A Wind Energy Area Siting Analysis for the Central Atlantic Call Area

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SUMMARY

This report provides the background, methods, and results for the development of the Central Atlantic Wind Energy Areas (WEAs) which includes an ecosystem-wide spatial suitability model developed to inform selection of wind energy areas 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 Oceanographic 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. To develop the Central Atlantic suitability model, 77 data layers were selected from over 200 data layers that represent major ocean characteristics for the Central Atlantic Call Area. Data were organized into categories (submodels) representing the major ocean sectors including national security, 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 acres grid cell of the study area. Using a cluster analysis, five draft WEAs were identified representing the most suitable areas within the call area. The Central Atlantic draft WEAs were announced in November, 2022 and open for review and public comment. In response to comments received as well as data provided by the Department of Defense (DOD) as well as the National Aeronautics and Space Administration (NASA); six WEA options were identified.

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 Central Atlantic WEA Siting Team (Team).

BACKGROUND

The Central Atlantic 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 by 2030. In 2020, the Virginia Clean Economy Act was passed into law which created the Commonwealth's first Clean Energy Standard committing to transitioning the electric grid to 100% clean energy by 2050. BOEM received a letter from Virginia's governor requesting the formation of a renewable energy regional task force that could lead to a lease sale. BOEM agreed to create a Central Atlantic Intergovernmental Renewable Energy Task Force encompassing the area offshore Delaware south to Cape Hatteras, North Carolina.

In 2021, the Initial Central Atlantic Planning Area contiguously spanned the offshore waters of the Atlantic Ocean from Delaware Bay, DE south to Cape Hatteras, NC (Figure 1.1). The Initial Planning Area overlapped with existing BOEM lease areas and extended beyond the continental shelf break into the deep ocean basin of the Atlantic. BOEM reviewed existing ocean uses within this broad area leading to the removal of several large areas in the development of the Central Atlantic Planning Area (Figure 1.2). Specifically, the western boundary of the Initial Planning Area removed active lease areas as well as military danger and restricted zones moving the western boundary further offshore. In response to fishing revenue intensity data provided by the National Marine Fisheries Service (NMFS), BOEM removed the Mid-Atlantic Scallop Rotational Area from consideration offshore Delaware Bay. This removal also was in response to multispecies (groundfish), surf clam, and ocean quahog fishing activities that occur in the Initial Planning Area. A large swath of ocean area was removed along the continental shelf break due to important pelagic and bottom trawl (65+ feet) fisheries activities and marine mammal use, which resulted in splitting the planning area into shallower (on shelf) and deeper (off shelf) areas. Military submarine transit lanes were removed perpendicular to the shelf break further splitting the deep offshore areas into two. Habitat Areas of Particular Concern and canyon heads extending from the shelf break into the ocean basin were identified as sensitive deep-sea coral habitat and withdrawn from leasing consideration.

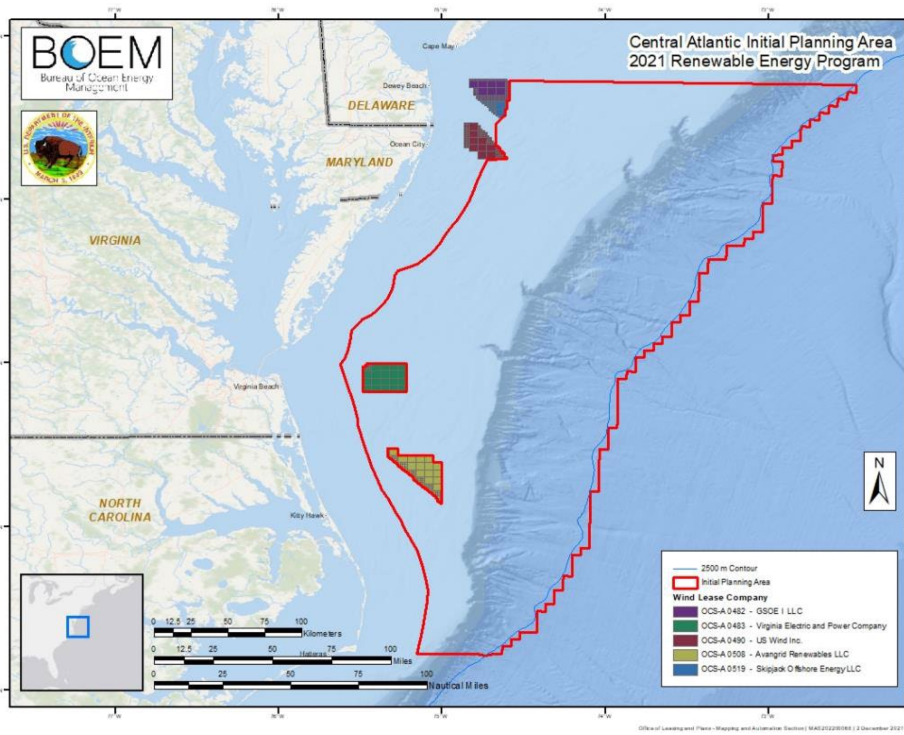

Figure 1.1. Central Atlantic Initial Planning Area

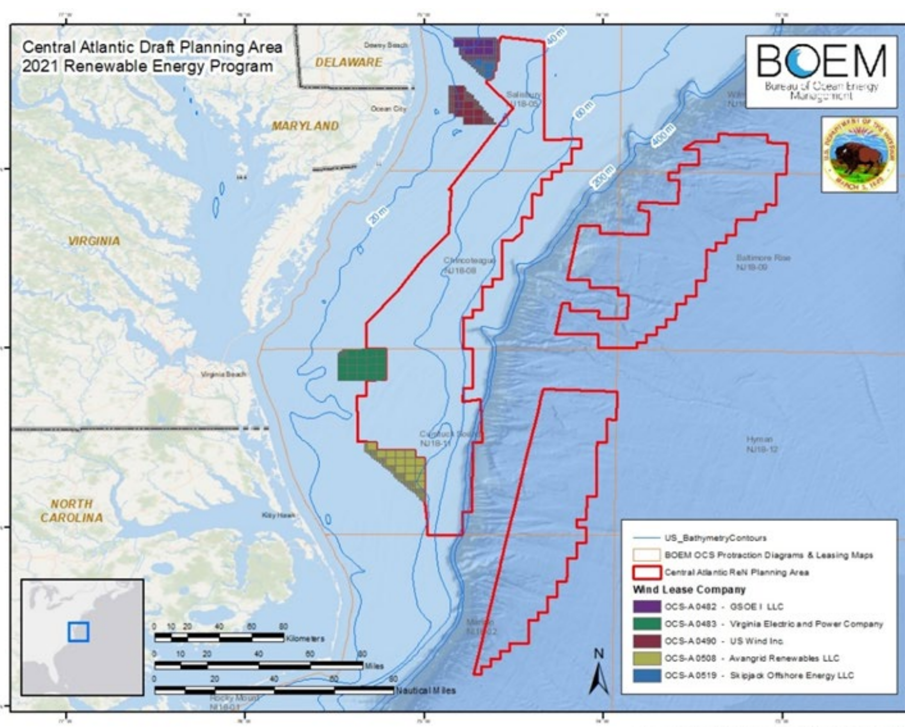

Figure 1.2. Central Atlantic Planning Areas

In December 2021 and January 2022, BOEM hosted a series of eight public meetings geared towards specific stakeholders such as fisheries, environmental NGOs, maritime industries, and wind developers. During these meetings, a Central Atlantic Planning Area was discussed (Figure 1.2), and feedback was collected. Incorporating feedback from these meetings as well as discussions with affected States, Federal partners, and tribal governments, BOEM delineated area for a draft Call for Information and Nominations (Figure 1.3).

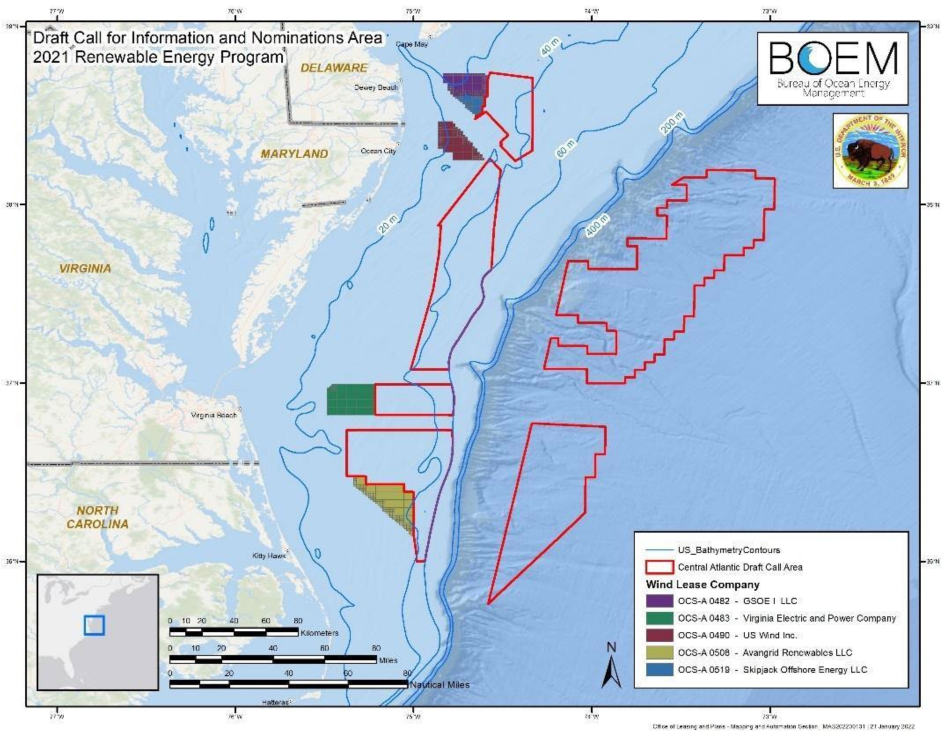

Figure 1.3. Central Atlantic draft Call for Information and Nominations Areas

The draft Call Areas were presented at the first Central Atlantic Intergovernmental Renewable Energy Task Force Meeting held on February 16, 2022. Considering all comments received, BOEM winnowed the draft Call areas and published the Call for Information and Nominations on April 29, 2022 (Figure 1.4) to assess commercial interest in and obtain public input on potential wind energy leasing activities in federal waters of the Central Atlantic.

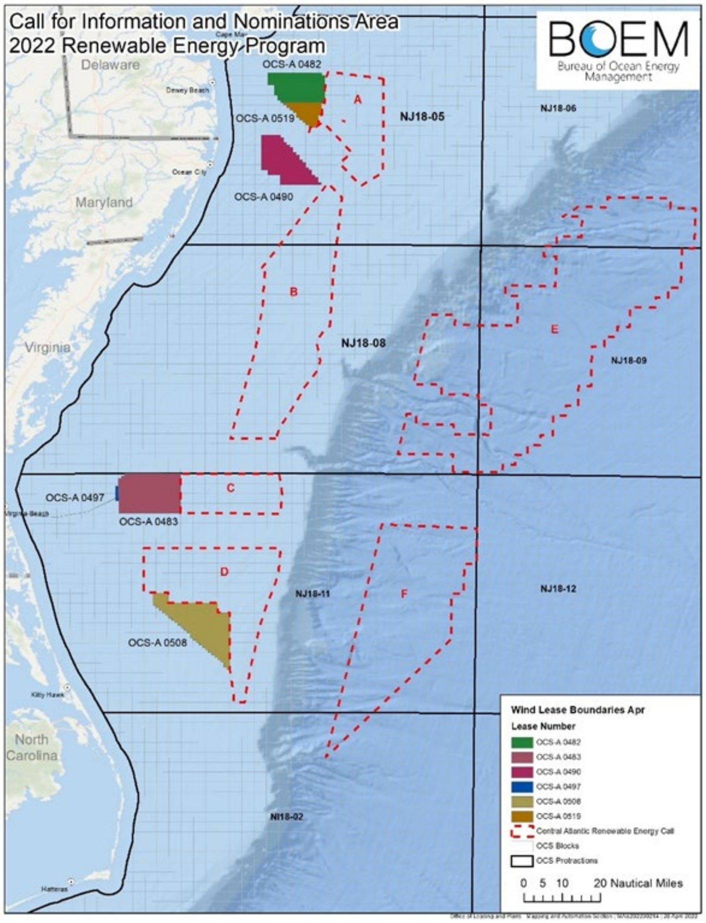

Figure 1.4. Central Atlantic Call for Information and Nominations Areas

The Call consisted of 6 areas labeled A-F. The comment period for the Call ended on June 28, 2022. BOEM received 66 comments which are available at https://www.regulations.gov/document/BOEM-2022-0023-0001. BOEM received nominations from 3 companies all of which have been legally, technically, and financially qualified. Nominations are available at https://www.boem.gov/renewable-energy/state-activities/central-atlantic-activities.

For purposes of recommending draft WEAs, BOEM considered the following non-exclusive list of information sources: comments and nominations received on the Call; information from the Central Atlantic Intergovernmental Renewable Energy Task Force; input from Delaware, Maryland, Virginia and North Carolina State agencies; input from Federal 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 for NOAA's Aquaculture Opportunity Area Atlases as well as for the Gulf of Mexico Renewable Energy ocean planning. In response, BOEM has modified the WEA ID process 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 Central Atlantic. 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.

In November 2022, NOAA and BOEM released a joint report, “Development of the Central Atlantic Wind Energy Areas”, outlining the methods used to determine the original 15 draft Wind Energy Areas. Available at https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/BOEM_NCCOS_JointReport_DraftWEAs_FINAL.pdf . On November 16, 2022, BOEM announced eight draft WEAs in the Central Atlantic for public review and comment. The draft WEAs were in federal waters offshore North Carolina, Virginia, Maryland, and Delaware. They covered approximately 1.7 million acres, representing a subset of the original 3.9 million acres of the Call Area that the Department of the Interior announced for public comment in April 2022.

BOEM held public engagement meetings with fishing communities and environmental organizations to gather more information on the draft WEAs. Additionally, consultations were completed with the Department of Defense, USCG, NASA, and other ocean users, such as the fishing industry to collect additional information that was considered before finalizing the WEAs. Using feedback received during the 30-day public comment period, BOEM, with support from NOAA, NCCOS conducted spatial analyses to determine optimal location for the Wind Energy Areas. This report summarizes the methods and results of the spatial analyses and modeling used to identify the WEAs in the Central Atlantic.

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 area of interest were identified by BOEM. The goal of this study was to identify a number of options for potential draft WEAs in the Central Atlantic Call Area. The steps within the workflow are described below.

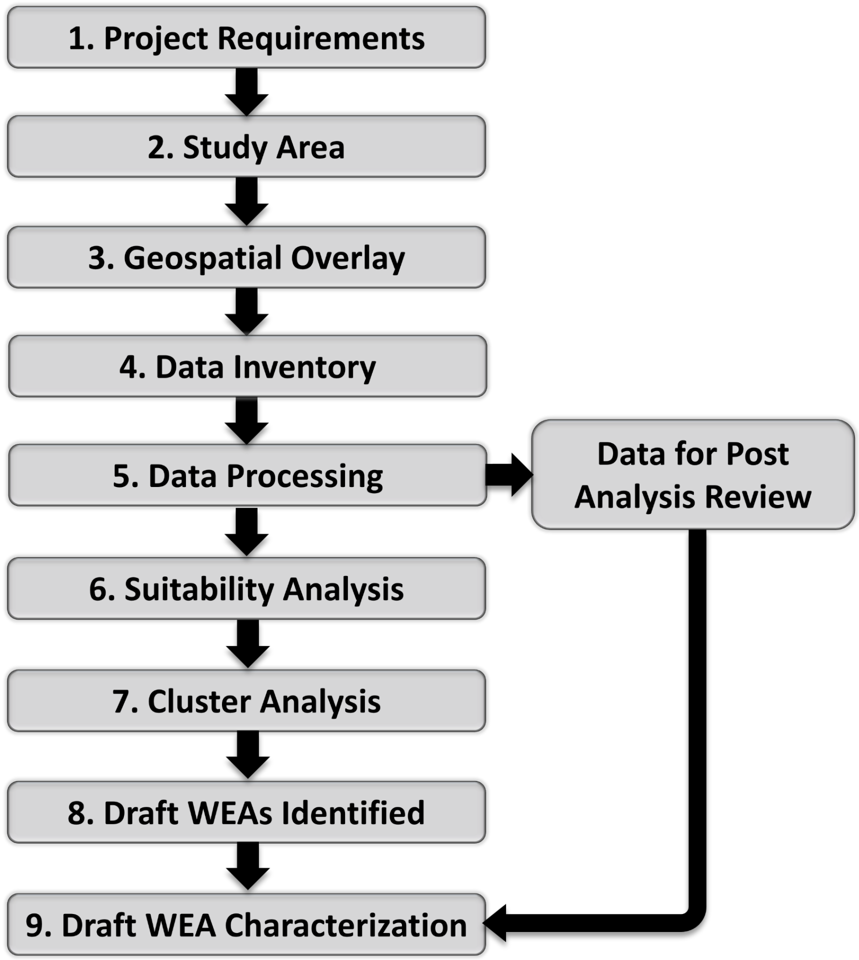

Figure 2.1. Workflow for Wind Energy Area options spatial analysis for the Central Atlantic Call Area.

Study Area

The Call Area is located offshore the Commonwealth of Virginia and the States of Delaware, Maryland, and North Carolina and comprises areas A-F. These six areas include 496 whole OCS blocks and 298 partial blocks and comprise approximately 3,897,388 acres (1,577,217 hectares) (Figure 2.2).

Call Area A: The boundary of Call Area A begins approximately 20 nautical miles (nm) offshore of Delaware and Maryland and extends eastward to the Sea Scallop Rotational Area and the proposed USCG's Port Access Route Studies (PARS) fairways. Call Area A is adjacent to two lease areas immediately to the west (OCS-A-0482 and OCS-A-0519). The area at its widest points is about 12 nmi from east to west and about 29 nmi from north to south. Call Area A does not include the Del-Jersey artificial reef and comprises approximately 235,222 acres (95,191 hectares).

Call Area B: The boundary of Call Area B begins approximately 21 nmi offshore of Maryland and Virginia and extends eastward to the 60-meter bathymetric contour and the proposed PARS fairways. The area at its widest points is about 14 nmi from east to west and about 69 nmi from north to south. Call Area B comprises approximately 652,218 acres (263,943 hectares).

Call Area C: The boundary of Call Area C begins approximately 35 nmi offshore of Virginia and extends eastward to the 60-meter bathymetric contour. The area is about 21 nmi from east to west and about 10 nmi from north to south. Call Area C comprises approximately 183,907 acres (74,425 hectares). Call Area C abuts the Coastal Virginia Offshore Wind – Commercial (OCS-A-0483) lease area to the west.

Call Area D: The boundary of Call Area D begins approximately 24 nmi offshore of Virginia and North Carolina and extends eastward to the 60-meter bathymetric contour. The area at its widest points is about 28 nmi from east to west and about 40 nmi from north to south. Call Area D comprises approximately 442,553 acres (179,095 hectares) and is adjacent to the Kitty Hawk lease area (OCS-A-0508).

Call Area E: The boundary of Call Area E begins approximately 56 nmi offshore of Delaware, Maryland, and Virginia and extends eastward to between the 2,500 and 2,600-meter bathymetric contour. The shallowest depth is approximately 816-meters. The area at its widest points is about 35 nmi from east to west and about 84 nmi from north to south. Call Area E comprises approximately 1.6 million acres (655,590 hectares).

Call Area F: The boundary of Call Area F begins approximately 44 nmi offshore of Virginia and North Carolina and extends eastward to between the 2,500 and 2,600-meter bathymetric contour. The shallowest depth is approximately 1,476-meters. The area at its widest points is about 20 nmi from east to west and about 66 nmi from north to south. Call Area F comprises approximately 763,491 acres (308,974 hectares).

For the purposes of the WEA analysis, Call Areas A - F were treated as one collective study area (domain), as opposed to two study areas (nearshore/offshore) as was previously done to determine the draft WEAs.

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 to the study area, which resulted in 394,926 grid cells (Figure 2.3). 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 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 course (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 only provide 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).

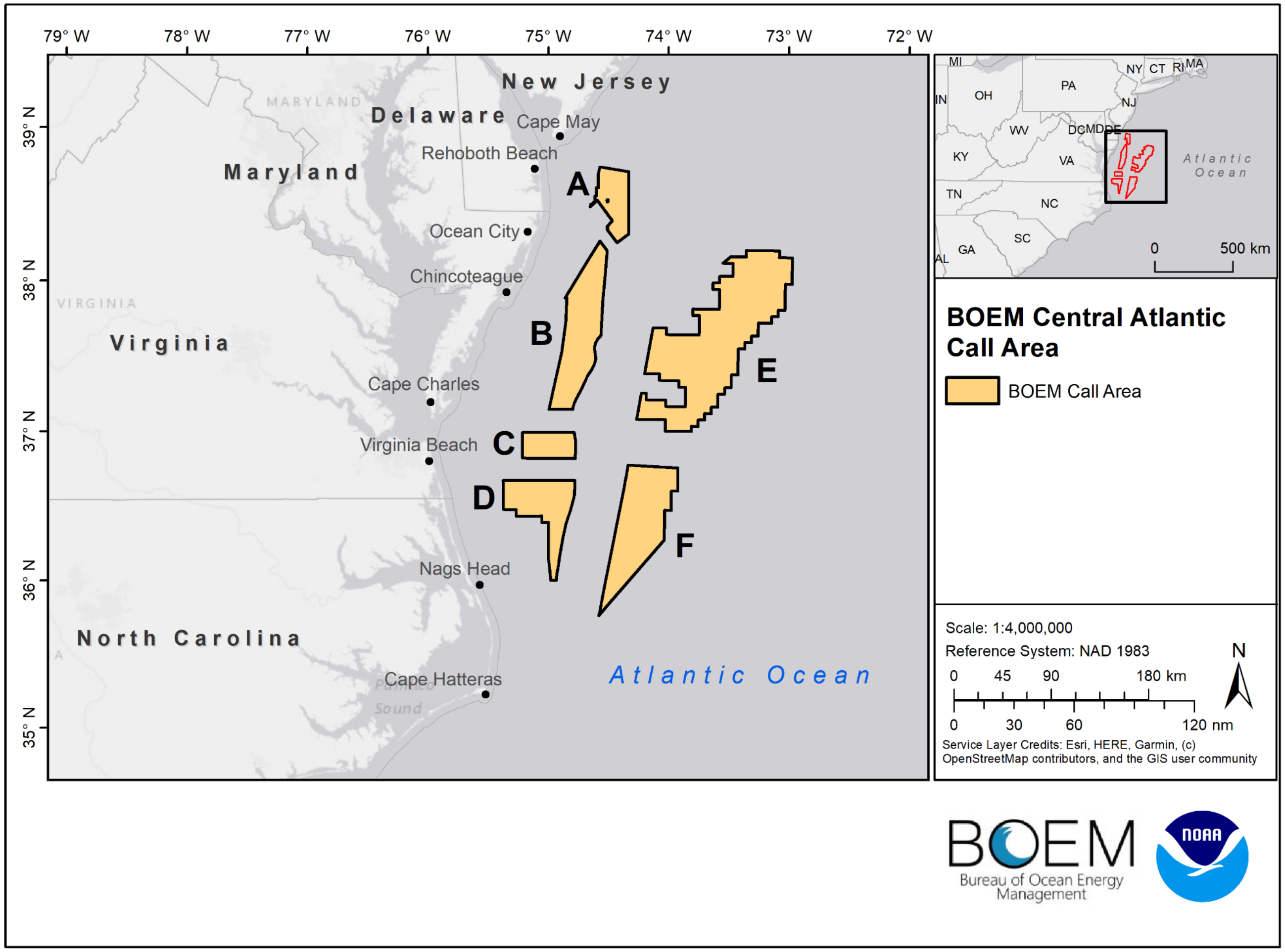

Figure 2.2. BOEM Central Atlantic Call Areas A - F for wind energy development.

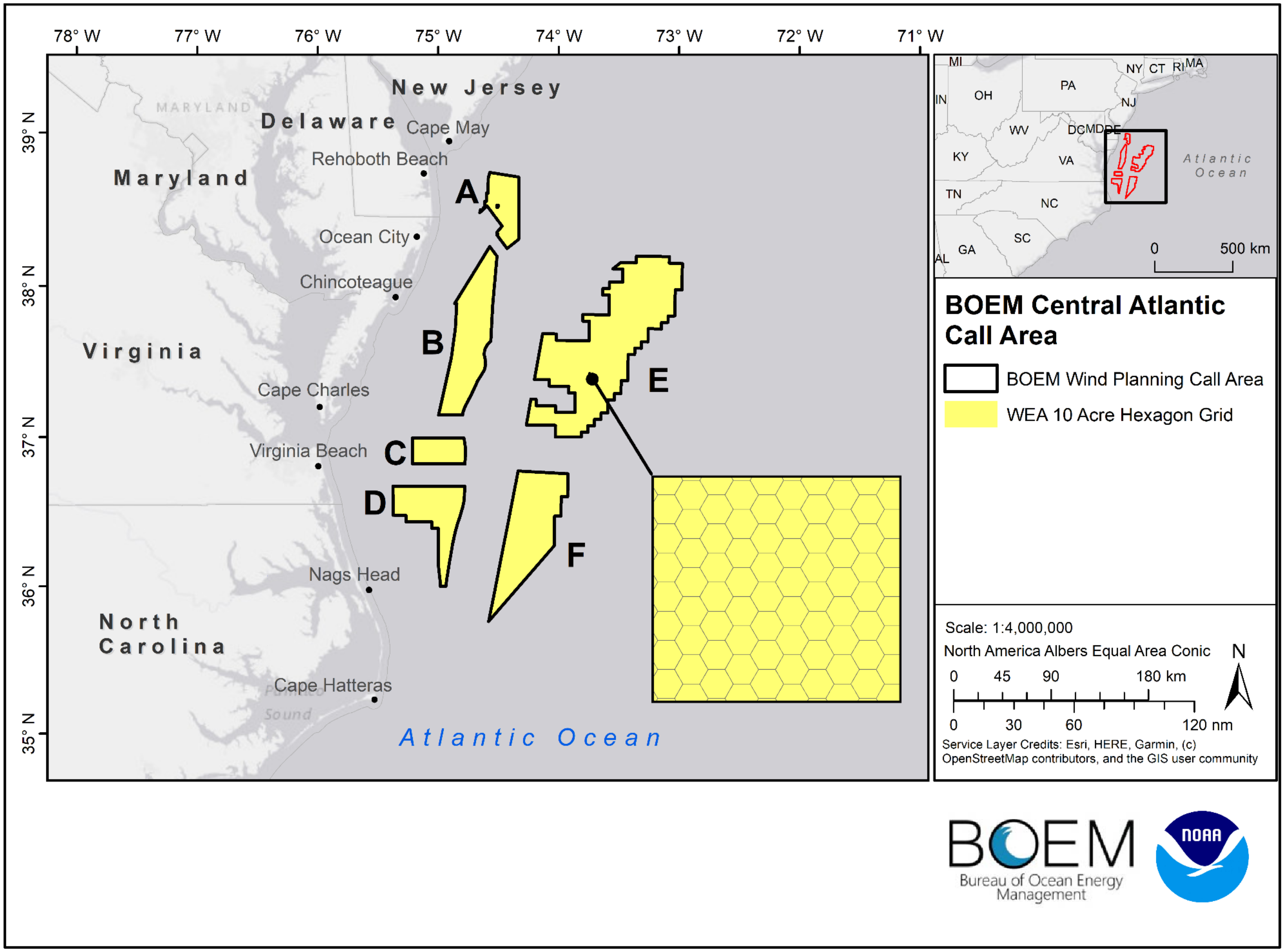

Figure 2.3. An example of the grid cells formulated for the Call Area. Each cell is a 10-acre or 4.05-hectare hexagon.

Data Acquisition, Categorization, and Inventory

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 ensures works to include necessary data that are needed for the wind energy area site suitability analysis, a specific type of ocean planning.

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. 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 and many studies conducted throughout the years by BOEM environmental studies 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 Albers Equal Area Conic projection (WKID: 102008, Projection: Albers, False Easting: 0.0, False Northing: 0.0, Central Meridian: -96.0, Standard Parallel 1: 20.0, Standard Parallel 2: 60.0, Latitude of Origin: 40.0). Appendix A provides a list of data utilized for this spatial planning analysis.

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.

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 habitat density model (Appendix B).

Table 2.1. Scoring system for NMFS protected resources.

Status	Trend	Score
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

*Small population equates to populations of 500 individuals or less (Franklin 1980)

A total of 31 data layers including Atlantic spotted dolphin (coastal), Atlantic white-sided dolphin, Bottlenose dolphin, Clymene dolphin, Cuvier's beaked whale, Dwarf and Pygmy sperm whale, Harbor porpoise, Mesoplodon beaked whales, Pantropical spotted dolphins, Pilot whale, Risso's dolphin, Rough-toothed dolphin, Short-beaked common dolphin, Striped dolphin, Blue whale, Fin whale, Humpback whale, Minke whale, North Atlantic right whale, Sei whale, Sperm whale, Seals, Atlantic sturgeon (All DPSs), Giant manta ray, Oceanic whitetip shark, Shortnose sturgeon, Green sea turtle (North Atlantic, South Atlantic DPSs), Hawksbill sea turtle, 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.

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

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

Table 2.2. Score and justification for ESA-listed and MMPA species known to occur within the Central Atlantic to be used in suitability modeling.

Species Common Name	Status and Trend	Score
Atlantic spotted dolphin	MMPA Listed, unknown	0.7
Atlantic white-sided dolphin	MMPA Listed, low use area	0.9
Bottlenose dolphin	MMPA Strategic, unknown/declining	0.6
Clymene dolphin	MMPA Listed, unknown/declining	0.7
Cuvier's beaked whale	MMPA Listed, unknown/declining	0.7
Dwarf and Pygmy sperm whale	MMPA Listed, unknown/declining	0.7
Harbor porpoise	MMPA Listed, unknown/declining	0.7
Mesoplodon beaked whales	MMPA Listed, unknown/declining	0.7
Pantropical spotted dolphin	MMPA Listed, unknown/declining	0.7
Pilot whale	MMPA Listed, unknown/declining	0.7
Risso's dolphin	MMPA Listed, unknown/declining	0.7

Rough-toothed dolphin	MMPA Listed, unknown/declining	0.7
Short-beaked common dolphin	MMPA Listed, unknown/declining	0.7
Striped dolphin	MMPA Listed, increasing/stable	0.8
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
Sei whale	ESA Endangered, unknown/stable	0.2
Sperm whale	ESA Endangered, unknown/stable	0.2
Atlantic sturgeon (All DPSs)	ESA Endangered, unknown/stable	0.2
Giant manta ray	ESA Threatened, unknown/declining	0.4
Oceanic whitetip shark	ESA Threatened, unknown/declining	0.4
Shortnose sturgeon	ESA Endangered, low use area	0.5
Green sea turtle	ESA Threatened, increasing/stable	0.5
Hawksbill sea turtle	ESA Endangered, unknown/stable	0.2
Kemp's ridley sea turtle	ESA Endangered, unknown/stable	0.2
Leatherback sea turtle	ESA Endangered, declining	0.1
Loggerhead sea turtle (NW Atlantic, NW Atlantic Ocean DPSs)	ESA Threatened, increasing/stable	0.5

NMFS Habitat Data Layer

NMFS provided the best available data sets[1] to be used for creating a combined habitat layer.

[1] NCCOS 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

Overall, five data sets were chosen to be combined to represent the suitability of the habitat in the call areas with offshore wind energy (Table 2.3). These data were combined using a 34-acre hexagonal grid, as that resolution best captured the coral and hardbottom data. All five datasets were summarized to create the combined grid and the product method was used to calculate a final 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)**
Coral and Hardbottom	Z Membership Function (0 – 0.4) "Very Low" = 1
Shelf Break 100 m bathymetric contour (20 km Setback)	0.4
Surf Clam/Scallop Areas	Z Membership Function
Sand Ridge Trough Complexes /Sand Shoals	0.8
None of the Above	1

Bathymetry

The U.S. Coastal Relief Model (CRM) provides comprehensive bathymetric data at 3 arc-second horizontal resolution (~90 x 90 m pixels) for the Central Atlantic. For full bathymetric coverage for the BOEM Central Atlantic wind energy Call Area, the CRM requires a download of the Southeast Atlantic, Volume 2 CRM (1998)[2]. Bathymetry data were clipped (i.e., data not overlapping the study area was removed) to the study area for ease of processing.

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 the Nationwide Automatic Identification System. 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[3].

Processed vessel traffic data of transits per 100 m² from 2015 through 2021 were downloaded

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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.

[2] https://www.ngdc.noaa.gov/mgg/coastal/crm.html

[3] https://w ww.navcen.uscg.gov/?pageName=AISRequirementsRev#Operations

from Marine Cadastre for the BOEM Call Area.[4] The sum of the six years was calculated and used for modeling.

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.[5] 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[6] 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.

VMS All Fishing Types (2016 - 2021)

NMFS provided annual summarized data sets of fisheries using Vessel Monitoring Data (VMS) from 2016-2021. The fishing industries represented by this data set include: Scallop, Highly Migratory Species (including the pelagic longline fishery), Monkfish, Squid/Mackerel/Butterfish, Surfclam, Herring, and Declare Out of Fishery (vessels who hold a permit requiring a VMS). The data are at a spatial resolution of 5 minutes and represent VMS poll counts per cell. Data points in state waters were excluded. For inclusion in the final data set, there needed to be at least 3 unique vessels per cell, and at least 24 polls (hrs) / cell. We took the mean of the six years of raster data, and created a summarized data set to be included in the Fisheries Submodel used for the suitability analysis.

Southeast Region Headboat Survey Data (2014 – 2020)

The NMFS Southeast Region Headboat Survey (SRHS) samples recreational headboats, wherein anglers pay a per-head fee to target reef fish and coastal migratory pelagic species (Fitzpatrick et al. 2017). Boats typically carry more than six passengers, ranging as high as 100 passengers. Data consist of trip-level logbook records submitted by captains. The SRHS electronic logbook was implemented in 2013 to improve data collection, and consequently, data from 2014 – 2020 were used in this analysis. In addition to information on the catch and operations, captains were required to report the geographic location of fishing activity in latitude

[4] https://marinecadastre.gov/ais/
[5] https://www.archives.gov/cui/about
[6] https://www.st.nmfs.noaa.gov/Assets/intranet2015/pdf/NOAA_216-100_Form.pdf

and longitude degrees and minutes. The NMFS SEFSC provided gridded point data with degrees and minutes of positional data, representing where boats were fishing. The point dataset was converted to a grid (0.0083333° x 0.0083333°). The sum of the points within each grid cell was calculated for each year and a sum for all years (2014 to 2020) was calculated and used in the suitability model.

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 active national security areas, maritime navigation, ocean industries, and natural resource management. We utilized a submodel structure to capture ocean use and conservation concerns including national security, natural and cultural resources, industry and operations, fisheries, and wind logistics. Data layers with no compatibility with wind energy development (e.g., shipping fairways or known deep sea corals) were captured in the list of incompatible constraints and removed from further analysis due to known incompatibility with wind energy (Figure 2.4). 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.

Relative Suitability Analysis Submodels

Figure 2.4. Overview of suitability model design and the submodel components. The constraints submodel includes all data layers with a score of 0; these data layers were removed before the remaining submodel scores were calculated.

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). For example, a regulated shipping lane that experiences regular traffic would be deemed unsuitable for wind energy and thus receive a score of 0 and be treated as completely unsuitable. Whereas, within certain military operating areas uncertainty exists, and even if a suitable location is found, additional communications and resources may be required; thus, a score of 0.5 would be given to capture that uncertainty.

After all data were gathered and integrated into the greater data inventory, certain data layers with constraints also required, either by action agency or for safety and security reasons, setbacks from the discrete/categorical layer. If a setback was established by a permitting authority as a 'no go' area, a score of 0 was applied as the setback (e.g., deep sea coral and sponge observations and a 1000 m setback, all scored as 0). Setbacks were also established based on governance, policy, and regulations, and taking the most conservative setback distance (i.e., buffer) to avoid interactions with other ocean activities.

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 habitat suitability 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 2.5). Other numerical datasets, such as distance to shore, used a standard linear function because of high certainty that the closer a location is to shore, 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 2.4 through 2.9.

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).

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

$x =$ *Input value to be rescaled*

$a =$ *Function begins falling from 1 (Minimum value of dataset)*

$b =$ *Function attains 0 (Maximum value of dataset +1 to ensure no 0 values in output)*

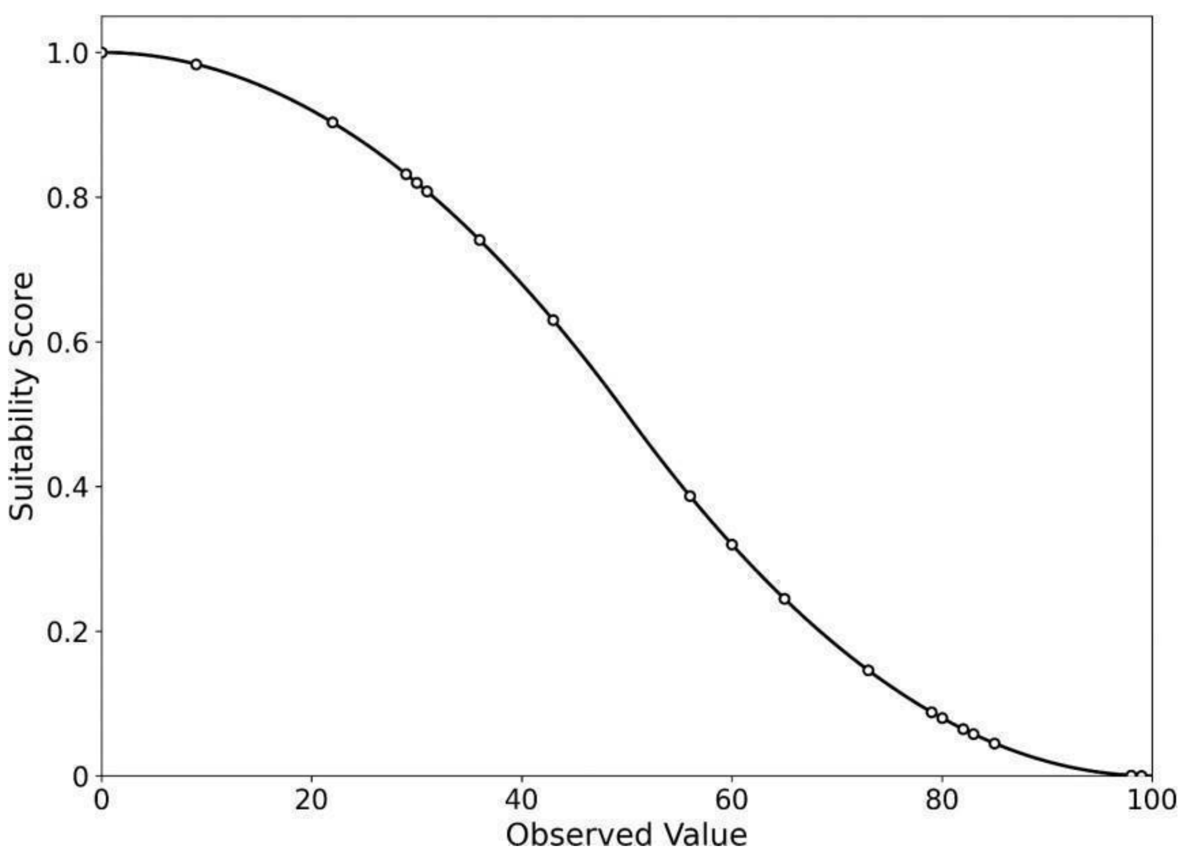


Figure 2.5. Example of hypothetical Z-shaped membership function, with the minimum observed value being 0 and the maximum observed value being 99. However, the total range of

the function goes to 99.0001, as 0.0001 was added to 99 when creating the function to ensure no observed values would be rescaled to 0. For example, the points on the line indicate the intersection of an observed value (e.g., vessel traffic) and the corresponding score to which it would be rescaled from the function.

Table 2.4. Constraints submodel data layers included in the relative suitability analysis. Each dataset in the constraints submodel was scored 0 for complete avoidance. A dash denotes when a dataset did not have a setback applied.

Data Layer	Setback Distance	Score
Deep Sea Coral and Sponge Observations	1000 m	0
Navy Assessment - Priority 1 Areas	-	0
Navy Assessment - Priority 2 Areas	-	0
Air Force Assessment - Priority 1 Areas	-	0
Air Force Assessment - Priority 2 Areas	-	0
Air Force Assessment - Priority 3 Areas	-	0
BWFA Exclusion Area	-	0
USCG Shipping Safety Fairways and Regulations	-	0
BOEM Proposed Fairway Extensions	-	0
DOD Area of No Seabed Disturbance	-	0
NASA Assessment – Extreme Risk Areas	-	0

Table 2.5. National security 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
Navy Assessment - Priority 3 Area	0.1
Navy Assessment – Areas that need further study	0.5
NASA Assessment – Major Risk Areas	0.5
NASA Assessment – Areas that need further study	0.5
Air Force Assessment – Areas that need further study	0.5
Air Force Assessment - Priority 4 Area	0.5
Air Force Assessment - Priority 5 Area	0.8
Air Force Assessment - Priority 6 Area	1.0

Table 2.6. 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
Protected Resource Division Combined Layer (31 species)	NMFS Scores
Habitat Combined Layer (4 habitats)	NMFS Scores
Black-Capped Petrel Annual Abundance	Z Membership Function
Highly Migratory Species (HMS) Essential Fish Habitat (EFH) Overfished/Prohibited Sharks Count (6 species)	Z Membership Function
Highly Migratory Species (HMS) Essential Fish Habitat (EFH) Target Species Count (6 species)	Z Membership Function

Table 2.7. 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
AIS Vessel Traffic All Vessels 2015 - 2021	Z Membership Function

Table 2.8. 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 shore	Linear Function (Closer to shoreline is better)
Distance to inlet	Linear Function (Closer to inlet is better)
Depth	0 - 70 m = 1.0 70 - 500 m = 0.8 500 - 1,300 m = 0.5 1,300+ m = 0.2
Atlantic Wind Speed - Annual Average	Linear Function (Greater mean wind speed is better)

Table 2.9. 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
VMS All Fishing Types 2016 - 2021	Z Membership Function
Southeast Region Headboat Survey	Z Membership Function

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. All constraints data layers were deemed unsuitable for wind energy, and not considered further in the analysis. 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 data layers and 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.

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

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

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.

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 600-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).

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 and non-governmental organizations. 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. Some data were included in the characterization data inventory (Appendix A) only to provide supplementary information beyond the scope of this study, but those data may be useful during the Programmatic Environmental Impact Statement (PEIS) process.

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 2.6). 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 WEA options 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).

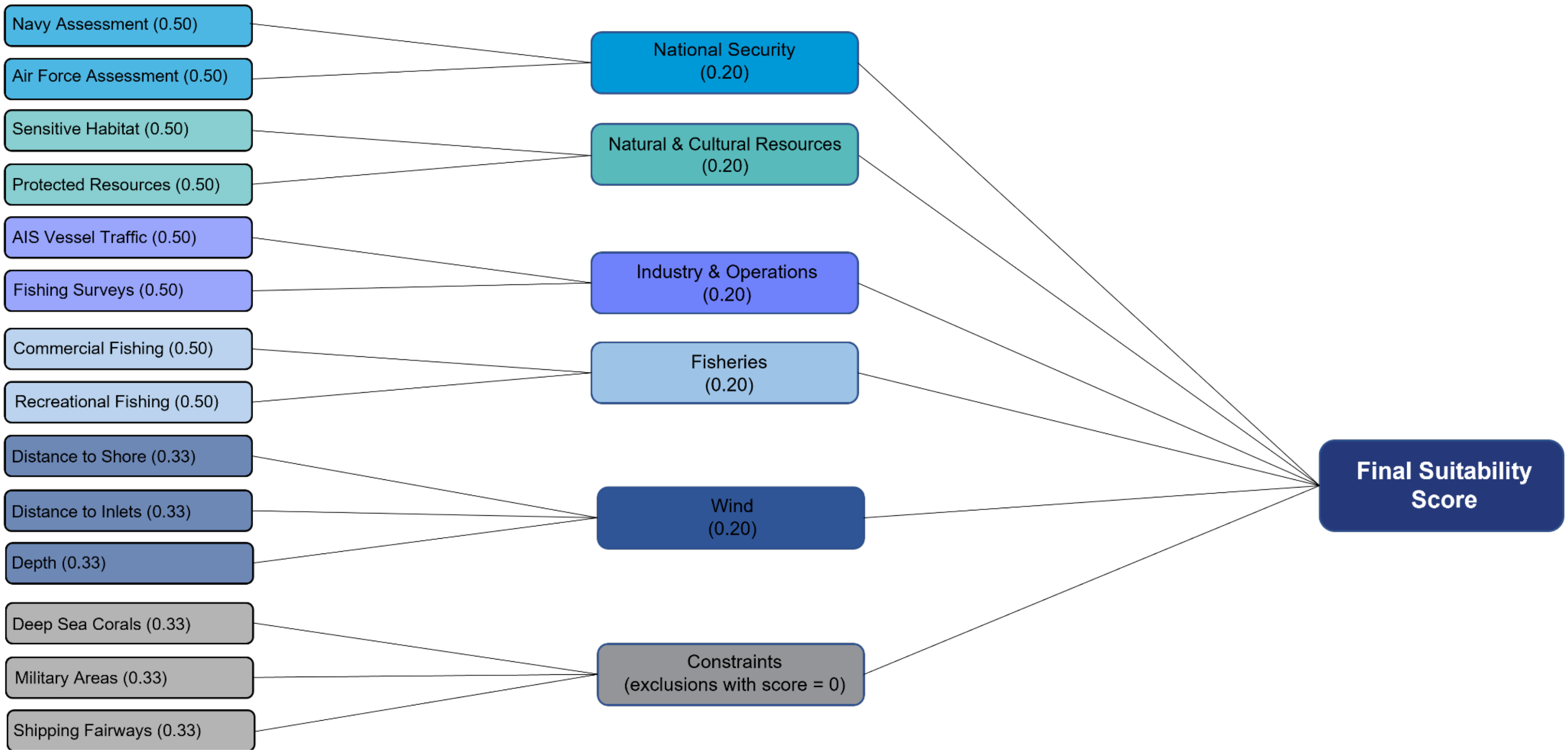


Figure 2.6. A generalized approach to a Multi-Criteria Decision Analysis (MCDA) suitability model with equally-weighted data layers in the submodels and final suitability model. Note that not all of the data layers are shown.

