Analysis of Potential Economic Impacts of the Northeast Canyons and Seamounts Marine National Monument on the Deep-Sea Red Crab and American Lobster Fisheries

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July 2017

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II. Executive Summary

Background

The Northeast Canyons and Seamounts Marine National Monument was established on September 15, 2016 and encompasses 4,913 square miles of ocean off the coast of New England. The monument protects a unique portion of the U.S. Atlantic Ocean that is home to a broad diversity of marine life including fish, sharks, corals, whales, and seabirds. It does this by prohibiting industrial-scale activities like commercial fishing and oil and gas exploration and extraction. The monument is subject to review under Executive Order 13792 and Executive Order 13795, issued in April 2017 by President Trump.

Commercial fisheries that potentially operate in the area of the monument include three main gear types: (1) Highly Migratory Species/Longline (2) Bottom Trawl; and (3) Lobster and Crab Pot. However, available information indicates that the Lobster and Crab Pot gear type – specifically, the deep-sea red crab (Chaceon quinquidens, red crab) and American lobster (Homarus americanus, lobster) commercial fisheries – are most likely to experience potential revenue impacts.

The monument proclamation specified that lobster and red crab fisheries, which were known to operate in the monument, could continue fishing in the monument for seven years after its designation. Despite this accommodation, members of the fishing industry continued to voice concerns about the magnitude of potential economic impacts as a result of the monument.[1,2] This analysis was developed to provide a range of scenarios that estimate potential impacts for the red crab and lobster fisheries if the Northeast Canyons and Seamounts Marine National Monument is maintained as designated.

The red crab fishery consists of five permitted boats, three of which have active licenses[3] to operate from the Hague line to the Virginia/North Carolina border. While revenue from this fishery is variable, its average annual revenue over the last ten years was approximately $2,662,817 over the portion of the East Coast continental shelf on which it operates,[4] with effort and revenue concentrated south and west of the monument.

[1] McDermott, J. 2016.
[2] Crimaldi, L. 2016.
[3] MAFMC. 2015.
[4] NEFMC. 2016.

The American lobster fishery was valued at approximately $618M in 2015[5], with more than 11,000 lobster permits in the fishery. The monument has the potential to impact approximately five permits[6] – less than 0.05% of the fishery.

Methodology for Developing Economic Scenarios

The analyses presented in the following pages are intended to provide a range of scenarios that estimate potential economic impacts to the red crab and lobster fisheries and are intended to approximate potential lower and upper bounds of impacts. This paper uses approaches based on methodological advances developed by NOAA economists,[7] terming the potential for an impact as "exposure" and then using exposure as a starting point to evaluate the potential economic impacts to fisheries. To develop the scenarios presented below, we first identified each fishery's average revenues[8] (or exposure) from the monument. Then, we mapped these revenues spatially, across fishing areas. Then, we applied reallocation scenarios at percentages ranging from 10% to 100%, as explained below. As the final step, we applied three "spillover" scenarios[9] – the amount of potential increased biomass available to fishermen outside the monument – to each reallocation scenario, providing an additional range of potential changes in revenues as a result of the monument. The analyses presented in the following pages are rough, order of magnitude estimates, and are intended to provide a range of potential impacts.

Red Crab Fishery Scenarios

The scenarios presented in this document show potential revenue losses to the red crab fishery due to loss of catch from the monument ranging from approximately $59,000 to a maximum of $213,000 annually. Potential increases in red crab biomass as a result of protection in the monument may mitigate those losses by allowing increased catch outside the monument; scenarios using varied, conservative levels of increased catch due to spillover suggest potential revenue losses could be reduced to a range of approximately $34,000 to a maximum of $188,000 annually.

Additional factors could reduce potential economic losses in the red crab fishery. Since this report intentionally uses conservative scenarios (that is, it is more likely to overestimate

[5] NMFS. 2017.
[6] Whitmore et al. 2016.
[7] Kirkpatrick et al. 2017.
[8] Red Crab revenue figures were sourced from NEFMC 2016, and are averaged across 5 years, from 2010-2015, and adjusted to 2010 dollars, American lobster revenues were sourced from GARFO 2016, are averaged across 10 years, from 2005-2014 and adjusted to 2014 dollars.
[9] The term "spillover" refers to the movement of individuals increasing in number or size from inside to outside a marine reserve.

impacts rather than understate them in order to generate defensible estimates), the potential for reallocation of effort may in reality be higher. This could result in smaller economic losses or a positive economic outcome for the red crab fishery. One reason greater or full reallocation of effort may be possible is that market demand has not driven the red crab fishery to harvest its full catch limit of 1,775 metric tons from 2002 to 2016, leaving a surplus of available red crab biomass for potential capture. Also, considering that the red crabs harvested in the areas south and west of the monument tend to be larger,[10] and processing capacity in Virginia[11,12] has supported the growth of new markets, it is possible that demand will draw the fishery further south and away from the monument, and is already doing so. Finally, allowing red crab and lobster fisheries operating in the monument to continue fishing there for seven years (until 2023) provides substantial time to reallocate effort outside the monument, which could support higher reallocation levels than those used in scenarios here. If the red crab fishery fully reallocated 100% of its effort outside of the monument boundaries, the fishery would experience positive revenue impacts under each of the biomass levels considered in this report.

Lobster Fishery Scenarios

The scenarios presented in this document estimate potential revenue losses to the lobster fishery due to loss of catch ranging from approximately $0 to a maximum of $89,000 annually – representing about 0.015% of the entire lobster fishery. Potential increases in lobster biomass as a result of protection in the monument may mitigate those losses and even provide for benefits by allowing increased catch outside the monument. Scenarios using varied, conservative levels of increased catch due to spillover suggest potential revenue impacts ranging from a gain of approximately $10,000 to a loss of approximately $85,000 annually. As in the red crab fishery, the seven-year sunset granted to these five lobster permit holders would reasonably enable these fishermen to shift effort to other areas in that period. They may also have the option of shifting effort outside of the monument to Jonah crab, a related species, to further reduce impacts. These factors further support the possibility that the lobster fishery may experience no economic losses or potentially achieve positive revenue impacts as a result of the monument.

[10] NEFMC. 2016.
[11] Eaton, L. 2013.
[12] Krenn, J. 2013.

Conclusions

The economic scenarios presented in this paper are intended to approximate potential lower and upper bounds. The worst-case scenario explored for removing red crab fishing from the monument resulted in potential revenue losses of approximately 8% of the fishery; the best-case scenarios showed about a 1% impact. Approximately five federal American lobster permits (out of a total of approximately 11,000 federal permits issued) are affected by the monument. The maximum potential losses as a result of the monument for the lobster fishery in the scenarios presented in this paper represent approximately 0.015% of the $618M lobster fishery; best-case scenarios showed estimated gains of approximately $10,000 annually. Because scenarios were developed to be conservative, scenarios closer to the lower bound of the range, or the best-case scenarios, may be more likely for both fisheries.

While this report did not evaluate potential economic benefits of the monument beyond those on the red crab and lobster commercial fisheries, the economic, social, and biological benefits of marine protected areas are generally well documented[13,14,15] and known to support various industries like commercial and recreational fisheries and nature-based tourism. For example, because high species diversity and abundance has been documented in the monument[16] and recreational fishing continues to be allowed there, this industry is likely to benefit from opportunities to fish "big game" species like tuna, billfish, mahi-mahi, and wahoo as a result of the prohibition of commercial extractive activity. Further, some of the most compelling cases in the scientific literature for spillover benefits from marine protects areas involve invertebrates, specifically lobster.[17,18,19]

Fishery scientists, managers, and members of the fishing industry recognize that "ecosystem integrity is the foundation for sustained production of fishery resources."[20] An important component of maintaining ecosystem integrity is setting aside some areas to function with minimal human impacts. When these areas are set aside, fish populations and fisheries may see direct and indirect benefits.

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[13] Murawski et al. 2005.
[14] Neubert, M.G. and G.E. Herrera, 2007.
[15] Di Lorenzo, M., Claudet, J., & Guidetti, P. 2016.
[16] Kraus, S.D. et al. 2016.
[17] Goñi, et al., 2010.
[18] Diaz, et al. 2011.
[19] Follesa, et al. 2011
[20] Buhl-Mortesen et al. 2015.

Appendices

Three Appendices follow the Conclusion. Appendix A contains further explanation of the "exposure" approach and its applicability here, and specifies the sources and limitations of data used in this analysis. Appendix B is a brief treatment of the recent economic analysis completed by the New England Fishery Management Council. Appendix C contains a full explanation of the scenarios in this report, including expanded tables. Appendix D contains a complete list of references.

III. Background

On September 15, 2016, President Obama issued a Presidential Proclamation creating the Northeast Canyons and Seamounts Marine National Monument. The area encompasses 4,913 square miles of ocean off the coast of New England.

On April 26, 2017, President Trump issued Executive Order 13792 (EO 13792, "Review of Designations Under the Antiquities Act"), charging the Secretary of the Interior, in consultation and coordination with the Secretary of Commerce and other heads of Executive Departments as appropriate, with reviewing certain National Monument designations to determine if they are in accordance with the policy set forth in EO 13792 §1.[21] Two days later, on April 28, 2017, Executive Order 13795 (EO 13795, "Implementing an America-First Offshore Energy Strategy") was issued, which included a similar review of certain Marine Monument designations, with the intent of encouraging energy exploration and production, including on the Outer Continental Shelf (OCS).[22]

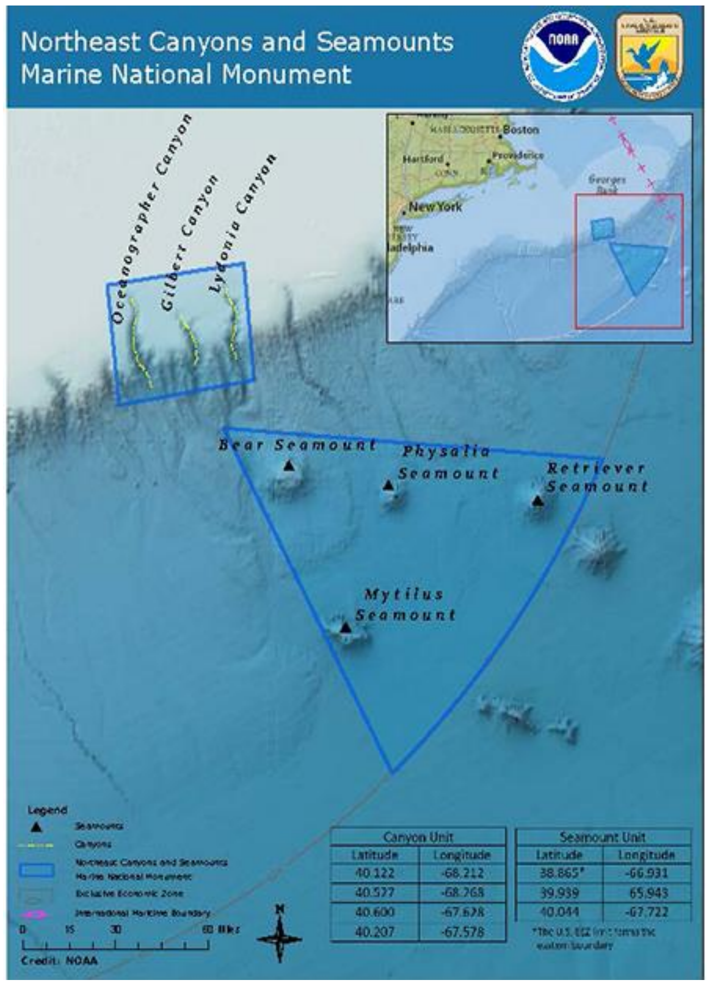

Figure 1. Northeast Canyons and Seamounts Marine National Monument.

