A Wind Energy Area Siting Analysis for the Gulf of Maine Call Area

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EXECUTIVE SUMMARY

This report provides the background, methods, and results for the development of the Gulf of Maine Draft Wind Energy Area (WEA) which includes an ecosystem-wide spatial suitability model developed to inform selection of WEAs in U.S. federal waters. Spatial suitability models have long been applied to terrestrial and marine environments for the purpose of assessing the relative potential for development or conservation. The National Oceanic and Atmospheric Administration's (NOAA), National Centers for Coastal Ocean Science (NCCOS) and the Bureau of Ocean Energy Management (BOEM) used similar methods to complete suitability modeling for siting of wind energy in the Gulf of Mexico, Central Atlantic, and Pacific regions. To develop the Gulf of Maine suitability model, 98 data layers were selected from over 100 data layers that represent major ocean characteristics for the Gulf of Maine Call for Information and Nominations (Call) Area. Data were organized into categories (submodels) representing the major ocean sectors including natural and cultural resources, wind, fishing, and industry and operations. All data layers were assigned scores of relative compatibility allowing the calculation of an overall suitability score for each 10-acre grid cell of the study area. Using a cluster analysis, one draft WEA was identified representing the most suitable areas within the Call Area.

The work presented here is the result of a WEA Siting Suitability model (model) developed by expert marine spatial scientists, marine ecologists, project coordinators, policy analysts, and subject matter experts (SMEs) at both BOEM and NCCOS. Collectively, this team provided input during the model construction process, reviewed data layers, assigned weights, and informed the Model development and interpretation of results. These parties are referred herein as the Gulf of Maine WEA Siting Team (Team).

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LIST OF ABBREVIATIONS AND ACRONYMS

AIS	Automatic Identification System
AUV	Autonomous underwater vehicle
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
CH	Critical habitat
CMECS	Coastal and Marine Ecological Classification Standard
DLCD	Department of Land Conservation and Development
DOD	Department of Defense
DPS	Distinct population segment
EFH	Essential fish habitat
EFHCA	Essential fish habitat conservation area
ESA	Endangered Species Act
HAPC	Habitat Areas of Particular Concern
ICPC	International Cable Protection Committee
LISA	Local Index of Spatial Association
MC	Marine Cadastre
MCDA	Multi-Criteria Decision Analysis
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Act
NCCOS	National Centers for Coastal and Ocean Science
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
ROV	Remotely operated vehicle
SME	Subject matter expert
USCG	United States Coast Guard
USGS	United States Geological Survey
VMS	Vessel Monitoring System
WCR	West Coast Region
WEA	Wind Energy Area

1. BACKGROUND

The Gulf of Maine is one of several regions where wind energy development in offshore federal waters is being considered to support the Biden-Harris Administration's goal of 30 gigawatts of offshore wind energy by 2030. In 2019, BOEM received a letter from Governor Sununu of New Hampshire requesting the formation of an intergovernmental offshore wind renewable energy task force for the State. Given the regional interest in offshore wind energy development, BOEM decided to establish the Gulf of Maine Intergovernmental Renewable Energy Task Force ("Task Force"), which comprises Federal officials and elected Tribal, State, and local officials (or their designated employees with authority to act on their behalf) from Maine, New Hampshire, and Massachusetts.

In advance of the May 2022 meeting of the Task Force, BOEM released the Gulf of Maine Planning Area (Figure 1.1). The Planning Area is roughly bounded on the west, north, and east by BOEM's jurisdiction for renewable energy activities on the outer continental shelf (OCS), ranging 3nmi from shore to the limits of the Exclusive Economic Zone (EEZ). BOEM delineated the southern boundary of the Planning Area by looking at the physiographic, oceanographic, and biotic variables that together uniquely define the Gulf of Maine.[1] The Planning Area also avoids any overlap with the Planning Area used for the previous Massachusetts/Rhode Island planning and leasing process.

1 The southern boundary of BOEM's Gulf of Maine Planning Area is an adaptation of the Gulf of Maine Ecological Production Unit defined in the "State of the Ecosystem Report" (Northeast Fisheries Science Center, 2021).

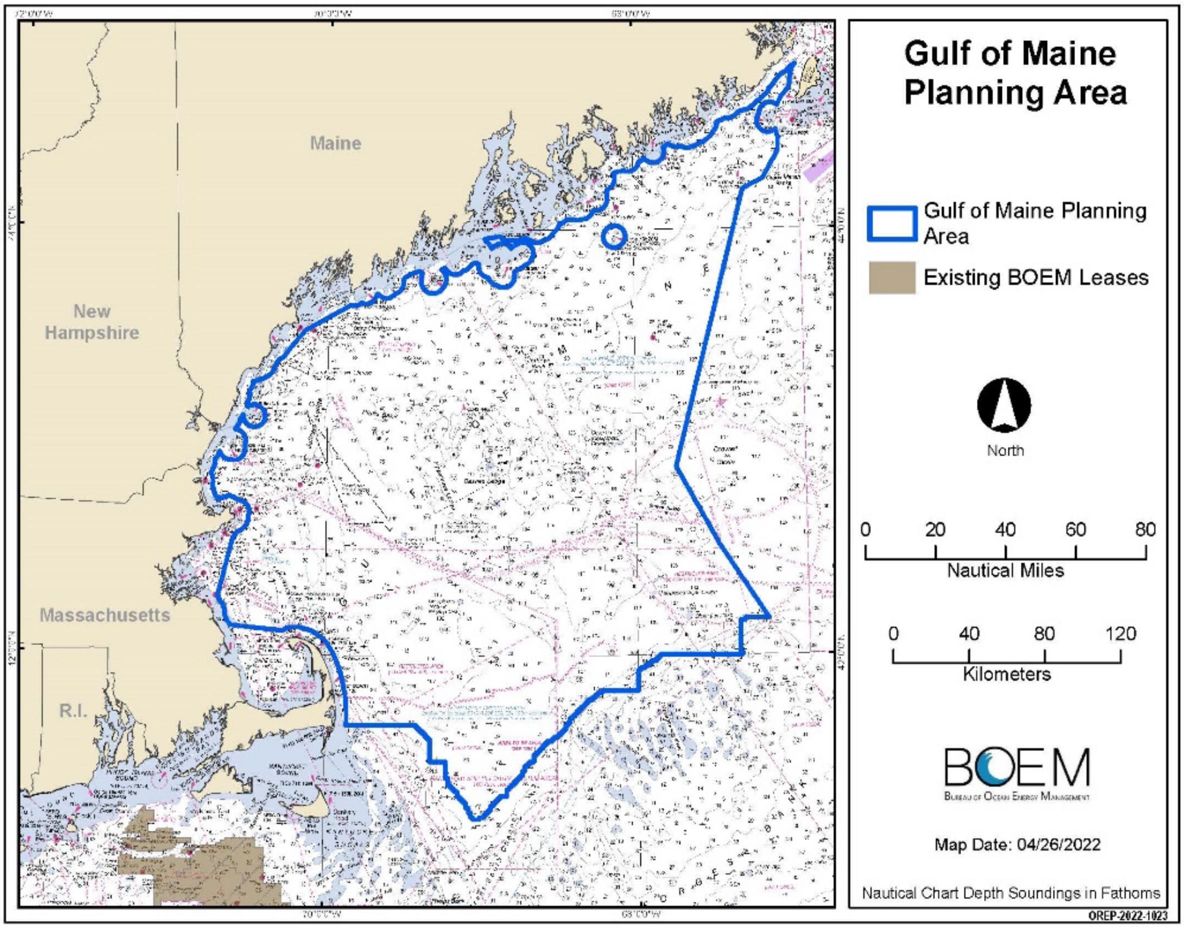


Figure 1.1. Gulf of Maine Planning Area.

Next, BOEM sought to refine the Planning Area to determine the extent of the Request for Interest (RFI) Area. The purpose of an RFI is to gauge interest in the development of commercial wind energy leases within the RFI Area. Defining the RFI Area involved removing areas that are incompatible with offshore wind energy development. These included areas in which offshore wind energy development cannot occur as a result of law, jurisdiction, or technical considerations. BOEM also removed any area undergoing a separate leasing process, including:

a) National Park System, National Wildlife Refuge System, National Marine Sanctuary System, or any National Monument (§585.204);
b) Existing Traffic Separation Schemes (TSS), fairways, or other internationally recognized navigation measures;
c) And Unsolicited lease request areas that are the subject of a separate request for competitive interest (e.g., State of Maine's requested research lease).

Following removal of these incompatible areas, and in conjunction with feedback and input from the Task Force from the May 2022 Task Force Meeting, BOEM generated the RFI Area (Figure 1.2).

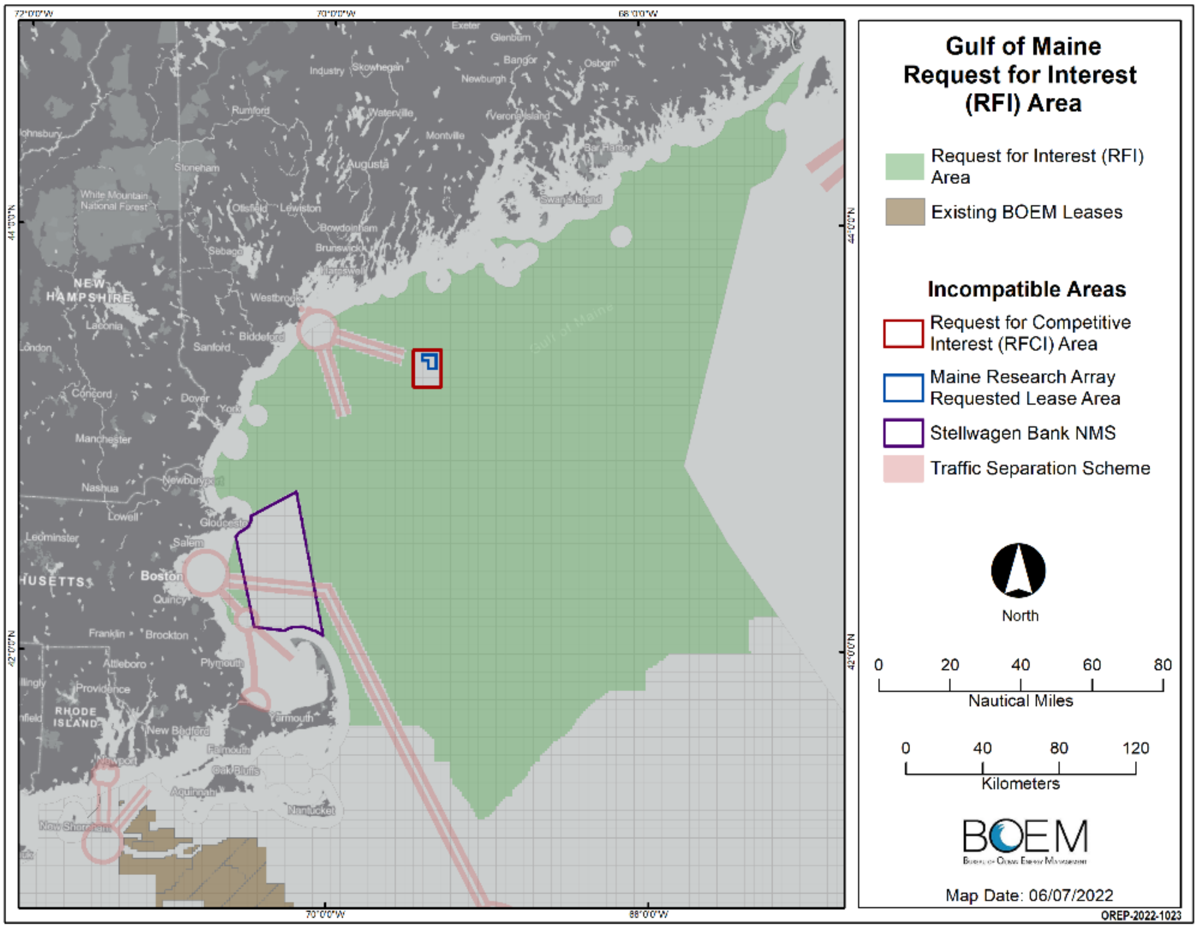


Figure 1.2. Gulf of Maine Request for Interest (RFI) Area.

On August 19, 2022, BOEM published an RFI for the Gulf of Maine in the *Federal Register* which included a 45-day comment period. In addition to gauging interest in the development of commercial wind energy leases within the RFI Area, BOEM also sought feedback from stakeholders, industry, Tribes, and others regarding the location and size of specific areas they wished to be included in (or excluded from) a future offshore wind energy lease sale, along with other planning considerations. Through the RFI, BOEM received 51 unique comments, which are available at: https://www.regulations.gov/docket/BOEM-2022-0040. Five companies, all of which have been legally, technically, and financially qualified, submitted indications of interest for a commercial wind energy lease within the RFI Area. Indications of interest are available at: https://www.boem.gov/renewable-energy/state-activities/maine/gulf-maine#tabs-7676.

Based on feedback received through the RFI, BOEM worked with NCCOS to conduct spatial analysis to inform the area for a Call for Information and Nominations (Draft Call Area). The Draft Call Area represented a 27% reduction from the RFI Area (Figure 1.3).

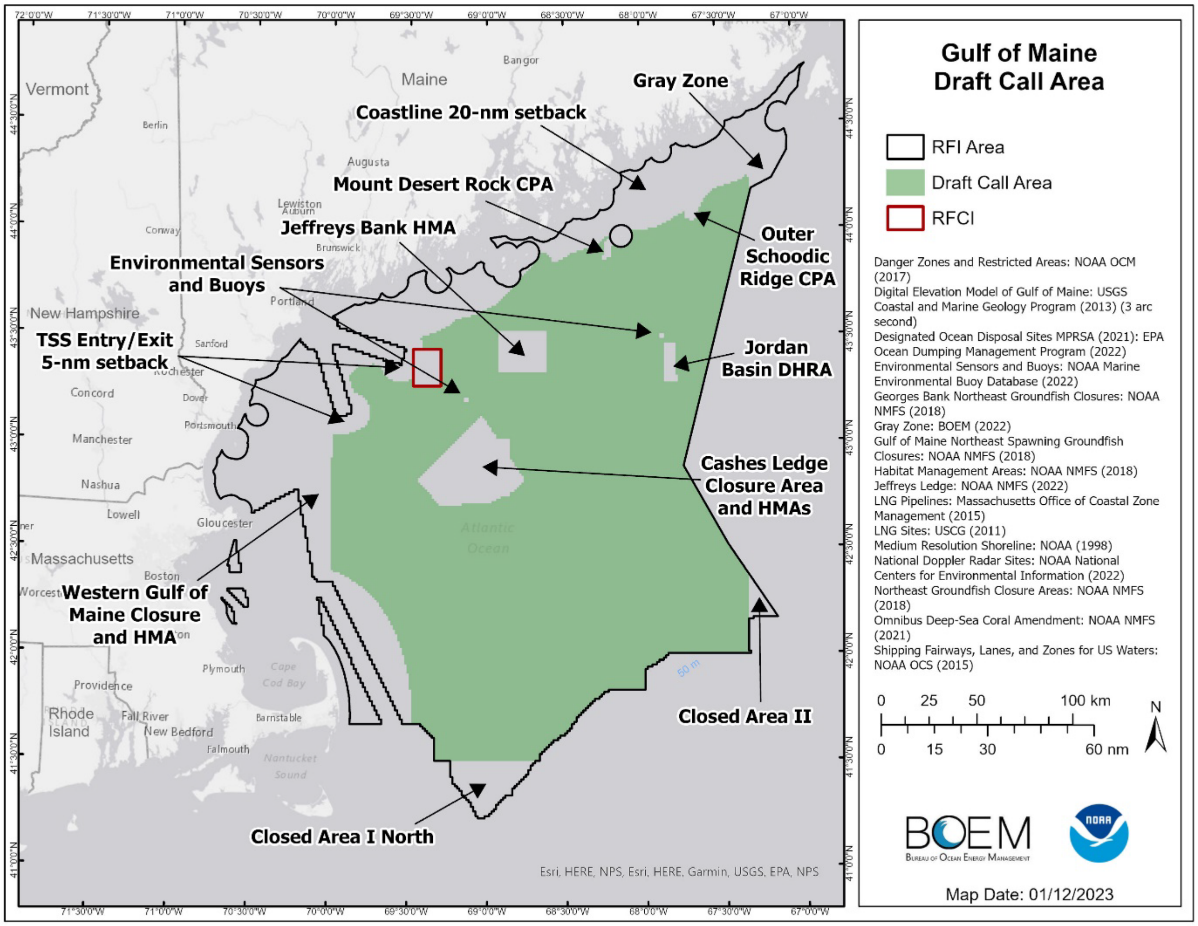


Figure 1.3. Gulf of Maine Draft Call Area. Arrows indicate specific areas removed.

Following publication of the Draft Call Area in early January 2023 on BOEM's website, BOEM held a series of in-person and virtual information exchanges to gain perspectives, feedback, and input on the Draft Call Area. In-person information exchanges were held in January 2023 in Salem, MA, Portsmouth, NH, and Portland, ME. Virtual information exchanges were held between January and March 2023, including meetings with Gulf of Maine Tribal Nations, environmental non-governmental organizations, fisheries sectors, and the shipping and commercial maritime industry.

On April 25, 2023, BOEM announced the publication of the Gulf of Maine Call for Information and Nominations (Call)—which included a 45-day public comment period. Feedback received through the early 2023 information exchanges resulted in the removal of areas from the southern edge of the final Call Area to avoid Georges Bank (Figure 1.4). In the Call, BOEM described plans to partner with NCCOS to develop a WEA spatial model to inform identification of WEAs and requested input on data for consideration. Through the Call, BOEM received 127 unique comments (available at: https://www.regulations.gov/docket/BOEM-2023-0025) and seven nominations from the wind industry (available at: https://www.boem.gov/renewable-energy/state-activities/maine/gulf-maine#tabs-7676). Comments included recommendations of: specific areas to avoid for leasing, fishing data to utilize in spatial modeling, and datasets representing protected species, amongst others. These comments, alongside those communicated during the RFI comment period and through various engagements, were considered in the development of the WEA spatial model described in this report.

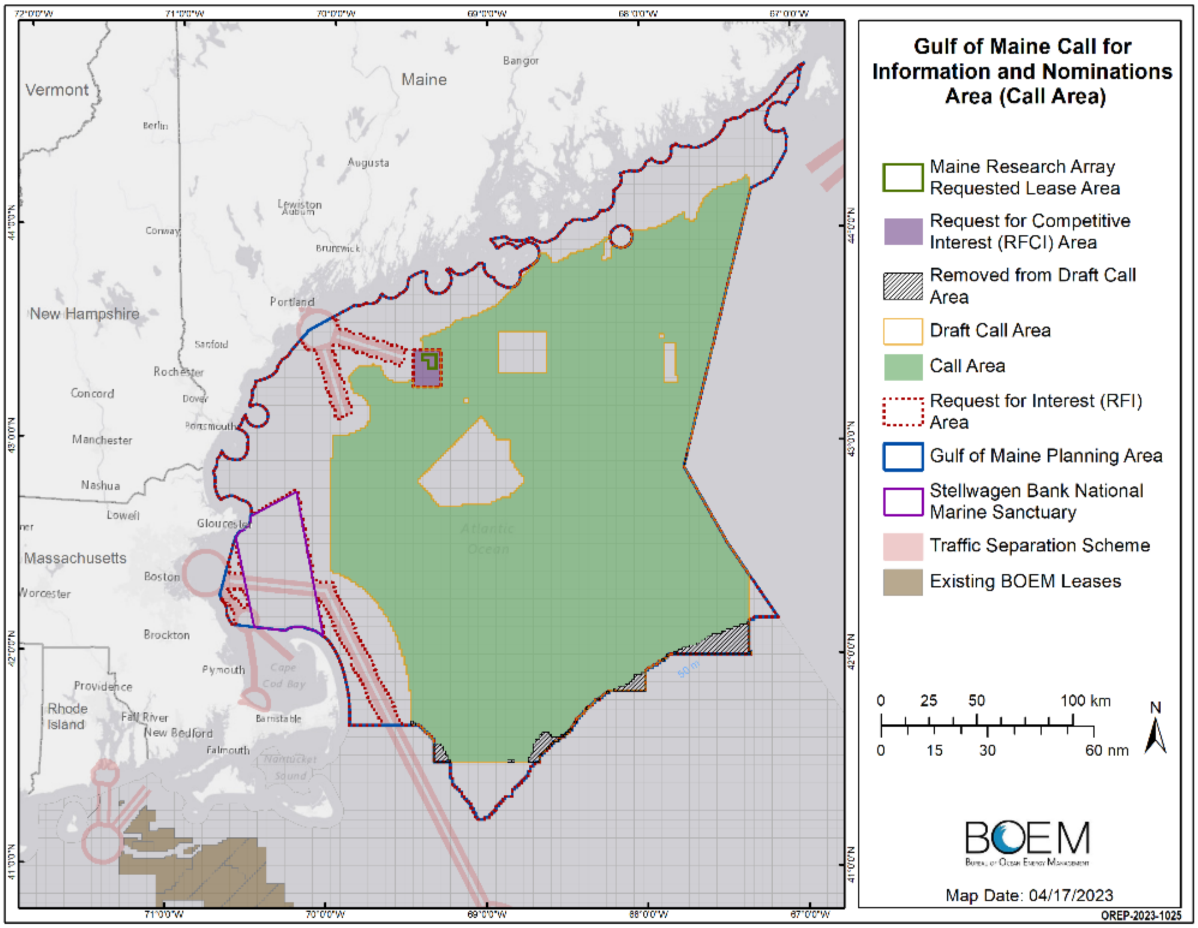


Figure 1.4. Gulf of Maine Call Area.

Ahead of publication of draft WEAs, BOEM held a series of engagement meetings in July 2023 to seek feedback to improve the spatial model developed to inform draft WEAs. These included a virtual meeting with Federal, Tribal, and State government agencies, as well as a series of in-person and virtual meetings with fisheries stakeholders throughout the Gulf of Maine region.

For purposes of recommending draft WEAs, BOEM considered the following non-exclusive list of information sources: comments and nominations received on the RFI and Call; information from the Gulf of Maine Intergovernmental Renewable Energy Task Force; input from Federal agencies and Tribes; input from Maine, Massachusetts, and New Hampshire State agencies; comments from stakeholders and ocean users, including the maritime community, offshore wind developers, and the commercial fishing industry; state and local renewable energy goals; and information on domestic and global offshore wind market and technological trends.

BOEM received ocean users' feedback to increase transparency in the Area Identification process and consider leveraging an existing ocean planning model previously used in the Gulf of Mexico and Southern California for NOAA's Aquaculture Opportunity Area Atlases as well as for the Gulf of Mexico, Central Atlantic, and Pacific renewable energy ocean planning. In response, BOEM modified the WEA identification process as explained in a Notice to Stakeholders issued on September 16, 2021, which is available at https://www.boem.gov/newsroom/notes-stakeholders/boem-enhances-its-processes-identify-future-offshore-wind-energy-areas. This process was used to support the identification of draft WEAs in the Gulf of Mexico, Central Atlantic, and Pacific regions. As part of this outlined process, BOEM, with support from NOAA, NCCOS has conducted spatial analyses to determine optimal locations for draft Wind Energy Areas. This report summarizes the methods and results of the spatial analyses and modeling used to identify draft WEAs in the Gulf of Maine.

2. METHODS

A spatial modeling workflow for Wind Energy Areas (WEAs) was developed following the approach from Morris et. al 2021 and Riley et. al 2021 (Figure 2.1). The project requirements and Call Area were identified by BOEM and NCCOS. The goal of this study was to identify a number of options for potential draft WEAs in the Gulf of Maine Call Area. The steps within the workflow are described below.

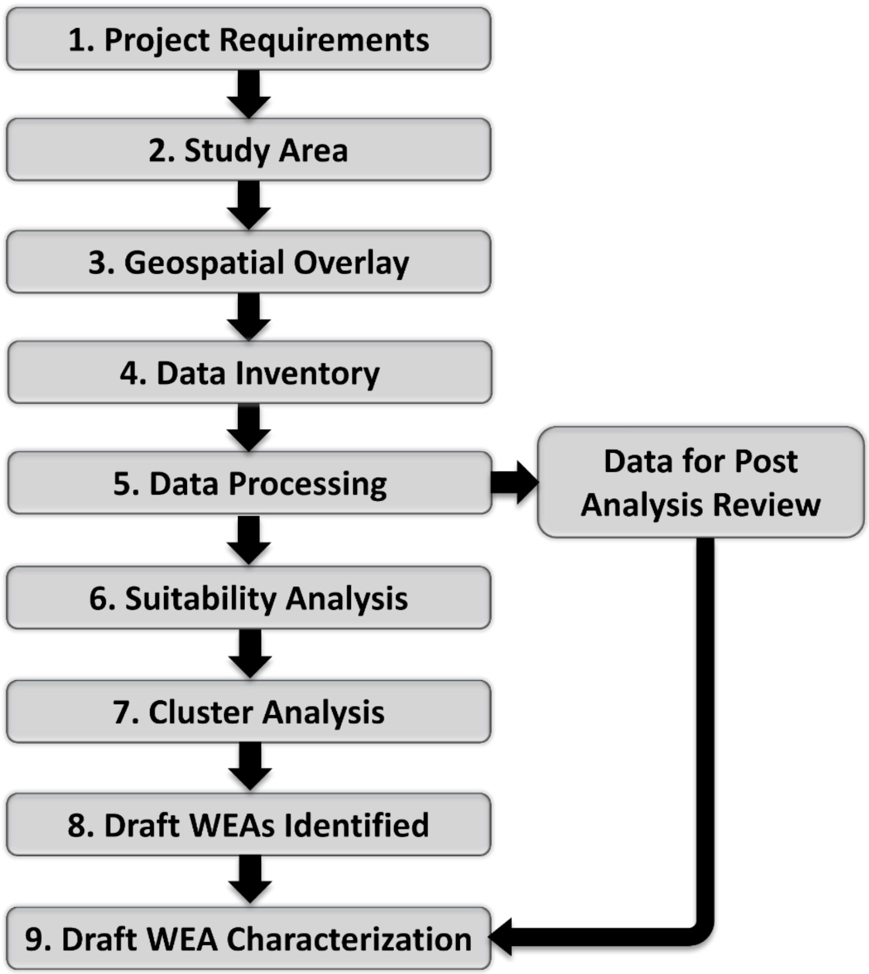


Figure 2.1. Workflow for Wind Energy Area options spatial analysis for the Gulf of Maine Call Area.

2.1. Study Area

The Call Area is located offshore the States of Maine, New Hampshire, and Massachusetts. The area includes 1,552 whole OCS blocks and 488 partial blocks and comprise approximately 9,847,970 acres (3,985,332.064 hectares) (Figure 2.2).

2.2. Geospatial Overlay

Grids are an efficient means for mapping spatial variation and establishing a common framework for spatial models (Olea 1984; Dale 1998). A 10-acre hexagonal grid was overlaid on the study area, which resulted in 984,797 grid cells (Figure 2.2). A hexagon grid was used because it fits organic shapes and curves (ex. pipeline, submarine cable, etc.) better than square grids, and it provides advantages for statistical analysis as all neighboring cells share a side and the distance from the center is the same distance to all neighboring cells (Birch et al 2007; Sousa et al 2006; Tsatcha et al 2014; Domisch et al. 2019). The 10-acre grid cell size was determined by a number of factors, including the extent of the analysis, minimum WEA size, processing time, and spatial resolution of data within the model (Hengl 2006). Grid resolution is a balancing act between the coarse (e.g., bathymetry, oceanographic) and fine (vector data with associated precision and accuracy errors) data in the model. Hengl (2006) and Liang et al. (2004) both acknowledge that grid-cell size selection can be optimized, but at a certain point, increased resolutions provide only minor improvements. Moreover, there is no ideal grid cell or pixel size, but it is recommended to avoid using resolutions that do not comply with inherent properties of input datasets (Hengl 2006).

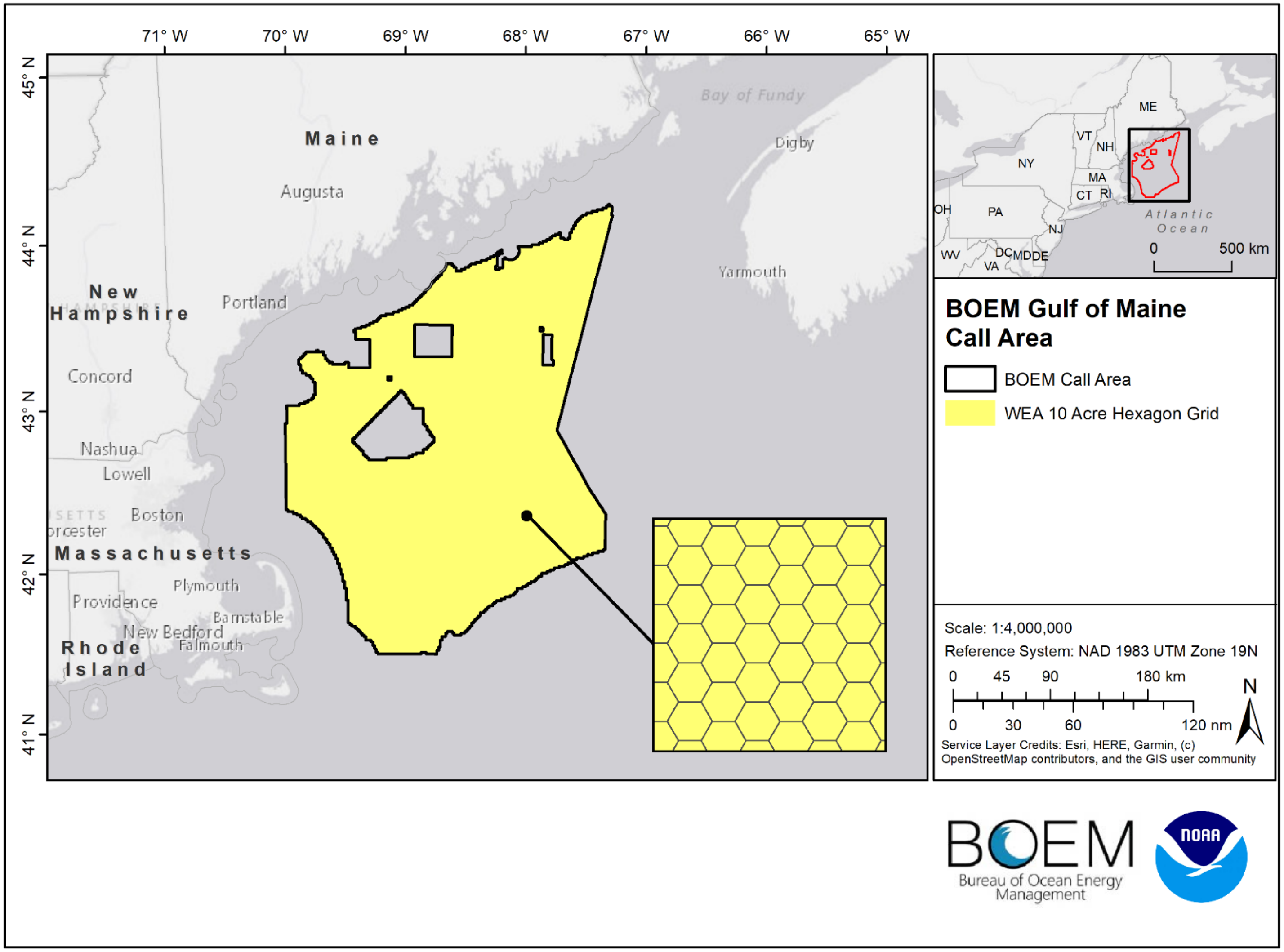


Figure 2.2. BOEM Gulf of Maine Call Area for wind energy development. The inset shows an example of the grid cells formulated for the Call Area. Each cell is a 10-acre (4.05-hectare) hexagon.

2.3. Data Inventory

2.3.1. Data Categorization

Geospatial analyses and ocean planning require the consideration of multiple, seemingly incompatible, datasets that require substantial data collection and processing to properly understand and implement within ocean planning suitability models. Spatial suitability modeling is a type of Multi-Criteria Decision Analysis (MCDA), which provides the ability to calculate a relative suitability score for each grid cell in an area. Data categorization is needed to describe the relationship among the data input into the models and to organize information into appropriate submodels for relative suitability modeling. Data categorization was modified from the schema provided in Lightsom et al. (2015) as the intent of the categorical structure is for ocean planning. The structure intends to bring transparency and a consistent framework for organizing complex and dynamic ocean systems (Lightstom et al. 2015). The framework included herein includes data that are needed for the wind energy area site suitability analysis, a specific type of ocean planning.

2.3.2. Data Acquisition

Collection and processing of spatial data is a key factor in model success because it is the base for further calculations and analysis (Molina et al. 2013). An initial review was completed to determine the broad suite of data and categories needed to properly support this ocean planning process. A comprehensive, authoritative spatial data inventory was developed including data layers relevant to national security, natural and cultural resources, industry and operations, fisheries, and wind logistics[2]. The data holdings were developed through engagement with non-governmental organizations and U.S. federal and state agencies representing a diverse array of stakeholders. The Marine Cadastre (www.marinecadastre.gov) and many studies conducted throughout the years by BOEM's environmental studies program were used to supply data for the study.

Data were evaluated for completeness and best quality, and the most authoritative, up-to-date sources available were used. All data were projected and calculations performed using the North America Datum (NAD) 1983 Universal Transverse Mercator (UTM) Zone 19N projection (Projection: Transverse Mercator, False Easting: 500000.0, False Northing: 0.0, Central Meridian: -69.0, Scale Factor 0.99960, Latitude of Origin: 0.0). Appendix A provides a list of data utilized for this spatial planning analysis.

2.4. Data Processing Steps

Many datasets required processing prior to use in the suitability model, subsequent cluster analysis, or for the option ranking model and characterization. Methods are provided for all data that required processing; many data were received in a ready-to-use format and processing notes can be found in metadata provided by the data originator. Setbacks (i.e., buffers) were applied when required by governance, policy, and regulations. In cases where an established setback requirement was not available from an authoritative source, conservative professional judgment was used when assigning setback distances.

[2] https://www.boem.gov/renewable-energy/state-activities/gulf-mainedatainventory

2.4.1. NMFS Protected Resources

To holistically consider protected species in the region, a combined data layer providing the overall score for selected protected species was developed through collaboration with NMFS Greater Atlantic Regional Fisheries Office (GARFO) and NMFS Office of Protected Resources (Appendix B). Protected species considered include those listed under the Endangered Species Act (ESA) and/or protected under the Marine Mammal Protection Act (MMPA). This approach was preferred given that this spatial planning process does not consider gear-specific wind planning or other secondary interactions with protected species. This combined data layer contains only highly vulnerable protected species. As a result, a number of protected species, including some marine mammals, were excluded from this analysis.

Scores were assigned to each species based on species' status, population size, and trajectory. The scores provided in Table 2.1 for MMPA and ESA-listed species range from 0.1 (most vulnerable species, based on their biological status) to 0.8 (least vulnerable species) using best- available data for each region (Appendix B). This scoring approach was developed for each species/stock using factors that are more or less likely to affect their ability to withstand mortality, serious injury, or other impacts that could affect the species' ability to survive and recover. For species with available distribution models, grid cells above the median maximal probability of occurrence were defined as high-use areas and assigned the chosen score for the species (Table 2.1); the areas below the median were assigned a default ESA (0.5) or MMPA (0.9) score, depending on species status. This facilitates necessary contrast between high- and low-use areas to inform marine spatial planning for distribution models that cover the entire extent of the data.

The extent of the scored spatial outputs for each species was the entire U.S. Atlantic Coast, however, for North Atlantic right whales, we also created a layer that was clipped to the Call Area to better depict the modeled density from the Duke University habitat density model (Appendix B).

Table 2.1. Scoring system from Farmer et al. (2022) for NMFS protected resources. A small population equates to populations of 500 individuals or less (Franklin 1980). A strategic stock is defined by the Marine Mammal Protection Act as "…a marine mammal stock for which the level of direct human-caused mortality exceeds the potential biological removal level; which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA, or is designated as depleted under the MMPA."

Status	**Trend**	**Score (0-1)**
Endangered	Declining, small population* or both	0.10
Endangered	Stable or unknown	0.20
Endangered	Increasing	0.30
Threatened	Declining or unknown	0.40
Threatened	Stable or increasing	0.50
MMPA Strategic	Declining or unknown	0.60
MMPA Listed	Small population* or unknown/declining	0.70
MMPA Listed	Large population or stable/increasing	0.80

A total of 22 data layers including Atlantic white-sided dolphin, Bottlenose dolphin, Harbor porpoise, Pilot whale, Risso's dolphin, Short-beaked common dolphin, Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale, Sperm whale, Seals, Atlantic salmon (Gulf of Maine DPS), Atlantic sturgeon (All DPSs), Giant manta ray, Shortnose sturgeon, Green sea turtle (North Atlantic, South Atlantic DPSs), Kemp's ridley sea turtle, Leatherback sea turtle, Loggerhead sea turtle (Northwest Atlantic, Northwest Atlantic Ocean DPSs) were combined into a single data layer using the product method, which provides the highest weight to the lowest score (Equation 2.1). Table 2.2 provides each species' status and trend, as well as the score used when creating the combined data layer for use within the relative suitability model. The combined data layer provides the highest resolution and contrast allowing for meaningful comparisons between grid cells, and correctly attributing increasing levels of concern for areas with multiple overlapping protected species data layers (Figure 2.4).

Equation 2.1. Product method equation used by NOAA NMFS PRD to calculate the final scoring layer for protected resource considerations.

$$p = x_1 \cdot x_2 \cdot \ldots \cdot x_i$$

x_1 = variable 1
x_2 = variable 2
x_i = additional variables

Table 2.2. Score, status, and trend for ESA-listed and MMPA species known to occur within the Gulf of Maine to be used in suitability modeling.

Species Common Name	Status and Trend	Score (0-1)
Atlantic white-sided dolphin	MMPA Listed, low use area	0.9
Bottlenose dolphin	MMPA Strategic, unknown/declining	0.6
Harbor porpoise	MMPA Listed, unknown/declining	0.7
Pilot whale	MMPA Listed, unknown/declining	0.7
Risso's dolphin	MMPA Listed, unknown/declining	0.7
Short-beaked common dolphin	MMPA Listed, unknown/declining	0.7
Seals	MMPA Listed, increasing/stable	0.8
Blue whale	ESA Endangered, unknown/stable	0.2
Fin whale	ESA Endangered, unknown/stable	0.2
Humpback whale	MMPA Listed, increasing/stable	0.8
Minke whale	MMPA Listed, unknown/declining	0.7
North Atlantic right whale	ESA Endangered, declining	0.1

Species Common Name	Status and Trend	Score (0-1)
Sei whale	ESA Endangered, unknown/stable	0.2
Sperm whale	ESA Endangered, unknown/stable	0.2
Atlantic Salmon (Gulf of Maine DPS)	ESA Endangered, low use area	0.5
Atlantic sturgeon (All DPSs)	ESA Endangered, unknown/stable	0.2
Giant manta ray	ESA Threatened, unknown/declining	0.4
Shortnose sturgeon	ESA Endangered, low use area	0.5
Green sea turtle	ESA Threatened, increasing/stable	0.5
Kemp's ridley sea turtle	ESA Endangered, unknown/stable	0.5
Leatherback sea turtle	ESA Endangered, declining	0.1
Loggerhead sea turtle (NW Atlantic, NW Atlantic Ocean DPSs)	ESA Threatened, increasing/stable	0.5

2.4.2. NMFS Habitat Data Layer

NOAA NMFS provided the best available data sets[3] to be used for creating a combined habitat layer. Overall, nine data sets were chosen to be combined to represent the suitability of the habitat in the call area with offshore wind energy (Table 2.3). All nine datasets were assigned a 0.1 suitability score to be used in the Natural and Cultural Resource Submodel.

Table 2.3. Data sets and scores provided by NMFS used to create the combined Habitat data layer.

Data Set	Score (0-1)
Jordan Basin Dedicated Habitat Research Area – 20 km setback	0.1
Coral Protections Areas (CPAs) (Mt. Desert Rock CPA, Outer Schoodic Ridge CPA) - 20 km setback	0.1
Jordan Basin (depths shallower than 250 m)	0.1
CPAs considered but not designated by NEFMC (Western Jordan Basin (WJB) 114 Fathom Bump, WJB 96 Fathom Bump, WJB 118 Fathom Bump, Central Jordan Basin, Lindenkohl Knoll) – 20 km setback	0.1
Coral-Sponge Locations – 5 km setback	0.1
Georges Bank (delineated by 140 m contour) - 10 km	0.1

3NCCOS is providing BOEM with technical assistance to support BOEM's spatial planning in relation to offshore wind projects. This support is being provided with funding resources from NCCOS and through reimbursable support from BOEM to NCCOS. NMFS is providing technical assistance to NCCOS regarding available science (i.e., data layers and modeling methods) for BOEM's consideration in their spatial modeling efforts. These efforts are supporting BOEM's ocean and coastal planning activities related to siting of call areas, wind energy areas, and transmission cable routing. The information provided by NMFS to NCCOS is purely technical in nature and does not reflect or constitute an official agency policy, position, or action. Official NMFS positions related to spatial planning for offshore wind activity will be submitted by NMFS through written comments to BOEM during the planning and review processes for each activity.

Data Set	Score (0-1)
setback	
HMAs considered but not designated by NEFMC (Bigelow Bight, Machais, Platts Bank 1, Platts Bank 2, Toothaker Ridge) - 20 km setback	0.1
Habitat Areas of Particular Concern (HAPCs)	0.1
Potential and Known Coral and Hardbottom (all locations within the Call Area shallower than 220 m)	0.1
None of the Above	1.0

2.4.3. NMFS North Atlantic Right Whale Considerations

NOAA NMFS provided the best available data sets to be used for creating a combined North Atlantic right whale layer. Overall, four data sets were chosen to be combined to represent the suitability of habitats for the North Atlantic right whale in the call area with offshore wind energy (Table 2.4). All four datasets were assigned a 0.1 suitability score to be used in the Natural and Cultural Resource Submodel.

Table 2.4. Data sets and scores provided by NMFS used to create the combined North Atlantic Right Whale Considerations data layer.

Data Set	Score (0-1)
Maine Coastal Current, Depths < 150 m	0.1
Jordan Basin, Depths > 200 m	0.1
Wilkinson Basin, Depths > 220 m	0.1
Sum of North Atlantic right whale density, > 1.018 individuals/100 km²	0.1

2.4.4. Bathymetry

A number of bathymetric data sets were available and reviewed for the Gulf of Maine. The U.S. Coastal Relief Model (CRM) provides a comprehensive bathymetric data at 3 arc-second horizontal resolution for the Gulf of Maine providing full bathymetric coverage, however the dataset is outdated, the CRM requires a download of the Southeast Atlantic, Volume 2 CRM (1998).[4] BlueTopo bathymetric data incorporates the most recent and best available bathymetric data for the Gulf of Maine in an easy to download and compatible format, however resolution will vary based on available data.[5]

2.4.5. Wind Nominations

In response to the Gulf of Maine Call, BOEM received seven nominations from the wind industry. BOEM reviewed each of the nominations and determined that they were all legally, technically, and financially qualified.

4 https://www.ngdc.noaa.gov/mgg/coastal/crm.html

5 https://www.nauticalcharts.noaa.gov/data/bluetopo.html

To understand the model's sensitivity to the nominations data layer, BOEM worked with NCCOS on model simulations without the nominations, and found that the wind speed, distance to points of interconnection, and distance to port data layers were not alone producing submodel results that mirrored the patterns of the nominations layer. Therefore, BOEM's Economics Division within the Office of Strategic Resources recommended that the nominations account for 50% of the submodel's weight to ensure that the model accurately reflected the perspective of those who responded from the wind industry on the Call Area's relative developability.

In reviewing the aggregated nominations map, as well as preliminary suitability model results with the nominations layer, BOEM realized that several of the companies who responded to the Call appeared to avoid areas the Department of Defense (DoD) previously identified as wind exclusion areas and military submarine transit lanes. The DoD Siting Clearinghouse provided an updated Gulf of Maine Assessment in 2022 (shared at the May 19, 2022 Gulf of Maine Task Force meeting), which does not include the same exclusion areas and submarine transit lanes. BOEM found that the nominations' avoidance of those outdated DoD areas significantly affected the performance of preliminary suitability model results. Therefore, BOEM used professional judgment to create an updated version of the company nominations data layer, which included aliquots that were likely avoided by companies due to outdated DoD concerns.

BOEM will request that the DoD Siting Clearinghouse perform an updated offshore wind compatibility assessment on the Draft WEA, at which time BOEM will consider any additional requested removals.

2.4.6. Vessel Traffic

Automatic Identification System (AIS) vessel traffic data are collected by the U.S. Coast Guard (USCG) to monitor real-time vessel information to improve navigation safety and support homeland security. Data such as ship name, purpose, course, and speed are acquired continuously from vessels through transmissions to 134 fixed stations that are part of AIS. AIS transponders are not required on every vessel but are carried on most self-propelled vessels of 1,600 or more gross tons. AIS transponders are also required on vessels of 19.8 m (65 ft) or more in length and engaged in commercial service; towing vessels of 7.9 m (26 ft) or more in length and with more than 600 horsepower; vessels certified to carry more than 150 passengers; vessels supporting dredging operations; and vessels transporting certain dangerous, flammable, or combustible cargo. Additionally, fishing industry vessels of various size and tonnage are required to carry AIS transponders to support commercial fishing and fish processing[6]. A number of different vessel types are included in this dataset: cargo, fishing military, other, passenger, pleasure and sailing, tanker, and tug and tow.

Processed vessel traffic data of transits per 100 m^2 from 2015 through 2022 were downloaded from Marine Cadastre for the BOEM Call Area.[7] All vessel types except fishing vessels were included in the eight-year sum for modeling. The reason fishing vessels were excluded is that these vessels are already represented in the Fisheries submodel in multiple data sets and it would be redundant to include that information in this data set.

6 https://w ww.navcen.uscg.gov/?pageName=AISRequirementsRev#Operations
7 https://marinecadastre.gov/ais/

2.4.7. NEFSC Trawl Survey Interpolated Biomass (2010 – 2019)

The Northeast Fisheries Science Center (NEFSC) Trawl Survey Interpolated Biomass data layers were downloaded from the Marine-Life Data Analysis Team (MDAT).[8] Expert recommendations were to include the Spring survey: Atlantic cod, monkfish (goosefish), pollock, and witch flounder, and Fall survey: Acadian redfish, American plaice, and Atlantic herring. These specific species were recommended by NMFS because these species' biomass concentrations differ from fishing effort in the VMS data layer. These seven data layers were each rescaled to a 0 –1 scale using a z membership function, with less biomass being more suitable and more biomass being less suitable for wind energy development. After all seven were rescaled, the geometric mean was taken to produce a single data layer used in the suitability modeling.

2.4.8. Commercial and Recreational Fishing Data

Commercial and recreational fishing are important economic drivers and considerations of use patterns are important for ocean planning and conflict reduction with an established and socio-economically important industry. Data were received from cooperating programs across NOAA. Fishing data are considered Controlled Unclassified Information (CUI) requiring specific measures for handling, safeguarding, and controlled protection of confidential data components.[9] Under NOAA dissemination, data and maps within this technical report reflect the resolution at which data can be displayed to the public to ensure Administrative Order 216-100[10] to protect confidential fisheries statistics. NMFS uses a rule of three or more submitters in a given stratum before it is considered suitable for public display. This process prevents any data identified with any individual or operation from being disclosed. Data not meeting these criteria were removed from map visualizations. NMFS data were used at the resolution received from the data provider for the suitability model and displayed at the appropriate resolution for public disclosure. Data processing steps for data used in the suitability model were summarized for each fishery dataset received.

2.4.9. VMS All Fishing Types (2009 - 2021)

NMFS Office of Law Enforcement (OLE) provided Vessel Monitoring System (VMS) data from 2009-2021. All data was filtered so that only points with <=4 knots were provided, which approximates active fishing. The fishing industries represented by this data include: Multispecies (groundfish), Scallop, Monkfish, Squid/Mackerel/Butterfish, Surfclam, Herring, and Ocean Quahog. The point data was aggregated to a 1 km x 1 km grid, with any grid cell having less than 3 unique vessels being removed from any maps to maintain confidentiality requirements. Each grid cell represents the sum of polls from 2009-2021. A z membership function was used to rescale this data to a 0-1 scale.

2.4.10. Combined Large Pelagic Survey (2011 - 2021) & Highly Migratory Fishing Trip (2010 - 2021) Layer

A combined data layer was created using Maine's Department of Marine Fisheries (DMR) data[11] and

8 https://seamap.env.duke.edu/models/mdat/MDAT-Technical-Report.pdf
9 https://www.archives.gov/cui/about
10 https://www.st.nmfs.noaa.gov/Assets/intranet2015/pdf/NOAA_216-100_Form.pdf
11 https://www.maine.gov/dmr/sites/maine.gov.dmr/files/inline-files/Report%20to%20the%20Gulf%20of%20Maine%20Mapping%20Project%20for%20Highly%20Migratory%20Species%20-%20Final%20Draft_0.pdf

NOAA's Large Pelagic Survey Data.[12] Maine's DMR data came in a gridded format and the maximum value that overlapped with the hexagonal grid was assigned value used. NOAA's Large Pelagic Survey data came as points, and a 10-mile setback distance was applied to each point, and the resulting polygons were overlaid to the hexagonal grid with the sum of overlapping points calculated for each grid cell. Both data sets were rescaled to a 0 to 1 scale using a z membership function, with less effort receiving a higher suitability score and more effort receiving a lower score. The geometric mean of the two rescaled datasets was taken and used as the combined score for the suitability model.

2.5. Suitability Analysis

A gridded relative suitability analysis, commonly used in MCDA, was performed to identify the grid cells with the highest suitability (Mahdy and Bahaj 2018; Deveci et al 2020; Abdel-Basset et al 2021; Abramic et al 2021; Vinhoza and Schaeffer 2021) for WEA development in the Call Area. Spatial data layers included in the suitability analysis identify space-use conflicts and environmental constraints such as maritime navigation, ocean industries, and natural resource management. We utilized a submodel structure to capture ocean use and conservation concerns including natural and cultural resources, industry and operations, fisheries, and wind logistics (Figure 2.3). This submodel structure ensures that each submodel is given equal weight in the final suitability model regardless of how many data layers are present in each submodel. BOEM considered comments to separate cultural resources into their own submodel, but concluded that many fishery, habitat, and protected resource data layers (among others), also hold significant cultural importance, and are well represented in their respective submodels.

BOEM decided to use four equally weighted submodels, shifting DoD Clearinghouse's primary concern (i.e., Warning Area 103) to the Industry & Operations submodel, rather than employing a standalone National Security submodel. BOEM made this decision after reviewing preliminary model results and seeing that Warning Area 103 was avoided under every scenario under consideration (likely because it overlaps with several other prominent conflicts, such as LMA1 and Platts Bank). Removal of this submodel, while still avoiding Warning Area 103, allowed BOEM to afford additional weight to the other submodels and conflicts. Also, after considering several modeling scenarios with constraints, BOEM ultimately selected a model option that did not have any constraints given exclusion of various areas within the Call area.

12 https://www.fisheries.noaa.gov/recreational-fishing-data/recreational-fishing-data-downloads#large-pelagics-survey-microdata-and-estimates

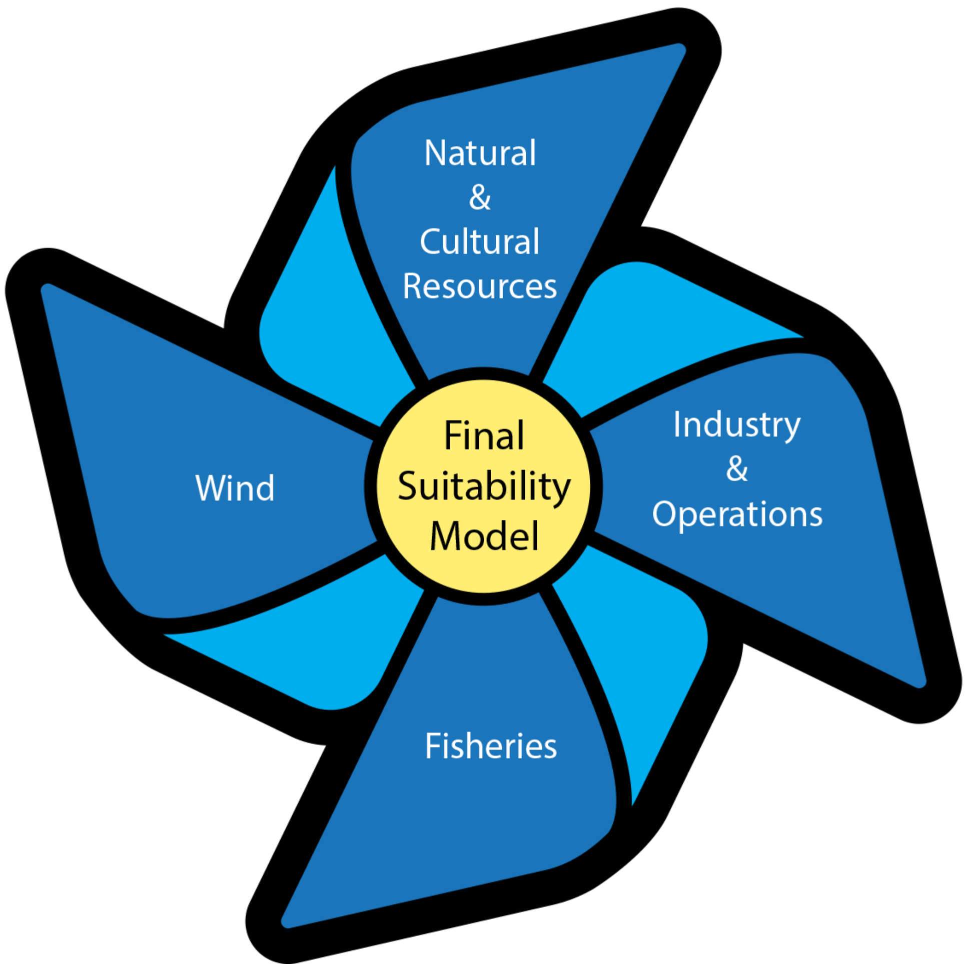


Figure 2.3. Overview of suitability model design and the submodel components.

2.5.1. Scoring Categorical Data

Categorical datasets (i.e., in which data are distinct and separate groups) were evaluated to determine if a constraining feature was present or absent in each grid cell. If a feature was absent, a score of 1 was given indicating suitability with wind energy development, otherwise a score ranging from 0 to 1 was assigned (0 = unsuitable with wind energy; 1 = being more suitable with wind energy).