Option Identification

WEA options were 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, for a total of 1,039 (Option 2.2 = 1,259) aliquots. Next, any aliquots that overlapped with shipping safety fairways and extensions were removed from the selection. Additionally, any aliquots that overlapped existing BOEM wind leases were removed. The remaining aliquots were grouped together based on location to make up the six WEA options. This methodology does allow for some constraints to be located within the final options (observed deep sea coral and sponges with a 1000 m setback, etc.), which are noted in the results and with the discussion of avoidance or mitigation to follow.

Characterization of WEA Options

An in-depth look at each of the identified WEA options 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, and when appropriate standardized to the size of the WEA to allow for comparisons between the WEAs (i.e., vessel traffic, fishing interactions, etc.). 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 WEA options.

RESULTS

Submodels

Constraints

This section presents a summary of the constraints that are likely to limit wind energy development either because of environmental sensitivities or high level of conflict with other ocean industries. It is important to note that the total area removed may not sum to 100% because of overlapping constraints. The constraints submodel in total overlapped with 69.10% of the Call Area, which included the complete removal of Call Areas B and D (Figure 3.1.a).

BOEM held additional consultations on the WEA suitability in Area B with the DoD Clearinghouse that included Navy and Airforce as well as with additional consultations with NASA. This additional consultation with DoD and NASA regarding Area B was in response to public comments. The Clearinghouse and NASA agreed to review possible OSW compatibility within the northern region of the Call Area B. As such, the constraints submodel was adjusted to include a post-hoc in-depth DoD and NASA assessment of the northern portion of Call Area B. Thus, the removal of constraints in the northern portion of Area B resulted in a total overlap with 63.35% of the Call Area (Figure 3.1.b and Table 3.1)

Table 3.1. Constraints submodel data layers included in the relative suitability analysis and the percent overlap. Each dataset in the constraints submodel was scored 0 for complete avoidance.

Data Layer	Setback Distance	Score	Percent Area Constrained
Deep Sea Coral and Sponge Observations	1000 m	0	0.52%
Navy Assessment - Priority 1 Areas	-	0	21.25%
Navy Assessment - Priority 2 Areas	-	0	14.30%
Air Force Assessment – Priority 1 Areas	-	0	9.96%
Air Force Assessment - Priority 2 Areas	-	0	1.12%
Air Force Assessment – Priority 3 Areas	-	0	19.00%
BWFA Exclusion Area	-	0	0.60%
USCG Shipping Safety Fairways and Regulations	-	0	11.48%
BOEM Proposed Fairway Extensions	-	0	10.15%
DOD Area of No Seabed Disturbance	-	0	5.61%
NASA Assessment – Extreme Risk Areas	-	0	43.25%
		All Constraints	63.35%

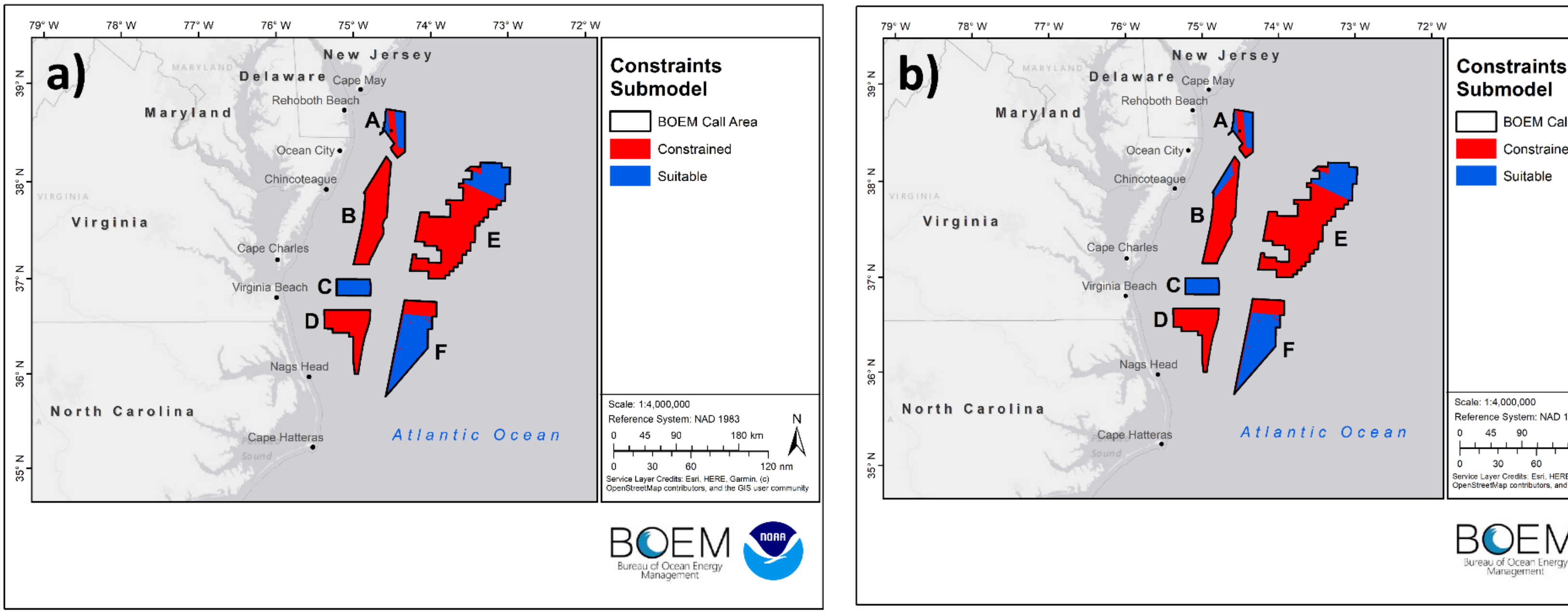


Figure 3.1. Constraints submodel relative suitability for the Call Area (a) with the northern portion of Area B removed as a constraint (b). Red color indicates those areas constrained by ocean activity, while blue areas are considered suitable.

National Security

National security assets are relatively extensive throughout many portions of U.S. federal waters, with uses varying over time and space. Consultations were completed with the Office of the Assistant Secretary of Defense (Energy, Installations an Environment), Military Aviation and Installation Assurance Siting Clearinghouse (Clearinghouse) where detailed compatibility assessments were produced for the Department of Navy (DON) and the Department of Air Force (DAF). A similar consultation and compatibility assessment was completed with the National Aeronautics and Space Administration (NASA). Each of the mission compatibility assessments recommended scoring based on known assets and potential conflicts. National security mission compatibility assessments were reviewed in relation to the Call Area (Table 3.2; Figure 3.2 - Figure 3.4).

DON Mission Compatibility Assessment

BOEM's Central Atlantic Call Areas are located within the Virginia Capes (VACAPES) Operating Area (OPAREA). The VACAPES OPAREA is a set of co-located areas of sea space, undersea space, land ranges, and overlying airspace designated for military training and testing operations, and it is the DON's most highly-utilized OPAREA on the East Coast. This OPAREA supports units home-ported in the Norfolk-Hampton Roads region, which contains the largest concentration of Naval forces and infrastructure in the United States, as well as the home port of United States Fleet Forces Command. Naval forces operate and train daily in the VACAPES OPAREA to generate and certify deployable combat-ready forces to meet worldwide Combatant Commander requirements. DON also uses the VACAPES OPAREA to support the Naval Air Warfare Center – Aircraft Division (NAWCAD) Atlantic Test Range headquartered at Naval Air Station Patuxent River. NAWCAD conducts research, development, test, and evaluation for all DON aircraft and aircraft systems. Overall, within BOEM's Call Areas, DON's utilization of air and sea space is high, with approximately 20,000 DON training and testing activities conducted annually. This air and sea space, combined with extensive shore infrastructure, provides capabilities that support the entire spectrum of DON training and testing, and is unique on the East Coast.

Of further note is that the Call Areas are also largely located within the at-sea warning areas (W-386 and W-72) portion of the VACAPES OPAREA. Warning areas are established by the Federal Aviation Administration to warn non-participating pilots that certain areas are special use airspaces in which activities that may be hazardous to non-participating aircraft may be present. Consistent with that designation, at-sea military readiness activities are typically conducted within warning areas. DON activities conducted in the warning areas require unobstructed low-altitude air, sea, and undersea space to safely and effectively execute the mission, whether for navigation purposes or to ensure standoff for hazardous activities. The DON schedules activities regularly throughout W-386 and W-72, and the introduction of any permanent obstruction will conflict with those current uses.

The DON's Central Atlantic mission compatibility assessment evaluated the potential for conflicts between current and expected future military requirements and offshore wind development. The assessment analyzed anticipated risk to national defense missions and ranked the locations where potential conflicts are likely to generate the greatest risks to national security due to the magnitude of impacts and the inability to feasibly or affordably mitigate them. The DON considers areas identified as Priority 1 and 2 to be unsuitable for wind energy development. As such, these areas were assigned a score of 0, indicating the need for complete avoidance, and moved to the constraints submodel. These constrained areas included the entirety of Call Areas B and D.

However, after additional consultation with the DON on WEA suitability in Call Area B, BOEM and the Clearinghouse agreed to take an in-depth review of the northern portion of Area B to determine if DoD activities could co-exist with wind energy development, with appropriate site-specific mitigation. The constraints submodel was adjusted to reflect the pending DON Assessment of the northern portion of Call Area B and the Priority 1 and Priority 2 sublayers in the northern portion of Call Area B were added to the National Security Submodel with a weighted score of 0.5 (Tables 3.1 and 3.2).

Areas identified by the DON as Priority 3 pose a modest risk to Naval Testing, Training, and readiness insofar as wind energy development is likely to conflict with current and future DON requirements and impact future flexibility for large scale test and training activities. As such, Priority 3 areas were assigned a score of 0.1. The entirety of Call Areas A and C pose potential conflicts with DON at-sea activities, but DON anticipates that potential conflicts can be acceptably mitigated through the inclusion of stipulations in the lease sale. Call Areas A and C were assigned a score of 0.5 (Figure 3.2).

DAF Mission Compatibility Assessment

Similar to the DON, the DAF utilizes the at-sea Warning Areas W-386 and W-72 within the VACAPES OPAREA for training and testing, primarily with Air Combat Command F-22s flying out of Langley AFB and other fighter aircraft use these warning areas as their primary operating areas, and 1FW units currently conduct air combat training, low-altitude flight training, and live munitions training in them as well. While there is no defined boundary for each of these training types within the warning areas, certain sections of airspace are better suited and more important for specific mission types.

The DAF divided the Central Atlantic Planning Area into six priority categories to illustrate the expected severity of impacts to missions presented by offshore wind energy development. Priority 1, 2, and 3 areas pose severe to moderate impacts, have been assigned a score of 0 indicating the need for complete avoidance, and were moved to the constraints submodel (Table 3.1). As previously stated, after further consultation with the Clearinghouse and DAF, the Priority 2 area within the northern portion of Call Area B was identified as appropriate for an in-depth review, removed from the constraints submodel, and added to the National Security Submodel with a weighted score of 0.5 (Table 3.2). Priority 4 areas pose minor impacts and were assigned a score of 0.5. Priority 5 areas have negligible impacts likely and were assigned a score of 0.8. Priority 6 areas have no impacts likely and were assigned a score of 1.0 (Figure 3.3).

NASA Mission Compatibility Assessment

NASA provided a mission compatibility assessment. Red extreme risk areas were determined to be incompatible with wind energy development. These areas were assigned a score of 0 and moved to the constraints submodel (Table 3.1). Similar to DoD's focused review of the northern portion of Area B, NASA agreed to conduct an in-depth review of the same area to determine if NASA activities could co-exist with wind energy development with appropriate site-specific mitigation. The red constrained extreme risk area was modified to exclude overlap with the northern portion of Call Area B and added to the National Security Submodel with a weighted score of 0.5 (Table 3.2). Yellow major risk areas within NASA's Hazard Area were assigned a score of 0.5 (Figure 3.4). Suitability results for the national security submodel are presented in Figure 3.5.

Table 3.2. National Security submodel data layers included in the relative suitability analysis,

the score assigned to each dataset, and the percent overlap. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	**Setback Distance**	**Score**	**Percent Overlap**
Navy Assessment - Priority 3 Area	-	0.1	45.66%
Navy Assessment – Areas that need further study	-	0.5	16.55%
NASA Assessment – Major Risk Areas	-	0.5	22.35%
NASA Assessment – Areas that need further study	-	0.5	5.73%
Air Force Assessment – Areas that need further study	-	0.5	5.73%
Air Force Assessment - Priority 4 Area	-	0.5	37.94%
Air Force Assessment - Priority 5 Area	-	0.8	16.14%
Air Force Assessment - Priority 6 Area	-	1.0	10.61%

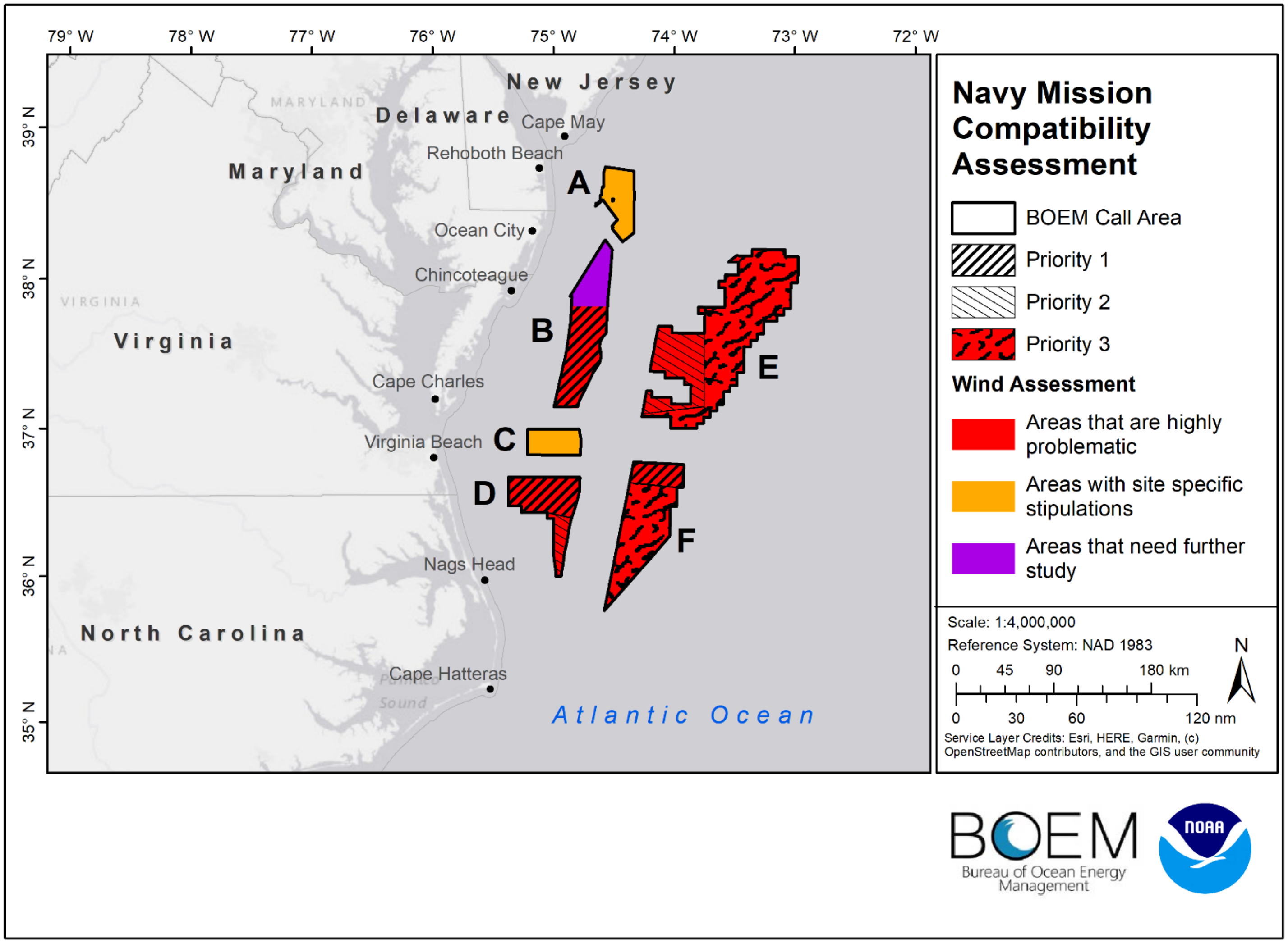


Figure 3.2. DON mission compatibility assessment for the Call Area.

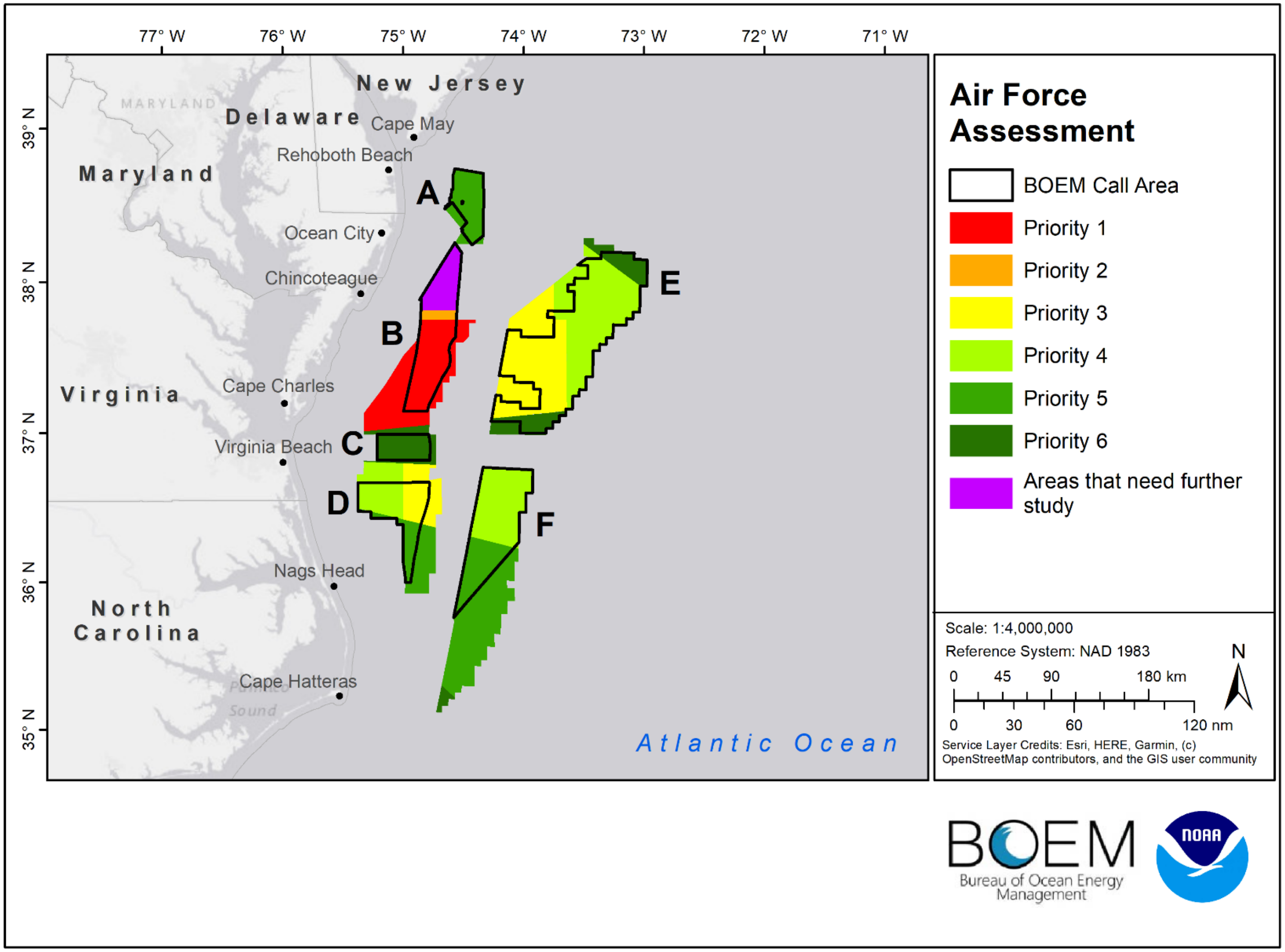


Figure 3.3. DAF mission compatibility assessment for the Call Area.

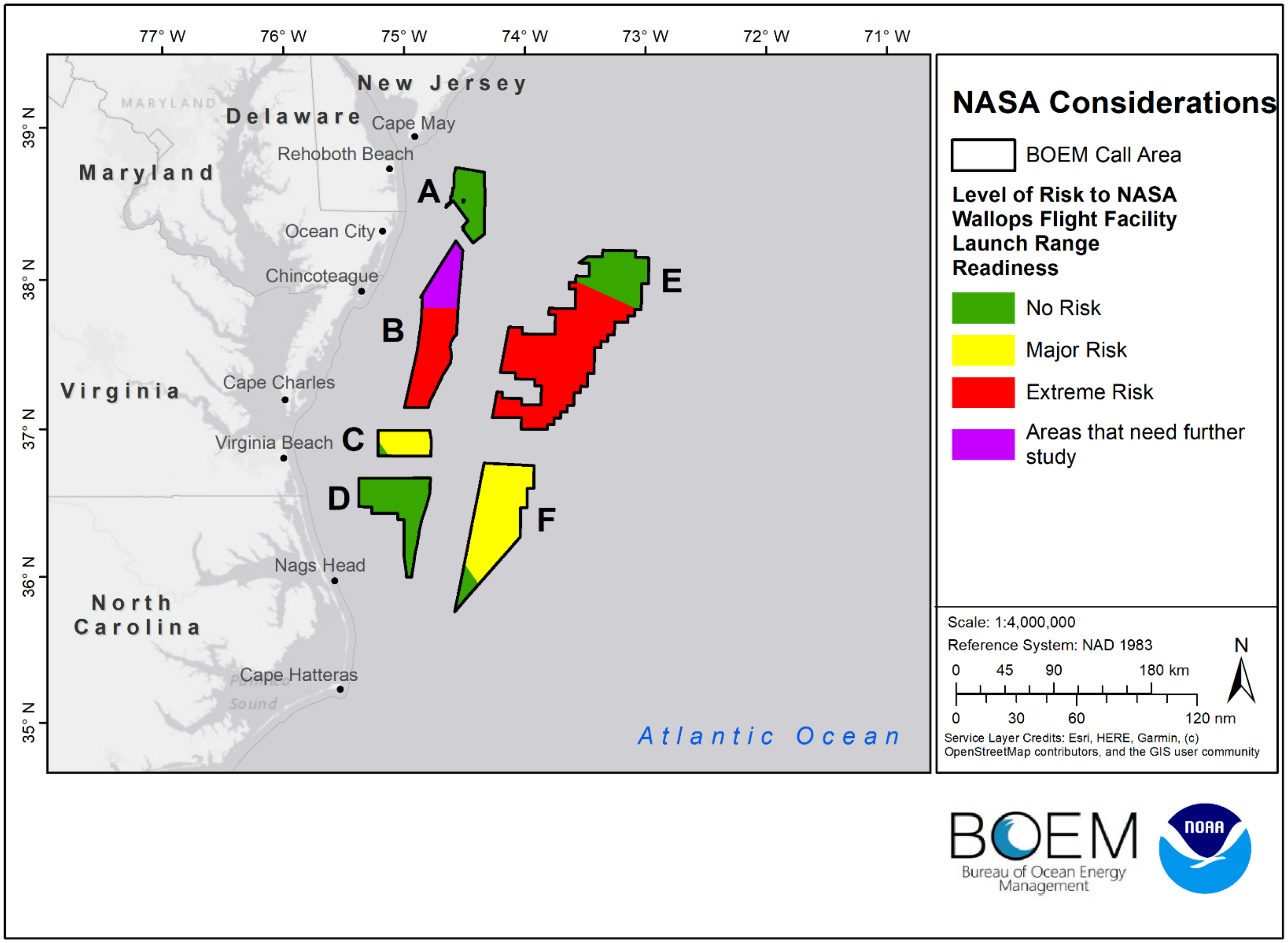


Figure 3.4. NASA mission compatibility assessment for the Call Area.

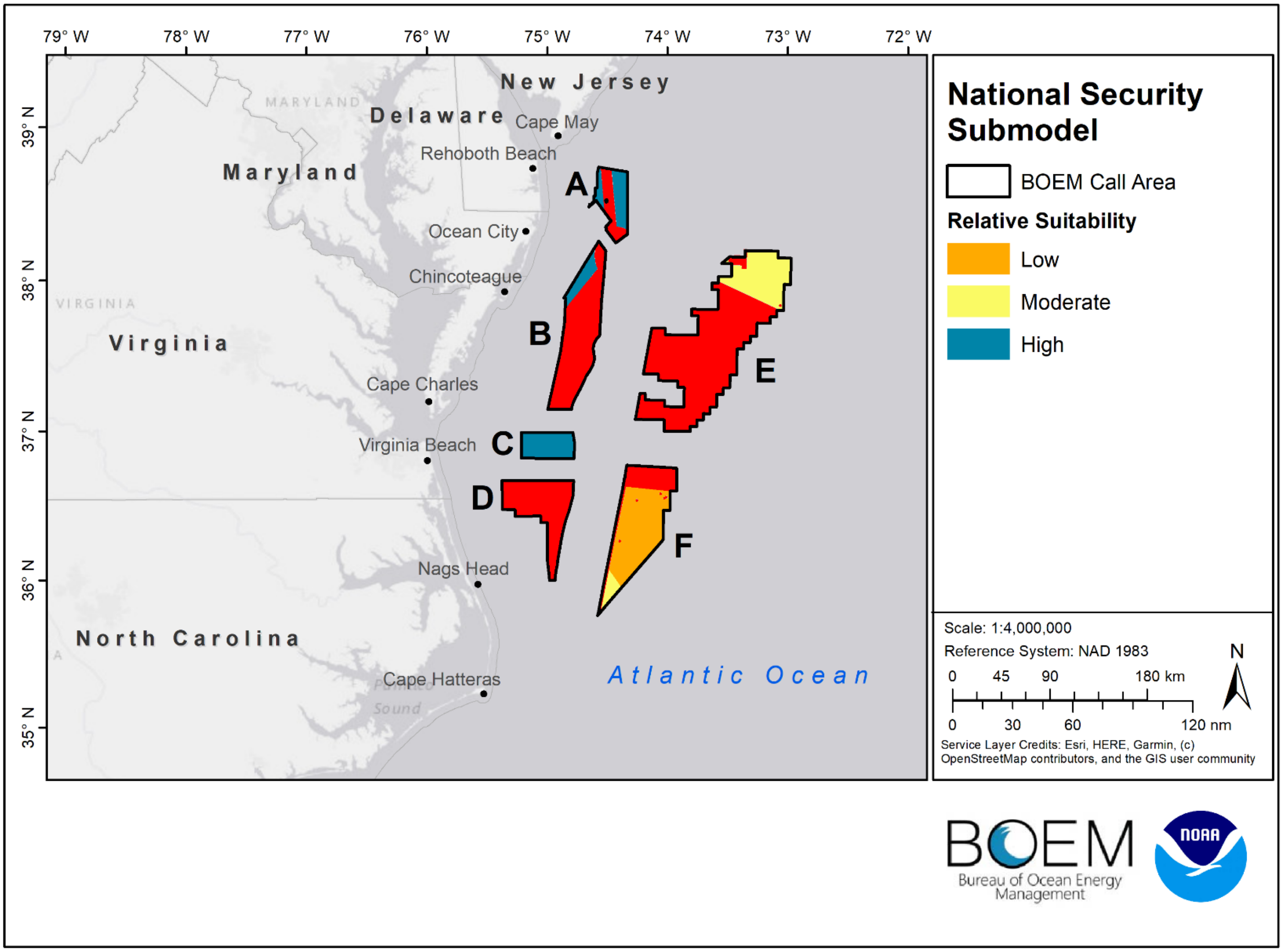


Figure 3.5. National security submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while yellow indicates areas of higher suitability. Areas displayed in red represent constrained areas.

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 3.3).

Protected Resource Considerations

A total of 31 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 3.6). The east portion of Call Areas C and D, and the west portion of Call Areas E and F had the lowest relative suitability. The north portion of Call Area and the southeast portion of Call Area F had the highest relative suitability.

Habitat Considerations

Many interactions with habitat considerations were mitigated prior to this analysis by way of call area design. Call Areas A, B, C, and D all had some overlap with sand shoals, and B, C, and D had the most overlap with the 20 km setback distance from the shelf break. Call Areas E and F had overlap with the shelf break, as well as coral and hardbottom habitat (Figure 3.7).

Black-capped petrel

The southernmost part of Call Area F had some overlap with High Black-capped petrel abundance, while all other Call Areas had moderately low overlap (Figure 3.8).

Highly Migratory Species Essential Fish Habitat Considerations

Call Areas A, B, C, and D had the most overlap with overfished and prohibited sharks, with D having the highest overlap (Figure 3.9). Call Areas E and F had the most overlap with the EFH Target species (Figure 3.10)

The overall suitability results for the natural and cultural resources submodel are presented in Figure 3.11.

Table 3.3. 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
Protected Resource Division Combined Layer (31 species)	NMFS Scores	100%
Habitat Combined Layer (4 habitats)	NMFS Scores	97%
Black-Capped Petrel Annual Abundance	Z Membership Function	100%
Highly Migratory Species (HMS) Essential Fish Habitat (EFH) Overfished/Prohibited Sharks Count (6 species)	Z Membership Function	98%
Highly Migratory Species (HMS) Essential Fish Habitat (EFH) Target Species Count (6 species)	Z Membership Function	100%

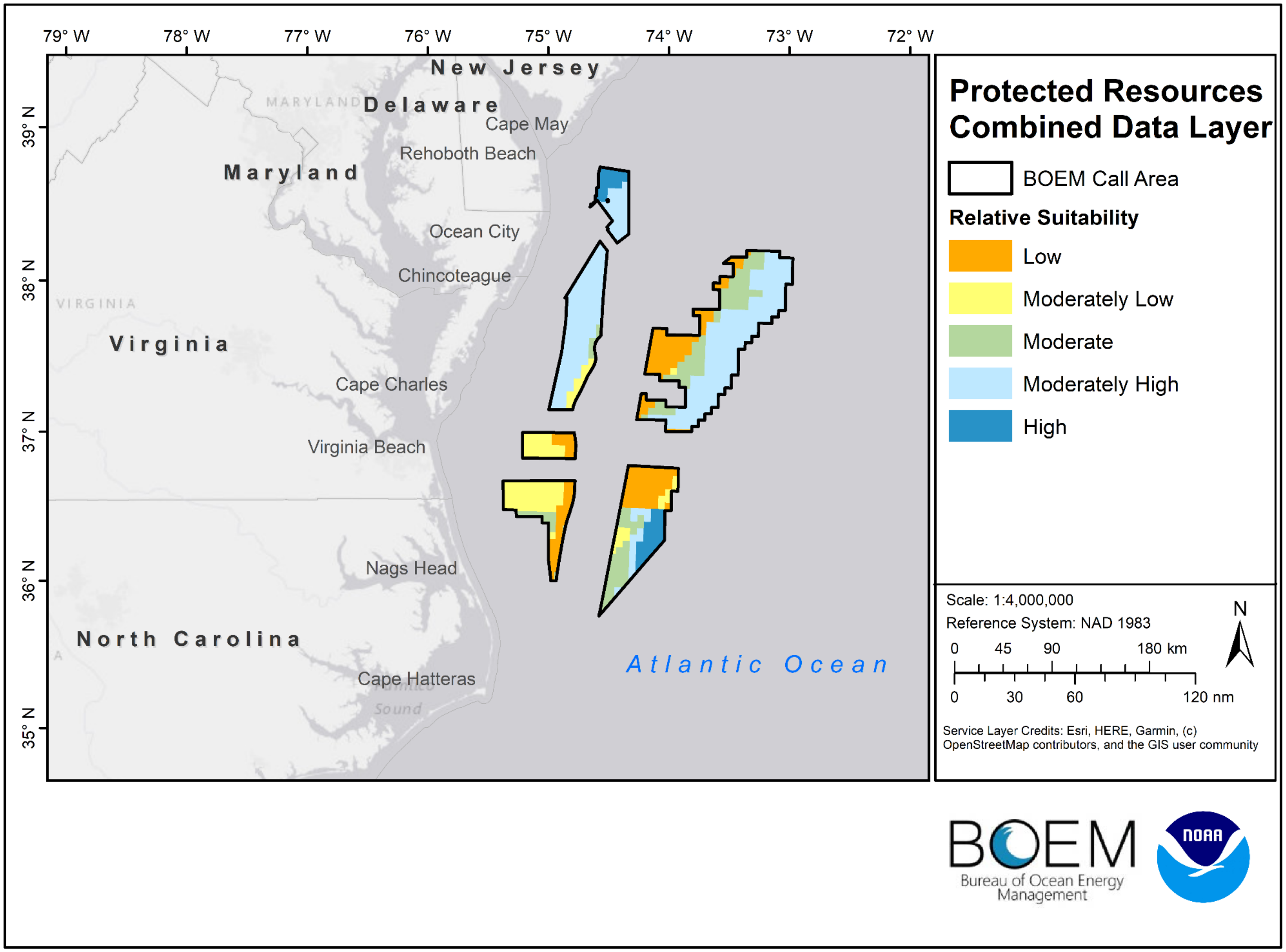


Figure 3.6. National Marine Fisheries Service Protected Resources combined composite data layer (31 species) implemented within the relative suitability analysis.

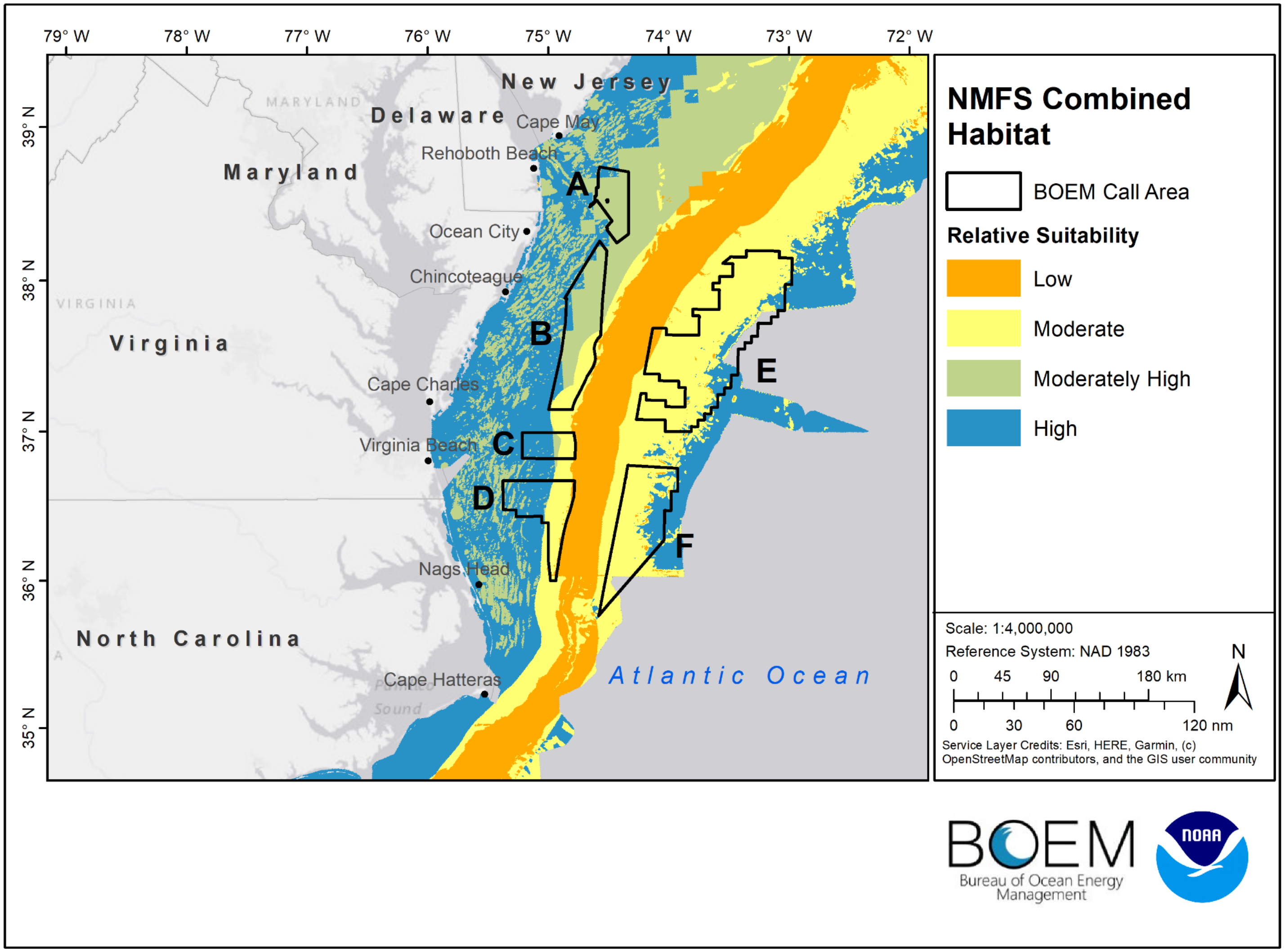


Figure 3.7. National Marine Fisheries Service Habitat combined composite data layer implemented within the relative suitability analysis.

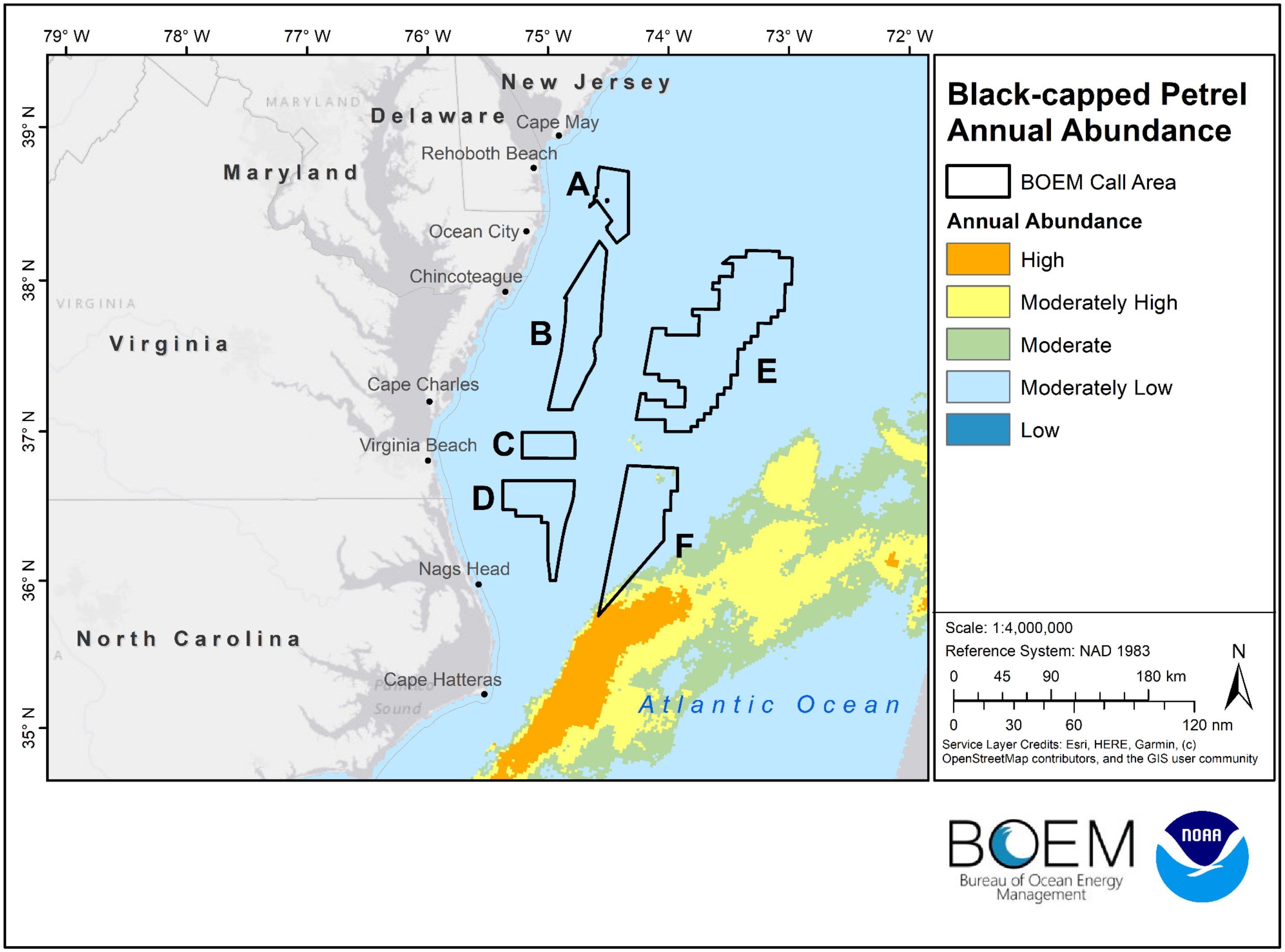


Figure 3.8. Black-capped petrel annual abundance data layer implemented within the relative suitability analysis. Orange/yellow areas represent high annual abundance for Black-capped petrel and are therefore less suitable for wind energy development. Blue areas represent lower annual abundance and are more suitable for wind energy development.

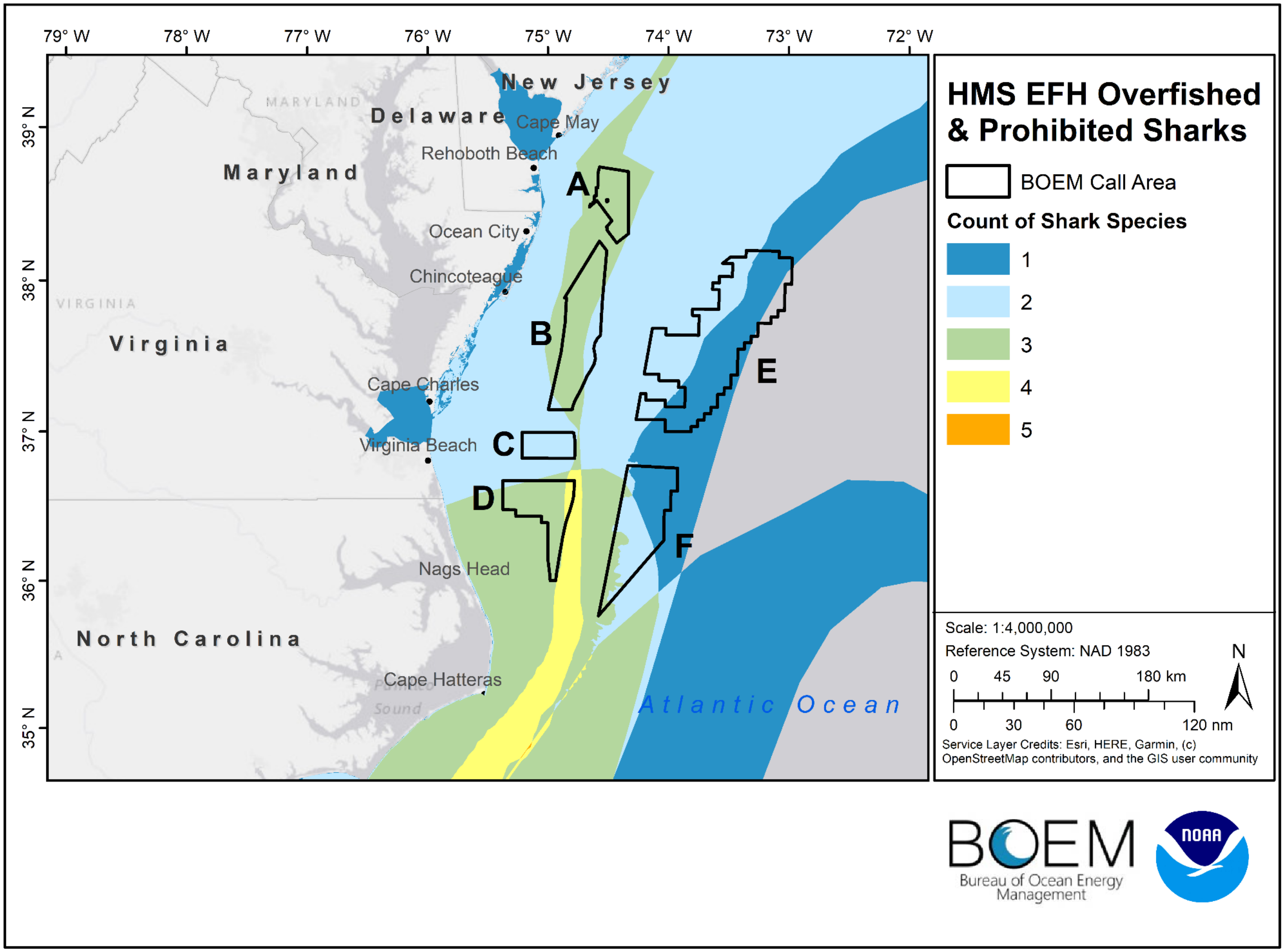


Figure 3.9. Highly Migratory Species (HMS) Essential Fish Habitat (EFH) overfished and prohibited sharks data layer implemented within the relative suitability analysis. Blue areas represent lower counts of overfished and prohibited shark species and are therefore more suitable for wind energy development. Orange/yellow areas represent higher counts of overfished and prohibited shark species and are less suitable for wind energy development.