The Northeast Canyons and Seamounts Marine National Monument (Figure 1) is subject to review under both EO 13792 and EO 13795. The information presented in this document is responsive to the review of National Monument designations required by both EO 13792 and EO 13795.

[21] Executive Order 13792. 82 FR 20429. 2017.
[22] Executive Order 13795. 82 FR 20815. 2017.

The monument proclamation specified that lobster and red crab fisheries, which were known to operate in the monument, could continue fishing in the monument for seven years after its designation.[23] Despite this accommodation, members of the fishing industry asserted after the monument was created that it would cause "devastating" economic impacts for the New England fishing industry.[24]

This analysis provides a range of economic scenarios that estimate potential impacts for the red crab and lobster fisheries if the Northeast Canyons and Seamounts Marine National Monument is maintained as designated. Traditionally, the type of analysis used to provide basic answers to policy questions is an "economic impact analysis," which takes a snapshot of all economic activity (in this case fishery activity) in a particular geographic area and summarizes it as the total "potential" impact. However, these analyses of fishing impacts often rely on a set of unrealistic assumptions – most importantly, that there is a full loss of fishery revenues from waters where fishing is no longer permitted and no reallocation of fishing effort into other areas occurs. Economic impact analyses can be considered as an extreme approach that presents the maximum upper-bound (or worst-case scenario) of potential direct economic impact. Also, many fisheries impact analyses rely heavily on Vessel Trip Report (VTR) data, which come with inherent challenges[25] described in more detail in Appendices A and B.

For these reasons, this paper uses approaches based on methodological advances developed by NOAA economists,[26] terming the potential for an impact as "exposure" and then using exposure as a starting point to evaluate the potential economic impacts to fisheries. Below, this paper identifies fisheries that would be exposed to changes as a result of the monument designation, maps revenue across spatially-explicit areas, and then assesses a set of scenarios based on different levels of reallocation and potential changes in fishery biomass resulting from the monument. The analyses presented in the following pages are rough, order-of-magnitude estimates, and are intended to provide a range of potential impacts.

In a recent letter to the Secretary of Interior commenting on EO 13792, the New England Fishery Management Council used an economic impact analysis approach to provide estimates of all commercial fishing revenues "associated" with the monument. As explained in Appendix B, these revenue estimates are likely higher than the likely potential impacts to revenues associated with fishing in the monument area primarily because of limitations in the particular

[23] Barack Obama. 2016.
[24] Crimaldi, L. 2016.
[25] NEFMC. 2017.
[26] Kirkpatrick et al. 2017.

VTR-based analytical method used by council staff, limitations that the NEFMC staff itself has recognized. If we take steps to correct for these model limitations, the council's estimates of associated revenues and those presented as the baseline "exposure" in this report are similar. Moreover, as explained above, estimates of revenues historically associated with fishing in the monument area are not an estimate of the monument's likely economic impact because of the potential for reallocation of effort, as well as the spillover benefits resulting from closing the area.

IV. Fisheries Exposure In and Around the Northeast Canyons and Seamounts Monument

The method used to examine fisheries exposure and impacts uses recent commercial fishing effort and gross revenue generated from within an area or group of areas to estimate the impact of closing the area(s) to fishing vessels, owners, and communities. In this paper, "exposure" is defined as the potential for impact from the establishment of the monument. Exposure is measured in revenues only, and represents the total fishing activity that occurs in and near the monument. These exposure figures should not be interpreted as a measure of economic impact or loss, but rather as a baseline from which to examine a series of re-allocation and catch scenarios for each fishery.

The authors identified thresholds for further analysis based on a similar study that determined the impact of wind energy development on fisheries in the U.S. Atlantic.[27] For this analysis an "exposed" fishery is any fishery where one of two thresholds is met:

- On average, more than $1 million in annual revenue was sourced from within the monument.
- More than 2 percent of average annual revenue was sourced from within the monument, and fishery's total exposed revenue is greater than $1,000 per year.

The following section describes the major commercial fishery gear types used in and around the monument and identifies the relative level of exposure from the monument on fishing revenue and behavior on each major group.

Longline/Highly Migratory Species (HMS)

The U.S. Atlantic pelagic longline fishery primarily targets swordfish, yellowfin tuna, and bigeye tuna in the U.S. Exclusive Economic Zone (generally, within 200 miles from shore) and high seas (generally, beyond 200 miles). There are 135 active pelagic longline vessels operating in the Atlantic, only a portion of which regularly fish in the waters off southern New England.[28] During the season, pelagic longline vessels primarily offload in the major ports of Fairhaven, MA;

[27] Kirkpatrick et al. 2017.
[28] NMFS. 2014.

Montauk, NY; Barnegat Light, NJ; Ocean City, MD; and Wanchese, NC.[29] Exposure for this fishery is lower than our established thresholds, with the monument area appearing to have been responsible for a very small part of the fishing activity and revenues for the longline/highly migratory species fishery. The monument area is 0.3% of the total areal extent of this fishery and an even smaller percentage of the fishery's total effort (i.e., the monument area is less than 2% of the fishery's Northeast Coastal reporting region, which was responsible for approximately 10% of all "hooks fished" in the fishery from 2008-2012).[30] For these reasons, we did not estimate potential changes in revenue for this fishery.

Bottom Trawl

Bottom trawl gear is the dominant gear used in the region, but it generally is not used in the monument because of the area's depth and/or ruggedness. Bottom trawling has been prohibited in Oceanographer and Lydonia Canyons, which are two of the canyons included in the monument, since 2009. The Mid-Atlantic Fishery Management Council stated in an economic analysis that the economic impacts of the bottom trawling prohibition would be "minimal."[31] The only bottom trawling in and around the rest of the monument area occurs in more gently sloping areas above the canyon heads, rather than on the steepening slope into the canyons or in the canyons themselves.[32] Though it is important ecologically, this shelf-break environment makes up a small portion, approximately 10%, of the overall monument area. No bottom trawling currently occurs on the seamounts or in the deep areas around the seamounts.

The squid, mackerel, and butterfish fishery is located primarily to the west and south (and to a lesser extent, east) of the monument area; the monument area is not an important fishing ground for this fishery as a whole. From 2012-2014, catch of each of these species from statistical area 525, of which the monument area is a small part (Figure 2), ranged from 0% to 7% of annual catch for the Northeast region.[33, 34] This is similarly the case for whiting.[35]

[29] NMFS. 1998.
[30] NMFS. 2014.
[31] MAFMC and NMFS. 2008.
[32] MAFMC and NMFS. 2008b.
[33] MAFMC and NMFS. 2015.
[34] Hendrickson, L. 2016.
[35] NEFMC. 2015.

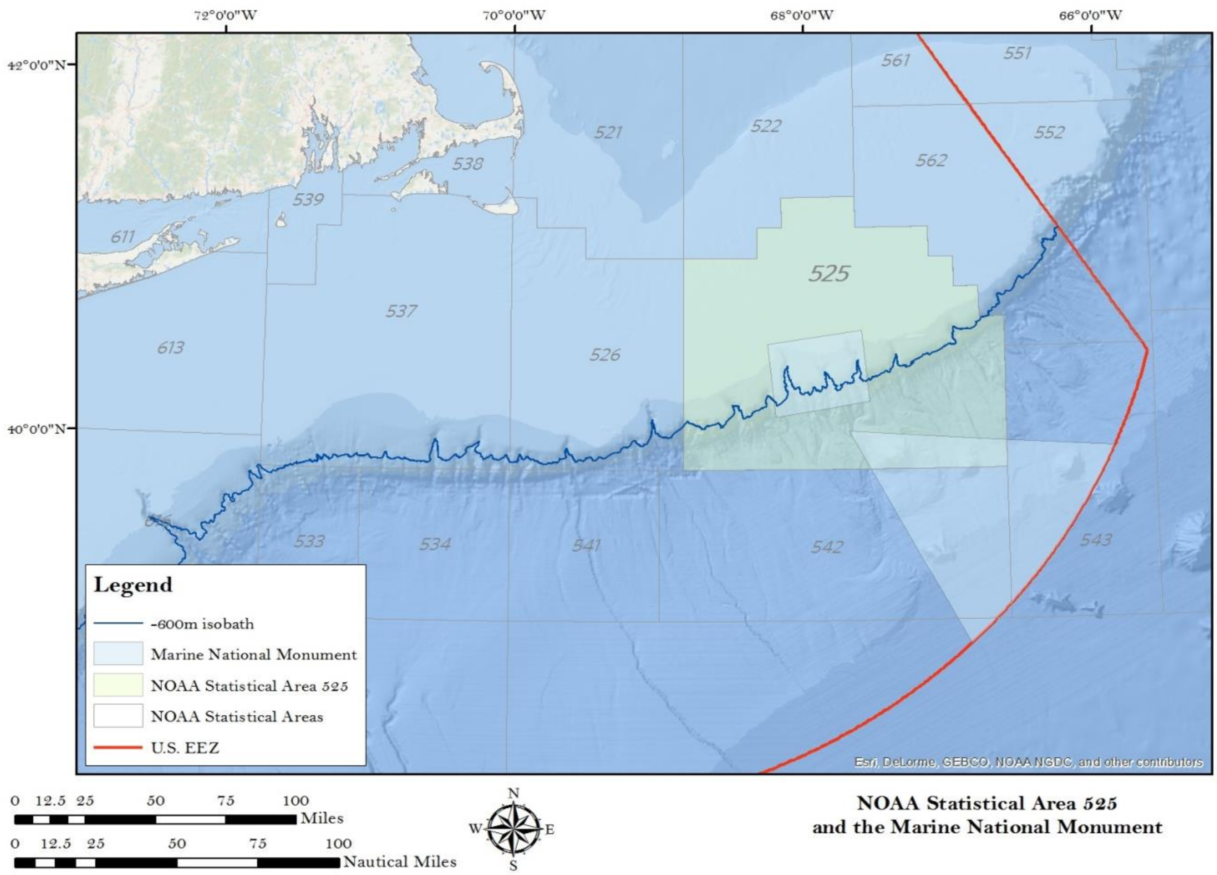

Figure 2. Showing NOAA Fisheries Statistical Areas, with emphasis on area 525.