After all data were gathered and integrated into the greater data inventory, certain data layers required, either by action agency or for safety and security reasons, setbacks from the discrete/categorical layer. Setbacks were established based on governance, policy, and regulations, and taking the most conservative setback distance (i.e., buffer) to avoid interactions with other ocean activities.

2.5.2. Scoring Numerical Data

Numerical data (i.e., data can represent any value within a given range) (e.g., continuous data) were reclassified to a 0 to 1 scale using a linear function or fuzzy logic membership functions (Vincenzi et al. 2006; Vafaie et al. 2015; Theuerkauf et al. 2019; Landuci et al. 2020).Fuzzy membership functions are similar to a linear or non-linear functional approach, however, use of fuzzy logic membership functions accounts for additional uncertainty when assigning scores to the data (Kapetsky and Aguilar-Manjarrez 2013). The function used for each numerical dataset was chosen based on the data and known interactions or compatibility with wind energy. The range of the numerical datasets (i.e., the minimum and maximum values) were used as the inputs for creating the function and were modified to ensure no output value would equal 0. No 0 values were allowed because no observed value in any numerical dataset used was known to be completely incompatible with wind energy infrastructure.

Vessel traffic, fishing effort, protected resources, and biomass datasets were reclassified using the Z-shaped membership function from the Scikit-Fuzzy (Version 0.4.2) Python library, where the higher the observed value (e.g., fishing effort, vessel traffic) the lower the compatibility with wind energy, and thus the lower the suitability score (Warner et al. 2019; Equation 2.2; Figure 2.4). Other numerical datasets, such as distance to port, used a standard linear function because of high certainty that the closer a location is to a port, the more suitable a wind energy area is regarding logistics and cost (Abdel-Basset et al 2021).

Categorical and numerical data used in scoring for the relative suitability analysis are in Tables 2.5 through 2.8.

Equation 2.2. The Z-shaped membership function from the Scikit-Fuzzy (Version 0.4.2) python library used to rescale numerical data to a 0 to 1 range, with input values modified to ensure no 0 values in the output (Warner et al. 2019). Equation of Z-shaped membership function is based on the MathWorks documentation example (MathWorks 2021). X = input value to be rescaled, a = Function begins falling from 1 (Minimum value of the dataset), b = Function attains 0 (Maximum value + (Maximum value * 1/10,000)) to ensure no 0 value in output.

$$zmf(x; a, b) = \begin{Bmatrix} 1, & x \leq a \\ 1 - 2\left(\frac{x-a}{b-a}\right)^2, & a \leq x \leq \frac{a+b}{2} \\ 2\left(\frac{x-b}{b-a}\right)^2, & \frac{a+b}{2} \leq x \leq b \\ 0, & x \geq b \end{Bmatrix}$$

Table 2.5. Natural and cultural resources submodel data layers included in the relative suitability analysis and the score assigned to each dataset. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	Score
NMFS Protected Resource Division Combined Layer (22 species)	NMFS Scores
NMFS Habitat Combined Layer (9 habitats)	0.1
NMFS North Atlantic Right Whale (NARW) Areas	0.1
<u>North Atlantic Right Whale Areas Recommended for Removal:</u> Massachusetts Restricted Area, Great South Channel Restricted Area, Lobster Management Area (LMA) 1 Restricted Area NARW Corridor and Extension, Cashes Ledge Extension	0.3 0.5
<u>FWS Avian Combined Layer:</u> BRI – Integrated Seabird Risk and Vulnerability Assessment – High (33%) BRI – Tracking Data for Diving Birds – Core Use Areas (33%) 24 nm buffer from shore, including islands (3%)	0.2 0.3 0.1
NEFSC Trawl Survey Interpolated Biomass 2010 - 2019	Z-Membership Function

Table 2.6. Industry and operations submodel data layers included in the relative suitability analysis and the score assigned to each dataset. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	Score
NMFS's Fisheries-Independent Surveys (13 total surveys)	Z-Membership Function
Wrecks and Obstructions – 500 ft setback	0.5
NEXRAD Stations Moderate Impact (35 – 70 km)	0.5
Aids to Navigation (beacons and buoys) - 500 m setback	0.5
AIS Vessel Traffic All Vessels 2015 - 2022	Z-Membership Function
USCG Draft MNM PARS Fairways	0.5
EPA Mandatory Class 1 Federal Areas - 50 km and 100 km setback	0.1 for 50 km setback 0.2 - 0.9 linear gradient for 50 – 100 km setback
Special Use Airspace Warning Area 103 (W103)	0.1

Table 2.7. Wind submodel data layers included in the relative suitability analysis and the score assigned to each dataset. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	Score
Distance to Ports (10%)	Linear Function (Closer to port is better)
Call Developer Nominations (50%)	Linear Function (More nominations is better)
Distance to Points of Interconnection (20%)	0 – 75 miles linear gradient from 0.4 - 1, with any cell > 75 miles receiving a score of 0.4
NREL 20-Year Mean Wind Speed (20%)	Linear Function (Greater wind speed is better)

Table 2.8. Fisheries submodel data layers included in the relative suitability analysis and the score assigned to each dataset. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	Score
Fishing Footprint Raster Data (revenue) 2008 - 2021	Z-Membership Function
Fishing Footprint Raster Data (landings) 2008 - 2021	Z-Membership Function
VMS Data 2009 - 2021	Z-Membership Function
Charter/Party VTR 2008 - 2020	Z-Membership Function
HMS Combined Layer: Large Pelagic Survey Trip Points (HMS/Recreational) 2011 – 2021 – 10 mi setback Maine DMR Highly Migratory Species Fishing Trip Data	 Z-Membership Function Z-Membership Function

Data Layer	Score
<u>Fisheries Considerations:</u>	
Lobster Management Area 1	0.1
Platts Bank	0.1; 0.1 to 0.5 from edge of Platts Bank to 20 km setback
Georges Bank	0.1 for 10 km from 140 isobath; 0.1 to 0.5 from 10 km – 20 km from 140 m isobath
Western Gulf of Maine Closure	0.1 to 0.5 from edge of W GoME Closure to 20 km setback
Jeffreys Bank Habitat Management Area (HMA)	0.1 to 0.5 from edge of Jeffreys Bank HMA to 20 km setback
HMAs considered, but not adopted by NEFMC (e.g., Toothaker Ridge, Large Eastern Maine proposed HMA, Wildcat Knoll)	0.5 for proposed HMAs
Closed Area II	0.1 to 0.5 from edge of Closed Area II to 20 km setback
Davis Swell, Parker Ridge, Three Dory Ridge	0.1 for area; 0.1 to 0.5 from edge to 20 km setback
Jordan Basin Dedicated Habitat Research Area	0.1 to 0.5 from edge of JBDHRA to 20 km setback
Cashes Ledge	0.1 to 0.5 from edge of Cashes Ledge to 20 km setback

2.6. Calculation of Final Score

Each data layer was scored on a 0 to 1 scale, with scores approaching 0 representing low suitability and 1 representing high suitability relative to the other grid cells for wind energy. Next, a final suitability score was calculated for each submodel by taking the geometric mean of all scores within each grid cell. The geometric mean of all submodels was used to calculate a final overall suitability score. The geometric mean (Equation 2.3) was chosen because it grants equal importance to each variable and provides a non-biased weighting of each submodel as they interact with each other (Bovee 1986; Longdill et al. 2008; Silva et al. 2011; Muñoz-Mas et al. 2012). Furthermore, all submodels had equal weight within the suitability model.

Equation 2.3. Geometric mean equation implemented for final suitability model scoring, after 0 values (constraints submodel) were removed.

$$g = \sqrt[n]{x_1 \cdot x_2 \cdot \ldots \cdot x_i}$$

$$n = \textit{number of variables}$$
$$x_1 = \textit{variable 1}$$
$$x_2 = \textit{variable 2}$$
$$x_i = \textit{additional variables}$$

2.6.1. Suitability Model Data and Constraints Submodel

After the suitability model was run, an analysis was performed to describe the data most influential (i.e., area removed by constraints) in removing or impacting the area for each submodel. A simple percentage of how many cells or how much area a particular variable was present in was calculated. This provides a general idea of how much area was constrained within the submodels and final suitability model outcome.

2.6.2. Local Index of Spatial Association

A Local Index of Spatial Association (LISA) analysis, which identifies statistically significant clusters and outliers, was performed on the final relative suitability modeling results (Anselin 1995). All cells with a score of 0 were not included in the cluster analysis, as these areas are unsuitable for wind energy and are not considered further. The ArcGIS Pro Cluster and Outlier Analysis tool was used to implement the LISA analysis (Esri 2021a). The fixed distance spatial conceptualization was utilized within this analysis as it allows the identification of localized clusters. The function inputs were a 250-m search distance and 9,999 iterations with row standardization. Statistically significant clusters at a 95% confidence interval ($p < 0.05$) of the highest suitable scores (i.e., high-high clusters) were identified (Esri 2021b).

2.6.3. Data Included in the Suitability Model and Cluster Analysis

All data layers utilized in the suitability model were considered authoritative and were from U.S. federal agencies, non-governmental organizations, and industry (i.e., developer nominations received by the Call for Information and Nominations). Before data were selected for use in modeling, data were evaluated for spatial accuracy and temporal and spatial completeness to ensure quality control. Data layers that did not meet these specifications, or did not overlap with the Call Area, were not included in the suitability model. For example, BOEM determined that the extent of submerged paleocultural landforms in the Gulf of Maine region likely did not extend past the 60-meter line of bathymetry[13]. The Team created a map to represent these submerged areas

[13] Kelley, Joseph T., Daniel F. Belknap, and Stefan Claesson. "Drowned coastal deposits with associated archaeological remains from a sea-level “slowstand”: Northwestern Gulf of Maine, USA." *Geology* 38.8 (2010): 695-698.

and found that none of them occurred within the Call Area and, therefore, the layer was not included in the model. BOEM will revisit these data and underlying reports in any evaluations of transmission feasibility. During the Call for Information and Nominations, BOEM received a comment recommending the use of sea bottom slope (i.e., >10% slope) as a proxy for potential presence of hardbottom habitat. The Team created a map to represent these areas of potential hardbottom habitat and found that they overlapped with all areas contained within the NOAA Fisheries Combined Habitat Layer, and therefore, the layer was not included in the model. Additionally, BOEM did not include data layers in the model that represent mitigable interactions with Department of Defense considerations (e.g., mitigable radar interference with the North American Aerospace Defense Command [NORAD]).

Some data were included in the characterization data inventory only to provide supplementary information beyond the scope of this study, but those data may be useful during the NEPA environmental review process.

2.6.4. Suitability Modeling Approach, Assumptions, and Limitations

Models, in general, can optimize planning choices and improve the decision-making process by avoiding common biases, offering objective results with limited subjectivity (i.e., equally weighted approach). However, assumptions must be made within a modeling framework. For instance, we assume multiple overlapping activities in the same space results in greater conflict and are less suitable with wind energy, which may not necessarily be the case depending on the activities.

Spatial data were used within a GIS framework to develop workflows with a series of interconnected steps (Stelzenmüller et al. 2012; 2017). A flexible, integrated GIS-based suitability model was implemented to consider complex interactions (i.e., equally weighted relative suitability model in an ocean environment) while also aiming for long-term sustainability (Perez et al. 2003; Cho et al. 2012; Pinarbasi et al. 2017, 2019; Stelzenmüller et al. 2017) (Figure 2.5). An attempt was made to minimize bias among submodels and data layers through the implemented equally weighted approach. Moreover, threshold values assigned for size of WEAs were determined by BOEM and guided by stakeholder engagement, as initial decisions are often made in wind energy planning. Models do have limitations (e.g., statistical assumptions, best-available data, modeling approach). For example, in the relative suitability spatial workflow approach used, scoring of categorical and numerical data, reporting statistic used, variability in data temporal and spatial coverage, years and number of years of AIS data used, p-value for LISA cluster and outlier analysis, variables in the suitability and precision siting model, and consideration of model error, could, if approached differently, impact, or change the draft WEA option reported. Other limitations include spatial and horizontal resolution of model data, the accuracy and precision of model data, and available time and data availability (See NMFS disclaimer in Appendix B).

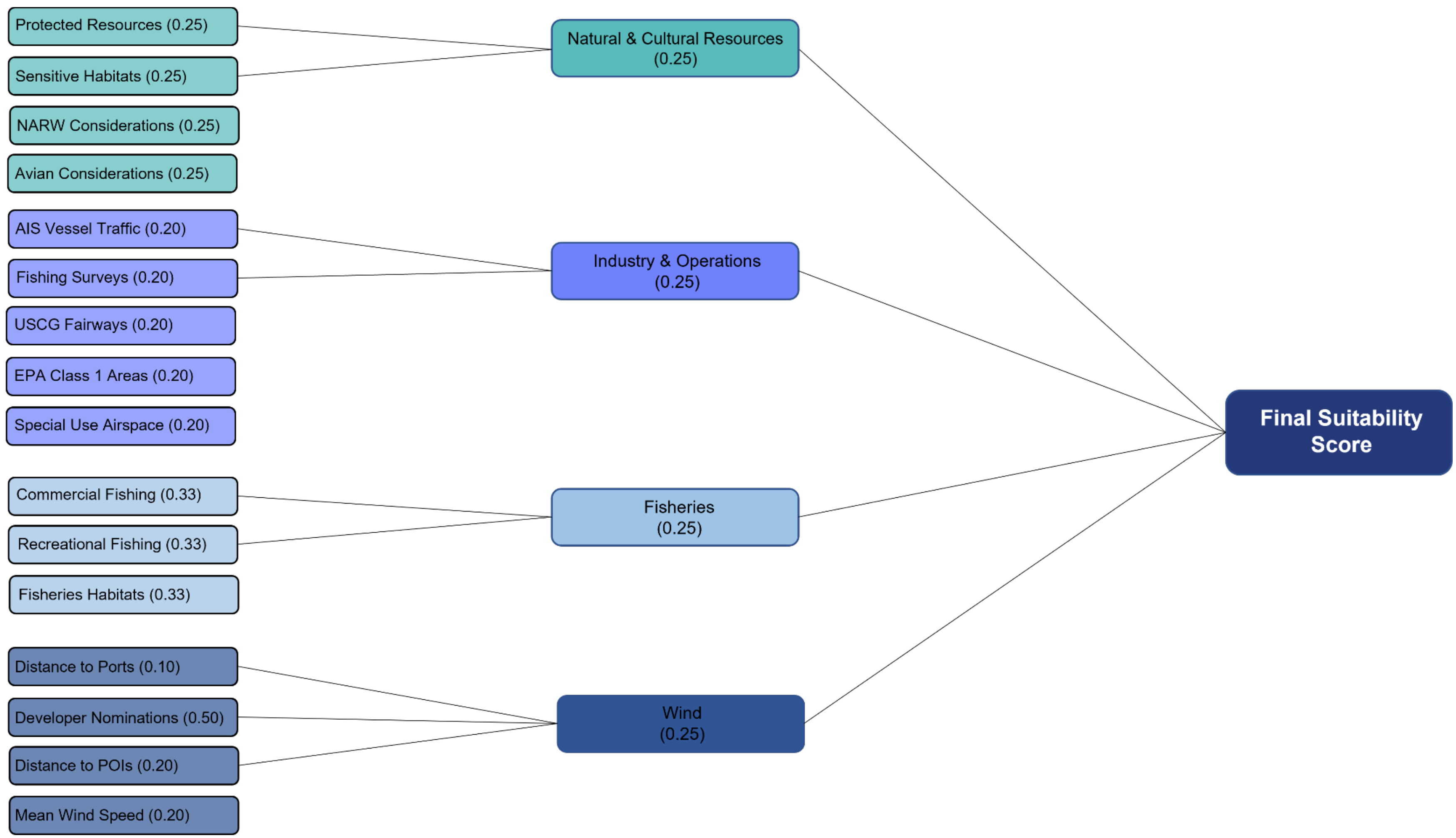


Figure 2.4. A generalized approach to a Multi-Criteria Decision Analysis (MCDA) suitability model with equally weighted data layers in the submodels and final suitability model. Note that not all of the data layers are shown.

2.7. Draft Wind Energy Area (WEA) Identification

The draft WEA was identified using the High-High clusters in conjunction with defined rules, with the goal of identifying suitable options with no minimum or maximum size requirement. The High-High clusters were overlaid with the lease block aliquots. The aliquots are 1/16th the size of a lease block (1 lease block = 16 aliquots). Aliquots that overlapped the High-High clusters were selected and extracted. Next, any aliquots that overlapped with Lobster Management Area (LMA) 1 were removed from the selection. Additionally, any aliquots that overlapped with the Great South Channel Restricted Area were removed. A total of 9,907 aliquots were selected and grouped together to make up the draft WEA.

2.8. Characterization of the Draft WEA

An in-depth look at the identified draft WEA was performed visually, and by examining metrics and summary statistics of data layers for evaluation and comparison. All relevant data layers from the modeling for each option were examined. In addition, there were some data layers that were not appropriate for suitability modeling but are still important in the final decision-making process. Therefore, additional data layers not included in the modeling process are examined in the characterization of the draft WEA.

3. RESULTS

3.1. Submodels

3.1.1. Natural and Cultural Resources

Natural resource assets were assessed to determine biologically important and sensitive habitats, culturally and archaeologically sensitive areas, and designated protected areas that may be incompatible with wind energy (Table 3.1).

3.1.1.1. Protected Resource Considerations

A total of 22 protected resource data layers were combined and used in the suitability model as a single NMFS protected resources layer. The final composite layer had complete overlap with the Call Area, however, the interactions for each species were highly variable (Figure 3.1). The southern portion of the Call Area had the lowest relative suitability. The northern portion and eastern portion of Call Area had the highest relative suitability.

3.1.1.2. Habitat Considerations

A total of nine habitat and habitat proxy layers were combined and used in the suitability model as a single NMFS habitat layer. Many interactions with habitat considerations were mitigated prior to this analysis by way of call area design. The combined habitat layer had coverage for the majority of the Call Area, except areas in the western portion of the Call Area (Wilkinson Basin) and areas in the southeast portion of the Call Area (north of Georges Bank) (Figure 3.2).

3.1.1.3. North Atlantic Right Whale Considerations

A total of four North Atlantic right whale habitat and density data layers were combined and used in the suitability model as a single North Atlantic right whale areas layer. The four layers included Maine coastal current depths greater than 150 m, Jordan Basin depths greater than 200 m, Wilkinson Basin depths greater than 220 m, and Duke MDAT data representing the sum of North Atlantic right whale density greater than 1.018 individuals per 100 km² (Figure 3.3). North Atlantic right whale areas recommended for removal were also included in the suitability model. These areas included the Massachusetts Restricted Area, Great South Channel Restricted Area, and Lobster Management Area 1 all scored a 0.3. Other areas for recommended removal included a North Atlantic right whale corridor and extension area determined by NMFS, and Cashes Ledge and a surrounding extension area. These areas were scored 0.5 in the suitability model (Figure 3.4).

3.1.1.4. Avian Considerations

A combined data layer was created for U.S. Fish and Wildlife avian considerations. Included in this data layer was the integrated seabird risk and vulnerability assessment, core use areas determined from tracking data for diving birds, and a 24 nm setback from shore that includes islands (Figure 3.5).

3.1.1.5. NEFMC Trawl Survey Interpolated Biomass

The Northeast Fisheries Science Center (NEFSC) Trawl Survey Interpolated Biomass data layers were accessed from the Marine-Life Data Analysis Team (MDAT). Expert recommendations were to include the Spring survey: Atlantic cod, monkfish (goosefish), pollock, and witch flounder, and Fall survey: Acadian redfish, American plaice, and Atlantic herring. These specific species were recommended by NMFS, because these species biomass concentrations differ from fishing effort in the VMS data layer. The northwest and central portions of the Call Area had the highest concentrations of biomass and are, therefore, less suitable (Figure 3.6).

The overall suitability results for the natural and cultural resources submodel are presented in Figure 3.7.

Table 3.1. Natural and cultural resources submodel data layers included in the relative suitability analysis, the score assigned to each dataset, and the percent overlap.

Data Layer	Score	Percent Overlap
NMFS Protected Resource Division Combined Layer (22 species)	NMFS Scores	100%
NMFS Habitat Combined Layer (9 habitats)	0.1	89%
NMFS North Atlantic Right Whale (NARW)	0.1	60.8%

Data Layer	Score	Percent Overlap
Areas		
North Atlantic Right Whale Areas Recommended for Removal: Massachusetts Restricted Area, Great South Channel Restricted Area, Lobster Management Area (LMA) 1 Restricted Area NARW Corridor and Extension, Cashes Ledge Extension	0.3 0.5	16.9% 18.4%
FWS Avian Combined Layer: BRI – Integrated Seabird Risk and Vulnerability Assessment – High (33%) BRI – Tracking Data for Diving Birds – Core Use Areas (33%) 24 nm buffer from shore, including islands (3%)	0.2 0.3 0.1	35.1% 14.0% 15.6%
NEFSC Trawl Survey Interpolated Biomass 2010 - 2019	Z-Membership Function	100%

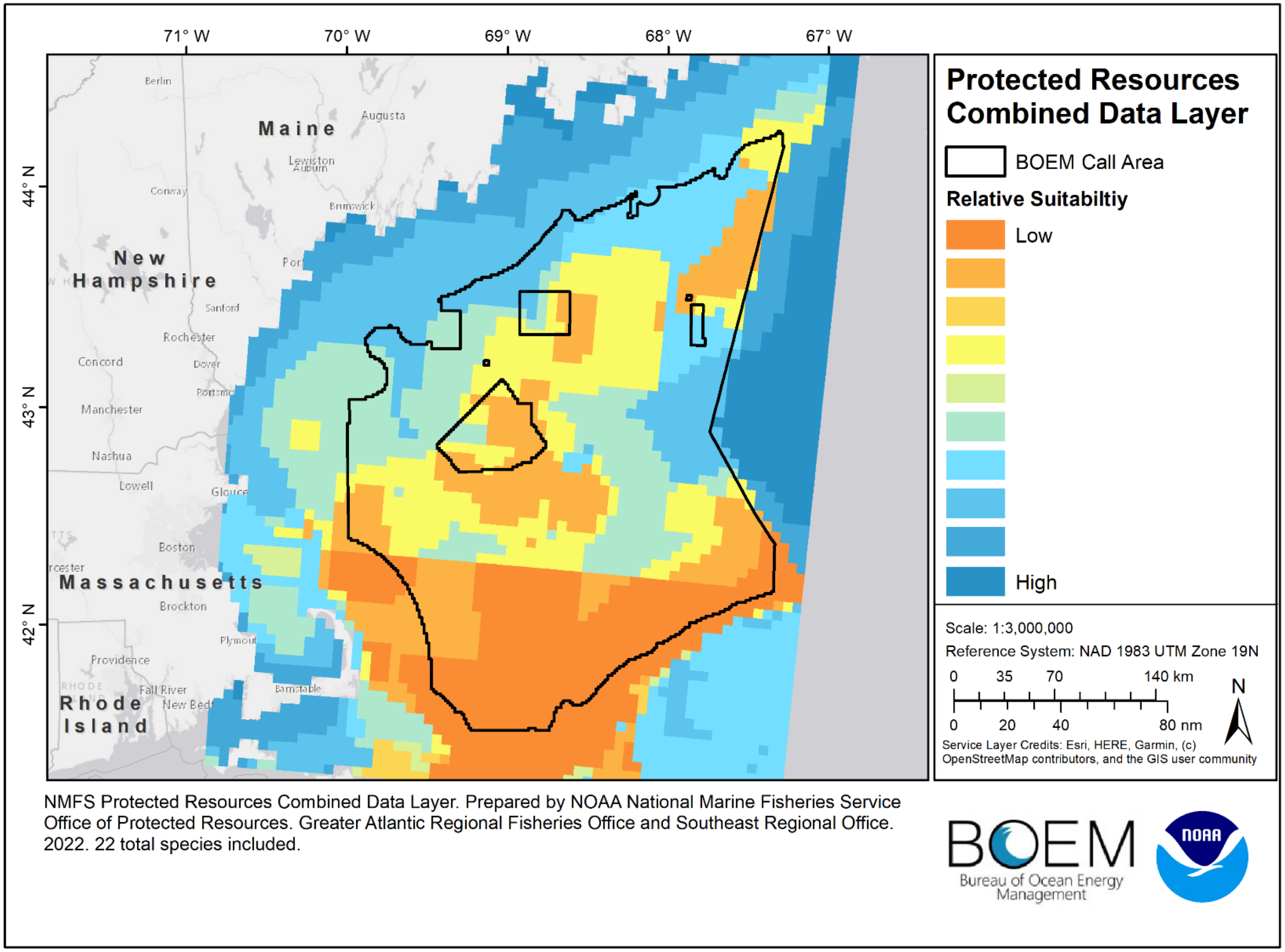
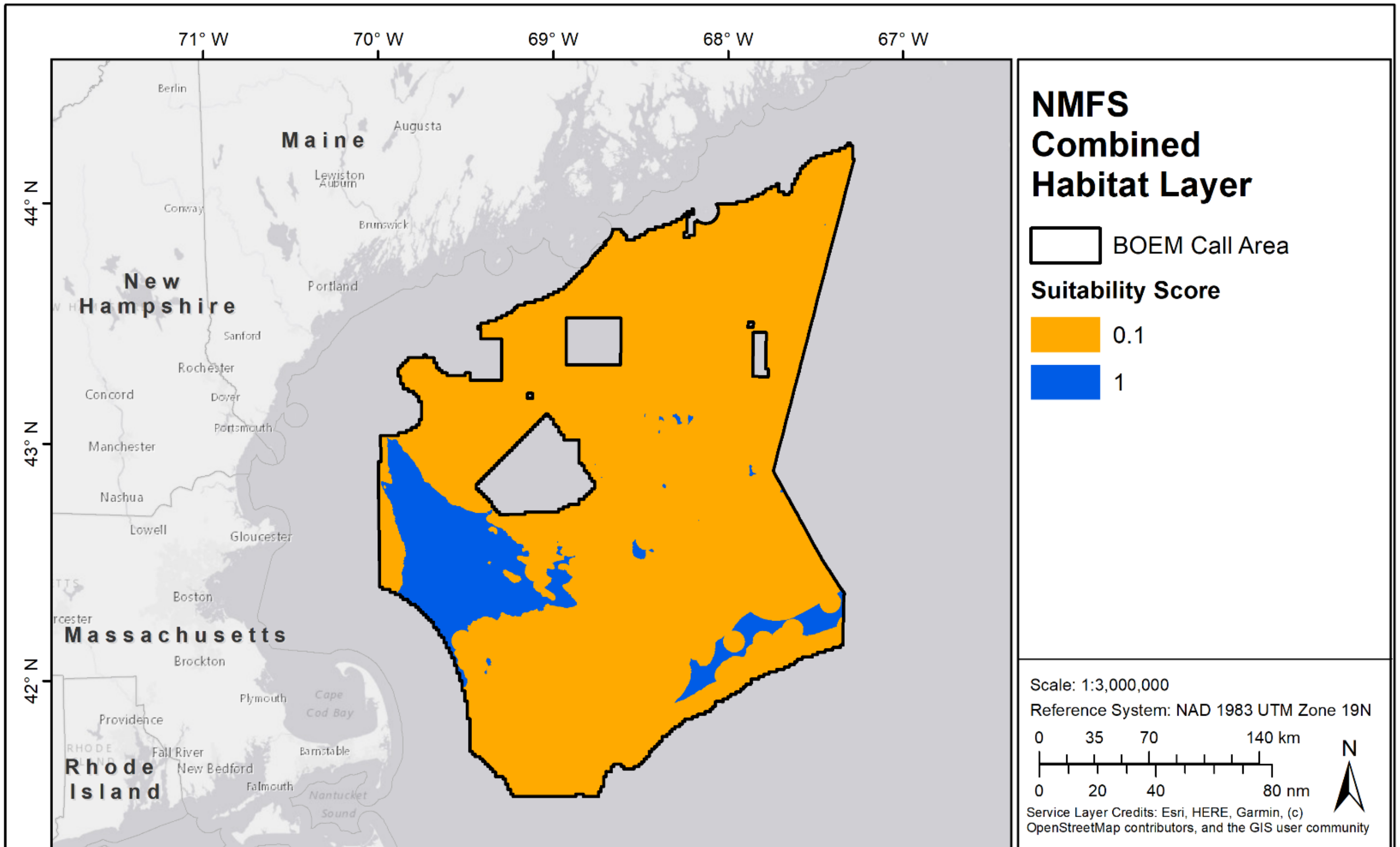


Figure 3.1 National Marine Fisheries Service Protected Resources combined composite data layer (22 species) implemented within the relative suitability analysis.



NMFS Combined Habitat Layer. Prepared by NOAA National Marine Fisheries Service. 2022. Habitats include: Jordan Basin Dedicated Habitat Research Area (20 km setback), Coral Protection Areas (20 km setback), Jordan Basin depths shallower than 250 m, CPAs considered but not desginated by NEFMC (20 km setback), coral and sponge locations (5 km setback), Georges Bank (10 km setback), HMAs not designated by NEFMC (20 km setback), HAPCs, potential and known coral and hardbottom.

BOEM Bureau of Ocean Energy Management

NOAA

Figure 3.2 National Marine Fisheries Service Habitat combined data layer implemented within the relative suitability analysis.

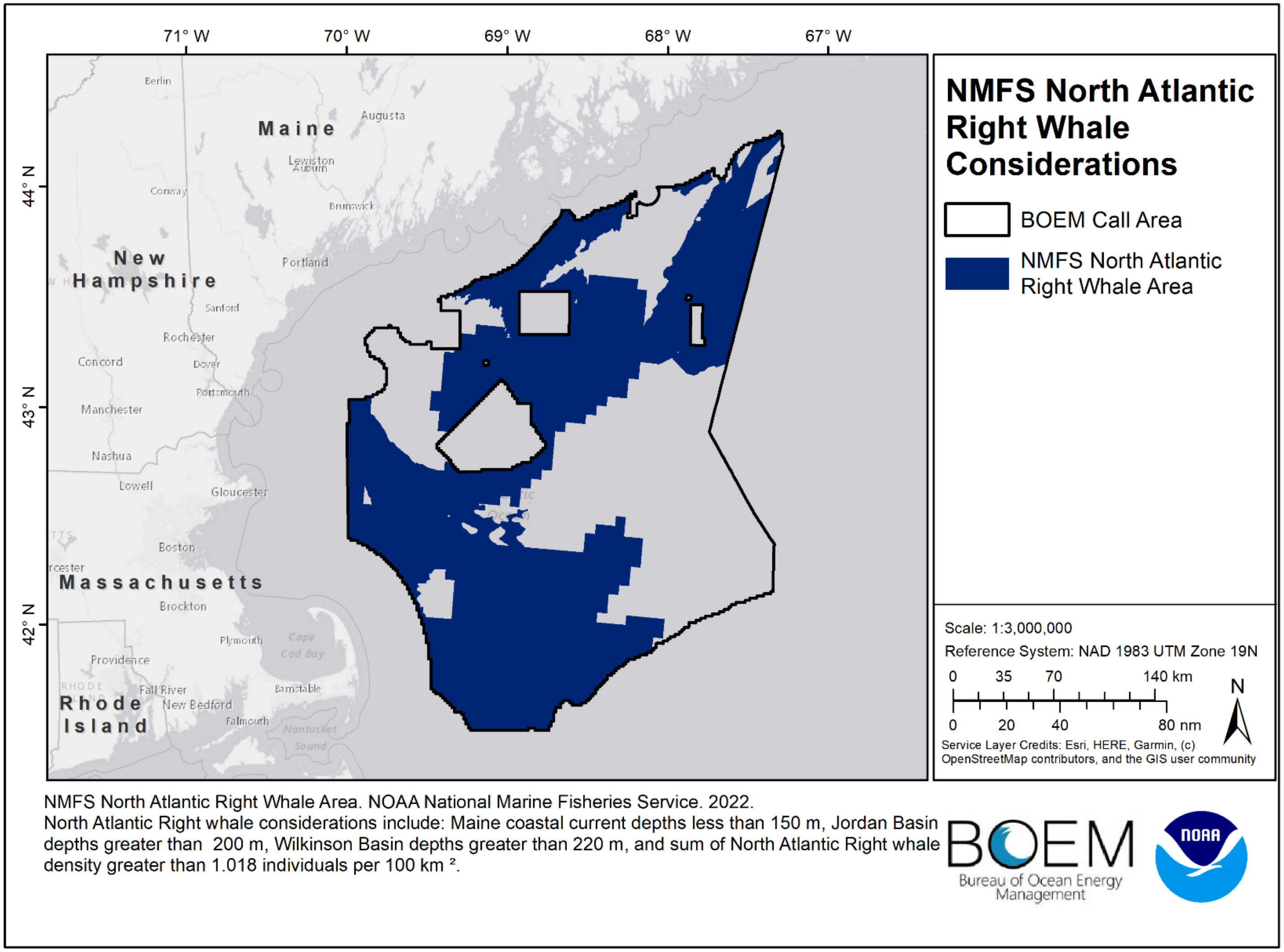
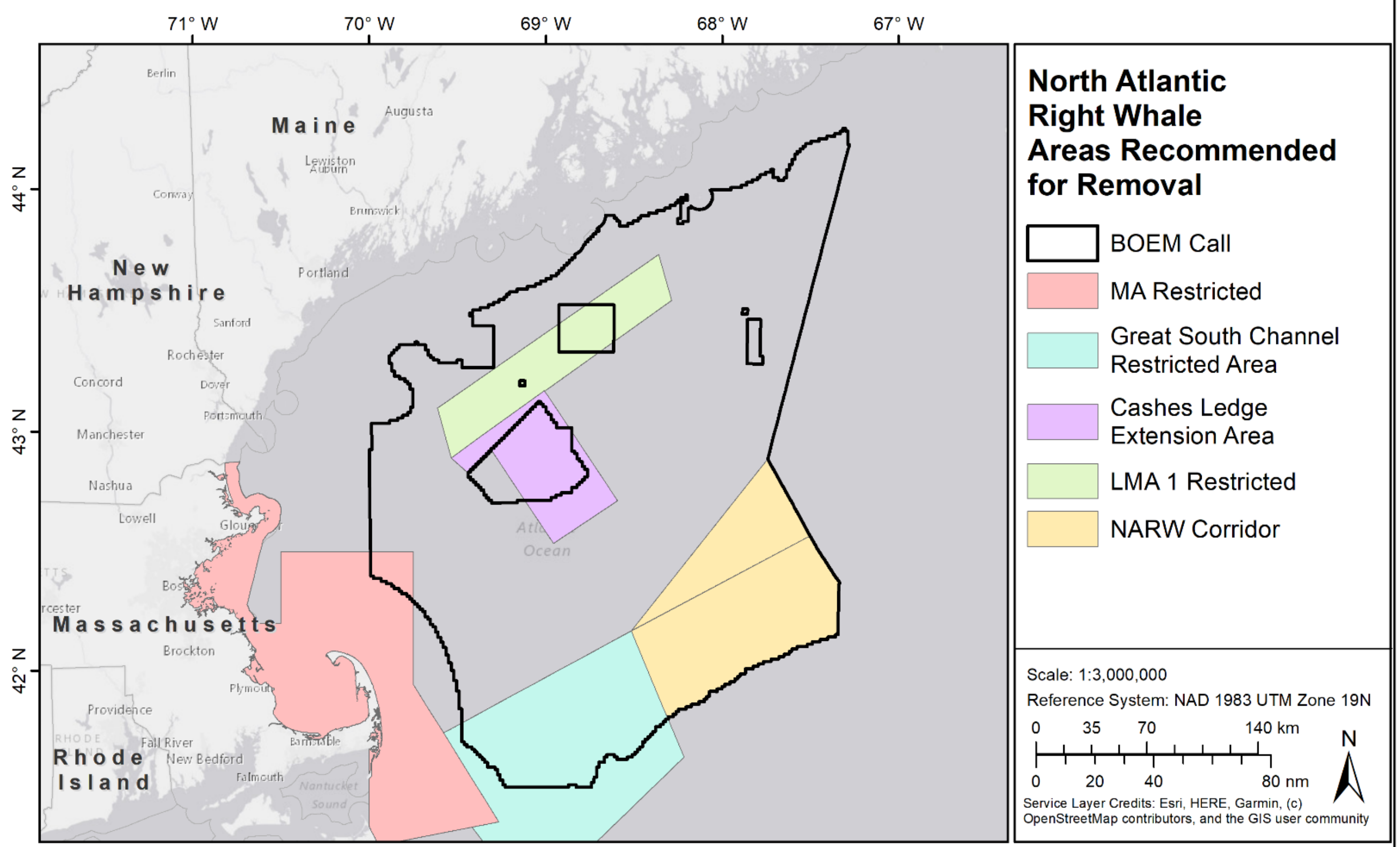


Figure 3.3 National Marine Fisheries Service North Atlantic Right Whale data layer implemented within the relative suitability. analysis.



Massachusetts Restricted Areas. NOAA National Marine Fisheries Service. 2022.
Great South Channel Restricted Area. NOAA National Marine Fisheries Service. 2022.
Cashes Ledge Extenstion Area. NOAA National Marine Fisheries Service. 2023.
Lobster Management Area 1 Restricted Area. NOAA National Marine Fisheries Service. 2022.
North Atlantic Right Whale Corridor. NOAA National Marine Fisheries Service. 2023.

Figure 3.4 National Marine Fisheries Service North Atlantic Right Whale areas recommended for removal data layer implemented within the relative suitability analysis.

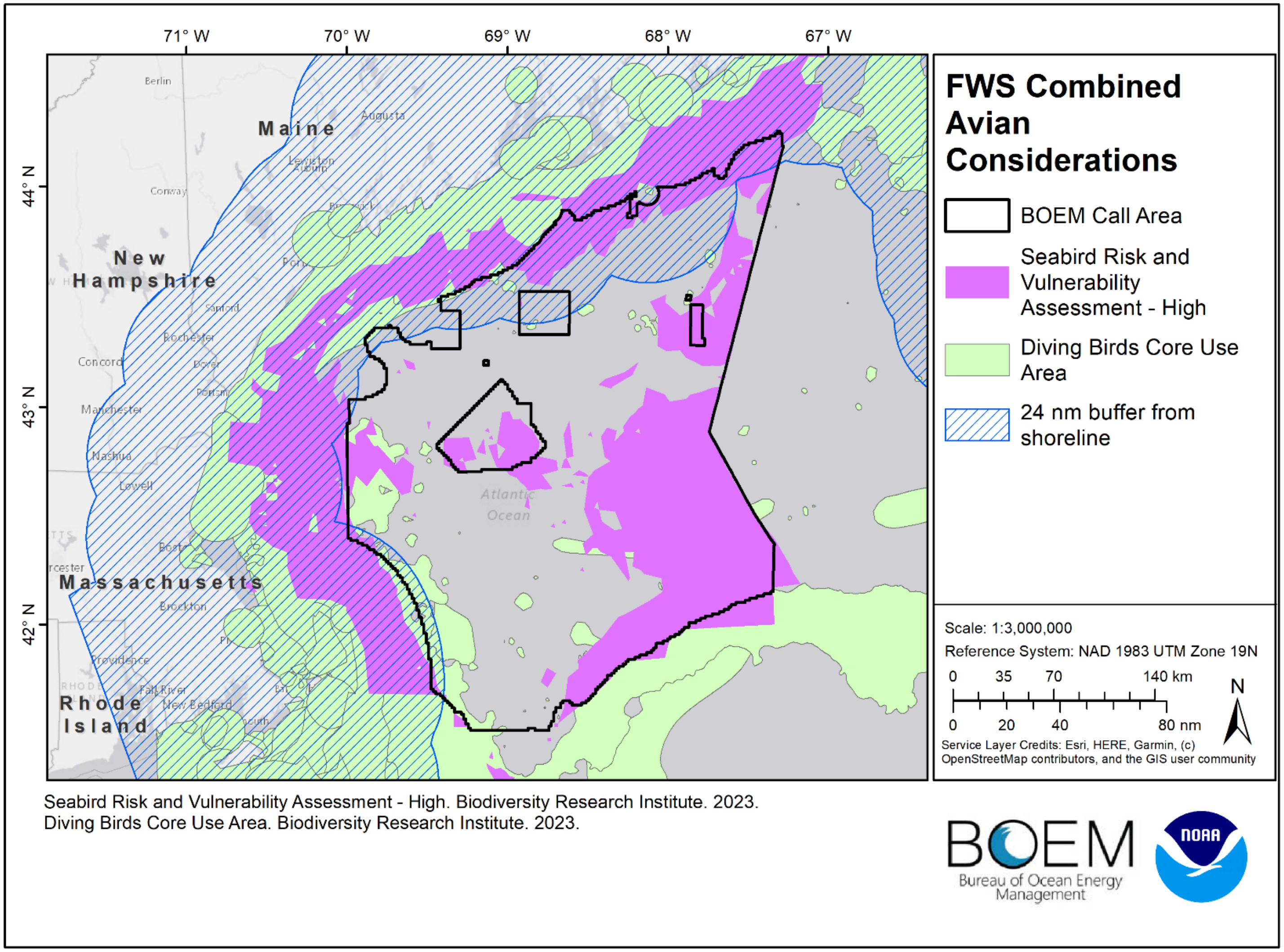


Figure 3.5 U.S. Fish and Wildlife combined avian data layer implemented within the relative suitability analysis.

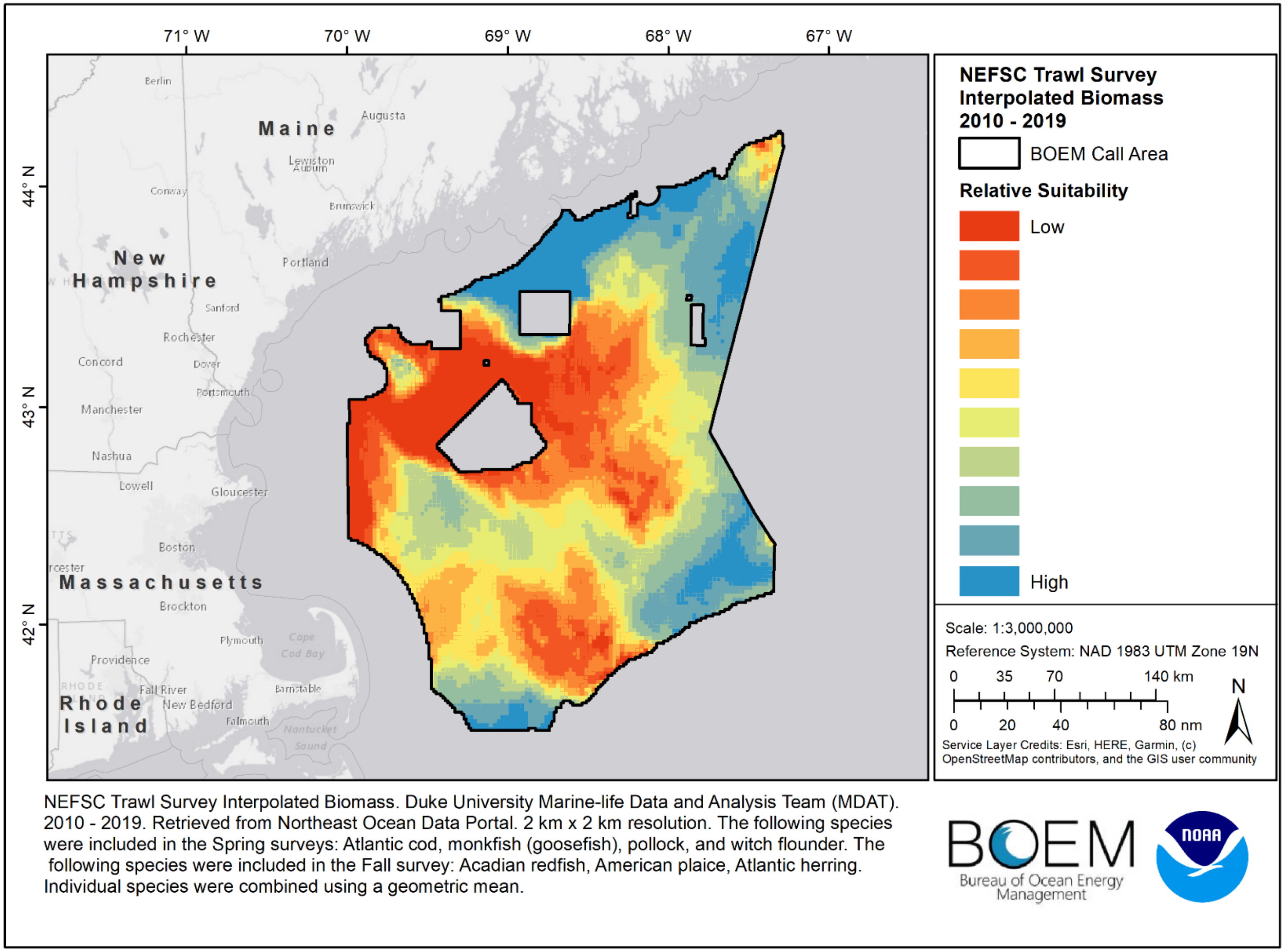


Figure 3.6. New England Fishery Management Council Trawl Survey Interpolated Biomass 2010 - 2019 data utilized in the relative suitability model. The red/orange colors represent areas of lower suitability (higher concentrations of biomass), while the color blue indicates areas of higher suitability (lower concentrations of biomass).

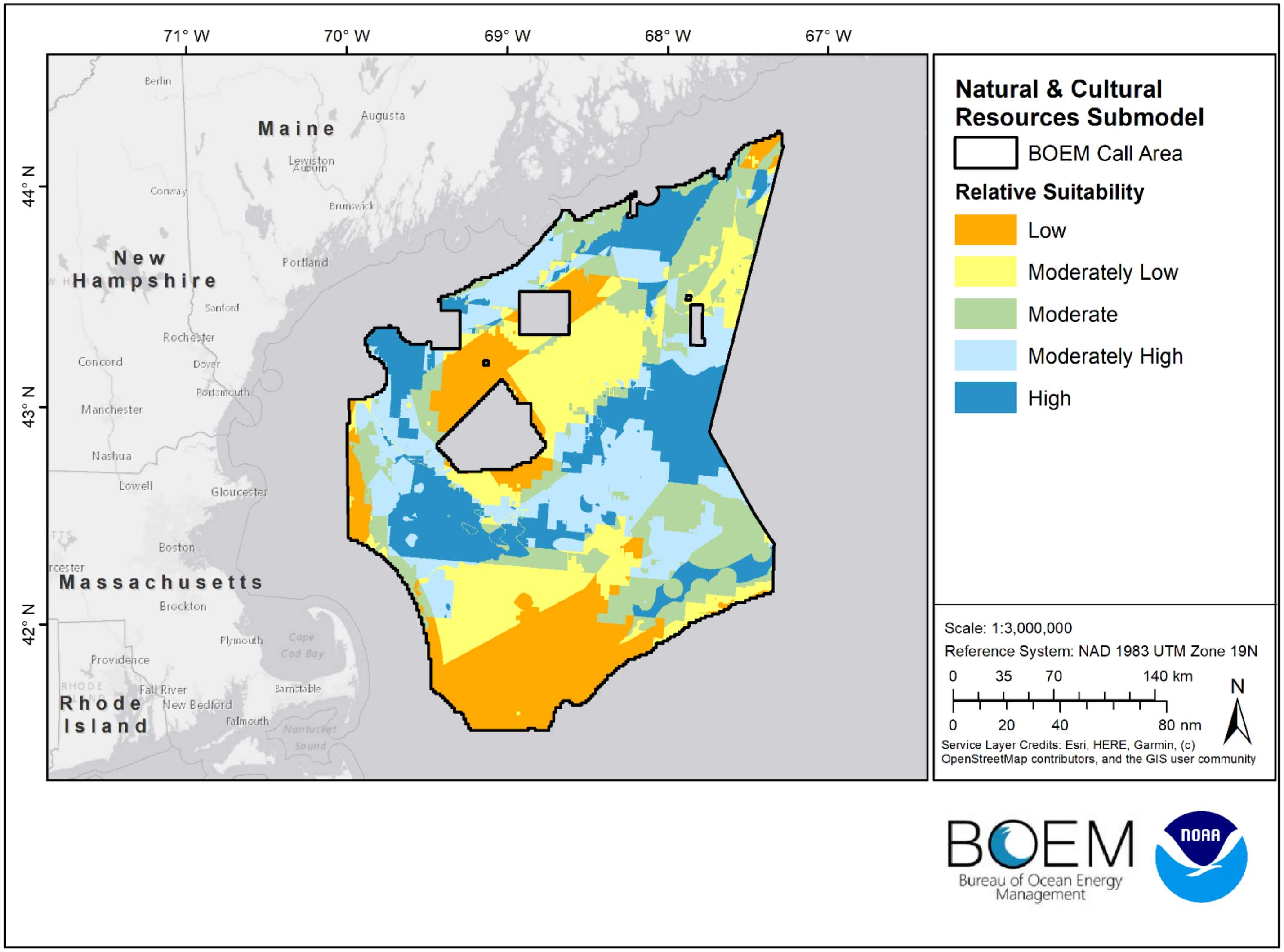


Figure 3.7. Natural and cultural resources submodel utilized in the relative suitability model. The red/orange colors represent areas of lower suitability, while the color blue indicates areas of higher suitability.

3.1.2. Industry and Operations

Industry activity in and around the Call Area was spatially examined (Table 3.2).

3.1.2.1. Industry and Operations Considerations

NMFS's fishery-independent surveys in the region were considered, with areas that have more fishing surveys given a lower score than areas with less fishing surveys (Figure 3.8). A total of 13 survey footprints were used including: AMAPPS aerial survey, bottom trawl fall survey, bottom trawl spring survey, EcoMon survey (4 occurrences), CRB bottom longline survey, North Atlantic right whale survey, shrimp survey, ocean quahog survey, scallop/shellfish survey, and surfclam survey.

Information on other industry and operations considerations were included in the suitability model such as the location of wrecks and obstructions with a 500 ft setback, NEXRAD station and their corresponding moderate impact zone (35 – 70 km from station location), aids to navigation locations with a 500 m setback, and the U.S. Coast Guard draft Maine, New Hampshire, and Massachusetts Port Access Route Study (MNMPARS) fairways (Figure 3.9). As the proposed safety fairways have not been finalized, BOEM will continue coordinating with USCG throughout both agencies' processes, including during any future development of any proposed lease areas.

3.1.2.2. Automated Vessel Identification System Transit Data

Vessel traffic data, or Automatic Identification System (AIS) data, are collected in real time by the USCG using very high frequency (VHF) maritime-band transponders, which are capable of handling over 4,500 reports per minute and updates as often as every two seconds (USCG 2020). AIS uses Self-Organizing Time Division Multiple Access technology, allowing for these high broadcast rates and ensuring reliable ship-to-ship operations (USCG 2020). AIS collects data on location and vessel characteristics (e.g., speed over ground, draft, beam, length, vessel type, maneuvering information) and was initially developed for ship collision avoidance (Marine Cadastre 2021; USCG 2020). In this study, AIS data were used as an approximation for potential transit conflicts with Draft WEAs. Specifically, AIS data from 2015 to 2022 were analyzed to determine the sum of vessel transits (i.e., vessel traffic) (Figure 3.10). Vessel types included in the AIS data are: tanker, cargo, passenger (e.g., cruise ships), ferries, tug and tow, pleasure and sailing, military and other vessels (e.g., first responders)[14].

3.1.2.3. EPA Mandatory Class 1 Federal Areas

Under the US Environmental Protection Agency Prevention of Significant Deterioration (PSD) program, all international parks, national wilderness areas and nation memorial parks that exceed 5,000 acres, and of national parks that exceed 6,000 acres are designated as mandatory federal Class I areas in order to preserve, protect and enhance air quality. Acadia National Park is designated as a mandatory federal Class 1 area and a portion of the Call Area does fall within a 50 km and 100 km setback from the park (Figure 3.11). These overlapping areas were included in the suitability model and assigned a score of 0.1 for the 50 km setback and a 0.2 to 0.9 linear gradient score for the 50 km to 100 km setback.

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14 https://www.google.com/url?q=https://www.navcen.uscg.gov/pdf/AIS/AISGuide.pdf&sa=D&source=editors&ust=1624640106728000&usg=AOvVaw0t9-X9iMuk-lF3VbUCDHf1

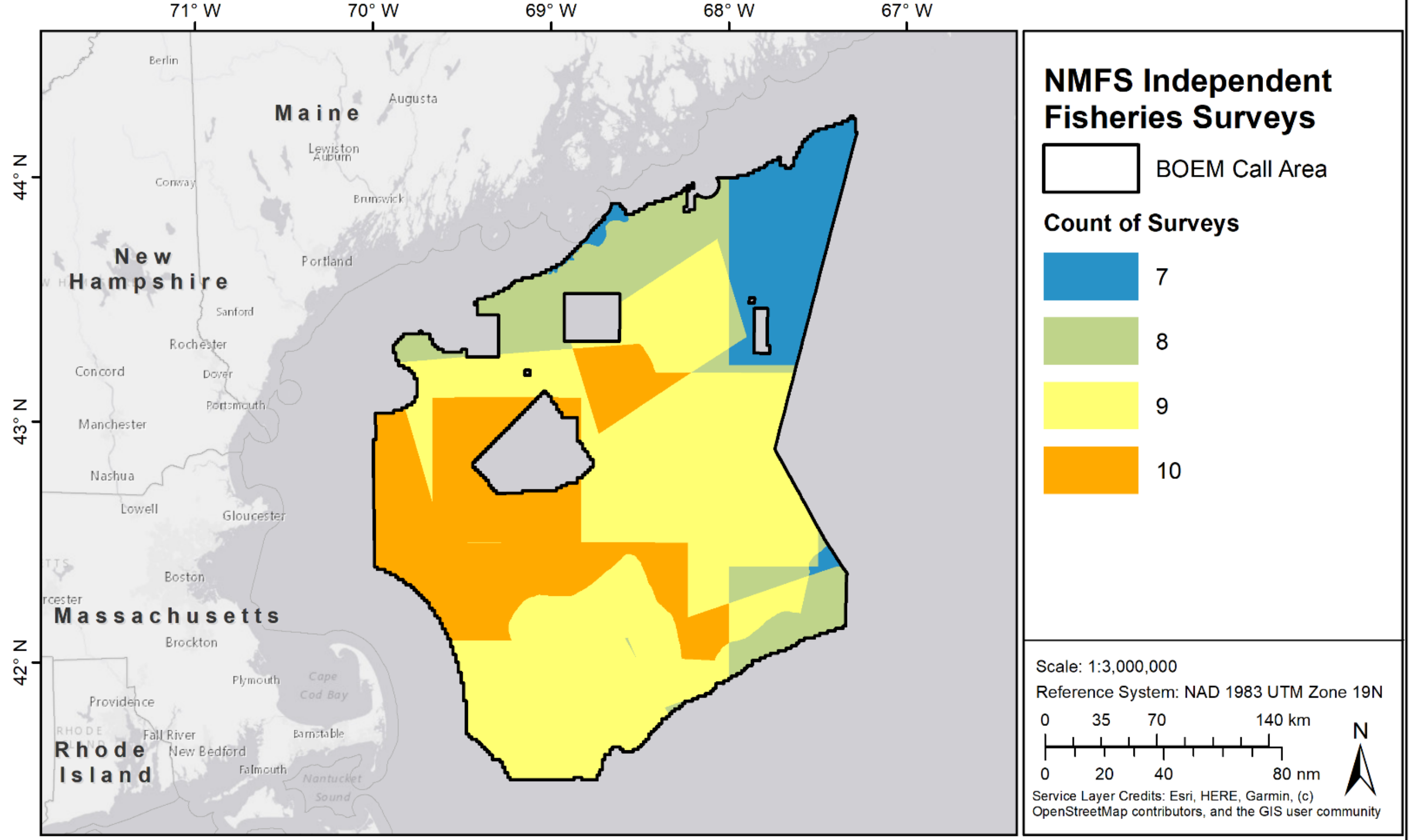
3.1.2.4. National Security

BOEM decided to use four equally weighted submodels, shifting Department of Defense (DoD) Clearinghouse's primary concern (i.e., Warning Area 103) to the Industry & Operations submodel, rather than employing a standalone National Security submodel. BOEM made this decision after reviewing preliminary model results and seeing that Warning Area 103 was avoided under every scenario under consideration (likely because it overlaps with several other prominent conflicts, such as LMA1 and Platts Bank). Removal of this submodel, while still avoiding Warning Area 103, allowed BOEM to afford additional weight to the other submodels and conflicts. Warning Area 103 was included in the Industry and Operations submodel and assigned a score of 0.1 (Figure 3.12).