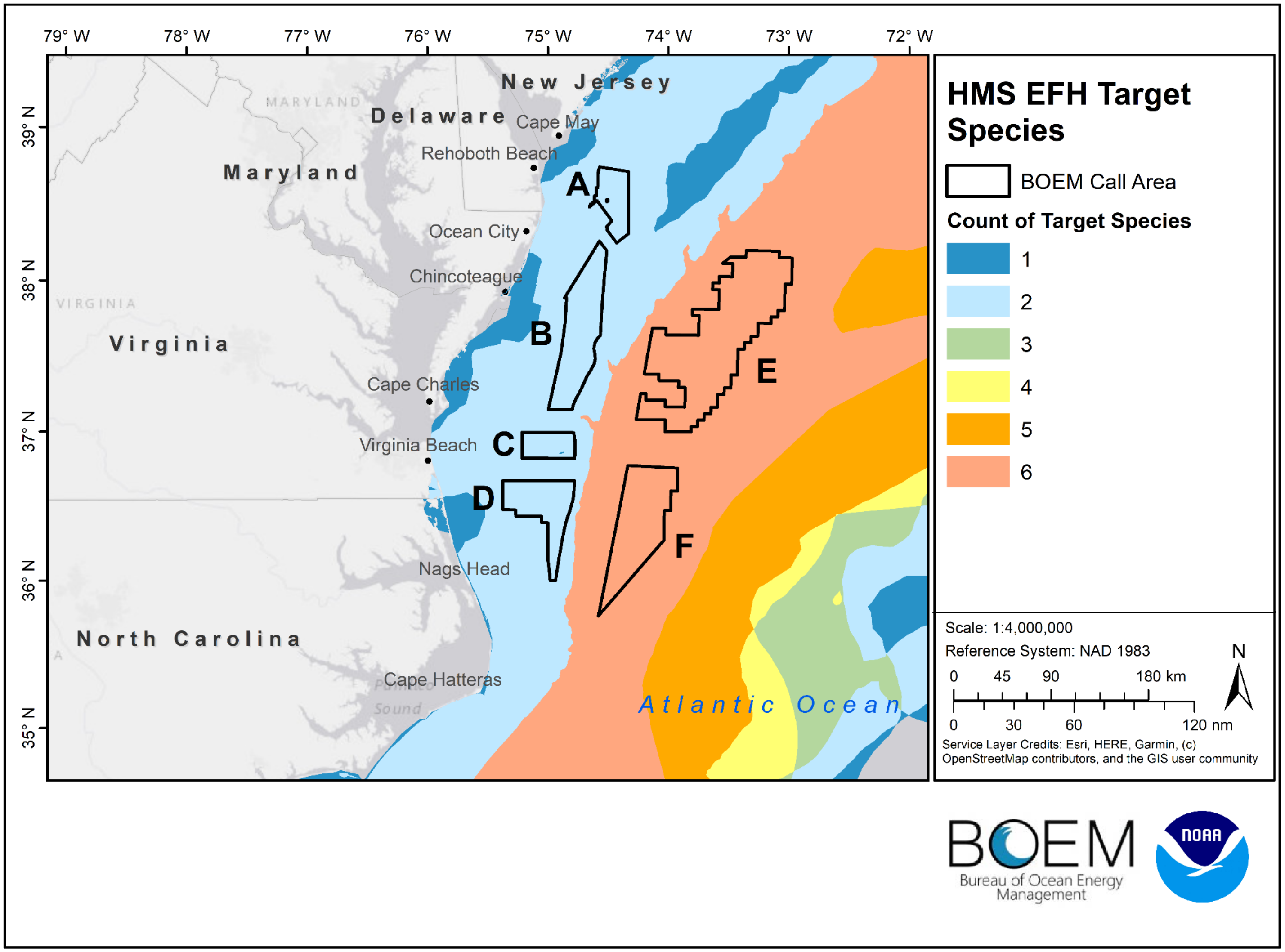


Figure 3.10. Highly Migratory Species (HMS) Essential Fish Habitat (EFH) target species data layer implemented within the relative suitability analysis. Blue areas represent lower counts of target species and are therefore more suitable for wind energy development. Orange/yellow areas represent higher counts of target species and are less suitable for wind energy development.

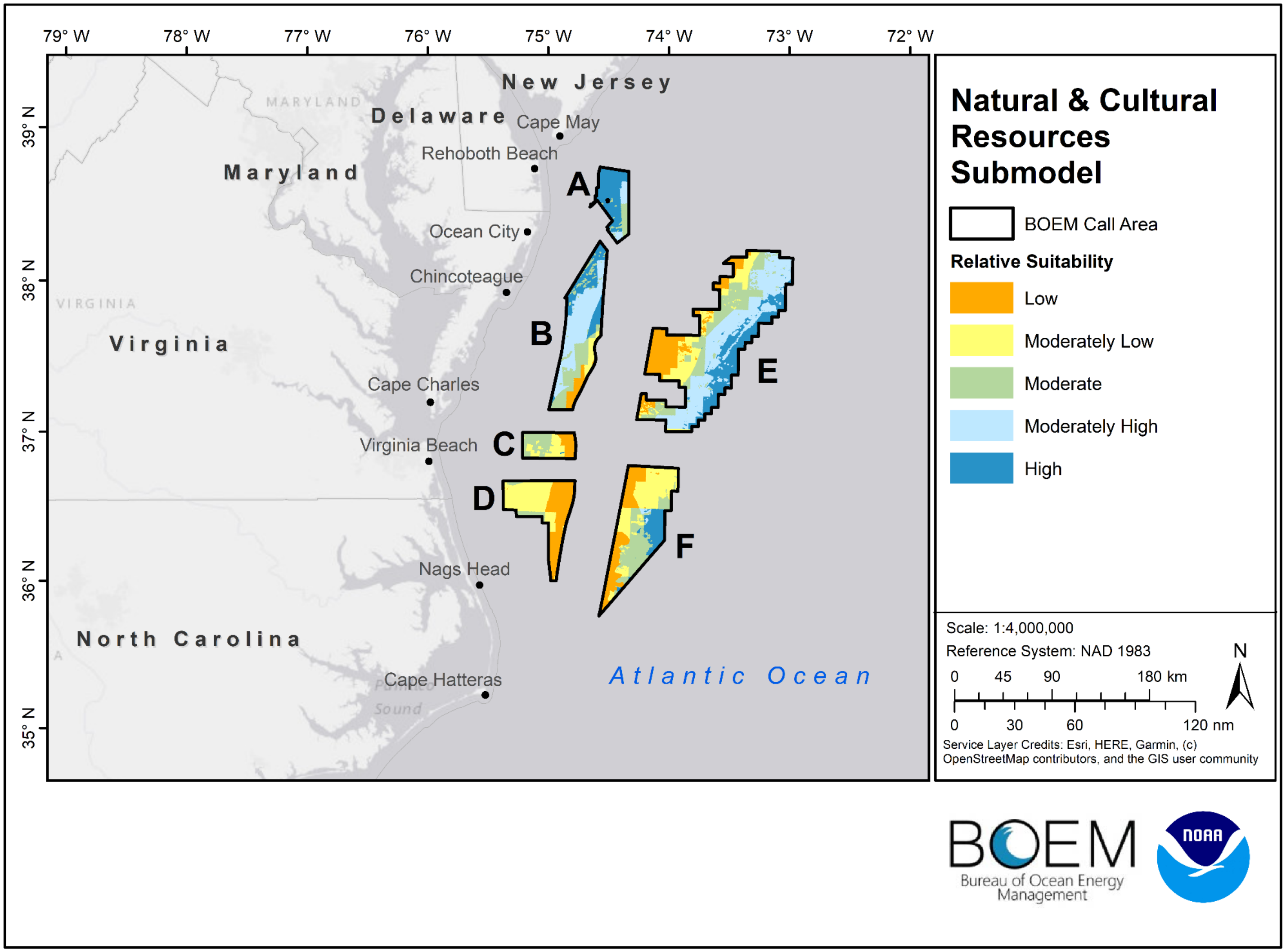


Figure 3.11. Natural and cultural resources submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

Industry and Operations

Industry activity in and around the Call Area was spatially examined (Table 3.4).

Navigation

BOEM incorporated the U.S. Coast Guard (USCG) Consolidated Port Approaches Port Access Route Studies, which was published on September 9, 2022, (CPAPARS) as a constraint in the NCCOS spatial model, because the USCG's safety fairways, once finalized, would prohibit the presence of surface structures. This constraint data layer was updated to include USCG's modifications to proposed shipping safety fairways published on March 10, 2023 (Figure 3.12). The March 2023 proposed modifications reduced the amount of the area removed from consideration (constraints) within Call Area A and the northern portion of Call Area B. 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.

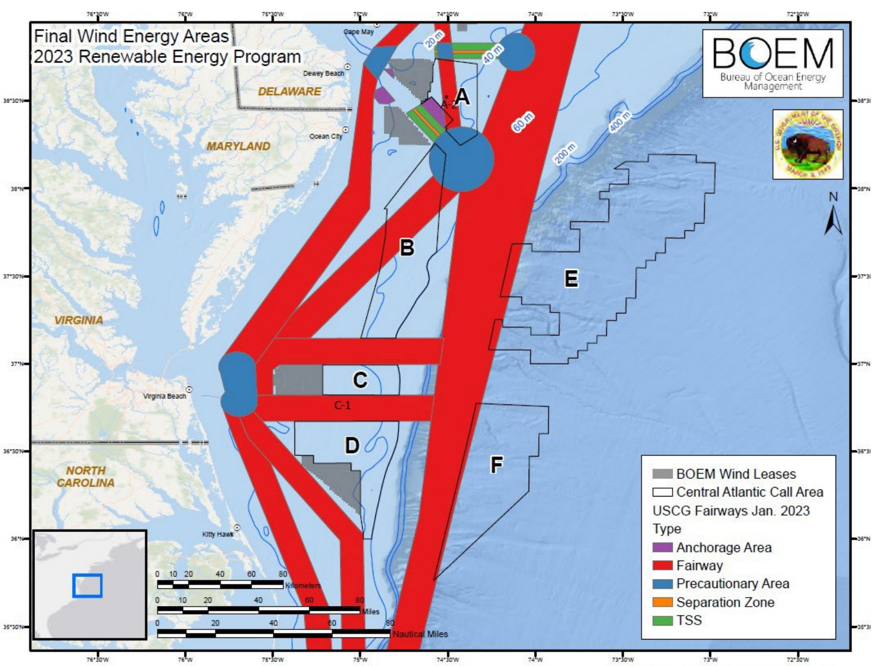


Figure 3.12. U.S. Coast Guard Modified Port Access Route Study (PARS)

Operations

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 3.13). Call Areas A - D had a relatively higher number of fisheries surveys occurring than Call Areas E - F.

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 WEA options. Specifically, AIS data from 2015 to 2021 were analyzed to determine the sum of vessel transits per 100 m^2 (i.e., vessel traffic) (Figure 3.14). 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)[7]. Suitability results for the industry and operations submodel are presented in Figure 3.15.

[7] 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

Table 3.4. 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%
AIS Vessel Traffic All Vessels 2015 - 2021	Z Membership Function	100%

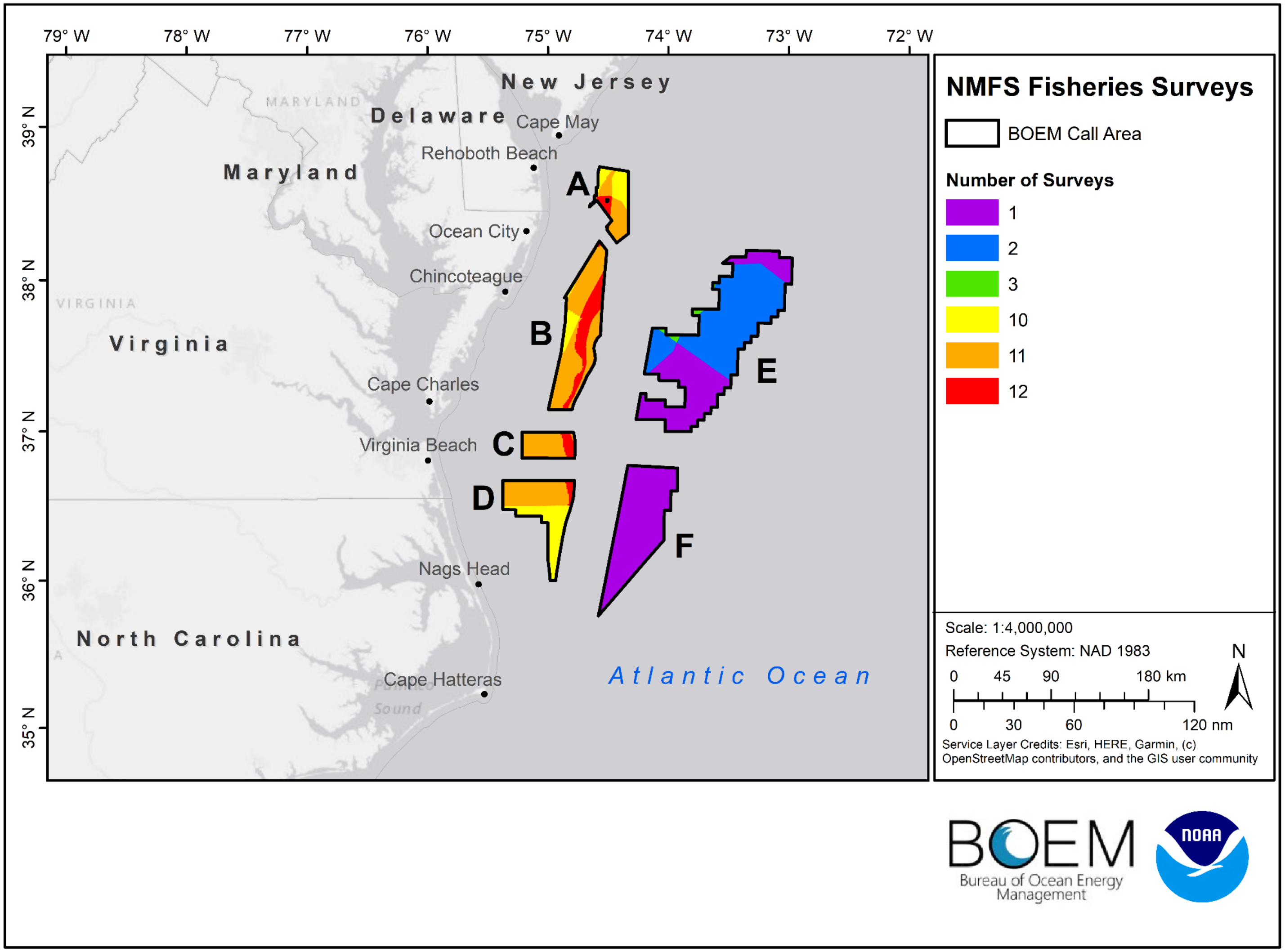


Figure 3.13. A count of overlapping NMFS Fisheries-Independent Surveys for the Call Area implemented within the relative suitability analysis

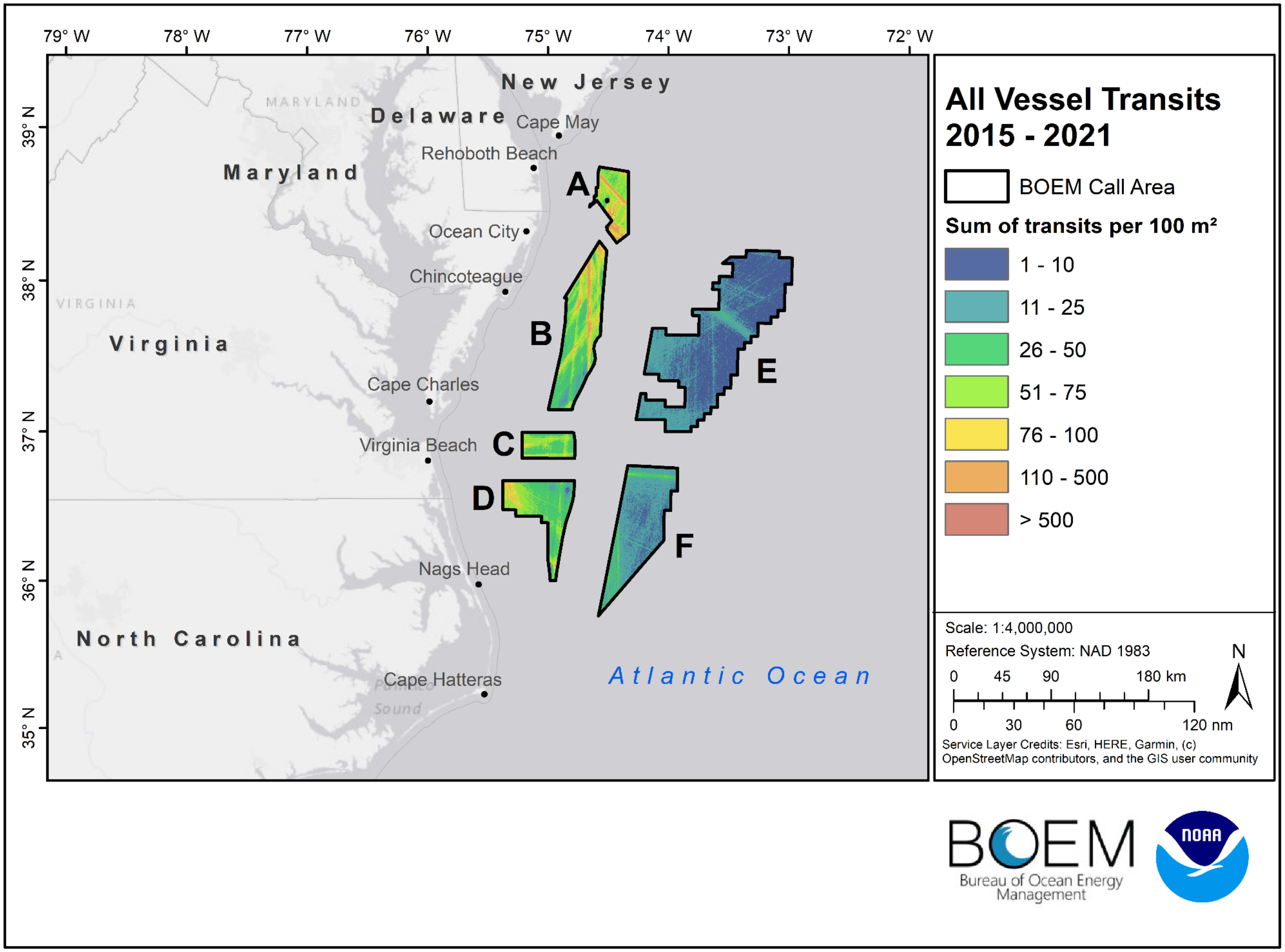


Figure 3.14. Automatic Identification System sum of vessel transits per 100 m ² for all vessel types, 2015 - 2021.

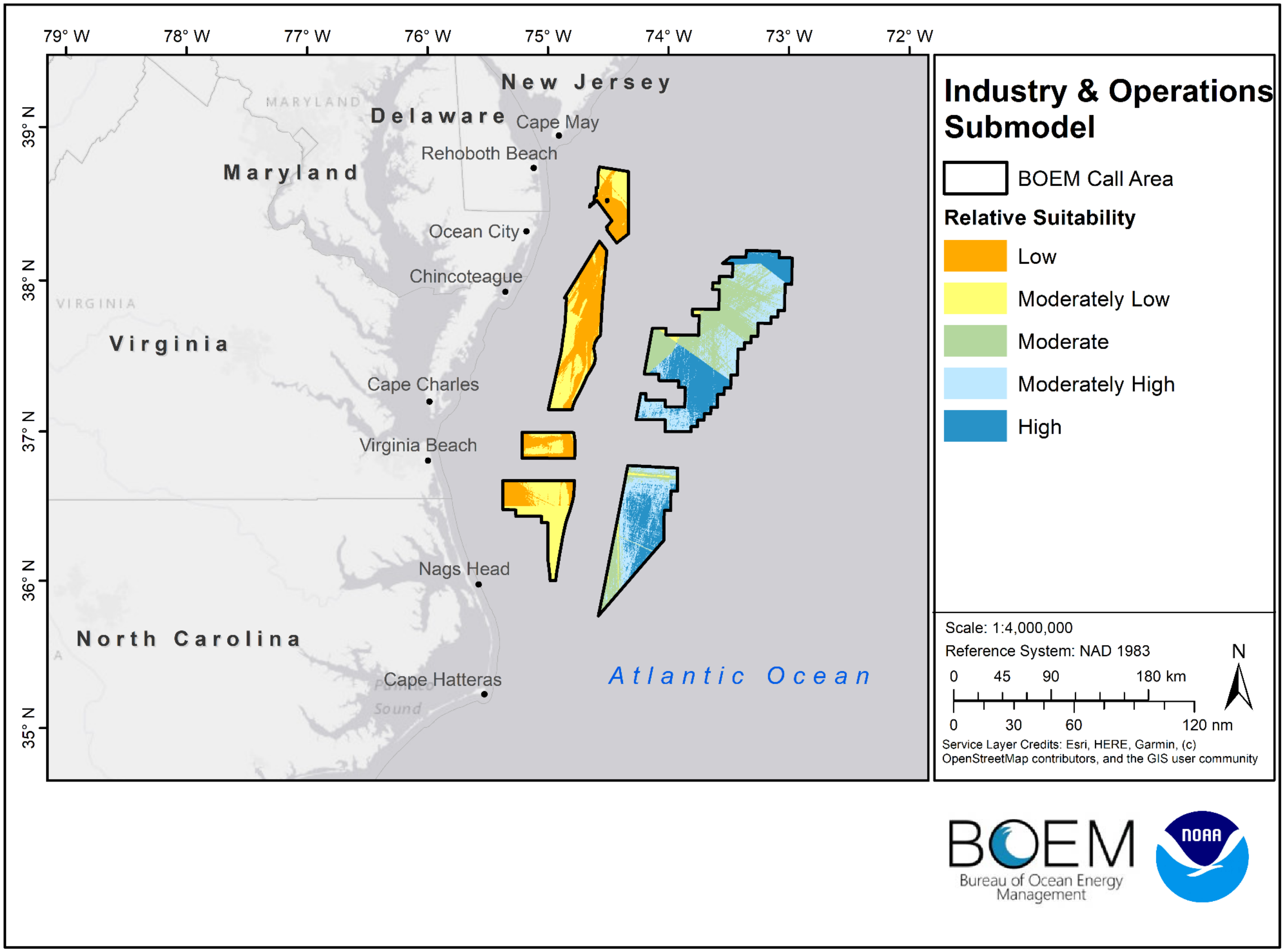


Figure 3.15. Industry and operations submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

Wind

The closer to shore a WEA is, the less fuel and travel time required and the lower cost of running transmission lines to land. 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. Distance to ports was measured using the location of the closest inlet to account for navigable waterway considerations. Shallower depths will generally make installation easier and more cost effective (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 in Call Areas E and F. (Figure 3.17). Suitability results for the logistics submodel are presented in Figure 3.18.

Table 3.5. Logistics 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 shore	Linear function (Closer to shoreline is better)	100%
Distance to inlet	Linear function (Closer to inlet is better)	100%
Depth	0 - 70 m = 1.0 70 - 500 m = 0.8 500 - 1,300 m = 0.5 1,300+ m = 0.2	100%
Atlantic Wind Speed - Annual Average	Linear function (Greater mean wind speed is better)	100%

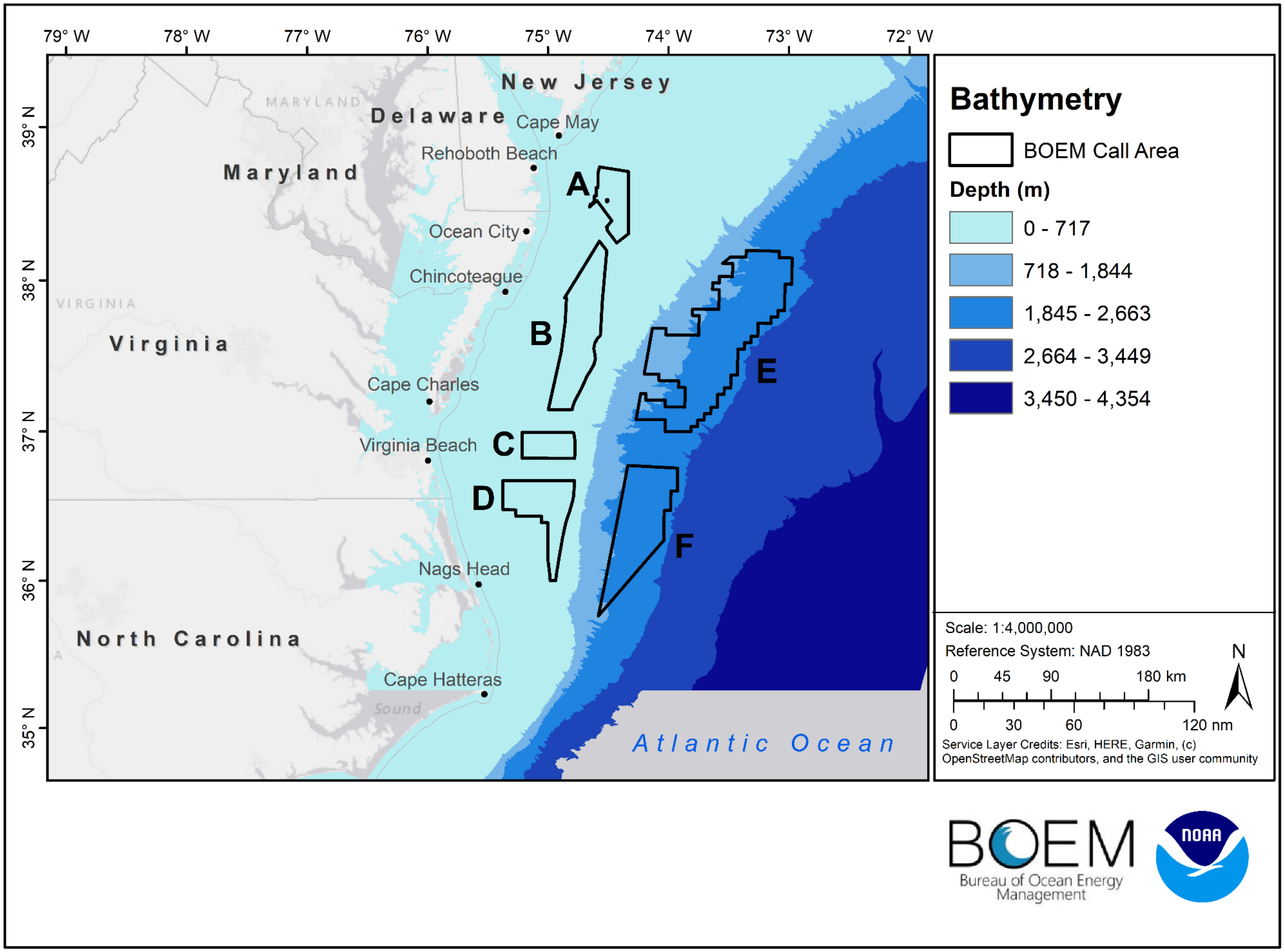


Figure 3.16. Bathymetry of the Call Area included in the wind submodel.

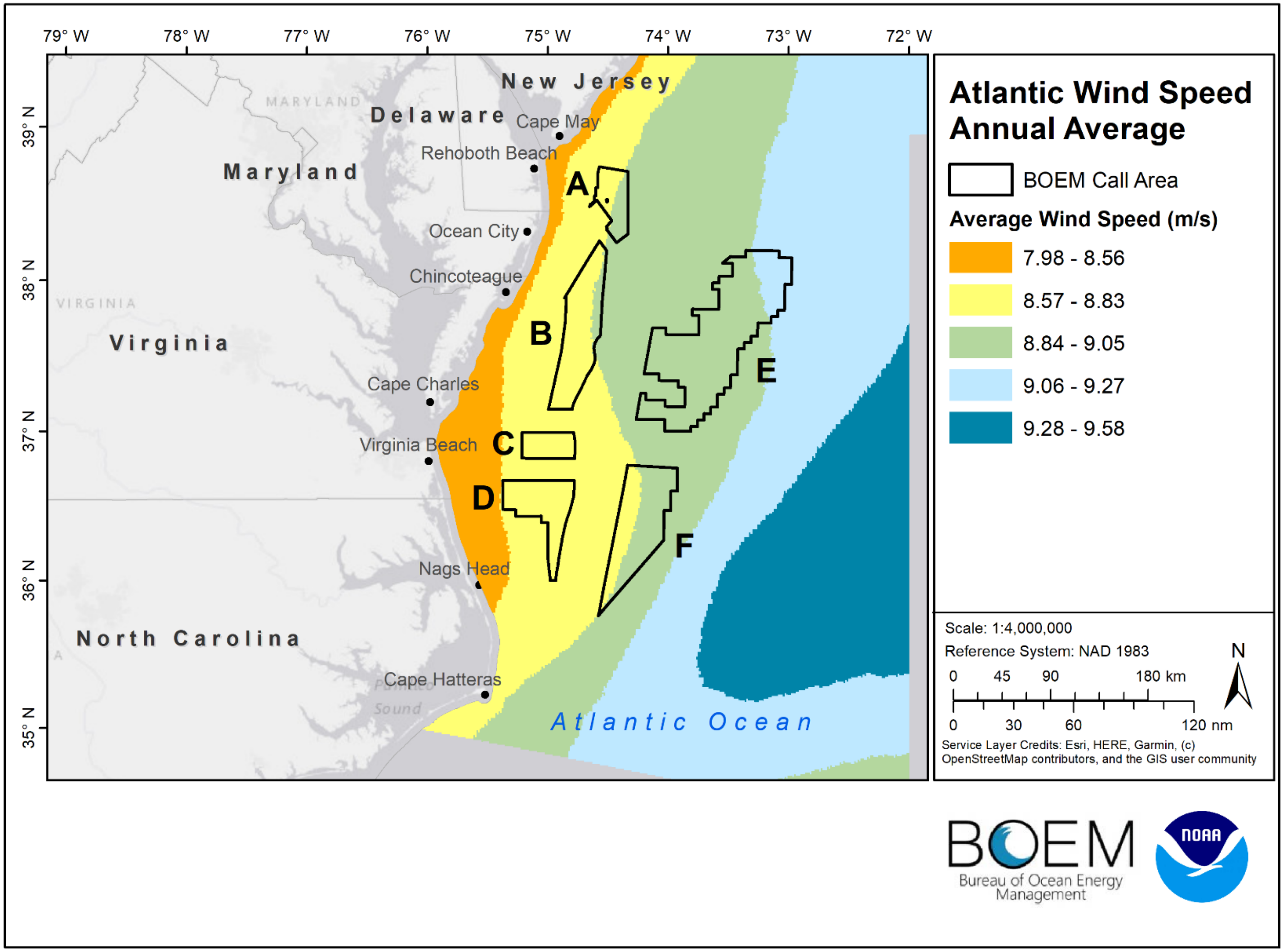


Figure 3.17. Average annual wind speed for the Call Area included in the wind submodel.

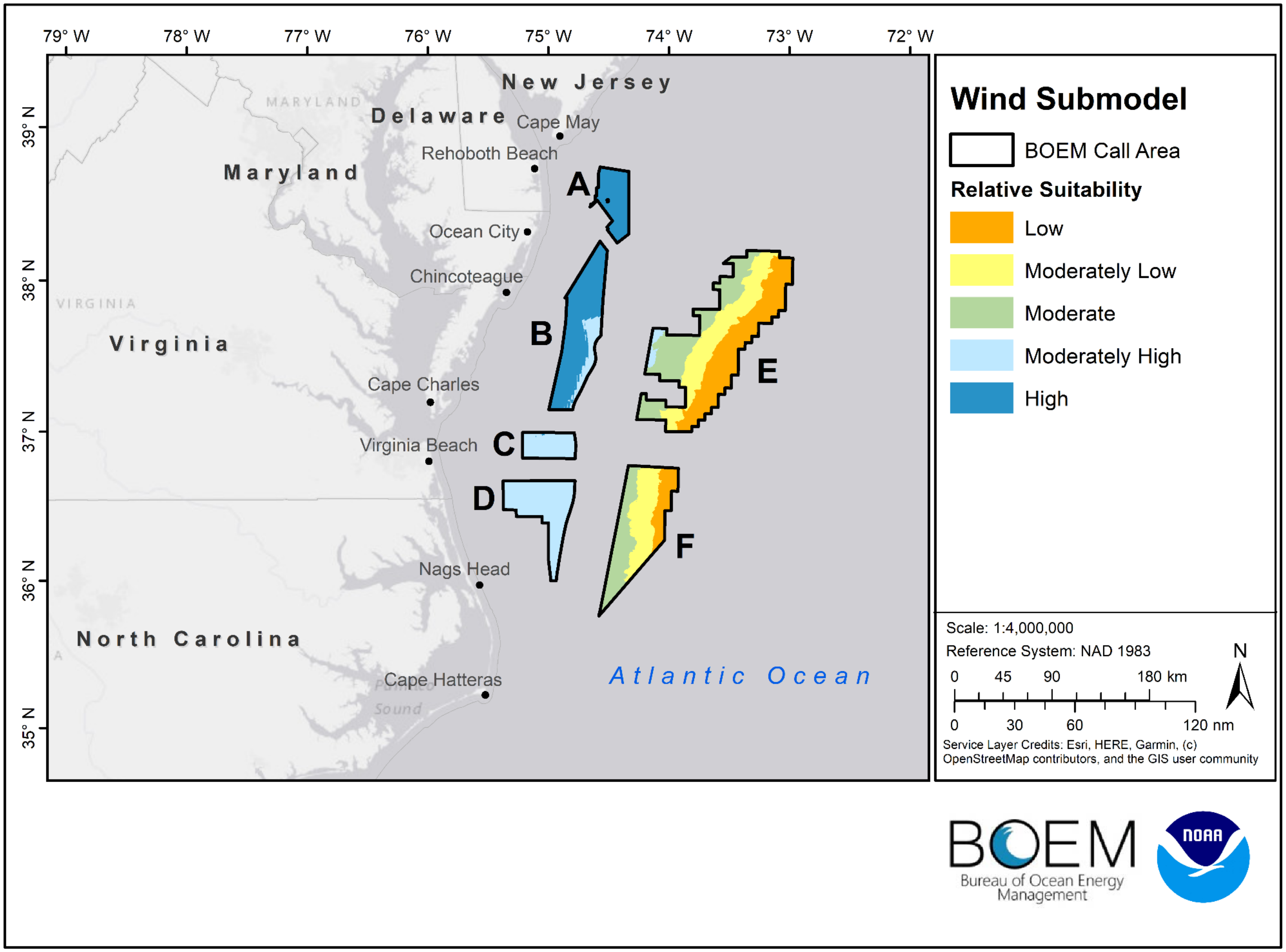


Figure 3.18. Wind submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

Fisheries

Both recreational and commercial fisheries data were included in the fisheries submodel (Table 3.6). The highest level of fishing effort is seen in Call Area A and the center portion of Call Area C (Figure 3.19). The only recreational fishing data included was the Southeast Region Headboat Survey (SRHS) (2014 - 2020) trips, which are not shown due to confidentiality. Suitability results for the fisheries submodel are presented in Figure 3.20.

Table 3.6. 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
VMS All Fishing Types 2016 - 2021	Z Membership Function	90%
Southeast Region Headboat Survey	Z Membership Function	3%

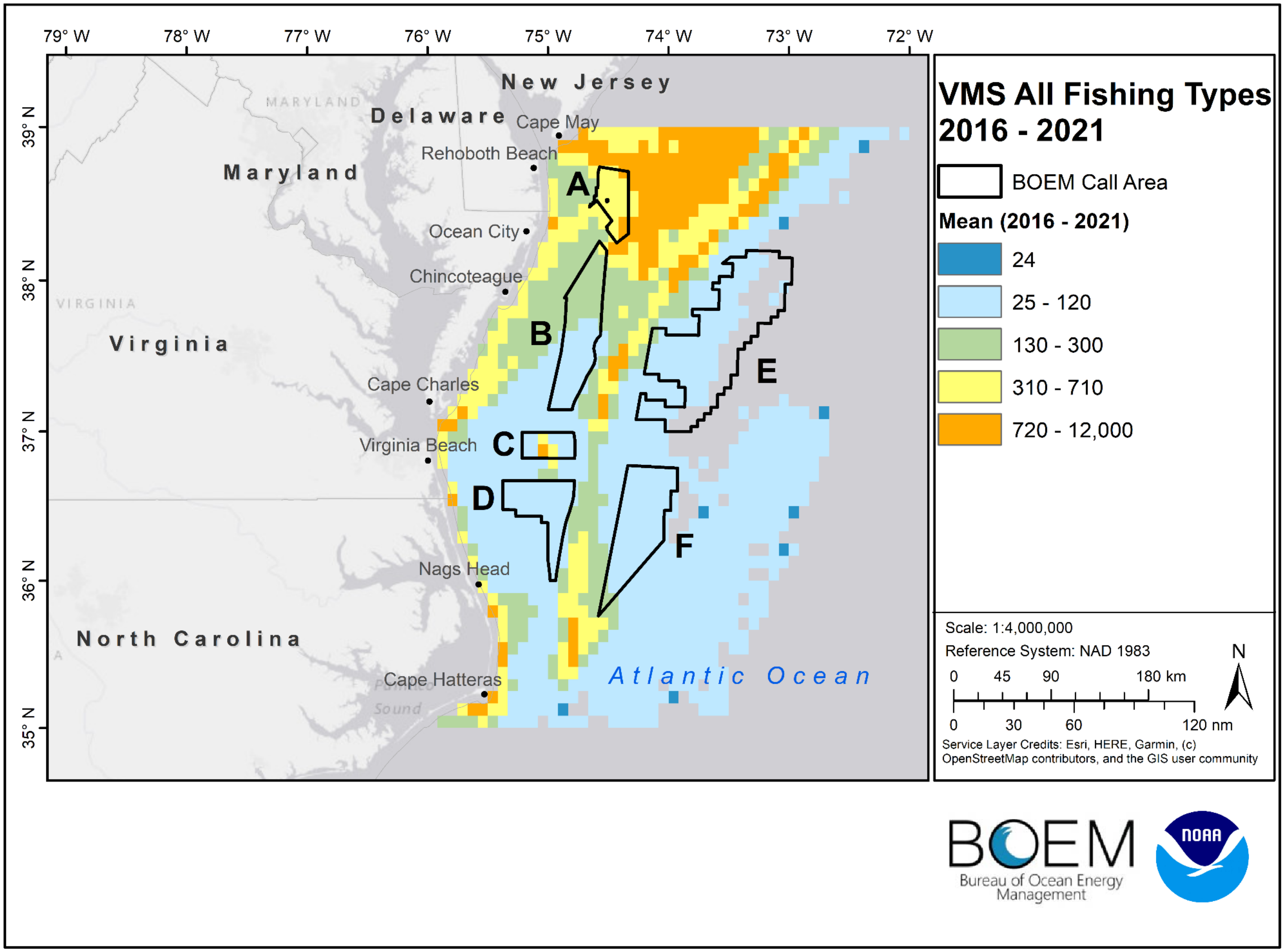


Figure 3.19. Mean VMS Fishing All Fishing Types 2016 - 2021 included in the fisheries submodel.

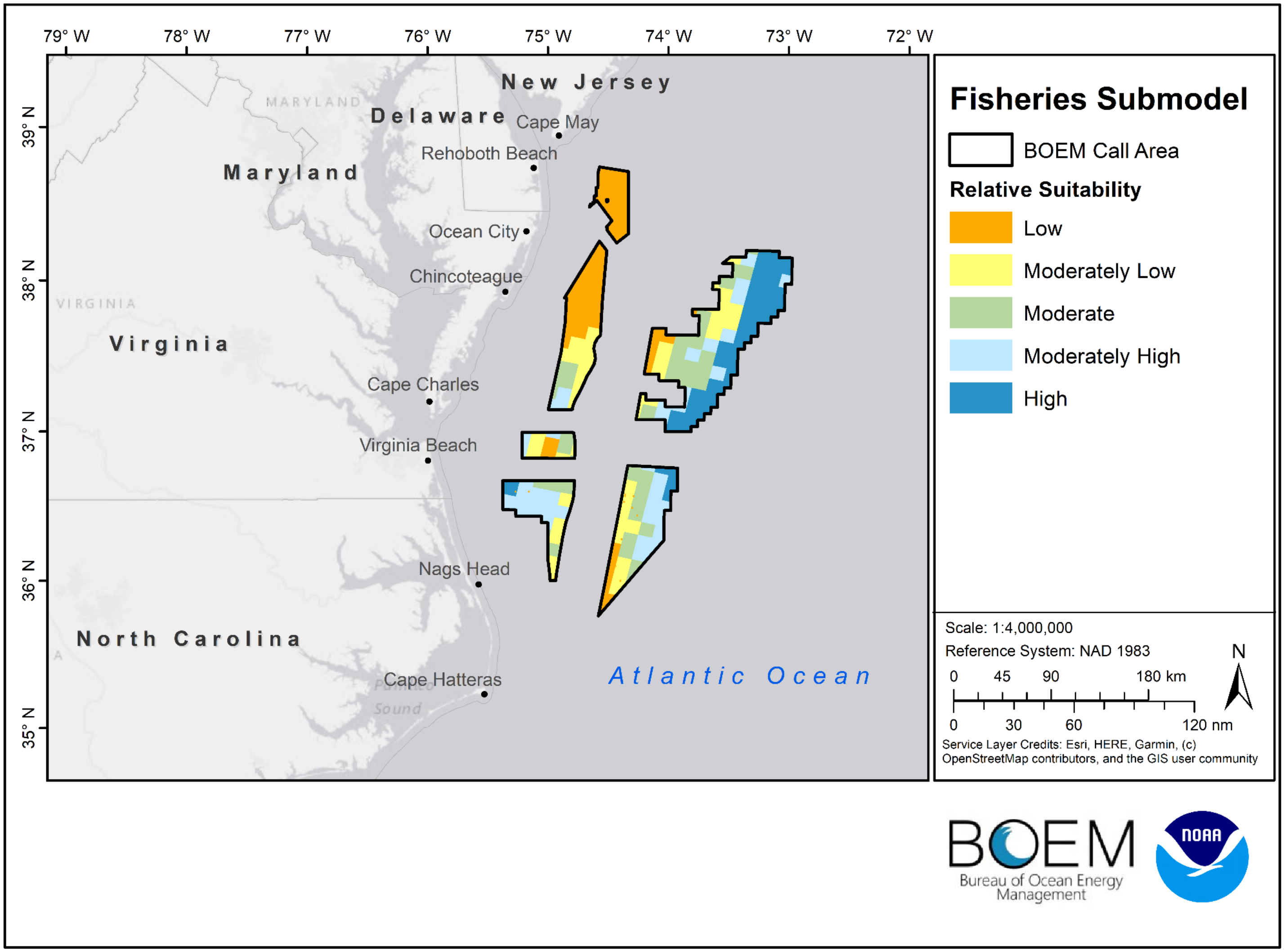


Figure 3.20. Fisheries submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color blue indicates areas of higher suitability.

Final Suitability

The final suitability results for all submodels are presented in Figure 3.21. Suitable areas were found in Call Areas A, B, C, E, and F. The additional suitability analysis of Area B identified a WEA option in the northern portion, which is currently pending further assessments by the DoD Clearinghouse and NASA. It is important to note that these suitability results are reflective of the planning objective to identify wind energy areas.

Cluster Analysis and WEA Options

The cluster analysis identified 421,712 ac of high-high clusters, which are groups of cells with high values that are statistically significant from other cells. Overall, six WEA options, ranging from 19,570 ac to 143,755 ac, were identified (Figure 3.22). Of the six WEA options identified, four are greater than 40,000 acres and two are less than 40,000 acres. Aliquots that overlapped the high-high clusters were selected and extracted, for a total of 1,259 aliquots. Next, any aliquots that overlapped with shipping safety fairways and extensions were removed from the selection. Additionally, any aliquots that overlapped existing BOEM wind leases were removed. The remaining aliquots were grouped together based on location to make up the six WEA options (Figure 3.23).

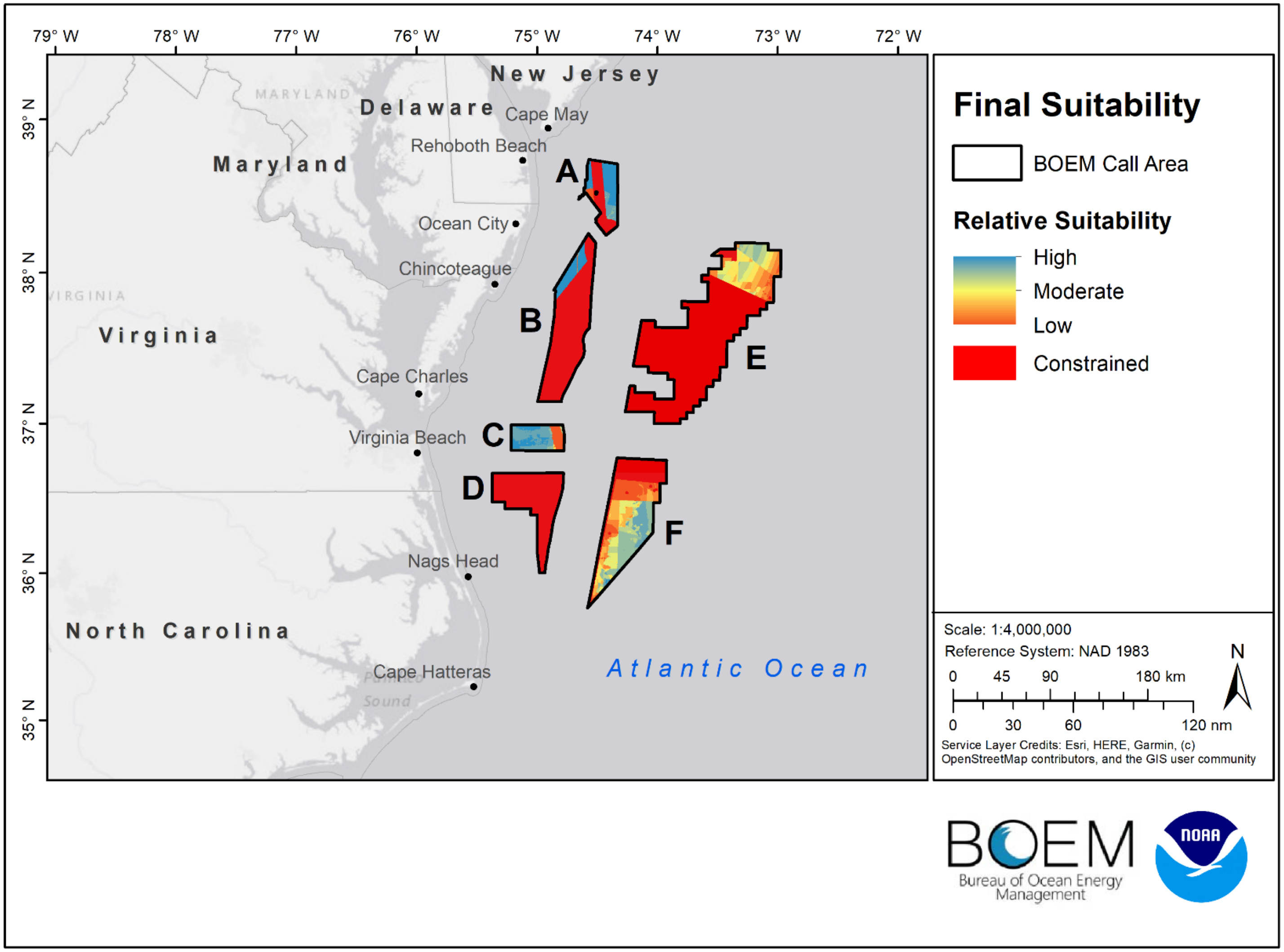


Figure 3.21. Final suitability modeling results for the Call Area. Red color indicates those areas where layers with a score of 0 occurred due to conflict with ocean activity. Blue color indicates areas of highest suitability.

