prior to final action.

7.10 Impacts of special fishery programs for coral zones

The alternatives in this section would create programs to allow special access fishing, exploratory fishing, and/or research activities within coral zones. Four alternatives are under consideration:

- **Alternative 1/No Action:** No special programs for access, exploratory fishing, or research tracking requirements.
- **Alternative 2. Special access program fishing:** This alternative would implement a special access program within some or all of the deep-sea coral zones.
- **Alternative 3. Exploratory fishing:** This alternative would implement an exploratory fishing program within some or all of the deep-sea coral zones.
- **Alternative 4. Research activities:** This alternative would help the council and NMFS keep track of research in coral zones by requesting that researchers ask for a letter of acknowledgement when working in coral zones.

7.10.1 Impacts on deep-sea corals

Alternative 1/No Action is expected to have negative to neutral impacts on deep-sea corals relative to baseline environmental conditions. No programs for continued special fishery access or exploratory fishing would be developed that could have negative impacts on coral habitats, but neither would tracking of research activities be enabled, which could have positive, indirect impacts on corals.

Alternatives 2 and 3 are expected to have negative to neutral impacts on deep-sea corals relative to baseline environmental conditions. If these alternatives are adopted, the programs will be carefully designed so as to minimize negative impacts on coral communities. However, the development of such programs could facilitate the continuance of existing fisheries or the development of future deep-water fisheries, which would have negative impacts on corals as compared to not allowing such programs.

Alternative 4 is expected to have indirect, positive impacts on deep-sea corals as the Council will be able to more easily track research activities in coral zones that could be used to inform future changes to the management program.

7.10.2 Impacts on managed species and essential fish habitats

Alternative 1/No Action is expected to have neutral impacts on managed species and their habitats. In the absence of special access or exploratory fishing programs implemented under Alternatives 2 and 3, managed species occurring within corals zones will be harvested in other locations, such that impacts to stocks will not change from current conditions. The specific impacts of Alternative 1/No Action can be discussed more fully once the preferred coral zone alternatives are known.

Alternatives 2 and 3 are expected to have neutral impacts on managed species and their habitats. If special access programs are developed (Alternative 2), managed species will be harvested in coral zones rather than other areas, but this will not change annual catch limits or other overall limits fishing effort in the individual FMPs. Alternative 3 is also expected to have neutral impacts on managed species. Exploratory fishing activities are not expected to contribute large amounts of removals from any given fishery stock, and would be accounted for as part of the overall management plan. The specific impacts of Alternatives 2 and 3 can be discussed more fully once the preferred coral zone alternatives are known.

Alternative 4 is expected to have neutral to slightly positive indirect impacts on managed species and their habitats. To the extent that this alternative helps the Council to track research in coral zones, and that research provides information about managed resources, their habitat usage, and their possible linkages to corals, Alternative 4 could improve the management of these resources.

7.10.3 Impacts on human communities

Alternative 1/No Action is expected to have slightly negative to neutral impacts on human communities.

Alternative 2 is expected to have positive impacts on fishing communities because development of special access programs will facilitate continued access to fishing opportunities within coral zones, but in a controlled fashion. Alternative 2 could have negative impacts on those concerned with coral conservation as special access programs could dilute the conservation benefits of coral zones. The specific impacts of Alternative 2 can be discussed more fully once the preferred coral zone alternatives are known.

Alternative 3 is expected to have positive impacts on fishing communities because it will provide some flexibility to explore commercial fishing opportunities within coral zones in the future. Alternative 3 could have negative impacts on those concerned with coral conservation as exploratory fishing could dilute the conservation benefits of coral zones. The specific impacts of Alternative 3 can be discussed more fully once the preferred coral zone alternatives are known.

Alternative 4 is expected to generally have neutral impacts on human communities as it is primarily an administrative requirement. There would be some additional effort required of researchers to comply with this requirement, but to ability of the Council to track research in coral zones could provide benefits overall in terms of coral conservation and development of fishery management programs. Science-based updates fishery management programs are expected to have indirect positive impacts on human communities overall.

7.10.4 Impacts on protected resources

To be completed prior to final action.

7.11 Impacts of framework provisions for deep-sea coral zones

Three alternatives would allow the measures adopted via this amendment to be changed via a future framework adjustment versus fishery management amendment. Under Alternative 1/No Action, no changes would be made to the coral-related framework adjustment provisions of NEFMC FMPs. Either Alternative 1/No Action, or one or more of the action alternatives could be selected.

- Alternative 1/No Action: No changes to framework adjustment provisions
- Alternative 2: Add, revise, or remove coral zones via framework adjustment
- Alternative 3: Change fishing restrictions in coral zones via framework adjustment
- Alternative 4: Allow changes to special access or exploratory fishing programs via framework adjustment

Framework adjustments 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 more quickly and address only one or a few issues in a fishery. In general, these alternatives are administrative and intended to simplify and improve the efficiency of future actions related to deep-sea coral protections. Thus, they are not expected to result in any direct impacts to any of the VECs, though indirect impacts are possible if they allow for more efficient responses to immediate conservation concerns for deep sea corals or associated habitats.

7.11.1 Impacts on deep-sea corals

Alternative 1/No Action would mean than an amendment would be required to adjust coral management measures in the future. This alternative could result in slightly negative indirect impacts to deep-sea corals if the alternatives considered in the future are related to the expansion of existing coral management areas, the creation of new areas, or the addition of new gear restrictions. If an immediate deep-sea coral conservation concern becomes apparent, requiring an amendment could result in indirect negative impacts to corals, as the typically lengthier process associated with an amendment would delay the implementation of protection measures. If the future alternatives considered would remove coral management areas, make them smaller in a way that reduces coral protection, remove gear restrictions, or allow special access program fishing, Alternative 1/No Action will likely have neutral to slightly positive impacts. Regardless of the management vehicle, framework or amendment, such changes to the coral management program would be fully analyzed, as required under MSA and NEPA. However, allowing such changes to occur via framework could make them more likely, as amendments require additional Council resources to complete and might not be as high a priority in any particular year.

Idirect positive impacts are possible from Alternatives 2 and 3 if they allow for more efficient responses to immediate threats to coral communities. Specifically, because the administrative process for an amendment is longer, it is possible that any immediate conservation concerns arising in the future could be addressed more quickly through a framework action rather than an amendment. In addition, because amendments typically require more Council and NMFS time and resources, it is possible that the Council may decide not to prioritize future adjustments to the coral measures if such actions would require an amendment. Under Alternatives 2 and 3, coral areas could be added or expanded, or additional gear restrictions could be enacted in a more rapid and responsive fashion. Conversely, if framework adjustments are used to remove coral areas or reduce their size (Alternative 2), reduce gear restrictions associated with the areas (Alternative 3), or add access programs (Alternative 4), there could be slight negative indirect impacts to corals. Because analysis of the impacts of such measures is required regardless of whether an amendment or framework adjustment is developed, these slight negative indirect impacts assume that the changes would not have been enacted if an amendment were required.

Thus, in summary, the potential impacts of the framework adjustment alternatives on deep-sea corals are indirect, and could range from slightly negative to slightly positive depending on the situation.

7.11.2 Impacts on managed species and essential fish habitats

In general, the framework alternatives are intended to simplify and improve the efficiency of future actions related to deep sea coral protections. Thus, they are not expected to result in any direct impacts to any of the managed resources. The framework provision alternatives are also unlikely to have indirect impacts on managed resources, as the process and timeline for any future coral action is unlikely to impact actions that may impact the managed stocks. Any immediate need to address issues with stock status or other FMP provisions would be addressed by NMFS and/or the Councils through a separate action not related to deep sea corals. Thus, the no action alternative 1 as well as the framework provision action alternatives 2 through 4 would be expected to result in neutral impacts to managed resources relative to baseline environmental conditions.

7.11.3 Impacts on human communities

Because the framework provision alternatives are administrative, they are not expected to result in any direct impacts to the human environment, though indirect impacts are possible from some of the alternatives if they allow for more efficient responses to pressing concerns for human communities. In addition, because amendments typically require more Council time and resources, it is possible that the Council may decide not to prioritize future adjustments to the coral measures if such actions would require an amendment rather than a framework. To the extent that framework provisions may allow more efficient responses to social or economic issues resulting from coral measures, or to the priorities of the conservation community, the framework provision action alternatives 2, 3, and 4 would be expected to result in indirect slight positive impacts to human communities.

7.11.4 Impacts on protected resources

Because the framework provision alternatives are administrative, they are not expected to result in any direct impacts to protected resources. The framework provision alternatives are also unlikely to have indirect impacts on protected resources, as the process and timeline for any future coral action is unlikely to impact protected resources interactions. Any immediate protected resources need to would be addressed by NMFS, or through a separate Council action not related to deep sea corals. Thus, the no action alternative 1 as well as the framework provision action alternatives 2 through 4 would be expected to result in neutral impacts to protected resources relative to baseline environmental conditions.

8 Cumulative effects analysis

To be developed prior to and after final Council action.

9 Compliance with the Magnuson Stevens Fishery Conservation and Management Act

To be developed prior to and after final Council action.

10 Compliance with the National Environmental Policy Act

To be developed prior to and after final Council action.

11 Relationship to other applicable laws

To be developed prior to and after final Council action.

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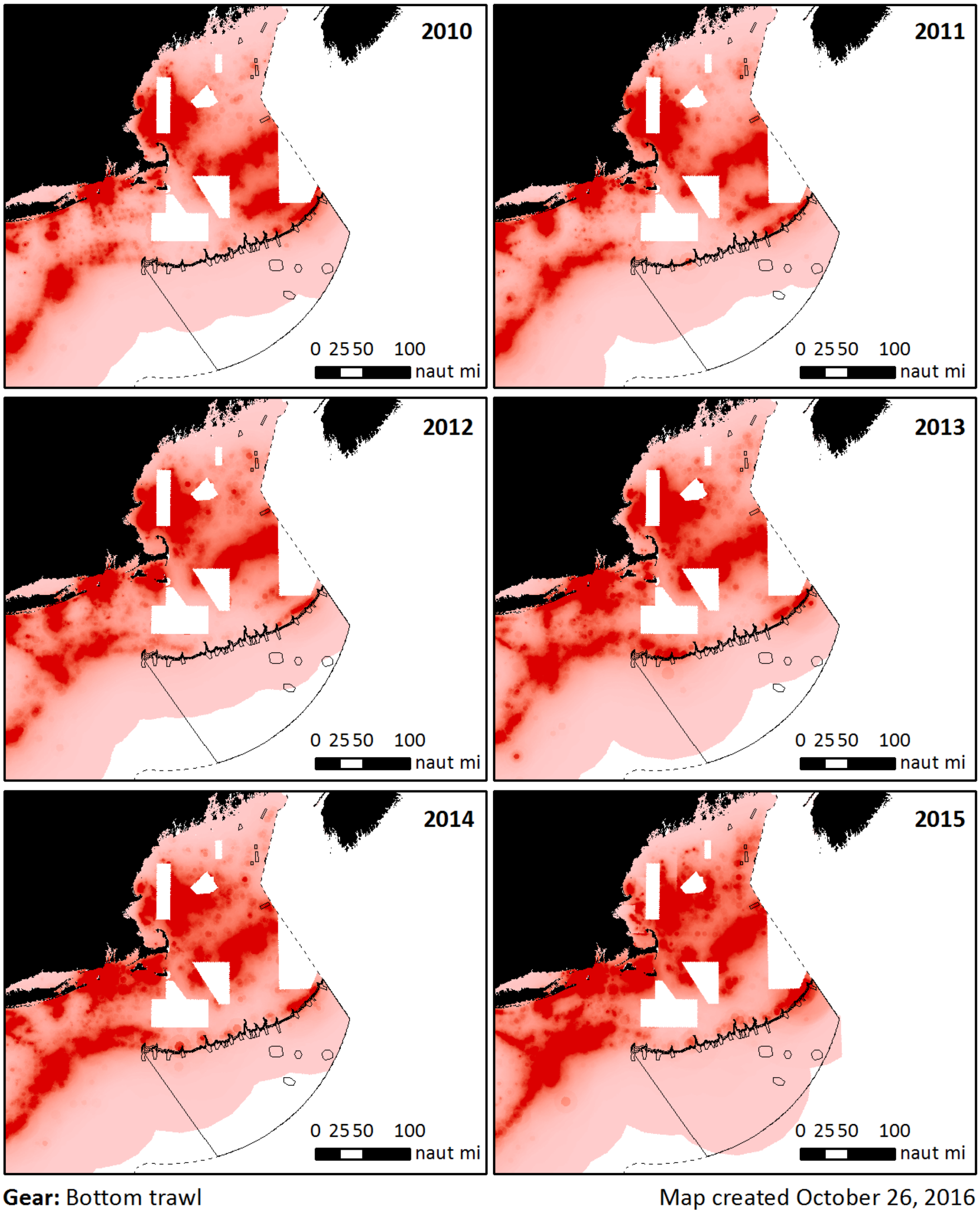
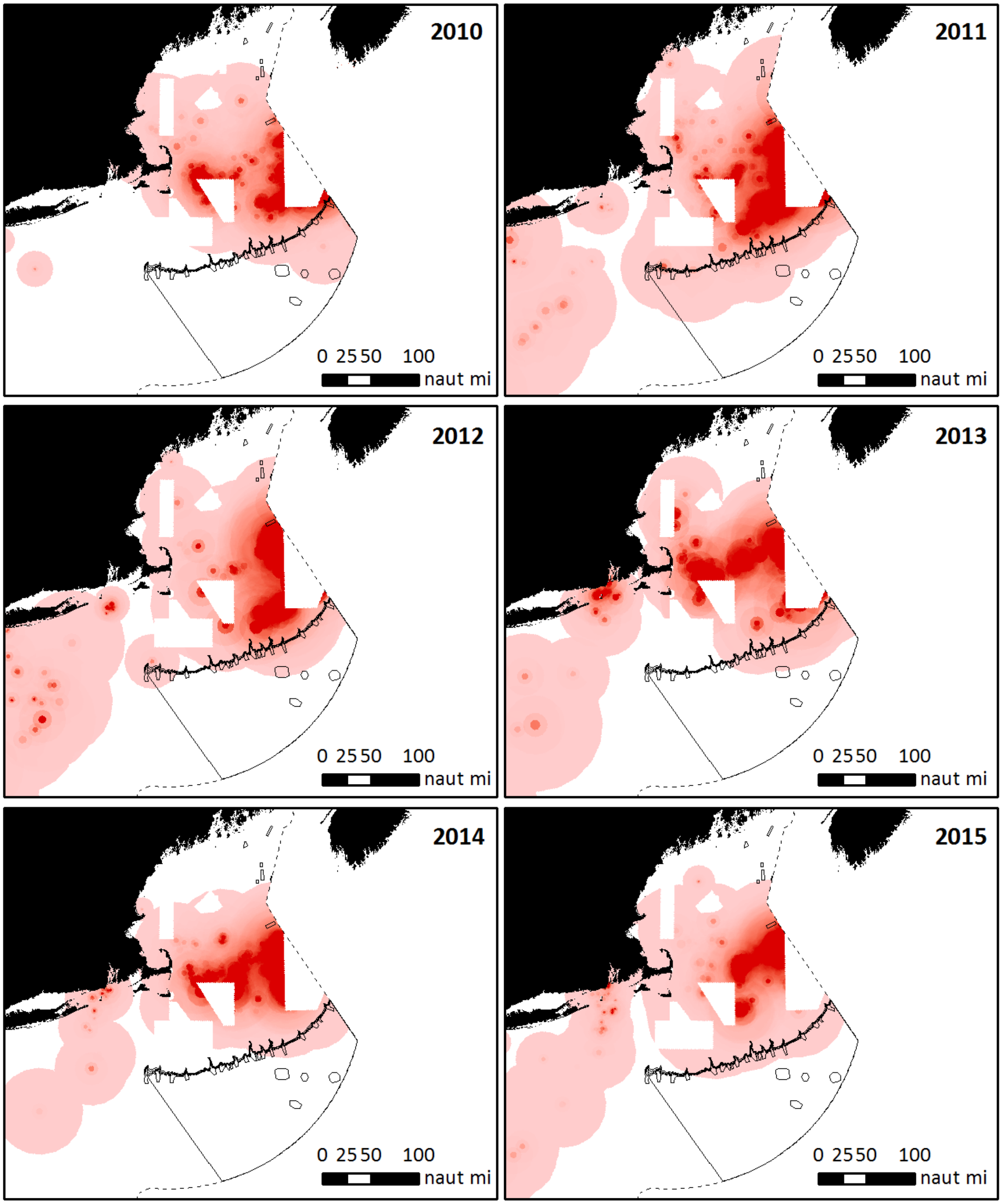
13 Revenue maps

Map 50 – Distribution of revenue generated by bottom trawl gear. Zero values excluded. Source: 2010-2015 VTR data.