For instance, Figure 3 shows the extent of fishing in 2014 for butterfish and squid, the fishery's most commercially valuable species.[36] The inset map shows most fishing in the region occurring in shallower areas and areas to the west of the monument (green, yellow, orange, and red areas). The map focused on the monument area indicates one small spot of fishing activity (visible as a green dot) to the west of Oceanographer Canyon in the monument. Outside of the monument, more fishing activity is visible in an area northeast of the monument, just inside of the shelf edge. This area was included in the original monument proposal presented by the

[36] The map is derived from satellite-based Vessel Monitoring System (VMS) data, which is required in this fishery and is the most accurate available on fishing location. Northeast Regional Ocean Council. Final Report to the Northeast Regional Ocean Council: Commercial Fisheries Spatial Characterization, September 2013 at 39, available at http://neoceanplanning.org/wp-content/uploads/2013/12/Commercial-Fisheries-Spatial-Characterization-Report.pdf. This VMS data is only publicly available for 2014. However, the fishing pattern shown on the map is generally consistent with maps of 2011-2014 fishing activity prepared from less-reliable Vessel Trip Reports that can be viewed at http://portal.midatlanticocean.org. The map label indicates Commercial squid fishing activity only, however the metadata behind the map indicates that it also includes vessels fishing for butterfish.

Connecticut delegation in early August 2016,[37] but excluded from the final monument boundary. For these reasons, exposure is lower than our established thresholds, so we did not evaluate the potential changes in fishery revenues from the monument on the Bottom Trawl fishery.

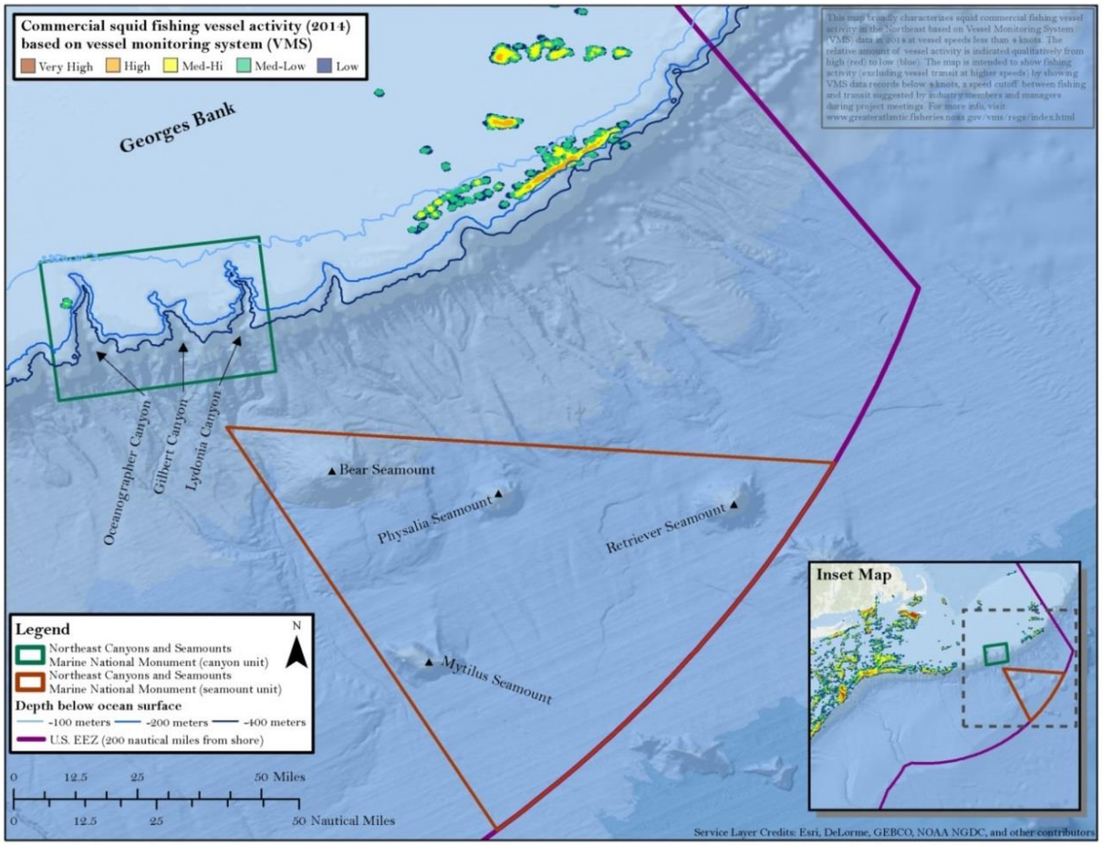

Figure 3. Commercial Squid Fishing Vessel Activity (2014) near the Northeast Canyons and Seamounts Marine National Monument.

Red Crab and Lobster Pot

Red crabs and lobsters are known to be fished in and around the canyons[38,39] though not on the seamounts.[40] These fisheries received a specific accommodation to continue fishing in the monument for seven years after its designation.[41] Some discussion of the Jonah crab fishery,

[37] U.S. Senator Richard Blumenthal. 2016.
[38] Whitmore et al. 2016.
[39] NEFMC. 2017.
[40] NEFMC. 2017.
[41] White House, Office of the Press Secretary. 2016.

which is associated with the lobster fishery, is presented below.

The red crab fishery consists of five permitted boats, three of which have active licenses[42] to operate from the Hague line to the Virginia/North Carolina border. While revenue from this fishery is variable, its average annual revenue over the last ten years was approximately $2,662,817, with effort and revenue concentrated south and west of the monument. This level of exposure meets the thresholds determined for further analysis in this study.

While the size and the fishing effort of the red crab fishery has fluctuated over time, it has remained small relative to other fisheries in the region, like groundfish, sea scallops, and lobster. The catch limit of 1,775 metric tons (mt) has been unchanged since 2002, with landings fluctuating between approximately 1,000mt to 1,700mt during this time. The red crab fishery is a small, demand-driven fishery: when landings are low, it is often because the demand for red crabs has decreased, and the fleet has shifted to targeting more profitable species.[43] Catch is attributed to three regions: Georges Bank/Southern New England (GB/SNE), New Jersey, and Delmarva. The GB/SNE area includes the monument area.[44]

The lobster fishery is one of the top fisheries on the U.S. Atlantic coast, with over $618M in total revenue in 2015. An average of 11,396 vessels, from Maine to New Jersey, were issued federal commercial lobster permits each year between 2009 and 2013, which are for use in federal waters (from three nautical miles offshore to the limit of the U.S. Exclusive Economic Zone, 200 miles offshore).

States also issue permits for lobster fishing within state waters (out to three nautical miles). Maine issues more permits (45%) than any other state. Maine and Massachusetts are also the most prominent among the 15 home port states for federal lobster permit vessels, with 48% listing Maine as their home ports and 28% listing Massachusetts in 2013.[45]

The monument is located within Lobster Conservation Management Area 3 (LCMA 3), a nearly 130,000 square mile area that ranges from approximately 30 miles offshore to the limit of the U.S. Exclusive Economic Zone. Although LCMA 3 encompasses nearly all federal waters in New England and the Mid-Atlantic (see Figure 4), most federal permits are used in federal waters closer to shore. Despite the large size of this management area, there are only 97 American lobster permit holders operate in LCMA 3 – about 3% of the federal permits issued–and about 0.8% of all American lobster permit holders.

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[42] MAFMC. 2015.
[43] NEFMC. 2016.
[44] NEFMC. 2017. *See*: EA pages 156-157.
[45] NEFSC. 2014.

In 2016, the Atlantic States Marine Fisheries Commission (ASMFC) conducted a survey of offshore American lobster and Jonah crab trap fishermen to help improve understanding of the fishing behavior in and around the deep-water canyons in LCMA 3, including the canyons in the monument. The ASMFC survey identified approximately five permit holders that regularly fished in the monument,[46] and NOAA[47] estimates that American lobster revenues from the monument area average about $100,000 annually. This level of exposure makes it appropriate for further analysis in this study.

The ASMFC instituted a Jonah crab fishery management plan in 2015. Although traditionally Jonah crab was bycatch in the lobster fishery, growing market demand for Jonah crab has increased fishing pressure on this species in recent years.[48] Commercial landings were valued at almost $13M in 2013. The Jonah crab fishery has seen recent increases in effort, with a spike in revenue occurring in 2014. Revenues in the Jonah crab fishery are likely to remain above historic levels for the foreseeable future. Jonah crab is a companion fishery to the American lobster fishery, but the scarcity and lack of spatial resolution in the Jonah crab data prevented us from running scenarios on this fishery.

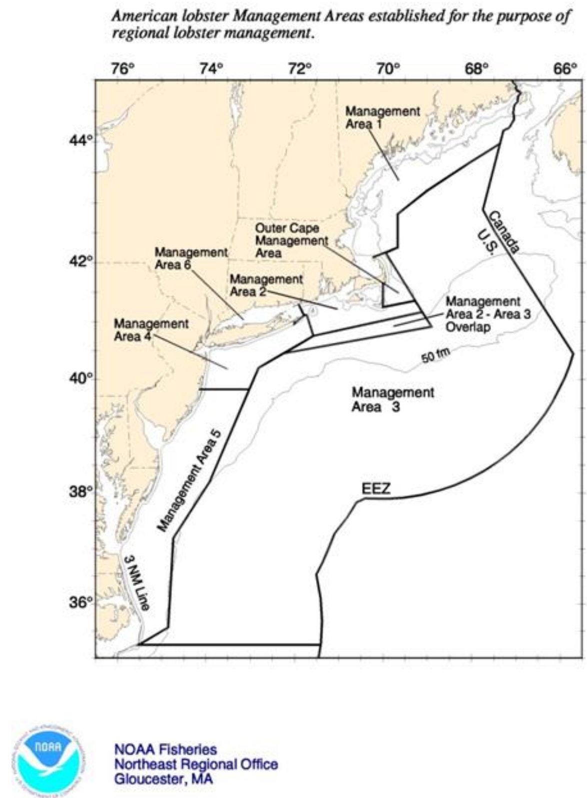

Figure 4. Lobster Conservation Management Areas.