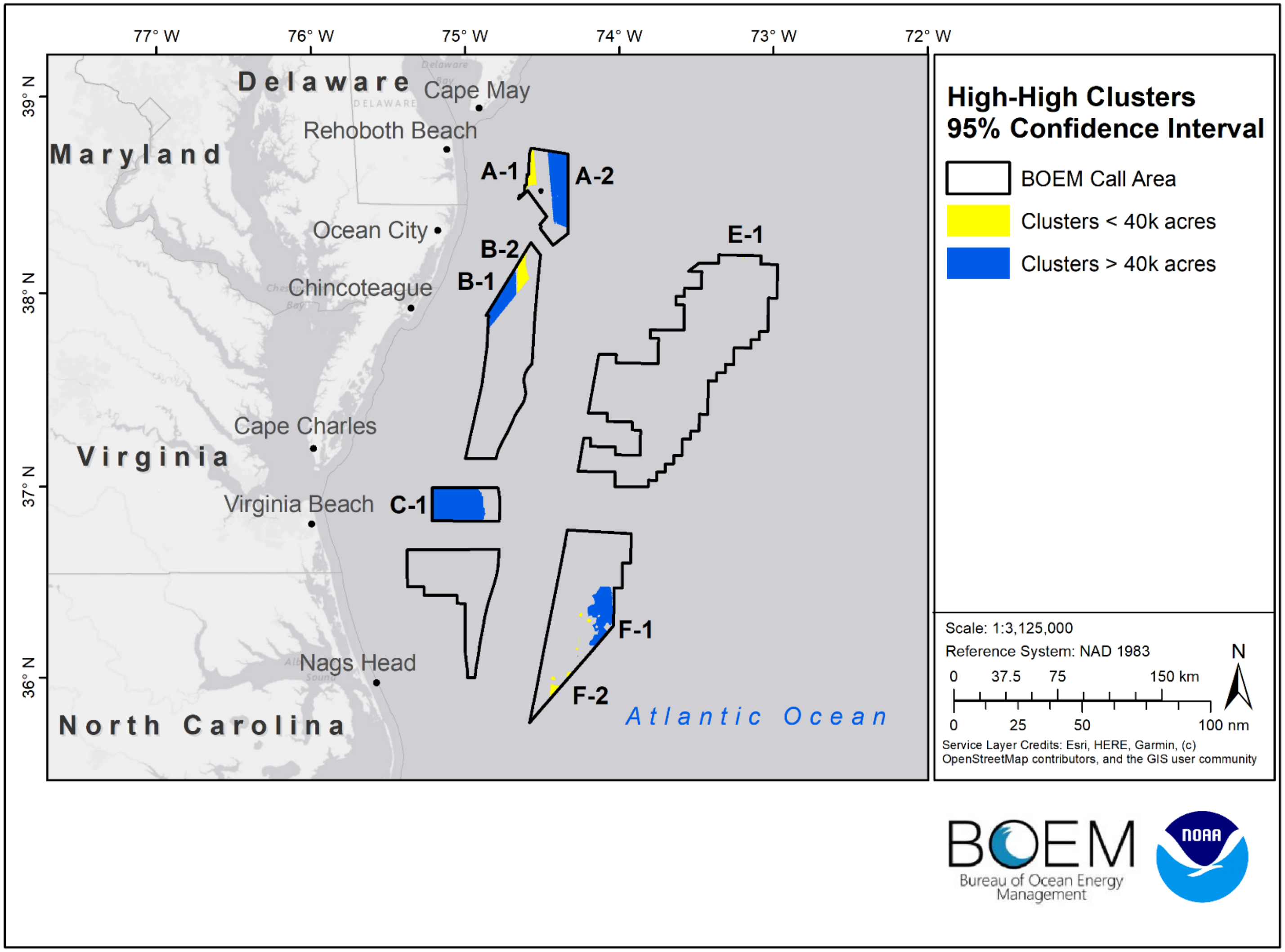


Figure 3.22. Cluster analysis of the Call Area at the 95% Confidence Interval (p = 0.05). Blue areas indicate areas determined to have the highest suitability (i.e., high-high clusters) greater than 40,000 acres and the yellow areas are less than 40,000 acres.

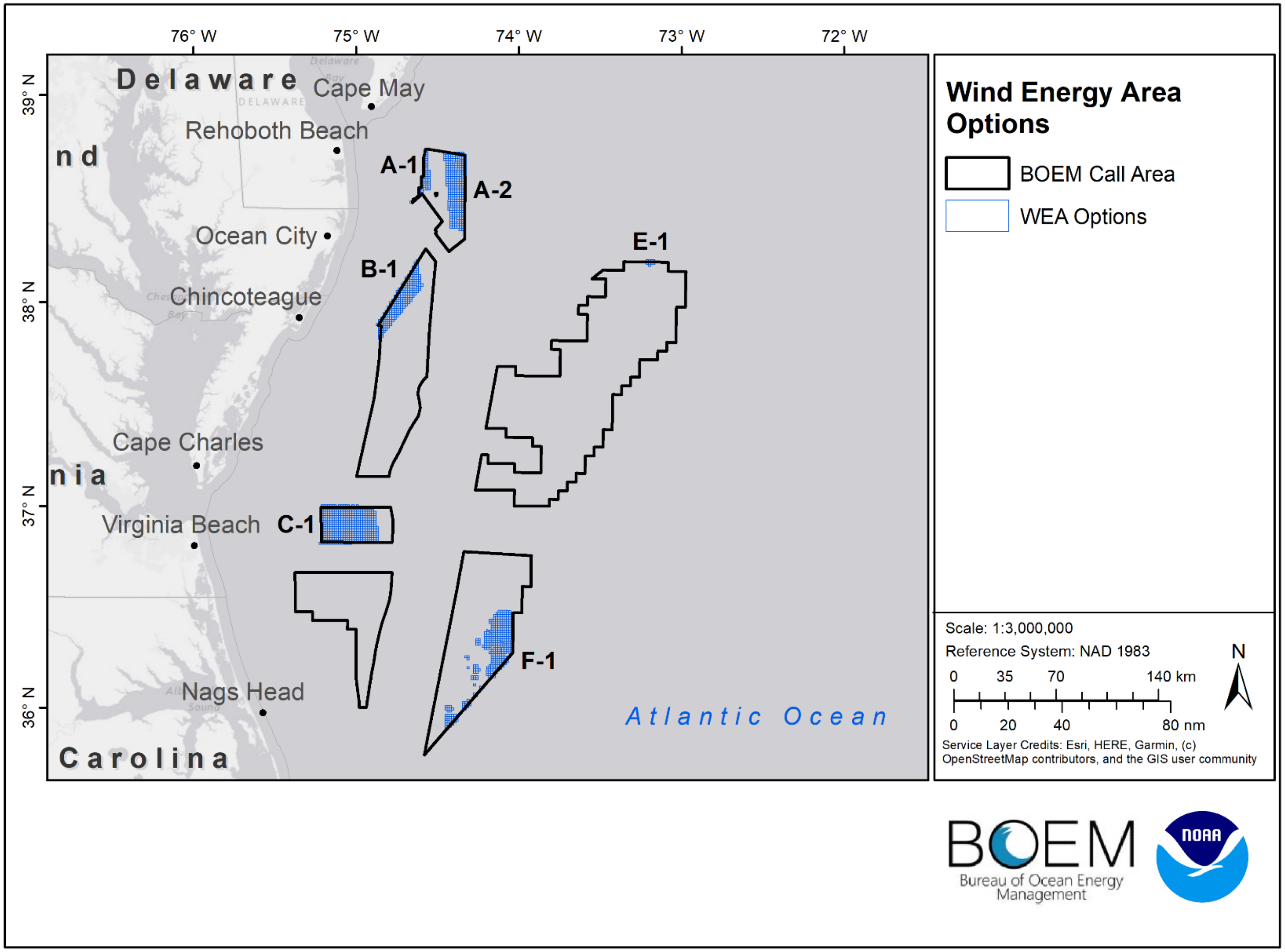


Figure 3.23. WEA options determined by selecting aliquots that overlapped high-high cluster areas. A total of 1,259 aliquots were selected totaling 447,990 acres. Blue areas represent WEA options.

Model Performance and Other Considerations

A review of data layers with the identified WEA options provides some information on how well the model performed (Figure 3.24 - 3.37). Additional considerations not used in the suitability or ranking models were examined in relation to the identified WEA options to further provide intelligence for decision makers, such as relation to nomination areas of competitive interest (Figure 3.38).

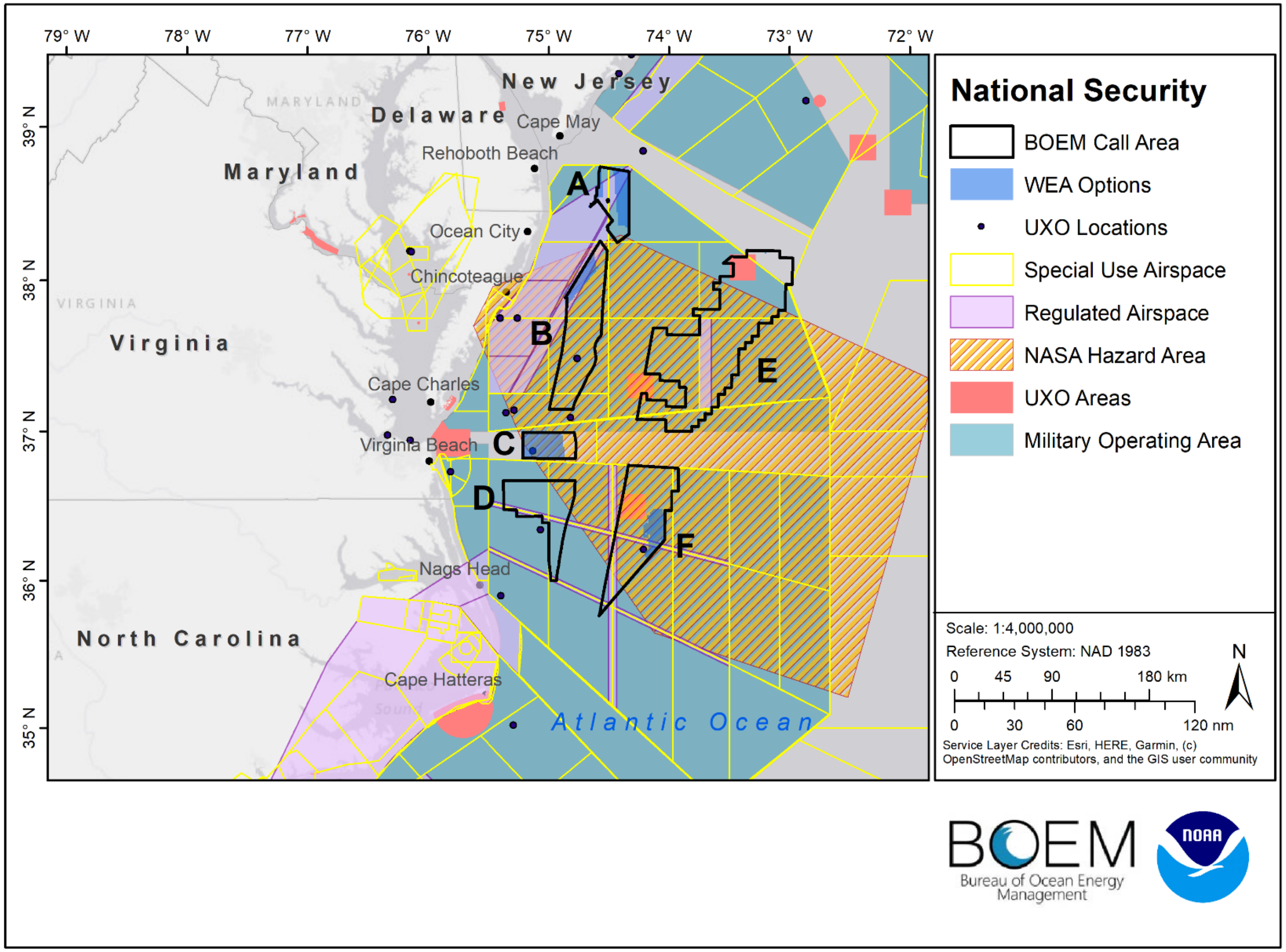


Figure 3.24. National security considerations in relation to the WEA options.

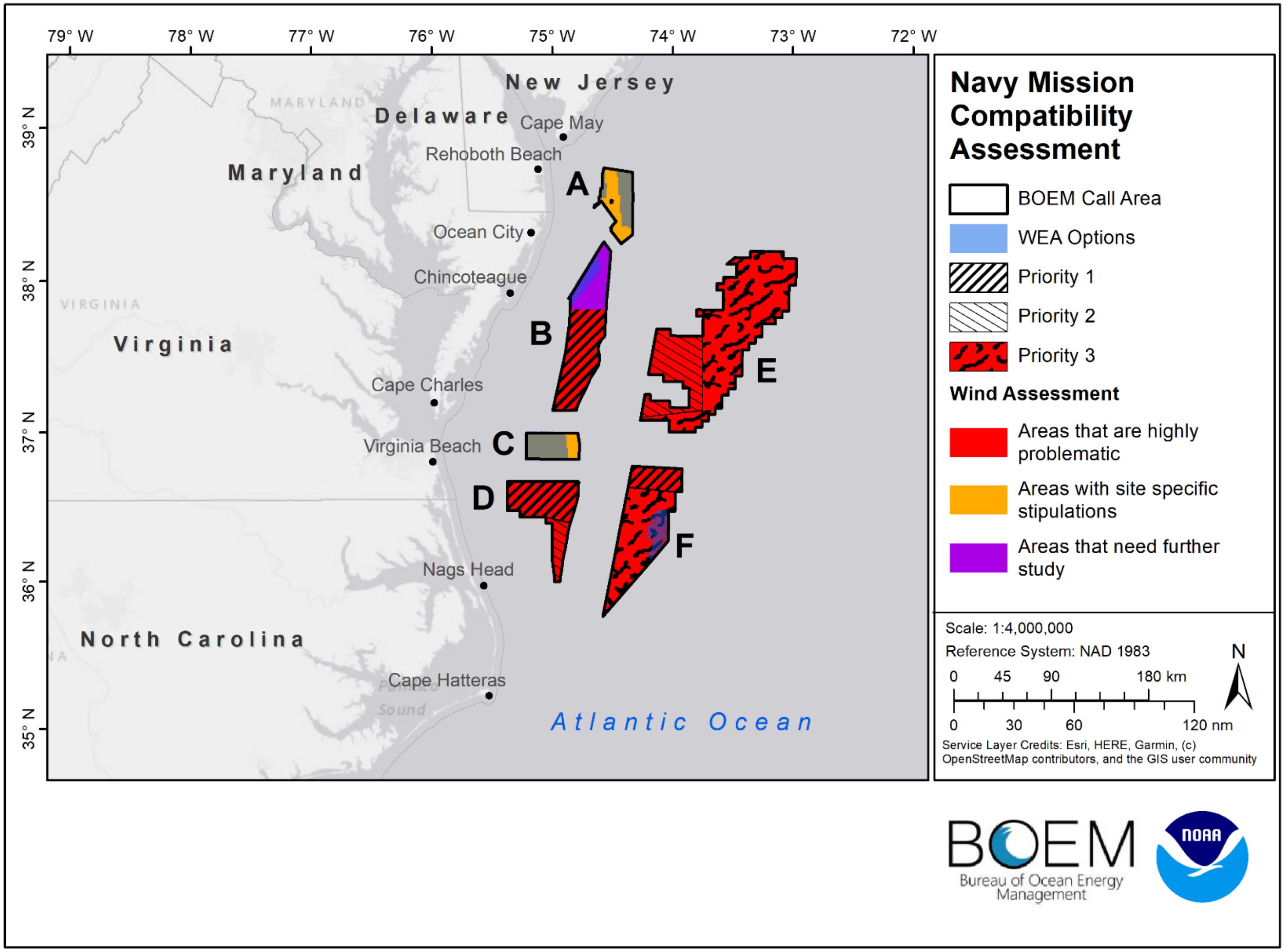


Figure 3.25. Navy mission compatibility assessment in relation to the WEA options.

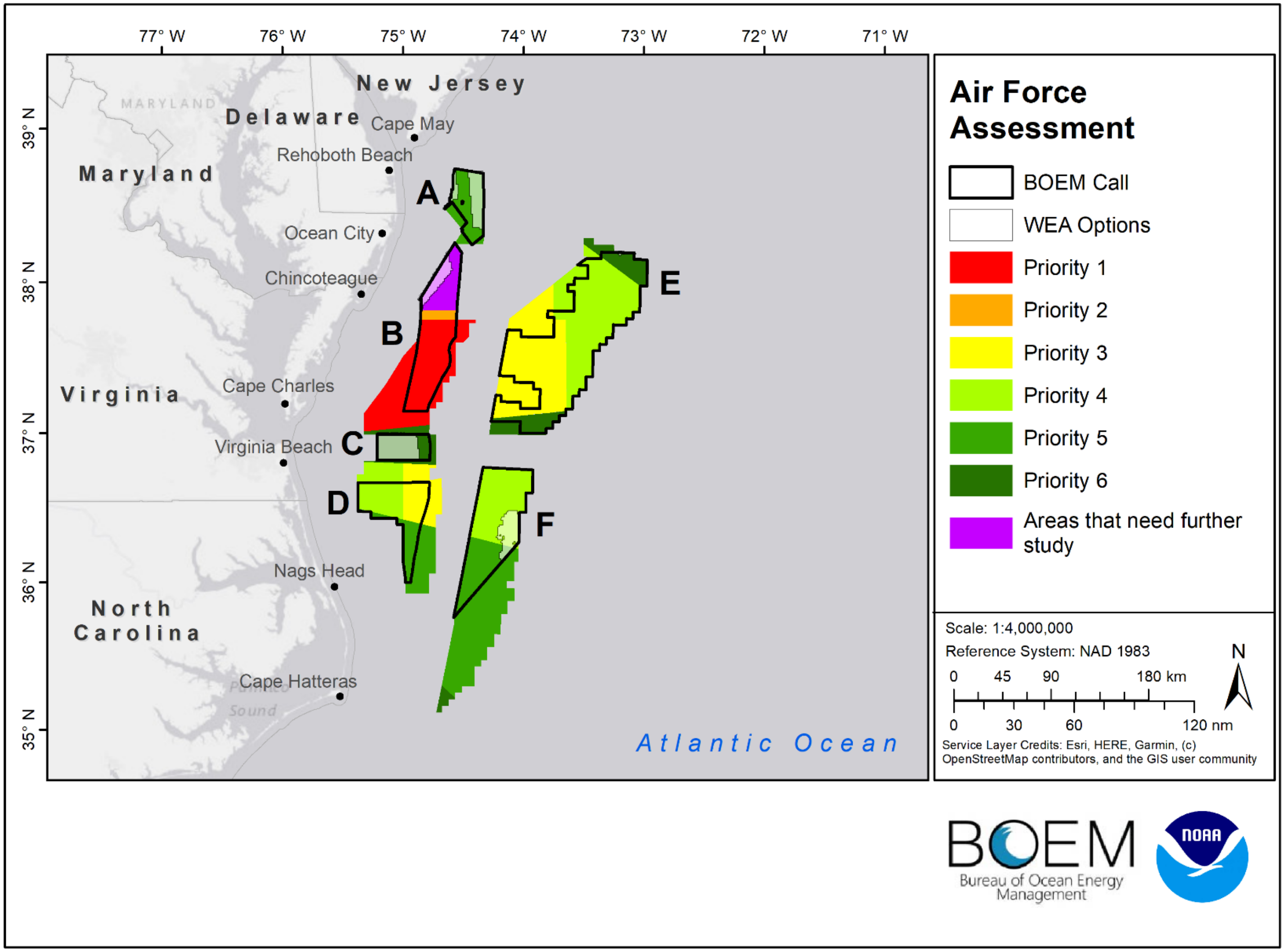


Figure 3.26. Air Force mission compatibility assessment in relation to the WEA options.

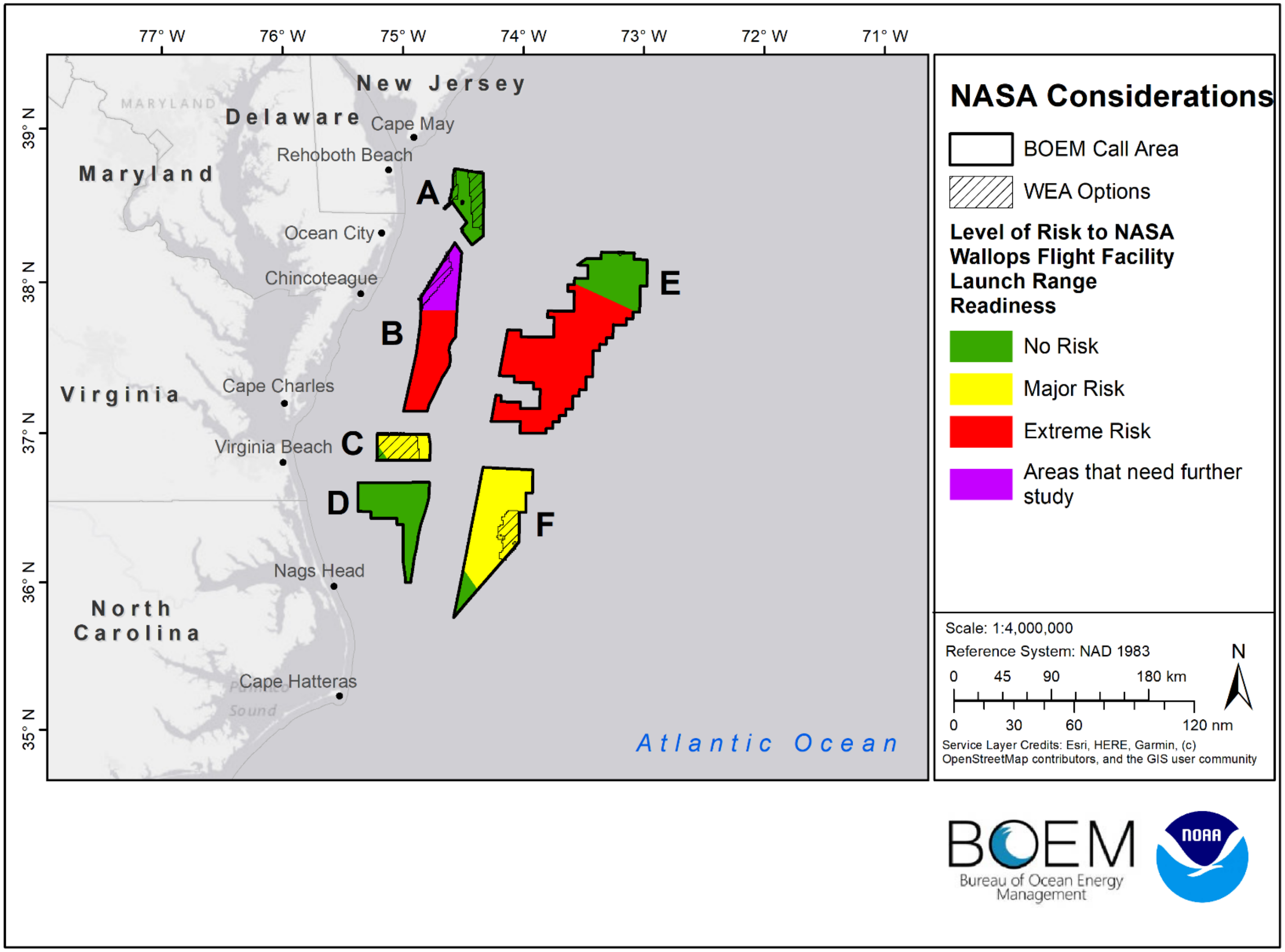


Figure 3.27. NASA mission compatibility assessment in relation to the WEA options.

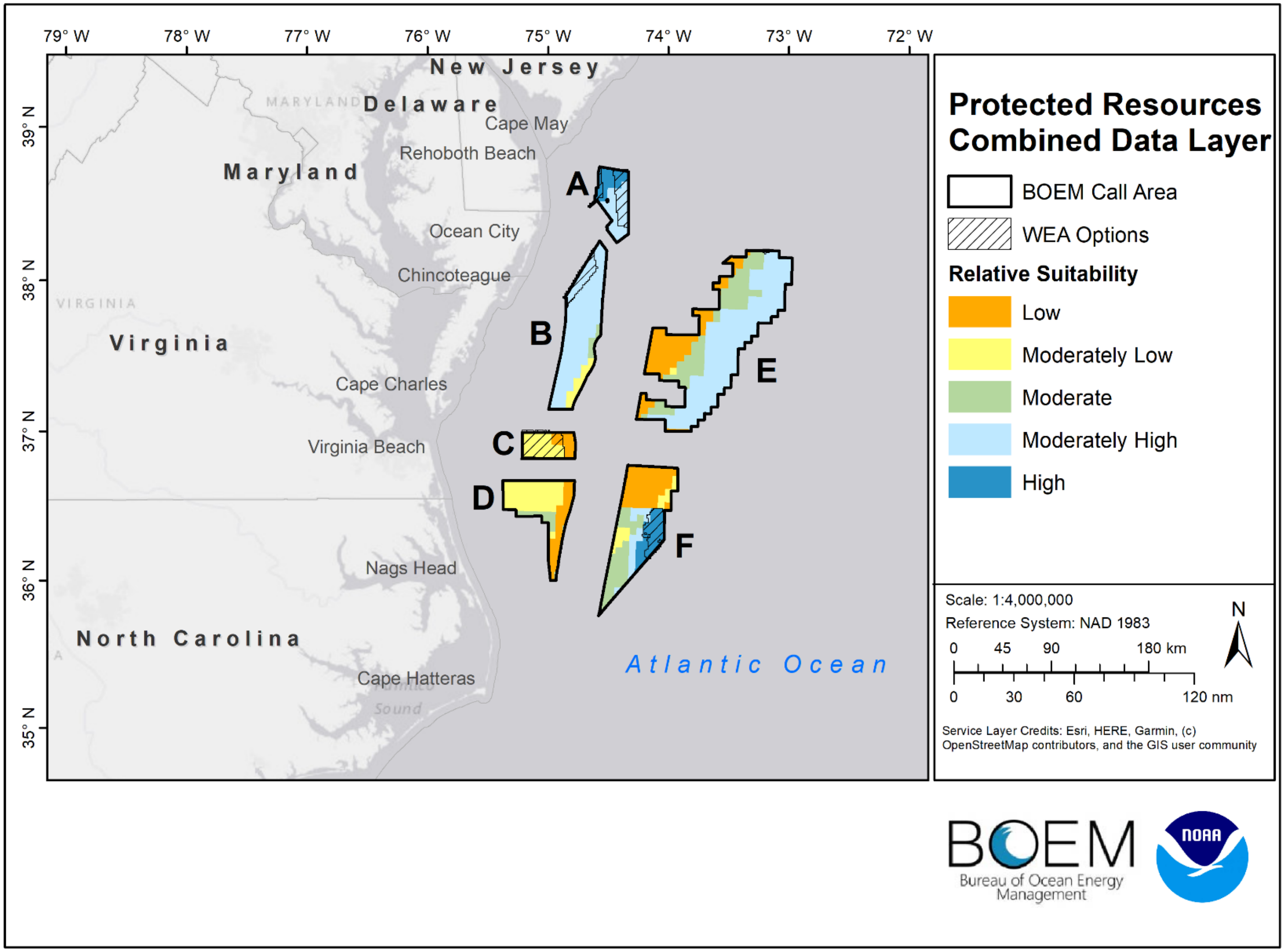


Figure 3.28. Protected resources considerations (31 species) in relation to the WEA options.

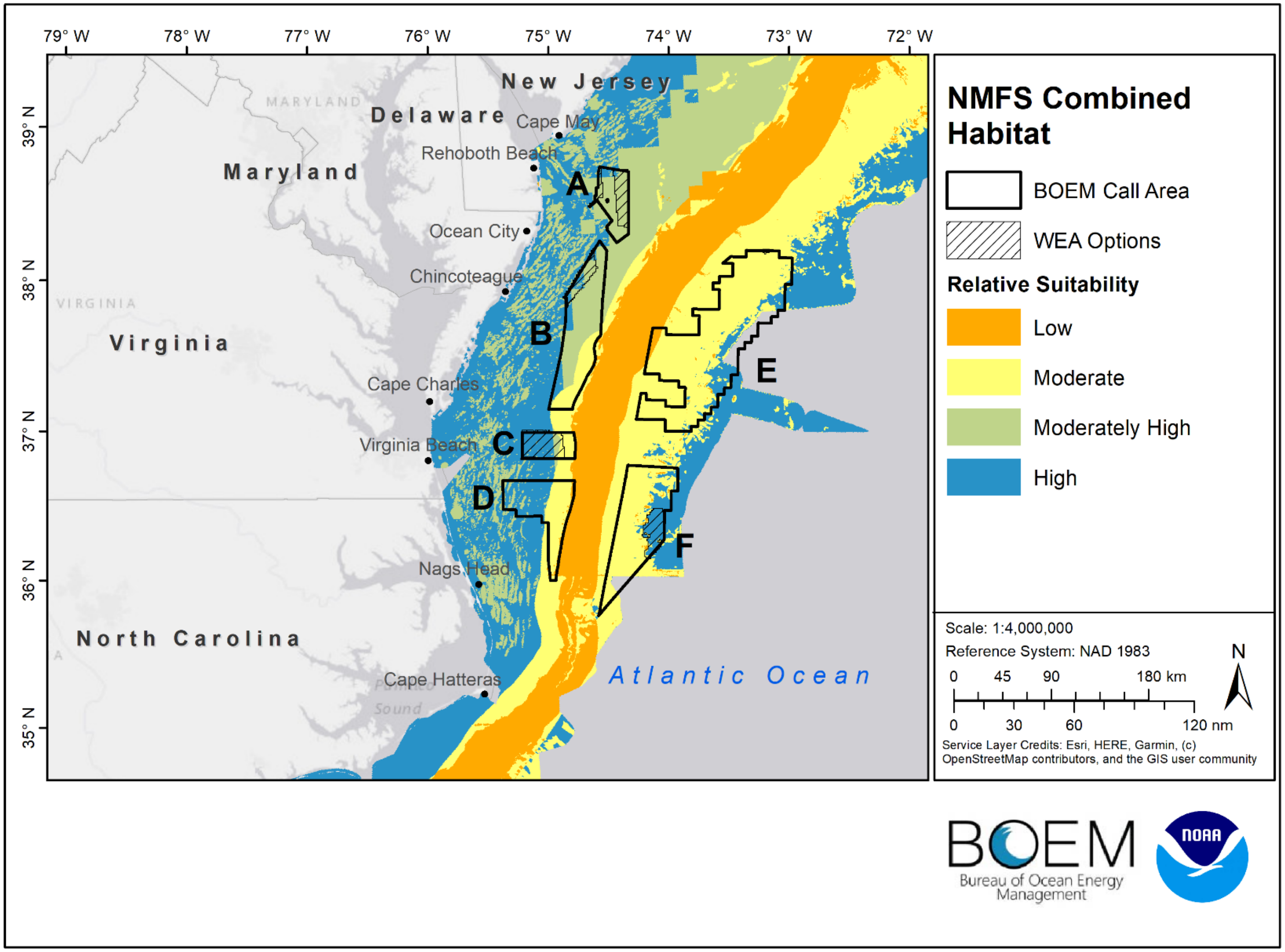


Figure 3.29. NMFS habitat considerations in relation to the WEA options.

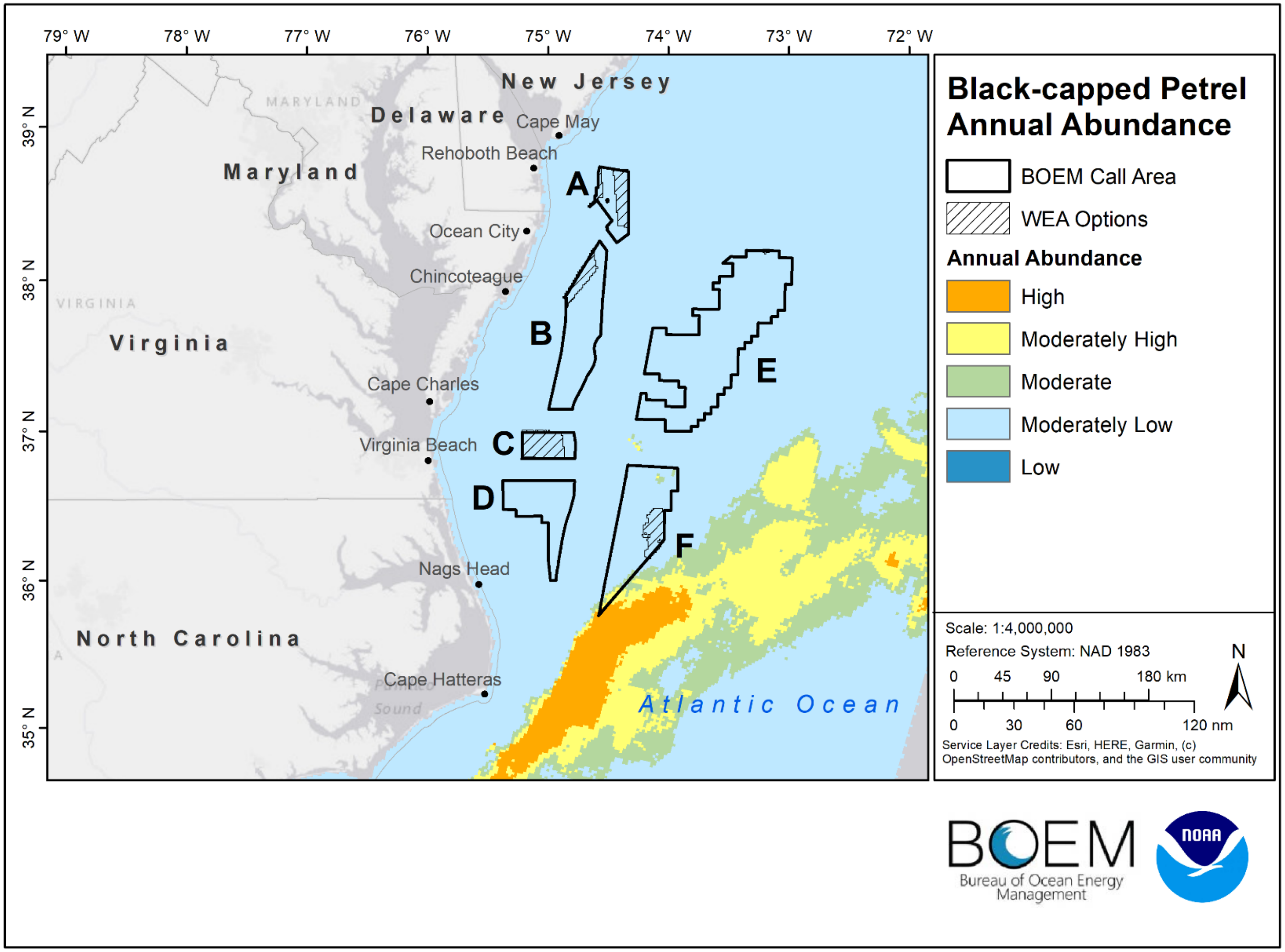


Figure 3.30. Black-capped petrel annual abundance in relation to the WEA options.

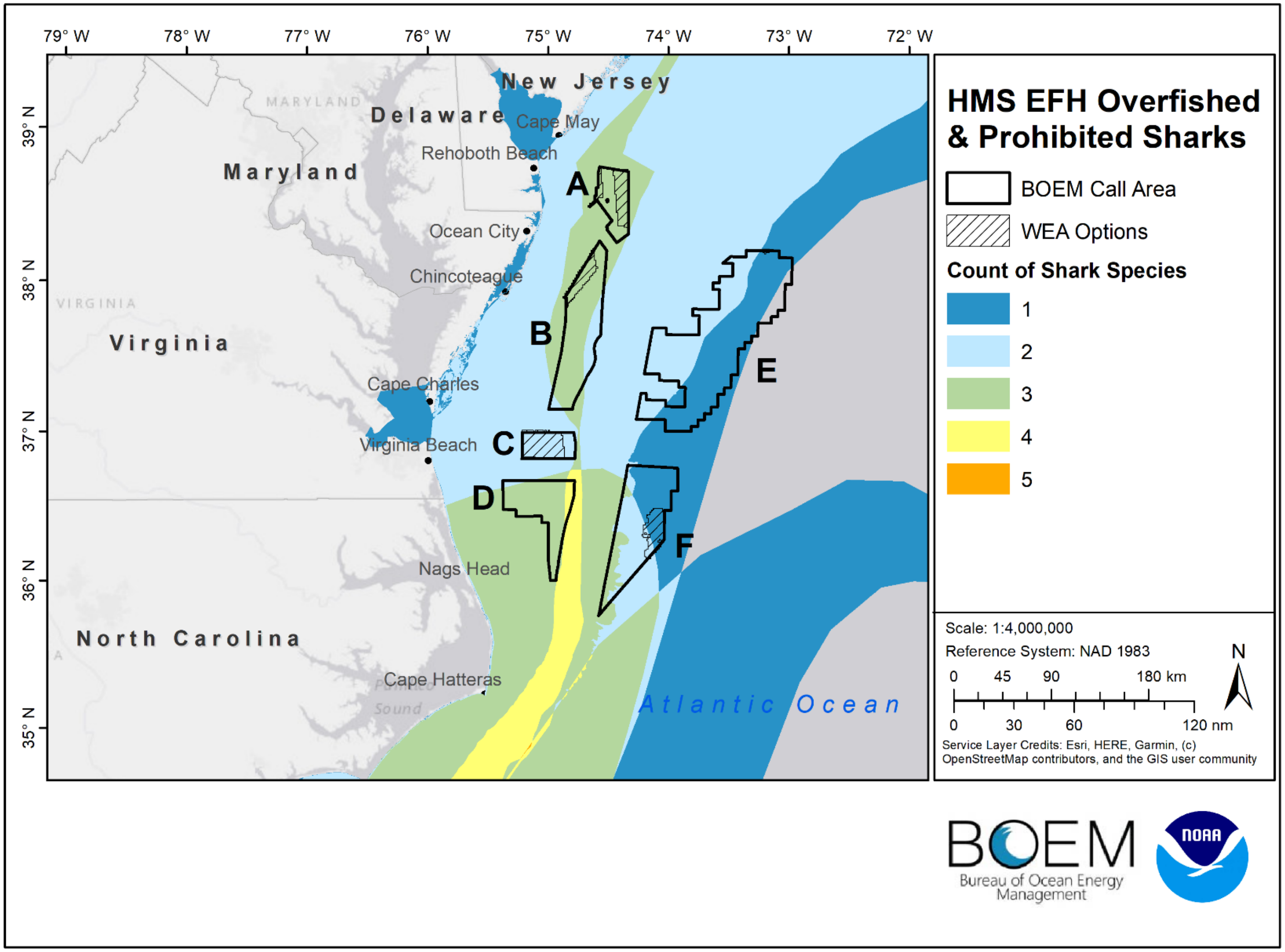


Figure 3.31. Highly Migratory Species (HMS) Essential Fish Habitat (EFH) count of overfished and prohibited shark species in relation to the WEA options.

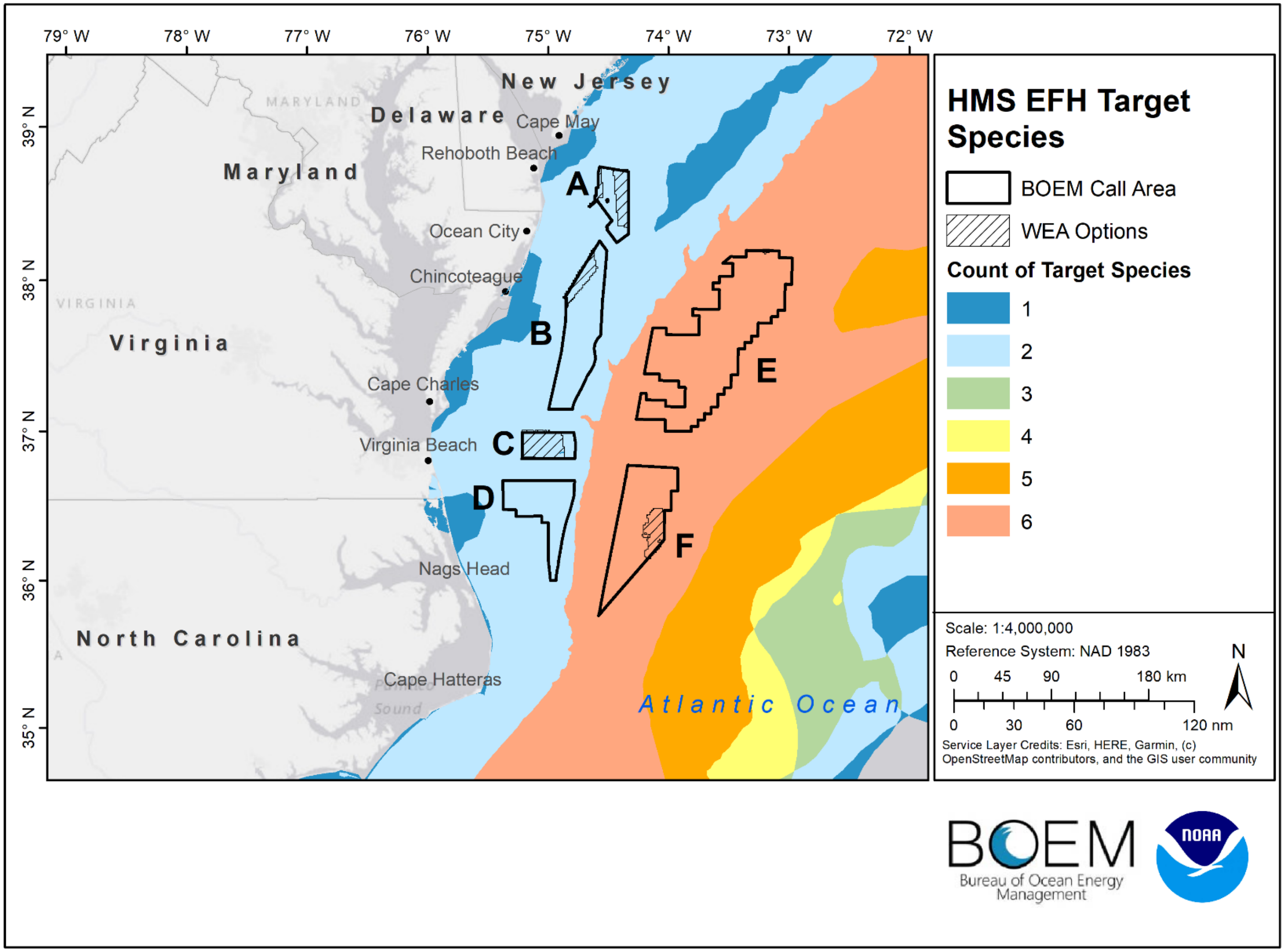


Figure 3.32. Highly Migratory Species (HMS) Essential Fish Habitat (EFH) count of target species in relation to the WEA options.

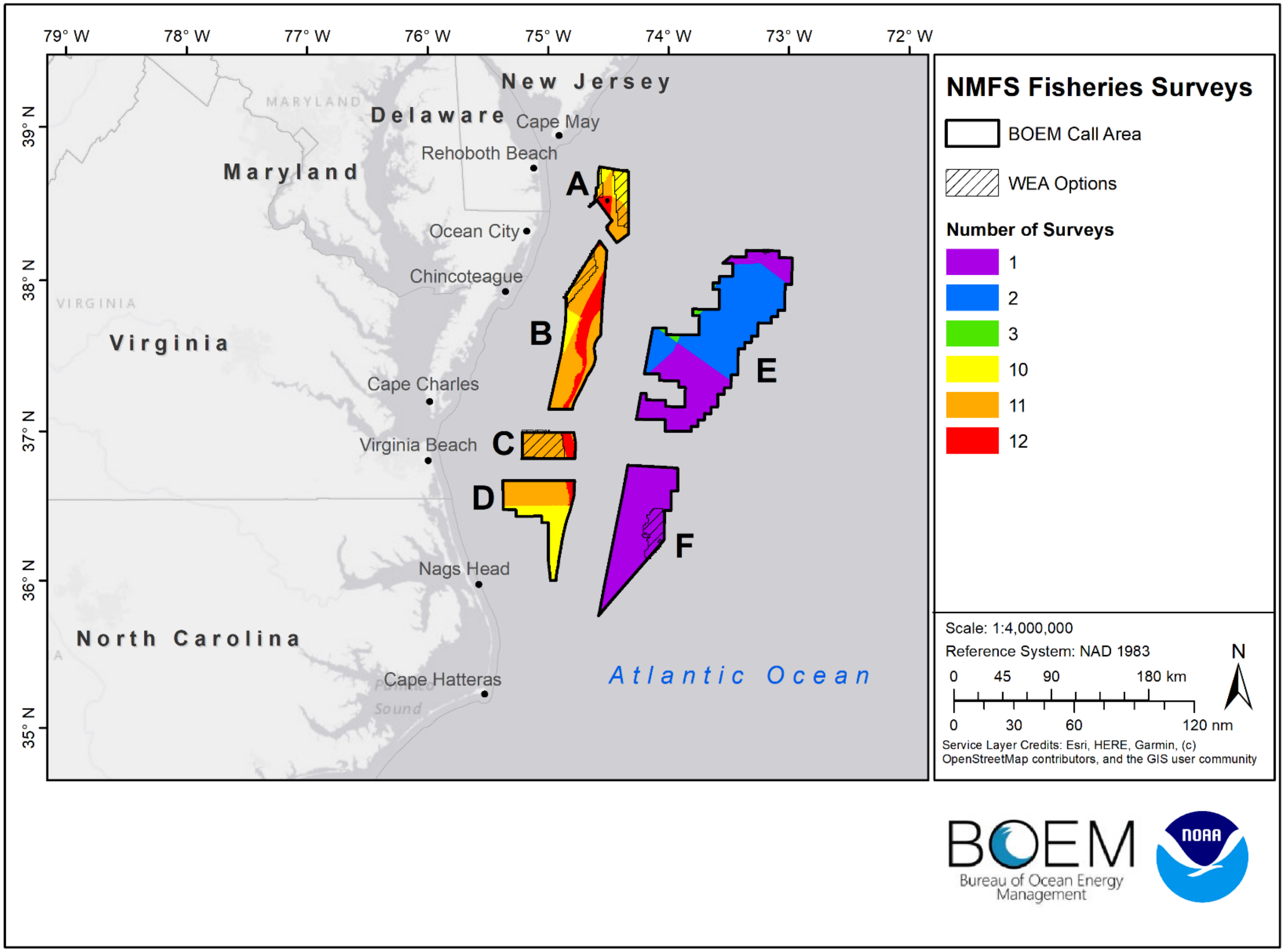


Figure 3.33. NMFS fisheries surveys in relation to the WEA options.