Suitability results for the industry and operations submodel are presented in Figure 3.13

Table 3.2. Industry and operations submodel data layers included in the relative suitability analysis, the score assigned to each dataset, and the percent overlap.

Data Layer	Score	Percent Overlap
NMFS's Fisheries-Independent Surveys (13 total surveys)	Z-Membership Function	100%
Wrecks and Obstructions – 500 ft setback	0.5	0.004%
NEXRAD Stations Moderate Impact (35 – 70 km)	0.5	0.02%
Aids to Navigation (beacons and buoys) - 500 m setback	0.5	0.001%
AIS Vessel Traffic All Vessels 2015 - 2022	Z-Membership Function	100%
USCG Draft MNM PARS Fairways	0.5	16.5%
EPA Mandatory Class 1 Federal Areas - 50 km and 100 km setback	0.1 for 50 km setback 0.2 - 0.9 linear gradient for 50 – 100 km setback	6.4% 25.5%
Special Use Airspace Warning Area 103 (W103)	0.1	2.7%



NMFS Independent Fisheries Surveys. NOAA National Marine Fisheries Service. 2023. Survey footprints include: EcoMon 1-4, Bottom Trawl Spring/Fall, AMAPPS Aerial, CRB Bottom Longline, North Atlantic Right whale, Shrimp, Surfclam, Scallop-Shellfish, and Ocean Quahog.

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Figure 3.8. A count of overlapping NMFS Fisheries-Independent Surveys for the Call Area implemented within the relative suitability analysis

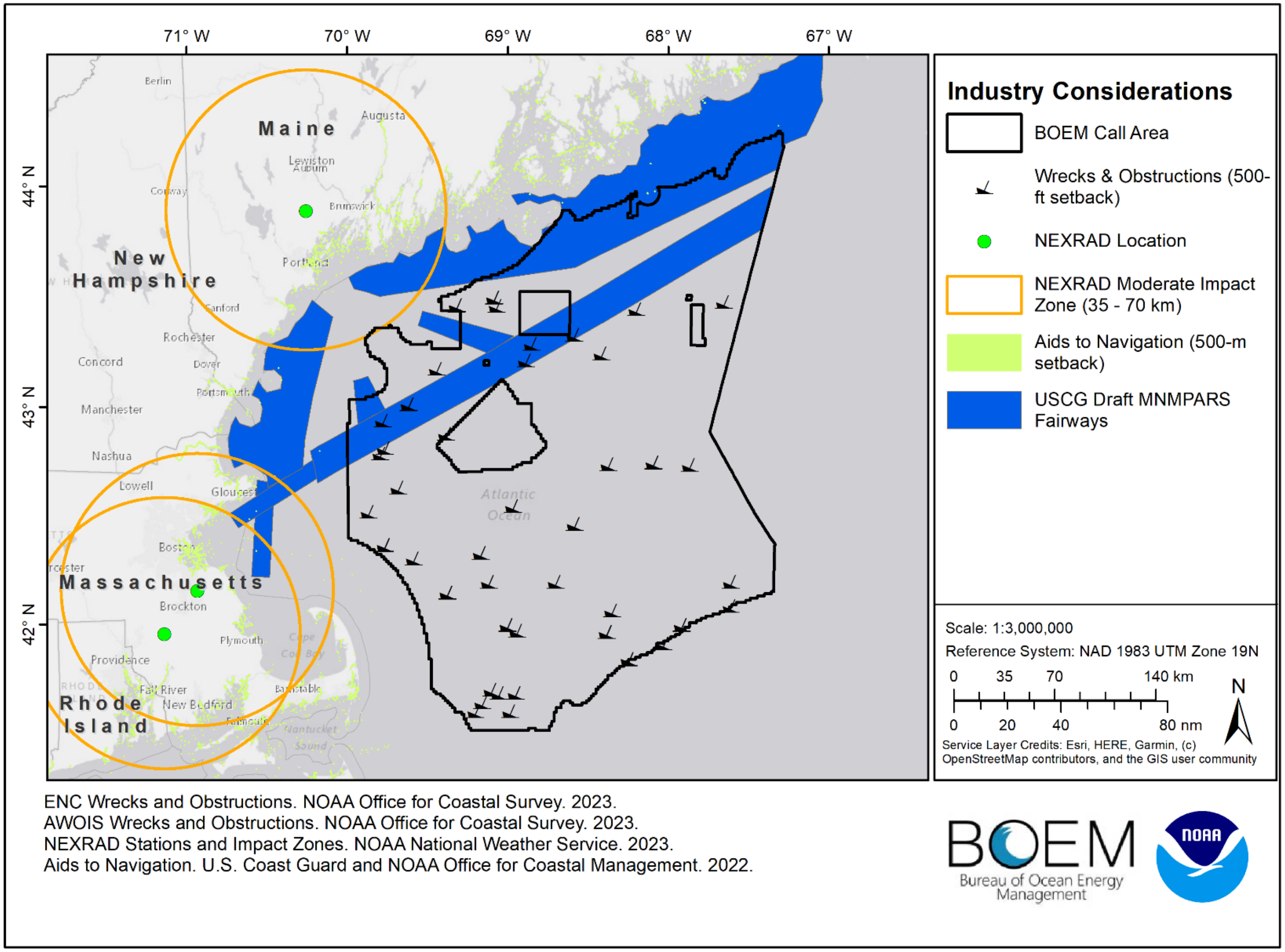
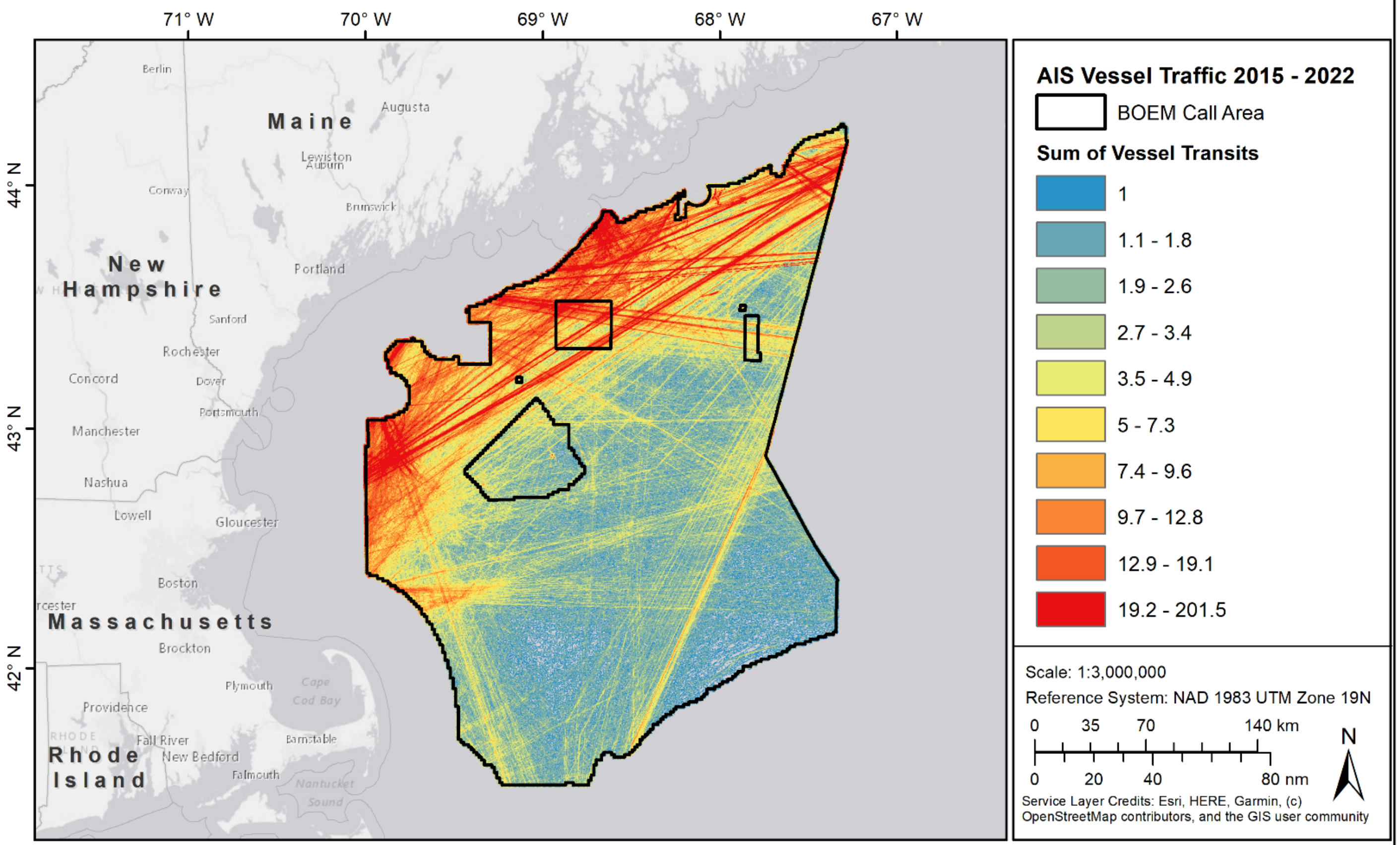


Figure 3.9. Industry considerations for the Call Area implemented within the relative suitability analysis. Considerations include wreck and obstructions, NEXRAD locations and impact zones, aids to navigation, and the USCG MNMPARS fairways.



Automatic Identification System (AIS) Vessel Transit Counts. U.S. Coast Guard Navigation Center. 2015 - 2022. Vessel types include: cargo, military, other, passenger, pleasure and sailing, tanker, and tug and tow. Fishing vessel tansits were removed.

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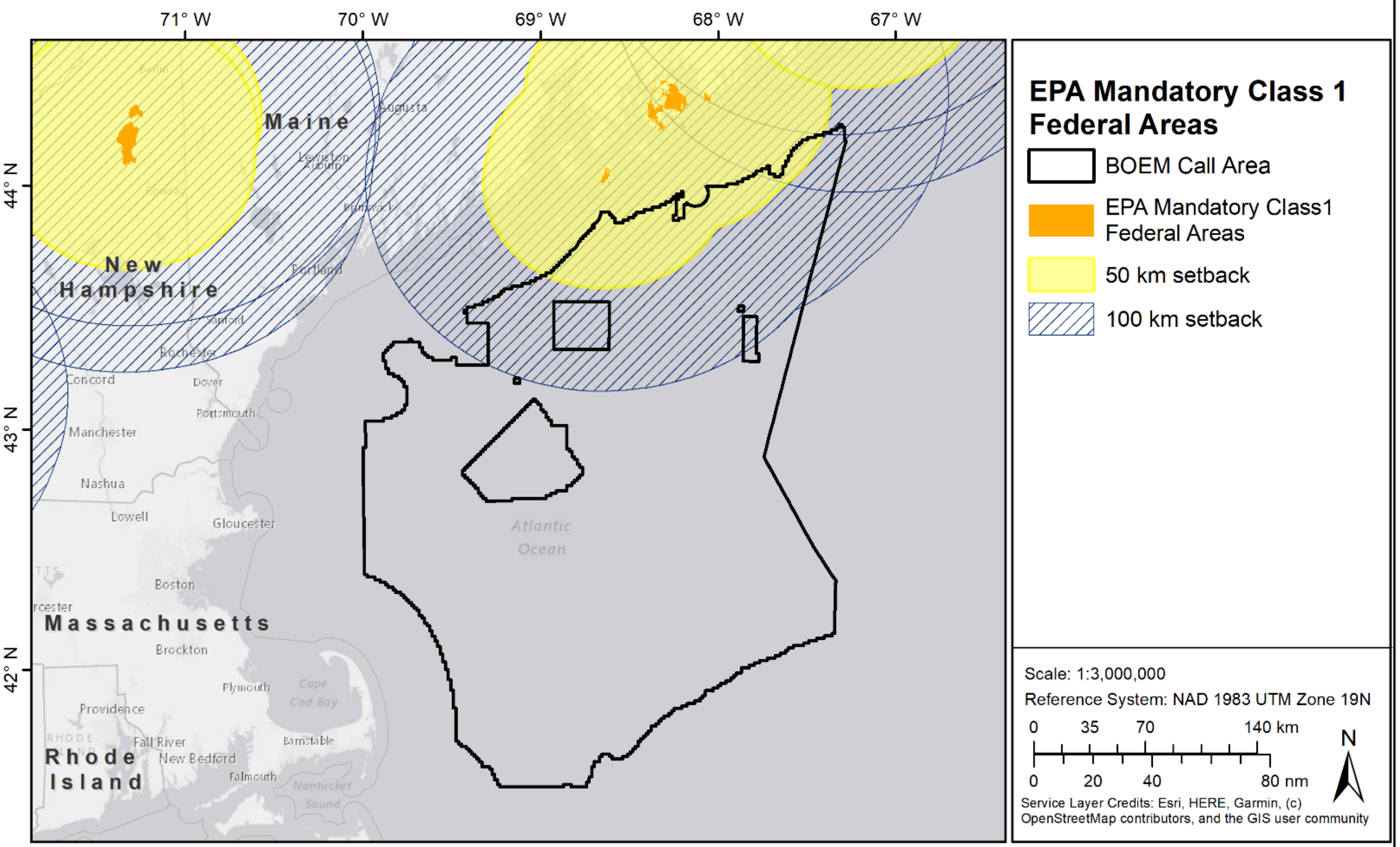
Figure 3.10. Automatic Identification System sum of vessel transits for all vessel types except fishing, 2015 – 2022.



EPA Mandatory Class 1 Federal Areas. U.S. Environmental Protection Agency. 2023.

Figure 3.11. EPA Mandatory Class 1 Federal Areas implemented within the relative suitability analysis.

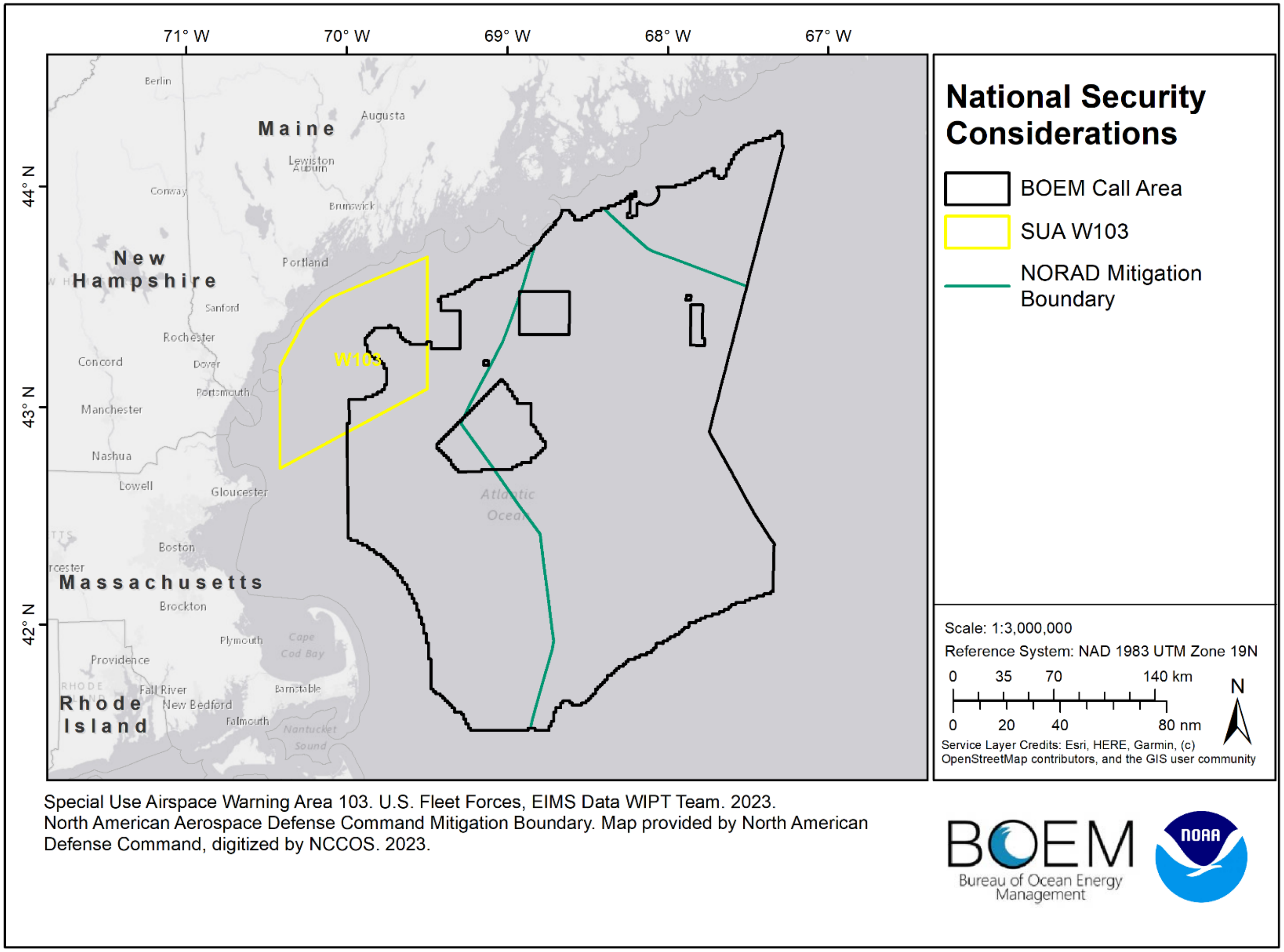


Figure 3.12. Special Use Airspace Warning Area 103 implemented within the relative suitability analysis.

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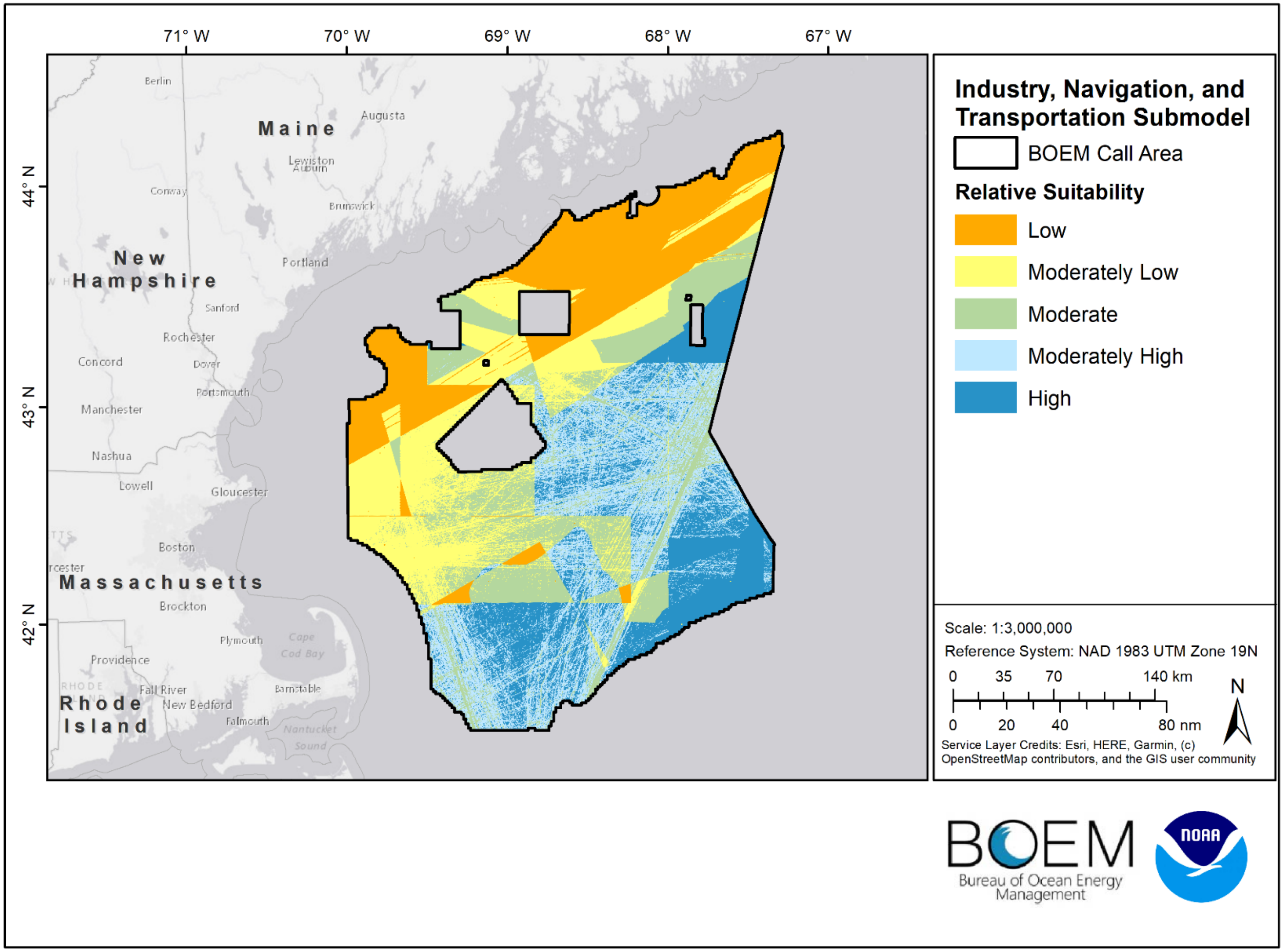


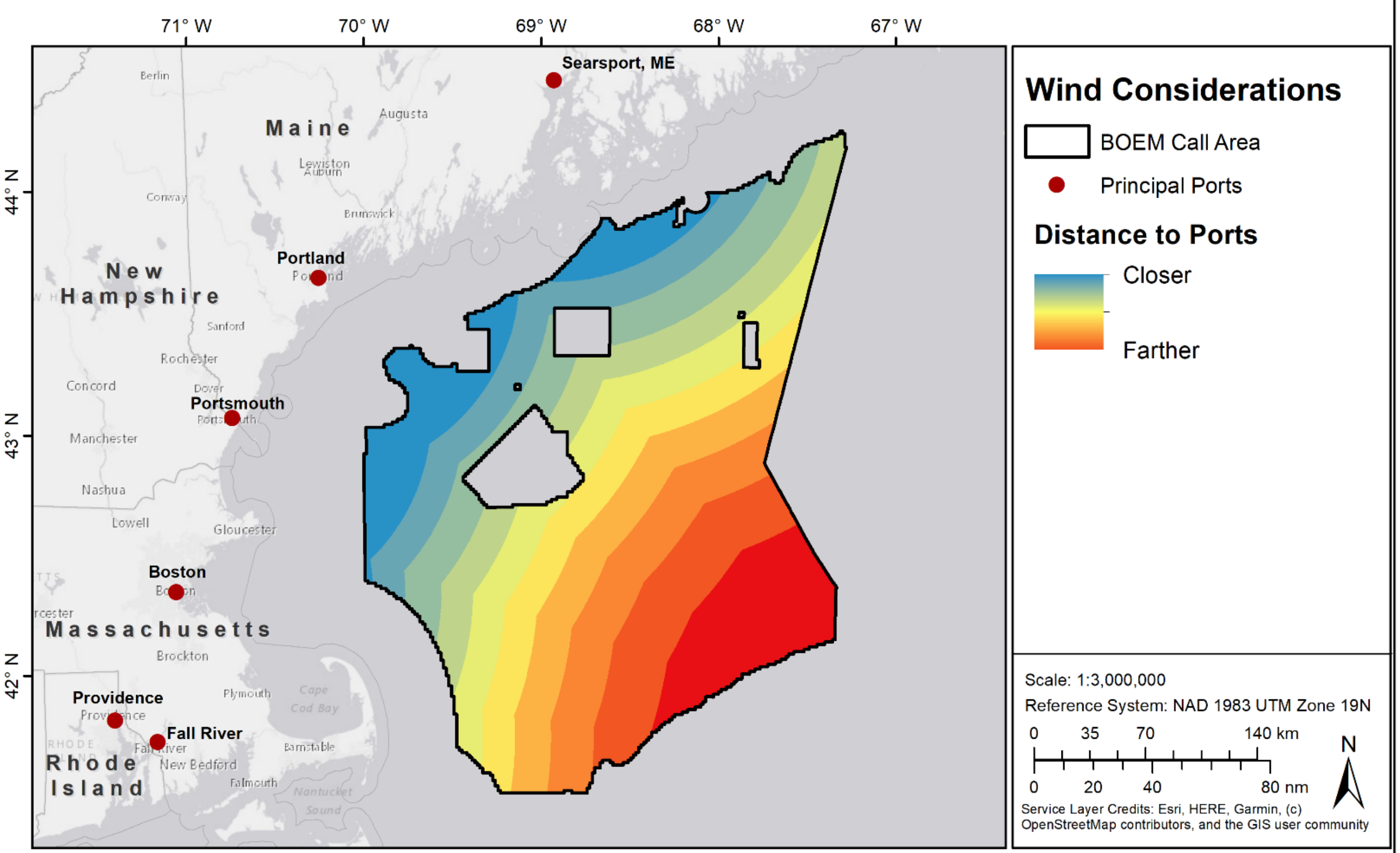
Figure 3.13. Industry and operations submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

3.1.3. Wind

Being closer to principal ports, which are the 150 largest ports based on annual tonnage, should aid in use of available port infrastructure needed for the deployment and installation of wind farms (Figure 3.14). Call developer nominations represent areas where offshore wind developers are interested in building infrastructure. An analysis was done to determine areas of overlapping interest from multiple developers (Figure 3.15). The closer to shore and Points of Interconnection a WEA is, the less fuel and travel time required and the lower cost of running transmission lines to land (Figure 3.16). In terms of wind speed, the greater mean wind speed is better to ensure consistent and continuous operation. Greater wind speeds occur farther offshore as you move east within the Call Area (Figure 3.17). Suitability results for the wind submodel are presented in Figure 3.18.

Table 3.3. Wind submodel data layers included in the relative suitability analysis, the score assigned to each dataset, and the percent overlap.

Data Layer	Score	Percent Overlap
Distance to Ports (10%)	Linear Function (Closer to port is better)	100%
Call Developer Nominations (50%)	Linear Function (More nominations is better)	100%
Distance to Points of Interconnection (20%)	0 – 75 miles linear gradient	100%
NREL 20-Year Mean Wind Speed (20%)	Linear Function (Greater wind speed is better)	100%



Principal Ports. NOAA Office for Coastal Management. 2019. Principal Ports are the top 150 U.S. ports based upon total annual tonnage. Variation in annual tonnage at a port may result in exclusion or inclusion on the Principal Port list. Distance is calculated using a linear function or "as the crow flies".

Figure 3.14. Distance to ports included in the wind submodel.

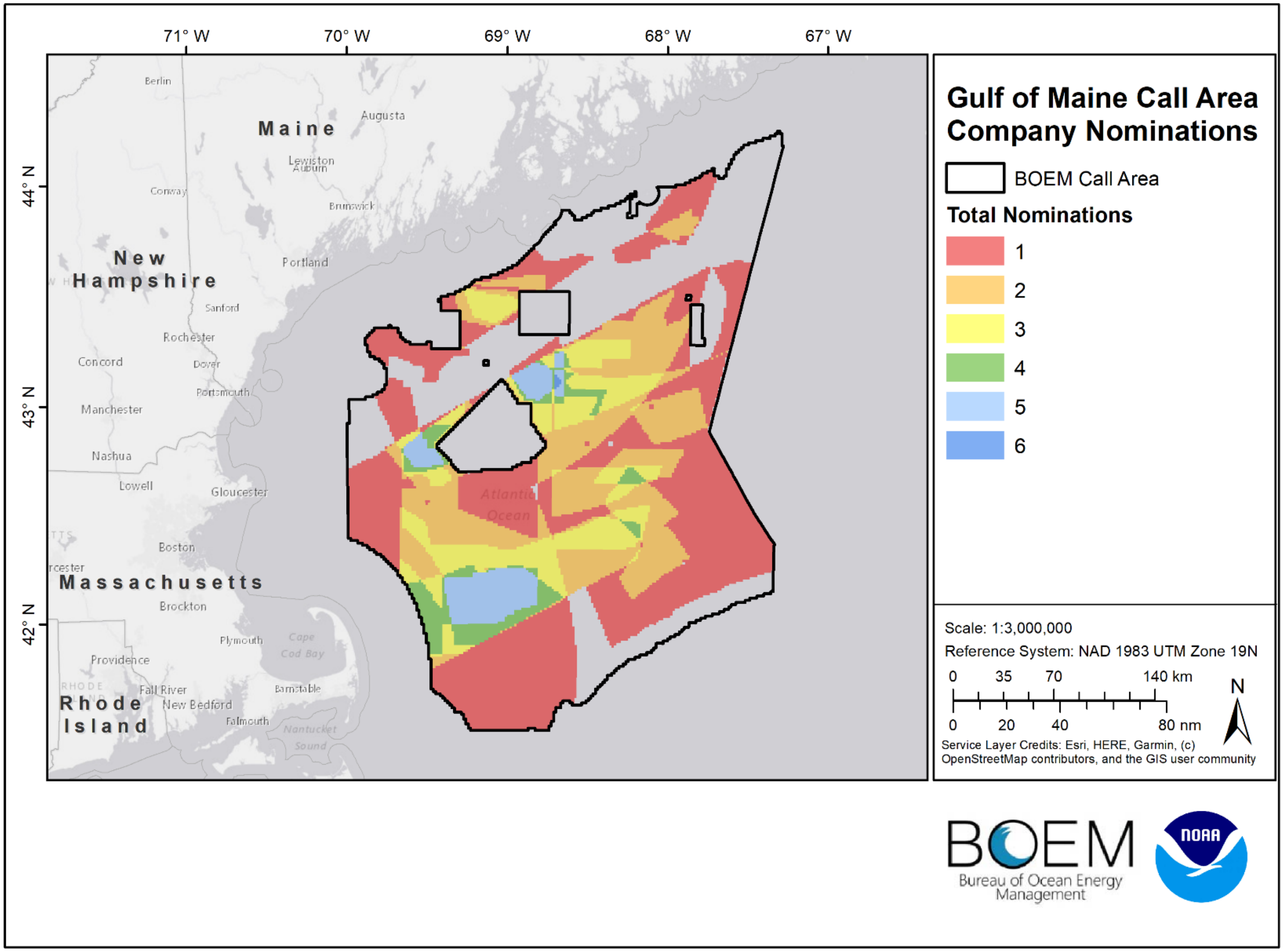


Figure 3.15. Gulf of Maine Call Area Company Nominations included in the wind submodel.

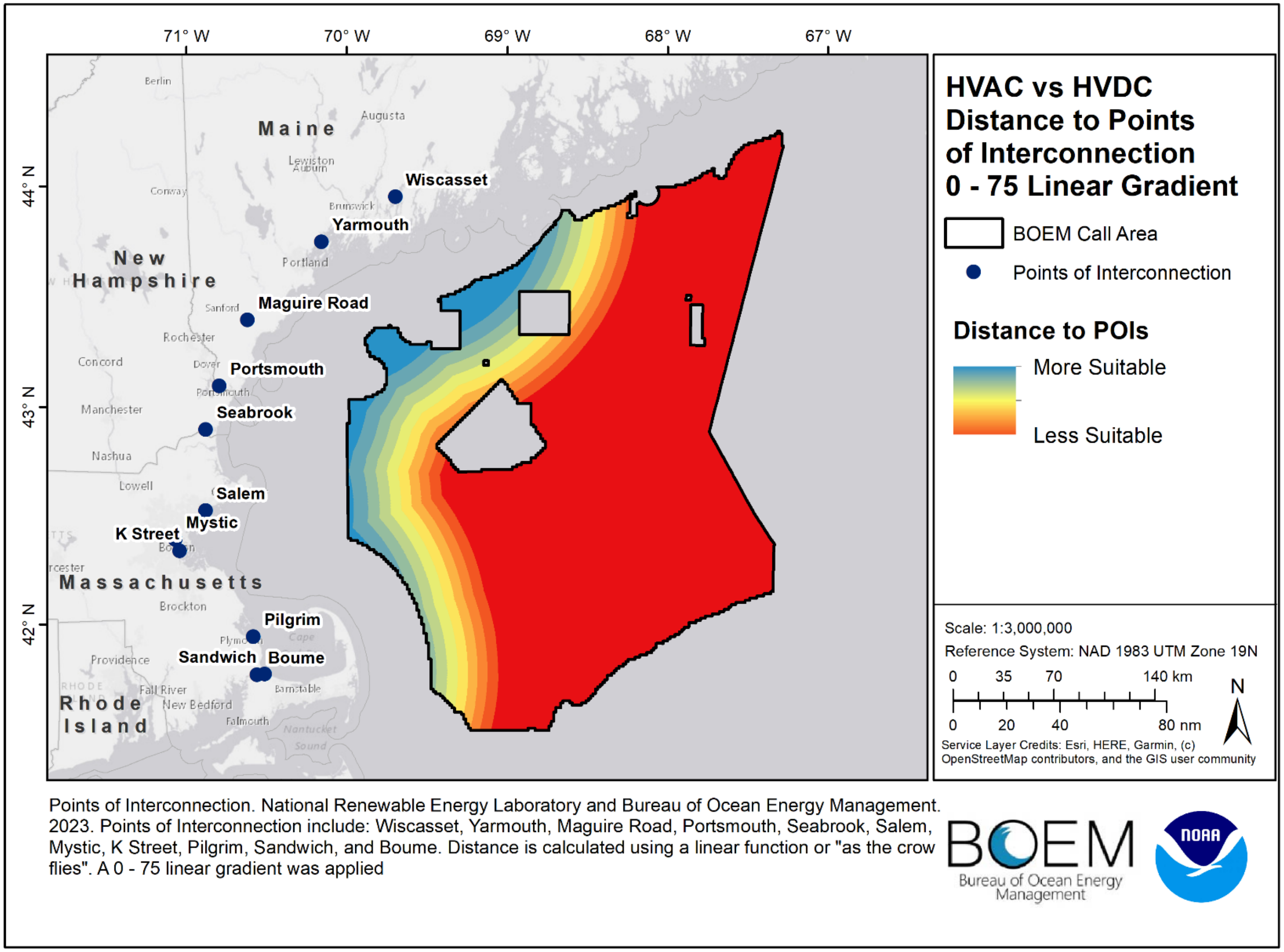


Figure 3.16. Distance to Points of Interconnection with a 0-to-75-mile linear gradient included in the wind submodel.

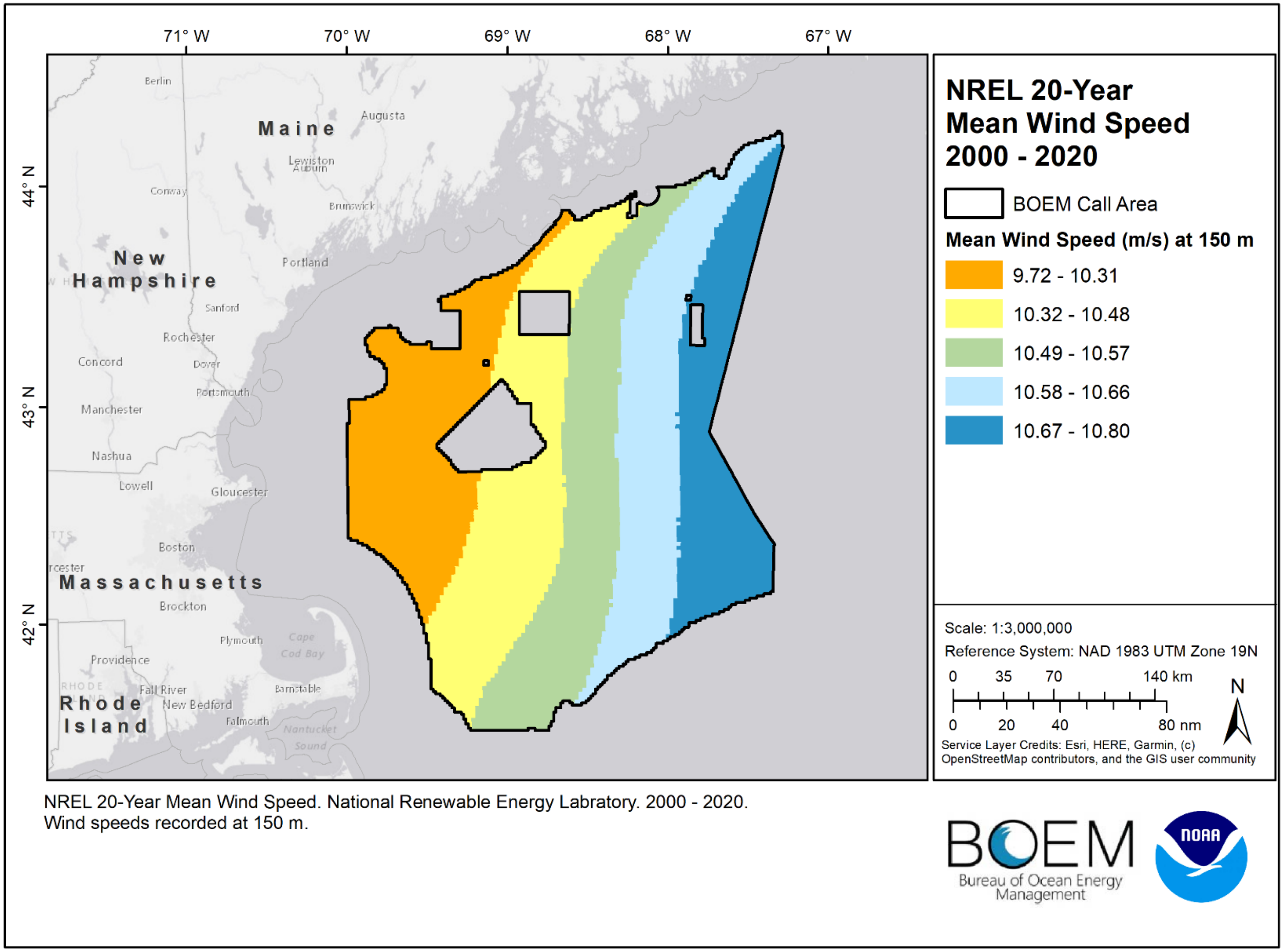


Figure 3.17. NREL 20-Year Mean Wind Speed at 150 m (2000 – 2020) included in the wind submodel.

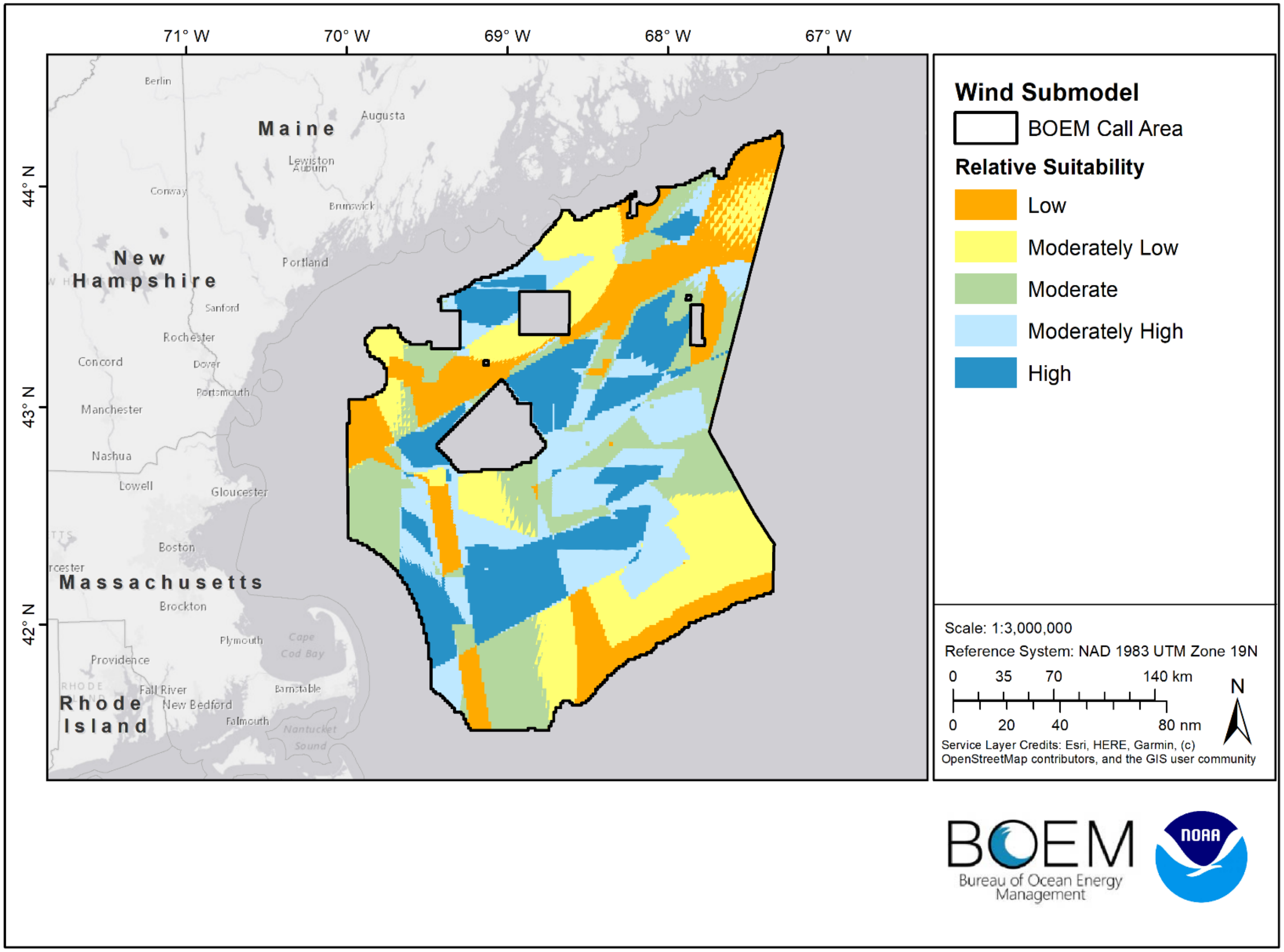


Figure 3.18. Wind submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

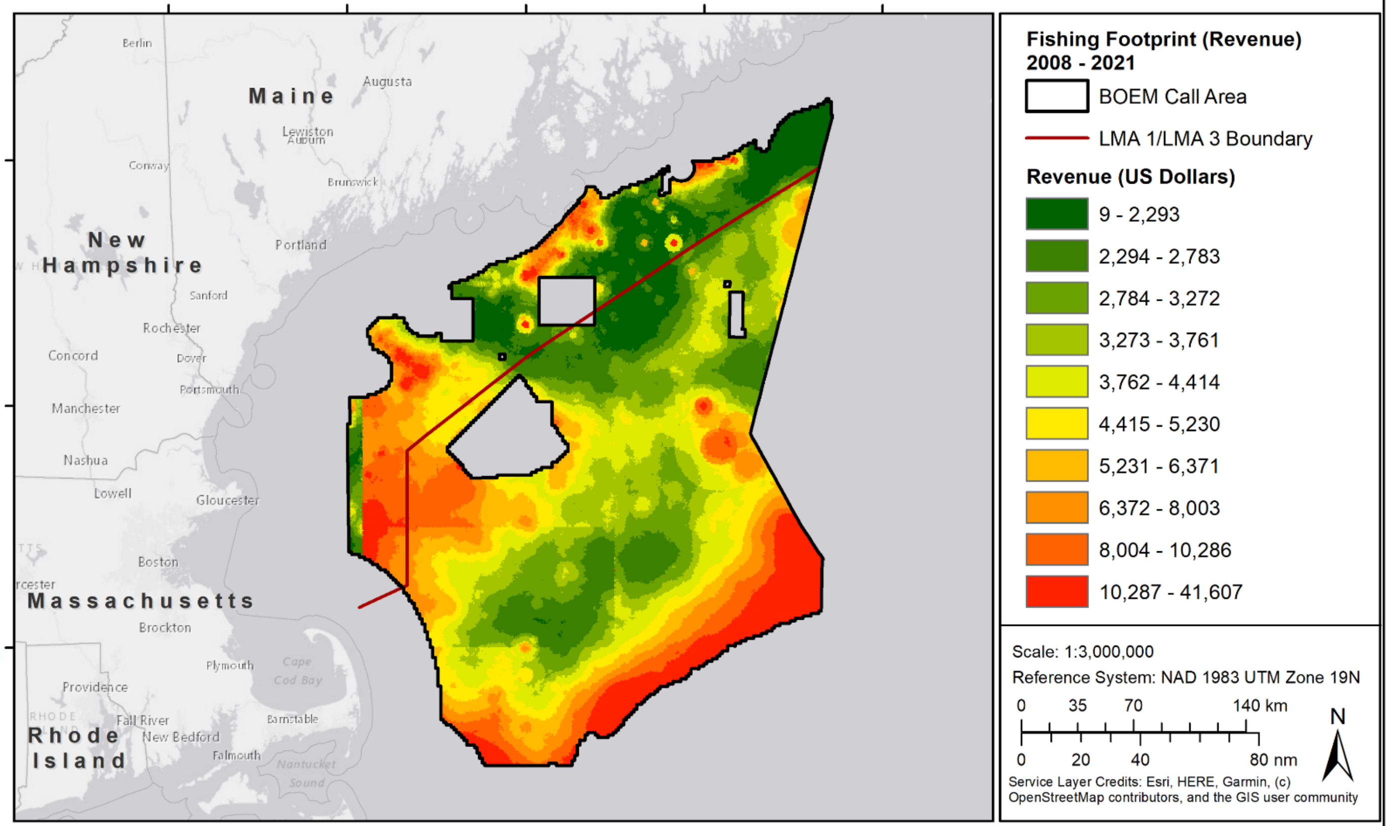
3.1.4. Fisheries

Both recreational and commercial fisheries data were included in the fisheries submodel (Table 3.4). The highest level of fishing effort is generally seen in the far western portion of the Call Area (Wilkinson Basin), as well as the southernmost portion of the Call Area (Georges Bank). Additional areas of high fishing effort occur along the northern portion of the Call Area and within Lobster Management Area 1 (Figures 3.19 - 3.23), including historic and current Tribal fishing activity. Known fisheries habitats were also included in the suitability model (Figure 3.24). Suitability results for the fisheries submodel are presented in Figure 3.25.

Table 3.4. Fisheries submodel data layers included in the relative suitability analysis, the score assigned to each dataset, and the percent overlap.

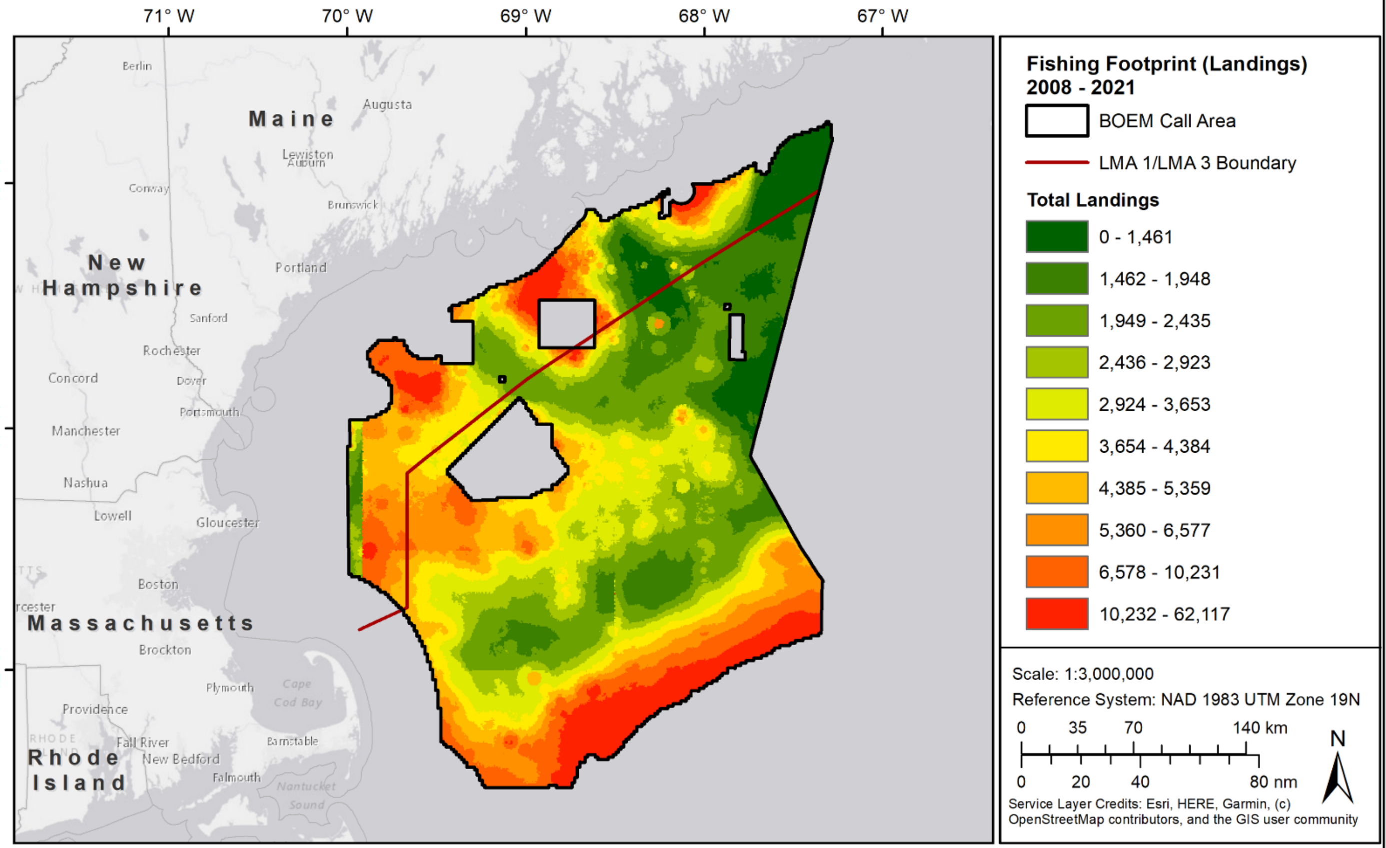
Data Layer	Score	Percent Overlap
Fishing Footprint Raster Data (revenue) 2008 - 2021	Z-Membership Function	100%
Fishing Footprint Raster Data (landings) 2008 - 2021	Z-Membership Function	100%
VMS Data 2009 - 2021	Z-Membership Function	100%
Charter/Party VTR 2008 - 2020	Z-Membership Function	98.7%
HMS Combined Layer: Large Pelagic Survey Trip Points (HMS/Recreational) 2011 – 2021 – 10 mi setback Maine DMR Highly Migratory Species Fishing Trip Data	 Z-Membership Function Z-Membership Function	100%
Fisheries Considerations: Lobster Management Area 1 Platts Bank Georges Bank Western Gulf of Maine Closure	 0.1 0.1; 0.1 to 0.5 from edge of Platts Bank to 20 km setback 0.1 for 10 km from 140 isobath; 0.1 to 0.5 from 10 km – 20 km from 140 m isobath 0.1 to 0.5 from edge of W GoME Closure to 20 km	 25.0% 4.4% 10.7% 4.2%

Data Layer	Score	Percent Overlap
	setback	
Jeffreys Bank Habitat Management Area (HMA)	0.1 to 0.5 from edge of Jeffreys Bank HMA to 20 km setback	7.1%
HMAs considered, but not adopted by NEFMC (e.g., Toothaker Ridge, Large Eastern Maine proposed HMA, Wildcat Knoll)	0.5 for proposed HMAs	3.5%
Closed Area II	0.1 to 0.5 from edge of Closed Area II to 20 km setback	1.0%
Davis Swell, Parker Ridge, Three Dory Ridge	0.1 for area; 0.1 to 0.5 from edge to 20 km setback	14.0%
Jordan Basin Dedicated Habitat Research Area	0.1 to 0.5 from edge of JBDHRA to 20 km setback	5.3%
Cashes Ledge	0.1 to 0.5 from edge of Cashes Ledge to 20 km setback	5.4%



Fishing Footprint Commercial VTR Modeled Logbook Data. NOAA National Marine Fisheries Service. 2008 – 2021. 500 m (0.25km²) resolution. Revenue displayed as total U.S. Dollars/0.25 km². Modeled data includes all gear types; bottom trawl, dredge, gillnet, lobster, longline, pots and traps, seine, and shrimp.

Figure 3.19. Fishing Footprint Revenue (2008 – 2021) included in the fisheries submodel.



Fishing Footprint Commercial VTR Modeled Logbook Data. NOAA National Marine Fisheries Service. 2008 – 2021. 500 m (0.25km²) resolution. Modeled data includes all gear types; bottom trawl, dredge, gillnet, lobster, longline, pots and traps, seine, and shrimp.

Figure 3.20. Fishing Footprint Landings (2008 – 2021) included in the fisheries submodel.

