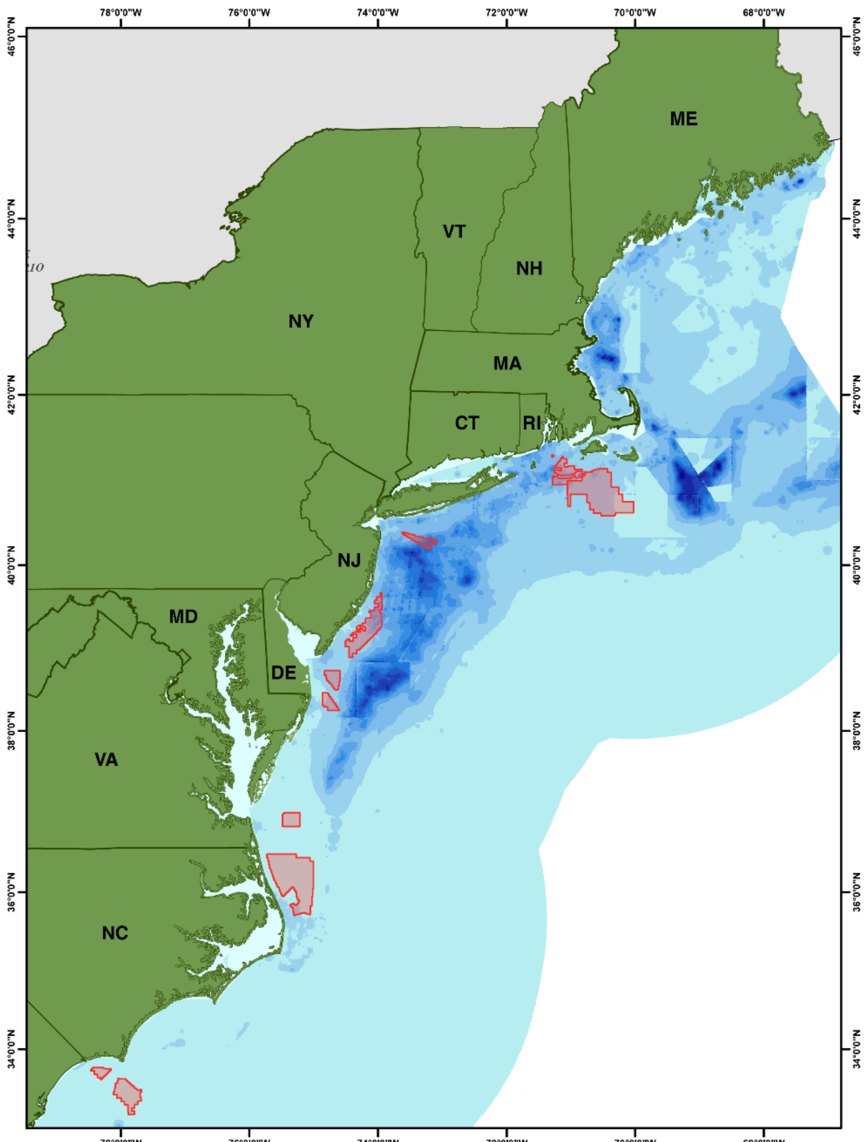
OCS Study
BOEM 2017-012

Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic

Volume I—Report Narrative



U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

BOEM
Bureau of Ocean Energy Management

OCS Study
BOEM 2017-012

Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic

Volume I—Report Narrative

Authors

A. Justin Kirkpatrick, Economist
Sharon Benjamin, GIS Analyst
Geret DePiper, Economist
Tammy Murphy, Economist
Scott Steinback, Economist
Chad Demarest, Economist

Prepared under BOEM Interagency Agreement
No: M12PG00028
by
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Social Sciences Branch
166 Water Street
Woods Hole, MA 02543-1026

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
February 2017

Disclaimer

This study was funded, in part, by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, D.C., through Inter-Agency Agreement Number M12PG00028 with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. This report has been technically reviewed by BOEM and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Report Availability

To download a PDF file of this Atlantic OCS Region report, go to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program Information System website and search on OCS Study BOEM 2017-012.

This report can be viewed at select Federal Depository Libraries. It can also be obtained from the National Technical Information Service; the contact information is below.

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Rd.
Springfield, VA 22312
Phone: (703) 605-6000, (800) 553-6847
Fax: (703) 605-6900
Website: http://www.ntis.gov/

Citation

Kirkpatrick, A.J., S. Benjamin, G.S. DePiper, T. Murphy, S. Steinback, and C. Demarest. 2017. Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic. Volume I—Report Narrative. U.S Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, D.C. OCS Study BOEM 2017-012. 150 pp.

Acknowledgement

Eastern Research Group, Inc. (ERG), under contract M16PD00035, copyedited this report.

Contents

Contents (Continued)

Contents (Continued)

List of Figures

List of Figures (Continued)

List of Tables

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

Abbreviations and Acronyms

AIC	Akaike information criterion
ASMFC	Atlantic States Marine Fisheries Commission
AR	artificial reef
BOEM	Bureau of Ocean Energy Management
CFDR	Commercial Fisheries Dealer Reports
CPUE	catch per unit effort
EMF	electromagnetic field
EU	European Union
FAD	fish aggregating device
FMP	Fishery Management Plan
GC	General Category (Scallop Permit)
GIS	geographic information system
GLM	generalized linear model
LA	Limited Access (Scallop Permit)
MAFMC	Mid-Atlantic Fishery Management Council
MPA	Marine Protected Area
MRIP	Marine Recreational Information Program
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
OWEZ	Windpark Egmond aan Zee (Dutch Offshore Wind Farm)
PII	personally identifiable information
PSP	paralytic shellfish poisoning
RFA	Regulatory Flexibility Act
RNVC	revenue net of variable costs
SAFMC	South Atlantic Fishery Management Council
SRHS	Southeast Region Headboat Survey
USCG	U.S. Coast Guard
VMS	Vessel Monitoring System
VTR	vessel trip report
VTR data	data from VTRs provided by Northeast fishermen and logbooks provided by Southeast fishermen
WEA	Wind Energy Area (used in this report to refer to wind energy areas, as well as wind energy planning area and leases, included in this analysis)

1 Executive Summary

Commercial and recreational fisheries play a significant part in the U.S. economy and food supply. In 2011, U.S. landings by U.S. commercial fishermen totaled $5.3 billion in revenue and 4.5 million metric tons. Commercial harvesting alone employed over 186,000 individuals across the U.S. In 2011, 11 million recreational saltwater anglers caught an estimated 345 million fish during over 69 million trips nationwide (NMFS 2012). The nation's fisheries operate alongside a variety of other ocean uses including transportation, natural resource extraction, and energy production. This report assesses the potential impacts to these fisheries and their shoreside dependents from wind energy development on the Atlantic Outer Continental Shelf (OCS).

This analysis was conducted by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) for the Bureau of Ocean Energy Management (BOEM). BOEM is responsible for managing activities associated with development of Wind Energy Areas (WEAs) on the OCS. Under the National Environmental Policy Act (NEPA) and other legislation, regulations, and executive orders, BOEM is required to assess the potential impacts of WEA development. BOEM will use this report to inform decision-making related to leases on the North and Mid-Atlantic OCS; help interested stakeholders understand how the report data were developed and what they say; identify areas that require refined data analysis; and conduct an environmental assessment under NEPA.

The area covered in this report extends from Massachusetts to North Carolina and includes eight wind energy planning areas, some of which were leased and some of which were still in earlier planning stages at the time of this analysis in 2013. All eight areas are generally referred to as WEAs in this report. Both *exposure* to WEA development and the potential associated *impacts* are assessed for individual WEAs and cumulatively across all eight WEAs. Exposure identifies the individuals and groups likely to be affected by WEA development, while impact analysis estimates the magnitude and direction (gain or loss) of the WEA's impact on those potentially affected individuals and groups.

1.1 Summary of Exposure Results

Exposure is defined as the *potential* for an impact from WEA development. Therefore, the exposure measures presented here do not measure economic impact or loss. Rather, they set the foundation for the impact analysis by identifying who *may be impacted*.

As described below, while commercial and recreational fisheries and their shoreside dependents (e.g., seafood dealers, bait shops) are exposed to WEA development, revenue exposure generally is within normal market dynamics. For example, the total cumulative exposure to commercial fisheries for all eight WEAs from 2007 to 2012 was 1.45 percent. This means that the annual revenue sourced from within all the WEAs is nearly equal to the historical fluctuation in fisheries revenue seen once every five years. Approximately, 6.3 percent ($23.9 million) of annual for-hire gross revenue, and 1.5 percent of shoreside-dependent income is exposed.

Exposure results for commercial and recreational fisheries and their shoreside dependents are presented below. These results describe the magnitude of resources that could *potentially* be impacted by WEA development. As detailed in Section 1.2, a variety of factors can influence economic impact.

1.1.1 Commercial Fisheries

Based on federal permit data, an annual average of about $14.0 million in commercial revenue was sourced from the eight proposed WEAs between 2007 and 2012, representing 1.5 percent of the total annual average commercial fishing revenue generated in New England and the Mid-Atlantic over the same time period. Figure 1-1 shows the location of the eight WEAs (circa 2013), along with the variation in the average intensity of commercial fishing in the New England and Mid-Atlantic region for 2007–2012.

Analysis of commercial fisheries exposure based on percentage and absolute total revenue showed the following results:

- **Ports most exposed in terms of total revenue.** The ports of New Bedford, MA; Atlantic City, NJ; Cape May, NJ; and Narragansett, RI, are the most exposed to potential impacts from WEA development in terms of total revenue.

- **Ports most exposed in terms of the percentage of total fishing revenue sourced from WEAs.** Ports in North Carolina's outer banks, Rhode Island, and Atlantic City, NJ, are the most exposed in terms of the percentage of total fishing revenue sourced from WEAs. Atlantic City is vulnerable in particular due to its social and economic characteristics, particularly gentrification pressure, as assessed by the work of Colburn and Jepson (2012) and Jepson and Colburn (2013).

- **Most exposed gear and vessel classes.** Primary gears and vessel classes exposed to potential impacts from WEA development include clam and scallop dredge vessels greater than 50 feet in length from ports in New York and New Jersey, and pot and gillnet vessels less than 50 feet in length from ports in Rhode Island and the South Coast of Massachusetts.

- **Most exposed species by total revenue.** Sea scallops represent the single most exposed species, with an average of $4.3 million in revenue sourced annually from WEAs between 2007 and 2012. Although this is the highest-revenue species sourced from within the proposed WEAs, the landings constitute only 1.0 percent of the total sea scallop landings over that same time period.

1.1.2 Recreational Fisheries

The analysis examined exposure and impacts on for-hire boats, as well as for-hire and private-boat angler trips. Recreational fishing aboard was considered "exposed" if it occurred within one nautical mile of a WEA during the study period (2007–2012).

- **For-hire boats.** The total average annual for-hire boat gross revenues are $378.3 million, 6.3 percent ($23.9 million) of which is considered exposed to WEAs (see Table III-xii in Section III.iv of Appendix III in Volume II). A total of 1,438 for-hire boats reported fishing between 2007 and 2012, with 25.7 percent reporting fishing in or near the WEAs and considered exposed (see Table 6-49 in Section 6.3.1).

- **For-hire and private-boat angler trips.** Over 103 million for-hire and private-boat angler trips occurred between 2007 and 2012, 3.8 percent of which are exposed to WEAs. New Jersey is the state most exposed to potential impacts of WEA development on recreational fishing, as defined by the number of anglers, number of trips, and permits potentially affected (see Table III-xiii in Section III.iv of Appendix III in Volume II).

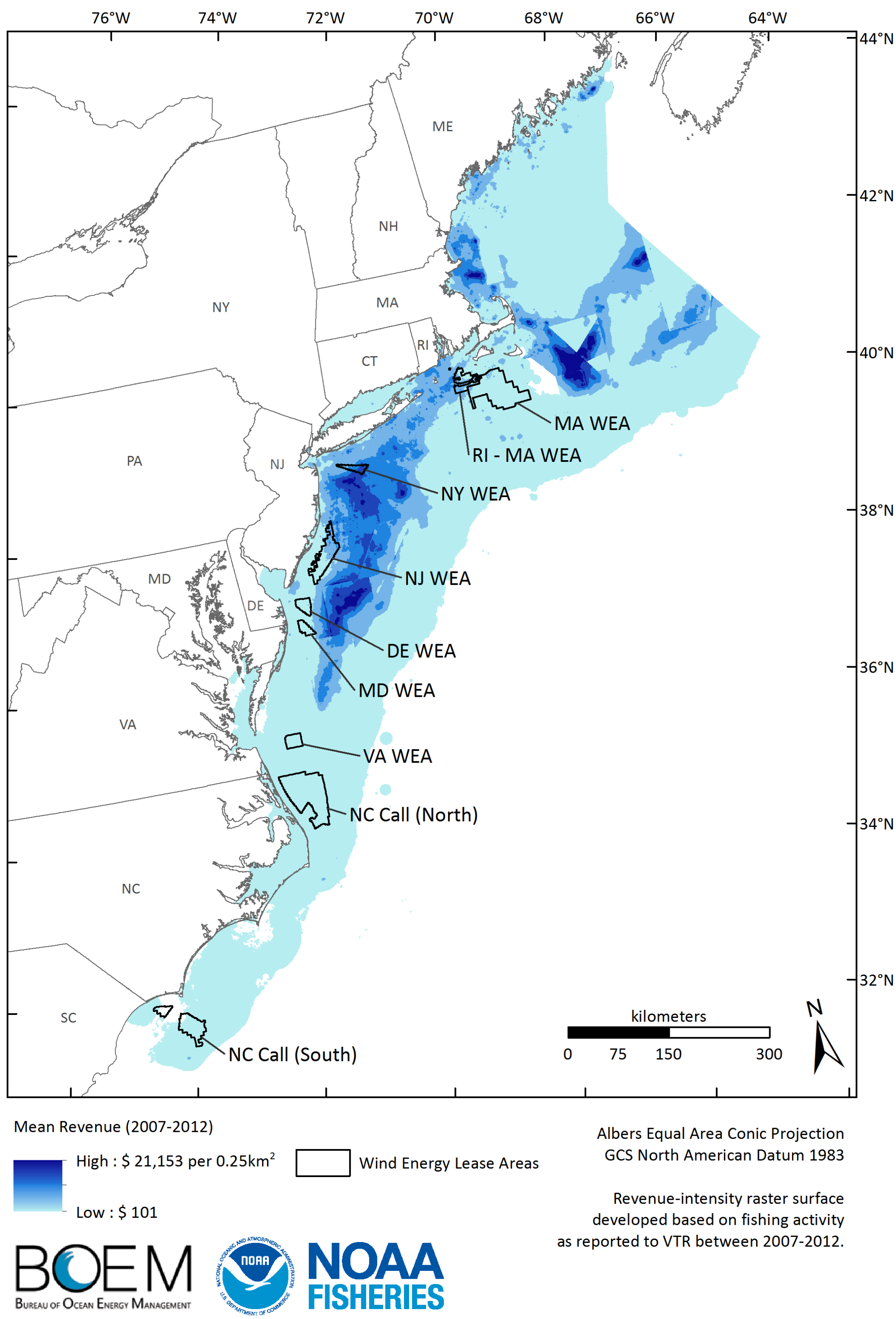


Figure 1-1. Commercial fishing revenue-intensity raster map.

1.1.3 Shoreside Dependents

Shoreside dependents are defined as industries that either directly support (e.g., gas stations, bait and ice dealers, transportation) or utilize (e.g., seafood dealers, restaurants) the landings of commercial and recreational fisheries. WEA-sourced commercial fish landings annually support a total of 199 jobs and $8.3 million in income in the New England region, and 338 jobs and $13.0 million in income in the Mid-Atlantic region. For context, the New England region has 17,484 jobs and wages of $769 million per year, and the Mid-Atlantic region has 17,017 jobs and wages of $684 million per year. Thus, slightly more than 1.5 percent of jobs and just under 1.5 percent of wages are generated from fish harvested in one of the eight WEAs.

Recreationally, trips in and around WEAs annually generate 614 full- and part-time jobs, over $31 million in income, and over $75 million sales across New England and the Mid-Atlantic, which constitute about 4.5 percent of the total across jobs, income, and sales.

With respect to recreational fisheries' direct shoreside dependents, New Jersey is the most exposed state, with about 11 percent of jobs, income, and sales exposed. Additional analysis is needed to determine economic impacts as they change depending on whether equivalent recreational fishing locations are available at little or no cost.

1.2 Impacts

The potential impacts of WEA development on commercial and recreational fisheries and their shoreside dependents are summarized below. They are varied and depend on both the area developed and the fishery exposed. Actual economic impact depends on many factors—foremost, the ability of a given vessel to fish within a WEA, as currently permitted by regulation, as well as the ecological impact on commercially viable fish residing within the WEA. Economic impact also depends upon a vessel's reallocation of effort. For example, if alternative fishing grounds are available nearby and may be fished at no additional cost, the economic impact may be minimal.

1.2.1 Literature Search to Identify Types of Impacts

As a first step, the authors conducted a literature search (summarized in Section 6.1 and presented in Appendix IV of Volume II) to examine the *types* of impacts that might occur during wind energy construction and operation. Results from the literature suggested that:

- **Construction.** The target species of recreational and commercial fisheries likely will be locally displaced during the construction phase of WEA development due to noise and other disturbances. These impacts generally will be localized and short-lived (e.g., within a few weeks of demobilization). See Section 6.1 for details.

- **Operation.** During operation, the WEA structures will likely serve as fish aggregating devices (FADs) in a similar manner to other man-made structures such as oil and natural gas platforms on the OCS. Nevertheless, WEA development has the potential to impact certain targeted species negatively. Anecdotal evidence suggests that WEAs could prevent highly mobile fishing gear, such as bottom trawls, from fully utilizing the developed area. Fishermen may generally avoid WEAs during inclement weather due to the increased risk to safe navigation.

1.2.2 Impacts to Commercial Fisheries and Their Shoreside Dependents

Based on the types of impacts that could occur during operation of a wind energy facility, the authors conducted a quantitative analytical impact assessment that examined scenarios ranging from the negative impacts associated with full closure of the WEA to fishing, to the positive impacts associated with increased catch per unit effort (CPUE) due to biomass increases for target species. The analysis found that impacts were expected to be minimal (see below) except for permitted vessels using pots and gillnets in Rhode Island and on the South Coast of Massachusetts:

- **Rhode Island and the South Coast of Massachusetts.** Only the permitted vessels in Rhode Island and on the South Coast of Massachusetts using pots and gillnets—those primarily fishing within the MA and RI-MA WEAs (with the boundaries defined as of January 2013)—are expected to face measurable impacts from WEA development. Modeling indicates a wide range of potential outcomes across the WEA operational phases and type of potential impact considered. Estimates of annual revenue net of variable costs (RNVC) range approximately from losses of $517,000 to gains of $353,000. These impacts are not distributed uniformly across fishery participants; 20 permits fishing out of the Rhode Island ports of Narragansett and Newport, and the Massachusetts ports of New Bedford and Fairhaven, are the most impacted across scenarios. Thus, development of the MA and RI-MA WEAs is expected to induce slightly negative to neutral impacts on both the pot and gillnet commercial fishermen currently plying these waters and their shoreside dependents.

- **All other WEAs.** The development of all other WEAs is expected to induce minimal impacts on commercial fisheries and their shoreside dependents, regardless of the scenario considered.

- **Permit clusters.** The authors analyzed three additional clusters of permits: scallop vessels along the Mid-Atlantic Bight, surfclam and ocean quahog permits from Southern New England ports, and permits landing in and around Roanoke Island, NC. For the scallop sector, NOAA's model showed a worst-case loss sectorwide of $15,350 to $15,760 in annual net revenues. A positive change was identified for the surfclam and ocean quahog sector as WEA operation pushed vessels into utilizing more productive fishing areas. Results for the NC permits are not relevant now that the majority of analyzed area is no longer under consideration for wind energy development.

1.2.3 Impacts to Recreational Fisheries and Their Shoreside Dependents

Due to a lack of fine-scale fishing location data for recreational fisheries, quantitative analysis of WEA development impacts on recreational fisheries and their shoreside dependents was not possible. Instead, the authors conducted a qualitative assessment for both construction and operational phases of WEA development, which yielded the following results:

- **Recreational fisheries during WEA construction phase.** The construction phase of WEA development is expected to have a slightly negative to neutral impact on recreational fisheries due to both direct exclusion of fishing activities in construction zones and displacement of mobile target species by the construction noise. Recreational anglers in both for-hire and private boats have a great variety of options for offshore fishing destinations, and thus should have suitable alternatives to fish if displaced from within WEAs.

- **Recreational fisheries during WEA operation phase.** Based on the experiences noted in other wind facilities and similar in-water structures, wind turbines will most likely have a neutral or slightly positive impact on recreational fishing activity while in operation, in both the short and long term. These impacts mainly derive from the expected aggregation of recreationally targeted fish that prefer complex hard bottom habitat.

- **Shoreside dependents.** The impacts on shoreside dependents of recreational fisheries are expected to be of the same general duration and magnitude as those to the fisheries themselves.

2 Introduction

2.1 Background and Purpose

Commercial and recreational fisheries play a significant part in the U.S. economy and food supply. In 2011, U.S. landings by U.S. commercial fishermen totaled $5.3 billion in revenue and 4.5 million metric tons. Commercial harvesting alone employed over 186,000 individuals across the U.S. In 2011, an estimated 345 million fish were caught or discarded during over 69 million trips by 11 million recreational saltwater anglers nationwide (NMFS 2012). The nation's fisheries operate alongside a variety of other ocean uses including transportation, natural resource extraction, and, on a limited scale, energy production.

The Bureau of Ocean Energy Management (BOEM) is responsible for managing activities associated with the development of Wind Energy Areas (WEAs) in the U.S. Outer Continental Shelf (OCS). As BOEM moves forward with the potential development of offshore wind energy, the bureau and other policymakers wish to minimize space-use conflicts within the fishing sector. To better understand the impacts of potential WEA development on the U.S. Atlantic OCS, BOEM contracted with the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) to analyze the potential impacts, to commercial and recreational fisheries and their shoreside dependents (e.g., seafood dealers, bait shops), from siting offshore wind turbines in the U.S. Atlantic region.

This report presents the results of that analysis. BOEM will use this report to inform decision-making related to leases on the North and Mid-Atlantic OCS; help interested stakeholders understand how the report data were developed and what they say; identify areas that require refined data analysis; and conduct an environmental assessment, as required under the National Environmental Policy Act (NEPA). Under NEPA and other relevant legislation and Executive Orders, BOEM must assess the potential environmental, social, and economic impacts from WEA development to characterize who may be affected by WEA development and how.

2.2 Analysis Overview

Commercial and recreational fisheries play a significant part in the economy and food supply of the Atlantic OCS region:

- **Commercial fisheries.** Between 2007 and 2012, an annual average of $966 million in commercial fishery revenue in the Atlantic OCS supported almost 17,500 jobs and provided $769 million in income per year in New England. In the Mid-Atlantic region, commercial fishery revenues supported over 17,000 jobs and provided $684 million per year in income.

- **Recreational fisheries.** In the Atlantic OCS region, the private boat and for-hire recreational fishery supported 13,602 full- and part-time jobs, generating $706 million in annual income and almost $1.7 billion in annual sales during that same period.

The area covered in this report extends from Massachusetts to North Carolina and includes eight wind energy planning areas (Figure 2-1), some of which were leased and some of which were still in earlier planning stages at the time of this analysis in 2013. All areas are generally referred to as WEAs in this report. Siting of potential WEAs was often shaped by an extensive public engagement undertaken by BOEM and the Intergovernmental Renewable Energy Task Forces (as established by

BOEM, with one Task Force for each WEA) to proactively avoid the most important fishing grounds, which likely contributed to some WEAs not having substantial exposure.

The boundaries used for analysis were current as of January 2013 (BOEM 2012); however, some refinements have occurred since then (e.g., blocks of OCS were removed before the New Jersey lease sale; two areas of the MA WEA were not leased). See BOEM's Renewable Energy Programs website (BOEM 2016) for publicly available information on the current WEAs. If offshore wind development is pursued in the WEAs, additional data collection and refinement will be needed for NEPA impact assessments.

Given the uncertainty regarding when or if WEAs will be developed, both *exposure* to WEA development and the potential associated *impacts* are assessed for individual WEAs and cumulatively across all eight WEAs:

- **Exposure analysis** identifies which individuals and groups are likely, based on their use of the area for fishing between 2007 and 2012, to be affected by WEA development. Exposure for both commercial and recreational fisheries was examined quantitatively.

- **Impact analysis** estimates how the potentially exposed individuals and groups identified by the exposure analysis may be impacted by WEA development, including the magnitude and direction (gain or loss) of that impact.

    - **Commercial fishery impacts.** The quantitative analysis of impact to commercial fisheries focused on four groups of commercial permits that were found to have the most exposure across the WEAs. The analysis examined scenarios ranging from the negative impacts associated with full closure of the WEA to fishing,[1] to the positive impacts associated with increased catch per unit effort (CPUE) due to biomass increases for target species.

    - **Recreational fishery impacts.** Due to a lack of fine-scale fishing location data for recreational fisheries, quantitative analysis of WEA development impacts on recreational fisheries was not possible. Instead, the authors conducted a qualitative assessment, based on the results of the exposure analysis, for both construction and operational phases of WEA development.

    - **Impacts on shoreside dependents.** Impact analysis was conducted quantitatively for shoreside dependents of commercial fisheries and qualitatively for shoreside dependents of recreational fisheries. In both cases, impacts were expected to mirror impacts to the commercial or recreational fisheries.

[1] Modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario). Some localized limitations on certain gear type usage are possible and will depend on local circumstances as well as safety, operating, and other considerations at the discretion of the fishing vessel operator.

Throughout the analysis, the authors adhered to the following key analytical parameters:

- **Timeframe.** The analysis examines available data on fishing activity for the six years from 2007 to 2012.
- **Scale.** Unless otherwise indicated, all analysis was performed at the landed port level.
- **Dollar values.** All dollar values are reported in 2012 U.S. dollars, unless otherwise noted.
- **Suppression of personally identifiable information (PII).** This study uses data containing PII, which are confidential by law. For aggregated landings, the magnitude of the Atlantic fishery is such that PII is rarely a concern. However, for subgroups of three or fewer individuals, landings data and exposure are not disclosed in detail, and this information is marked as not disclosable and is suppressed when appropriate.

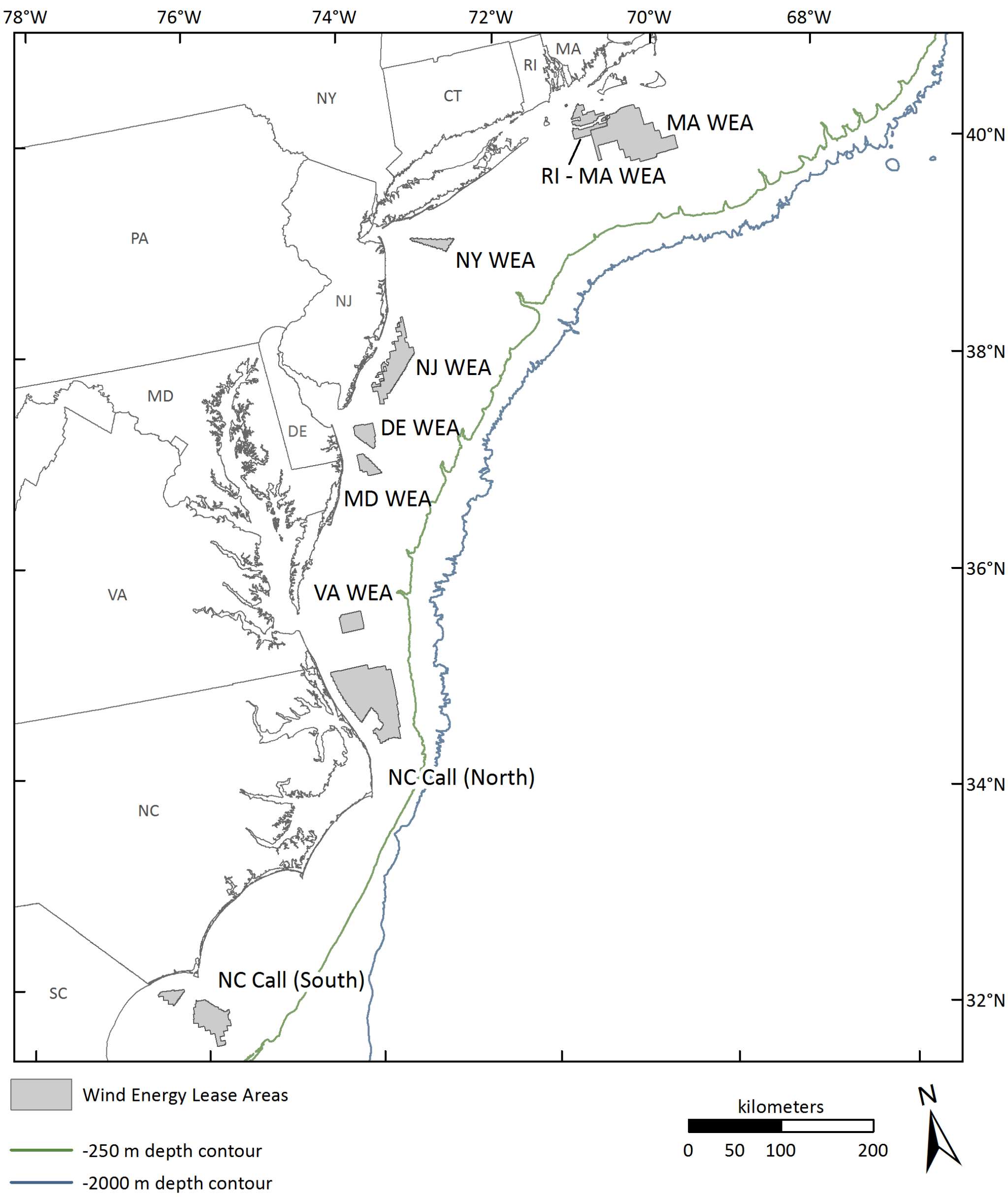


Figure 2-1. Location and extent of WEAs studied.

2.3 Report Organization

The report first presents the methods used for this analysis, followed by the results by individual WEA and then cumulatively across all eight WEAs. Appendices I through IV present additional details on methods and results.

Methods. Section 3 describes the methods used to assess exposure (Section 3.1) and impacts (Section 3.2), followed by the limitations and uncertainly of this analysis (Section 3.3).

Results. Exposure and impact results for the eight individual WEAs are presented in Sections 4 and 5, respectively, followed by the cumulative exposure and impact results across all WEAs in Section 6:

- **Individual WEA exposure results:** Section 4 presents the exposure results, with a separate section for each WEA. Results for commercial fisheries are presented first, followed by results for recreational fisheries.
- **Individual WEA impact results:** Section 5 presents the impact results, with a separate section for each WEA. Results are presented first for commercial fisheries, then for recreational fisheries, and finally for shoreside dependents.
- **Cumulative exposure results:**
  - **Commercial fisheries:** Results for commercial fisheries are broken down by state (Section 6.2.1), species (Section 6.2.2), port (Section 6.2.3), and permit data (Section 6.2.4).
  - **Recreational fisheries:** Section 6.3.1 presents exposure results for recreational fisheries.
  - **Shoreside dependents:** Section 6.4.1 presents exposure results for shoreside dependents.
- **Cumulative impact results:**
  - **Types of potential impacts:** Section 6.1 summarizes the results of a synthesis of literature conducted at the beginning of the impact analysis to identify the types of ecological and economic impacts to fisheries and shoreside dependents that can result from wind energy development. (See Appendix IV for the full synthesis.)
  - **Commercial fisheries:** Results for commercial fisheries are presented separately for each of the four clusters analyzed (Sections 6.2.5 to 6.2.8) and then summarized in Section 6.2.9.
  - **Recreational fisheries:** Section 6.3.2 presents impact results for recreational fisheries.
  - **Shoreside dependents:** Section 6.4.2 presents impact results for shoreside dependents.

For readability, both exposure and impact assessments presented in Volume I focus on main results. Further details are presented in Volume II's appendices:

- **Appendix I, Research Design and Methodology,** provides more information on data sources, general assumptions, and the exposure and impact assessment methodologies summarized in Section 3.
- **Appendix II, Estimation Results,** describes results from the location choice models that provides the foundation for the cluster impact analysis described in Section 3.2.

- **Appendix III, Full Exposure Analysis,** provides additional details of the exposure results presented in the main report.

- **Appendix IV, Synthesis of Literature on Potential Ecological and Economic Impacts,** presents the results of the literature synthesis summarized in Section 6.1.

- **Appendix V, References,** provides a combined list of all references cited in the main text and appendices.

Unless otherwise noted, tables that present original data developed as part of this analysis do not have citations.

3 Methodology, Limitations, and Uncertainty

This section provides an overview of the exposure methods (Section 3.1) and impact methods (Section 3.2) used in this analysis. Section 3.3 describes limitations and uncertainty associated with these methods. Appendix I provides a more detailed description of the analytical methodology.

3.1 Exposure Methods

3.1.1 What Is Meant by "Exposure"?

The exposure assessment begins by examining exposure for each individual WEA (Section 4) and then aggregates those results to discuss cumulative exposure across all eight WEAs (Sections 6.2.1–6.2.4, 6.3.1, and 6.4.1).

In this report, "exposure" is defined as the *potential* for an impact from WEA development. Depending on the type of fishing and the data available, commercial and recreational fisheries exposure may be measured in different ways. This report assesses exposure in six categories:

- Total revenue for the WEA.
- Commercial revenue by ports.
- Commercial revenue by Fisheries Management Plans (FMPs).
- Commercial revenue by permit and gear type.
- Total recreational expenditures.
- Recreational expenditures by ports.

Exposure measures quantify the amount of fishing that occurs in and near individual WEAs and therefore represent the total fishing activity that *may be impacted* by energy development in the WEAs. Exposure measures presented here *should not be interpreted as a measure of economic impact or loss*. Actual economic impact will depend upon many factors—foremost, the ability of a given vessel to fish within a WEA as currently permitted by regulation, as well as the ecological impact on commercially and recreationally viable fish residing within the WEA. Economic impacts also depend on a vessel's ability to adapt by changing where it fishes. For example, if alternative fishing grounds are available nearby and may be fished at no additional cost, the economic impact will be lower.

3.1.2 Where Do the Fisheries Exposure Data Come From?

No single dataset contains all fishing activity in the U.S. Atlantic coast. Instead, multiple databases hold information on most, but not all, harvesting occurring between Maine and South Carolina. The analysis in this report examines different data sources and makes the appropriate linkages to allow for these datasets to work together to characterize fishing activity in federal waters.

For *commercial* fishing**,** data sources analyzed in this report provide information on commercial harvest by location, species caught, gear type, and port group. By examining catch in multiple dimensions, distinctly affected subgroups of commercial fishermen could be identified and their impacts analyzed.

Different data sources were used for the Northeast and Southeast regions:

- In the Northeast, spatial data on fishery catch are derived from three main sources: Vessel Trip Reports, spatial data from the Northeast Fisheries Observer Program database (NEFOP), and Vessel Monitoring System (VMS). Because the VMS is used to generate high-resolution vessel-specific spatial data, VMS data were used only to analyze specific impacts where appropriate.

- The Southeast reports data in a logbook very similar to the vessel trip reports (VTRs) in the Northeast, so these data are also referred to as "VTR data" in this report.

Both Northeast and Southeast data are referred to as "VTR data" in this report.

Because these datasets do not provide information on the *value* associated with the fishing activities, price data were drawn from a third database: Commercial Fisheries Dealer Reports (CFDR).

Using the VTR and spatial data, the authors defined a method for mapping revenue across the ocean tied to individuals within specific subgroups to create a *revenue surface*. The authors of this study acknowledge that data used in this analysis only provide a partial picture of the fishing activity along the Atlantic coast (see Section 3.3).

For *recreational* fishing, this report analyzes data from several sources:

- **Recreational fishing for-hire vessels in the Northeast**, including charter and head boats fishing north of Cape Hatteras for federally permitted species, are required to submit VTRs to NMFS. Northeast VTR data provide the best spatial information on for-hire fishing activity north of Cape Hatteras.

- **Recreational fishing for-hire vessels in the Southeast** report their activity to the Southeast Region Head Boat Survey (SRHS). The SRHS is divided into geographic areas assigned to port agents. The SRHS includes a dockside intercept sampling component and a logbook component, though this report only utilizes the logbook data, which are self-reported trip summaries of catch and effort for each vessel trip. This analysis designates as "exposed" each SRHS for-hire boat trip that visited any grid cell that intersects a WEA. Grid cells are not well-aligned with the contours of the study WEAs. This may result in an exaggerated estimate of exposed fishing, because for-hire boat trips outside a WEA, but within a grid cell intersecting a WEA, are still designated as "exposed."

- **Private boat recreational fishing** is also an important part of the Atlantic coast economy. The most comprehensive dataset available to estimate private boat recreational fishing activity is the Marine Recreational Information Program (MRIP), an integrated series of surveys coordinated by NMFS to provide estimates of marine recreational catch, effort, and participation across states and fishing modes.

While the landings data provided by VTR (including SRHS) and MRIP form the core of the data analyzed, additional data sources were used to augment and corroborate the core landings data used in this report. See Appendix I for more detail on these supplementary sources.

3.1.3 Establishing Thresholds for Fisheries Exposure

Because of the sheer complexity of commercial fisheries occurring near and around the WEAs from Maine to South Carolina, the authors established thresholds, or minimum exposure levels, to identify subgroups that are more likely to be impacted by WEA development. Subgroups at or above either of these thresholds[2] were included in the exposure analysis:

- An annual average revenue of more than $1 million sourced from WEAs.
- More than 2 percent of the average annual revenue sourced from WEAs *and* total exposed revenue greater than $1,000.

The $1 million threshold ensures that ports that make large economic contributions but are not highly exposed as a share of revenue are included in the analysis. The threshold based on revenue percentage ensures that lower-revenue ports that heavily use the WEAs are also included. For example, this would include small, rural, low-revenue ports that rely almost exclusively on a WEA and may be a community's primary income source, but have total revenues less than $1 million per year. Section I.ii.ii.i in Appendix I of Volume II provides additional detail on the exposure thresholds.

3.1.4 Calculating Fisheries Exposure

3.1.4.1 Commercial Fisheries

Federally permitted vessels are required to submit a VTR for each trip, the requirements of which include indicating a general fishing location as a set of geographic coordinates. These self-reported coordinates do not precisely indicate the location of fishing effort, given that only one point is provided regardless of trip length or distance covered during the trip. In the absence of spatially explicit fishery effort data for many fisheries, the VTR mapping model allows for more robust analysis using VTR data by taking into account some of the uncertainties around each reported point (MAFMC 2016). Using observer data, for which precise locations are available, the model was developed to derive probability distributions for actual fishing locations around a provided VTR point. Other variables likely to impact the precision of a given VTR point, such as trip length, vessel size, and fishery, were also incorporated into the model. This model allows for generation of maps that predict the spatial footprint of fishing. Price information from dealer reports was used to transform VTR catches into revenues. Trip information was used to incorporate information about revenue generated from each trip, resulting in a model that can produce maps of revenue generated for a given set of specified parameters such as gear type, species, or port of landing. The revenue-mapping model covers the years 2007–2012, and can be used to identify areas important to specific fishing communities, species, gears, and seasons to establish a baseline of commercial fishing effort.

NMFS presented data and methods used for this analysis to the Mid-Atlantic Fishery Management Council during the April 2014 meeting in Montauk, NY. Briefing materials and a recording of the presentation may be accessed at the following link: http://www.mafmc.org/briefing/april-2014.

[2] Note that the authors used different thresholds for the exposure and impact analyses. While both thresholds are based on absolute and percentage values, the impact thresholds (described in Section 3.2.2.1) are lower than the exposure thresholds. This is because the commercial fisheries impact assessment was conducted at the permit level, thus was based on smaller divisions (such as permits with lower total revenue) than used in the exposure analysis (which was based on larger subgroups). Section I.ii.ii.i in Appendix I of Volume II provides additional detail.

The authors acknowledge that data used in this analysis of commercial fisheries exposure only provide a partial picture of the fishing activity along the Atlantic coast (see Section 3.3).

3.1.4.2 Recreational Fisheries

Recreational fishing aboard for-hire and private boats is considered "exposed" if it occurred within one nautical mile of a WEA during the study period (2007–2012). For recreational for-hire fisheries, the authors developed a method of statistically accounting for the spatial distribution around the self-reported VTR location. This method is described in detail in Appendix I. Fish caught recreationally by private boats do not have associated revenue since they are not sold. Therefore, the value of recreational fishing is also estimated from the MRIP data. Data at both the boat and angler level were used for the exposure analysis:

- **Boat level.** Recreational fishing exposure of for-hire *boats* was assessed in terms of the average annual number and percentage of exposed boats, trips, and revenues. (Private boats were not included due to the lack of fine-scale fishing location data at the boat level.)

- **Angler level.** Angler exposure in both for-hire and private boats was estimated in terms of average annual number and percentage of exposed angler trips and expenditures.

3.1.4.3 Shoreside-Dependent Exposure

Exposure of shoreside dependents is analyzed cumulatively for commercial and recreational fisheries in the New England and Mid-Atlantic regions using economic data (e.g., shoreside sales, income, and employment data). Results are presented in Section 6.4.1.

3.2 Impact Methods

This section describes the methods used to assess the potential impacts of offshore wind energy development on fishing in the U.S. Atlantic. The impact assessment included multiple components to examine how WEA development may impact the region's ecological systems and how WEA development would affect fishing behavior and revenue in commercial and recreational fleets and, in turn, their shoreside dependents. The impact assessment examined cumulative impacts across all WEAs, as well as impacts on individual WEAs. The key components of the assessment, described below, are as follows:

- Synthesis of literature on potential ecological and economic impacts (Section 3.2.1).

- Assessment of cumulative impacts across all WEAs on:

    - Commercial fisheries (Section 3.2.2) and their shoreside dependents (Section 3.2.3).

    - Recreational fisheries and their shoreside dependents (Section 3.2.4).

- Assessment of WEA-specific impacts (Section 3.2.5).

Results of the impact assessment are presented in Section 5 (individual WEAs) and Sections 6.2.5 to 6.2.9 (cumulative impact assessment). Detailed descriptions of data used, specific methods employed, and full results are presented in Section I.iii of Appendix I in Volume II.

3.2.1 Synthesis of Literature on Potential Ecological and Economic Impacts

In what ways might WEA development impact fisheries, both directly and indirectly? To answer this question, the authors reviewed and synthesized the results of current and ongoing research on the ecological and economic impacts of the installation and operation of wind turbines and similar artificial structures around the globe, with particular attention to the experience of fishermen in European waters (for which more data are available).

This involved extensive review of both scientific and gray literature, as well as the elicitation of first-hand knowledge shared by a United Kingdom (UK) fisherman who works as a liaison between the fishing industry and wind companies. The review examined:

- **Potential ecological impacts**, including the effects on fish populations from turbine structures, electromagnetic fields, and noise, and the subsequent impact of these effects on commercial and recreational fisheries. Both the potential impacts and how ecological systems adapt to development were examined.

- **Potential economic impacts,** specifically potential boundary and congestion impacts on commercial fisheries.

- **Area accessibility to fishing vessels** to understand how fishing access can change after installation is complete. This section also provides context from the European Union (EU) offshore wind experience.

Results of this review are summarized in Section 6.1. Details of this literature synthesis are presented in Appendix IV.

3.2.2 Cumulative Impacts on Commercial Fisheries

The analysis of cumulative impacts from WEA development on commercial fisheries involved three components:

- **Clusters.** The analysis is based on four 'clusters' (or permit groups) of commercial fishing trips identified in the exposure assessment as earning large portions of revenue from areas of potential offshore wind development relative to other permit groups examined (see Section 3.2.2.2 below).

- **Scenarios.** The authors defined four scenarios to represent the most likely range of potential exclusion that could potentially occur as a result of WEA development (see Section 3.2.2.3 below).

- **Location choice models.** The authors developed a location choice model for each of the four permit clusters (see Section 3.2.2.4 below). Location choice fishery models estimate the likelihood that fishing will occur in each defined patch of ocean based on observed choices and observable characteristics. The end result does not determine a specific vessel's choice, but rather returns a probability for each location fished. The authors modeled potential impacts under scenarios (see Section 3.2.2.3) relevant to each of the four clusters. Results are reported by cluster in Sections 6.2.5 to 6.2.8 and cumulatively for all four clusters in Section 6.2.9. Sections 6.2.5 to 6.2.8 provide additional details of the methodology for each cluster.

Each component is described below and in further detail in Section I.iii of Appendix I in Volume II. In addition, as described below, the authors established thresholds for cumulative impacts on commercial fisheries.

3.2.2.1 Establishing Thresholds for Commercial Fisheries Impacts

As described in Section 3.1.3, the authors established thresholds, or minimum levels for the *exposure assessment* that identify subgroups that are more likely to be impacted by WEA development. With respect to assessing cumulative *impacts* on commercial fisheries, the authors drilled down to the permit level to form the basis for their analysis. For smaller divisions such as permits that have lower total revenue, it is appropriate to use lower percentage and absolute thresholds than for larger subgroups. Accordingly, the authors used different percentage and absolute thresholds for the commercial fisheries impact analysis than for the exposure assessment:

- **Percentage threshold.** The authors adopted a 1 percent threshold commonly used in Regulatory Flexibility Act (RFA) analysis to determine which subgroups to analyze. Although exposure to a WEA is not equal to the "compliance cost" that would be calculated in an RFA analysis, this threshold is informative. Note: The authors' use of this threshold does not imply or designate WEA establishment as a regulatory action, nor does this analysis serve as an RFA certification in any form.

- **Absolute threshold.** For the commercial fisheries impact analysis, the authors use an absolute threshold of $100,000 in WEA-sourced revenue per year at the permit level regardless what percentage that amount is of the vessel's total revenue. This captures vessels that earn very high revenue but only occasionally harvest within or near a WEA and therefore do not reach the 1 percent threshold. In addition, when examining the permits to develop the four clusters, a "highly exposed" threshold was added at 15 percent of a permit's revenue, to focus the analysis on those individuals most likely to be impacted by WEA development.

3.2.2.2 Clusters

To provide a focus for the assessment, the authors studied specific permit groups within the available data and referred to these as "clusters." These clusters are not defined by gear type or vessels leaving from a single state. Rather, they represent specific subsets of individual permits that habitually fished in highly exposed areas during the study period and are most likely to experience the greatest, if any, impacts from WEA development. The four aggregated "clusters" are defined as follows:

- **Cluster 1: Pot and gillnet permits in Rhode Island and Massachusetts' South Coast.** Owing mainly to the size of the MA and RI-MA WEAs, ports from Rhode Island to the South Coast of Massachusetts—including New Bedford, Westport, and other smaller ports in the vicinity—have relatively higher exposure. Among these ports, exposure of gillnetters and pot fishermen varies between 2 percent and 27 percent. This cluster also includes two other highly exposed groups of Cape Cod–based gillnetters—in Harwich Port, MA (15 percent) and Chatham, MA (2.2 percent).

