A WIND ENERGY AREA SITING ANALYSIS FOR THE GULF OF MEXICO CALL AREA

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EXECUTIVE SUMMARY

This report provides the methods and results for the first ecosystem-wide spatial suitability model developed to inform selection of wind energy areas in federal waters in the Gulf of Mexico. Spatial suitability models have long been applied to terrestrial and marine environments and is routinely used for the purpose of assessing the relative potential for development or conservation. To develop this model, approximately 75 data layers were utilized representing major ocean characteristics for the Gulf of Mexico Call Area. Data were organized into categories (submodels) representing the major ocean sectors including natural resources, fishing, and industry and operations. Ocean characteristics that drive favorability for wind energy development were represented in the economics and logistics submodels. All data layers were assigned scores of relative compatibilities, allowing the calculation of an overall suitability score for each 10 acre grid cell of the study area. Using a cluster analysis, 14 potential wind energy areas were identified as the most suitable areas within the Call Area based on the model configuration which provided significant consideration (i.e., weighting) for both natural resources and other ocean industries. However, one area was eliminated due to a preliminary DoD assessment after the model run, which left 13 potential wind energy areas moving forward. A ranking of these areas provides insight into the relative suitability of the areas. Lastly, a precision siting model was developed to maximize the number of lease sale areas for two specific wind energy area options of highest interest.

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1 INTRODUCTION

The Gulf of Mexico 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. The Gulf of Mexico has the potential to support an offshore wind energy industry with the highest wind resource potential occurring in the western planning areas. To date, the Bureau of Ocean Energy Management (BOEM) has formed the Gulf of Mexico Intergovernmental Renewable Energy Task Force, hosted four sector-specific Gulf of Mexico Fisheries workshops, issued a Request for Interest (RFI), a Call for Information and Nominations (Call), announced that it is preparing a draft environmental assessment for offshore wind leasing, and sought public comment on the development of offshore wind in the GOM Call Area. BOEM, with support from NOAA, has also conducted spatial analyses to determine optimal locations for Wind Energy Areas. This report summarizes the results of these spatial analyses.

2 METHODS

A spatial modeling workflow for Wind Energy Areas (WEA) 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 through stakeholder engagement. The goal of this study was to identify potential WEAs in the Gulf of Mexico with a minimum area of ~39,000 acres or seven lease blocks. The steps within the workflow are described below.

2.1 AREA OF INTEREST

On June 11, 2021, BOEM published a Request for Interest (RFI) for commercial leasing for wind power development on the Gulf of Mexico OCS to gauge specific interest in obtaining commercial wind energy leases in the GOM. On Nov. 1, 2021, BOEM published a Call for Commercial Leasing for Wind Power on the OCS in GOM. The Call Area provided by BOEM was used as the study area boundaries for this study. The Call Area comprises the area located seaward of the Gulf of Mexico Submerged Lands Act Boundary, bounded on the east by the north-south line located at -89.857° W. longitude, and bounded on the south by the 400-meter bathymetry contour, the U.S. Mexico Maritime Boundary established by the Treaty between the Government of the United States of America and the Government of the United Mexican States on the Delimitation of the Continental Shelf in the Western Gulf of Mexico beyond 200 Nautical Miles. BOEM delineated the Call Area taking into account the comments from the RFI and consultation with numerous parties and information sources, including the States of Alabama, Mississippi, Louisiana, Texas, and the Intergovernmental Renewable Energy Task Force. The Call area size is 29,693,940 acres (**Figure 2.2**). The water depth within the Call Area ranged from 1.5 to 833 m using the Coastal Relief Model Bathymetry.[1]

2.2 GRID 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

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

study area, which resulted in 2,975,760 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 coarsest (e.g., bathymetry, oceanographic) and finest (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).

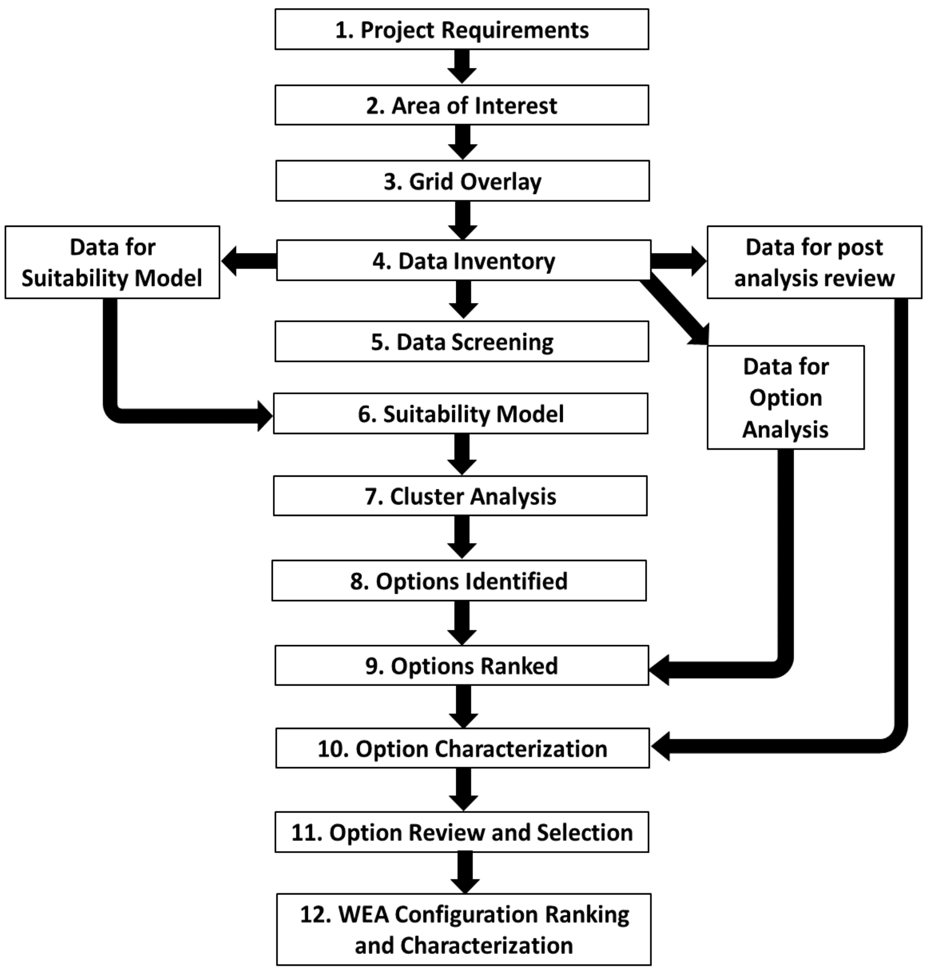

Figure 2.1. *Workflow for Wind Energy Area options spatial analysis for the Gulf of Mexico Call Area.*

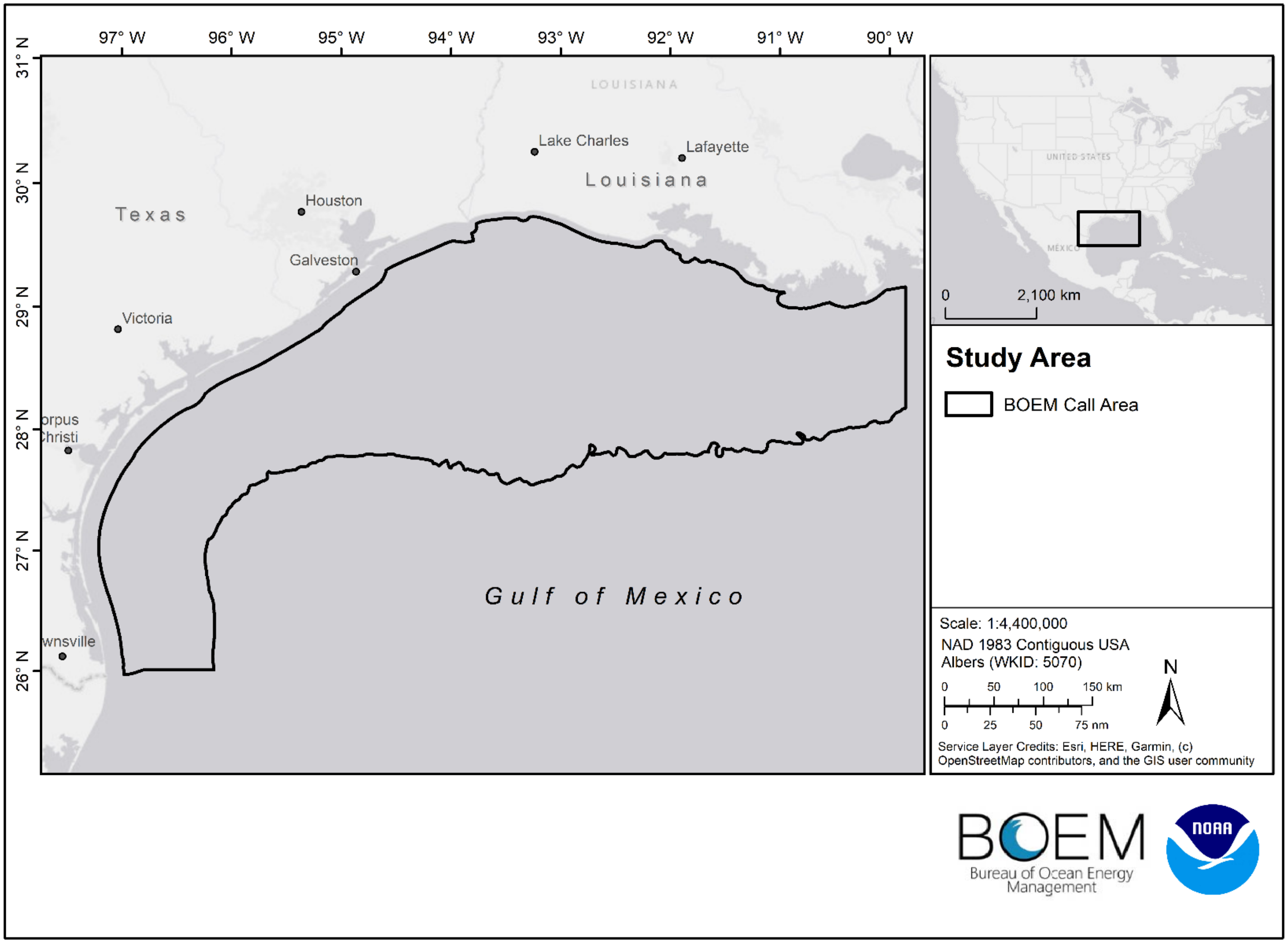

Figure 2.2. *BOEM Gulf of Mexico Call Area for wind energy development.*

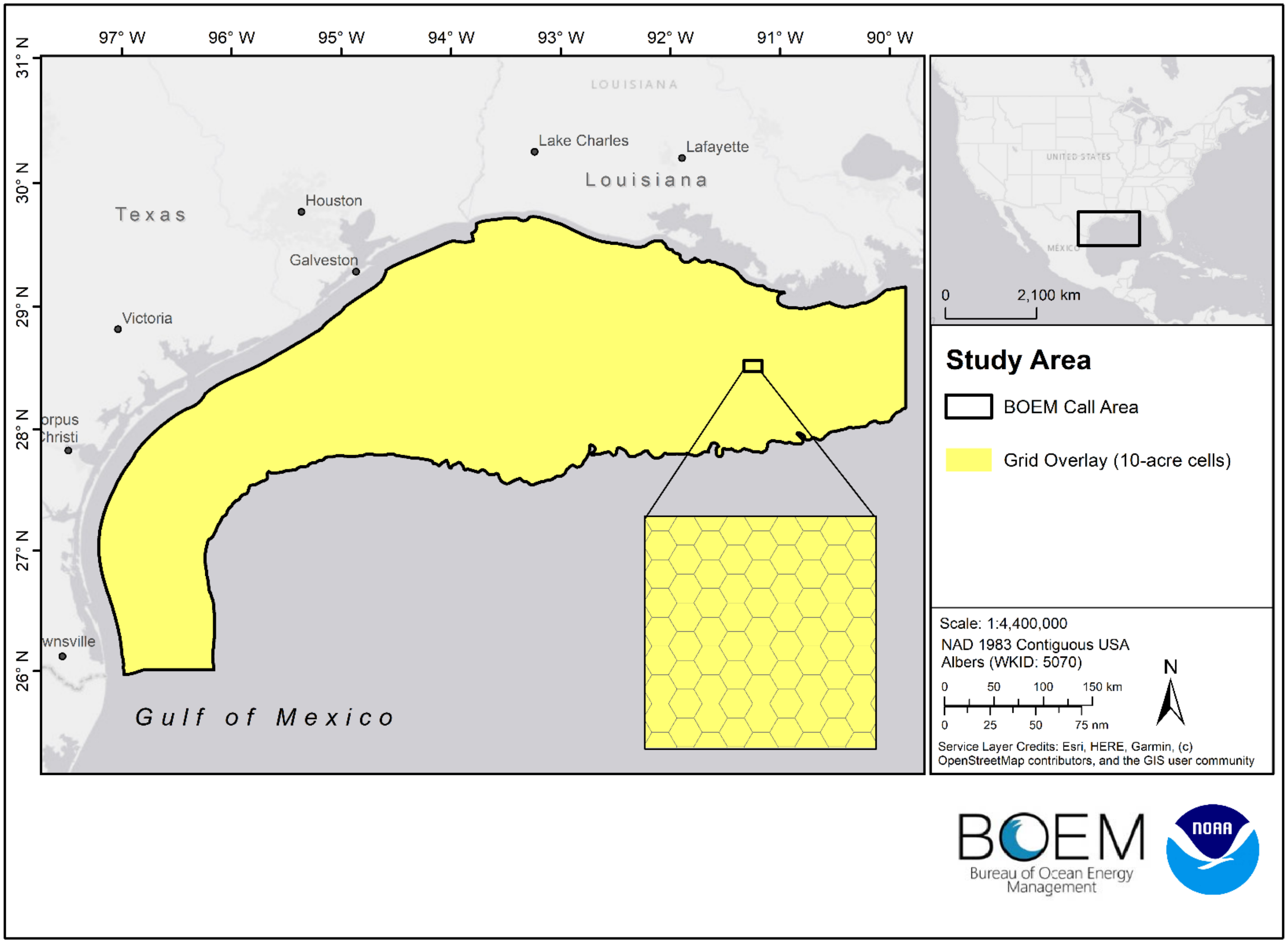

Figure 2.3. *An example of the grid cells formulated for the Call Area. Each cell is a 10-acre or 4.05-ha hexagon.*

2.3 Data Inventory, Screening, Acquisition, and Categorization

Geospatial analyses and ocean planning require the consideration of multiple, seemingly incompatible datasets that require substantial data collection and processing to properly understand and implement within ocean planning suitability models. Spatial suitability modeling is a type of Multi-Criteria Decision Analysis 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 basis 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, logistics, and economics. 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 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 NAD 1983 Contiguous USA Albers projection (WKID: 5070, Projection: Albers, False Easting: 0.0, False Northing: 0.0, Central Meridian: -96.0, Standard Parallel 1: 29.5, Standard Parallel 2: 45.5, Latitude of Origin: 23.0). Appendix A provides a list of data utilized for this ocean planning analysis.