[46] Whitmore et al. 2016.
[47] GARFO. 2016.
[48] NEFMC. 2017.

V. Methodology for Fisheries Impacts Scenarios

As described in the previous section, this economic analysis focuses on the deep-sea red crab (*Chaceon quinquidens)* (red crab) and American lobster (*Homarus americanus)* (lobster) fisheries, since these fisheries meet the thresholds for exposure, and face the highest potential impacts from the designation of the monument. Assessing the level of exposure depends on the areas slated for closure and the crab and lobster fishing activity there, and assessing impacts depends on how those fishermen redirect fishing effort elsewhere. The impacts analysis explores several possible options fishermen might choose, based on current distributions of effort.

To assess the scenarios presented below, we first identified each fishery's average revenues[49] (or exposure) from the monument and apportioned these spatially across fishing areas. For red crab, this was the 600-meter (m) isobath, or depth contour along the seafloor, because these vessels focus effort along the center of a narrow range of depth targeting 350 fathoms (640 meters[50]). For lobster, we used Lobster Conservation Management Area (LCMA) 3. Then, we applied reallocation scenarios at percentages ranging from 10% to 75%, as explained below. Finally, we applied three biomass increase spillover scenarios (at 3.5%, 7%, and 10.5%) to each re-allocation scenario to provide a range of potential changes in revenues as a result of the monument.

Because of the high levels of uncertainty attached to lobster revenue data–current lobster trip reports include data only at a very broad statistical reporting area[51] –we included one set of scenarios using the revenue figures from NOAA *and a second which doubles the annual revenue figures*. This helps to ensure the range of scenarios is responsive to this uncertainty and accounts for what we know about these fisheries.

There are caveats associated with revenue estimates, which are explained in more detail in Appendix A. It is worth noting here however, is that the spatial revenue allocations are derived mainly from Vessel Trip Reports (VTRs). While VTRs are recognized as the best available data for

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[49] Red Crab revenue figures were sourced from NEFMC 2016, and are averaged across 5 years, from 2010-2015, and adjusted to 2010 dollars, American lobster revenues were sourced from GARFO 2016, are averaged across 10 years, from 2005-2014 and adjusted to 2014 dollars.
[50] MAFMC and NMFS. 2016.
[51] Whitmore et al. 2016.

revenues associated with fishing effort, the “spatial resolution of VTR data does not adequately support management at fine spatial scales, due to its imprecise nature.”[52] Redistribution of effort into other locations may mitigate negative effects; however, we recognize that alternative fishing choices are difficult to predict.

Fine-scale data are also sparsely available, particularly for the red crab fishery, where detailed landings data and exposure are not publicly disclosed because Federal regulations that require suppression of data for subgroups of three or fewer individuals for confidentiality purposes. Relocation of fishing effort may be initially challenging if other locations are already crowded with gear (this may be the case for the lobster pot fishery, which, as a fixed gear type, can be territorial in nature), or if the target species has a restricted range (such as for the deep-sea red crab fishery, where the distribution of the target species is restricted to specific ocean depths).[53]

Biomass increase “spillover” scenarios developed for each reallocation scenario to provide an additional range of potential changes in revenues as a result of the monument. Spillover occurs when individuals that are increasing in number or size within a protected area move outside the boundary. It can benefit the surrounding ecology of a system, as well as commercial and recreational fisheries by increasing the yield or efficiency of fishing along the boundaries.[54] Protected areas can serve as spawning and nursery areas, including for commercially and recreationally important species, allowing more to survive during these species’ critical and vulnerable life stages. And a protected area that contains a species dependent on ocean currents to disperse its larvae widely can extend benefits to areas far beyond the monument boundaries. While spillover effects have been well documented after the establishment of marine protected areas,[55,56,57,58] an understanding of the magnitude of effects on specific fisheries, both across time and space, is still being researched.

We used three levels of spillover (3.5%, 7%, and 10.5%) based on an examination of the literature on the beneficial impact of areas closed to various forms of fishing. NOAA’s New England Fisheries Science Center researchers reported studies in which increased biomass adjacent to fishing restricted areas ranged from 1.5% to 37%, with a rough average of about

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[52] NEFMC. 2017.
[53] Ibid.
[54] Murawski et al. 2005
[55] Murawski et al. 2000
[56] Murawski et al. 2005.
[57] Hilborn, R. et al. 2004.
[58] Díaz, D., et al. 2011.

7%.[59] We added and subtracted 50% from that rough average to arrive at our three biomass scenario values. A spillover benefit of 7% is also consistent with a number of studies pertaining to spillover, including of lobster, from marine protected areas.[60,61] It is important to note that these calculations do not include improvements in catch efficiency that have been reported for fishing around marine protection areas.[62,63] Though it was not included in the scenarios in this report, it is worth noting that a 100% reallocation scenario – a full reallocation of effort outside the monument – would show positive revenue impacts for the red crab and lobster fishery under each of the three biomass spillover scenarios.

Detailed results are presented below, with additional methodology details in the Appendices. These scenarios present rough, order-of-magnitude potential impacts, and more research by NOAA staff or others could develop a more comprehensive or finer-scale picture.

[59] Kirkpatrick et al. 2017
[60] Goñi, et al. 2010.
[61] Diaz, et al. 2011.
[62] Follesa, et al. 2011.
[63] Goñi, et al. 2010.

VI. Red Crab Scenarios

Scenarios for the red crab fishery include four levels of reallocation effort (10%, 25%, 50%, and 75%) across three distinct geographic areas, denoted by lines of different colors in Figure 5:

- Area 1: East of the eastern monument border to the Hague Line
- Area 2: The monument
- Area 3: West of the monument to the edge of the red crab management area

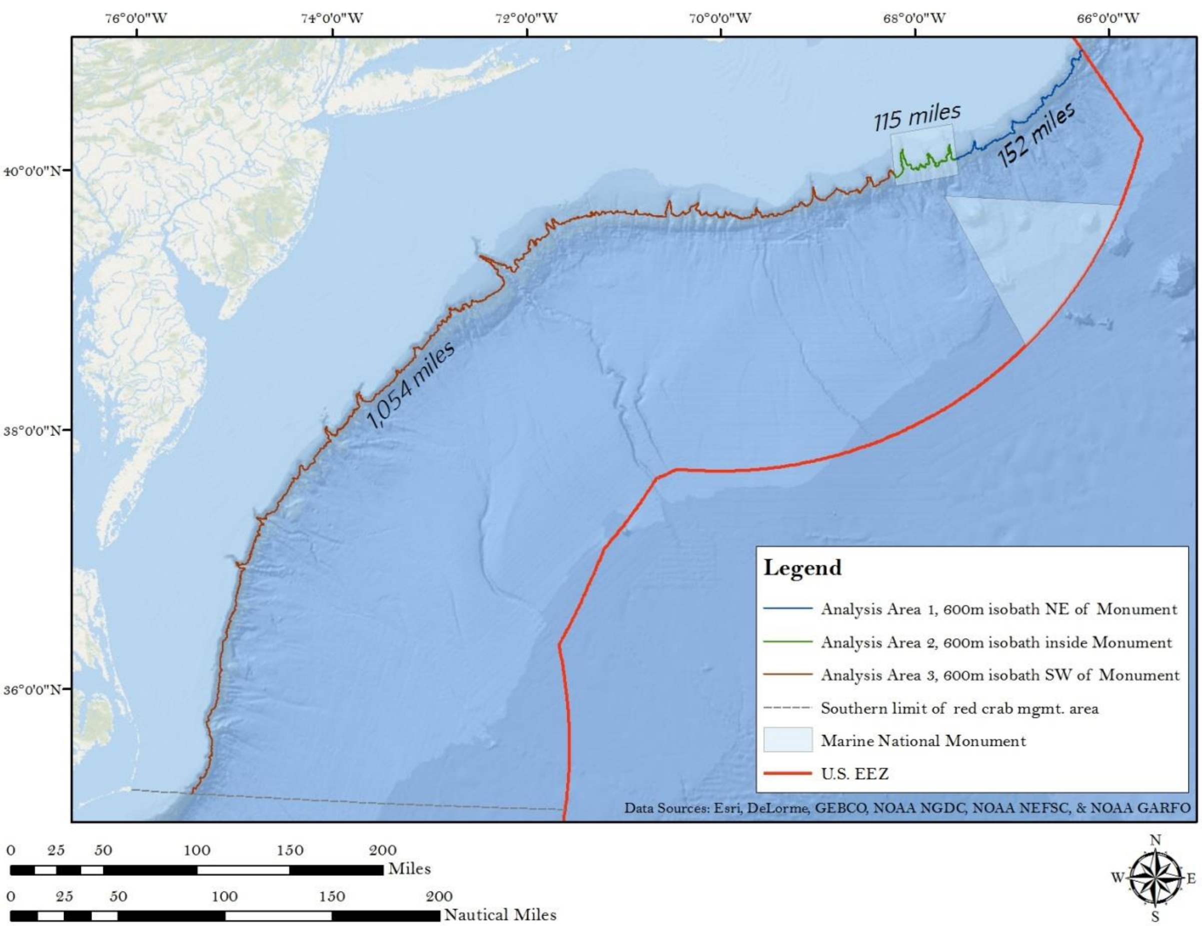

Figure 5. Areas 1, 2, and 3 Used in Red Crab Scenarios.

Because the red crab fishery is generally more spatially limited than other fisheries in the region, operating only along the 640m isobath, we did not include a scenario for 100% reallocation of effort. This assumption is conservative, and assumes that the fishery is operating the full length of the 640m isobaths within the red crab management areas.

Table 1 shows potential annual revenue losses when Area 2, the monument area, is removed from the available fishing area. Rows show the four levels of reallocation: 10%, 25%, 50%, and 75%. The blue bars present a visual interpretation of potential annual revenue losses. These levels of reallocation and biomass increases are ranges presented for comparison, and the scenarios could easily be rerun with different figures.

