Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: American Lobster Management Board

FROM: American Lobster Technical Committee

DATE: January 25, 2017

SUBJECT: Analysis on Potential Fishery Impacts as a Result of the NEFMC Coral Amendment

The New England Fishermen Management Council is currently working on an Omnibus Deep Sea Coral Amendment which looks to protect deep sea coral habitat in the northwest Atlantic Ocean. This Amendment may impact the lobster and Jonah crab fisheries as currently, there are proposed closures in the Gulf of Maine and Georges Bank. In an effort to estimate potential impacts to the lobster and Jonah crab fisheries, the Technical Committee (TC) conducted two analyses, one which estimates impacts to the offshore fleet which fishes in and around the canyons, and another which estimates impacts to the Maine lobster fleet which fishes around Mount Desert Rock and Outer Schoodic Ridge. The intent of these analyses is twofold. The first objective is to provide an estimate of the potential impacts to the lobster and Jonah crab fisheries which does not rely on data solely from Vessel Trip Reports. The second objective is to provide another method of analysis which can be compared to the impact analysis currently being conducted by the New England Fishery Science Center.

This report is comprised of two parts. The first part estimates impacts to the offshore lobster and Jonah crab fleet by using data from ASMFC's recent mail-in survey as well as bathymetry data from NOAA. It looks at the impact of various scenarios, including discrete canyon zones, broad depth zones, and the national monument. The second part estimates impacts to the Maine lobster fleet which fishes around Mount Desert Rock and Outer Schoodic Ridge. This analysis uses three different methods to estimate impacts to landings and revenue, and considers potential implications of deep-sea coral closures on whales.

1. Alternative Analysis of Lobster Fishing Activity in Deep-Sea Coral Zones Off Georges Bank.

The New England Fisheries Management Council is considering different scenarios for protecting potentially sensitive benthic habitats along the shelf edge of Southern New England and the south side of Georges Bank. Specifically, the Council is interested in understanding how different closure scenarios would impact fisheries in this region. One analysis has been conducted by NEFSC staff, based primarily on revenue and coordinates from vessel trip reports (VTRs). This first approach recognizes and attempts to model the uncertainty of the reported VTR coordinates by distributing the reported landings to a neighborhood around the reported coordinates, then estimating impacts of different spatial closures. The TC's analysis examines an alternate method for assigning value to different habitats and exploring the impacts of different scenarios. The method is applied specifically to the offshore American lobster and Jonah crab

industry, one of the fleets expected to be most affected by such closures, and is largely independent of the VTR data. The primary purpose for this alternate analysis is to validate the estimates from NEFSC based on VTR coordinates. However, comparisons to this analysis are not included in this document because the NEFSC report is not yet finalized.

Methods

The region of interest was defined, based on provided shapefiles for different scenarios, to include NMFS statistical areas *525, 526, 541, 542, 543, 562, and areas 534 and 537 east of -70.55 longitude.*

A value for each portion of habitat in the proposed closure region was estimated by combining results from a recent mail-in survey of LMA3 Fishermen (Whitmore et al. 2016) with a regional bathymetry map. In the survey, fishermen provided the estimated proportion of their effort and revenue across depth intervals of <100m, 100-200m, 200-300m, 300-400m, and >400m. Fishermen also provided their gross lobster and Jonah crab revenue for 2014 and 2015 from the region of interest. Though all fishermen with Area 3 lobster licenses were contacted for the survey, less than half responded and not all responses included all relevant information for this analysis. Thus, it was necessary to assume that the responses that included the necessary information are representative of the fishing fleet in this region (35% of Area 3 fishermen responded to the survey). Percent effort and revenue were averaged across applicable fishermen to get mean unweighted estimates of effort and revenue for each depth interval. To account for differences in catch and revenue among reporting vessels, the vessel reported depth distributions of effort and revenue were weighted by the mean reported revenue for lobsters and Jonah crabs across 2014-2015 to get a weighted distribution of effort and revenue across depth.

To attribute this effort and revenue to bottom habitat, bathymetry data from the NOAA NCEI U.S. Coastal Relief Model was used (*Retrieved 9/10/2013, http://www.ngdc.noaa.gov/mgg/coastal/crm.html),* which has a resolution of 3 arc minutes. The spatial extent of the raster was trimmed to the area of interest with depths of less than 500m as fishermen's responses indicate that there is minimal fishing occurring below 500m. Potential caveats of this assumption are addressed in the discussion. Each pixel was then assigned to a depth category consistent with the depth intervals that were used in the fishermen survey and distributed the reported mean effort for each depth interval evenly across all pixels in the respective depth interval. This is a critical oversimplification and potential source of bias in this analysis as it assumes that all pixels within a depth interval are equally productive for lobster and Jonah crab fishing (i.e. habitat along submarine canyons have the same productivity as habitat at a similar depth along the shelf edge between canyons).

Impacts of a closure scenario on effort or revenue were calculated by overlaying the closed areas on the bathymetry map and summing the effort or revenue value (unweighted or weighted) of all pixels falling inside the closure scenario. Of the proposed scenarios, evaluated closures included depths greater than 300m or 400m, (hereafter 300m+ and 400m+ respectively) the closure of Discrete Canyons (hereafter DC), and the combinations of the depth

based and Discrete Canyons scenarios (Figures 1-3). There are also scenarios proposed for depths greater than 500m or 600m but there was not enough effort data for these scenarios in this analysis. Because a national monument has been legislated for habitat within this region, the impacts of the national monument were also evaluated as well as the five above scenarios plus the national monument to get the total impacts of closures, existing and proposed.

Actual loss of revenue for each of the above scenarios was estimated by applying percentage of lost revenue to the total revenue from the region. Though estimated revenue was reported in the survey, the survey responses represent an unknown portion of the total vessels operating in the regions, so it was necessary to use VTRs to estimate total revenue for all vessels in the region. While vessels fishing in federal waters only for lobsters are not required to file VTRs, 95% of responses to the Whitmore et al survey reported filing VTRs, so it may be assumed that the majority of catch from this region is recorded in VTRs and accounted for in our analysis. To examine fishery revenue for this area over the last decade, data was extracted for all VTRs from 2006 – 2015 that reported fishing lobster pots. Precise spatial data was not necessary for most cases as the analysis mostly includes the spatial extent of entire statistical areas. Not all VTRs had assigned statistical areas but examination of the VTR landings by year suggested that >99.9% of VTR landings included a reported statistical areas if the data were constrained to 2011 – 2015. Statistical areas 534 and 537 are only partially included in the proposed closure areas, requiring more precise spatial data for these areas. Thus, these stat areas were split at 70.55^{o}W longitude (western extent of closure scenarios) and, using the VTRs that had reported coordinates, calculated the percentage of landings by year east of this boundary, relative to landings for the entire statistical areas and then applied these percentages to the remaining VTRs that lacked coordinates to calculate the total landings for these statistical areas east of the boundary.

Revenue was then summed across statistical areas within year and examined landings trends for 2011 – 2015. Regional revenue increased across these years but was similar for 2014 and 2015, so the average of the two years were used to project revenue loss.

Results

Of the vessels that replied to the mail-in survey, 15 reported fishing in the region of interest and supplied effort and revenue percentages by depth. 12 of these 15 also reported total revenue for the region so only these 12 were used for calculating weighted depth-distributions of effort and revenue.

Based on the survey results, the 200 – 300m depth zone has the highest fishing effort but the 100 – 200m depth zone has marginally higher revenue value (Table 1). A total of 26.6% and 32.6% of effort (unweighted and weighted) is in 300m depths or greater and 3.7% and 6.1% of effort (unweighted and weighted) is in greater than 400m. Similarly, a total of 20.9% and 27.9% of lobster and Jonah crab revenue (unweighted and weighted) is reported from depths greater than 300m and 2.7% and 4.8% of lobster and Jonah crab revenue (unweighted and weighted) comes from depths greater than 400m. Most (78.8%) of the habitat within the statistical areas that encompass the region of interest is in less than 100m depths with only 3.1% of the habitat

in deeper than 300 meters and 1.4% of the habitat deeper than 400m (recall that habitat deeper than 500m is not included as potential lobster habitat for the purpose of this analysis). It is noteworthy that the 300-400m depth interval represents a moderate amount of effort (22.9% and 26.5%) and revenue (18.1% and 23.1%) but also represents a very small portion of the habitat. This suggests that this depth increment may have the highest density of fishing activity (i.e. highest effort-to-habitat area or revenue-to-habitat area ratios), followed by the 200 – 300m depth increment.

For scenarios where the existing National Monument were not included, the weighted estimates were consistently higher than the unweighted estimates, suggesting that vessels that reported higher revenues were generally fishing deeper than vessels that reported lower revenues (Table 2). In general, the area within the Discrete Canyons scenario accounts for about 10% of the effort and 8% of the revenue, representing $1.4 – 1.8 million in annual lobster and Jonah crab revenue. The 300m+ scenario encompasses 23 – 28% of the effort, and 17 – 23% of the revenue, representing $3.4 – $4.5 million in annual lobster and Jonah crab revenue. The combined 300m+ and DC scenario are only slightly higher than the 300m+ scenario as the DC scenario includes very little habitat that is not already accounted for in the 300m+ scenario. The 400m+ scenario encompasses 5.5-7.5% of the effort and 4.1-6.2% of the revenue, accounting for $0.8 - $1.2 million in annual lobster and Jonah crab revenue. Because adding the DC scenario to the 400m+ scenario adds a significant amount of shallower habitat, the combined scenario has considerably higher impacts, encompassing 11.9-14.6% of the effort and 9-12.3% of the revenue, representing $1.7 – 2.4 million in annual lobster and Jonah crab revenue.
The newly-designated national monument itself is estimated to account for 13-14.3% of the regional effort and 12.2 – 14.3% of the revenue, representing $2.4 – 2.8 million in annual lobster and Jonah crab revenue (Table 3). Because the national monument includes considerable amounts of productive habitat shallower than 300m, combining the national monument with the different scenarios increases the expected impacts for all scenarios, increasing effort and revenue impacts by about an additional 10%. The 300m+ with DC and the monument combined scenario would have the highest impact, encompassing 33-38.4% of regional effort and 27.5 – 33.4% of revenue, accounting for about $5.4 – 6.5 million in annual lobster and Jonah crab revenue.

Discussion

The range in values presented for each scenario above represents the difference between unweighted and weighted estimates and do not represent the uncertainty in the estimates. The depth distributions of effort and revenue data come from self-reported mail-in surveys from a limited number of fishermen that may not accurately represent all the vessels in the survey area. Thus, given the small sample size, it is difficult to know how accurate the assumed depth distributions of effort and revenue are. The analysis is also based on data from the recent years and not necessarily predictive of the future. From conversations with industry, many of the vessels working this region have been fishing the same general area for many years. However, given large-scale shifts in lobster distributions to the south and west and the increasing pressure on Johan crabs, this region may become more important to the offshore fishery.