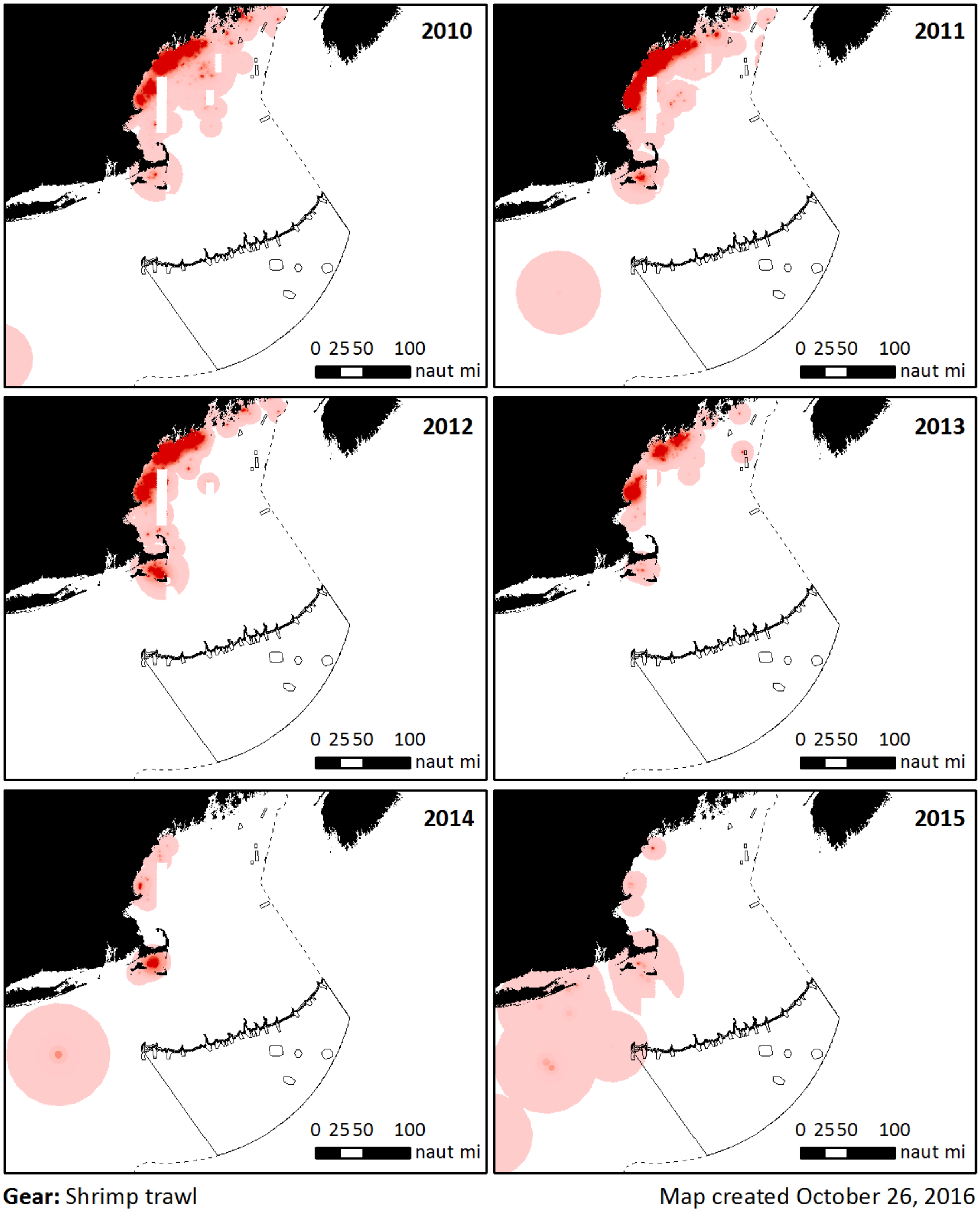
Map 51 – Distribution of revenue generated by Ruhle and separator trawl gear. Zero values excluded. Source: 2010-2015 VTR data.



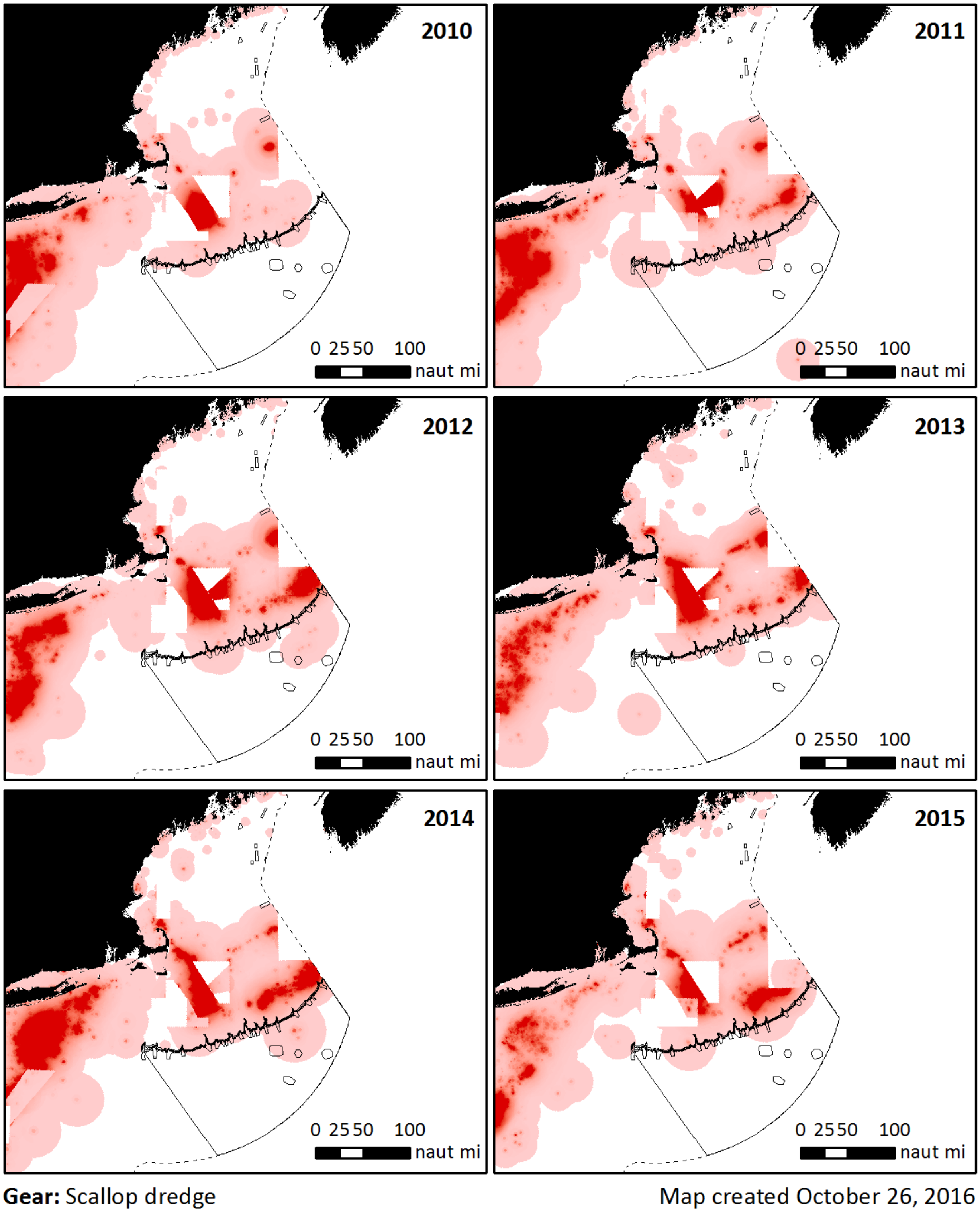
Gear: Ruhle and separator trawls

Map created October 26, 2016

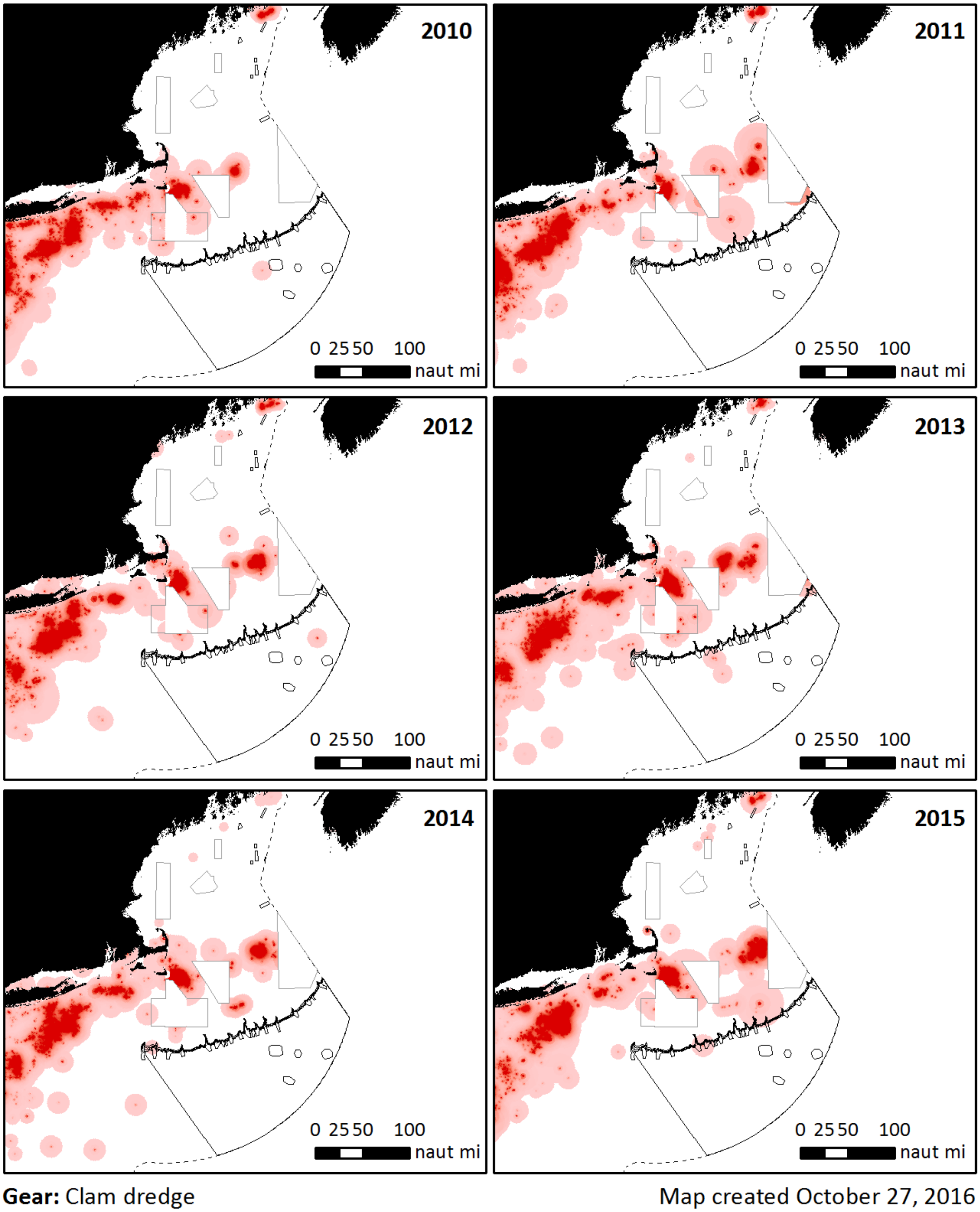
Map 52 – Distribution of revenue generated by shrimp trawl gear. Zero values excluded. Source: 2010-2015 VTR data.



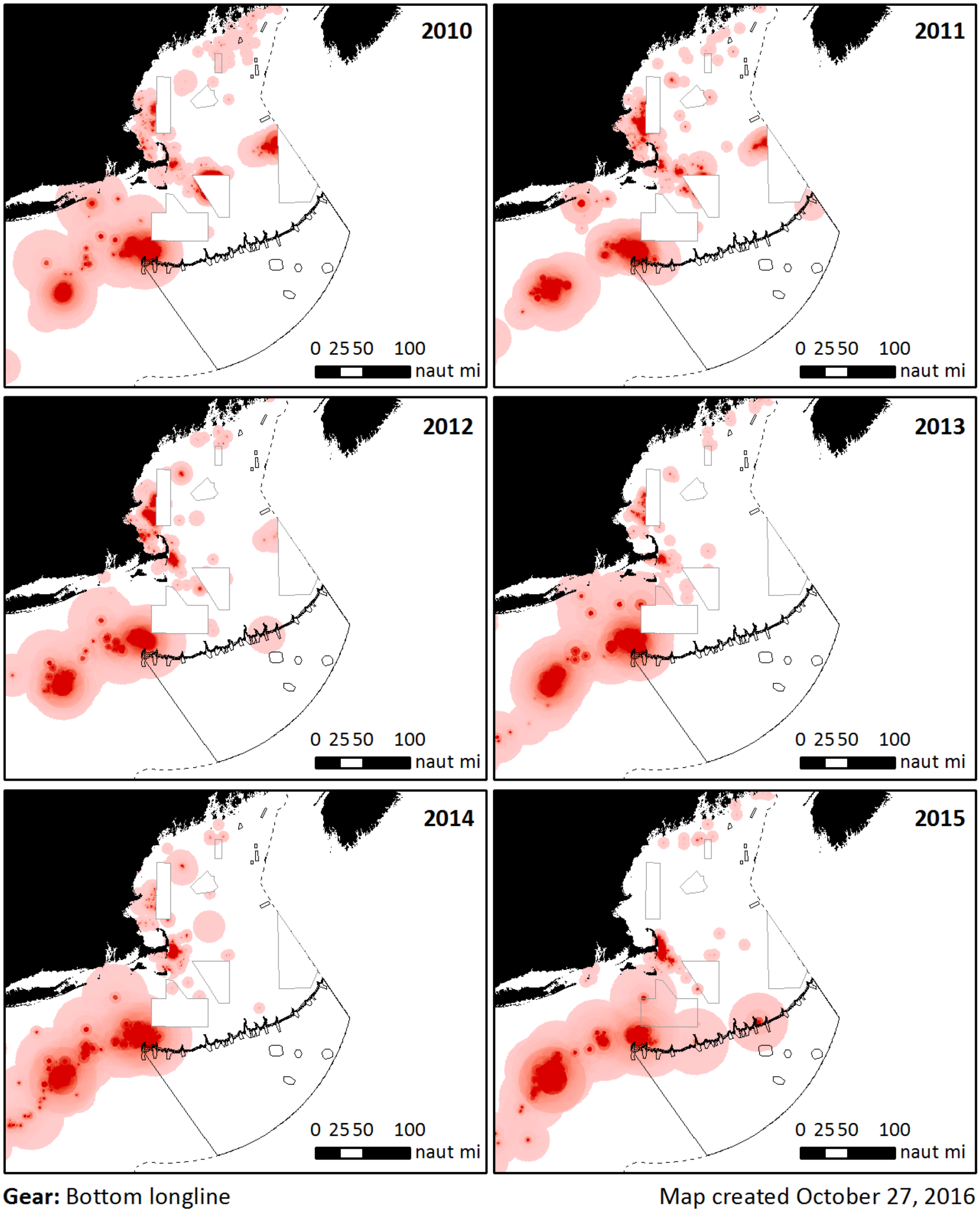
Map 53 – Distribution of revenue generated by scallop dredge gear. Zero values excluded. Source: 2010-2015 VTR data.