Table 1. Potential Annual Revenue Impacts for the Red Crab Fishery for Area 2 (the monument)

Reallocation Scenario	**Potential Annual Revenue Impact**	**Potential revenue impact scenarios with increased biomass/spillover**		
		3.5%	7%	10.5%
10% reallocation	$213,220	$204,928	$196,636	$188,344
25% reallocation	$177,683	$169,392	$161,100	$152,808
50% reallocation	$118,456	$110,164	$101,872	$93,580
75% reallocation	$59,228	$50,936	$42,644	$34,352

The column labeled "Potential Annual Revenue Impact" shows that the removal of Area 2, the monument area, from fishing grounds would result in potential losses ranging from approximately $59,000 to $213,000 annually, given different levels of reallocation and no biomass increases. The potential amount of revenue lost is higher when assuming the lowest level of reallocation (10%) compared to higher reallocation percentages given the reduced amount of fishing assumed. Logically, when the percentage of reallocation of fishing effort is increased, the amount of potential impact is reduced and revenue losses are not as pronounced. As the blue bars show, if 75% of red crab fishing effort is reallocated to areas outside the monument, the potential revenue loss of approximately $59,000 is less than a third of the approximately $213,000 potential revenue loss at the 10% reallocation level (see Table 1).

Reallocation scenarios with increased biomass/spillover show similar characteristics. Potential losses are higher with the lowest biomass increase/spillover effect (3.5%), ranging from approximately $51,000 to $205,000 given different reallocation levels for Area 2. When the highest biomass increase/spillover effect (10.5%) is considered, potential losses are lower, ranging from approximately $34,000 to $188,000.

Because the industry has asserted that it may be inefficient for red crab fishers to port their gear from Area 1,[64] across the Monument (Area 2) and then begin fishing again in Area 3, we have also provided scenarios that remove both the Monument and Area 1 from fishing.

Table 2 shows potential impacts to revenue (losses) when both Areas 1 and 2 are removed from the available fishing area, given four different levels of reallocation (10, 25, 50 and 75%), and three levels of spillover (3.5%, 7%, and 10.5% biomass increases within the monument that affect areas outside the monument). The blue bars present a visual interpretation of potential annual revenue losses. As above, these levels of reallocation and biomass increases are ranges presented for comparison, and the scenarios could easily be re-run with different figures. We note also that fishing levels along the bathymetric line are not even -- lower fishing intensity is observed in Area 1 and the highest intensity is observed in Area 3. This influenced the assumptions made regarding how fishing grounds could be reallocated post closure; in our scenarios, all effort was reallocated to Area 3. Given that crab biomass increases in Area 1, which we treat as a potential de facto closure, are not likely to spill over to Area 3, spillover effects are only estimated for Area 2 (the monument) and added to revenue estimates in Area 3 (west of the monument).

Table 2. Potential Annual Revenue Impacts for the Red Crab Fishery for Areas 1 and 2 (Hague Line to Western Edge of the Monument)

Reallocation Scenario	**Potential Annual Revenue Impact**	**Potential revenue impact scenarios with increased biomass/spillover**		
		3.5%	7%	10.5%
10% reallocation	$372,405	$364,113	$355,821	$347,529
25% reallocation	$310,337	$302,046	$293,754	$285,462
50% reallocation	$206,892	$198,600	$190,308	$182,016
75% reallocation	$103,446	$91,154	$86,862	$78,570

The scenarios estimate that the removal of Area 1 and 2 from fishing would result in potential losses ranging from approximately $103,000 to $372,000 annually, given different levels of reallocation and no biomass increases. Logically, when the percentage of reallocation of fishing effort is increased, the amount of potential impact is reduced and revenue losses are not as pronounced.

[64] MAFMC. 2015.

Reallocation scenarios with biomass impacts show similar characteristics. Potential losses are higher when assuming the lowest biomass increase/spillover effect (3.5%), ranging from approximately $91,000 to $364,000. When the highest biomass increase/spillover effect (10.5%) is considered, potential losses are lower, ranging from approximately $79,000 to $348,000.

It is important to note that the closure of the Monument for the red crab and American lobster fisheries will occur over a seven-year period, as the monument designation accommodated the red crab and the American lobster pot and trap fisheries by allowing them to continue fishing there with existing permits for this time period. Gradual or phased reallocation schemes could be developed during this period for affected fishing vessels operating in the monument area to allow these permit holders to adapt to new fishing grounds and behavior. Regardless, it is important to include a discussion of the positive impacts from increased spillover benefits in any consultations with potentially affected fishermen.

VII. Lobster Scenarios

Table 3 shows potential impacts to revenue (losses) for the American lobster fishery at five levels of reallocation effort (10%, 25%, 50%, and 75%, and 100%), and with two average annual revenue scenarios (the ten-year average from NOAA, and the ten-year average doubled). The blue bars present a visual interpretation of potential annual impacts to revenue. We included a 100% reallocation scenario due the small number of permits (approximately 5) potentially affected by the monument, and the vast area covered by LCMA 3. Though the authors recognize that the lobster fishery is inherently more territorial than other fisheries because the gear is largely stationary, it seems reasonable to assume that over the seven-year period for phasing out the lobster fishery in the monument, at least five permits will leave the fishery overall, allowing these five a full transition of effort to other areas. As discussed in the methods section, these levels of reallocation (10-100%) are ranges presented for comparison, and the scenarios could easily be re-run with different figures.

Table 3. Potential Annual Revenue Impacts for American Lobster Fishery with No Spillover Effects

Reallocation Scenario (assumes 0% biomass increase)	Potential Annual Revenue Impact
10 yr avg annual rev with 10% reallocation	$89,348
10 yr avg annual rev with 25% reallocation	$74,456
10 yr avg annual rev with 50% reallocation	$49,638
10 yr avg annual rev with 75% reallocation	$24,819
10 yr avg annual rev with 100% reallocation	$0
10 yr avg annual rev (doubled) with 10% reallocation	$178,695
10 yr avg annual rev (doubled) with 25% reallocation	$148,913
10 yr avg annual rev (doubled) with 50% reallocation	$99,275
10 yr avg annual rev (doubled) with 75% reallocation	$49,638
10 yr avg annual rev (doubled) with 100% reallocation	$0

Table 4 shows the scenarios from Table 3, with the additional effects of three levels of spillover: 3.5%, 7%, and 10.5%. Potential revenue losses are in black text; potential revenue gains are in red text. As above, the blue bars present a visual interpretation of potential annual revenue losses to revenue; red bars provide a visual interpretation of potential revenue gains. As described previously for the red crab scenarios, we chose these three spillover levels based on an examination of the literature on the beneficial impact of areas closed to various forms of fishing. Northeast Fisheries Science Center researchers reported studies in which increased biomass adjacent to fishing restricted areas ranged from 1.5% to 37% increase in biomass, with a rough average of about 7%.[65] We added and subtracted 50% from that rough average to arrive at our three biomass scenario values. We believe that the ranges of percentages are based on reasonable assumptions.

Table 3 and 4 show that potential impact to revenues changes depending on the percentage of the fishery reallocated, as well as on the given spillover due to increases in biomass from the monument. Potential losses range from $0 to approximately $179,000 annually, before potential spillover is taken into account. Accordingly, potential revenue losses are lower at the 75% reallocation level and are higher when lower levels of reallocation are assumed. Logically, when the percentage of reallocation of fishing effort is increased, the amount of potential impact is reduced, and revenue losses are lower.

Table 4. Potential Annual Revenue Impacts for American Lobster Fishery with Spillover Effects

Reallocation Scenario	Catch Increase scenarios due to increased biomass/spillover		
	3.50%	7%	10.50%
10 yr avg annual rev with 10% reallocation	$85,873	$82,398	$78,924
10 yr avg annual rev with 25% reallocation	$70,982	$67,507	$64,032
10 yr avg annual rev with 50% reallocation	$46,163	$42,688	$39,214
10 yr avg annual rev with 75% reallocation	$21,344	$17,870	$14,395
10 yr avg annual rev with 100% reallocation	($3,475)	($6,949)	($10,424)
10 yr avg annual rev (doubled) with 10% reallocatio	$171,746	$164,797	$157,847
10 yr avg annual rev (doubled) with 25% reallocatio	$141,963	$135,014	$128,065
10 yr avg annual rev (doubled) with 50% reallocatio	$92,326	$85,377	$78,427
10 yr avg annual rev (doubled) with 75% reallocatio	$42,688	$35,739	$28,790
10 yr avg annual rev (doubled) with 100% reallocati	($6,949)	($13,899)	($20,848)

When potential biomass increases are included, as in Table 4, the highest reallocation scenarios result in potential gains in revenue. For example, using the ten-year average annual revenue, the 25% reallocation level with 7% spillover, approximately $68,000 is estimated to be lost. At the same level of spillover and with 100% reallocation, a potential gain of approximately $7,000 results. The potential increases in revenue as a result of spillover grow larger as the value of the

65 Kirkpatrick et al. 2017.

fishery increases. For instance, at a 3.5% level of spillover, the difference between the 100% reallocation scenario and the 75% reallocation scenario for the ten-year average revenue is a potential gain of approximately $25,000. Using the same reallocation scenarios on the *doubled* ten-year average annual revenue results in double the gain: approximately $50,000.

It is important to remember that the monument will remain open to the red crab and American lobster fisheries with existing permits in the area for seven years. Gradual or phased reallocation schemes could be developed during this period for affected fishing vessels operating in the monument area to assist these permit holders in adapting to new fishing grounds, behavior, and/or targeted species. Regardless, the potential for positive impacts from increased spillover benefits should be acknowledged during consultations with potentially affected fishermen.

VIII. Conclusions

This analysis provides a wide range of possible scenarios for the deep-sea red crab and American lobster fisheries if the Northeast Canyons and Seamounts Marine National Monument is maintained as designated.

The red crab fishery consists of five boats, with three active licenses.[66] The fishery's average value over the past five years was approximately $2,662,817 annually. The reallocation scenarios presented in this paper are intended to approximate potential lower and upper bounds. The worst-case scenario explored for removing red crab fishing from the monument resulted in potential revenue losses of approximately 8% of the fishery; the best-case scenarios showed about a 1% impact.

The potential for reallocation of effort in the red crab fishery is likely to be higher than our best-case scenarios show, as scenarios were developed to be conservative. In addition, the decisions made by fishermen on how and where to reallocate effort are likely to be subject to finer nuances than are presented in the scenarios examined in this paper. Although we chose not to model a 100% reallocation of effort, given that the fishery has not yet harvested to its catch limit of 1,775 mt, there is some surplus of red crab biomass which may support a full reallocation of existing effort to outside the monument boundaries. If spillover effects from the monument area are also considered, the red crab fishery could see a positive economic outcome.

The monument designation specified that existing red crab fishermen could continue fishing in the monument for seven years. Gradual or phased reallocation schemes could be developed during this period to assist these permit holders in adapting to different fishing grounds and behavior. For instance, if different fishing methods are necessary to cost-effectively fish in Area 1 once Area 2 (the monument) is closed, the seven-year accommodation period could provide an opportunity for the red crab fishery to develop and test new fishing methods and not leave this portion of the catch limit unfished.