Closures will also impact vessels unequally. As mentioned in the results, the weighted estimates of effort and revenue impacts are consistently higher than unweighted estimates across the scenarios. This suggests that vessels reporting higher landings in this region tend to fish deeper and would be more impacted by closures. Of the 14 survey respondents that provided a depth distribution of their fishing effort, three reported no effort below 300m and five reported 50% or more of their effort below 300m.

It is similarly difficult to predict the directionality of bias in this analysis. The total revenue impacts are partially derived from Vessel Trip Reports and assume that 100% of vessels fishing this area are submitting VTR's. Thus, any level of reporting below 100% would necessarily bias the total revenue estimates lower than actual.

The necessary assumption that all habitat is equally productive is almost certainly incorrect, as deep habitat along canyons is probably more structurally complex and productive than such habitat along the shelf edge, which would also bias the Discrete Canyons, as well as the 400m+ and DC, scenarios low. Lobster vessels have to distribute their fishing gear across a fair amount of space to fish effectively. Thus, it is also possible that, with the closure of deeper habitats, there may be insufficient habitat along the closure boundary to fish efficiently and impacts may be greater than estimated.

Conversely, some lobsters in this region seasonally migrate into shallower water where they would become available to the fishery, though the portion of the population that undergoes this migration is poorly understood. In this case, the analysis would overestimate the impacts on revenue as the results assume that lobsters protected in one area do not become available in other areas. It should also be noted that fishermen commonly follow this annual migration to a degree, fishing in shallower water in the warmer seasons and deeper water in the colder seasons. Thus, closing deeper portions of the lobster fishing habitat in this region would have seasonal impacts on the displacement of fishing effort that are not assessed in this analysis. Finally, the analysis does not explore the impacts of closing habitat deeper than 500m as quantitative data on lobster fishing effort below this depth are not available. While results of the survey indicate that a smaller amount of effort and revenue is allocated to waters deeper than 400m (on average 4% of traps and 3% of revenue from waters deeper than 400m), this does not mean that fishing does not take place in those areas. Of the 19 respondents who did fish in the area of interest, 42% reported setting their deepest traps in water greater than 400m.

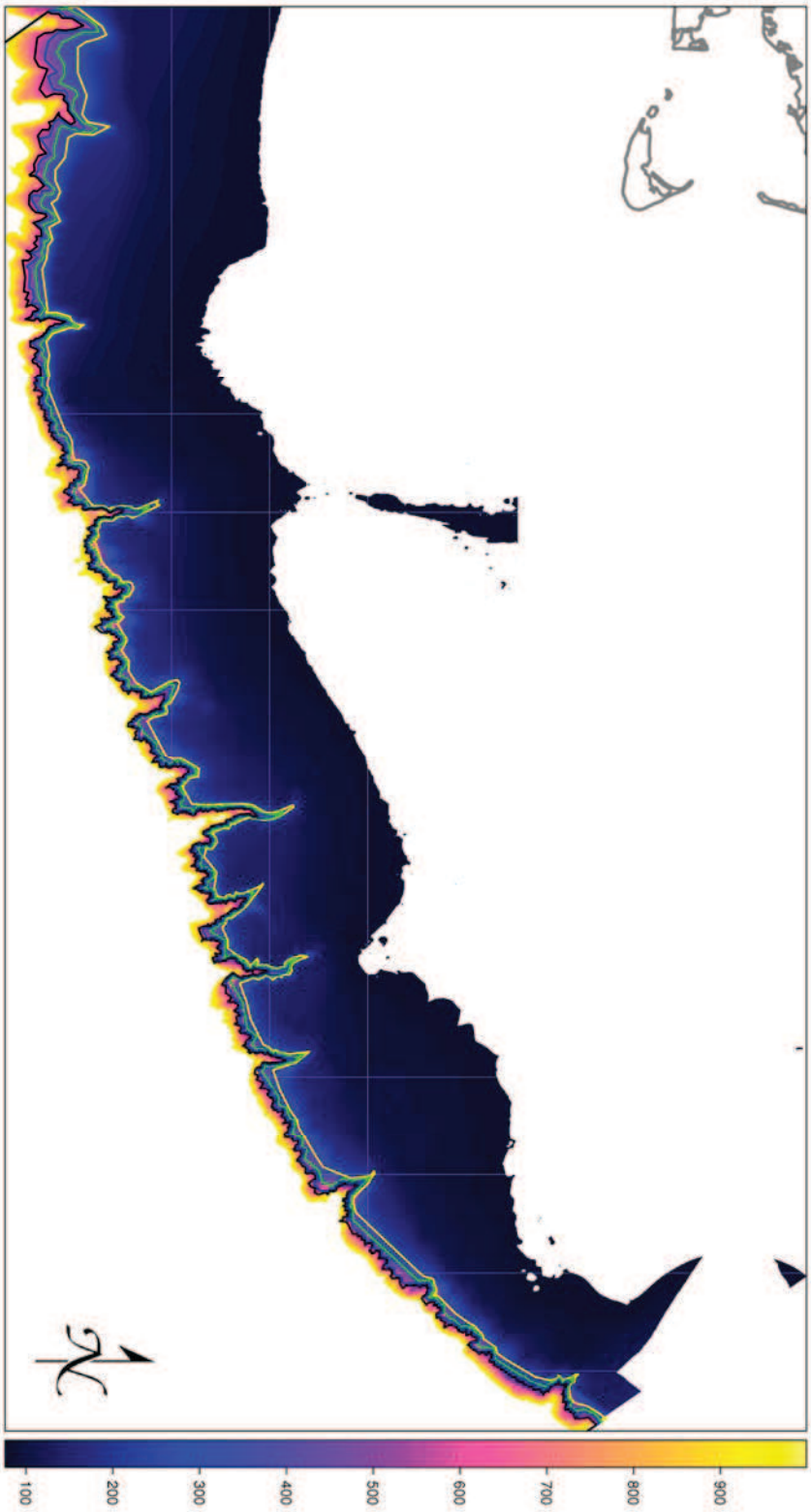

Figure 1. Bathymetry map (rotated) of southern Georges Bank with boundaries for broad-zone designations marked in yellow (300m), green (400m), blue (500m) and black (600m). Depths <75m and >1,000m not shown.

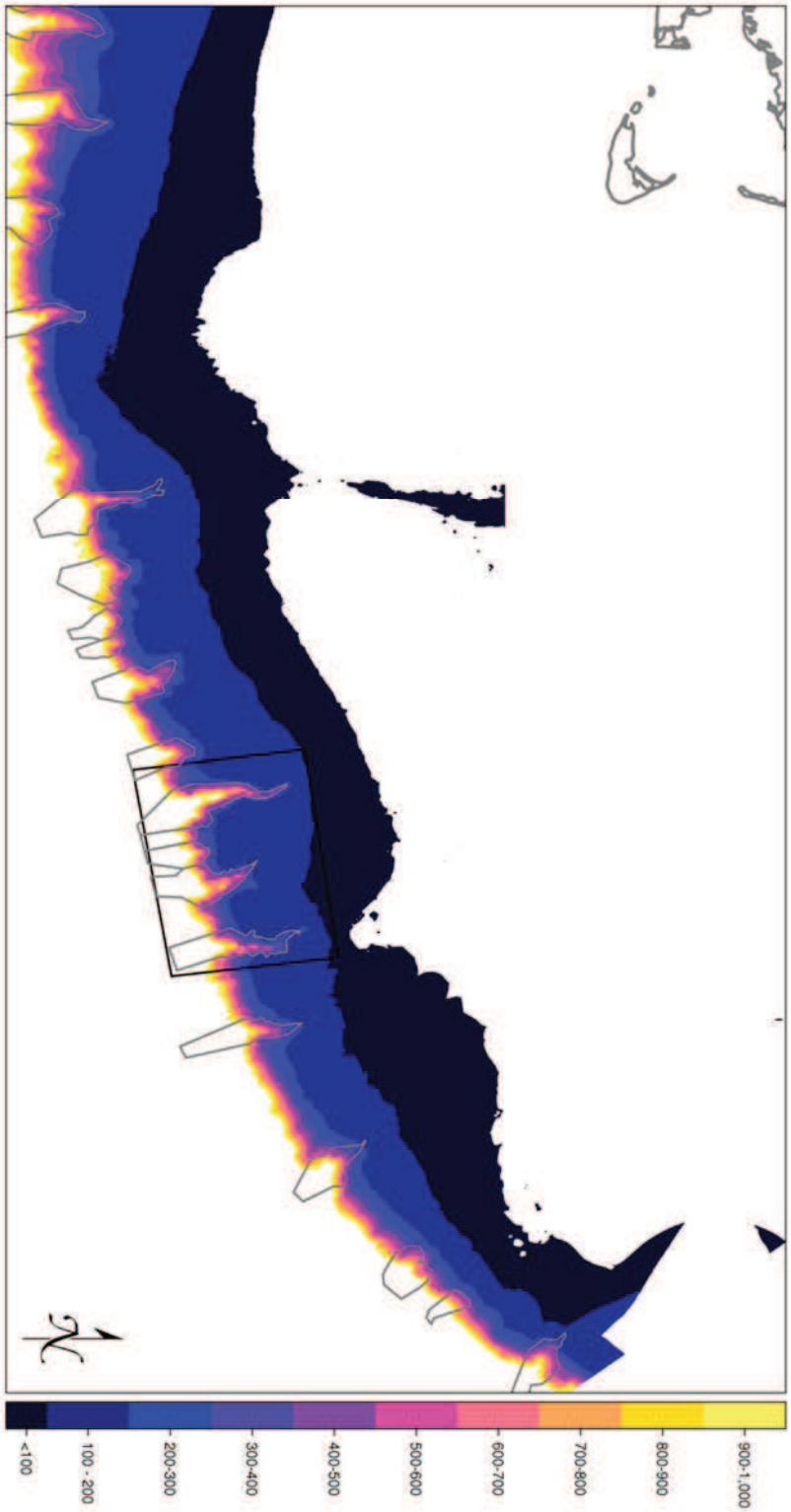

Figure 2. Bathymetry in 100m depth bins with the Discrete Canyons scenario and boundaries of the National Monument. Depths <75m and >1,000m not shown.