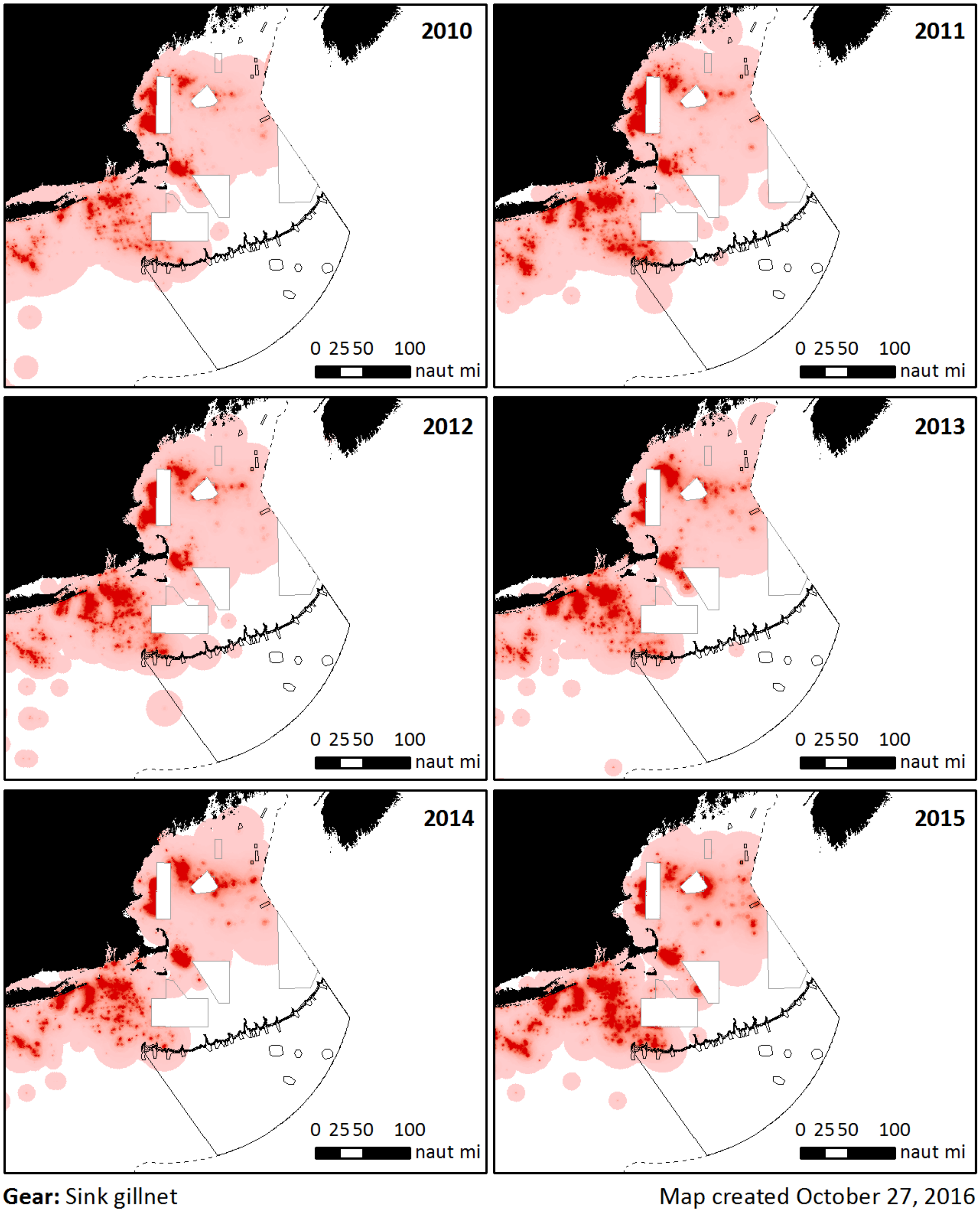
Map 54 – Distribution of revenue generated by clam dredge gear. Zero values excluded. Source: 2010-2015 VTR data.



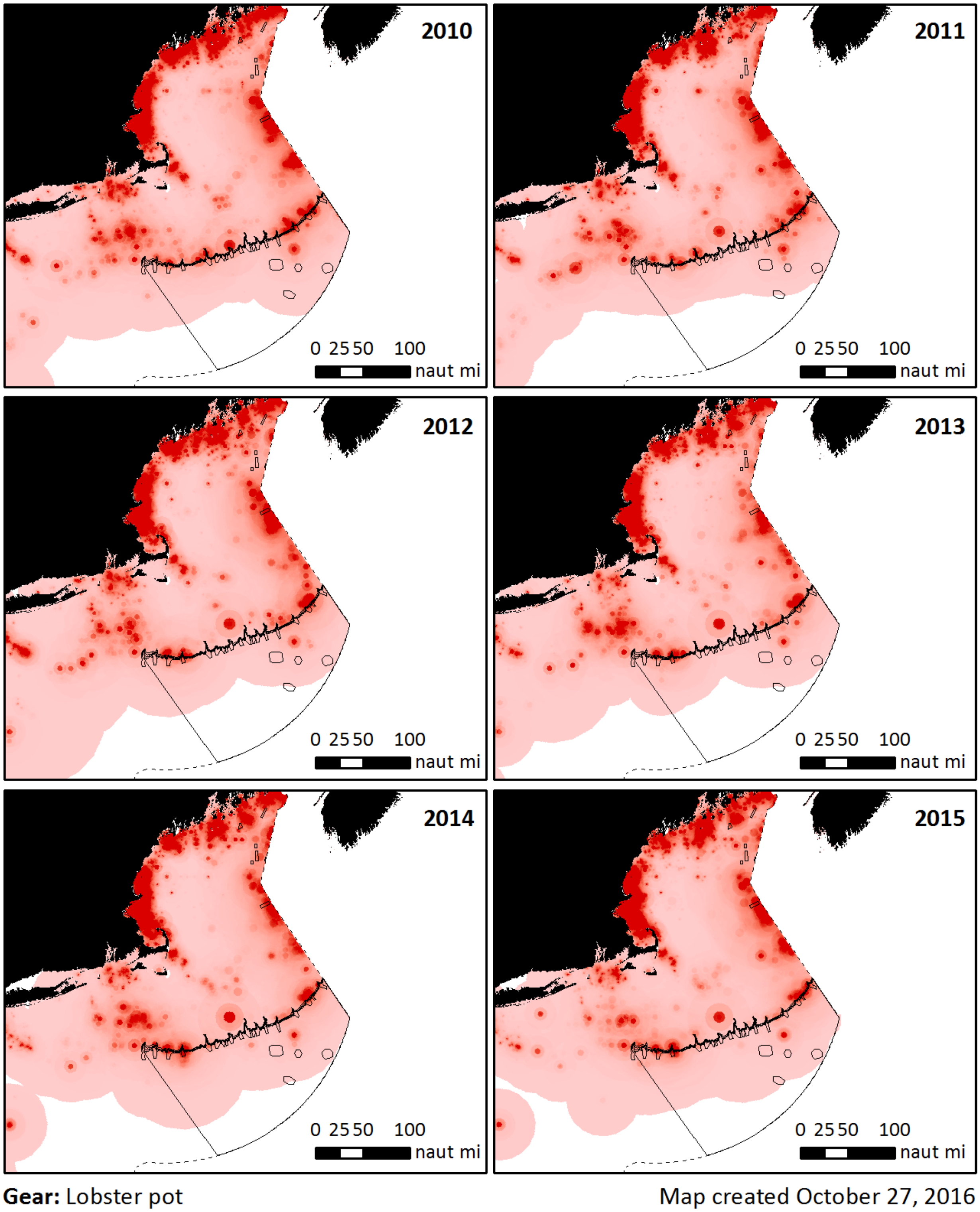
Map 55 – Distribution of revenue generated by bottom longline gear. Zero values excluded. Source: 2010-2015 VTR data.



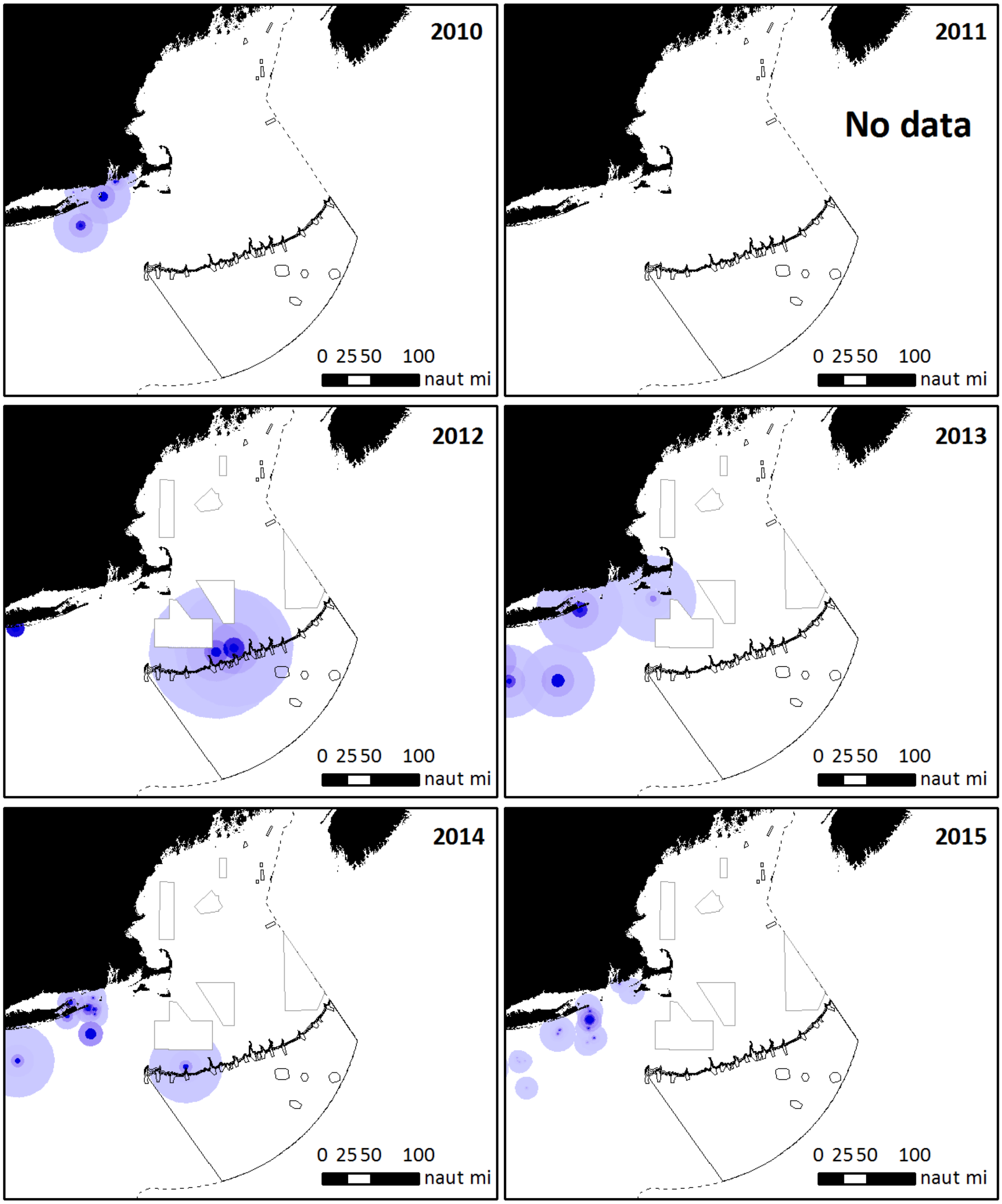
Map 56 – Distribution of revenue generated by sink gillnet gear. Zero values excluded. Source: 2010-2015 VTR data.



Map 57 – Distribution of revenue generated by lobster pot gear. Zero values excluded. Source: 2010-2015 VTR data.