2.4 Data Processing Steps

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

2.4.1 NMFS Protected Resources

To holistically consider protected species in the region, a novel combined data layer providing the overall score for select protected species was developed through collaboration with NMFS

Southeast Regional Office (SERO) 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 ocean 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.

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 23 data layers including Atlantic spotted dolphin (coastal), Atlantic spotted dolphin (oceanic), Beaked whale, Bottlenose dolphin (coastal), Bottlenose dolphin (oceanic), Clymene dolphin, Blackfish (False killer, Pygmy killer, and Melon-headed whales), Giant manta ray, Green sea turtle, Gulf sturgeon, Hawksbill sea turtle, Kemp's ridley sea turtle, Kogia (Dwarf and Pygmy sperm whale), Leatherback sea turtle, Loggerhead sea turtle, Oceanic whitetip shark, Pantropical spotted dolphin, Pilot whale, Rice's whale, Smalltooth sawfish (U.S. DPS), Sperm whale, Spinner dolphin, and Striped dolphin 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 Gulf of Mexico to be used in suitability modeling.

Species Common Name	Status and Trend	Score
Atlantic spotted dolphin (coastal)	MMPA Listed, unknown	0.7
Atlantic spotted dolphin (oceanic)	MMPA Listed, large population	0.8
Beaked whale	MMPA Listed, unknown	0.7
Bottlenose dolphin (coastal)	MMPA Listed, large population	0.8
Bottlenose dolphin (oceanic)	MMPA Listed, unknown	0.7
Clymene dolphin	MMPA Strategic, unknown	0.6
Blackfish (False killer, Pygmy killer, & Melon-headed whale)	MMPA Listed, unknown	0.7
Giant manta ray	Threatened, declining	0.4
Green sea turtle	Threatened, increasing	0.5
Gulf sturgeon	Threatened, increasing	0.5
Hawksbill sea turtle	Endangered, unknown	0.2
Kemp's ridley sea turtle	Endangered, unknown	0.2
Kogia (Dwarf and Pygmy sperm whale)	MMPA Listed, unknown	0.7
Leatherback sea turtle	Endangered, declining	0.1
Loggerhead sea turtle	Threatened, unknown/stable	0.4
Oceanic whitetip shark	Threatened, unknown/declining	0.4
Pantropical spotted dolphin	MMPA Listed, unknown	0.7
Pilot whale	MMPA Listed, unknown	0.7
Rice's whale	Endangered, small population	0.1
Risso's dolphin	MMPA Listed, unknown	0.7
Smalltooth sawfish (U.S. DPS)	Endangered, increasing	0.3
Sperm whale	Endangered, unknown	0.2
Spinner dolphin	MMPA Strategic, unknown	0.6
Striped dolphin	MMPA Strategic, unknown	0.6

2.4.2 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 Gulf of Mexico. For full bathymetric coverage for the BOEM Gulf of Mexico wind energy Call Area, the CRM requires download of the Central Gulf of Mexico, Volume 4 CRM (2001) and Western Gulf of Mexico CRM, Volume 5 (2001)[2]. Bathymetry data were clipped (i.e., data not overlapping the study area was removed) to the study area for ease of processing.

2.4.3 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].

Vessel traffic data from 2015 through 2020 were acquired and processed for the BOEM Call Area.[4] Tracklines for each vessel were created from the transmission points, with points not being connected if greater than 1.6 km (1 mi) apart or longer than 30 minutes apart in time. The vessel traffic tracklines were categorized by vessel type (cargo, fishing, military, other, passenger, pleasure and sailing, tanker, and tug and tow)[5]. The 2019 vessel traffic data were used in the suitability model, with the number of vessels transiting a grid cell being counted for the entire year. The COVID-19 pandemic, beginning in late February/early March 2020, resulted in impacts to global and regional vessel traffic patterns. Therefore, 2020 vessel traffic data were not used in the modeling as they do not necessarily reflect regular traffic patterns overtime.

2.4.4 Fish Havens

Fish havens are defined as artificial reefs or "submerged structures deliberately constructed or placed on the seabed to emulate some functions of a natural reef, such as protecting, regenerating, concentrating, and/or enhancing populations of living marine resources" (UN Environment Programme 2009; NOAA 2016). Fish haven boundary data were extracted from the NOAA electronic navigational chart (ENC) using the ENC Direct to GIS tool. The extracted features were quality assured by overlaying the features onto the ENC within ArcGIS Pro and performing manual checks to ensure polygons lined up with those on navigation charts. As recommended by the USACE, a setback of 500

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

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

[4] https://marinecadastre.gov/ais/

[5] https://api.vtexplorer.com/docs/ref-aistypes.html

ft (152 m) was applied to preserve ecosystems associated with fish havens and artificial reefs, and to avoid recreational user activity for WEA planning.

2.4.5 Commercial and Recreational Fishing Data

Commercial and recreational fishing are important economic drivers for the Gulf of Mexico region (NMFS 2021), and considerations of use patterns are important for ocean planning and conflict reduction with an established and socio-economically important industry. Data were predominantly received as point data 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.[6] 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[7] 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. To further maintain confidentiality, all maps containing fishing data were categorized by quantiles into descriptive categories, “Low”, “Moderately Low”, “Moderate”, “Moderately High”, “High” for map visualization (i.e., the descriptive “Low” category would contain the lower quantiles, while the “High” category would contain the upper quantile). Within the maps, standardized colors were used to depict categories, with blue representing “Low”, light blue “Moderately Low, yellow “Moderate”, orange “Moderately High”, and red “High”. 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.

Commercial Shrimp Electronic Logbook (ELB) Data

The NMFS Southeast Fisheries Science Center (SEFSC) provided shrimp industry data collected from vessels operating with a NMFS Gulf of Mexico Shrimp Commercial Fishing Permit and participating in the vessel monitoring program. Vessel data (i.e., trawl vessels) were collected from electronic logbook (ELB) records from 2004 to 2019. Approximately 50 to 60% of vessels are required to participate in the ELB program; however, participation has been variable over the years since inception. The ELB records a signal at 10-minute intervals indicating vessel location and speed over ground. For trawl fisheries, data were categorized into an assumed activity, where 2.0 to 3.8 knots was the speed when trawling is assumed to be occurring. All vessel transmissions where trawling was assumed to be occurring were extracted from the full dataset. Tracklines were then created from the transmission points, with points not being connected if greater than 1.6 km (1.0 mi) apart or the time difference greater than 30 minutes. Additionally, tracklines that crossed land features were removed. Five years of data, 1/1/2015 to 12/31/2019, were used, as these years had the most comprehensive and complete data sets. Data collected during 2020 encountered data collection issues, while data prior to 2015 varied in the number of vessels with transponders. This was due to the program starting

[6] https://www.archives.gov/cui/about

[7] https://www.st.nmfs.noaa.gov/Assets/intranet2015/pdf/NOAA_216-100_Form.pdf

in the early years, as well as the transition period when a different organization took over running the program in 2013. All tracklines were binned by day and converted to a 100 x 100 m raster grid. For each year the sum of days trawled was calculated, with the mean days trawled per year calculated from the five-year time period. The sum of days was chosen after discussion with industry and understanding a metric that would provide the most conservative estimates.

Reef Fish Bandit Gear Fishing Data (2007 - 2021)

Vessels targeting reef fish in the Gulf of Mexico often employ bandit reels and handlines for the vertical line fishery. Bandit reels are a preferred gear based on their use in the industry and efficiency in operations. Although many reef fish species are retained, the predominant target species are groupers and snappers (Scott-Denton et al. 2011). NMFS SEFSC with support from NMFS Office of Law Enforcement (OLE) provided point data of predicted fishing locations from 2007 to 2021. The sum of values for each of the points were aggregated to the suitability grid for modeling purposes.

Reef Fish Longline Gear Fishing Data (2007 - 2021)

In contrast to the vertical line fishery for reef fish, some vessels utilize bottom longlines to target the species among the same reef fish complex. For example, longliners may target red grouper in shallow waters, and in deeper waters yellowedge grouper, tilefish, and sharks (Scott-Denton et al. 2011). NMFS SEFSC with support from NMFS OLE provided point data of predicted fishing locations for 2007 to 2021. The sum values for each of the points were aggregated to the suitability grid for modeling purposes.

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 pelagics (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. NMFS has collected the data since 1986 in the Gulf of Mexico. 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 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.

Highly Migratory Species Pelagic Longline Gear (2011-2020)

NMFS SEFSC with support of NMFS OLE provided raw pelagic catch and effort data from the Unified Data Processing (UDP) Logbook data with a temporal range from 2011-2020.Overlapping points were dissolved into a single layer and the count was calculated for each point (i.e., one point = 1 fishing trip, five overlapping points = 5 fishing trips). A setback (i.e., buffer) of 0.0083333 decimal degrees was used for each of the points. Then the Minimum Bounding Geometry tool was run on the layer using the “Envelope” Geometry type to turn the circle buffer into a rectangular grid. These data are not displayed in map visualizations because they do not meet data confidentiality requirements for publication.

Menhaden Fishery Data (2000 - 2019)

NMFS SEFSC provided point data on the menhaden fishery. Each set had an associated 5-digit code for location. This corresponded with a latitude/longitude that was the centroid of the 10-minute x 10-minute grid cell in which the set occurred. These data were plotted for the years 2000 - 2019. We recreated the 10-minute x 10-minute grid and estimated the total number of sets occurring in each grid cell for the given time period.

2.5 Suitability Analysis

A Multi-Criteria Decision Analysis (MCDA) is a technique used to inform decisions for spatial problems that have many criteria and data layers and is widely used in ocean planning. A gridded relative suitability analysis, commonly used in a 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, logistics, and economics. Data layers with no compatibility with wind energy development (e.g., shipping fairways or known sand resources areas) 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.

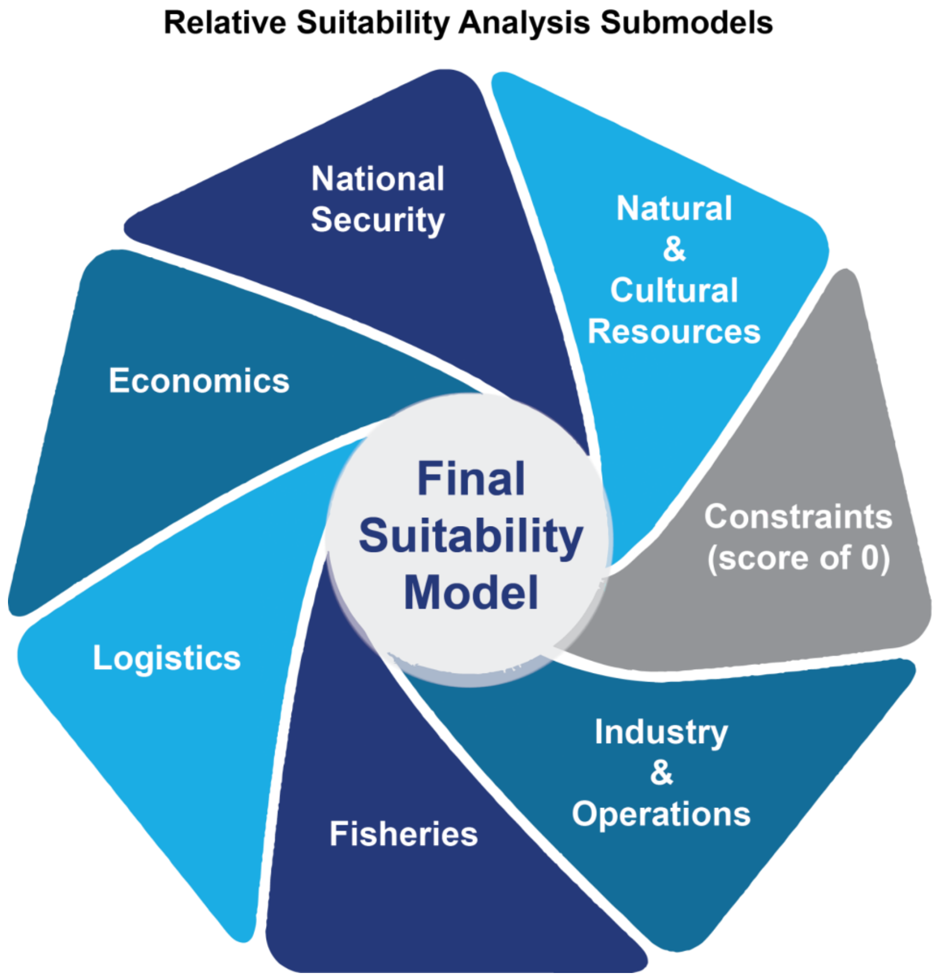

Figure 2.4. Overview of suitability model design and the submodel components. The constraints submodel includes all data layers with a score of 0; these data layers were removed before the remaining submodel scores were calculated.

2.5.1 Scoring Categorical Data

Categorical datasets (i.e., in which data are distinct and separate groups) were evaluated to determine if a constraining feature was present or absent in each grid cell. If a feature was absent, a score of 1 was given indicating suitability with wind energy development, otherwise a score ranging from 0 to 1 was assigned (0 = unsuitable with wind energy; 1 = being more suitable with wind energy). 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., shipping lanes and a 2nm setback from the outer boundary, 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. If there is potential for interaction with a transient resource, but uncertainty remains as to what that interaction is with wind industry infrastructure, then varying scores were assigned. These scores range from 0.2 to 0.7, depending on the degree of conflict decided by BOEM based on the best available science.

2.5.2 Scoring Numerical Data

Numerical data (i.e., data can represent any value within a given range) (e.g., continuous data) were reclassified to a 0 to 1 scale using a linear function or fuzzy logic membership functions (Vincenzi et al. 2006; Vafaie et al. 2015; Theuerkauf et al. 2019; Landuci et al. 2020).

Fuzzy membership functions are similar to a linear or non-linear functional approach, however, use of fuzzy logic membership functions accounts for additional uncertainty when assigning scores to the data (Kapetsky and Aguilar-Manjarrez 2013). The function used for each numerical dataset was chosen based on the data and known interactions or compatibility with wind energy. The range of the numerical datasets (i.e., the minimum and maximum values) were used as the inputs for creating the function and were modified to ensure no output value would equal 0. No 0 values were allowed because no observed value in any numerical dataset used was known to be completely incompatible with wind energy infrastructure.

Vessel traffic, fishing effort, and pelagic bird 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 2.3** through **2.9**, with a detailed list and rationale for each score found in **Appendix C**.