It is also possible that it will be more advantageous to redirect effort to the areas south and west of the monument, where red crabs tend to be larger and overall catch and catch per unit effort higher.[67] Red crabs may also be more abundant here; one researcher found crabs almost

[66] MAFMC. 2015.
[67] NEFMC. 2016.

twice as dense in the south compared to the north.[68] Given those factors and growing demand from the new markets made possible by processing capacity in Virginia,[69] it is possible that market forces may pull the fishery further south, and away from the monument, and are already doing so. Given these factors, of the range of scenarios, scenarios closer to 1% or less impact on the red crab fishery may be more likely.

Approximately five federal American lobster permits (out of a total of approximately 11,000 federal permits issued) are affected by the monument. The maximum potential losses as a result of the monument for the lobster fishery in the scenarios presented in this paper (approximately $89,000-$178,000–which assume no biomass spillover and minimal reallocation of effort) represent 0.015% to 0.03% of the lobster fishery, which had a value of approximately $618M in 2015. In addition, reallocation of effort for the lobster boats fishing in the monument could potentially result in increased revenue, as a result of increased biomass and spillover. Our scenarios, which are conservative, show gains of up approximately $21,000 (doubling the NOAA ten-year average annual revenue[70] and with full reallocation of fishing effort and potential biomass gains). Further, some of the most compelling cases in the scientific literature for spillover benefits from marine protects areas involve invertebrates, specifically lobster.[71,72,73]

While reallocation in a territorial fishery like lobster may be more challenging, the seven-year sunset granted to these five lobster permit holders, and the option for lobstermen to fish for Jonah crab, make it likely that these permit owners could reasonably shift to other areas, where they may be able to enjoy the benefits of spillover from increased biomass. Existing federal and state programs could assist in this transition.[74]

Because exposure for the Highly Migratory Species/Longline and Bottom Trawl fisheries are much lower than that of the red crab and lobster fisheries, we did not develop scenarios for them. Moreover, given that the Highly Migratory Species fishery is pelagic and covers a very large area, there are ample opportunities for this fishery to reallocate its effort around the monument area. Bottom trawl fisheries cover a large area in New England and historically their

[68] Syuhada, I. 2014.
[69] Eaton, L. 2013.
[70] Because of the high levels of uncertainty attached to lobster revenue data–current lobster trip reports include data only at a very broad statistical reporting area –we included one set of scenarios using the revenue figures from NOAA Greater Atlantic Regional Fisheries Office and a second which doubles the annual revenue figures. This helps to ensure the range of scenarios is responsive to this uncertainty and accounts for what we know about these fisheries.
[71] Goñi, et al., 2010.
[72] Diaz, et al. 2011.
[73] Follesa, et al. 2011
[74] White House, Office of the Press Secretary. 2016.

fishing effort inside of the monument was minimal so they are also likely able to reallocate their effort outside of the monument. These fisheries may also see potential benefits due to spillover, though to what extent is beyond this report's scope.

Fishery scientists, managers, and members of the fishing industry recognize that "ecosystem integrity is the foundation for sustained production of fishery resources."[75] An important component of maintaining ecosystem integrity is setting aside some areas to function with minimal human impacts. When these areas are set aside, fish populations and fisheries may see direct and indirect benefits. While this report did not evaluate potential benefits of the monument beyond those on red crab and lobster commercial fisheries, evidence on the effects of marine protected areas points to benefits for associated commercial and recreational fisheries as well as other industries such as nature-based tourism, like whale-watching.

In New England, these industries are valuable: recreational saltwater fishing added more than $1 billion to the economy and supported approximately 17,000 jobs in 2015.[76] Almost 1 million people take whale-watching trips in New England annually, contributing to a multi-billion dollar global industry.[77] More than 100 head boat and charter boat captains from the surrounding region, in commenting on EO 13792, noted the "world-class offshore fishing" experienced in the monument, and described how restricting commercial fishing (and other commercial extractive uses like energy development) "will protect and preserve the offshore big-game recreational fishing experience and the jobs tied to our very important industry."[78]

High species diversity and richness have also been documented in the monument.[79] This biodiversity holds the potential for biomedical, pharmaceutical, and scientific discoveries and advancements, with corresponding market and non-market values.

This analysis has been necessarily constrained by the availability of public data on these exposed fisheries. In addition, fisheries scientists now recognize the need for multi-criteria approaches and for considering the economic and ecological trade-offs of multiple scenarios in assessing the potential responses to alternate marine management strategies,[80,81] but it is outside the scope of this paper to develop these kinds of dynamic models for each of the

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[75] Brown, C. J. et al. 2015.
[75] Thébaud, O. et al. 2014.
[75] Buhl-Mortesen et al. 2015.
[76] NMFS. 2017.
[77] Cisneros-Montemayor A. et al. 2010.
[78] Department of the Interior. 2017.
[79] Kraus, S.D. et al. 2016.
[80] Brown, C. J. et al. 2015.
[81] Thébaud, O. et al. 2014.

fisheries examined. Despite these limitations, we believe this document provides useful analysis for understanding the scale of potential economic impacts of the monument on the most affected fisheries, as well as potential scenarios that could result if the monument remains in place. Future analysis by federal agencies, such as the Northeast Fisheries Science Center, could lend additional technical expertise and tools to further analyze the potential economic impacts, and with the benefit of non-public data.

IX. Appendix A: Exposure vs. Impacts and Data Limitations

Economics is a complicated science, and there is rarely a single answer to a weighty question. Different methodologies will generally produce different results, and interpretation of the results is often subject to varying levels of uncertainty, based in part on imperfect data. Yet despite these limitations, economic analyses can provide new insights and perspectives to assist in good decisions and policies.

Economists from NOAA Fisheries' Northeast Fisheries Science Center have made advances in addressing the challenges associated with economic impact analyses and the use of vessel trip report (VTR) data. In "The Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic", economists from NOAA's National Marine Fisheries Service, Northeast Fisheries Science Center took an alternative approach in assessing a similar question (the potential impacts of the closure of wind energy development areas on various fisheries). They termed the "potential for an impact" as "exposure," explaining that "the exposure measures…do not measure economic impact or loss. Rather, they set the foundation for the impact analysis by identifying who may be impacted." They then used the exposure assessments to identify the fisheries that were the most "exposed" (i.e. had the most potential for an impact), and analyzed these groups using models under four separate scenarios, based on different levels of potential reallocation of effort and changes in fishery biomass.

Source of the Fisheries Exposure Data

Multiple databases hold information on most, but not all, marine species harvesting occurring between Maine and South Carolina. These sources of information were used to characterize commercial fishing activity in the areas of interest. We analyzed available data on commercial harvest by location, species caught, and gear type.[82] Using the VTR and spatial data, we outlined our approach for mapping revenue across the ocean linked to individuals fishing within specific areas. The limitations of the data available for and used in this analysis may not be able to provide a complete picture of the fishing activity along this section of the Atlantic coast.[83]

As outlined in the Draft Coral Amendment Environmental Assessment, VTRs are a primary source of data for understanding fishing location, revenue, days absent, and number of vessels

[82] Kirkpatrick et al. 2017. p 13.
[83] Ibid.

that might be affected by a particular alternative. But the estimates of revenue, effort, or landings attributed to each of these fishing areas area are not exact because of a number of limitations. For instance, while VTRs are required for all vessels fishing with a federal permit, this does not apply to those whose only federal permit is for lobster. For fishing trips where VTR is required, the vessel must submit a VTR for each gear type used and/or statistical area is fished in; each VTR contains a single recorded point, recorded as latitude and longitude coordinates, as representing the location of the fishing activity. Studies indicate, however, that this self-reporting under-reports switches in gear type and statistical area. In addition, the literature shows that, given that commercial fishing trips can be quite long, a single spatial point is unlikely to adequately represent the actual footprint of fishing in a given area.

Therefore, while VTR data can be useful for providing information on the important fishing areas, species targeted, number of fishery participants and projected revenue, such data may provide a limited understanding of the spatial footprint of the fishing and associated revenue. As highlighted in the draft EA, the spatial resolution of the VTR data is imprecise, so does not adequately support management at fine spatial scales.[84] This is discussed more below.

As is frequently the case with studies like this, data limitations and data confidentiality standards constrain the extent of the analysis in this document. Despite these limitations, we believe this document still provides useful analysis for understanding the potential economic impacts of the monument on the most affected fisheries, as well as potential scenarios that could result if the monument remains in place.

[84] NEFMC. 2017.

X. Appendix B: Review of NEFMC Letter on Potential Monument Impacts

Explanation of Differences between TBD Economics Analysis and NEFMC Analysis of Fisheries Associated with the Monument

The NEFMC submitted a comment letter to the Department of Interior and the Department of Commerce, dated June 29, 2017, that provided a description and analysis of the monument's overlap with NEFMC-managed bottom gear fisheries. An explanation of the differences between the NEFMC's analysis and this report is provided below.

1. **The NEFMC analysis did not estimate revenues potentially lost as a result of the monument, as this report did. Rather, the NEFMC only estimated revenues historically associated with commercial fishing in the monument, which is the upper bound on potential lost revenues.**

To develop the assessment of the potential impact of the Monument on commercial fisheries, this analysis estimated catch revenues specific to fisheries in the monument and then adjusted these estimates to account for compensatory behavior by fishermen (i.e., when unable to fish in an area, fishermen will seek to catch these fish in another area) to establish a set of potential economic scenarios. It also accounted for potential spillover benefits from the Monument as an additional set of scenarios. The NEFMC comment letter only included the first part of this equation and therefore presents a maximum, or upper bound estimate, rather than estimating the potential range of impacts, as provided in the this analysis.

2. **Although the NEFMC identified more fisheries affected by the monument than this analysis, its analysis showed that monument-associated revenues for most of these fisheries were likely extremely small.**

The NEFMC comment letter lists ten species as "top species" associated with the monument, according to VTR analysis. However, the revenues presented by the NEFMC for most of these species are relatively small. According to Figure 4 of the NEFMC analysis, the majority of revenues in NEFMC bottom gear fisheries associated with the monument were in four fisheries: red crab, lobster, the squid and butterfish combined trawl fishery, and scallops. Of these four fisheries, only the scallop fishery is not addressed in this report, for reasons discussed below.

3. **As the NEFMC recognizes, the VTR-based model findings –that the scallop fishery had high revenues associated with the monument area–are incorrect, and VMS analysis indicates**

no "real concentration of fishing effort" for scallop dredges.