- **Cluster 2: Scallop vessels (General Category permits and Limited Access permits).** Due to the high value of scallop landings, many ports show high revenues sourced from within a WEA, but in a few cases, these revenues are less than 1 percent of total species revenue. Cluster 2 comprises scallop vessels from the six of the eight ports that have a greater than 1 percent exposure of scallop landings sourced from within a WEA (i.e., scallop landings exceed 1 percent of total revenue): Cape May, NJ (1.2 percent); Point Pleasant, NJ (3.4 percent); Point Lookout, NY (10.1 percent); Freeport, NY (16.9 percent); New London, CT (3.2 percent); and Stonington, CT (1.4 percent).[3] Located along the Mid-Atlantic bight from New Jersey to the Rhode Island–Connecticut border, all exhibit exposure within their scallop fisheries, both from dredge and bottom trawl vessels.

- **Cluster 3: Surfclam and ocean quahog permits from New Jersey, Massachusetts, and Rhode Island ports.** As described in Section 6.2.2, surfclam and ocean quahog harvests are the second-highest exposed harvests in average annual revenue (behind only sea scallops) and are significantly highly exposed as a percentage of revenue (6.6 percent). Cluster 3 therefore focuses on surfclam and ocean quahog permits from four Southern New England ports:

    - Atlantic City, NJ, which accounts for the majority of all exposed surfclam and ocean quahog revenue in all WEAs. Atlantic City pulls in over $3 million annually on average (see Table 6-5), and over 30 percent of the permits for Atlantic City are highly exposed (see Appendix III, Table III-xi, in Volume II).

    - New Bedford, MA ($5.8 million, 5.6 percent of all Cluster 3 exposed revenue,) also accounts for a part of the fleet with exposed surfclam revenue (see Appendix III, Table III-v, in Volume II).

    - Two other ports with a total of over $2 million in exposed revenue are located in the Southern New England area (due to the confidentiality criteria described in Section 2.2, the identity of these two ports is not disclosed).

- **Cluster 4: Permits landing on Roanoke Island, NC.** The southern portion of the sizable North Carolina WEA (circa 2013) is sited due east of the Oregon Inlet. Cluster 4 examines the exposure of the following ports located in Dare or nearby Hyde County: Wanchese, NC; Engel, NC; Nags Head, NC; and "Dare County, NC." The final port in Cluster 4 is the designation for all Dare County landings data from Southeast logbook data (NOAA/NMFS Southeast Logbook Database), as this dataset does not designate the individual port names.

  In these ports, the most commonly landed FMPs (from federally reported data) are "None" ($24.8 million, primarily Atlantic croaker, tilefish, king mackerel, shrimp, and Spanish mackerel); summer flounder, scup, and black sea bass species; bluefish; highly migratory species FMP; and mackerel, squid, and butterfish species.

Together, these four clusters **represent 82.5 percent of all exposed revenue** in the study area. The remaining 17.5 percent of total exposed revenue was not modeled. At least one-third of this remaining exposed revenue is from menhaden landings, which were excluded because the menhaden fishery (including the reduction fishery) is not a federally managed species and is not subject to VMS/VTR reporting requirements (as discussed in Section 3.1.2). The lack of available spatial data makes it difficult to relate menhaden harvest to these clusters. It is recommended that economic impacts on menhaden be examined in a future study.

[3] Narragansett, RI ($393,356, 2.4 percent) and Newport News, VA ($3.1 million, 1.5 percent) were not included in the analysis.

Using Cluster 1 (described above) as an example, Figure 3-1 displays fishing revenue-intensity maps to show how the activity of specific permits included in a cluster (fifth frame, bottom left) differs from the activity groupings based on gear type (first four frames).

Each cluster is described in greater detail in Sections 6.2.5–6.2.8.

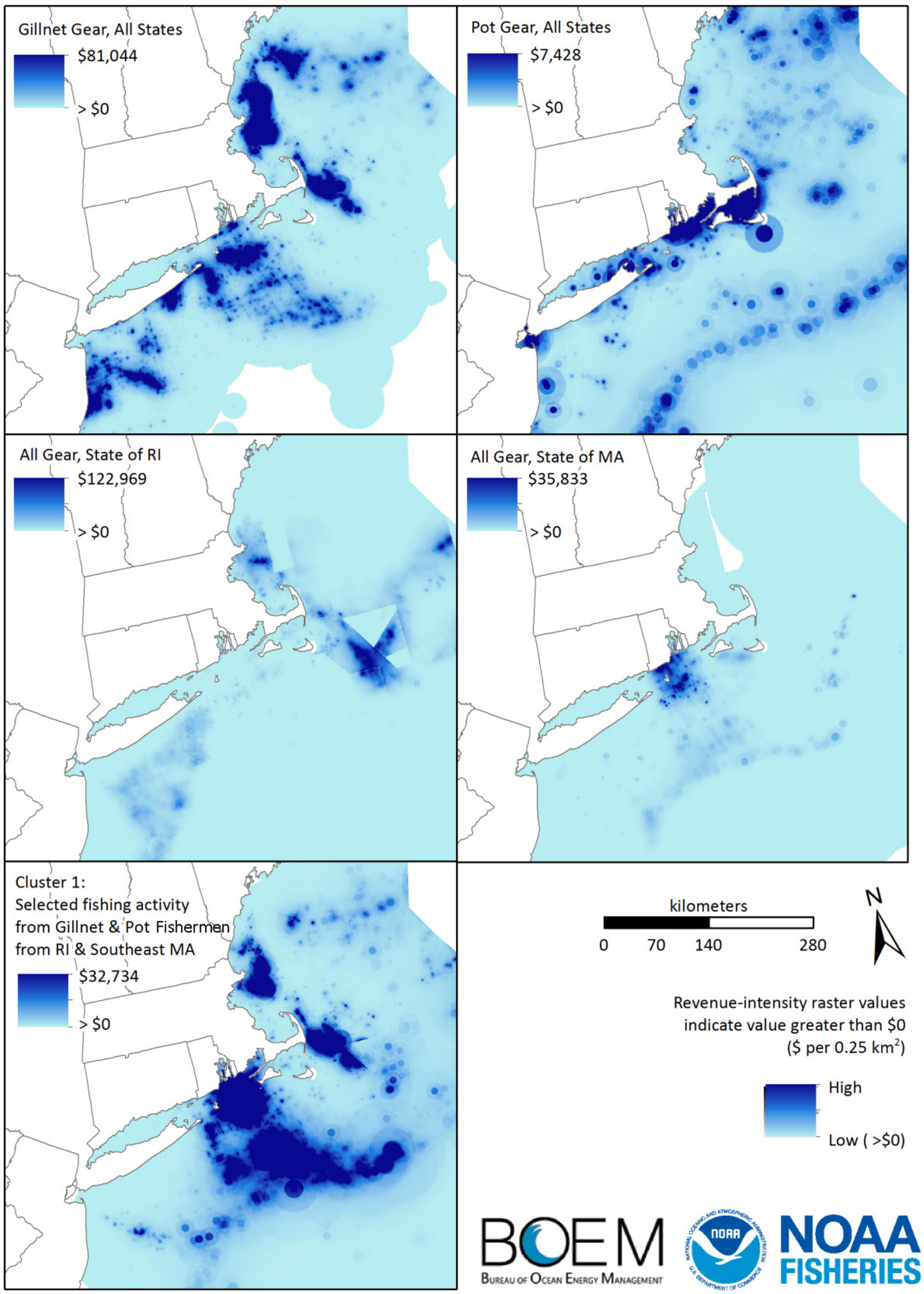


Figure 3-1. Comparison of four groups of permits that use specific gear types (top four quadrants) with a "cluster" of permits that uses specific gear types (bottom left).

3.2.2.3 Four Scenarios

To account for the varied circumstances that could occur as a result of WEA development, four scenarios were modeled:

- **Scenario 1: Fully closed.** This scenario assumes that no fishing will occur within the WEA, but allows the fisherman to select an alternative fishing location. This is a conservative scenario. It provides a potential upper boundary of impact; real impacts will be much lower because there will be no restrictions on vessel access and facility designs will not occupy the entire WEA footprint.[4]

- **Scenario 2: Fully open with biomass impacts.** This scenario assumes status quo in ability to fish in the WEA during operations (i.e., no exclusionary zone). Studies—reviewed in Appendix IV, Section IV.i—on the impacts of offshore wind development on fish abundance and catch report biomass changes ranging from loss of 25 percent to a gain of 7 percent.[5] To determine sensitivity, four catch impact assumptions were modeled:

    - Minus 25 percent catch.
    - Minus 7 percent catch.
    - No impact on catch (referred to as constant catch).
    - Plus 7 percent catch.

- **Scenario 3: Weather-based closure.** Experience in the United Kingdom (Appendix IV) indicates that vessels are reluctant to enter into developed WEAs when winds exceed 9.35 m/second wind speed—a speed generally associated with a wave height of 2–3 m. The analysis incorporated estimates of changes in expected RNVC to account for fishermen's likely alteration of trips to planned WEAs when wind speed exceeds 9.35 m/second.

- **Scenario 4: Gear-based closure.** Experiences in the UK and Northern Europe, as well as conversations with U.S. vessel operators (see Appendix IV), suggest that de facto exclusion zones may occur within parts of the wind energy facility depending on gear characteristics (Industrial Economics, Inc. 2012; Watson 2014). When the fisheries modeled include both

---

[4] Modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario). Some localized limitations on certain gear type usage are possible and will depend on local circumstances as well as safety, operating, and other considerations at the discretion of the fishing vessel operator.

[5] A review of the literature on the impacts of offshore wind development (and artificial reefs, oil rigs, and Marine Protected Areas) on fish abundance and catch is presented in Section IV.i in Appendix IV and summarized in Table IV-i. As described in Section I.ii.i.iv of Appendix I, a rough average of about 7 percent positive changes in abundance can be gleaned from the literature, which matches the abundance change found in Leonhard and Pedersen (2006). Because detrimental ecological impacts are possible as well, a negative range was also established.

mobile (dredge, trawl) and fixed (gillnet, pot, etc.) gear, then the gear-based closure scenario considers the impact of a de facto exclusion for all mobile gear.

3.2.2.4 Location Choice Models

For this analysis, NOAA's Northeast Fisheries Science Center built a location choice model for each of the four permit clusters described above.[6] Location choice fishery models estimate probabilities of fishing in defined patches of ocean (called zones) based on observed fishing activity choices and observable characteristics. The end result does not determine a specific vessel's choice, but rather returns, for each location fished, a *probability* that a particular vessel will fish in that location. For example, if the influence of wind speed (an observable characteristic) on fishing zone choice is known, then for a given trip, a probabilistic estimate of the choices can be calculated based on current wind conditions. If each trip's costs and revenue to each zone can be estimated, then an expected change in revenue net of variable costs (RNVC) can be calculated for each trip. (For details, see Section I.iii.iv in Appendix I, Volume II.)

The location choice models allowed other calculations. For example, by including predicted catch in the model, the analysts were able to estimate a probability distribution of fishing location under various catch scenarios. They also calculated a probability distribution of fishing location for trips using specific gears or under certain weather conditions for fishing scenarios.

For this analysis, revenue was estimated for each trip and zone using observed data on landings, vessel characteristics, time, and location. Total trip costs were calculated from observer-reported variable costs, including fuel, ice, bait, and an average measure of gear damage or loss. Trip costs did not include: (1) payments to crew (because crew payment structures vary—e.g., daily rate, share of landings), and (2) fixed costs related to the vessel, berthing fees, safety equipment, etc. The authors calculated the expected RNVC by weighting the difference in estimated revenues and costs by the probability of fishing in a particular zone.

Model results that feed into the impact analysis described in Sections 6.2.5 to 6.2.9, including revenue and cost estimates, are presented in Appendix II. The limitations of the location choice model are discussed in Section 3.3.2.

3.2.3 Cumulative Impacts on Shoreside Dependents of Commercial Fisheries

For this analysis, the authors used the Northeast Region Commercial Fishing Input-Output Model, developed by NOAA's Northeast Fisheries Science Center, to estimate the impact of commercial fisheries in the local economy in terms of the number of jobs, sales, and income they support (Steinback and Thunberg 2007). Input-output models are the most commonly employed approach used by economists to estimate the total economic activity attributable to marine recreational fishing.

[6] Valuation of a spatially defined patch of ocean has long been an area of study for fisheries economists. Beginning with Bockstael and Opaluch (1983), discrete choice models have been used to analyze fishery behavior, frequently to understand potential impacts of changes in fishery management (Eales and Wilen 1986; Holland and Sutinen 1999; Hicks and Strand 2000; Smith and Wilen 2003; Smith 2005). Estimation of changes in economic welfare followed thereafter (Curtis and Hicks 2000; Hicks et al. 2004; Haynie and Layton 2010).

- **Inputs.** Inputs to the model consist of average annual revenue by sector, where fishing sectors are defined at the gear-region or gear-region-size level (e.g., "Downeast Maine large bottom trawl").

- **Outputs.** For each sector considered, the model estimates total sales, income, and employment dependent on the input revenue. In this analysis, income and employment were the primary data presented. They were delineated by economic sectors, including fishing, processing, and other sectors dependent on both commercial and recreational fisheries.

More detail on this model is provided in Appendix III, Section III.v.

3.2.4 Cumulative Impacts on Recreational Fisheries and Their Shoreside Dependents

Due to a lack of fine-scale fishing location data for recreational fisheries, quantitative analysis of WEA development impacts on recreational fisheries and their shoreside dependents was not possible. Instead, the authors conducted a *qualitative* assessment for both construction and operational phases of WEA development. Results are presented in Sections 6.3.2 and 6.4.2.

3.2.5 WEA-Specific Impacts

WEA-specific impacts were analyzed for both commercial and recreational fisheries, as described below. WEA-specific impacts are presented in Section 5.

3.2.5.1 Commercial Fisheries

To analyze the WEA-specific impacts to commercial fisheries, the authors used the results from one set of scenarios—the "worst-case" scenarios of "Fully Closed"—from the cumulative impact analysis described above. They applied the "Fully Closed" results twice to individual WEAs and their associated clusters: first to examine impacts with only that single WEA developed, and then to examine impacts with all WEAs developed. The results show "WEA-specific impacts" (i.e., how fully closing a single WEA would impact each cluster that fished in that WEA). For example, closing the Massachusetts WEA may impact Clusters 1–3, but will not impact Cluster 4, so for this WEA, impacts were modeled for Clusters 1–3.

This WEA-specific impact analysis focused on the five WEAs (Massachusetts, Rhode Island–Massachusetts, New York, New Jersey, and North Carolina) that met or exceeded the exposure thresholds described in Section 3.1. Given the uncertainty regarding when or if WEAs will be developed, impacts were assessed both individually for each of these five WEAs and cumulatively across all five WEAs.

The other three WEAs (Delaware, Maryland, and Virginia) were excluded from the WEA-specific impact analysis because of their low potential for exposure. As described in Section 2.2, potential WEAs were developed with involvement of the Intergovernmental Renewable Energy Task Force established for each WEA and were sited to avoid the most important fishing grounds based on input received from a public engagement process organized by BOEM. The low exposure for the Delaware, Maryland, and Virginia WEAs is in part a result of this intentional avoidance.

3.2.5.2 Recreational Fisheries and Shoreside Dependents

Analysis of recreational impacts was based on the exposure results (described in Section 4). Impacts to shoreside dependents were expected to mirror impacts to the commercial or recreational fisheries in that WEA.

3.3 Limitations and Uncertainty

In almost any analysis, data are limited and assumptions must be made; factors central to the analysis (e.g., environmental conditions and human behavior) vary in ways that are not entirely predictable; and data must be aggregated to some degree. It is generally not possible to individually analyze the impact to every potentially affected individual, but insights can be provided for the group as a whole. Following standard practice for this type of analysis, the authors identified these factors and designed methods that take them into account to the extent feasible. This section describes the major assumptions, limitations, and uncertainties associated with this analysis and its results.

3.3.1 Data Limitations

As described in Section 2.1, data for the exposure assessments in this reports are sourced from several spatially explicit databases including VMS, VTR, SRHS, and MRIP. The authors of this study acknowledge that data used in this analysis only provide a partial picture of the fishing activity along the Atlantic coast. Known concerns about the data (Battista et al. 2013) include:

- A number of fisheries are not required to report in the VMS/VTR programs. Absence of data does not indicate an absence of fishing activity in the area. Fisheries with known gaps for this project include:
    - Lobster
    - Shrimp
    - Menhaden
    - Harvest of non-federally-permitted species
- VMS data points are associated with only one species, while the fishing vessel may be harvesting multiple species.
- VMS data do not distinguish between steaming, transit, and fishing activity.

Studies of ecological and/or economic impacts of existing offshore wind energy development are another important data source for this analysis. However, currently, only a small number of large-scale offshore wind farms exist worldwide, and most do not cover a time span appropriate for use in analyzing their ecological impacts on fisheries. Therefore, in many cases, the literature and understanding of these processes may be conflicting, or inconclusive. In light of data gaps in this area, the authors also use research on several related environments (described in Section 6.1 and Appendix IV) to provide initial insights on possible ecological and economic impacts:

- **Oil platforms.** Data on oil platforms were used to address changes in biomass, species distribution, and aggregation of commercially viable and recreationally desired fish species.

Oil platforms involve hard, artificial structures that extend throughout the water column and likely represent the best comparison in terms of ecological and economic impacts to fisheries and fishing. However, few oil platforms exist in Atlantic waters, creating some uncertainty concerning extrapolation of oil platform impacts to WEAs.

- **Artificial reefs (ARs) and Marine Protected Areas (MPAs).** Data on ARs and MPAs were also used to address changes in biomass and species distribution and aggregation. However, access to ARs has not been reduced or restricted. Therefore, ARs are only partially useful in understanding fishery responses to WEA development. Literature on the economic impact of "no-take" MPAs is most useful to understand fishery response and the associated economic impacts, as it simulates the "fully closed" scenario described in Section 3.2.2.3.

- **European experience with WEAs.** Because the EU has had working offshore wind farms in existence for some time, qualitative and quantitative data and information from Europe are used to support the findings in this report. The EU offshore wind experience is useful for understanding potential impacts; however, differences between the Europe and the U.S. create some level of uncertainty. For example, ecological response to turbine installation in Europe and U.S. may differ due to differences in species composition, sediment profiles of the ocean floor, and external pressures. Also, the U.S. and EU fishing economies differ in fleet composition, fishery history, market demands for species, and regulatory structures. These differences could lead to different outcomes in response to wind turbine construction on both sides of the Atlantic Ocean even when that construction is identical. Conclusions based on the EU experience should therefore be considered with this caveat in mind.

This report is based on potential ecological and economic impacts described in the available literature for existing WEAs and related environments. However, due to the uncertainties noted above, the possibility exists that wind turbine development and operation may impact fish populations in positive or negative ways that have not yet been documented. Impacts to each particular project will depend on a variety of project-specific factors, including technology design choices, mitigation features, and environmental characteristics.

3.3.2 Limitations and Assumptions for the Location Choice Models

Compiling a single, tractable model covering every fishery that is active within the study area would not be feasible. Further, many fisheries simply do not coincide with proposed WEAs, especially given that WEAs were designed to avoid known high-value fishing areas. The location choice model is the best tool available for this type of analysis; however, like all models it has limitations and assumptions, as described below.

In a location choice model, each zone is assumed to have some utility of use to each fisher. That utility is assumed to be influenced by (1) observable variables such as revenue net of variable costs (RNVC), and (2) time-varying conditions such as wind speed. Although expected RNVC and wind speed can be observed, researchers cannot directly observe their relative importance to fishermen—for example, how much more revenue a fisherman would require from a zone to make up for a 1 m/s increase in wind speed. Researchers also cannot observe several other factors relevant to the analysis, such as the fishermen's personal tastes, specific knowledge of fishing conditions gleaned from a network of personal relationships, and historic habits. These unobserved factors vary over areas and over time, making the relative importance of these variables difficult to measure and include in the analysis.

Another limitation to a location choice model is that there are caveats on the economic interpretation of the results. Those caveats are discussed briefly in Sections 3.3.3 and 3.3.4; more detailed information can be found in Appendix I, Section I.iii.i.

A number of assumptions underlie this method. For example, because the model data are based on trips actually taken, the model assumes that fishermen always choose to fish, and thus cannot estimate a change in the number of trips regardless of the location choices. As a result of this assumption, the model results may include trips with large negative changes in RNVC (for example, when a vessel usually fishes in one specific area where revenue is high and costs are low, and all other areas are comparatively low in revenues and high in costs). Conversely, this assumption can lead to large positive impacts in some cases, even though fishermen likely are already making the most profitable choices for their fishing trips.

The location choice model employed here also assumes no time shifting of WEA-displaced effort. For example, if a trip occurred on a given day, the model assumes the trip remains on that day even when it occurs at a different location. However, revenues are calculated at either the monthly or quarterly level for each vessel. Therefore, small temporal shifts would not change the model's outcome. Shifting between seasons, however, is a possible response, but cannot be accounted for in this model. Likewise, port-switching could occur in the medium-term. Permanently moving ports may give fishermen the ability to fish second-best areas without incurring costs as high as those estimated based on the observed landing port. This model does not account for this behavior, which could improve net revenues and mitigate negative impacts from WEA development to an unknown extent.

In addition to limitations associated with the model itself, the economic interpretation of results is also subject to caveats, as described in Sections 3.3.3 and 3.3.4 and discussed in more detail in in Appendix I, Section I.iii.i.

3.3.3 Assumed Versus Actual Behavior

In this analysis, as in every economic analysis, the populations included in the analysis—fishermen in this case—are assumed to behave in an "economically rational" way. That means they are assumed to maximize profit by factoring in the trade-off between travel costs and the quality of the fishing ground. However, a common criticism of economic models is that the subjects do not always behave the way that economic theory states they should. Though the location choice models and analysis developed for this report fit fisherman's behavior on the whole, they fail to fully explain each individual's behavior independently. The analysis presented here contains instances where, based on the observed data, some fishermen did not appear to choose the fishing location that economic theory would suggest they would, based on the assumed economic rational, profit-maximizing behavior.

3.3.4 Aggregated Versus Individual Impacts

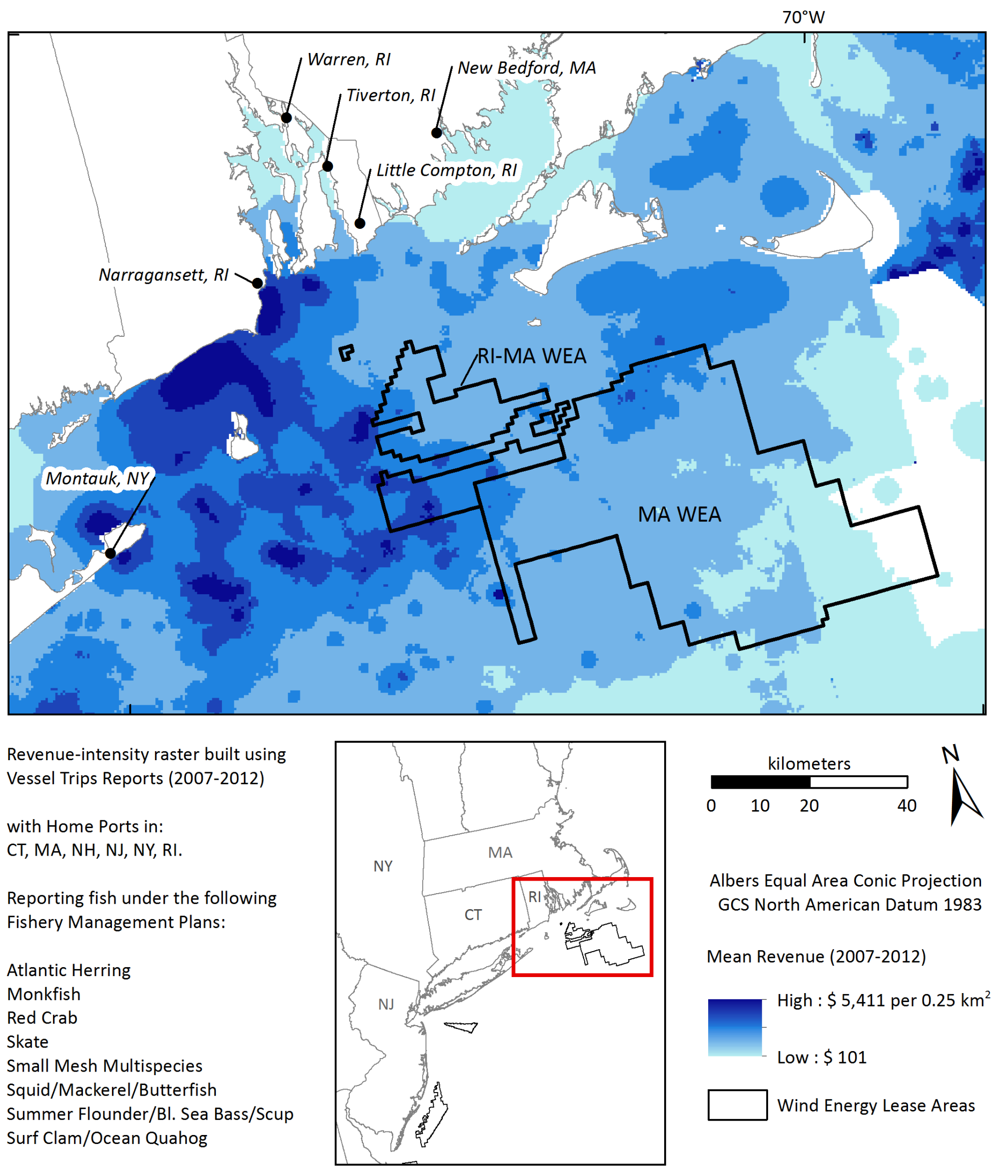
This analysis does not address impacts on individual fishermen.

U.S. fisheries require examination at a regional or finer scale in order to capture the dynamics in different subgroups due to the variations in environment and socioeconomic conditions. For example, landings revenue may be increasing statewide, but simultaneously decreasing in particular ports in that state. This may happen when consolidation of a fleet improves the economic health of one community but draws vessels, dealers, or catch allocations from another. Essentially, one external influence may affect two different ports or gear types in different ways, which is not captured at an aggregated level. Conversely, effects may be minor across the board, but significant when aggregated over a region. Also, when using monetary values as the foundation for analysis, species with lower dockside values may be underrepresented in the analysis. Therefore, the analysis in this report employs a multi-level strategy to assess exposure and vulnerability, and in the design of the economic impact models. However, even at the most local level of this analysis, data are aggregated to some degree to describe impacts on fishermen in the particular subgroups examined. Thus, this analysis does not address impacts on individual fishermen, whose actual impacts will depend on several factors, including factors that may lead them to behave differently than assumed in the analysis.

4 Exposure by Individual Wind Energy Area

4.1 Massachusetts WEA

The MA WEA (Figure 4-1) (circa 2013), with all four lease areas, is the source of approximately $3.03 million in total revenue per year, equivalent to $1,009 per km². This ranks the WEA as the fourth most valuable (per km²) of the eight WEAs studied, behind the NY WEA, the neighboring RI-MA WEA, and the NJ WEA. As of December 2016, only 48 percent of the MA WEA has been leased.



BOEM Bureau of Ocean Energy Management NOAA FISHERIES

Figure 4-1. Commercial fishing activity from ports most exposed to the MA WEA, 2007–2012.

4.1.1 Commercial Fisheries

4.1.1.1 Ports and Fishery Management Plans

For commercial fisheries, the MA WEA is relied on primarily by Rhode Island ports fishing with gillnet, pot, bottom trawl, and midwater trawl gear (see Table 4-1, which shows the most affected ports based on percent total revenue exposed). Landings from the WEA consist mainly of small mesh species (hake, squid), ocean quahogs, skates, monkfish, and Jonah crab (Table 4-2). Four other ports are also exposed but to a lesser degree (less than 1 percent of revenue exposed, with revenue sourced from the MA WEA ranging from $53,000 to $83,000): Chatham, MA; Newport, RI; Fair Haven, MA; and Gloucester, MA. See Table III-ix in Appendix III, Volume II for more details.

Table 4-1. Commercial ports most exposed to the MA WEA, 2007–2012.

Port Group	Average Annual Revenue from MA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to MA WEA
Warren, RI	Not Disclosable	Not Disclosable	—
Tiverton, RI	$64,543	$834,891	7.7
Little Compton, RI	$59,391	$1,734,344	3.4
Narragansett, RI	$666,623	$32,122,869	2.1
Montauk, NY	$211,825	$16,077,058	1.3
New Bedford, MA	$1,416,869	$292,229,242	0.5

Table 4-2 identifies the management jurisdictions, by FMP, exposed to development of the MA WEA. Exposure is less than 4 percent across all FMPs.

Table 4-2. FMPs exposed to MA WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from MA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Small Mesh Multispecies	NEFMC	$368,710	$10,675,728	3.5
Skate	NEFMC	$199,021	$7,796,915	2.6
Monkfish	NEFMC, MAFMC	$340,775	$19,759,447	1.7
Surfclam, Ocean Quahog	MAFMC	$854,205	$64,967,095	1.3
Squid, Mackerel, Butterfish	MAFMC	$357,115	$40,849,295	0.9
Atlantic Herring	NEFMC	$138,193	$23,241,713	0.6
Summer Flounder, Scup, Black Sea Bass	MAFMC	$158,752	$33,166,172	0.5

Note: MAFMC = Mid-Atlantic Fishery Management Council; NEFMC = New England Fishery Management Council.

4.1.1.2 Commercial Permits/Gear

Table 4-3 presents the number of permits and revenue, by gear type, exposed to development of the MA WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

The primary commercial gears used in the MA WEA (by average annual MA WEA-sourced revenue, fourth column) are gillnet, bottom trawl, and dredge. Most dredge revenue is landed in either Massachusetts or Rhode Island, while most bottom trawl revenue is landed in Rhode Island, primarily in Narragansett (which includes Point Judith, RI) and Tiverton, RI, along with Montauk, NY. Most gillnet revenue from the MA WEA is landed in Massachusetts, primarily in New Bedford, but also in Chatham and Fairhaven. Midwater trawl use is heavier in the MA WEA relative to other WEAs, but total revenue sourced by this gear is still less than 1 percent. A notable amount of lobster pot gear revenue comes from within the WEA as well and is landed primarily in Massachusetts.

Table 4-3. Number of permits and revenue, by gear, exposed to development of the MA WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from MA WEA	Percent Revenue from MA WEA	Top 4 FMPs	Top 5 Port Groups
Dredge	88	$486,160,813	$1,057,372	0.2	Surfclam, Ocean Quahog;[a] Sea Scallop;[b] Monkfish;[c] Small Mesh Multispecies[b]	New Bedford, MA; Warren, RI; Cape May, NJ; Stonington, CT; Barnegat, NJ
Gillnet	95	$34,164,385	$447,819	1.3	Monkfish;[c] Skate;[b] Spiny Dogfish;[c] Summer Flounder, Scup, Black Sea Bass[a]	New Bedford, MA; Chatham, MA; Fairhaven, MA; Little Compton, RI; Newport, RI
Hand	24	$8,339,830	$2,772	~0	Unmanaged;[d] Summer Flounder, Scup, Black Sea Bass;[a] Highly Migratory Species;[e] Large Mesh Multispecies[b]	South Kingstown, RI; Narragansett, RI; South Yarmouth, MA; Montauk, NY; Washington County, RI
Long-line	7	$7,399,976	$23,349	0.3	Golden Tilefish;[a] Spiny Dogfish;[c] Large Mesh Multispecies;[b] Summer Flounder, Scup, Black Sea Bass[a]	Montauk, NY; Hampton Bays, NY; Barnegat, NJ; Narragansett, RI
Pot	33	$11,071,430	$5,525	0.1	Summer Flounder, Scup, Black Sea Bass;[a] Unmanaged;[d] Red crab;[b] Large Mesh Multispecies[b]	Westport, MA; New Bedford, MA; Barnstable, MA; Little Compton, RI; Narragansett, RI
Lobster Pot	114	$213,321,675	$282,692	0.1	Unmanaged;[d] Summer Flounder, Scup, Black Sea Bass;[c] Small Mesh Multispecies;[b] Large Mesh Multispecies[b]	New Bedford, MA; Newport, RI; Narragansett, RI; Sandwich, MA; Westport, MA

Gear	Permits	Average Annual Revenue	Average Annual Revenue from MA WEA	Percent Revenue from MA WEA	Top 4 FMPs	Top 5 Port Groups
Bottom Trawl	234	$174,094,198	$1,032,021	0.6	Small Mesh Multispecies;[b] Squid, Mackerel, Butterfish;[a] Summer Flounder, Scup, Black Sea Bass;[a] Large Mesh Multispecies[b]	Narragansett, RI; Montauk, NY; New Bedford, MA; Tiverton, RI; Newport, RI
Mid-water Trawl	21	$21,384,152	$182,118	0.9	Atlantic Herring;[b] Squid, Mackerel, Butterfish;[a] Unmanaged;[d] Small Mesh Multispecies[b]	New Bedford, MA; Gloucester, MA; Fall River, MA; Narragansett, RI; North Kingstown, RI

a MAFMC management

b NEFMC management

c Joint NEFMC and MAFMC management

d Unmanaged species

e AHMS management

Gillnet fishermen in the MA WEA land primarily monkfish, skates, and spiny dogfish, as well as some species from the summer flounder, scup, and black sea bass FMP. Bottom trawl fishermen land primarily species from the small mesh multispecies FMP as well as the squid, mackerel, and butterfish FMP. Of the small mesh species sourced from the MA WEA, silver hake is the most caught—approximately 3.4 percent of all silver hake landings are sourced from the MA WEA. A total of 3.1 percent of all ocean quahogs landed in the Atlantic region are sourced from the MA WEA.

Table 4-4 lists the top 10 exposed species within the MA WEA.

Table 4-4. Top 10 exposed species within the MA WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Hake, Silver	$327,355	$9,592,553	3.4%
Ocean Quahog	$851,030	$27,233,867	3.1%
Skates	$119,890	$6,054,223	2.0%
Monkfish	$340,775	$19,759,447	1.7%
Crab, Jonah	$87,011	$5,130,697	1.7%
Squid (Loligo)	$285,547	$24,867,195	1.1%
Herring, Atlantic	$138,193	$23,241,713	0.6%
Flounder, Summer	$90,433	$22,019,367	0.4%
Lobster	$175,972	$212,474,994	0.1%
Scallop, Sea	$203,180	$428,413,267	0.0%

4.1.2 Recreational Fisheries

Table 4-5 presents the average annual exposure of recreational for-hire boat trips, for-hire and private angler trips, and angler expenditures to development of the MA WEA. At the state level, percent exposure is 1.0 percent or less across recreational trips and expenditures—except for trips departing from Massachusetts that pass through the MA WEA, which have a calculated exposure of 4.4 percent total expenditures.

Table 4-5. State-level average annual exposure of recreational fishery to MA WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
MA	3,972	0.6	54,118	0.1	1,912,662	1.0	$27,192,915	4.4
NH	1,992	~0	49,449	~0	158,473	~0	$3,717,740	~0
NY	7,027	0.2	128,062	0.1	2,652,092	~0	$23,166,177	0.1
RI	2,264	0.5	23,558	0.6	542,768	0.1	$13,400,145	0.4

Table 4-6 presents the exposure of for-hire boat trips, private and for-hire angler trips, and angler expenditures by port group to the MA WEA. Less than 2 percent of trips are considered exposed. Montauk, NY, had the highest annual average for-hire boat trips (16); however, this represented less than 1 percent of the total trips. Average annual angler trips exposed to the MA WEA leaving from Falmouth, MA, are more than 10,000, but represented less than 10 percent of the total annual average angler trips. Angler expenditures exposed to the MA WEA were highest in port groups in Massachusetts. No private angler trips were from New Hampshire, and only one New Hampshire for-hire trip traveled within a nautical mile of the MA WEA.

Table 4-6. MA WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
MA	Barnstable	2	0.6	10	0	~0	$10,871,936	~0
	Chilmark	0	0	0	293	10.0	$186,517	10.0
	Edgartown	~0	8.3	1	344	10.0	$221,693	10.0
	Falmouth	1	0.9	7	10,150	9.8	$7,155,353	9.1
	Nantucket	1	2.4	3	3,775	10.0	$2,441,297	9.9
	New Bedford	~0	0.3	0	0	~0	$3,180,682	~0
	Oak Bluffs	1	33.3	4	624	10.0	$401,243	10.2
	Onset	1	1.8	7	0	0.2	$567,858	0.4
	Other Dukes	0	0	0	291	10.0	$185,329	10.0
	Tisbury	~0	25	1	3,109	10.0	$1,981,008	10.0
NY	City Island	~0	0.2	11	0	~0	$2,472,905	0.1
	Greenport	~0	0.6	1	0	~0	$3,627,097	~0
	Montauk	16	0.5	79	0	~0	$17,066,175	0.1
RI	Little Compton	0	0	0	486	4.0	$483,178	4.0
	Narragansett	8	0.4	130	0	0.1	$7,788,984	0.3

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
	New Shoreham	0	0	0	47	3.1	$108,699	1.7
	Newport	~0	0.8	~0	0	~0	$1,179,298	~0
	South Kingstown	2	2.0	11	0	~0	$2,369,047	0.1
	Tiverton	~0	1.9	1	0	~0	$255,127	0.1
	Westerly	1	1.4	7	0	~0	$1,215,813	0.1
Total		**34**	**0.6**	**271**	**19,119**	**1.8**	**$67,476,977**	**1.9**

4.2 Rhode Island–Massachusetts WEA

The RI-MA WEA (Figure 4-2) is the source of approximately $1.97 million in total revenue per year ($2,960 per km^2), ranking it second in revenue intensity, behind only the NY WEA.

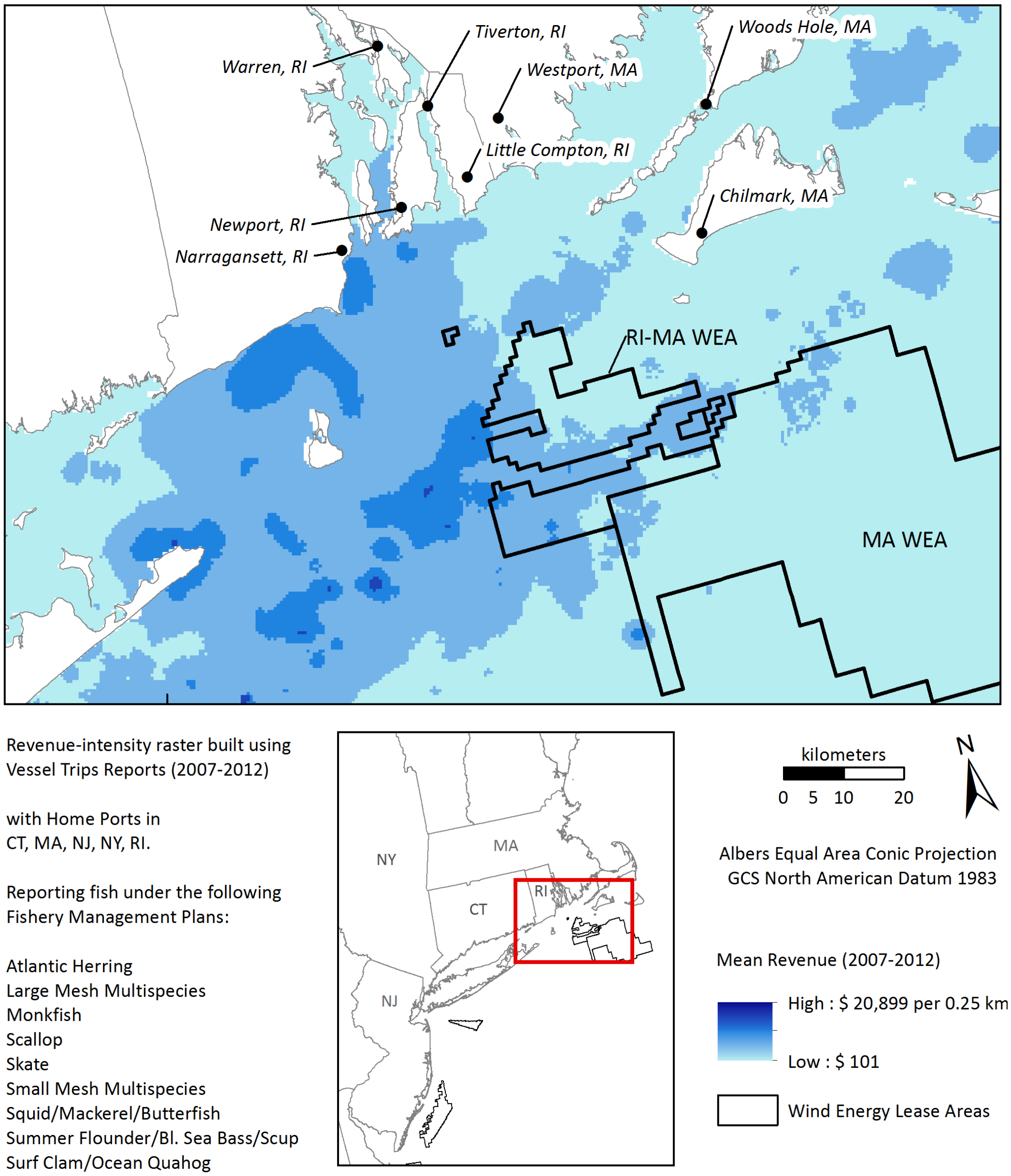


Figure 4-2. Commercial fishing activity from ports most exposed to the RI-MA WEA, 2007–2012.

4.2.1 Commercial Fisheries

4.2.1.1 Ports and Fishery Management Plans

This WEA is a popular destination for commercial vessels landing in Rhode Island and southern coast Massachusetts. Table 4-7 identifies the commercial ports most exposed to the RI-MA WEA. Ports in Massachusetts and Rhode Island are most exposed. The New Bedford, MA, port has the most annual exposed revenue, followed by three Rhode Island ports—Narragansett, Newport, and Little Compton—with more than $200,000 in average revenue from the RI-MA WEA.

Table 4-7. Commercial ports most exposed to the RI-MA WEA, 2007–2012.

Port Group	Average Annual Revenue from RI-MA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to RI-MA WEA
Little Compton, RI	$273,190	$1,734,344	15.8
Westport, MA	$83,203	$1,125,907	7.4
Warren, RI	Not Disclosable	Not Disclosable	Not Disclosable
Chilmark, MA	$22,043	$364,715	6.0
Woods Hole, MA	$17,971	$318,762	5.6
Tiverton, RI	$24,664	$834,891	3.0
Newport, RI	$212,144	$8,869,136	2.4
Narragansett, RI	$461,407	$32,122,869	1.4
New Bedford, MA	$686,991	$292,229,242	0.2
Montauk, NY	$28,050	$16,077,058	0.2

Table 4-8 presents data for the FMPs most exposed to RI-MA development. A mix of both NEFMC- and MAFMC-managed species are sourced within the area. In terms of percent exposure (fifth column), the primary species sourced include skates, monkfish, ocean quahog, and silver hake (small mesh multispecies FMP). Sea scallops represent more than $337,000 in average revenue from the RI-MA WEA, but are less than 0.1 percent of the total species revenue in the Atlantic.

Table 4-8. FMPs exposed to RI-MA WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from RI-MA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Skate	NEFMC	$243,046	$7,796,915	3.1
Monkfish	NEFMC, MAFMC	$436,897	$19,759,447	2.2
Small Mesh Multispecies	NEFMC	$68,964	$10,675,728	0.7
Surfclam and Ocean Quahog	MAFMC	$300,009	$64,967,095	0.5
Summer Flounder, Scup, Black Sea Bass	MAFMC	$90,014	$33,166,172	0.3
Squid, Mackerel, Butterfish	MAFMC	$66,762	$40,849,295	0.2
Unmanaged		$301,739	$248,316,185	0.1
Large Mesh Multispecies	NEFMC	$84,316	$76,625,579	0.1
Atlantic Herring	NEFMC	$21,533	$23,241,713	0.1
Sea Scallop	NEFMC	$337,292	$428,413,267	0.1

4.2.1.2 Commercial Permits/Gear

Table 4-9 identifies the number of permits and revenue, by gear type, exposed to development of the RI-MA WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

Commercial fishing activity in this WEA is primarily executed using gillnet, dredge, lobster pot, and bottom trawl. This WEA is a source for a greater percentage of gillnet revenue in Rhode Island ports, while dredge landings primarily head to Massachusetts. Although New Bedford, MA, is also an important landing port for gillnet revenue, those vessels are fishing in other areas such as the Gulf of Maine or George's Bank. Lobster pot landings are split evenly between Rhode Island and Massachusetts ports.

Table 4-9. Number of permits and revenue, by gear, exposed to development of the RI-MA WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from RI-MA WEA	Percent Revenue from RI-MA WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	101	$486,160,813	$639,853	0.1	Sea Scallop;[b] Surfclam, Ocean Quahog;[c] Monkfish;[d] Summer Flounder, Scup, Black Sea Bass[c]	New Bedford, MA; Warren, RI; Narragansett, RI; Woods Hole, MA; Stonington, CT
Gillnet	92	$34,164,385	$634,417	1.9	Monkfish;[d] Skate;[b] Large Mesh Multispecies;[b] Spiny Dogfish[d]	Little Compton, RI; New Bedford, MA; Newport, RI; Narragansett, RI; Tiverton, RI
Hand	62	$8,339,830	$5,090	0.1	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Highly Migratory Species;[f] Large Mesh Multispecies[b]	South Kingstown, RI; Montauk, NY; Narragansett, RI; Shelter Island, NY; Newport, RI
Long-line	4	$7,399,976	$4,253	0.1	Large Mesh Multispecies;[b] Summer Flounder, Scup, Black Sea Bass;[c] Golden Tilefish;[c] Skate[b]	Montauk, NY; Tiverton, RI

Gear	Permits	Average Annual Revenue	Average Annual Revenue from RI-MA WEA	Percent Revenue from RI-MA WEA	Top 4 FMPs[a]	Top 5 Port Groups
Pot	49	$11,071,430	$9,485	0.1	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Squid, Mackerel, Butterfish;[c] Bluefish[c]	Westport, MA; Little Compton, RI; Narragansett, RI; New Bedford, MA; Harwich Port, MA
Lobster Pot	134	$213,321,675	$296,223	0.1	Unmanaged;[d] Summer Flounder, Scup, Black Sea Bass;[c] Large Mesh Multispecies;[b] Monkfish[d]	Narragansett, RI; New Bedford, MA; Westport, MA; Chilmark, MA; Little Compton, RI
Seine	1	$10,258,052	$0	~0	Squid, Mackerel, Butterfish;[c] Summer Flounder, Scup, Black Sea Bass;[c] Bluefish[c]	Narragansett, RI
Bottom Trawl	190	$174,094,198	$361,138	0.2	Skate;[b] Small Mesh Multispecies;[b] Summer Flounder, Scup, Black Sea Bass;[c] Large Mesh Multispecies[b]	Narragansett, RI; Newport, RI; New Bedford, MA; Montauk, NY; Hampton, VA
Mid-water Trawl	18	$21,384,152	$22,823	0.1	Squid, Mackerel, Butterfish;[c] Atlantic Herring;[b] River Herring;[g] Large Mesh Multispecies[b]	Gloucester, MA; New Bedford, MA; North Kingstown, RI; Fall River, MA; Cape May, NJ

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b NEFMC management

c MAFMC management

d Joint NEFMC and MAFMC management

e Unmanaged species

f AHMS management

g ASMFC management

Gillnet fishermen land primarily monkfish, skates, groundfish, and spiny dogfish on trips to the RI-MA WEA. Dredge fishermen land primarily sea scallops and ocean quahogs, though the RI-MA WEA represents a very small portion (0.1 percent) of total dredge gear revenue in the region. Bottom trawl fishermen land species similar to gillnet fishermen—i.e., monkfish, skates, and spiny dogfish.