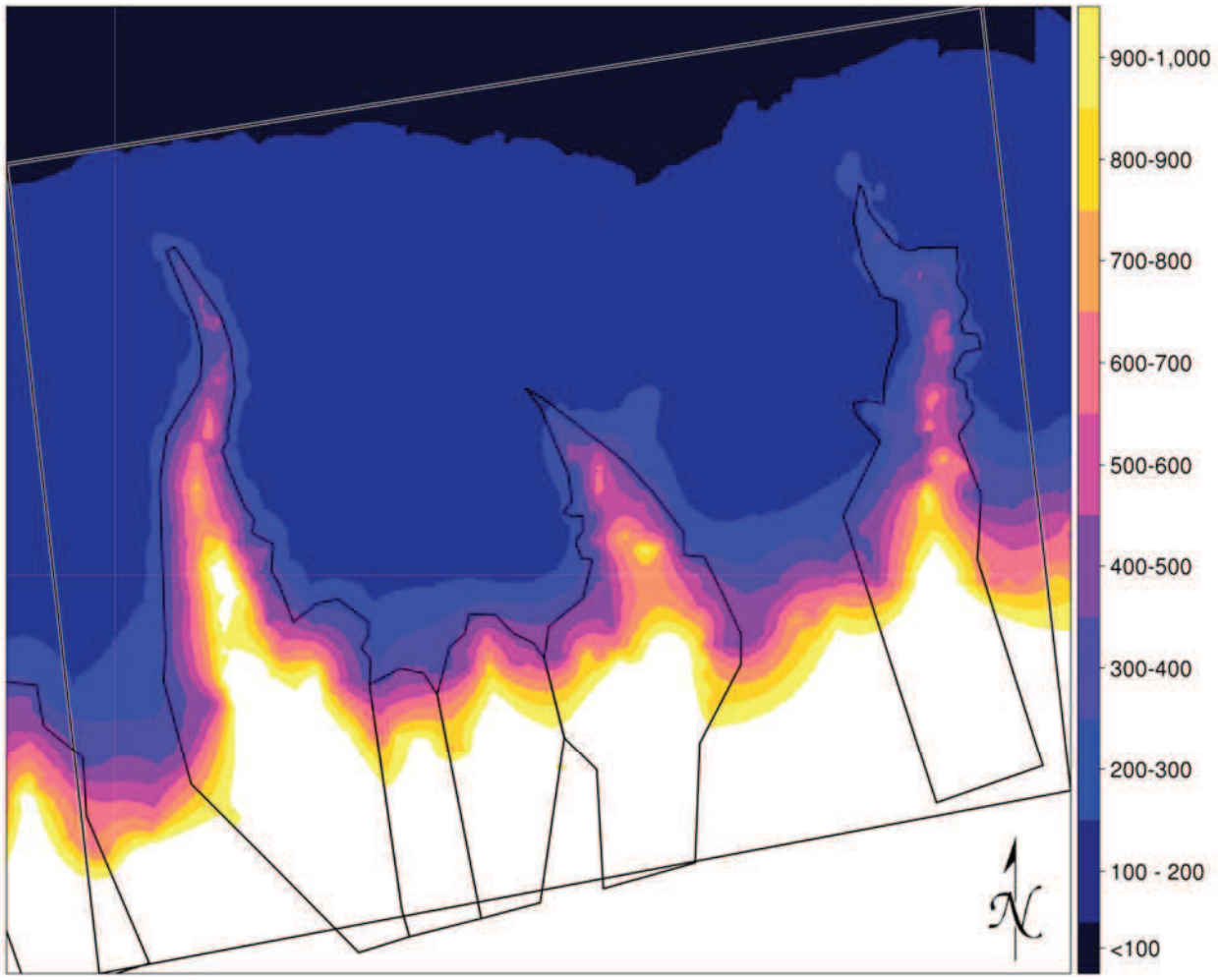

Figure 3. Higher resolution map (example for bathymetry detail) of the National Monument area with included Discrete Canyons. Depths <75m and >1,000m not shown.

Table 1. Depth distributions of effort and revenue, unweighted and weighted, and proportion of habitat by depth available in the region or interest.

DepthBin	Effort		Revenue		Proportion
	Unweighted	Weighted	Unweighted	Weighted	of habitat
<100m	17.3%	9.1%	23.0%	17.1%	78.8%
100-200m	20.5%	22.2%	32.7%	28.7%	15.5%
200-300m	35.5%	36.1%	23.4%	26.3%	2.7%
300-400m	22.9%	26.5%	18.1%	23.1%	1.7%
>400m	3.7%	6.1%	2.7%	4.8%	1.4%

Table 2. Proportion of effort and revenue impacted by different scenarios, not accounting for the National Monument. Revenue value is in millions annually.

Metric	Weighting	Discrete Canyons	300m	300m plus Discrete Canyons	400m	400m plus Discrete Canyons
Effort	Unweighted	9.3%	22.9%	24.3%	5.5%	11.9%
	Weighted	11.1%	27.8%	29.3%	7.5%	14.9%
Revenue	Unweighted	7.0%	17.5%	18.6%	4.1%	9.0%
	Weighted	9.2%	23.4%	24.6%	6.2%	12.3%
Revenue Value	Unweighted	$1.4	$3.4	$3.6	$0.8	$1.7
	Weighted	$1.8	$4.5	$4.8	$1.2	$2.4

Table 3. Proportion of effort and revenue impacted by different scenarios, including the National Monument. Revenue value is in millions annually.

Metric	Weighting	Monument	Discrete Canyons	300m	300m plus Discrete Canyons	400m	400m plus Discrete Canyons
Effort	Unweighted	13.0%	19.1%	32.1%	33.0%	17.3%	21.6%
	Weighted	14.3%	21.7%	37.4%	38.4%	20.3%	25.2%
Revenue	Unweighted	12.2%	16.8%	26.8%	27.5%	15.5%	18.7%
	Weighted	14.3%	19.3%	32.6%	33.4%	18.1%	22.1%
Revenue Value	Unweighted	$2.4	$3.3	$5.2	$5.4	$3.0	$3.6
	Weighted	$2.8	$3.7	$6.3	$6.5	$3.5	$4.3

2. Potential Impacts to the Gulf of Maine Lobster Fleet from Proposed Coral Closures

The New England Fisheries Management Council (NEFMC) Omnibus Deep Sea Coral Amendment is considering two potential closures to protect deep sea corals in Lobster Management Area 1[1]. These two areas of sensitive benthic habitat are the Outer Schoodic Ridge and Mount Desert Rock in eastern Maine (Figure 4). An important component of evaluating these areas for habitat protection is understanding the potential economic impact to coinciding fisheries. These two discrete areas under consideration are recognized as productive fishing grounds particularly for the Maine lobster fleet. NEFMC staff has looked at vessel trip report (VTR) data to try and characterize the lobster fishing effort and revenue in these areas; however, this approach likely does not accurately characterize the Maine lobster fishery. Federal permit holders that designate lobster-only are not required to report through VTRs in Maine. Because of this exemption, only 10% of all Maine federal permit holders and 3% of the total Maine lobster fleet report through VTRs. The permits are not uniformly distributed as there is a spatial difference between eastern and western zones. The federal permits requiring VTRs landed 8% of the 2015 federal permit lobster landings in the eastern zones (A, B, and C) while 13% of the 2015 federal landings were by VTR permits in the western zones (D, E, F, and G) (Figure 4). This lack of representative coverage renders the VTR lobster dataset inadequate to assess the economic impact of the potential coral closures on the Maine lobster fleet. The analysis presented here uses Maine landings data to try to characterize the potential range of economic impacts should the two proposed areas be closed. The following figures were provided to the NEFMC Habitat Committee with notes by the Maine Department of Marine Resources, but not as a fully developed report.

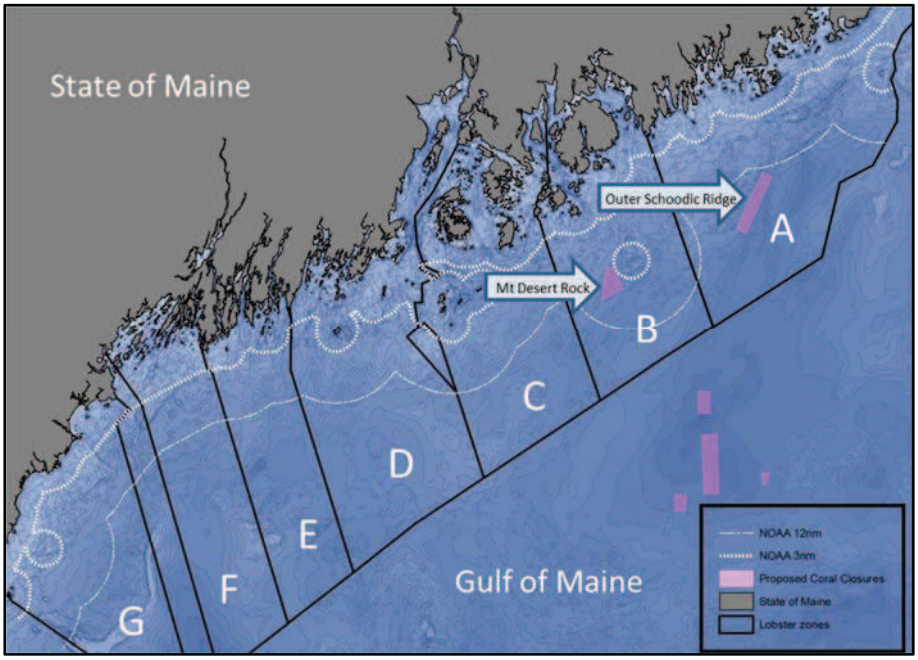

Figure 4. Maine Fishing Zones A through G, east to west with proposed coral closures. License holders declare a zone and must fish 51% of their gear in their declared zone.

[1] http://www.nefmc.org/library/omnibus-deep-sea-coral-amendment

Available Data and Methods

The two areas under consideration are in the eastern part of the Gulf of Maine within federal waters of Lobster Conservation Management Area 1. The Mount Desert area is within the 3-12nm distance from shore in Maine Fishing Zone B while the Outer Schoodic Ridge area is more than 12nm offshore in Zone A (Figure 4). The GIS shapefiles in the maps and area calculations for potential closures were provided by the NEFMC. Due to knowledge of the areas and evidence from Maine at-sea sampling data, it is known that these areas were historically, and are currently, fished by lobster fishermen from adjacent zones. As a result, this analysis considers fishery data from Zones A, B, and C. All federal permit holders must also hold a Maine state license and can fish in either state or federal waters but are required to fish, at a minimum, 51% of their gear in their declared zone. Very few Maine vessels (<3) fish in Area 3 because of the conflicting management rules between LCMA 1 and 3 that prevents boats from fishing both areas.