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).*

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

$x =$ *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)*

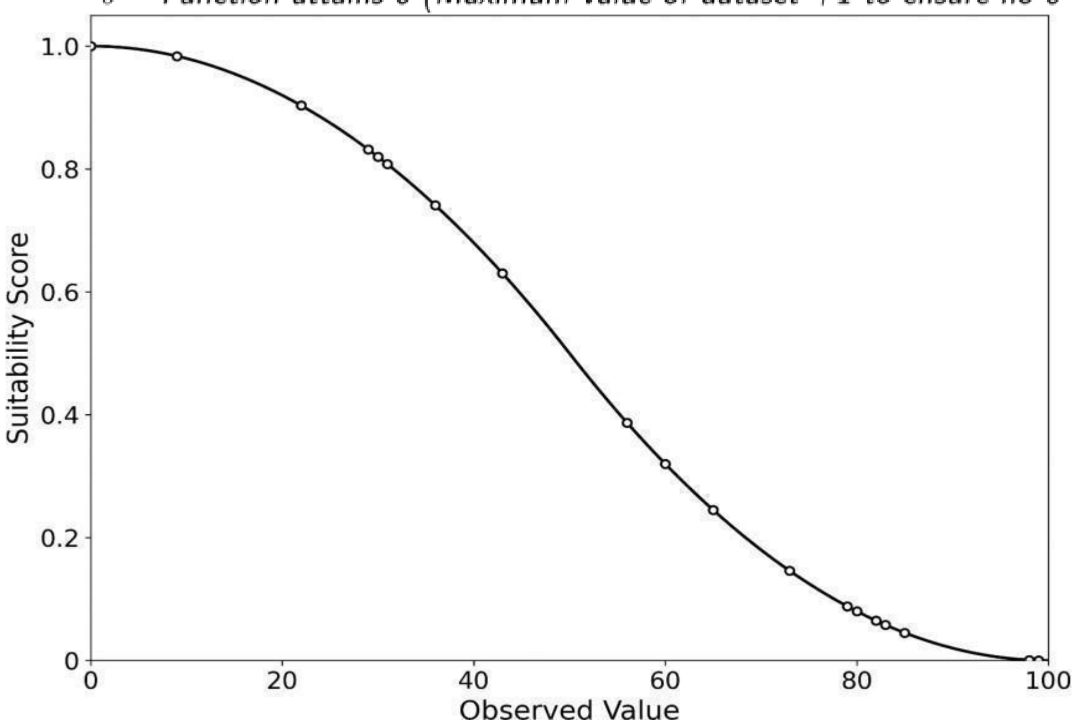

Figure 2.5. *Example of hypothetical Z-shaped membership function, with the minimum observed value being 0 and the maximum observed value being 99. However, the total range of the function goes to 99.0001, as 0.0001 was added to 99 when creating the function to ensure no observed values would be rescaled 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 2.3. 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
VMS Shrimp Fishing areas of Moderate-High fishing effort (>4.5 days)	-	0
Recommended 20 nm coastal buffer	-	0
Shipping Fairways and Regulations	2 nm	0
Rice's whale 100 m to 400 m	-	0
Active Oil and Gas Lease Blocks (Including FGBNMS Blocks)	-	0
BOEM Lease Blocks with Significant Sediment Resources	-	0
BOEM No Activity Zones	-	0
Oil and Gas Pipelines (Only Active Pipelines)	200 ft	0
Menhaden Fishing - Area between 90° - 91° out to 20 miles	-	0
Oil and Gas Boreholes, Test Wells, and Wells	200 ft	0
Anchorage Areas (used/disused)	-	0
Oil and Gas Drilling Platforms	500 ft	0
Submarine Cables	500 ft	0
Unexploded Ordnance (UXO) polygon	-	0
LA permitted artificial reefs	500 ft	0
Aids to Navigation (beacons and buoys)	500 m	0
TX permitted artificial reefs	1000 ft	0
Environmental Sensors and Buoys	500 m	0

Table 2.4**.** 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
Military Operating Area (MOA)- Corpus Christi	0.3
Military Operating Area (MOA)- New Orleans	0.5
Military Training Routes (MTR)- Flight Corridors - 12-mile setback	0.3
Special Use Airspace (SUA) A381 - Alert Area LOOP facility	0.5
Special Use Airspace (SUA) Warning Area - W59A, W59B, W54A, W54B, W54C, W92, W147A, W147B, W147C, W147D, W228A, W228B, W228C, W228D	0.5

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

Data Layer	Score
NOAA Fish Havens (500-ft setback included in polygon)	0.7
Potentially Sensitive Biological Features provided by FGBNMS (1000-ft)	0.5

Low Relief Structures provided by Flower Garden Banks National Marine Sanctuary (FGBNMS) (1000-ft setback)	0.5
BOEM's Potentially Sensitive Biological Features (250-ft setback)	0.2
Existing Coral HAPCs (with regulations and without regulations)	0.2
Coral 9 HAPC (no regulations and regulated areas)	0.2
Protected Resource Division Combined Layer (without Rice's Whale)	NMFS values
U.S. Fish and Wildlife Service (FWS) - GOMAPPS 24 Pelagic Bird Spp. Habitat Suitability	Z Membership Function

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

Data Layer	Score
Federal Lightering Rendezvous Areas	0.5
Outside of Carbon Capture WEAs	0.5
NEXRAD Sites	0 - 35 km = 0 35 -70 km = 0.5
NMFS's Fishery-Independent Surveys	Z membership function
AIS Vessel Traffic 2019 – Cargo	Z membership function
AIS Vessel Traffic 2019 – Fishing	Z membership function
AIS Vessel Traffic 2019 – Other	Z membership function
AIS Vessel Traffic 2019 – Passenger	Z membership function
AIS Vessel Traffic 2019 – Pleasure and Sailing	Z membership function
AIS Vessel Traffic 2019 – Tanker	Z membership function
AIS Vessel Traffic 2019 – Tug and Tow	Z membership function

Table 2.7. Logistics 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 ports	Linear function (Closer to principal port is better)
Depth	Linear function (Shallower depth is better)

Table 2.8. Economics 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
National Renewable Energy Lab (NREL)- Netvalue2015	Linear function (Greater net value is better)
Competitive Lease Blocks	Cells outside =0.5, Cells inside =1

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
Commercial Shrimp Electronic Logbook Data (2015 - 2019) Mean days fished per year	Z membership function - The moderate, mod/high, and high effort data categories (natural breaks) are included in the constraints model
Menhaden Fishery Data (2000 - 2019)	Z membership function - Area between 90°-91° strata (coastal Louisiana) out to 20 miles would be used in the constraints model.
Highly Migratory Species Pelagic Longline Gear (2011-2020)	Z membership function
Reef Fish Bandit Gear Fishing Data (2007 - 2021)	Z membership function
Reef Fish Longline Gear Fishing Data (2007 - 2021)	Z membership function
Southeast Region Headboat Survey Data (2014 - 2020)	Z membership function

2.6 Calculation of Final Score

Each data layer was scored on a 0 to 1 scale, with scores approaching 0 representing low suitability and 1 representing high suitability relative to the other grid cells for wind energy. 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 (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.*

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

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

2.6.1 Suitability Model Data and Constraints Submodel

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

2.6.2 Local Index of Spatial Association

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

2.6.3 Data Included in the Suitability Model and Cluster Analysis

All data layers utilized in the suitability model were considered authoritative and were from federal or state agencies. 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 only to provide supplementary information beyond the scope of this study, but those data may be useful during the PEIS process.

2.6.4 Suitability Modeling Approach, Assumptions, and Limitations

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

Spatial data were used within a GIS-framework to develop workflows with a series of interconnected steps (Stelzenmüller et al. 2012; 2017). A flexible, integrated GIS-based suitability model was implemented to consider complex interactions (i.e., equally weighted relative suitability model in an ocean environment) while also aiming for long-term sustainability (Perez et al. 2003; Cho et al. 2012; Pinarbasi et al. 2017, 2019; Stelzenmüller et al. 2017) (**Figure 2.6**). 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, the relative suitability spatial workflow approach used scoring of categorical and numeric data; reporting statistic; variability in coverages for temporal and spatial data; years and number of years of AIS data; p-value for LISA cluster and outlier analysis; variables in the suitability and precision siting model; and consideration of model error. If approached differently, this may have impacted or changed the final WEA options.

Other limitations include spatial and horizontal resolution of model data, the accuracy and precision of model data, primary socio-economic data available, and time availability (See NMFS disclaimer in Appendix B). Further, we consistently chose the most conservative approach for scoring assignments and other judgements to ensure a high level of accuracy for wind energy compatibility within the constraints of the data and model.

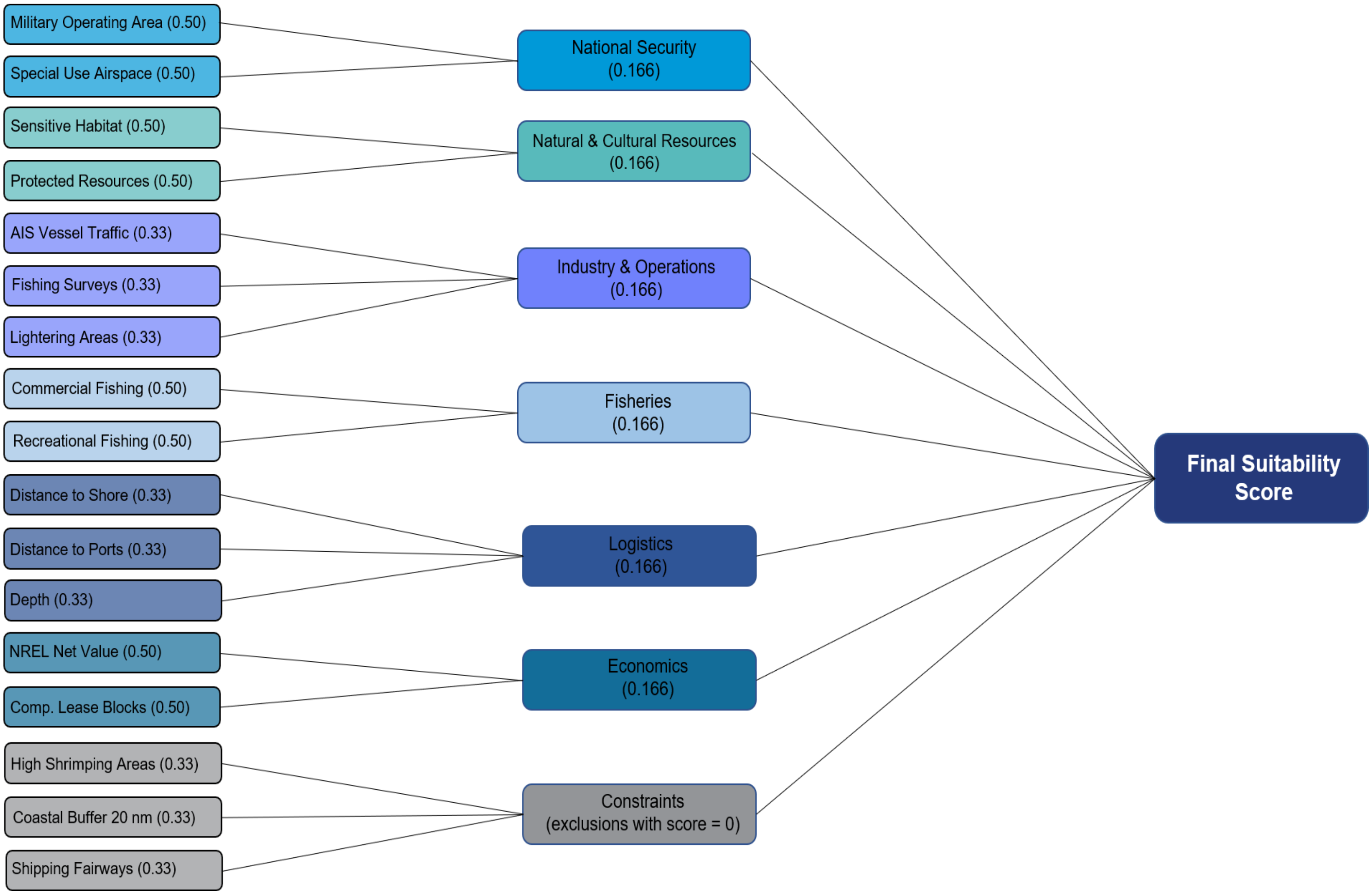

Figure 2.6. A generalized approach to a Multi-Criteria Decision Analysis suitability model with equally-weighted data layers in the submodels and final suitability model. Note that not all of the data layers are shown.

2.7 OPTION IDENTIFICATION

WEA options were identified using the High-High clusters in conjunction with defined rules, with the goal of identifying at least seven contiguous lease blocks (>39,000 acres). 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 had ≥ 50% area in the High-High clusters were selected and extracted. Then lease blocks that contained ≥ 50% area of selected aliquots were extracted and selected. Options were created from the groups of contiguous lease blocks with at least seven lease blocks (≥ 39,000 acres). Lease blocks from the options were removed if a lease block did not have 3 neighbors using Queen case logic (Cliff 1968), unless the removal would reduce an option below seven lease blocks or 39,000 acres (**Figure 2.7**). Therefore, for each option, there were at least seven lease blocks, with each lease block containing at least half the aliquots as being in High-High Clusters. This methodology does allow for some constraints to be located within the final options (pipeline, oil and gas platform, etc.), which are noted in the results and with the discussion of avoidance or mitigation to follow.