Although a number of handgear and generic pot fishermen are active in the area, the total revenue estimated to be sourced by these gears from within the WEA is very low (0.1 percent each). This indicates that the RI-MA WEA likely abuts more productive fishing grounds for these gears, but is not a center of fishing activity itself.

Table 4-10 lists the top 10 exposed species within the RI-MA WEA.

Table 4-10. Top 10 exposed species within the RI-MA WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Skates	$216,554	$6,054,223	3.6%
Monkfish	$436,897	$19,759,447	2.2%
Ocean Quahog	$300,009	$27,233,867	1.1%
Hake, Silver	$59,516	$9,592,553	0.6%
Scup	$25,090	$5,724,624	0.4%
Flounder, Summer	$54,224	$22,019,367	0.2%
Squid (Loligo)	$44,595	$24,867,195	0.2%
Cod	$39,661	$24,541,424	0.2%
Lobster	$282,195	$212,474,994	0.1%
Scallop, Sea	$337,292	$428,413,267	0.1%

4.2.2 Recreational Fisheries

Table 4-11 presents the average annual exposure of recreational for-hire boat trips, for-hire and private angler trips, and angler expenditures to development of the RI-MA WEA. State rankings (third and fifth columns) are generally consistent between the exposure of for-hire boat and angler trips. However, Massachusetts is the second most highly exposed state in terms of private angler trips, but has no significant for-hire activity occurring within the WEA, except for trips originating from Rhode Island.

Table 4-11. State-level average annual exposure of recreational fishery to RI-MA WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
CT	1,314	0.2	17,569	0.3	943,129	0	$13,981,830	0.1
MA	3,972	~0	54,118	~0	1,912,662	1.9	$34,291,859	6.8
NH	1,992	~0	49,449	~0	158,473	~0	$3,717,740	~0
NY	7,027	0.7	128,062	0.7	2,652,092	~0	$21,535,950	0.7
RI	2,264	4.3	23,558	6.0	542,768	3.6	$23,727,372	4.4

Table 4-12 presents the total average annual exposure of for-hire boat trips, private and for-hire angler trips, and angler expenditures to the RI-MA WEA. For most ports within 30 nautical miles of the WEA, for-hire boat trips are minimally exposed. The highest annual number of for-hire boat trips that fished in or near RI-MA WEA were from Montauk, NY (51) and Narragansett, RI (89). These trips represent less than 2 percent of the total leaving from Montauk, NY, and approximately 5 percent of the total leaving from Narragansett, RI. With respect to angler trips and expenditures, port groups in Massachusetts and Rhode Island are most exposed to RI-MA WEA development.

Table 4-12. RI-MA WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
CT	Clinton	~0	0.4	1	0	~0	$1,468,878	~0
	Groton	1	0.4	29	0	~0	$3,722,520	0.1
	New London	~0	0.2	1	0	~0	$1,175,211	~0
	Noank	~0	0.4	~0	0	~0	$331,229	~0
	Pawcatuck	1	7.9	3	0	~0	$406,830	0.1
	Stonington	0	0	0	0	0	$4,778,159	0
CT	Waterford	~0	0.1	12	0	~0	$2,099,002	0.1
MA	Chilmark	0	0	0	293	10.0	$186,517	10.0
	Edgartown	0	0	0	344	10.0	$221,693	9.9
	Fairhaven	0	0	0	3,257	10.0	$2,074,312	10.0
	Fall River	0	0	0	4,133	10.0	$2,632,396	10.0
	Falmouth	1	0.5	3	10,150	9.8	$7,155,353	9.1
	Marshfield	~0	~0	~0	0	~0	$9,322,900	~0
	New Bedford	~0	0.3	~0	4,067	9.6	$3,180,682	8.2
	Oak Bluffs	~0	6.7	1	624	10.0	$401,243	10.0
	Onset	0	0	0	173	5.5	$567,858	1.9
	Other Dukes	0	0	0	291	10.0	$185,329	10.0
	Other MA	0	0	0	171	10.0	$108,930	10.0
	Tisbury	~0	12.5	~0	3,109	10.0	$1,981,008	10.0
	Westport	0	0	0	9,852	10.0	$6,273,640	10.0
NH	Portsmouth	~0	0.1	1	0	~0	$3,717,740	~0
NY	Greenport	1	2.3	2	0	~0	$3,627,097	~0
	Montauk	51	1.9	936	0	0.4	$17,066,175	0.9
	Orient	~0	0.2	4	0	~0	$586,841	0.1
	Shelter Island	~0	16.7	1	0	~0	$255,837	0.1
RI	Barrington	0	0	0	240	4.0	$238,673	4.0
	Bristol	0	0	0	1,342	4.0	$1,357,341	3.9
	Charlestown	~0	1.2	1	2,354	4.0	$2,347,895	4.0
	East Greenwich	~0	0.3	1	2,223	4.0	$2,241,747	3.9
	Little Compton	0	0	0	486	4.0	$483,178	4.0
	Narragansett	89	5.1	1,366	3,764	4.5	$7,788,984	5.3
	New Shoreham	0	0	0	47	3.1	$108,699	1.7
	Newport	1	2.4	2	1,169	4.0	$1,179,298	4.0
	Portsmouth	0	0	0	1,024	4.0	$1,029,241	4.0
	South Kingstown	5	4.8	37	2,245	4.0	$2,369,047	4.1

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
	Tiverton	1	5.7	2	248	4.0	$255,127	4.0
	Warren	~0	0.4	1	43	3.5	$76,456	2.4
	Warwick	~0	1.6	2	3,044	4.0	$3,035,874	4.0
	Westerly	2	2.1	10	1,134	4.0	$1,215,813	3.9
Total		**154**	**2.8**	**2,416**	**55,824**	**3.3**	**$97,254,752**	**3.6**

4.3 New York WEA

The NY WEA (Figure 4-3) is the source of approximately $3.59 million in total revenue per year ($10,937 per km^2), ranking it highest in revenue per km^2 exposed among those BOEM WEAs examined. The NY WEA was the second highest in total revenue exposed. The NY WEA analyzed is 2 percent (about 1,780 acres) larger than the area leased.

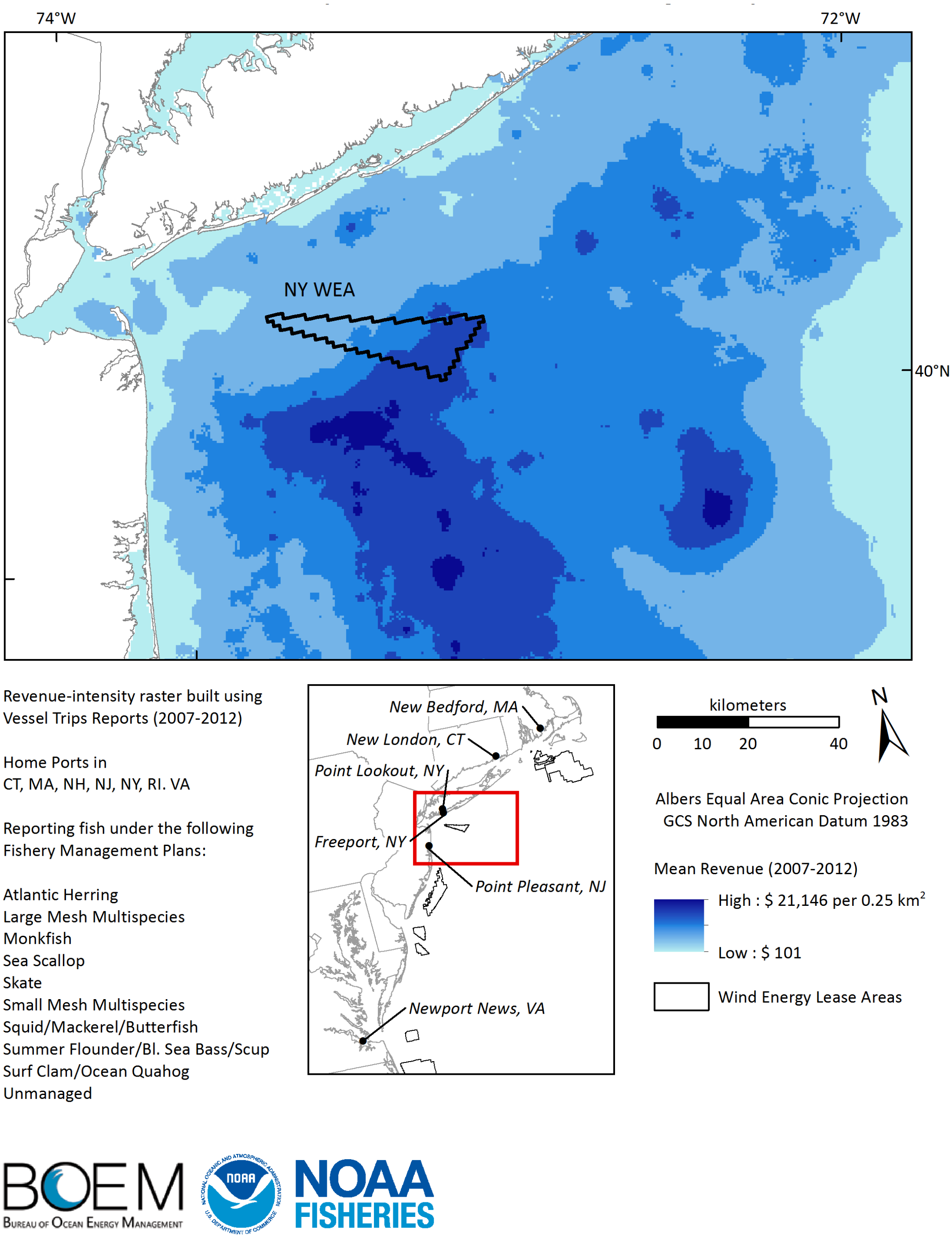


Figure 4-3. Commercial fishing activity from ports most exposed to the NY WEA, 2007–2012.

4.3.1 Commercial Fisheries

4.3.1.1 Ports and Fishery Management Plans

Table 4-13 identifies the commercial ports most exposed to the NY WEA. As shown, ports in both the New England and Mid-Atlantic regions are exposed to development of the NY WEA. The ports most affected, as measured by average annual revenue from the NY WEA (second column), are the common sea scallop landing ports of New Bedford, MA; Cape May, NJ; Point Pleasant, NJ; and Newport News, VA. In turn, the ports most exposed as a share of total revenue (fourth column) are Freeport, NY; Point Lookout, NY; New London, CT; and Point Pleasant, NJ.

Table 4-13. Commercial ports most exposed to the NY WEA, 2007–2012.

Port Group	Average Annual Revenue from NY WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to NY WEA
Freeport, NY	$77,363	$783,641	9.9
Point Lookout, NY	$166,664	$2,417,162	6.9
New London, CT	$112,670	$6,101,710	1.8
Point Pleasant, NJ	$478,290	$30,335,241	1.6
Newport News, VA	$398,210	$38,319,620	1.0
Long Beach, NJ	$57,165	$6,226,706	0.9
Stonington, CT	$61,099	$7,607,928	0.8
Cape May, NJ	$562,111	$75,665,163	0.7
Barnegat, NJ	$97,142	$16,706,499	0.6
New Bedford, MA	$1,264,815	$292,229,242	0.4

Table 4-14, which provides data for FMPs exposed to NY WEA development, shows that the landings are from species managed by both the NEFMC and the MAFMC. The NY WEA contains valuable sea scallop grounds (especially in the eastern portion), but is not as productive as other areas in the mid-Atlantic or Georges Bank.

Table 4-14. FMPs exposed to NY WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from NY WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Sea Scallop	NEFMC	$3,262,785	$428,413,267	0.8
Squid, Mackerel, Butterfish	MAFMC	$194,935	$40,849,295	0.5
Monkfish	NEFMC, MAFMC	$28,340	$19,759,447	0.1
Atlantic Herring	NEFMC	$28,086	$23,241,713	0.1
Summer Flounder, Scup, Black Sea Bass	MAFMC	$39,452	$33,166,172	0.1
Surfclam and Ocean Quahog	MAFMC	$22,385	$64,967,095	~0
Skate	NEFMC	$1,395	$7,796,915	~0
Small Mesh Multispecies	NEFMC	$1,572	$10,675,728	~0
Unmanaged		$10,959	$248,316,185	~0
Large Mesh Multispecies	NEFMC	$960	$76,625,579	~0

4.3.1.2 Commercial Permits/Gear

Table 4-15 presents the number of permits and revenue, by gear type, exposed to development of the NY WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the “unmanaged” category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

Landings from the NY WEA (fourth column) are dominated by dredge gear and, to a lesser extent, bottom trawl. Dredge gear in the NY WEA almost exclusively lands sea scallops, resulting in very high revenue compared to other gear types, given the relative value of sea scallops. However, only 0.6 percent of the dredge gear revenue would be exposed to development of the NY WEA. The trawling vessels are primarily targeting squid. Although a number of gillnet, handgear, and lobster pot fishermen are active in the area, the total revenue estimated to be sourced by these gears from within the WEA is low. This indicates that the NY WEA likely abuts more productive fishing grounds for these gears, but is not a center of fishing activity itself.

Table 4-15. Number of permits and revenue, by gear, exposed to development of the NY WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NY WEA	Percent Revenue from NY WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	373	$486,160,813	$2,914,060	0.6	Sea Scallop;[b] Surfclam, Ocean Quahog;[c] Monkfish;[d] Unmanaged[e]	New Bedford, MA; Cape May, NJ; Newport News, VA; Point Pleasant, NJ; New London, CT
Gillnet	55	$34,164,385	$13,254	0.04	Monkfish;[d] Skate;[b] Unmanaged;[e] Bluefish[c]	Barnegat, NJ; Long Beach, NJ; Point Pleasant, NJ; Belford, NJ; Portsmouth, NH
Hand	31	$8,339,830	$178	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Bluefish;[c] Small Mesh Multispecies[b]	Freeport, NY; Suffolk County, NY; Brooklyn, NY; Point Lookout, NY; Island Park, NY
Longline	1	$7,399,976	$106	~0	Golden Tilefish	Long Beach, NJ
Pot	13	$11,071,430	$146	~0	Unmanaged;[e] Summer Flounder, Scup, Black Sea Bass;[c] Small Mesh Multispecies;[b] Large Mesh Multispecies[b]	Islip, NY; Freeport, NY; Neptune, NJ; Brooklyn, NY; Other NY, NY

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NY WEA	Percent Revenue from NY WEA	Top 4 FMPs[a]	Top 5 Port Groups
Lobster Pot	33	$213,321,675	$4,724	~0	Unmanaged;[e] Summer Flounder, Scup, Black Sea Bass;[c] Small Mesh Multispecies;[b] Large Mesh Multispecies[b]	Point Pleasant, NJ; Freeport, NY; Belmar, NJ; Neptune, NJ; Belford, NJ
Seine	5	$10,258,052	$478	~0	Unmanaged;[e] Monkfish;[d] Small Mesh Multispecies;[b] Summer Flounder, Scup, Black Sea Bass[c]	Gloucester, MA; Fall River, MA; Belford, NJ
Bottom Trawl	212	$174,094,198	$569,332	0.3	Sea Scallop;[b] Squid, Mackerel, Butterfish;[c] Summer Flounder, Scup, Black Sea Bass;[c] Monkfish[d]	Point Lookout, NY; Point Pleasant, NJ; Freeport, NY; Belford, NJ; Narragansett, RI
Midwater Trawl	18	$21,384,152	$89,500	0.4	Squid, Mackerel, Butterfish;[c] Atlantic Herring;[b] Unmanaged;[e] Spiny Dogfish[d]	Gloucester, MA; New Bedford, MA; Cape May, NJ; Fall River, MA; North Kingstown, RI

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b NEFMC management

c MAFMC management

d Joint NEFMC and MAFMC management

e Unmanaged species

Table 4-16 lists the top 10 exposed species within the NY WEA.

Table 4-16. Top 10 exposed species within the NY WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Mackerel, Chub	ND	ND	ND
Mackerel, Atlantic	$70,862	$5,201,950	1.4%

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Scallop, Sea	$3,262,785	$428,413,267	0.8%
Squid (Loligo)	$123,703	$24,867,195	0.5%
Flounder, Summer	$37,654	$22,019,367	0.2%
Monkfish	$28,340	$19,759,447	0.1%
Herring, Atlantic	$28,086	$23,241,713	0.1%
Ocean Quahog	$19,013	$27,233,867	0.1%
Surfclam	$3,373	$35,291,040	0.0%
Lobster	$4,413	$212,474,994	0.0%

4.3.2 Recreational Fisheries

Table 4-17 presents the average annual exposure of recreational for-hire boat trips, for-hire and private angler trips, and angler expenditures to development of the NY WEA. In aggregate, the New York and New Jersey recreational fisheries are only lightly exposed (0.4 percent of all for-hire boat trips were within one nautical mile of the NY WEA [third column]).

Table 4-17. State-level average annual exposure of recreational fishery to NY WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
NJ	8,177	0.1	153,989	0.1	3,028,511	2.6	$59,763,696	8.4
NY	7,027	0.3	128,062	0.2	2,652,092	1.3	$117,948,854	1.8

Table 4-18 presents the average annual exposure of for-hire boat trips, for-hire and private angler trips, and angler expenditures to the NY WEA. A total of 26 for-hire boat trips from all port groups combined are exposed to NY WEA development; the majority of for-hire boat trips would either be unaffected or marginally affected by NY WEA development. With respect to private angler trips, the two port groups with at least 20,000 exposed private angler trips annually—Middletown, NJ, and smaller ports in Suffolk County, NY (e.g., Moriches)—would be most exposed to developing the NY WEA.

Table 4-18. NY WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
NJ	Belmar	1	0.1	36	9,544	8.5	$8,117,633	7.5
	Brielle	3	0.5	70	4,249	7.8	$4,266,892	6.5
	Highlands	0	0	0	893	3.2	$2,893,798	2.0
	Jersey City	0	0	0	1,763	9.8	$1,152,601	9.7
	Keyport	0	0	0	7,505	9.8	$4,935,741	9.6
	Manasquan	0	0	0	1,008	9.9	$646,370	9.9
	Middletown	0	0	0	22,569	10.0	$14,270,895	10.0

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
	Neptune	0	0	0	6,264	10.0	$3,961,675	10.0
	Old Bridge	0	0	0	1,756	10.0	$1,110,866	10.0
	Other Monmouth	0	0	0	13,625	10.0	$8,618,106	10.0
	Point Pleasant	3	0.2	64	4,180	5.8	$6,400,534	4.3
	Woodbridge	~0	0.4	4	5,253	9.9	$3,388,585	9.8
NY	Brooklyn	4	0.5	84	1,733	1.8	$7,614,106	1.5
	Freeport	4	1.5	41	804	1.8	$3,313,952	1.7
	Hempstead	0	0	0	531	2.0	$1,585,965	2.0
	Island Park	0	0	0	50	2.0	$150,351	2.0
	Jamaica Bay—Rockaway	0	0	0	338	2.0	$1,012,290	2.0
	Long Beach	0	0	0	498	2.0	$1,489,506	2.0
	New York	0	0	0	2,084	2.0	$6,608,751	1.9
	Oak Beach-Captree	3	0.2	57	1,695	1.4	$11,890,056	0.9
	Oceanside	~0	0.6	1	357	2.0	$1,086,507	2.0
	Other Bronx	0	0	0	191	1.8	$709,717	1.6
	Other Nassau	0	0	0	4,123	2.0	$12,320,410	2.0
	Other Richmond	6	21.1	25	0	20.8	$18,970	20.8
	Other Suffolk	0	0	0	20,433	2.0	$61,226,193	2.0
	Point Lookout	3	0.6	71	1,265	1.7	$6,190,136	1.4
	Queens	0	0	0	913	2.0	$2,731,943	2.0
Total		**26**	**0.5**	**453**	**113,624**	**4.2**	**$137,466,945**	**2.7**

4.4 New Jersey WEA

The NJ WEA (Figure 4-4) is the source of $3.8 million in annual revenue, or $2,601 per km², the third-highest-intensity WEA. The NJ WEA analyzed is 3 percent larger than the New Jersey leases.

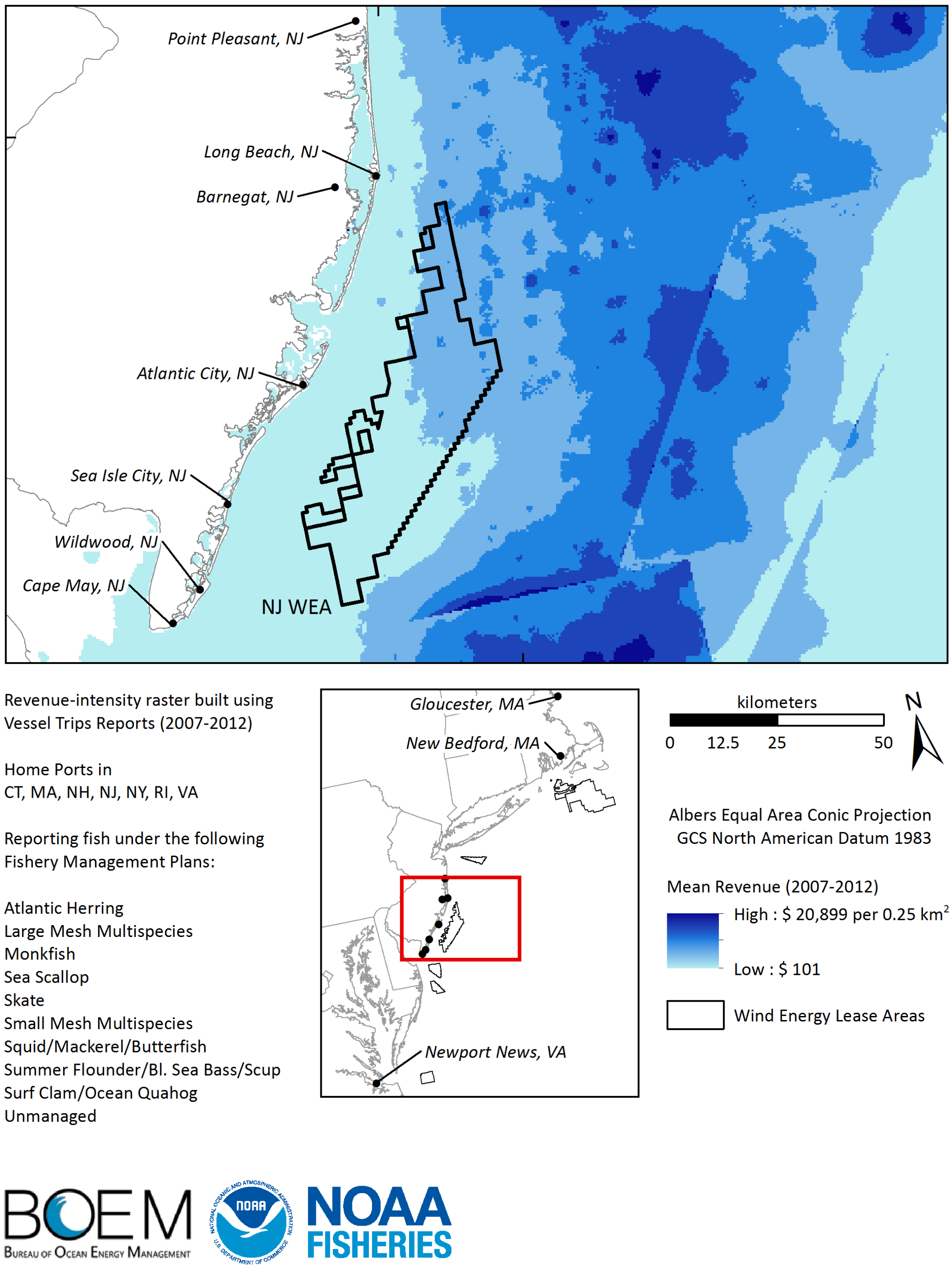


Figure 4-4. Commercial fishing activity from ports most exposed to the NJ WEA, 2007–2012.

4.4.1 Commercial Fisheries

4.4.1.1 Ports and Fishery Management Plans

Table 4-19 identifies the commercial ports most exposed to the NJ WEA. The NJ WEA is heavily fished by the dredge fleet with a total of $3.41 million per year on average sourced from this WEA. Seine fishing also occurs in the WEA, and it is likely that menhaden fishing occurs in this area but is not represented in the data. The ports most affected as measured by total revenue are those that process clams in the region—Atlantic City, NJ; Cape May, NJ; and Newport News, VA. While clam landings have been declining in the mid-Atlantic region since 2007, clams are still sourced from within this WEA in substantial amounts. Data on seine fishing indicate that landings are sent primarily to Cape May, NJ, and Gloucester, MA. Menhaden fishing, which is not represented in the federal data, occurs in the NJ WEA and would be landed in Virginia as well.

Table 4-19. Commercial ports most exposed to the NJ WEA, 2007–2012.

Port Group	Average Annual Revenue from NJ WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to NJ WEA
Atlantic City, NJ	$3,073,911	$27,890,274	11.0
Sea Isle City, NJ	$28,920	$912,124	3.2
Wildwood, NJ	$28,188	$2,893,981	1.0
Long Beach, NJ	$34,604	$6,226,706	0.6
Cape May, NJ	$235,212	$75,665,163	0.3
Newport News, VA	$115,741	$38,319,620	0.3
Barnegat, NJ	$35,637	$16,706,499	0.2
Gloucester, MA	$63,324	$43,210,602	0.1
Point Pleasant, NJ	$44,351	$30,335,241	0.1
New Bedford, MA	$43,678	$292,229,242	0.0

Table 4-20 shows FMPs exposed to NJ WEA development. Species sourced from the NJ WEA fall under jurisdiction of both the NEFMC and MAFMC, although the latter is more highly exposed in terms of percentage. Almost all revenue from the NJ WEA is surfclam: close to $3.05 million per year, which represents 8.6 percent of all surfclam landings in the U.S. Atlantic. The ports most exposed as measured by total revenue (Table 4-19, second column) are those that process clams in the region—Atlantic City, NJ; Cape May, NJ; and Newport News, VA, primarily, as well as those ports which process menhaden. Nearly all exposure from the NJ WEA is through the surfclam fishery, which is itself highly consolidated.

Table 4-20. FMPs exposed to NJ WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from NJ WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Surfclam and Ocean Quahog	MAFMC	$3,048,870	$64,967,095	4.7
Summer Flounder, Scup, Black Sea Bass	MAFMC	$103,854	$33,166,172	0.3
Monkfish	NEFMC, MAFMC	$38,816	$19,759,447	0.2
Bluefish	MAFMC	$2,517	$1,578,705	0.2
Skate	NEFMC	$8,760	$7,796,915	0.1
Sea Scallop	NEFMC	$363,559	$428,413,267	0.1
Unmanaged		$193,494	$248,316,185	0.1

FMP	Jurisdiction	Average Annual Revenue from NJ WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Squid, Mackerel, Butterfish	MAFMC	$23,722	$40,849,295	0.1
Atlantic Herring	NEFMC	$2,225	$23,241,713	~0
Small Mesh Multispecies	NEFMC	$998	$10,675,728	~0

4.4.1.2 Commercial Permits/Gear

Table 4-21 presents the number of permits and revenue, by gear type, exposed to development of the NJ WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

Almost all revenue from dredge gear in the NJ WEA is surfclam and, to a lesser extent, ocean quahog. Seine fishing is also represented in the WEA, and it is likely that menhaden fishing occurs in this area but is not fully represented in the data. From all gears, menhaden and black sea bass are the second- and third-most-landed species, though black sea bass totals only $62,734 per year (see Table 4-22).

Table 4-21. Number of permits and revenue, by gear, exposed to development of the NJ WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NJ WEA	Percent Revenue from NJ WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	286	$486,160,813	$3,410,005	0.7	Surfclam, Ocean Quahog;[b] Sea Scallop;[c] Monkfish;[d] Summer Flounder, Scup, Black Sea Bass[b]	Atlantic City, NJ; Cape May, NJ; Newport News, VA; Point Pleasant, NJ; New Bedford, MA
Gillnet	61	$34,164,385	$51,037	0.15	Monkfish;[d] Skate;[c] Unmanaged;[e] Bluefish[b]	Barnegat, NJ; Long Beach, NJ; Waretown, NJ; Point Pleasant, NJ; Ocean County, NJ
Hand	10	$8,339,830	$1,513	0.02	Summer Flounder, Scup, Black Sea Bass;[b] Spiny Dogfish;[d] Unmanaged;[e] Bluefish[b]	Barnegat, NJ; Sea Isle City, NJ; Long Beach, NJ; Point Lookout, NY; Cape May, NJ
Longline	3	$7,399,976	$38	~0	Highly Migratory Species;[f] Spiny Dogfish;[d] Unmanaged[e]	Ocean County, NJ; Barnegat, NJ

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NJ WEA	Percent Revenue from NJ WEA	Top 4 FMPs[a]	Top 5 Port Groups
Pot	34	$11,071,430	$97,972	0.9	Summer Flounder, Scup, Black Sea Bass;[b] Unmanaged;[e] Red Crab;[b] Large Mesh Multispecies[c]	Atlantic City, NJ; Sea Isle City, NJ; Cape May, NJ; Wildwood, NJ; Point Pleasant, NJ
Lobster Pot	18	$213,321,675	$2,368	~0	Unmanaged;[e] Summer Flounder, Scup, Black Sea Bass;[b] Small Mesh Multispecies;[c] Skate[c]	Sea Isle City, NJ; Waretown, NJ; Neptune, NJ; Atlantic City, NJ; Other NY, NY
Seine	18	$10,258,052	$137,765	1.3	Unmanaged[e]	Cape May, NJ; Gloucester, MA; Atlantic City, NJ; Fall River, MA
Bottom Trawl	149	$174,094,198	$82,736	0.1	Summer Flounder, Scup, Black Sea Bass;[b] Squid, Mackerel, Butterfish;[b] Unmanaged;[e] Sea Scallop[c]	Cape May, NJ; Long Beach, NJ; Chincoteague, VA; Barnegat, NJ; Newport News, VA
Midwater Trawl	13	$21,384,152	$5,396	~0	Squid, Mackerel, Butterfish;[b] Atlantic Herring;[b] Unmanaged;[e] Highly Migratory Species[f]	Cape May, NJ; New Bedford, MA; Worcester County, MD; Ocean County, NJ; Cape May County, NJ

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b MAFMC management

c NEFMC management

d Joint NEFMC and MAFMC management

e Unmanaged species

f AHMS management

Table 4-22 lists the top 10 exposed species within the NJ WEA.

Table 4-22. Top 10 exposed species within the NJ WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Surfclam	$3,031,617	$35,291,040	8.6%
Menhaden	$137,788	$3,870,799	3.6%
Sea Bass, Black	$62,734	$5,422,180	1.2%

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Whelk, Channeled	$18,132	$2,419,819	0.7%
Croaker, Atlantic	$13,179	$3,081,688	0.4%
Monkfish	$38,816	$19,759,447	0.2%
Flounder, Summer	$40,688	$22,019,367	0.2%
Squid (Illex)	$14,888	$9,961,263	0.1%
Scallop, Sea	$363,559	$428,413,267	0.1%
Ocean Quahog	$17,253	$27,233,867	0.1%

4.4.2 Recreational Fisheries

Table 4-23 presents the average annual exposure of recreational for-hire boat trips, for-hire and private angler trips, and angler expenditures to development of the NJ WEA. Only the recreational fisheries in Maryland and New Jersey indicate trips to the NJ WEA, with a negligible amount from Delaware.

Table 4-23. State-level average annual exposure of recreational fishery to NJ WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
DE	1,093	~0	12,512	~0	522,766	~0	$4,473,090	~0
MD	696	1.1	12,422	1.2	1,704,515	~0	$12,328,325	0.3
NJ	8,177	4.6	153,989	3.8	3,028,511	7.7	$171,048,700	9.0
NY	7,027	~0	128,062	~0	2,652,092	~0	$9,504,089	~0

Table 4-24 presents the average annual exposure of for-hire boat trips, for-hire and private angler trips, and angler expenditures to the NJ WEA. For-hire boat trips out of Atlantic City, NJ; Barnegat, NJ; and Long Beach, NJ, are most exposed to development of the NJ WEA. Approximately 73 percent of for-hire boat trips from Atlantic City, NJ, were exposed annually to the NJ WEA during the study period. Angler trips and expenditures from Cape May, NJ, and smaller ports in Atlantic County, NJ. are most exposed to the NJ WEA.

Table 4-24. NJ WEA average annual private and for-hire recreational exposure, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
DE	Indian River	~0	0.1	2	0	~0	$4,473,090	~0
MD	Ocean City	8	1.1	152	0	~0	$12,328,325	0.3
NJ	Absecon	4	29.9	23	13,933	10.0	$8,817,397	10.0
	Atlantic City	148	73.4	1,500	1,992	16.1	$1,481,501	20.8
	Avalon	9	4.1	107	2,722	9.0	$2,224,241	8.3
	Barnegat	64	9.2	1,678	19,780	10.0	$14,550,903	10.0
	Belmar	1	0.1	3	0	~0	$8,117,633	~0

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
	Brielle	0	0	0	4,249	7.7	$4,266,892	6.3
	Brigantine	4	5.1	30	14,979	9.9	$9,633,502	9.9
	Cape May	8	0.6	52	47,348	9.7	$32,011,401	9.4
	Eagleswood	2	10.1	7	1,063	10.0	$680,056	10.0
	Forked River	0	0	0	5,910	10.0	$3,738,344	10.0
	Galloway	6	57.8	37	318	10.9	$208,874	11.8
	Highlands	~0	~0	1	893	3.2	$2,893,798	2.0
	Little Egg Harbor	25	34.4	132	950	11.0	$646,028	11.8
	Long Beach	51	9.81	1,239	1,340	10.6	$2,177,627	10.8
	Manasquan	0	0	0	1,008	9.9	$646,370	9.9
	Margate City	6	17.6	21	11,233	10.0	$7,177,014	9.9
	Middle	0	0	0	7,408	10.0	$4,697,579	10.0
	Ocean City	37	28.2	869	2,042	12.5	$1,646,222	14.3
	Other Atlantic	~0	2.0	2	25,966	10.0	$16,423,263	10.0
	Other Cape May	0	0	0	5,728	10.0	$3,621,507	10.0
	Other Cumberland	0	0	0	13,593	10.0	$8,603,913	10.0
	Other Gloucester	0	0	0	386	10.0	$244,232	10.0
	Other Ocean	~0	1.2	1	4,618	10.0	$2,926,625	10.0
	Point Pleasant	1	~0	13	4,180	5.8	$6,400,534	4.2
	Port Norris	0	0	0	11,391	10.0	$7,202,550	10.0
	Sea Isle City	9	6.9	184	3,333	9.9	$2,373,273	9.8
	Stone Harbor	~0	2.2	0	3,312	10.0	$2,095,571	10.0
	Toms River	~0	2.4	1	472	10.0	$301,910	9.9
	Tuckerton	3	11.8	17	5,709	10.0	$3,626,342	10.0
	Waretown	~0	1.7	4	5,525	10.0	$3,509,089	10.0
	Wildwood	~0	~0	1	10,549	9.0	$8,104,510	8.2
NY	Freeport	~0	0.1	6	0	~0	$3,313,952	~0
	Point Lookout	~0	~0	11	0	~0	$6,190,136	~0
Total		**386**	**8.0**	**6,089**	**231,930**	**7.9**	**$197,354,204**	**7.8**

4.5 Delaware WEA

The DE WEA (Figure 4-5) has a total of $356,631 in annual commercial revenue, which is equal to $852 per km^2—the fourth-lowest intensity of all eight WEAs.

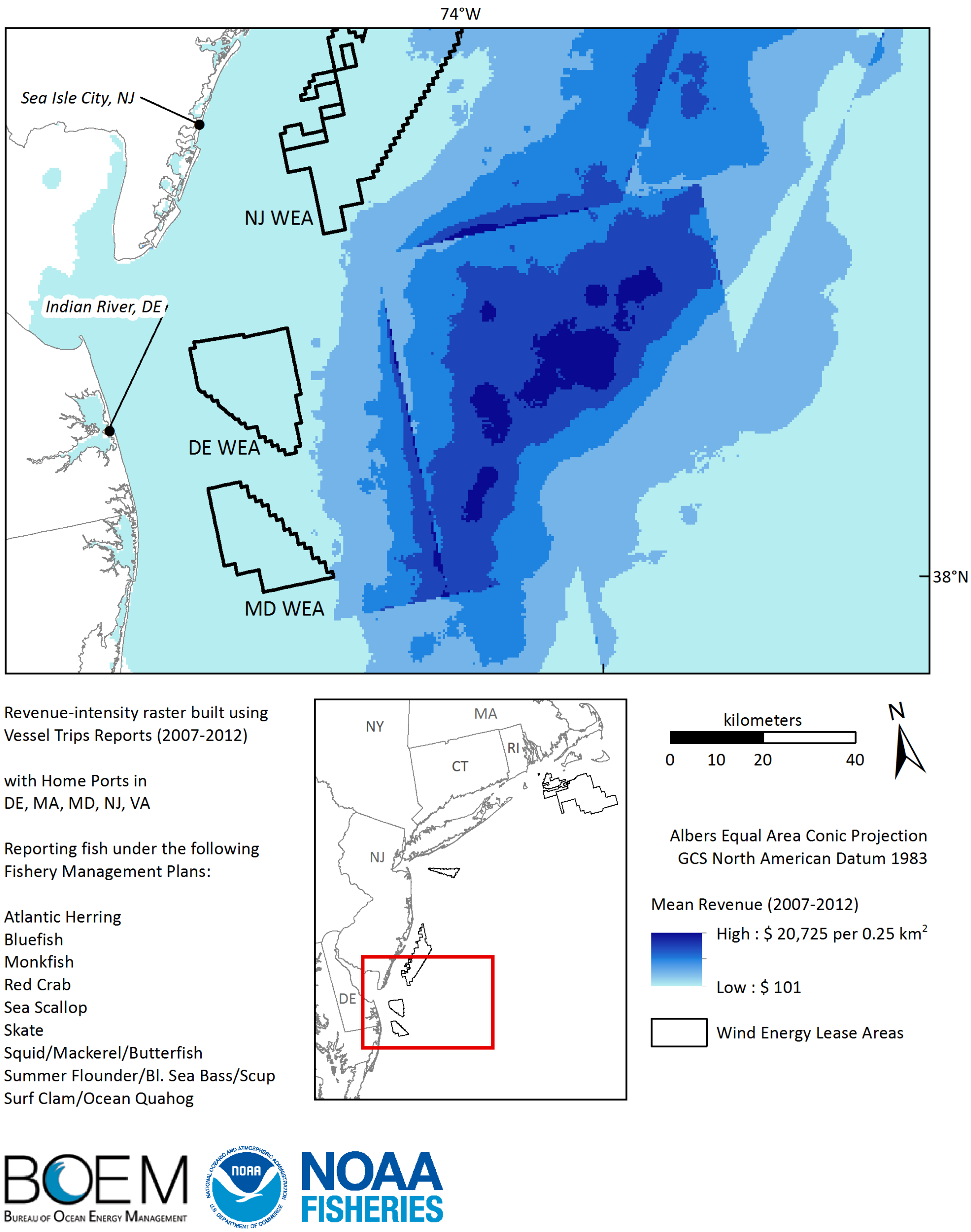


Figure 4-5. Commercial fishing activity from ports most exposed to the DE WEA, 2007–2012.

4.5.1 Commercial Fisheries

4.5.1.1 Ports and Fishery Management Plans

Table 4-25 identifies the most exposed ports to the DE WEA. As the data show, the DE WEA is lightly fished commercially. Cape May, NJ, is the most commonly used port for vessels landing fish ($186,000 annually) from the DE WEA, but only 0.2 percent of Cape May landings come from the DE WEA. Sea Isle City, NJ, and Indian River, DE, have the most exposure, with slightly less than 4 percent and 1.5 percent exposed, respectively. Exposure of the remaining eight ports ranges from almost 0 to 0.4 percent.

Menhaden is the main species sourced from the DE WEA, but because landings are not fully reported to the federal VTR system, it is difficult to assess the proportion of total menhaden fishing in the area. Besides menhaden, black sea bass is the only other species estimated at over $100,000 in landings from the DE WEA (Table 4-26).

Table 4-25. Commercial ports most exposed to the DE WEA, 2007–2012.

Port Group	Average Annual Exposed Revenue from DE WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to DE WEA
Sea Isle City, NJ	$34,379	$912,124	3.8
Indian River, DE	$4,753	$320,704	1.5
Wildwood, NJ	$11,150	$2,893,981	0.4
Cape May, NJ	$185,954	$75,665,163	0.2
Ocean City, MD	$21,747	$9,242,687	0.2
Chincoteague, VA	$6,432	$3,130,890	0.2
Atlantic City, NJ	$20,907	$27,890,274	0.1
Seaford, VA	$8,031	$15,391,392	0.1
Newport News, VA	$18,817	$38,319,620	~0.0
New Bedford, MA	$31,222	$292,229,242	~0.0

Table 4-26. FMPs and revenue most exposed to DE WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from DE WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Summer Flounder, Scup, Black Sea Bass	MAFMC	$111,813	$33,166,172	0.3
Surfclam and Ocean Quahog	MAFMC	$36,640	$64,967,095	0.1
Unmanaged		$113,306	$248,316,185	0.1
Sea Scallop	NEFMC	$89,722	$428,413,267	~0
Bluefish	MAFMC	$191	$1,578,705	~0
Red Crab	NEFMC	Not Disclosable	Not Disclosable	Not Disclosable
Squid, Mackerel, Butterfish	MAFMC	$3,627	$40,849,295	~0
Skate	NEFMC	$253	$7,796,915	~0
Monkfish	NEFMC, MAFMC	$312	$19,759,447	~0
Atlantic Herring	NEFMC	$214	$23,241,713	~0

4.5.1.2 *Commercial Permits/Gear*

Table 4-27 presents the number of permits and revenue, by gear type, estimated to be fishing within the DE WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP. Dredge, seine, pot, and bottom trawl are most exposed to the DE WEA, with landings ranging from around $47,000 to just over $123,000 per year. All other gears source less than $2,400 per year from the DE WEA.

Table 4-27. Number of permits and revenue, by gear, exposed to development of the DE WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from DE WEA	Percent Revenue from DE WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	139	$486,160,813	$123,167	~0	Sea Scallop;[b] Surfclam, Ocean Quahog;[c] Monkfish;[d] Summer Flounder, Scup, Black Sea Bass[c]	New Bedford, MA; Cape May, NJ; Atlantic City, NJ; Ocean City, MD; Newport News, VA
Gillnet	19	$34,164,385	$2,114	~0	Unmanaged;[e] Spiny Dogfish;[d] Bluefish;[c] Monkfish[d]	Ocean City, MD; Long Beach, NJ; Chincoteague, VA; Worcester County, MD; Point Pleasant, NJ
Hand	5	$8,339,830	$1,357	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Spiny Dogfish;[d] Bluefish[c]	Cape May, NJ; Sea Isle City, NJ; Indian River, DE; Wildwood, NJ; Sussex County, DE
Longline	1	$7,399,976	$31	~0	Highly Migratory Species;[f] Unmanaged[e]	Cape May County, NJ
Pot	29	$11,071,430	$97,348	0.9	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Red Crab;[b] Large Mesh Multispecies[b]	Cape May, NJ; Sea Isle City, NJ; Wildwood, NJ; Indian River, DE; Lewes, DE
Lobster Pot	12	$213,321,675	$2,317	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Large Mesh Multispecies;[b] Small Mesh Multispecies[b]	Cape May, NJ; Sea Isle City, NJ; Indian River, DE; Ocean City, MD; Wildwood, NJ

Gear	Permits	Average Annual Revenue	Average Annual Revenue from DE WEA	Percent Revenue from DE WEA	Top 4 FMPs[a]	Top 5 Port Groups
Seine	14	$10,258,052	$82,492	0.8	Unmanaged[e]	Cape May, NJ; Gloucester, MA
Bottom Trawl	116	$174,094,198	$47,379	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Sea Scallop;[b] Squid, Mackerel, Butterfish[c]	Cape May, NJ; Chincoteague, VA; Ocean City, MD; Newport News, VA; Hampton, VA
Midwater Trawl	7	$21,384,152	$426	~0	Squid, Mackerel, Butterfish;[c] Atlantic Herring;[b] Highly Migratory Species;[f] Unmanaged[e]	Cape May, NJ; New Bedford, MA; Worcester County, MD; Cape May County, NJ

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b NEFMC management

c MAFMC management

d Joint NEFMC and MAFMC management

e Unmanaged species

f AHMS management

Table 4-28 lists the top 10 exposed species within the DE WEA.

Table 4-28. Top 10 exposed species within the DE WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Menhaden	$82,525	$3,870,799	2.1%
Sea Bass, Black	$82,609	$5,422,180	1.5%
Tautog	$2,629	$393,352	0.7%
Whelk, Channeled	$7,463	$2,419,819	0.3%
Croaker, Atlantic	$9,475	$3,081,688	0.3%
Flounder, Summer	$29,159	$22,019,367	0.1%
Surfclam	$36,640	$35,291,040	0.1%
Scallop, Sea	$89,722	$428,413,267	0.0%
Squid (Loligo)	$2,030	$24,867,195	0.0%
Lobster	$5,093	$212,474,994	0.0%

4.5.2 Recreational Fisheries

Table 4-29 presents the recreational fishery exposure of states to the development of the DE WEA, with average annual exposure broken out by for-hire boat trips, for-hire and private angler trips, and angler expenditures. Fewer than 5 percent of for-hire boat trips in Delaware, Maryland, and

New Jersey traveled to within a nautical mile of the DE WEA. The percentage of for-hire boat and for-hire and private angler trips exposed to the DE WEA are highest in Delaware, followed by New Jersey and then Maryland. Approximately 8.5 percent of total New Jersey private and for-hire trip expenditures would be exposed to development of the DE WEA. This equates to approximately $4.9 million annually in New Jersey. The development of the DE WEA also exposes just over 5 percent of total for-hire and private trip expenditures in Delaware, and about 1.6 percent in Maryland.

Table 4-29. State-level average annual exposure of recreational fishery to DE WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
DE	1,093	4.7	12,512	6.9	522,766	4.5	$19,771,177	5.5
MD	696	0.4	12,422	0.2	1,704,515	0.3	$12,328,325	1.6
NJ	8,177	2.1	153,989	1.6	3,028,511	2.4	$57,607,517	8.5

Table 4-30 presents the total average annual exposure of for-hire boat trips, for-hire and private angler trips, and private and for-hire expenditures to the DE WEA. For-hire boat trips in Milford, DE, and Cape May, NJ, are most exposed to development of the DE WEA. Angler trips and angler expenditures in Cape May, NJ, are also more exposed to the DE WEA than any other port group.

Table 4-30. DE WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
DE	Indian River	17	5.1	330	5,512	6.0	$4,473,090	6.1
	Lewes	34	4.7	532	8,424	6.1	$6,813,618	6.2
	Milford	1	23.0	2	0	~0	$2,092,891	~0
	Other Sussex	~0	1.0	1	9,726	6.0	$6,391,579	6.0
MD	Ocean City	3	0.4	19	4,364	1.9	$12,328,325	1.6
NJ	Avalon	~0	0.1	9	2,722	8.7	$2,224,241	7.8
	Cape May	163	12.5	2,295	47,348	10.1	$32,011,401	10.2
	Margate City	~0	1.1	1	0	~0	$7,177,014	~0
	Other Cape May	0	0	0	5,728	10.0	$3,621,507	10.0
	Sea Isle City	1	0.4	11	3,333	9.4	$2,373,273	8.9
	Stone Harbor	0	0	0	3,312	10.0	$2,095,571	10.0
	Wildwood	11	2.3	147	10,549	9.1	$8,104,510	8.5
Total		**229.8**	**5.8**	**3,348**	**101,018**	**6.7**	**$89,707,019**	**6.9**

4.6 Maryland WEA

The MD WEA's $185,741 in annual revenue is equal to $575 per km², third-lowest of the eight WEAs studied here (Figure 4-6).