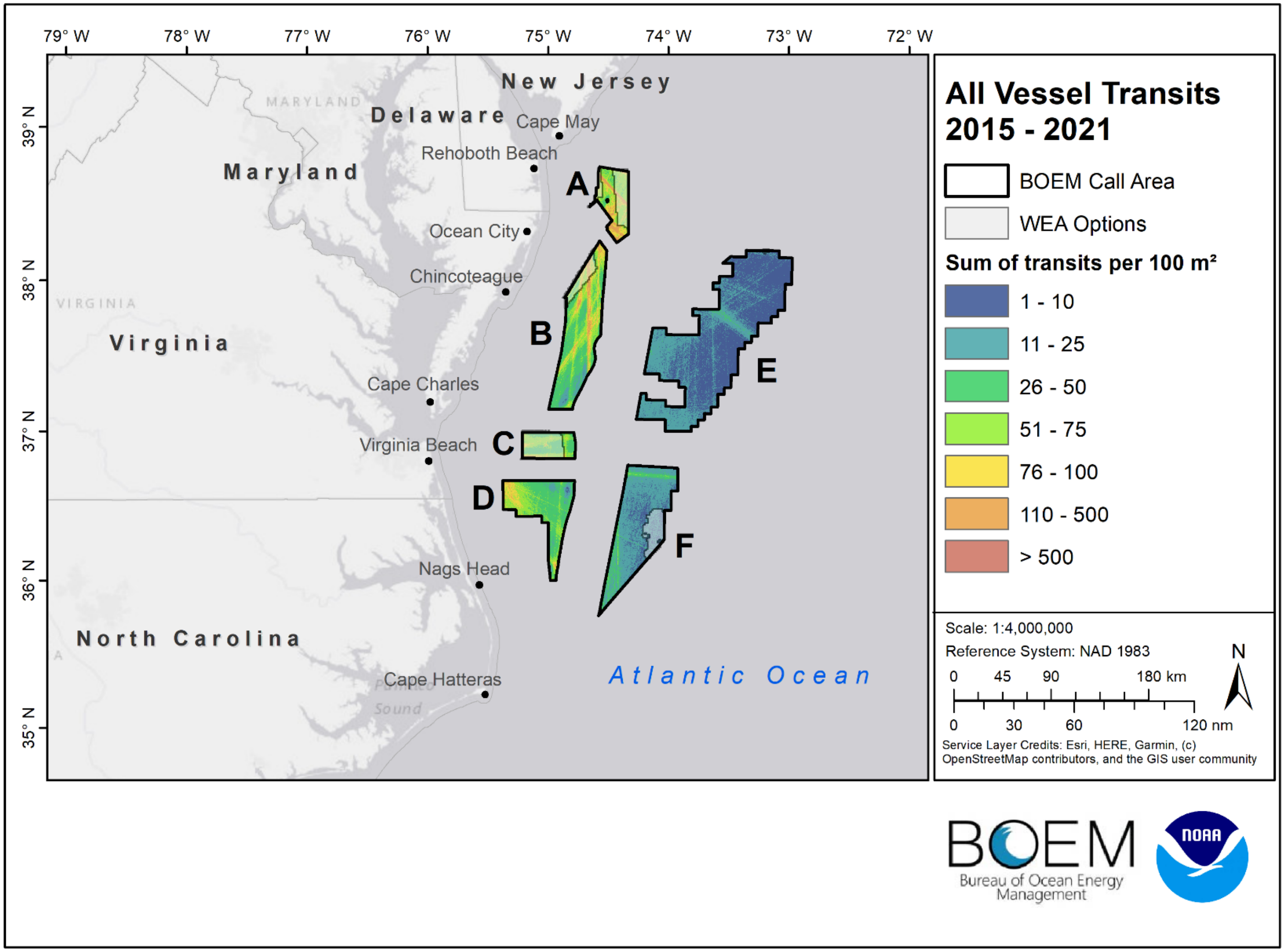


Figure 3.34. AIS all vessel transits 2015 - 2021 in relation to the WEA options.

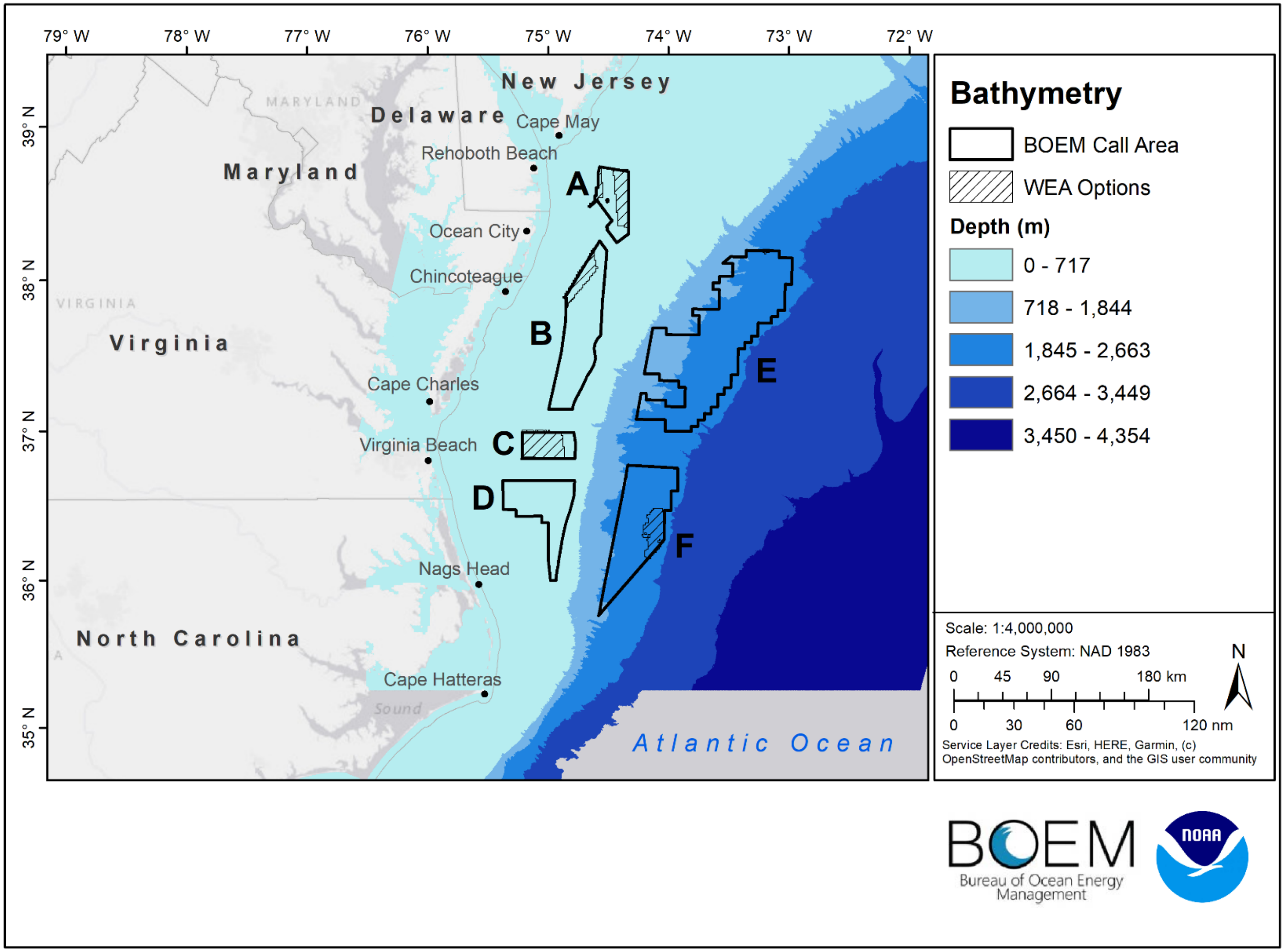


Figure 3.35. Bathymetry in relation to the WEA options.

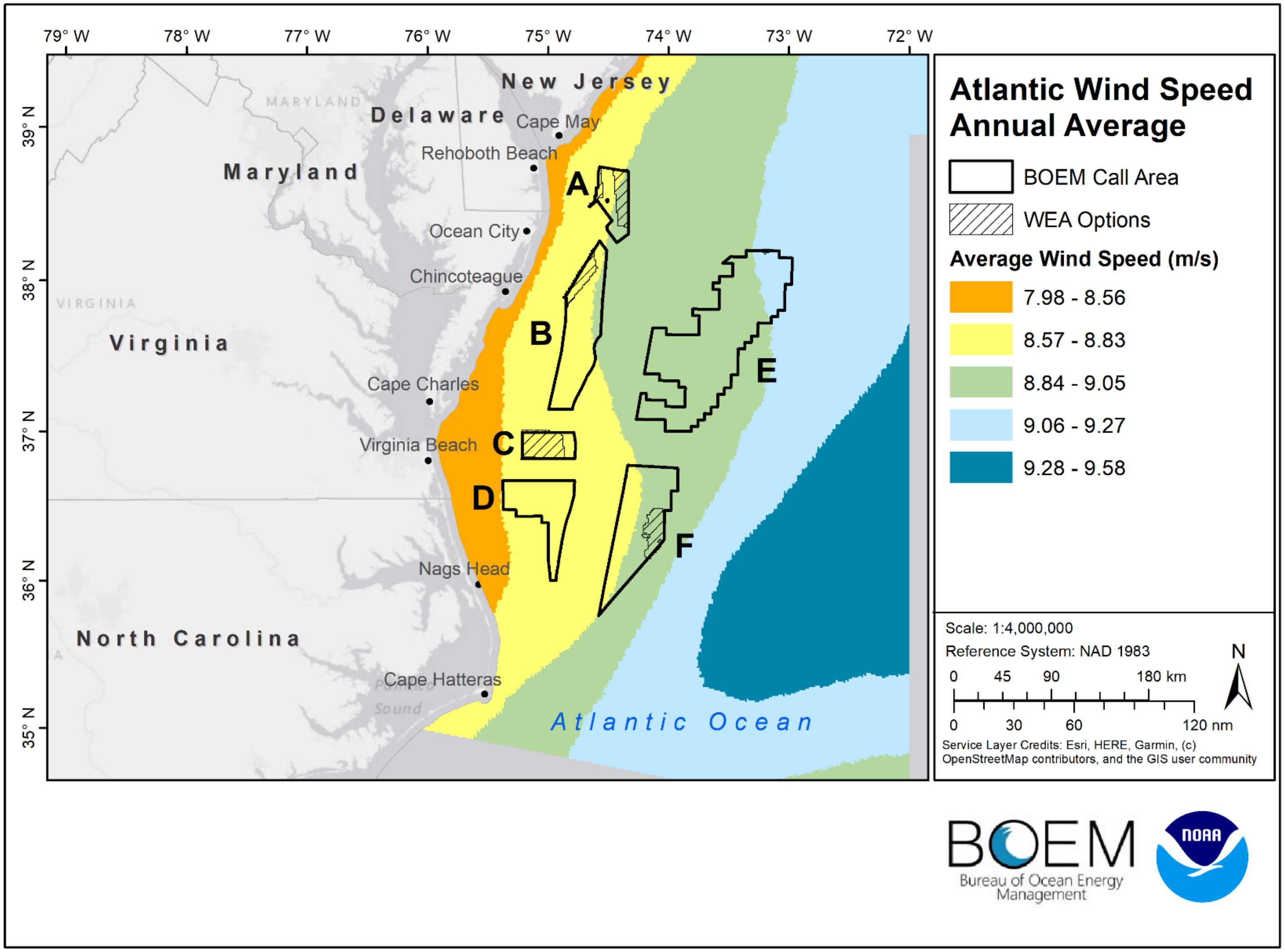


Figure 3.36. Annual average Atlantic wind speed in relation to the WEA options.

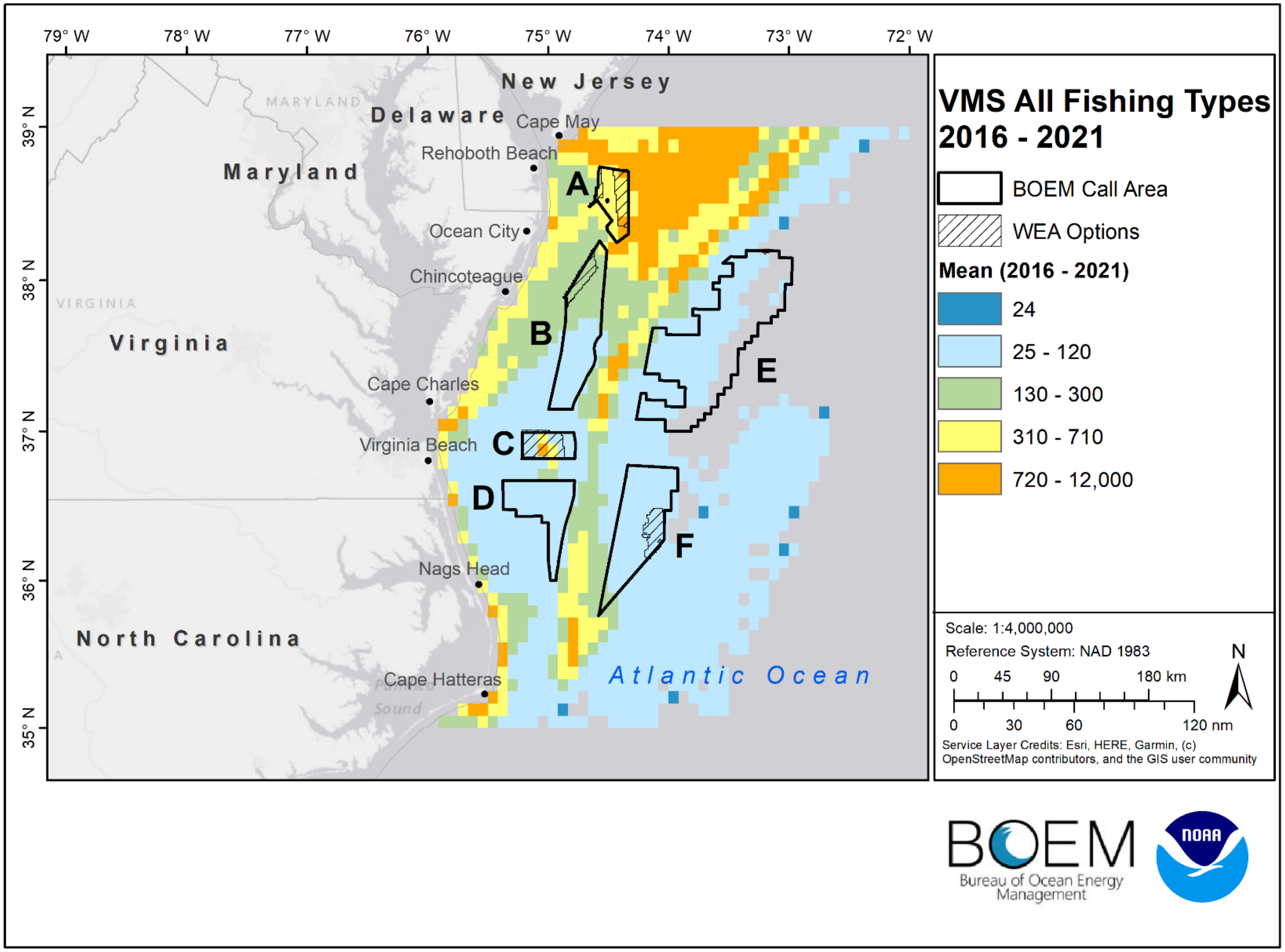


Figure 3.37. VMS all fishing types mean for 2016 - 2021 in relation to the WEA options.

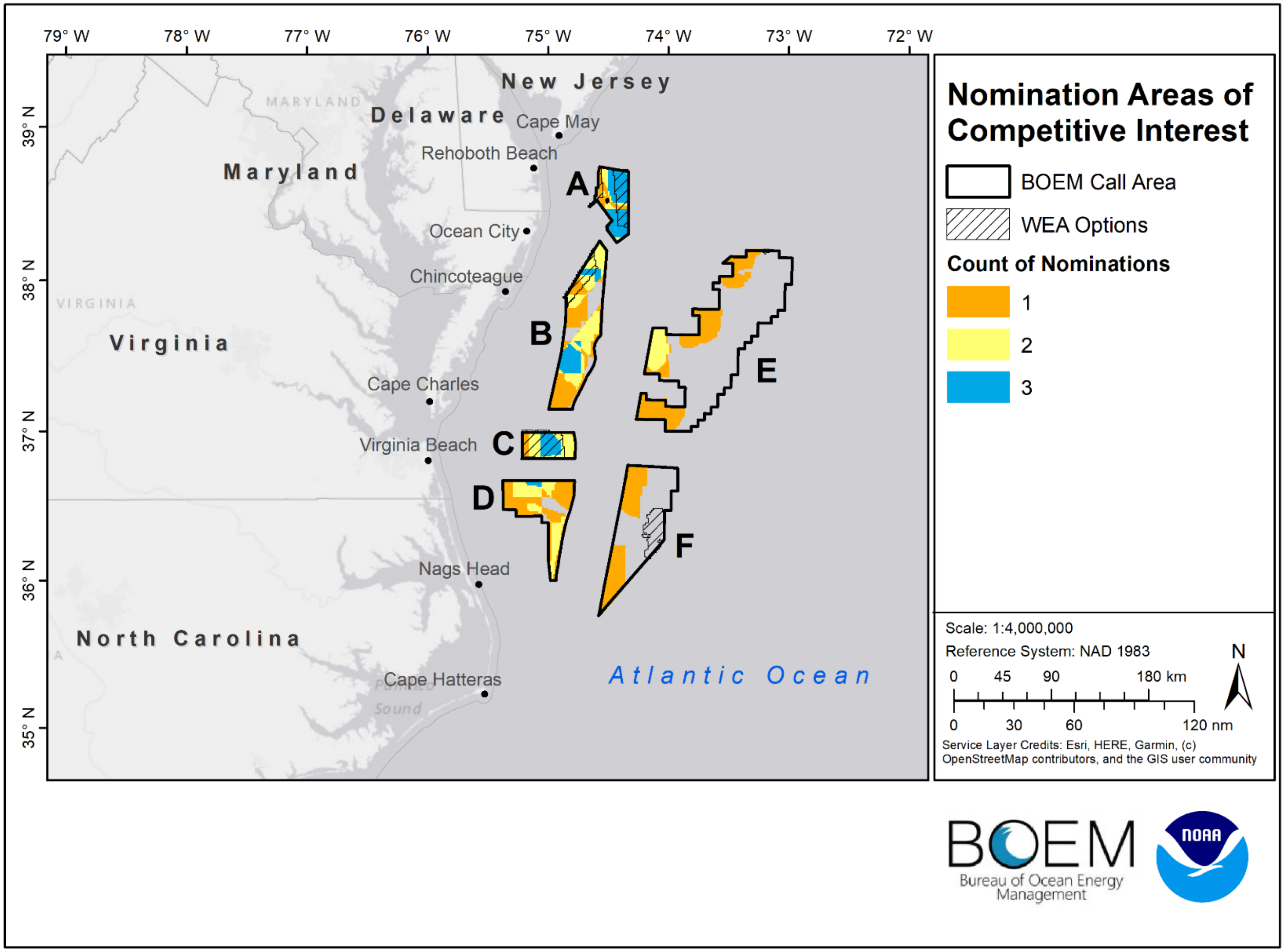


Figure 3.38. Nomination areas of competitive interest in relation to the WEA options. This data was not used in the suitability model.

Characterization of WEA Options

All six WEA options are characterized below. The characterizations provide option specific details regarding the geographic location, national security, natural and cultural resources, industry and operations, fisheries, and wind logistics.

WEA Option A-1 Characterization

WEA option A-1 is located on the northwest side of Call Area A. The 19,570-acre site is located offshore approximately 39.1 km southeast of the Delaware Bay inlet (Figure 3.39). The mean depth across the entire option is 30.5 m, with a maximum depth of 38 m and a minimum of 23 m (Table 3.7; Figure 3.40).

Table 3.7. Characterization summary for Wind Energy Area Option A-1.

Logistics	**Value**
Size (acres)	19,570
Distance to Inlet (km)*	Delaware Bay; 39.1 km
Distance to Shore (km)*	36.4; Rehoboth Beach
Depth (m) (minimum, maximum, mean)	min = 23 m, max = 38 m, mean = 30.5 m
Annual Average Wind Speed (m/s)	8.74 - 7.78 m/s
Constraints	
Shipping and Safety Fairways (no overlap)	1 nearby east of option, 1 southwest of option
National Security	
Navy Mission Compatibility Assessment	Priority 4
Air Force Mission Compatibility Assessment	Priority 5
NASA Mission Compatibility Assessment	No Risk Area
Military Operating Area	Overlaps with Virginia Capes
Special Use Airspace	Overlaps with SUA W386
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Harbor porpoise Short-beaked common dolphin Striped dolphin Seals Blue whale **Fin whale** Humpback whale Minke whale **North Atlantic right whale**

	Sei whale Sperm whale **Atlantic sturgeon** Giant manta ray Shortnose sturgeon Green sea turtle **Kemp's ridley sea turtle** **Leatherback sea turtle** Loggerhead sea turtle
NMFS Habitat Combined Layer – Habitat overlap	Sand ridge trough complexes/Sand shoals Surf clam/Scallop area
HMS EFH Overfished and Prohibited Sharks – count of species overlap	3
HMS EFH Target Species – count of species overlap	2
Fish Havens	1 southeast; outside of option
Wrecks and Obstructions	1 overlaps option
Industry and Operations	
NOAA NMFS Fishing Surveys	10 – 12
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	42 – 251
Fisheries	
VMS All Fishing Types Mean 2016-2021	334 – 412

*Distance to inlet and shore 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.

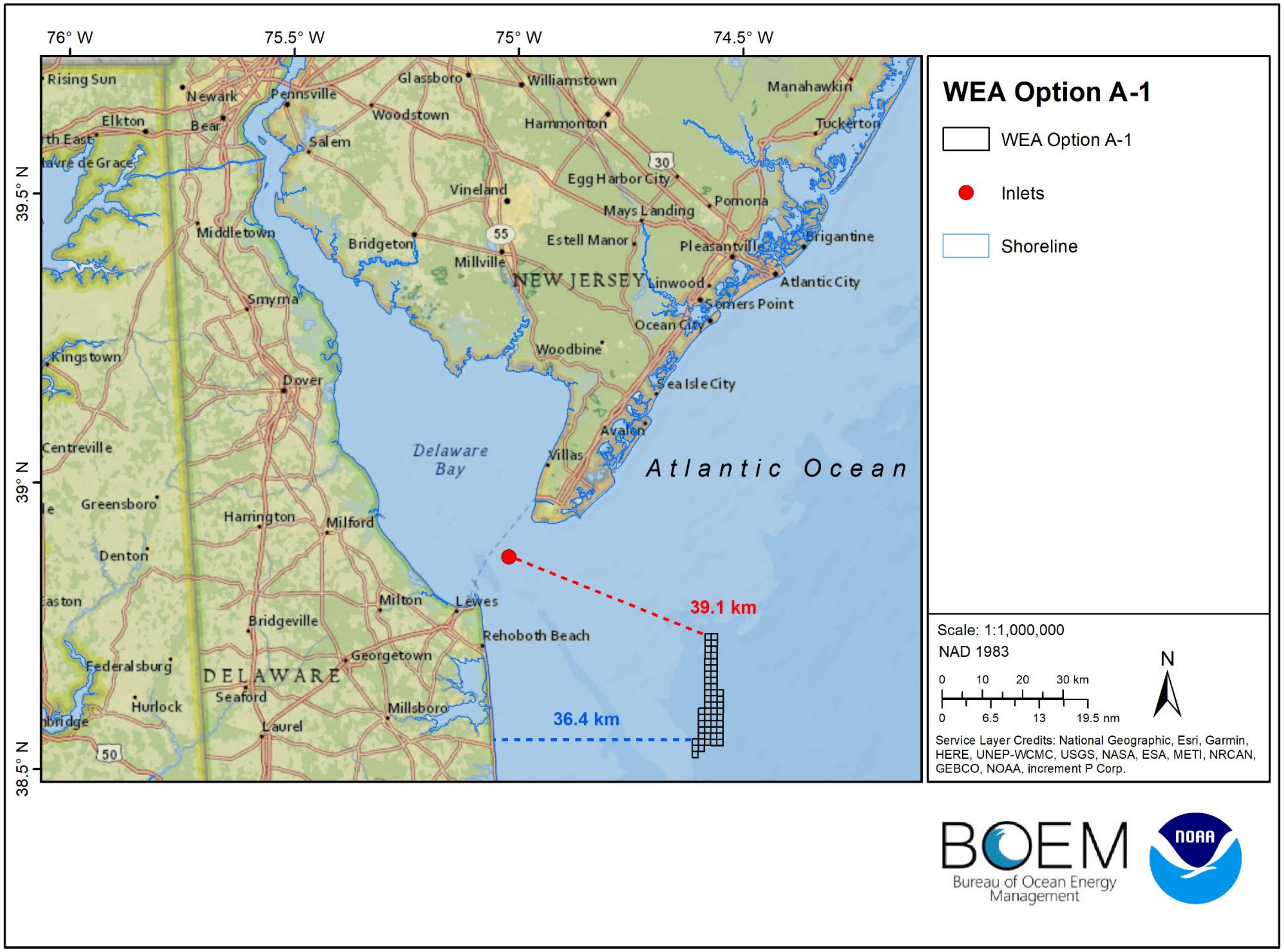


Figure 3.39. WEA option A-1 (black outlined box) and distance to Delaware Bay inlet.

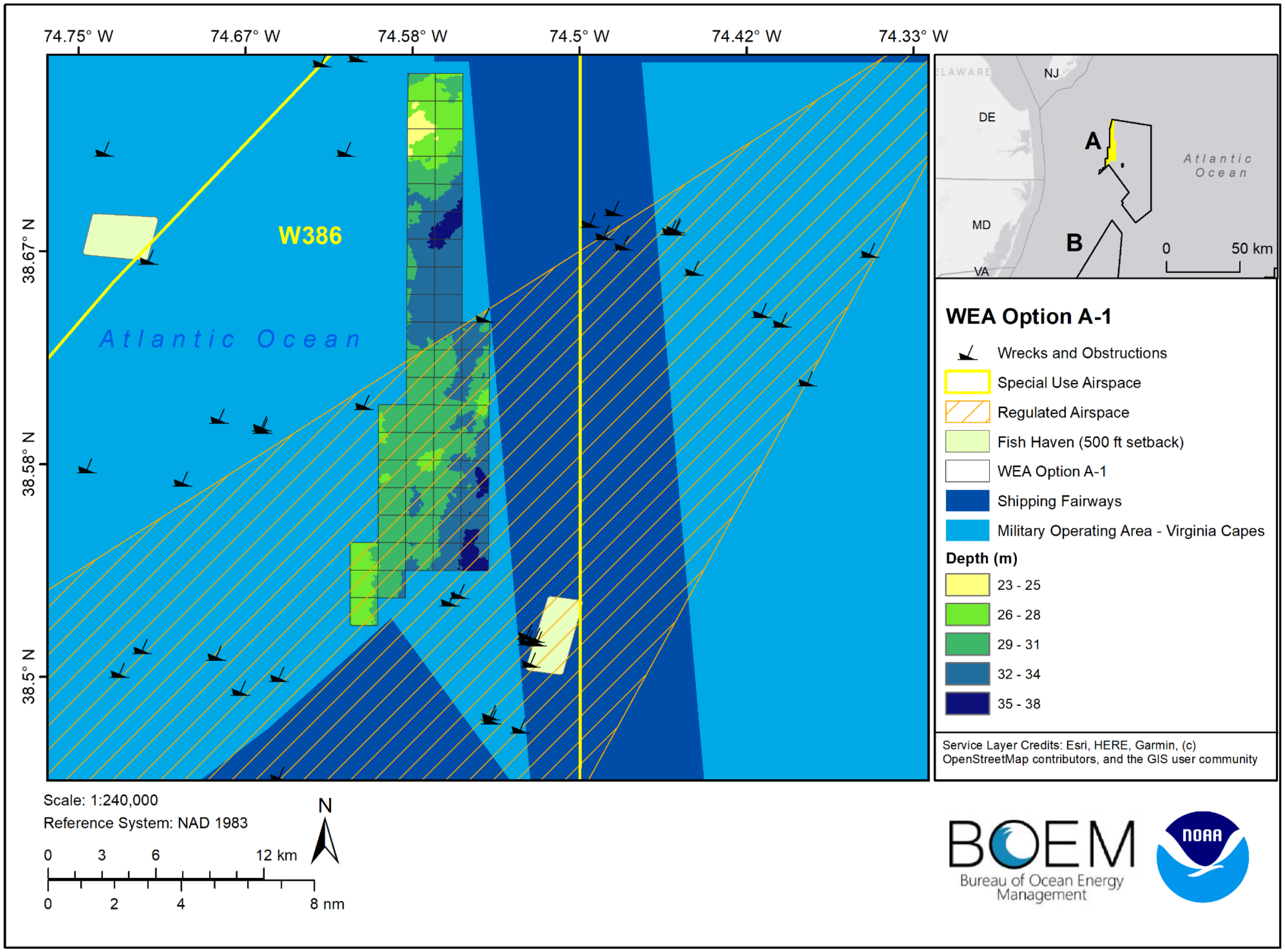


Figure 3.40. Map depicting noteworthy characterization features for Wind Energy Area option A-1.

WEA Option A-2 Characterization

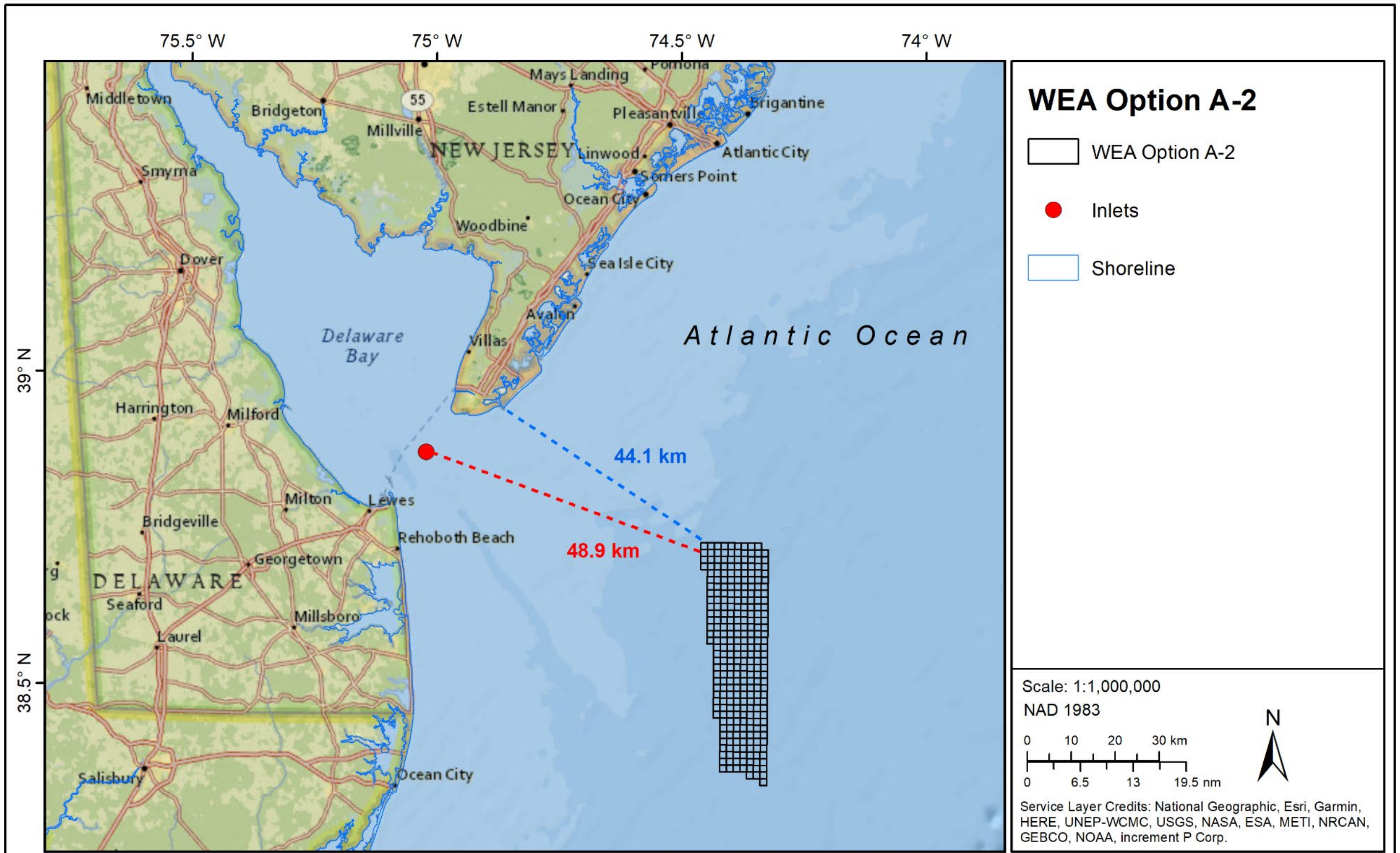
WEA option A-2 is located on the northeast side of Call Area A. The 101,767-acre site is located offshore approximately 48.9 km southeast of Delaware Bay inlet (Figure 3.41). The mean depth across the entire option is 37 m, with a maximum depth of 48 m and a minimum of 26 m (Table 3.8; Figure 3.42).

Table 3.8. Characterization summary for Wind Energy Area Option A-2.

Logistics	**Value**
Size (acres)	101,767
Distance to Inlet (km)	Delaware Bay; 48.9 km
Distance to Shore (km)	44.1; Cape May
Depth (m) (minimum, maximum, mean)	min = 26 m, max = 48 m, mean = 37 m
Annual Average Wind Speed (m/s)	8.79 - 8.89 m/s
Constraints	
Shipping and Safety Fairways (no overlap)	Surrounded on all sides of option
National Security	
Navy Mission Compatibility Assessment	Priority 4
Air Force Mission Compatibility Assessment	Priority 5
NASA Mission Compatibility Assessment	No Risk Area
Military Operating Areas	Overlaps with Virginia Capes
Special Use Airspace	Overlaps with SUA W386
Regulated Airspace	Overlaps with Test Track A
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Harbor porpoise Risso's dolphin Short-beaked common dolphin Striped dolphin Seals Blue whale **Fin whale** Humpback whale Minke whale **North Atlantic right whale** **Sei whale** Sperm whale **Atlantic sturgeon** Giant manta ray Shortnose sturgeon

	Green sea turtle **Kemp's ridley sea turtle** **Leatherback sea turtle** Loggerhead sea turtle
NMFS Habitat Combined Layer - Habitat overlap	Sand ridge trough complexes/Sand shoals Surf clam/Scallop area
HMS EFH Overfished and Prohibited Sharks - count of species overlap	3
HMS EFH Target Species - count of species overlap	2
Fish Havens	1 west; outside of option
Wrecks and Obstructions	1 overlaps option
Industry and Operations	
NOAA NMFS Fishing Surveys	10 - 11
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	31 - 172
Fisheries	
VMS All Fishing Types Mean 2016-2021	396 - 1,090

*Distance to inlet and shore 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.



BOEM Bureau of Ocean Energy Management

Figure 3.41. WEA option A-2 (black outlined box) and distance to Delaware Bay inlet.

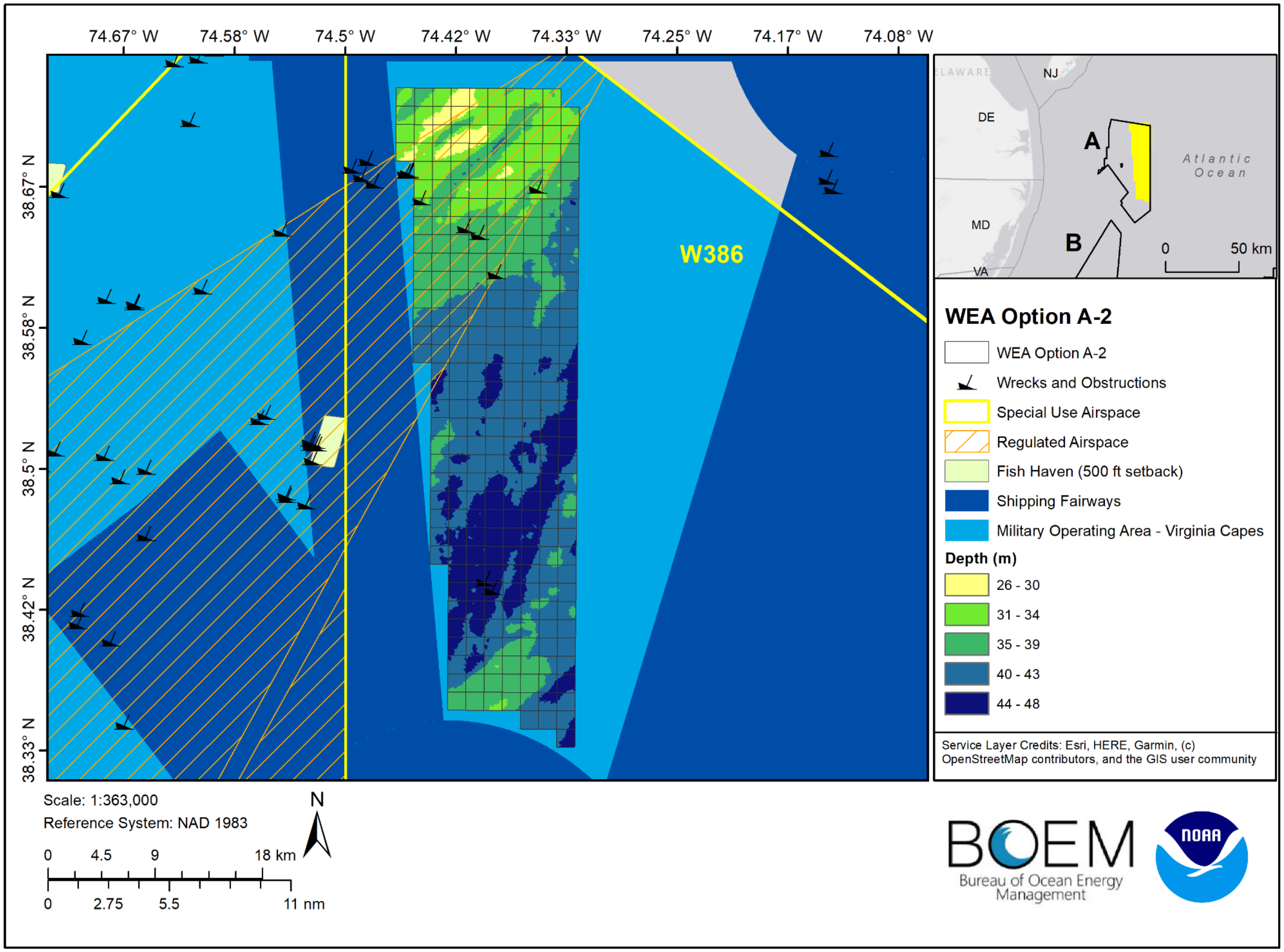


Figure 3.42. Map depicting noteworthy characterization features for Wind Energy Area option A-2.

WEA Option B-1 Characterization

WEA option B-1 is located in the northwest portion of Call Area B. The 78,285-acre site is located offshore approximately 103.5 km southeast of the Delaware Bay inlet (Figure 3.43). The mean depth across the entire option is 32 m, with a maximum depth of 42 m and a minimum of 22 m (Table 3.9; Figure 3.44). The compatibility of WEA Option B-1 with DoD and NASA operations is currently undergoing an additional assessment.

Table 3.9. Characterization summary for Wind Energy Area Option B-1.

Logistics	**Value**
Size (acres)	78,285
Distance to Inlet (km)	Delaware Bay; 103.5 km
Distance to Shore (km)	45.4; Assateague Island
Depth (m) (minimum, maximum, mean)	min = 22 m, max = 42 m, mean = 32 m
Annual Average Wind Speed (m/s)	8.78 - 8.81 m/s
Constraints	
Shipping and Safety Fairways (no overlap)	On east and south of option
National Security	
Navy Mission Compatibility Assessment	Areas that need further study
Air Force Mission Compatibility Assessment	Areas the need further study
NASA Mission Compatibility Assessment	Areas that need further study
Military Operating Area	Overlaps with Virginia Capes
Special Use Airspace	Overlaps with W386
Regulated Airspace	Overlaps with regulated airspace
NASA Hazard Area	Overlaps with NASA Hazard Area
Danger and Restricted Area	Overlaps with southern portion of option
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Harbor porpoise Risso's dolphin Short-beaked common dolphin Striped dolphin Seals Blue whale **Fin whale** Humpback whale Minke whale **North Atlantic right whale** **Sei whale** Sperm whale **Atlantic sturgeon** Giant manta ray Shortnose sturgeon Green sea turtle **Kemp's ridley sea turtle**

	Leatherback sea turtle Loggerhead sea turtle
NMFS Habitat Combined Layer - Habitat overlap	Sand ridge trough complexes/Sand shoals Surfclam/Scallop area
HMS EFH Overfished and Prohibited Sharks - count of species overlap	3
HMS EFH Target Species - count of species overlap	2
Wrecks and Obstructions	4 overlap
Industry and Operations	
NOAA NMFS Fishing Surveys	11
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	15 - 254
Fisheries	
VMS All Fishing Types Mean 2016-2021	185 - 234

*Distance to port and shore 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.

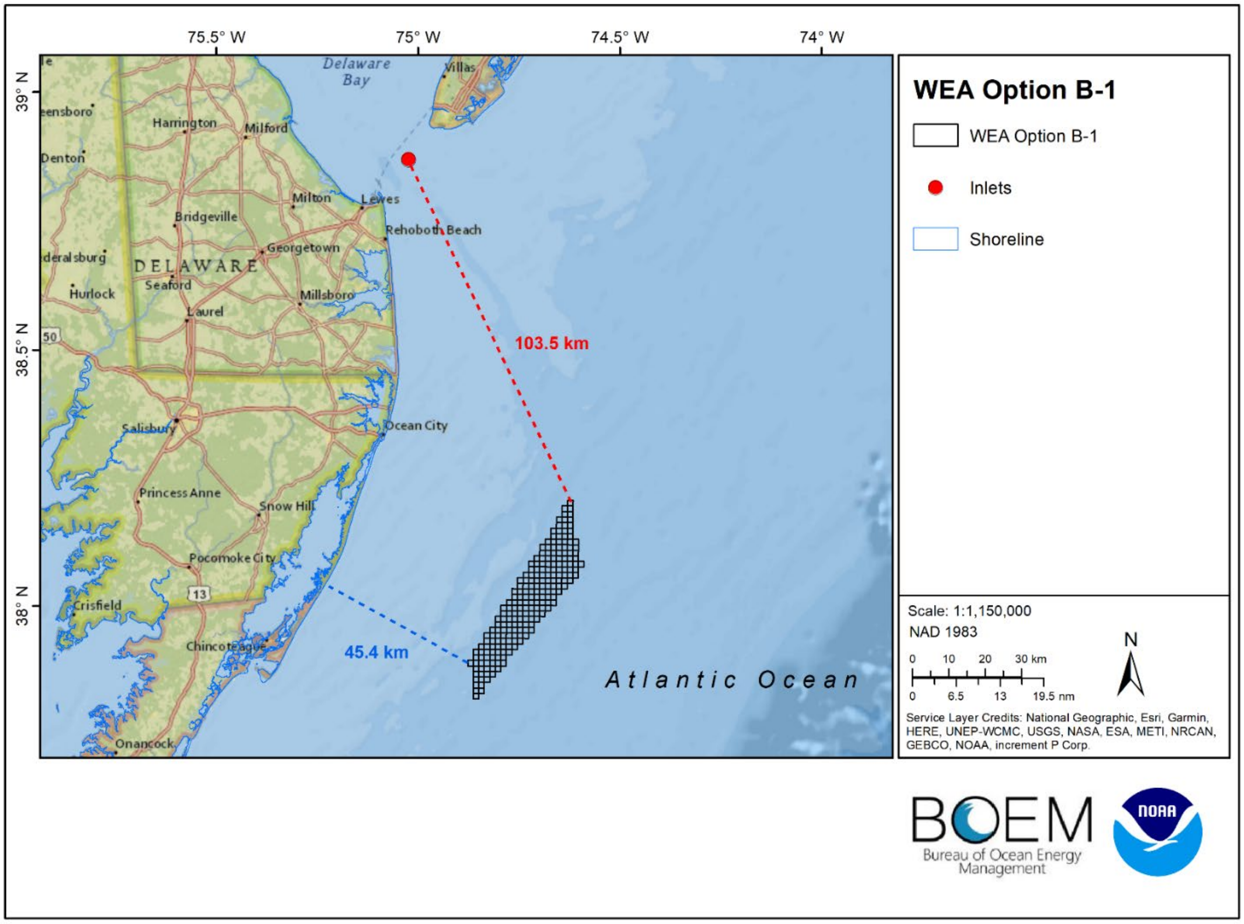


Figure 3.43. WEA option B-1 (black outlined box) and distance to the Delaware Bay inlet.