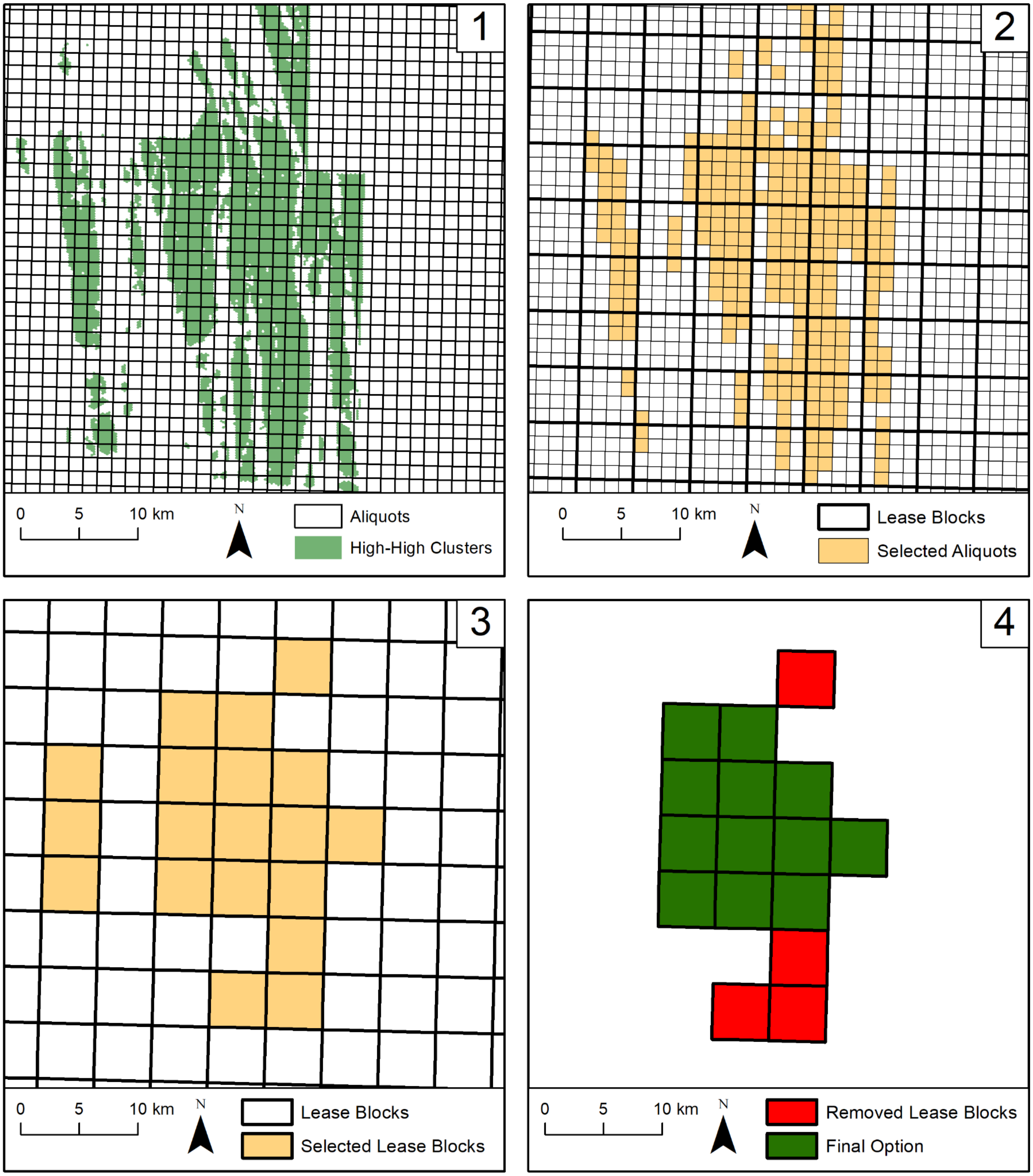

Figure 2.7. *Wind Energy Area steps for option identification. 1) High-High (HH) clusters overlaid on Aliquots. 2) Selected aliquots had ≥ 50% area in HH clusters. 3) Selected lease blocks had ≥ 50% of selected aliquots. 4) Groups of contiguous lease blocks containing at least seven lease blocks (≥ 39,000 acres) were selected, with lease blocks removed if a lease block does not have three neighbors using Queen case logic, unless removal of a block would reduce an option below seven lease blocks (~39,000 acres).*

2.8 Option Ranking Model

An adapted version of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to rank WEA options was utilized. This method and similar techniques have been extensively used within ocean planning framework for land and ocean-based renewable energy site selection (Hsu-Shih et al. 2007; Singh et al. 2017; Diaz and Soares 2021). Generally used after suitable areas within an MCDA framework are determined, the TOPSIS method is implemented to further refine and rank the results to aid the decision-making process (Sindhu et al. 2017; Konstantinos et al. 2019).

Here we used the same structure from the suitability model for the Option Ranking Model, although the constraint features were not used in the ranking model. Therefore, the same six submodels were used, using the same variables and rescaling techniques as used in the suitability model (**Figure 2.4; Tables 2.3 - 2.9**). However, rather than calculating a relative comparison of every grid cell, each of the WEA options were compared. For example, the WEA option with the lowest interaction with shrimp fishing effort compared to all of the other WEA options would receive the highest suitability score, while the option with the highest interaction with shrimp fishing effort would receive the lowest suitability score.

Again, the geometric mean of all variables for each submodel was calculated, and the resultant geometric mean of the six submodels was calculated to produce the final score for each WEA option. The WEA option with the highest overall score in the ranking model was then considered the most suitable option relative to the other options for wind energy in the Gulf of Mexico. However, it is important to remember that all the WEA options contain the most suitable areas. Even if one option ranks above another, that only means there are relatively fewer conflicts. Further review and evaluation of the conflicts within each of the identified WEA options will be important for decision making, as not all conflicts are equal in terms of avoiding or mitigating.

2.9 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. For example, some data were at a resolution too coarse to include in the modeling process. Therefore, additional data layers not included in the modeling process are examined in thecharacterization of the WEA options.

3 RESULTS

3.1 SUBMODELS

3.1.1 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 67.4% of the Call Area (**Figure 3.1** 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
VMS Shrimp Fishing areas of Moderate-High fishing effort	-	0	29.2%
Recommended 20 nm coastal buffer	-	0	20.7%
Shipping Fairways and Regulations	2nm	0	19.5%
Rice's Whale 100 m to 400 m	-	0	17.5%
Active Oil and Gas Lease Blocks (Including FGNMS Blocks)	-	0	9.1%
BOEM Lease Blocks with Significant Sediment Resources	-	0	5.6%
BOEM No Activity Zones	-	0	3.5%
Oil and Gas Pipelines (Only Active Pipelines)	200 ft	0	3.3%
Menhaden Fishing between 90° - 91° out to 20 nm	-	0	2.7%
Oil and Gas Boreholes, Test Wells, and Wells	200 ft	0	2.4%
Anchorage Areas (used/disused)	-	0	1.0%
Oil and Gas Drilling Platforms	500 ft	0	0.9%
Submarine Cables	500 ft	0	0.4%
Unexploded Ordnance (UXO) polygon	-	0	0.3%
LA permitted artificial reefs	500 ft	0	0.2%
Aids to Navigation (beacons and buoys)	500 m	0	0.1%
Texas permitted artificial reefs	1000 ft	0	0.1%
Environmental Sensors and Buoys	500 m	0	0.04%
			67.4%

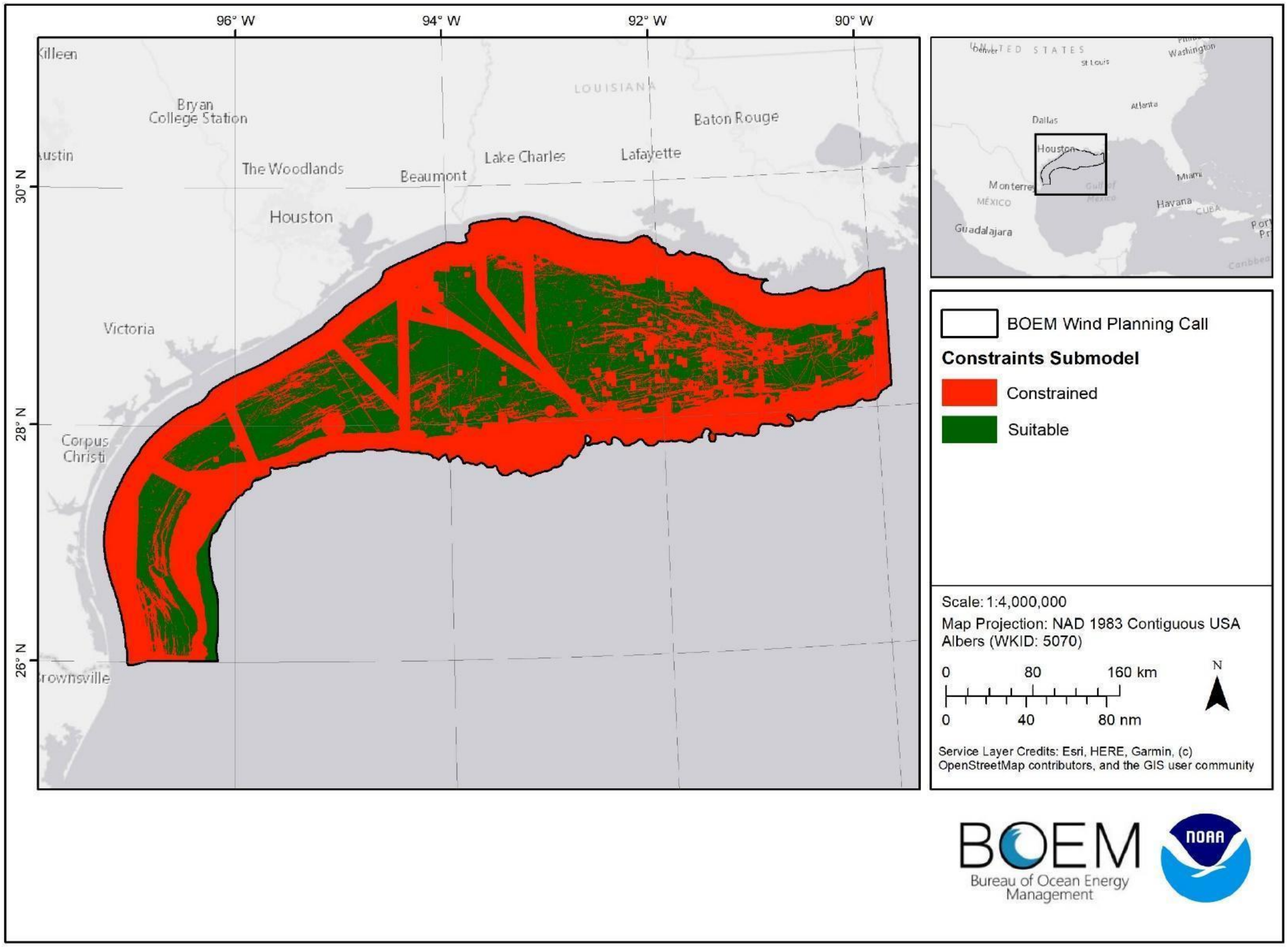

Figure 3.1. Constraints submodel relative suitability for the Call Area. Red color indicates those areas constrained by ocean activity, while green areas are considered suitable.

3.1.2 National Security

National security assets are relatively extensive throughout many portions of U.S. federal waters, with uses varying over time and space. National security operational areas and other areas of national security interest were reviewed in and around the Call Area (**Figure 3.2**).

Military Operating Areas (MOAs) are defined as airspaces where military flight activities include air combat maneuvers, air intercepts, low altitude tactics, and other flight training (FAA, 2011). MOA Corpus Christi overlaps with 13.2% of the Call Area and MOA New Orleans overlaps 0.7% (**Table 3.2**). Special Use Airspace (SUAs) warning areas are airspaces where activities must be confined due to their nature, or where they may limit other aircraft operations not involved in the training exercise.[8] SUAs overlap the Call Area (73%), with scheduled daily training activities varying over space and time, particularly as use of areas change with need and strategic objectives. The Alert Area LOOP facility (SUA A381) occurs in 22.7% of the northern region of the Call Area. Military Training Routes (MTRs) have a floor of 457 m (1,500 ft) or below and are considered low-level altitude military airspaces (MAIASC 2021). Overlap with MTRs occurs in 3.9% of the Call Area. Unexploded ordnance sites (i.e., areas defined under 10 USC 101(e)(5)) where military munitions may pose unique explosive safety risk)[9],occur in the western portion of the Call Area (0.30% overlap). These sites were included in the constraints submodel and assigned a score of 0 (i.e., no suitability) due to concerns about compatibility with wind energy.

Guidance on compatibility of wind energy operations in the Call Area with DOD activities was provided through consultations with DOD staff at regional and headquarters locations, USCG, NASA, and the Military Aviation and Installation Assurance Siting Clearinghouse (MAIASC).[10] Some Gulf of Mexico national security considerations were assigned a score of 0.5 within the analysis to account for uncertainty within that area and unknown types of training activities occurring or possibly occurring within a space (e.g., SUAs) (**Table 3.2**). These layers were included in the national security submodel for suitability analysis. Data layers with 0.5 scores included the New Orleans MOA, and 17 SUAs including the Alert Area LOOP facility (SUA A381). The Corpus Christi MOA and the MTRs both were assigned a score of 0.3 as military activity can be greater in these areas and are therefore less suitable. Suitability results for the national security submodel are presented in **Figure 3.3**.

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[8] https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap3_section_4.html

[9] https://www.law.cornell.edu/uscode/text/10/101

[10] https://www.acq.osd.mil/dodsc/

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
Special Use Airspace (SUA)-W59A, W59B, W54A, W54B, W54C, W92, W147A, W147C, W147D, W228A, W228B, W228C, W228D	-	0.5	73.0%
Special Use Airspace (SUA) A381 - Alert Area LOOP facility	-	0.5	22.7%
Military Operating Area (MOA)- Corpus Christi	-	0.3	13.2%
Military Training Routes (MTR)- Flight Corridors	12 mi	0.3	3.9%
Military Operating Area (MOA)- New Orleans	-	0.5	0.7%

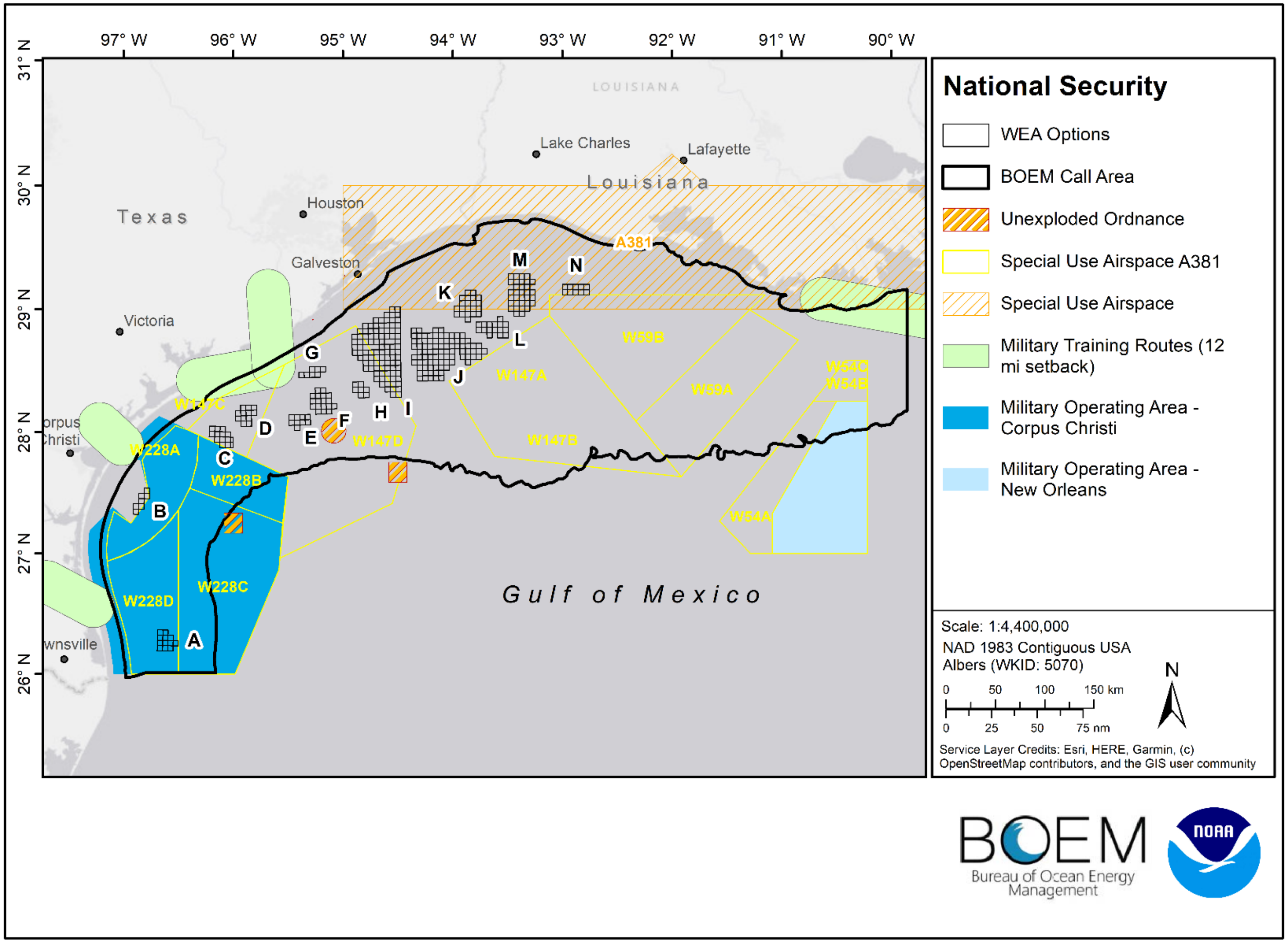

Figure 3.2. *National security considerations for the Call Area. Considerations include special use airspace (SUA), military training routes, military operating areas, and unexploded ordnance.*