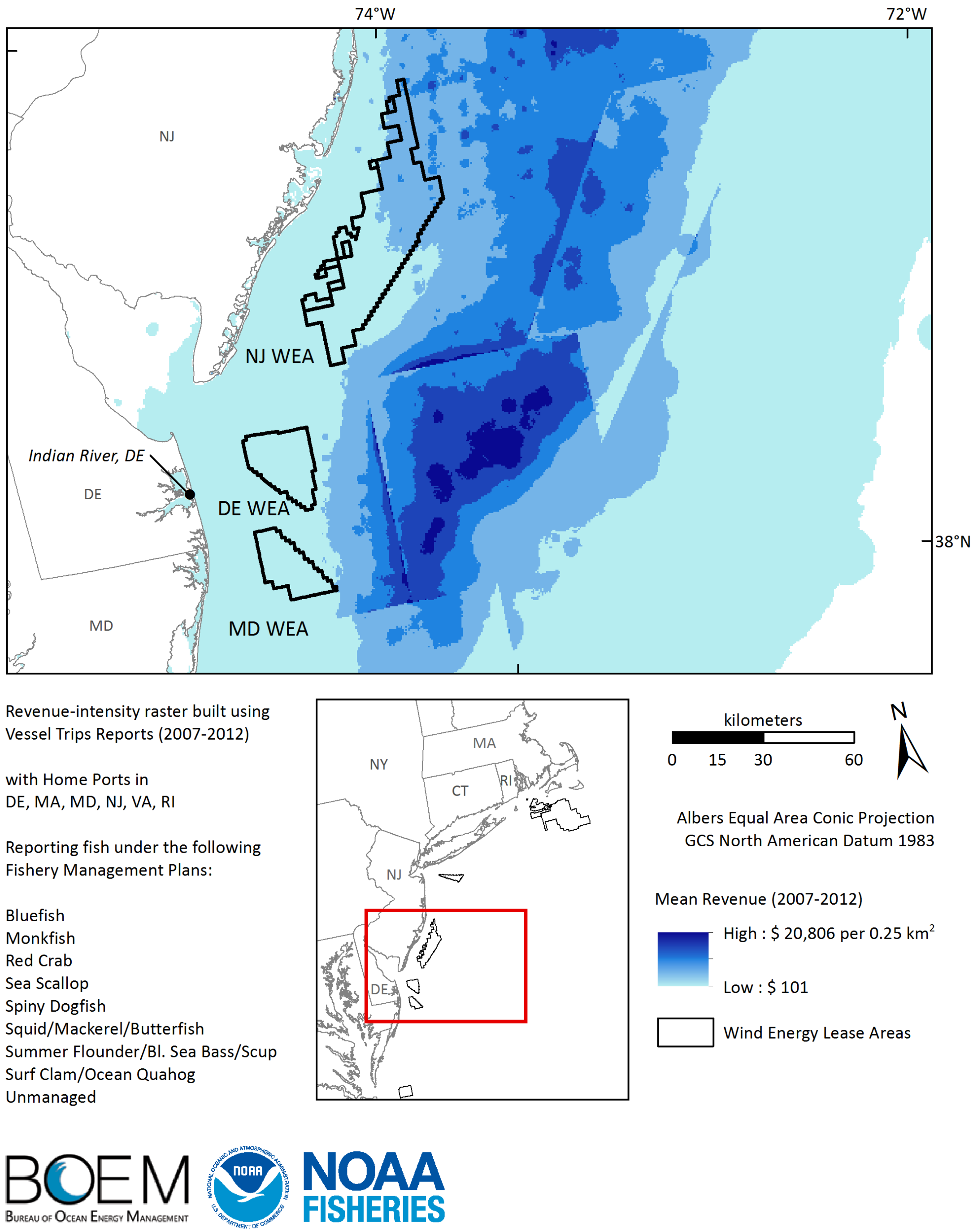


Figure 4-6. Commercial fishing activity from ports most exposed to the MD WEA, 2007–2012.

4.6.1 Commercial Fisheries

4.6.1.1 Ports and Fishery Management Plans

Table 4-31 identifies the commercial ports most highly exposed to the MD WEA. As the data show, the MD WEA is lightly fished commercially, with only Indian River, DE, and Other York, VA, having at least 2 percent of their revenue sourced from the WEA. Table 4-32 presents FMP exposure to MD WEA development. The most exposed FMP is summer flounder, scup, and black sea bass, averaging less than $90,000 and 0.3 percent of total revenue in exposure annually.

Table 4-31. Commercial ports most exposed to MD WEA, 2007–2012.

Port Group	Average Annual Revenue from MD WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to MD WEA
Indian River, DE	$31,457	$320,704	9.8
Other York, VA	Not Disclosable	Not Disclosable	Not Disclosable
Ocean City, MD	$82,188	$9,242,687	0.9
Chincoteague, VA	$7,030	$3,130,890	0.2
Cape May, NJ	$29,074	$75,665,163	~0.0

Table 4-32. FMPs exposed to MD WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from MD WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Summer Flounder, Scup, Black Sea Bass	MAFMC	$89,110	$33,166,172	0.3
Spiny Dogfish	NEFMC, MAFMC	$5,302	$2,172,246	0.2
Bluefish	MAFMC	$1,091	$1,578,705	0.1
Red Crab	NEFMC	Not Disclosable	Not Disclosable	Not Disclosable
Skate	NEFMC	$1,893	$7,796,915	~0
Unmanaged		$35,087	$248,316,185	~0
Monkfish	NEFMC, MAFMC	$2,237	$19,759,447	~0
Sea Scallop	NEFMC	$40,202	$428,413,267	~0
Squid, Mackerel, Butterfish	MAFMC	$3,806	$40,849,295	~0
Surfclam and Ocean Quahog	MAFMC	$5,797	$64,967,095	~0

4.6.1.2 Commercial Permits/Gear

Table 4-33 presents the number of permits and revenue, by gear type, fishing within the MD WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP. For dredge gear, Cape May, NJ, and Ocean City, MD, are the primary landing locations. For pot fishermen, Indian River, DE; Ocean City, MD; and Cape May, NJ, are the primary landing locations. Bottom trawl vessels tend to land in Ocean City, MD; Cape May, NJ; and Chincoteague, VA. Black sea bass and summer flounder (fluke) are the primary species landed by pot and trawl gears, while sea scallops are the primary dredge-landed species, though landings only average $40,202 per year from the MD WEA for this species (Table 4-32).

Table 4-33. Number of permits and revenue, by gear, exposed to development of the MD WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from MD WEA	Percent Revenue from MD WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	179	$486,160,813	$45,331	~0	Sea Scallop;[b] Surfclam, Ocean Quahog;[c] Monkfish;[d] Summer Flounder, Scup, Black Sea Bass[c]	Cape May, NJ; Ocean City, MD; New Bedford, MA; Seaford, VA; Other York, VA
Gillnet	30	$34,164,385	$18,314	~0	Unmanaged;[e] Spiny Dogfish;[d] Monkfish;[d] Bluefish[c]	Ocean City, MD; Chincoteague, VA; Long Beach, NJ; Greenbackville, VA; Barnegat, NJ
Hand	9	$8,339,830	$2,578	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Bluefish;[c] Highly Migratory Species[f]	Chincoteague, VA; Indian River, DE; Wildwood, NJ; Ocean City, MD; Long Beach, NJ
Longline	4	$7,399,976	$269	~0	Spiny Dogfish;[d] Unmanaged;[e] Skate;[b] Bluefish[c]	Ocean City, MD; Cape May County, NJ
Pot	29	$11,071,430	$53,757	0.5	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Red Crab;[b] Large Mesh Multispecies[b]	Indian River, DE; Ocean City, MD; Cape May, NJ; Lewes, DE; New Bedford, MA
Lobster Pot	8	$213,321,675	$5,748	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Large Mesh Multispecies;[b] Small Mesh Multispecies[b]	Indian River, DE; Ocean City, MD; Cape May, NJ
Seine	10	$10,258,052	$6,532	~0	Unmanaged[e]	Cape May, NJ; Gloucester, MA
Bottom Trawl	144	$174,094,198	$53,071	~0	Summer Flounder, Scup, Black Sea Bass;[c] Unmanaged;[e] Squid, Mackerel, Butterfish;[c] Skate[b]	Ocean City, MD; Cape May, NJ; Chincoteague, VA; Hampton, VA; North Kingstown, RI

Gear	Permits	Average Annual Revenue	Average Annual Revenue from MD WEA	Percent Revenue from MD WEA	Top 4 FMPs[a]	Top 5 Port Groups
Midwater Trawl	6	$21,384,152	$142	~0	Atlantic Herring;[b] Squid, Mackerel, Butterfish;[c] Unmanaged[e]	Cape May, NJ; Worcester County, MD; Sussex County, DE; Cape May County, NJ

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.
b NEFMC management
c MAFMC management
d Joint NEFMC and MAFMC management
e Unmanaged species
f AHMS management

Table 4-34 lists the top 10 exposed species within the MD WEA.

Table 4-34. Top 10 exposed species within the MD WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Crab, Horseshoe	$2,696	$153,524	1.8%
Sea Bass, Black	$52,163	$5,422,180	1.0%
Dogfish, Smooth	$6,052	$631,373	1.0%
Croaker, Atlantic	$8,214	$3,081,688	0.3%
Dogfish Spiny	$5,302	$2,172,246	0.2%
Menhaden	$6,599	$3,870,799	0.2%
Flounder, Summer	$36,933	$22,019,367	0.2%
Surfclam	$5,793	$35,291,040	0.0%
Scallop, Sea	$40,202	$428,413,267	0.0%
Lobster	$6,058	$212,474,994	0.0%

4.6.2 Recreational Fisheries

Table 4-35 identifies the recreational fishery exposure of states to the development of the MD WEA. State rankings are consistent between the exposure of for-hire boat trips and angler trips. Both Delaware and New Jersey have higher exposure levels in the private versus for-hire segments of the recreational fishery, with the opposite trend in Maryland. Approximately 6.8 percent of private and for-hire angler trip expenditures in New Jersey would be exposed annually to development of the MD WEA, followed by Delaware (5.0 percent), and Maryland (2.8 percent).

Table 4-35. State-level average annual exposure of recreational fishery to MD WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
DE	1,093	1.7	12,512	2.6	522,766	4.53	$19,771,177	5.0
MD	696	6.3	12,422	6.6	1,704,515	0.36	$16,122,478	2.9
NJ	8,177	0	153,989	0	3,028,511	1.56	$44,135,406	6.8

Table 4-36 presents the average annual exposure of for-hire boat trips, for-hire and private angler trips, and angler expenditures to the MD WEA. The highest number of for-hire boats exposed annually to the MD WEA during the study period occurred in Ocean City, MD (44) and Indian River (18). Angler trips and angler expenditures in Cape May, NJ, are estimated to be more exposed to the MD WEA than any other port group.

Table 4-36. MD WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
DE	Indian River	18	5.2	316	5,512	6.0	$4,473,090	6.1
	Lewes	~0	~0	2	8,424	5.7	$6,813,618	4.9
	Milford	~0	7.7	1	0	~0	$2,092,891	~0
	Other Sussex	~0	1.0	~0	9,726	6.0	$6,391,579	6.0
MD	Ocean City	44	6.3	823	4,364	2.3	$12,328,325	3.1
	Pocomoke City	0	0	0	1,767	2.0	$3,794,153	2.0
NJ	Cape May	1	~0	7	47,348	9.7	$32,011,401	9.4
	Ocean City	~0	0.1	2	0	~0	$1,646,222	~0
	Sea Isle City	~0	0.1	10	0	~0	$2,373,273	~0
	Wildwood	~0	0.1	8	0	~0	$8,104,510	~0
Total		**63**	**0.4**	**1,168**	**77,141**	**5.4**	**$80,029,061**	**5.6**

4.7 Virginia WEA

The VA WEA (Figure 4-7) is the least fished WEA at $66,105 total revenue per year on average. For fishing intensity, this WEA also ranks last of the eight WEAs at only $145 per km².

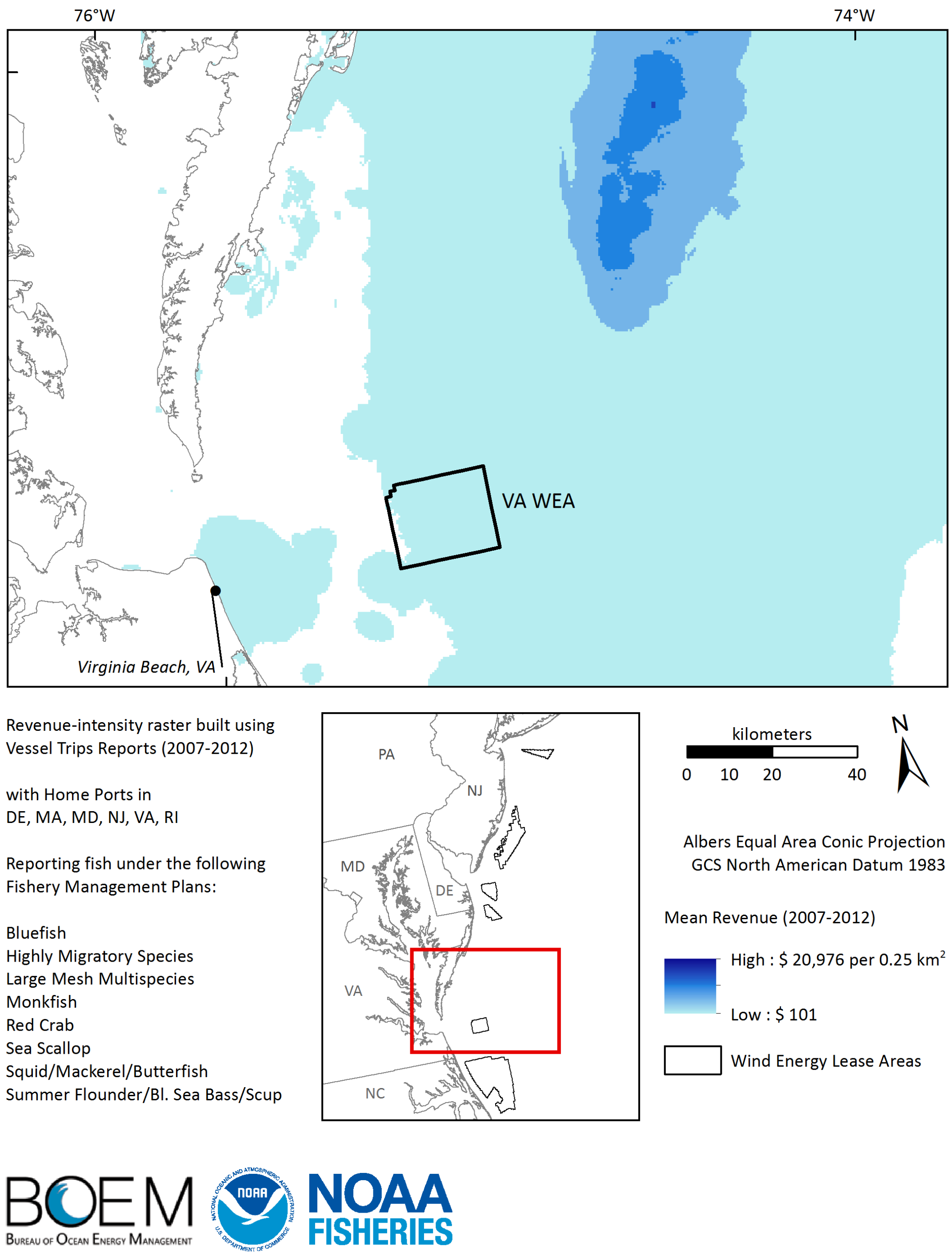


Figure 4-7. Commercial fishing activity from ports most exposed to the VA WEA, 2007–2012.

4.7.1 Commercial Fisheries

4.7.1.1 Ports and Fishery Management Plans

Table 4-37 identifies the commercial ports most exposed to the VA WEA, which is best characterized as being very lightly fished. The Virginia Beach port group had the highest exposure, with 3.6 percent of their revenue from the area. No other port relies on fishing in the VA WEA for more than 0.1 percent of its federally reported landings. Table 4-38, which presents FMP exposure, indicates that none of the FMPs is substantially exposed to VA WEA development.

Table 4-37. Commercial ports most exposed to the VA WEA, 2007–2012.

Port Group	Average Annual Revenue from VA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to VA WEA
Virginia Beach, VA	$40,251	$1,122,195	3.6
Norfolk, VA	Not Disclosable	Not Disclosable	0.1
North Kingstown, RI	$9,530	$9,555,145	0.1
Engelhard, NC	$2,109	$2,307,195	0.1
Oriental, NC	$1,087	$1,272,725	0.1
Chincoteague, VA	$808	$3,130,890	~0.0
Newport News, VA	$5,633	$38,319,620	~0.0
Hampton, VA	$1,176	$15,344,027	~0.0
Cape May, NJ	$1,437	$75,665,163	~0.0

Table 4-38. FMPs exposed to VA WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from VA WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Summer Flounder, Scup, Black Sea Bass	MAFMC	$36,584	$33,166,172	0.1
Red Crab	NEFMC	Not Disclosable	Not Disclosable	Not Disclosable
Squid, Mackerel, Butterfish	MAFMC	$11,060	$40,849,295	~0
Highly Migratory Species	AHMS	$308	$1,824,519	~0
Unmanaged		$16,322	$248,316,185	~0
Bluefish	MAFMC	$85	$1,578,705	~0
Monkfish	NEFMC, MAFMC	$226	$19,759,447	~0
Skate	NEFMC	$63	$7,796,915	~0
Large Mesh Multispecies	NEFMC	$32	$76,625,579	~0
Sea Scallop	NEFMC	$41	$428,413,267	~0

4.7.1.2 Commercial Permits/Gear

Table 4-39 presents the number of permits and revenue, by gear type, fishing within the bounds of the VA WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

Pot gear has the most exposed average annual revenue to the WEA ($41,789), and bottom trawl is the only other gear that exceeds $5,000 per year in average annual revenue. Pot fishermen land primarily black sea bass and channeled whelk, while trawlers land small amounts of squid. Both gears land small amounts of summer flounder as well.

Table 4-39. Number of permits and revenue, by gear, exposed to development of the VA WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from VA WEA	Percent Revenue from VA WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	2	$486,160,813	Not Disclosable	~0	Not Disclosable	Not Disclosable
Gillnet	12	$34,164,385	$628	~0	Unmanaged;[b] Monkfish;[c] Skate;[d] Bluefish[e]	Virginia Beach, VA; Chincoteague, VA; Hampton, VA; Wanchese, NC; Accomack County, VA
Hand	9	$8,339,830	$1,937	~0	Summer Flounder, Scup, Black Sea Bass;[e] Unmanaged;[b] Bluefish[e]	Norfolk, VA; Virginia B, VA; Hampton, VA; Accomack County, VA; Dare County, NC
Longline	2	$7,399,976	Not Disclosable	~0	Highly Migratory Species;[f] Unmanaged[b]	Dare County, NC
Pot	19	$11,071,430	$41,789	0.4	Summer Flounder, Scup, Black Sea Bass;[e] Unmanaged;[b] Red Crab;[d] Large Mesh Multispecies[d]	Virginia Beach, VA; Newport News, VA; New Bedford, MA; Chincoteague, VA; Fall River, MA
Lobster Pot	4	$213,321,675	$597	~0	Not Disclosable	Not Disclosable
Bottom Trawl	109	$174,094,198	$20,942	~0	Squid, Mackerel, Butterfish;[e] Summer Flounder, Scup, Black Sea Bass;[e] Unmanaged;[b] Highly Migratory Species[f]	North Kingstown, RI; Newport News, VA; Engelhard, NC; Cape May, NJ; Hampton, VA
Midwater Trawl	1	$21,384,152	Not Disclosable	~0	Not Disclosable	Not Disclosable

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b Unmanaged species

c Joint NEFMC and MAFMC management

d NEFMC management

e MAFMC management

f AHMS management

Table 4-40 lists the top 10 exposed species within the VA WEA.

Table 4-40. Top 10 exposed species wtihin the VA WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Sea Bass, Black	$31,845	$5,422,180	0.6%
Whelk, Channeled	$8,054	$2,419,819	0.3%
Croaker, Atlantic	$2,925	$3,081,688	0.1%
Hagfish	ND	ND	ND
Squid (Illex)	$7,225	$9,961,263	0.1%
Crab, Red	ND	ND	ND
Shrimp (Pandalid)	$1,358	$4,844,490	0.0%
Flounder, Summer	$4,737	$22,019,367	0.0%
Squid (Loligo)	$3,816	$24,867,195	0.0%
Lobster	$1,043	$212,474,994	0.0%

4.7.2 Recreational Fisheries

Table 4-41 identifies the recreational fishery exposure of states to the development of the VA WEA. Unlike other WEAs, only one state, Virginia, showed recreational trips that traveled within one nautical mile of the VA WEA. Approximately 2 percent of annual for-hire boat trips, 3.3 percent of for-hire angler trips, and 1.5 percent of private angler trips were in or near the VA WEA. Just under 6 percent of total annual private and for-hire angler trip expenditures would be exposed to development of the VA WEA.

Table 4-41. State-level average annual exposure of recreational fishery to VA WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
VA	694	2.0	11,646	3.3	1,958,706	1.5	$31,702,092	5.7

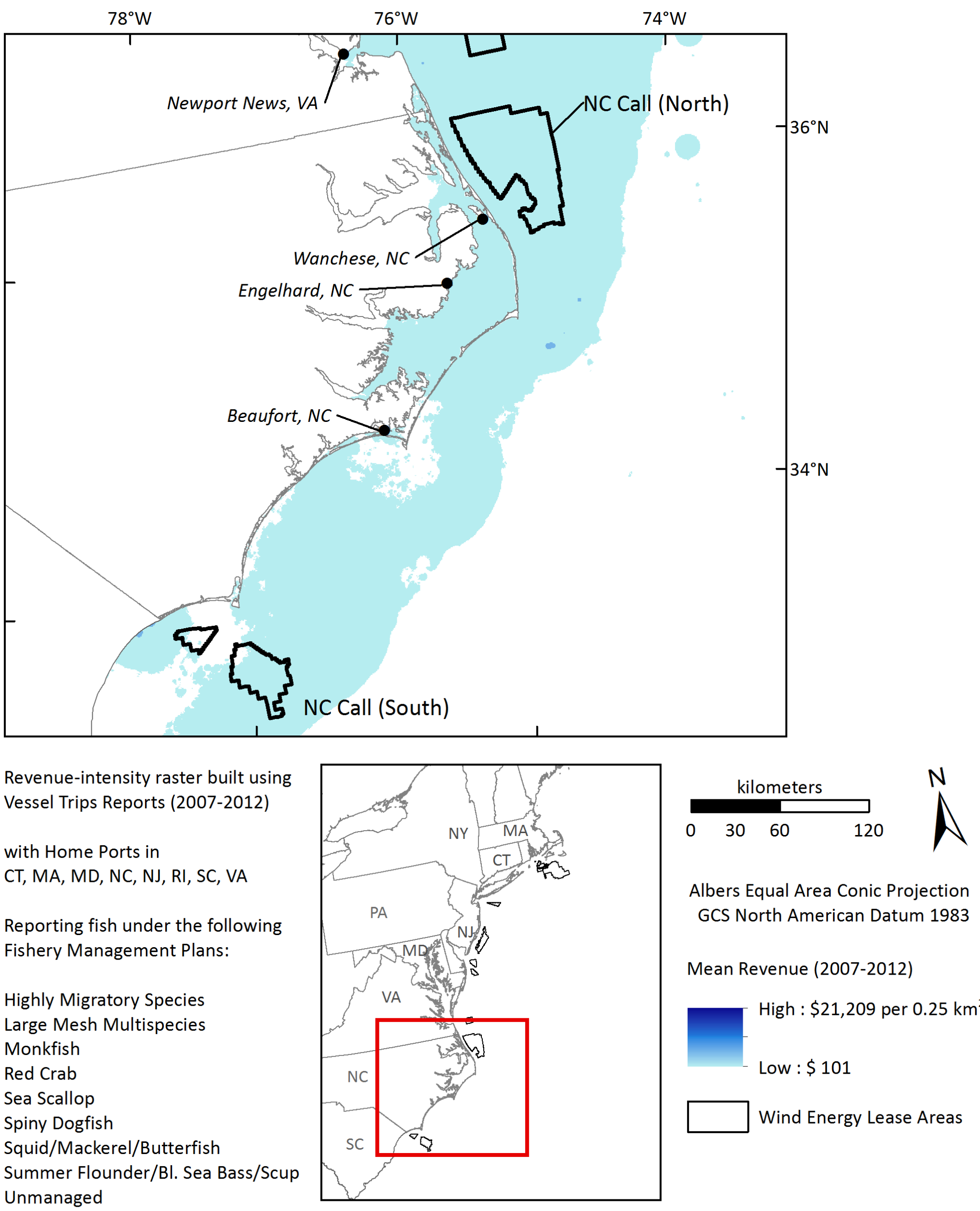
Table 4-42 presents the average annual exposure of for-hire boat trips, for-hire and private angler trips, and angler expenditures to the VA WEA. Approximately 3 percent of for-hire boat trips in Norfolk and Virginia Beach, VA, fish in or near the VA WEA. While no private angler trips from Norfolk appear to travel near the VA WEA, almost 28,600 private angler trips from Virginia Beach do.

Table 4-42. VA WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
VA	Norfolk	1	2.5	3	~0	~0	$10,035,665	~0
	Virginia Beach	13	2.8	377	28,575	8.5	$21,666,428	8.3
Total		**14**	**0.1**	**379**	**28,570**	**5.7**	**$31,702,092**	**5.7**

4.8 North Carolina WEA

The average annual revenue from the NC WEA (circa 2013) totals $1.05 million, but due to the large size of this WEA, the revenue intensity is second-lowest of the eight WEAs at $212 per km² (Figure 4-8). Since 2013, 75 percent of the area has been removed from leasing consideration.



BOEM Bureau of Ocean Energy Management | NOAA FISHERIES

Figure 4-8. Commercial fishing activity from ports most exposed to the NC WEA, 2007–2012.

4.8.1 Commercial Fisheries

4.8.1.1 Ports and Fishery Management Plans

Table 4-43 identifies the commercial ports exposed to the NC WEA. The ports most affected, as measured by average total annual revenue (third column), are those located near the Oregon Inlet as well as Newport News, VA.

Table 4-43. Commercial ports most exposed to the NC WEA, 2007–2012.

Port Group	Average Annual Revenue from NC WEA	Average Total Annual Revenue	Percent Total Revenue Exposed to NC WEA
New Hanover County, NC	$57,461	$838,758	6.9
Brunswick County, NC	$68,009	$1,163,775	5.8
Dare County, NC	$118,875	$2,245,733	5.3
Wanchese, NC	$212,589	$4,483,149	4.7
Beaufort, NC	$44,294	$962,400	4.6
Engelhard, NC	$97,390	$2,307,195	4.2
Oriental, NC	$49,621	$1,272,725	3.9
North Kingstown, RI	$60,758	$9,555,145	0.6
Hampton, VA	$68,237	$15,344,027	0.4
Newport News, VA	$92,824	$38,319,620	0.2

Table 4-44 identifies the management plans exposed to WEA development, with only summer flounder, scup, and black sea bass exposed at 1.2 percent of total revenue exposed. Exposure of the remaining FMPs ranges from 0.3 percent down to almost 0 percent.

Table 4-44. FMPs exposed to NC WEA, 2007–2012.

FMP	Jurisdiction	Average Annual Revenue from NC WEA	Average Total Annual Revenue	Percent Total Revenue Exposed
Summer Flounder, Scup, Black Sea Bass	MAFMC	$404,634	$33,166,172	1.2
Red Crab	NEFMC	Not Disclosable	Not Disclosable	Not Disclosable
Highly Migratory Species	AHMS	$6,082	$1,824,519	0.3
Squid, Mackerel, Butterfish	MAFMC	$100,953	$40,849,295	0.3
Unmanaged		$471,546	$248,316,185	0.2
Monkfish	NEFMC, MAFMC	$8,652	$19,759,447	~0
Spiny Dogfish	NEFMC, MAFMC	$766	$2,172,246	~0
Sea Scallop	NEFMC	$16,643	$428,413,267	~0
Large Mesh Multispecies	NEFMC	$950	$76,625,579	~0

4.8.1.2 Commercial Permits/Gear

Table 4-45 presents the number of permits and revenue, by gear type, fishing within the bounds of the NC WEA. Note that: (1) gear categories are not mutually exclusive, in that a single individual can be represented in multiple gear categories, and (2) the "unmanaged" category indicates revenue generated from unmanaged species—i.e., species that do not fall under an FMP.

The NC WEA is fished primarily by bottom trawl, hand gear (primarily bandit reels), midwater trawl, and gillnet. Hand gear is used primarily by vessels permitted in the Southeast region, where landings are reported at the county level; primary counties include Brunswick (NC), New Hanover (NC), Horry (SC), Georgetown (SC), and Dare County (NC). The main species landed from the NC WEA include king mackerel, croaker, and summer flounder, with croaker totaling $136,043 revenue per year on average and summer flounder totaling $369,967 per year on average (Table 4-46). These species are landed primarily by bottom trawl gear.

Table 4-45. Number of permits and revenue, by gear, exposed to development of the NC WEA, 2007–2012.

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NC WEA	Percent Revenue from NC WEA	Top 4 FMPs[a]	Top 5 Port Groups
Dredge	4	$486,160,813	$15,983	~0	Sea Scallop;[b] Unmanaged;[c] Bluefish;[d] Monkfish[e]	New London, CT; New Bedford, MA; Cape May, NJ; Hampton, VA
Gillnet	96	$34,164,385	$72,186	0.2	Unmanaged;[c] Bluefish;[d] Monkfish;[e] Highly Migratory Species[f]	Wanchese, NC; Dare County, NC; Chincoteague, VA; Engelhard, NC; Nags Head, NC
Hand	249	$8,339,830	$131,821	1.6	Unmanaged;[c] Summer Flounder, Scup, Black Sea Bass;[d] Highly Migratory Species;[f] Bluefish[d]	Brunswick County, NC; New Hanover County, NC; Horry County, SC; Georgetown County, SC; Dare County, NC
Longline	23	$7,399,976	$14,640	0.2	Unmanaged;[c] Highly Migratory Species;[f] Bluefish;[d] Summer Flounder, Scup, Black Sea Bass[d]	Dare County, NC; Wanchese, NC; Hampton County, VA; Accomack County, VA; Charleston County, SC
Other	4	$35,038	$113	0.3	Unmanaged[c]	Pamlico County, NC; Dare County, NC; Brunswick County, NC
Pot	59	$11,071,430	$69,347	0.6	Unmanaged;[c] Summer Flounder, Scup, Black Sea Bass;[d] Red Crab;[b] Golden Tilefish[d]	Newport News, VA; Virginia Beach, VA; New Hanover County, NC; New Bedford, MA; Wanchese, NC

Gear	Permits	Average Annual Revenue	Average Annual Revenue from NC WEA	Percent Revenue from NC WEA	Top 4 FMPs[a]	Top 5 Port Groups
Lobster Pot	6	$213,321,675	$1,848	~0	Unmanaged;[c] Red Crab;[b] Large Mesh Multispecies[b]	Ocean City, MD; Newport News, VA; Cape May, NJ; New Bedford, MA; Fall River, MA
Seine	2	$10,258,052	Not Disclosable	Not Disclosable	Not Disclosable	Not Disclosable
Bottom Trawl	141	$174,094,198	$632,582	0.4	Summer Flounder, Scup, Black Sea Bass;[d] Unmanaged;[c] Squid, Mackerel, Butterfish;[d] Bluefish[d]	Wanchese, NC; Engelhard, NC; Newport News, VA; Hampton, VA; North Kingstown, RI
Midwater Trawl	235	$21,384,152	$106,733	0.5	Unmanaged;[c] Highly Migratory Species;[f] Summer Flounder, Scup, Black Sea Bass;[d] Bluefish[d]	Dare County, NC; New Hanover County, NC; Brunswick County, NC; Onslow County, NC; Pender County, NC

a Some gear types may meet exposure thresholds for fewer than four FMPs, in which case only the FMPs that are considered exposed are listed.

b NEFMC management

c Unmanaged species

d MAFMC management

e Joint NEFMC and MAFMC management

f AHMS management

Table 4-46 lists the top 10 exposed species within the NC WEA.

Table 4-46. Top 10 exposed species within the NC WEA.

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Mackerel, King	$112,659	$1,089,857	10.3%
Croaker, Atlantic	$136,043	$3,081,688	4.4%
Grouper, Red	$24,734	$899,914	2.7%
Grouper	$22,923	$976,023	2.3%
Snapper, Vermillion	$30,024	$1,307,436	2.3%
Flounder, Summer	$369,967	$22,019,367	1.7%
Bluefish	$24,256	$1,578,705	1.5%
Sea Bass, Black	$34,640	$5,422,180	0.6%
Squid (Illex)	$51,707	$9,961,263	0.5%

Species	Species Average Exposed Revenue	Species Average Total Revenue	Exposed Species Revenue (Percent)
Squid (Loligo)	$47,449	$24,867,195	0.2%

4.8.2 Recreational Fisheries

Table 4-47 identifies the recreational fishery exposure of states to the development of the NC WEA. Approximately 22 to 26 percent of for-hire boat trips and for-hire angler trips from North Carolina and South Carolina travel in the NC WEA. Angler expenditures in all three states (North Carolina, South Carolina, and Virginia) with trips to the NC WEA area would be exposed to development of the NC WEA. Annual expenditures in North Carolina would be most affected, with over 9 percent of total angler trip expenditures estimated to be exposed to the NC WEA ($14 million).

Table 4-47. State-level average annual exposure of recreational fishery to NC WEA, 2007–2012.

State	Total For-Hire Boat Trips	Percent Total For-Hire Boat Trips Exposed	Total For-Hire Angler Trips	Percent Total For-Hire Angler Trips Exposed	Total Private Angler Trips	Percent Total Private Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expenditures Exposed
NC	1,586	24.0	41,195	26.1	2,215,795	6.9	$150,958,104	9.2
SC	1,447	22.3	41,697	22.0	1,086,631	0.1	$58,598,583	6.6
VA	694	0.5	11,646	0.2	1,958,706	1.5	$27,543,442	6.4

Table 4-48 presents the average annual exposure of for-hire boat trips, for-hire and private angler trips, and angler expenditures to the NC WEA. For-hire boat trips and for-hire angler trips in Swansboro, NC, and Little River, SC, were most likely to travel within a nautical mile of the NC WEA. Several North Carolina port groups indicated that approximately 13 percent of angler (private and for-hire) trips utilize the NC WEA. In percentage terms, angler expenditures in Little River, SC, and North Myrtle Beach, SC are the most exposed to the NC WEA.

Table 4-48. NC WEA average annual private and for-hire recreational exposure by port group, 2007–2012.

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
NC	Hatteras	1	0.9	35	0	0.1	$5,596,329	0.2
	Manteo	14	38.3	290	12,650	13.2	$6,979,961	13.9
	Morehead City	~0	0.1	7	0	~0	$18,177,072	~0
	Nags Head	3	4.4	13	31,471	13.0	$16,865,044	13.0
	Other Carteret	0	0	0	0	0	$36,095,283	~0
	Other Dare	1	1.6	4	3,655	12.9	$2,014,918	12.6
	Swansboro	362	34.0	9,841	105,427	13.8	$65,229,497	16.1
SC	Hilton Head	0	0	0	0	0	$4,012,638	~0
	Litter River	246	33.7	4,940	235	22.2	$5,301,262	38.8
	Mount Pleasant	0	0	0	0	0	$26,657,625	~0
	Murrells Inlet	10	4.6	745	0	0.3	$17,453,678	1.8

State	Port Group	Exposed For-Hire Boat Trips	Percent For-Hire Boat Trips Exposed	Exposed For-Hire Angler Trips	Exposed Private Angler Trips	Percent Total Angler Trips Exposed	Total Angler Expenditures (Private and For-Hire)	Percent Total Expen-ditures Exposed
	North Myrtle Beach	66	50.1	3,484	1,009	7.8	$5,173,380	28.8
VA	Virginia Beach	2	0.4	16	28,570	8.4	$21,666,428	8.1
	Wachapreague	2	1.4	9	0	~0	$5,877,014	~0
Total		**706**	**3.5**	**19,382**	**183,016**	**5.6**	**$206,346,767**	**9.0**

5 Impact by Individual Wind Energy Area

This section describes impacts to commercial fisheries, recreational fisheries, and shoreside dependents for each of the eight WEAs. Methods used to conduct the impact analysis are described in Section 3.2.

- **Commercial fisheries.** For commercial fisheries, the WEA-specific impacts described here are derived from the results of the cluster analysis detailed in Sections 6.2.5 to 6.2.8. Impacts are presented in terms of RNVC. As described in Section 3.2.2.4, the authors used the location choice model for this analysis to estimate each trip's costs and revenue to each zone, and then calculate an expected change in revenue net of variable costs (RNVC) for each trip.

- **Recreational fisheries.** Analysis of recreational impacts is based on exposure results described in Section 4.

- **Shoreside dependents.** Impacts to shoreside dependents are expected to mirror impacts to the commercial or recreational fisheries in that WEA.

5.1 Massachusetts WEA

5.1.1 Commercial Fisheries

The MA WEA is explicitly modeled in Clusters 1, 2 GC (General Category), 2 LA (Limited Access), and 3, described in Sections 6.2.5 to 6.2.7. Table 6-48 summarizes potential impacts by cluster. These data indicate that only Cluster 1 (gillnet and pot fishermen in Rhode Island and the South Coast of Massachusetts) is likely to experience measurable impacts to commercial fisheries from WEA development (see Appendix II, Section II.i, for a full description of Cluster 1 impacts). Comparing results for the RI-MA WEA fully closed scenario (Section 6.2.5.1) with results for the worst-case scenario, in which all WEAs are fully closed (Section 6.2.5.2), indicates that:

- **Gillnet fishermen** are able to recover virtually all RNVC displaced by closure of the MA WEA in the worst-case scenario of concurrent full closure of both Cluster 1 WEAs to commercial fishing. Gillnets represent just under 73 percent of the total Cluster 1 gross revenue exposed to development of the MA WEA (see Appendix II).

- **Pot fishermen** are more substantially impacted by the worst-case scenario because they rely more heavily than gillnet fishermen on the MA WEA and are thus less able to offset closure of this area. Nevertheless, the impact under this worst-case scenario is still relatively small: a loss of 2 percent of pot fishermen's total RNVC with concurrent development of all WEAs. However, distribution analysis (Figure 6-5) indicates that these impacts likely will not be uniformly distributed among individual fishermen. Therefore, some pot fishermen can be expected to experience a greater percentage of RNVC loss.

The 82.5 percent of exposed revenue directly modeled in this analysis represented those fishermen most highly exposed to WEA development. Though results cannot be extrapolated from the modeled groups to non-modeled groups (representing 17.5 percent of exposed revenue for the MA WEA), the exposure and impact analyses indicate that MA WEA development would have slightly negative to neutral impacts on commercial fishermen overall, with uncertainty driven primarily by uncertainty over how the impacts will ultimately manifest (i.e., which modeled scenario best represents actual impacts resulting from MA WEA development).

5.1.2 Recreational Fisheries

Exposure of recreational fishing to MA WEA development is described in Section 4.1.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in Massachusetts, New Hampshire, New York, and Rhode Island reported fishing in or near the MA WEA. On average, of the 15,255 for-hire boat trips that left from those ports each year during the study period, 0.2 percent occurred in or near the MA WEA.

- **Angler trips.** Only about 1 percent of anglers' for-hire and private boat trips in Massachusetts, New Hampshire, New York, and Rhode Island are estimated to be exposed to development of the MA WEA.

Given this relatively low exposure level, the potential impact (negative or positive) of MA WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.1.3 Shoreside Dependents

Impacts of MA WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend:

- **Commercial fisheries.** Section 6.4.2 and Appendix II, Tables II-xxviii to II-xxxi, make clear that even the worst-case scenario of concurrent and full closure of both Cluster 1 WEAs will likely only have a slightly negative impact to shoreside dependent businesses of commercial fisheries. Thus, the actual impact of MA WEA development is expected to be neutral to slightly negative. Impacts are expected to mirror those to the region's commercial fishery, with dependents of lobster pot fishermen affected most. Uncertainty over the impact is driven primarily by uncertainty over how the impacts will ultimately manifest (i.e., which modeled scenario best represents the actual outcomes ultimately realized).

- **Recreational fisheries.** Mirroring impacts to recreational fisheries described above, impacts of MA WEA development to shoreside dependents of these fisheries are expected to be minimal.

5.2 Rhode Island–Massachusetts WEA

5.2.1 Commercial Fisheries

The RI-MA WEA is explicitly modeled in Clusters 1, 2 GC (General Category), 2 LA (Limited Access), and 3; see Sections 6.2.5 to 6.2.7. Data presented in Table 6-48, which summarizes potential impacts for the individual clusters, indicate that only Cluster 1 (gillnet and pot fishermen in Rhode Island and the South Coast of Massachusetts) is likely to experience measurable impacts to commercial fisheries from WEA development (see Appendix II, Section II.i, for a full description of Cluster 1 impacts).

Section 6.2.5.1 models the full closure of the RI-MA WEA to Cluster 1. Results of this scenario indicate that gillnet fishermen bear the majority of the impact from closure of the RI-MA WEA, although the lost RNVC represents only 2.8% of this cluster's total annual gillnet RNVC (see Table 6-8), and the impact is not expected to be uniform across permitted vessels.

Section 6.2.5.2 presents the worst-case scenario—concurrent and full closure of all WEAs—on Cluster 1. Results indicate that concurrent closure would induce additional impacts on lobster fishermen in Cluster 1, but not substantially increase the expected impact on gillnet and other pot fishermen beyond what is expected from developing the RI-MA WEA alone. The total impact of this worst-case scenario for both pot and gillnet fishermen is still a relatively small 2.2 percent of RNVC across Cluster 1 (Table 6-10).

This analysis suggests that, generally, RI-MA WEA development is expected to have neutral to slightly negative impacts, with uncertainty driven primarily by uncertainty over how the impacts will ultimately manifest (i.e., which modeled scenario best represents the actual impacts from RI-MA WEA development).

5.2.2 Recreational Fisheries

Exposure of recreational fishing to RI-MA WEA development is described in Section 4.2.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island reported fishing in or near the RI-MA WEA. On average, of the 16,569 reported for-hire boat trips that left from those ports each year during the study period, 0.9 percent occurred in or near the RI-MA WEA.

- **Angler trips.** Less than 1 percent of anglers' for-hire and private boat trips in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island are estimated to be exposed to development of the RI-MA WEA.

Given this low exposure level for recreational fisheries, the potential impact (negative or positive) of RI-MA WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.2.3 Shoreside Dependents

Impacts of RI-MA WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend:

- **Commercial fisheries.** Section 6.4.2 and Appendix II, Tables II-xxviii to II-xxxi, make clear that even the worst-case scenario of concurrent and full closure of all WEAs will likely only have a slightly negative impact to shoreside dependents of commercial fisheries. Thus, the actual impact of RI-MA WEA development is expected to be neutral to slightly negative. Impacts are expected to mirror those to the region's commercial fishery, with dependents of gillnet fishermen affected most. Uncertainty over the impact is driven primarily by uncertainty over how the impacts will ultimately manifest (i.e., which modeled scenario best represents the actual outcomes ultimately realized).

- **Recreational fisheries.** Due to the low exposure levels for for-hire and angler recreational groups, impacts of RI-MA WEA development to shoreside dependents of recreational fisheries are expected to be minimal.

5.3 New York WEA

5.3.1 Commercial Fisheries

The NY WEA is explicitly modeled in Cluster 2 (Mid-Atlantic scallop fishermen) (see Section 6.2.6). Appendix II, Section II.ii, provides a full description of Cluster 2 impacts.

The impact of an independent closure of the NY WEA on the Cluster 2 GC and LA segments is described in Sections 6.2.6.1.1 and 6.2.6.2.1 respectively, while the impact on the Cluster 2 GC segment of closing all WEAs concurrently is presented in Section 6.2.6.1.2.

Table 6-48 presents the range of potential impacts. It indicates that Cluster 2 is likely to experience relatively low impacts from WEA development because only 2.9 percent of this cluster's RNVC is exposed, and most this exposed RNVC (94.4 percent to 96.8 percent for the GC segment, and 98.6 percent to 98.9 percent for the LA segment) is recoverable by fishing in alternative locations.

5.3.2 Recreational Fisheries

Exposure of recreational fishing to NY WEA development is described in Section 4.3.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in New Jersey and New York reported fishing in or near the NY WEA. On average, of the 15,204 reported for-hire boat trips that left from those ports each year during the study period, 0.2 percent occurred in or near the NY WEA.

- **Angler trips.** Less than 2 percent of anglers' for-hire and private boat trips in New Jersey and New York are estimated to be exposed to development of the NY WEA.

Given this relatively low exposure level, the potential impact (negative or positive) of NY WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.3.3 Shoreside Dependents

Impacts of NY WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of NY WEA development to shoreside dependents of commercial fisheries are expected to be very low, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

5.4 New Jersey WEA

5.4.1 Commercial Fisheries

The NJ WEA is explicitly modeled in the Cluster 2 GC segment (Mid-Atlantic scallop fishermen) and in Cluster 3 (Mid-Atlantic clam fishermen), as described in Section 6.2.6 and Section 6.2.7, respectively:

- Section 6.2.7.1 describes the impact of independent closure of the NJ WEA on Cluster 3.
- Section 6.2.6.1.2 describes impacts for the worst-case Cluster 2 scenario: closure of all WEAs.
- Section 6.2.7.2 describe the impact of the worst-case Cluster 3 scenario: closure of all WEAs.

See Appendix II for a full description of Cluster 2 (Section II.ii) and Cluster 3 (Section II.iii) impacts.

Table 6-48 presents the range of potential impacts. It indicates that Cluster 2 is likely to experience relatively low impacts from WEA development because only 2.9 percent of this cluster's RNVC is exposed, and 94.4 percent to 96.8 percent of the Cluster 2 GC exposed RNVC is recoverable by fishing in alternative locations. Likewise, although highly exposed to the NJ WEA, Cluster 3 is expected to be negligibly impacted by its development, with 100 percent of displaced RNVC expected to be recovered by fishing in alternative locations.

5.4.2 Recreational Fisheries

Exposure of recreational fishing to NJ WEA development is described in Section 4.4.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in Delaware, Maryland, New Jersey, and New York reported fishing in or near the NJ WEA. On average, of the 16,993 reported for-hire boat trips that left from those ports each year during the study period, 2.3 percent occurred in or near the NJ WEA.
- **Angler trips.** Only about 3 percent of anglers' for-hire and private boat trips in Delaware, Maryland, New Jersey, and New York are estimated to be exposed to development of the NJ WEA.

Given the level of recreational fishing exposure, the potential impact (negative or positive) of NJ WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.4.3 Shoreside Dependents

Impacts of NJ WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of NJ WEA development to shoreside dependents of commercial fisheries are expected to be minimal, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

5.5 Delaware WEA

5.5.1 Commercial Fisheries

The DE WEA was not explicitly modeled in Section 6.2 due to negligible exposure of commercial fisheries to development of this area, with no commercial fisheries meeting the exposure thresholds of greater than $1 million in annual revenue exposed, or greater than $1,000/year and greater than 2 percent of total revenue sourced within the WEA (see Section 4.5.1). Commercial fisheries are thus expected to have negligible impacts from development of the DE WEA.