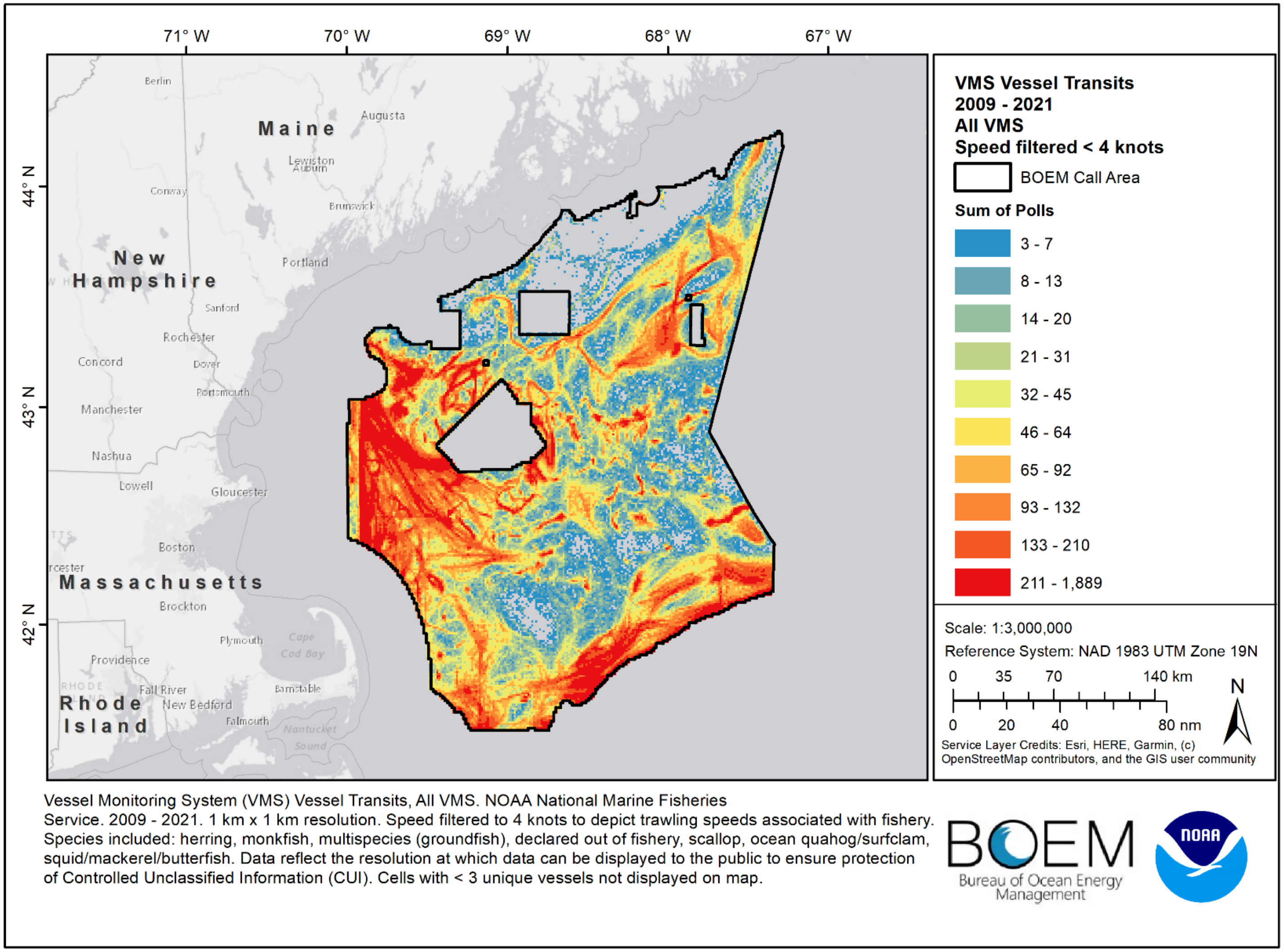
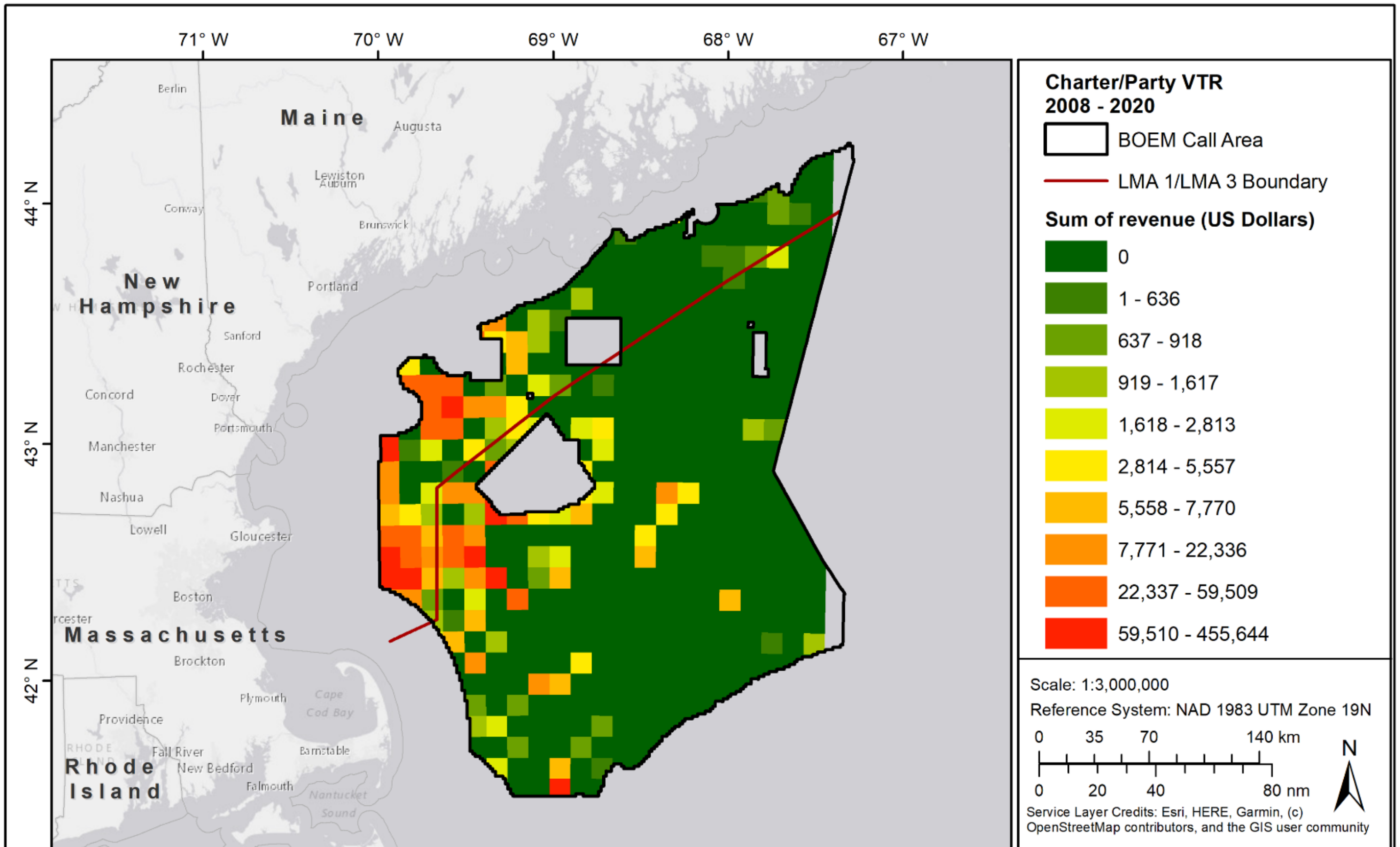


Figure 3.21. Vessel Monitoring System (VMS) Vessel Transits for all VMS fisheries speed filtered to less than 4 knots (2009 – 2021) included in the fisheries submodel.



Charter/Party VTR Data. NOAA National Marine Fisheries Service. 2008 – 2020. 193.2 km² resolution. Trip point locations are required to be submitted by any vessel issued GARFO charter party permit. Points represent best approximate position of that trip. Points are linked with survey derived angler price data to calculate revenue.

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Figure 3.22. Charter/Party VTR (2008 – 2020) included in the fisheries submodel.

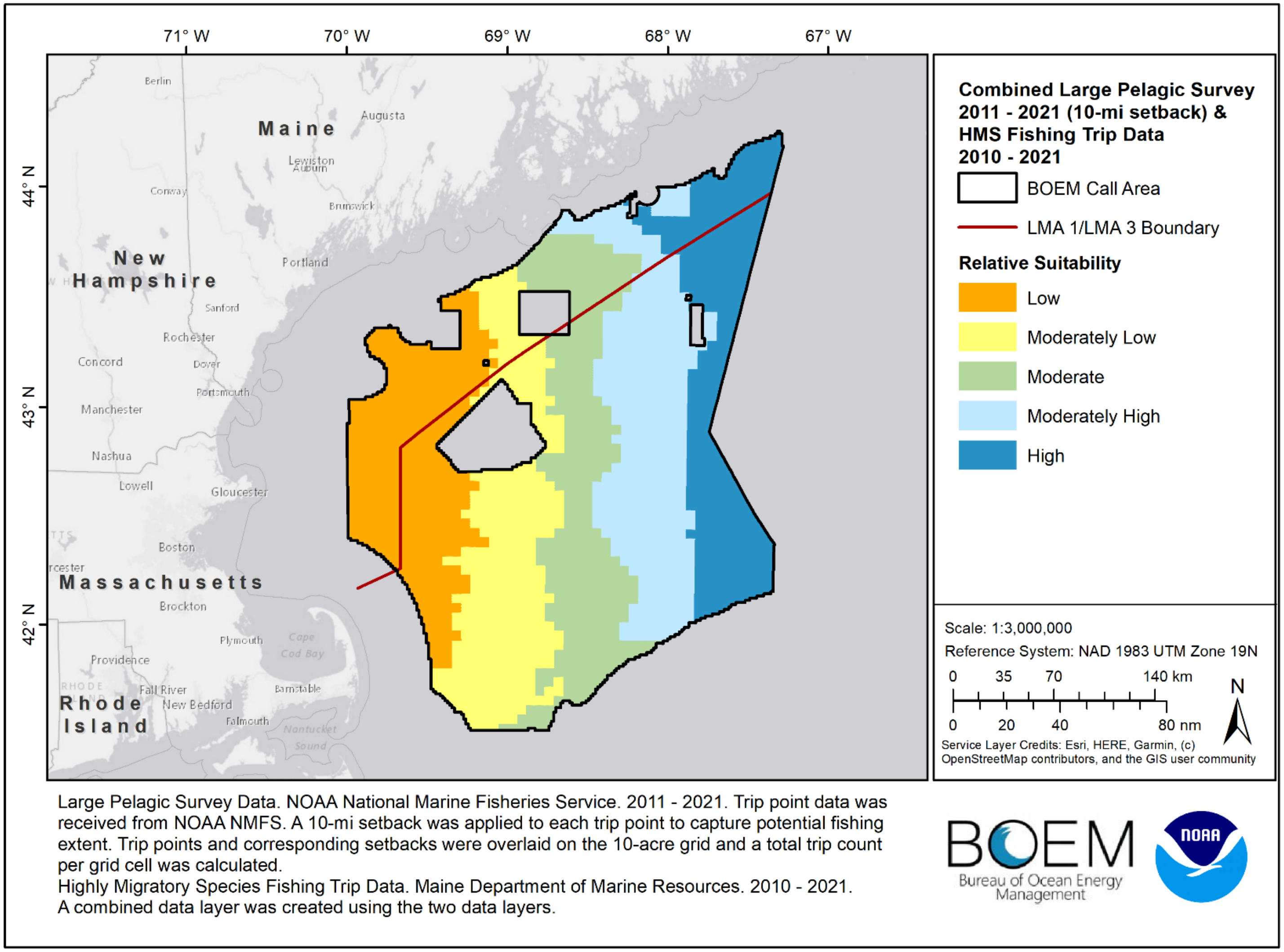


Figure 3.23. Highly Migratory Species combined layer included in the fisheries submodel. This layer includes Large Pelagic Survey 2011 – 2021 and Maine Department of Marine Resources Highly Migratory Species Fishing Trip data 2010 – 2021.

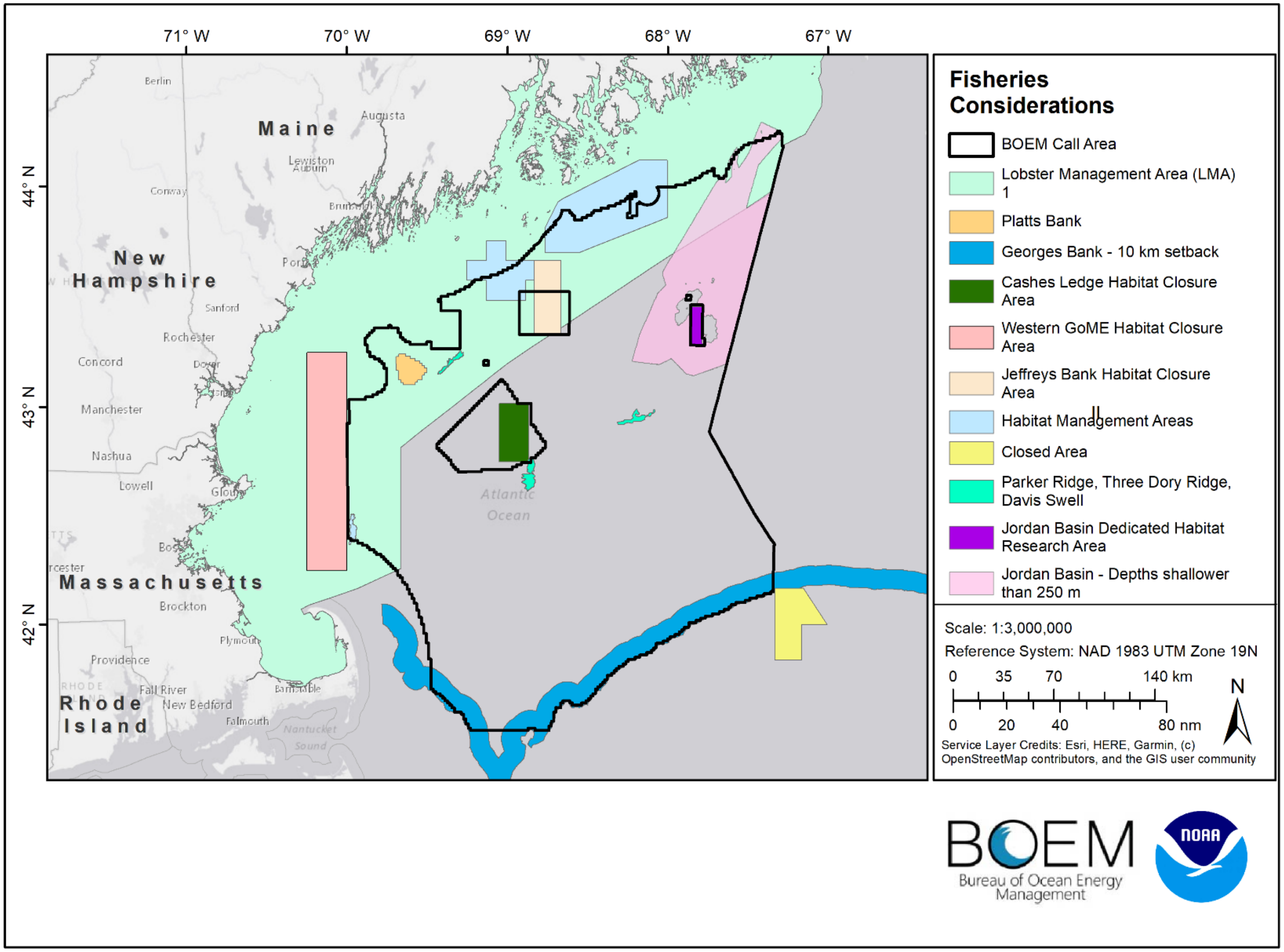


Figure 3.24. Fisheries habitat considerations included in the fisheries submodel.

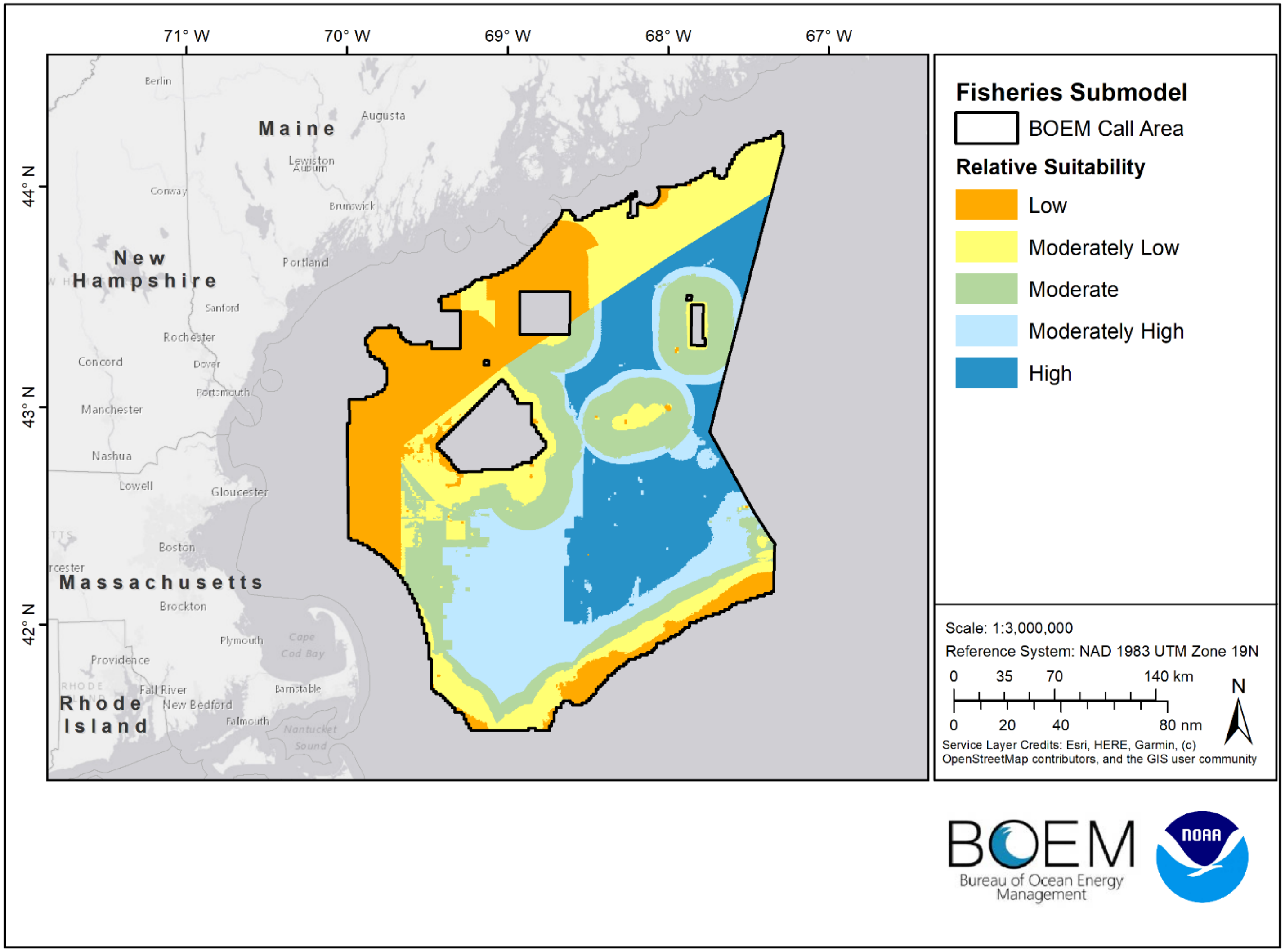


Figure 3.25 Fisheries submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

3.2. Final Suitability

The final suitability results for all submodels are presented in Figure 3.26. Suitable areas were found in the northern portion of the Call Area, as well as the central portion spanning from west to east. It is important to note that these suitability results are reflective of the planning objective to identify wind energy areas.

3.3. Cluster Analysis and WEA Options

The cluster analysis identified 3,341,873 ac of high-high clusters, which are groups of cells with high values that are statistically significant from other cells (Figure 3.27). Aliquots that overlapped the high-high clusters were selected and extracted, for a total of 10,074 aliquots. Next, any aliquots that overlapped with Lobster Management Area 1 (132 aliquots; 46,969 ac) were removed from the selection. Additionally, any aliquots that overlapped the Great South Channel Restricted Area (35 aliquots; 12,454 ac) were removed. The remaining aliquots were grouped together to create one Draft WEA comprised of 3,519,067 ac (Figure 3.28).

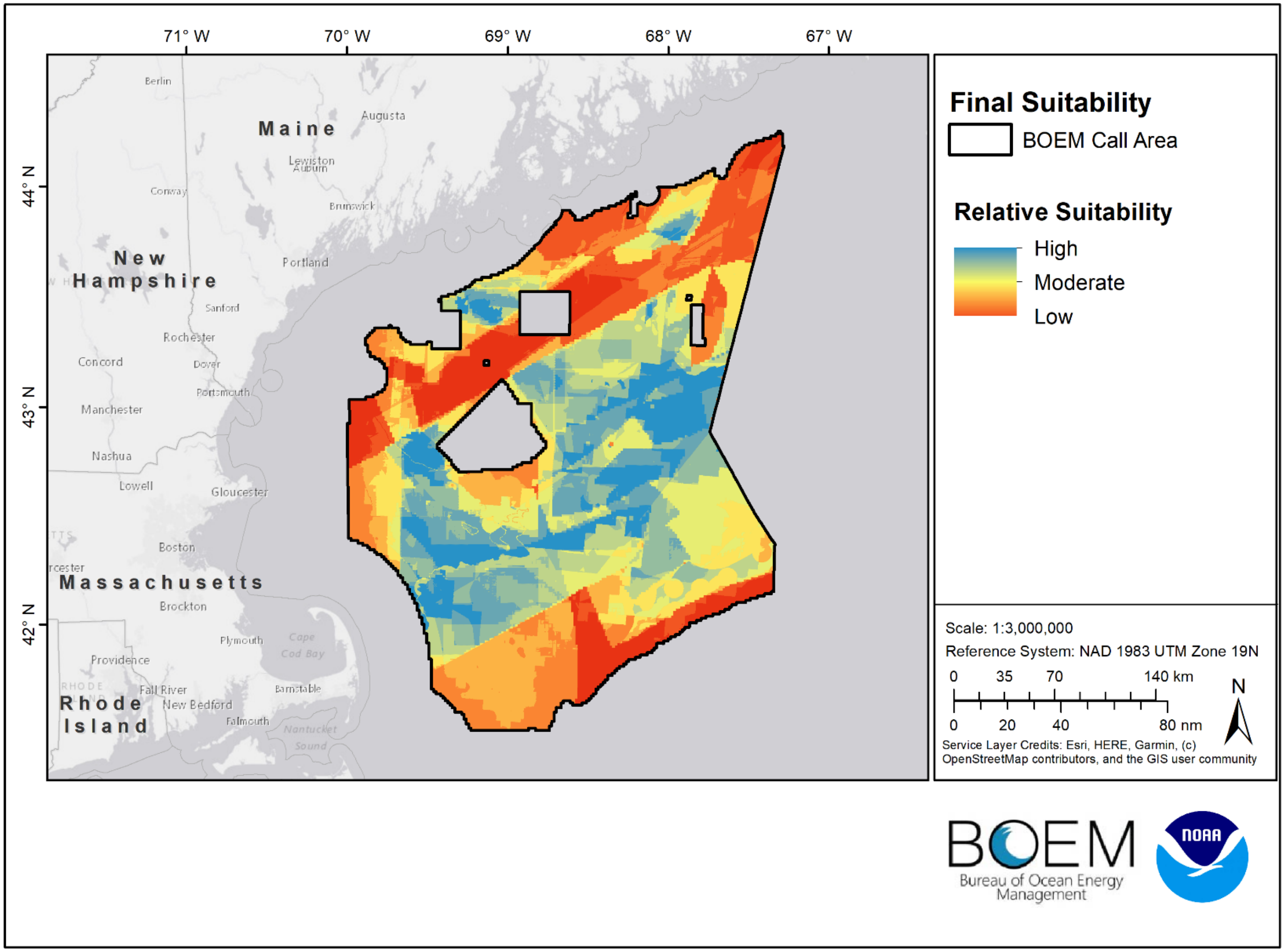


Figure 3.26. Final suitability modeling results for the Call Area. Red/orange colors indicates those areas of lowest suitability. Blue color indicates areas of highest suitability.

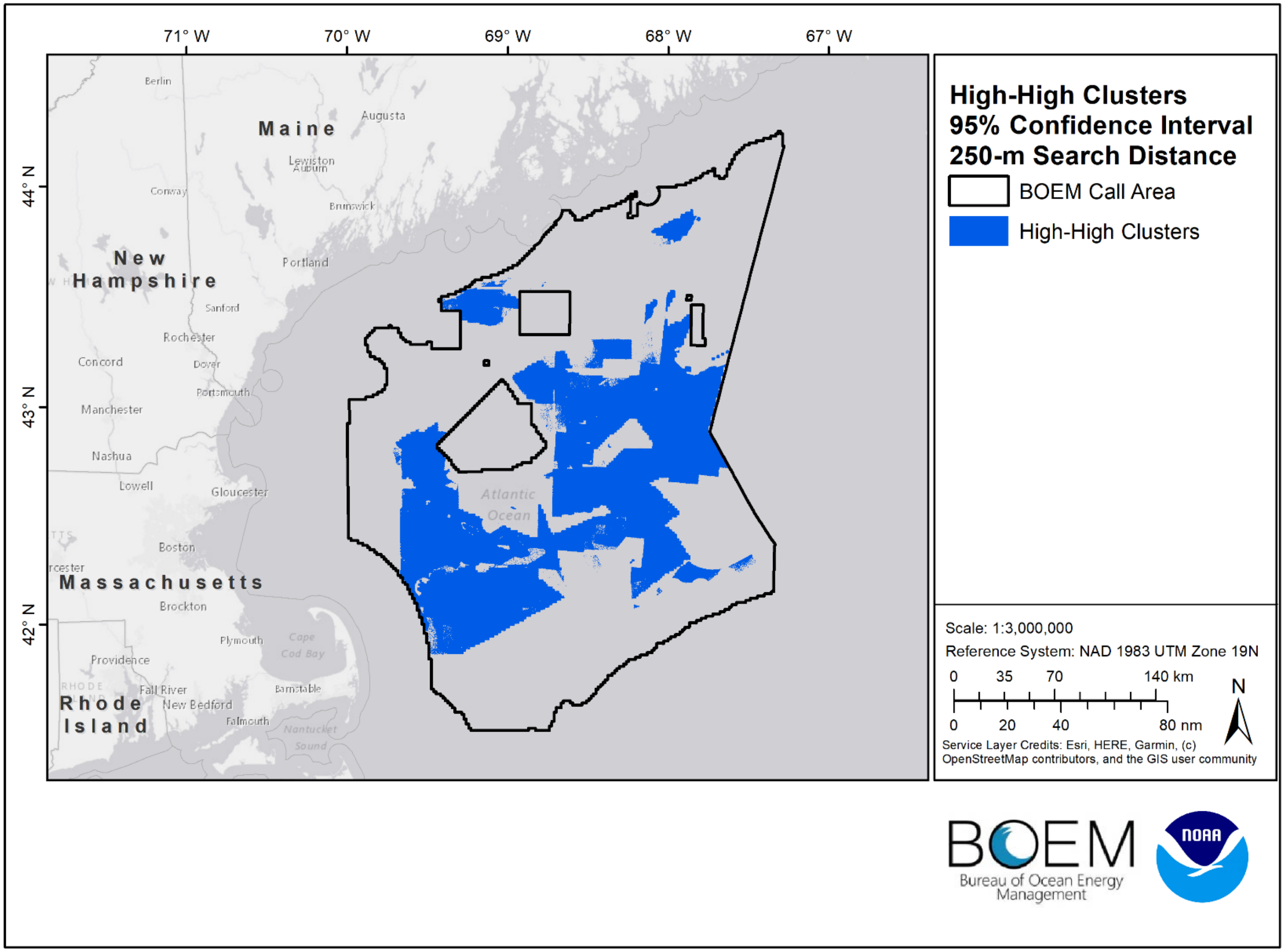


Figure 3.27. Cluster analysis of the Call Area at the 95% Confidence Interval (p = 0.05). Blue areas indicate areas determined to have the highest suitability.

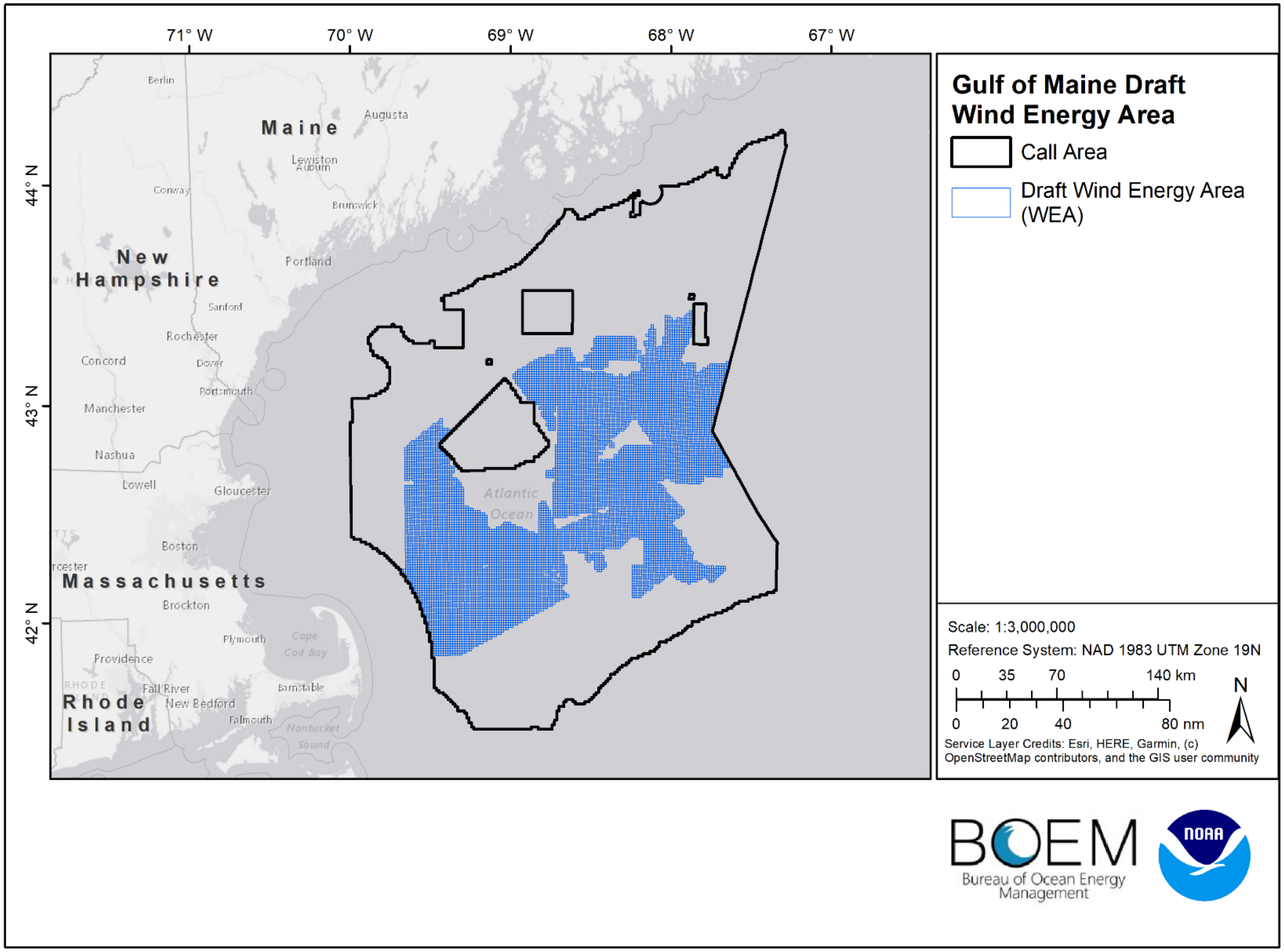


Figure 3.28. Gulf of Maine Draft WEA determined by selecting aliquots that overlapped high-high cluster areas. A total of 9,907 aliquots were selected totaling 3,519,067 acres. Blue areas represent the Draft WEA.

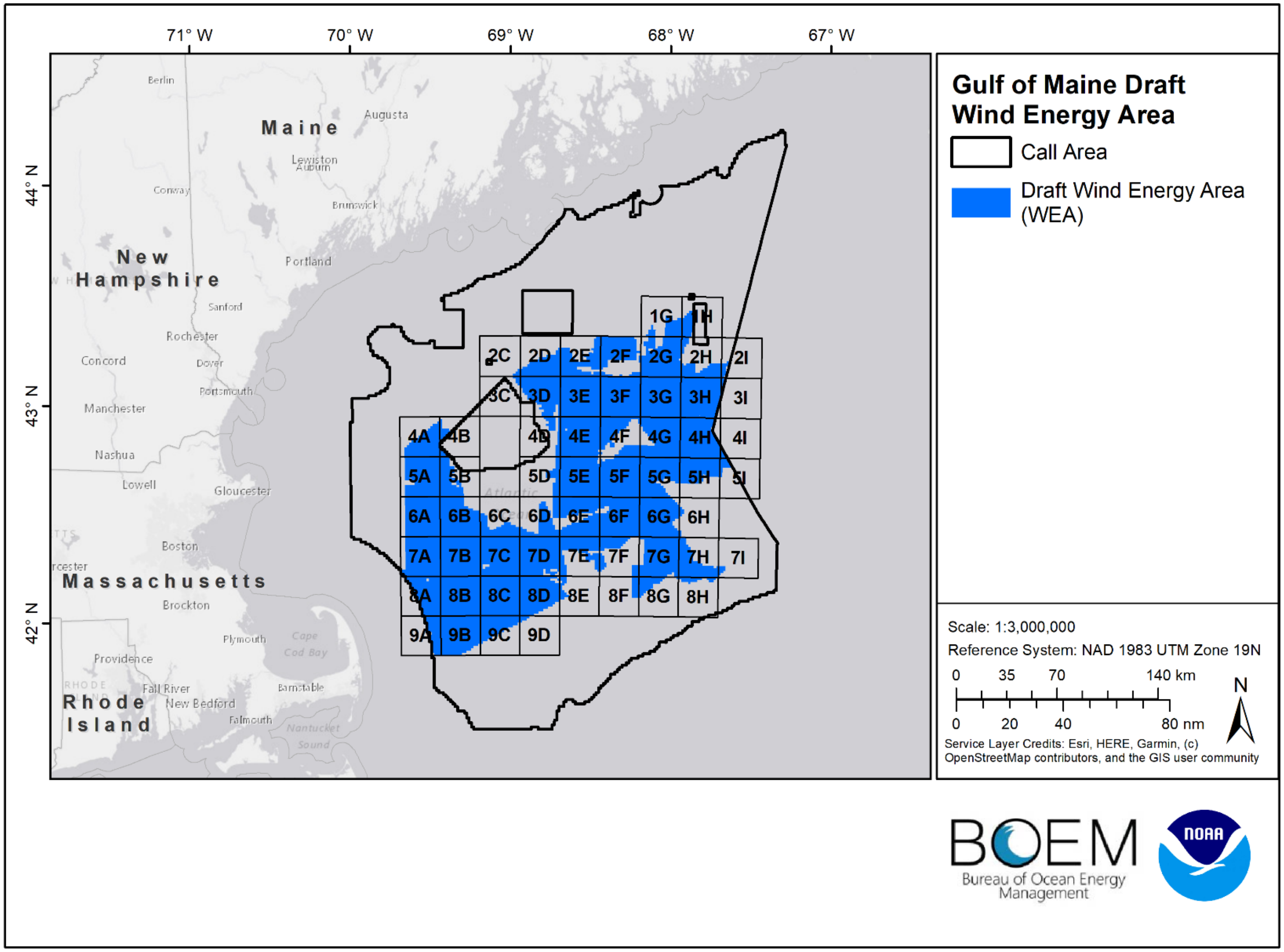
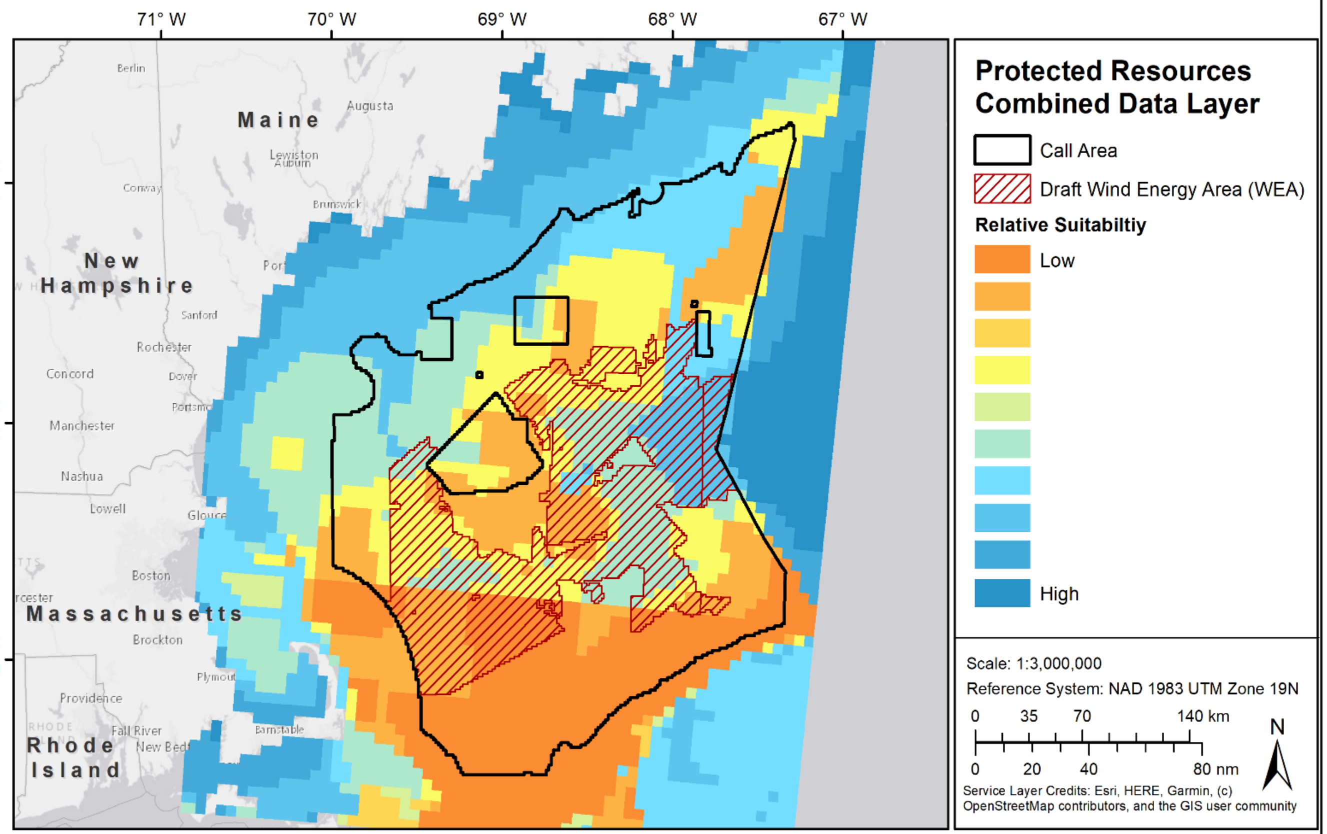


Figure 3.29. Gulf of Maine Draft WEA with reference grid. Grid cells represent roughly 100,000 acres.

3.4. Model Performance and Other Considerations

A review of data layers with the identified Draft WEA provides some information on how well the model performed (Figure 3.30 - 3.50).



NMFS Protected Resources Combined Data Layer. Prepared by NOAA National Marine Fisheries Service Office of Protected Resources. Greater Atlantic Regional Fisheries Office and Southeast Regional Office. 2022. 22 total species included.

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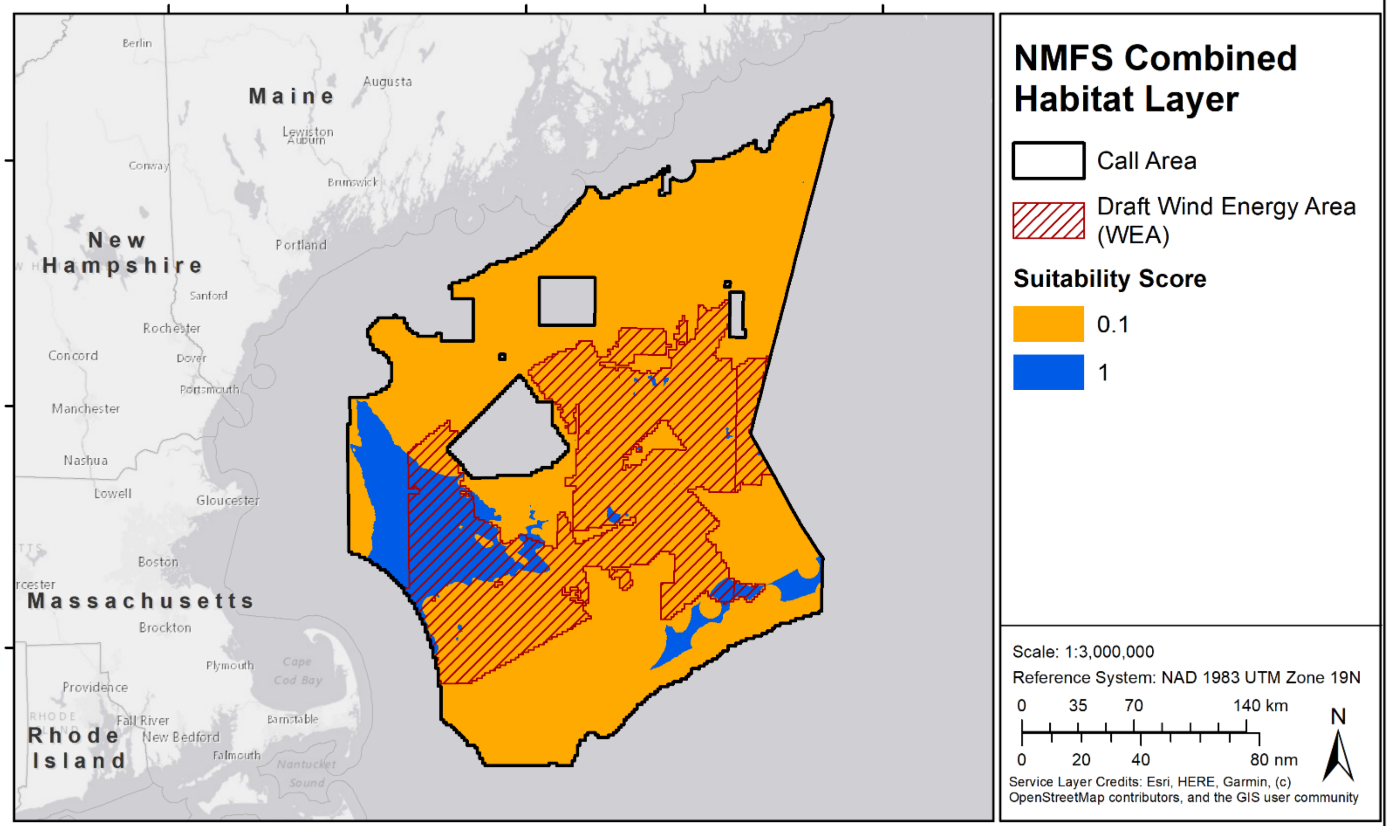
Figure 3.30. NOAA NMFS protected resources considerations in relation to the Draft WEA.



NMFS Combined Habitat Layer. Prepared by NOAA National Marine Fisheries Service. 2022. Habitats include: Jordan Basin Dedicated Habitat Research Area (20 km setback), Coral Protection Areas (20 km setback), Jordan Basin depths shallower than 250 m, CPAs considered but not desginated by NEFMC (20 km setback), coral and sponge locations (5 km setback), Georges Bank (10 km setback), HMAs not designated by NEFMC (20 km setback), HAPCs, potential and known coral and hardbottom.

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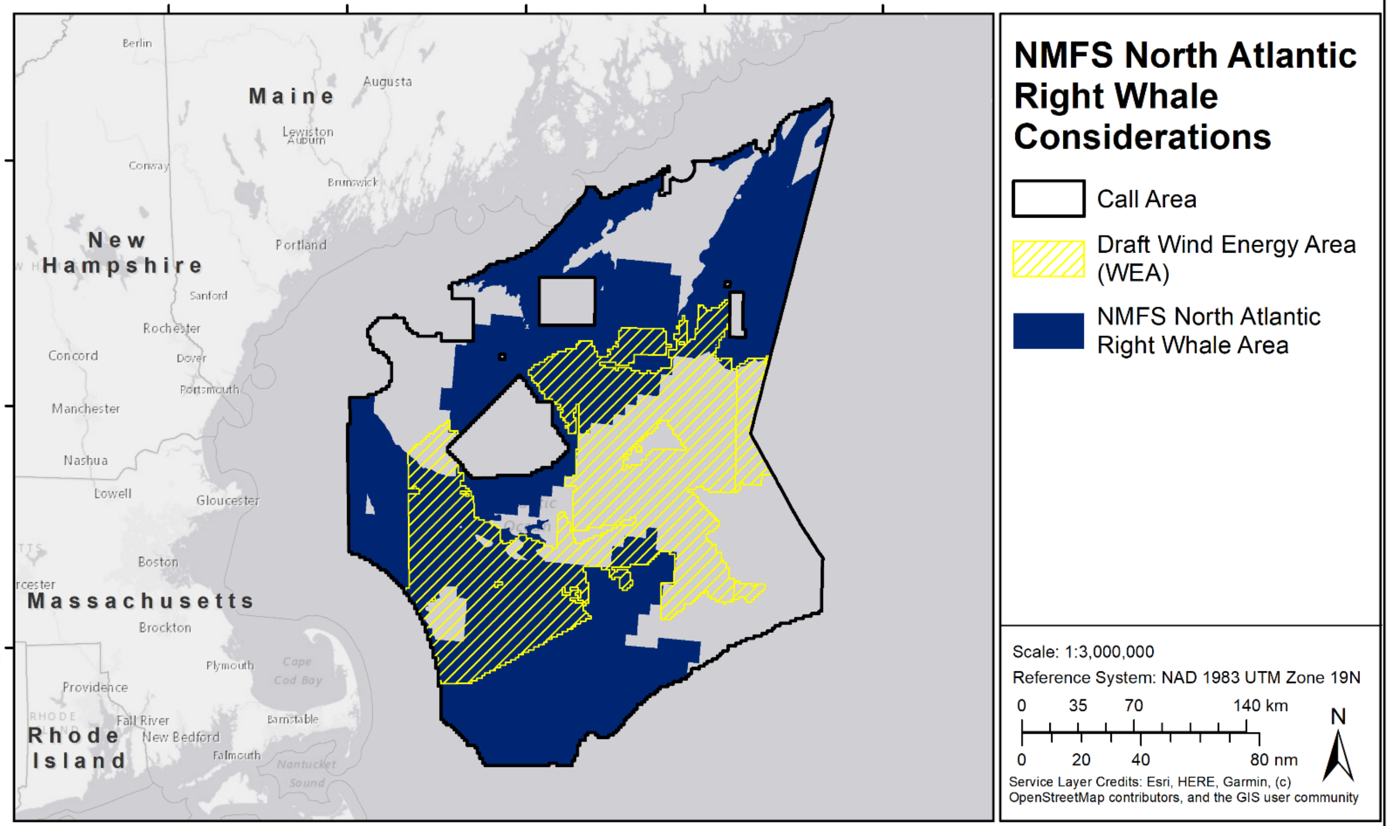
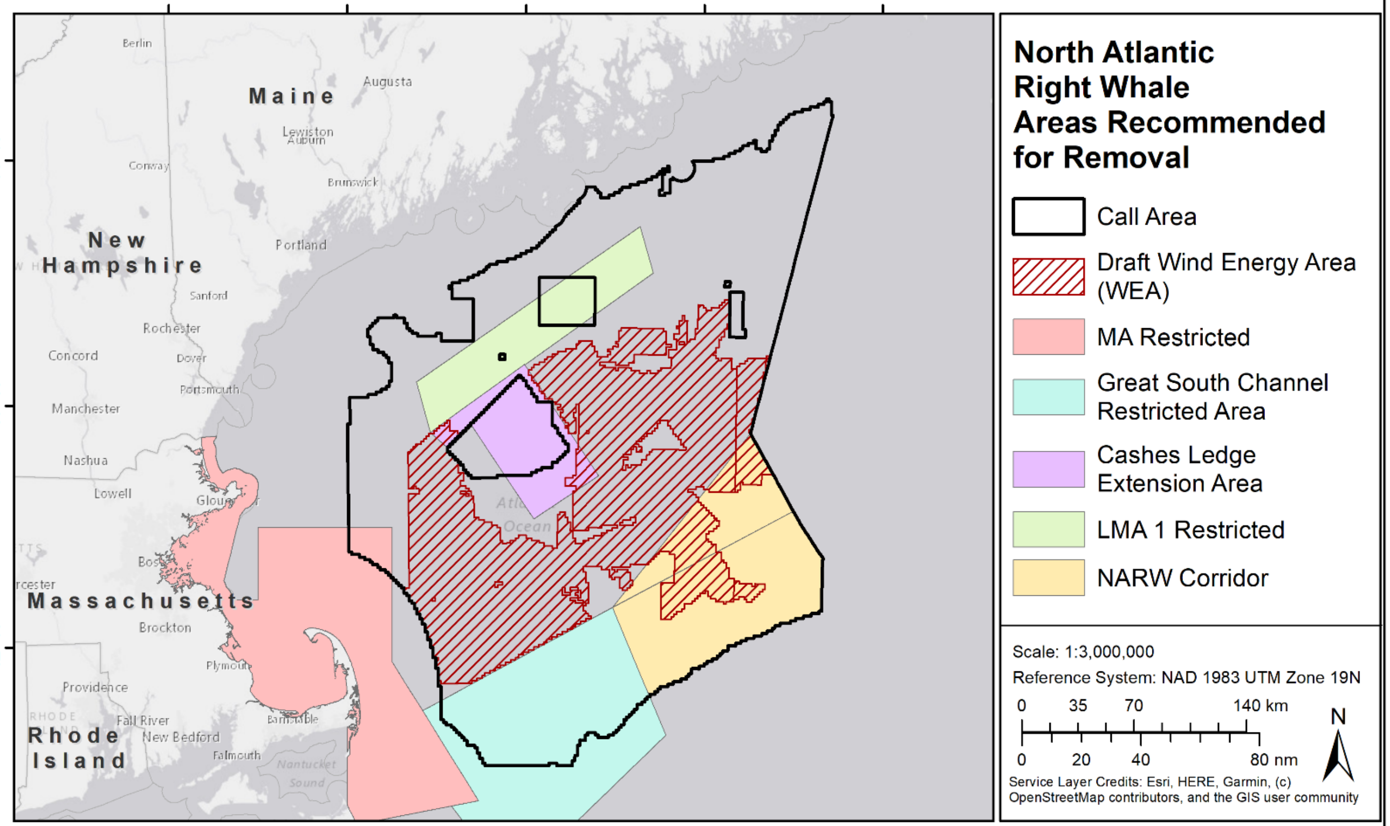
Figure 3.31. NOAA NMFS habitat considerations in relation to the Draft WEA.



NMFS North Atlantic Right Whale Area. NOAA National Marine Fisheries Service. 2022.
North Atlantic Right whale considerations include: Maine coastal current depths less than 150 m, Jordan Basin depths greater than 200 m, Wilkinson Basin depths greater than 220 m, and sum of North Atlantic Right whale density greater than 1.018 individuals per 100 km ^{2}.

Figure 3.32. NOAA NMFS North Atlantic Right Whale considerations in relation to the Draft WEA.



Massachusetts Restricted Areas. NOAA National Marine Fisheries Service. 2022.
Great South Channel Restricted Area. NOAA National Marine Fisheries Service. 2022.
Cashes Ledge Extenstion Area. NOAA National Marine Fisheries Service. 2023.
Lobster Management Area 1 Restricted Area. NOAA National Marine Fisheries Service. 2022.
North Atlantic Right Whale Corridor. NOAA National Marine Fisheries Service. 2023.

Figure 3.33. NOAA NMFS North Atlantic Right Whale areas recommended for removal in relation to the Draft WEA.

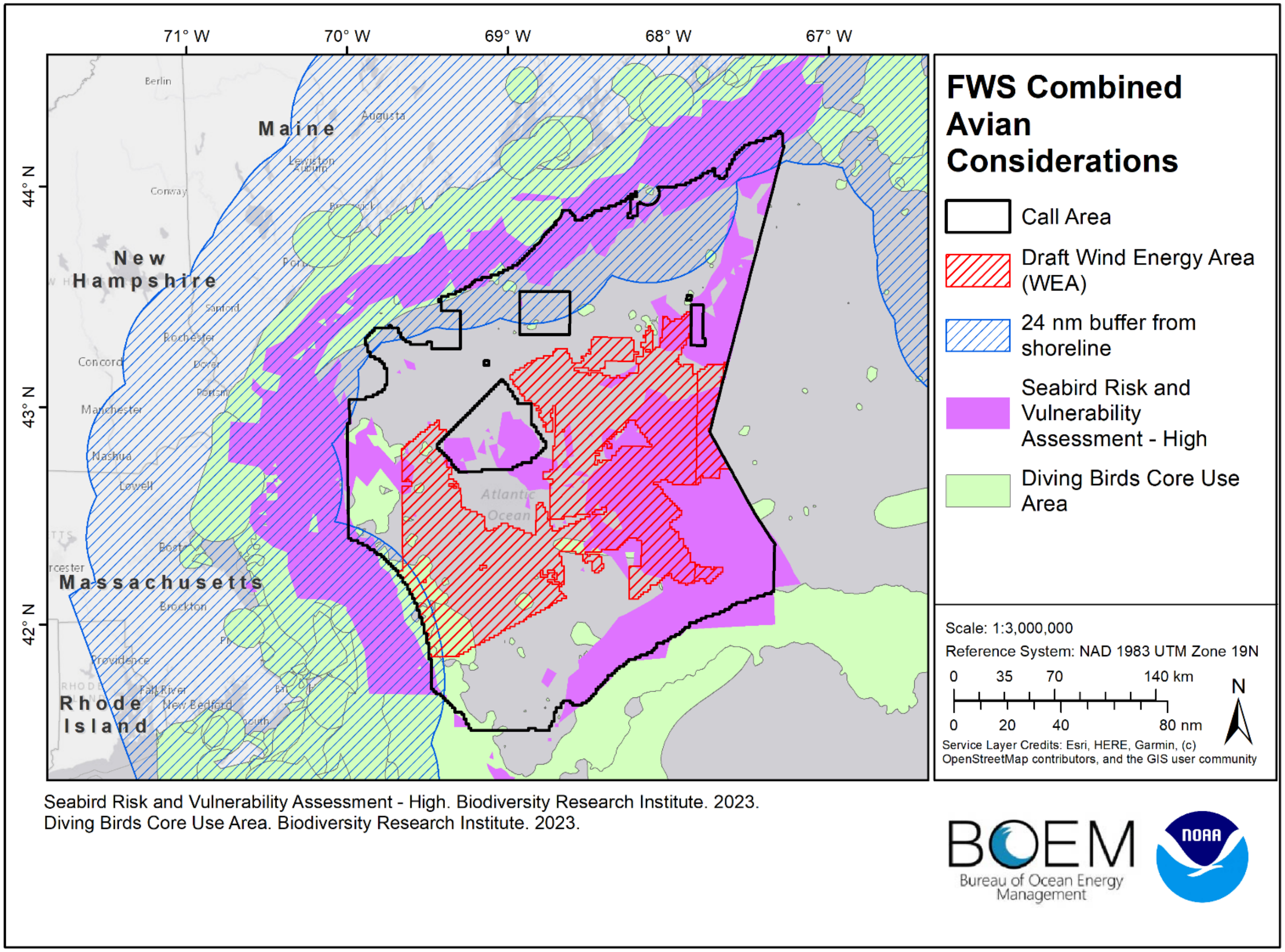


Figure 3.34. U.S. Fish and Wildlife Service avian considerations in relation to the Draft WEA.