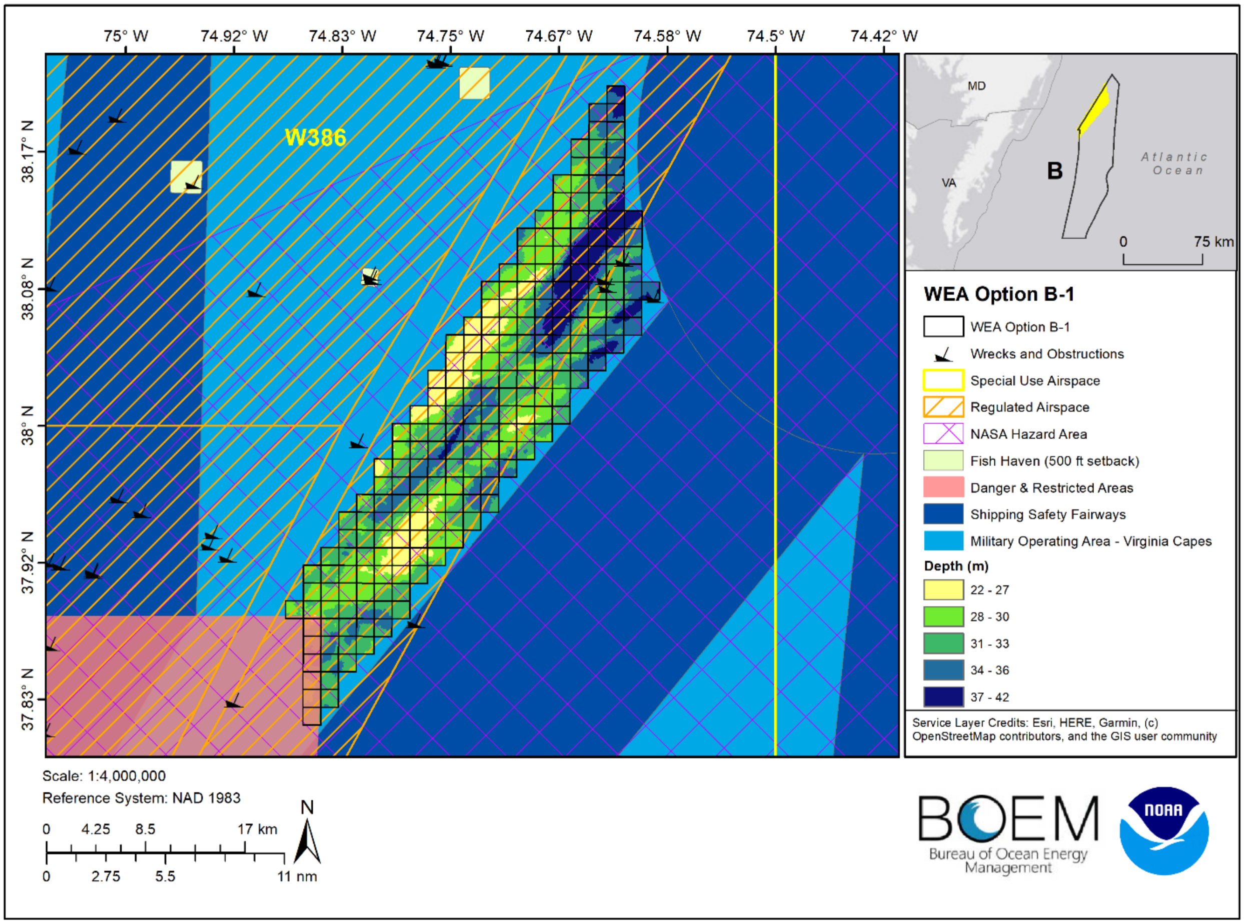


Figure 3.44. Map depicting noteworthy characterization features for Wind Energy Area option B-1.

WEA Option C-1 Characterization

WEA option C-1 is located in the western and center portion of Call Area C. The 143,755-acre site is located offshore approximately 66.2 km east of the Chesapeake Bay inlet (Figure 3.45). The mean depth across the entire option is 36.5 m, with a maximum depth of 50 m and a minimum of 23 m (Table 3.10; Figure 3.46).

Table 3.10. Characterization summary for Wind Energy Area Option C-1.

Logistics	**Value**
Size (acres)	143,755
Distance to Inlet (km)	Chesapeake Bay; 66.2 km
Distance to Shore (km)	56.4; Cape Charles
Depth (m) (minimum, maximum, mean)	min = 23 m, max = 50 m, mean = 36.5 m
Annual Average Wind Speed (m/s)	8.63 - 8.74 m/s
Constraints	
Shipping and Safety Fairways (no	On north and south of option

overlap)	
National Security	
Navy Mission Compatibility Assessment	Priority 4
Air Force Mission Compatibility Assessment	Priority 6
NASA Mission Compatibility Assessment	Major Risk Area
Unexploded Ordnance	1 overlaps with option
NASA Hazard Area	Overlaps with NASA Hazard Area
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Harbor porpoise Pilot whales Risso's dolphin Short-beaked common dolphin Striped dolphin Seals Blue whale **Fin whale** Humpback whale Minke whale **North Atlantic right whale** **Sei whale** Sperm whale **Atlantic sturgeon** Giant manta ray Shortnose sturgeon Green sea turtle **Hawksbill sea turtle** **Kemp's ridley sea turtle** **Leatherback sea turtle** Loggerhead sea turtle
NMFS Habitat Combined Layer - Habitat overlap	Sand ridge trough complexes/Sand shoals Shelf break (with 20 km setback)
HMS EFH Overfished and Prohibited Sharks - count of species overlap	2
HMS EFH Target Species - count of species overlap	2
Wrecks and Obstructions	4 overlap
Industry and Operations	
NOAA NMFS Fishing Surveys	11 - 12
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	17 - 142
Fisheries	
VMS All Fishing Types Mean 2016-2021	56 - 813

*Distance to port and shore 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.

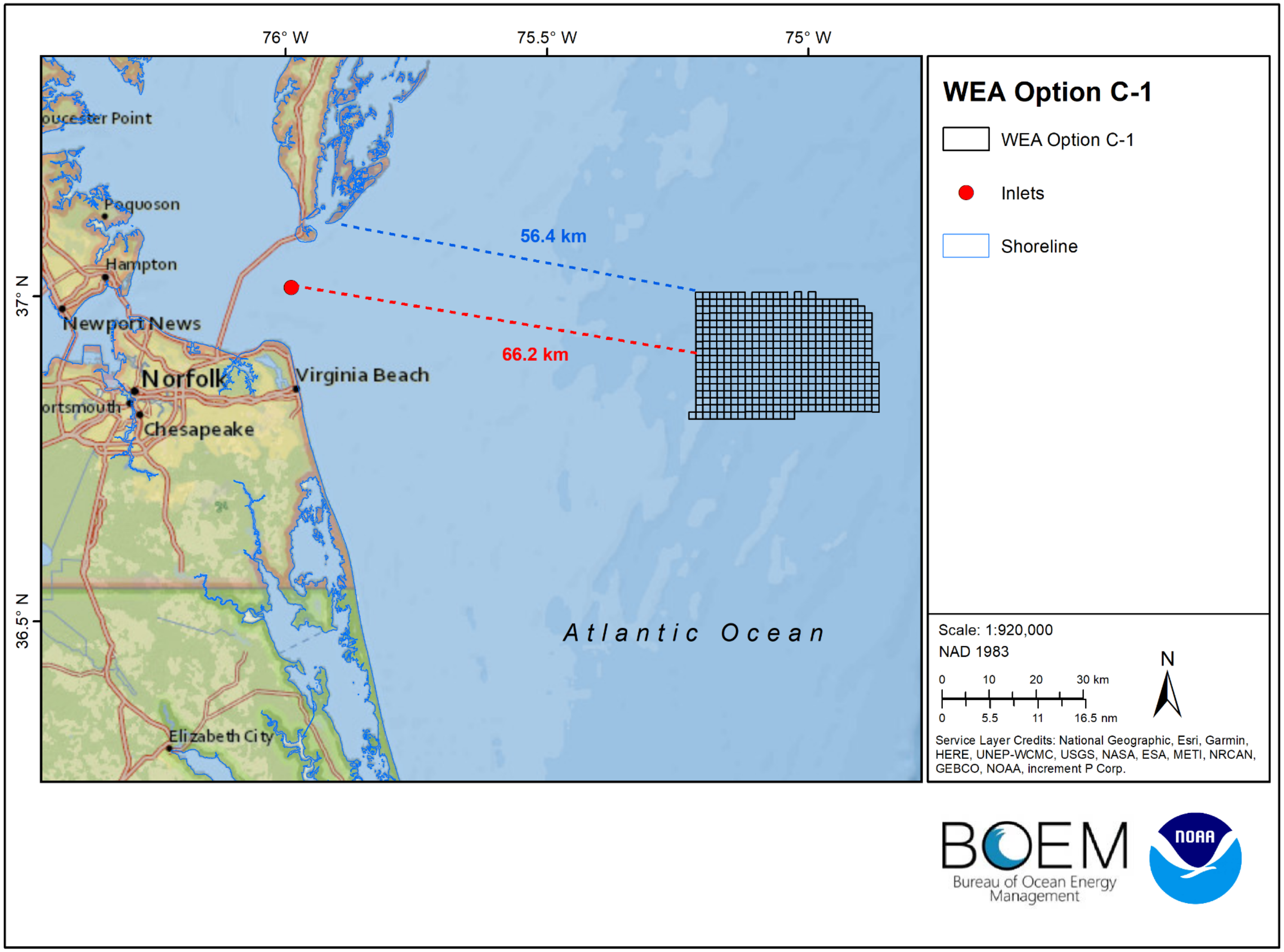


Figure 3.45. WEA option C-1 (black outlined box) and distance to the Chesapeake Bay inlet.

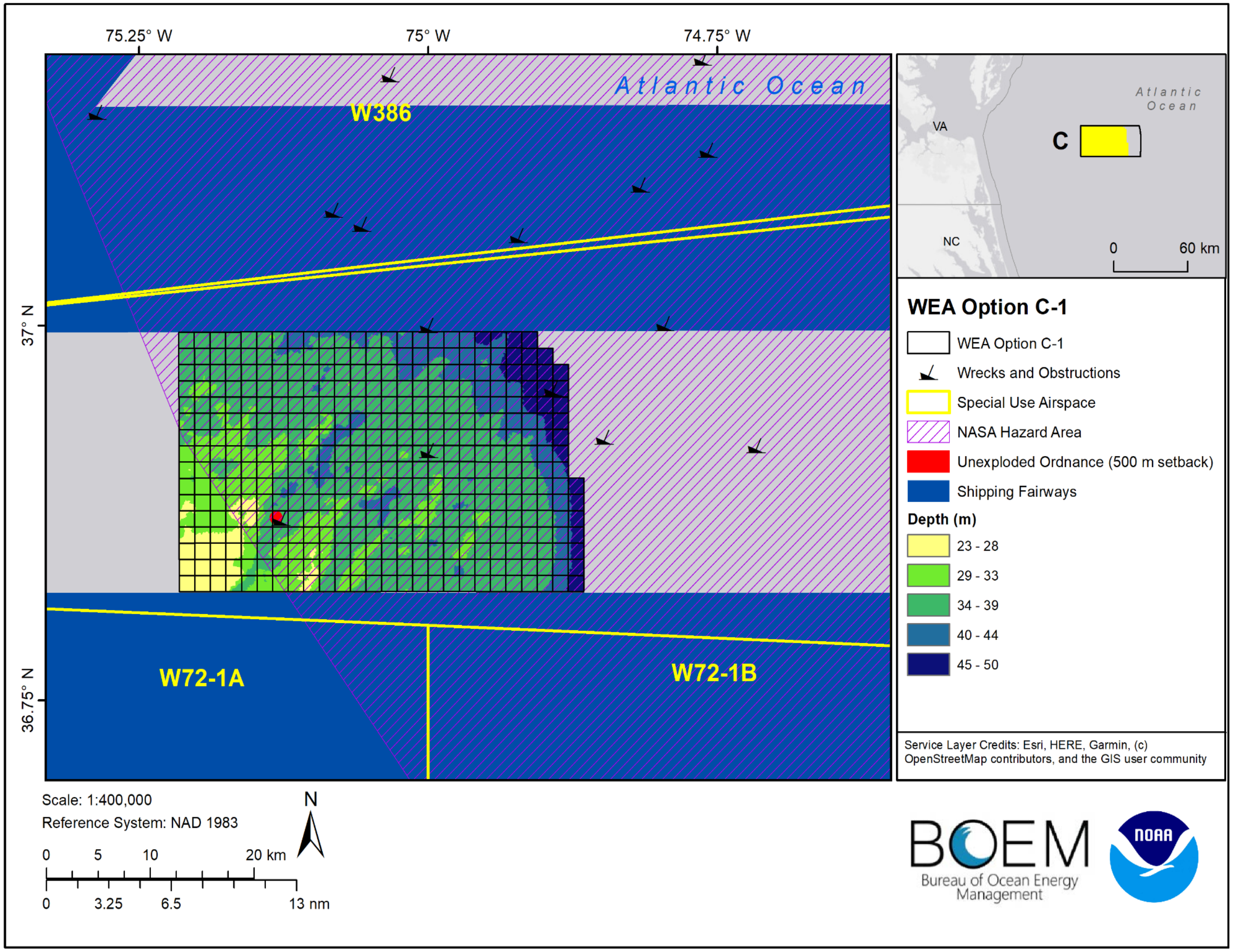


Figure 3.46. Map depicting noteworthy characterization features for Wind Energy Area option C-1.

WEA Option E-1 Characterization

WEA option E-1 is located in the northern portion of Call Area E. The 3,202-acre site is located offshore approximately 167.7 km southeast of Delaware Bay inlet (Figure 3.47). The mean depth across the entire option is 2,086 m, with a maximum depth of 2,207 m and a minimum of 1,965 m (Table 3.110; Figure 3.48).

Table 3.11. Characterization summary for Wind Energy Area Option E-1.

Logistics	**Value**
Size (acres)	3,202
Distance to Inlet (km)	Delaware Bay; 167.7 km
Distance to Shore (km)	154 km; Rehoboth Beach
Depth (m) (minimum, maximum, mean)	min = 1,965 m, max = 2,207 m, mean = 2,086 m
Annual Average Wind Speed (m/s)	9.1 m/s
National Security	
Navy Mission Compatibility Assessment	Priority 3
Air Force Mission Compatibility Assessment	Priority 6
NASA Mission Compatibility Assessment	No Risk Area
Unexploded Ordnance Area	1 southwest of option
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Cuvier's beaked whale Dwarf and Pygmy sperm whales Harbor porpoise Mesoplodon beaked whales Pilot whales Risso's dolphin Short-beaked common dolphin Striped dolphin Seals **Blue whale** **Fin whale** Humpback whale Minke whale North Atlantic right whale **Sei whale** **Sperm whale** **Atlantic sturgeon** Shortnose sturgeon Giant manta ray Green sea turtle Hawksbill sea turtle **Kemp's ridley sea turtle**

	Leatherback sea turtle Loggerhead sea turtle
NMFS Habitat Combined Layer - Habitat overlap	Coral and hardbottom
HMS EFH Overfished and Prohibited Sharks - count of species overlap	1
HMS EFH Target Species - count of species overlap	6
Industry and Operations	
NOAA NMFS Fishing Surveys	1
Submarine Cables	1 overlaps with southern portion of option
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	1 - 18
Fisheries	
VMS All Fishing Types Mean 2016-2021	0

*Distance to port and shore 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.

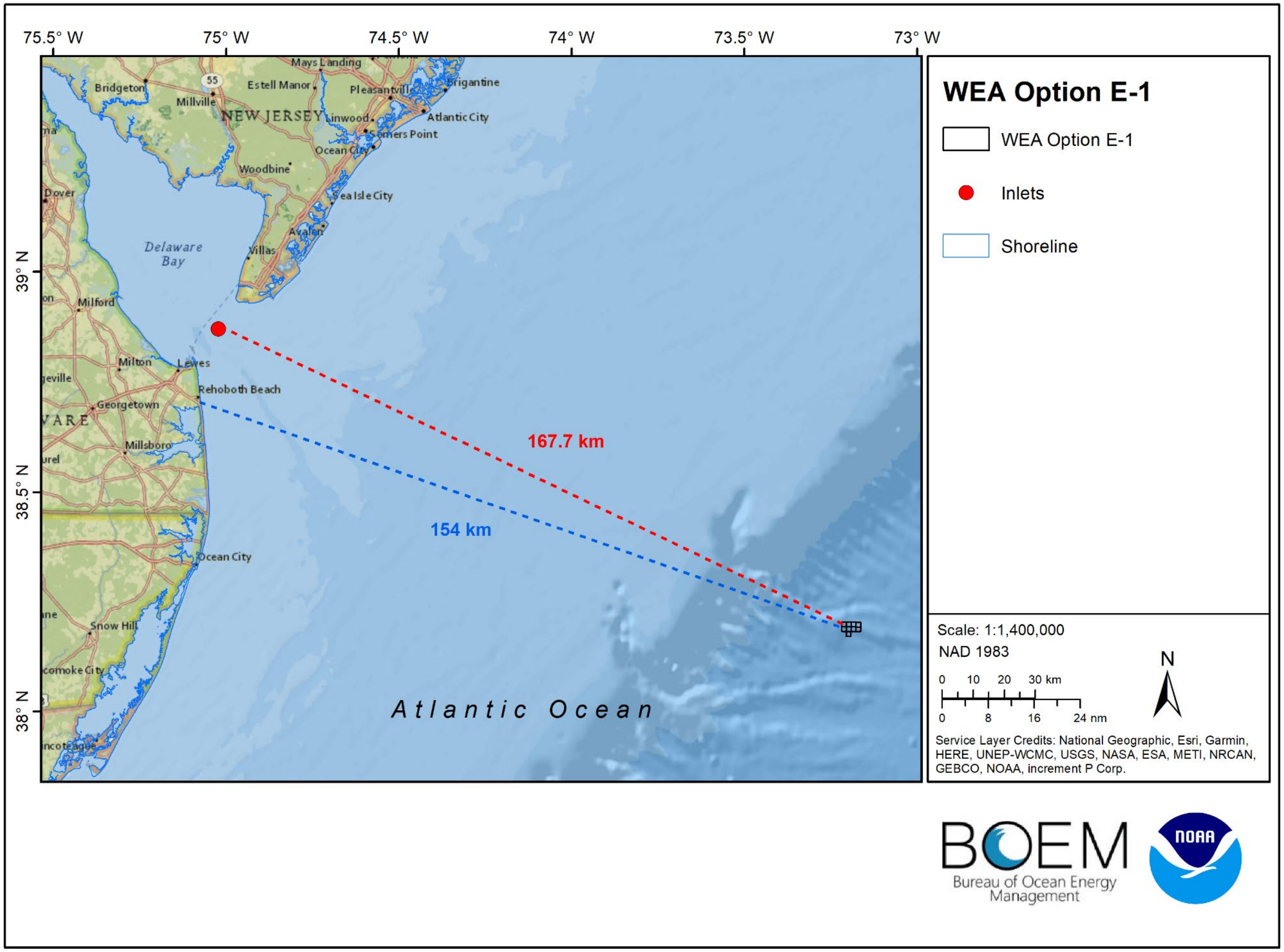


Figure 3.47. WEA option E-1 (black outlined box) and distance to Delaware Bay inlet.

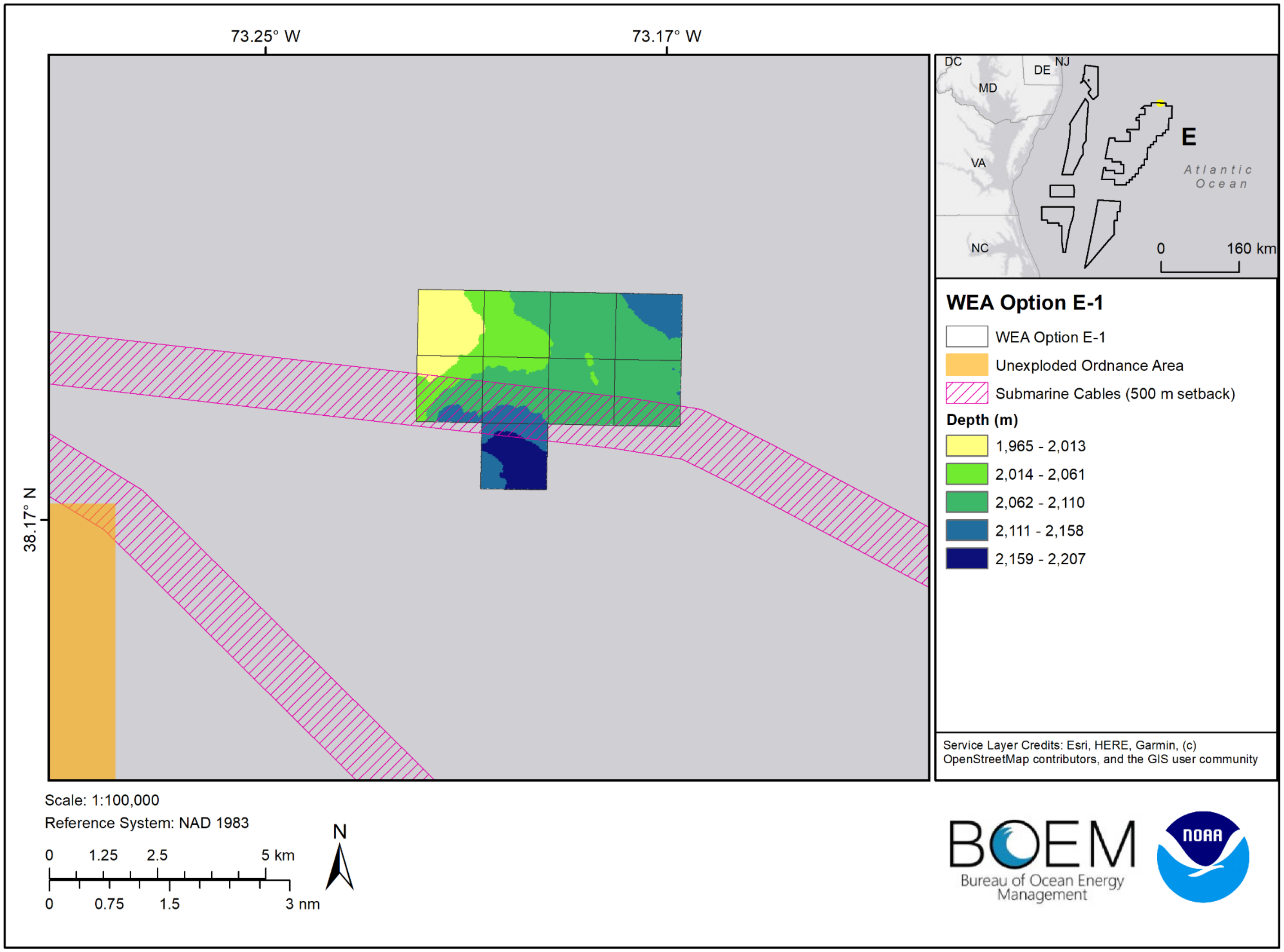


Figure 3.48. Map depicting noteworthy characterization features for Wind Energy Area option E-1.

WEA Option F-1 Characterization

WEA option F-1 is located in the southeast portion of Call Area F. The 101,411-acre site is located offshore approximately 166.6 km southeast of the Chesapeake Bay inlet (Figure 3.49). The mean depth across the entire option is 2,437 m, with a maximum depth of 2,600 m and a minimum of 2,275 m (Table 3.12; Figure 3.50).

Table 3.12. Characterization summary for Wind Energy Area Option F-1.

Logistics	**Value**
Size (acres)	101,411
Distance to Inlet (km)	Chesapeake Bay; 166.6 km
Distance to Shore (km)	136.7; Virginia Beach
Depth (m) (minimum, maximum, mean)	min = 2,275 m, max = 2,600 m, mean = 2,437 m
Annual Average Wind Speed (m/s)	8.8 - 8.96 m/s
National Security	
Navy Mission Compatibility Assessment	Priority 3
Air Force Mission Compatibility Assessment	Priority 4 & 5
NASA Mission Compatibility Assessment	Major Risk Area
Military Operating Areas	Overlaps with Virginia Capes
Special Use Airspace	Overlaps with SUA W72-1C
NASA Hazard Area	Overlaps with NASA Hazard Area
Regulated Airspace	Overlaps Test Track A
Unexploded Ordnance	1 west of option
Natural and Cultural Resources	
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 spotted dolphin Bottlenose dolphin Clymene dolphin Cuvier's beaked whale Dwarf and Pygmy sperm whales Mesoplodon beaked whales Pantropical spotted dolphin Pilot whales Risso's dolphin Rough-toothed dolphin Short-beaked common dolphin Striped dolphin Seals **Blue whale** **Fin whale** Minke whale North Atlantic right whale Sei whale **Sperm whale** Oceanic whitetip shark Green sea turtle **Hawksbill sea turtle** **Kemp's ridley sea turtle**

	Leatherback sea turtle Loggerhead sea turtle
HMS EFH Overfished and Prohibited Sharks - count of species overlap	1 - 2
HMS EFH Target Species - count of species overlap	6
Industry and Operations	
NOAA NMFS Fishing Surveys	1
AIS Vessel Traffic All Vessels 2015-2021 per 100 m²	1 - 38
Fisheries	
VMS All Fishing Types Mean 2016-2021	27 - 39

*Distance to port and shore 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.

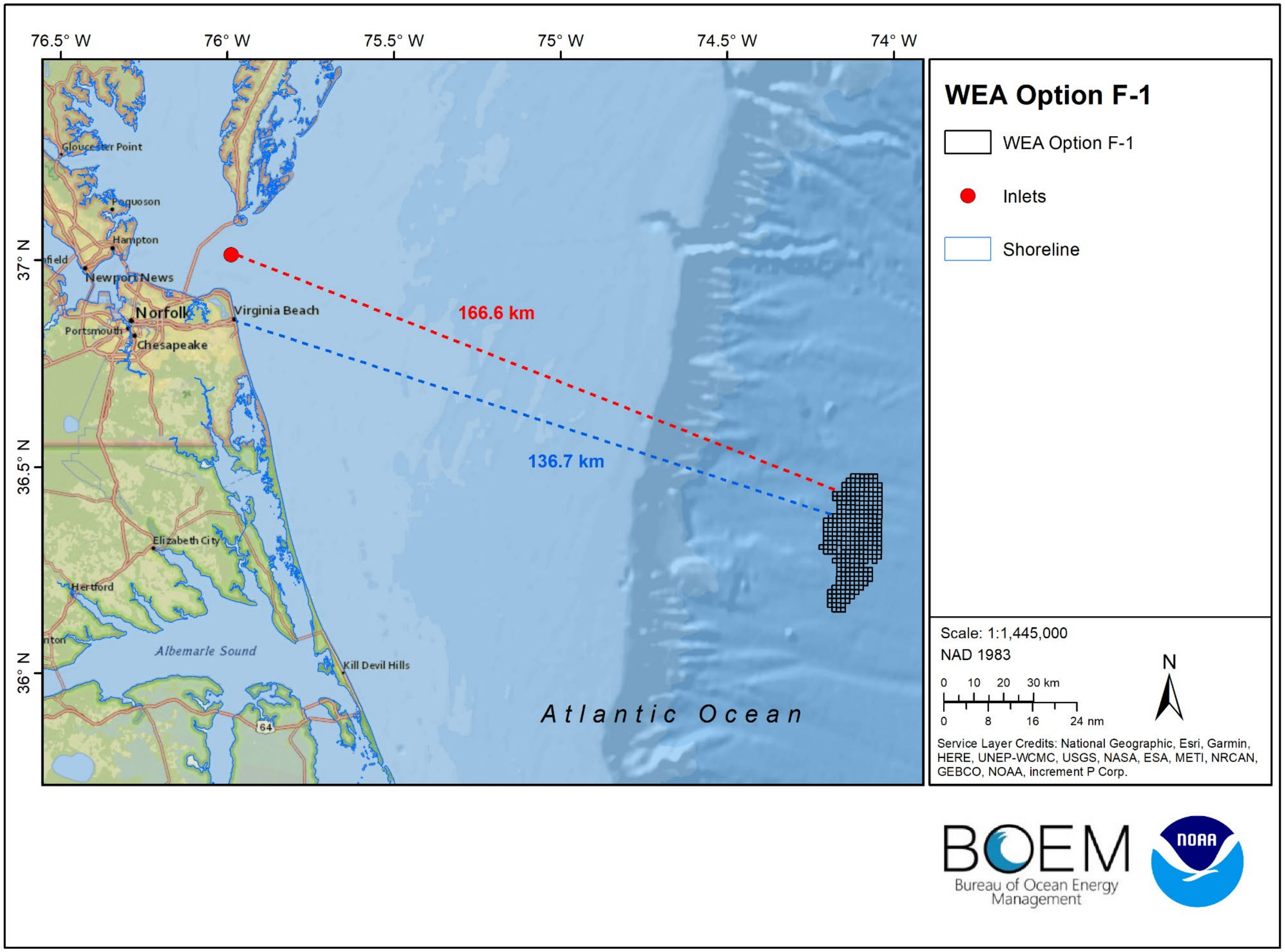


Figure 3.49. WEA option F-1 (black outlined box) and distance to the Chesapeake Bay inlet.

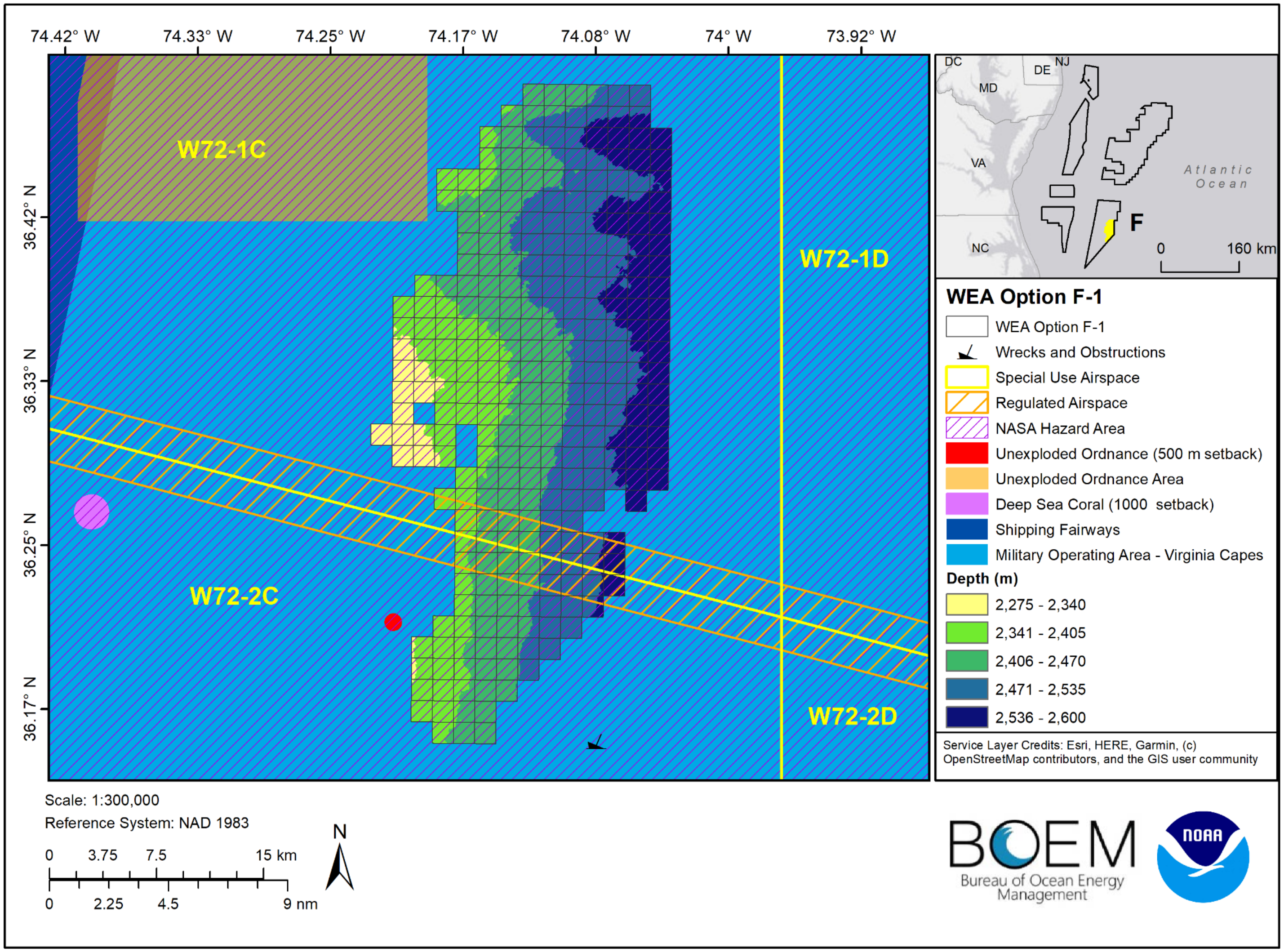


Figure 3.50. Map depicting noteworthy characterization features for Wind Energy Area option F-1.

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Appendix A – Central Atlantic WEA Siting Data Inventory

Table 1. National security data layers

National Security			
Military Operating Area (MOA) - Virginia Capes	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/d ownloads/data/mc/MilitaryAr eas.zip	https://www.fisheries.noaa.gov/inport/item/55364
Special Use Airspace (SUA)	MAIASC	https://hub.arcgis.com/datas ets/dd0d1b726e504137ab3c 41b21835d05b_0/explore?lo cation=31.783141%2C2.891 673%2C2.40	https://www.arcgis.com/sharing/rest/cont ent/items/dd0d1b726e504137ab3c41b21 835d05b/info/metadata/metadata.xml?for mat=default&output=html
Military Regulated Airspace	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/downloads/data/mc/MilitaryRegulatedAirspace.zip	https://www.fisheries.noaa.gov/inport/item/48897
NASA Wallops Flight Exclusion Area	NASA	Received from BOEM	https://services5.arcgis.com/g7OtfotLzNoMMSUp/arcgis/rest/services/NASA_WFF_ExclusionArea_PROPRIETARY/FeatureServer
NASA Hazard Area	NASA	Received from BOEM	https://services5.arcgis.com/g7OtfotLzNoMMSUp/arcgis/rest/services/NASA_WFF_HazardArea_PROPRIETARY/FeatureServer

Unexploded Ordnance (UXO) Areas	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/d ownloads/data/mc/Unexplod edOrdnanceArea.zip	https://www.fisheries.noaa.gov/inport/item/66206
Unexploded Ordnance (UXO) Locations	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/downloads/data/mc/UnexplodedOrdnance.zip	https://www.fisheries.noaa.gov/inport/item/66208
Navy Mission Compatibility Assessment	United States Navy	Received from US Navy	Unpublished
Air Force Mission Compatibility Assessment	United States Air Force	Received from US Air Force	Unpublished
NASA Mission Compatibility Assessment	NASA	Received from NASA	Unpublished

Table 2. Natural and cultural resources data layers

Natural & Cultural Resources			
Atlantic spotted dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Atlantic white-sided dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Bottlenose dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Clymene dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Cuvier’s beaked whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Dwarf and Pygmy sperm whales	NOAA NMFS	PRD Combined Data Layer	Unpublished
Harbor porpoise	NOAA NMFS	PRD Combined Data Layer	Unpublished
Mesoplodon beaked whales	NOAA NMFS	PRD Combined Data Layer	Unpublished
Pantropical spotted dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Pilot whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Risso’s dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Rough-toothed dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Short-beaked common dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Striped dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished

Seals	NOAA NMFS	PRD Combined Data Layer	Unpublished
Blue whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Fin whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Humpback whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Minke whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
North Atlantic right whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Sei whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Sperm whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Atlantic sturgeon	NOAA NMFS	PRD Combined Data Layer	Unpublished
Giant manta ray	NOAA NMFS	PRD Combined Data Layer	Unpublished
Oceanic whitetip shark	NOAA NMFS	PRD Combined Data Layer	Unpublished
Shortnose sturgeon	NOAA NMFS	PRD Combined Data Layer	Unpublished
Green sea turtle	NOAA NMFS	PRD Combined Data Layer	Unpublished
Hawksbill sea turtle	NOAA NMFS	PRD Combined Data Layer	Unpublished
Kemp’s ridley sea turtle	NOAA NMFS	PRD Combined Data Layer	Unpublished
Leatherback sea turtle	NOAA NMFS	PRD Combined Data Layer	Unpublished
Loggerhead sea turtle	NOAA NMFS	PRD Combined Data Layer	Unpublished
NOAA Fish Havens - 500-ft setback	NOAA NOS	https://encdirect.noaa.gov	https://www.fisheries.noaa.gov/inport/item/ 39976

AWOIS Wrecks Polluting, ENC Wrecks and obstructions, ENC Danger Wrecks - 500-ft setback	NOAA and BOEM (i.e., marinecadastre.gov	http://www.nauticalcharts.noaa.gov/hsd/awois.html	https://www.fisheries.noaa.gov/inport/item/ 39961
RULET Wrecks - 500-ft setback	USACE	https://sanctuaries.noaa.gov/protect/ppw/wrecks_regions.html	https://nmssanctuaries.blob.core.windows. net/sanctuaries-prod/media/archive/ protect/ppw/pdfs/2013_potentiallypollutingwrecks.pdf
Model output for deep-sea coral habitat suitability in the U.S. North and Mid-Atlantic	NOAA National Deep Sea Coral Research and Technology Program	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:145923	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:145923
Sea Scallops Average Abundance	TNC	https://www.northeastoceandata.org/data-download/	https://easterndivision.s3.amazonaws.com/Marine/MooreGrant/AveragePresenceAbundanceSMAST.pdf
NCCOS Assessment: Modeled Distribution of sand shoals of the Gulf of Mexico and US Atlantic Coast	NOAA NCCOS	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0221906	https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0221906
Frank R. Lautenberg Deep Sea Coral Protection Area	NOAA	https://www.fisheries.noaa.gov/resource/map/frank-r-lautenberg-deep-sea-coral-protection-areas-map-gis	https://oceandata.rad.rutgers.edu/arcgis/rest/services/Fishing/Lautenberg_DeepSea_Coral_Protection_Area/MapServer
Black-capped petrel annual relative density	Duke University and NOAA	https://tiles.arcgis.com/tiles/g7OtfotLzNoMMSUp/arcgis/rest/services/Black_capped_petrel_WTL1/MapServer	https://tiles.arcgis.com/tiles/g7OtfotLzNoMMSUp/arcgis/rest/services/Black_capped_petrel_WTL1/MapServer

HMS EFH Overfished and Prohibited Sharks	NOAA NMFS	Upon Request	Unpublished
HMS EFH Target Species	NOAA NMFS	Upon Request	Unpublished

Table 3. Industry, transportation, and navigation data layers

Industry, Navigation, and Transportation			
AIS Vessel Traffic 2015 - 2021	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.go v/ais/	https://www.fisheries.noaa.gov/inport/ite m/53161
Submarine Cables - 500-m setback	NOAA and BOEM (i.e., marinecadastre.gov	Confidential; version for public distribution available at https://marinecadastre.go v/downloads/data/mc/Sub marineCable.zip	Confidential; version for public distribution available at https://www.fisheries.noaa.gov/i nport/ite m/57238
Environmental Sensors and Buoys - 500-m setback	NOAA NWS	https://www.ndbc.noaa.g ov/	https://www.ndbc.noaa.gov/
Aids to Navigation (beacons and buoys) - 500-m setback	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.go v/downloads/data/mc/Ato N.zip	https://www.fisheries.noaa.gov/inport/ite m/56120

Shipping Fairways and Regulations	NOAA NOS	http://encdirect.noaa.gov/ theme_layers/data/shippi ng_lanes/shippinglanes.zi p	https://www.fisheries.noaa.gov/inp ort/ite m/39986
Shipping and Safety Fairways and Extensions	USCG	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
NMFS Independent Fisheries Surveys	NOAA NMFS	Upon request	Upon request

Table 4. Commercial and recreational fishing data layers

Commercial and Recreational Fishing			
VMS All Fishing Types Mean (2016 - 2021)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)

Southeast Region Headboat Survey Data (2014 - 2020)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)

Appendix B – Protected Resources Data

Protected Species Considerations for the Marine Spatial Planning Process for the Central Atlantic Offshore Wind Energy Call Area

August 2022

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Disclaimer: NCCOS 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.

Introduction

This document describes the process and data sources used to develop a protected species (i.e. species under NOAA Fisheries jurisdiction protected under the Endangered Species Act (ESA) and/or Marine Mammal Protection Act (MMPA)) layer for inclusion in a spatial suitability model. The model is being developed by NOAA's National Centers for Coastal Ocean Science (NCCOS) to inform the site selection process for the Central Atlantic Call Area being considered for offshore wind energy development by the Bureau of Ocean Energy Management. Considerations for using the protected species layer are also described. This effort builds off of the process used in the Gulf of Mexico (Farmer et al., in prep) to develop a protected species layer for a spatial suitability model used to inform the siting of offshore wind leasing.

The Call Area is located on the U.S. Outer Continental Shelf (OCS) and ranges from 20 to 56 nautical miles offshore the U.S. East Coast between Delaware and North Carolina. The Call Area includes 496 whole OCS blocks and 298 partial blocks and comprises approximately 3,897,388 acres (BOEM 2022).

Methods

For the Central Atlantic protected species layer, 31 species listed under the ESA and/or MMPA whose occurrence overlaps the Central Atlantic Call Area were included in the modeling process

(Table 1). Using the process outlined in Farmer et al. (In Review) and Farmer et al. (In Prep), 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 2021b), the NOAA Fisheries Report to Congress (NOAA 2022b), and expert opinion to inform relative risk in spatial modeling. 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).

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. 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). The giant manta ray data layer uses a distribution model input from Farmer et al. (2022). Green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, and the Atlantic sturgeon data layers are from the Greater Atlantic Region (GAR) and Southeast Region (SER) Section 7 Mappers (NOAA 2021a, NOAA 2022a). 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 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.

Due to the Call Area spanning both the Greater Atlantic and Southeast Regions, outputs from the respective Section 7 Mappers were combined to ensure complete coverage for these species. However, data layers for some species were obtainable from only one of the Section 7 Mappers and thus the spatial coverage of the data layer did not span all the Call Area. Oceanic whitetip shark and hawksbill sea turtle data layers were obtained from the SER Section 7 Mapper and the shortnose sturgeon data layer was obtained from the GAR Section 7 Mapper (the SER Section 7 Mapper layer was further inshore than the Call Area). See the Supplemental Figures for maps of all species input and final output layers.

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 habitat density model (Figure 4). To develop a combined protected species data layer using the Product method described in Farmer et al. (in Review) and Farmer et al. (in Prep), 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 31 species was used to combine the protected species data layer and produce the final combined protected species data layer to be incorporated into the NCCOS spatial suitability model. A final combined data layer was developed for the extent of the entire U.S. Atlantic Coast, containing information and guidance for the Central Atlantic Call Area. Expansion of this model beyond the current Call Area would require consideration of additional species; especially Atlantic salmon. The final protected species data layer is presented at both scales to provide additional context regarding the relative vulnerability of species within the current Call 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 layer.

Common Name	Scientific Name	Data Source	Status	Score
Delphinids				
Atlantic spotted dolphin	*Stenella frontalis*	Duke Habitat-based Density Model	MMPA-protected	0.7
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
Clymene dolphin	*Stenella clymene*	Duke Habitat-based Density Model	MMPA-protected	0.7
Cuvier's beaked whale	*Ziphius cavirostris*	Duke Habitat-based Density Model	MMPA-protected	0.7
Dwarf and pygmy sperm whales	*Kogia spp.*	Duke Habitat-based Density Model	MMPA-protected	0.7
Harbor porpoise	*Phocoena phocoena*	Duke Habitat-based Density Model	MMPA-protected	0.7
Mesoplodont beaked whales	*Mesoplodon spp.*	Duke Habitat-based Density Model	MMPA-protected	0.7
Pantropical spotted dolphin	*Stenella attenuata*	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

Rough-toothed dolphin	*Steno bredanensis*	Duke Habitat-based Density Model	MMPA protected	0.7
Short-beaked common dolphin	*Delphinus delphis*	Duke Habitat-based Density Model	MMPA-protected	0.7
Striped dolphin	*Stenella coeruleoalba*	Duke Habitat-based Density Model	MMPA protected	0.8
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 sturgeon (All DPSs)	*Acipenser oxyrinchus oxyrinchus*	GAR/SER Section 7 Mappers	Endangered	0.2
Giant manta ray	*Manta birostris*	Farmer et al. 2022	Threatened	0.4

Oceanic whitetip shark	*Carcharhinus longimanus*	SER Section 7 Mapper	Threatened	0.4
Shortnose sturgeon	*Acipenser brevirostrum*	GAR Section 7 Mapper	Endangered	0.5
Sea Turtles				
Green sea turtle (North Atlantic, South Atlantic DPSs)	*Chelonia mydas*	GAR/SER Section 7 Mappers	Threatened	0.5
Hawksbill sea turtle	*Eretmochelys imbricata*	SER Section 7 Mapper	Endangered	0.2
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, 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.

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 for all species considered in the final combined protected species 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 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 MSP process (Figure 1).

The final combined product layers were generated using the product method. The extent of the combined product layer for all 31 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 Call Area. Both final combined layers show relatively higher vulnerabilities for protected species across the Call Area and in particular along the shelf environments of the U.S. Mid-Atlantic (Figures 2).

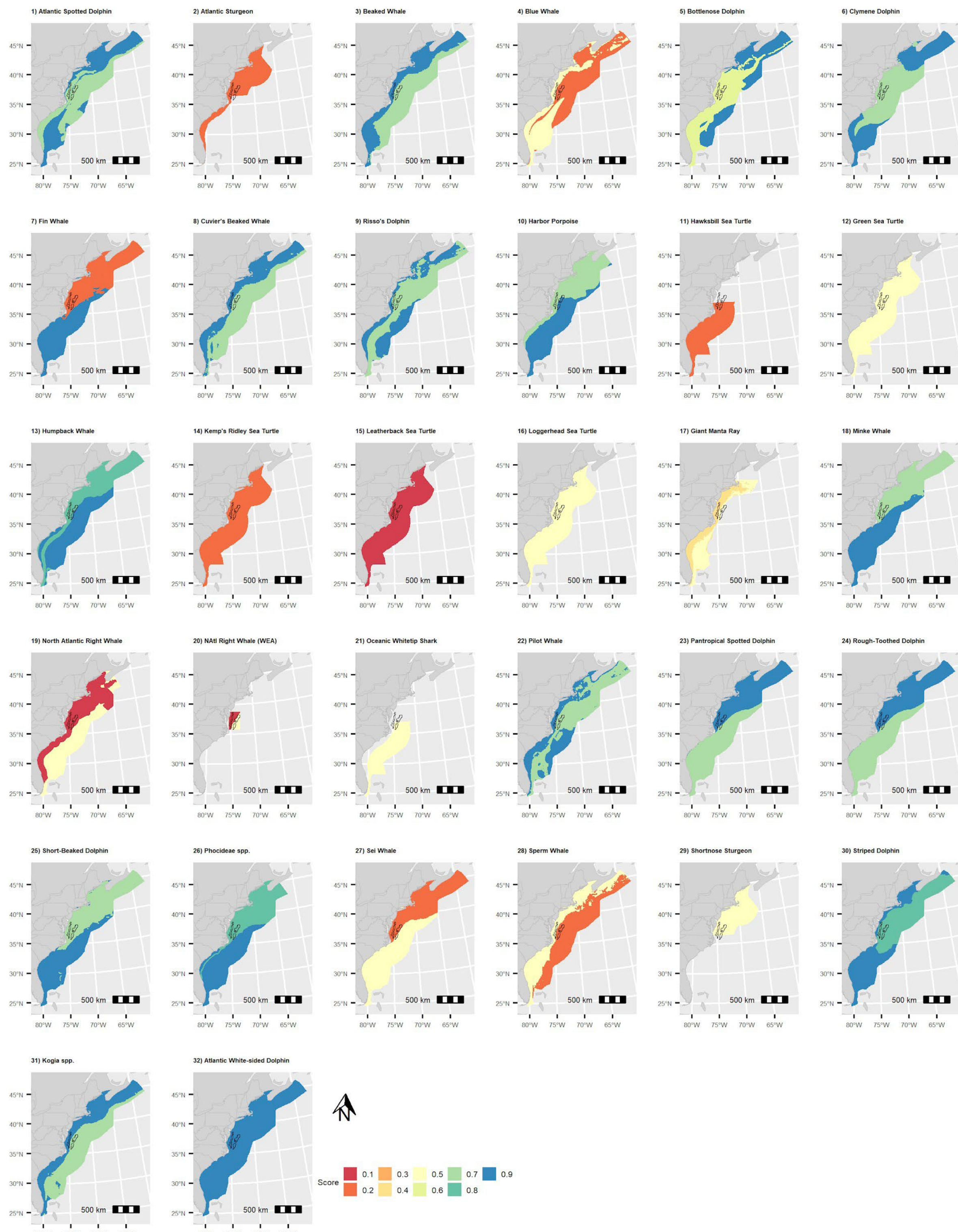

Figure 1. Scores across all 31 protected species data layers. Black outlined areas show the Central Atlantic Call Area. Calculated scores for all species. Note that North Atlantic right whales have two scores, plot 19 shows scores for the U.S. Atlantic Coast extent and plot 20 shows scores for the Central Atlantic Call Area.