5.5.2 Recreational Fisheries

Exposure of recreational fishing to DE WEA development is described in Section 4.5.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in Delaware, Maryland, and New Jersey reported fishing in or near the DE WEA. On average, of the 9,966 reported for-hire boat trips that left from those ports each year during the study period, 2.3 percent occurred in or near the DE WEA.

- **Angler trips.** Less than 2 percent of anglers' for-hire and private boat trips in Delaware, Maryland, and New Jersey are estimated to be exposed to development of the DE WEA.

Given this low exposure level, the potential impact (negative or positive) of DE WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.5.3 Shoreside Dependents

Impacts of DE WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of DE WEA development to shoreside dependents of commercial fisheries are expected to be negligible, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

5.6 Maryland WEA

5.6.1 Commercial Fisheries

The MD WEA was not explicitly modeled in Section 6.2 due to negligible exposure of commercial fisheries to development of this area, with no commercial fisheries meeting the exposure thresholds of greater than $1 million in annual revenue exposed, or greater than $1,000/year and greater than 1 percent of total revenue sourced within the WEA (see Section 4.6.1). Commercial fisheries are thus expected to have negligible impacts from development of the MD WEA.

5.6.2 Recreational Fisheries

Exposure of recreational fishing to MD WEA development is described in Section 4.6.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in Delaware, Maryland, and New Jersey reported fishing in or near the MD WEA. On average, of the 9,966 reported for-hire boat trips that left from those ports each year during the study period, 0.6 percent occurred in or near the MD WEA.

- **Angler trips.** Only about 1 percent of anglers' for-hire and private boat trips in Delaware, Maryland, and New Jersey are estimated to be exposed to development of the MD WEA.

Given the low exposure level of recreational fisheries, the potential impact (negative or positive) of MD WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As described in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.6.3 Shoreside Dependents

Impacts of MD WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of MD WEA development to shoreside dependents of commercial fisheries are expected to be very low, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

5.7 Virginia WEA

5.7.1 Commercial Fisheries

The VA WEA was not explicitly modeled in Section 6.2 due to negligible exposure of commercial fisheries to development of this area, with no commercial fisheries meeting the thresholds of exposure of greater than $1 million in annual revenue, or greater than $1,000/year and greater than 1 percent of total revenue sourced within the WEA (see Section 4.7.1.2). Commercial fisheries are thus expected to have negligible impacts accrue from development of the VA WEA.

5.7.2 Recreational Fisheries

Exposure of recreational fishing to VA WEA development is described in Section 4.7.2. Briefly, as shown in Table 4-41:

- **For-hire boat trips.** Only for-hire boat trips from ports in Virginia reported fishing in or near the VA WEA. On average, of the 694 reported for-hire boat trips that left from those ports each year during the study period, 2.0 percent occurred in or near the VA WEA.

- **Angler trips.** Only slightly more than 1 percent of anglers' for-hire and private boat trips in VA are estimated to be exposed to development of the VA WEA.

Given this low exposure level of recreational fisheries, the potential impact (negative or positive) of VA WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As detailed in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.7.3 Shoreside Dependents

Impacts of VA WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of VA WEA development to shoreside dependents of commercial fisheries are expected to be very low, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

5.8 North Carolina WEA

5.8.1 Commercial Fisheries

The NC WEA (circa 2013) is explicitly modeled in the Cluster 2 GC subset (Mid-Atlantic scallop fishermen) and in Cluster 4 (permits landing on Roanoke Island, NC):

- Section 6.2.8.1 describes the impact of independent closure of the NC WEA on Cluster 4.
- Section 6.2.6.1.2 describes impacts for the worst-case scenario of full closure of all WEAs.

See Appendix II for a full description of Cluster 2 (Section II.ii) and Cluster 4 (Section II.iv) impacts.

Table 6-48 presents the full range of potential impacts. It indicates that Cluster 2 is likely to experience relatively low impacts from WEA development because only 2.9 percent of this cluster's RNVC is exposed, and 94.4 percent to 96.8 percent of the exposed RNVC for the Cluster 2 GC segment is recoverable by fishing in alternative locations. Similarly, the analysis suggests that Cluster 4 is likely to experience minimal impacts from WEA development, with 4.9 percent of this cluster's RNVC exposed, and 97.3 percent to 97.9 percent of exposed RNVC recoverable by fishing in alternative locations. The impact on commercial fisheries of developing the NC WEA is thus expected to be minimal for both scenarios.

5.8.2 Recreational Fisheries

Exposure of recreational fishing to NC WEA development is described in Section 4.8.2. Briefly:

- **For-hire boat trips.** For-hire boat trips from ports in North Carolina, South Carolina, and Virginia reported fishing in or near the NC WEA. On average, of the 3,727 reported for-hire boat trips that left from those ports each year during the study period, about 19 percent occurred in or near the NC WEA. However, due to data limitations in North Carolina and South Carolina, this estimate of exposed for-hire boat trips should be interpreted as an estimate of the maximum exposure of for-hire boat trips to development of the NC WEA. Appendix I describes the analytical approach for defining for-hire boat exposure to the NC WEA and delineates the data limitations.

- **Angler trips.** Only about 4 percent of anglers' for-hire and private boat trips in North Carolina, South Carolina, and Virginia are estimated to be exposed to development of the NC WEA.

Overall, given the exposure level, the potential impact (negative or positive) of NC WEA development on recreational for-hire businesses and recreational anglers is expected to be minimal. As described in Section 6.3.2, localized disruption to the area directly around WEA construction may result in slightly negative to neutral impacts to exposed recreational anglers in the short run, but positive to neutral impacts are expected over the longer term if the turbines attract fish habitat and improve the recreational fishing experience.

5.8.3 Shoreside Dependents

Impacts of NC WEA development to shoreside dependents are expected to mirror the impacts (described above) to the commercial or recreational fisheries on which they depend. Therefore, impacts of NC WEA development to shoreside dependents of commercial fisheries are expected to be minimal, and impacts to shoreside dependents of recreational fishing are expected to be minimal.

6 Cumulative Exposure and Impacts Across All Wind Energy Areas

This section describes the analytical results for *cumulative* exposure and impacts (i.e., across all WEAs). Section 6.1 summarizes the results of a literature review on how WEA development may impact fisheries in the U.S. Atlantic. This review provided a foundation for the cumulative impact analysis. Sections 6.2, 6.3, and 6.4 present the exposure and impact results for commercial fisheries, recreational fisheries, and shoreside dependents, respectively. Methods used for this analysis are summarized in Section 3 and described in further detail in Appendix I.

6.1 Synthesis of Literature on Potential Ecological and Economic Impacts

As described in Section 3.2.1, the authors conducted a literature review to better understand how WEA development may impact fisheries in the U.S. Atlantic. The results provided a foundation for subsequent steps in the cumulative impact analysis. This review synthesized current and ongoing research on the ecological and economic impacts of the installation and operation of wind turbines and similar artificial structures around the globe, with particular attention to the experience of fishermen in European waters (for which more data are available). Sources included the scientific and gray literature, as well as a United Kingdom (UK) fisherman who works as a liaison between the fishing industry and wind companies. The review examined:

- **Potential ecological impacts**, including the effects on fish populations from turbine structures, electromagnetic fields, and noise, and the subsequent impact of these effects on commercial and recreational fisheries. Both the potential impacts and how ecological systems adapt to development were examined.

- **Potential economic impacts,** specifically potential boundary and congestion impacts on commercial fisheries.

- **Area accessibility to fishing vessels,** to understand how fishing access can change after installation is complete. This section also provides context from the EU offshore wind experience.

Results of this review are summarized below. The full synthesis is presented in Appendix IV.

6.1.1 Potential Ecological Impacts

Only a small number of large-scale offshore wind farms exist worldwide, and most have yet to cover a time span appropriate for analysis of fish and fishermen responses. However, as described below, wind turbine installation and operation may have unforeseen effects on life cycle activities (including feeding, spawning, migration) in fish populations of commercial and recreational interest.

6.1.1.1 Impact of Turbine Structure

Research suggests that wind energy turbines may act as FADs with the potential to attract commercially and recreationally harvested species that in turn attract human fishing activity.

Near-shore fixed turbines have acted as FADs (Wilhelmsson et al. 2006), and research on floating and fixed artificial structures suggests that offshore wind turbines are likely to act as FADs (Vella et al. 2001; Rodmell and Johnson 2003; Reubens et al. 2011), which can greatly increase fish catchability (Itano and Holland 2000). Depth and location (Moffit et al. 1989) and the surrounding habitat (Einbinder 2006) may influence the degree to which a turbine attracts fish.

Research in the Belgian part of the North Sea showed that Atlantic cod and pouting had greater CPUE near windmill artificial reefs (ARs), indicating distinct aggregation around the hard-structure turbine foundations (Reubens, Vandendriessche, et al. 2013). After installation, offshore structures become home to sessile invertebrates, which form the basis of a complex food web attracting the larger, commercially and recreationally harvested species that in turn attract human fishing activity (Kaiser 2006; MBC Applied Environmental Sciences 1987; Krone et al. 2013; Coates et al. 2014).

There are similarities between offshore wind and offshore oil platforms. Oil platforms involve hard, artificial structures that extend throughout the water column and likely include base scour protection. Oil platforms are frequently studied as ARs, even when the primary purpose is not ecological. Oil and gas platforms in California have even been considered as potential Essential Fish Habitat, given that certain managed groundfish species inhabit the platforms. Several studies (Helvey 2002; Macreadie et al. 2011; Stanley and Wilson 1996) suggest that the oil and gas platform decommissioning process should include recognition of the important ecological role that retired energy platforms play. Few oil platforms have existed in Atlantic waters; inferences from the impacts of oil platforms must consider this important difference.

6.1.1.2 Impact of Electromagnetic Fields

Researchers are examining how electromagnetic fields (EMF) may affect a variety of species following concerns regarding behavioral and ecological impacts from submarine cables associated with offshore WEAs. While some fishes (e.g., elasmobranchs—a category that includes spiny dogfish and most species within the NE Skate Complex) are known to sense EMF, other fishes including sturgeon may also be affected. Normandeau Associates et al. (2011) stated:

> There are suggestions that if navigation is affected then migratory species may be slowed or deviated from their intended routes with subsequent potential problems for populations if they do not reach essential feeding, spawning or nursery grounds. On a more local scale species that use EMF for finding food may be confused and spend time hunting EMF that is non-biological and hence reducing daily food/energy intake. Species that use EMF to detect predators…could unnecessarily alter their behavior, or this capability could be undermined by anthropogenic EMF sources. The consequence is that if enough individuals are affected then the population and communities that these species belong to may be adversely affected. Nevertheless, these impacts are all currently speculation and it is essential to gain direct evidence to assess if these potential impacts are real and of ecological significance.

6.1.1.3 Impact of Noise

Noise from wind turbine construction (e.g., pile driving) and operation (i.e., turbine vibration under operating conditions) may alter the behavior and commercially exploitable biomass of fishes in the vicinity of WEAs. Despite over 50 years of research on fish hearing, much is still unknown about how sounds affect hearing and, in turn, fish behavior (Popper and Fay 2011).

With respect to construction, pile driving is the only man-made, non-blasting sound source that has killed and caused hearing damage in fish in the natural environment. Pile driving activities have the potential to cause direct fish mortality by damaging internal organs at distances of less than 50 m. However, many studies found no statistically significant change in direct mortality, even at distances of less than 10 m (Popper and Hastings 2009).

The literature suggests that installation activities with low-intensity noise from drilling, dredging, or increased vessel traffic may induce fish and mammals to leave the area, but that animals are likely to return soon after the noise ceases, and that construction activities should be planned to occur outside important recruitment areas for fish, as well as outside biologically sensitive periods of the year for migrating species (Bergstrom et al. 2014).

With respect to operation, far fewer studies have identified impacts associated with normal operational turbine noise. No studies have observed or posited direct mortality from operational noise, and there is no conclusive evidence that wind turbine noise from normal operation impacts commercially exploitable biomass. However, many of the studies of fish behavioral changes due to noise within the range of detectability have not been peer reviewed.

There are some concerns about whether noise and vibration would impact longfin and *Illex* squid commonly harvested in the areas south of Rhode Island. Squid employ statocysts, which act as accelerometers and are primarily used for balance and motion detection (Mooney et al. 2010). Particle acceleration thresholds for detection by similar species were recorded as low as 0.004 ms^{-2} (Packard et al. 1990), which is less than half of the particle acceleration measured at 4–7 m from a turbine base (Wahlberg and Westerberg 2005). On a large scale, it is not likely that vibrations from turbine operation would affect squid species significantly.

6.1.2 Potential Economic Impacts

As summarized below, potential economic impacts from WEA development include increases in fish density and associated fishing activity, particularly along the boundary of areas closed to fishing. These increases have the potential to result in congestion effects and gear conflicts. However, different vessels may respond very differently to area closures, and the scale of areas proposed for wind development in the study area suggests that these effects are not likely to be substantial and that the change in catch would likely be unobservable.

6.1.2.1 Potential Impacts on Commercial Fisheries

The existing literature on biological effects (see Section 6.1.1) indicates a likelihood that WEA development may increase fish density, either through aggregation or increases in biomass. Aggregation could contribute toward increased CPUE, while increased biomass could portend increase in both CPUE and total catch. Studies of gillnets in the North Sea identified catches within 150 m of the platform base that were three to four times higher than elsewhere (Løkkeborg et al. 2002). Polovina and Sakai (1989) found, for studied species, increases in catch around an AR despite mixed changes in biomass. Although many studies have found no increase in CPUE around an AR, this is usually attributed to increases in fishing that coincide with increases in local biomass as opposed to a lack of benefits generally (Pickering and Whitmarsh 1997).

6.1.2.2 Potential Impacts on Recreational Fisheries

Generally, offshore wind turbines are expected to act similarly to other offshore artificial structures, such as oil and gas platforms. In the Gulf of Mexico, oil and gas platforms have long been popular destinations for recreational anglers (Dauterive 2000; Harville 1983; Reggio Jr 1989). Past research on retired oil platforms found that these reefs were a key recreational fishing destination in 70 percent of all recreational angling trips in the Exclusive Economic Zone (Reggio 1987) and 37 percent of all saltwater recreational angling trips off the coast of Louisiana (Witzig 1986). According to one study (Stanley and Wilson 1990), fishing off oil and gas platforms produced the highest catch rates of all recreational fisheries in the United States.

6.1.2.3 Boundary Effects

Changes in CPUE along a closed area boundary are highly dependent on: (1) the current health and density of stocks in the area to be closed, (2) the dynamics of larval dispersion and stock mobility, (3) stock effects within the existing fishery, (4) fishery effort reallocation dynamics (Halpern et al. 2004), and (5) the size and extent of the closed area. This raises significant uncertainty over the range of expected impacts. Large changes in CPUE are unlikely to be observed due to dissipation from increased effort. However, Vandeperre et al. (2011) and Stobart et al. (2009) suggest that, when these so-called spillover effects are present, fishing along the boundary is the preferred alternative for many vessels. A reasonable range of increased CPUE, based on empirical and theoretical evidence, is zero to 10 percent.

6.1.2.4 Congestion Effects

If aggregation or enhancement of biomass within a WEA occurs, congestion effects and gear conflicts may increase as a result (Samples and Sproul 1985). This is especially true with intense boundary fishing (Stobart et al. 2009). Boundary fishing is widely observed around closed areas in Northeast VMS data (NMFS Northeast Regional Office 2013). An increase in fishing between two WEAs in Denmark was observed for some, but not all, gear types (Degraer et al. 2011). However, in this case, the WEA was fully closed to all fishing and no congestion effects were noted. Different vessels can respond very differently to area closures; assuming a single response (e.g., all vessels will choose a similar alternative fishing ground) may lead to erroneous models and conclusions (Smith 2004).

The scale of areas proposed for wind development in the study area suggests that boundary effects (reallocation of effort out of a proposed WEA and into boundary areas due to exclusion from the WEA) are not likely to be substantial. While some local boundary fishing will likely be observed, the change in catch would likely be unobservable, meaning congestion effects are not expected.

6.1.3 Area Accessibility to Fishing Vessels

As described below, while the U.S. Coast Guard (USCG) does not plan to create exclusionary zones around wind turbines during normal operation, informal exclusion may occur if fishing vessel operators avoid WEAs due to concerns about safety or increased insurance costs. At several UK WEAs, traditional methods of fishing continued despite similar initial concerns, although wind energy developments did require some adaptation.

Under current regulations, the USCG is responsible for determining any type of safety or exclusionary zone around any structure placed in the open ocean. The USCG has stated that it does not plan to create exclusionary zones around wind turbines except for safety zones during construction and decommissioning. National Environmental Policy Act documentation for the development of the Cape Wind project off Massachusetts indicates that no exclusionary zone was sought or required by the USCG around that development (MMS 2009).

Construction of wind turbines in fishing grounds may result in informal exclusion if fishing vessel operators perceive or are not actually able to safely navigate the area, either in transit or while fishing. Concerns over navigation safety and insurance costs may lead vessels to avoid a WEA. In the UK, this concern was voiced by fishermen, and was of particular concern to those operating vessels longer than 10 m (33 feet) (RWE nPower Renewables 2011). In the U.S., the same concern was voiced during BOEM Mitigation Measure workshops (BOEM 2014), in informal interviews with fishermen, and in previous reports (Industrial Economics, Inc. 2012). While some vessel operators suggested that, if turbines aggregated commercially exploitable fish species, they would specifically target the WEAs, others indicated that they would not do so regularly.

Vessels using mobile gear (dredge, trawl) expressed greater concern over WEA fishing, while fixed-gear vessels expressed concerns about other navigation issues due to the relatively low risk of fishing with pots, traps, or gillnets within the WEA. Therefore, a practical closure may occur for one gear type and not another, or for larger vessels but not smaller vessels, even in the same WEA. In planning for the Triton Knoll development in the UK, it was noted that "some operators of smaller vessels based in Grimsby and Skegness have developed experience of operating in the existing Lyn and Inner Dowsing site. Skippers of two of these Grimsby based vessels that are known to fish within the (proposed) site have consequently stated their intention to return to their current potting operations" (RWE nPower Renewables 2011).

In the UK, fishing within operating WEAs has been observed. In a presentation to the Mid-Atlantic Fishery Management Council (MAFMC), available at www.mafmc.org/briefing/april-2014, an experienced UK trawl fisherman discussed at length the effects of the Ormonde, Barrow, and Walney Wind Farms located off the coast of Fleetwood, Cumbria, England, in the East Irish Sea. In his report, fishermen testimonies established little difference in general operating patterns within and outside the wind farm. In general, the presentation established that the fishery had strong preferences *against* the development of WEAs, but that the worst fears of the fishery had failed to materialize. Although the wind energy developments required adaptation, traditional methods of fishing in the area had continued.

In scoping meetings, the issue of a potential increase in vessel insurance costs for vessels regularly fishing within a WEA was raised on multiple occasions (BOEM 2014). While no specific incidences of increased premiums have been cited and marine insurance underwriting relies on the insurer's individual experience with each customer, insurance costs could potentially contribute to reduced accessibility. WEAs may also act as transit impediments for vessels with no intent of fishing within the turbines. Depending on placement and weather conditions, vessels may be forced to steam around a developed wind energy facility, adding transit time and fuel cost.

6.2 Commercial Fisheries

The total average yearly commercial fishing revenue generated by the federally managed fisheries throughout the New England and Mid-Atlantic regions between 2007 and 2012 was about $966 million. A total of $84.25 million, or $14.04 million per year, was sourced from the eight proposed WEAs during that time period, representing 1.45 percent of all commercial revenue. This means that the annual revenue sourced from within all the WEAs is nearly equal to the historical fluctuation in fisheries revenue seen once every five years. Put another way, the maximum potential change in fishery revenue from development of a WEA would be equivalent to the fluctuation in revenue that is observed in the dataset every five years, even assuming no reallocation of effort and no harvesting occurs within a WEA. Methods used to assess exposure to WEA development are summarized in Section 3.1 and described in further detail in Appendix I.

This section summarizes the results of the commercial fisheries analysis, which covers the entire six-year period from 2007 to 2012.:

- **Exposure.** Sections 6.2.1 to 6.2.4 summarize exposure results by state, species, port, and permits. Note that this analysis is based on the following "worst-case" scenario, which is an unrealistic assumption:

- All WEAs are fully developed as proposed in 2012.[7]
- During both construction and operation, fishing is fully excluded and no substitute fishing location is available.[8]

- **Impacts.** Sections 6.2.5 to 6.2.8 summarize results for each of the four permit clusters analyzed, and Section 6.2.9 presents a summary of commercial fisheries impacts over all four clusters.

6.2.1 Exposure Results by State

This section assesses exposure, by state, to WEA development for commercial fishery landings from federal waters. Table 6-1 presents the *average annual* revenue exposed for each state during this period, and Figure 6-1 presents the *total* exposed revenue over all six years.

As stated earlier, the average annual revenue from commercial fishing during 2007–2012 for all WEAs was approximately $14 million per year (about 1.45% of the total annual commercial fisheries revenue for New England and the mid-Atlantic). Table 6-1 shows:

- How this approximately $14 million in average annual commercial fishing revenue breaks out at the state level (second column).
- What percent of the average annual state commercial fishing revenue (i.e., including landings from WEAs and other federal waters) sources from WEAs (third column).

Table 6-1. Average annual federally reported commercial fisheries revenue from WEAs.

Landing State	Average Annual Revenue from WEAs (2007–2012)	Percent of Total Annual Revenue from WEA
NJ	$5,099,623	3.1
MA	$4,073,551	1.0
RI	$2,198,963	4.0
VA	$966,168	1.3
NC	$696,038	4.0
NY	$568,144	1.8
CT	$246,716	1.8
MD	$114,414	1.2
DE	$39,395	11.3[a]
SC	$38,209	2.0
NH	$175	~0
ME	$8	~0

a A limited amount of federally permitted fish is landed in Delaware. Most of Delaware's landings are in state waters and revenues from landings in state waters are not included in this analysis.

[7] Approximately a third of the acres under consideration for wind energy leasing (circa January 2013) were removed from consideration.

[8] Modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario). Some localized limitations on certain gear type usage are possible and will depend on local circumstances as well as safety, operating, and other considerations at the discretion of the fishing vessel operator.

Looking at the *percentage* of states' average annual revenue sourced from WEAs (third column), no state except Delaware has more than 4 percent exposure. Delaware has 11.3 exposure, though one of the lowest values in terms of annual revenue. A key reason for Delaware's higher percentage is that Delaware sits on the state-managed Delaware Bay and therefore has relatively few landings from federal waters. States like Delaware that have a larger share of revenue from state waters will show a disproportionately higher percentage of revenue sourced from WEAs.

Figure 6-1 shows the total exposed revenue by state for 2007–2012. These data show that New Jersey was the most exposed state over that entire six-year period, followed by Massachusetts and Rhode Island. This is mainly due to New Jersey's close proximity to multiple WEAs and the harvest of highly valued species in those areas. More details on exposure for each WEA are presented in Section 4.

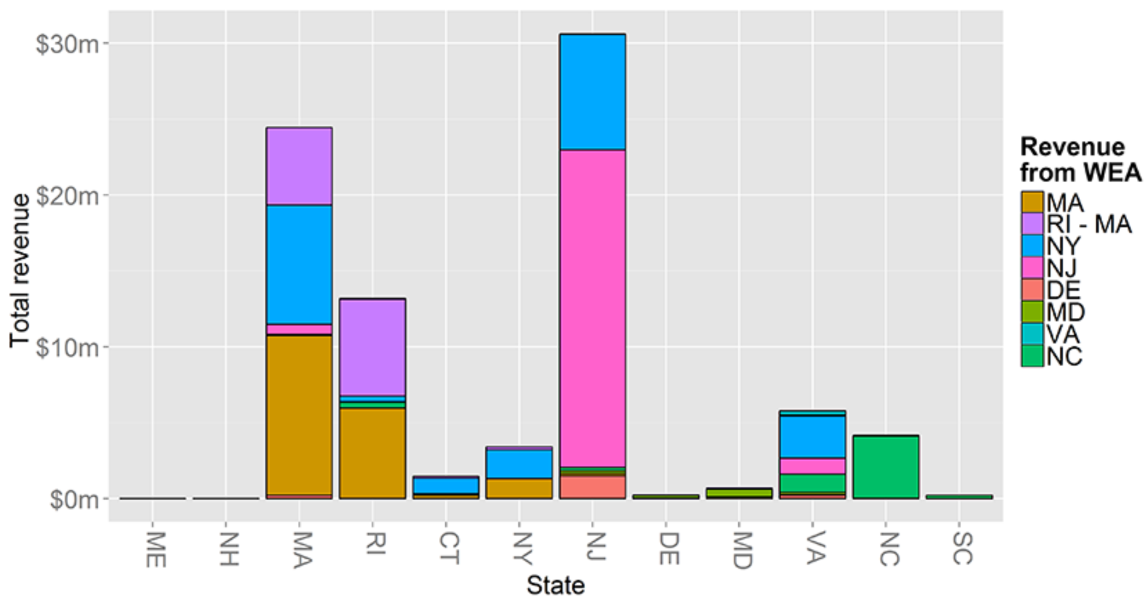


Figure 6-1. Total exposed revenue by state for all years, 2007–2012, with state revenue broken down by WEA.

6.2.2 Exposure Results by Species

6.2.2.1 Species-Level Exposure

Table 6-2 shows average annual exposure by species for the top 30 species exposed to the development of WEAs, based on the thresholds defined in Section 3.1.3. A full list of species can be found in Section III.i of Appendix III. At a species level, the higher the exposure, the greater the potential that WEA development could impact the domestic supply or trade in that species, which could in turn impact dealers, processors, and end consumers.

Table 6-2. Average annual revenue of the top 30 species exposed to WEA development, 2007–2012.

Management Jurisdiction[a]	Exposed Species	Average Annual Revenue from WEA	Percent of Total Annual Revenue
AHMS	Miscellaneous Tuna	$1,682	6.3
AHMS	Little Tuna	$1,583	5.0

Management Jurisdiction[a]	Exposed Species	Average Annual Revenue from WEA	Percent of Total Annual Revenue
ASMFC	Menhaden[b]	$230,605	6.0
ASMFC	Atlantic Croaker	$169,915	5.5
ASMFC	Bluefish	$38,305	2.4
ASMFC	Smooth Dogfish	$21,143	3.3
ASMFC	Tautog	$9,966	2.5
ASMFC	Triggerfish	$7,268	2.0
ASMFC	Horseshoe Crab	$3,012	2.0
ASMFC	Sandbar Shark	$2,879	16.1
MAFMC	Surfclam	$3,080,597	8.7
MAFMC	Ocean Quahog	$1,187,308	4.4
MAFMC	Summer Flounder	$663,795	3.0
MAFMC	Loligo Squid	$514,752	2.1
MAFMC	Black Sea Bass	$283,790	5.2
MAFMC	Atlantic Mackerel	$146,062	2.8
MAFMC	Butterfish	$26,080	3.2
MAFMC	Blueline Tilefish	$13,596	2.1
NEFMC	Sea Scallop	$4,313,425	1.0
NEFMC	Silver Hake	$389,003	4.1
NEFMC	Miscellaneous Skates	$346,472	5.7
NEFMC	Little Skate	$59,882	13.4
NEFMC	Winter Skate	$48,149	3.7
NEFMC	Red Hake	$33,725	5.1
NEFMC	Offshore Hake	$17,451	10.3
NEFMC, MAFMC	Monkfish	$856,254	4.3
SAFMC	King Mackerel	$112,710	10.3
SAFMC	Vermillion Snapper	$30,024	2.3
SAFMC	Red Grouper	$24,734	2.7
SAFMC	Grouper	$22,923	2.3
SAFMC	Scamp Grouper	$12,968	2.6
SAFMC	Grunts	$3,690	3.9
SAFMC	Hogfish	$2,903	5.3
SAFMC	Greater Amberjack	$2,889	3.1
SAFMC	Red Porgy	$2,291	2.3
SAFMC	Sheepshead	$1,362	18.3
SAFMC	Rock Hind	$1,028	3.5
Individual States	Channeled Whelk	$52,158	2.2
Individual States	Southern Flounder	$20,115	7.5
Individual States	King Whiting	$17,316	3.5
Unmanaged	Jonah Crab	$101,444	2.0
Unmanaged	Rock Crab	$19,582	5.4
Unmanaged	Chub Mackerel	$3,323	5.3
Unmanaged	Miscellaneous Eel	$1,650	6.7
Unmanaged	Conger Eel	$1,036	7.3

a Management jurisdiction refers to the entity responsible for management of the species.

b Reporting of menhaden is underrepresented because vessels that target only this species are not federally permitted.

Although sea scallops have the highest exposure in terms of magnitude ($4.3 million), those landings from the WEAs comprise only 1 percent of the total federally reported sea scallop revenues. Conversely, surfclam is relatively highly exposed, in terms of both magnitude ($3.1 million) and percentage (8.7 percent).

Surfclam and ocean quahog processing is specialized, meaning that impacts to the harvesting of this species will trickle down to other aspects of the seafood industry (e.g., processors would find it costly to switch from clams to an alternative species). Specialized clam dredges, the most commonly used gear, also create switching costs for harvesters.

6.2.2.2 FMP-Level Aggregated Exposure

FMPs represent groupings of various species that are managed in tandem. Usually, an FMP combines similar species or species caught in a similar manner, targeted by the same vessels at different times, or best managed together for geographic or technical reasons. Table 6-3 presents the FMPs with more than $1 million in total revenue from all WEAs between 2007 and 2012.

The summer flounder, scup, and black sea bass FMP sourced more than 3 percent of all revenue from a proposed WEA from 2007 to 2012 for a total of $6.2 million in revenue. This is consistent with species-level exposure where summer flounder and black sea bass were both relatively highly exposed.

Monkfish species from the mackerel, squid, and butterfish FMP; the Northeast skate complex FMP; and the small mesh multispecies FMP also exceeded 1 percent exposure and greater than $1 million in revenue from 2007 to 2012.

Table 6-3: Top exposed FMPs (greater than $1 million total revenue from all WEAs, 2007–2012).

FMP	Total Revenue from All WEAs 2007–2012	Percent of FMP Revenue from All WEAs
Sea Scallop—Northeast	$25,880,550	1.0
Surfclam, Ocean Quahog—Mid-Atlantic	$25,607,433	6.6
Non-Permitted Species	$8,683,938	0.6
Summer Flounder, Scup, and Black Sea Bass—Mid-Atlantic	$6,205,291	3.1
Monkfish Joint	$5,137,525	4.3
Mackerel, Squid, Butterfish—Mid-Atlantic	$4,571,885	1.9
Northeast Skate	$2,729,652	5.8
Northeast Multi Small	$2,641,921	4.1
Atlantic Herring—Northeast	$1,141,996	0.8

6.2.3 Exposure Results by Ports

Table 6-4 shows the top ports that land fish from the WEAs, according to the thresholds established in Section 3.1.3. (Section III.ii in Appendix III provides a complete list of all ports identified in the data, along with different exposure measures.) The four landing port groups with at least $1 million in average annual revenue from all WEAs are New Bedford, MA; Atlantic City, NJ; Narragansett, RI; and Cape May, NJ. New Bedford has the highest average annual revenue from all WEAs, close to $3.5 million annually; however, that is only 1.2 percent of its federally permitted revenue. Atlantic City's average annual revenue from all WEAs is $3.1 million, which represents more than 11 percent of its federally permitted revenue.

Table 6-4 also presents gentrification and social vulnerability scores, following Colburn and Jepson (2012) and Jepson and Colburn (2013). This provides insight into the relative sensitivity of ports to large economic disruptions. Although exposure does not necessarily translate into impact, this further identifies port groups that may warrant additional attention in future analyses, as it assesses a community's ability to adapt.

Table 6-4. Average annual revenue from all WEAs for exposed port groups, 2007–2012.

State	Port Group	Average Annual Revenue from all WEAs	Percent of Port Revenue	Social Vulnerability[a]	Gentrification Vulnerability[a]
MA	New Bedford	$3,459,358	1.2	High	Low
NJ	Atlantic City	$3,104,017	11.1	High	Moderate
RI	Narragansett	$1,179,184	3.7	Low	Low
NJ	Cape May	$1,063,512	1.4	Low	High
RI	Little Compton	$332,581	19.2	Low	Moderate
RI	Newport	$294,671	3.3	Low	Low
NC	Wanchese	$216,316	4.8	Low	Low
NY	Point Lookout	$166,770	6.9	Low	Low
CT	New London	$138,863	2.3	High	Low
MA	Westport	$125,455	11.1	Low	Low
NC	Engelhard	$101,431	4.4	Moderate	Low
RI	Tiverton	$89,207	10.7	Low	Low
NY	Freeport	$77,422	9.9	Moderate	Low
NJ	Sea Isle City	$63,326	6.9	Low	Moderate
VA	Virginia Beach	$55,507	4.9	Low	Low
NC	Oriental	$52,989	4.2	Low	Moderate
MA	Fall River	$45,930	2.3	High	Low
NC	Beaufort	$45,663	4.7	Moderate	Low
MA	Chilmark	$39,399	10.8	Low	Moderate
DE	Indian River	$37,221	11.6	Moderate	Low
MA	Woods Hole	$23,653	7.4	Low	Moderate
NY	Islip	$17,273	4.8	Low	Low
SC	Georgetown County	$15,388	2.4	—	—
NJ	Highlands	$7,248	24.1	Low	Low
NY	Other Suffolk	$6,924	10.1	—	—
NC	Nags Head	$2,249	34.7	Low	Low
SC	Charleston County	$1,851	3.3	—	—

a Gentrification and social vulnerability scores are based on Colburn and Jepson (2012) and Jepson and Colburn (2013).

Just as the distribution of impacts *across* ports is vital to identifying groups that may bear a higher level of exposure, the distribution of impacts *within* a port is vital to identifying subgroups with significant exposure. Table 6-5 presents the gears exposed within the landing ports identified in Table 6-4. In general, the highest exposure at the port-gear level is fixed gear along the South Coast of Massachusetts and Rhode Island and certain dredge gear along the Mid-Atlantic.

Table 6-5. Average annual revenue for port groups by exposed gear, 2007–2012.

State	Port Group	Gear	Average Annual Revenue from all WEAs	Percent of Total Average Annual Revenue
MA	Chilmark	Bottom Trawl	$5,413	5.7
MA	Chilmark	Lobster Pot	$28,065	11
MA	New Bedford	Gillnet	$370,013	21.2
MA	Westport	Gillnet	$34,815	9.1
MA	Westport	Lobster Pot	$71,534	11.5
MA	Woods Hole	Dredge	$21,667	17.4
MD	Ocean City	Bottom Trawl	$35,964	3.6
MD	Ocean City	Gillnet	$19,770	5.3
MD	Ocean City	Pot	$24,889	6.3
NC	Beaufort	Bottom Trawl	$45,649	5.0
NC	Engelhard	Bottom Trawl	$95,383	5.8
NC	Oriental	Bottom Trawl	$52,982	4.4
NC	Wanchese	Bottom Trawl	$171,295	4.8
NC	Wanchese	Gillnet	$34,973	4.8
NJ	Atlantic City	Dredge	$3,041,970	11.0
NJ	Atlantic City	Pot	$55,088	27.1
NJ	Cape May	Pot	$56,410	11.1
NJ	Long Beach	Bottom Trawl	$13,435	7.6
NJ	Sea Isle City	Pot	$59,364	14.7
NY	Freeport	Bottom Trawl	$75,854	11.7
NY	Point Lookout	Bottom Trawl	$164,831	7.1
RI	Little Compton	Gillnet	$301,450	27
RI	Little Compton	Lobster Pot	$28,262	9.4
RI	Narragansett	Bottom Trawl	$891,438	4.0
RI	Narragansett	Gillnet	$41,961	4.7
RI	Newport	Bottom Trawl	$81,053	4.5
RI	Newport	Gillnet	$158,923	26.7
RI	Tiverton	Gillnet	$22,802	8.4
SC	Georgetown County	Pot	$1,483	5.6
VA	Virginia Beach	Pot	$54,157	7.8

If a port is identified in Table 6-4, but not in Table 6-5, this indicates that the port's impact is spread across gear classifications in a manner such that although the port is exposed, no single gear group within the port rises to the level of exposure defined in Section 3.1.3. Conversely, gear groups within a port can be exposed, while the port itself fails to meet the threshold of exposure. In general, the highest exposure at the port-gear level is for fixed gear along the South Coast of Massachusetts and Rhode Island, and for certain dredge gear along the mid-Atlantic.

6.2.4 Exposure Results from Permit Data Analysis

Between 2007 and 2012, 45 percent of 4,147 permits (1,867 permits) submitting VTR data fished within a WEA. Figure 6-2 shows the distribution of permits by percent revenue earned from landings sourced within a WEA. As the figure shows, the number of permits starts to sharply decline at around 1.25 percent or more of WEA-sourced revenue.

A total of 990 permits have at least 1 percent of their revenue from the WEAs. Of those, only 16 permits exceed $100,000 per year. For the 990 vessels with at least 1 percent exposure, no vessel length category is more impacted greatly than another. Between 2007 and 2012, 148 permits met the threshold of 15 percent for “highly exposed” (see Section 3.2.2.1) (i.e., they sourced 15 percent or more of their revenue from within a WEA), and an additional five permits source more than $150,000. No gear type trend was identified among the highly exposed permits.

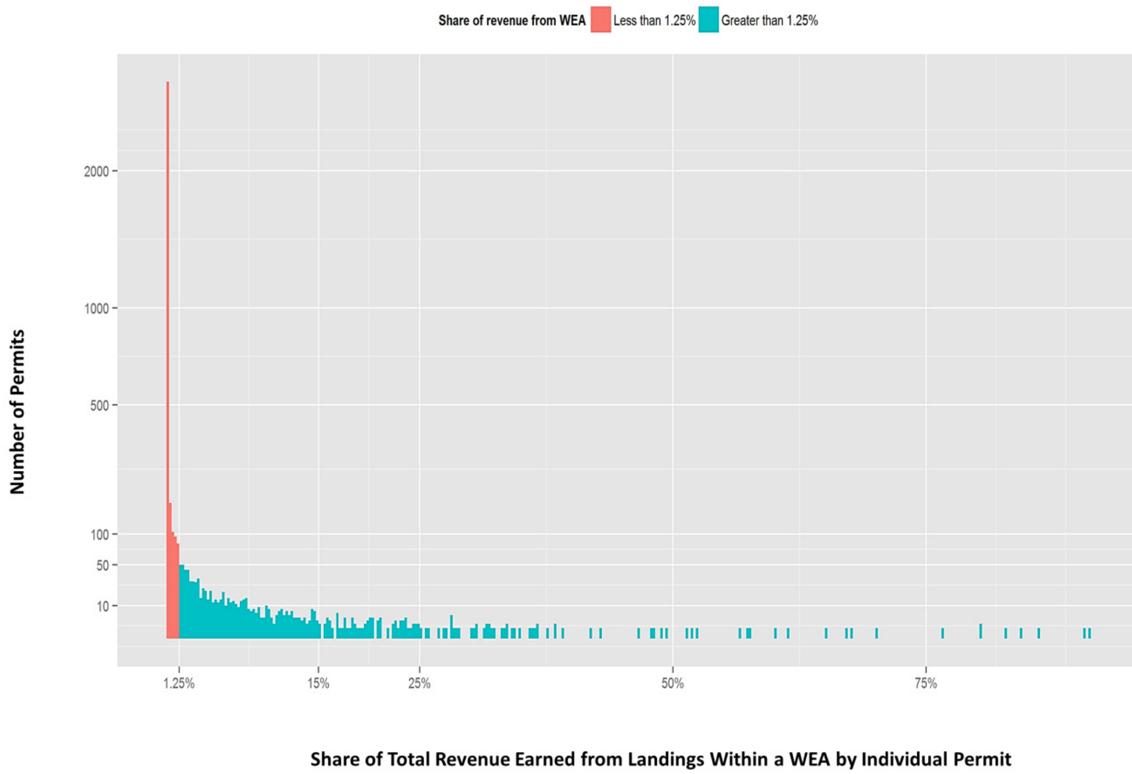


Figure 6-2. Distribution of permits with WEA-sourced revenue by percent revenue earned from WEA-sourced landings, 2007–2012.

The highly exposed threshold of 15 percent is exceeded by a slightly higher share of small vessels (3.4 percent) versus large vessels (2.5 percent). Given the difficulty that small vessels face in extending their fishing grounds due to limits on trip length and safety, this result indicates the need to further study small fleet impacts. Home ports for these permits again tend to be clustered around the exposed landing ports identified in Table 6-4, as detailed in Appendix III.

The location choices of the 153 highly exposed permits provide a sense as to which WEAs are most heavily utilized (Figure 6-3). The NJ WEA is the location most fished by highly exposed permits, in terms of both absolute revenue and by revenue per square mile. Similarly, the MA and RI-MA WEAs are heavily fished by highly exposed permits. Notably, few individual permits seem to rely on the VA WEA for a significant percentage of their revenue, with the major caveat being that the menhaden fishery is underrepresented in the dataset, as discussed in Appendix I.

By examining exposure at different thresholds, different patterns of use appear. Those permits that are most highly exposed (15 percent or more of revenue is from a WEA) are predominantly using the NJ WEA. This is in contrast to permits at the lower exposure threshold (1 percent or more of revenue from a WEA), which are exposed predominantly to the NY WEA.

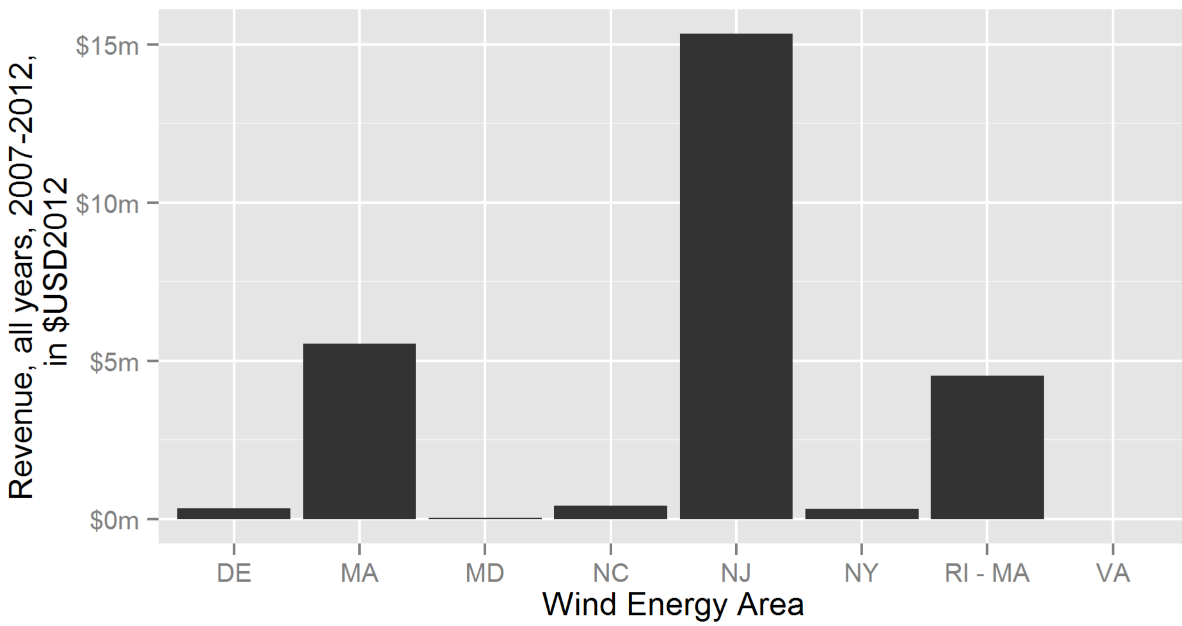


Figure 6-3. Revenue, by WEA, for the 153 highly exposed permits, all years, 2007–2012.

6.2.5 Impact Analysis: Cluster 1 Impacts

Cluster 1 is composed of 218 pot and gillnet permits from Rhode Island and the South Coast of Massachusetts, which represent 11.8 percent of the total commercial fishery exposure to full development of all eight WEAs. Approximately 5 percent of their trips occur in the RI-MA WEA (Zone 17; Figure 6-4), likely because of its proximity to shore and its bottom features, and 1.6 percent of their trips occur in the MA WEA (Zone 18; Figure 6-4). The Cluster 1 analysis models only these two WEAs and does not include the Cape Wind and Deepwater Block Island areas (see Figure 6-4).

Table 6-6 compares the percentage of actual (i.e., observed) fishing trips to the model predictions under current (baseline) conditions—that is, without any wind energy development—for all zones fished by Cluster 1 permits during 2007–2012. Comparison of the actual (column 2) versus predicted (column 3) share of trips for each zone shows a strong correspondence.

This section presents the impacts as predicted by applying the location choice model to each of the four scenarios described in Section 3.2.2.3: (1) fully closed,[9] (2) fully open with biomass impacts, (3) weather-based closure, and (4) gear-based closure. (For Scenario 1, impacts with just the RI-MA WEA closed are compared with impacts with both RI-MA and MA WEAs closed.)

Results are then compared to the actual and predicted shares shown in Table 6-6. If a zone is not listed in the table, then no permits in Cluster 1 took trips to that zone during 2007–2012.

[9] As noted earlier, modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the “fully closed” scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the “fully closed” scenario).

Table 6-6. Percentage of actual and predicted Cluster 1 trips, by zone fished, under current (baseline) conditions, 2007–2012.

Zone[a]	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)
2	0.4	0.4
3	0.3	0.4
4	1.2	0.7
5	0.5	1.0
6	17.7	17.7
7	16.2	14.6
8	56.0	56.4
9	1.2	1.3
12	0.2	0.3
17 (RI-MA WEA)	4.6	5.0
18 (MA WEA)	1.6	2.2

a Zones with no trips for permits in Cluster 1 during 2007–2012 were not included in the analysis.