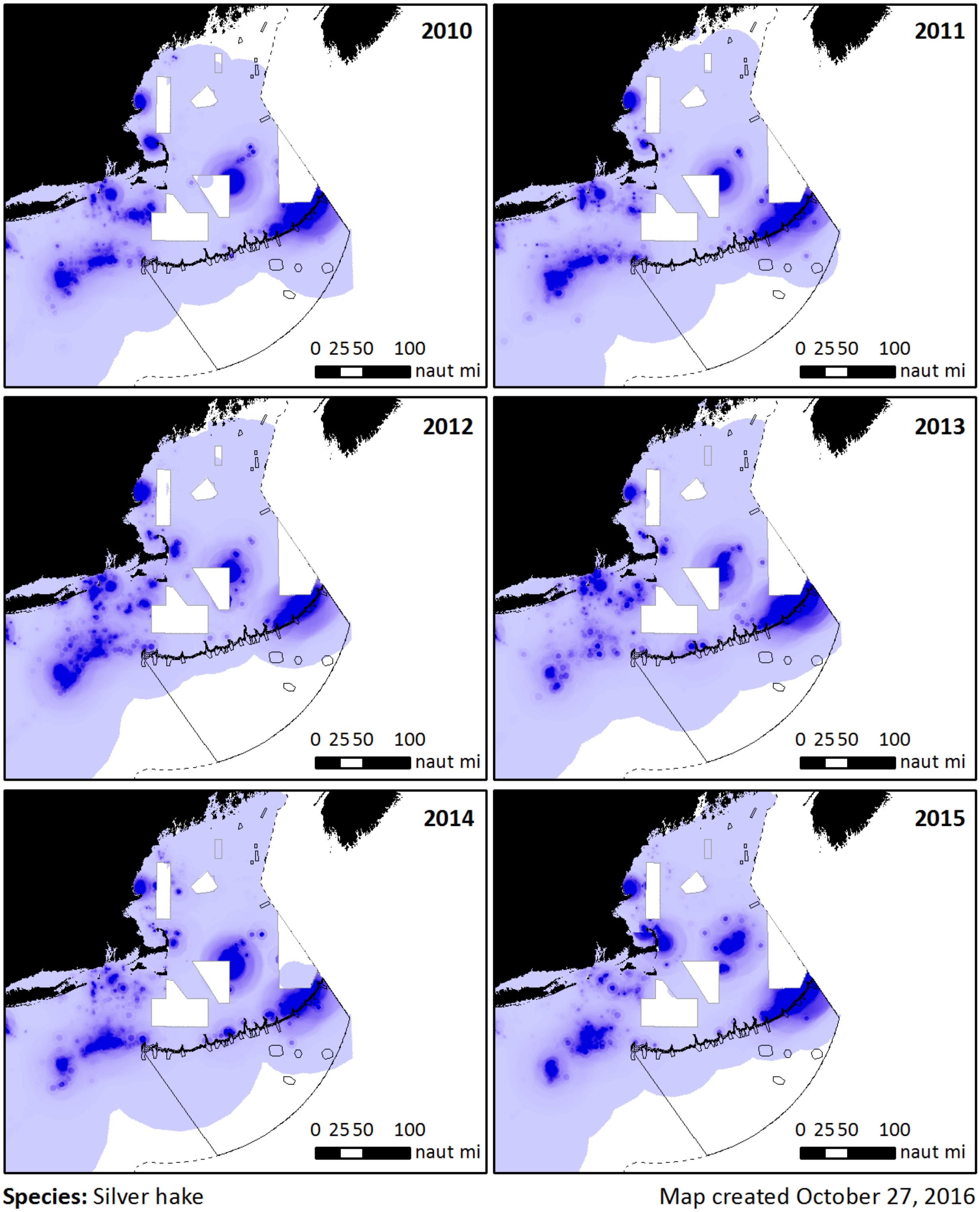
Map 58 – Smooth skate revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



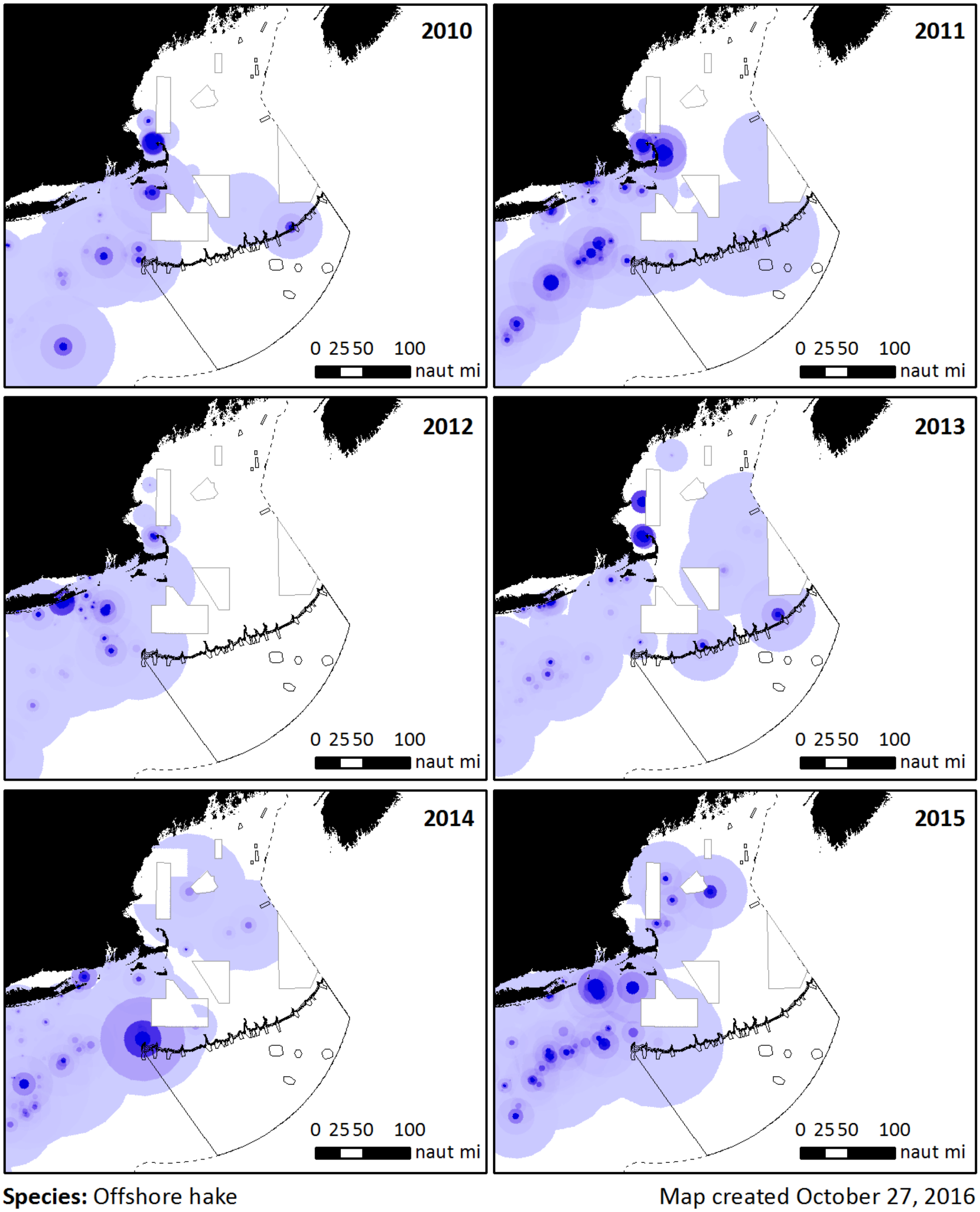
Species: Smooth skate

Map created October 31, 2016

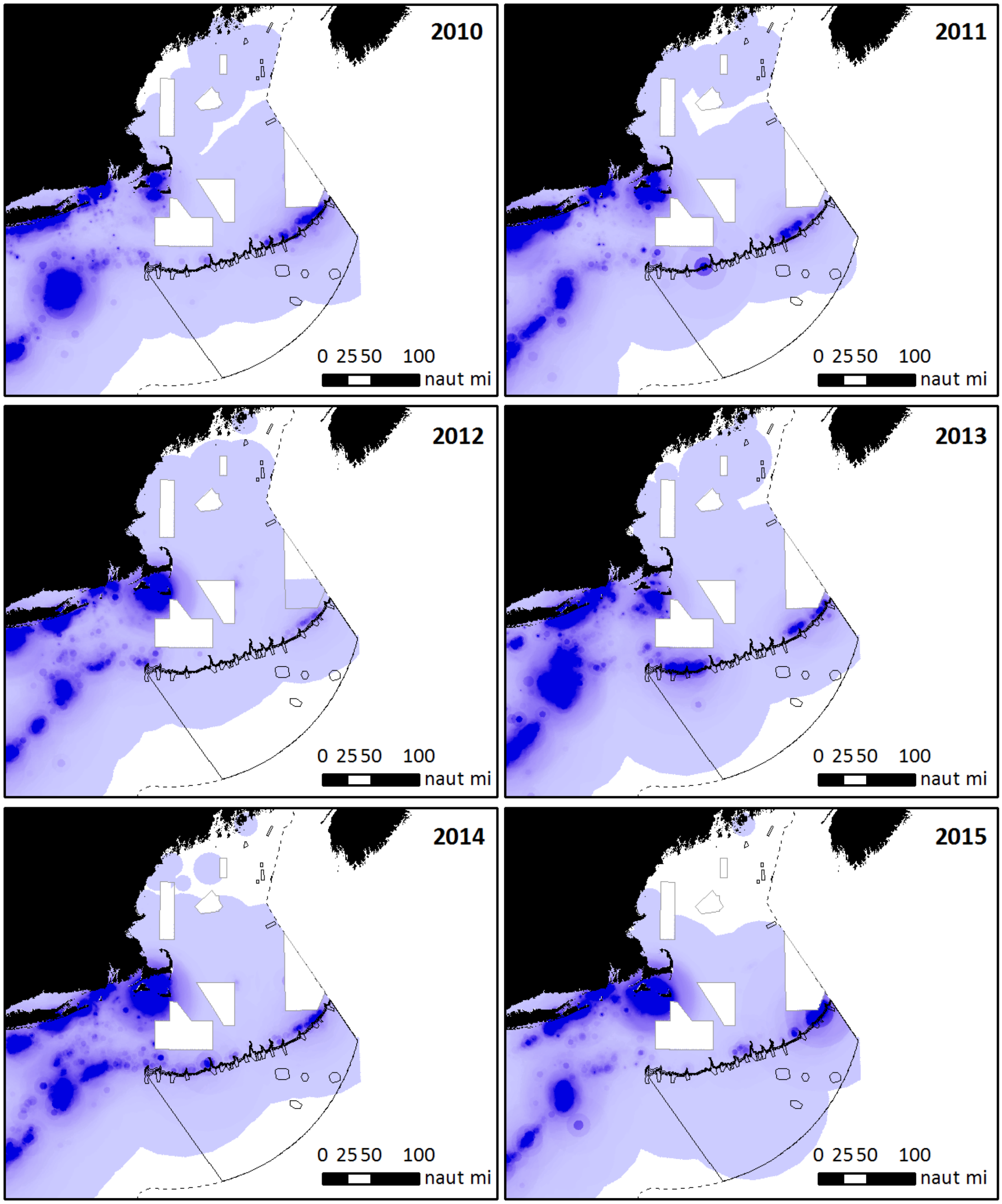
Map 59 – Silver hake revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



Map 60 – Offshore hake revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



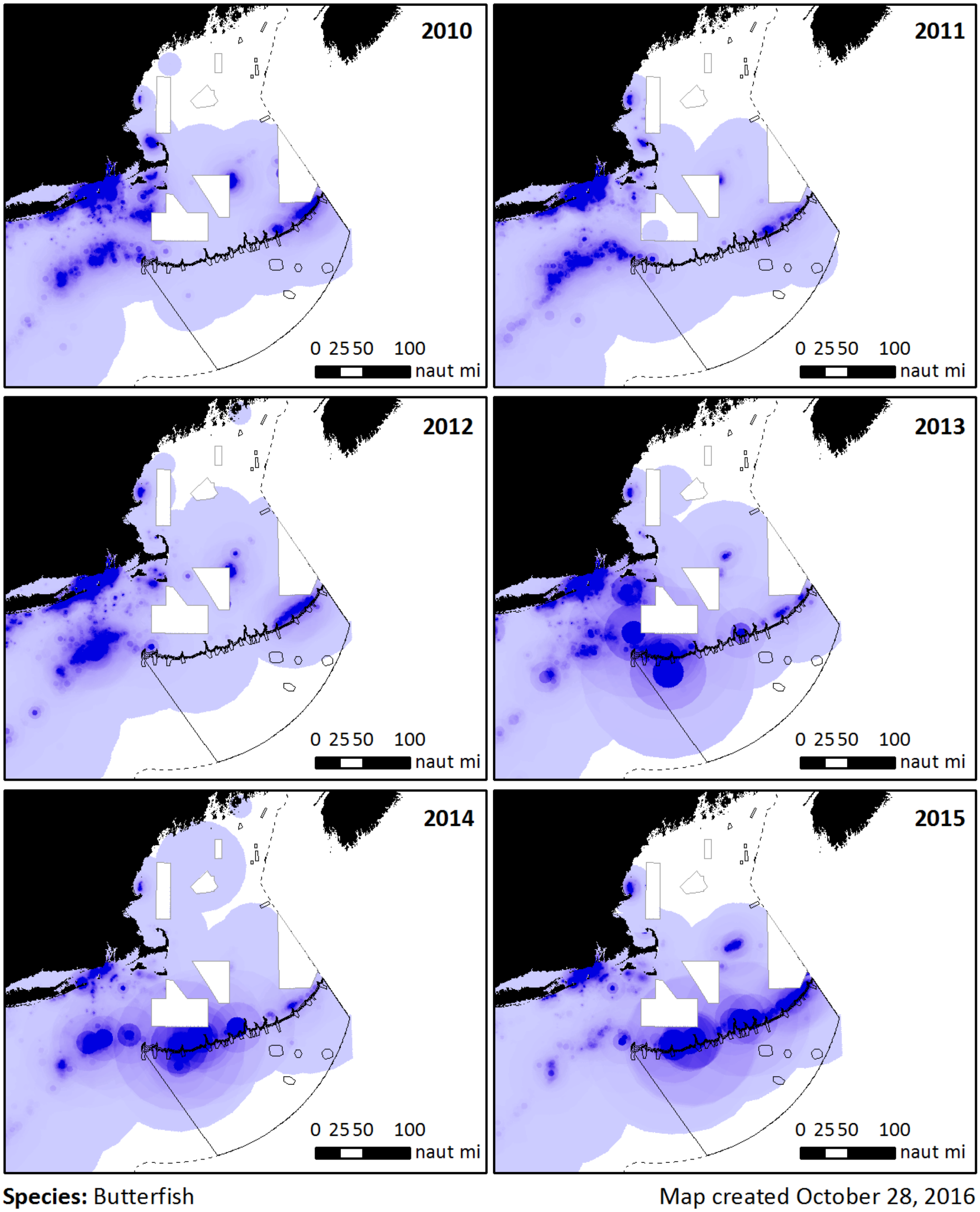
Map 61 – Longfin squid revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