The Maine lobster industry currently has no fleet-wide reporting requirements that provide spatial resolution finer than the zone level. The State of Maine collects 100% trip-level data through lobster dealers. In this analysis, dealer data were summarized by fishing zone and provided information such as: pounds landed, value, total number of trips, and total number of permits fished annually. Dealer data were categorized by zone according to port landed, so catch could originate from an adjacent zone. Because of this adjacency issue, all analyses using the dealer data included Zones A, B, and C. These data were available for fishing years 2008-2015. We chose to use data from the most recent year of dealer reports, 2015, which consisted of 269,939 transactions.

Maine harvester logbooks are required on an annual basis from a randomly selected 10% of fishermen, stratified by fishing zone and Maine license class. The license classes are based on age (<18 years old, 18-70 yo, and > 70 yo) and number of unlicensed crew allowed to work on the boat in addition to the captain (none, 1, or 2). There is no stratification for federal versus state-only permits in the harvester report selection process. All Maine lobster license holders, except those chosen the previous year, are included in the annual random draw, including licenses that had no landings the previous year and permits that are required to submit VTRs. Those permit holders that are required to submit VTRs do not submit duplicate reports to the Maine harvester logbook, but continue to report only through the VTR process. To complete the representative 10% in this analysis, the VTR permits that were part of the selected 10% were added to the Maine harvester logbook dataset. VTRs collect similar information, except the spatial data comes as a single coordinate of latitude and longitude. To complete the dataset with comparable data, the single point for each trip was plotted in GIS and assigned a zone and distance from shore. The combined VTR and harvester data were summarized into numbers of pounds landed, value, number of permits, by month, zone fished, average depth, and distance from shore (0-3nm, 3-12nm, and >12nm). The zone fished was reported by the fishermen and was assumed to be where the gear was set, not necessarily the license's declared zone. These data were available for fishing years 2008-2014, but we chose to use the most recent four years. In addition to the expansion estimates described later, monthly average trip value and depth were derived from the 2011-2014 harvester data.

For both dealer and harvester data, the monetary value of the catch was calculated for each trip using an average price per month per zone for each year. All data were categorized by permit type as state-only, federal with VTR, and federal without VTR. Although we considered the total value of the fishery in the three zones including all permit types for the three zones, for further expansion, we only used federal permits (with and without VTR) from both the dealer and harvester datasets because only federal permit holders would be directly impacted by the potential closures (state-only permits do not have access).

Through outreach, the Maine DMR and the Maine Lobstermen's Association (MLA) gathered information about the use of the potential closure areas from industry. This was not a systematic survey, but rather a targeted consultation with representative industry members who fish in these areas to determine how many and which harbors could be impacted, rough estimates of numbers of boats, and at what time of year these areas are fished most heavily. The industry members consulted were fishermen identified by the Maine DMR at-sea sampling program, MLA board members and some industry members recommended by the original DMR and MLA contacts.

Expansions

We used three methods to expand total revenue estimates from the more spatially specific but limited (10%) harvester data into the total impacted population. The first approach (Expansion Method 1) applied the average proportions of federal permit holders determined by the harvester logbook data for 2011-2014 to the dealer data. This expansion, using the proportions from the 10% harvester data, assigned the total reported value, landings, and trips from the dealer database into distance from shore categories for each zone. This expansion shows the spatial distribution of the variables across zones and distance from shore, but not the specific value of the smaller coral closures.

The second method (Expansion Method 2) estimated a range of revenue derived from the catch in specific closure areas. We used a combination of industry information on numbers of boats with combined harvester logbook data on average value per trip and number of trips per license by month and distance from shore. Some boats reported fishing in these areas nearly all year, but we concentrated on the months of highest effort described by the industry interviews, November through April. Recognizing the uncertainty of industry-estimated boat counts and that, while a certain number of boats could be fishing in an area, they likely did not fish all of their gear or earn all of their income in the areas under consideration, we applied a range of percent income and two options for boat counts per area. The combined harvester data were averaged over 2011-2014 for > 12nm in Zone A and 3-12nm in Zone B to determine the average trips per month per license and the average value per trip. The value was tallied for an annual estimate for the two areas for each boat count and income percentage category.

The third method (Expansion Method 3) assigned a revenue value by square area and made the assumption that every square mile is equally productive for fishing. Because of the assumption (likely inaccurate) of equal productivity and the uncertainty related to the ability of vessels to fish adjacent zones, we combined the data for Zones A, B, and C. To attribute the value by area,

we used average proportions by distance from shore derived from combined harvester data (2011-2014). It was necessary to average the proportions over four years because of confidentiality and uncertainty due to the relatively small sample size. These value proportions, categorized by distance from shore, were applied to the total value and number of pounds landed, trips, from the 2015 dealer data in the combined three zones. The total area for each zone and distance from shore were calculated in ArcGIS. The square mileage of the proposed closures was 1.5% of the total area of the three zones combined outside 3nm, so the estimates for the entire area (Zones A-C) were multiplied by 1.5% to estimate the value within the proposed closures.

Characterization of the Maine fishery

In 2015, the Maine lobster fishery was worth more than $500 million in total ex-vessel value for both state-only and federally permitted vessels. The combined total value for the three eastern zones was more than $296 million with state-only licenses making up the largest proportion of permits (Figure 5). Zone C represented the greatest value in landings overall, with the highest proportion from state-only permits of the three zones. Zone A had the second highest overall landings value, and Zone B had the lowest overall value. While almost 75% of permits were state-only (Table 4), the federal permits without VTR requirements produced the highest proportion of value in Zones A and B (Figure 5). In all three zones, the VTR permits represented the smallest proportion of value of the three permit types.

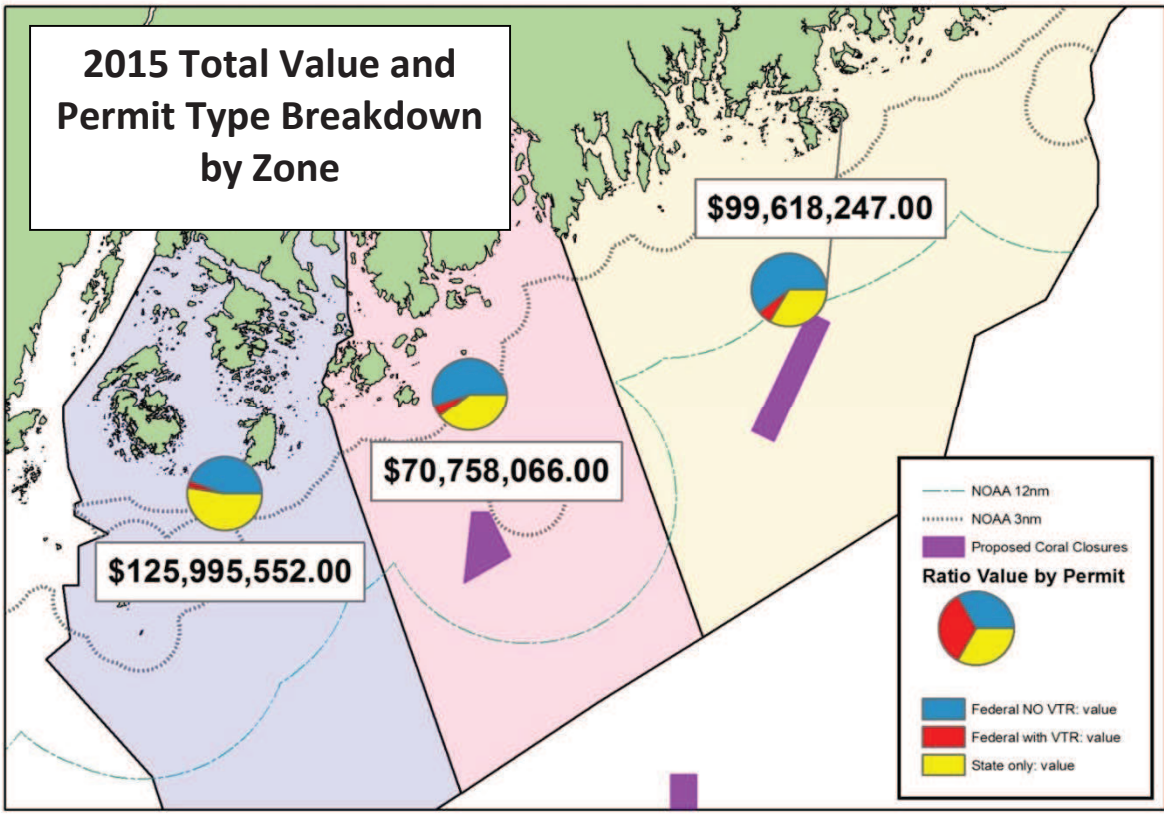

Figure 5. Total value from Maine dealer data for Zones A, B, and C with the ratio of value by permit type for federal with and without VTR requirements and state-only permits.

The total number of permits for Zones A, B and C in 2015 was 2,316 with 640 of those permits being federal permits, with or without VTRs (Table 4). In 2015, federal permits required to submit VTRs harvested 8% of the landings for Zones A, B, and C while all federal permits landed 57% of the total landings in the same area. Within the three eastern zones, 139,780 trips were completed by the lobster fleet with 56,381 trips from the federally permitted vessels (Table 4).

Table 4. Maine 100% trip-level dealer data for 2015 by permit type. Federal includes both VTR and no VTR permits.

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%

The combination of harvester and VTR data determined the proportions of value, number of trips, and landings by zone and distance from shore. Within a given zone, the proportion of effort (trips) that took place in each distance category was not necessarily representative of the resulting landings or value (Table 5). Although there were fewer trips in the > 12nm region, the relative proportion of value was higher (than the trip proportion) in all zones, especially in Zone A (Table 5). For permits and trips, all zones had the highest proportion in state waters, less in 3-12nm, and the smallest distribution in >12nm. For value and landings, Zone A was different from the other two zones where the region between 3-12nm had the highest proportion for value and landings while Zones C and B had the highest in state waters.

Table 5. Proportion of trips, value, and landings by distance from shore (nautical miles) of federal permits averaged over 2011-2014 from the combined harvester and VTR data by zone.