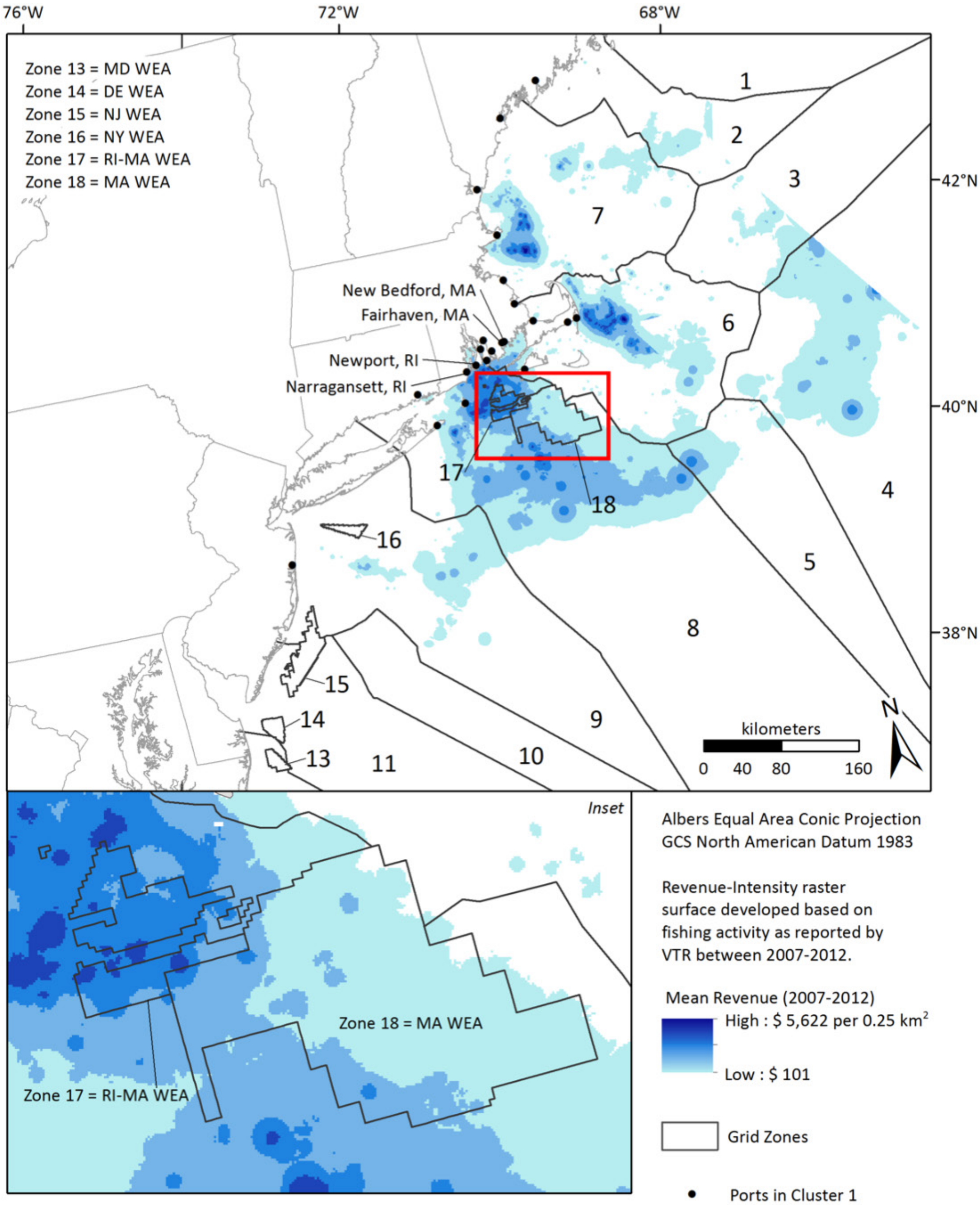


Figure 6-4. Revenue-intensity raster map and fished zones for Cluster 1 permits.

6.2.5.1 Scenario 1A: RI-MA WEA Fully Closed

From 2007 to 2012, approximately 4.6 percent of the cluster's trips were centered in the RI-MA WEA (Zone 17; Figure 6-4):

- For **gillnet vessels**, the average RNVC per hour in the RI-MA WEA was $188.75. Other zones had higher average RNVCs per hour, including Zone 6 ($280.03), Zone 7 ($205.85), and Zone 12 ($231.37).

- For **pot vessels**, the average RNVC per hour for the RI-MA WEA was $44.15, the lowest of all zones.

Table 6-7 compares predicted percentage trips by zone for the RI-MA WEA closure scenario (column 4) with actual (column 2) and predicted (column 3) percentage trips under the current (baseline) scenario. The model results indicate that gillnet and pot vessels will increase trips to Zones 6, 7, 8, 9, and 18 if the RI-MA WEA is fully closed.

Table 6-7. Percentage of Cluster 1 trips, by zone fished, for the RI-MA WEA closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario		RI-MA WEA Closed
	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)	Predicted (% of Fishing Trips)
2	0.4	0.4	0.4
3	0.3	0.4	0.4
4	1.2	0.7	0.7
5	0.5	1.0	1.0
6	17.7	17.7	19.0
7	16.2	14.6	15.3
8	56.0	56.4	59.2
9	1.2	1.3	1.4
12	0.2	0.3	0.3
17 (RI-MA WEA)	4.6	5.0	—
18 (MA WEA)	1.6	2.0	2.3

Table 6-8 presents by-zone-trip RNVC estimates for the RI-MA WEA (Zone 17) closed scenario. These estimates incorporate changes in distance traveled, steaming time, and estimated catch that may results from changes in fishing behavior.

The majority of impact falls on the gillnet portion of the cluster. Pot revenues tend to be higher outside the WEA, leading to fewer pot vessels visiting the area and lower probability-weighted losses. On average, the gillnet portion of the cluster loses approximately 2.8 percent of total RNVC over all trips when the RI-MA WEA is unavailable for fishing.

Table 6-8. Expected changes in Cluster 1 annual and per trip RNVC with RI-MA WEA closed.

Metric	Pot	Gillnet	Combined
Total Change in Annual RNVC	-$18,203	-$295,938	-$314,141
Total Percent Change in Annual RNVC	-0.1	-2.8	-1.3
Mean Change in RNVC per Trip	-$4	$-55	-$31
Median Change in RNVC per Trip	-$4	-$21	-$9
Median Percent Change in RNVC per Trip	-0.2	-1.9	-1.3

6.2.5.2 Scenario 1B: RI-MA and MA WEAs Fully Closed

From 2007 to 2012, 6.2 percent of the trips taken by pot and gillnet fishermen from Rhode Island and from the South Coast of Massachusetts were centered in the MA or RI-MA WEAs (Zones 17 and

18; Figure 6-4). For gillnet vessels, the average RNVC per hour in the MA WEA (Zone 18) was $193.87, ranking the zone seventh of 11 studied. For pot vessels, the MA WEA (Zone 18) averaged $118.51, also the seventh highest of the 11 zones studied. Predicted shares with and without closure of both the RI-MA and MA WEAs are shown in Table 6-9.

Table 6-9. Percentage of Cluster 1 trips, by zone fished, for the RI-MA WEA and MA WEA closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		RI-MA and MA WEAs Closed (% of Fishing Trips)
	Actual	Predicted	Predicted
2	0.4	0.4	0.4
3	0.3	0.4	0.4
4	1.2	0.7	0.7
5	0.5	1.0	1.1
6	17.7	17.7	19.3
7	16.2	14.6	15.8
8	56.0	56.4	60.6
9	1.2	1.3	1.4
12	0.2	0.3	0.3
17 (RI-MA WEA)	4.6	5.0	—
18 (MA WEA)	1.6	2.2	—

Table 6-10 presents RNVC estimates for each zone in the RI-MA WEA (Zone 17) and MA WEA (Zone 18) closed scenario. The average RNVC changes for gillnet trips are *smaller* when both the RI-MA WEA (Zone 17) and MA WEA (Zone 18) are closed compared to closure of only the RI-MA WEA (Zone 17) (see Table 6-8). This means that, on average and when accounting for costs and predicted revenues, Zone 18 has fishing location alternatives that are less costly or have higher predicted catch compared to Zone 17. About 2 percent of gillnet trips are fished in Zone 18.

Full closure of both the RI-MA WEA and the MA WEA (Zones 17 and 18) would be expected to result in a 2.2 percent decrease in Cluster 1 RNVC (a total decrease of $516,984 per year), assuming a constant number of trips and constant trip length (net of steaming time). As some small portion of every trip is assumed to have some chance of fishing with Zone 17 or Zone 18, taking the combined total of $516,984 and dividing it by the number of trips taken per year to a WEA (631 per year) results in a per-WEA-trip average of $819.

Table 6-10: Expected changes in Cluster 1 annual and per trip RNVC with RI-MA and MA WEAs closed.

Metric	Pot	Gillnet	Combined
Total Change in RNVC per Year	-$226,992	-$290,002	-$516,984
Total Percent Change in RNVC per Year	-2.0	-2.8	-2.2%
Mean Change in RNVC per Trip	-$48	-$54	-$51
Median Change in RNVC per Trip	-$10	-$21	-$13
Median Percent Change in RNVC per Trip	-1.0	-1.9	-1.8%

Figure 6-5 shows the distribution of total expected changes in RNVC for 2007–2012 for Cluster 1 permits by landed port. The ports in closest proximity to the proposed WEAs are the drivers of expected changes, including Narragansett, RI; Newport, RI; New Bedford, MA; and Fairhaven, MA.

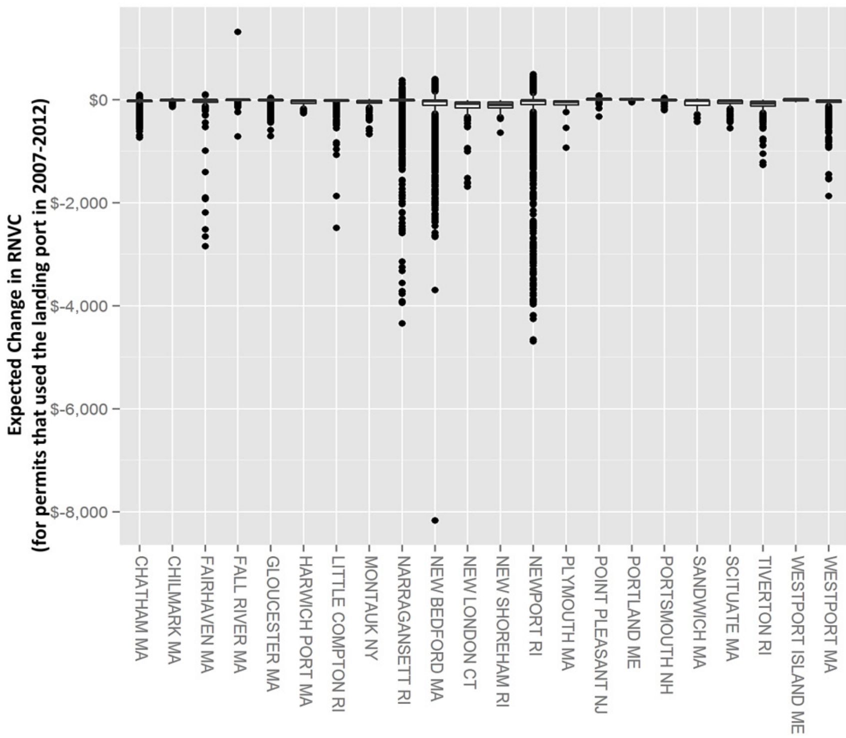


Figure 6-5. Distribution of total expected changes in RNVC for 2007–2012 for Cluster 1 permits by landed port.

Specific permit-level impacts must be interpreted with caution—the expected change is based in part on the vessel's likelihood of visiting an affected area based on characteristics like length and season, as well as the expected RNVC for each trip. The overall distribution, however, is meaningful. Approximately 20 to 30 of the 218 vessels account for most of the expected negative changes.

6.2.5.3 Scenario 2: RI-MA and MA WEAs Fully Open with Biomass Impacts

Scenario 2, in which both RI-MA and MA WEAs are fully open, was modeled for four biomass impact assumptions: minus 25 percent catch, minus 7 percent catch, no catch impact (current baseline), and plus 7 percent catch. Predicted percentage shares are presented in Table 6-11. Changes in RNVC are presented in Table 6-12 and Figure 6-6.

Table 6-11. Percentage of Cluster 1 trips, by zone fished, in fully open RI-MA and MA WEAs for three biomass impact assumptions compared to current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		RI-MA and MA WEAs Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
2	0.4	0.4	0.4	0.4	0.3
3	0.3	0.4	0.4	0.4	0.4
4	1.2	0.7	0.7	0.7	0.6
5	0.5	1.0	1.0	1.0	1.0
6	17.7	17.7	18.7	18.1	17.0
7	16.2	14.6	15.3	15.0	14.1
8	56.0	56.4	58.5	57.4	54.7
9	1.2	1.3	1.4	1.4	1.1

Zone	Current (Baseline) Scenario (% of Fishing Trips)		RI-MA and MA WEAs Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
12	0.2	0.3	0.3	0.3	0.3
17 (RI-MA WEA)	4.6	5.0	2.3	3.9	6.6
18 (MA WEA)	1.6	2.2	1.0	1.4	3.9

Table 6-12. Expected changes in Cluster 1 per trip RNVC for three biomass impact assumptions for the RI-MA and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$17.89	-$4.72	-$41.59	-$1.77	-$421,875	-1.8
-7% Catch	-$7.11	-$1.61	-$25.87	-$0.56	-$262,426	-1.1
+7% Catch	$0.60	$1.90	$34.81	$9.84	$353,116	+1.5

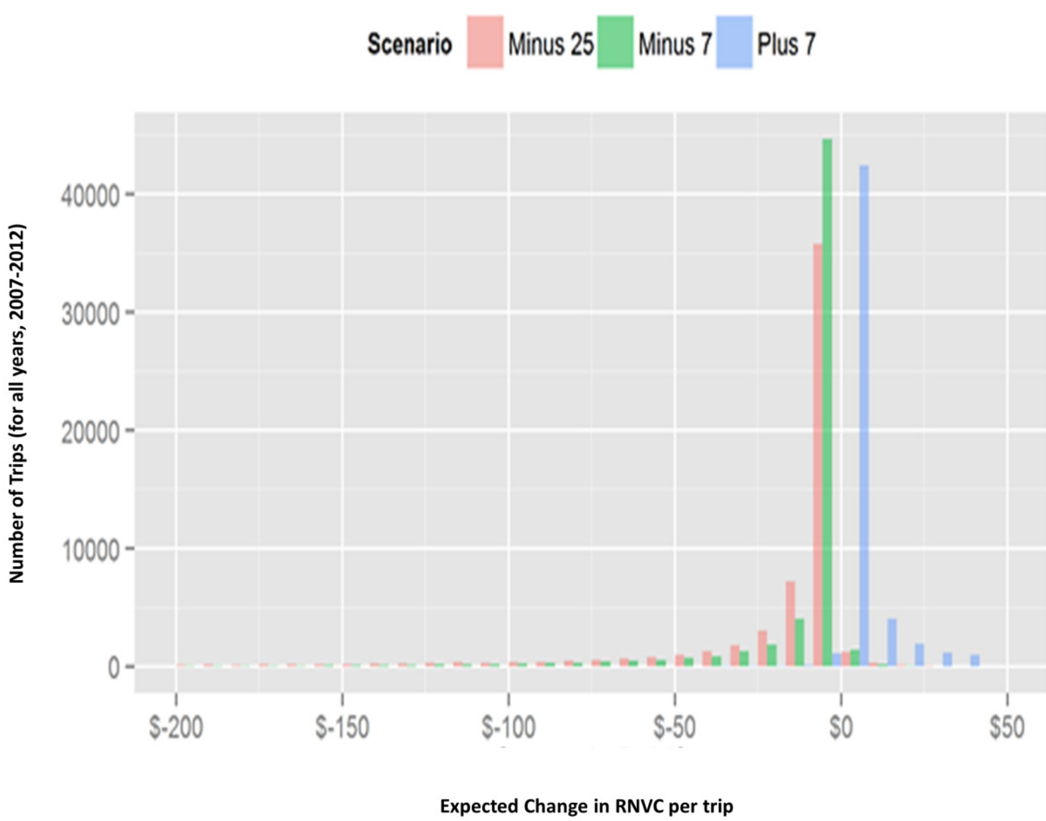


Figure 6-6. Distribution of expected change in Cluster 1 RNVC per trip for three biomass impact assumptions in the RI-MA and MA WEAs, with both WEAs fully open.

The visitation rate to the RI and RI-MA WEAs is relatively low (6.2 percent) compared to other fishing areas. Consequently, it is not surprising that the median (i.e., most likely) RNVC per trip impacts from minus 25 and 7 percent biomass decreases are predicted to be indistinguishable from zero. However, the distribution of impacts shows that a small number of trips will likely face impacts greater than $150 per trip (Figure 6-6). Assuming that these few highly impacted trips are the 6.2 percent of trips that occurred in the WEAs, the impact per affected trip can be calculated by dividing total impact by the number of trips to impacted areas. This results in an impact of $668 per affected trip over 3,785 total trips for the minus 25 percent scenario, and $416 per affected trip for the minus 7 percent scenario. Full closure of both WEAs would have an average impact of $819 per affected trip.

The fully open scenario with plus 7 percent biomass increase would increase visits to Zones 17 and 18 (RI WEA and RI-MA WEA, respectively) by approximately 2.6 percentage points each, a total increase of 263 visits per year for each zone. Given the size of the zones, it is unlikely that this increase would increase congestion within the area.

6.2.5.4 Scenario 3: Weather-Based Closure

Weather-based-scenarios estimate how fishery effort allocation would change assuming that wind speeds of 9.35 m/second or greater would keep vessels from fishing within a WEA. During 2007 to 2012, more than 2,560 Cluster 1 trips (4.2 percent of the total) were made during this strong wind weather; 150 of those trips were to the RI-MA or MA WEA (Zones 17 or 18). The 150 WEA-located trips represent 0.24 percent of all Cluster 1 trips, and are excluded from the model choice set, meaning that fishermen would be fishing in an alternative zone. This weather-based closure is modeled alone and combined with biomass changes in catch, with results presented in Table 6-13.

Table 6-13. Percentage of Cluster 1 trips, by zone fished, in RI-MA and MA WEAs with weather-based closures combined with four biomass impact assumptions.

Zone	Current (Baseline) (% of Fishing Trips)		Weather-Based Closures and Changes in Catch in RI-MA and MA WEAs Predicted (% of Fishing Trips)			
	Actual	Predicted	-25% Catch	-7% Catch	Constant Catch	+7% Catch
2	0.4	0.4	0.4	0.4	0.4	0.3
3	0.3	0.4	0.4	0.4	0.4	0.4
4	1.2	0.7	0.7	0.7	0.7	0.7
5	0.5	1.0	1.0	1.0	1.0	1.0
6	17.7	17.7	18.7	18.2	17.7	17.1
7	16.2	14.6	15.3	15.0	14.7	14.2
8	56.0	56.4	58.6	57.5	56.6	55.1
9	1.2	1.3	1.4	1.4	1.3	1.1
12	0.2	0.3	0.3	0.3	0.3	0.3
17 (RI-MA WEA)	4.6	5.0	2.2	3.7	4.8	6.3
18 (MA WEA)	1.6	2.2	0.9	1.4	2.0	3.5

Table 6-14. Expected changes in Cluster 1 per trip RNVC with weather-based closures, combined with four biomass impact assumptions for the RI-MA and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$18.71	-$5.07	-$42.04	-$1.84	-$426,371	-1.8
-7% Catch	-$8.65	-$1.80	-$27.65	-$0.58	-$280,441	-1.2
Constant Catch	$0.00	$0.00	-$4.77	$0.00	-$48,430	-0.2
+7% Catch	$0.48	1.59	$25.54	$8.21	+$259,018	+1.1

Under a scenario where WEAs are accessible only under favorable weather conditions, impacts are similar to the fully open scenarios (Section 6.2.5.3), indicating that a weather-based de facto closure would have little additional impact. This is observed in the “Constant Catch” scenario—i.e., a weather-based closure with no concurrent change in catch, where the annual impact on RNVC is minus 0.2 percent (Table 6-14, seventh column).

6.2.5.5 Scenario 4: Gear-Based Closure

Figure 6-7 shows the distribution of changes in RNVC for each gear in the cluster. Results for non-lobster pot fishing are mixed. Most fishermen in this gear group are expected to see relatively small changes in RNVC, as indicated by the number of trips clustered around $0 in Figure 6-7. However, the range of expected changes in RNVC for non–lobster pot fishermen, approximately -$8,000 to $1,000, is larger than for lobster pot and gillnet fishermen. Most lobster pot and gillnet fishermen are expected to be negatively affected, with declines in RNVC.

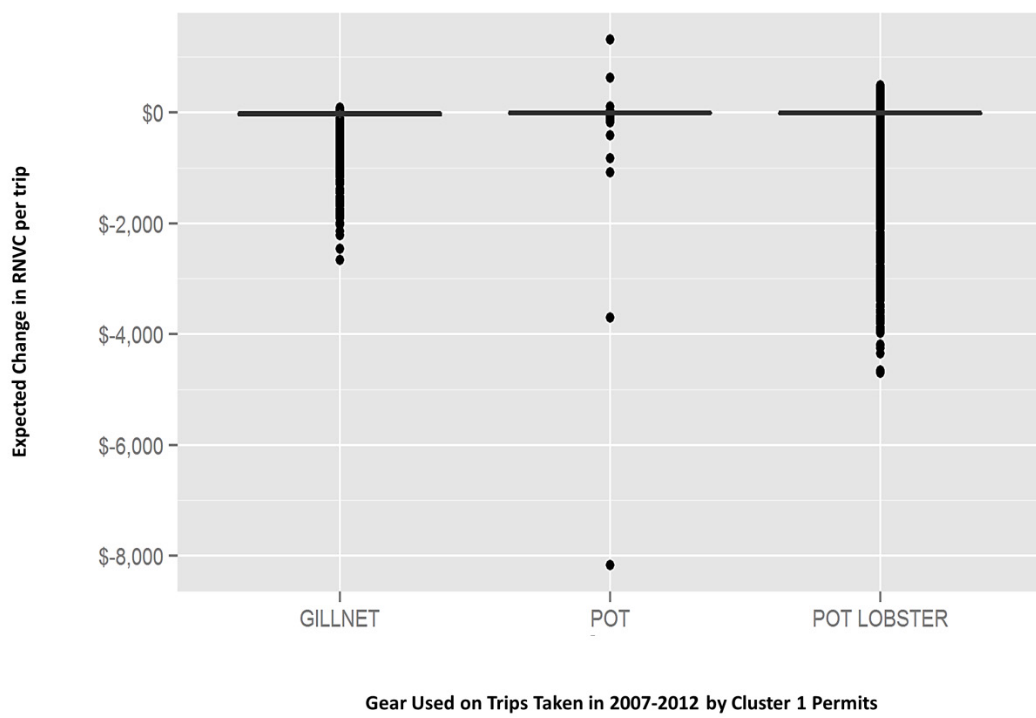


Figure 6-7. Distribution of expected changes in RNVC per trip for Cluster 1 permits.

6.2.6 Impact Analysis: Cluster 2 Impacts

Cluster 2 is composed of 211 scallop vessels in the Mid-Atlantic, fishing primarily in the NY WEA (Zone 12; Figure 6-8), likely due to its proximity to shore as well as its bottom features. Zone 7, the NC Call (North) WEA, is not heavily visited but has average revenues of over $13,000 per trip for the General Category (GC) permits, and over $82,000 for the Limited Access (LA) trips (see Appendix II, Table II-vii and Table II-xii). A more thorough overview of Cluster 2, along with specific methodologies used to estimate impacts, can be found in Appendix II, Section II.ii.

The scallop fishery has regulatory limits that highly influence fishing choices. Further, many permitted vessels land scallops only occasionally, which resulted in a large number of non-scallop-targeting vessels initially appearing as part of the scallop cluster. To better target the analysis, the scallop cluster was refined to examine those permits:

- With greater than 1 percent "exposed."
- Landing more than 40 percent of total permit revenue as sea scallops.

The refinement resulted in 211 permits with a total of almost $13.3 million in "exposed" revenue. Of the 25,769 trips in the refined dataset, more than 23,044 were identified as Limited Access General Category trips (referred to previously as GC).[10] The remaining 2,725 were designated as Limited Access Days at Sea trips (referred to previously as LA). Cluster 2 was therefore further segmented into GC and LA subgroups for modeling purposes, given the differences in fishing between the permit categories. Cluster 2 impacts are described separately below for each category.

6.2.6.1 General Category

The NC Call (North) WEA (Zone 7), NJ WEA (Zone 11), NY WEA (Zone 12), RI-MA WEA (Zone 13), and MA WEA (Zone 14) are all explicitly modeled for the GC segment (Figure 6-8). Table 6-15 compares the percentage of actual (i.e., observed) fishing trips to the model predictions under current (baseline) conditions—i.e., without any wind energy development—for all zones fished by Cluster 2 GC permits during 2007–2012. Comparison of the actual (column 2) versus predicted (column 3) share of trips for each zone shows a strong correspondence.

This section presents the impacts predicted by applying the location choice model to three of the four scenarios described in Section 3.2.2.3: (1) fully closed,[11] (2) fully open with biomass impacts, and (3) weather-based closure. The gear-based scenario was not included because Cluster 2 is composed only of scallop vessels. Results are then compared to the actual and predicted shares shown in Table 6-15. (For Scenario 1, two closure scenarios are analyzed: [1] just the NY WEA fully closed, and [2] the NC Call [North], NJ, NY, RI-MA, and MA WEAs fully closed.)

Table 6-15. Percentage of actual and predicted Cluster 2 GC trips, by zone fished, under current (baseline) conditions, 2007–2012.

Zone	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	8.8	8.8
2	16.6	16.7
3	63.3	63.5
4	3.0	2.9
5	0.8	0.9
6	2.5	2.3
7 (NC Call [North] WEA)	0.3	0.3
11 (NJ WEA)	0.2	0.2
12 (NY WEA)	2.8	2.7
13 (RI-MA WEA)	1.3	1.2
14 (MA WEA)	0.4	0.4

[10] These trips are made by vessels holding a GC permit and are subject to a possession limit of 600 lb meat weight of scallops (or 750 lb under certain observer-based conditions).

[11] As noted earlier, modeling the economic impact of full closure estimates the upper boundary, or worst-case, scenario for costs to the fishery and is an appropriate way to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario).

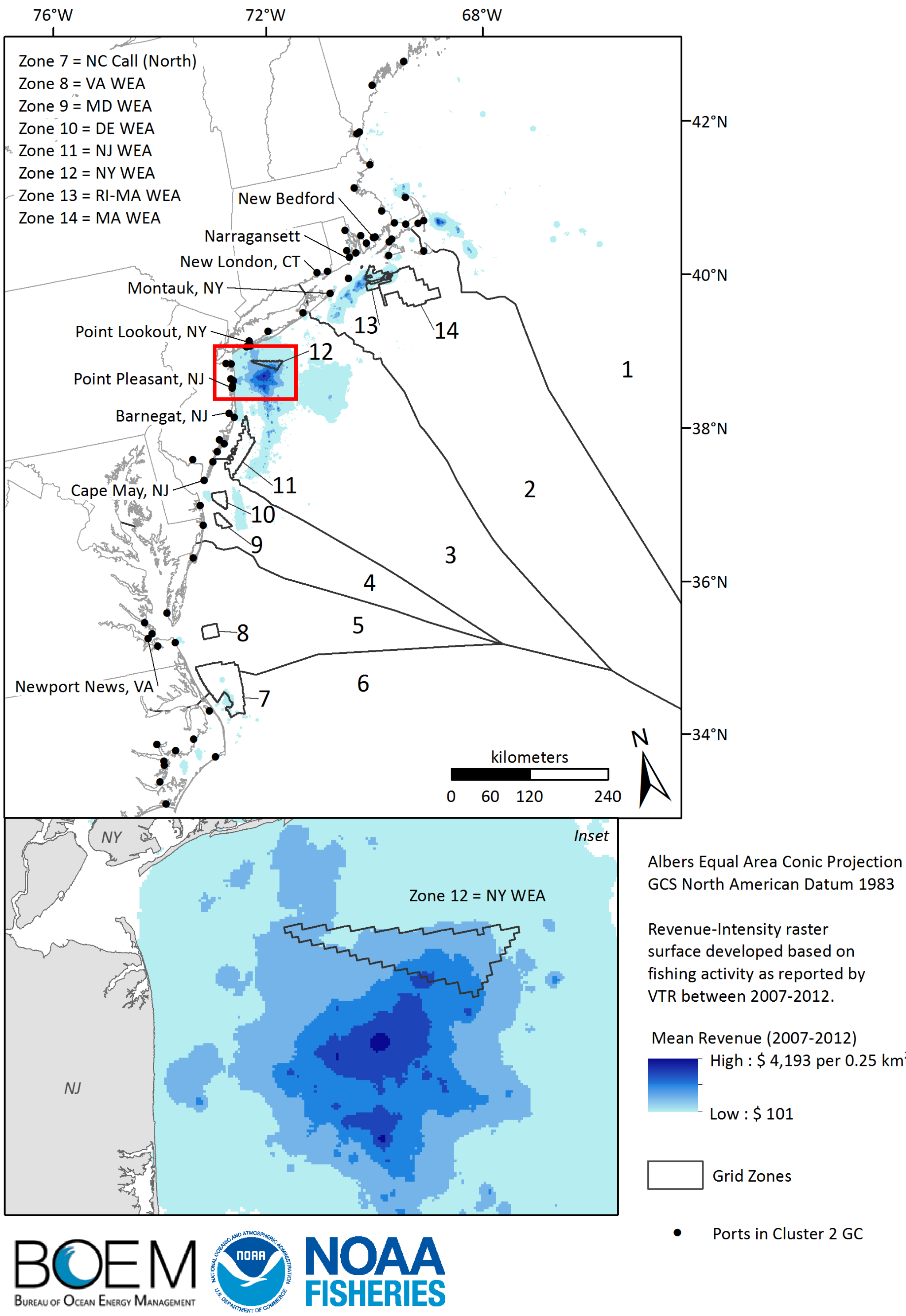


Figure 6-8. Revenue-intensity raster map and fished zones for Cluster 2 GC permits.

6.2.6.1.1 Scenario 1A: New York WEA Fully Closed

The NY WEA (Zone 12; Figure 6-8) was the most fished WEA location, accounting for 2.8 percent of all trips in Cluster 2 GC from 2007 to 2012. Average revenue per hour for trips in the NY WEA was $155.46 (see Appendix II, Table II-vii). Fishing in the area immediately outside the NY WEA (Zone 3) increases average revenue to $188.34 per hour. Notably, pounds of scallops per hour in the NY WEA (25 lb/hr) were higher than in Zone 3 (22 lb/hr). This indicates that total net revenues tended to be higher in the zone surrounding the NY WEA, but scallop landings were better within the WEA. This illustrates the multi-faceted nature of the GC scallop fishery—because landings are limited by possession limits and individual quota, fishermen who rely on scallops also land substantial revenue from alternative species.

Table 6-16 compares predicted percentage trips by zone for the closed NY WEA scenario (column 4) with actual (column 2) and predicted (column 3) percentage trips under the current (baseline) scenario. The model predicts that Zone 3, the area surrounding the NY WEA, gains most of the affected trips, with a slight increase in Zone 2, with the NY WEA closed.

Table 6-16. Percentage of Cluster 2 GC trips, by zone fished, for the NY WEA closed scenario versus current (baseline) scenario.

	Current (Baseline) Scenario		NY WEA Closed
Zone	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	8.8	8.8	8.8
2	16.6	16.8	17.1
3	63.3	63.5	65.4
4	3.0	2.9	3.0
5	0.8	1.0	1.0
6	2.5	2.3	2.3
7 (NC Call [North] WEA)	0.3	0.3	0.3
11 (NJ WEA)	0.2	0.2	0.2
12 (NY WEA)	2.8	2.7	—
13 (RI-MA WEA)	1.3	1.2	1.3
14 (MA WEA)	0.4	0.4	0.4

Changes in fishing behavior, such as changes in distance traveled, steaming time, and estimated catch are incorporated into the by-zone-trip RNVC estimates presented in Table 6-17. Results are presented with summary statistics for all trips (Table 6-17) and as a distribution of changes over all trips (Figure 6-9).

Table 6-17. Expected changes in Cluster 2 GC annual and per trip RNVC with NY WEA fully closed.

Metric	Change
Mean Change in RNVC per Trip	-$1.41
Median Change in RNVC per Trip	-$1.24
Total Change in RNVC per Year	-$5,292
Median Percent Change in RNVC per Trip	-0.1
Total Percent Change in RNVC per Year	-0.1

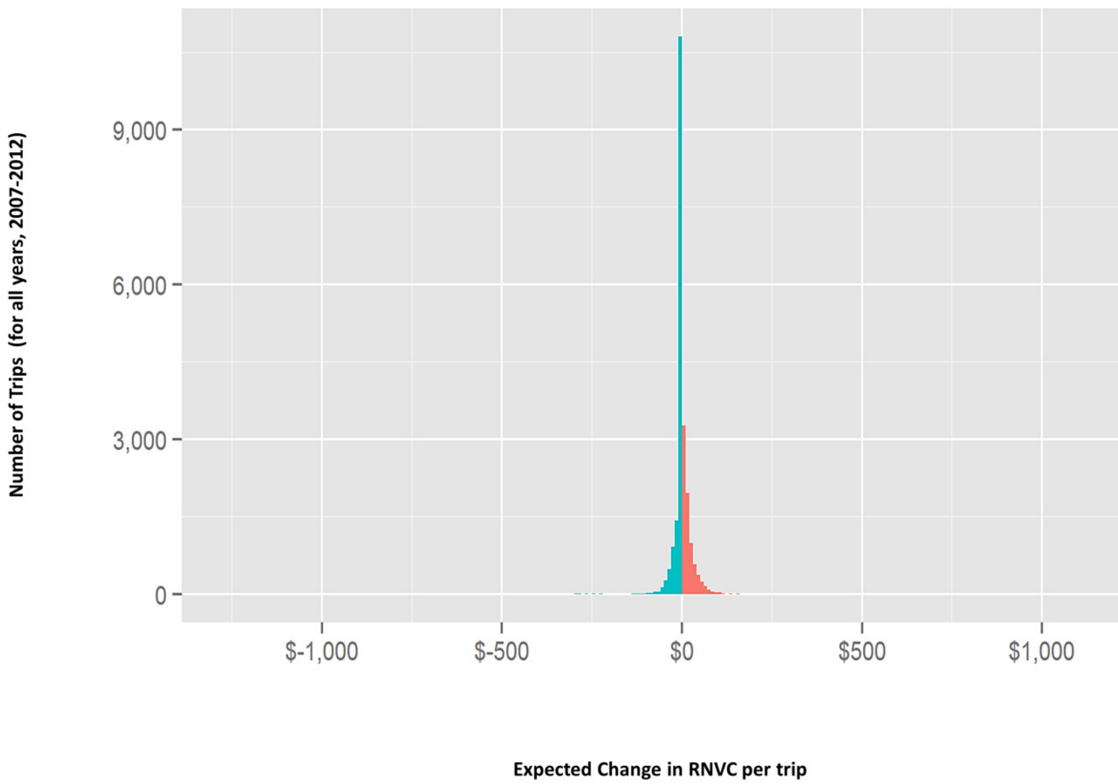


Figure 6-9. Distribution of expected changes in Cluster 2 GC RNVC per trip with NY WEA closed.

The expected change in RNVC resulting from a closure of the NY WEA is limited and slightly negative. These results indicate that alternatives are available to fishermen who traditionally fish in the area. Observed average revenue per hour is $183.34 for Zone 3 and $155.46 for Zone 12 (see Appendix II, Table II-vii).

The cost of fishing in Zone 3 instead of Zone 12 may be higher for some vessels (e.g., those on Long Island, NY, that have to travel further), but the reverse is true for vessels landing further south. Figure 6-9 illustrates that the distribution of expected change in RNVC is tightly clustered around $0 (no change). This result suggests that few trips taken to Zone 12 are without a suitable alternative location should the area be closed to fishing. Assuming that the estimated change in RNVC would fall primarily on the 531 trips in the dataset that were taken to the NY WEA from 2007 to2012, the average per-affected-trip change is -$69.62 per trip.

6.2.6.1.2 Scenario 1B: NC Call (North), NJ, NY, RI-MA, and MA WEAs Fully Closed

From 2007 to 2012, 4.7 percent of the GC scallop vessel trips were centered in one of the WEAs (Zones 7, 11, 12, 13, and 14; Figure 6-8). Of these areas, the NJ WEA (Zone 11) had the highest average revenues per hour ($221.64) (see Appendix II, Table II-vii), though this zone was not a top scallop zone. The RI-MA WEA (Zone 13) had the highest amount of scallops per hour, but the lowest amount of revenue per hour. Table 6-18 compares the percentage shares of trips to each zone fished with/without closure. Expected changes in RNVC with closure are shown in Table 6-19.

Table 6-18. Percentage of Cluster 2 GC trips, by zone fished, for the NC Call (North) WEA, NJ, NY, RI-MA, and MA WEAs closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NC Call (North), NJ, NY, RI-MA, and MA WEAs Closed (% of Fishing Trips)
	Actual	Predicted	Predicted
1	8.8	8.8	9.3
2	16.6	16.7	17.9
3	63.3	63.5	66.1
4	3.0	2.9	3.1
5	0.8	0.9	1.1
6	2.5	2.3	2.5
7 (NC Call [North] WEA)	0.3	0.3	—
11 (NJ WEA)	0.2	0.2	—
12 (NY WEA)	2.8	2.7	—
13 (RI-MA WEA)	1.3	1.2	—
14 (MA WEA)	0.4	0.4	—

Table 6-19. Expected changes in Cluster 2 GC annual and per trip RNVC with NC Call (North), NJ, NY, RI-MA, and MA WEAs fully closed.

Metric	Change
Mean Change in RNVC per Trip	-$4.21
Median Change in RNVC per Trip	$6.20
Total Change in RNVC per Year	-$15,760
Median Percent Change in RNVC per Trip	0.3
Total Percent in RNVC per Year	-0.2

The most likely expected change is *positive*, indicating that, on average, there are areas that have higher expected RNVC than the WEA zones. The average change in expected RNVC is negative. Assuming that the expected negative change in RNVC would have fallen primarily on the 1,116 trips that were taken to a proposed WEA, the average change per-affected-trip is -$84.73. The highest predicted net annual loss for a permit is over $6,000, while the highest predicted net gain is $2,105.

Figure 6-10 shows the distribution of expected change in RNVC by permit. Specific permit-level impacts must be interpreted with caution—the expected change is based in part on the vessel's likelihood of visiting an affected area based on previous visits and changes in scallop prices, in addition to the expected RNVC for each trip. The overall distribution, however, is meaningful. The largest expected losses fall on three permits, but possibilities for negative impacts are common throughout the distribution. Thirty permits have predominantly positive expected changes, suggesting that there are alternative areas to the closed WEAs that would yield higher annual net returns for the permit. This suggests that those permits chose fishing locations within the WEAs for some trips during the study period that did not result in maximum returns.

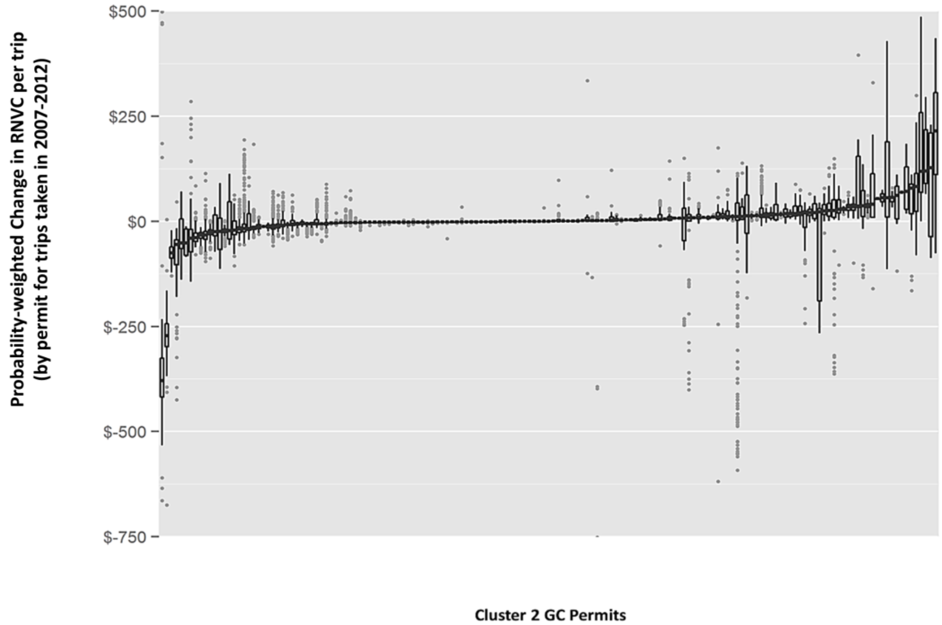


Figure 6-10. Distribution of expected changes in RNVC per trip, by each of the 162 permits in Cluster 2 GC, with NC Call (North), NJ, NY, RI-MA, and MA WEAs closed.

6.2.6.1.3 Scenario 2: NC Call (North), NJ, NY, RI-MA, and MA WEAs Fully Open with Biomass Impacts

Scenario 2, in which the NC Call (North), NJ, NY, RI-MA, and MA WEAs are fully open, was modeled for four catch impact assumptions: minus 25 percent catch, minus 7 percent catch, no catch impact (current baseline), and plus 7 percent catch. Model runs of catch impacts were evaluated assuming the impacts apply to all WEAs modeled for Cluster 2 GC, but without any access restrictions. Percentage shares and changes in RNVC for the different catch assumptions are presented in Table 6-20, Table 6-21, and Figure 6-11.

Table 6-20. Percentage of Cluster 2 GC trips, by zone fished, in fully open NC Call (North), NJ, NY, RI-MA, and MA WEAs, for three biomass impact assumptions compared to current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NC Call (North), NJ, NY, RI-MA, and MA WEAs Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
1	8.8	8.8	8.7	8.7	8.6
2	16.6	16.8	17.0	16.8	16.7
3	63.3	63.5	64.1	63.7	63.3
4	3.0	2.9	3.0	3.0	2.9
5	0.8	1.0	1.2	1.1	0.8
6	2.5	2.3	2.4	2.3	2.3
7 (NC Call [North] WEA)	0.3	0.3	0.1	0.2	0.5
11 (NJ WEA)	0.2	0.2	0.2	0.2	0.2
12 (NY WEA)	2.8	2.7	2.1	2.5	2.9
13 (RI-MA WEA)	1.3	1.2	1.0	1.1	1.3
14 (MA WEA)	0.4	0.4	0.3	0.3	0.4

Table 6-21. Expected changes in Cluster 2 GC per trip RNVC for three biomass impact assumptions for the NC Call (North), NJ, NY, RI-MA, and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$0.03	$0.93	-$5.42	$2.21	-$20,272.25	-0.2
-7% Catch	-$0.01	$0.28	-$1.88	$0.67	-$7,017.64	-0.1
+7% Catch	-$-0.71	-$0.29	-$0.69	$0.01	-$2,566.91	~0

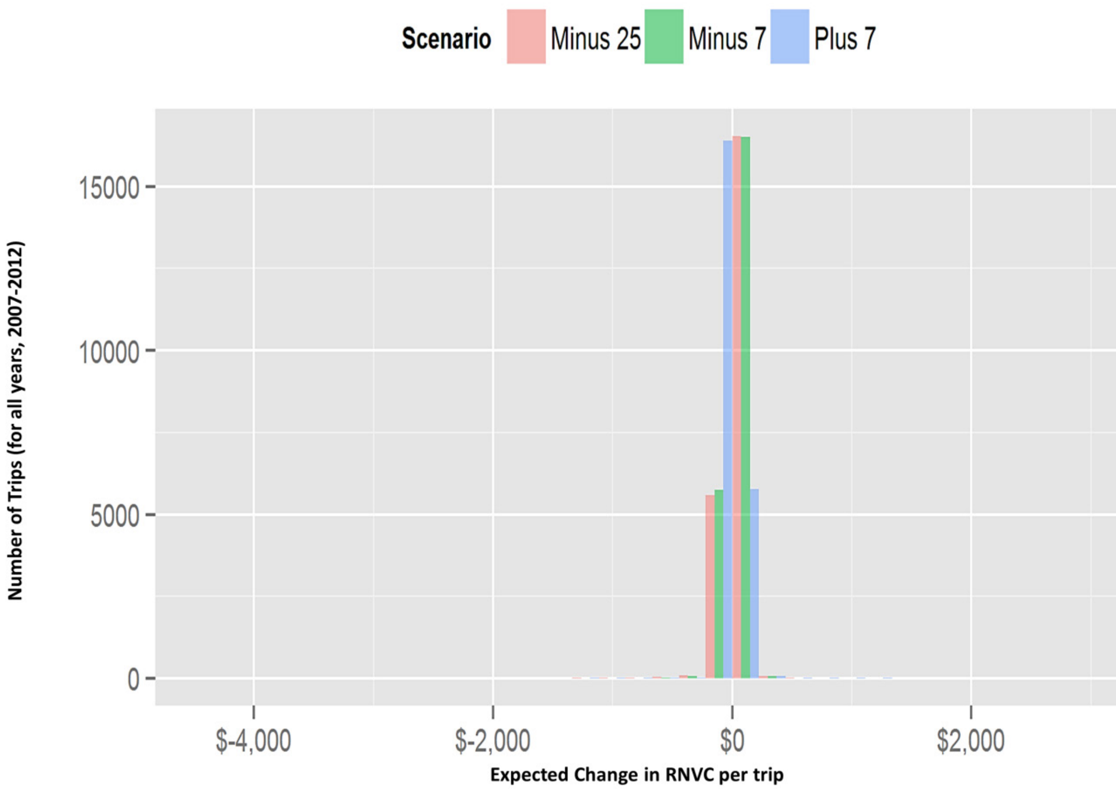


Figure 6-11. Distribution of expected change in Cluster 2 GC RNVC per trip with the NC Call (North), NJ, NY, RI-MA, and MA WEAs fully open.

At 5 percent, the visitation rate to the WEAs is lower than the rates for other fishing areas. As a result of the low visitation rate and substantial number of alternative fishing areas, the model shows that within the WEAs the most likely impact on RNVC per trip is not distinguishable from zero. Increases in catch (plus 7 percent scenario) yield only small increases in estimated number of visits, indicating that congestion effects are unlikely.

6.2.6.1.4 Scenario 3: Weather-Based Closure

Weather-based scenarios estimate how fishery effort allocation would change assuming that winds of 9.35 m/second would keep fishermen from fishing within a WEA. During 2007 to 2012, 3.6 percent of Cluster 2's trips were in this type of wind, with only 55 (or 0.26 percent of trips) located in one of the WEAs. The modeled results are presented in Table 6-22 and Table 6-23 under various biomass scenarios. Weather-based closures generated changes in expected RNVCV of nearly 0 to -0.9 percent.

Table 6-22. Percentage of Cluster 2 GC trips, by zone fished, in the NC Call (North), NJ, NY, RI-MA, and MA WEAs with weather-based closures combined with four biomass impact assumptions.

Zone	Current (Baseline) (% of Fishing Trips)		Weather-Based Closures and Changes in Catch in the NC Call (North), NJ, NY, RI-MA, and MA WEAs Predicted (% of Fishing Trips)			
	Actual	Predicted	-25% Catch	-7% Catch	Constant Catch	+7% Catch
1	8.8	8.8	8.8	8.7	8.7	8.6
2	16.6	16.8	17.0	16.9	16.8	16.8
3	63.3	63.5	64.2	63.8	63.6	63.5
4	3.0	2.9	3.0	3.0	2.9	2.9
5	0.8	1.0	1.2	1.1	1.1	0.9
6	2.5	2.3	2.4	2.3	2.3	2.3
7 (NC Call [North] WEA)	0.3	0.3	0.1	0.2	0.3	0.5
11 (NJ WEA)	0.2	0.2	0.2	0.2	0.2	0.2
12 (NY WEA)	2.8	2.7	2.1	2.4	2.6	2.8
13 (RI-MA WEA)	1.3	1.2	0.9	1.1	1.1	1.2
14 (MA WEA)	0.4	0.4	0.3	0.3	0.3	0.3

Table 6-23. Expected changes in Cluster 2 GC per trip RNVC with weather-based closures, combined with four biomass impact assumptions for the NC Call (North), NJ, NY, RI-MA, and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$0.01	$0.99	-$5.46	$2.38	-$20,429.43	-0.2
-7% Catch	-$0.01	$0.31	-$2.23	$0.75	-$8,360.05	-0.1
Constant Catch	$0.00	$0.00	-$0.49	$0.00	-$1,824.47	~0
+7% Catch	-$0.71	-$0.27	-$0.98	$0.08	-$3,671.00	~0

Under a scenario where WEAs are accessible only under favorable weather conditions, impacts are similar to the fully open scenarios, indicating that a weather-based de facto closure would have little additional impact.