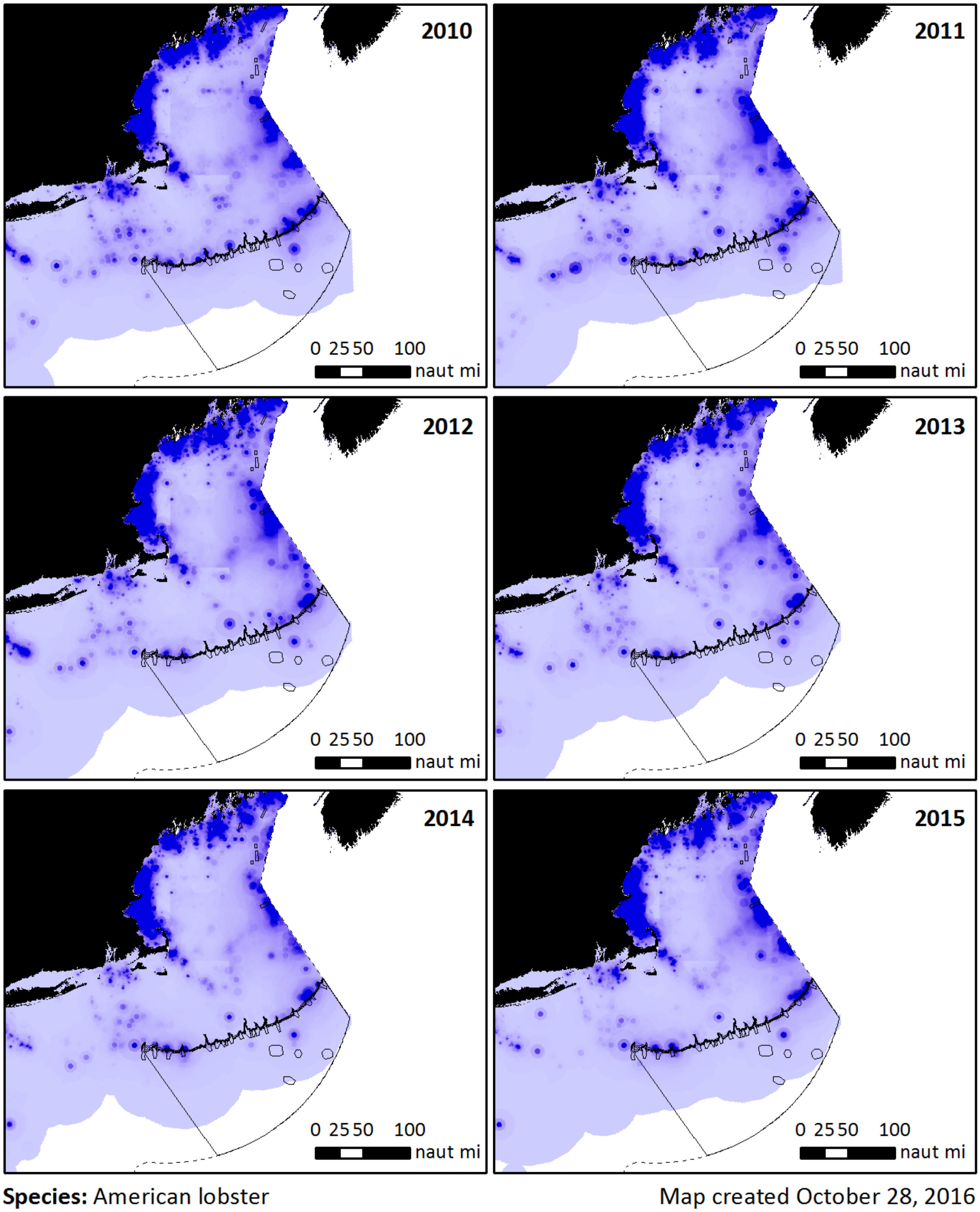
Species: Longfin squid

Map created October 28, 2016

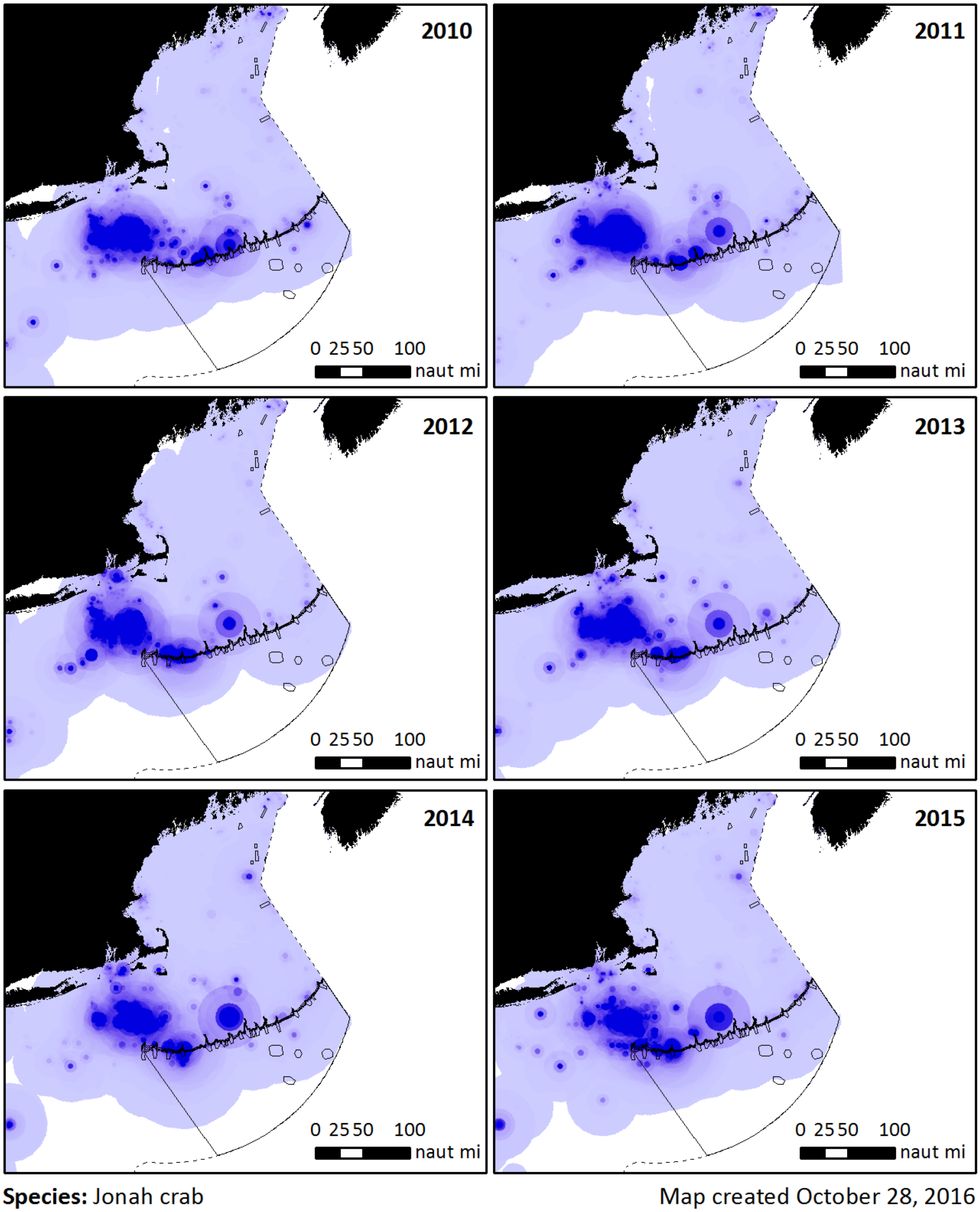
Map 62 – Butterfish revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



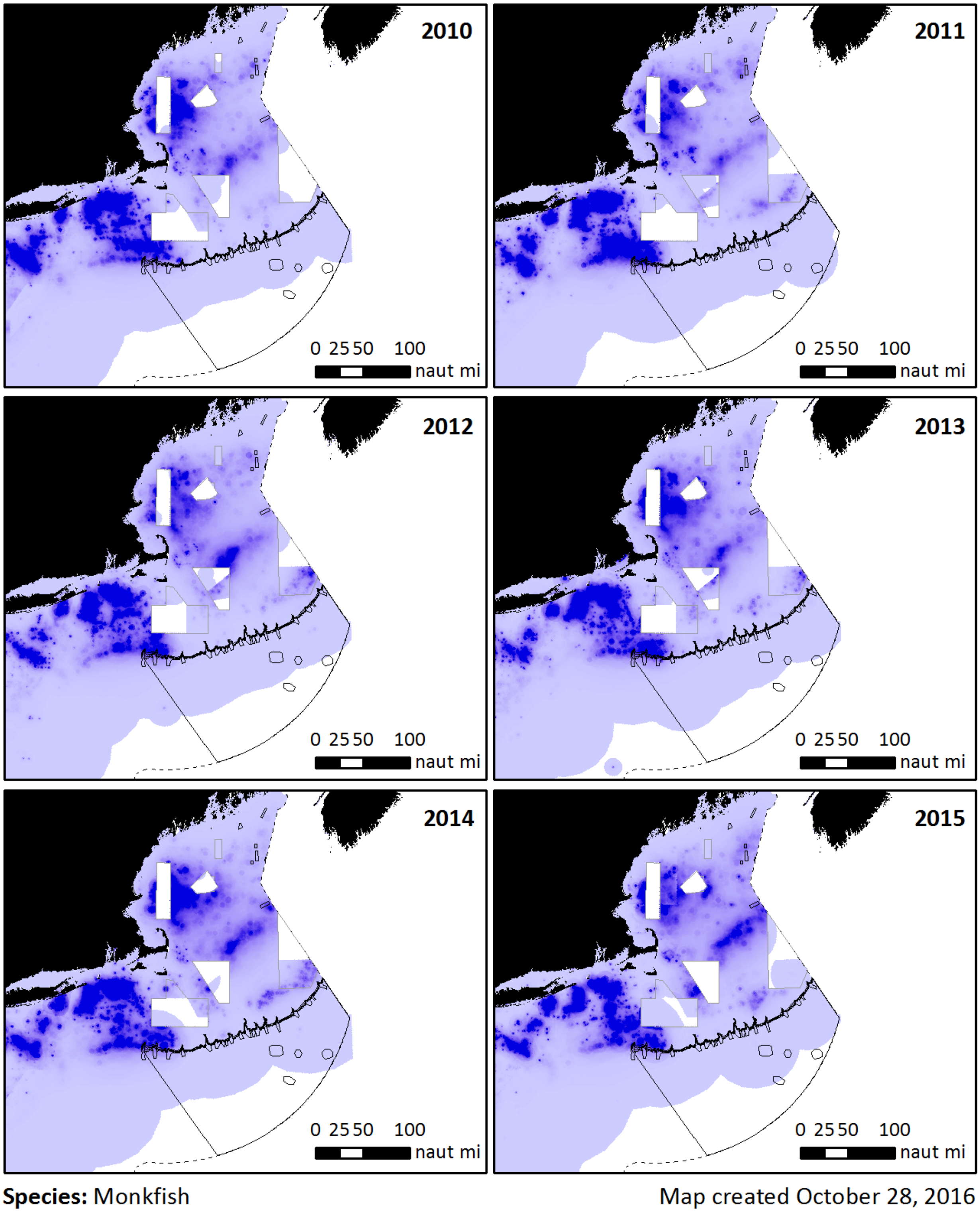
Map 63 – Lobster revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



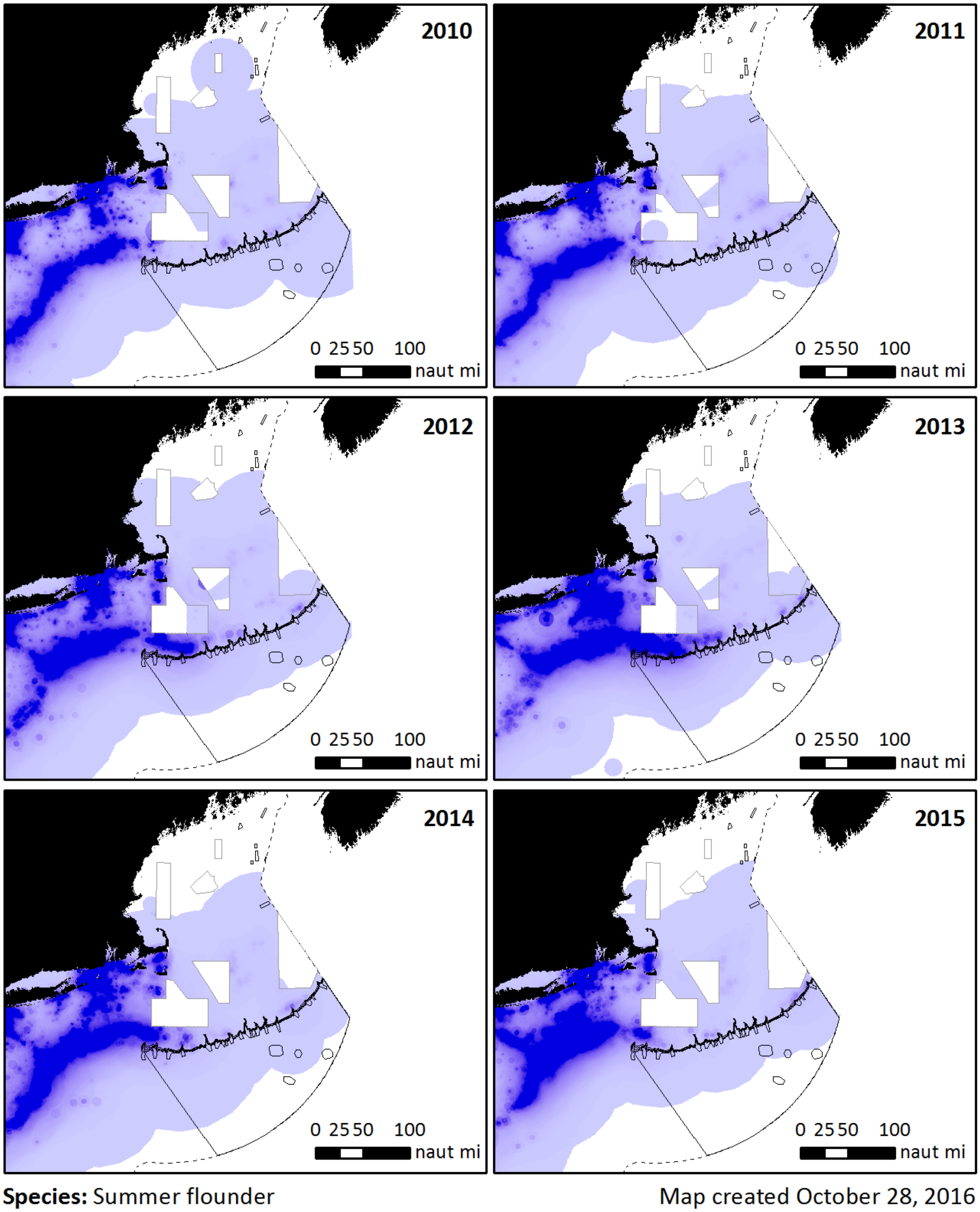
Map 64 – Jonah crab revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



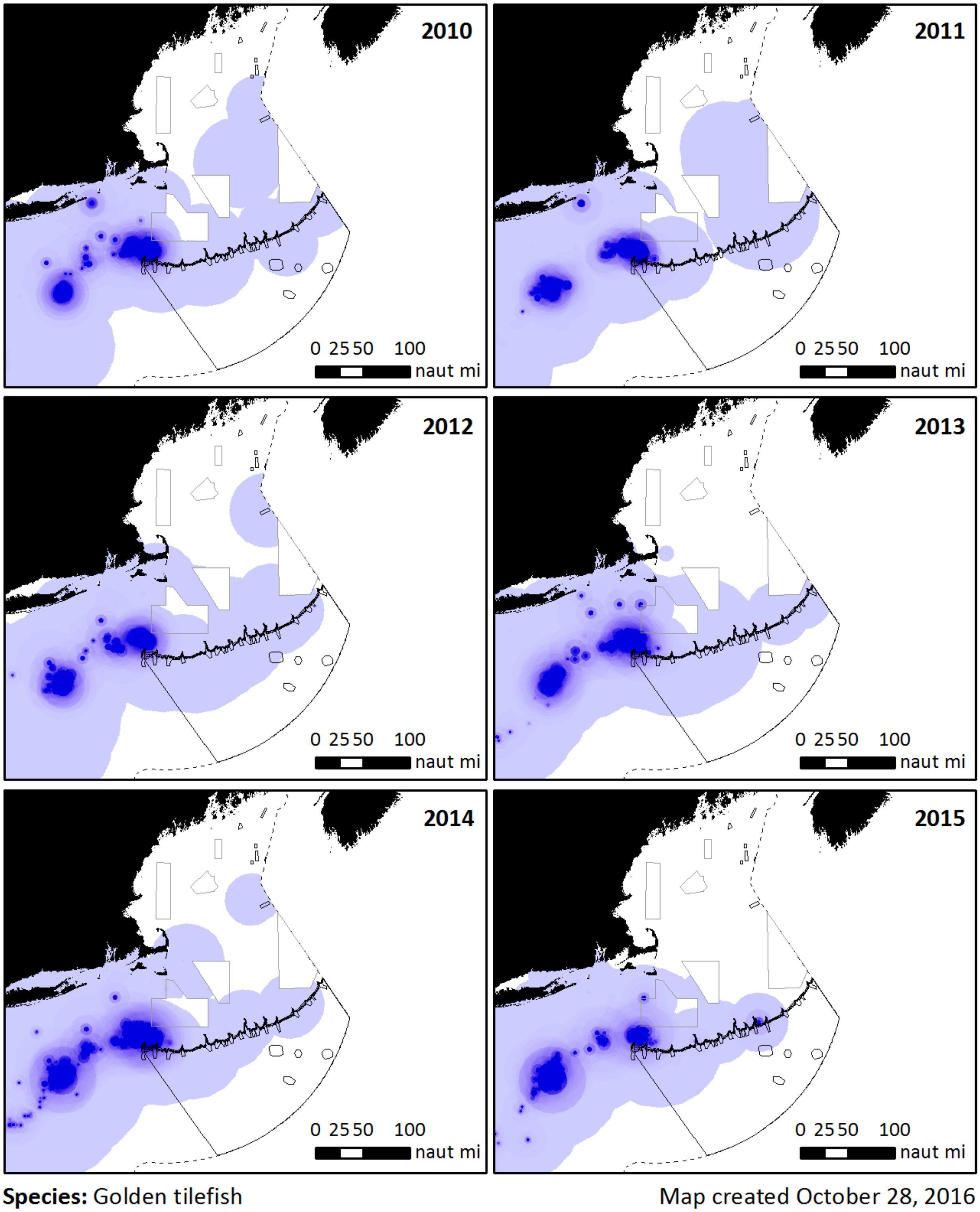
Map 65 – Monkfish revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