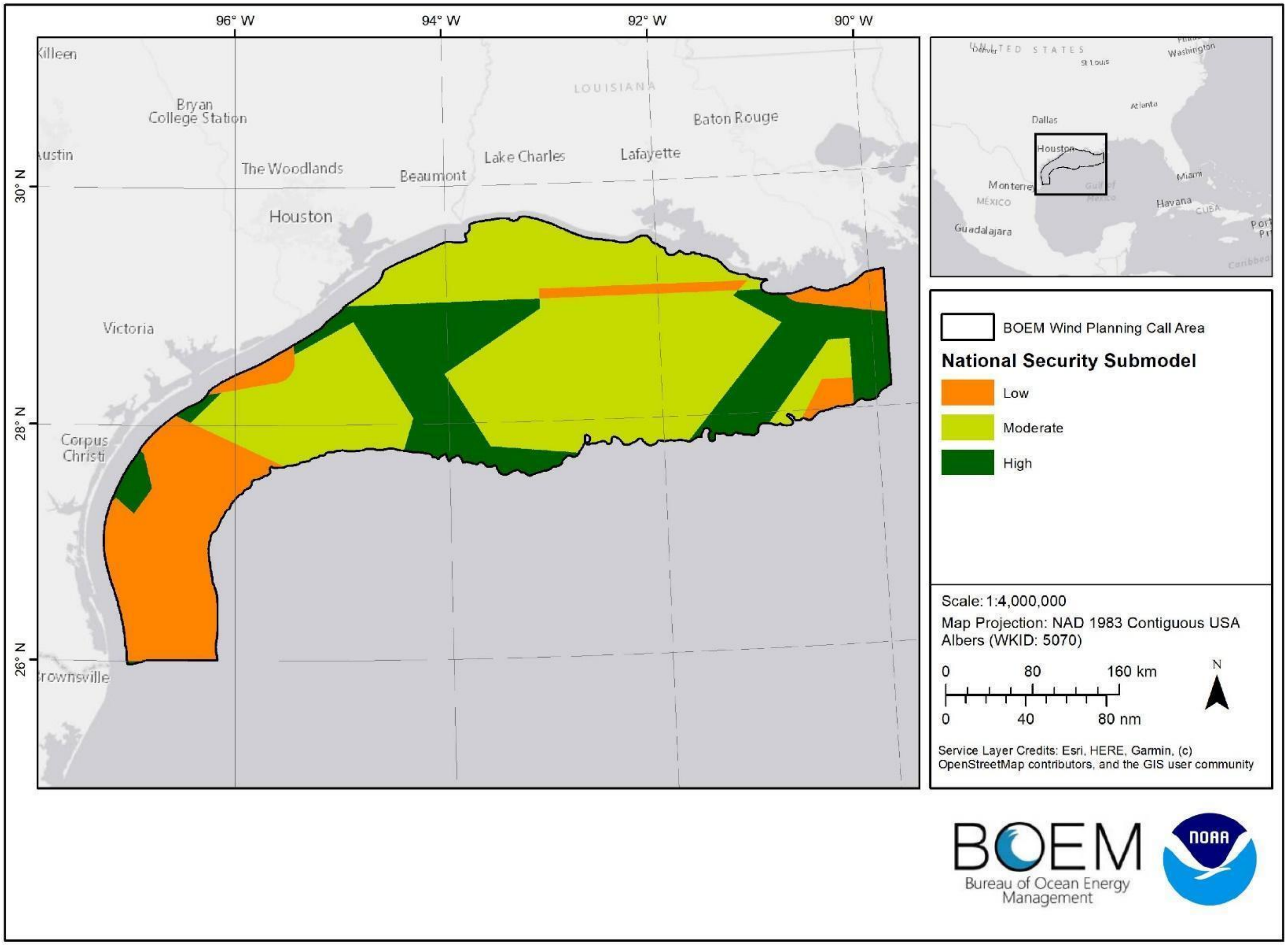

Figure 3.3. *National security submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while dark green indicates areas of higher suitability.*

3.2 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. Hardbottom and natural reefs were found throughout the Call Area, however most of the potentially sensitive biological features (PSBF) and low relief structures, as well as the BOEM No Activity Areas, were located in and around the Flower Garden Banks National Marine Sanctuary (**Figure 3.4**). BOEM's PSBFs and NMFS's Coral 9 habitat areas of particular concern (regulated and non-regulated) were assigned a score of 0.2 due to hardbottom habitats and associated organisms being sensitive to bottom disturbing activities. Data layers assigned a score of 0.5 include low relief structures and PSBFs, both provided by the Flower Garden Banks National Marine Sanctuary. These data layers were given a score of 0.5 because PSBFs in this layer are likely encompassed within the "BOEM No Activity Zones" and the "FGBMNS Boundary" layers that are already included in the constraints model. NOAA fish havens were assigned a score of 0.7 due to a lack of indication that offshore wind developments are highly incompatible with fish haven sites (**Table 3.3**).

3.2.1 Protected Resource Considerations

A total of 23 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 3.5**). The Rice's whale 100 - 400 m data layer was included in the constraints model and assigned a score of 0 for complete avoidance.

3.2.2 Pelagic Bird Considerations

The USFWS GoMMAPPS pelagic seabirds habitat suitability data layer was used to display avian habitat suitability for the Gulf of Mexico (Jodice et al. 2019). This data layer combines the maximum entropy (MAXENT) habitat suitability scores for 24 pelagic seabird species (Phillips et al. 2006). Overall suitability results for the natural and cultural resources submodel are presented in **Figure 3.7**.

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. 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
BOEM's Potentially Sensitive Biological Features	250 ft	0.2	0.6%
Coral 9 HAPC (no regulations and regulated areas)	-	0.2	0.6%
Low Relief Structures provided by FGBNMS	1000 ft	0.5	0.5%
Potentially Sensitive Biological Features provided by FGBNMS	1000 ft	0.5	0.3%

Existing Coral HAPCs (with regulations and without regulations)	-	0.2	0.2%
NOAA Fish Havens	500 ft	0.7	0.1%
Protected Resource Division Combined Layer	-	NMFS Values	100%
USFWS - GoMMAPPS 24 Pelagic Bird Spp. Habitat Suitability	-	Z Membership Function	100%

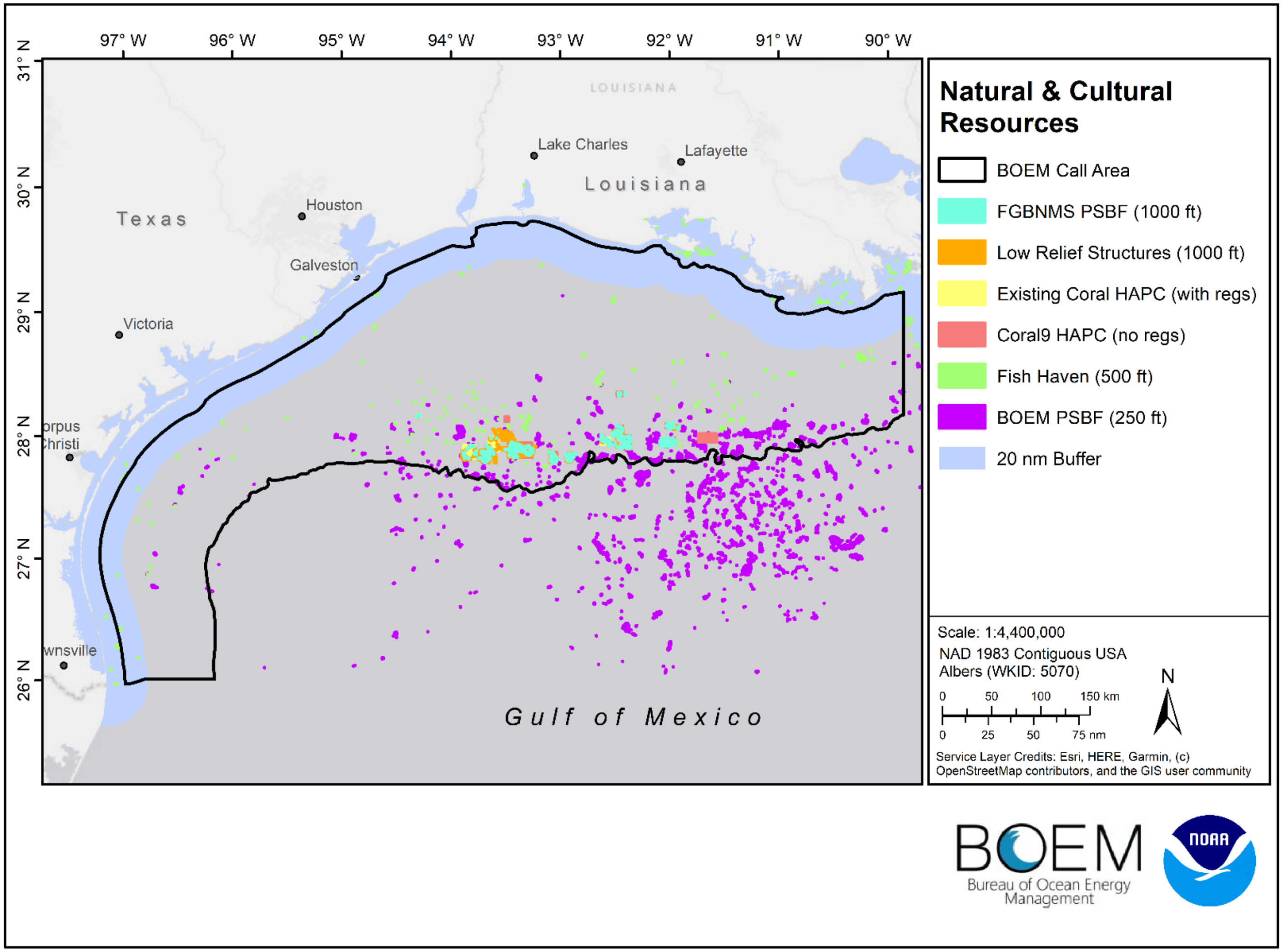

Figure 3.4. *Natural and Cultural Resource considerations for the Call Area. Considerations include fish havens, potentially sensitive biological features, low relief structures, and coral habitat.*

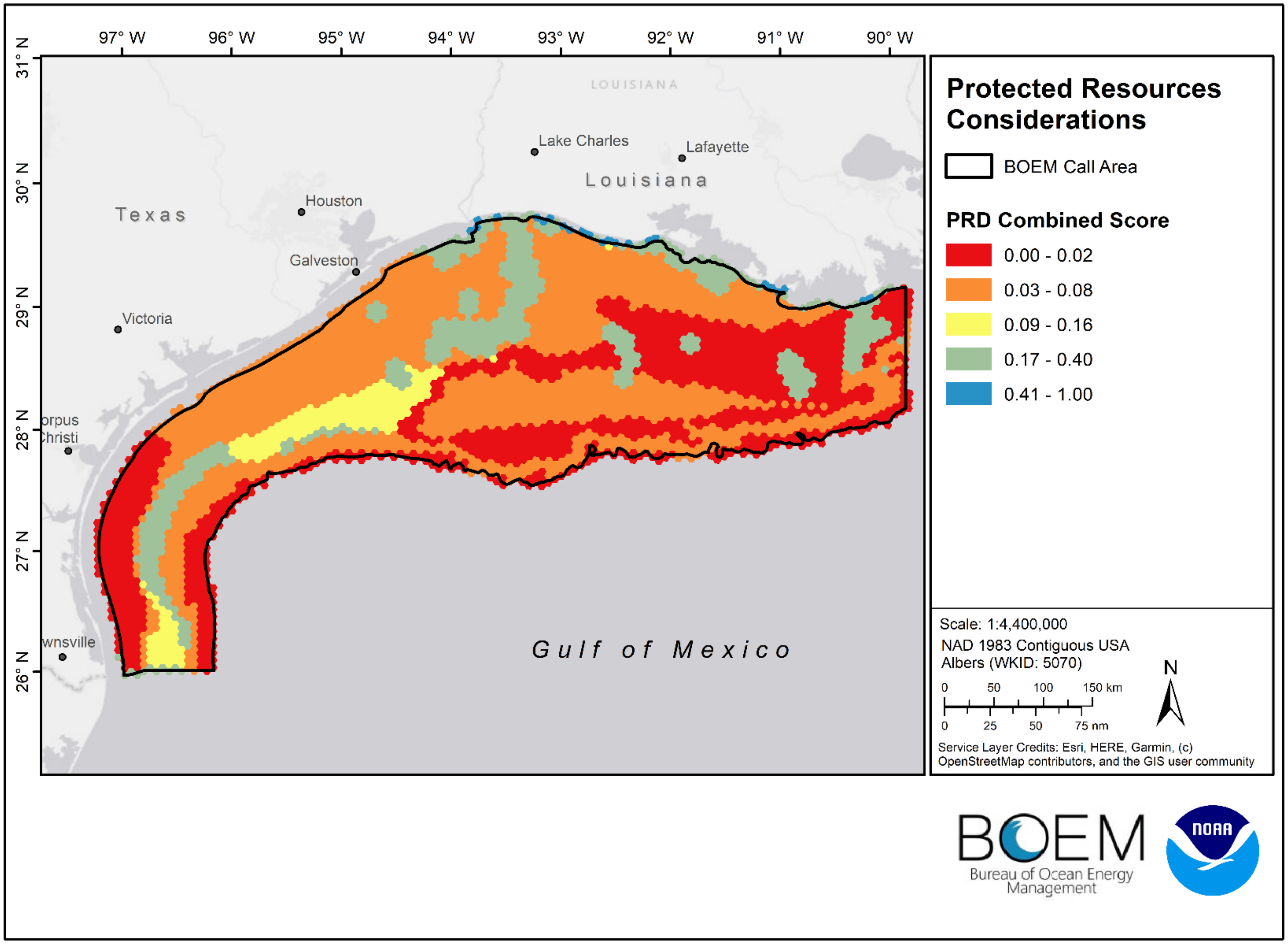

Figure 3.5. *National Marine Fisheries Service Protected Resources combined composite data layer implemented within the relative suitability analysis.*