6.2.6.2 Limited Access

In Cluster 2 LA, the primary WEA fished is the NY WEA (Zone 12), which shows a high amount of scallop revenue in the eastern extent and is accessible to vessels in the Mid-Atlantic bight, especially the fishing communities on Long Island. Zone 7, the NC Call (North) WEA, was dropped due to insufficient trips, confirming that the trips observed in Cluster 2 GC were not entirely scallop-targeting. To illustrate the economic impacts of exclusion, the change in RNVC is only estimated for closure of the NY WEA, which is the only WEA explicitly modeled in Cluster 2 LA (Figure 6-12).

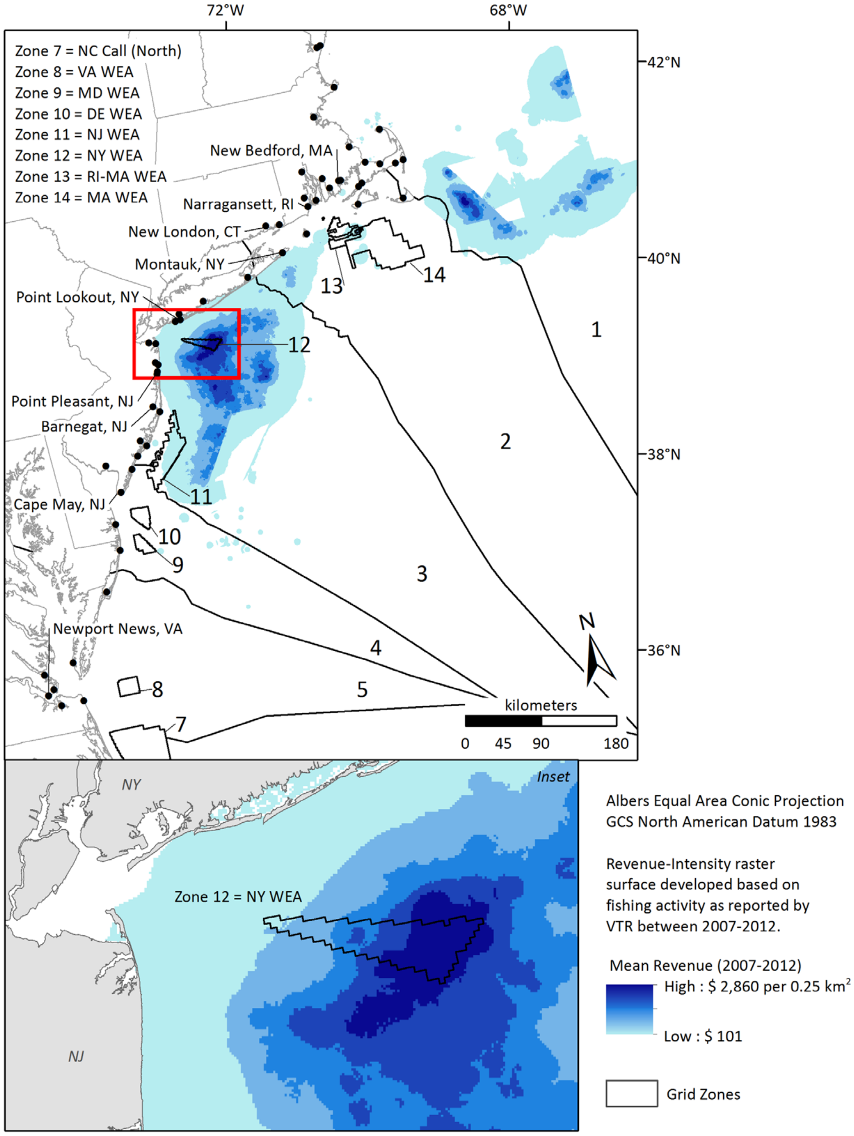


Figure 6-12. Revenue-intensity raster map and fished zones for Cluster 2 LA permits.

Table 6-24. Percentage of actual and predicted Cluster 2 LA trips, by zone fished, under current (baseline) conditions.

Zone	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	20.4	20.4
2	4.4	4.4
3	73.1	73.1
12 (NY WEA)	2.1	2.1

6.2.6.2.1 Scenario 1: New York WEA Fully Closed

From 2007 to 2012, 2.1 percent of the cluster's trips were centered in the NY WEA (Zone 12; Figure 6-12). Zone 12 has the highest average revenues per hour ($801.33) (see Appendix II, Table II-xii), primarily due to the rate of scallops landed per hour. Table 6-25 shows the percentage shares with/without closure, and Table 6-26 presents expected changes in annual and per trip RNVC.

Table 6-25. Percentage of Cluster 2 LA trips, by zone fished, for the NY WEA closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario		NY WEA Closed
	Actual (% of Fishing trips)	Predicted (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	20.4	20.4	20.2
2	4.4	4.4	4.6
3	73.1	73.1	75.2
12 (NY WEA)	2.1	2.1	—

Table 6-26. Expected changes in Cluster 2 LA annual and per trip RNVC with the NY WEA closed.

Metric	Change
Mean Change in RNVC per Trip	-$34.63
Median Change in RNVC per Trip	-$32.47
Total Change in RNVC per Year	-$15,349
Median Percent Change in RNVC per Trip	~0
Total Percent Change in RNVC per Year	~0

Expected RNVC impacts are negative for the LA fleet, but not distinguishable from zero. As noted above, only 2.1 percent of Cluster 2 LA trips occurred in the NY WEA (Zone 12), which is reflected in the very low percentage change in RNVC. Overall, the lower average revenue per hour in Zone 3 is expected to yield lower landings or longer fishing times compared to Zone 12. In some cases, the change in distance makes the RNVC positive. The median change, however, is negative but small.

Figure 6-13 presents the distribution of expected changes in RNVC per trip at the permit level. Specific permit-level impacts must be interpreted with caution—the expected change is based in part on the vessel's likelihood of visiting an affected area based on previous visits and changes in scallop prices, as well as the expected RNVC for each trip. The overall distribution, however, is meaningful. Expected losses are fairly evenly distributed across nearly half of all permits, with 20–30 permits seeing a primarily positive expected change. The scale of changes is quite small: a loss of roughly $35 for a trip that yields an average revenue of $135,000 per LA scallop trip.

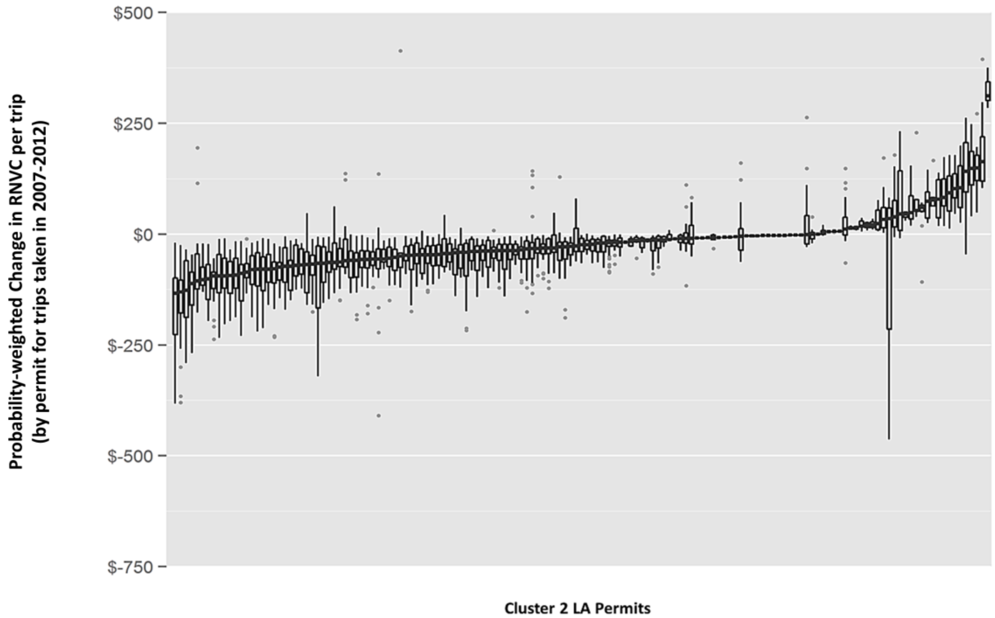


Figure 6-13. Distribution of expected changes in RNVC per trip, by each of the 152 permits in Cluster 2 LA.

6.2.6.2.2 Scenario 2: New York WEA Fully Open with Biomass Impacts

Model runs of biomass impact scenarios were evaluated assuming the effect applies to the NY WEA—the only WEA explicitly modeled in Cluster 2 LA. Percentage shares and changes in RNVC are presented in Table 6-27 and Table 6-28, respectively. The estimated percent change in RNVC is zero under all the biomass scenarios.

Table 6-27. Percentage of Cluster 2 LA trips, by zone fished, in fully open NY WEA for three biomass impact assumptions compared to current (baseline) scenario.

	Current (Baseline) Scenario (% of Fishing Trips)		NY WEA Fully Open Predicted (% of Fishing Trips)		
Zone	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
1	20.4	20.4	19.9	19.8	19.4
2	4.4	4.4	4.5	4.5	4.5
3	73.1	73.1	74.5	74.1	73.4
12 (NY WEA)	2.1	2.1	1.1	1.7	2.7

Table 6-28. Expected changes in Cluster 2 LA RNVC per trip for three biomass impact assumptions for the NY WEA, with this WEA fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$43.30	-$13.42	-$19.76	-$0.82	-$8,758	~0
-7% Catch	-$16.81	-$4.53	-$8.09	-$0.24	-$3,589	~0
+7% Catch	$0.25	$5.30	$11.60	$21.76	$5,140	~0

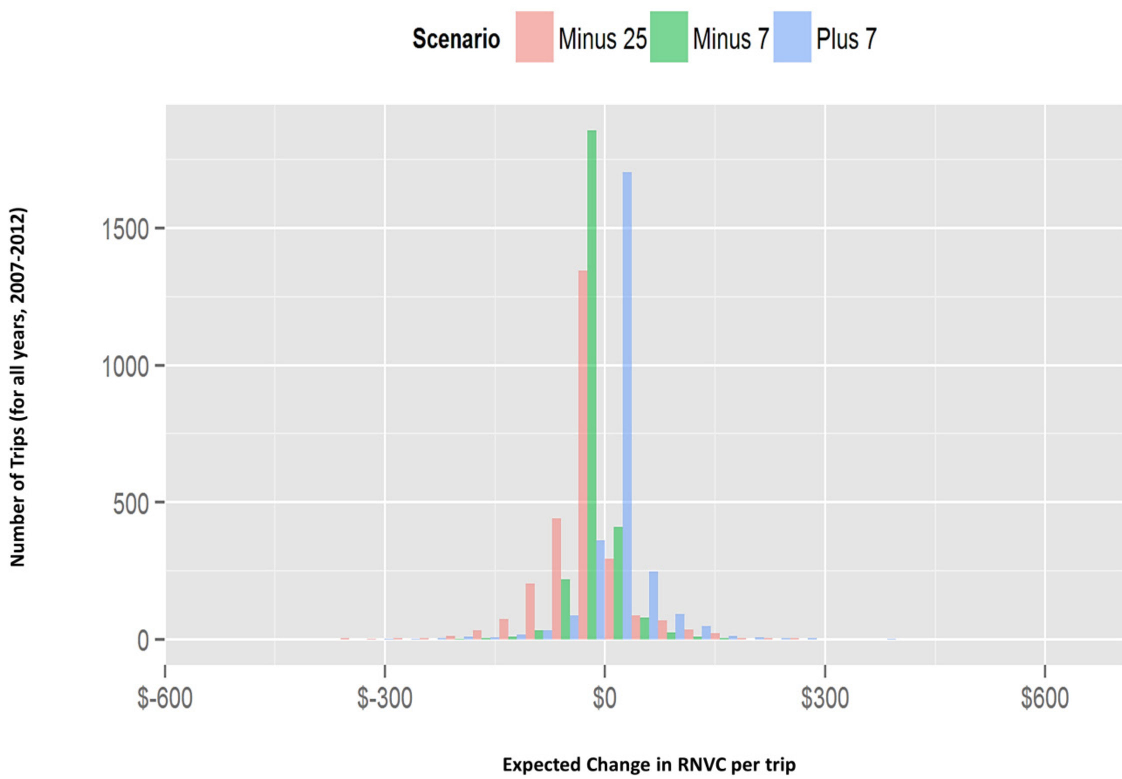


Figure 6-14. Distribution of expected change in Cluster 2 LA RNVC per trip for three biomass impact assumptions with the WEA fully open.

Figure 6-14 shows the distribution of expected change in Cluster 2 LA RNVC per trip for three biomass impact assumptions. At 2.1 percent, the visitation rate to the WEA is relatively low compared to other fishing areas, and there are many alternative zones available to most fishermen. As a result, the model shows that the most likely impact on RNVC per trip of decreases in catch within the NY WEA across all three scenarios is not distinguishable from zero.

6.2.6.2.3 Scenario 3: Weather-Based Closure

Only seven trips (0.002 percent) were to Zone 12 during wind speeds of 9.3 m/second, which was deemed too small a number to induce an impact. Therefore, impacts from weather-based closures are expected to be virtually identical to those in the Scenario 2 (fully open with biomass impacts) (Section 6.2.6.2.2).

6.2.7 Impact Analysis: Cluster 3 Impacts

Cluster 3 is composed of 27 surfclam and ocean quahog permits in the Mid-Atlantic region. The primary WEAs fished are the NJ WEA, RI-MA WEA, and MA WEA (Zones 8, 10, 11; Figure 6-15). The NJ WEA, RI-MA WEA, and MA WEA contain 10 percent, 0.9 percent, and 2 percent, respectively, of all fishing trips for this cluster. The same characteristics that make the NJ WEA desirable for wind energy development (i.e., it is shallow and close to shore) are the same features that make it desirable as surfclam and ocean quahog habitat.

Table 6-29 compares the percentage of actual (i.e., observed) fishing trips to the model predictions under current (baseline) conditions—i.e., without any wind energy development—for all zones fished by Cluster 3 permits during 2007–2012. Comparison of the actual (column 2) versus predicted (column 3) share of trips for each zone shows a strong correspondence.

This section presents the impacts predicted by applying the location choice model to three of the four scenarios described in Section 3.2.2.3: (1) fully closed,[12] (2) fully open with biomass impacts, and (3) weather-based closure. (The gear-based scenario was not included because Cluster 3 is composed only of surfclam and ocean quahog permits.) Results are then compared to the actual and predicted shares shown in Table 6-29. To illustrate the economic impacts of exclusion, the change in RNVC was evaluated for two closures under Scenario 1: (1) closure of only the NJ WEA (Zone 8) and (2) closure of all three Cluster 3 WEAs (i.e., the NJ WEA [Zone 8], RI-MA WEA [Zone 10], and MA WEA [Zone 11]) (Figure 6-15).

[12] As noted earlier, modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario).

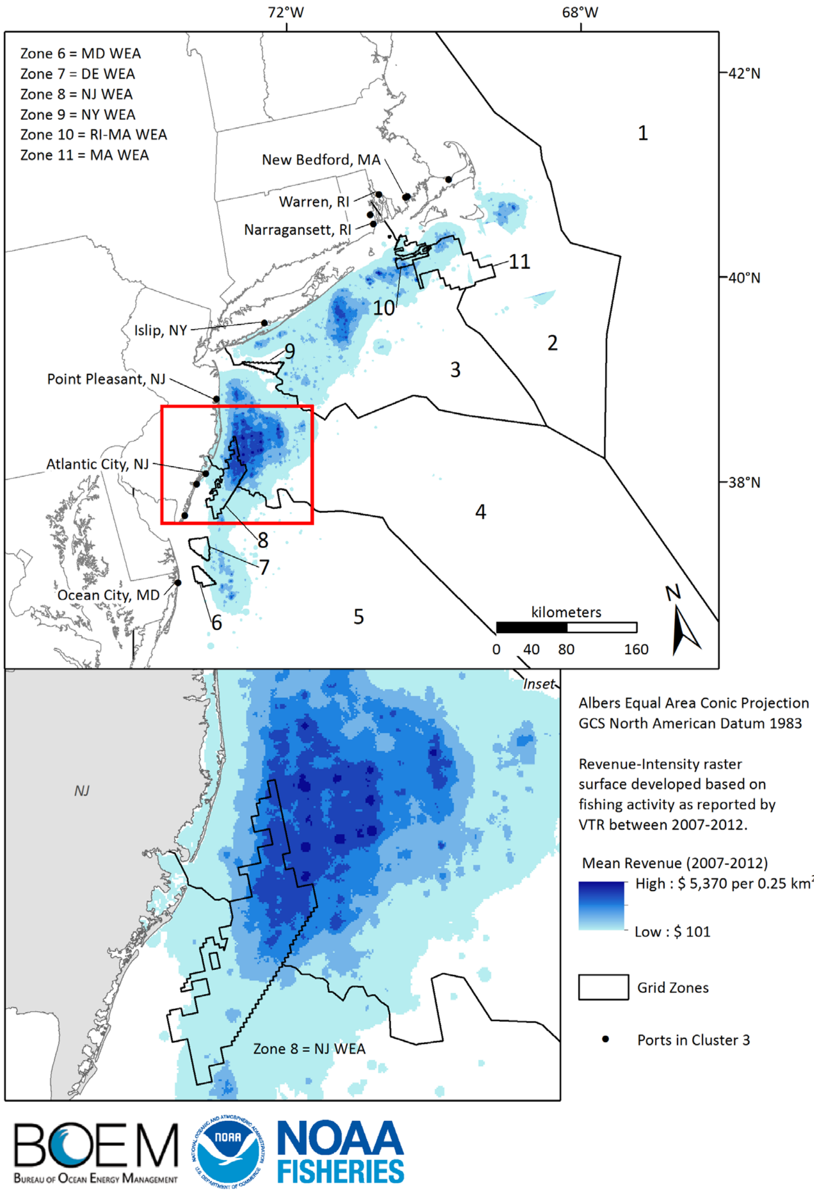


Figure 6-15. Revenue-intensity raster map and fished zones for Cluster 3 permits.

Table 6-29. Percentage of actual and predicted Cluster 3 trips, by zone fished, under current (baseline) conditions, 2007–2012.

Zone	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)
2	5.5	5.5
3	26.2	26.2
4	47.1	47.1
5	8.3	8.3
8 (NJ WEA)	10.0	10.0
10 (RI-MA WEA)	0.9	0.9
11 (MA WEA)	2.0	2.0

6.2.7.1 Scenario 1A: New Jersey WEA (Zone 8) Fully Closed

From 2007 to 2012, approximately 10 percent of the cluster's trips were reported in the NJ WEA (Zone 8; Figure 6-15). Table 6-30 compares predicted percentage trips by zone for the NJ WEA closure scenario (column 4) with actual (column 2) and predicted (column 3) percentage trips under the current (baseline) scenario.

Table 6-30. Percentage of Cluster 3 trips, by zone fished, for the NJ WEA closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario		NJ WEA Closed
	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)	Predicted (% of Fishing Trips)
2	5.5	5.5	5.8
3	26.2	26.2	27.4
4	47.1	47.1	54.4
5	8.3	8.3	9.3
8 (NJ WEA)	10.0	10.0	—
10 (RI-MA WEA)	0.9	0.9	1.0
11 (MA WEA)	2.0	2.0	2.1

Changes in fishing behavior, such as changes in distance traveled, steaming time, and estimated catch, are incorporated into the by-zone-trip RNVC estimates presented in Table 6-31. Figure 6-16 shows the distribution of expected RNVC change over all trips. The average RNVC per hour (using estimated costs and observed revenues) in the NJ WEA was $531, lower than in most other zones (see Appendix II, Figure II-xiv). The average RNVC per hour for Zone 4 ($614), and Zone 5 ($531) equaled or exceeded the average RNVC per hour of the NJ WEA. This result suggests that, under baseline conditions, some Cluster 3 permits are making fishing location choices that are not strictly economically rational by choosing to fish in the NJ WEA, rather than other zones that are available to them and yield higher net revenues. These alternatives have similar or better observed harvests (conditional on trip and vessel characteristics), with either lower costs or increased costs that are more than offset by the improved harvest. Fishing effort is predicted to be reallocated to other zones if the NJ WEA is closed, leading to positive changes in RNVC for most trips (Figure 6-16). However, the percent change in total RNVC per year, +0.6 percent (Table 6-31), indicates that the magnitude of this expected change is quite small compared to the fishery as a whole. Therefore, although *positive* impact is predicted, it likely cannot be distinguished from zero impact.

Table 6-31. Expected changes in Cluster 3 annual and per trip RNVC with NJ WEA closed.

Metric	Change
Total Change in RNVC per Year	$211,325
Mean Change in RNVC per Trip	$109
Median Change in RNVC per Trip	$81
Median Percent Change in RNVC per Trip	0.5
Total Percent Change in RNVC per Year	0.6

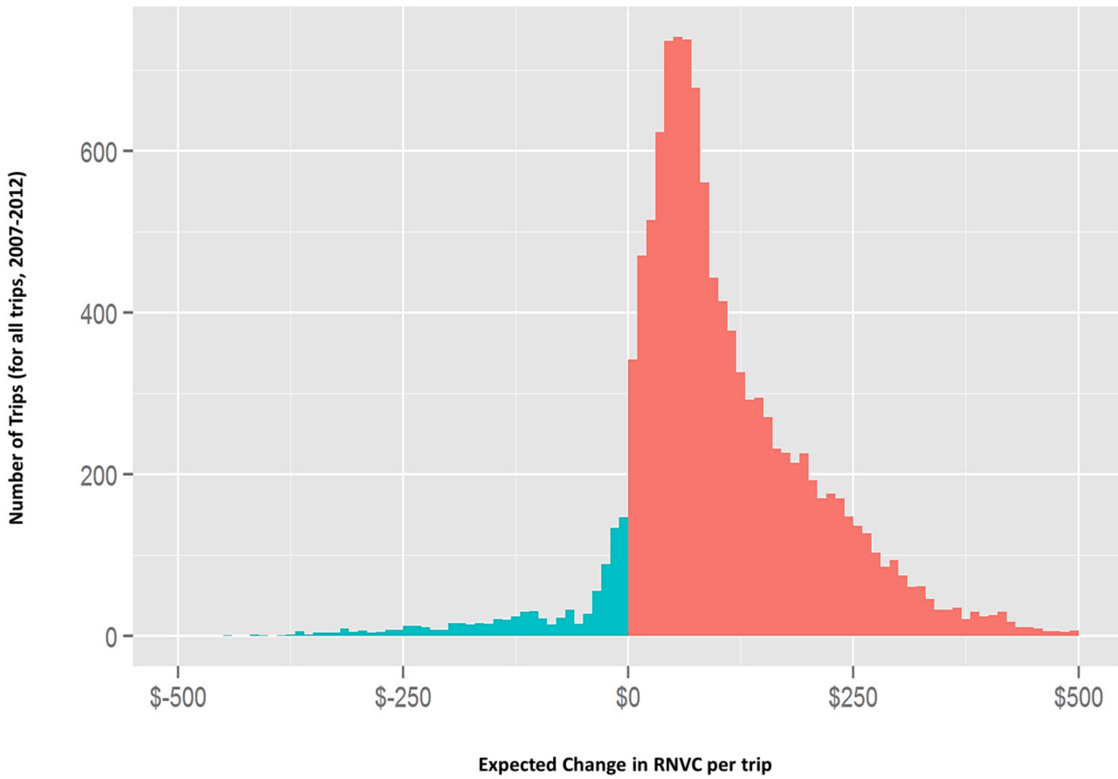


Figure 6-16. Distribution of expected change in Cluster 3 RNVC per trip with NJ WEA closed.

6.2.7.2 Scenario 1B: NJ WEA, RI-MA WEA, and MA WEA Fully Closed

From 2007 to 2012, approximately 12.9 percent of Cluster 3 trips were centered in a proposed WEA, with 10.0 percent hosted by the NJ WEA and 2.9 percent by the RI-MA WEA (Zone 10) and MA WEA (Zone 11) (Table 6-30). The average RNVC per hour (using estimated costs and observed revenues) in the RI-MA WEA was $961, considerably higher than most other zones. However, even though expected RNVC in this zone is higher, it is rarely visited by fishermen from Cluster 3.

Predicted percentage of trips and with and without closure and associated RNVC changes are shown in Table 6-32 and Table 6-33, respectively. Figure 6-17 shows the distribution of expected change in Cluster 3 RNVC per trip. Note that effort is expected to shift towards grounds in Southern New England that have been closed due to paralytic shellfish poisoning (PSP) concerns for years; these grounds are only recently becoming accessible again due to improved PSP testing. Effort may shift onto Georges Bank as well. While effort shifts onto Georges Bank would not be prevented by construction of any of the proposed WEAs, the MA WEA overlaps with the general area identified by the clam industry as potentially important fishing grounds. By virtue of having been closed to clam fishing for decades, the area contains a substantial number of mature clams and is of great economic value to the fishery. This information is not reflected in the model because the model data do not extend to pre-PSP closure.

Table 6-32. Percentage of Cluster 3 trips, by zone fished, for the NJ, RI-MA, and MA WEAs closed versus current (baseline) scenarios.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NJ, RI-MA, and MA WEAs Closed (% of Fishing Trips)
	Actual	Predicted	Predicted
2	5.5	5.5	6.2
3	26.2	26.2	28.8
4	47.1	47.1	55.5
5	8.3	8.3	9.5
8 (NJ WEA)	10.0	10.0	—
10 (RI-MA WEA)	0.9	0.9	—
11 (MA WEA)	2.0	2.0	—

Table 6-33. Expected changes in Cluster 3 annual and per trip RNVC with NJ, RI-MA, and MA WEAs closed.

Metric	Change
Total Change in RNVC per Year	$199,852
Mean Change in RNVC per Trip	$103.10
Median Change in RNVC per Trip	$96.78
Median Percent Change in RNVC per Trip	0.7
Total Percent Change in RNVC per Year	0.6

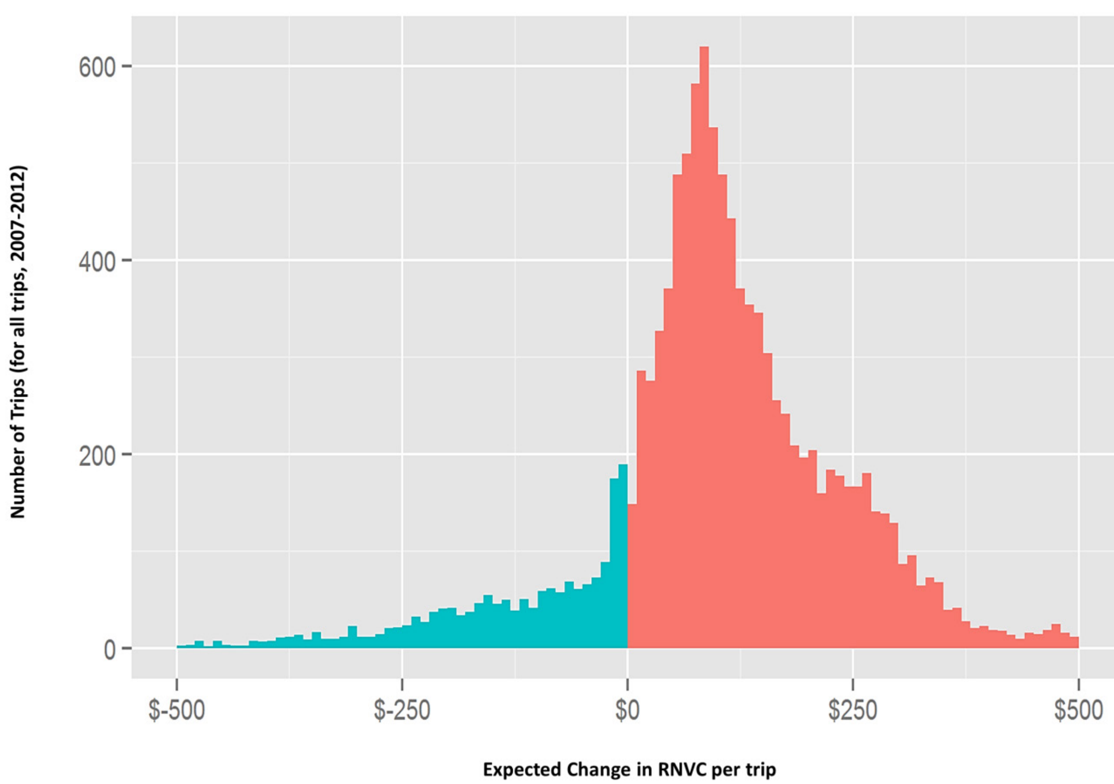


Figure 6-17. Distribution of expected change in Cluster 3 RNVC per trip with the NJ, RI-MA, and MA WEAs closed.

Closure of the relatively high-yield RI-MA (Zone 10) and MA (Zone 11) WEAs, in addition to the NJ WEA (Zone 8), reduces the positive change (when closing only the NJ WEA) by approximately $11,474 per year overall for all Cluster 3 permits.

Figure 6-18 shows the distribution of expected changes in RNVC per trip for each of the 27 permits in Cluster 3. Specific permit-level impacts must be interpreted with caution—the expected change is based in part on the vessel's likelihood of visiting an affected area based on previous visits and changes in clam prices, as well as the expected RNVC for each trip. However, the overall distribution is meaningful. Expected changes are fairly evenly distributed across the permits, with the exception of a single permit that is expected to gain the vast majority of positive benefits.

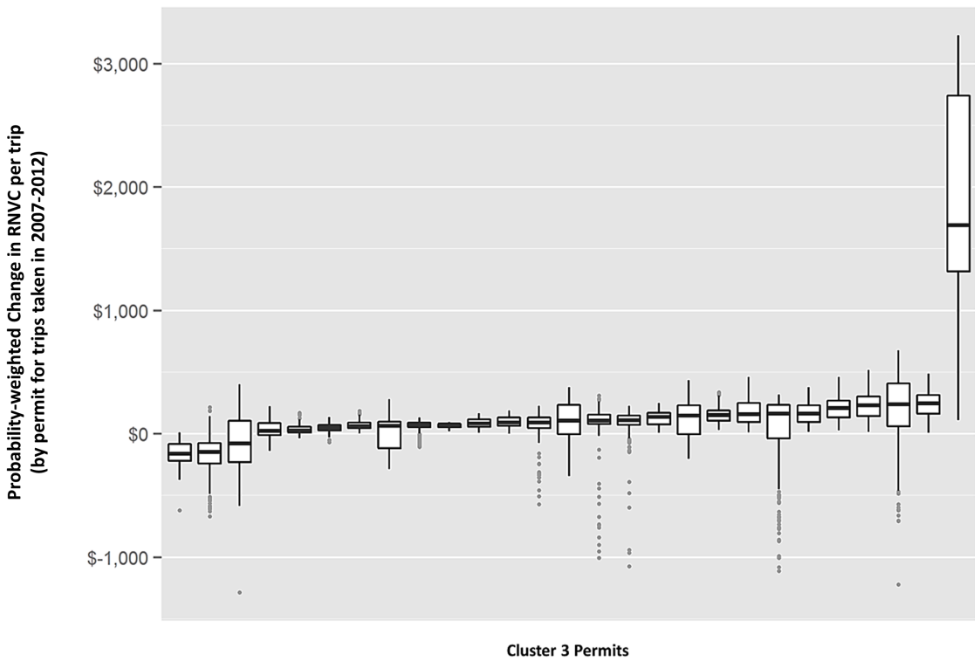


Figure 6-18. Distribution of expected changes in RNVC per trip, by each of the 27 permits in Cluster 3.

6.2.7.3 Scenario 2: NJ, RI-MA, and MA WEAs Fully Open with Biomass Impacts

Scenario 2, in which the NJ, RI-MA, and MA WEAs are fully open, was modeled for four biomass impact assumptions assuming the effect applies to all three WEAs: minus 25 percent catch, minus 7 percent catch, no catch impact (current baseline), and plus 7 percent catch. Predicted percentage shares are presented in Table 6-34. Changes in RNVC are presented in Table 6-35 and Figure 6-19.

Table 6-34. Percentage of Cluster 3 trips, by zone fished, in fully open NJ, RI-MA, and MA WEAs for three biomass assumptions compared to current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NJ, RI-MA, and MA WEAs Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
2	5.5	5.5	5.9	5.7	5.2
3	26.2	26.2	28.1	27.1	24.8
4	47.1	47.1	52.4	49.3	44.1

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NJ, RI-MA, and MA WEAs Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
5	8.3	8.3	9.0	8.6	8.0
8 (NJ WEA)	10.0	10.0	3.9	7.5	13.5
10 (RI-MA WEA)	0.9	0.9	0.2	0.6	1.5
11 (MA WEA)	2.0	2.0	0.5	1.3	3.0

Table 6-35. Expected changes in Cluster 3 per trip RNVC for three biomass impact assumptions for the NJ, RI-MA, and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	$17.43	$59.18	$59.73	$116.10	$115,778	0.3
-7% Catch	$5.61	$21.91	$22.01	$47.64	$42,657	0.1
+7% Catch	$-63.58	$-26.81	$-29.00	$-5.88	$-56,207	-0.2

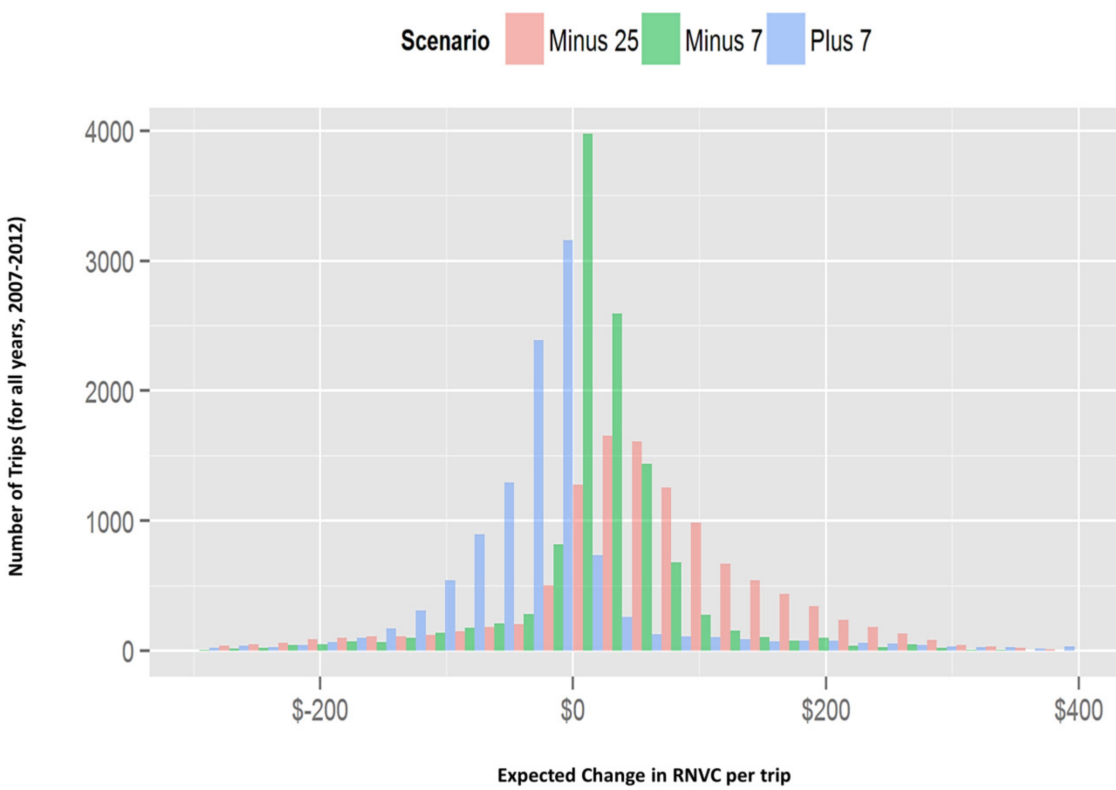


Figure 6-19. Distribution of expected change in Cluster 3 RNVC per trip for three biomass impact assumptions with NJ, RI-MA, and MA WEAs fully open.

Similar to the effects seen in the fully closed scenarios, changes in catch within the proposed WEAs lead to a reversed impact—decreasing the catch (the minus 25 percent and minus 7 percent scenarios) leads to fishing in areas with higher observed revenue per hour fished. This results in a positive outcome for the majority of trips, as shown by Table 6-34, Table 6-35, and Figure 6-19. However, some trips in Cluster 3 are expected to experience negative changes in RNVC, with the largest loss being $300 per trip. Increases in catch (the plus 7 percent catch scenario) within a proposed WEA attract effort from areas with higher revenue per hour averages, leading to decreases in expected RNVC. The percentage changes are measured in tenths of a percent, indicating that, on average, the impact is likely not distinguishable from zero.

6.2.7.4 Scenario 3: Weather-Based Closure

Weather-based scenarios estimate how fishery effort allocation would change assuming that winds of 9.35 m/second would keep fishermen from fishing within a WEA. Table 6-36 presents the results of applying the weather-based scenario to Cluster 3 trips with four biomass impact assumptions. Of the 11,630 Cluster 3 trips, 701 (6.0 percent) were to areas measuring these winds or greater. Of those 701 trips, 121 were to a proposed WEA area, and would therefore not occur due to safety concerns. These 121 trips represent 1.0 percent of all Cluster 3 trips. Table 6-37 presents expected changes in Cluster 3 per trip RNVC with weather-based closures.

Table 6-36. Percentage of Cluster 3 trips, by zone fished, in NJ, RI-MA, and MA WEAs with weather-based closures combined with four biomass impact assumptions.

Zone	Current (Baseline) (% of Fishing Trips)		Weather-Based Closures and Change in Catch in the NJ, RI-MA, and MA WEAs Predicted (% of Fishing Trips)			
	Actual	Predicted	-25% Catch	-7% Catch	Constant Catch	+7% Catch
2	5.5	5.5	5.9	5.7	5.5	5.2
3	26.2	26.2	28.1	27.2	26.4	25.2
4	47.1	47.1	52.5	49.6	47.6	44.8
5	8.3	8.3	9.0	8.6	8.4	8.0
8 (NJ WEA)	10.0	10.0	3.7	7.1	9.5	12.7
10 (RI-MA WEA)	0.9	0.9	0.2	0.5	0.8	1.3
11 (MA WEA)	2.0	2.0	0.5	1.2	1.8	2.7

Table 6-37. Expected changes in Cluster 3 per trip RNVC with weather-based closures, combined with four biomass impact assumptions for the NJ, RI-MA, and MA WEAs, with these WEAs fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	$18.30	$61.21	$61.40	$118.80	$119,014	0.4
-7% Catch	$6.04	$23.53	$25.05	$52.51	$48,563	0.1
Constant Catch	$0.00	$0.00	$3.42	$0.00	$6,637	~0
+7% Catch	-$62.35	-$25.32	-$25.48	-$3.36	-$49,395	-0.1

Weather-based closures result in impacts nearly identical to those under Scenario 2 (WEAs fully open with biomass catch assumptions) (Section 6.2.7.3). In the absence of any change in catch (the "Constant Catch" scenario), the total impacts on expected RNVC are predicted to be less than two-tenths of a percent of the study fleet's total, indicating negligible expected impacts of WEA development due to this scenario (Table 6-37).

6.2.8 Impact Analysis: Cluster 4 Impacts

Cluster 4 is composed of 131 permits landing in Roanoke Island, NC, and primarily fishing in the NC Call (North) WEA (Zone 11) (Figure 6-20). Other WEAs in the vicinity had insufficient trips to include in analysis. A full overview of the cluster can be found in Appendix II, Section II.iv, and model results are presented in Appendix II, Section II.v.

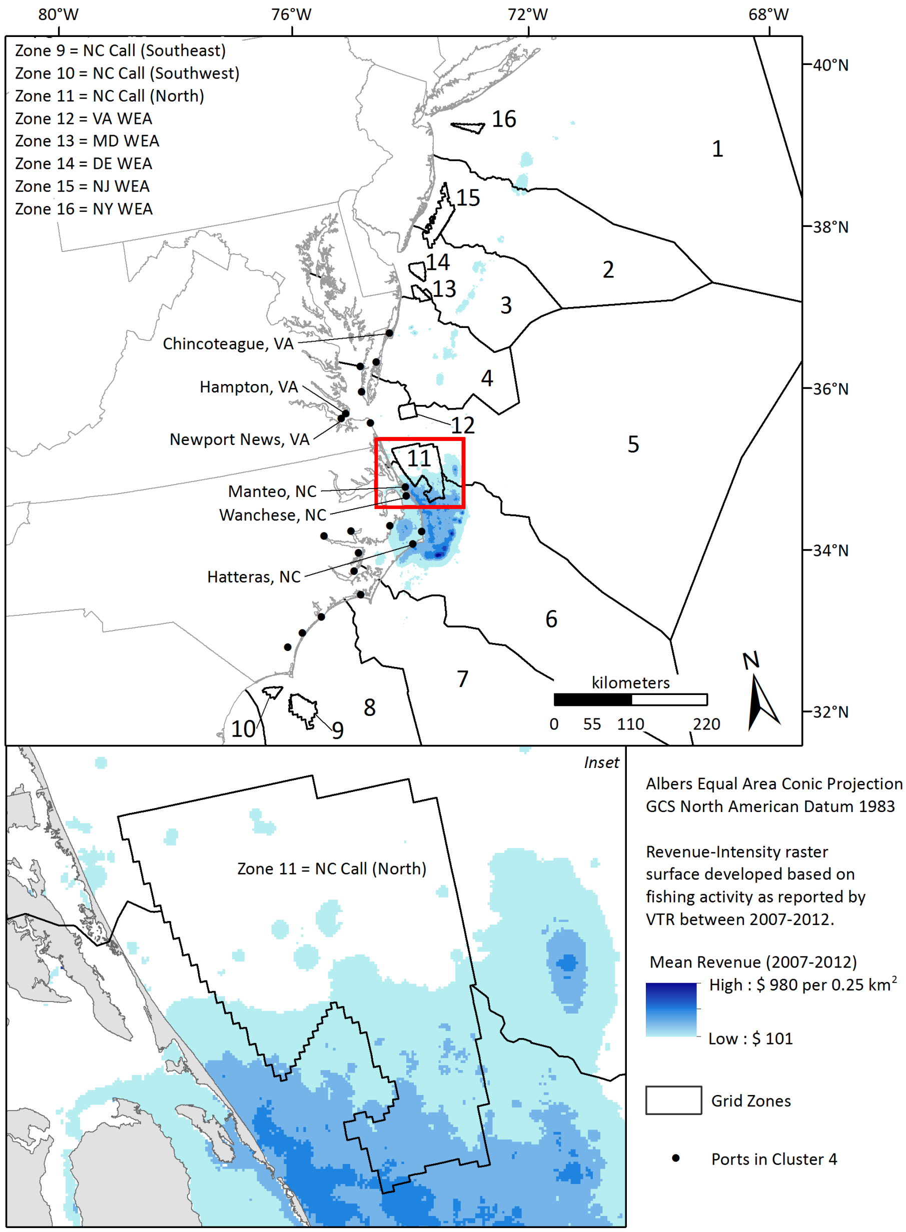


Figure 6-20. Revenue-intensity raster map and fished zones for Cluster 4 permits.

Table 6-38 compares the percentage of actual (i.e., observed) fishing trips to the model predictions under current (baseline) conditions—i.e., without any wind energy development—for all zones fished by Cluster 4 permits during 2007–2012. Comparison of the actual (column 2) versus predicted (column 3) share of trips for each zone shows a strong correspondence.

This section presents the impacts predicted by applying the location choice model to the four scenarios described in Section 3.2.2.3: (1) fully closed,[13] (2) fully open with biomass impacts, (3) weather-based closure, and (4) gear-based scenario. Results are then compared to the actual and predicted shares shown in Table 6-38.

Table 6-38. Percentage of actual and predicted Cluster 4 trips, by fished zone, under current (baseline) conditions, 2007–2012.

Zone	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	1.6	1.6
2	0.9	1.1
3	1.1	1.0
4	4.5	4.4
5	3.7	5.0
6	77.9	76.7
7	1.5	1.4
8	3.2	3.1
11 (NC Call [North] WEA)	5.6	5.7

6.2.8.1 Scenario 1: NC Call (North) WEA Fully Closed

The percentages of Cluster 4 trips with and without closure of the NC Call (North) WEA are shown in Table 6-39. Table 6-40 presents the expected changes in Cluster 4 RNVC with the NC Call (North) WEA closed. From 2007 to 2012, approximately 5.6 percent of the cluster's trips were centered in a proposed WEA. The average RNVC per hour (using estimated costs and observed revenues) in the NC Call (North) WEA was $87.17, higher than Zone 6 to the south ($67.74/hour) but lower than Zone 5 to the north ($127.15/hour). Despite having a lower RNVC per hour, Zone 6 accounts for 77.5 percent of all trips in the cluster.

Table 6-39. Percentage of Cluster 4 trips, by zone fished, for the NC Call (North) WEA closed scenario versus current (baseline) scenario.

Zone	Current (Baseline) Scenario		NC Call (North) WEA Closed
	Actual (% of Fishing Trips)	Predicted (% of Fishing Trips)	Predicted (% of Fishing Trips)
1	1.6	1.6	0.8
2	0.9	1.1	1.5
3	1.1	1.0	0.8
4	4.5	4.4	5.2
5	3.7	5.0	5.5
6	77.9	76.7	81.6
7	1.5	1.4	1.5
8	3.2	3.1	3.1
11 (NC Call [North] WEA)	5.6	5.7	—

[13] As noted earlier, modeling the economic impact of full closure estimates the upper boundary, or worst-case scenario, for costs to the fishery and is appropriate to understand the full range of potential impacts. However, inclusion of the "fully closed" scenario does not imply that this scenario is desired or even legally feasible (no federal agency has the regulatory authority to restrict access to wind energy facilities, which would be necessary to implement the "fully closed" scenario).

Table 6-40. Expected changes in Cluster 4 annual and per trip RNVC with NC Call (North) WEA closed.

Metric	Change
Total Change in RNVC per Year	$6,589
Mean Change in RNVC per Trip	-$2.54
Median Change in RNVC per Trip	-$1.17
Median Percent Change in RNVC per Trip	-0.1
Total Percent Change in RNVC per Year	-0.1

Closure of Zone 11 results in most trips experiencing a slightly negative change in RNVC. However, a handful of trips would experience a negative change of more than $200 and, conversely, a handful of trips would experience a positive change of similar magnitude, resulting in an average change in RNVC not distinguishable from zero. Vessels using bottom trawl gear are expected to experience positive changes in RNVC, while midwater trawl gears are more likely to experience negative per-trip changes.

Figure 6-21 shows the distribution of changes in RNVC for each permit in Cluster 4, by landing ports used by Cluster 4 permits. Twelve ports with less than three unique permits that landed in 2007–2012 are removed for confidentiality. Wanchese, NC (which includes landings in nearby Manteo, NC, and comprises the entirety of Roanoke Island) is the clear driver of the cluster's changes in RNVC.