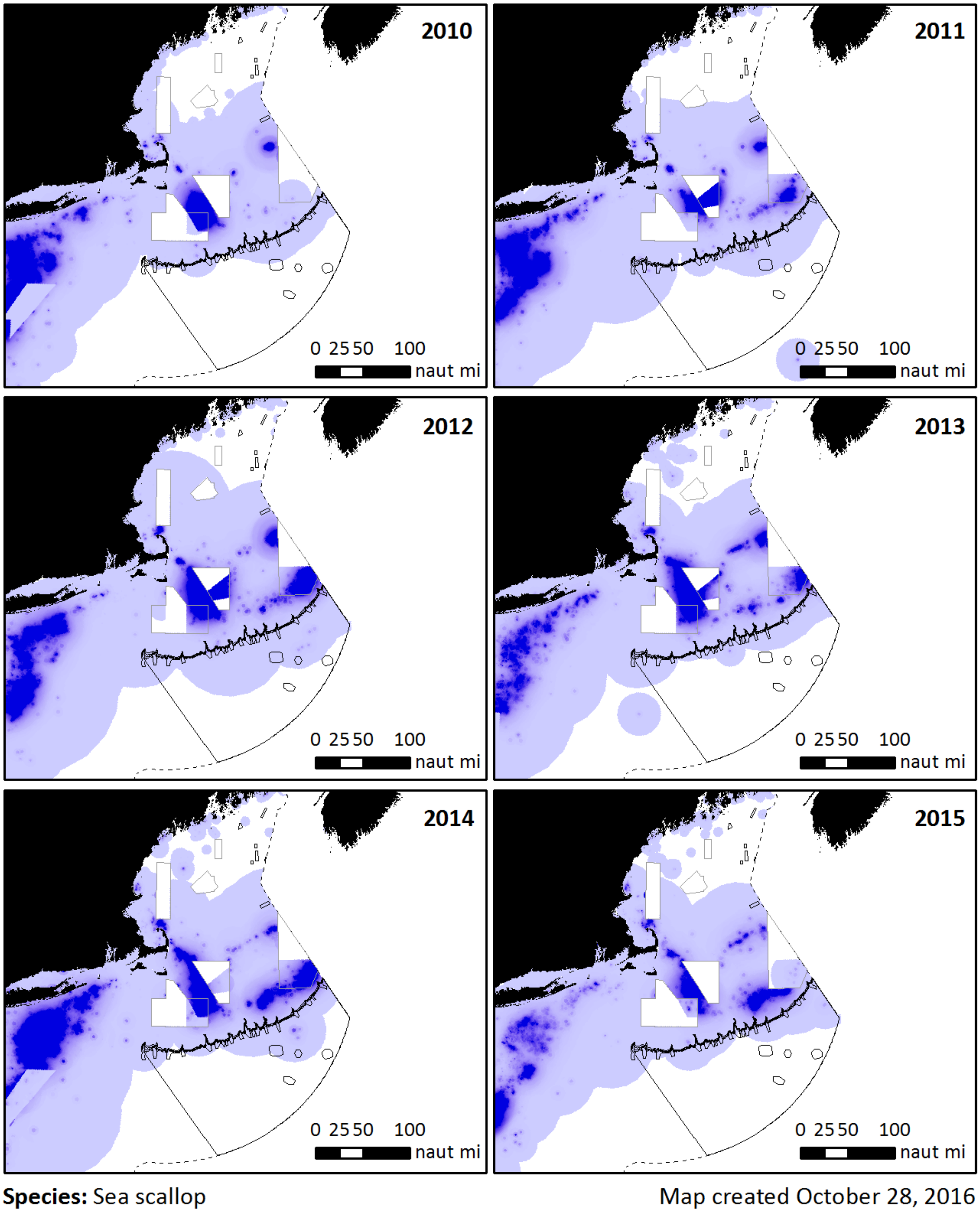
Map 66 – Summer flounder revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



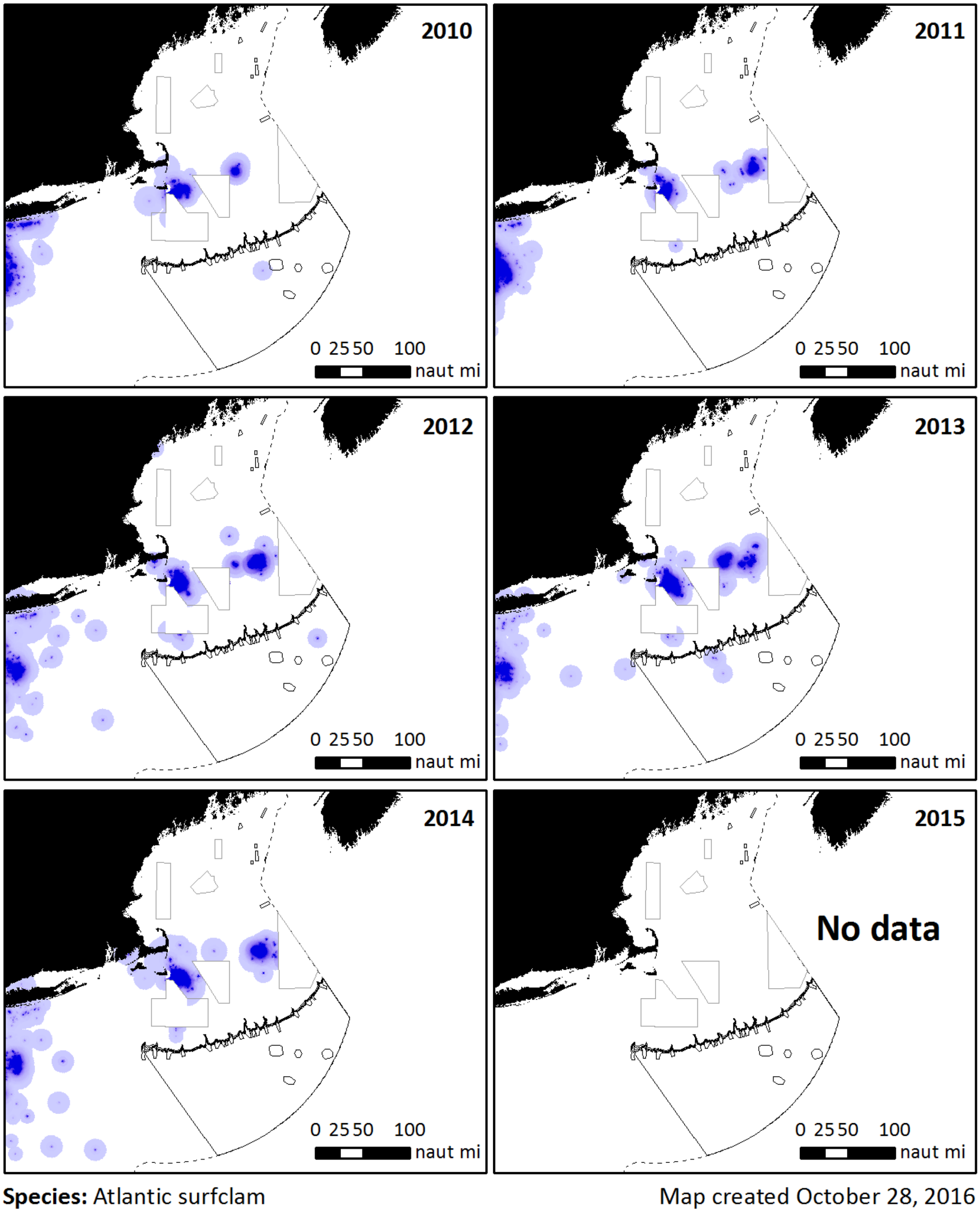
Map 67 – Golden tilefish revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



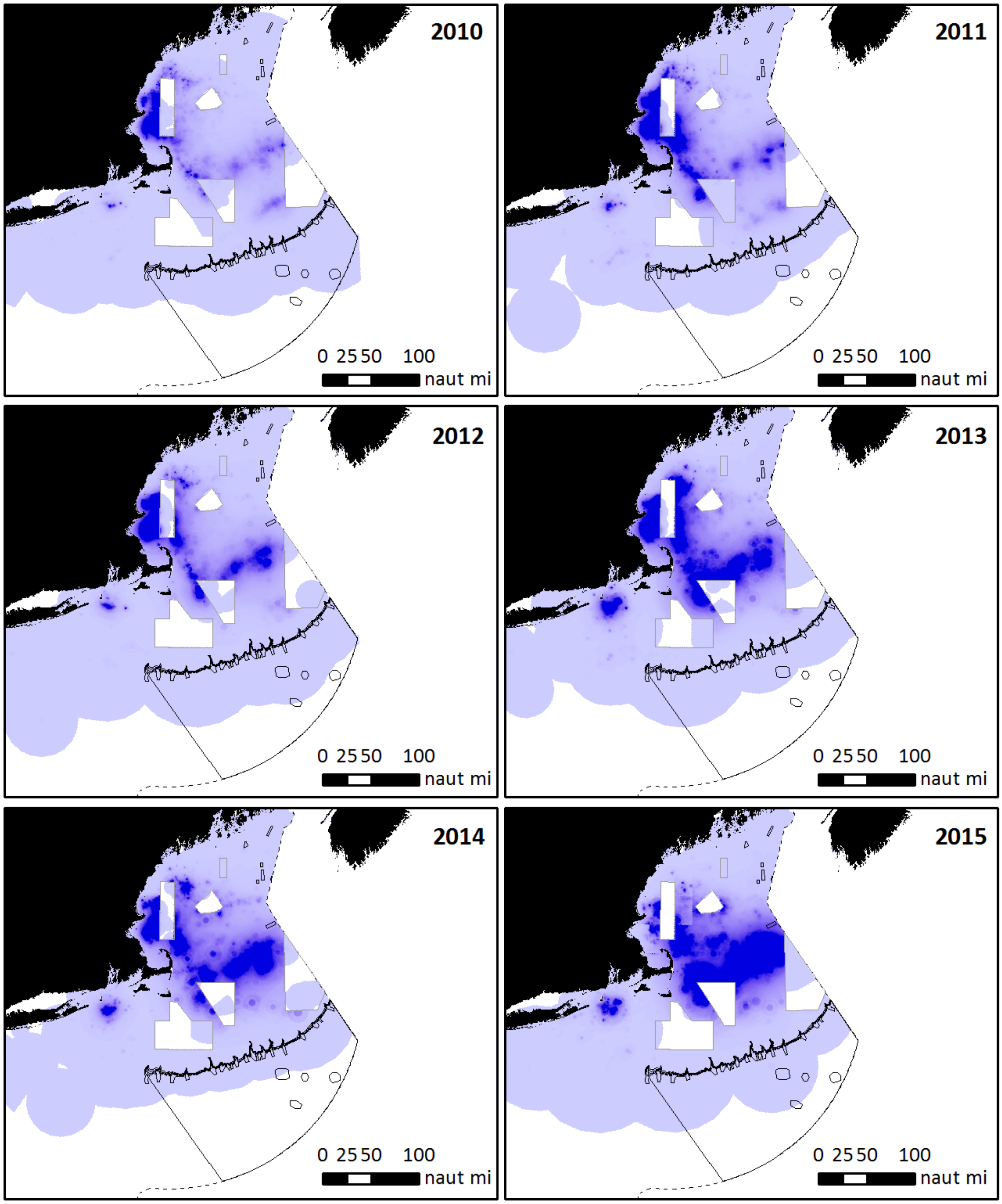
Map 68 – Sea scallop revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



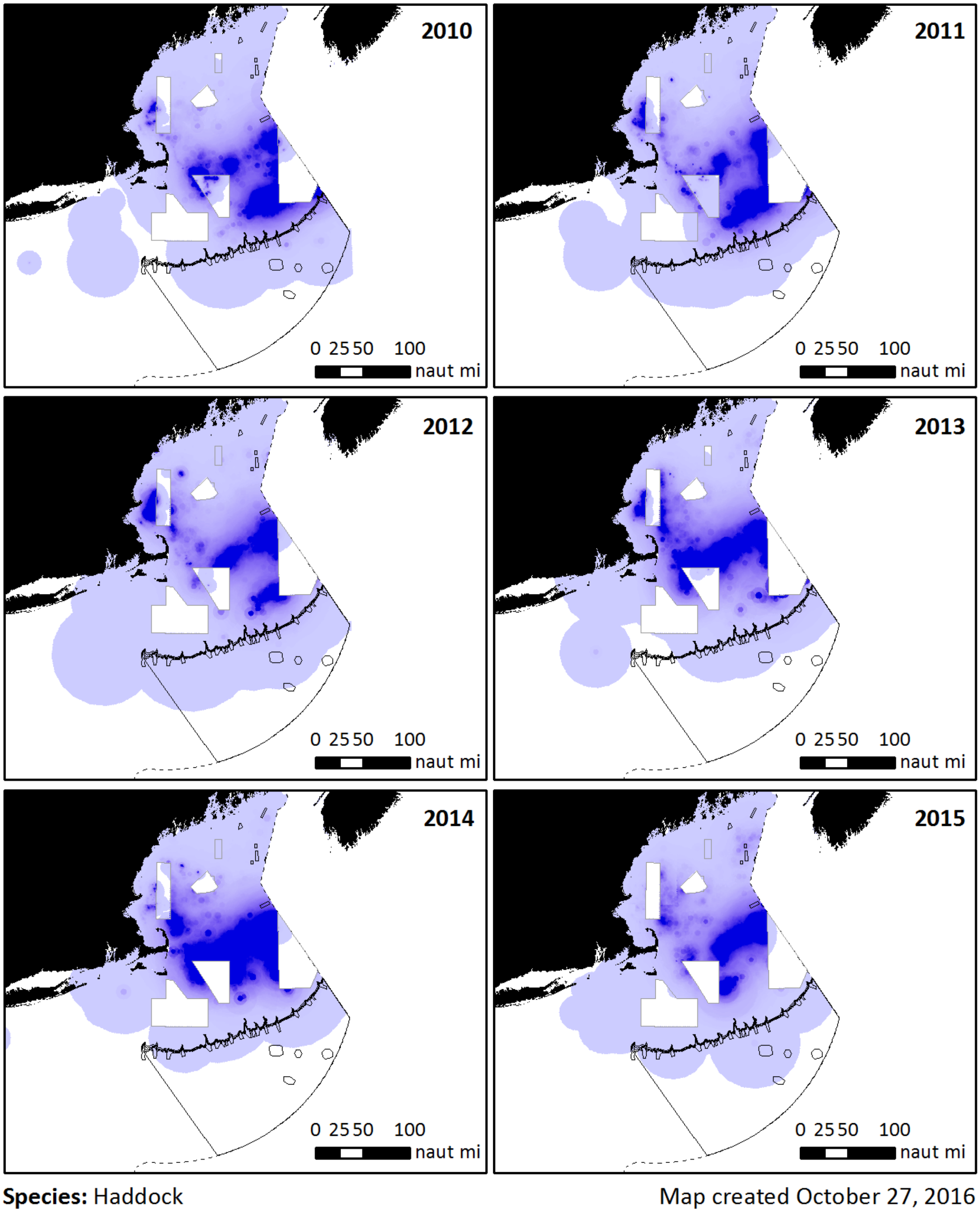
Map 69 – Atlantic surfclam revenue distribution. Zero values excluded. Source: 2010-2014 VTR data.