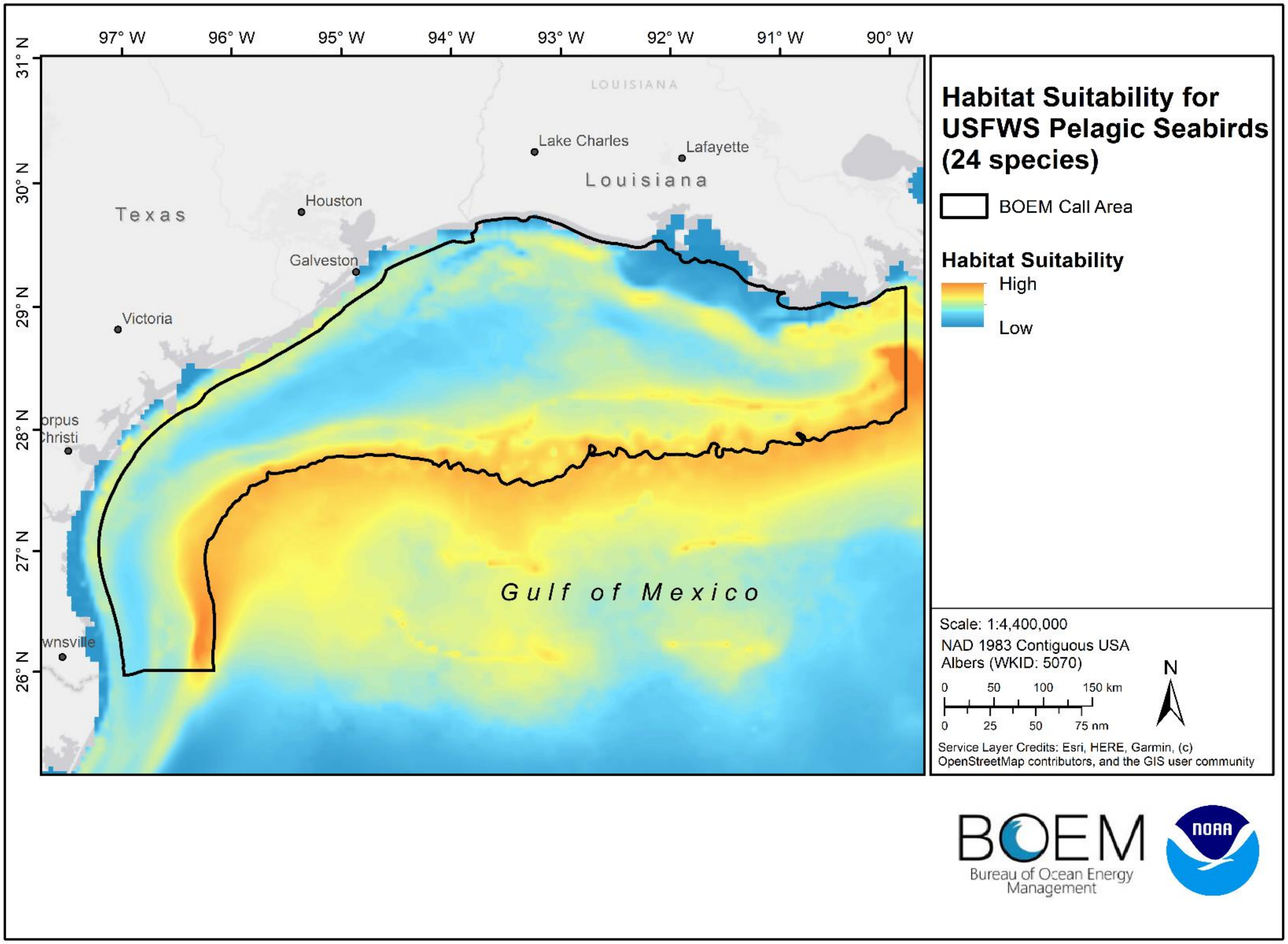

Figure 3.6. *USFWS GoMMAPPS 24 pelagic bird habitat suitability data layer implemented within the relative suitability analysis. Blue areas represent low habitat suitability for pelagic seabirds and are therefore more suitable for wind energy development. Orange/yellow areas represent higher habitat suitability that is less conducive to wind energy development.*

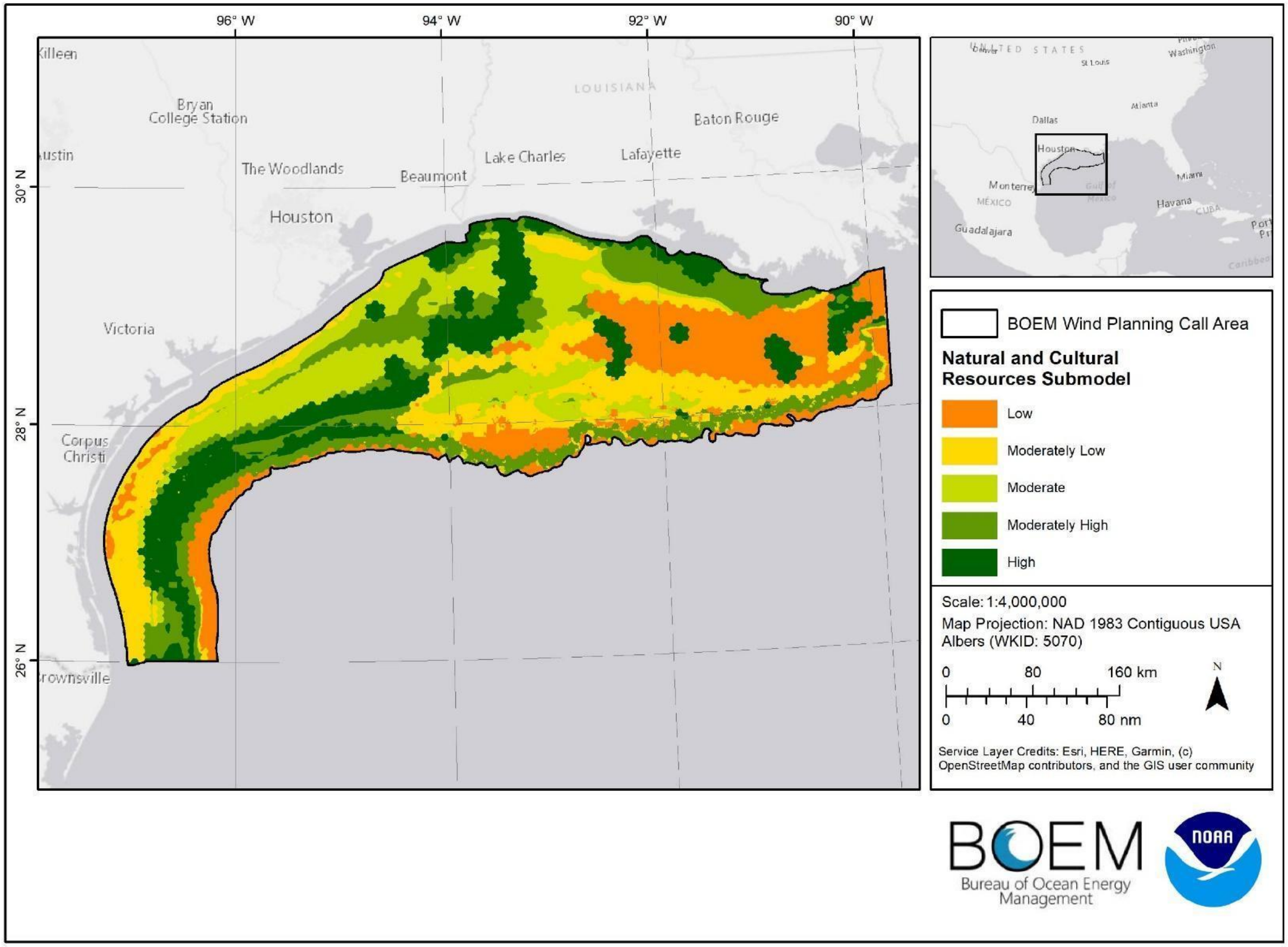

Figure 3.7. *Natural and cultural resources submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color green indicates areas of higher suitability.*

3.3 Industry and Operations

3.3.1 Industry and Seafloor Infrastructure

The Gulf of Mexico supplies trillions of dollars annually to the national economy via major marine industries (e.g., oil and gas production, commercial seafood, shipping) (NOAA 2021). Given the substantial presence of ocean industries in the region, industry activity in and around the Call Area was spatially examined (**Table 3.4**).

The Gulf of Mexico continues to be the nation's primary offshore source of oil and gas, generating about 97% of all U.S. OCS oil and gas production, making this energy sector one of the largest industrial users of regional marine resources (NOAA 2021). BOEM active oil and gas lease blocks, platforms (including active drilling structures), oil and gas pipelines (active), and oil and gas boreholes were all assigned a score of 0 and moved to the constraints submodel for analysis. Submarine cables transmit 95% of international communications and approximately ten trillion dollars (USD) in financial transactions each day (Tri-Service Strategy 2020); therefore, these were considered critical infrastructure incompatible with wind development, assigned a score of 0 and moved to the constraints submodel.

3.3.2 Navigation

Shipping is a multi-billion-dollar (USD) industry in the Gulf of Mexico, with two of the largest ports in the world, Houston and New Orleans, in the region (NOAA 2021). Navigational constraints were evaluated for the suitability model and included shipping fairways, anchorage areas, aids to navigation, and environmental sensors and buoys. These data layers were assigned a score of 0 and moved to the constraints submodel for complete avoidance. Shipping fairways overlap with 19.5% of the Call Area. Federal lightering rendezvous areas involve oil and hazardous material transfer operations and overlap 12.2% of the Call Area. Rendezvous areas are where lightering can begin and continue for a given time and speed (**Figure 3.8**). Due to this activity, these areas were assigned a score of 0.5.

3.3.3 Operations

NWS provided recommendations for siting wind energy in relation to Next Generation Weather Radar (NEXRAD). With areas <35 km being completely avoided (none within the Call Area), and areas 35 to 70 km being scored a 0.5 due to potential interactions. NMFS's fishery-independent surveys in the region were also considered, with areas that have more fishing surveys given a lower score than areas with less fishing surveys.

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. Scores closer to 0 are less suitable for wind energy development, while scores closer to 1 are more suitable.

Data Layer	Score	Percent Overlap
Outside of Carbon Capture WEAs	0.5	71.4%
Federal Lightering Rendezvous Areas	0.5	12.2%
NEXRAD Sites	0 - 35 km = 0 35 - 70 km = 0.5	4.1%
NMFS's Fishery-Independent Surveys	Z Membership Function	100%
AIS Vessel Traffic 2019 – Cargo	Z Membership Function	23.3%
AIS Vessel Traffic 2019 – Fishing	Z Membership Function	53.5%
AIS Vessel Traffic 2019 – Other	Z Membership Function	66.4%
AIS Vessel Traffic 2019 – Passenger	Z Membership Function	49.0%
AIS Vessel Traffic 2019 – Pleasure and Sailing	Z Membership Function	8.5%
AIS Vessel Traffic 2019 – Tanker	Z Membership Function	27.2%
AIS Vessel Traffic 2019 – Tug and Tow	Z Membership Function	31.6%

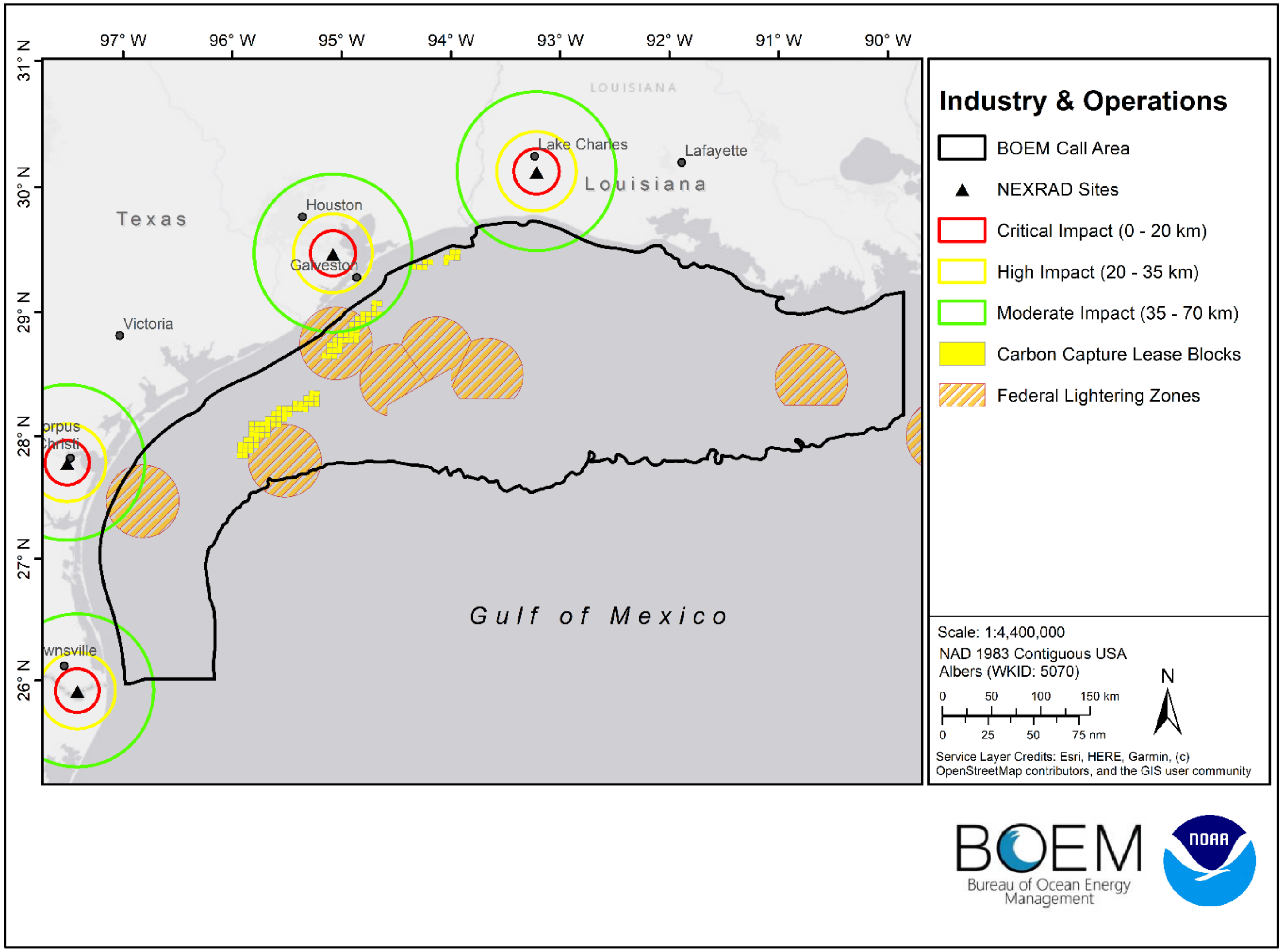

Figure 3.8. Industry and Operations considerations for the Call Area. Considerations include NEXRAD sites and impact areas, federal lightering rendezvous zones, and BOEM lease blocks identified for carbon capture.