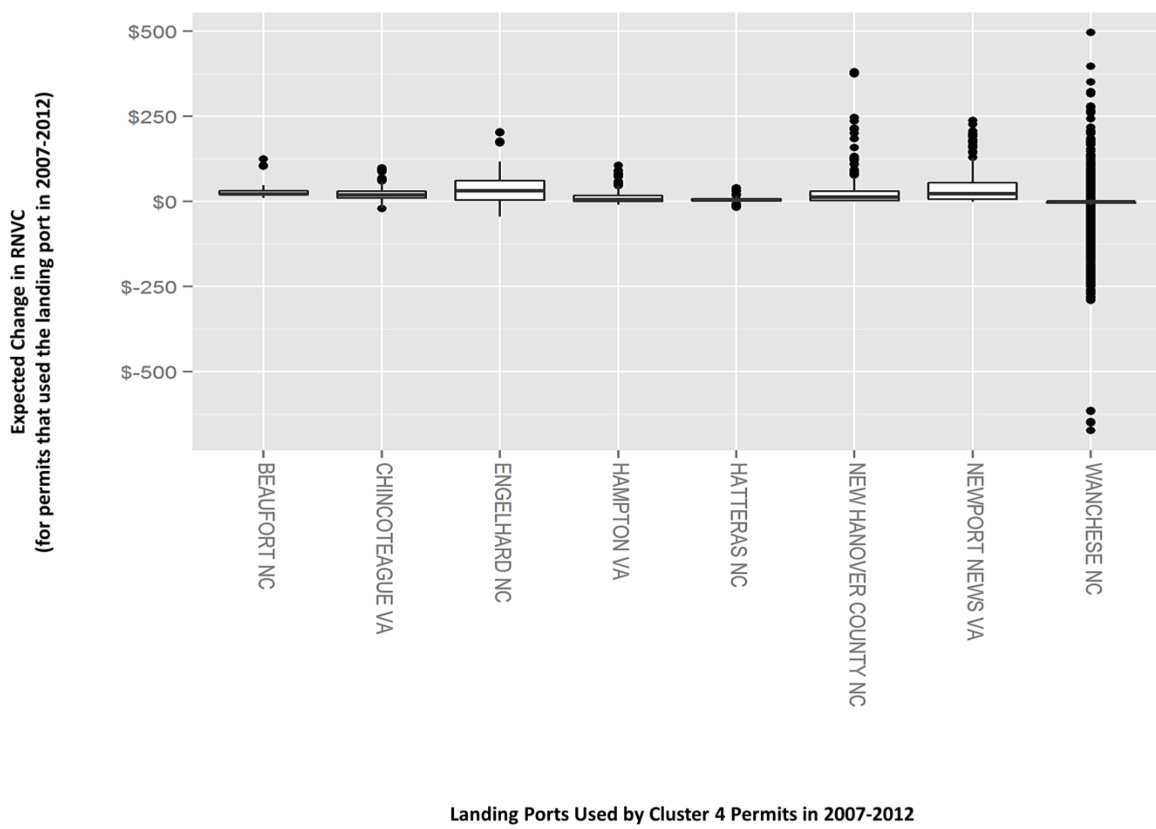


Figure 6-21. Distribution of total expected changes in RNVC for Cluster 4 permits, by landed port, 2007–2012.

Figure 6-22 shows the distribution of changes in RNVC per trip for each gear landing in Wanchese, NC. Although bottom trawl gear has mixed changes, midwater trawl and gillnet trips are mostly negative.

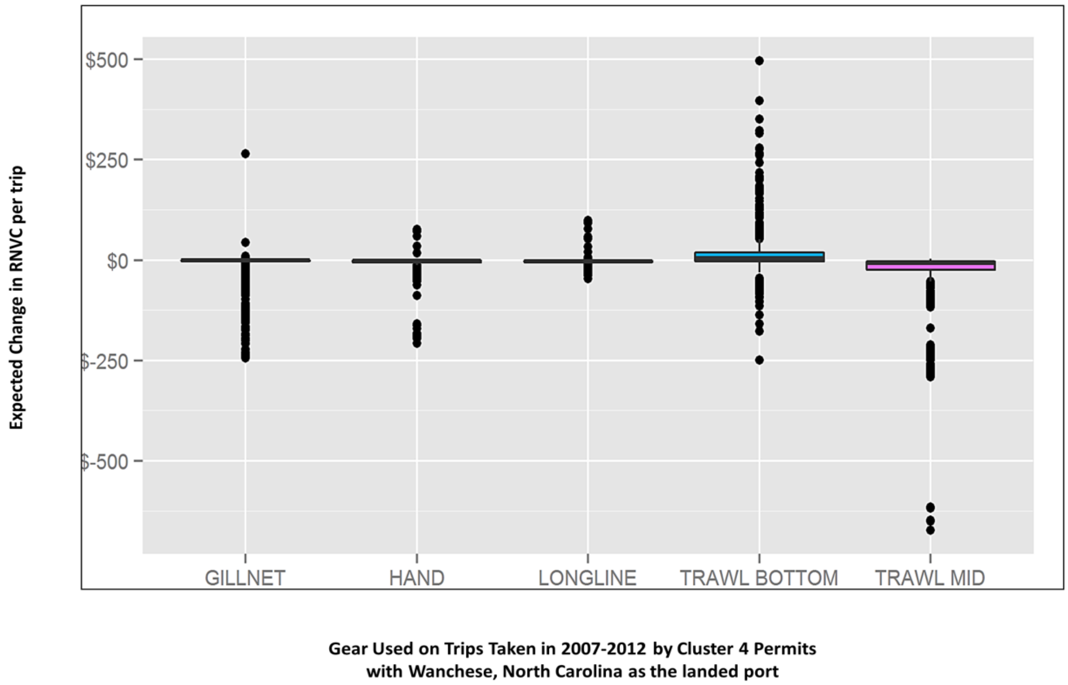


Figure 6-22. Distribution of expected changes in RNVC per trip for trips taken by Cluster 4 permits landed in Wanchese, NC, by gear group.

Figure 6-23 shows the distribution of expected changes in RNVC per trip for each permit in Cluster 4. Specific permit-level impacts must be interpreted with caution—the expected change is based in part on the vessel's likelihood of visiting an affected area based on previous visits and changes in fish prices, as well as the expected RNVC for each trip. The overall distribution is meaningful. Expected losses are fairly evenly distributed across permits, with a handful of permits showing a likely positive change.

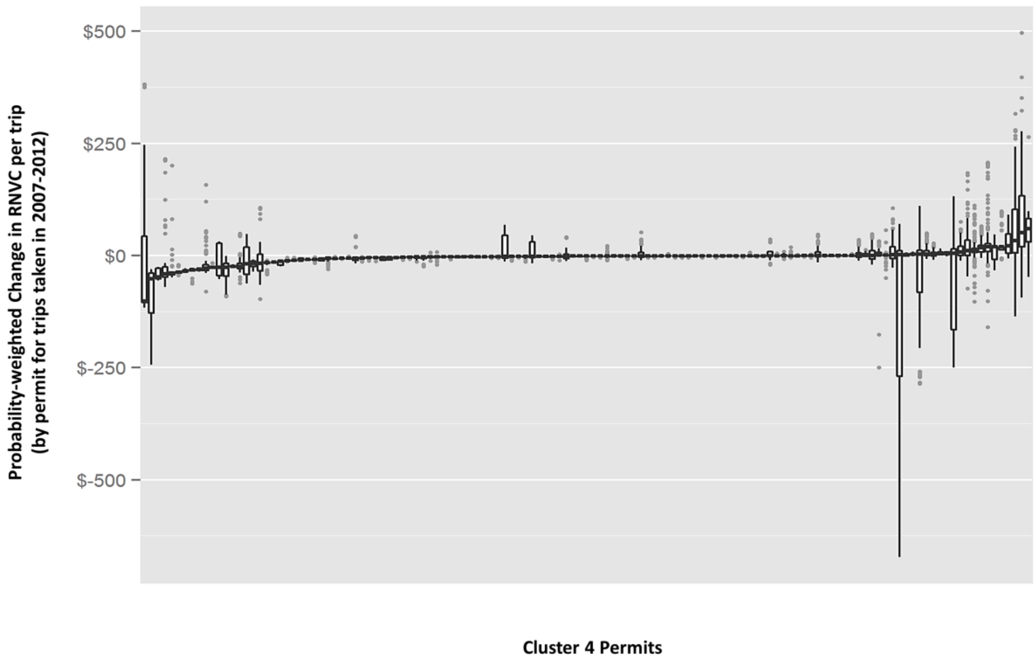


Figure 6-23. Distribution of expected changes in RNVC per trip, by each of the 166 permits in Cluster 4.

6.2.8.2 Scenario 2: Fully Open with Biomass Impacts

Scenario 2, in which the NC Call (North) WEA is fully open, was modeled for four biomass impact assumptions: minus 25 percent catch, minus 7 percent catch, no catch impact (current baseline), and plus 7 percent catch. Predicted percentage shares are presented in Table 6-41. Changes in RNVC are presented in Table 6-42 and distribution of RNVC per trip is shown in Figure 6-24.

Table 6-41. Percentage of Cluster 4 trips, by zone fished, in fully open NC Call (North) WEA for three biomass impact assumptions compared to current (baseline) scenario.

Zone	Current (Baseline) Scenario (% of Fishing Trips)		NC Call (North) WEA Fully Open Predicted (% of Fishing Trips)		
	Actual	Predicted	-25% Catch	-7% Catch	+7% Catch
1	1.6	1.6	0.8	0.8	0.8
2	0.9	1.1	1.5	1.5	1.5
3	1.1	1.0	0.8	0.8	0.8
4	4.5	4.4	5.1	5.1	5.0
5	3.7	5.0	5.3	5.2	5.0
6	77.9	76.7	78.1	77.3	76.4
7	1.5	1.4	1.3	1.3	1.3
8	3.2	3.1	2.9	2.9	2.9
11 (NC Call [North] WEA)	5.6	5.7	4.2	5.2	6.4

Table 6-42. Expected changes in Cluster 4 per trip RNVC for three biomass impact assumptions for the NC Call (North) WEA, with this WEA fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$1.09	-$0.27	$1.46	-$0.07	$3,799	0.1
-7% Catch	-$0.36	-$0.08	$1.05	-$0.02	$2,739	0.1
+7% Catch	$0.02	$0.09	-$2.86	$0.40	-$7,442	-0.1

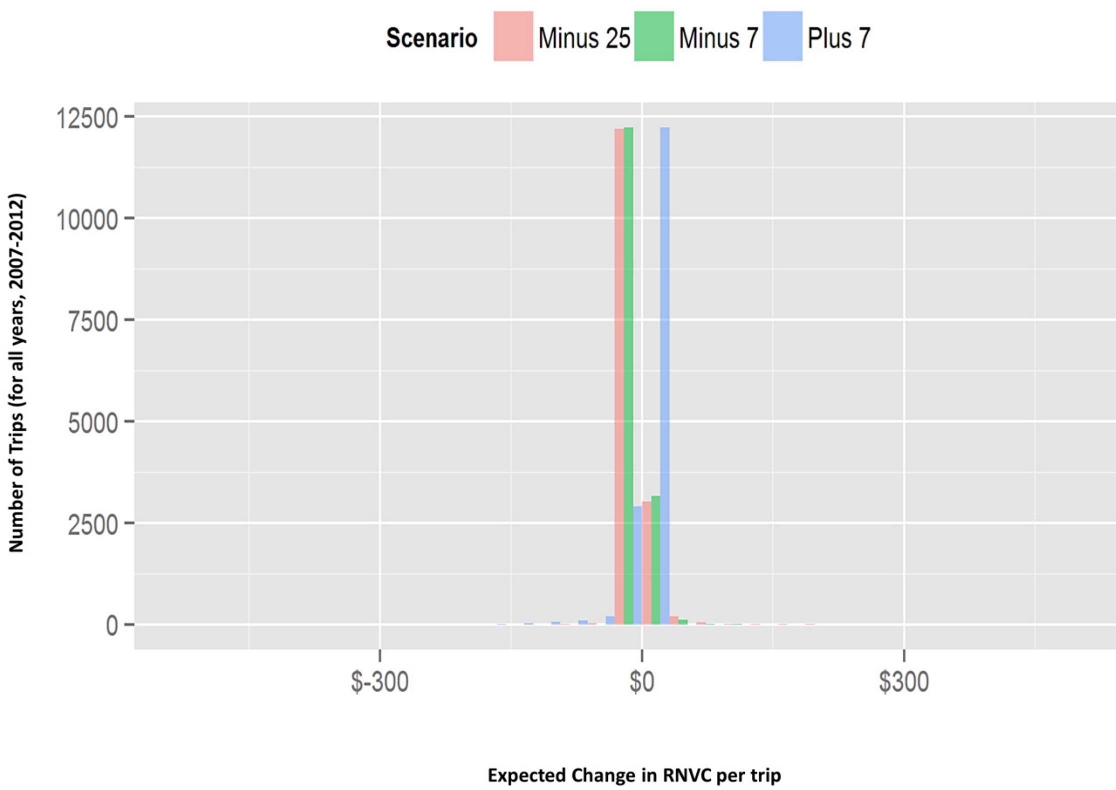


Figure 6-24. Distribution of expected change in Cluster 4 RNVC per trip for three biomass impact assumptions with the NC Call (North) WEA fully open.

Decreasing the catch as a result of reduced biomass (minus 25 percent and minus 7 percent scenarios) appears to lead to a positive outcome, based on the average expected change in RNVC per trip (see Table 6-42, middle column). However, the distribution of estimated changes in trip-level RNVC, presented in Figure 6-24, is not consistent. Many more trips experience small negative impacts; however, the few positively impacted trips result in a slightly positive percent change. Increases in catch within a proposed WEA (represented by the plus 7 percent catch scenario) may attract effort from areas with higher revenue per hour averages, which can potentially lead to decreases in expected RNVC.

Table 6-41 shows that increases in catch yield only a slight increase in the number of trips visiting the NC Call (North) WEA, indicating that congestion effects are unlikely to result from this scenario. Table 6-42 illustrates that the likely expected (i.e., median) change in RNVC per trip (third column) for the plus 7 percent catch scenario is very slightly positive, while the average expected change (fourth column) is negative due to a few trips with extreme negative changes in expected RNVC per trip (see Figure 6-24). Overall, the expected change in total RNVC is negative, but with a decrease of less than 1 percent.

6.2.8.3 Scenario 3: Weather-Based Closure

Weather-based scenarios estimate how fishery effort allocation would change assuming that winds of 9.35 m/second would keep fishermen from fishing within a WEA. Table 6-43 presents the results of applying the weather-based scenario to Cluster 4 trips with four biomass impact assumptions.

During 2007–2012, 1,026 (6.6 percent) of a total 15,584 Cluster 4 trips were to areas experiencing these strong winds. Of those 1,026 trips, 77 (0.5 percent) were to the NC Call (North) WEA. Weather-based closures result in an impact nearly identical to the fully open scenario with changes in catch (comparing Table 6-43 with Table 6-41). In the absence of any change in catch, the "Constant Catch" scenario (Table 6-44, fourth row), the total impacts on expected RNVC are predicted to be less than one tenth of a percent of Cluster 4's total. These changes are not distinguishable from zero.

Table 6-43. Percentage of Cluster 4 trips, by zone fished, in NC Call (North) WEA with weather-based closures combined with four biomass impact assumptions.

	Current (Baseline) (% of Fishing Trips)		Weather-Based Closures and Changes in Catch in the NC Call (North) WEA Predicted (% of Fishing Trips)			
Zone	Actual	Predicted	-25% Catch	-7% Catch	Constant Catch	+7% Catch
1	1.6	1.6	0.8	0.8	0.8	0.8
2	0.9	1.1	1.5	1.5	1.5	1.5
3	1.1	1.0	0.8	0.8	0.8	0.8
4	4.5	4.4	5.1	5.1	5.0	5.0
5	3.7	5.0	5.3	5.2	5.1	5.0
6	77.9	76.7	78.3	77.6	77.2	76.8
7	1.5	1.4	1.3	1.3	1.3	1.3
8	3.2	3.1	2.9	2.9	2.9	2.9
11 (NC Call [North] WEA)	5.6	5.7	4.0	4.9	5.3	6.0

Table 6-44. Expected changes in Cluster 4 per trip RNVC with weather-based closures, combined with four biomass impact assumptions for the NC Call (North) WEA, with this WEA fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent Change
-25% Catch	-$1.24	-$0.29	$1.36	-$0.07	$3,528	0.1
-7% Catch	-$0.44	-$0.09	$1.08	-$0.02	$2,815	0.1
Constant Catch	$0.00	$0.00	$0.24	$0.00	$624	~0
+7% Catch	$0.01	$0.09	-$2.09	$0.43	-$5,435	-0.1

6.2.8.4 Scenario 4: Gear-Based Closure

Mobile gear (bottom and midwater trawl) was the primary gear used for 4,937 (31.7 percent) of Cluster 4 trips. While the USCG has stated it has no regulatory authority to create exclusion zones, Industrial Economics, Inc. (2012) identified mobile gear, including all trawls, as potentially affected by WEA development. Thus, these gears may face a de facto exclusion from a developed WEA.

Although only 31.7 percent of Cluster 4 trips used mobile gear primarily, revenue from these trips tends to be significantly higher, totaling approximately 65 percent of all Cluster 4 revenue. Table 6-45 presents the percentage of Cluster 4 trips in the NC Call (North) WEA for gear-based closures combined with four biomass impact assumptions. Table 6-46 presents expected changes in Cluster 4 per trip RNVC due to gear closures.

Table 6-45. Percentage of Cluster 4 trips, by zone fished, in the NC Call (North) WEA for gear-based closures combined with four biomass impact assumptions.

Zone	Status Quo (% of Fishing Trips)		Gear-Based Closures and Changes in Catch in the NC Call (North) WEA Predicted (% of Fishing Trips)			
	Actual	Predicted	-25% Catch	-7% Catch	Constant Catch	+7% Catch
1	1.6	1.6	0.8	0.8	0.8	0.8
2	0.9	1.1	1.5	1.5	1.5	1.5
3	1.1	1.0	0.8	0.8	0.8	0.8
4	4.5	4.4	5.1	5.1	5.1	5.1
5	3.7	5.0	5.4	5.4	5.3	5.3
6	77.9	76.7	79.8	79.4	79.2	78.9
7	1.5	1.4	1.4	1.3	1.3	1.3
8	3.2	3.1	3.0	3.0	3.0	2.9
11 (NC Call [North] WEA)	5.6	5.7	2.3	2.8	3.0	3.3

Table 6-46. Expected changes in Cluster 4 per trip RNVC with gear-based closures, combined with four biomass impact assumptions for the NC Call (North) WEA, with this WEA fully open.

Scenario	1st Quartile	Median	Mean	3rd Quartile	Sum (per Year)	Percent
-25% Catch	-$1.94	-$0.28	-$1.03	-$0.07	-$2,689	-0.1
-7% Catch	-$0.69	-$0.09	-$0.96	-$0.02	-$2,500	-0.1
Constant Catch	$0.00	$0.00	-$0.94	$0.00	-$2,441	-0.1
+7% Catch	-$0.51	$0.07	-$0.93	$0.31	-$2,404	-0.1

Gear-based closures have little impact across the board in this cluster. Changes in overall expected RNVC are measured in tenths of a percent and are essentially not distinguishable from zero (Table 6-46). Zones 5 and 6 absorb the majority of reallocated effort (Table 6-45), and average catch per unit hour in those zones is similar (Zone 6) or higher (Zone 5) to that in Zone 11 (see Appendix II, Table II-xxiv). Changes in distance traveled, on average, are not sufficient to result in significantly negative net changes.

The potential for a net positive change resulting from a restriction of the choices of fishing location warrants further examination. Because WEAs were developed in part with the intent of avoiding well-known, high-value fishing grounds, it is feasible that removing marginal grounds could, on average, result in a very small, positive impact. If this were the case, two conditions would have to be met: (1) cost differences between Zone 11 and the most likely alternatives would have to be small or negative, and (2) revenue differences would have to be small or positive. Large revenue differences not explained by cost differences would signal potential problems with the assumption of profit maximization implicit in the location choice model. Small differences may be explained by the existence of exploratory trips (trips to less-profitable areas are taken occasionally as information search trips) or variance in model estimates. Since bottom trawl gear dominates the affected trips (see Figure 6-25, which presents the distribution of *observed* RNVC per hour), particular attention is paid to the gear here.

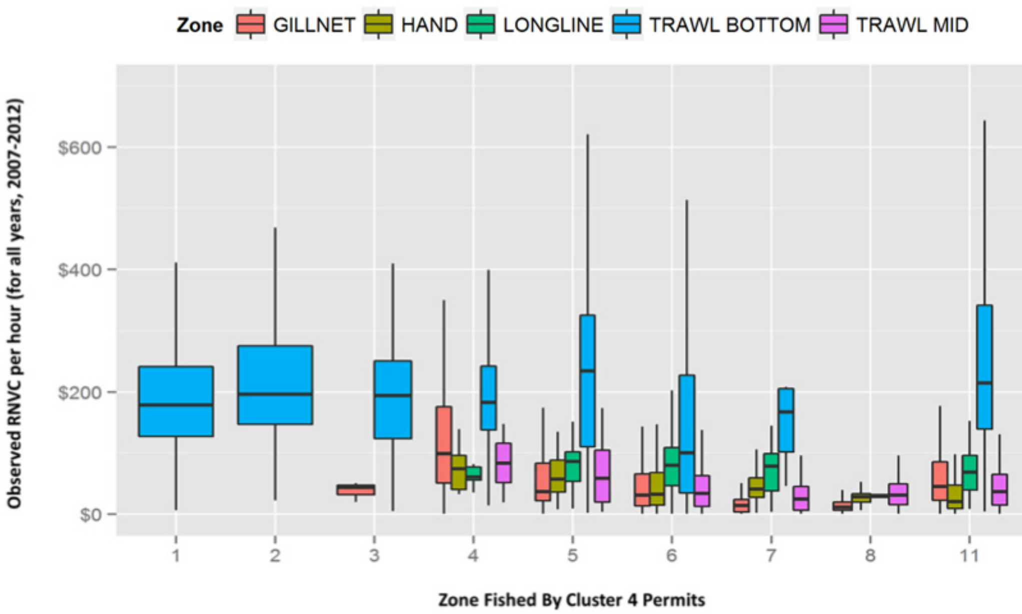


Figure 6-25. Distribution of observed RNVC per hour by primary gear used and zone fished for Cluster 4 trips.

Bottom trawl gear (Figure 6-25, blue boxes) is observed to have higher hourly RNVC across almost all zones. Observed hourly RNVC in Zone 11 (NC Call [North] WEA) is higher than in Zones 6 and nearly identical to Zone 5, the areas surrounding the NC Call [North] WEA. However, much of this variation is explained by the type of trip, month and season of trip, permit taking the trip, and the trip cost. Figure 6-26, below, plots the by-zone-gear distribution of revenue *predicted by the model*. Figure 6-26 shows that the model predicts combinations of gear and zones, and resulting revenues, that were not observed, as shown in Figure 6-25.

In the event of a gear-based closure, absent the effect of trip cost and with all other factors (permit, month, etc.) held constant, it is apparent that expected revenues in Zone 11 (the NC Call [North] WEA), as predicted by the revenue model (black dots in Figure 6-26), are at the lower end of the range for bottom trawl (blue rectangle). Zones 5 and 6, the areas surrounding Zone 11, are equal to or higher than those in Zone 11.

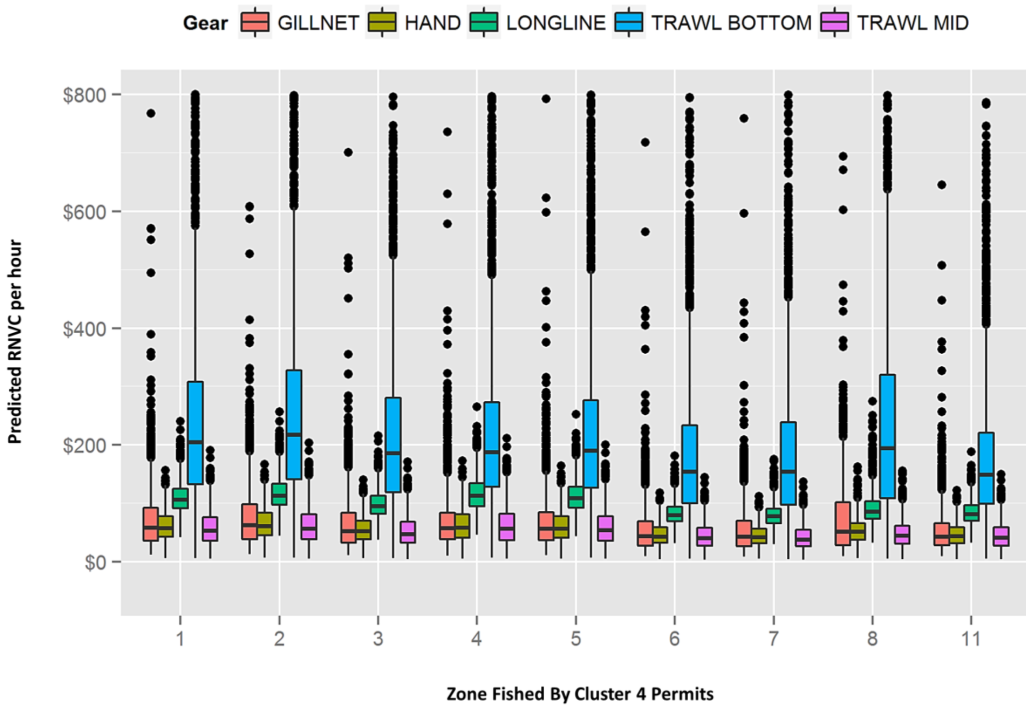


Figure 6-26. Distribution of estimated (unconditional) RNVC per hour by primary gear used and zone fished for Cluster 4 trips.

6.2.9 Commercial Fisheries Impact Summary

The four clusters modeled for this analysis account for approximately 82.5 percent of all exposed revenue identified in Section 6.2.1. As shown in Table 6-47, Clusters 2, 3, and 4 had relatively low percent change in RNVC compared to Cluster 1, owing primarily to the accessibility of suitable alternative fishing grounds with comparable revenues and comparatively low increases in costs to access those areas.

The model predicts that Cluster 1 will lose $516,984 per year in RNVC with full closure of all eight WEAs. This indicates that permits in Cluster 1, which tend to be smaller fixed-gear vessels, would have difficulty in recovering the lost fishing grounds if WEA development results in full exclusion.

Table 6-47. Cumulative commercial fishery impact summary—changes in RNVC.

	Full Closure of All WEAs		-25% Catch		Weather-Based Closure		Gear-Based Closure	
Cluster	RNVC Change per Year	RNVC Percent Change	RNVC Change per Year	RNVC Percent Change	RNVC Change per Year	RNVC Percent Change	RNVC Change per Year	RNVC Percent Change
1	-$516,984	-2.2	-$421,875	-1.8	-$58,430	-0.2	—	—
2 GC	-$15,760	-0.2	-$7,017	-0.1	-$1,824	~0	—	—
2 LA	-$15,348	~0	-$8,759		—	—	—	—
3	$199,851	+0.6	$115,778	0.3%	$6,637	~0	—	—
4	-$6,588	-0.1	$3,798	0.1%	$623.87	~0	-$2,441	~0

Table 6-48 shows how the clusters compare with respect to various exposure measures. The ranges for exposure share that may be mitigated through reallocation (rightmost column of Table 6-48) indicate each fishery's ability to reallocate effort when faced with negative impacts. Ability to adapt and reallocate effort is vital to the fishery, and to the shore-side businesses and infrastructure that rely on the local fishing fleets. The percentage of exposed revenue that cannot be mitigated through reallocation of effort indicates the expected economic impact of that exposure.

Table 6-48. Cumulative commercial fishery impact summary—comparison of cluster exposure.

<table>
<tr><th>Cluster</th><th>Percent Share of Total Exposed Revenue for All WEAs</th><th>Percent of Revenue Sourced from WEAs</th><th>Percent of Total Trips Taken to WEAs</th><th>Percent Change in Total RNVC—Full Closure</th><th>Percent Share of Exposure That May Be Mitigated by Reallocation of Fishing Effort</th></tr>
<tr><td>1</td><td>11.8</td><td>4.6</td><td>6.2</td><td>-2.2</td><td>52–65</td></tr>
<tr><td>2 GC</td><td rowspan="2">34.3</td><td rowspan="2">2.9</td><td>5.0</td><td>-0.2</td><td>94.4–96.8</td></tr>
<tr><td>2 LA</td><td>2.1</td><td>~0</td><td>98.6–98.9</td></tr>
<tr><td>3</td><td>33.4</td><td>11.2</td><td>12.9</td><td>0.6</td><td>100</td></tr>
<tr><td>4</td><td>3.0</td><td>4.9</td><td>5.6</td><td>-0.1</td><td>97.3–97.9</td></tr>
</table>

Only Cluster 3 (surfclam and ocean quahog fishermen) exceeds 10 percent exposure (both as a percent of revenue sourced from WEAs and percent of total trips). This cluster is unique in that the clam fishery is highly consolidated, which leaves primarily larger, efficient vessels. These vessels seem to have the ability to adapt to the WEA development identified in this report, with the ability to travel to more productive grounds and mitigate most of the impact. Combined with the recent decline in clam CPUE in the NJ WEA vicinity, Cluster 3 shows little expected change in RNVC. Caution should be used in the use of this estimate—while Mid-Atlantic clamming grounds have undergone declines in catch recently, movement in the fishery has been directed to the Northeast, including the vicinity around the MA WEA. Further, recent developments in PSP testing have made it possible to clam in areas that were closed throughout the study period. Because the location choice model depends on accurate catch estimates as well as constant location choices, Cluster 3 results must be interpreted with caution.

Significant levels of exit from the fishery are unlikely in any of the clusters modeled here. Cluster 1, which has the highest predicted change in RNVC, would only face, in sum, a decrease of 2.2 percent of RNVC under the full closure scenario (Table 6-47). Only 6.2 percent of all trips from this cluster were exposed to a proposed WEA, and 65 percent of the exposed revenue and RNVC could be recovered by fishing in other areas (Table 6-48). A 2.2 percent decrease in RNVC is highly unlikely to drive fishery exit, though a small number of individual fishermen who may rely disproportionately on the proposed WEAs may have a higher chance of fishery exit. Because the location choice model is probabilistic, showing the likelihood of an event happening rather than predicting individual behavior, estimates are for the cluster as a whole, and should not be extrapolated to the individual level. The three other clusters, including the highest-exposed Cluster 3, have a greater ability to reallocate effort and are not likely to face significant pressure to exit the fishery.

Model results indicate that reallocation of effort is possible for some exposed fisheries due to the existence of areas with similar revenue per unit effort that can be reached at costs commensurate with the expected change in revenue. In reality, fishing location choice is much more complex than the model employed here and decisions may be constrained by direct management areas, gear-area restrictions, local knowledge and perceptions, or other influences on fishermen's accessible fishing areas. To some extent, these omitted variables are reflected in the estimated revenue over each zone that is used to estimate changes in RNVC. These differences in vessel choices could be driven by different permits held, different gear preferences or availability, or simply habit and tradition, though the model includes a variable that attempts to account for such tradition (see Appendix II, Section II.ii.iii). If fewer available fishing locations result in more visits to a WEA, losses in RNVC would likely increase. However, most vessels in the fisheries studied here are expected to react similarly—most species targeted by Clusters 1 and 4 are not under severe access restrictions, and vessels in Clusters 2 and 3 carry the same permits but can reallocate to nearby fishing areas.

The changes in RNVC modeled here should be interpreted carefully as a potential range of impacts for a given amount of exposure, particularly using the "Percent Share of Exposure That May Be Mitigated by Reallocation of Fishing Effort" column in Table 6-48. Economic impact is a function of both exposure and reallocation of effort, as well as the assumptions on the direct effects on access and catch.

6.3 Recreational Fisheries

As described earlier, recreational fishing aboard for-hire and private boats is considered "exposed" if it occurred within one nautical mile of a WEA during the study period (2007–2012). The analysis examined exposure and impacts for for-hire boats, as well as for-hire and private-boat angler trips, for each individual WEA and cumulatively for all WEAs. Sections 4 and 5 present results for individual WEAs. Results of the cumulative assessment are presented below.

6.3.1 Exposure

Data at both the boat and angler level were used for the exposure analysis:

- **Boat level.** Recreational fishing exposure of for-hire boats was assessed in terms of the average annual number and percentage of exposed boats, trips, and revenues. (Private boats were not included due to the lack of fine-scale fishing location data at the boat level.)

- **Angler level.** Angler exposure in both for-hire and private boats was estimated in terms of average annual number and percentage of exposed trips and expenditures.

Results are summarized below. Appendix III presents the cumulative exposure results in more detail, including at the state/port group level.

Table 6-49 presents the average annual number and percentage of exposed recreational for-hire (1) fishing boats (third and fourth columns), (2) boat trips (sixth and seventh columns), and (3) angler trips aboard for-hire boats (ninth and tenth columns). Exposure at the for-hire boat trip level is substantially lower than at the angler trip level; this indicates that although some permitted for-hire boats fish in or near a WEA, the majority of trips do not take place in exposed areas. Recreational fishing locations from the SRHS showed for-hire boats concentrated in only a few grid areas on the map (see Appendix I, Section I.ii.ii.ii), resulting in substantially higher percent boat trip exposure (Table 6-49, seventh column) in North Carolina (24.0 percent) and South Carolina (22.3 percent) compared to other states. Massachusetts (5.0 percent) and New Hampshire (1.6 percent) had the lowest percentage exposure of for-hire boats (fourth column) compared to other states.

Table 6-49. Exposure of for-hire boats, for-hire boat trips, and for-hire angler trips to WEA development, by state, 2007–2012.

State	Average Annual Total Boats	Average Annual Exposed Boats	Average Annual Percent Boats Exposed	Average Annual Boat Trips	Average Annual Boat Trips Exposed	Percent Boat Trips Exposed	Average Annual Angler Trips	Average Annual Exposed Angler Trips	Percent Angler Trips Exposed
CT	46	7	15.2	1,314	3	0.2	17,569	47	0.3
DE	66	31	47.0	1,093	71	6.5	12,512	1,185	9.5
MA	323	16	5.0	3,972	7	0.2	54,118	37	0.1
MD	58	20	34.5	696	54	7.8	12,422	994	8.0
NC	56	30	53.6	1,586	381	24.0	41,195	10,189	24.7
NH	61	1	1.6	1,992	~0	~0	49,449	1	~0
NJ	321	131	40.8	8,177	561	6.9	153,989	8,584	5.6
NY	269	54	20.1	7,027	88	1.3	128,062	1,328	1.0
RI	141	43	30.5	2,264	109	4.8	23,558	1,570	6.7
SC	31	20	64.5	1,447	322	22.3	41,697	9,168	22.0
VA	66	17	25.8	694	18	2.5	11,646	404	3.5
Total	**1,438**	**370**	**25.7**	**30,259**	**1,614**	**5.3**	**546,217**	**33,506**	**6.1**

Table 6-50 provides private angler trips exposed to WEA development. Generally, private angler trips are less exposed to WEA development than for-hire angler trips due to the WEA's distance from shore. This is especially notable for North Carolina and South Carolina.

Table 6-50 also indicates the lack of exposure for private angler trips in Connecticut to WEA development. Although an average of just over 943,000 private angler trips left from Connecticut port groups annually during the study period, the National Marine Fisheries Service's (NMFS's) Marine Recreational Information Program (MRIP) data indicate that no private angler trips from Connecticut fished in federal waters during that time period. This is because the entire body of water between Connecticut and Long Island, from Fishers Island eastward (drawing a straight line from Napatree Point, RI, to Orient Point, NY), is designated as Long Island Sound, an inland water body by definition. Anglers fishing from private boats rarely report fishing outside Long Island Sound during the study period. Although it is possible that some private boat trips leave from Connecticut and travel to the ocean, those trips appear to be rare, and do not appear in the data. Thus, Connecticut anglers fishing from private boats will not likely be exposed to any WEA. Similarly, the distance from New Hampshire ports to the closest WEA means that private boats leaving from New Hampshire are highly unlikely to be exposed to WEA development.

Table 6-50. Exposure of private boat recreational trips to WEA development, by state, 2007–2012.

State	Average Annual Private Angler Trips	Average Annual Exposed Private Angler Trips	Percent Private Angler Trips Exposed
CT	943,129	0	0
DE	522,766	23,308	4.5
MA	1,912,662	39,433	2.1
MD	1,704,515	4,843	0.3
NC	2,215,795	154,833	7.0
NH	158,473	0	0
NJ	3,028,511	307,638	10.2
NY	2,652,092	33,450	1.3
RI	542,768	19,898	3.7

State	Average Annual Private Angler Trips	Average Annual Exposed Private Angler Trips	Percent Private Angler Trips Exposed
SC	1,086,631	1,325	0.1
VA	1,958,706	28,570	1.5
Total	**16,726,048**	**613,299**	**3.7**

The authors estimated angler expenditures on fishing trips exposed to WEAs by combining Northeast VTR and MRIP effort estimates with angler expenditure data derived from Lovell, Steinback, and Hilger 2013 (see Appendix I for details). Table 6-51 shows average annual angler expenditures on all for-hire and private boat trips exposed to WEA development. More than $1 billion was spent during 2007 to 2012, approximately 4.5 percent ($47.6 million) of which was associated with exposed angler trips. The three states with the highest percentages (5.9 percent to 9.8 percent) of exposed recreational angler expenditures are North Carolina, New Jersey, and South Carolina.

Table 6-51. Exposure of for-hire and private angler expenditures to WEA development, by state, 2007–2012.

State	Average Annual Angler Expenditures	Average Annual Exposed Angler Expenditures	Percent Expenditures Exposed
CT	$32,137,672	$7,710	~0
DE	$22,736,972	$1,121,781	4.9
MA	$139,449,266	$2,522,963	1.8
MD	$76,172,831	$444,753	0.6
NC	$167,031,917	$14,055,867	8.4
NH	$14,351,533	$184	~0
NJ	$210,163,413	$20,491,330	9.8
NY	$178,627,101	$2,207,698	1.2
RI	$26,060,428	$1,090,198	4.2
SC	$65,949,146	$3,859,054	5.9
VA	$121,549,221	$1,803,741	1.5
Total	**$1,054,229,501**	**$47,605,279**	**4.5**

Annual for-hire boat gross revenues averaged over $378 million in the coastal states from Massachusetts to South Carolina during the study period (Table 6-52) (New Hampshire revenues were non-disclosable). Approximately 6.3 percent ($23.9 million) of annual for-hire gross revenues is exposed. Exposure of for-hire boat gross revenues to the WEAs is highest in North Carolina (18.0 percent) and South Carolina (20.3 percent).

Table 6-52. Exposure of for-hire boat gross revenues to WEA development, by state, 2007–2012.

State	Average Annual For-Hire Boat Gross Revenues	Average Annual Exposed For-Hire Boat Gross Revenues	Percent Revenues Exposed
CT	$14,519,809	$38,567	0.3
DE	$6,255,284	$592,516	9.5
MA	$62,405,111	$42,089	0.1
MD	$6,465,899	$517,123	8.0
NC	38,835,847	$6,977,974	18.0
NH	$25,807,845	Not Disclosable	Not Disclosable
NJ	$69,870,400	$3,894,952	5.6
NY	$86,219,176	$893,866	1.0
RI	$15,606,829	$1,039,999	6.7

State	Average Annual For-Hire Boat Gross Revenues	Average Annual Exposed For-Hire Boat Gross Revenues	Percent Revenues Exposed
SC	$47,793,143	$9,715,939	20.3
VA	$4,475,392	$155,055	3.5
Total	**$378,254,736**	**$23,868,776**	**6.3**

6.3.2 Impacts

The assessment of WEA impacts on recreational fisheries was qualitative. Impacts differ for WEA construction and operation.

During WEA construction, recreational fishing activity in federal waters may be temporarily disrupted due to:

- Direct closure of WEA tracts.
- Displacement of fish species targeted by recreational anglers, primarily due to construction noise. (See Sections IV.i and IV.ii in Appendix IV for a broader discussion of these impacts.)

Disruption is expected to be local to the construction area, and is not expected to last longer than the construction activities themselves, based on a review of the current literature.

Recreational anglers in both for-hire and private boats have many options for offshore fishing destinations, and thus should have suitable alternatives to fish while displaced from within WEAs. Thus, WEA construction is expected to have slightly negative to neutral impacts on recreational fishing in the short run and no impacts in the long run.

With respect to WEA operation, the turbine infrastructure is expected to increase complex habitat on the seabed, and attract and potentially enhance fish populations, which could improve the recreational fishing experience in WEAs. As turbine bases become established fish habitat, they will most likely become popular fishing locations, and saltwater anglers may alter their behavior to actively seek out WEAs. The combination of improved catch rates at WEAs and the novelty of visiting an ocean wind turbine may lead to an increased number of fishing trips. In general, increased recreational interest in WEAs could support an increase in angler expenditures, which would in turn help bait shops, gas stations, and other shoreside dependents.

Shore-based recreational fishermen generally have many locations from which to fish. Given that restrictions to shoreside access will likely be highly localized at WEA construction sites, and temporary for the duration of the WEA installation period (APS Group Scotland 2011), impacts on shoreside fishing will most likely be minimal in both the short and long run.

6.4 Shoreside Dependents

Commercial fishery landings support substantial direct and indirect sales, income, and employment (see Table 6-53). Every pound of fish landed requires inputs such as bait and ice, capital expenditures for vessels and infrastructure, and services such as insurance and maintenance. Landed fish also require employees to process, market, and ship fish for domestic or international consumption. Indirect impacts include the goods and services purchased by those employed in the harvesting and processing sectors.

Both commercial fisheries and recreational fishing generate shoreside jobs and income. Shoreside-dependent exposure was analyzed quantitatively. Impacts were analyzed quantitatively for commercial fishing and qualitatively for recreational fishing. Results are presented below.

It is important to note that WEA construction and operation are expected to generate additional jobs and income within New England and the Mid-Atlantic. These additional economic impacts were not directly assessed in this analysis.

6.4.1 Exposure

Table 6-53 shows the amount and percentage of shoreside-dependent income and jobs of exposed to WEA development in the New England and Mid-Atlantic regions. Cumulatively, 1.5 percent (just over $12 million) of income and 1.6 percent (537) of jobs are exposed. See Appendix III for details on the baseline income and employment generated by commercial fisheries.

Table 6-53. Total and exposed shoreside-dependent income and jobs generated by commercial fisheries in New England and the Mid-Atlantic, by region, 2007–2012.

Economic Sector	Total Income	Exposed Income	Percent Income Exposed	Total Jobs	Exposed Jobs	Percent Jobs Exposed
New England						
Commercial Fishing	$301,299,648	$2,919,226	1.0	7,803	91	1.2
Other	$467,727,248	$5,341,525	1.1	9,681	108	1.1
Subtotal	*$769,026,896*	*$8,260,752*	*1.1*	*17,484*	*199*	*1.1*
Mid-Atlantic						
Commercial Fishing	$134,366,958	$3,301,898	2.5	6,392	147	2.3
Other	$550,243,617	$9,651,658	1.8	10,624	191	1.8
Subtotal	*$684,610,575*	*$12,953,556*	*1.9*	*17,017*	*338*	*2.0*
Grand Total	**$1,453,637,471**	**$21,214,308**	**1.5**	**34,501**	**537**	**1.6**

Table 6-54 presents the total economic contribution (sales, income, and jobs) of private boat and for-hire angler expenditures to shoreside dependents, and the amount and percent exposed (see Section I.ii.iii in Appendix I for more detail). Exposure ranges from approximately zero for Connecticut and New Hampshire to 8.4 percent for North Carolina and 9.8 percent for New Jersey.

Table 6-54. Average annual total and exposed sales, income, and jobs generated by private boat and for-hire angler expenditures, by state, 2007–2012.

State	Average Annual Sales Generated	Average Annual Exposed Sales	Percent Sales Exposed	Average Annual Income Generated	Average Annual Exposed Income	Percent Income Exposed	Average Annual Jobs Generated	Average Annual Exposed Jobs	Percent Jobs Exposed
CT	$38,213,352	$9,168	~0	$15,673,052	$3,760	~0	250	0.1	~0
DE	$26,304,636	$1,297,800	4.9	$8,211,563	$405,137	4.9	219	11	4.9
MA	$186,728,434	$3,378,354	1.8	$79,198,448	$1,432,885	1.8	1,415	26	1.8
MD	$89,887,706	$524,830	0.6	$33,328,050	$194,594	0.6	737	4	0.6
NC	$217,718,010	$18,321,142	8.4	$83,262,030	$7,006,565	8.4	2,055	173	8.4
NH	$18,905,688	$243	~0	$8,267,917	$106	~0	161	0	~0
NJ	$285,918,068	$27,877,552	9.8	$103,963,205	$10,136,609	9.8	1,975	193	9.8
NY	$214,706,792	$2,653,616	1.2	$91,117,290	$1,126,142	1.2	1,638	20	1.2

State	Average Annual Sales Generated	Average Annual Exposed Sales	Percent Sales Exposed	Average Annual Income Generated	Average Annual Exposed Income	Percent Income Exposed	Average Annual Jobs Generated	Average Annual Exposed Jobs	Percent Jobs Exposed
RI	$31,757,458	$1,328,524	4.2	$12,630,131	$528,362	4.2	288	12	4.2
SC	$80,917,929	$4,734,961	5.9	$31,692,730	$1,854,519	5.9	881	52	5.9
VA	$132,568,189	$1,967,258	1.5	$43,241,744	$641,690	1.5	1,156	17	1.5
Total	**$1,697,309,497**	**$76,644,499**	**4.5**	**$706,333,766**	**$31,895,537**	**4.5**	**13,602**	**614**	**4.5**

6.4.2 Impacts

6.4.2.1 Commercial Fisheries

The authors used the Northeast Region Commercial Fishing Input-Output model (see Section 3.2.3) to assess how the changes in commercial fishery landings would impact related industries for each of the four clusters described in Sections 6.2.5–6.2.8 (Steinback and Thunberg 2007). The worst-case scenario involved concurrent development of all eight WEAs, with full closure to both recreational and commercial fishing.

The only cluster that showed any measurable impacts was Cluster 1 (pot and gillnet permits from Rhode Island and the South Coast of Massachusetts). Model results indicate that this scenario is expected to result in an annual loss of three full-time and part-time jobs in New England and one job in the Mid-Atlantic, which constitute 0.02 percent of total jobs in these sectors. Under the same scenario, income is expected to decrease by $239,724 in New England and $169,602 in the Mid-Atlantic, for a total annual decrease of $409,326 (-0.04 percent) during the construction phase. This entire impact is due to losses accrued to permitted vessels on the Rhode Island and South Coast of Massachusetts using pots and gillnets within the MA and RI-MA WEAs. Thus, this worst-case scenario corresponds to a slight negative impact to the regional economies of interest. Expected impacts on shoreside dependents of commercial fisheries thus range from slightly negative (if the worst-case scenario corresponds to the actual outcome) to neutral, depending on which modeled scenario best represents the outcomes ultimately realized.

6.4.2.2 Recreational Fisheries

The impact of WEA development on shoreside dependents of recreational fisheries is likely to follow a similar trend to the recreational fisheries themselves (see Section 6.3.2), with impacts depending on the stage of WEA development:

- **WEA construction.** Slightly negative to neutral impacts are expected during WEA construction, as recreational fishermen and target fish species are potentially displaced. However, these impacts are not expected to have a measurable effect on shoreside dependents of recreational fisheries, and thus neutral to slightly negative multiplier effects are expected in both the New England and Mid-Atlantic regions for these supporting industries during construction.

- **WEA operation.** Similarly, the neutral to slightly positive impacts on recreational fishing during WEA operation are expected to translate into neutral to slightly positive multiplier effects on shoreside dependents of recreational fishing over the longer term.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Bureau of Ocean Energy Management

As a bureau of the Department of the Interior, the Bureau of Ocean Energy (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEM Environmental Studies Program

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.