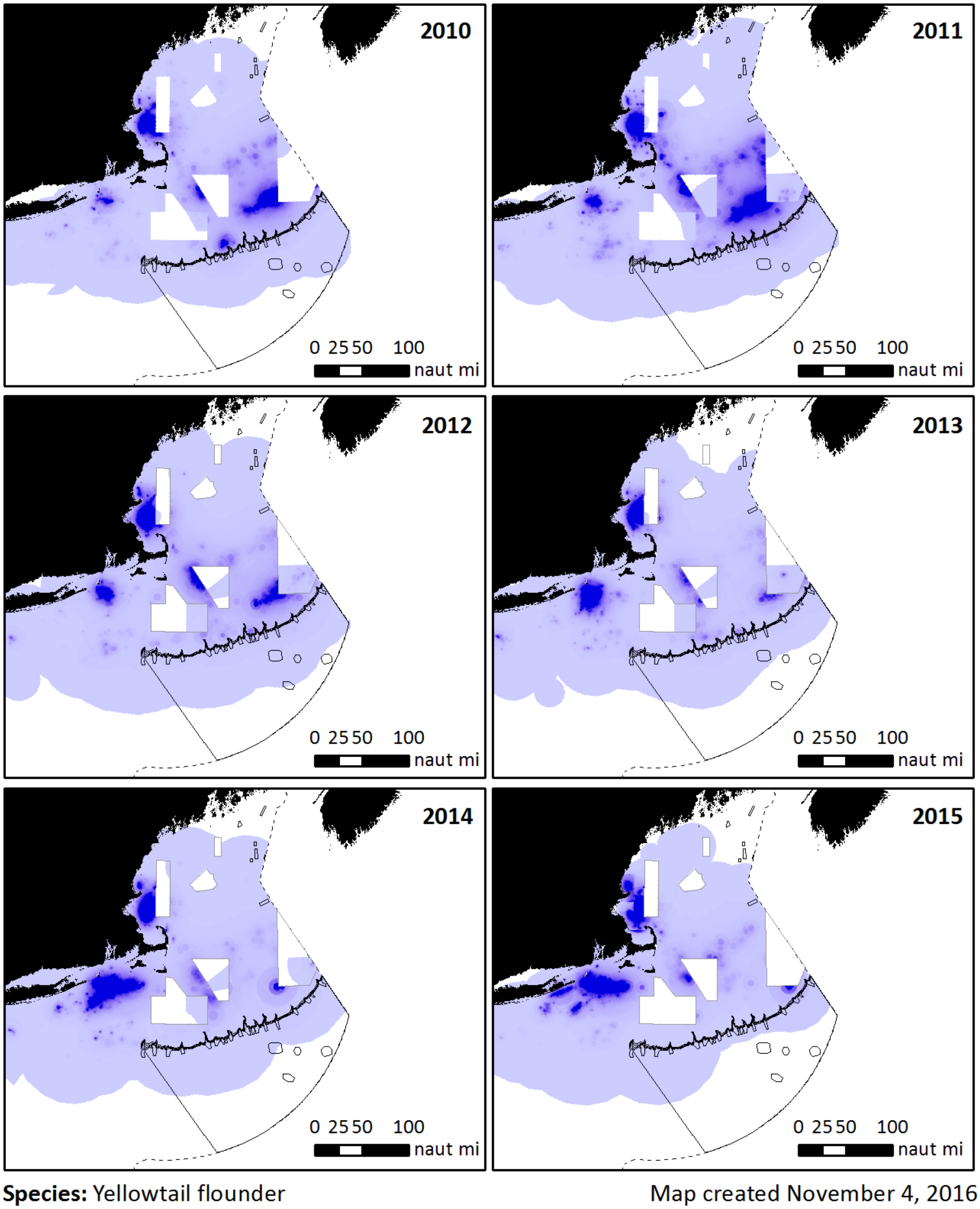
Map 70 – Atlantic cod revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



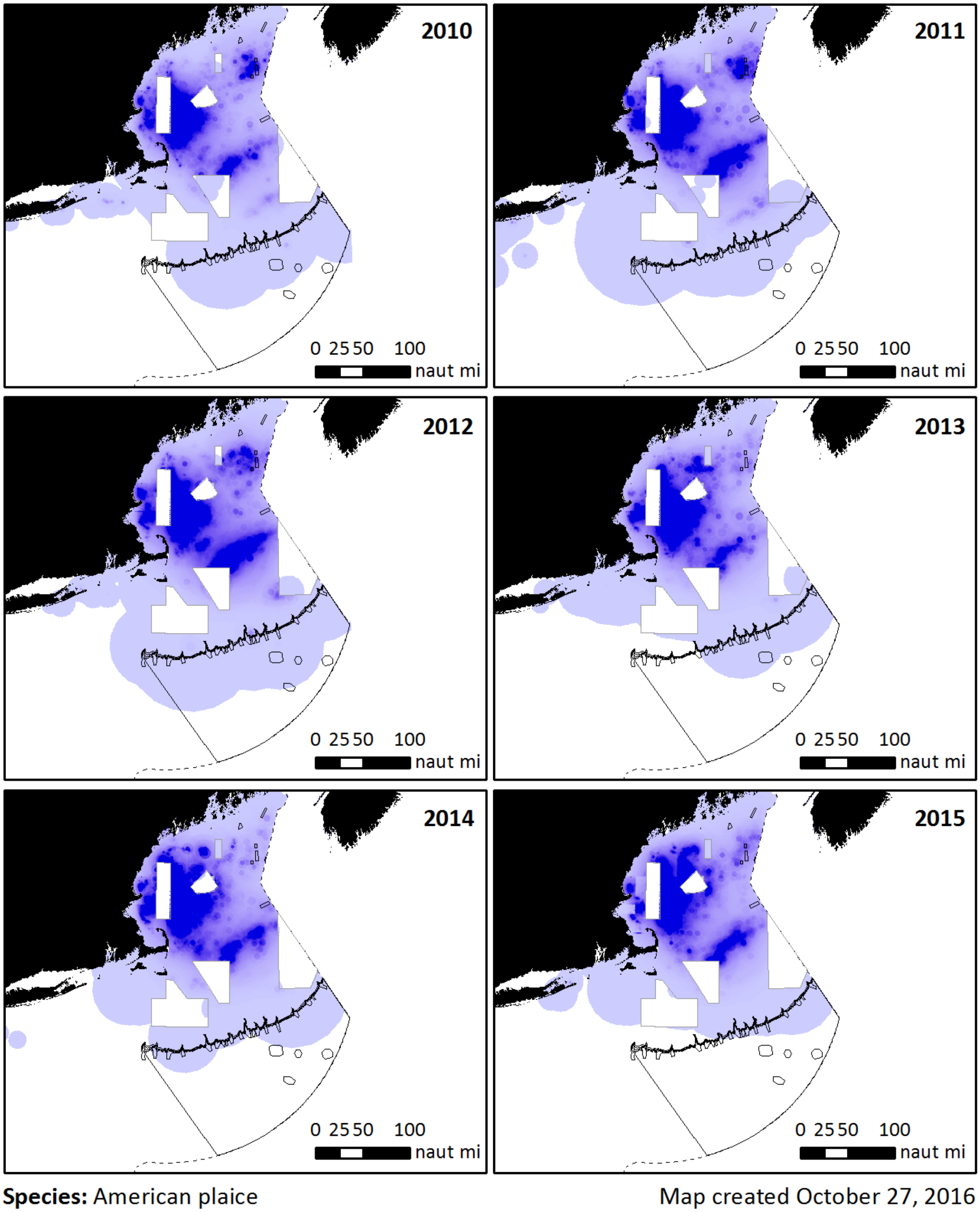
Map 71 – Haddock revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



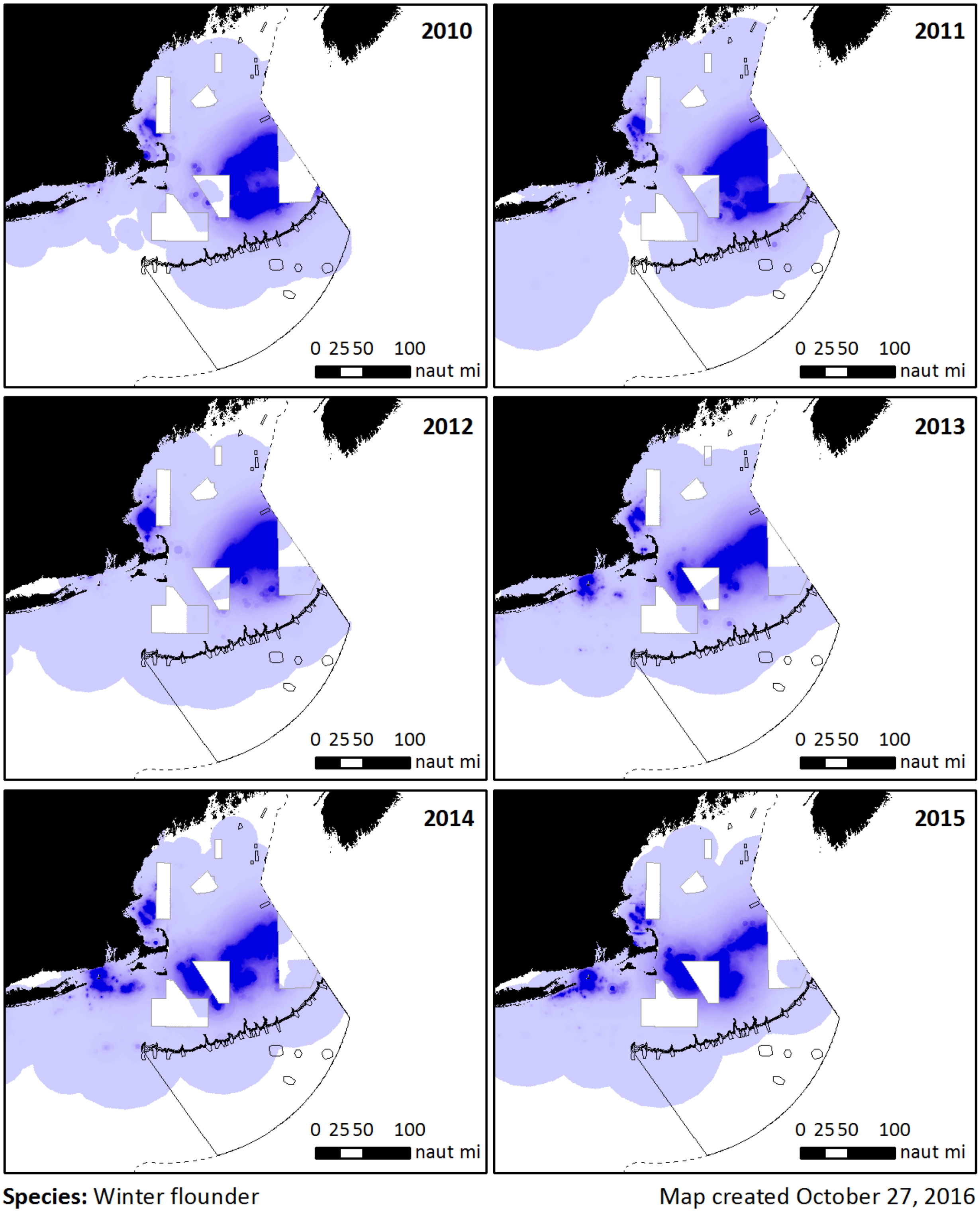
Map 72 – Yellowtail flounder revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



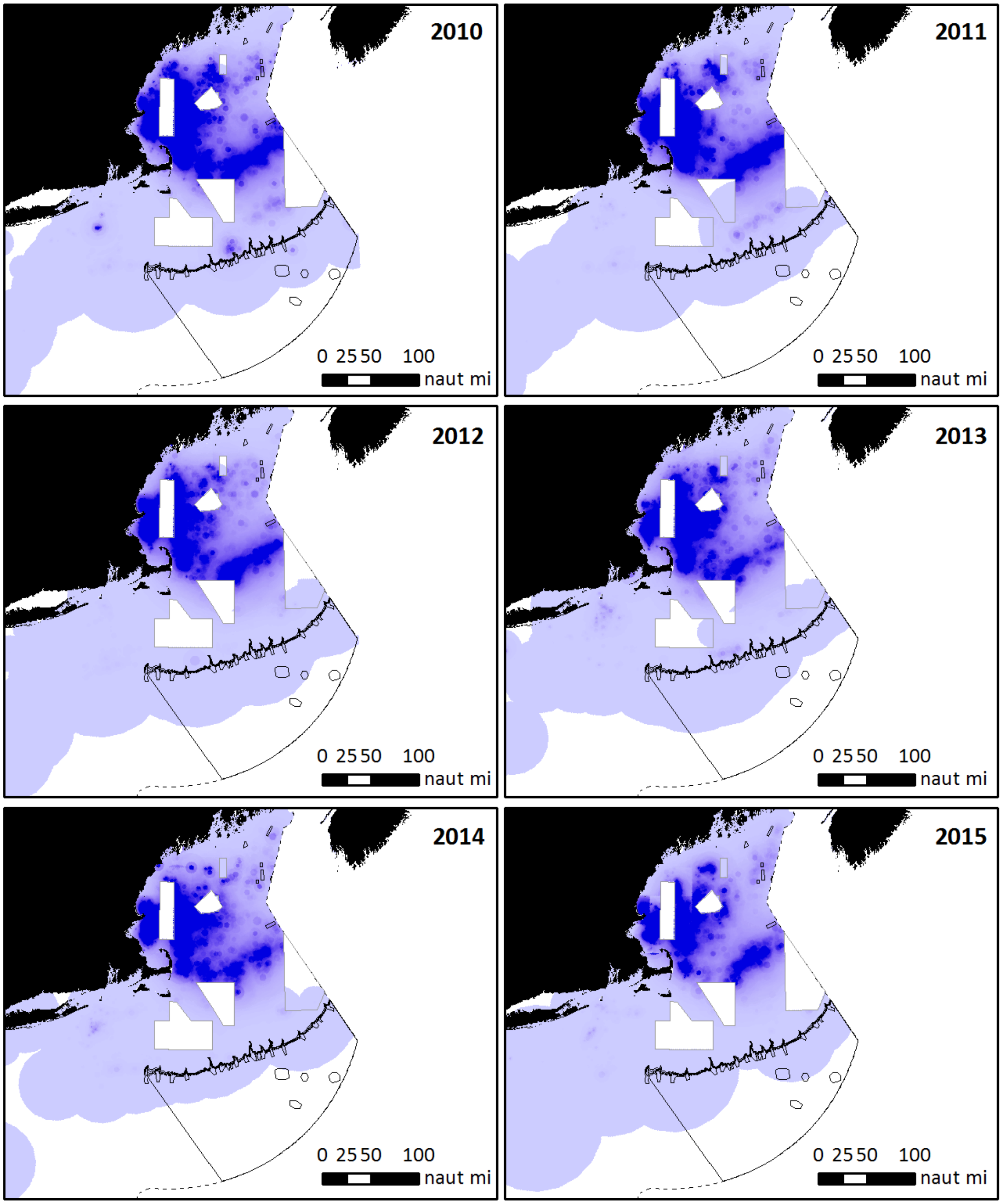
Map 73 – American plaice revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