TRIPS			
	0-3	3-12	>12
Zone A	53%	39%	8%
Zone B	59%	31%	10%
Zone C	66%	25%	9%
VALUE			
	0-3	3-12	>12
Zone A	38%	47%	15%
Zone B	49%	36%	14%
Zone C	60%	30%	10%
LANDINGS			
	0-3	3-12	>12
Zone A	40%	48%	13%
Zone B	52%	36%	13%
Zone C	63%	28%	9%

Monthly characteristics of depth and value

The reported value and depth from the harvester logbook dataset indicated trends depending on zone, month, and distance from shore. The highest mean value was found in late fall (October through December) in Zone A outside of 12nm (Figure 6). There was higher variability of value in the late fall, winter and spring months indicated by the length of the violin wands. Generally all areas had a greater value per trip in the fall months when the catch was higher. Prices are typically higher in the winter and spring but the catch volume is lower. Because there are fewer federally permitted vessels and the state-only boats do not have access to offshore fishing grounds, there is opportunity to catch more volume and value per trip offshore in the fall months.

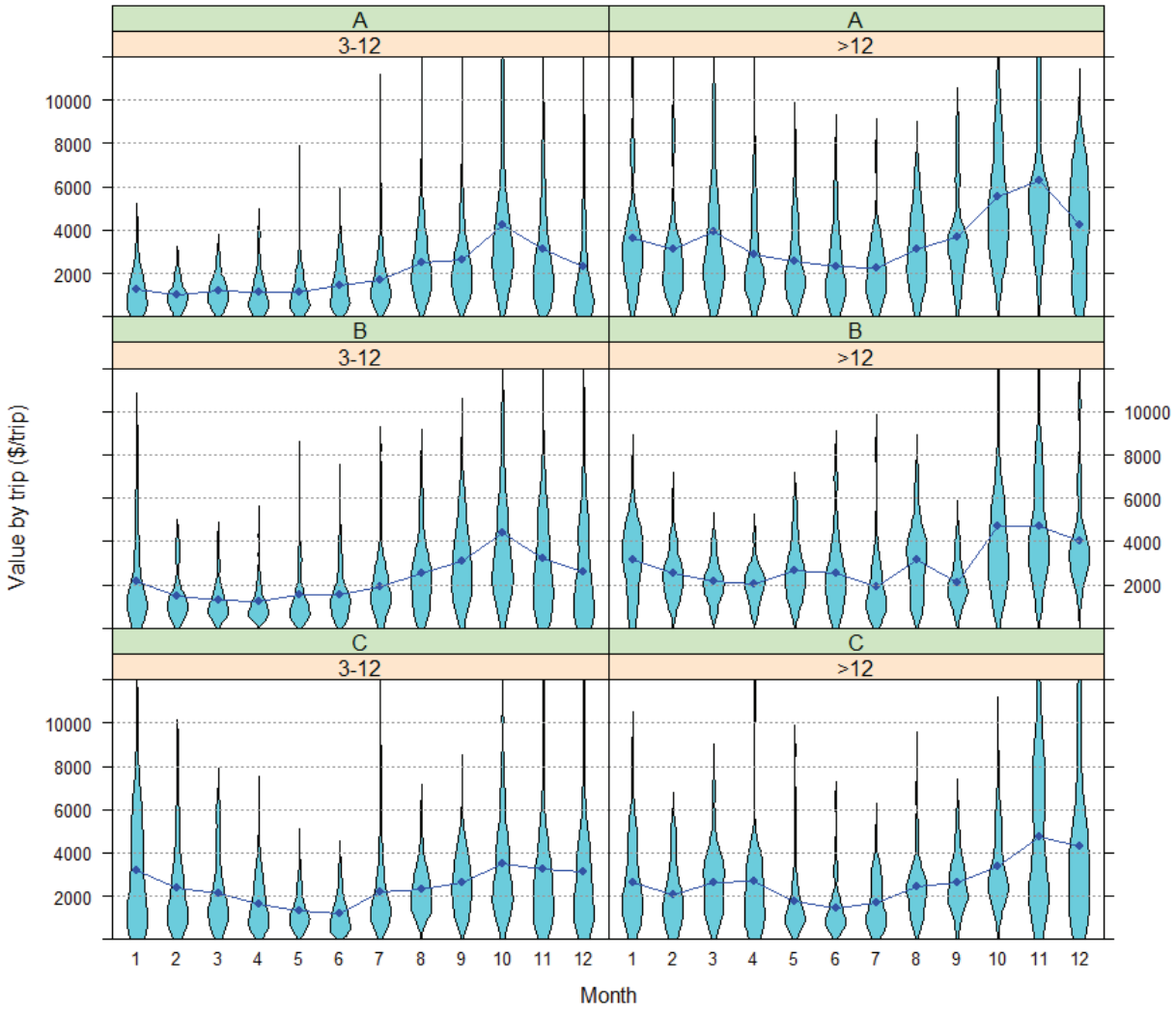

Figure 6. Violin plots of monthly value per trip by zone and distance from shore for federal permits reported by the combined VTR and harvester data over years 2011-2014. The blue dots represent the mean while the width and length of the shape represents the distribution of the data.

Generally the lobster fleet fishes in shallow water during the summer following the lobster movement (molting) and into deep waters for the winter. In the 3-12nm distance from shore,

the average depth fished was less than 100m in all three zones. The greatest average depths fished were outside of 12nm in Zones A. Overall, greater depths were reported in winter and spring but there was high variability year-round (Figure 7). Depths reported in harvester logbooks and VTRs are difficult to verify without more detailed spatial data, but the average trends follow understood patterns of the fleet behavior. The range of depth in the proposed closures is between 100-250m. Using the bathymetry map data from the NOAA NCEI U.S. Coastal Relief Model[2] we characterized the depths of the potential closures (Figure 8). While the fleet fishes shallower depths on average, the distributions of depth within the closures and the reported depths by the Maine lobster fleet overlap, especially in the winter and spring months (Figures 7 and 8).

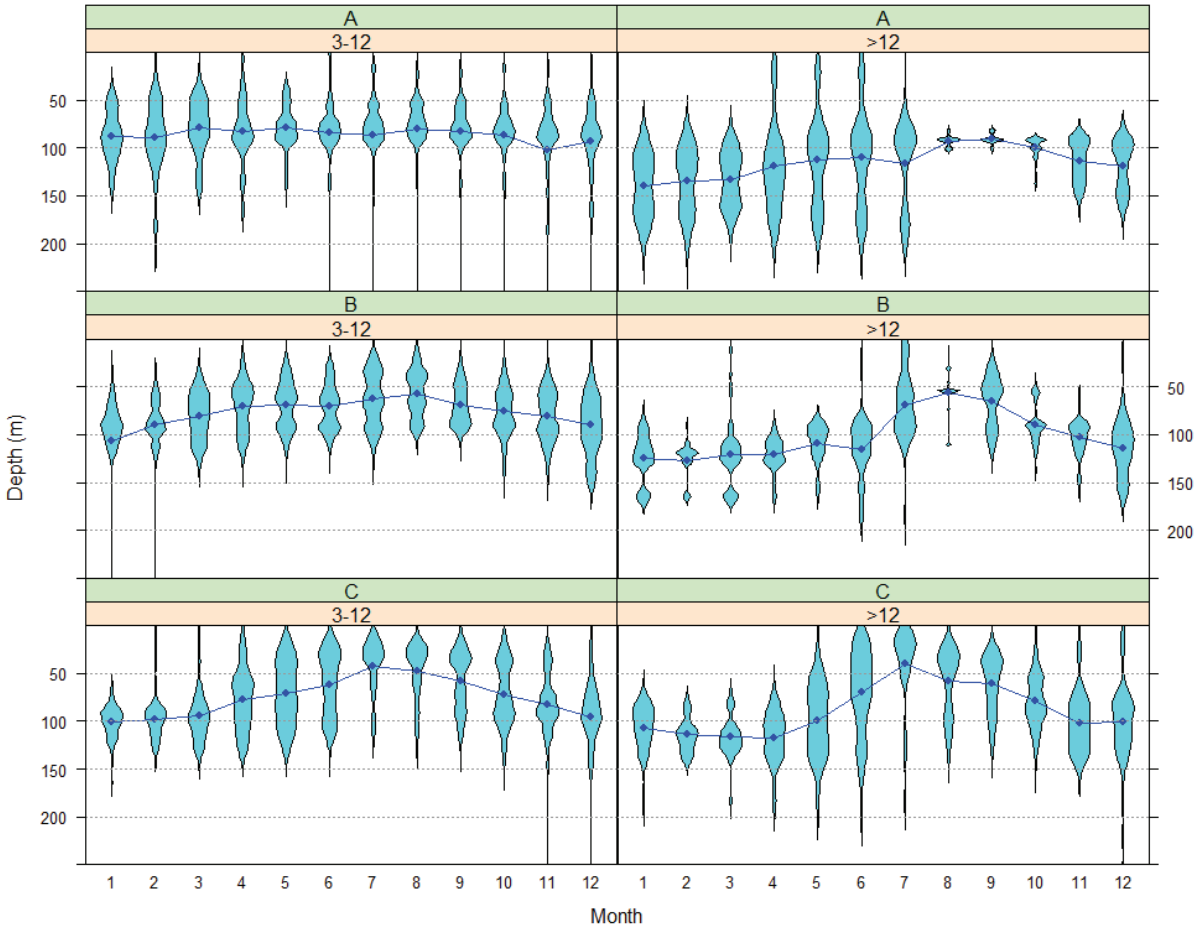

Figure 7. Violin plots of monthly depths per trip by zone and distance from shore for federal permits reported by the combined VTR and harvester data over years 2011-2014. The blue dots represent the mean while the width and length of the shape represents the distribution.

[2] data from the NOAA NCEI U.S. Coastal Relief Model (Retrieved 9/10/2013, http://www.ngdc.noaa.gov/mgg/coastal/crm.html), which has a resolution of 3 arc minutes.