The NEFMC analysis identifies that the VTR-based model results, that identify the scallop fishery as potentially affected by the Monument, resulted from the model's limitations and the spatial imprecision of VTR. They note about the more spatially-precise VMS data that 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.[85]" According to the NEFMC, a substantial scallop fishery existed , "close to, but not within" the monument during the time period analyzed (2010-2015), and scallops only occur in commercial abundance shallower than 110 meters, which is outside the monument. The NEFMC also examined data from vessel monitoring systems (VMS), which are satellite-based polling systems used on most vessels in the Northeast with federal permits and which are able to show fishing effort at a "much more refined scale." This data confirmed that the scallop fishery did not rely on the monument area. Based on VMS polling, the scallop fleet, which has almost 100% VMS coverage, averaged less than an hour annually in the monument, including transiting. As the NEFMC noted, because the scallop fishery is extremely valuable, this small amount of catch/revenues, allocated incorrectly by the VTR-based models to the Monument, had a big impact on the analysis. For example, in the two most recent years analyzed, 2015 and 2014, the VTR-based model attributed (based on the analysis' bar graphs) approximately $1.7 million and $750,000 respectively in scallop revenues to the monument. This can be compared to the annual average of $1.8 million in revenues for all fisheries that the NEFMC contends are associated with the monument.

4. **The NEFMC's estimate of average annual squid/butterfish revenues associated with the monument is higher than what is assumed in this report. The reason for the discrepancy is the recognized limitations of the NEFMC's VTR-based model when applied to areas like the monument. When these limitations are adjusted for, the results are similar.**

NEFMC used a VTR-based model to make its revenue estimates, including for the squid/butterfish fishery. As NEFMC recognizes, VTRs are self-reported single geographic points representing all fishing activity (as long as statistical area and gear type do not change) and thus are "spatially imprecise." (As discussed above, this report also relied on VTR-based estimates of lobster and red crab catch associated with the monument.) According to the NEFMC, this means that VTRs often record fishing as occurring where it is unlikely. In some cases, a VTR's recorded location is simply inaccurate. For example, NEFMC maps of VTR data in different fisheries show significant lobster VTR activity recorded at a point immediately north of the

[85] NEFMC Comment Letter. 2017. p. 8

monument's seamounts in 2000+ meters of water.[86] However, lobster traps are reported to be set only as deep as 550 meters.[87]

The NEFMC also used a VTR-based model that was recognized as problematic around the shelf edge and slope where the monument is located. The VTR-based model addresses VTRs' lack of spatial precision by using human observer data to create a probabilistic distribution of fishing activity around the single VTR-recorded point, or a type of "heat map." While it is often reasonable to assume that it is equally likely for the actual fishing location to be in any given direction from the point estimate, this assumption is faulty around the monument where depth and slope can change rapidly and, as a consequence, the bottom transitions quickly from fished to not fished. Unlike what the model predicts, fishing activity in locations like the canyon areas is not equally likely to occur in all directions, i.e., in a circular fashion, around VTR-reported point. Rather, it is more likely to occur only at depths similar or shallower than the reported point. The NEFMC recognized the problem, noting that that "[s]ome types of fishing are known to occur within a particular depth range, or fish along depth contours, so modeling a circular distribution of fishing effort around a VTR point attributes fishing to unlikely locations."[88] According to the NEFMC, the squid fishery is one of the problem fisheries for the VTR model as trawl tows in this fishery run along the slope in narrow bands of similar depth, but the model distributes this effort and resulting revenues more widely, including into water depths that are not fished by these gears[89] .

NEFMC's examination of more spatially refined VMS data helps confirm these shortcomings of VTR-based analyses. The NEFMC examined how much of the vessel activity identified in the VTR analysis as having fished in the monument actually had a corresponding VMS poll in the monument. For the trawl fishery for squid and butterfish, the NEFMC found that only 25% of the vessel activity identified in the VTR analysis as having fished in the monument had a corresponding VMS poll in the monument. The NEFMC noted that this provided a relatively accurate gauge of actual fishing activity for fisheries in which VMS coverage is very high, such as the squid and butterfish fishery. Even the 25% figure likely overstates the actual fishing activity occurring in the monument, since VMS polling occurs regardless of whether the vessel is fishing or merely transiting. Because most of the monument is too deep and rugged to fish with bottom trawls or traps, many instances of VMS polls from within the monument were likely from transiting vessels.

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[86] NEFMC. 2017.
[87] Ibid.
[88] NEFMC. 2017.
[89] Ibid.

According to the information presented in the NEFMC analysis' bar graphs, average 2010-2015 annual revenues for squid and butterfish were approximately $140,000. If this figure is adjusted using the VMS:VTR ratio identified by the NEFMC for these trawl fisheries is applied, the monument-associated revenue estimates are very small, approximately $35,000. Considering this fishery is a large and highly mobile regional fishery, these very small revenue figures support the authors' decision not to undertake an impacts analysis for this fishery.

The NEFMC comment letter contends that the monument may be associated with much higher revenues than indicated by VTR data, citing to ASMFC (2016). ASMFC (2016), which compiles responses from a questionnaire sent to permit holders in the offshore lobster fishery, should not be considered a reliable source of information on revenues in this fishery. Recipients of the questionnaire were told that their responses would be used in ongoing efforts to protect deep-sea coral areas in offshore canyons, including those in the monument, thus strongly biasing responses. Only a portion of the permit holders responded and information provided by the respondents was not verified or otherwise corroborated.

XI. Appendix C: Detailed Methodology for Red Crab and Lobster Analysis

The primary methodology for the red crab and lobster analysis is presented in the main document (Fisheries Exposure and Impacts Scenarios). Those sections, however, do not include a detailed treatment of the data or provide detailed tables that the results are drawn from. This information is presented below.

Red Crab

For the red crab analysis, we named 4 distinct geographic areas. Because data for the 640m isobath was not available in sufficiently high resolution, we relied on the 600m isobath as a proxy in each of these areas, which are defined as follows:

- Area 1 includes that portion of the isobath that runs from the Hague line to the eastern edge of the monument;
- Area 2 includes the isobath in the monument;
- Area 3 includes the isobath south and west of the monument to the edge of the red crab management unit; and
- Area 4 includes the isobath for the entire span of the area, from the Hague line to the southwest edge of the red crab fishing management unit.

We used the average annual red crab revenue data from the Atlantic Deep-Sea Red Crab Fishing Years 2017-2019 Specifications.[90] Given annual variations in revenue, we used a five-year average of the revenue (2011-2015), inflation-adjusted to 2010 dollars, to calculate the baseline number for analysis across the entire span of the area (that is, Area 4). The average annual baseline revenue value for Area 4 is approximately $2,662,817. We then used GIS tools to measure the lengths of each area along the isobaths, and apportioned out the baseline revenue proportionately across each area. The average annual baseline revenue value is $176,872 for Area 1; $236,911 for Area 2; and $2,249,033 for Area 3.

Table 1 begins with a null scenario row showing full fishing, for reference, in each Area. The column labeled Area 4 is also a reference, showing the average annual baseline revenue value for the entire area. The Total Revenue column is compared to the Area 4 column to produce the Potential Annual Revenue Impact column.

[90] NEFMC. 2016.

We developed two different scenarios for where reallocation might occur, as described previously. The first of these scenarios is the removal of only Area 2, the monument area. The second scenario removes both Area 2 and Area 1, since it has been asserted that fishermen may treat Area 1 as a de facto closure. We then applied four reallocation percentages (10%, 25%, 50% and 75%) to each of these scenarios.

For each row, we subtracted the revenue from the appropriate area – in some scenarios it was only revenue from Area 2, in the others from both Area 1 and 2 – and added the percentage reallocation in terms of revenue to Area 3, since we assumed all reallocation of effort would take place in Area 3.

Table 2 then applies the three levels of biomass impacts (3.5%, 7%, and 10.5%) to each scenario developed in Table 1.

Table 1. Red Crab Reallocation Scenarios.

Reallocation Scenario	Area 1 (East of Monument to Hague Line)	Area 2 (Monument)	Area 3 (South and West of Monument)	Area 4 (Full ledge)	Total Revenue	Potential Annual Revenue Impact
Null	$176,872.07	$236,911.22	$2,249,033.88	$2,662,817.17	$2,662,817.17	$0.00
Area 2 removed (no reallocation)	$176,872.07	$0.00	$2,249,033.88	$2,662,817.17	$2,425,905.95	$236,911.22
Areas 1&2 removed (no reallocation)	$0.00	$0.00	$2,249,033.88	$2,662,817.17	$2,249,033.88	$413,783.29
Area 2 removed with 10% reallocation	$176,872.07	$0.00	$2,272,725.00	$2,662,817.17	$2,449,597.07	$213,220.09
Areas 1&2 removed with 10% reallocation	$0.00	$0.00	$2,290,412.21	$2,662,817.17	$2,290,412.21	$372,404.96
Area 2 removed with 25% reallocation	$176,872.07	$0.00	$2,308,261.68	$2,662,817.17	$2,485,133.75	$177,683.41
Areas 1&2 removed with 25% reallocation	$0.00	$0.00	$2,352,479.70	$2,662,817.17	$2,352,479.70	$310,337.47
Area 2 removed with 50% reallocation	$176,872.07	$0.00	$2,367,489.49	$2,662,817.17	$2,544,361.56	$118,455.61
Areas 1&2 removed w/50% reallocation	$0.00	$0.00	$2,455,925.52	$2,662,817.17	$2,455,925.52	$206,891.64
Area 2 removed with 75% reallocation	$176,872.07	$0.00	$2,426,717.29	$2,662,817.17	$2,603,589.36	$59,227.80
Areas 1&2 removed with 75% reallocation	$0.00	$0.00	$2,559,371.34	$2,662,817.17	$2,559,371.34	$103,445.82

Table 2. Red Crab Reallocation Scenarios with Biomass Impacts.