Map 74 – Winter flounder revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



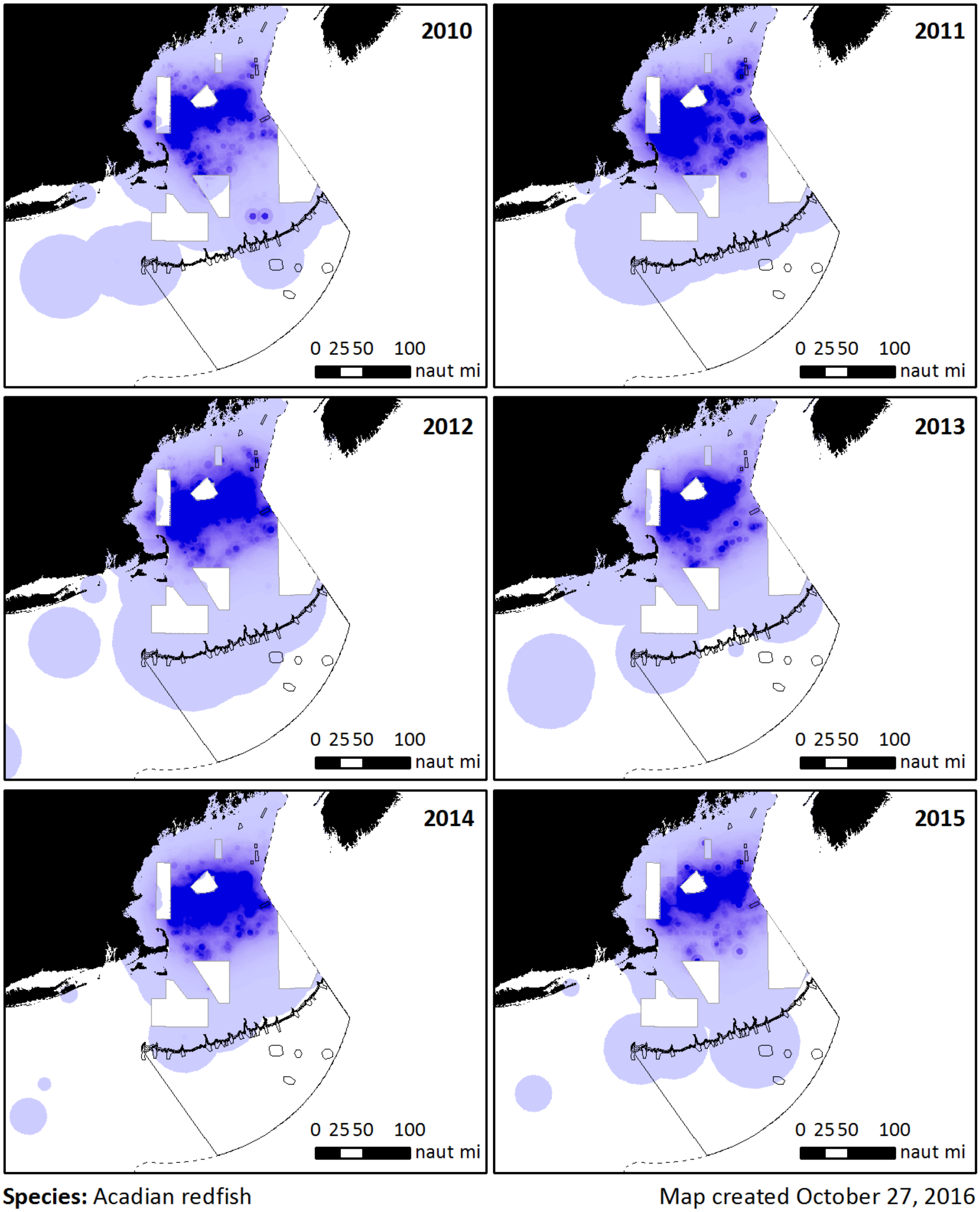
Map 75 – Witch flounder revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



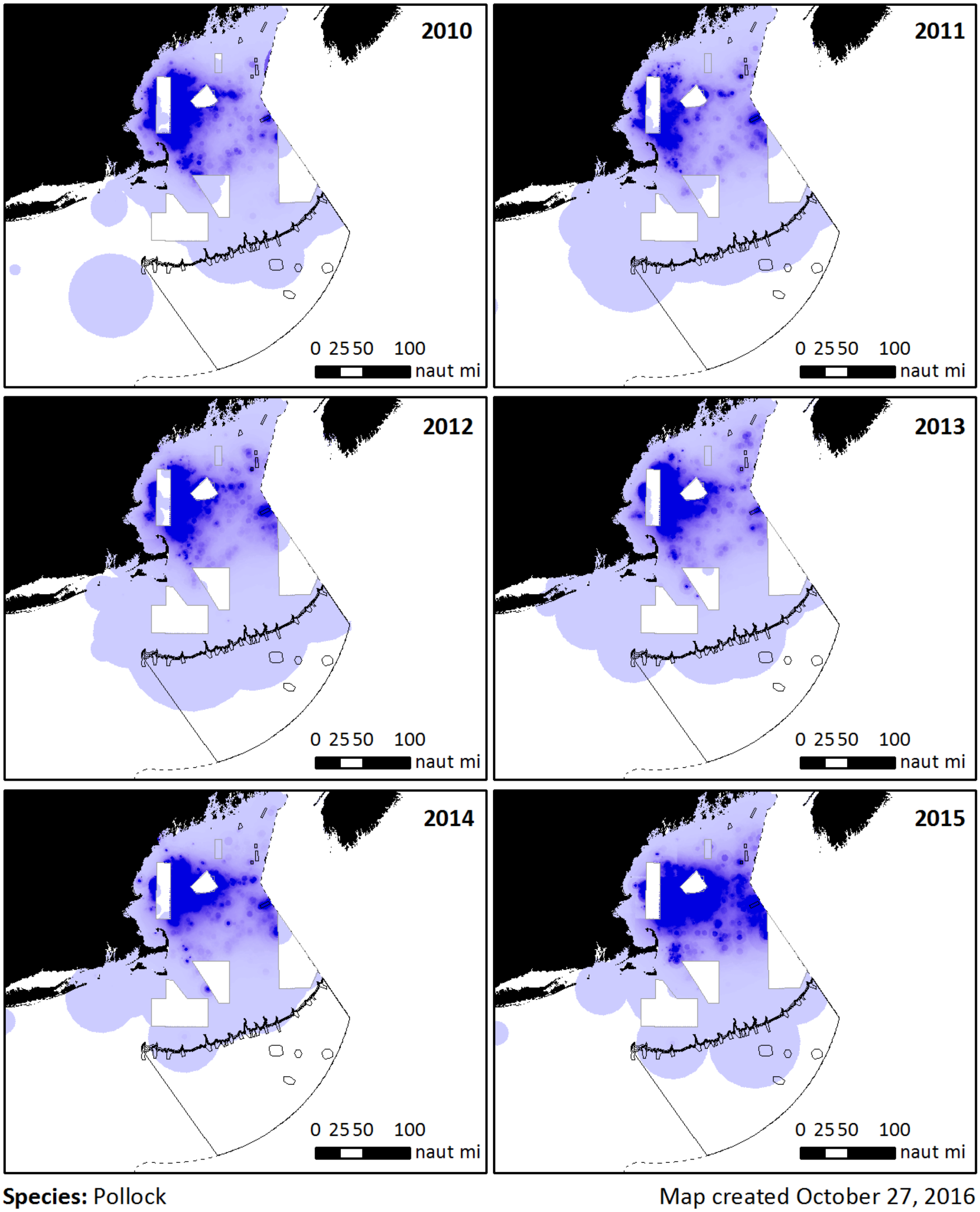
Species: Witch flounder

Map created October 27, 2016

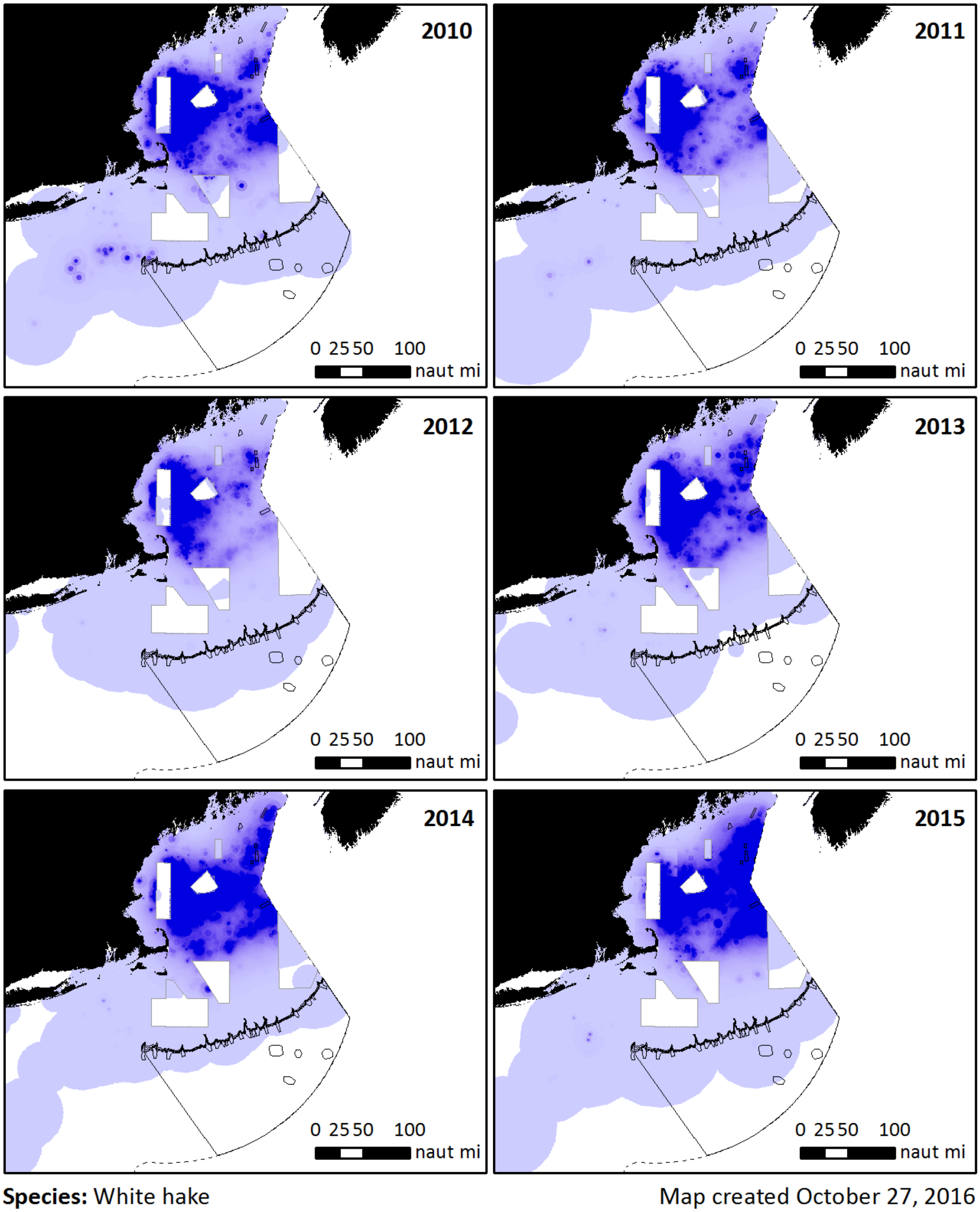
Map 76 – Redfish revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



Map 77 – Pollock revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



Map 78 – White hake revenue distribution. Zero values excluded. Source: 2010-2015 VTR data.



14 Coral zone size

Area sizes (km^2 and mi^2) are summarized in Table 62. For reference, the entire New England region shown on **Map 43** is approximately 200,000 km^2. The discrete zones in combination cover approximately 4,400 km^2. For comparison, this is roughly two thirds the size of groundfish Closed Area II, which covers 6,916 km^2. For the discrete zones, the seamount areas are generally largest (mean size 318 km^2, n=4), followed by the canyon zones (mean size 136 km^2, n=20) and Gulf of Maine zones (mean size 59 km^2, n=7).

Table 61 – Size of each deep-sea coral zone.

Broad zones		
Zone name	***Area (km^2)***	***Area (mi^2)***
300 m broad zone	67,142	25,923
400 m broad zone	66,410	25,641
500 m broad zone	65,838	25,420
600 m broad zone	65,365	25,237
Canyons		
Zone name	***Area (km^2)***	***Area (mi^2)***
Alvin	210	81
Atlantis	218	84
Nantucket	176	68
Veatch	127	49
Hydrographer	211	82
Dogbody	150	58
Clipper	64	25
Sharpshooter	46	18
Welker	144	55
Heel Tapper	104	40
Oceanographer	236	91
Filebottom	56	22
Chebacco	83	32
Gilbert	167	65
Lydonia	179	69
Powell	138	53
Munson	130	50
Nygren	112	43
Unnamed Canyon	45	17
Heezen	122	47
Seamounts		
Zone name	***Area (km^2)***	***Area (mi^2)***
Bear	527	204
Mytilus	258	100
Physalia	169	65
Retriever	317	122
Gulf of Maine		
Zone name	***Area (km^2)***	***Area (mi^2)***
Mount Desert Rock	47	18
Outer Schoodic Ridge	79	31
Western Jordan Basin - 114 Fathom Bump	103	40
Western Jordan Basin - 96 Fathom Bump	23	9

Western Jordan Basin - 118 Fathom Bump	30	12
Central Jordan Basin	19	7
Lindenkohl Knoll	114	44