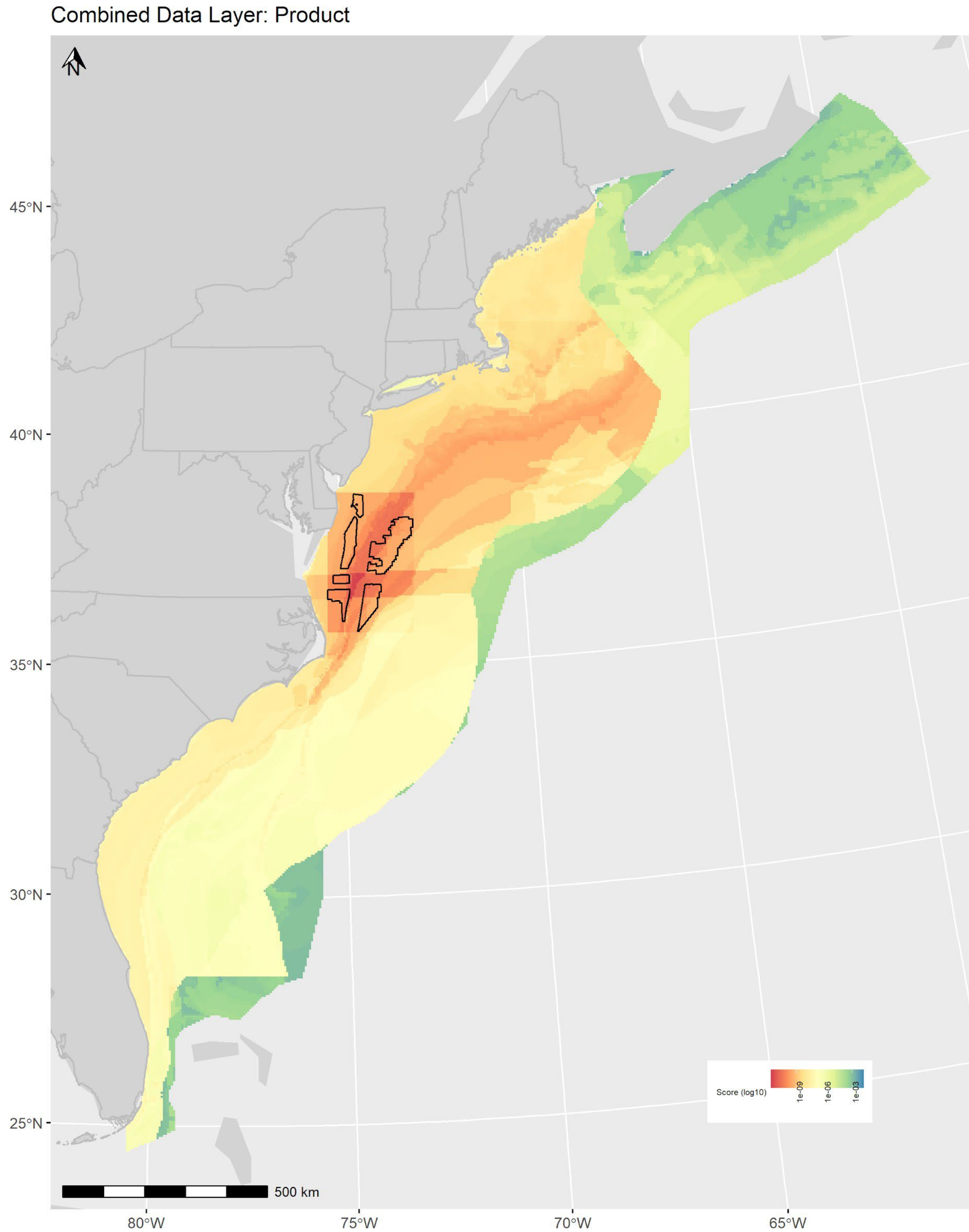

Figure 2. Final combined protected species data layer for the Central Atlantic Call Area showing the U.S. Atlantic Coast extent. Black outlined areas show the Central Atlantic Call Area. Spatial distribution of risk for protected species based on vulnerability and trend, with layers combined using the product of risk scores across all 31 species considered.

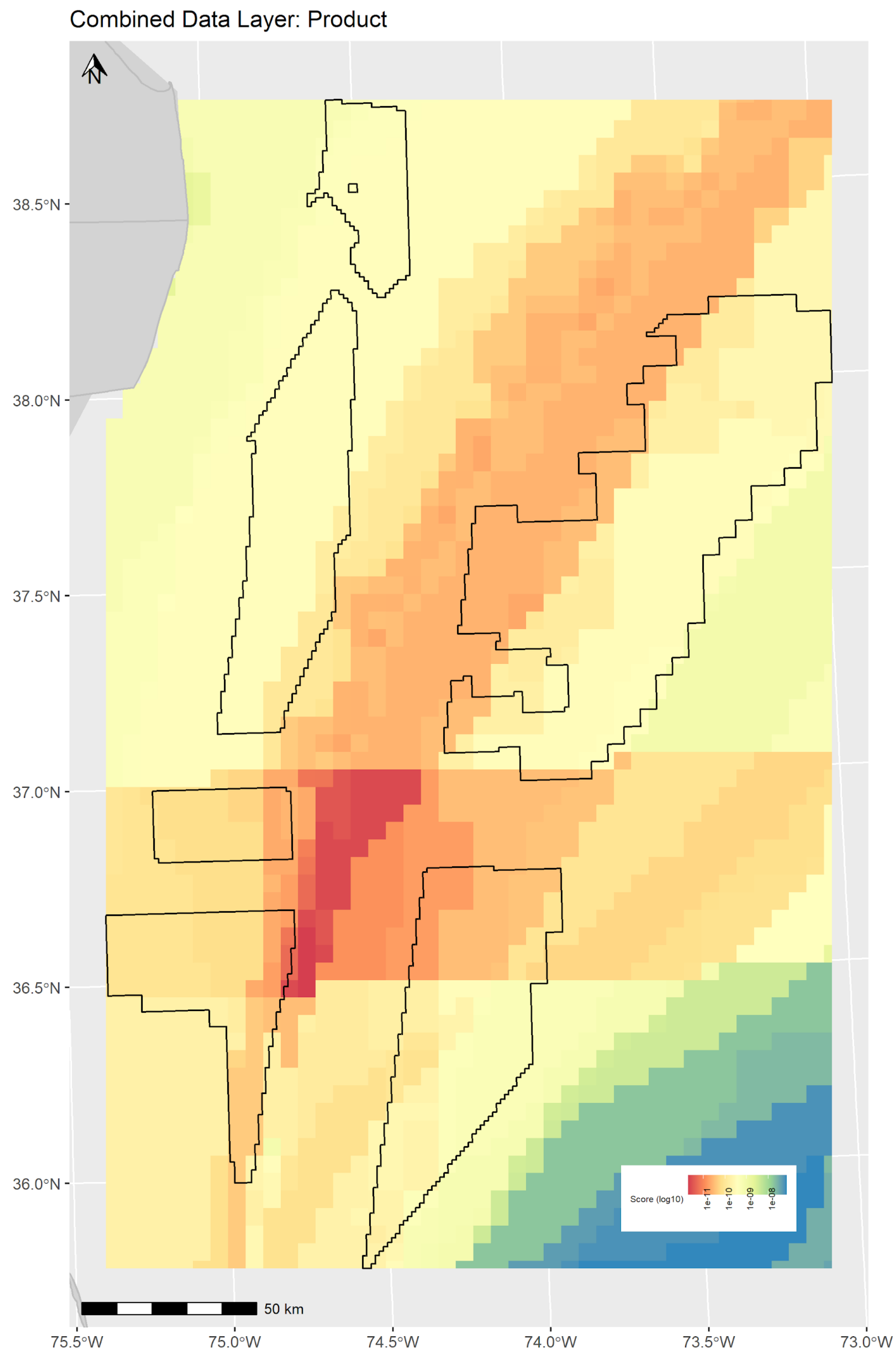

Figure 3. Final combined protected species data layer for the Central Atlantic Call Area showing the Call Area extent. Spatial distribution of risk for protected species based on vulnerability and trend, with layers combined using the product of risk scores across all 31 species considered.

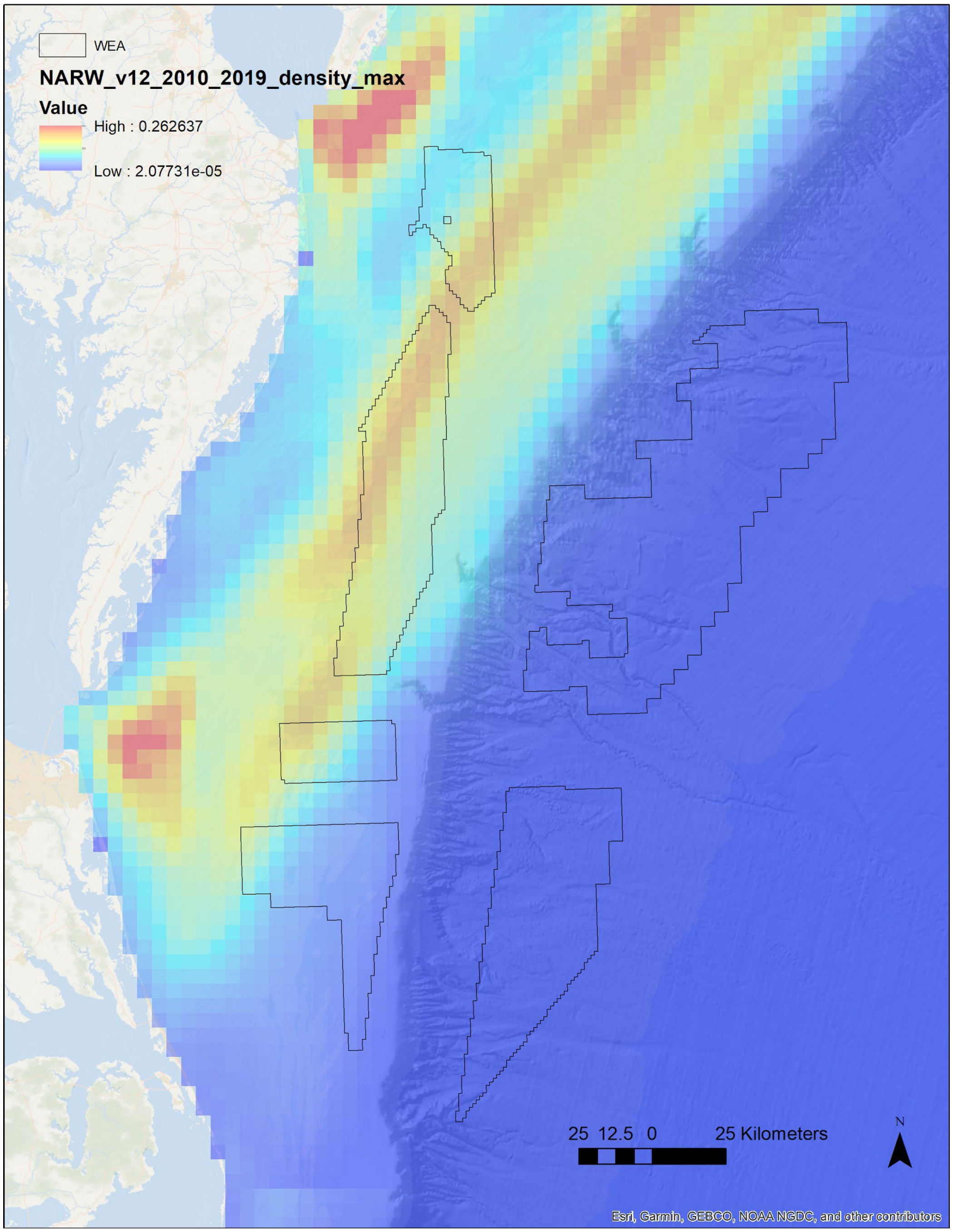

Figure 4. North Atlantic right whale density model output relative to Central Atlantic Call Area. Black outlined areas show the Central Atlantic Call Area.

Discussion

It should be noted that the protected species layer for the Central Atlantic Call Area was completed in a short amount of time and awareness of the data should be taken when utilizing the output. However, the process undertaken to develop the layer is an established process (see Farmer et al. In Review; Farmer et al. In Prep) and the best available data sources were incorporated into the development of the protected species layer. Additionally, although there is a final combined protected species data layer forthe extent of the U.S. Atlantic, this effort was focused on the Central Atlantic Call Area and the species that are likely to occur there. Thus this layer may not be suitable for marine spatial planning purposes in other areas along the U.S. Atlantic coast. For application of the results please contact the authors.

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 offshore wind energy planning prior to lease sales taking place. In this effort we integrated across 31 protected species using a variety of available data to inform the Central Atlantic Call 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 Central Atlantic Call Area, though results are not likely to vary. It should be noted that the respective Section 7 Mapper data layers (e.g., Atlantic and shortnose sturgeon, oceanic whitetip shark) are not distribution models, they just display species presence and thus show no contrast in the final outputs and thus does not inform the marine spatial planning process (see plots 2, 11, 12, 14, 15, 16, 21, and 29 in Figure 1). Furthermore, in plots 2, 11, 12, 14, 15, 16, 21, and 29 in Figure 1 there is a horizontal artifact at the Virginia/North Carolina border, where the GAR and SER Section 7 Mapper layers overlap. In the two final combined protected species data layers there is a vertical artifact around the entire Call Area area, due to the incorporation of the Call Area-restricted score for North Atlantic right whale. The Section 7 Mapper layers were included in the protected species layer for completeness because it is anticipated that these species do occur in the Call 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, but the models will not be available until Fall 2022. 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). The giant manta ray data layer uses a distribution model input from Farmer et al. (2022).

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 (plot 19, Figure 1). However, upon examining the output for the U.S. Atlantic Coast extent, it showed all of the Call 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 looking at the Duke density model output (Figure 4) and right whale sightings data (Johnson et al. 2021), there was a clear differentiation between on-shelf and off-shelf habitat use. Thus, to provide greater resolution to inform the marine spatial planning process we created an additional spatially scored output that was clipped to the Call Area (plot 20, Figure 1). In this plot you can see that the Call Area blocks under consideration on the continental shelf are above the median score and the Call Area blocks off the continental shelf are below the median score. These two outputs were joined together with the other 30 protected species spatial outputs, to create a final combined protected species data layer for the U.S. Atlantic Coast (Figure 2) and a final combined protected species data layer for the Call Area (Figure 3). The two layers 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. 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 Central Atlantic Call Area but also to contrast the suitability of this Call Area to other regions along the U.S. Atlantic coast.

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Supplemental Figures

Note: Scores in the second pane may differ from Table 1 and are clarified in the figure caption. The Atlantic white-sided dolphin pane is missing.

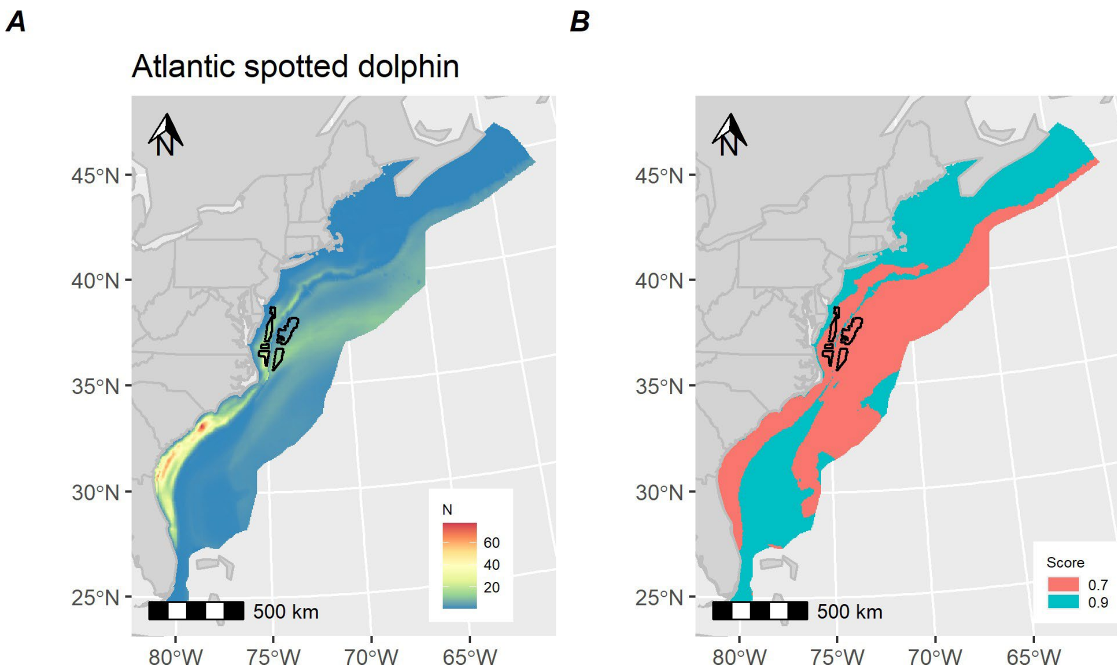

Figure S-1. Atlantic spotted dolphin distribution and score. A) Estimated abundance of Atlantic spotted dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for Atlantic spotted dolphin showing areas above (coral) and below (teal) median predictions from distribution model.

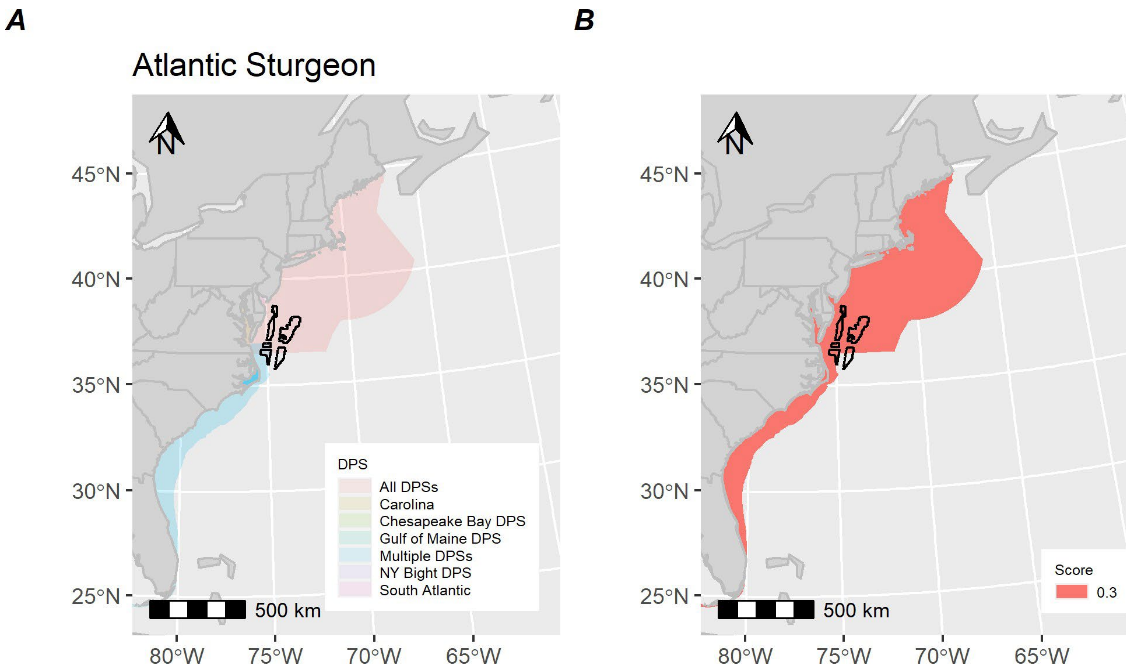

Figure S-2. Atlantic sturgeon range and score. A) Greater Atlantic Region Section 7 Mapper area (light red) and Southeast Region Section 7 Mapper area (light blue) for Atlantic sturgeon. B) Calculated score for Atlantic sturgeon showing areas receiving a score. Note score in panel B should be 0.2.

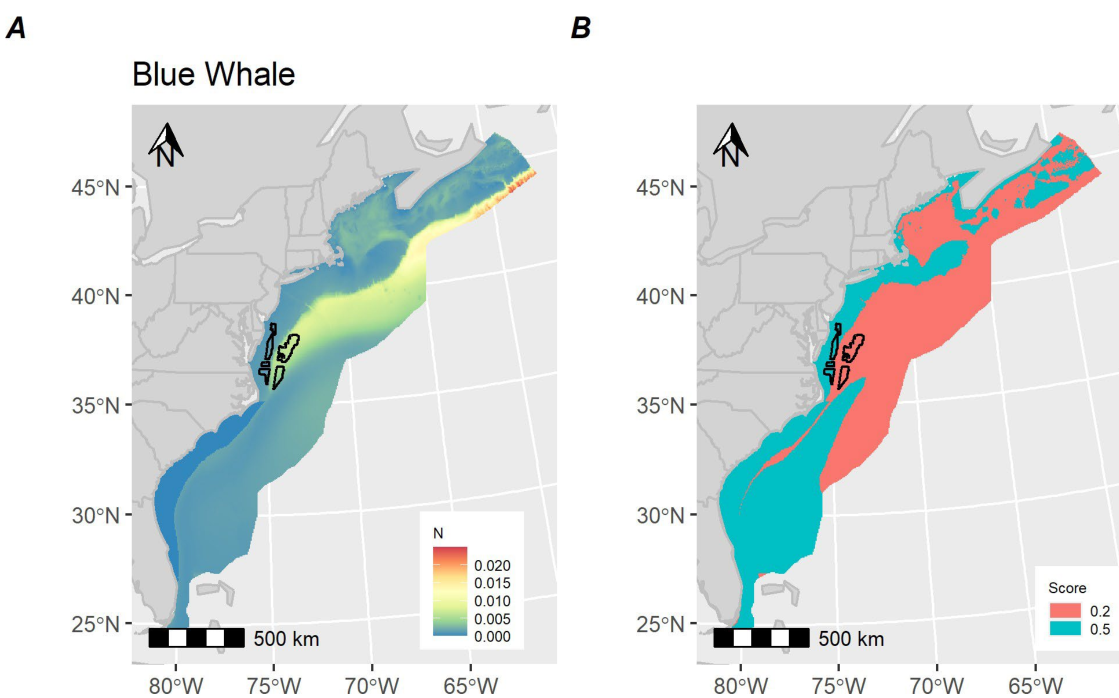

Figure S-3. Blue whale distribution and score. A) Estimated abundance of blue whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for blue whale showing areas above (coral) and below (blue) median predictions from distribution model.

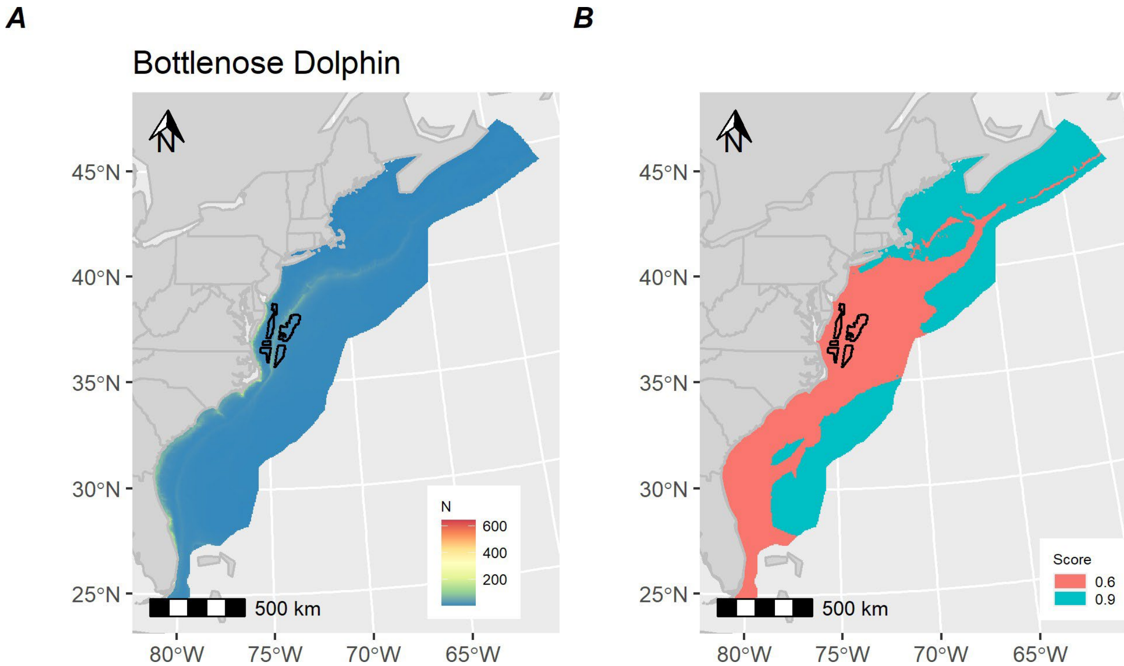

Figure S-4. Bottlenose dolphin distribution and score. A) Estimated abundance of bottlenose dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for bottlenose dolphin showing areas above (coral) and below (teal) median predictions from distribution model.

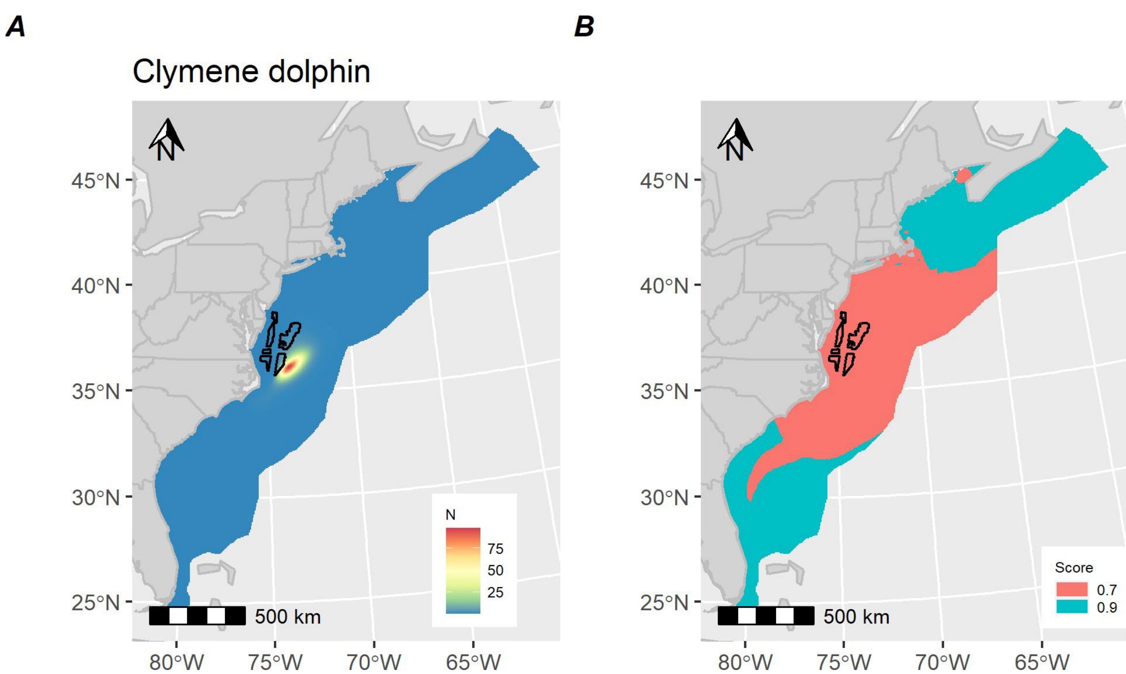

Figure S-5. Clymene dolphin (shelf) distribution and score. A) Estimated abundance of Clymene dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for Clymene dolphin showing areas above (coral) and below (teal) median predictions from distribution model.

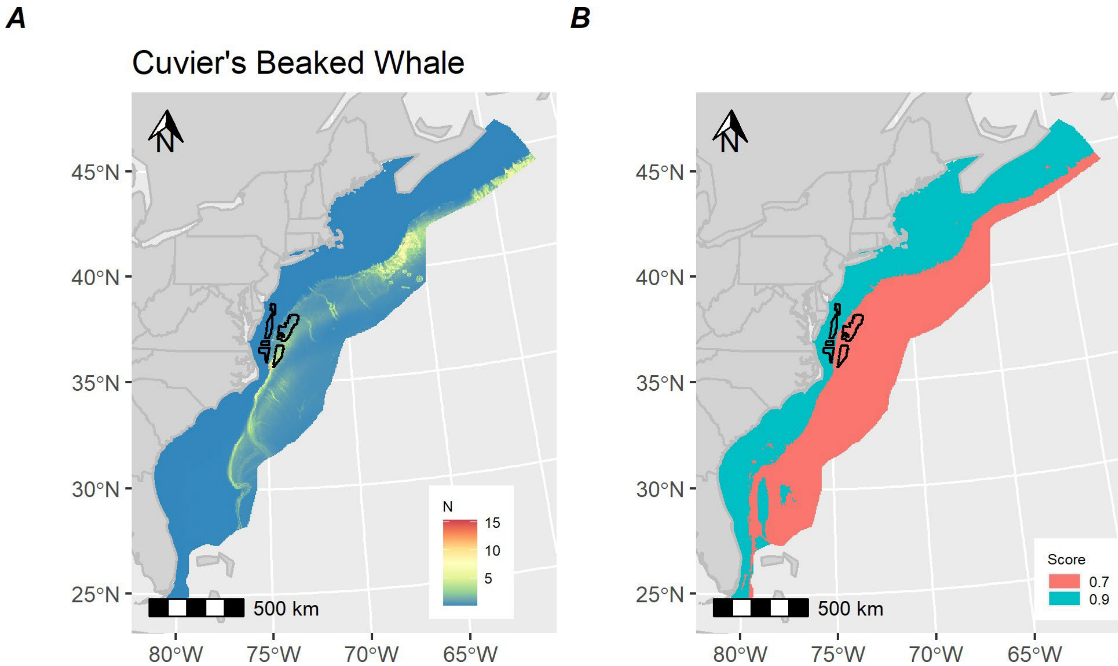

Figure S-6. Cuvier's beaked whale distribution and score. A) Estimated abundance of Cuvier's beaked whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for Cuvier's beaked whale showing areas above (coral) and below (teal) median predictions from distribution model.

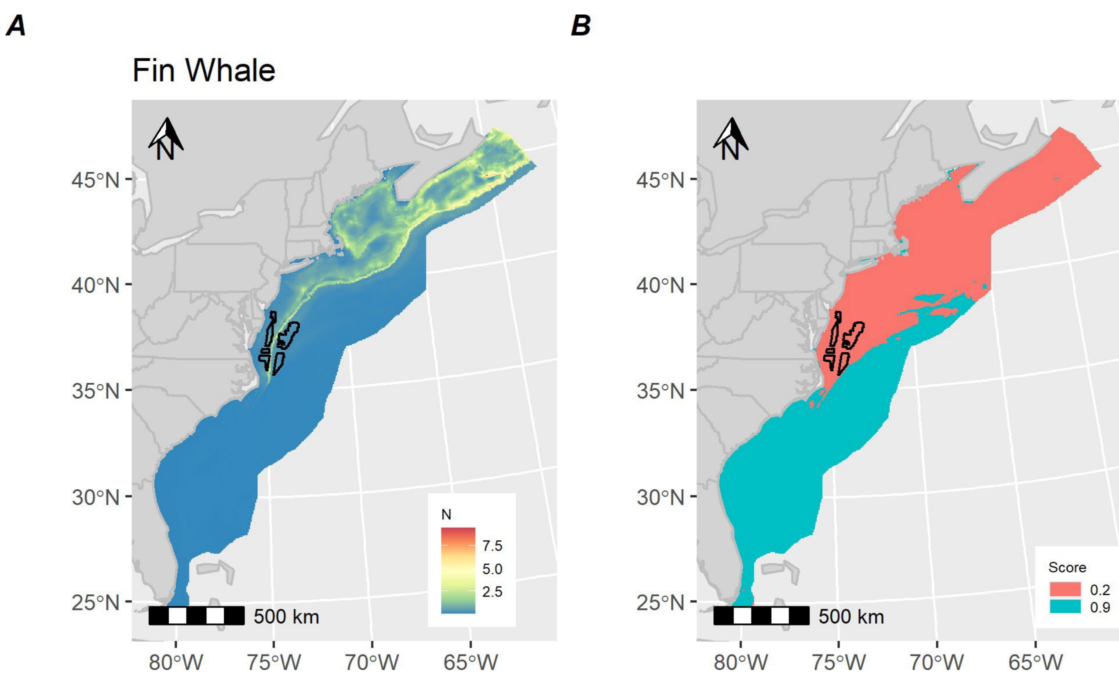

Figure S-7. Fin whale distribution and score. A) Estimated abundance of fin whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for fin whale showing areas above (coral) and below (teal) median predictions from distribution model.

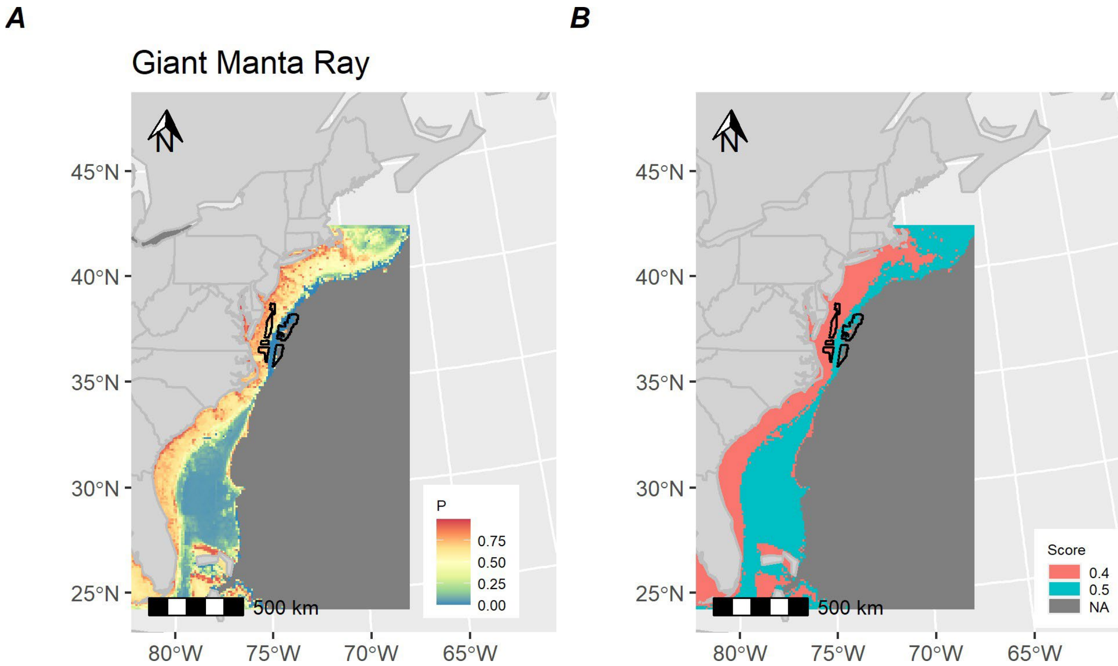

Figure S-8. Giant manta ray distribution and score. A) Estimated abundance of giant manta rays along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for giant manta ray showing areas above (coral) and below (teal) median predictions from distribution model.

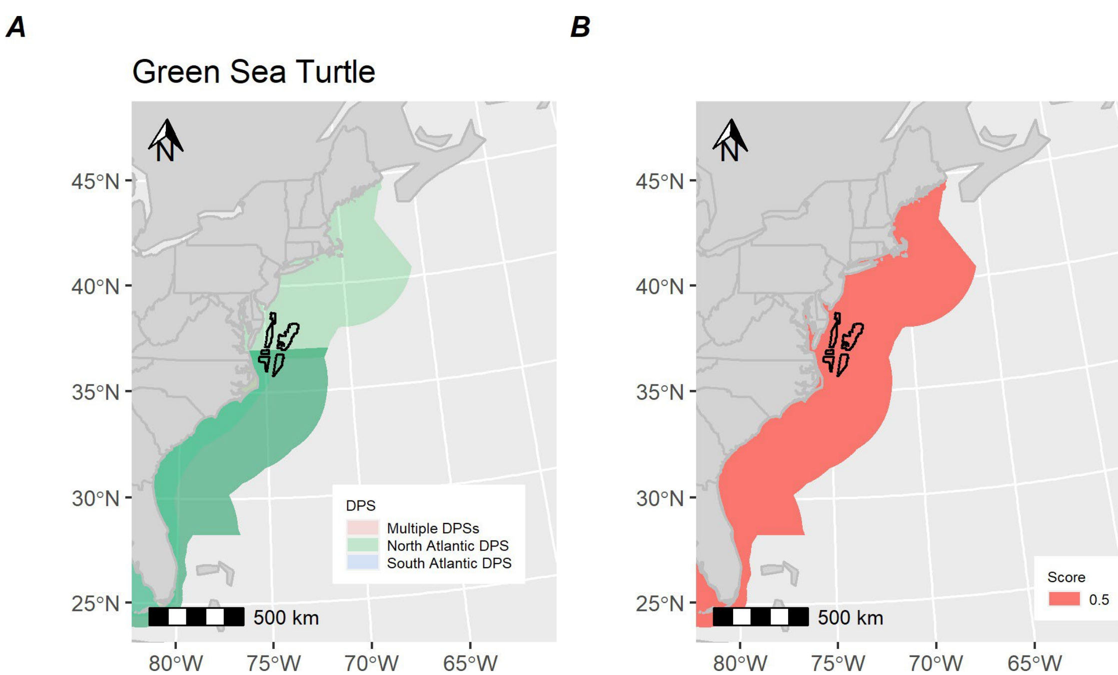

Figure S-9. Green sea turtle range and score. A) Greater Atlantic Region Section 7 Mapper area (light green) and Southeast Region Section 7 Mapper area (dark green) for Green sea turtles. B) Calculated score for Green sea turtle showing areas receiving a score.

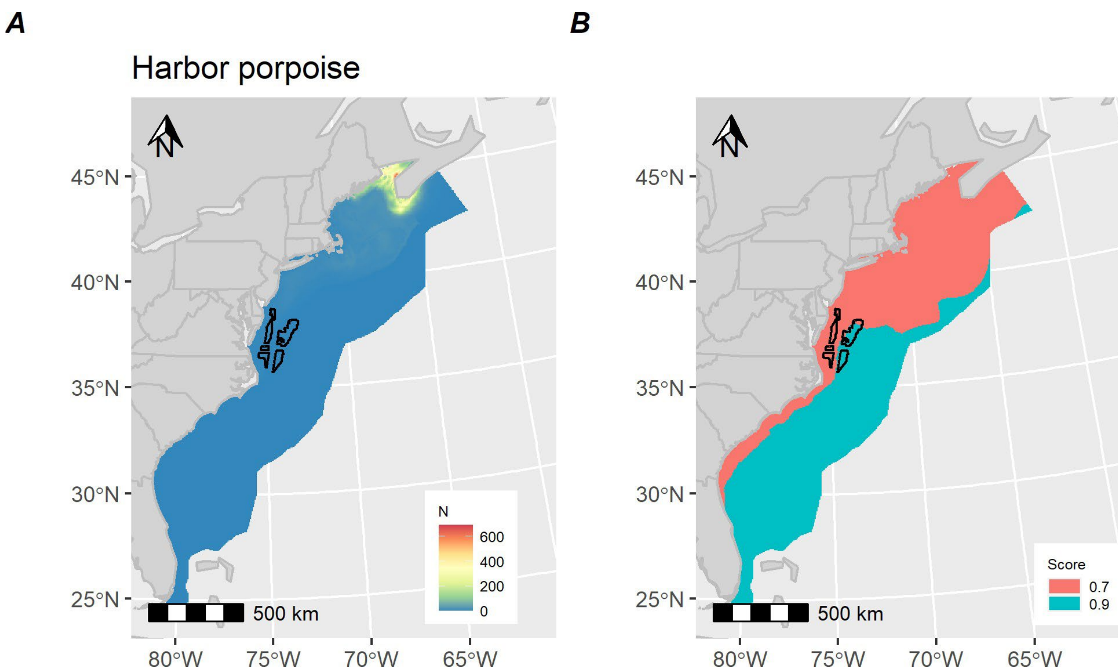

Figure S-10. Harbor porpoise distribution and score. A) Estimated abundance of harbor porpoise along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for harbor porpoise showing areas above (coral) and below (teal) median predictions from distribution model.

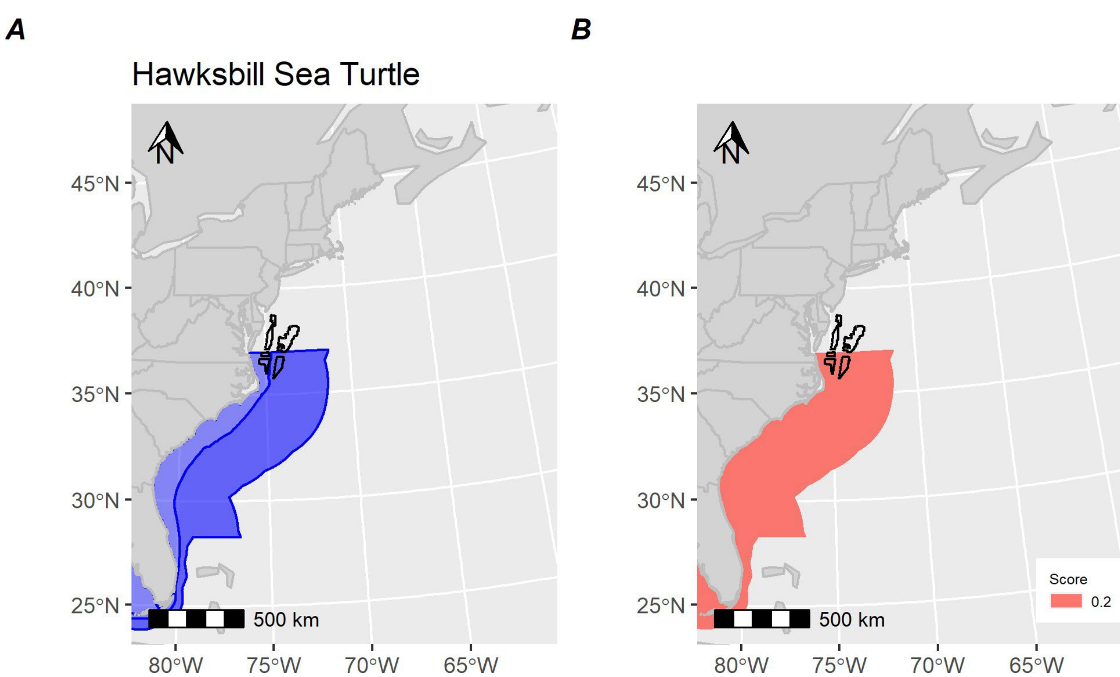

Figure S-11. Hawksbill sea turtle range and score. A) Southeast Region Section 7 Mapper area (blue) for hawksbill sea turtles, note no Greater Atlantic Region Section 7 Mapper layer for this species. B) Calculated score for hawksbill sea turtle showing areas receiving a score.

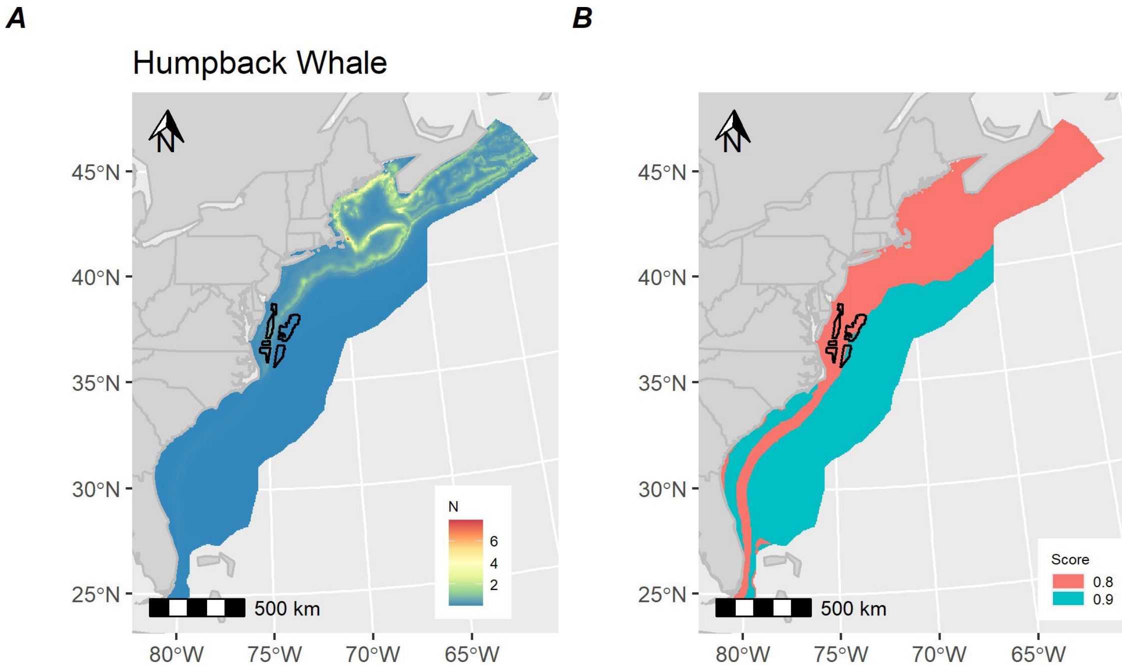

Figure S-12. Humpback whale distribution and score. A) Estimated abundance of humpback whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for humpback whale showing areas above (coral) and below (teal) median predictions from distribution model.