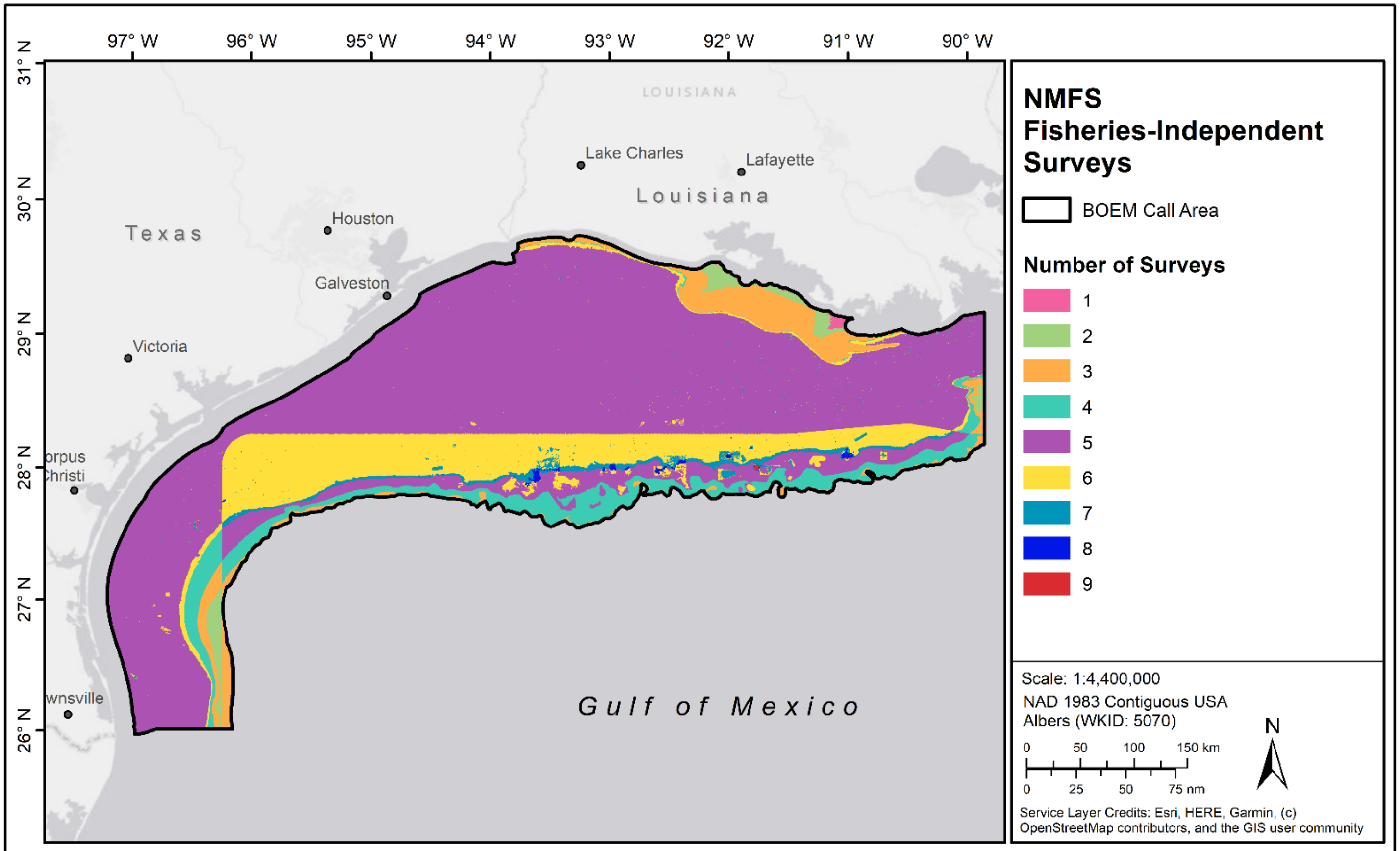

Figure 3.9. *A count of overlapping NMFS Fisheries-Independent Surveys for the Call Area implemented within the relative suitability analysis*

3.3.4 Automated Vessel Identification System Transit Count 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 2019 were analyzed to determine the relative vessel transit counts (i.e., vessel traffic) of each vessel type: tanker, cargo, passenger (e.g., cruise ships), ferries, tug and tow, pleasure and sailing, military and other vessels (e.g., first responders)[11] within the Call Area (**Figures 3.10 – 3.16**).

Cargo and tanker vessel transits disperse from land-based ports in the Houston/Galveston, TX area with additional dense traffic dispersing from Cameron, LA, and Freeport, Port Arthur, Matagorda, Corpus Christi, and Brownsville, TX. Cargo transits intersected with 23.3% of the Call Area, while tanker transits intersected with 27.2% (**Figures 3.10 – 3.11**). Dense traffic for cargo and tanker vessels (larger vessels) is largely confined to shipping fairways within the Call Area, with some deviations of vessels, especially of tanker vessels. Tug and tow vessels tend to occur inshore around major ports or working around the shipping fairways as tenders. Tug and tow overlapped 31.6% of the Call Area, mostly in areas closest to land-based infrastructure associated with ports in Louisiana and Texas (**Figure 3.12**). Passenger vessels intersected with 49.0% of the Call Area (**Figure 3.13**). Pleasure and sailing vessel transits were relatively low with 8.5% overlap (**Figure 3.14**). Transit counts from fishing vessels with AIS transponders in 2019 indicate 53.5% intersection with the Call Area (**Figure 3.15**). Transits by the other category of AIS vessels, which includes several different craft types[12], are the most widely dispersed in the Call Area with 66.4% overlap (**Figure 3.16**). Suitability results for the industry and operations submodel are presented in **Figure 3.17**.

[11] https://www.google.com/url?q=https://www.navcen.uscg.gov/pdf/AIS/AISGuide.pdf&sa=D&source=editors&ust=162 4640106728000&usg=AOvVaw0t9-X9iMuk-lF3VbUCDHf1

[12] https://www.navcen.uscg.gov/pdf/AIS/AISGuide.pdf

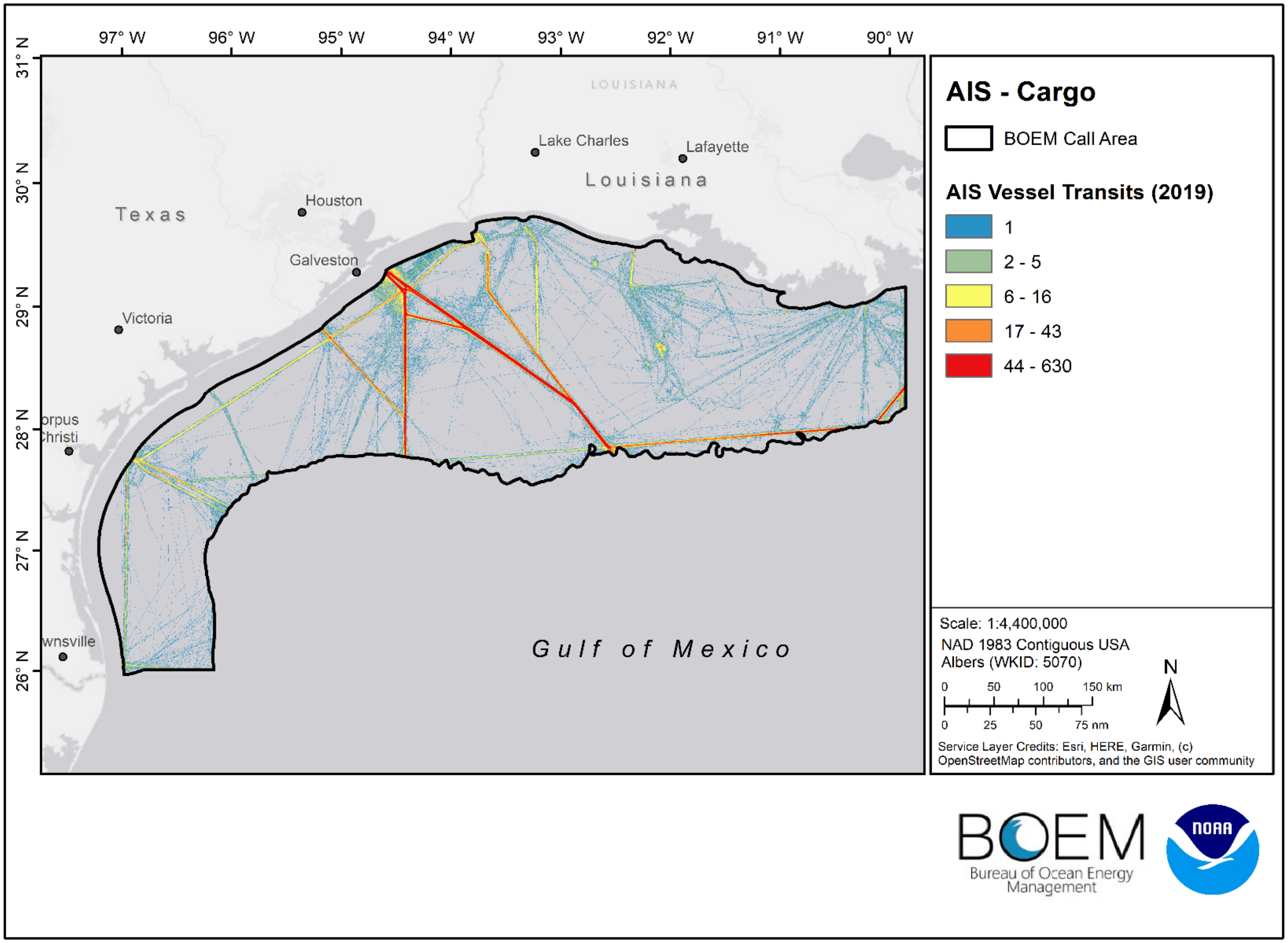

Figure 3.10. *Automatic Identification System Vessel transit data from 2019 for cargo vessels in the Call Area.*

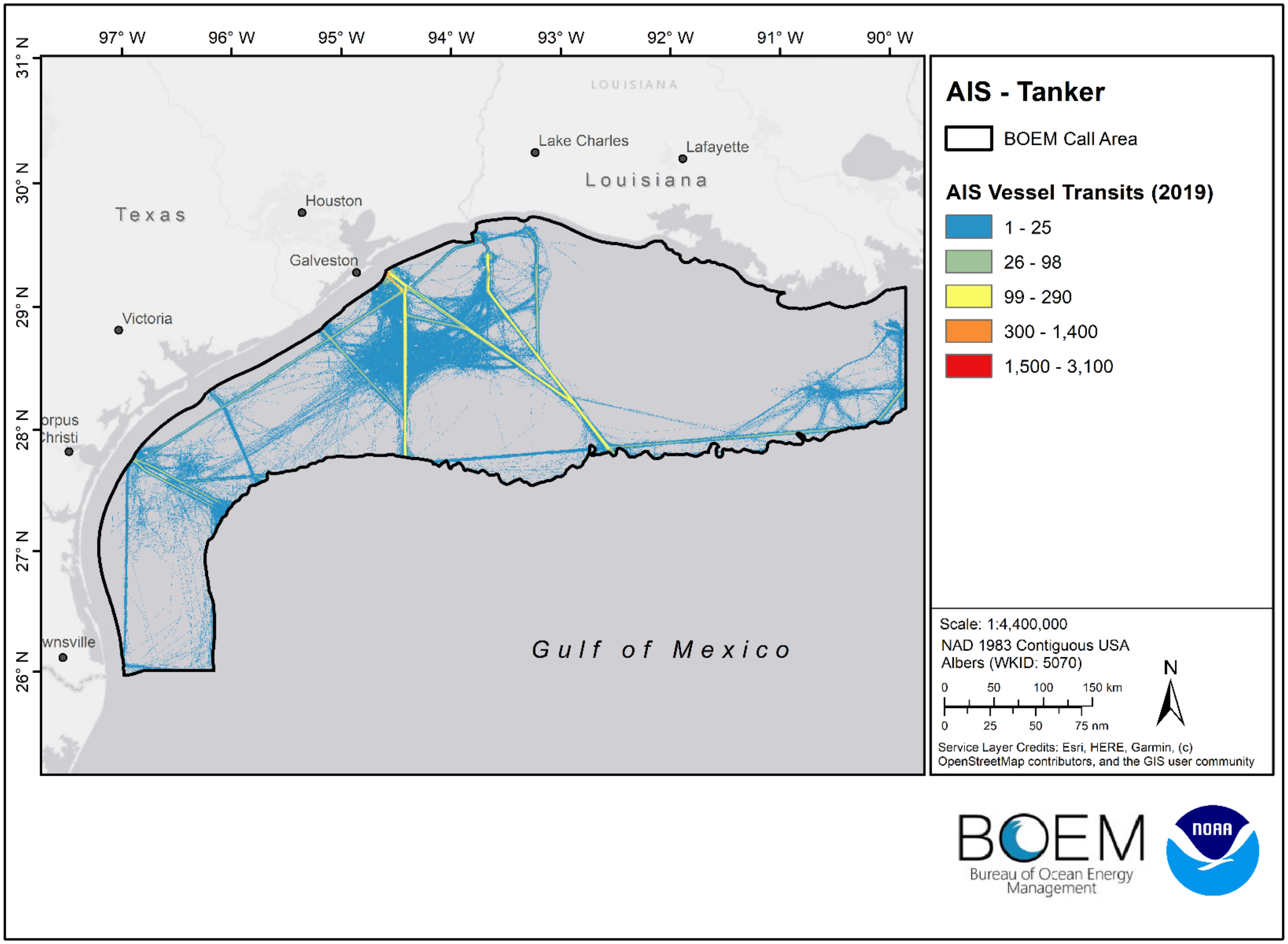

Figure 3.11. *Automatic Identification System Vessel transit data from 2019 for tanker vessels in the Call Area.*