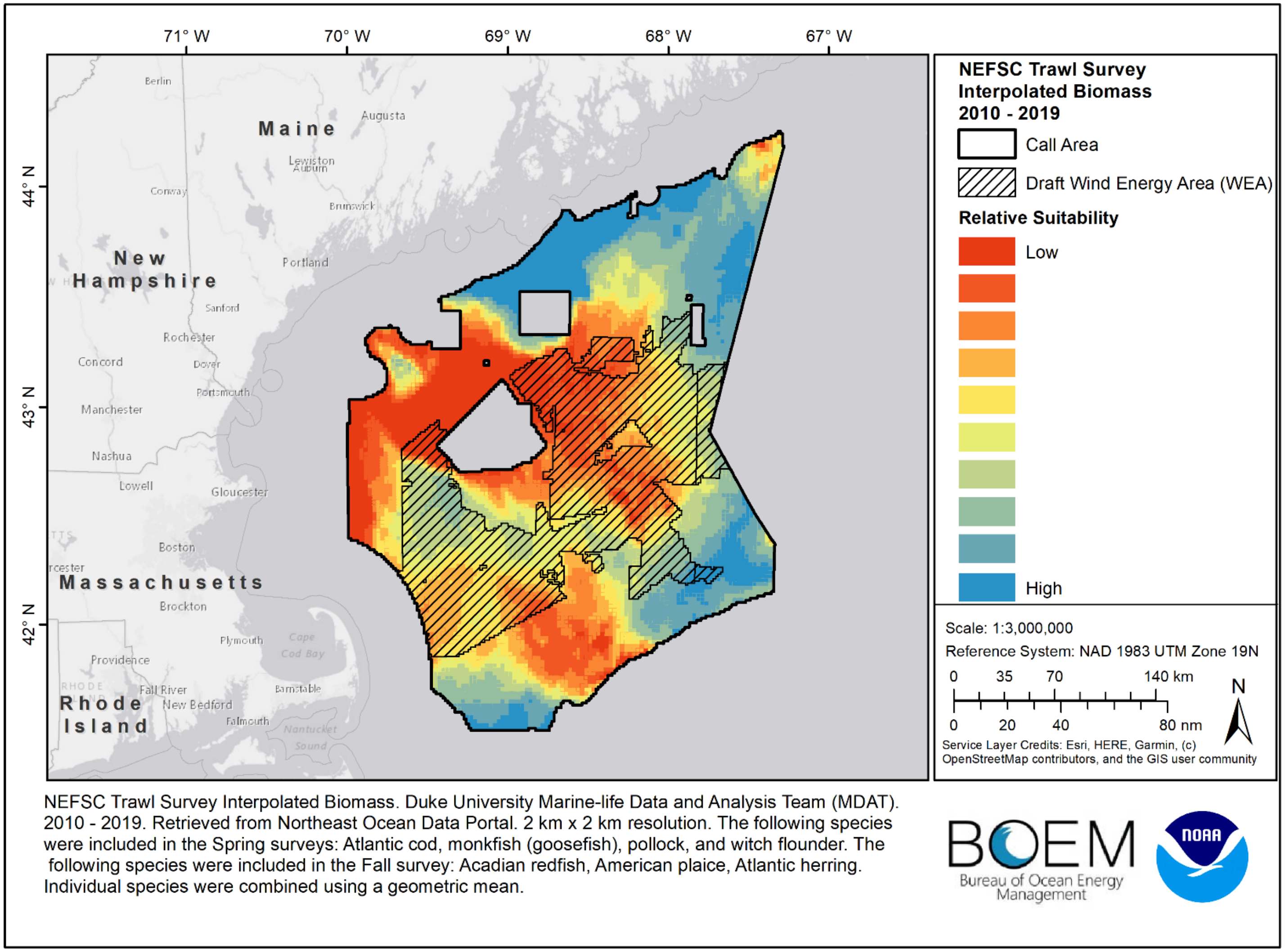
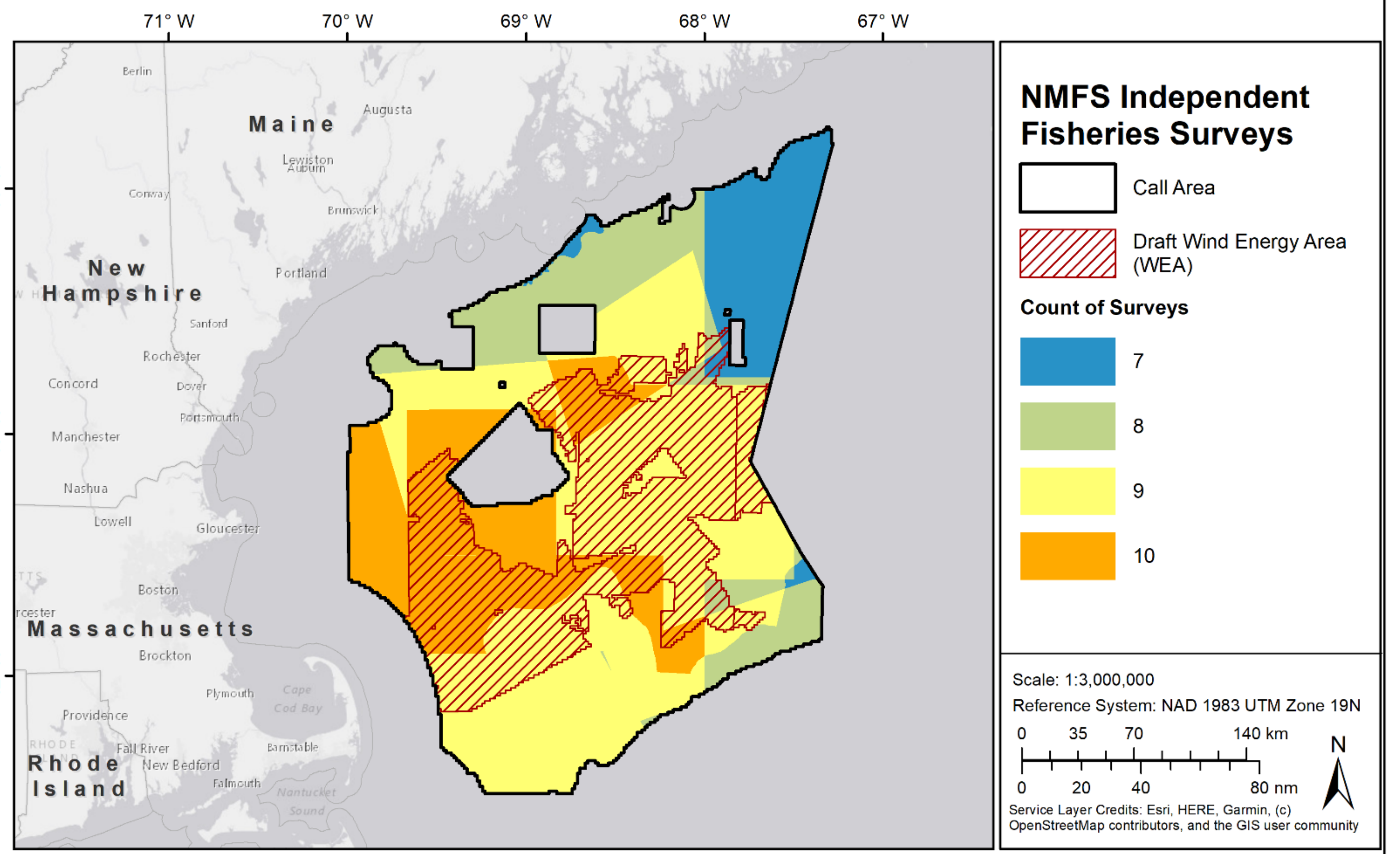


Figure 3.35. New England Fishery Management Council Trawl Survey Interpolated Biomass 2010 - 2019 in relation to the Draft WEA.



NMFS Independent Fisheries Surveys. NOAA National Marine Fisheries Service. 2023. Survey footprints include: EcoMon 1-4, Bottom Trawl Spring/Fall, AMAPPS Aerial, CRB Bottom Longline, North Atlantic Right whale, Shrimp, Surfclam, Scallop-Shellfish, and Ocean Quahog.

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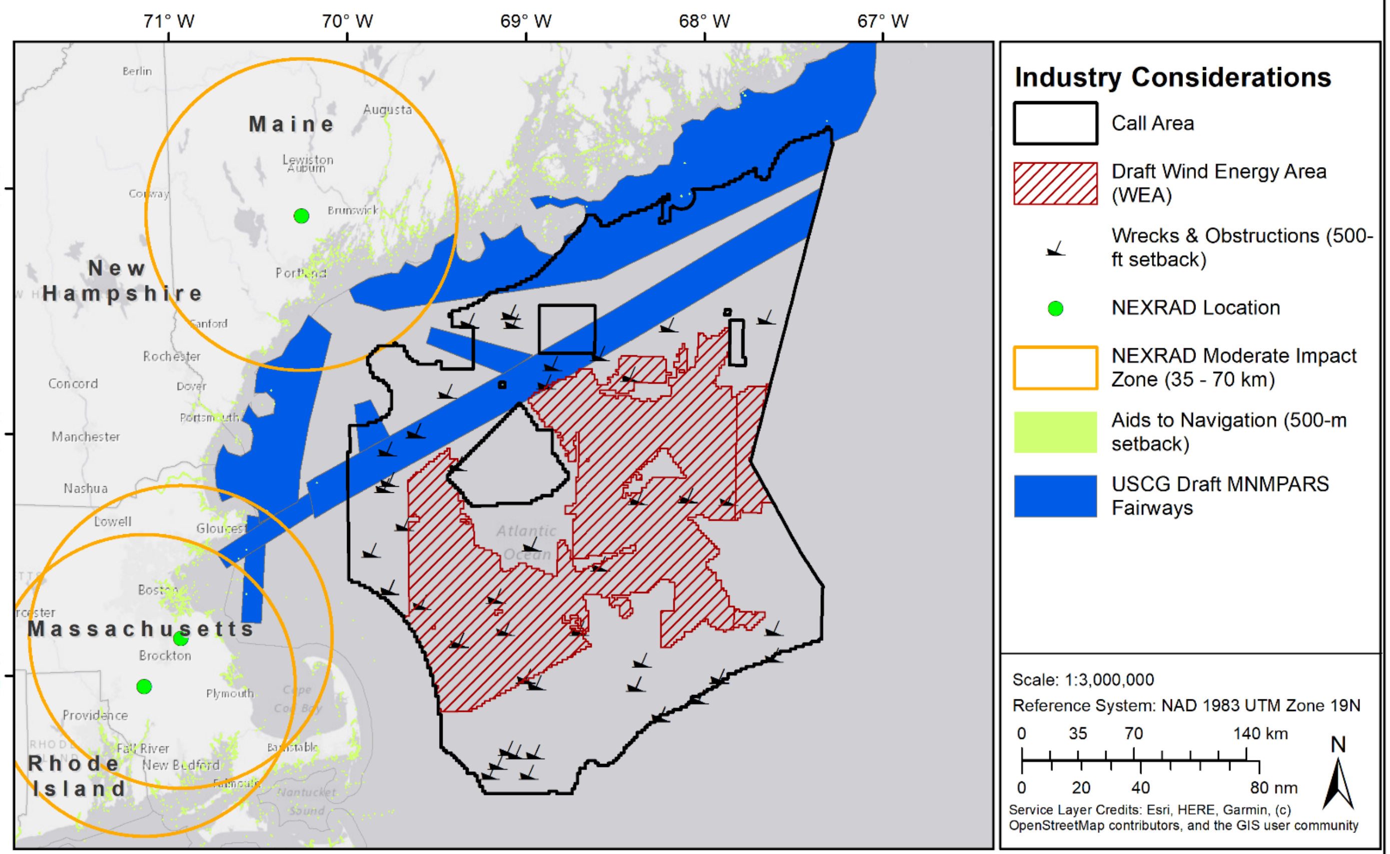
Figure 3.36. NOAA NMFS Independent Fisheries Surveys in relation to the Draft WEA.



ENC Wrecks and Obstructions. NOAA Office for Coastal Survey. 2023.
AWOIS Wrecks and Obstructions. NOAA Office for Coastal Survey. 2023.
NEXRAD Stations and Impact Zones. NOAA National Weather Service. 2023.
Aids to Navigation. U.S. Coast Guard and NOAA Office for Coastal Management. 2022.

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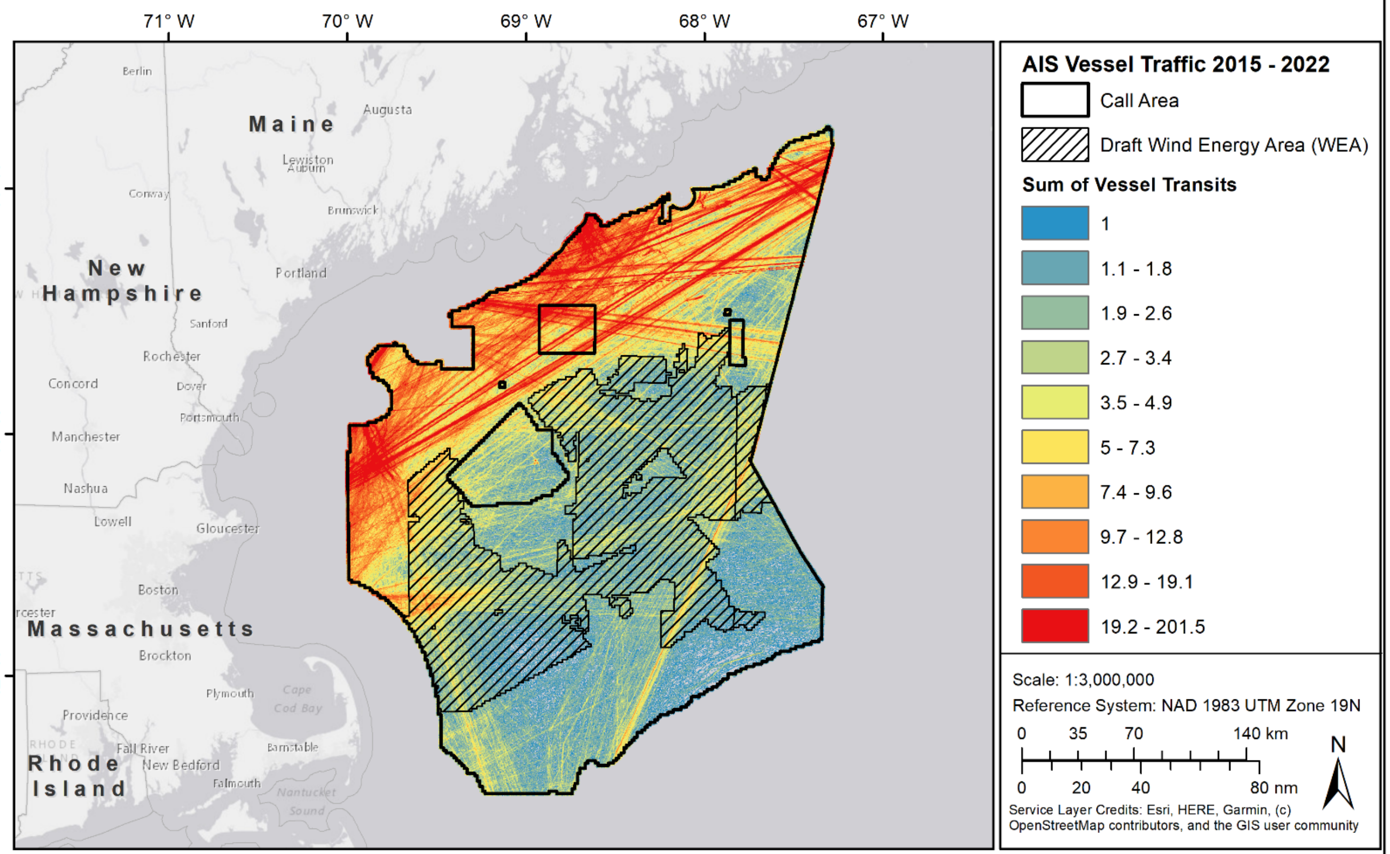
Figure 3.37. Industry considerations in relation to the Draft WEA. Considerations include wrecks and obstructions, NEXRAD locations and impact areas, aids to navigation, and the USCG Draft MNMPARS fairways.



Automatic Identification System (AIS) Vessel Transit Counts. U.S. Coast Guard Navigation Center. 2015 - 2022. Vessel types include: cargo, military, other, passenger, pleasure and sailing, tanker, and tug and tow. Fishing vessel tansits were removed.

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Figure 3.38. Automatic Identification System sum of vessel transits for all vessel types except fishing 2015 – 2022 in relation to the Draft WEA.

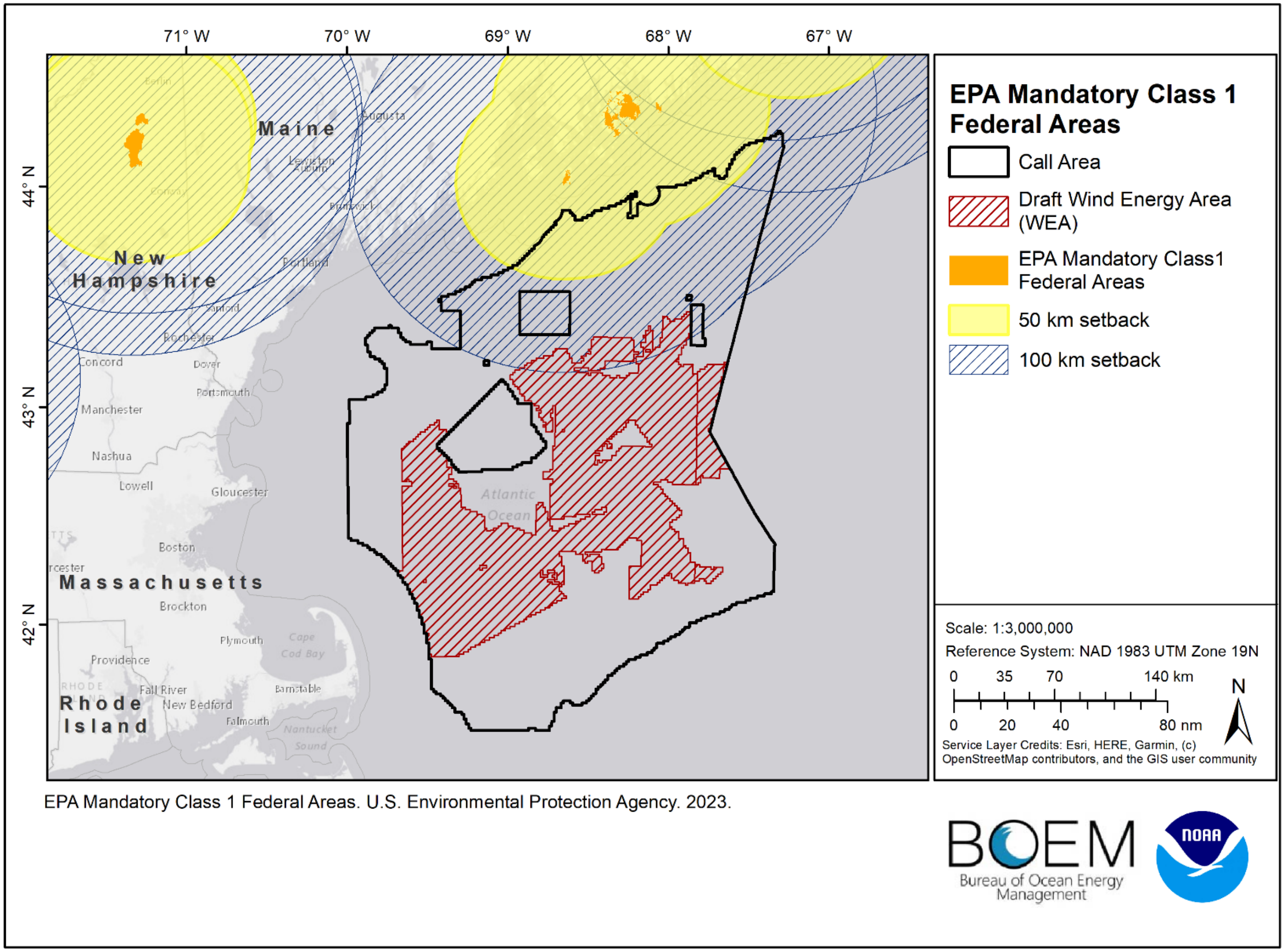
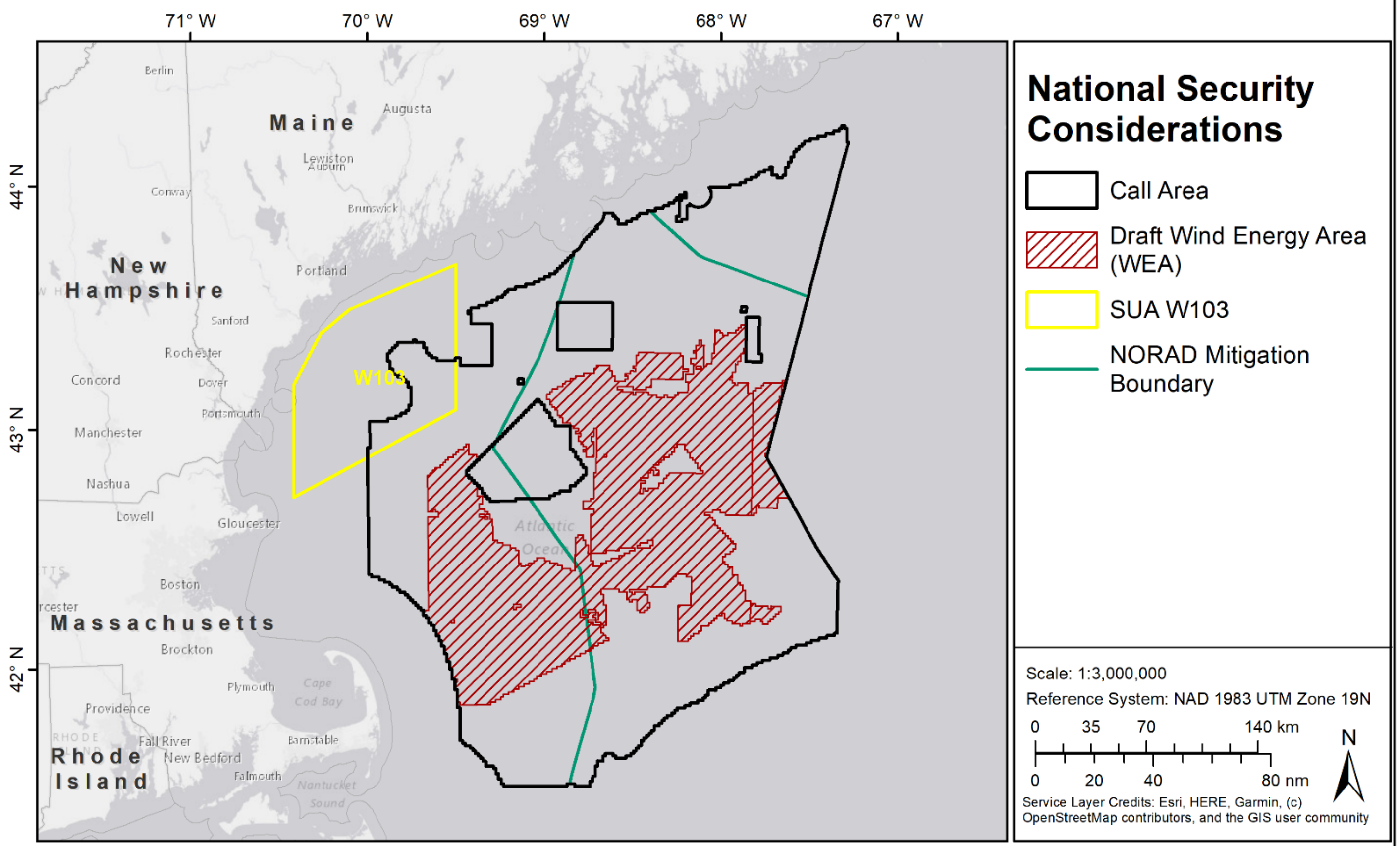
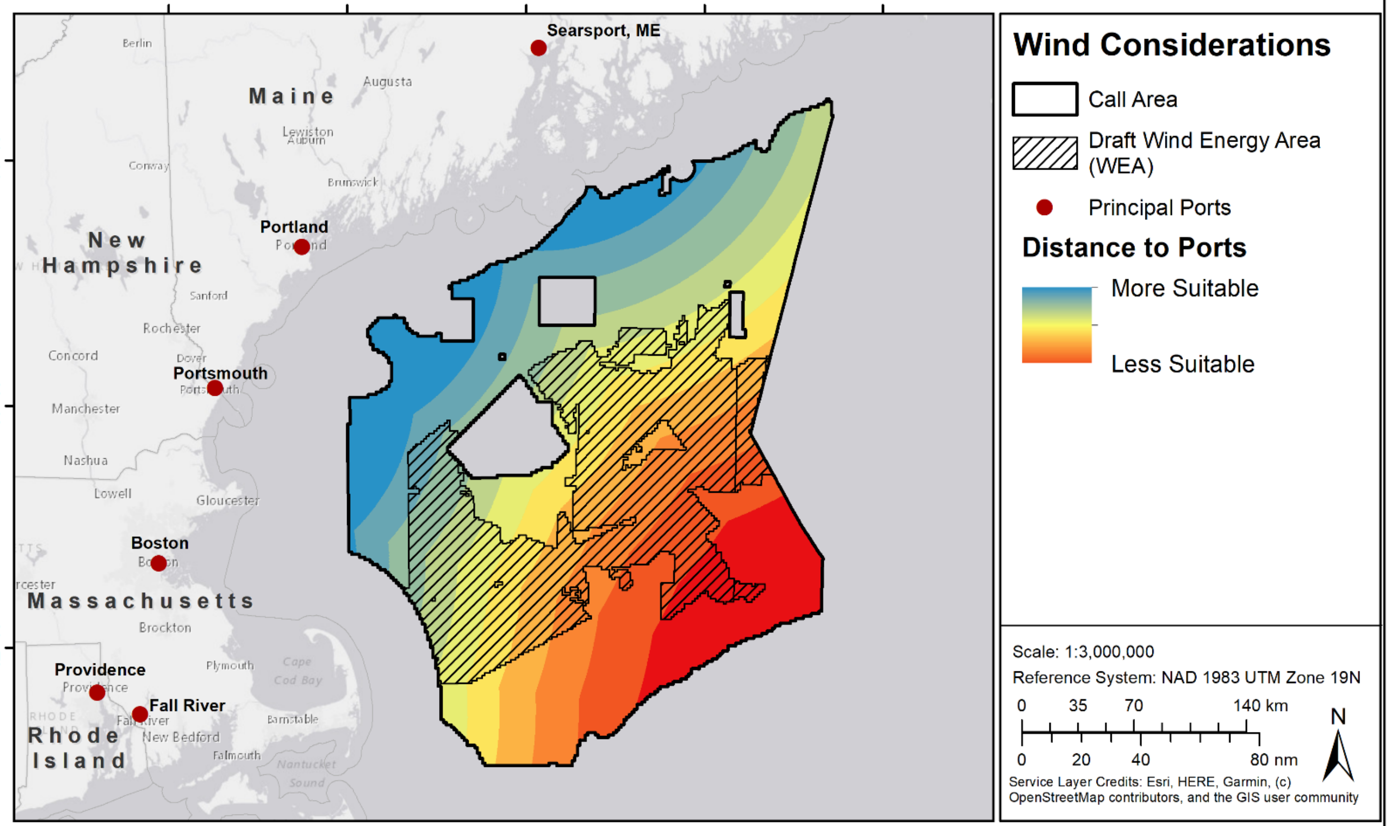


Figure 3.39. EPA Mandatory Class 1 Federal Areas in relation to the Draft WEA.



Special Use Airspace Warning Area 103. U.S. Fleet Forces, EIMS Data WIPT Team. 2023.
North American Aerospace Defense Command Mitigation Boundary. Map provided by North American Defense Command, digitized by NCCOS. 2023.

Figure 3.40. Special Use Airspace Warning Area 103 in relation to the Draft WEA.



Principal Ports. NOAA Office for Coastal Management. 2019. Principal Ports are the top 150 U.S. ports based upon total annual tonnage. Variation in annual tonnage at a port may result in exclusion or inclusion on the Principal Port list. Distance is calculated using a linear function or "as the crow flies".

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Figure 3.41. Distance to principal ports in relation to the Draft WEA.

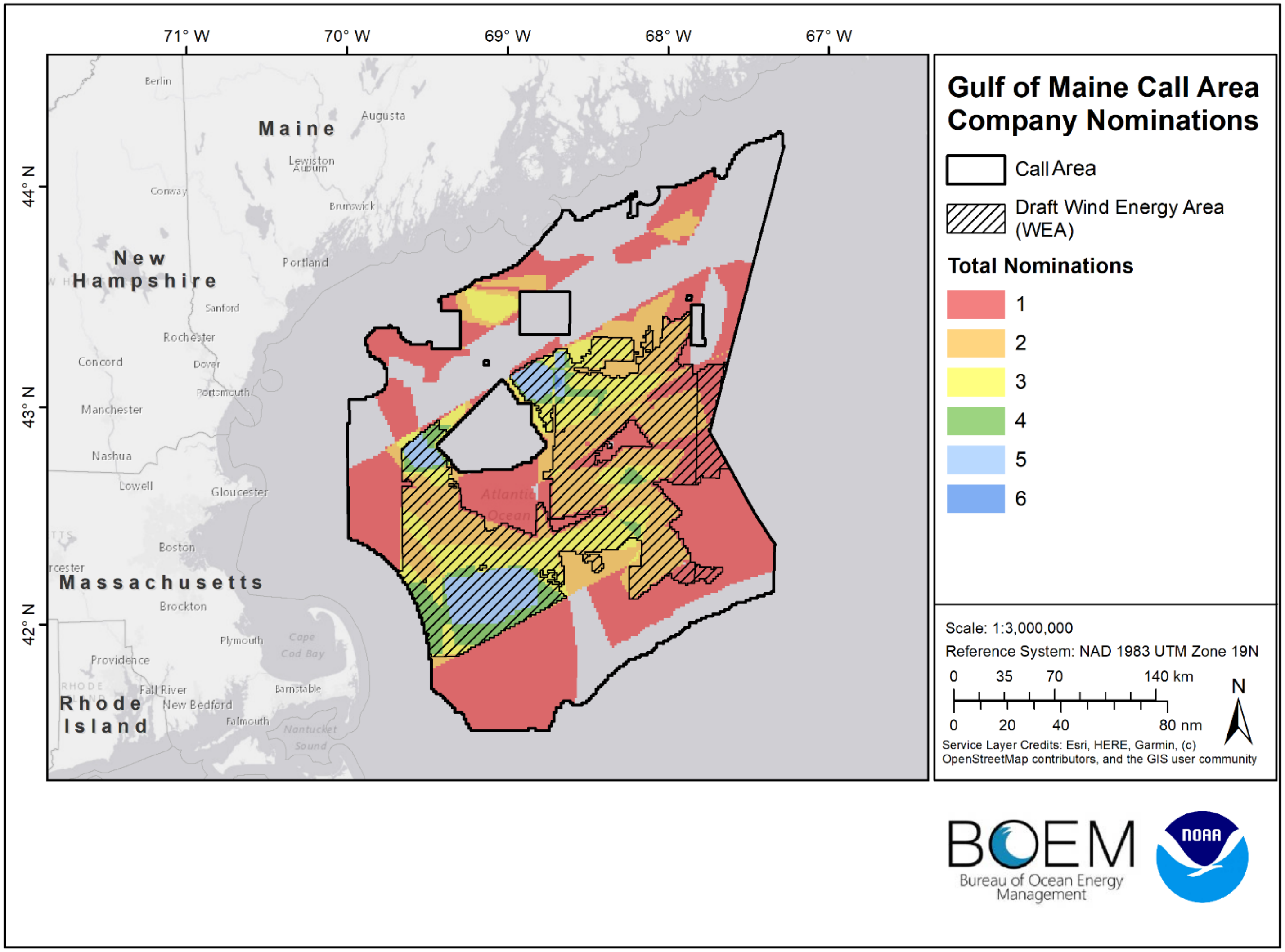


Figure 3.42. Gulf of Maine Call Area Company Nominations in relation to the Draft WEA.

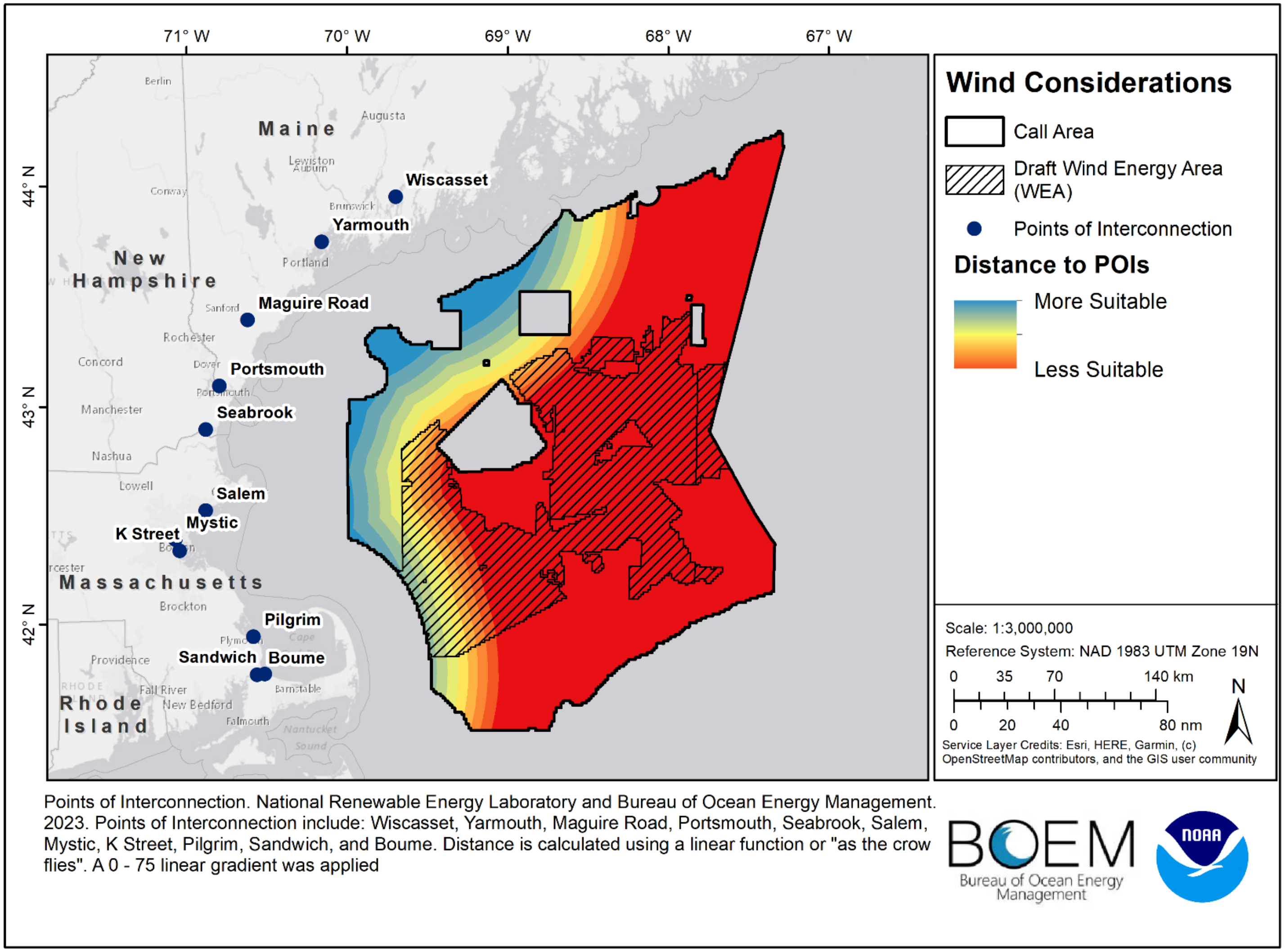


Figure 3.43. Distance to Points of Interconnection in relation to the Draft WEA.

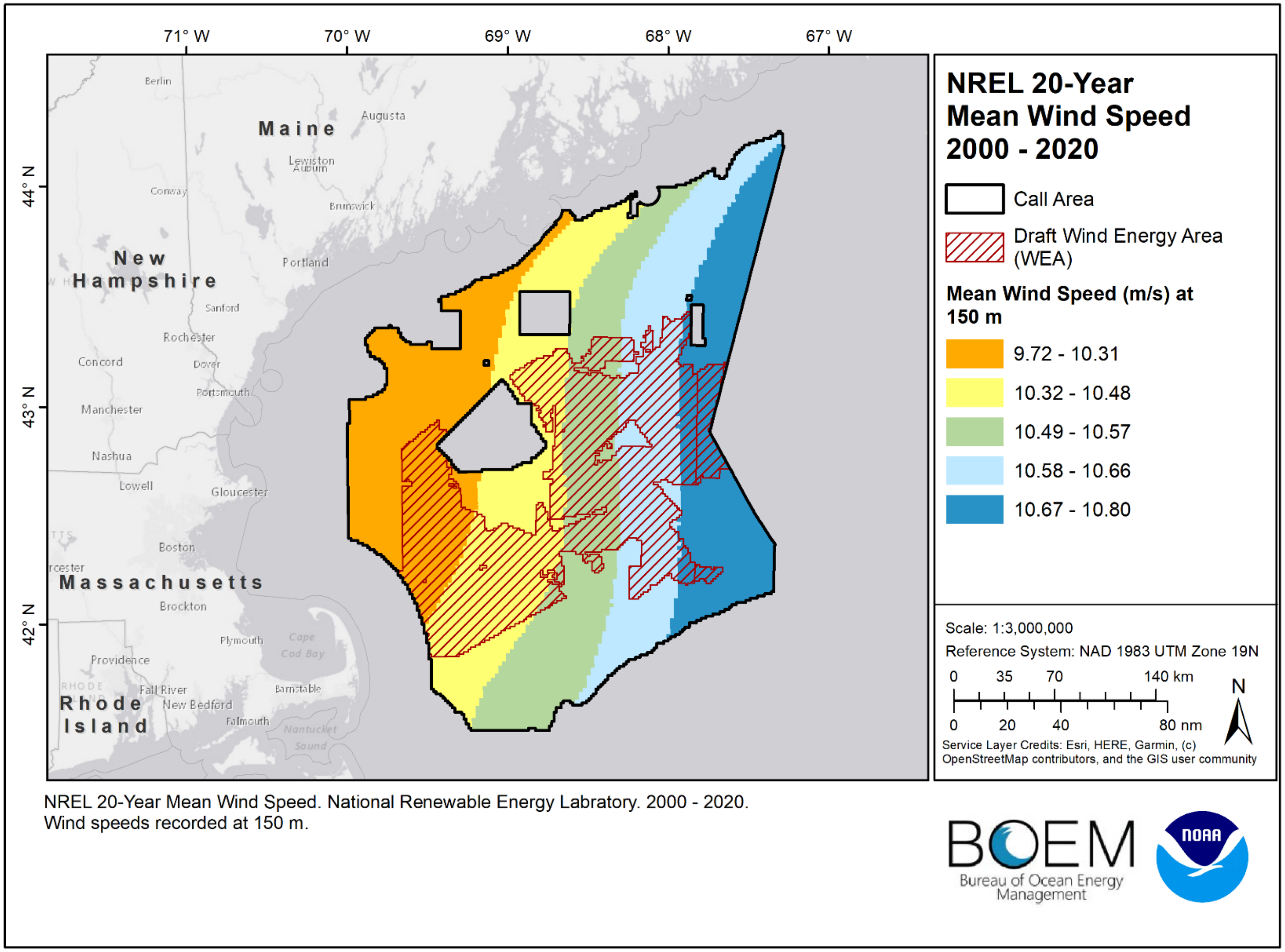
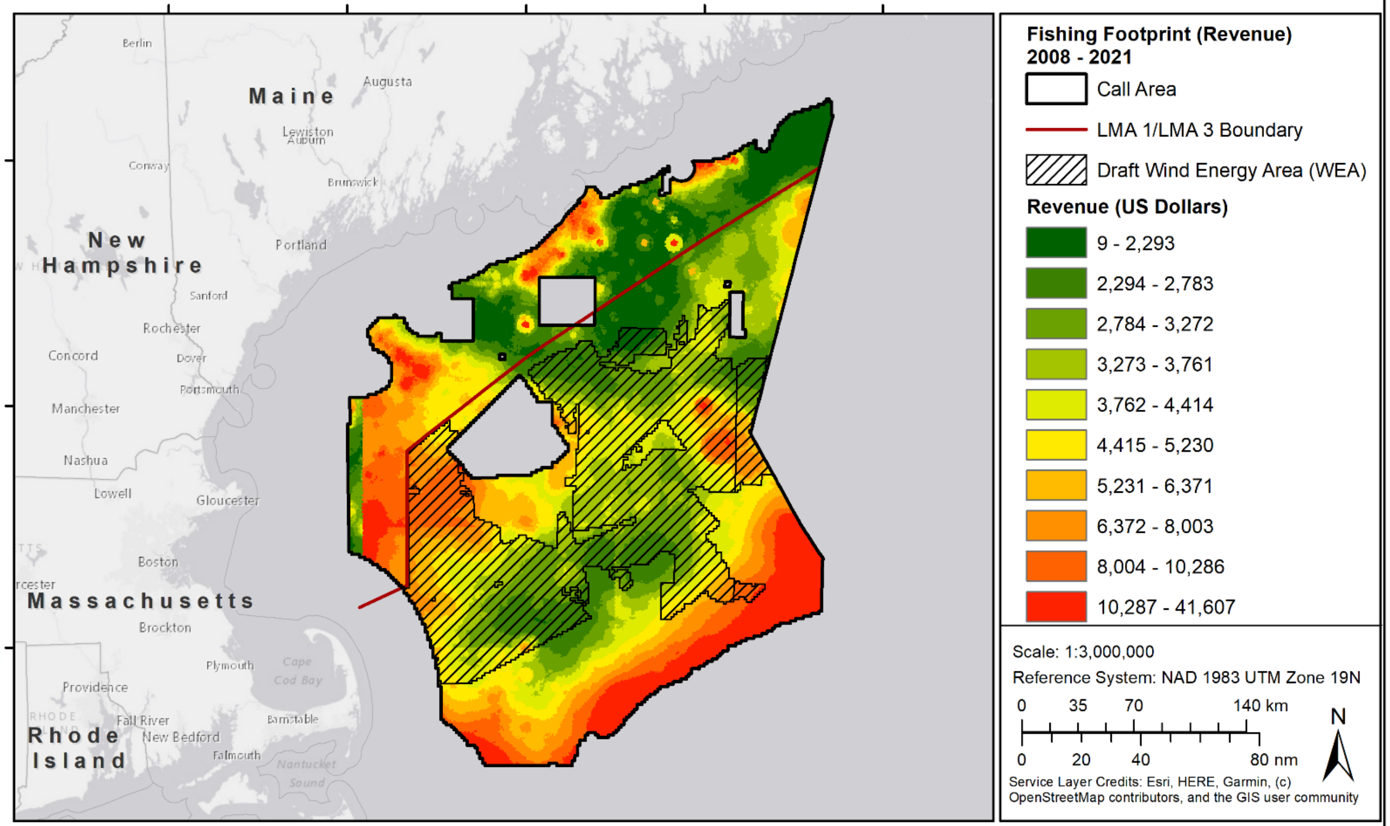


Figure 3.44. NREL 20-Year Mean Wind Speed 2000 - 2020 in relation to the Draft WEA.



Fishing Footprint Commercial VTR Modeled Logbook Data. NOAA National Marine Fisheries Service. 2008 - 2021. 500 m (0.25km²) resolution. Revenue displayed as total U.S. Dollars/0.25 km ². Modeled data includes all gear types; bottom trawl, dredge, gillnet, lobster, longline, pots and traps, seine, and shrimp.

BOEM Bureau of Ocean Energy Management

NOAA

Figure 3.45. Fishing Footprint Revenue (2008 – 2021) in relation to the Draft WEA.

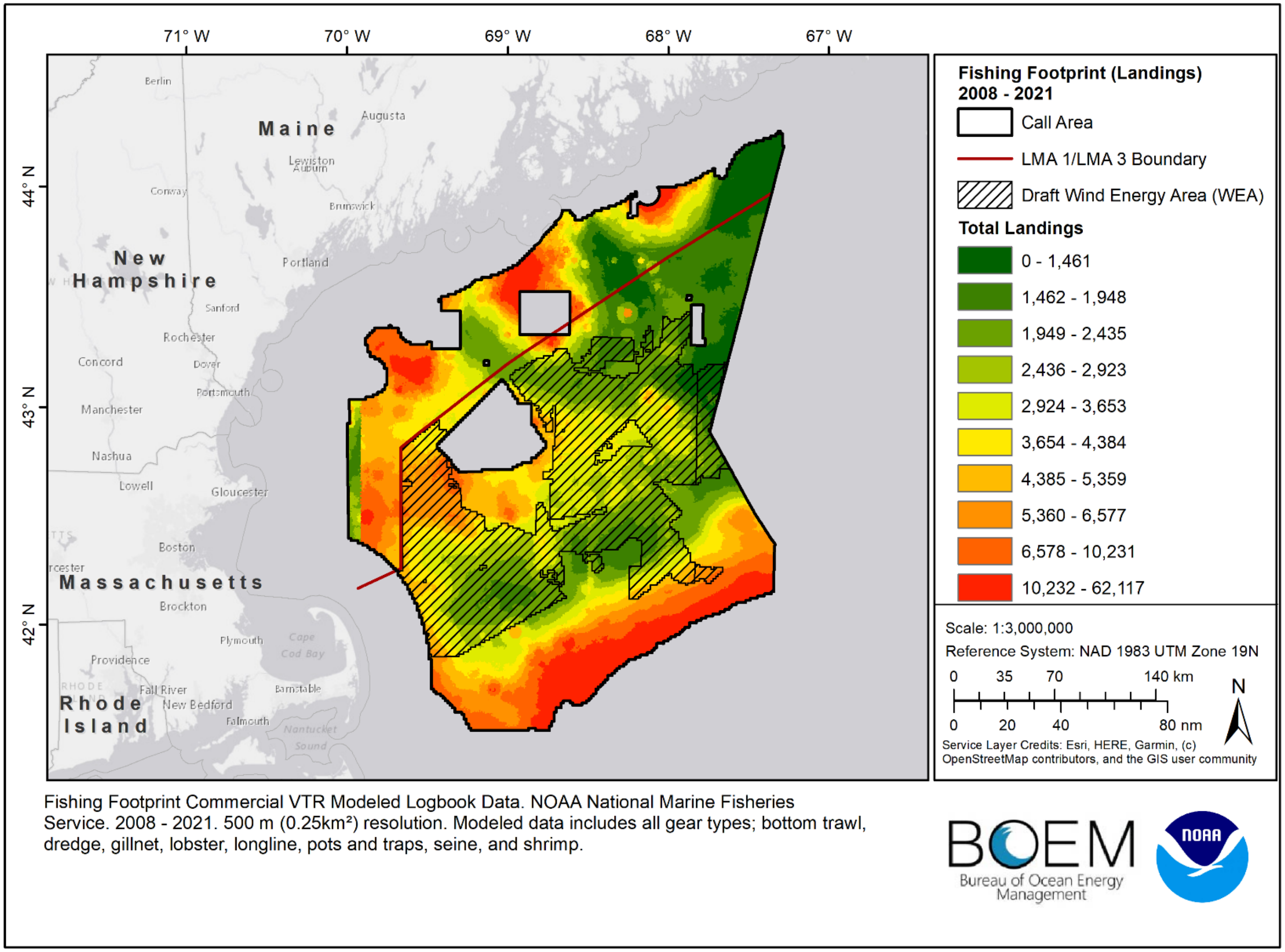


Figure 3.46. Fishing Footprint Landings (2008 – 2021) in relation to the Draft WEA.

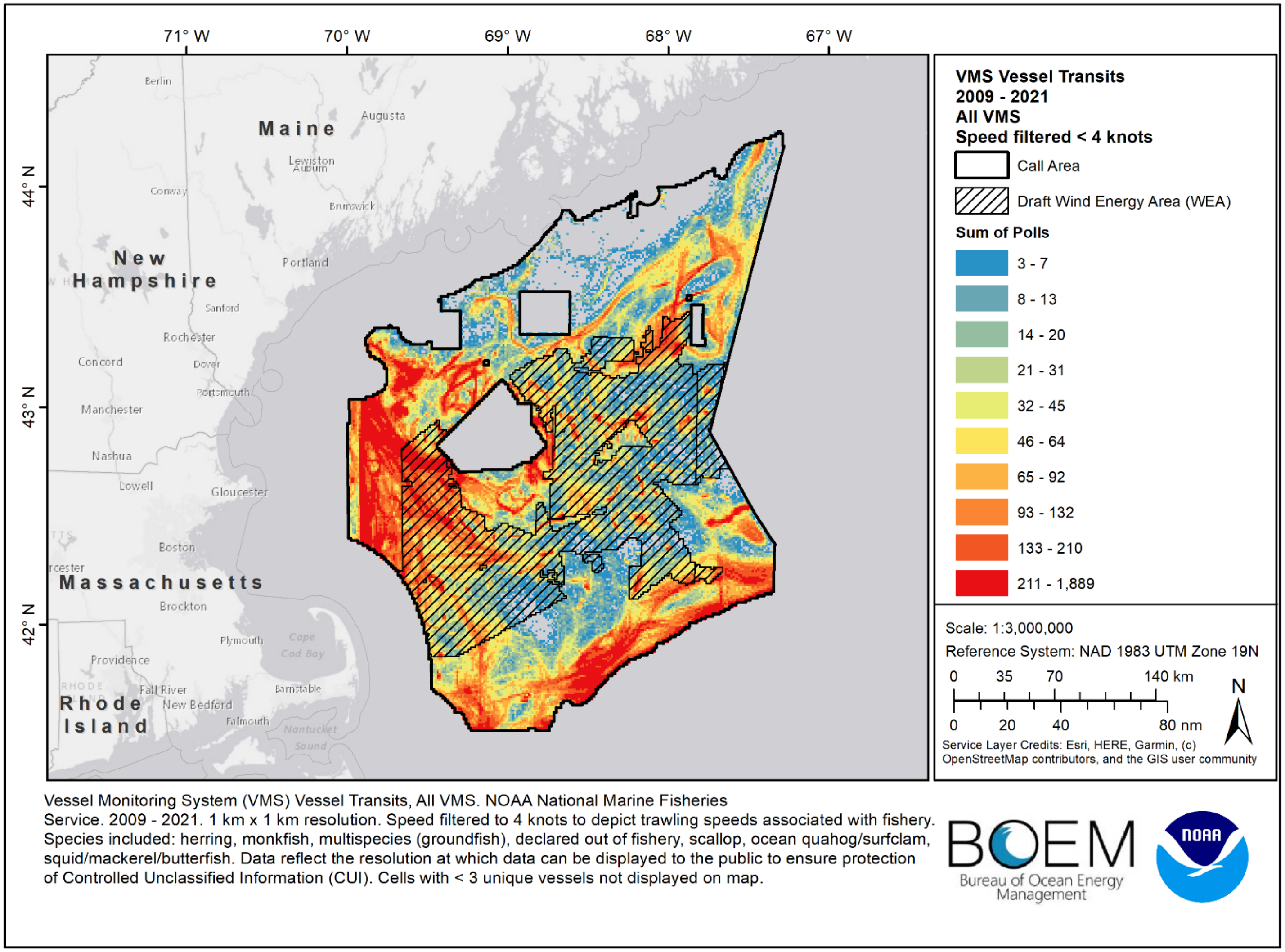


Figure 3.47. Vessel Monitoring System (VMS) Vessel Transits for all VMS fisheries speed filtered to less than 4 knots (2009 – 2021) in relation to the Draft WEA.