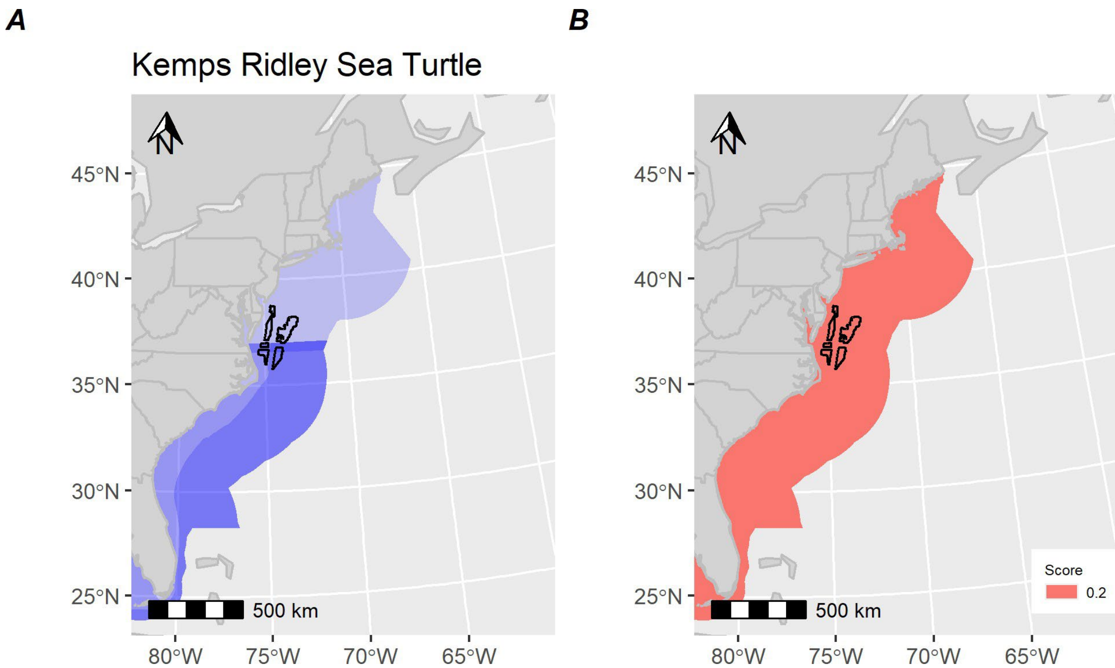

Figure S-13. Kemp's ridley sea turtle range and score. A) Greater Atlantic Region Section 7 Mapper area (light blue) and Southeast Region Section 7 Mapper area (dark blue) for Kemp's ridley sea turtle. B) Calculated score for Kemp's ridley sea turtle showing areas receiving a score.

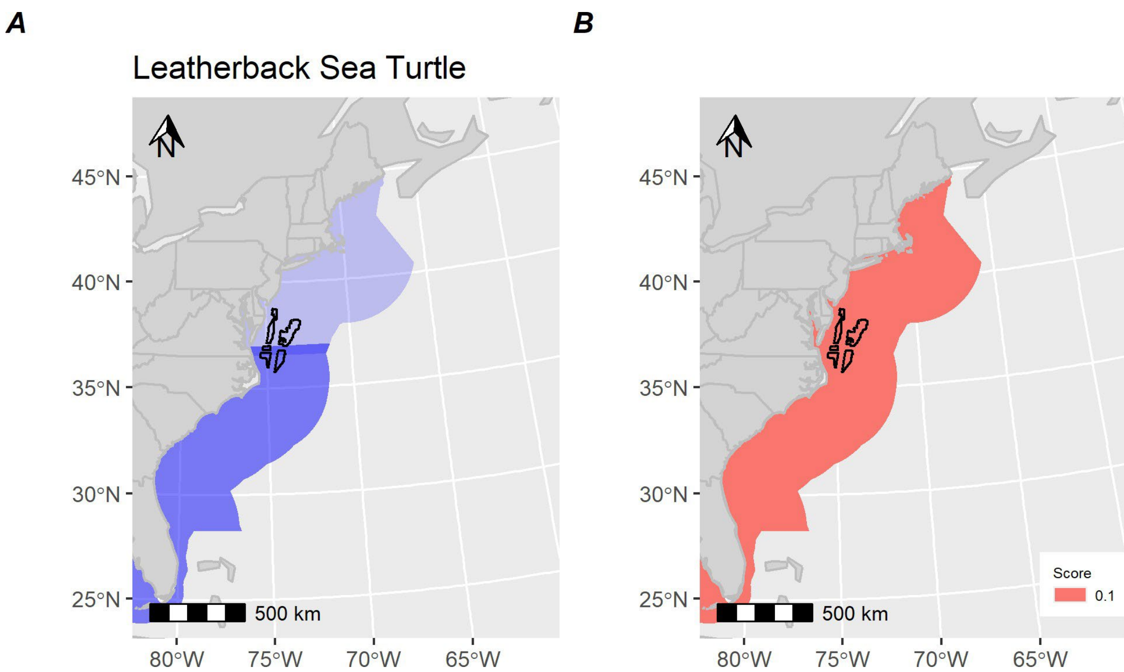

Figure S-14. Leatherback sea turtle range and score. A) Greater Atlantic Region Section 7 Mapper area (light blue) and Southeast Region Section 7 Mapper area (dark blue) for leatherback sea turtles. B) Calculated score for leatherback sea turtle showing areas receiving a score.

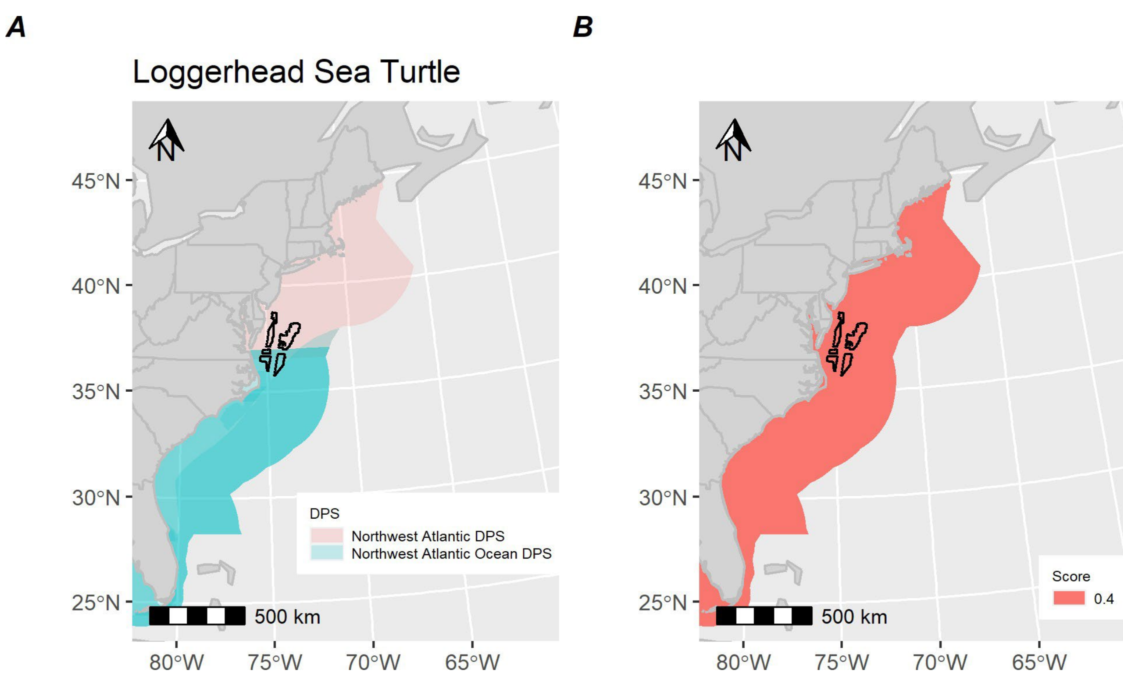

Figure S-15. Loggerhead sea turtle range and score. A) Greater Atlantic Region Section 7 Mapper area (light red) and Southeast Region Section 7 Mapper area (light teal) for loggerhead sea turtles. B) Calculated score for loggerhead sea turtle showing areas receiving a score. Note score in panel B should be 0.5.

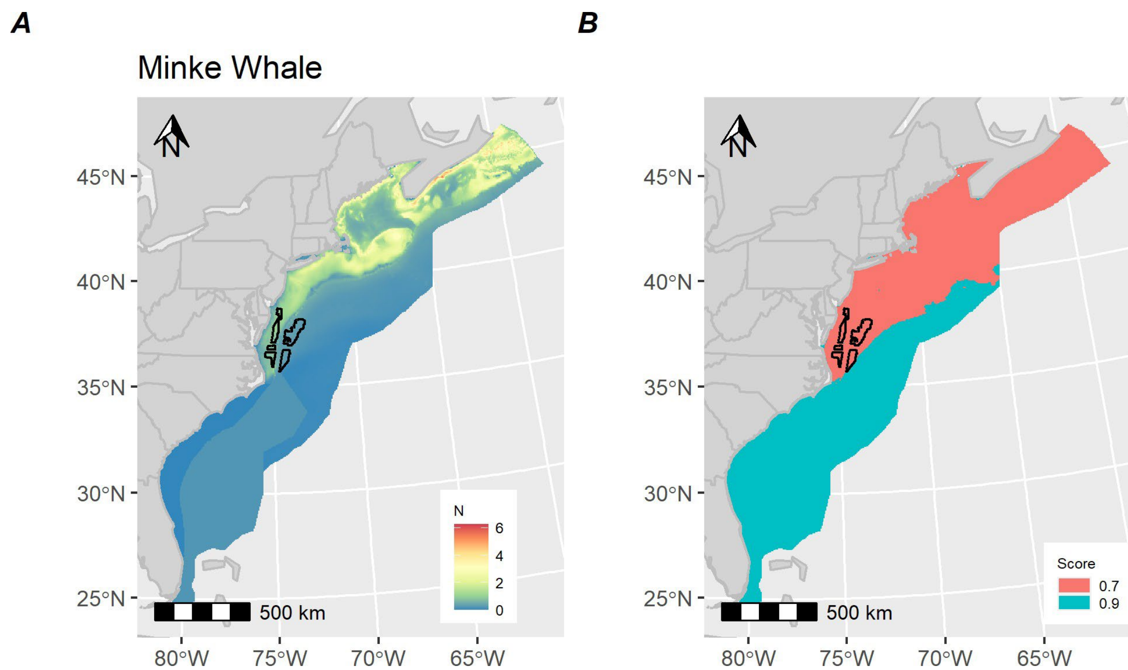

Figure S-16. Minke whale distribution and score. A) Estimated abundance of minke whales along the
U.S. Atlantic Coast based on a species distribution model. B) Calculated score for minke whale showing areas above (coral) and below (teal) median predictions from distribution model.

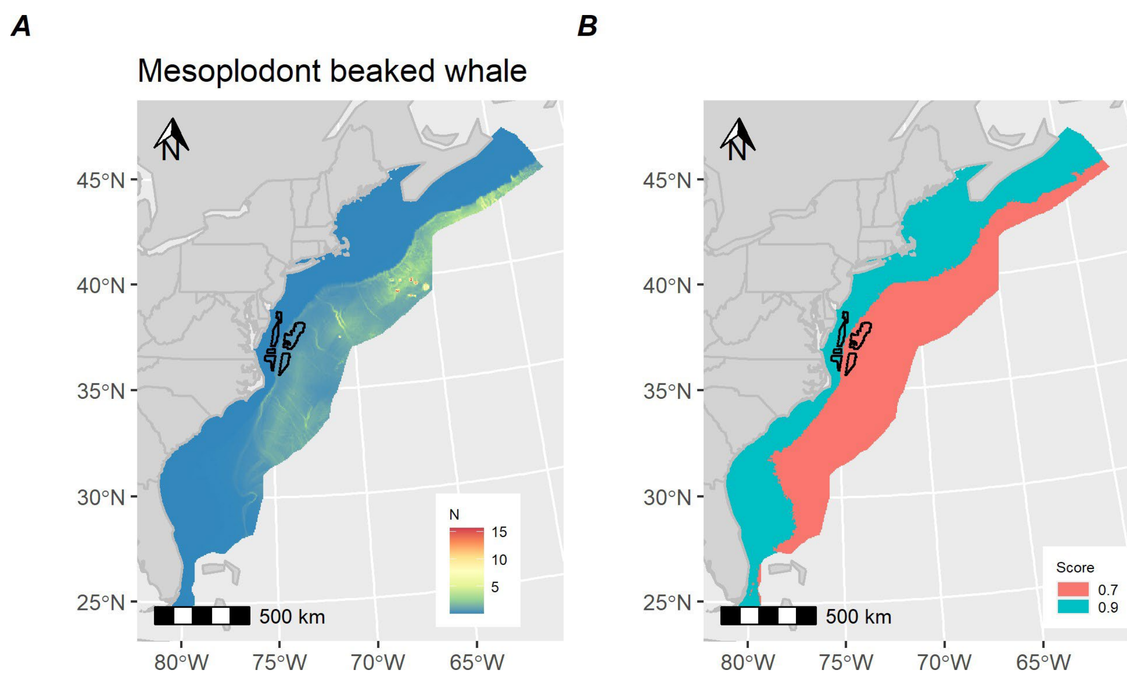

Figure S-17. Mesoplodont beaked whale distribution and score. A) Estimated abundance of Mesoplodont beaked whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for Mesoplodont beaked whale showing areas above (coral) and below (teal) median predictions from distribution model.

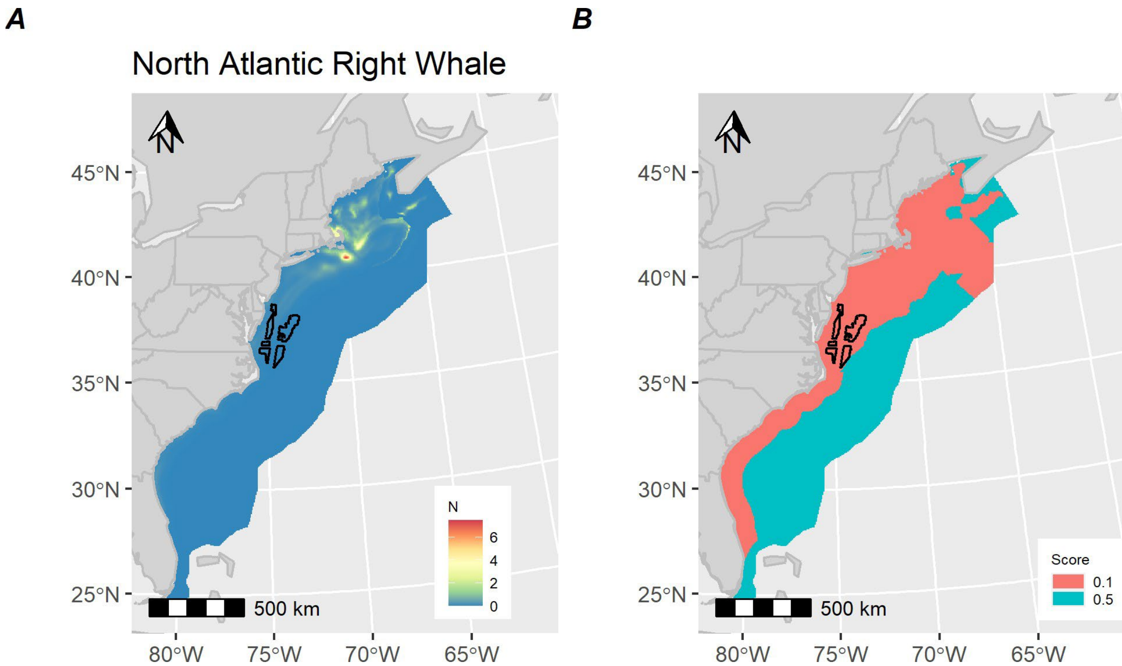

Figure S-18. North Atlantic right whale distribution and score. A) Estimated abundance of North Atlantic right whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for North Atlantic right whale showing areas above (coral) and below (teal) median predictions from distribution model.

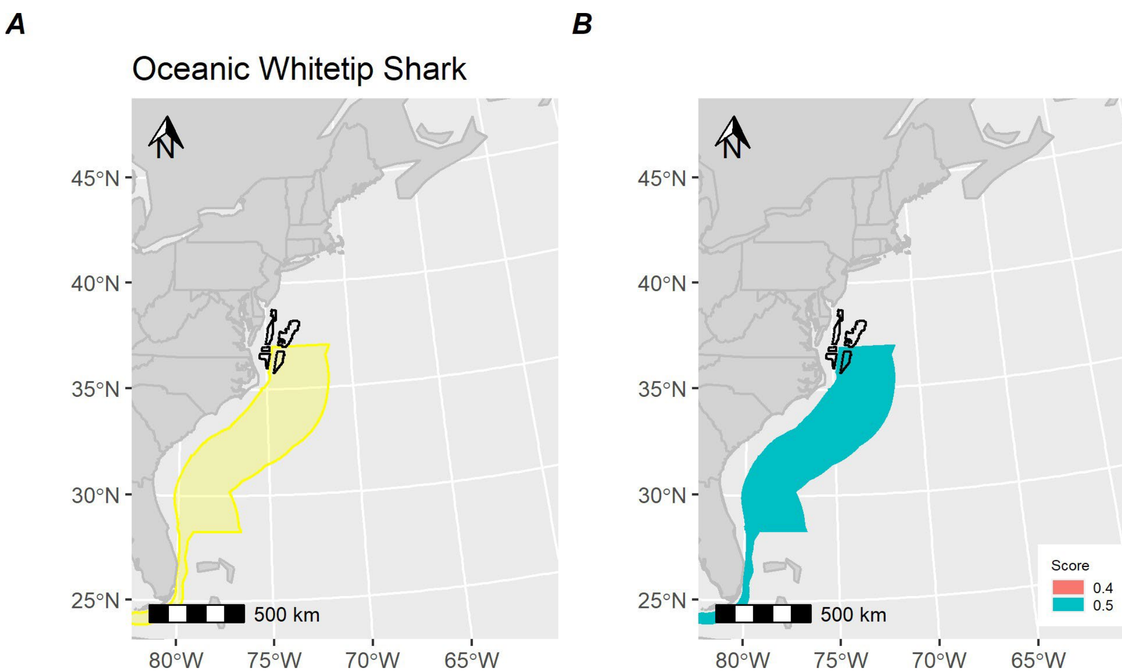

Figure S-19. Oceanic whitetip shark range and score. A) Southeast Region Section 7 Mapper area (light yellow) for Oceanic whitetip shark, note no Greater Atlantic Region Section 7 Mapper layer for this species. B) Calculated score for oceanic whitetip shark showing areas receiving a score.

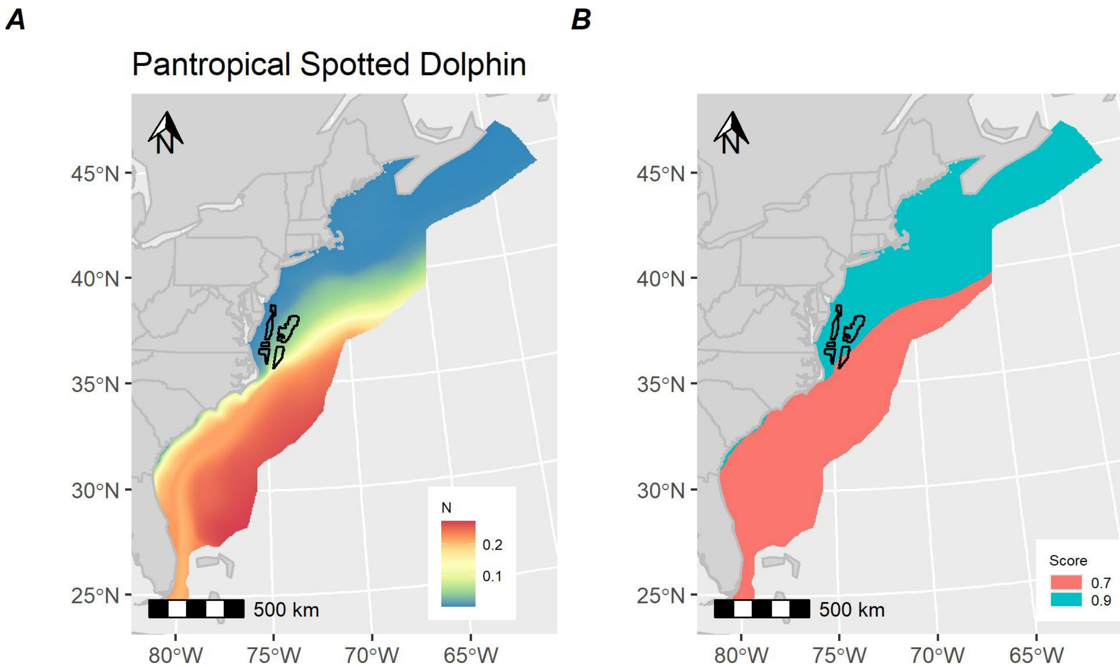

Figure S-20. Pantropical spotted dolphin distribution and score. A) Estimated abundance of pantropical spotted dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for pantropical spotted dolphin showing areas above (coral) and below (teal) median predictions from distribution model.

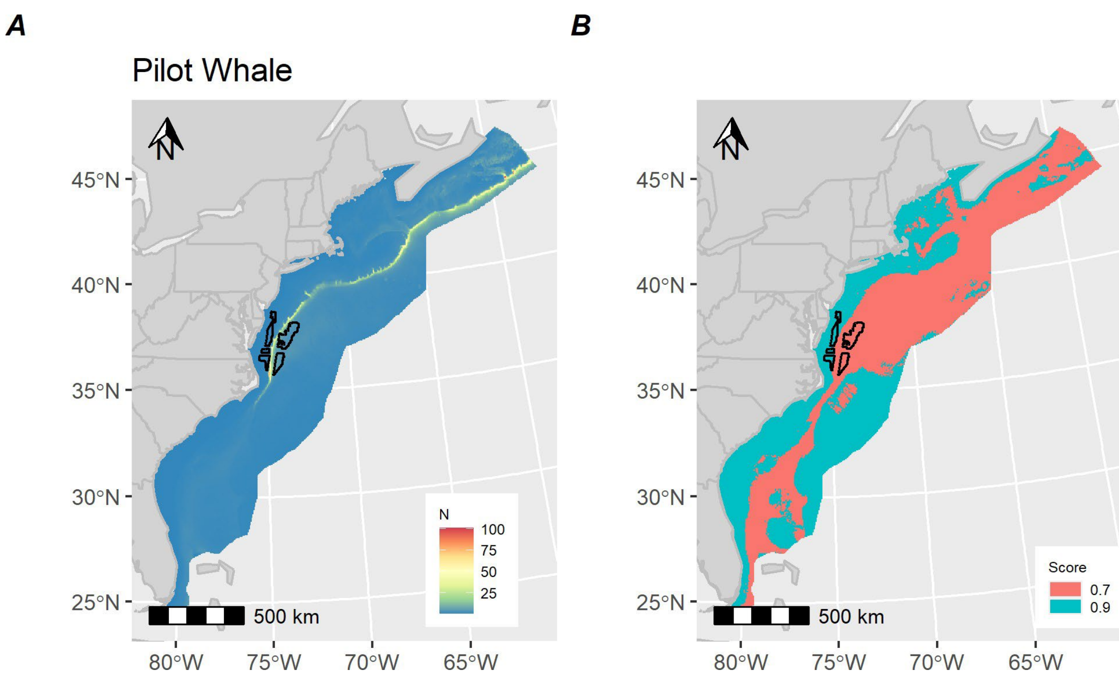

Figure S-21. Pilot whale distribution and score. A) Estimated abundance of pilot whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for pilot whales showing areas above (coral) and below (teal) median predictions from distribution model.

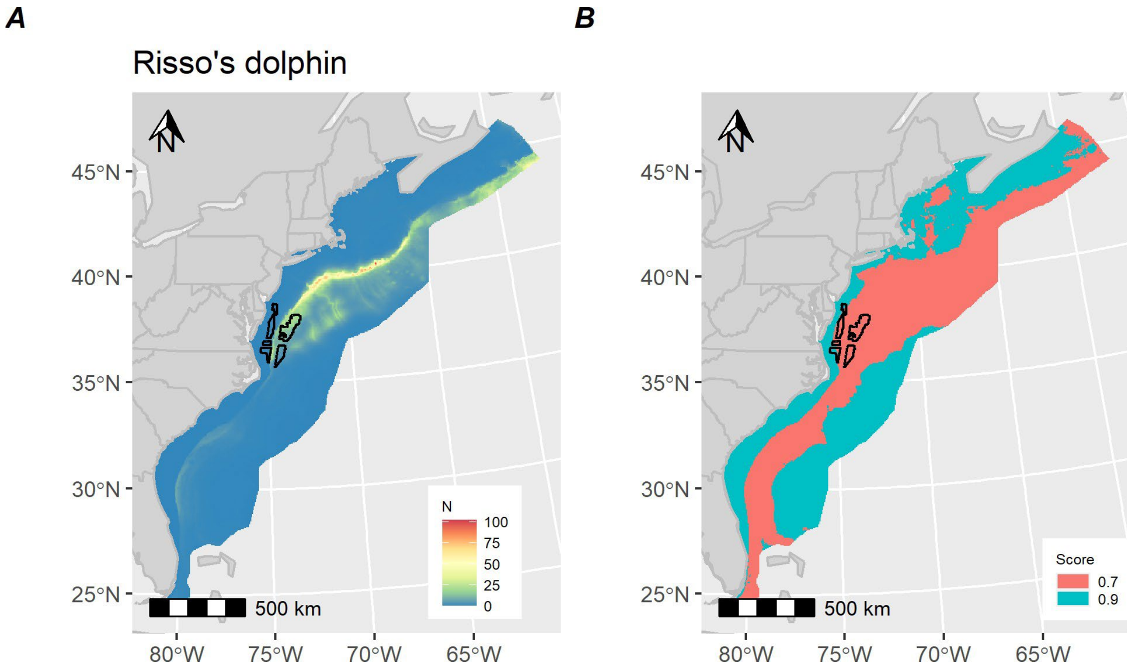

Figure S-22. Risso's dolphin distribution and score. A) Estimated abundance of Risso's dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for Risso's dolphins showing areas above (coral) and below (teal) median predictions from distribution model.

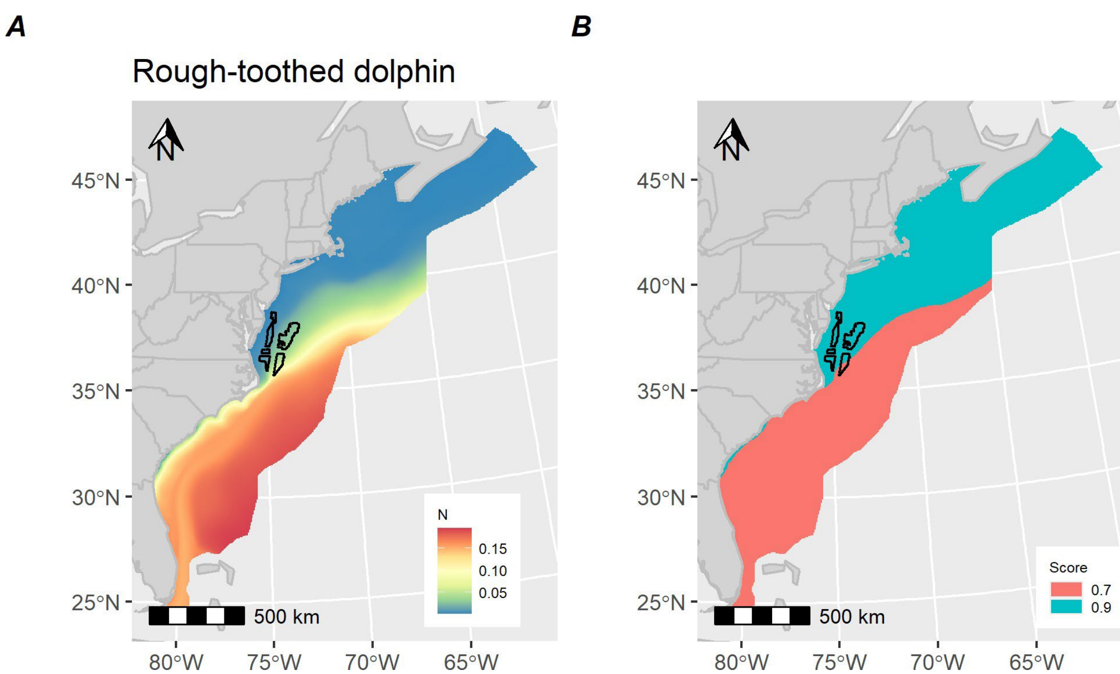

Figure S-23. Rough-toothed dolphin distribution and score. A) Estimated abundance of rough-toothed dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for rough-toothed dolphins showing areas above (coral) and below (teal) median predictions from distribution model.

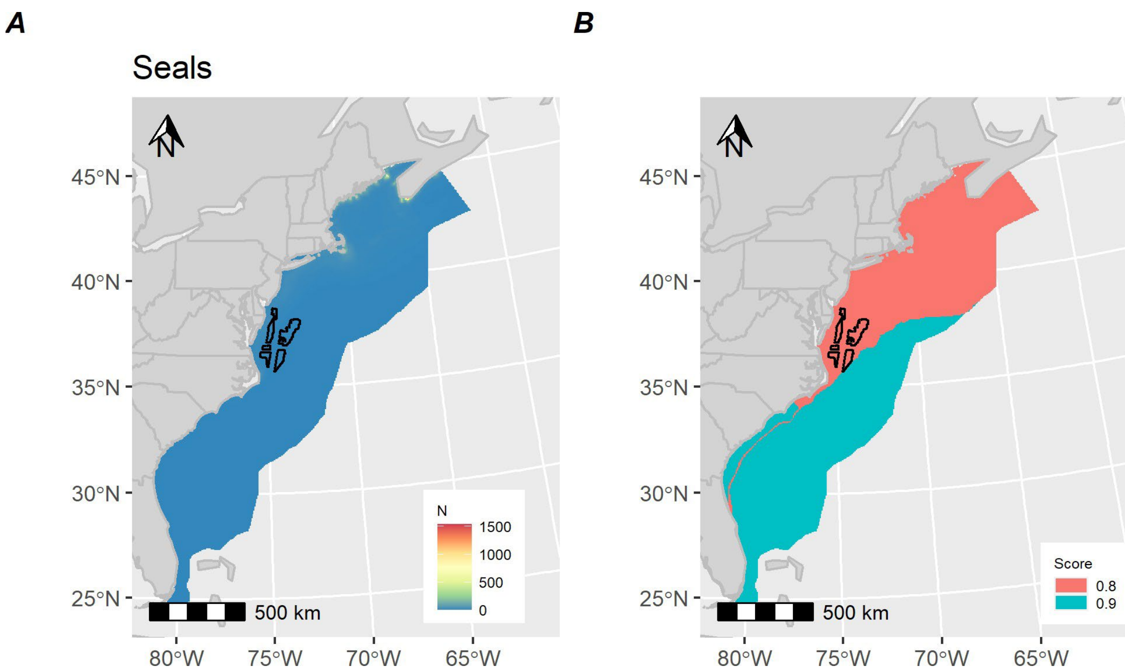

Figure S-24. Seals (spp.) distribution and score. A) Estimated abundance of seals along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for seals showing areas above (coral) and below (teal) median predictions from distribution model.

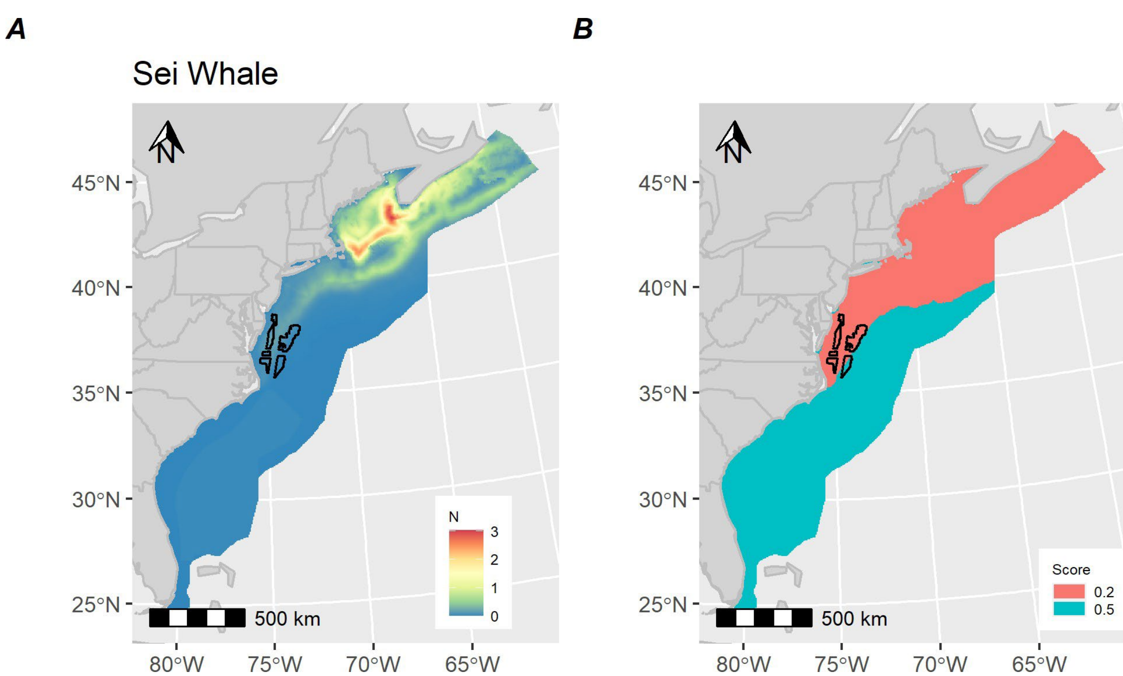

Figure S-25. Sei whale distribution and score. A) Estimated abundance of sei whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for sei whales showing areas above (coral) and below (teal) median predictions from distribution model.

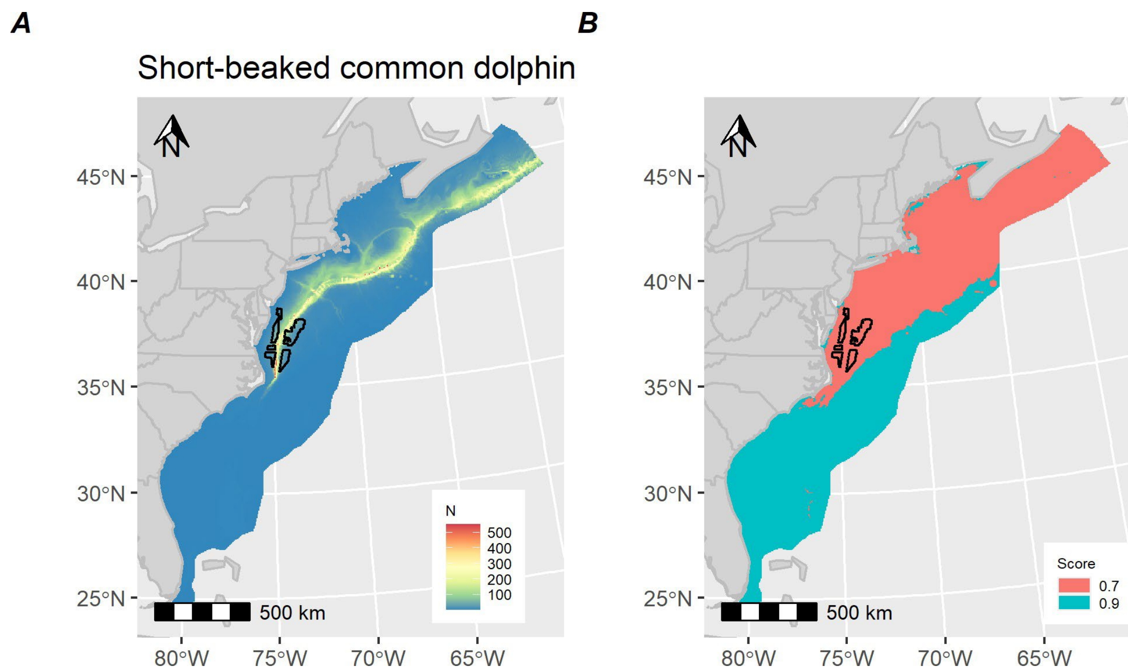

Figure S-26. Short-beaked common dolphin distribution and score. A) Estimated abundance of short-beaked common dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for short-beaked common dolphins showing areas above (coral) and below (teal) median predictions from distribution model.

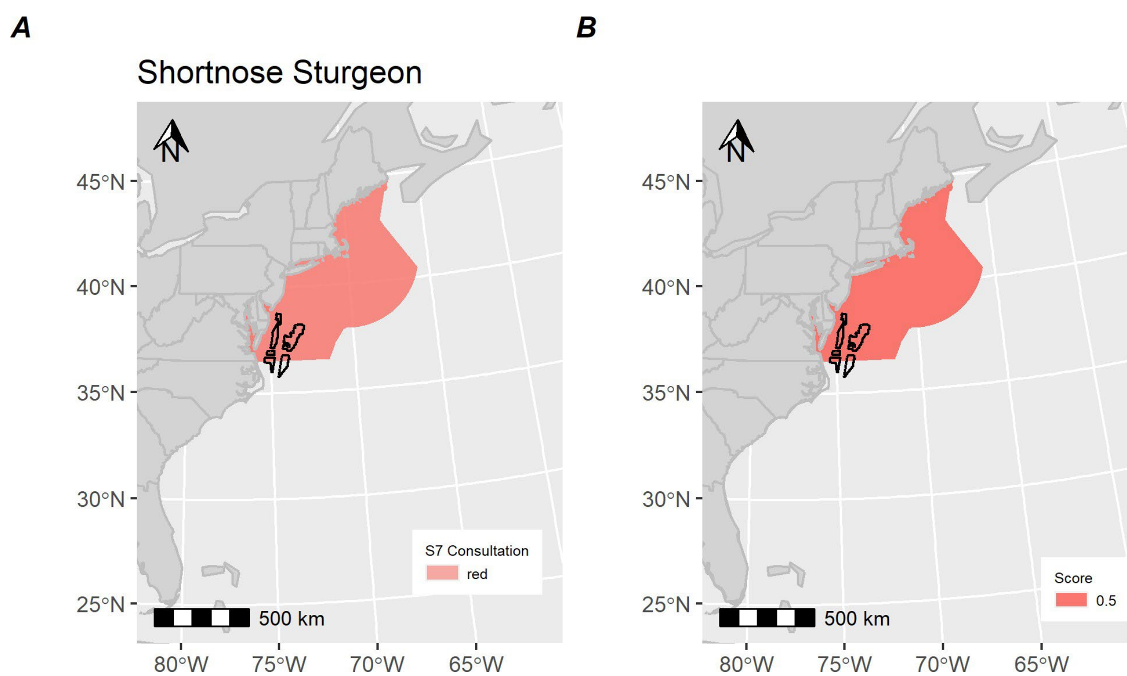

Figure S-27. Shortnose sturgeon range and score. A) Greater Atlantic Region Section 7 Mapper area (coral), note no Southeast Region Section 7 Mapper layer for this species. B) Calculated score for shortnose sturgeon showing areas receiving a score.

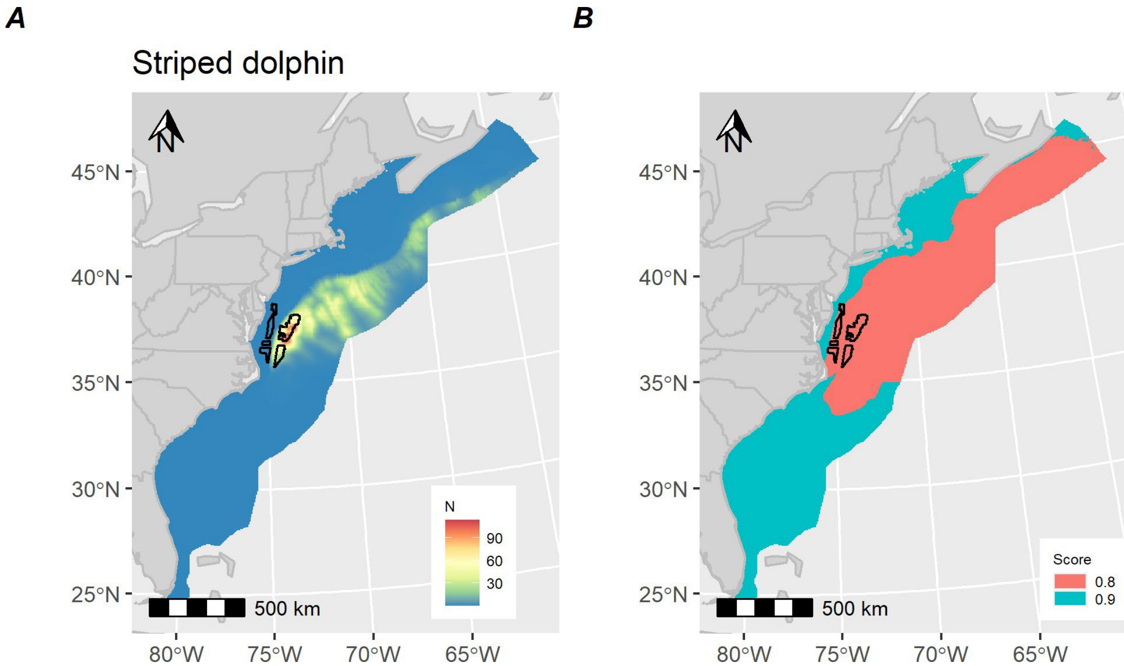

Figure S-28. Striped dolphin distribution and score. A) Estimated abundance of striped dolphins along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for striped dolphin showing areas above (coral) and below (teal) median predictions from distribution model.

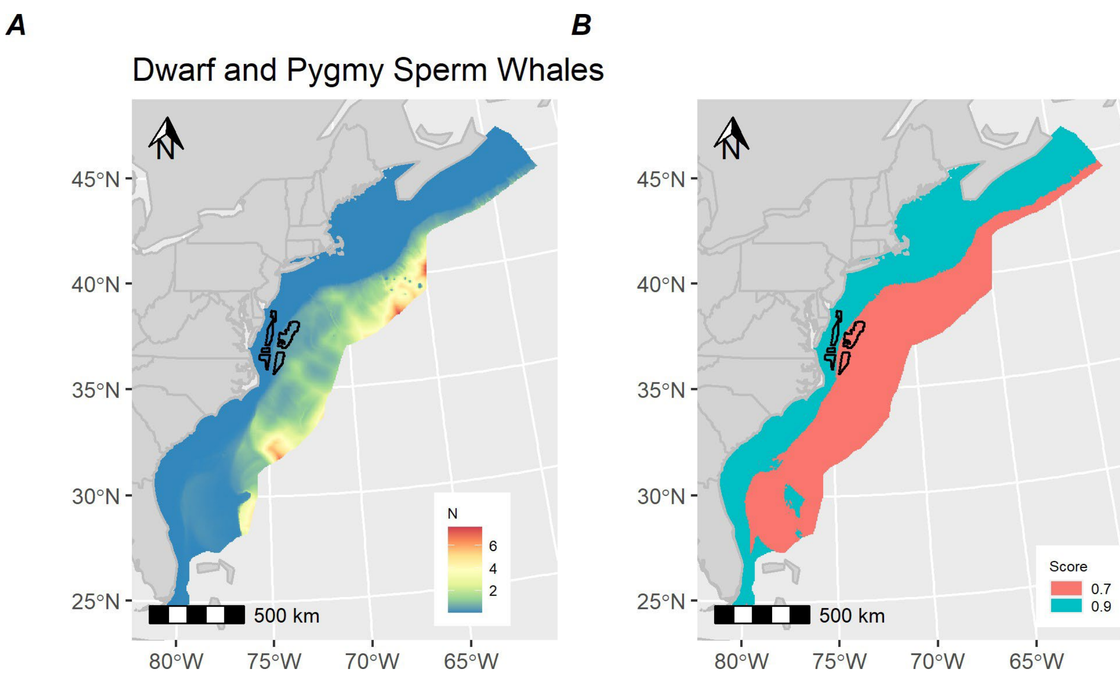

Figure S-29. Dwarf and pygmy sperm whale distribution and score. A) Estimated abundance of dwarf and pygmy sperm whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for dwarf and pygmy sperm whale showing areas above (coral) and below (teal) median predictions from distribution model.

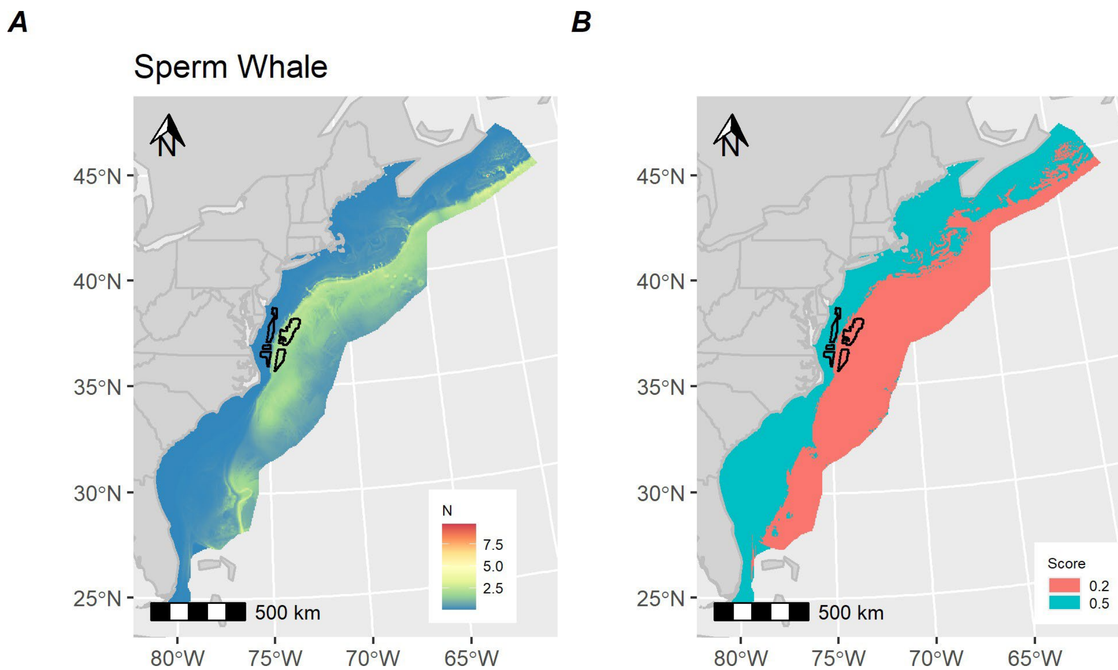

Figure S-30. Sperm whale distribution and score. A) Estimated abundance of sperm whales along the U.S. Atlantic Coast based on a species distribution model. B) Calculated score for sperm whale showing areas above (coral) and below (teal) median predictions from distribution model.