Reallocation Scenario	Area 1 (East of Monument to Hague Line)	Area 2 (Monument)	Area 3 (South and West of Monument)	Area 4 (Full ledge)	Total Revenue	Potential Annual Revenue Impact
Null	$176,872.07	$236,911.22	$2,249,033.88	$2,662,817.17	$2,662,817.17	$0.00
Area 2 removed (no reallocation)	$176,872.07	$0.00	$2,249,033.88	$2,662,817.17	$2,425,905.95	$236,911.22
Areas 1&2 removed (no reallocation)	$0.00	$0.00	$2,249,033.88	$2,662,817.17	$2,249,033.88	$413,783.29
Area 2 removed with 10% reallocation + 3.5% biomass*	$176,872.07	$0.00	$2,281,016.89	$2,662,817.17	$2,457,888.96	$204,928.20
Area 2 removed with 10% reallocation + 7% biomass*	$176,872.07	$0.00	$2,289,308.78	$2,662,817.17	$2,466,180.86	$196,636.31
Area 2 removed with 10% reallocation + 10.5% biomass	$176,872.07	$0.00	$2,297,600.68	$2,662,817.17	$2,474,472.75	$188,344.42
Areas 1&2 removed with 10% reallocation + 3.5% biomass	$0.00	$0.00	$2,298,704.10	$2,662,817.17	$2,298,704.10	$364,113.07
Areas 1&2 removed with 10% reallocation + 7% biomass	$0.00	$0.00	$2,306,995.99	$2,662,817.17	$2,306,995.99	$355,821.18
Areas 1&2 removed with 10% reallocation and 10.5% biomass	$0.00	$0.00	$2,314,103.33	$2,662,817.17	$2,314,103.33	$348,713.84
Area 2 removed with 25% reallocation + 3.5% biomass	$176,872.07	$0.00	$2,316,553.57	$2,662,817.17	$2,493,425.65	$169,391.52
Area 2 removed with 25% reallocation + 7% biomass	$176,872.07	$0.00	$2,324,845.47	$2,662,817.17	$2,501,717.54	$161,099.63
Area 2 removed with 25% reallocation + 10.5% biomass*	$176,872.07	$0.00	$2,333,137.36	$2,662,817.17	$2,510,009.43	$152,807.73
Areas 1&2 removed w/25% reallocation + 3.5% biomass	$0.00	$0.00	$2,360,771.59	$2,662,817.17	$2,360,771.59	$302,045.57
Areas 1&2 removed with 25% reallocation + 7% biomass	$0.00	$0.00	$2,369,063.48	$2,662,817.17	$2,369,063.48	$293,753.68
Areas 1&2 removed with 25% reallocation + 10.5% biomass	$0.00	$0.00	$2,377,355.38	$2,662,817.17	$2,377,355.38	$285,461.79
Area 2 removed with 50% reallocation + 3.5% biomass*	$176,872.07	$0.00	$2,375,781.38	$2,662,817.17	$2,552,653.45	$110,163.72

Area 2 removed with 50% reallocation + 7% biomass*	$176,872.07	$0.00	$2,384,073.27	$2,662,817.17	$2,560,945.34	$101,871.82
Area 2 removed with 50% reallocation + 10.5% biomass*	$176,872.07	$0.00	$2,392,365.16	$2,662,817.17	$2,569,237.24	$93,579.93
Areas 1&2 removed with 50% reallocation + 3.5% biomass	$0.00	$0.00	$2,464,217.41	$2,662,817.17	$2,464,217.41	$198,599.75
Areas 1&2 removed with 50% reallocation + 7% biomass	$0.00	$0.00	$2,472,509.31	$2,662,817.17	$2,472,509.31	$190,307.86
Areas 1&2 removed with 50% reallocation + 10.5% biomass	$0.00	$0.00	$2,480,801.20	$2,662,817.17	$2,480,801.20	$182,015.97
Area 2 removed with 75% reallocation + 3.5% biomass*	$176,872.07	$0.00	$2,435,009.18	$2,662,817.17	$2,611,881.26	$50,935.91
Area 2 removed with 75% reallocation + 7% biomass*	$176,872.07	$0.00	$2,443,301.08	$2,662,817.17	$2,620,173.15	$42,644.02
Area 2 removed with 75% reallocation + 10.5% biomass*	$176,872.07	$0.00	$2,451,592.97	$2,662,817.17	$2,628,465.04	$34,352.13
Areas 1&2 removed with 75% reallocation + 3.5% biomass	$0.00	T$0.00	$2,567,663.24	$2,662,817.17	$2,567,663.24	$95,153.93
Areas 1&2 removed with 75% reallocation + 7% biomass	$0.00	$0.00	$2,575,955.13	$2,662,817.17	$2,575,955.13	$86,862.04
Areas 1&2 removed with 75% reallocation + 10.5% biomass	$0.00	$0.00	$2,584,247.02	$2,662,817.17	$2,584,247.02	$78,570.14

American Lobster

Analysis for American lobster analysis is more straightforward than red crab for two reasons: we were able to use revenues for the canyon area only, and we did not have to run scenarios based on different area closures. The canyon area-only revenue figures originate from NOAA's Greater Atlantic Fisheries Office webpage on "Fisheries Landings Reported from Monument Areas"[91] which provide a ten-year cumulative total of lobster landings in the monument. We divided that number by 10 to arrive at our average annual baseline revenue figure of $99,275.

Table 3 begins with a null scenario showing full fishing, for reference. Subsequent rows apply five reallocation percentages (10%, 25%, 50%, 75%, and 100%) to the average annual baseline revenue value. Due to the uncertainty surrounding lobster revenues as described in the main text, Table 3 also applies these five reallocation percentages to *double* the average annual baseline revenue figure.

Table 4 then applies the three levels of biomass impacts (3.5%, 7%, and 10.5%) to each scenario developed in Table 3.

In both tables, red text in parentheses identifies a net economic benefit to the fishery.

[91] GARFO. 2016.

Table 3. American Lobster Reallocation Scenarios.

Reallocation Scenario	Avg. Annual Revenue from Monument 2005-2014	Scenario Revenue	Potential Annual Revenue Impact
Null	$99,275.00	99,275.00	$0.00
10 yr. avg. annual rev with 10% reallocation	$99,275.00	$9,927.50	$89,347.50
10 yr. avg. annual rev with 25% reallocation	$99,275.00	$24,818.75	$74,456.25
10 yr. avg. annual rev with 50% reallocation	$99,275.00	$49,637.50	$49,637.50
10 yr. avg. annual rev with 75% reallocation	$99,275.00	$74,456.25	$24,818.75
10 yr. avg. annual rev with 100% reallocation	$99,275.00	$99,275.00	$0.00
10 yr. avg. annual rev doubled with 10% reallocation	$198,550.00	$19,855.00	$178,695.00
10 yr. avg. annual rev doubled with 25% reallocation	$198,550.00	$49,637.50	$148,912.50
10 yr. avg. annual rev doubled with 50% reallocation	$198,550.00	$99,275.00	$99,275.00
10 yr. avg. annual rev doubled with 75% reallocation	$198,550.00	$148,912.50	$49,637.50
10 yr. avg. annual rev doubled with 100% reallocation	$198,550.00	$198,550.00	$0.00

Table 4. American Lobster Reallocation Scenarios with Biomass Impacts.

Revenue Plus Biomass Scenario	Avg. Annual Revenue from Monument 2005-2014	Scenario Revenue	Potential Annual Revenue Impact
Null	$99,275.00	$99,275.00	$0.00
10 yr. avg. annual rev with 10% reallocation + 3.5% biomass	$99,275.00	$13,402.13	$85,872.88
10 yr. avg. annual rev with 25% reallocation + 3.5% biomass	$99,275.00	$28,293.38	$70,981.63
10 yr. avg. annual rev with 50% reallocation + 3.5% biomass	$99,275.00	$53,112.13	$46,162.88
10 yr. avg. annual rev with 75% reallocation + 3.5% biomass	$99,275.00	$77,930.88	$21,344.13
10 yr. avg. annual rev with 100% reallocation + 3.5% biomass	$99,275.00	$102,749.63	($3,474.63)
10 yr. avg. annual rev doubled with 10% reallocation + 3.5% biomass	$198,550.00	$26,804.25	$171,745.75
10 yr. avg. annual rev doubled with 25% reallocation + 3.5% biomass	$198,550.00	$56,586.75	$141,963.25
10 yr. avg. annual rev doubled with 50% reallocation + 3.5% biomass	$198,550.00	$106,224.25	$92,325.75
10 yr. avg. annual rev doubled with 75% reallocation + 3.5% biomass	$198,550.00	$155,861.75	$42,688.25
10 yr. avg. annual rev doubled with 100% reallocation + 3.5% biomass	$198,550.00	$205,499.25	($6,949.25)
10 yr. avg. annual rev with 10% reallocation + 7% biomass	$99,275.00	$16,876.75	$82,398.25
10 yr. avg. annual rev with 25% reallocation + 7% biomass	$99,275.00	$31,768.00	$67,507.00
10 yr. avg. annual rev with 50% reallocation + 7% biomass	$99,275.00	$56,586.75	$42,688.25
10 yr. avg. annual rev with 75% reallocation + 7% biomass	$99,275.00	$81,405.50	$17,869.50
10 yr. avg. annual rev with 100% reallocation + 7% biomass	$99,275.00	$106,224.25	($6,949.25)
10 yr. avg. annual rev doubled with 10% reallocation + 7% biomass	$198,550.00	$33,753.50	$164,796.50
10 yr. avg. annual rev doubled with 25% reallocation + 7% biomass	$198,550.00	$63,536.00	$135,014.00
10 yr. avg. annual rev doubled with 50% reallocation + 7% biomass	$198,550.00	$113,173.50	$85,376.50
10 yr. avg. annual rev doubled with 75% reallocation + 7% biomass	$198,550.00	$162,811.00	$35,739.00
10 yr. avg. annual rev doubled with 100% reallocation + 7% biomass	$198,550.00	$212,448.50	($13,898.50)
10 yr. avg. annual rev with 10% reallocation + 10.5% biomass	$99,275.00	$20,351.38	$78,923.63

10 yr. avg. annual rev with 25% reallocation + 10.5% biomass	$99,275.00	$35,242.63	$64,032.38
10 yr. avg. annual rev with 50% reallocation + 10.5% biomass	$99,275.00	$60,061.38	$39,213.63
10 yr. avg. annual rev with 75% reallocation + 10.5% biomass	$99,275.00	$84,880.13	$14,394.88
10 yr. avg. annual rev with 100% reallocation + 10.5% biomass	$99,275.00	$109,698.88	($10,423.88)
10 yr. avg. annual rev doubled with 10% reallocation + 10.5% biomass	$198,550.00	$40,702.75	$157,847.25
10 yr. avg. annual rev doubled with 25% reallocation + 10.5% biomass	$198,550.00	$70,485.25	$128,064.75
10 yr. avg. annual rev doubled with 50% reallocation + 10.5% biomass	$198,550.00	$120,122.75	$78,427.25
10 yr. avg. annual rev doubled with 75% reallocation + 10.5% biomass	$198,550.00	$169,760.25	$28,789.75
10 yr. avg. annual rev doubled with 100% reallocation + 10.5% biomass	$198,550.00	$219,397.75	($20,847.75)

XII. Appendix D: References

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