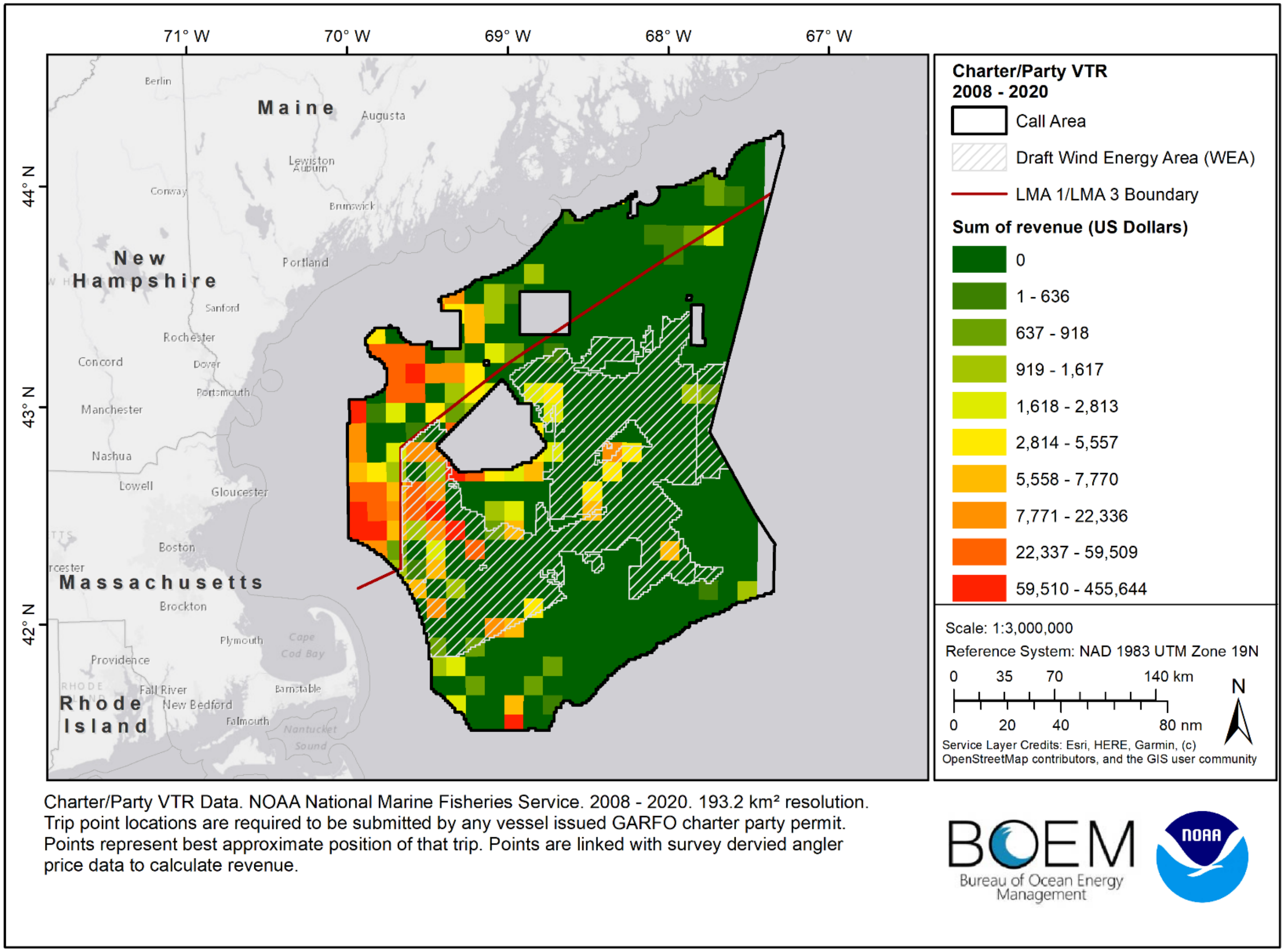
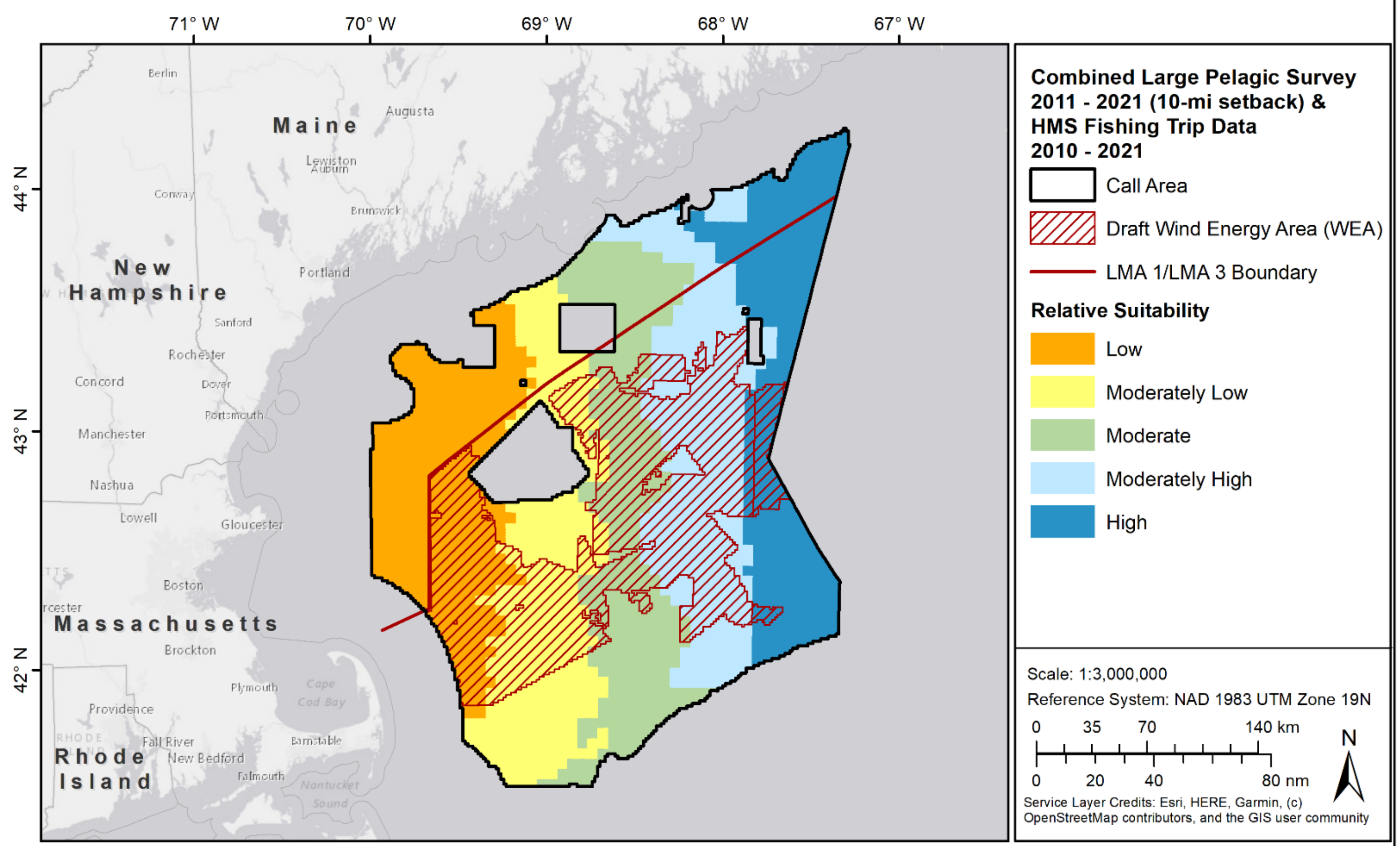


Figure 3.48. Charter/Party VTR 2008 - 2020 in relation to the Draft WEA.



Large Pelagic Survey Data. NOAA National Marine Fisheries Service. 2011 - 2021. Trip point data was received from NOAA NMFS. A 10-mi setback was applied to each trip point to capture potential fishing extent. Trip points and corresponding setbacks were overlaid on the 10-acre grid and a total trip count per grid cell was calculated.
Highly Migratory Species Fishing Trip Data. Maine Department of Marine Resources. 2010 - 2021.
A combined data layer was created using the two data layers.

Figure 3.49. Large Pelagic Survey 2011 – 2021 and Maine Department of Marine Resources Highly Migratory Species Fishing Trip data 2010 – 2021 in relation to the Draft WEA.

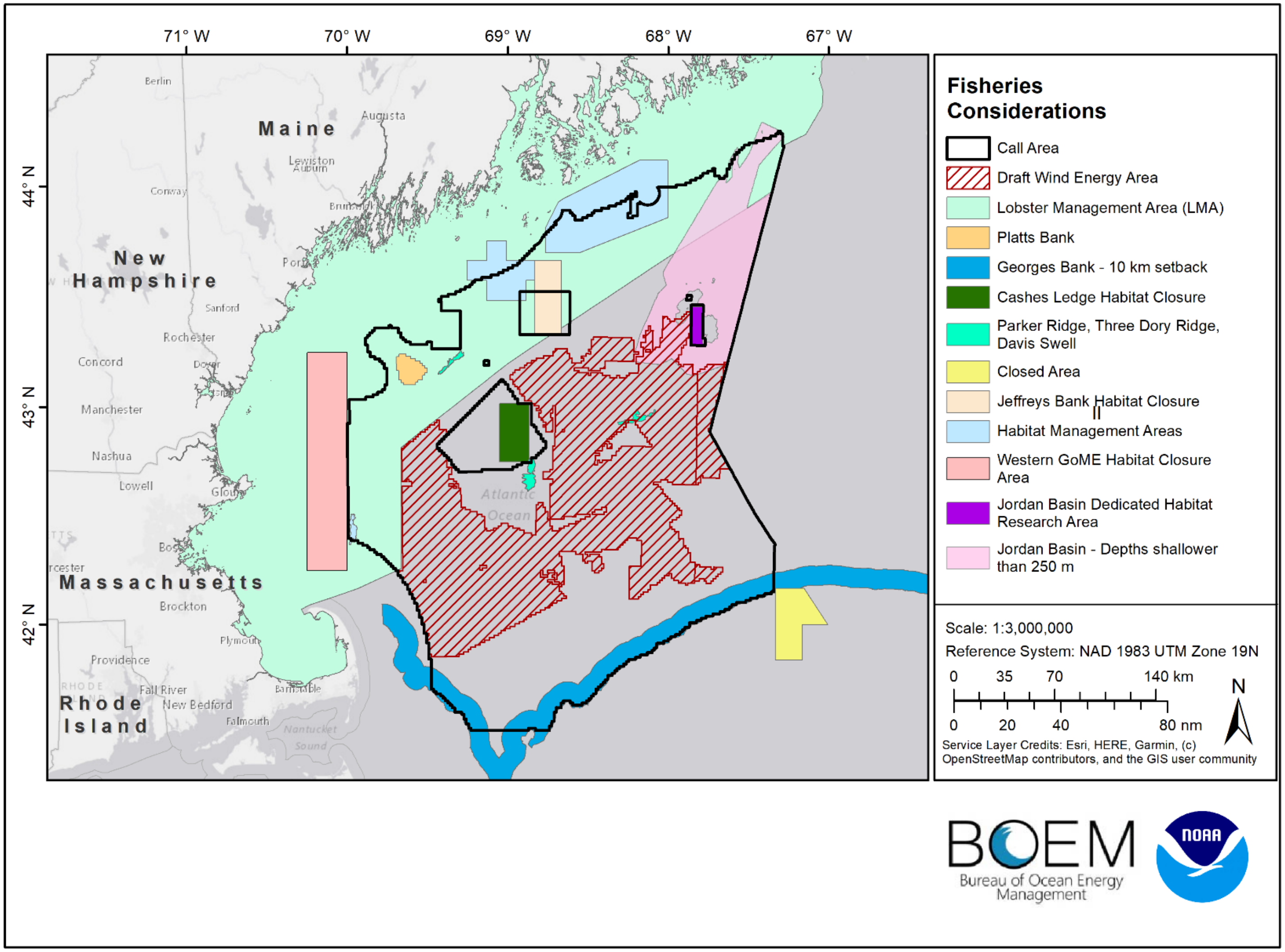


Figure 3.50. Fisheries habitat considerations in relation to the Draft WEA.

3.5. Characterization of the Draft WEA

The Draft WEA is characterized below. Characterization provides specific details regarding the geographic location, natural and cultural resources, industry and operations, fisheries, and wind logistics for the defined Draft WEA boundary.

3.5.1. Draft WEA

The 3,519,067-acre site is located offshore approximately 20 nm off of the Cape Cod shoreline. The closest port is Portsmouth, NH, located 67 nm west and the closest Point of Interconnection is Pilgrim, located 43.5 nm west (Figure 3.51). The mean depth across the entire Draft WEA is 198 m, with a maximum depth of 296 m and a minimum of 120 m (Table 3.5; Figure 3.52). Additional wind logistics considerations for the Draft WEA boundary are shown in Figures 3.53 - 3.54. Natural and Cultural Resources considerations for the Draft WEA boundary are shown in Figures 3.55 - 3.60. Industry and Operations considerations for the Draft WEA boundary are shown in Figures 3.61 - 3.64. Fisheries considerations for the Draft WEA boundary are shown in Figures 3.65 - 3.70.

Table 3.5. Characterization summary for the Draft WEA.

Logistics	**Value**
Size (acres)	3,519,067 acres
Distance to Mainland (nm)*	20 nm
Distance to Closest Port (nm)*	Portsmouth, NH; 67 nm
Distance to Closest Point of Interconnection (nm)*	Pilgrim; 43.5 nm
Depth (m) (minimum, maximum, mean)	min = 120 m, max = 296 m, mean = 198 m
NREL 20-Year Mean Wind Speed (m/s) at 150 m	10.10 - 10.74 m/s
Call Developer Nominations	0 - 6
Natural and Cultural Resources	**Value**
NMFS Protected Resource Division Combined Layer – Species overlap **Bolded species are designated as Endangered under the Endangered Species Act (ESA) and have declining or unknown/stable populations. These species received the lowest scores (0.1 or 0.2) in the combined layer.*	Atlantic white-sided dolphin (0.9) Bottlenose dolphin (0.6 & 0.9) Harbor porpoise (0.7) Pilot whale (0.7 & 0.9) Risso's dolphin (0.7 & 0.9) Short-beaked common dolphin (0.7) Seals (0.8) **Blue whale** (0.2) **Fin whale** (0.2) Humpback whale (0.8) Minke whale (0.7) **North Atlantic right whale** (0.1 & 0.5) **Sei whale** (0.2)

	Sperm whale (0.5) Atlantic salmon (0.5) **Atlantic sturgeon** (0.2) Giant manta ray (0.4 & 0.5) Shortnose sturgeon (0.5) Green sea turtle (0.5) Kemp's ridley sea turtle (0.5) **Leatherback sea turtle** (0.1) Loggerhead sea turtle (0.5)
NMFS Habitat Combined Layer – Habitat overlap	Known deep-sea coral & sponge locations Potential coral & hardbottom (areas shallower than 220 m) Jordan Basin (depths shallower than 250 m)
NMFS North Atlantic Right Whale Areas overlap	Maine Coastal Current; Depths < 150 m Jordan Basin; Depths > 200 m Wilkinson Basin; Depths > 220 m Sum of North Atlantic right whale density, > 1.018 individuals/100 km2
North Atlantic Right Whale Area Recommended for Removal overlap	Cashes Ledge Extension Area North Atlantic Right Whale Corridor & Extension Area
FWS Avian Combined Layer overlap	BRI – Integrated Seabird Risk and Vulnerability Assessment – High BRI – Tracking Data for Diving Birds – Core Use Area 24 nm buffer from shore, including islands
Industry and Operations	**Value**
NMFS Fisheries-Independent Surveys	7 - 10
Wreck and Obstructions – 500 ft setback	11
NEXRAD Stations Moderate Impact (35 – 70km)	No overlap
Aids to Navigation (beacons and buoys) - 500 m setback	No overlap
USCG Draft MNM PARS Fairways	Overlaps 19 aliquots (0.2%) in the northern portion of the Draft WEA
EPA Mandatory Class 1 Federal Areas – 50 km and 100 km setback	Overlap with 100 km setback

AIS Vessel Traffic All Vessels 2015-2022	1 - 25
Special Use Airspace Warning Area 103	No overlap
Fisheries	**Value**
Fishing Footprint Raster Data (revenue) 2008 - 2021	$1,953 - $21,079
Fishing Footprint Raster Data (landings) 2008 - 2021	0 – 8,514
VMS Data 2009 - 2021	0 – 1,369
Charter/Party VTR 2008 – 2020 Sum of Revenue	$0 - $205,066
<u>Fisheries Considerations:</u> Lobster Management Area 1 Platts Bank Georges Bank Western Gulf of Maine Closure Jeffreys Bank Habitat Management Area (HMA) HMAs considered, but not adopted by NEFMC (e.g., Toothaker Ridge, Large Eastern Maine proposed HMA, Wildcat Knoll) Closed Area II Davis Swell, Parker Ridge, Three Dory Ridge Jordan Basin Dedicated Habitat Research Area Cashes Ledge	 No overlap No overlap Overlaps with 10 km – 20 km setback No overlap Overlaps with 20 km setback No overlap No overlap Completely overlaps with Davis Swell; Overlaps with Parker Ridge 20 km setback Overlaps with 20 km setback Overlaps with 20 km setback

*Distance to mainland, ports, and points of interconnection are calculated using Euclidean distance or “as the crow flies”. This method measures a straight line between two locations and does not account for navigational routing.	

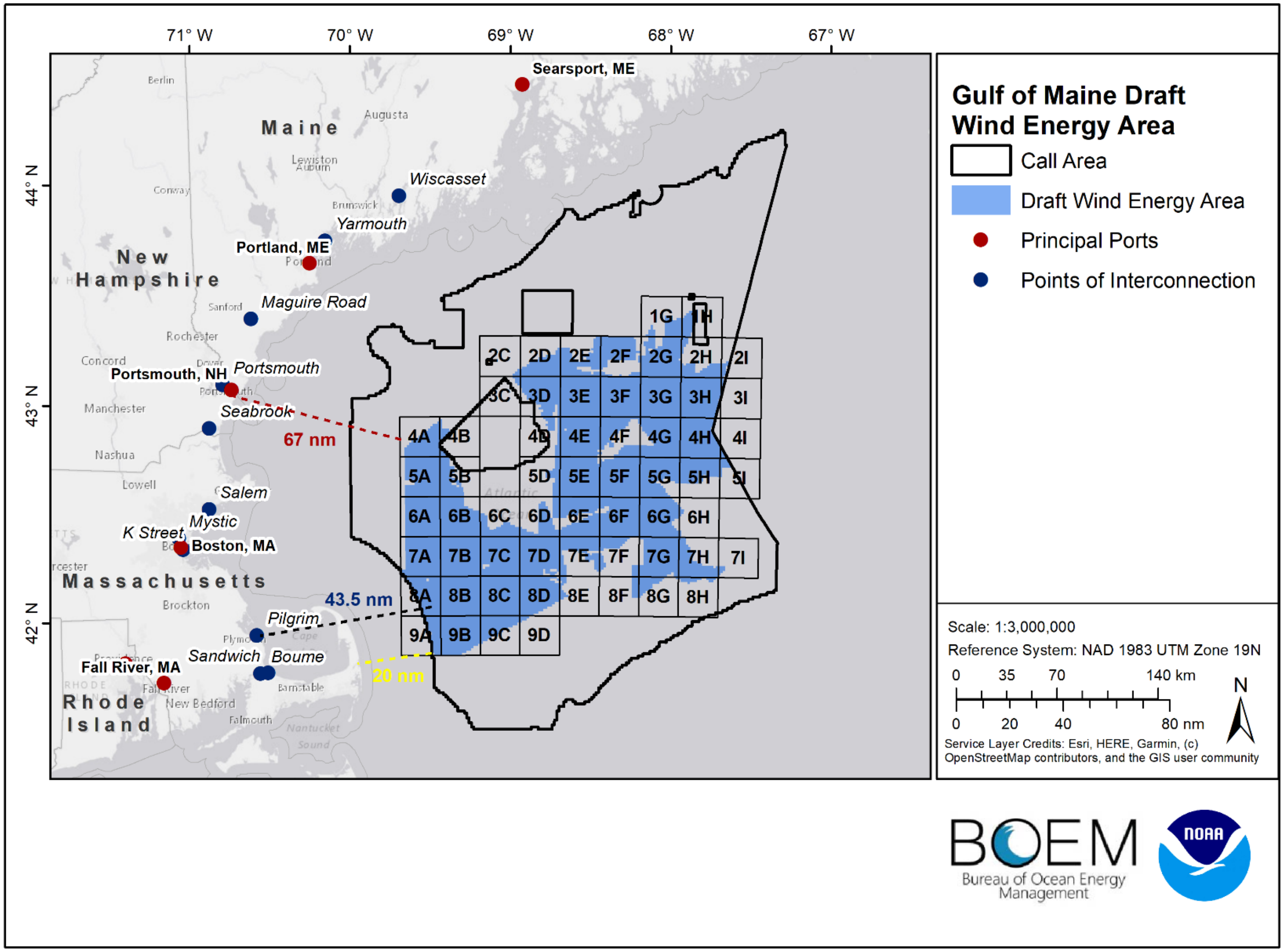


Figure 3.51. Draft WEA (blue area) and distance to mainland (20 nm), the Port of Portsmouth, NH (67 nm), and the closest Point of Interconnection (Pilgrim; 43.5 nm).

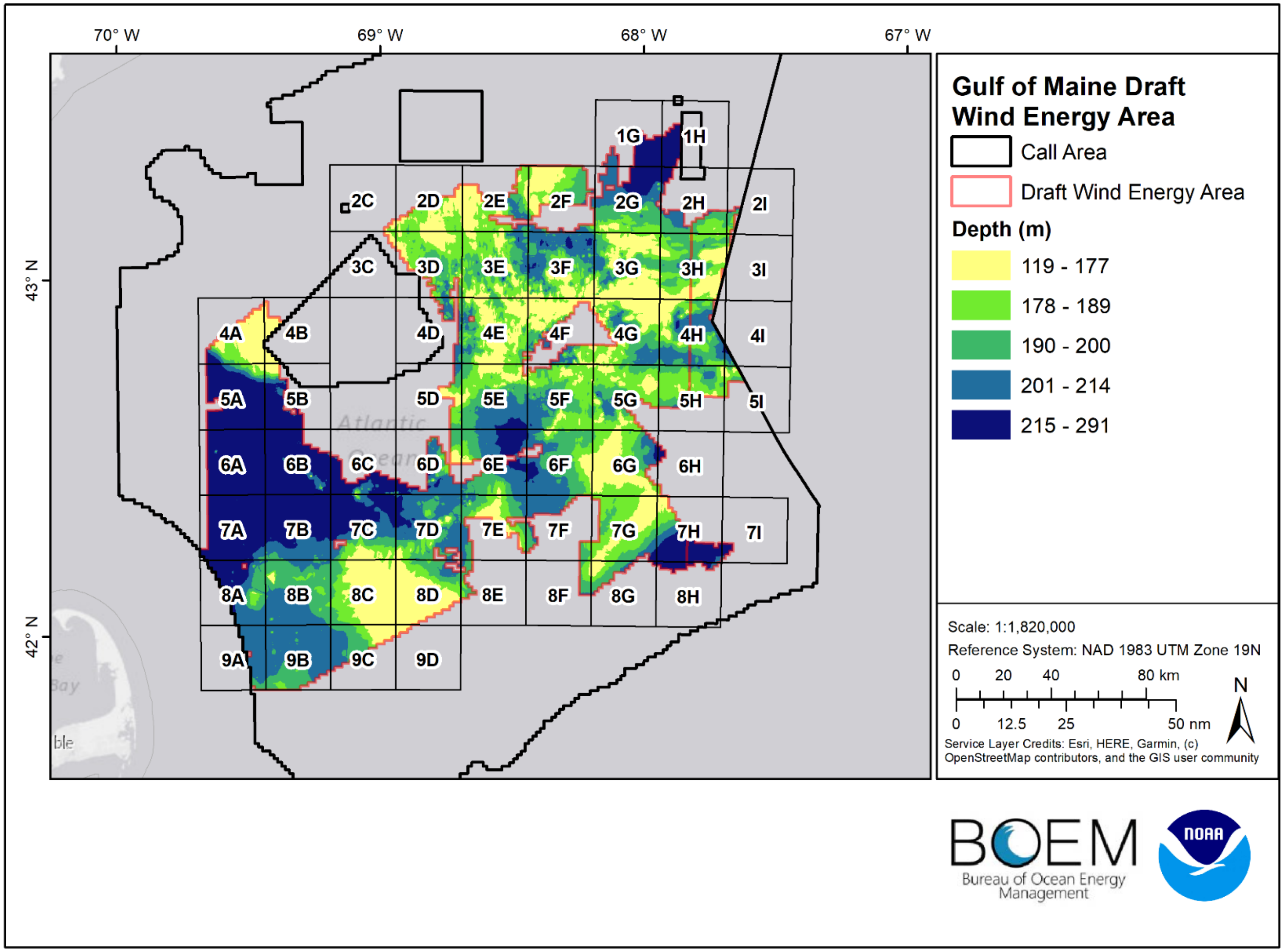


Figure 3.52. Map depicting maximum depth for the Draft WEA.

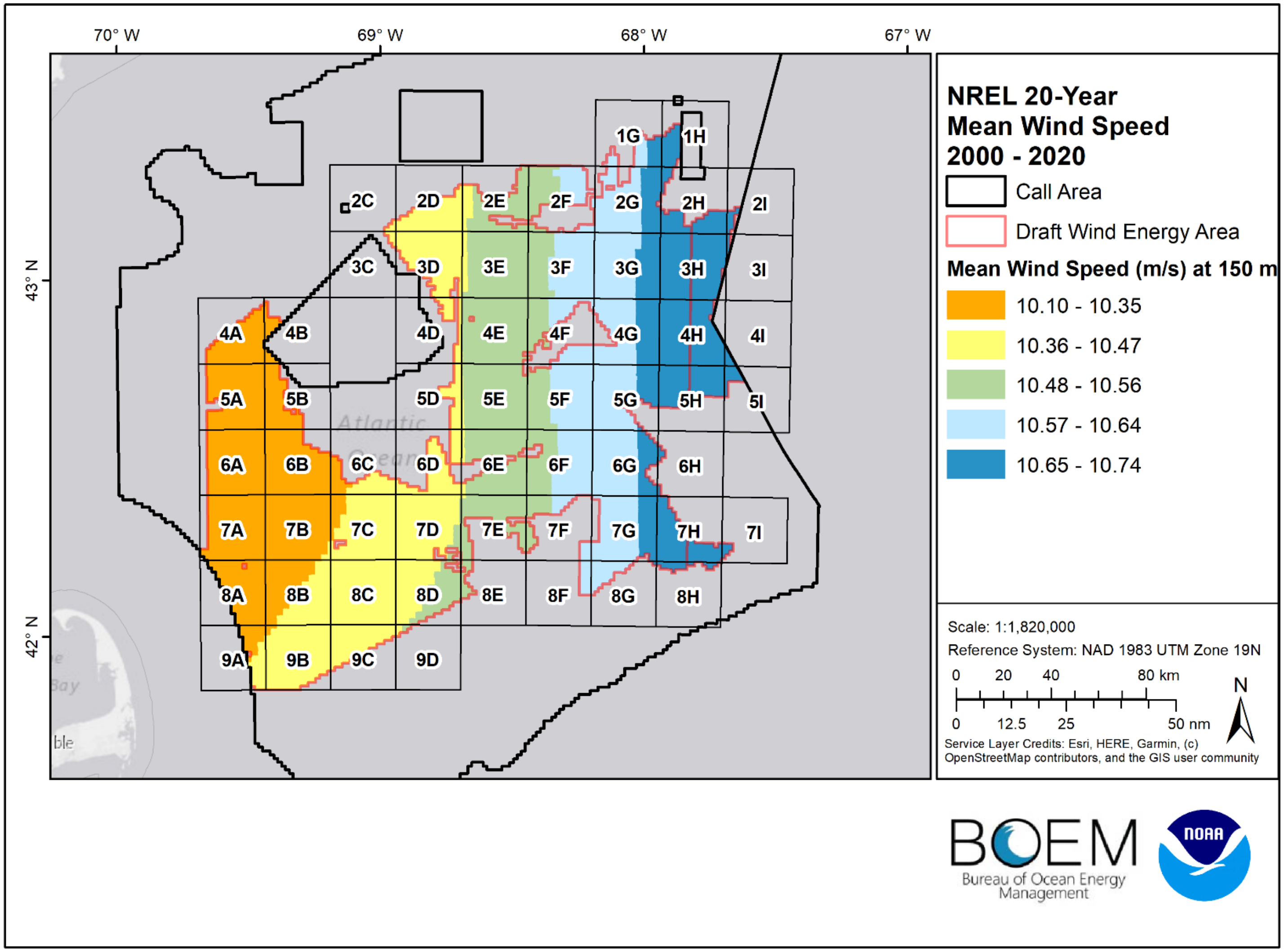


Figure 3.53. Map depicting NREL 20-Year Mean Wind Speed (2000 – 2020) for the Draft WEA.

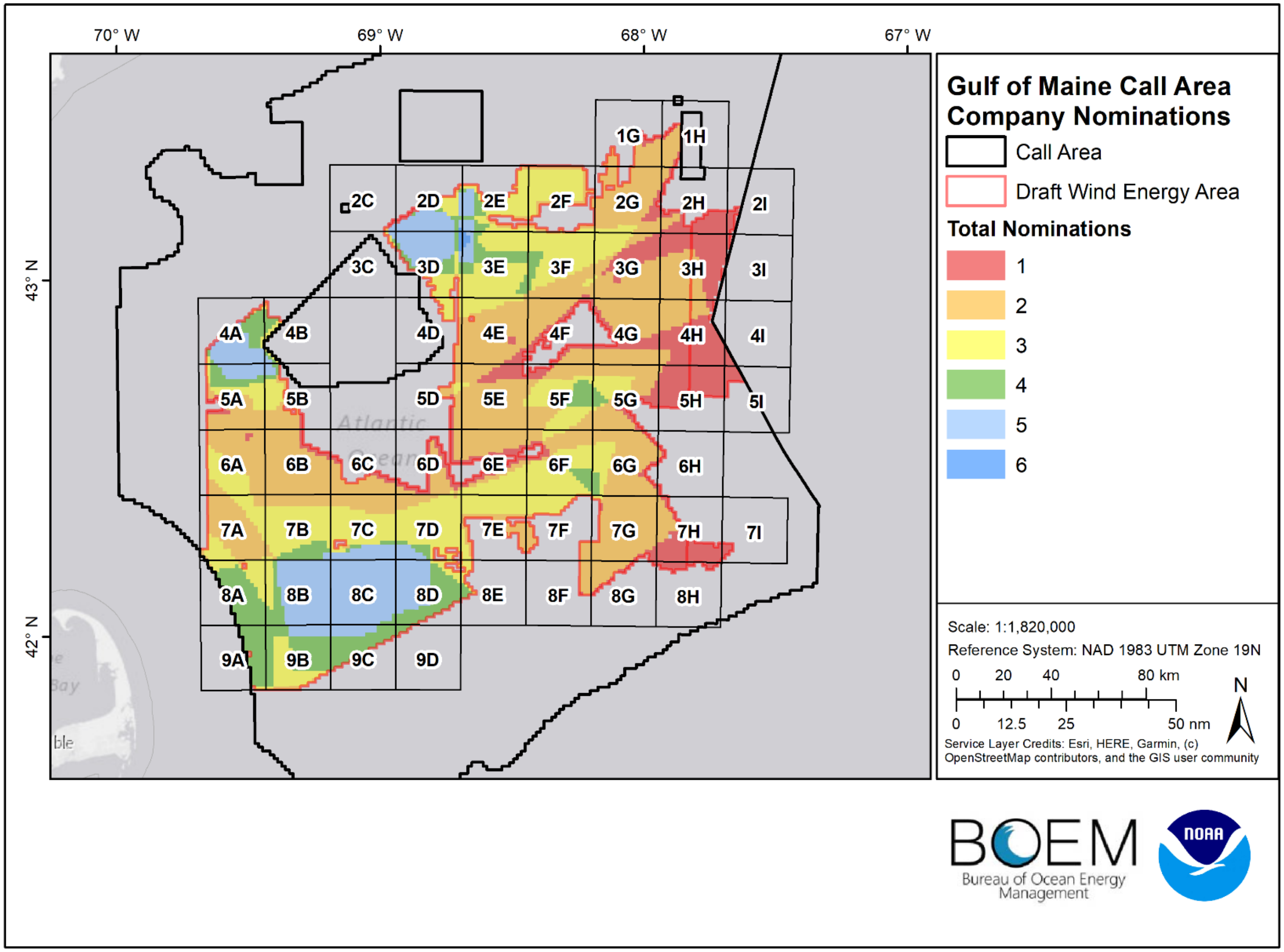


Figure 3.54. Map depicting Call Area Company Nominations for the Draft WEA.

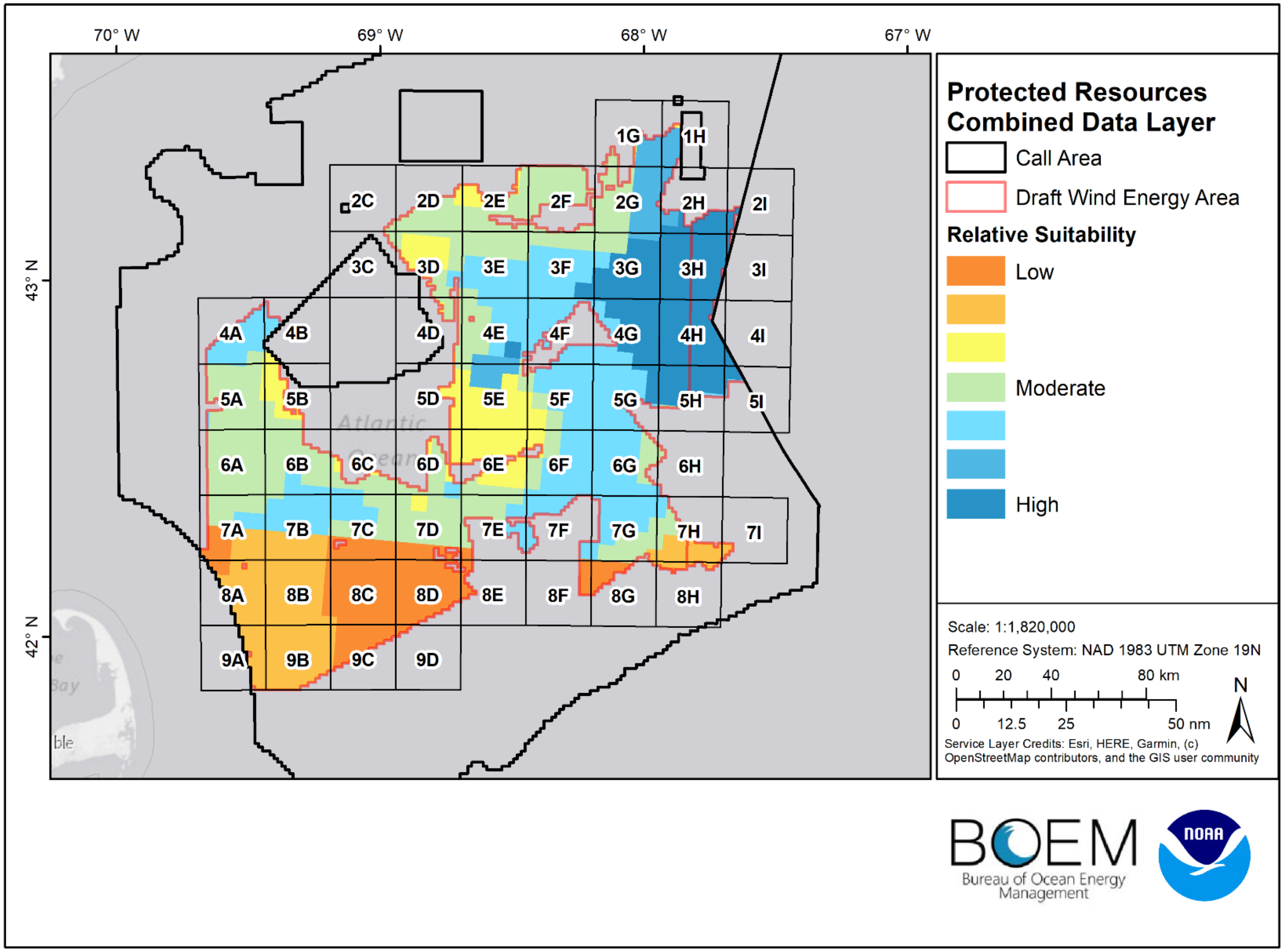


Figure 3.55. Map depicting NMFS Protected Resources Division Combined layer (22 species) relative suitability for the Draft WEA.

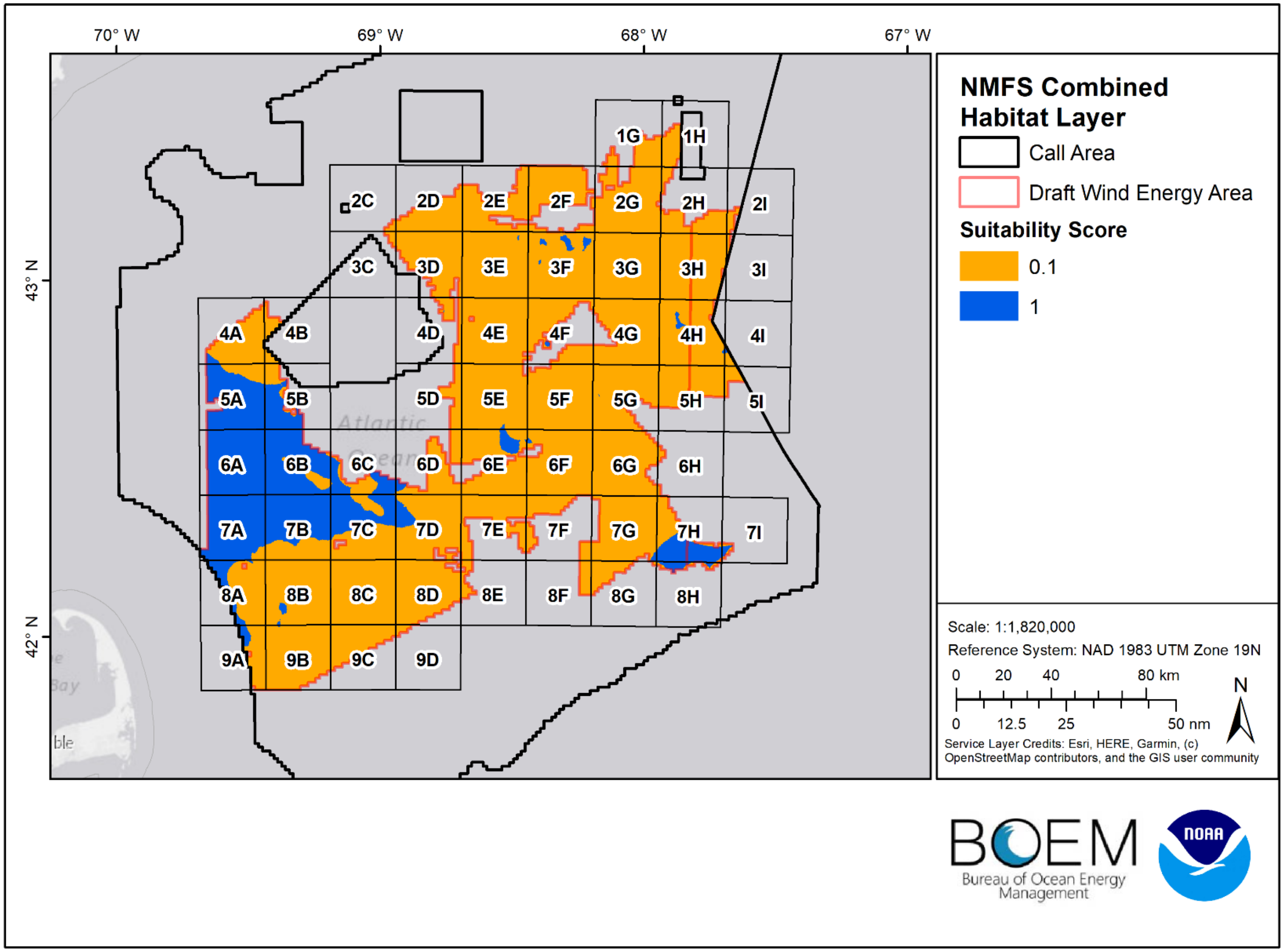


Figure 3.56. Map depicting NMFS Habitat Combined layer overlap with the Draft WEA.

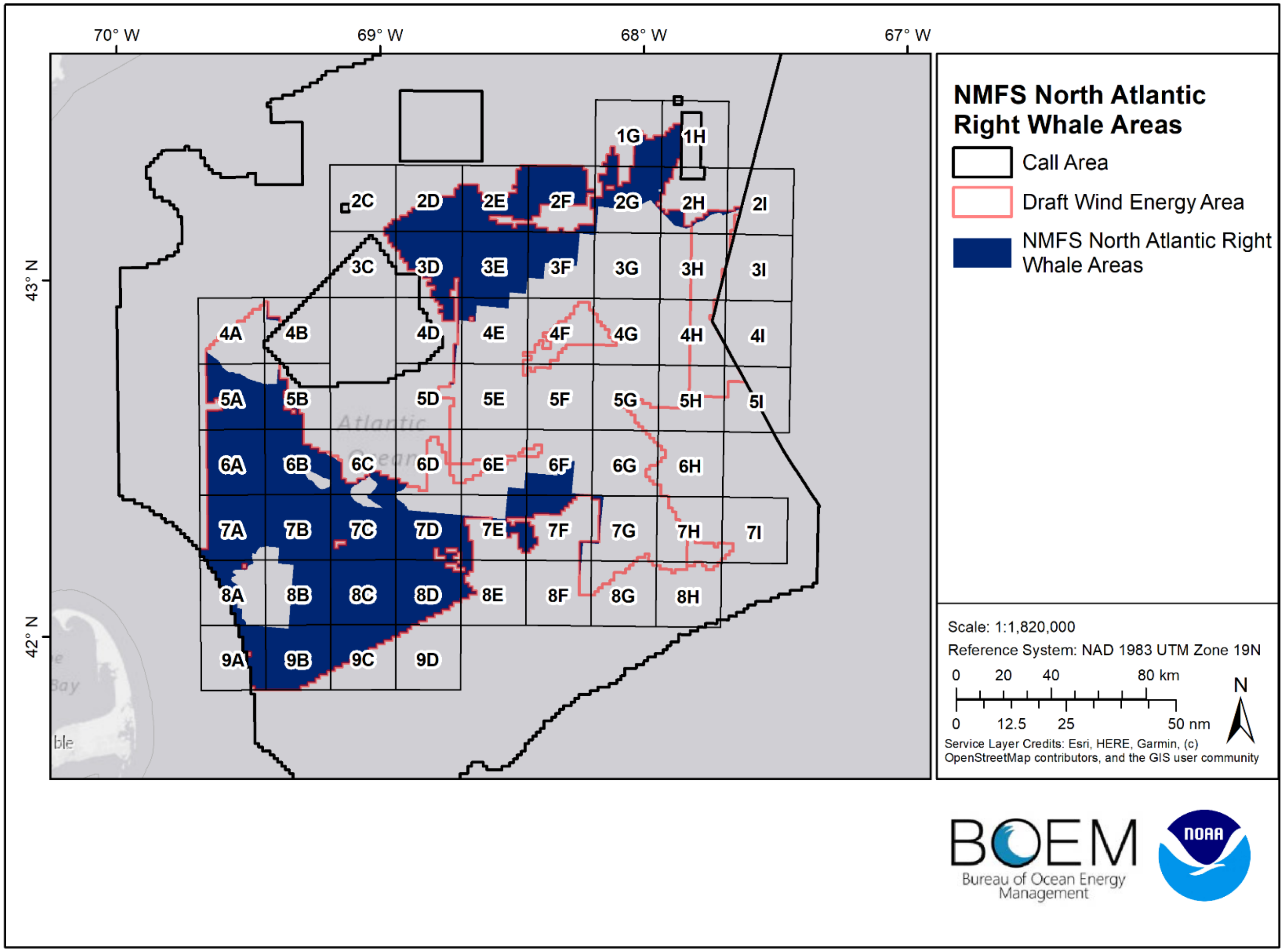


Figure 3.57. Map depicting North Atlantic Right Whale Areas overlap with the Draft WEA.

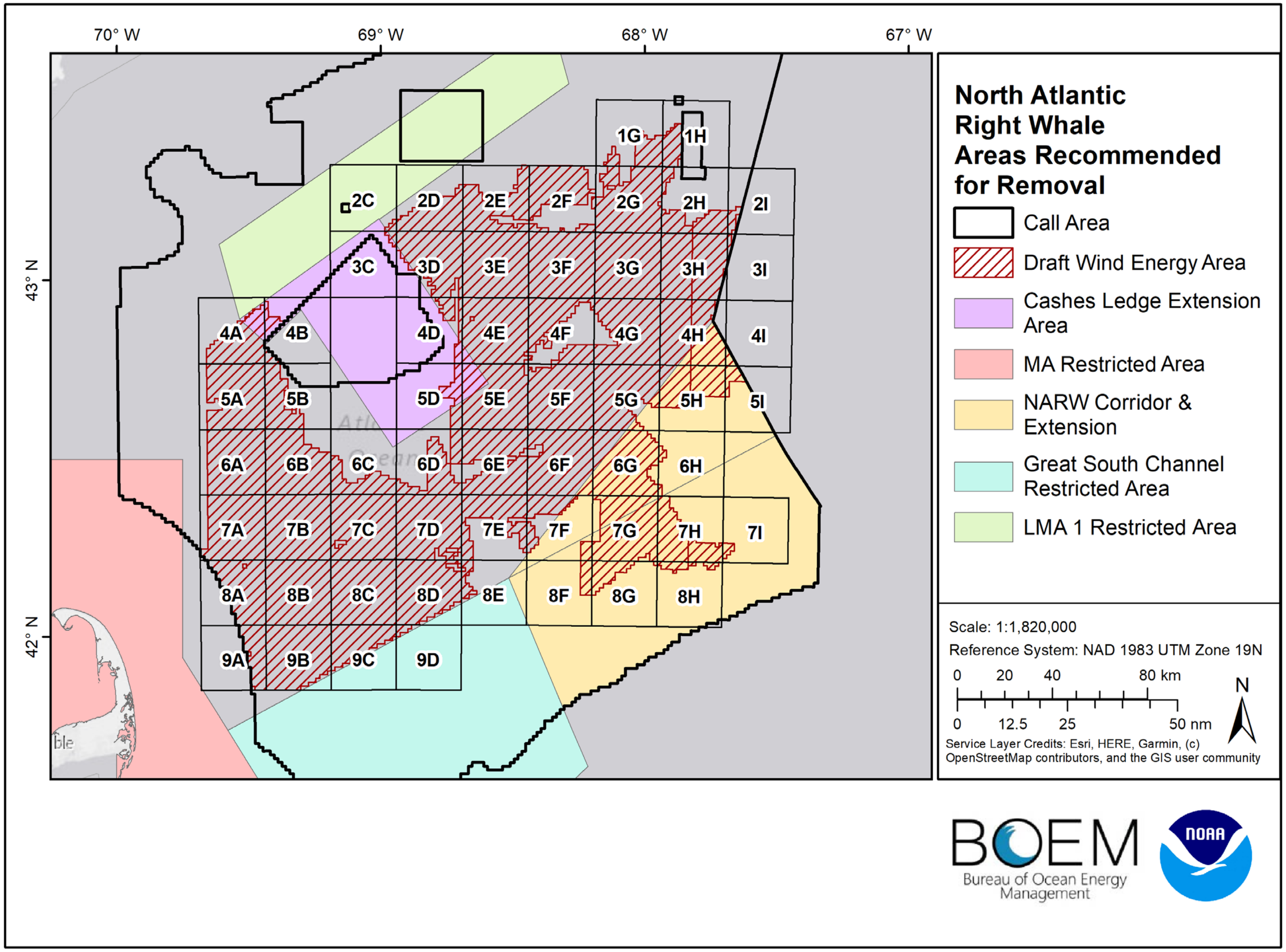


Figure 3.58. Map depicting North Atlantic Right Whale Areas Recommended for Removal overlap with the Draft WEA.

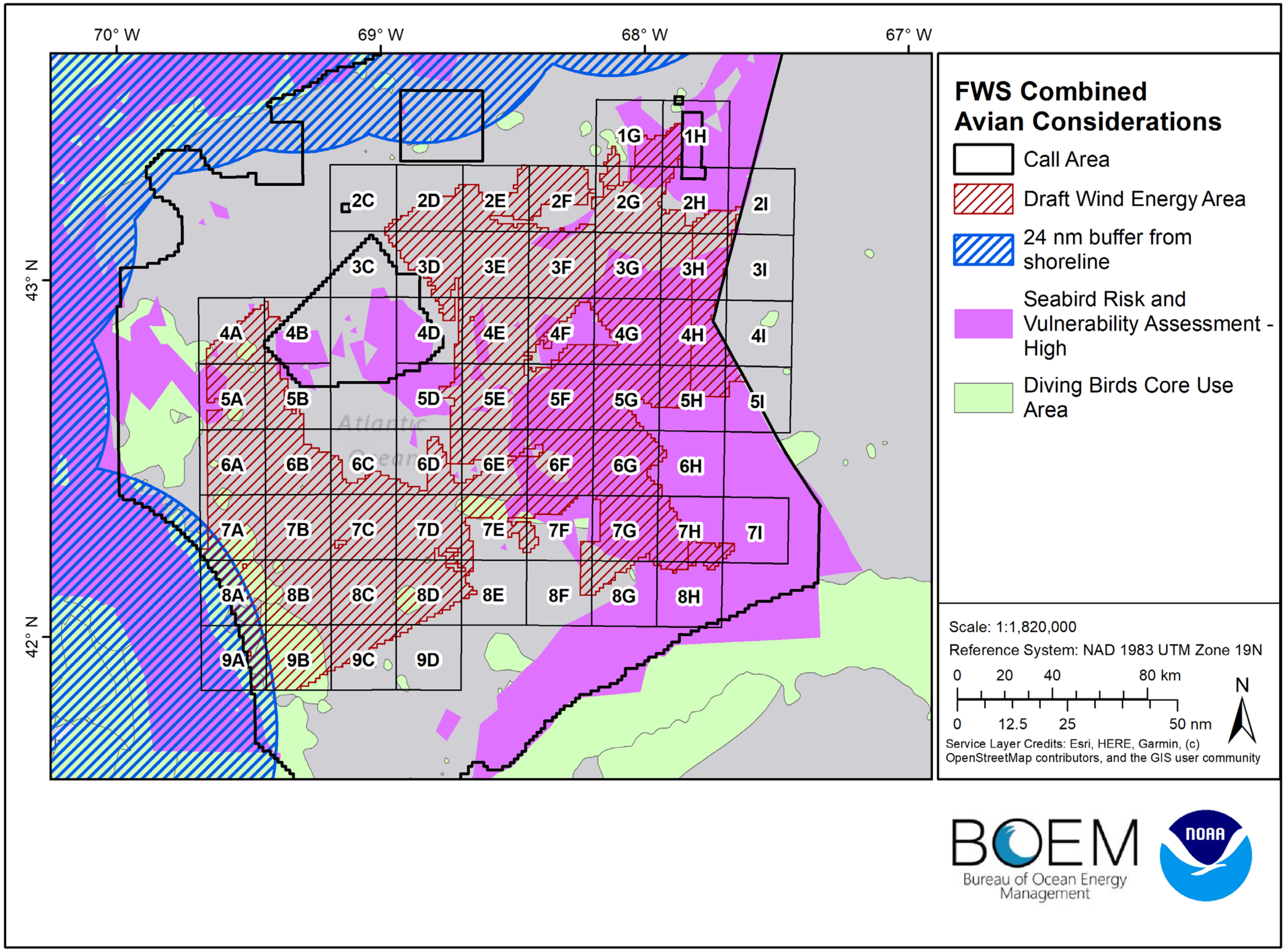


Figure 3.59. Map depicting USFWS Combined Avian Considerations layer overlap with the Draft WEA.

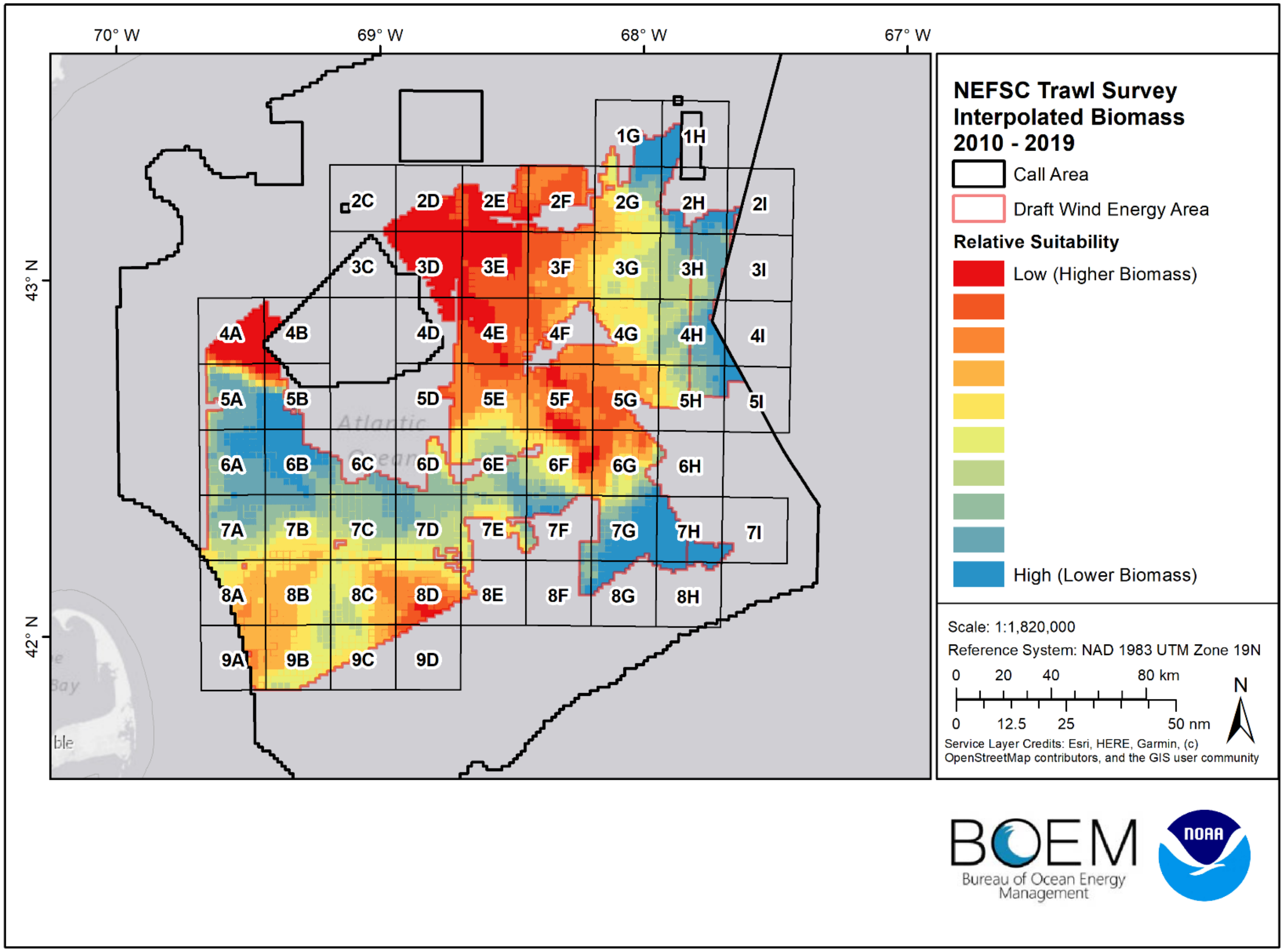


Figure 3.60. Map depicting NEFSC Trawl Survey Interpolated Biomass (2010 – 2019) suitability for the Draft WEA.