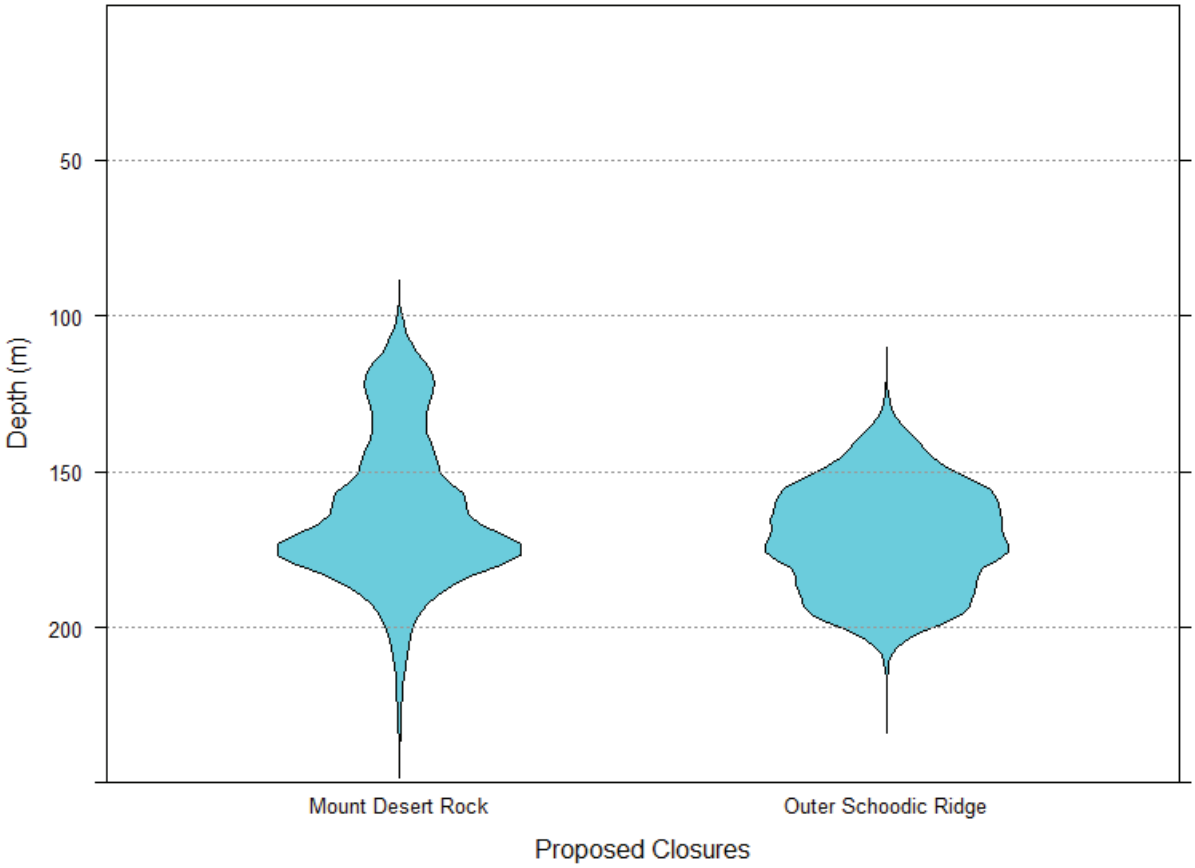

Figure 8. Depth distribution of the proposed closures based on the bathymetry shapefile[2].

Spatially specific industry contributions on potential coral closure

Interviews with lobster industry members indicated that lobster harvesting is the primary economic driver for both Washington and Hancock Counties, the counties adjacent to the closures. The proposed closed areas have recently become particularly important fishing grounds for vessels originating from these counties during the late fall, winter, and spring. Industry members reported that both areas are fished year-round by a smaller number of fishermen. Roughly 35-50 boats from both Zones B and C fish the Mount Desert Rock Area which has become an increasingly valuable fishing ground over the past decade. The Outer Schoodic Ridge Area is fished by at least 50 boats from both Zones B and A and is historically an important fishing area. Combined, the two areas are currently fished by boats from at least 15 different harbors in the two counties across the three zones. Most of these boats employ two crew members in addition to the captain. Areas around the borders of these potential closures are also heavily fished so displacement of effort would likely cause conflict.

Expansion Results

Expansion Method 1: Proportions by distance from shore

Data derived from Tables 4 and 5 were used to apportion trips, value, and landings to distance from shore categories within each zone (Figures 9, 10 & 11). The proportions derived from the 2011-2014 combined harvester and VTR data were used to allocate the totals from the dealer data into different spatial areas. For the Mount Desert Rock area, the value, landings and trips for Zone B between 3 and 12nm was estimated to be $15.3 million and 3.6 million pounds from more than 4,300 trips. The area outside of 12nm in Zone A, surrounding the Outer Schoodic Ridge closure, the numbers were $9.8 million and 2.1 million pounds from about 1,900 trips. Some uncertainty was introduced using this method of combining two data streams because fishermen report the zone fished in the harvester report and VTR, while the total fleet value, pounds, and trips collected by the dealers were attributed to the port and zone where the harvest was sold. With this in mind, some of the 3-12nm region data for Zone C dealer reported value could be attributed to Zone B and some of the greater than 12nm data from Zone B could be attributed to Zone A.

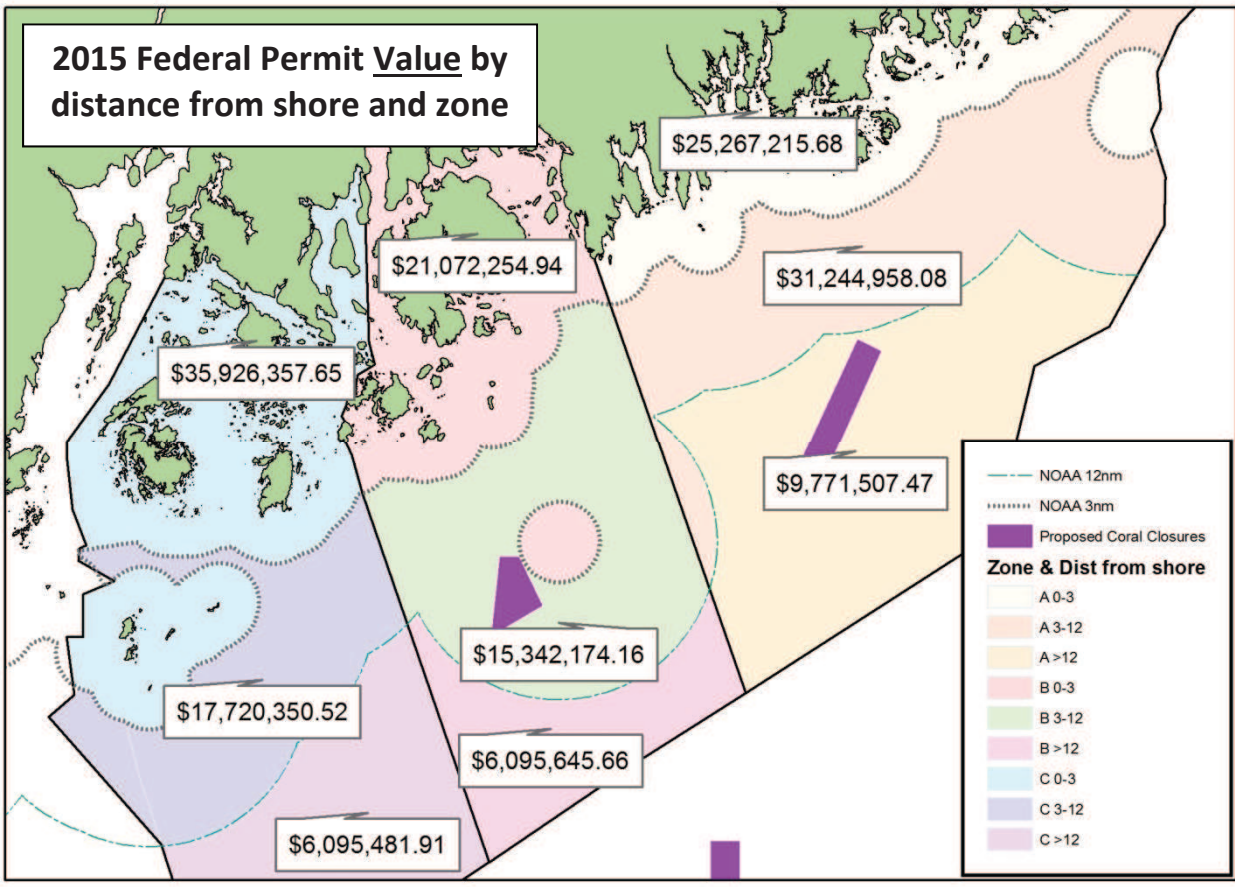

Figure 9. Value from 2015 Maine dealer data by distance from shore (nm) in each zone. Value allocation was based on the average proportions from 2011-2014 from the combination of harvester reports and selected VTRs. Only federal permit data were included.

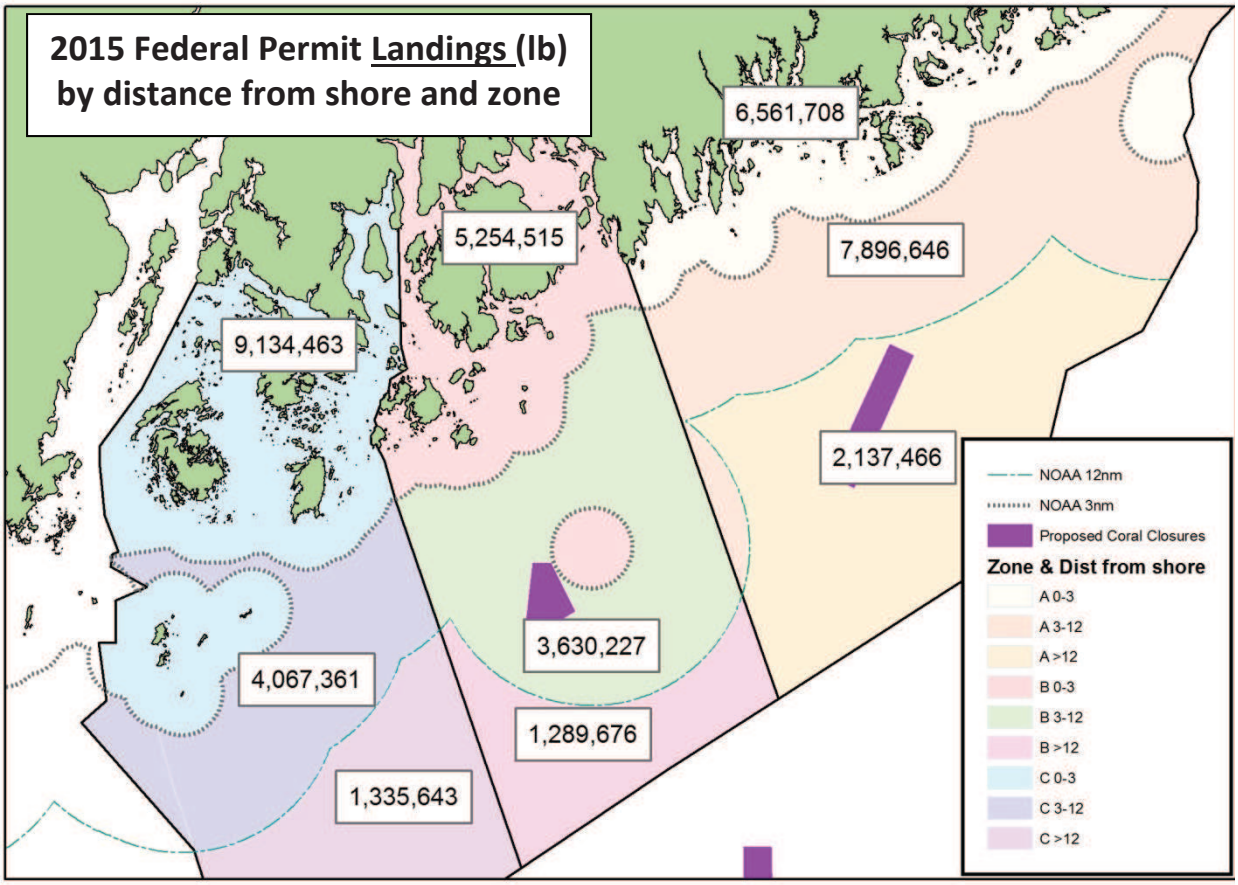

Figure 10. Landings from 2015 Maine dealer data by distance from shore (nm) in each zone. Landings were allocated based on the average proportions from 2011-2014 from the combination of harvester reports and selected VTRs. Only federal permit data were included.