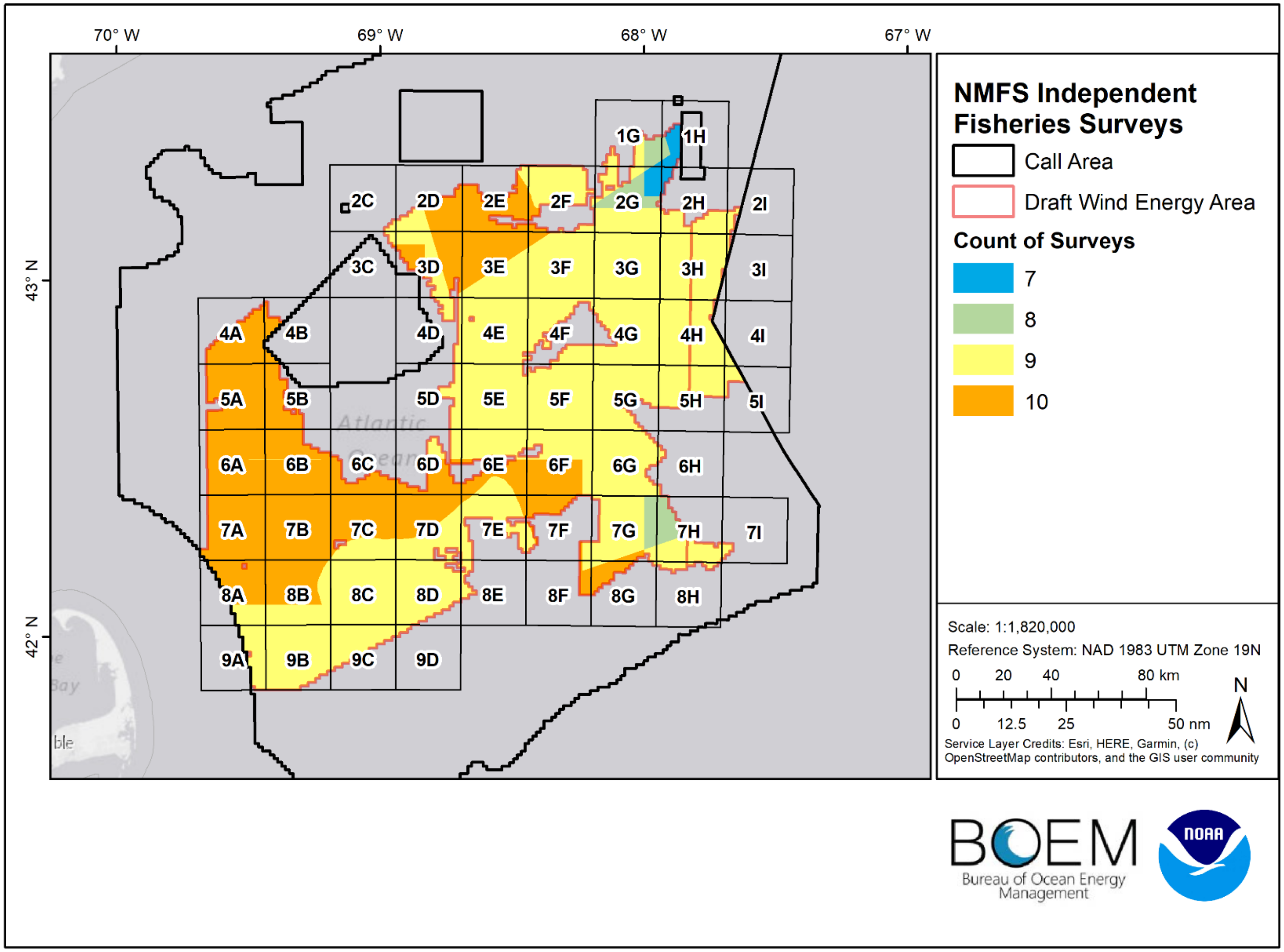


Figure 3.61. Map depicting NMFS Fisheries-Independent Surveys (13 total survey) overlap with the Draft WEA.

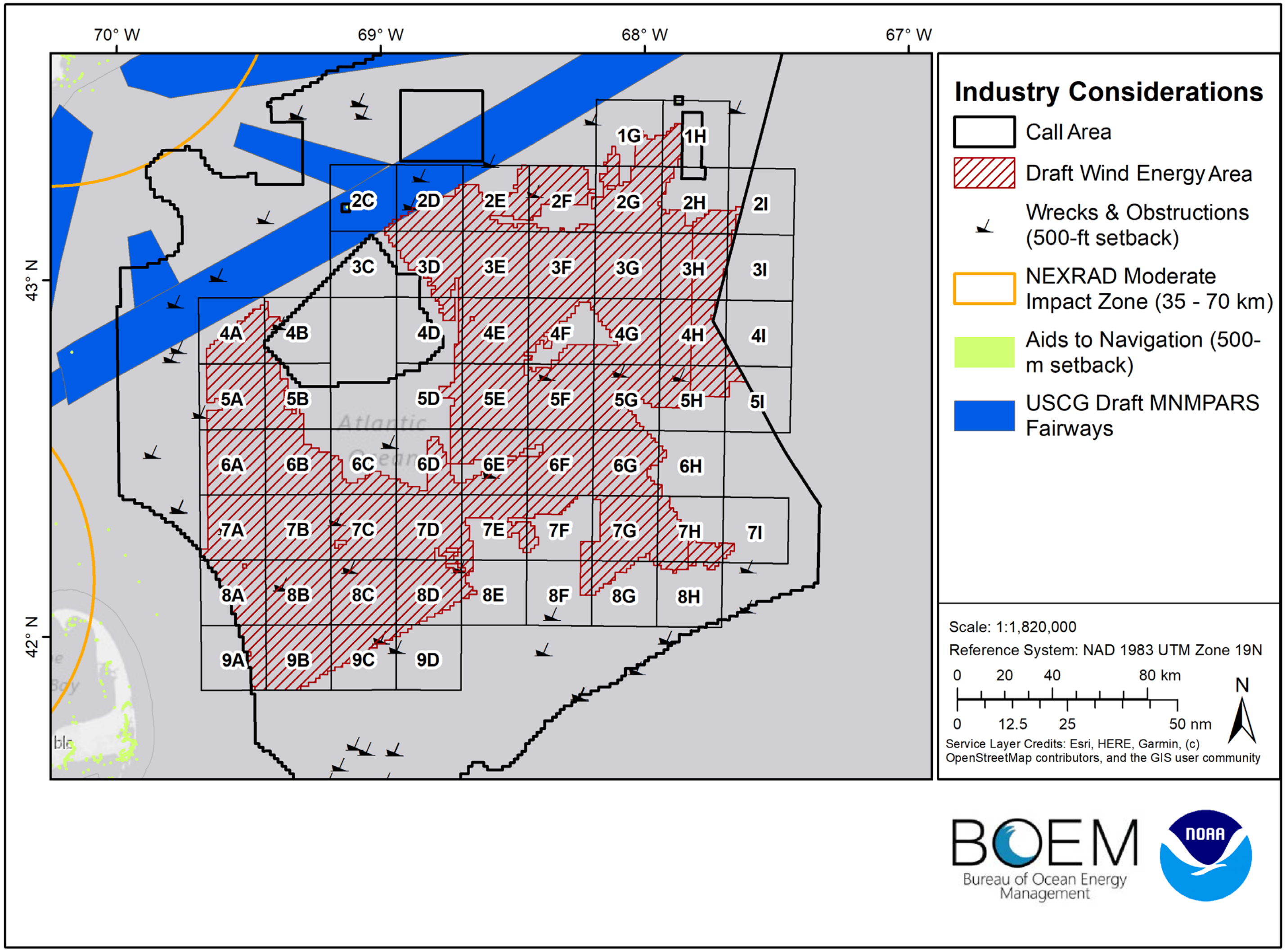


Figure 3.62. Map depicting industry considerations overlapping the Draft WEA.

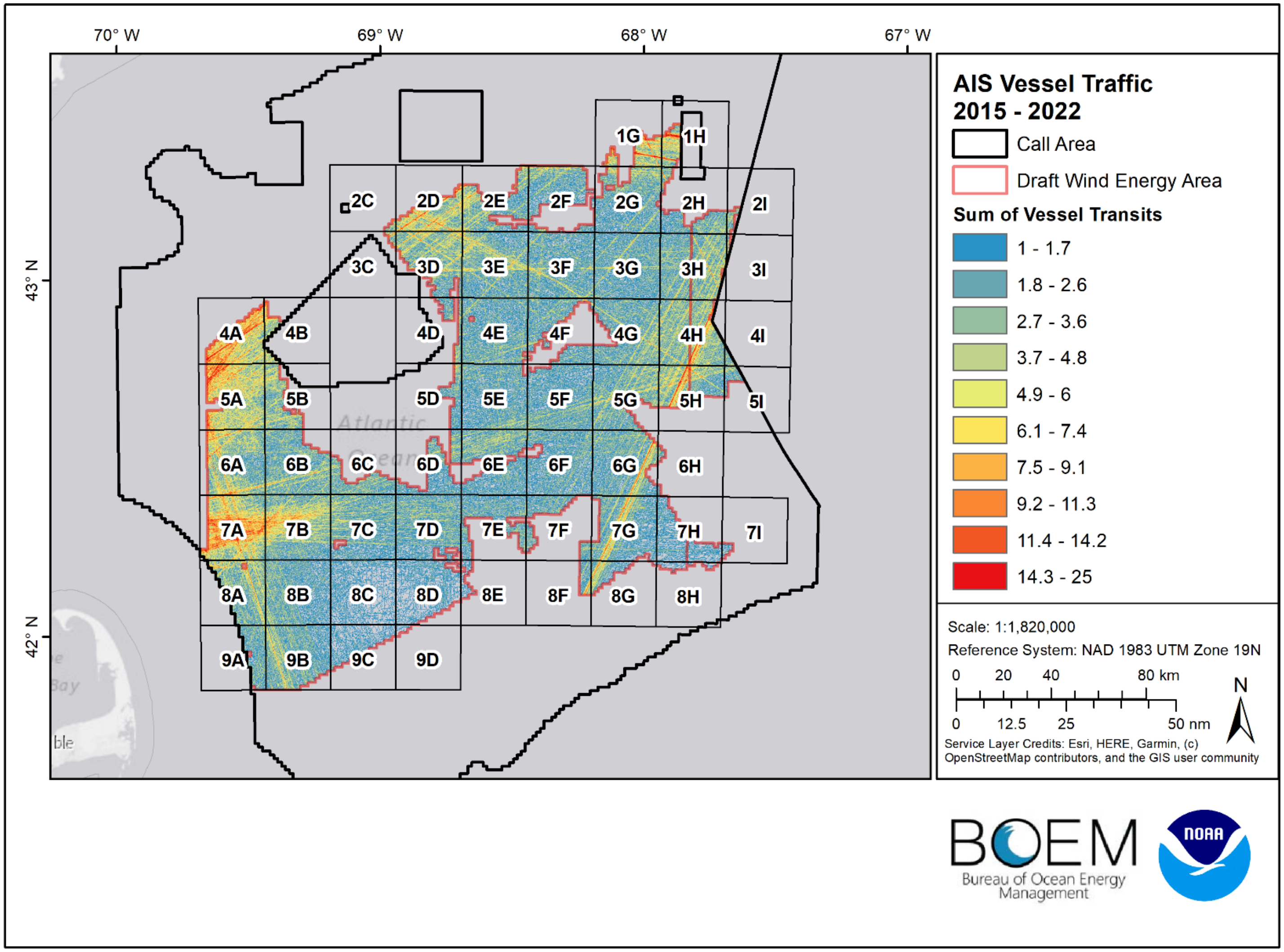


Figure 3.63. Map depicting AIS Vessel Traffic 2015 - 2022 for the Draft WEA.

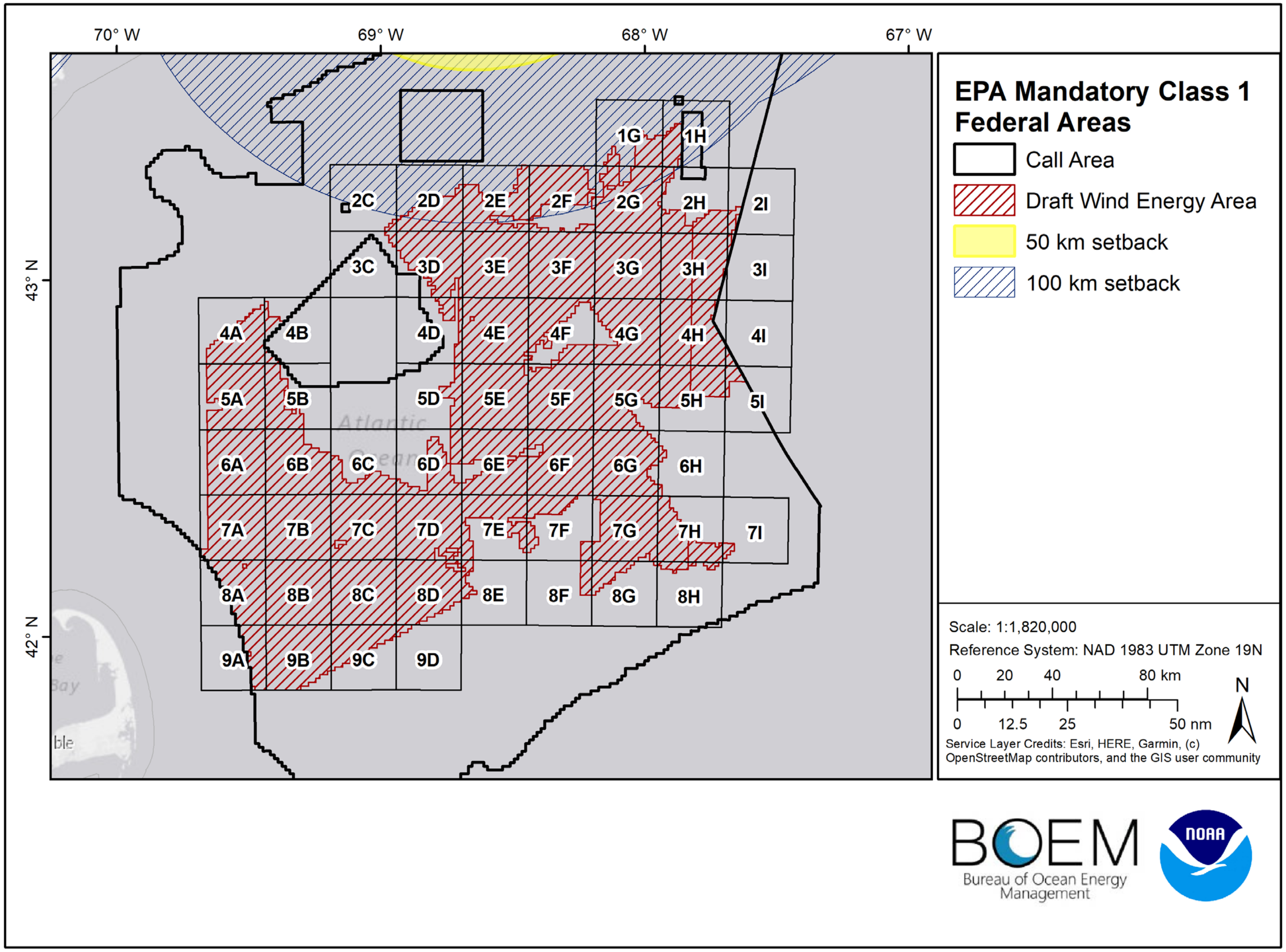


Figure 3.64. Map depicting EPA Mandatory Federal Class 1 Areas and setbacks for the Draft WEA.

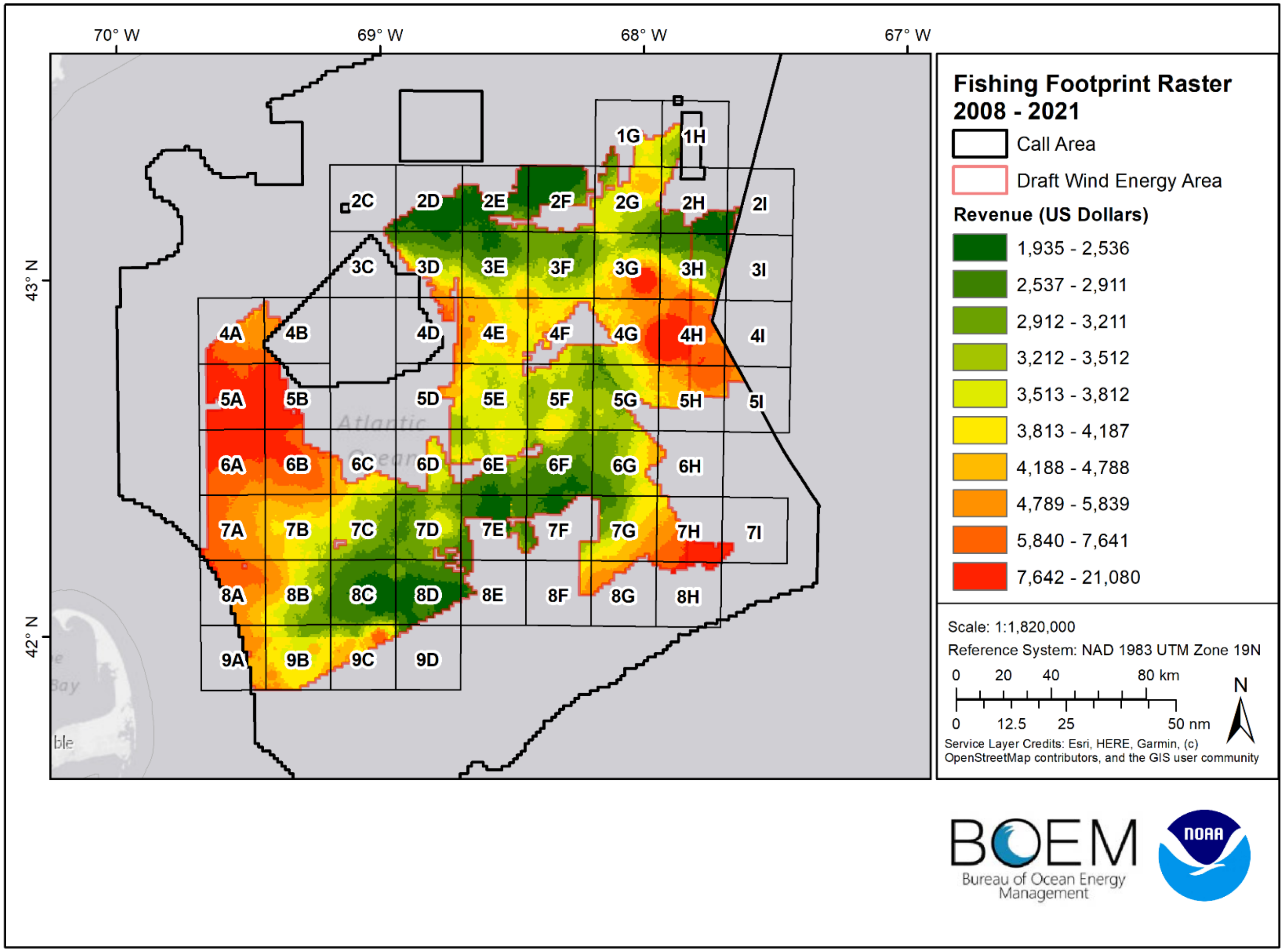


Figure 3.65. Map depicting Fishing Footprint Revenue (2008 – 2021) for the Draft WEA.

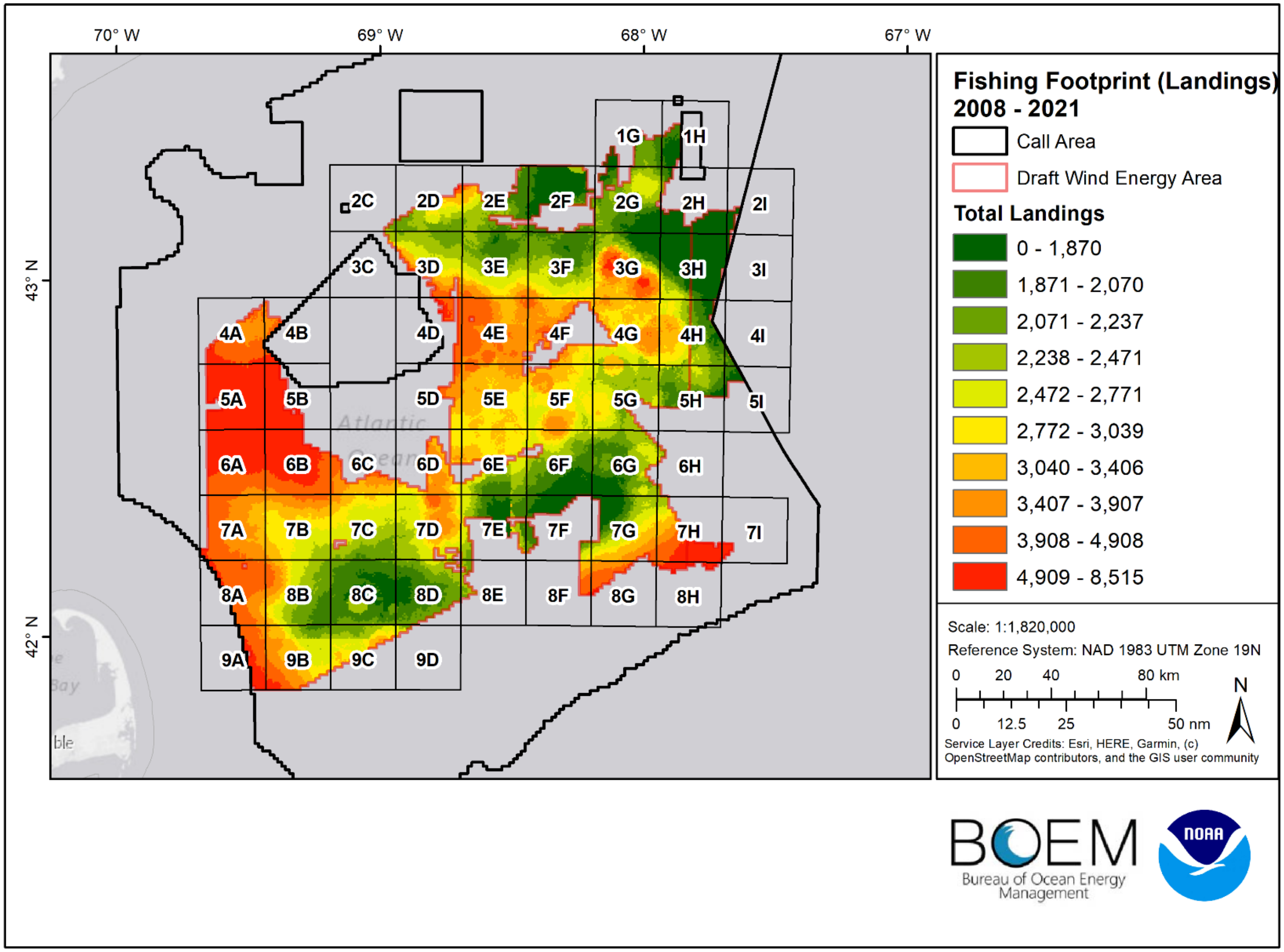


Figure 3.66. Map depicting Fishing Footprint Landings (2008 – 2021) for the Draft WEA.

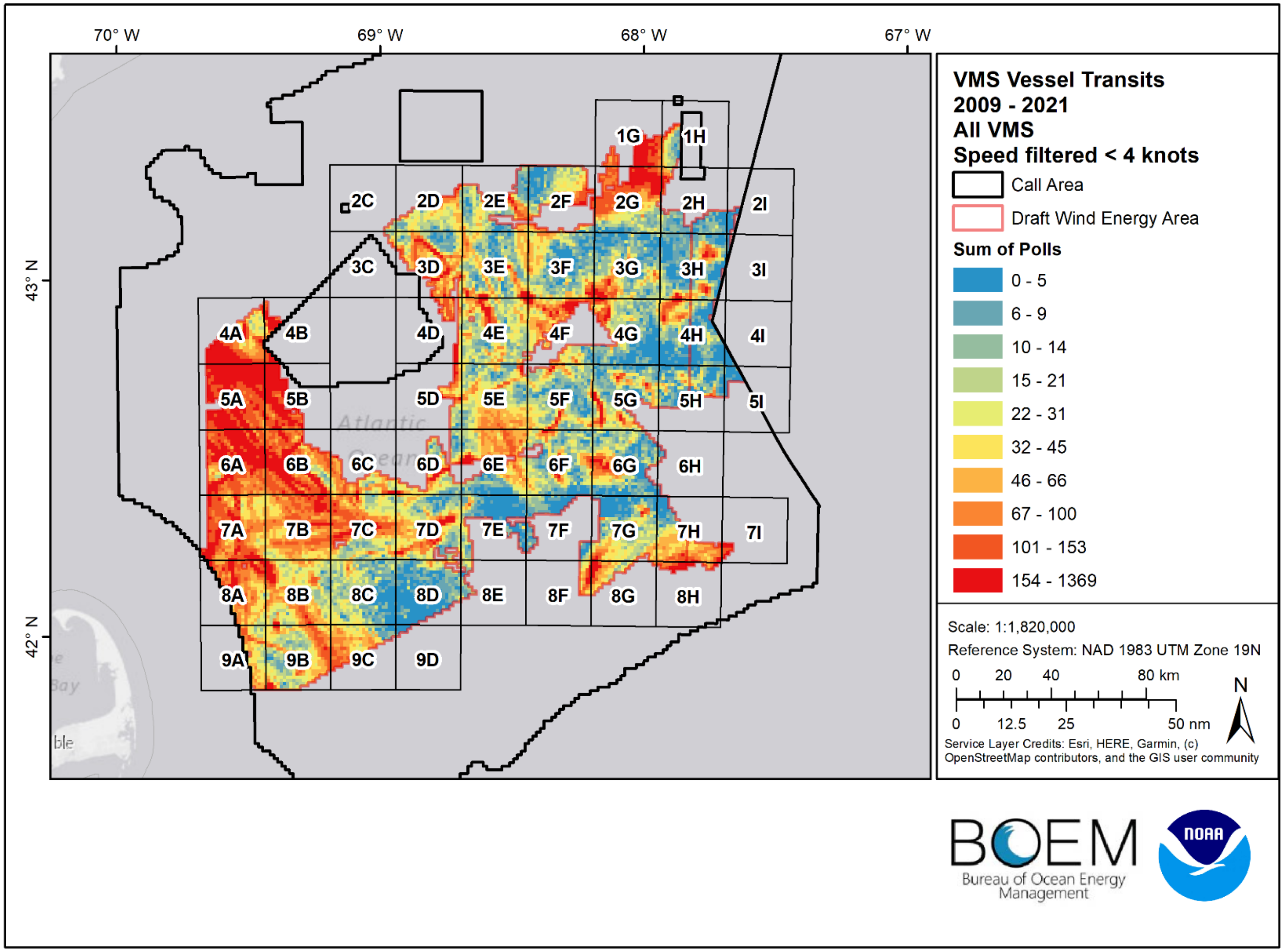


Figure 3.67. Map depicting VMS data (2009 – 2021) for the Draft WEA.

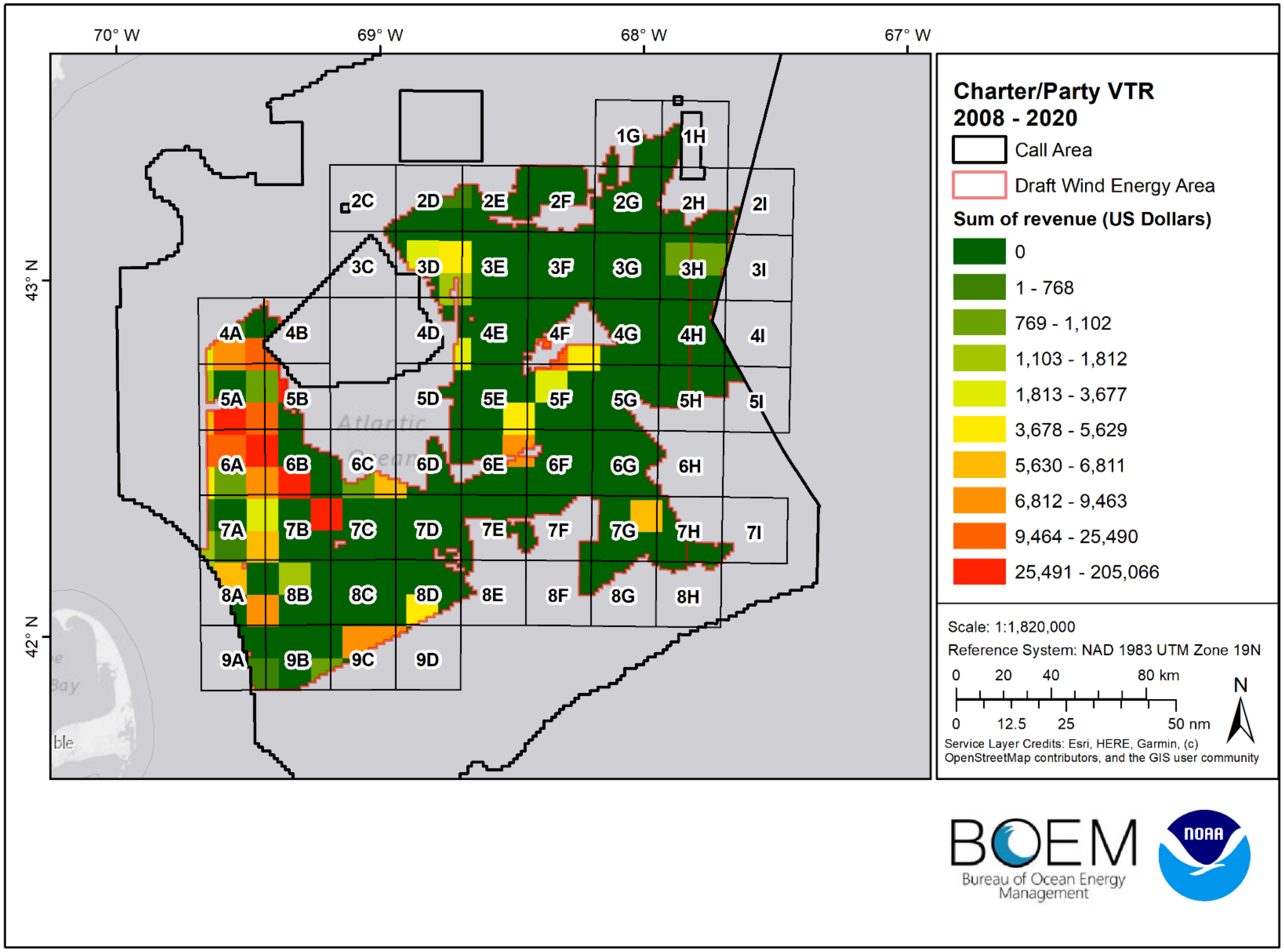


Figure 3.68. Map depicting Charter/Party VTR (2008 – 2020) for the Draft WEA.

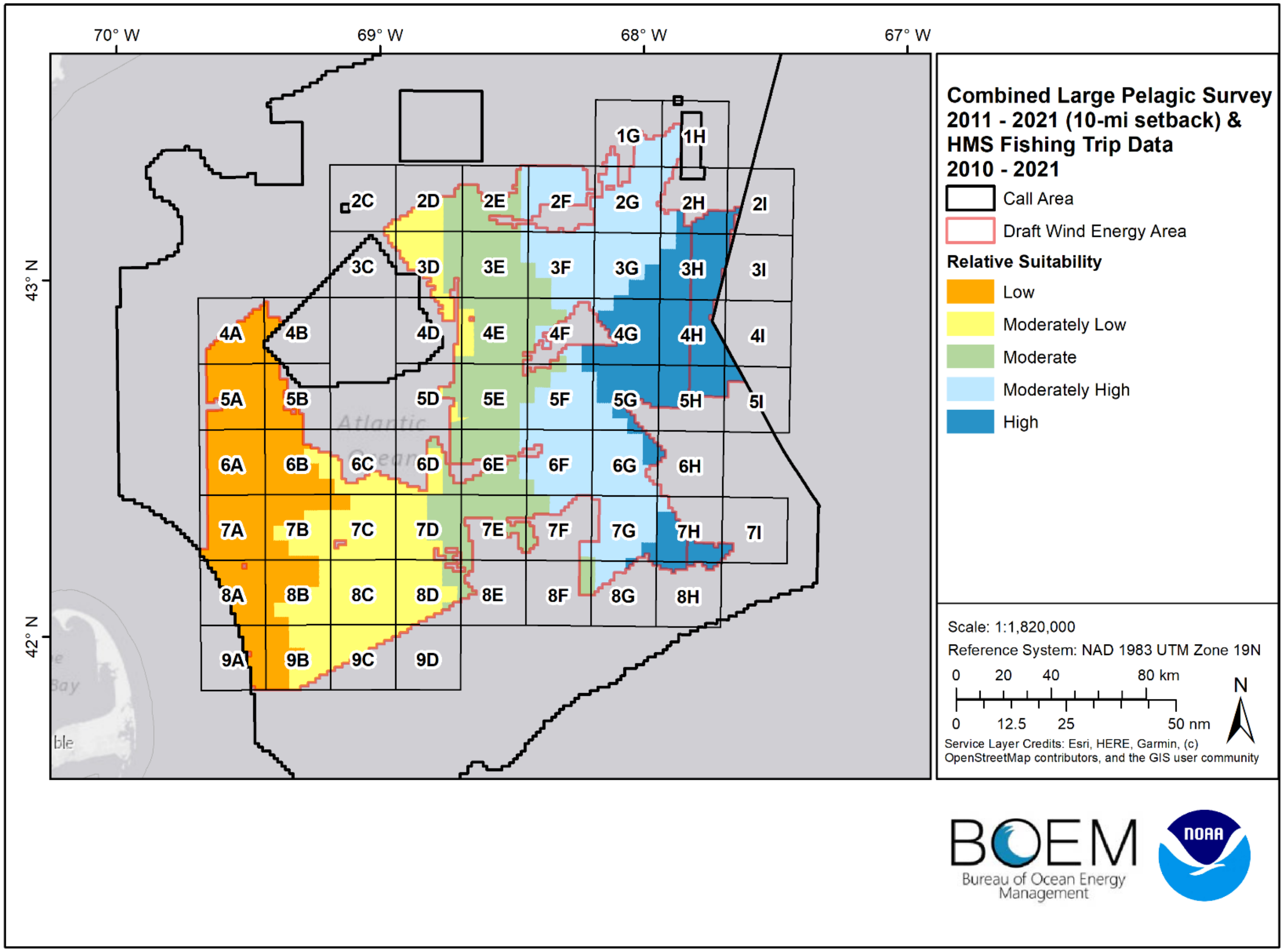


Figure 3.69. Map depicting Combined Large Pelagic Survey (2011 – 2021) and Highly Migratory Species Fishing Trip data (2010 – 2021) for the Draft WEA.

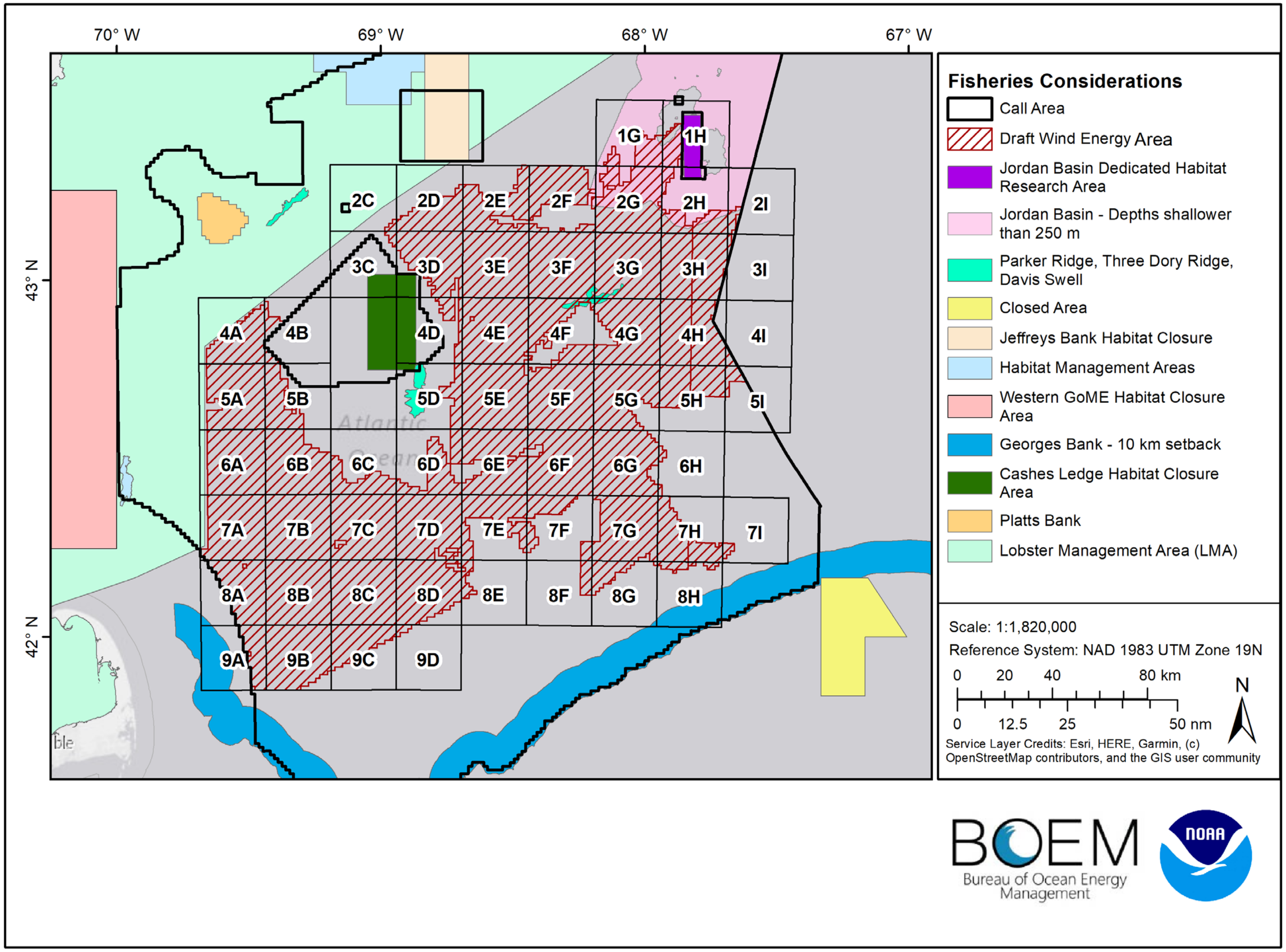


Figure 3.70. Map depicting fisheries habitat considerations overlap with the Draft WEA.

4. BOEM Recommendations for Draft WEAs

Based on the cluster analysis and using the results provided by the final suitability model, BOEM identified one contiguous Draft WEA (Figure 4.1), which consists of 3,519,067 acres. The total area of the Draft WEA represents a 64.11% reduction of the Call Area. The Draft WEA has a combined capacity of over 40 GW (assuming a power density of 3 megawatts per square kilometer), which exceeds the current combined offshore wind planning goals for the Gulf of Maine states: 10 GW for Massachusetts; 3 GW for Maine. BOEM anticipates future reductions to the Draft WEA, while striving to retain sufficient area to meet the States' planning goals. These reductions will be informed by comments received in response to the Notice for Comment (search for BOEM-2023-0054 on Regulations.gov), as well as through BOEM's public engagement efforts on the Draft WEA detailed here:
https://www.boem.gov/renewable-energy/state-activities/maine/gulf-maine

At its nearest points, the Draft WEA is approximately:

- 23 miles east of Wellfleet, MA;
- 70 miles east of Boston, MA;
- 48 miles east of Rockport, MA;
- 56 miles east of Portsmouth, NH;
- 64 miles southeast of Portland, ME;
- 44 miles southeast of Monhegan Island, ME; and
- 57 miles south of Mount Desert Island, ME.

The mean depth across the entire Draft WEA is 198 meters with a maximum depth of 296 meters and a minimum depth of 120 meters. The wind energy industry expressed interest in areas throughout the Draft WEA, particularly areas west and northeast of the Cashes Ledge Groundfish Closure Area, as well as east of Cape Cod (Figure 4.1). Potential spatial and environmental conflicts identified in the Draft WEA include, but are not limited to, National Marine Fisheries Service (NMFS) fisheries scientific surveys, commercial fishing (e.g., Wilkinson's Basin and LMA3), visual impacts to the National Seashore, and natural resources, including presence of protected species, marine birds, and deep-sea corals.

The Draft WEA avoids LMA1 and all NARW Restricted Areas. The Draft WEA also avoids several other important fishing areas and habitats, including important groundfish areas east of the Western Gulf of Maine Closure and within the 10-kilometer buffer from Georges Bank (defined by the 140-meter line of bathymetry), Platts Bank, Parker Ridge, and Three Dory Ridge. From initial conversations with Tribal Nations located within Maine, the Draft WEA also likely avoids a majority of historic and present fishing grounds of those Tribes. BOEM also investigated the extent of submerged paleocultural landforms in the Gulf of Maine region and determined they likely did not extend past the 60-meter line of bathymetry;[15] all of these areas are outside of the Draft WEA. BOEM will continue to consult with all Tribal Nations with an interest in the region to understand their concerns with potential offshore wind energy development, including viewshed and transmission impacts, and strive to minimize potential conflicts.

The DoD Clearinghouse requested avoidance of Warning Area 103, which is located outside of the Draft WEA. The Draft WEA almost entirely avoids the U.S. Coast Guard's Maine, New Hampshire, Massachusetts Port Access Route Study (MNMPARS) recommended safety fairways; however, there are several aliquots that partially overlap the Gulf of Maine fairway in the area directly northeast of the Cashes Ledge Groundfish Closure.

[15] Kelley, Joseph T., Daniel F. Belknap, and Stefan Claesson. "Drowned coastal deposits with associated archaeological remains from a sea-level "slowstand": Northwestern Gulf of Maine, USA." *Geology* 38.8 (2010): 695-698.

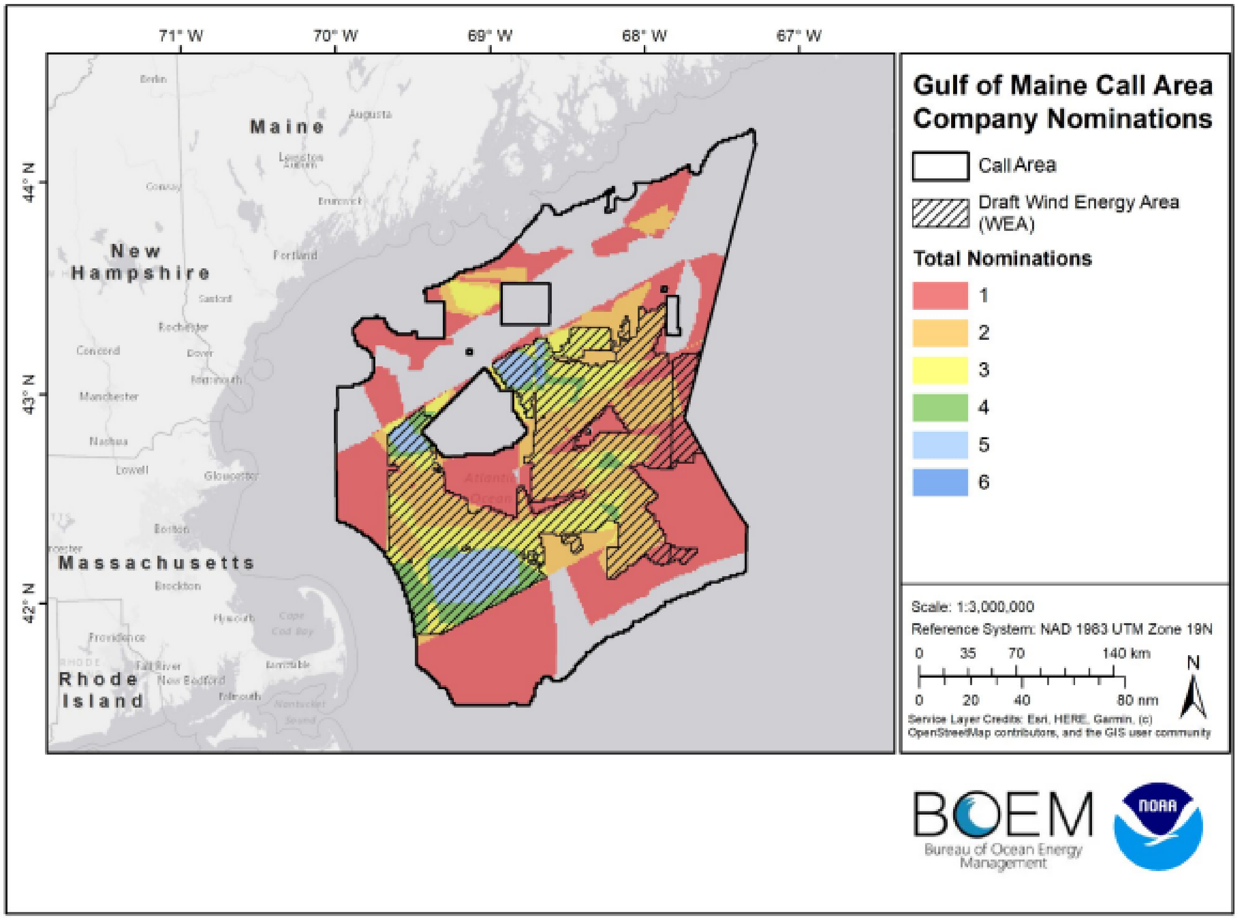


Figure 4.1. Density of wind industry nominations within the Gulf of Maine Call Area, with an overlay of the Draft WEA.

4.1. Secondary Areas for Further Analysis

BOEM has identified three Secondary Areas for further analysis (Secondary Areas). These areas are not part of the Draft WEA; however, BOEM seeks additional comment from the public on whether these areas (or a certain portion of them) should receive consideration as Final WEAs, and if so, under what recommended conditions. See the section “Requested Information from Interested or Affected Parties” for a full list of information requested related to these areas. BOEM will review all comments before making a decision on whether to incorporate these areas into Final WEAs.

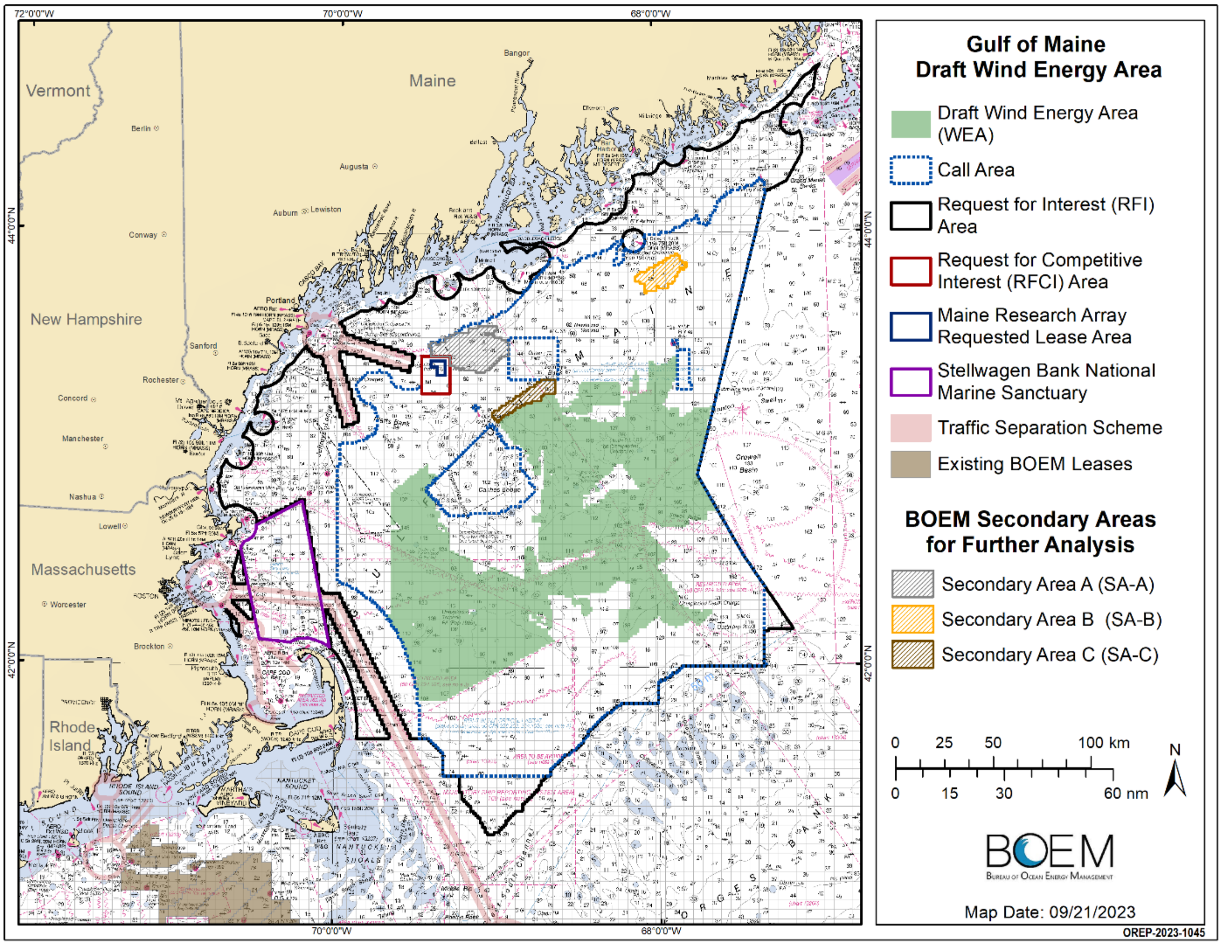


Figure 4.2. Gulf of Maine Secondary Areas for Further Analysis.

BOEM is providing an opportunity for comment on Secondary Areas to be transparent about two areas that the model indicated were highly suitable, as well as to give the State of Maine and its stakeholders additional options for consideration and comment given the State's offshore wind renewable energy goals and the considerable distance of the Draft WEA from potential points of interconnection in Maine.

4.1.1. Secondary Area A and Secondary Area B

Both Secondary Area A and B represent High-High clusters within the model used to inform the Draft WEA, suggesting that, based on the underlying data and model parameters, these are two of the most highly suitable areas for offshore wind energy development in the Gulf of Maine. BOEM decided to exclude these areas from the Draft WEA because of their presence within LMA1 and other natural resource and visual impact concerns.

Secondary Area A is approximately:

- 43 miles east of Portland, ME;
- 15 miles south of Monhegan Island, ME; and
- Adjacent to the Request for Competitive Interest (RFCI) Area related to the State of Maine Research Lease Application.

Secondary Area A is 151,228 acres. The mean depth is 148 meters, with a maximum depth of 206 meters and a minimum depth of 79 meters. BOEM received as many as three overlapping commercial nominations in this area (Figure 4.2). Potential spatial and environmental conflicts identified in Secondary Area A include, but are not limited to, National Marine Fisheries Service (NMFS) fisheries scientific surveys, commercial fishing (e.g., lobster), and natural resources, including presence of protected species and marine birds. Secondary Area A mostly avoids, but has several aliquots that partially overlap with the USCG recommended Portland Eastern Approach and Coastal Zone Fairways and the LMA1 NARW Restricted Area.

Secondary Area B is approximately:

- 30 miles south of Mount Desert Island, ME; and
- 60 miles southeast of Searsport, ME.

Secondary Area B is 63,693 acres. The mean depth is 172 meters, with a maximum depth of 217 meters and a minimum depth of 146 meters. BOEM received as many as two overlapping commercial nominations in this area (Figure 11). Potential spatial and environmental conflicts identified in Secondary Area B include, but are not limited to, NMFS fisheries scientific surveys, Tribal, commercial, and recreational fishing, visual impacts to sites of cultural importance to Tribes and Acadia National Park, and natural resources, including presence of protected species and marine birds. Secondary Area B partially overlaps the USCG recommended Coastal Zone Fairway.

4.1.2. Secondary Area C

Unlike Secondary Areas A and B, Secondary Area C was not a product of the spatial suitability model. In looking at the suitability model results, BOEM concluded that this area had a lower suitability score than the Draft WEA to its south because of its overlap with the MNMPARS recommended Gulf of Maine Fairway. The Team included all of the recommended Fairways in the Industry and Operations submodel (scored a 0.1), and several developers avoided the recommended fairways in their nominations (the nominations were 50% of the Wind submodel).

The Fairway remains a recommendation and is still subject to the USCG's rulemaking process. Therefore, BOEM selected the aliquots within Secondary Area C to allow for public comment and additional consultation with the USCG. This area is of interest, as it would increase the amount of acreage under leasing consideration that is closest to key ports and points of potential interconnection in Maine, while still avoiding LMA1.

Secondary Area C is approximately:

- 69 miles southeast of Portland, ME;
- 41 miles southeast of Monhegan Island, ME; and
- 49 miles south of Vinalhaven, ME.

Secondary Area C is 53,374 acres. The mean depth is 160 meters, with a maximum depth of 192 meters and a minimum depth of 111 meters. Likely for the reasons stated above, BOEM received one commercial nomination in this area (Figure 4.2). Potential spatial and environmental conflicts identified in Secondary Area C include, but are not limited to, the Gulf of Maine (recommended) Fairway, NMFS fisheries scientific surveys, commercial fishing, and natural resources, including presence of protected species.

Table 4.1. Description of the Gulf of Maine Draft WEA and Secondary Areas for Further Analysis*

Area	Area (ac)	Bathymetry Shallowest (m)	Bathymetry Mean (m)	Bathymetry Deepest (m)	Distance to Mainland** (nm)	Distance to POI (nm)	Closest identified POI
Draft WEA	3,519,051	120	198	296	20	43.5	Pilgrim
Secondary Area A	151,228	79	148	206	20.1	29.6	Wiscasset
Secondary Area B	63,694	146	172	217	25.9	68.9	Wiscasset
Secondary Area C	53,375	111	160	192	41.8	54.5	Wiscasset

* Bathymetry calculations were made using the most recent “BlueTopo” bathymetry data: https://www.nauticalcharts.noaa.gov/data/bluetopo.html
** Distance to Mainland does not include islands.

5. CONCLUSION

BOEM invites public comment on the Gulf of Maine Draft WEA and Secondary Areas and will consider information received to determine the Final WEAs. For full explanation on the commenting period and instructions, please read BOEM's Notice for Comment (search for BOEM-2023-0054 on Regulations.gov). BOEM requests comments regarding features, activities, mitigations, or concerns within or around the Draft WEA and Secondary Areas. Commenters should be as specific and detailed as possible to help BOEM understand and address comments, including whether your comment pertains to a particular part of the Draft WEA or Secondary Area. To assist with commenting on the Draft WEA, please see the gridded area in Figure 5.1. The Secondary Areas are labeled in Figure 4.2.