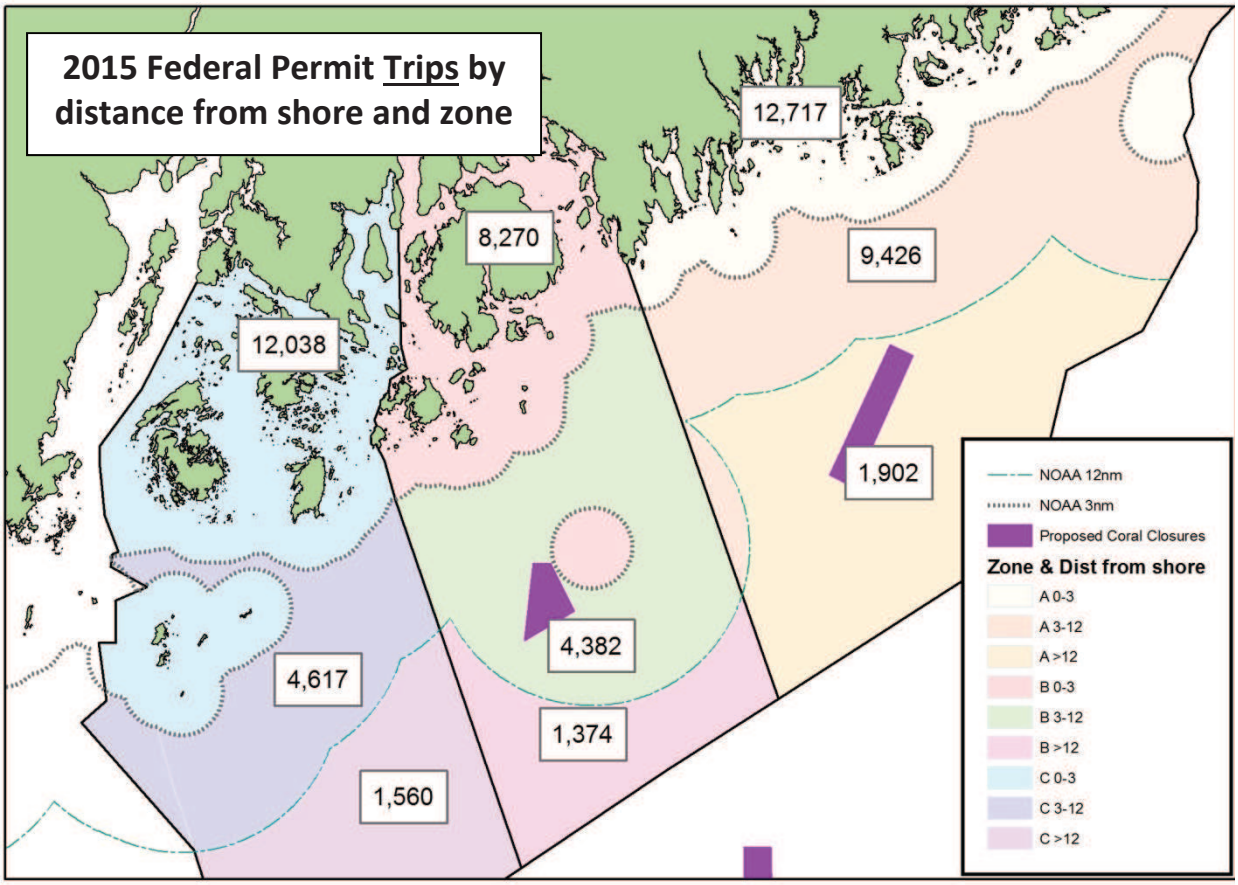

Figure 11. Trip from 2015 Maine dealer data by distance from shore (nm) in each zone. Trip allocation was based on the average proportions from 2011-2014 from the combination of harvester reports and selected VTRs. Only federal permit data were included.

Expansion Method 2: Average value of trip and number of boats

The second method for estimating the revenues associated with specific closure areas used a combination of industry input and average trip values from the harvester data. Interviews indicated each area supported a maximum of 50 boats in the late fall, winter, and early spring (MLA/DMR Interviews). We limited the analysis to the months of November through April, understanding that some effort does occur year-round. To account for uncertainty in the numbers of boats over time, we conducted the analysis for two levels of fishing effort: 50 and 25 boats per area. Additional uncertainty was recognized because the proportion of income and gear per license for the specific closure areas was unknown. Assuming that the boats were unlikely to derive 100% of their income from these discrete coral protection areas, we used 100% as a maximum, 50% as the moderate level, and 25% as the minimum.

Expansion of these industry numbers was based on average value per trip and average trips per month per license estimated from the 2011-2014 harvester logbook and selected VTR dataset for the two regions containing the proposed closures (Table 6). The value ranged from a maximum $6,610 per trip in Zone A, >12nm in November to a minimum $1,129 in Zone B, 3-12nm in April. In general, the average number of trips for each permit was highest in the fall

and lowest in January through March. The revenues were summed over both areas and the number of boats was held constant over all included months. The estimated revenues ranged from a maximum of $8.5 million to a minimum of around $1 million from 50 boats, 100% income and 25 boats 25% income, respectively (Table 7).

Table 6. Average value per trip and number of trips per permit per month from the combined harvester report and VTR dataset 2011-2014 for the two specific regions of the potential closures.

Average VALUE per trip (from combined harvester/selected VTR)						
	Jan	Feb	Mar	Apr	Nov	Dec
Zone A >12	$3,260	$3,719	$3,446	$2,632	$6,610	$4,378
Zone B 3-12 mi	$1,822	$1,286	$1,294	$1,129	$3,264	$2,151
Average # of trips per permit (from combined harvester/selected VTR)						
	Jan	Feb	Mar	Apr	Nov	Dec
Zone A >12	3	3	3	4	9	5
Zone B 3-12	3	3	3	5	7	4

Table 7. Expanded revenue estimates using value per trip and number of trips per month with a range of boat numbers and percent income derived from the closure areas.

	100% income	50% income	25% income
25 boats per area	$4,250,650	$2,125,325	$1,062,663
50 boats per area	$8,501,300	$4,250,650	$2,125,325

Expansion Method 3: Percent of Area

High uncertainty was associated with the Expansion Method 3 because of the assumption that every square mile of ocean habitat was equally productive lobster bottom; however, this approach did account for the error associated with boats fishing in adjacent zones and reporting in their home port by combining the three zones. Average proportions of value, trips, and landings by distance from shore derived from the harvester report and VTR dataset were calculated from the combined data for Zones A, B, and C for 2011-2014 (Table 8). The dealer data provided the total value, trips, and landings for the combined three zones (Table 9). The harvester logbook proportions were applied to the dealer data annually from 2011 through 2015 to estimate the trips, landings, and value for each distance from shore category for the whole area. We focused on the total estimates for outside of 3nm (Table 10). Using the 1.5% area calculation of the proposed closures, the estimated revenue was $1.2 million from 349 trips and ~300,000 pounds landed in 2015 (Table 10).

Table 8. Proportion of value, trips, and landings by distance from shore (nm) from the three zones combined based on harvester and VTR data from 2011-2014. Federal permits only.

		Value	Trips	Landings
Zones ABC	0-3	49%	59%	51%
	3-12	38%	33%	37%
	>12	13%	9%	11%

Table 9. Annual total value, trips, and landings from the three zones combined from the dealer data 2011-2015. Federal permits only.

	Value	Trips	Landings
2011	$ 98,088,305	53,384	31,089,672
2012	$ 107,877,076	56,606	40,374,885
2013	$ 127,118,351	58,273	44,492,387
2014	$ 162,049,914	56,483	44,116,485
2015	$ 168,753,780	56,381	41,342,794

Table 10. Expanded estimates for trips, landings and value for all three zones outside of 3nm and for the proposed coral closures (1.5% of the total area outside of 3nm).

Zone	Year	Expanded trips in >3	Est. trips in coral areas	Expanded landings in >3	Est. landings in coral areas	Expanded value in >3	Est. value in coral areas
A, B, & C	2011	22,015	330	15,100,568	226,509	$49,459,548	$741,893
A, B, & C	2012	23,344	350	19,610,490	294,157	$54,395,388	$815,931
A, B, & C	2013	24,031	360	21,610,403	324,156	$64,097,511	$961,463
A, B, & C	2014	23,293	349	21,427,824	321,417	$81,711,225	$1,225,668
A, B, & C	2015	23,251	349	20,080,614	301,209	$85,091,548	$1,276,373

Discussion

The first step in the expansion process that determined the distribution of revenue value, landings, and trips among the three impacted zones by distance from shore illustrates the high value and level of effort in the eastern Maine lobster fishery (Expansion Method 1). Federal permit holders fish in both state and federal waters. The state waters were the most valuable with the highest landings, but the areas outside of 3nm where the proposed closures are located were also important sources of value and significant levels of effort.

The two expansion methods (Expansion Methods 2 and 3) to calculate the fishery revenues and potential direct impact of the proposed coral closure areas likely provide a minimum and maximum range that should encompass the true value. The Technical Committee was wary of trying to determine revenue at a finer spatial scale than the scale at which the data were collected. We considered the best estimate of the revenue value potentially lost from these closures to be the Expansion Method 2 combining industry interviews estimating boats and months fished with the harvester logbooks reporting average number of trips and value by month. Providing the range of estimates based on the maximum and minimum number boats fishing and percent income associated with the closures was intended to account for the uncertainty in those data sources. Taking the full industry estimate of 50 boats in each area for the fall and winter time period and assuming 100% incomes likely produced an overestimate of revenue. Given that the combined area-based estimate (for Zone A >12 and Zone B 3-12) was $25 million (see Figure 8), the $8 million revenue estimate from these two discrete areas was likely too high. Finding middle ground and relying on the input from fishermen, the $4.2 million

revenue estimate for 50 boats in each area and 50% income for the included months seems likely to be the most realistic scenario to estimate the economic impact of these proposed closures (Figure 12). There are unresolved issues concerning uncertainty in the relationship between the amounts of gear fished, value, and months fished. There was substantial variability in the data for value per trip (as reported through logbooks and VTRs), thus estimates of value could be mis-characterized. Additionally, if half the gear for 50 boats was set in these areas at one time, the trap density could be up to 500-1,000 traps per square mile, which seems unrealistically high.