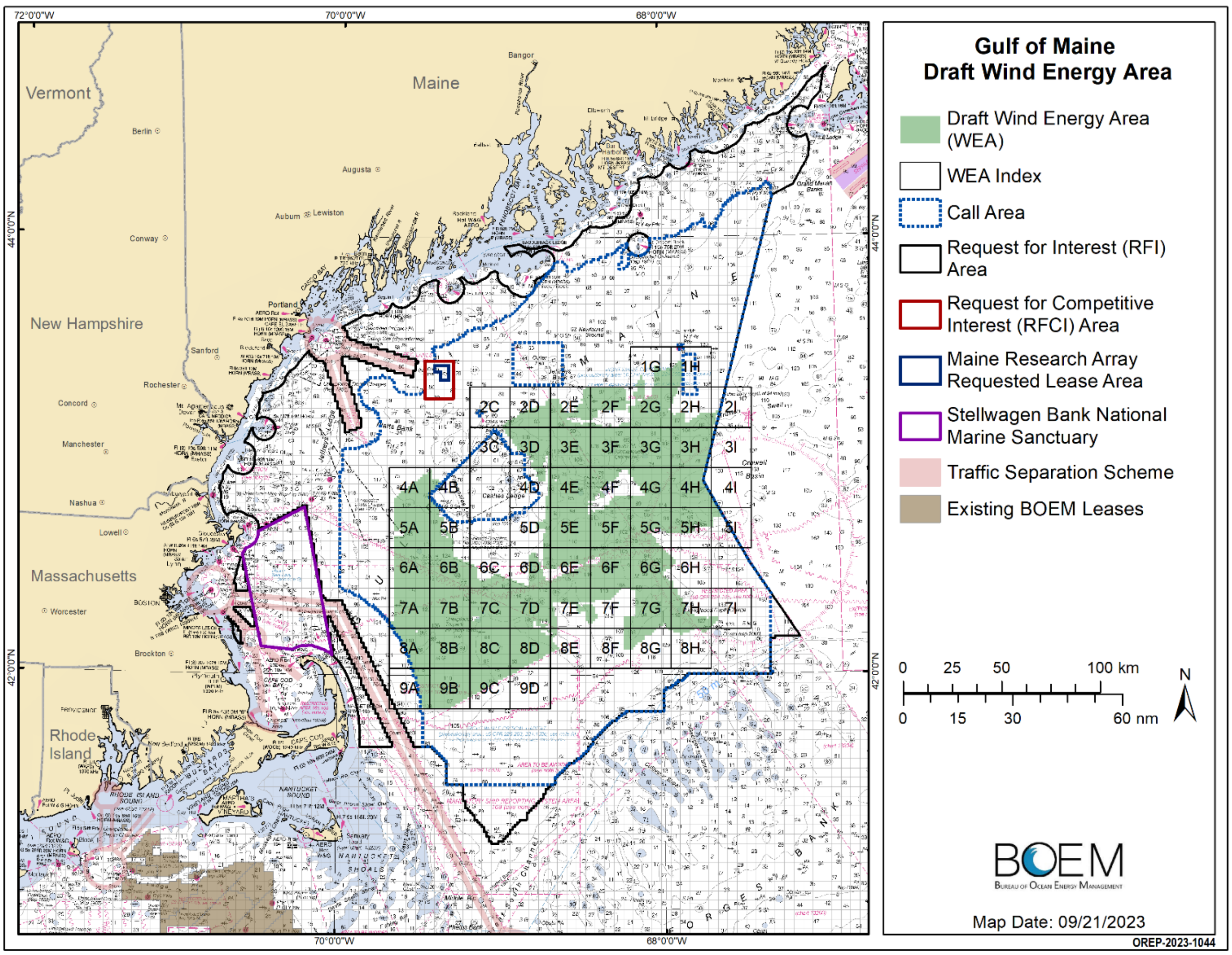


Figure 5.1. Gulf of Maine Draft WEA with Grid Overlay

6. Requested Information from Interested or Affected Parties

a. Should Secondary Areas A, B, and/or C (Figure 4.2), or any portion of those areas, receive consideration as Final WEAs, and if so, under what recommended conditions (e.g., leasing should be considered only after a certain number of years of electronic vessel tracking data are collected on lobster vessels)?
b. Information related to the relative economic and technical developability of different areas within the Draft WEA and/or Secondary Areas.
    - Is there a general threshold distance from shore and/or water depth where the estimated time horizon for development meaningfully changes? For example, BOEM recognizes that a majority of the Draft WEA is more than 75 miles from shore and would likely be serviced by high voltage direct current transmission solutions. How does this fact contribute to overall developability?
c. Information to support division of the eventual Final WEAs into lease areas.
    - What distance between leases would support wake recovery?
    - What distance between leases would best facilitate vessel traffic or fishing activities?
d. Phased leasing. BOEM is interested in advancing a phased commercial leasing program for the Gulf of Maine, through which multiple lease sales may occur.
    - What are the benefits and drawbacks of such a program?
    - What is the estimated leasing timeline needed by Massachusetts and Maine respectively to achieve their renewable energy goals?
e. In a multiple factor bidding format, BOEM limits the total value of bidding credits to 25 percent of the winning bid. Recent sales have focused bidding credits on developing the domestic offshore wind supply chain, workforce training, and providing compensatory mitigation for offshore wind's potential impacts to the fishing industry. Consistent with BOEM statutory authorities, what bidding credits and percentages would be most beneficial for the development of floating offshore wind in the Gulf of Maine?
f. BOEM's analysis shows that the Draft WEA overlaps with the existing footprints of as many as 10 NMFS scientific surveys. We are seeking more information about the relative compatibility of each of these individual surveys with potential offshore wind energy development.
g. Geological, geophysical, and biological bathymetric conditions (including bottom and shallow hazards).
h. Known archaeological and cultural resource sites on the seabed.
i. Information regarding the identification of historic properties or potential effects to historic properties from leasing, site assessment activities, or commercial wind energy development in the Draft WEA. This includes potential offshore archaeological sites or other historic properties within the areas described in this notice and onshore historic properties, including Traditional Cultural Places that could potentially be affected by renewable energy activities within the Draft WEAs. This information will inform BOEM's review of future undertakings under section 106 of the NHPA and NEPA.
j. Additional information, particularly spatial data, about potentially conflicting uses of the Draft WEA, including navigation (commercial shipping and recreational vessel use), fisheries (commercial and recreational), habitat, and protected species.

- For commercial and recreational fisheries, information on the types of fishing gear used, seasonal use, migration patterns, and recommendations for reducing use conflicts.
- For protected species, information on the seasonality of different life stages and behaviors within the Draft WEA, including known migration routes, and thoughts about their relative compatibility with offshore wind energy development.

k. Additional information relating to visual resources and aesthetics, the potential impacts of wind turbines and associated infrastructure to those resources, and potential strategies to help mitigate or minimize any visual effects.
    - If BOEM were to generate visual simulations, which key observation points should be prioritized?

l. Information on the constraints and advantages of possible electrical cable transmission routes, including onshore landing and interconnection points for cables connecting offshore wind energy facilities to the onshore electrical grid and future demand for electricity in the Gulf of Maine region.

m. Other relevant socioeconomic, cultural, biological, and environmental data and information.

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8. Appendix A – Data Inventory

Gulf of Maine Data Layers under Consideration for Draft Wind Energy Area Suitability Modeling

Contents

Background

In September 2022, BOEM announced enhancements to its area identification process. Through our commitment to use the best available science and modeling approaches, BOEM has partnered with NOAA's National Centers for Coastal Ocean Science (NCCOS) to employ a spatial model that analyzes entire marine ecosystems to identify the best areas for wind energy sites. NCCOS and BOEM are leveraging a team of expert spatial planners, marine and fisheries scientists, project coordinators, environmental policy analysts, and other subject matter experts to develop the Gulf of Maine Offshore Wind Suitability Model (suitability model). An overview of this modeling approach is available here.

BOEM and NCCOS intend to use the same methods previously applied to offshore wind energy siting efforts in the Gulf of Mexico and Central Atlantic to inform Gulf of Maine draft wind energy areas (WEAs). NCCOS's spatial modeling approach integrates a broad range of natural resource and socioeconomic considerations to provides a powerful, data-driven tool for assisting in the identification of areas that are most suitable for offshore wind energy development. Additionally, BOEM intends for this partnership and modeling approach to enhance transparency, improve engagement, and provide a consistent, reproducible methodology for understanding and deconflicting ocean space.

Tables 1-5 (below) are organized by the 5 submodels BOEM intends to use within the draft WEA suitability model, and describe the subset of data layers that BOEM plans to utilize within those submodels. This document will be updated as new data become available and BOEM learns new information through public comment and engagements with Tribal, federal, and state governments, and other important stakeholder groups. Please note the **date** the document was last updated in any comment letters provided to BOEM.

Table 1: Fisheries

Fisheries Datasets	Already Constrained/ Removed?[1]	Source	Source/link	Metadata link
Charter/Party Vessel Trip Report (VTR), 2008-2020	No	NOAA	Received directly from NMFS	https://repository.library.noaa.gov/view/noaa/4806
Fishing Footprint Raster (Commercial VTR Raster), 2008-2021	No	NOAA	Received directly from NMFS	https://repository.library.noaa.gov/view/noaa/23030
Georges Bank Northeast Groundfish Closures (Closed Area I North, Closed Area II)	Yes	NOAA	https://media.fisheries.noaa.gov/2020-04/gb-spawning-groundfish-closures-20180409-noaa-garfo.zip?null	https://media.fisheries.noaa.gov/dam-migration/gb-spawning-groundfish-closures-metadata-noaa-fisheries_.pdf
Large Pelagic Survey, 2011-2021	No	NOAA	https://www.st.nmfs.noaa.gov/st1/recreational/LPS_Data/CSV/	https://www.st.nmfs.noaa.gov/st1/recreational/LPS_Data/LPS_Read_Me_website.doc
Lobster Effort, 2016-2020	No	NOAA	Received directly from NMFS	https://media.fisheries.noaa.gov/2023-01/DST-Model-Peer-Review-Documentation_Jan2023-nefsc.pdf
Northeast Groundfish Closure Areas (Cashes Ledge Closure Area, Closed Area II Closure Area, Western Gulf of Maine Closure Area)	Yes	NOAA	https://s3.amazonaws.com/media.fisheries.noaa.gov/2020-09/Groundfish_Closure_Areas_20180409_0.zip?ON7sHgWHiJxpWm.B1IW5REVNRKhUvMrz	https://s3.amazonaws.com/media.fisheries.noaa.gov/2020-09/Groundfish_Closure_Areas_METADATA_0.pdf?xWv1p3RjolcasWxdTlEn8MJlvaySUvvx
Vessel Monitoring System (VMS) Putative Fishing (2-5.5kts), 2012-2021	No	NOAA	Confidential; version for public distribution available at https://www.northeastoceandata.org/	https://www.northeastoceandata.org/files/metadata/Themes/CommercialFishing/VMSCommercialFishingDensity_2022.pdf

[1] A “Yes” in this column indicates that BOEM either A) treated the feature as a constraint, thus removing the area from further leasing consideration; or B) the feature was indirectly removed from leasing consideration because the area overlapped with one or more constraints (e.g., the 20 nautical mile coastline buffer). See Section 6 of the Gulf of Maine Call for Information and Nominations for more information. A “No” in this column indicates that BOEM intends to use this feature and the accompanying dataset within the suitability model to further analyze it for potential leasing consideration.

Table 2: Industry, Navigation, and Transport

Industry, Navigation, and Transport Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Aids to Navigation	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/AtoN.zip	https://inport.nmfs.noaa.gov/inport/item/56120
Automatic Identification System (AIS) Vessel Traffic (2015, 2016, 2017, 2018, 2019, 2020, 2021) for All Vessel Types (Cargo, Passenger, Fishing, Tug and Tow, Fishing, Tanker, Pleasure and Sailing, Military, and Other)	No	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://marinecadastre.gov/ais/
Cable and Pipeline Areas	No	NOAA and Northeast Ocean Data Portal	https://www.northeastoceandata.org/files/metadata/Themes/EnergyAndInfrastructure.zip	https://www.northeastoceandata.org/files/metadata/Themes/EnergyAndInfrastructure/CableAndPipelineAreas.htm
Environmental Sensors and Buoys	Yes (with 500-m setback)	NOAA	https://www.ndbc.noaa.gov/	https://www.ndbc.noaa.gov/
Gray Area	Yes	ME DMR	Received directly from ME DMR	-
Isle of Shoals North Disposal Site (IOSN)	Yes	USEPA	https://epa.maps.arcgis.com/home/item.html?id=a183aea47781468382b4b612c672bba8	https://epa.maps.arcgis.com/sharing/rest/content/items/a183aea47781468382b4b612c672bba8/info/metadata/metadata.xml?format=default&output=html
Liquefied Natural Gas Pipelines	Yes (with 200-ft setback)	MA CZM and Northeast Ocean Data Portal	http://www.northeastoceandata.org/files/metadata/Themes/EnergyAndInfrastructure.zip	https://www.northeastoceandata.org/files/metadata/Themes/EnergyAndInfrastructure/LNGPipelines.pdf
Liquefied Natural Gas Sites	Yes (with 200-ft setback)	USCG and Northeast Ocean Data Portal	http://www.northeastoceandata.org/files/metadata/Themes/EnergyAndInfrastructure.zip	https://services.northeastoceandata.org/arcgis1/rest/services/EnergyAndInfrastructure/MapServer/9

Industry, Navigation, and Transport Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Maine, New Hampshire, and Massachusetts Port Access Route Study (MNMPARS)	No	USCG and Northeast Ocean Data Portal	https://www.northeastoceandata.org/data-download/?#MarineTransportation	https://www.northeastoceandata.org/files/metadata/Themes/MarineTransportation/MNMPARSDraftReport_ExecutiveSummary.pdf
Next Generation Weather Radar (NEXRAD) Stations	Yes (with 35-km setback)	NOAA	https://www.ncdc.noaa.gov/nexradinv/map.jsp	https://www.ncei.noaa.gov/products/radar/next-generation-weather-radar
NOAA NMFS Survey Areas (Atlantic Marine Assessment Program for Protected Species (AMAPPS), Bottom Trawl, Cooperative Research Branch (CRB) Bottom Longline, Ecosystem Monitoring (EcoMon), North Atlantic Right Whale, Shrimp, Surfclam, Scallop-Shellfish, Ocean Quahog)	No	NOAA	Received directly from NMFS	https://www.fisheries.noaa.gov/national/science-data/research-surveys
Shipping Fairways, Lanes, and Zones for US Waters	Yes (with 2-nm setback from TSS sides; 5-nm setback from TSS entry)	NOAA and BOEM (i.e., marinecadastre.gov)	http://encdirect.noaa.gov/theme_layers/data/shipping_lanes/shippinglanes.zip	https://inport.nmfs.noaa.gov/inport/item/39986
Submarine Cables	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/SubmarineCableArea.zip	https://www.fisheries.noaa.gov/inport/item/66190
Vessel Monitoring System (VMS) Transits, 2012-2021	No	NOAA	Confidential; version for public distribution available at https://www.northeastoceandata.org/	https://www.northeastoceandata.org/files/metadata/Themes/CommercialFishing/VMSCommercialFishingDensity_2022.pdf
Wrecks and Obstructions	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html	https://www.fisheries.noaa.gov/inport/item/39961

Table 3: National Security

National Security Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Danger Zones and Restricted Areas	Yes	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/DangerZoneRestrictedArea.zip	https://www.fisheries.noaa.gov/inport/item/48876
Military Operating Area - Boston	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitaryOperatingAreaBoundary.zip	https://www.fisheries.noaa.gov/inport/item/55364
Special Use Airspace (SUA) AEGIS	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W102H	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W102L	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W103	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W104A	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W104B	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Special Use Airspace (SUA) W104C	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/MilitarySpecialUseAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48898
Unexploded Ordnance Point Data	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/UnexplodedOrdnance.zip	https://www.fisheries.noaa.gov/inport/item/66208
Unexploded Ordnance Polygon Data	No	NOAA and BOEM (i.e., marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/UnexplodedOrdnanceArea.zip	https://www.fisheries.noaa.gov/inport/item/66206

Table 4: Natural and Cultural Resources

Natural Resources Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Avian Abundance All Species Summary Product	No	Marine-life Data and Analysis Team (MDAT)	https://seamap.env.duke.edu/seamap-models-files/mdat/MDAT_AvianModels_SummaryProducts.zip	https://seamap.env.duke.edu/models/mdat/Avian/MDAT_Avian_Summary_Products_Metadata.pdf
Avian Flyways	No	USFWS	https://ecos.fws.gov/ServCat/DownloadFile/113670	https://ecos.fws.gov/ServCat/DownloadFile/60697
Birds/Whales/Turtles Persistent Hotspots	No	BOEM	Received directly from BOEM	https://noaa-edab.github.io/tech-doc/protected-species-hotspots.html Note: the Gulf of Maine suitability model will incorporate 2023 data that is an updated version of the data described above. The updated data will be published with the 2023 State of the Ecosystem Report
Coral Protection Areas (CPAs) considered by not designated by NEFMC (WJB 114 Fathom Bump, WJB 96 Fathom Bump, WJB 118 Fathom Bump, Central Jordan Basin, Lindenkohl Knoll)	No	NOAA and NEFMC	Received directly from NMFS	https://d23h0vhsm26o6d.cloudfront.net/200102_Coral_Amendment-final-with-IRFA-edits.pdf
Deep-Sea Coral and Sponge Observations	No	NOAA	https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm	https://deepseacoraldata.noaa.gov/library/dscrtp-database-metadata/; https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/other/other_crcp_publications/DeepSeaCoralRT/Intro_Natl_DB_for_DSCS.pdf

Natural Resources Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Georges Bank	Yes (BOEM removed areas from the southern edge of the Call Area following the 140-meter line of bathymetry to avoid Georges Bank)	NOAA	Received directly from NMFS	https://www.integratedecosystemassessment.noaa.gov/regions/northeast/georges-bank
Gulf of Maine Northeast Spawning Groundfish Closures (Gulf of Maine Cod Spawning Protection Area, Spring Massachusetts Bay Spawning Protection Area, Winter Massachusetts Bay Spawning Protection Area)	Yes	NOAA	https://media.fisheries.noaa.gov/2020-04/gom-spawning-groundfish-closures-20180409-noaa-garfo.zip?null	https://media.fisheries.noaa.gov/dam-migration/gom-spawning-groundfish-closures-metadata-noaa-fisheries_.pdf
Habitat Areas of Particular Concern (HAPCs) (Cashes Ledge, Great South Channel Juvenile Cod, Inshore 20 m Juvenile Cod, Jeffreys & Stellwagen, Northern Edge Juvenile Cod)	Yes	NOAA and NEFMC	https://www.habitat.noaa.gov/protection/efh/newInv/data/new_england/neweng_hapc.zip	https://idpgis.ncep.noaa.gov/arcgis/rest/services/NMFS/HAPC/MapServer/info/metadata; https://www.marinecadastre.gov/SiteCollectionDocuments/SoWhat_HAPCs_final_template.pdf
Habitat Management Areas (HMAs) considered but not designated by NEFMC (Bigelow Bight, Machias, Platts Bank 1, Platts Bank 2, Toothaker Ridge)	No	NOAA and NEFMC	Received directly from NMFS	https://cdxapps.epa.gov/cdx-enepa-II/public/action/eis/details;jsessionid=44CC0DF1A3622D8F8B54C6173D553BE4?downloadAttachment=&attachmentId=240639
Habitat Management Areas (HMAs) (Eastern Maine HMA, Jeffreys Bank HMA, Cashes Ledge HMA, Fippennies Ledge HMA, Ammen Rock HMA, Western Gulf of Maine HMA, Closed Area II Habitat Closure Area)	Yes	NOAA	https://media.fisheries.noaa.gov/2020-04/habitat_management_areas_20180409_%282%29.zip?null	https://media.fisheries.noaa.gov/dam-migration/habitat_management_areas_metadata.pdf

Natural Resources Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Integrated Seabird Risk and Vulnerability Assessment	No	Biodiversity Research Institute (BRI)	Received directly from BRI	
Jeffreys Ledge	Yes (Depths shallower than 120 m)	NOAA	Received directly from NMFS	Received directly from NMFS
Maine Seabird Nesting Islands	No	BRI and FWS	Received directly from FWS	-
NOAA NMFS combined Habitat Layer	No	NOAA	Received directly from NMFS	In development
NOAA NMFS combined Protected Species Layer	No	NOAA	Received directly from NMFS	In development
North Atlantic Right Whale Density Model	No	MDAT	https://seamap.env.duke.edu/seamap-models-files/mdat/MDAT_MammalModels_Abundance.zip	https://seamap.env.duke.edu/models/mdat/Mammal/MDAT_Mammal_Model_Metadata.pdf
Omnibus Deep-Sea Coral Amendment (Mount Desert Rock Coral Protection Area (CPA), Outer Schoodic Ridge CPA, Jordan Basin Dedicated Habitat Research Area)	Yes	NOAA	https://media.fisheries.noaa.gov/2021-07/Omnibus_Deep_Sea_Coral_Amendment.zip?null	https://media.fisheries.noaa.gov/2021-07/Omnibus%20DeepSea%20Coral%20Protection%20Area_metadata.pdf?null
Passive Acoustic Monitoring (PAM) Data	No	NOAA	Passive Acoustic Cetacean Map. 2023. Woods Hole (MA): NOAA Northeast Fisheries Science Center v1.1.4 [April 12, 2023]. https://apps-nefsc.fisheries.noaa.gov/pacm	Passive Acoustic Cetacean Map. 2023. Woods Hole (MA): NOAA Northeast Fisheries Science Center v1.1.4 [April 12, 2023]. https://apps-nefsc.fisheries.noaa.gov/pacm
Stellwagen Bank National Marine Sanctuary	No	NOAA	https://sanctuaries.noaa.gov/library/imast/sbnms_py2.zip	https://sanctuaries.noaa.gov/library/imast/sbnms_py.html#1

Natural Resources Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Stellwagen Dedicated Habitat Research Area	Yes	NOAA	https://media.fisheries.noaa.gov/2020-04/dedicated_habitat_research_area_20180409_%281%29.zip?null	https://media.fisheries.noaa.gov/dam-migration/dedicated_habitat_research_area_metadata.pdf
Tracking Data for Diving Birds - Utilization Distributions from Dynamic Brownian Bridge Movement Models (50% core range contour)	No	BRI	Received directly from BRI	https://downloads.regulations.gov/BOEM-2022-0040-0037/attachment_2.pdf

Table 5: Wind Industry

Wind Industry Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Average Wind Speed at All Heights	No	NREL	https://www.nrel.gov/gis/assets/images/us-wind-data.zip	https://www.nrel.gov/gis/wind-resource-maps.html
3 Arc Second Digital Elevation Model (DEM) of the Gulf of Maine	No	USGS	https://pubs.usgs.gov/of/2011/1127/data/gom03_v1_0asc.zip	https://pubs.usgs.gov/of/2011/1127/GOM03_v1_0meta.htm
Data Quality Index for usSEABED Atlantic Coast Offshore Surficial Sediment	No	USGS	https://www.northeastoceandata.org/files/metadata/Themes/Habitat.zip	https://www.northeastoceandata.org/files/metadata/Themes/Habitat/usSEABEDDataQuality.pdf
Principal Ports	No	USACE	ftp://ftp.coast.noaa.gov/pub/MSP/PrincipalPorts.zip	https://inport.nmfs.noaa.gov/inport/item/56124
NOAA Medium Resolution Shoreline	20-nm setback from mainland	NOAA	https://coast.noaa.gov/htdata/Shoreline/us_medium_shoreline.zip	https://shoreline.noaa.gov/data/datasheets/medres.html
Offshore Wind Levelized Cost of Energy (LCOE), 2027 Projection	No	NREL	https://data.nrel.gov/system/files/67/170514_OSW%20cost%20analysis_output%20file%20%281%29.xlsx	https://data.nrel.gov/submissions/67

Wind Industry Datasets	Already Constrained/ Removed?	Source	Source/link	Metadata link
Request for Interest (RFI) Developer Nominations	No	BOEM	Received directly from BOEM	https://www.boem.gov/renewable-energy/state-activities/maine/gulf-maine; https://www.boem.gov/sites/default/files/images/Gulf_of_maine%20Total_nominations.png

9. Appendix B – Protected Resources Data

Protected Species Considerations for the Marine Spatial Planning Process for Gulf of Maine Offshore Wind Energy Development

November 2022, revised September 2023

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Introduction

This document describes the data sources and method used to develop a protected species (i.e. species under National Marine Fisheries Service (NMFS) jurisdiction protected under the Endangered Species Act (ESA) and/or Marine Mammal Protection Act (MMPA)) layer ("Protected Species Combined Layer") for inclusion in a spatial suitability model. The model is being developed by NOAA's National Centers for Coastal Ocean Science (NCCOS) (under contract to the Bureau of Ocean Energy Management [BOEM]) to inform BOEM's site selection process for offshore wind energy development in the Gulf of Maine. Considerations for using the Protected Species Combined Layer are also described in this document. This effort builds off of the process used to develop a protected species layer for the spatial suitability model used to inform the siting of offshore aquaculture and offshore win leasing in the Gulf of Mexico (Farmer et al. 2022a, Farmer et al. 2023) and offshore energy wind leasing in the Central Atlantic (Sisson & Farmer 2022).

The Protected Species Combined Layer described here was originally developed to inform BOEM's site selection process for offshore wind leasing in the Gulf of Maine at the Request for Interest Area (RFI Area) stage in Fall 2022. The RFI Area is located on the U.S. Outer Continental Shelf (OCS) offshore the coasts of Massachusetts, New Hampshire, and Maine, ranging three nautical miles from shore to the Exclusive Economic Zone (EEZ). The RFI Area includes approximately 2,619 OCS blocks and partial blocks and comprises approximately 13,713,825 acres (BOEM 2022). References to the RFI Area remain in the report because that was the region analyzed. Since that time, BOEM has moved through the site selection process by identifying a draft Call Area and final Call Area, located within the original RFI Area, and is now in the process of identifying draft Wind Energy Areas (WEAs). To date, the Protected Species Combined Layer has not been used by BOEM to inform any phase of the site selection process but is planned to be used in the NCCOS spatial suitability model to inform the draft WEAs. The domain of the Protected Species Combined Layer that is within the Call Area will be included in the spatial suitability model to inform siting of the draft WEAs. Since the RFI Area, the area under consideration has been reduced (RFI Area > draft Call Area > final Call Area). The overall geographic area of consideration in the Protected Species Combined Layer contains the entire area being considered for draft WEAs and remains appropriate to inform the site selection process from Call Area to draft WEAs. We note that the areas defined as "high and low use" for protected species do depend on the geographic scale being evaluated. The Protected Species Combined Layer is evaluated at the scale of the U.S. East Coast. Because the entire Gulf of Maine RFI Area was considered "high-use" for North Atlantic right whales relative to the East Coast scale (Figure 1, Panel 20), we also evaluated North Atlantic right whale space use at the scale of the RFI Area to identify lower use areas within this "high use" habitat (Figure 1, Panel 21). Because these lower use areas for North Atlantic right whales were identified at the scale of the RFI

Area, there may be some minor variation from what areas would be considered “high use” at the scale of the Call Area. Given additional time, “low(er) use” areas within the Call Area could be evaluated; however, it is most important to note that the entire Gulf of Maine area is considered a high-use area for this endangered species (Figure 3). Because the RFI Area is larger than the Call Area, the delineation of high(er) vs. low(er) use areas within the RFI Area is conservative for the species relative to delineation of high(er) vs. low(er) use areas for the species within the Call Area.

Methods

To create the Gulf of Maine Protected Species Combined Layer, 22 species listed under the ESA and/or MMPA whose occurrence overlaps the RFI Area were included in the modeling process (Table 1). Using the process outlined in Farmer et al. (2022a) and Farmer et al. (2023), a generalized risk scoring system was applied to measure protected species vulnerability based on species status under the ESA or MMPA, population size, and population trajectory for species, as determined from stock assessments (NOAA 2021), the NOAA Fisheries Report to Congress (NOAA 2022a), and expert opinion to inform relative risk in spatial modeling. This methodology was also used in the NCCOS/BOEM spatial suitability modeling process for the Central Atlantic Call Area (Sisson and Farmer 2022). Under this generalized system, scores for MMPA and ESA-listed species data layers range from 0.1 (most vulnerable species, based on their biological status) to 0.9 (least vulnerable species) (Table 2). Given the analysis was adapted from the spatial suitability modeling process for the Central Atlantic Call Area, species from that analysis that were not expected to be found in the Gulf of Maine were scored a 1, indicating suitable area for development. These species included the Atlantic spotted dolphin, Clymene dolphin, Cuvier's beaked whale, dwarf and pygmy sperm whales, mesoplodont beaked whales, pantropical spotted dolphin, rough-toothed dolphin, striped dolphin, oceanic whitetip shark, and hawksbill sea turtle. Thus these species had no impact on the Protected Species Combined Layer for the spatial suitability model being developed to inform BOEM’s offshore wind site selection in the Gulf of Maine and are not included in Table 1. For more information about the generalized scoring system, see Farmer et al. (2022a, 2023).

Protected species distribution layers were assembled and evaluated across the entire U.S. Atlantic Coast, from state shorelines out to the U.S. exclusive economic zone (EEZ) boundary as this was the model domain for the marine mammal distribution outputs. All analyses and images were generated in R (v. 4.2.0; R Core Team 2022) or ArcPro (v. 2.9.0; ESRI Inc.) in projection WGS84. All marine mammal species data layers use a distribution model input developed and recently updated in 2022 by the Marine Geospatial Ecology Laboratory at Duke University (Roberts et al. 2016, Roberts et al. 2023). The giant manta ray data layer uses a distribution model input from Farmer et al. (2022b). For marine mammal species with available distribution models (Roberts et al. 2016, Roberts et al. 2023), the maximum predicted density for each spatial cell was selected from these predictions to depict the maximal spatial population distributions for each species. The spatial cells were then coded as above or below the median of the distribution across cells to identify high- vs. low-use areas, respectively. Grid cells above the median maximal probability of occurrence were defined as high-use areas and assigned the chosen score for the species (Table 1); the areas below the median were assigned a default ESA (0.5) or MMPA (0.9) score, depending on species status. This facilitates necessary contrast between high- and low-use areas to inform marine spatial planning for distribution models that cover the entire extent of the data. For the giant manta ray distribution model, the maximum observed probability of occurrence across the model domain (January 2003 to December 2019) was retained for each grid cell and the same process as above was undertaken for assigning scores and high- and low-use areas.

Green sea turtle, Kemp’s ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon data layers are from the Greater Atlantic Region (GAR) Section

7 Mapper (NOAA 2022b). The Section 7 Mapper is a technical assistance tool to assist federal action agencies in determining if a proposed federal action overlaps with listed species or critical habitat. The Mappers depict a best estimate of the range of ESA-listed species that may be present in waters of the GAR and SER. This data source only provides general presence-only information. The Section 7 Mapper layers do not allow for any contrast between high- and low-use areas and thus only depict one score.

To develop a combined protected species data layer, the “product method” described in Farmer et al. (2022a) and Farmer (2023) was used where all scored layers for all species were spatially joined in sequence, such that a single column score remained for each species with a merge rule of minimum score, resulting in a single score per species, per cell. Cells without scores for a species were assigned a score of 1 (e.g., “suitable”). The product of risk scores across all 22 species was used to combine the protected species data layers and produce the final combined protected species data layer to be incorporated into the NCCOS spatial suitability model. A final protected species combined data layer was developed for the extent of the entire U.S. Atlantic Coast, but contained relevant species information and guidance specifically for the Gulf of Maine RFI Area. However, for North Atlantic right whales, we also created a layer that was clipped to the RFI Area to better depict the modeled density from the Duke habitat density model (Figure 2). Expansion of this model beyond the current RFI Area may require consideration of additional species. The final protected species combined data layer is presented at both scales (U.S. Atlantic Coast and RFI Area) to provide additional context regarding the relative vulnerability of species within the current RFI Area relative to the remaining U.S. Atlantic Coast. Images of the final data layer are presented at both scales and were developed using the same shapefile, but color-coded to the extent of the layer so contrast was more apparent to inform the marine spatial planning process.

Table 1. Species, data sources, and scores included in the Protected Species Combined Layer.

Common Name	Scientific Name	Data Source	Status	Score
Delphinids				
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Duke Habitat-based Density Model	MMPA-protected	0.9
Bottlenose dolphin	*Tursiops truncatus*	Duke Habitat-based Density Model	MMPA-strategic	0.6
Harbor porpoise	*Phocoena phocoena*	Duke Habitat-based Density Model	MMPA-protected	0.7
Pilot whales	*Globicephala spp.*	Duke Habitat-based Density Model	MMPA protected	0.7
Risso's dolphin	*Grampus griseus*	Duke Habitat-based Density Model	MMPA protected	0.7
Short-beaked common dolphin	*Delphinus delphis*	Duke Habitat-based Density Model	MMPA-protected	0.7
Phocids				

Seals	*Phocidae spp.*	Duke Habitat-based Density Model	MMPA-protected	0.8
Large Whales				
Blue whale	*Balaenoptera musculus*	Duke Habitat-based Density Model	Endangered	0.2
Fin whale	*Balaenoptera physalus*	Duke Habitat-based Density Model	Endangered	0.2
Humpback whale	*Megaptera novaeangliae*	Duke Habitat-based Density Model	MMPA-protected	0.8
Minke whale	*Balaenoptera acutorostrata*	Duke Habitat-based Density Model	MMPA-protected	0.7
North Atlantic right whale	*Eubalaena glacialis*	Duke Habitat-based Density Model	Endangered	0.1
Sei whale	*Balaenoptera borealis*	Duke Habitat-based Density Model	Endangered	0.2
Sperm whale	*Physeter macrocephalus*	Duke Habitat-based Density Model	Endangered	0.2
Fish				
Atlantic salmon (Gulf of Maine DPS)	*Salmo salar*	GAR Section 7 Mapper	Endangered	0.5
Atlantic sturgeon (All DPSs)	*Acipenser oxyrinchus oxyrinchus*	GAR/SER Section 7 Mappers	Endangered	0.2
Giant manta ray	*Manta birostris*	Farmer et al. 2022a	Threatened	0.4
Shortnose sturgeon	*Acipenser brevirostrum*	GAR Section 7 Mapper	Endangered	0.2
Sea Turtles				
Green sea turtle (North Atlantic, South Atlantic DPSs)	*Chelonia mydas*	GAR/SER Section 7 Mappers	Threatened	0.5
Kemp's ridley sea turtle	*Lepidochelys kempii*	GAR/SER Section 7 Mappers	Endangered	0.2
Leatherback sea turtle	*Dermochelys coriacea*	GAR/SER Section 7 Mappers	Endangered	0.1
Loggerhead sea turtle (Northwest Atlantic Ocean DPSs)	*Caretta caretta*	GAR/SER Section 7 mapper	Threatened	0.5

Table 2. A generalized scoring system for endangered and threatened species data layers (see Farmer et al. 2022a, Farmer et al. 2023).

Status	***Trend***	***Converted scores for model***
Endangered	Declining, Small Population or Both	0.1
Endangered	Stable or Unknown	0.2
Endangered	Increasing	0.3
Threatened	Declining or Unknown	0.4
Threatened	Stable or Increasing	0.5
ESA-Listed	Low Use Area or Default Score	0.5
MMPA Strategic	Declining or Unknown	0.6
MMPA-listed	Small Population or Unknown/Declining	0.7
MMPA-listed	Large Population or Stable/Increasing	0.8
MMPA-listed	Low Use Area or Default Score	0.9

Results

The spatial scoring results for each species considered in the final protected species combined data layer are presented in Figure 1; differences in scores within a map for a given species reflect high-use (lower score) and low-use (higher score) areas, as determined by areas above and below the median maximal probability of occurrence, respectively. The Gulf of Maine Call Area under consideration for potential leasing is also displayed; species with different colors within the Call Area have spatial scoring that is informative to the NCCOS spatial suitability modeling process (Figure 1). The Call Area is shown rather than the RFI Area because the domain of the Protected Species Combined Layer within the Call Area will be included in the spatial suitability model to inform siting of the draft WEAs.

The final combined product layer was generated using the “product method.” The extent of the combined product layer for all 22 protected species was the entire U.S. Atlantic Coast, however, to provide greater resolution to inform the marine spatial planning process, especially for North Atlantic right whales, we also produced a final combined layer clipped to the extent of the RFI Area. The final combined layer (Figure 3) shows relatively high vulnerabilities for protected species across the entire RFI Area as noted by the warmer colors. Panel 20 of Figure 1 shows the output for the North Atlantic right whale with the entire RFI Area scoring higher than the median density compared to the whole U.S. Atlantic Coast extent. To provide greater resolution to inform the spatial suitability process, we also produced an output for North Atlantic right whales clipped to the extent of the RFI Area to better match the modeled density (Figure 1, Panel 21; Figure 2). Panels in Figure 1 (i.e. 2, 4, 7, 9, 12, 22, 24, 25, 31, and 32) with no color are those species scored as a 1 (suitable).

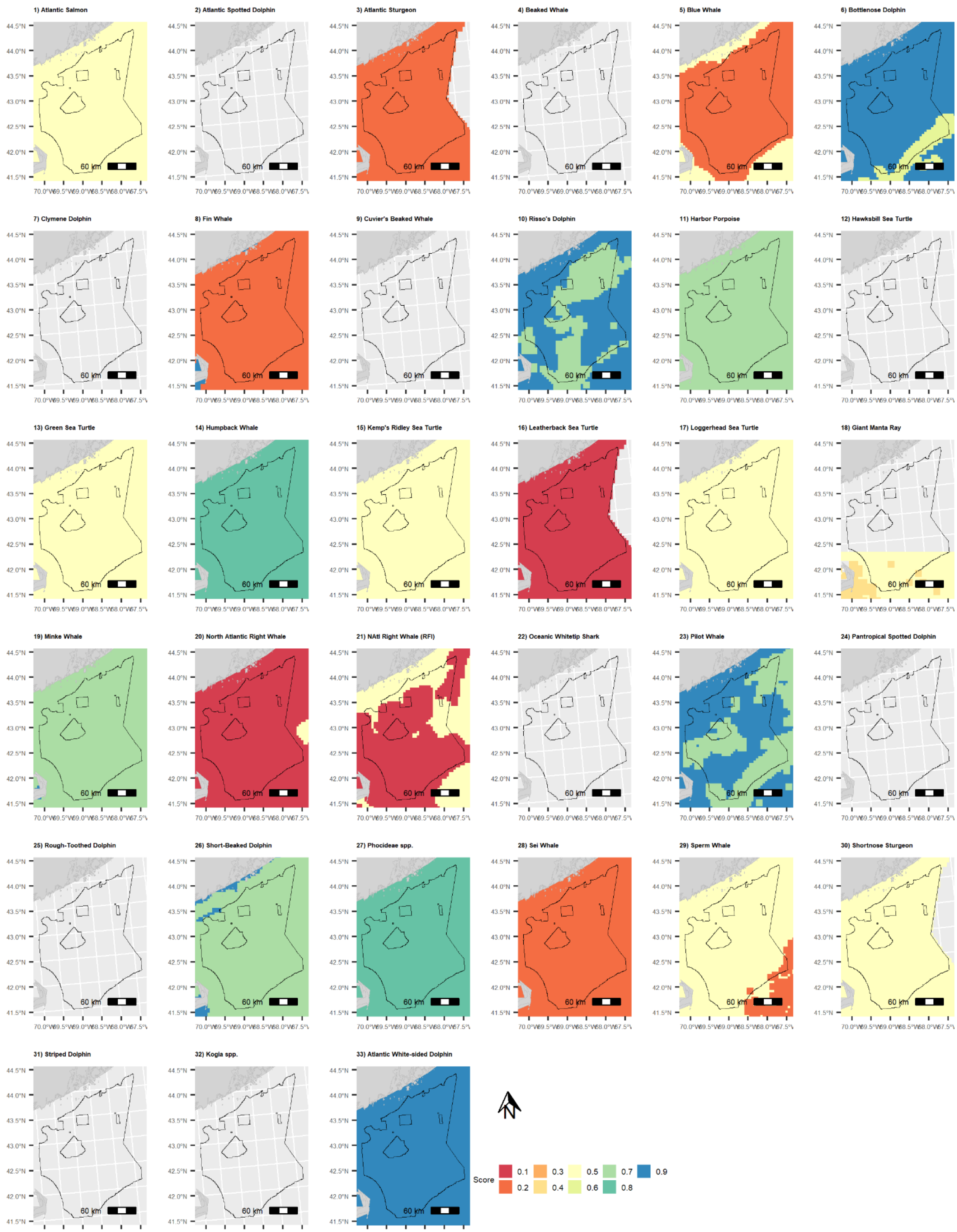
1) Atlantic Salmon
2) Atlantic Spotted Dolphin
3) Atlantic Sturgeon
4) Beaked Whale
5) Blue Whale
6) Bottlenose Dolphin
7) Clymene Dolphin
8) Fin Whale
9) Cuvier's Beaked Whale
10) Risso's Dolphin
11) Harbor Porpoise
12) Hawksbill Sea Turtle
13) Green Sea Turtle
14) Humpback Whale
15) Kemp's Ridley Sea Turtle
16) Leatherback Sea Turtle
17) Loggerhead Sea Turtle
18) Giant Manta Ray
19) Minke Whale
20) North Atlantic Right Whale
21) NAtl Right Whale (RFI)
22) Oceanic Whitetip Shark
23) Pilot Whale
24) Pantropical Spotted Dolphin
25) Rough-Toothed Dolphin
26) Short-Beaked Dolphin
27) Phocideae spp.
28) Sei Whale
29) Sperm Whale
30) Shortnose Sturgeon
31) Striped Dolphin
32) Kogia spp.
33) Atlantic White-sided Dolphin
60 km
44.5°N
44.0°N
43.5°N
43.0°N
42.5°N
42.0°N
41.5°N
70.0°W 69.5°W 69.0°W 68.5°W 68.0°W 67.5°W
N
Score
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

Figure 1. Calculated scores across all 22 protected species data layers. Black outlined areas show the Gulf of Maine Call Area. The Call Area is shown here rather than the RFI Area because the domain of the Protected Species Combined Layer within the Call Area will be included in the spatial suitability model to inform siting of the draft WEAs. Species with no color have no score because they do not occur in the RFI Area/Call Area. Note that North Atlantic right whales have two scores, Panel 20 shows scores for the U.S. Atlantic Coast extent and Panel 21 shows scores clipped to the RFI Area extent.

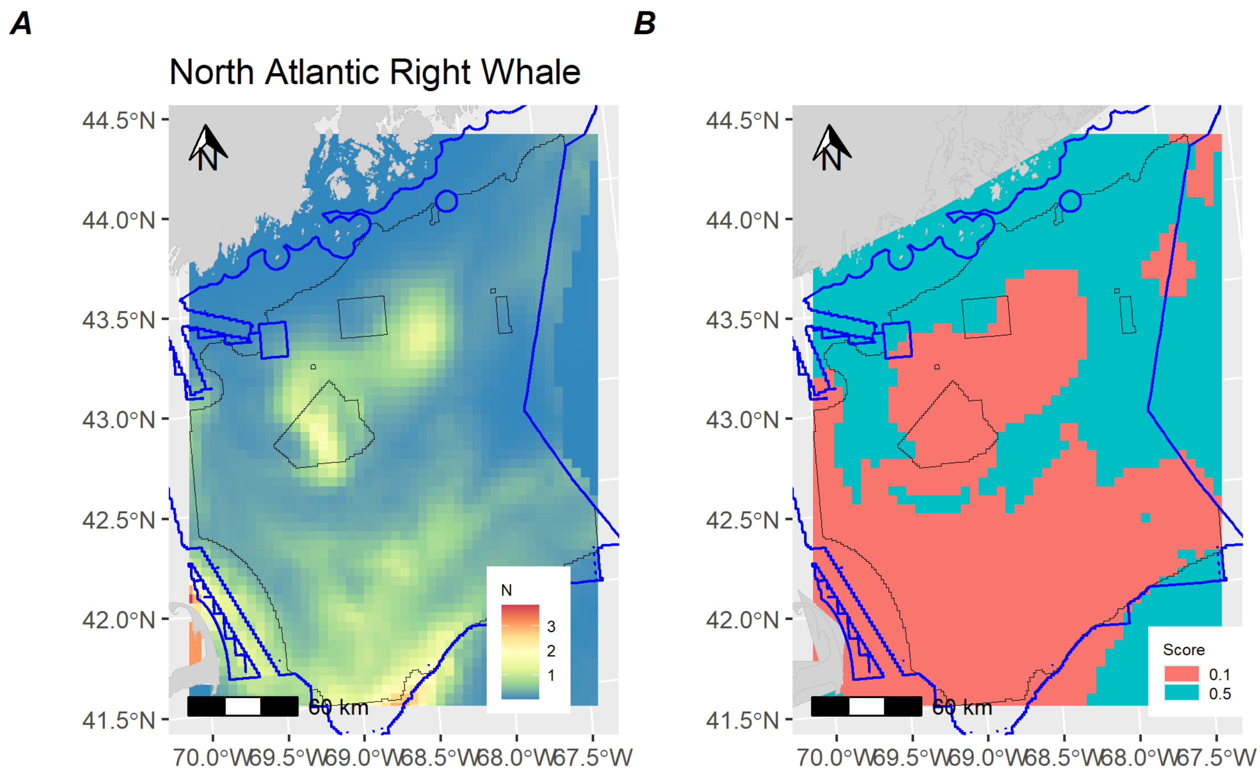

Figure 2. Panel A: North Atlantic right whale density model output (Roberts et al.) from (maximum predicted density for each grid cell) relative to RFI Area and final Call Area. Panel B: Scoring output for North Atlantic right whales clipped to the extent of the RFI Area. Blue outlined area shows the RFI Area and black outlined area shows the final Call Area.

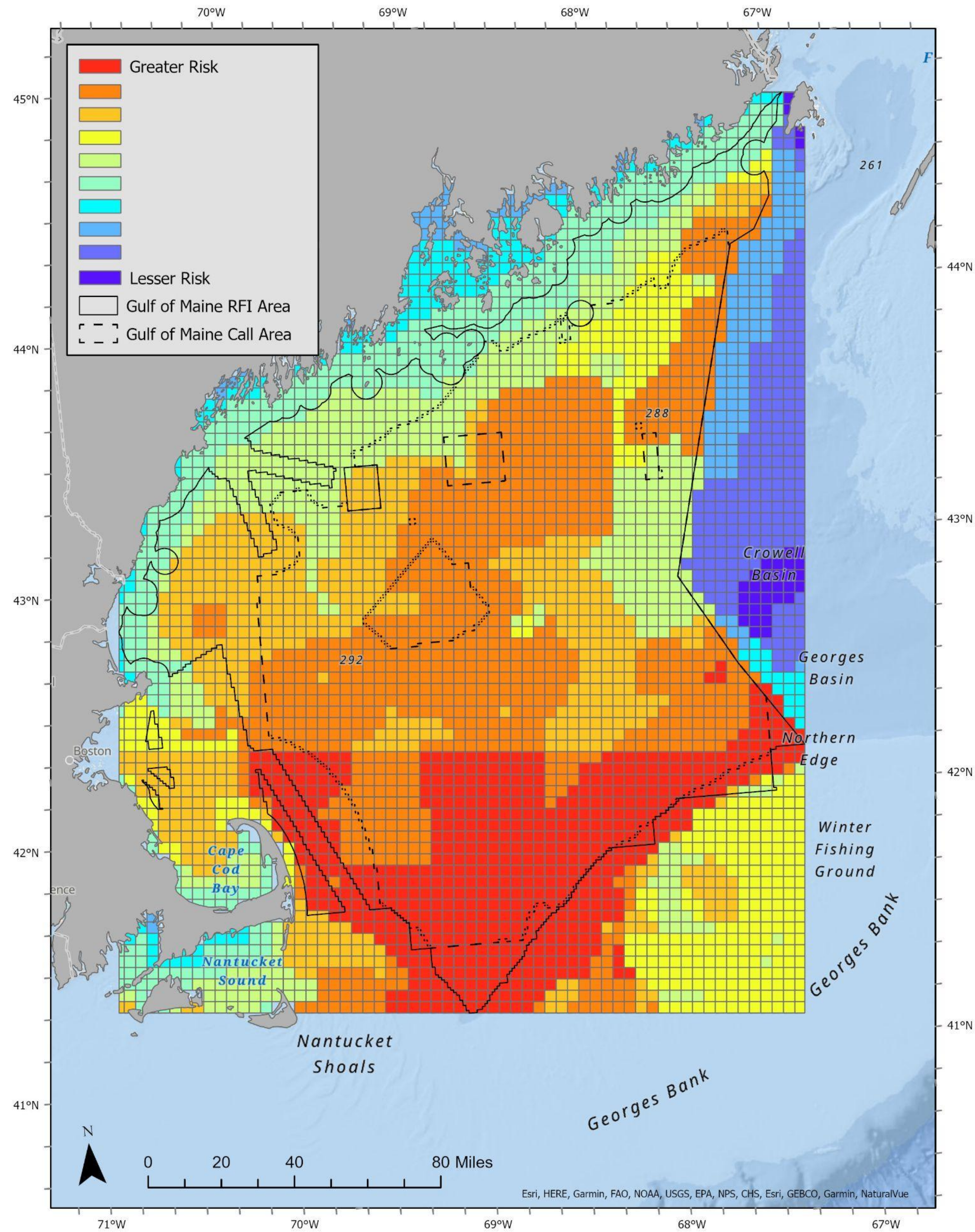

Figure 3. Final combined protected species data layer to inform offshore wind site selection in the Gulf of Maine. Spatial distribution of risk for protected species based on vulnerability and trend, with layers combined using the product of risk scores across all 22 species considered is shown.

Discussion

It should be noted that the protected species layer for the Gulf of Maine RFI Area was completed in a short amount of time with the data layers that were currently available, thus awareness of the data should be taken into consideration when utilizing the output. However, the process undertaken to develop the layer is an established process (see Farmer et al. 2022a; Farmer et al. 2023) and the best available data sources were incorporated into the development of the protected species layer. Thus this layer may not be suitable for marine spatial planning purposes in other areas along the U.S. Atlantic Coast or for applications to other industries. For application of the results or alternative uses, please contact the authors. Additionally, although the final protected species combined data layer domain covers the extent of the U.S. Atlantic, this effort was focused on the Gulf of Maine RFI Area and the species that are likely to occur there. With additional time for analysis, two steps could be undertaken to potentially improve the utility of the combined layer. Given the habitat usage of some protected species (e.g. deep diving marine mammals), in order to most accurately capture their presence it may be prudent to split the distribution models for species that would most likely occur on the continental shelf and off the continental shelf. Additionally, to provide a more rigorous analysis of a respective area of interest vs. a species' coastwide distribution, the combined product layer should assess all species at both the area of interest scale and coastwide scale. This would provide an important perspective on relative habitat use coastwide while still providing guidance for siting within the respective area of interest.

The generalized scoring approach used in the protected species layer does not consider risk associated with specific offshore wind energy-related activities as the spatial suitability modeling effort is intended to inform BOEM's offshore wind energy planning prior to lease sales taking place. As such, the final combined layer (Figure 3) shows relatively high vulnerabilities for protected species across the entire RFI Area with slightly lower risk closer to shore in the northwest portion of the RFI Area. As a marine spatial planning tool, the combined layer is meant to provide a robust, analytically driven approach to identify and avoid planning activities in areas with high overlap of vulnerable protected species. In this effort we integrated across 22 protected species using a variety of available data to inform the RFI Area spatial suitability modeling effort. The availability and quality of data used to develop scoring layers varied by species. In general, we took a holistic approach by producing results for the extent of the U.S. Atlantic Coast to match the scale of model outputs. Additional time could be taken to evaluate the difference between producing U.S. Atlantic Coast-wide scored spatial outputs versus scored spatial outputs clipped to the RFI Area, though results are not likely to vary. It should be noted that the respective Section 7 Mapper data layers (e.g., Atlantic salmon, Atlantic and shortnose sturgeon, leatherback sea turtle, loggerhead sea turtle, green sea turtle, Kemp's ridley sea turtle) are not distribution models, they just display species presence and thus show no contrast in the final outputs (i.e. no differentiation of high/low-use areas) (see panels 1, 3, 13, 15, 16, 17, and 30 in Figure 1). The GAR Section 7 Mapper layers were included in the protected species layer for completeness because it is anticipated that these species do occur in the RFI Area. However, there are two efforts (Navy funded and the Atlantic Marine Assessment Program for Protected Species) underway to develop spatial density models for sea turtles. The inclusion of these distribution model outputs in the protected species layer would greatly increase the utility of the layer for spatial planning purposes as the sea turtle distribution models would show a contrast similar to the marine mammal species outputs. All marine mammal species data layers use a distribution model input developed and recently updated in 2022 by the Marine Geospatial Ecology Laboratory at Duke University (Roberts et al. 2016, Roberts et al. 2023). The giant manta ray data layer uses a distribution model input from Farmer et al. (2022b), however the output does not cover the entirety of the RFI Area (Figure 1, Panel 18). Because the modeling process considers the maximum density across several years of monthly model fits, the maximum seasonal occurrence is considered; however, the output is a static map and intended to address long-term (multi-annual) averaged risk. Due to their life history, the protected species considered in this analysis may not be in the RFI Area year-round.

With regards to the method for producing spatially scored outputs for North Atlantic right whales, we initially took the approach of producing a U.S. Atlantic Coast-wide extent. However, upon examining the output for the U.S. Atlantic Coast extent (Figure 1, Panel 20), it showed all of the RFI Area was above the median score and thus low suitability. Given this result was not informative for the marine spatial planning process we took a revised approach by further examining the Duke density model output (Figure 2) and right whale occurrence data (Johnson et al. 2021). To provide greater resolution to inform the spatial suitability process, we created an additional spatially scored output clipped to the RFI Area (Figure 1, Panel 21). This approach provides greater contrast for the area under consideration by evaluating them above and below the median score within the general RFI Area only. It is essential to note that the "low-use" areas depicted by this approach are "high-use" areas for North Atlantic right whales when considering the entire distribution of the species. As such, the species is potentially highly vulnerable throughout the RFI Area. The clipped output for North Atlantic right whales was joined together with the other 22 protected species spatial outputs, including the coast-wide output for North Atlantic right whales, to create a final combined protected species data layer (Figure 3). The two layers (Figure 1, Panel 20 and 21) were developed using the same shapefile, but color-coded to the extent of the layer so contrast was more apparent to inform the spatial suitability process. We believe this approach was warranted given the perilous status of North Atlantic right whales. We retained scoring for both approaches and present data at both scales to inform the site selection in the RFI Area. However, we again note that the final layer developed for the RFI Area should not be applied to other areas given the restricted consideration of the second North Atlantic right whale layer and the removal of layers for species not believed to occur significantly in the Gulf of Maine. This approach is also consistent with the methodology taken in the Protected Species Combined Layer developed for the Central Atlantic Call Area (Sisson and Farmer 2022). The RFI Area also nearly overlaps with the entirety of designated critical habitat for North Atlantic right whales (Unit 1), however, critical habitat was not included in the protected species combined layer. Critical habitat and alternative features of critical habitat were recommended by NMFS for inclusion in the suitability model during the public comment period.

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