Expansion Method 3, based on calculated area assumed equal productivity of each square mile outside of state waters in the three zones, likely resulted in an underestimate of revenue. It is unlikely that the entire habitat within Zones A, B, and C is equally productive lobster bottom, especially when boats are fishing further from shore. Attempting to estimate the revenue value for a small subset of the total area introduced high uncertainty and error since neither the 10% harvester data nor the 100% dealer data was collected at a finer spatial scale than distance from shore and/ or zone. The scale of the fishery in eastern Maine and the stated importance of these discrete areas at certain times of the year make the annual estimate of less than $1.5 million (Table 10) seem very unlikely. Fishermen interviews indicated that the proposed coral areas could be two to four times as productive as other bottom habitat so the $1.5 million estimate could scale up closer to the $4.2 million estimate.

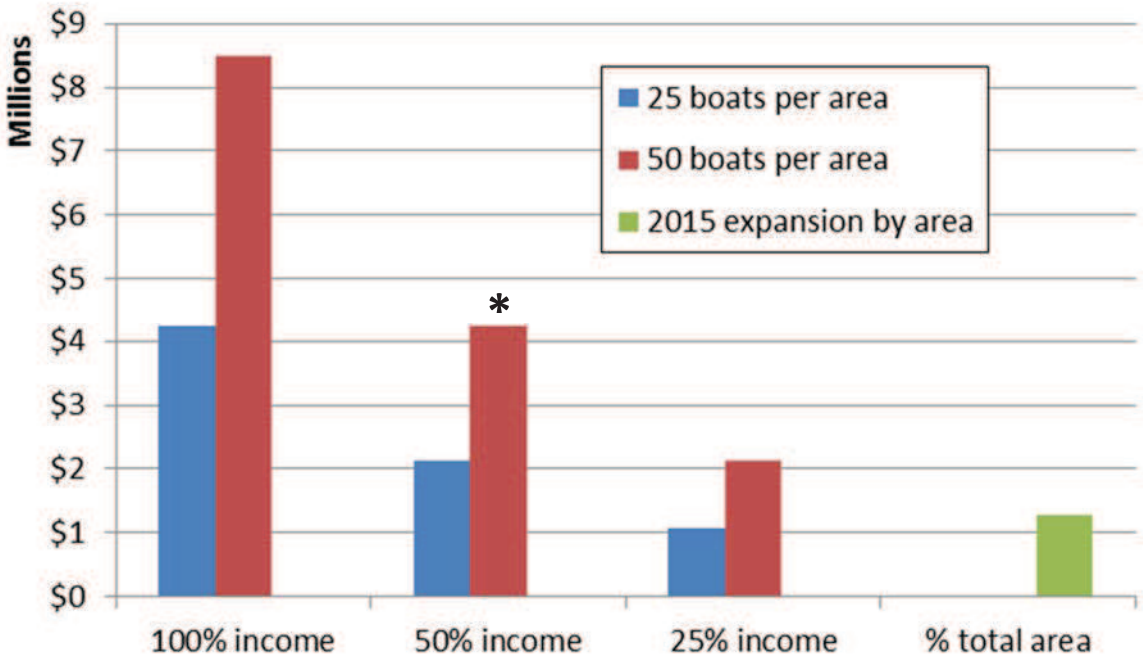

Figure 12. Comparison of revenue estimates based on Expansion Methods 2 and 3. Expansion Method 2 was based on the average value of trip and number of boats with split percent income while Expansion Method 3 calculated the percent value of the total area. The * denotes the scenario determined to best estimate revenues.

Recent observations of corals from ROV surveys were typically found at depths greater than 180m[3]. The Maine logbook data indicates some Maine lobster boats fish at or greater than 180m, but, even during the winter, the fleet does not fish at those depths on average. While the average depth fished by the Maine lobster fleet was less than depths of likely high coral abundance, the depth distribution within the closures does overlap with the fleet's fishing activity as the closures extend to shallower depths (see Figures 7 and 8).

Another source of uncertainty regarding the interaction between the lobster industry and deep sea corals was identified by the industry interviews and could not be quantified. The NEFMC Omnibus Amendment determined that hard corals were most likely to be found in the steepest gradients of depth on hard bottom habitat forming "walls". The lobster fishery is required to use sinking groundlines to prevent large whale entanglements, and this line may chafe when gear is fished near corals or the jagged edges of coral habitat, resulting in loss of gear. Because of this, most fishermen reported trying to avoid corals to prevent the loss of fishing gear.

Whale Co-Occurrence

An additional concern that needs to be addressed relates to the displacement of effort out of closed areas, and the resulting interactions with existing regulations. NOAA Fisheries, in consultation with the Atlantic Large Whale Take Reduction Team, developed a co-occurrence model of endangered right whales and fixed gear fishing effort for the Final Rule of the Atlantic Large Whale Take Reduction Plan in 2014[4]. The lobster industry comprises the majority of fixed gear with vertical lines in this region and is represented in the model using a variety of data sources, including State of Maine dealer and harvester reports, VTR, and fishing practices surveys completed by DMR in 2010. The model explored the overlap of right whales and gear in the form of whale sightings and densities of vertical lines in space and time expressed as a co-occurrence score in ten minute grid cells. The scores have no unit other than the relative amount of overlap between sightings and vertical lines. This can be driven by high numbers of whale sightings, high densities of vertical lines, or the occurrence of both. A plot of co-occurrence scores with the potential coral closure areas was created to show any potential conflicts (Figure 13). The proposed Outer Schoodic Ridge coral closure overlapped with a relatively high co-occurrence score (100-1,000), whereas the other proposed area near Mount Desert Rock did not directly coincide with but is located adjacent to areas of high co-occurrence.

Spatial closures in Maine have been avoided in the Atlantic Large Whale Take Reduction Plan, due in part to concerns about the displacement of effort and the potential to increase the density of vertical lines along the edges of a closure. A similar scenario exists here relative to the proposed coral closures, with displacement of gear creating a higher risk of entanglement in the areas surrounding the closure. For this reason, there is greater concern regarding

[3] Personal communication. M. Bachman, NEFMC 1/24/2017

[4] Final Environmental Impact Statement for Amending the Atlantic Large Whale Take Reduction Plan: Vertical Line Rule. May 2014.

unintended impacts to whales in the Outer Schoodic Ridge area where whales are known to frequent, while the impact near Mount Desert Rock is less certain.

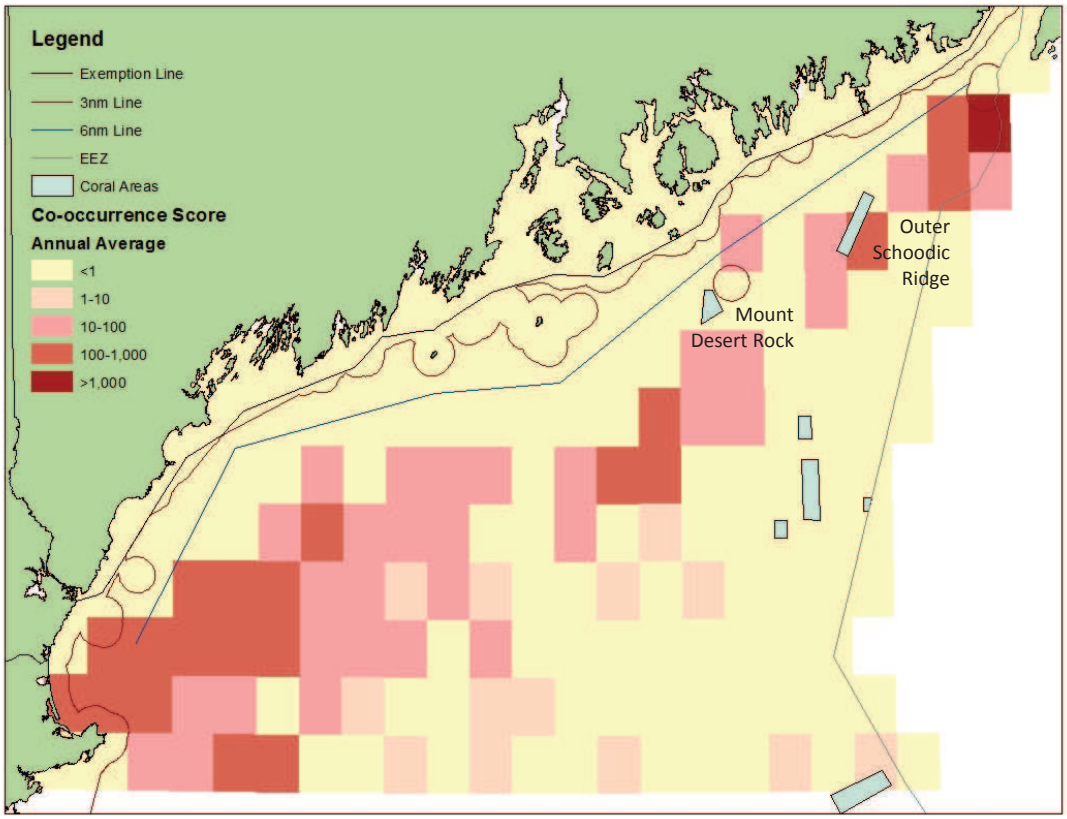

Figure 13. The annual average co-occurrence score in ten minute grid cells shown with proposed coral closure areas. Right whale sightings used to calculate the co-occurrence score include aerial and shipboard standardized surveys from 1978-2011 summarized in the North Atlantic Right Whale Consortium Database and the Navy Marine Resource Assessment Database. Vertical line densities used to calculate the co-occurrence scores include VTR, State of Maine dealer and harvester data, and voluntary gear configuration surveys done by DMR in 2010.

Literature Cited:

Whitmore, K., Morrissey, E., Ware, M., and Glenn, R. 2016. Characterization of the offshore American lobster and Jonah crap trap fishery in Lobster Conservation Management Area 3 in and around the Southern New England and Georges Bank canyons. Prepared for the Atlantic States Marine Fisheries Commission. Updated July 5, 2016; 17pp