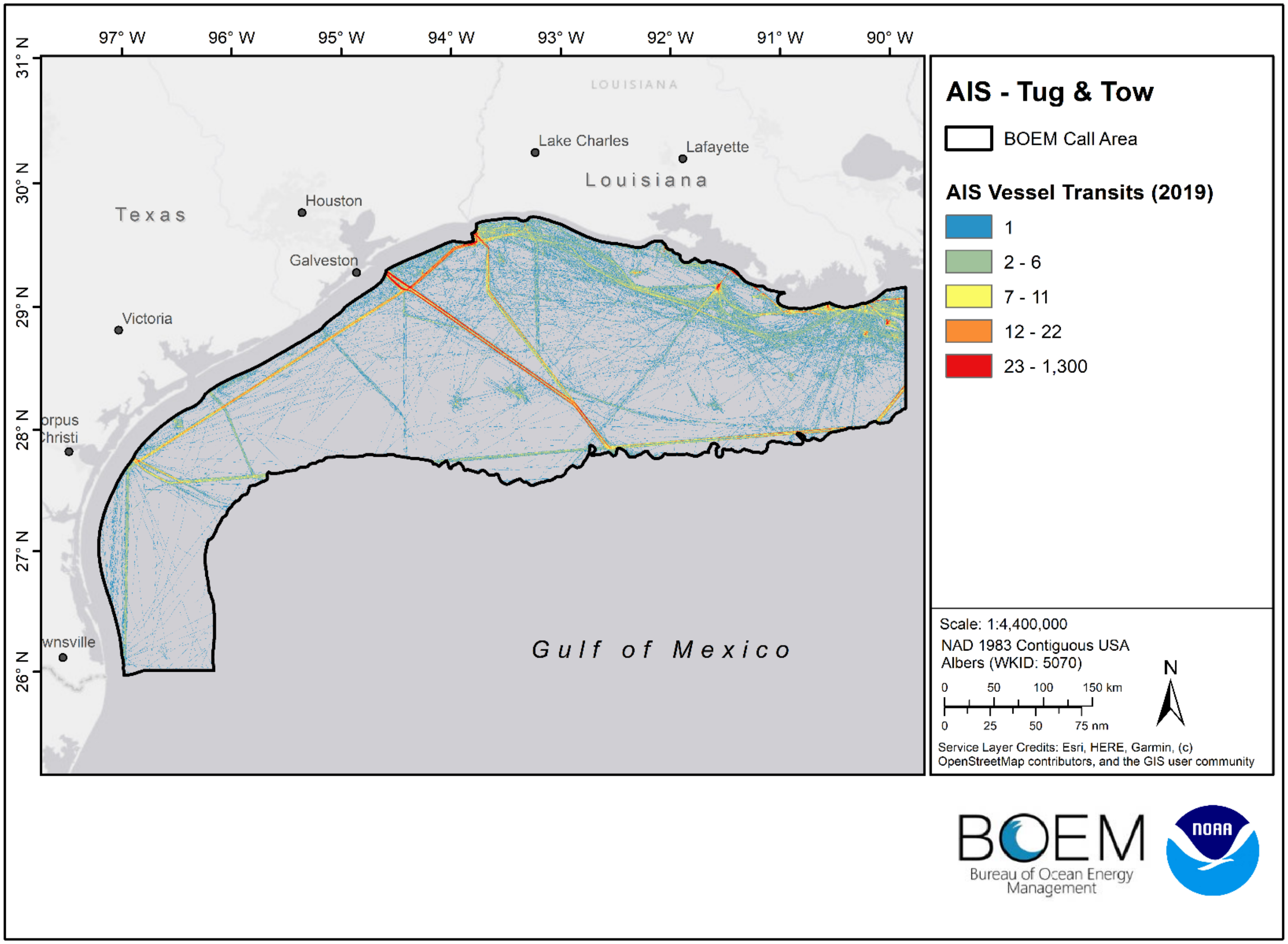

Figure 3.12. *Automatic Identification System Vessel transit data from 2019 for tug and tow vessels in the Call Area.*

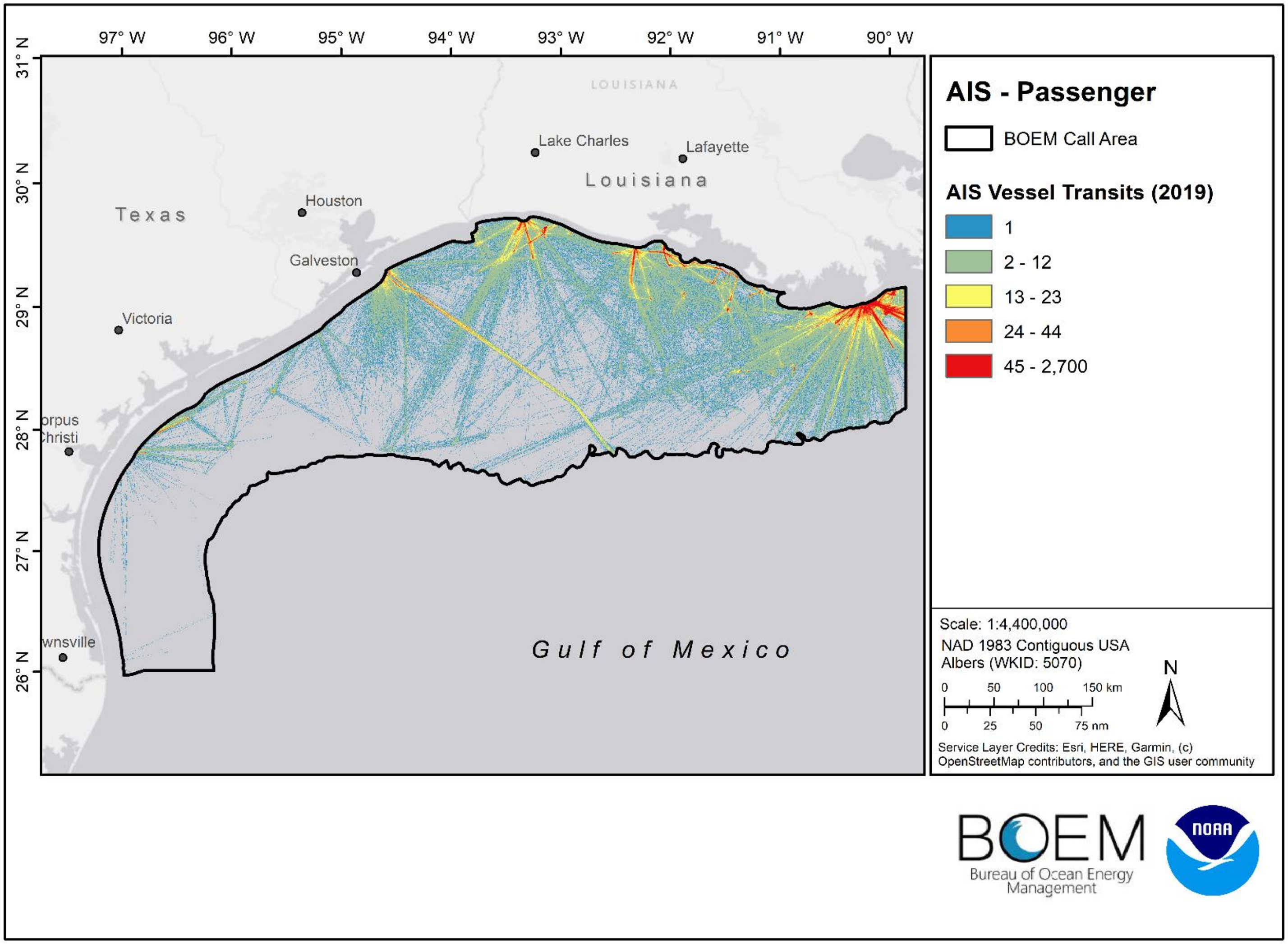

Figure 3.13. *Automatic Identification System Vessel transit data from 2019 for passenger vessels in the Call Area.*

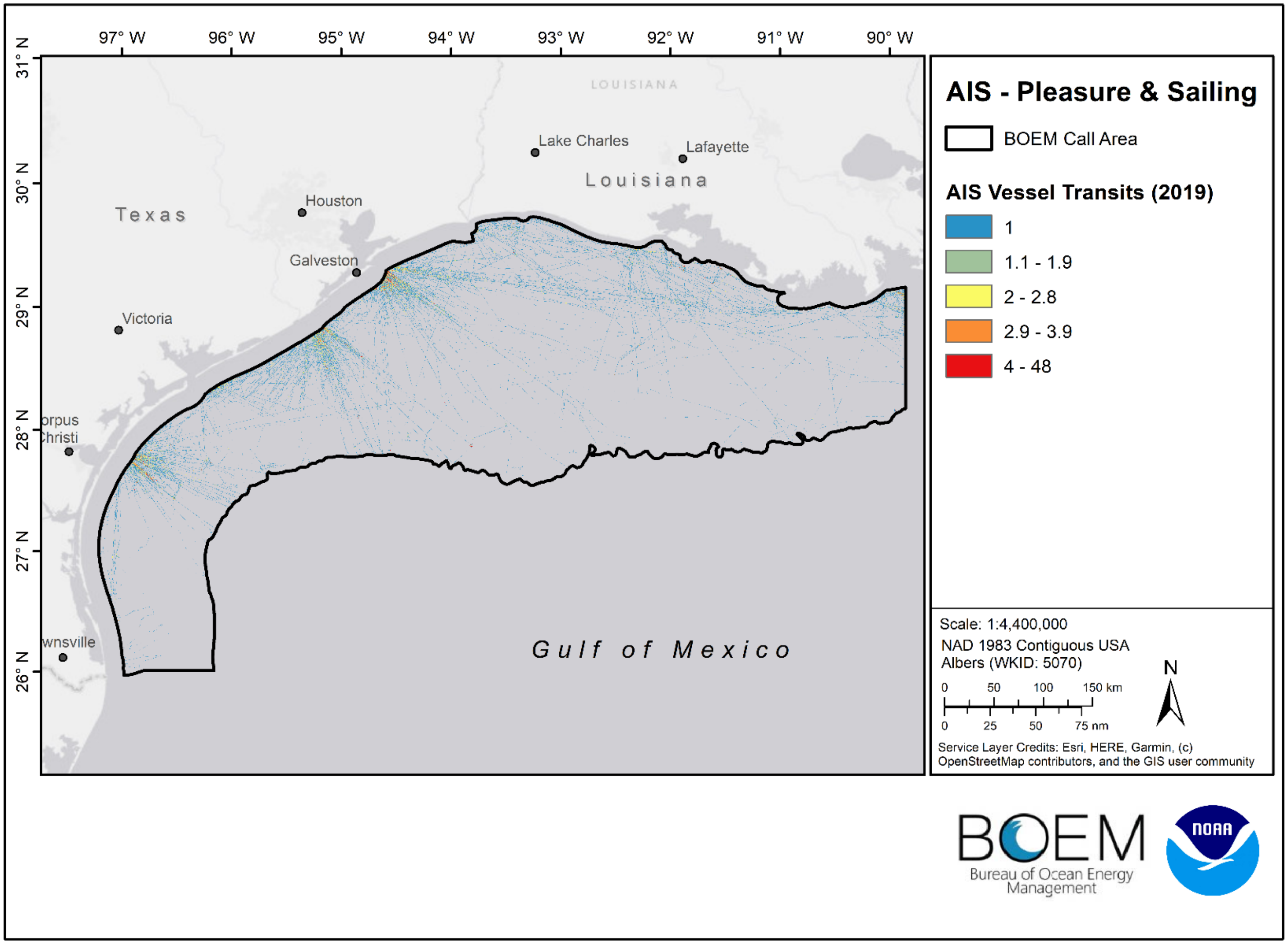

Figure 3.14. *Automatic Identification System Vessel transit data from 2019 for pleasure and sailing vessels in the Call Area.*

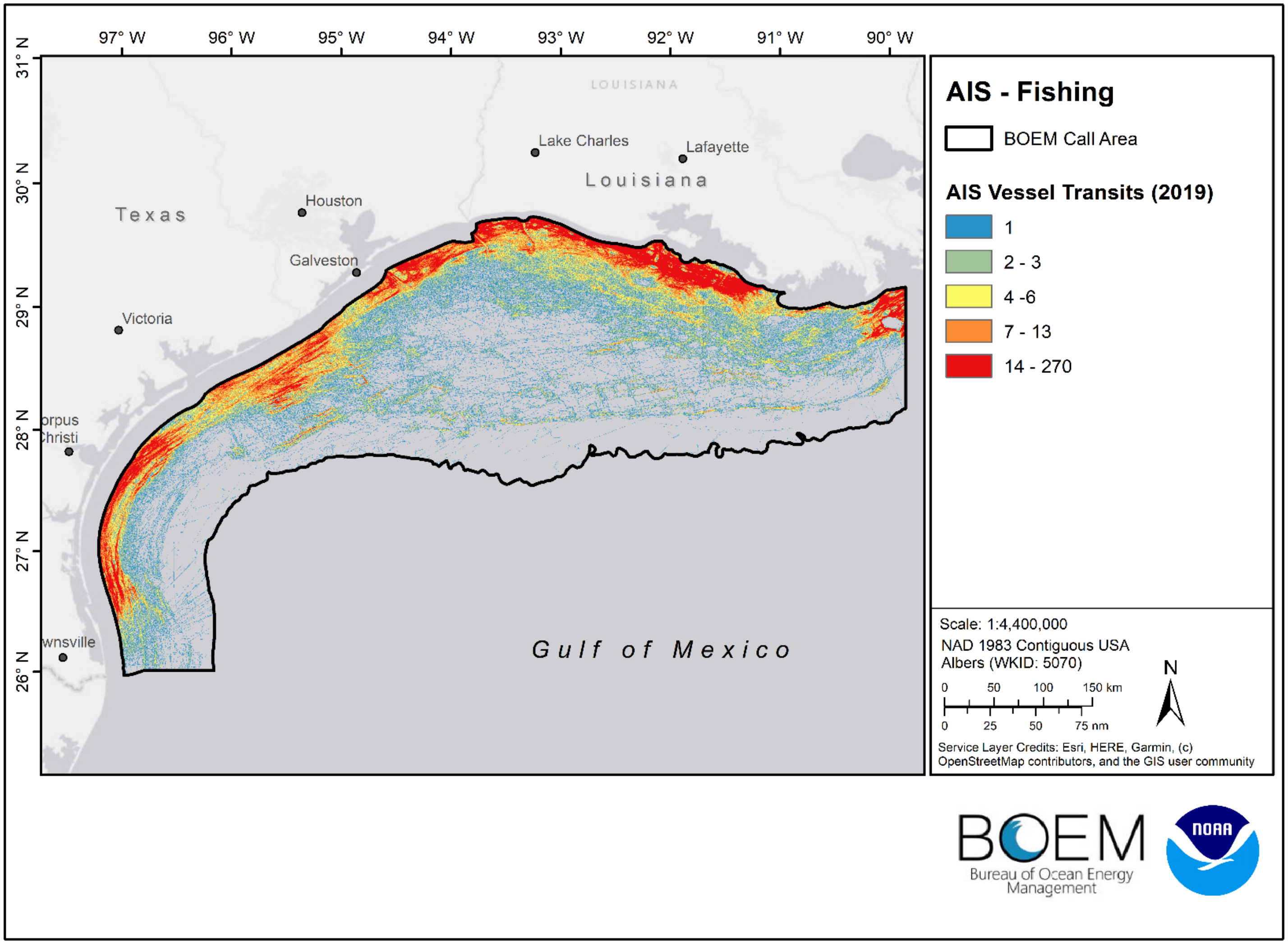

Figure 3.15. *Automatic Identification System Vessel transit data from 2019 for fishing vessels in the Call Area.*

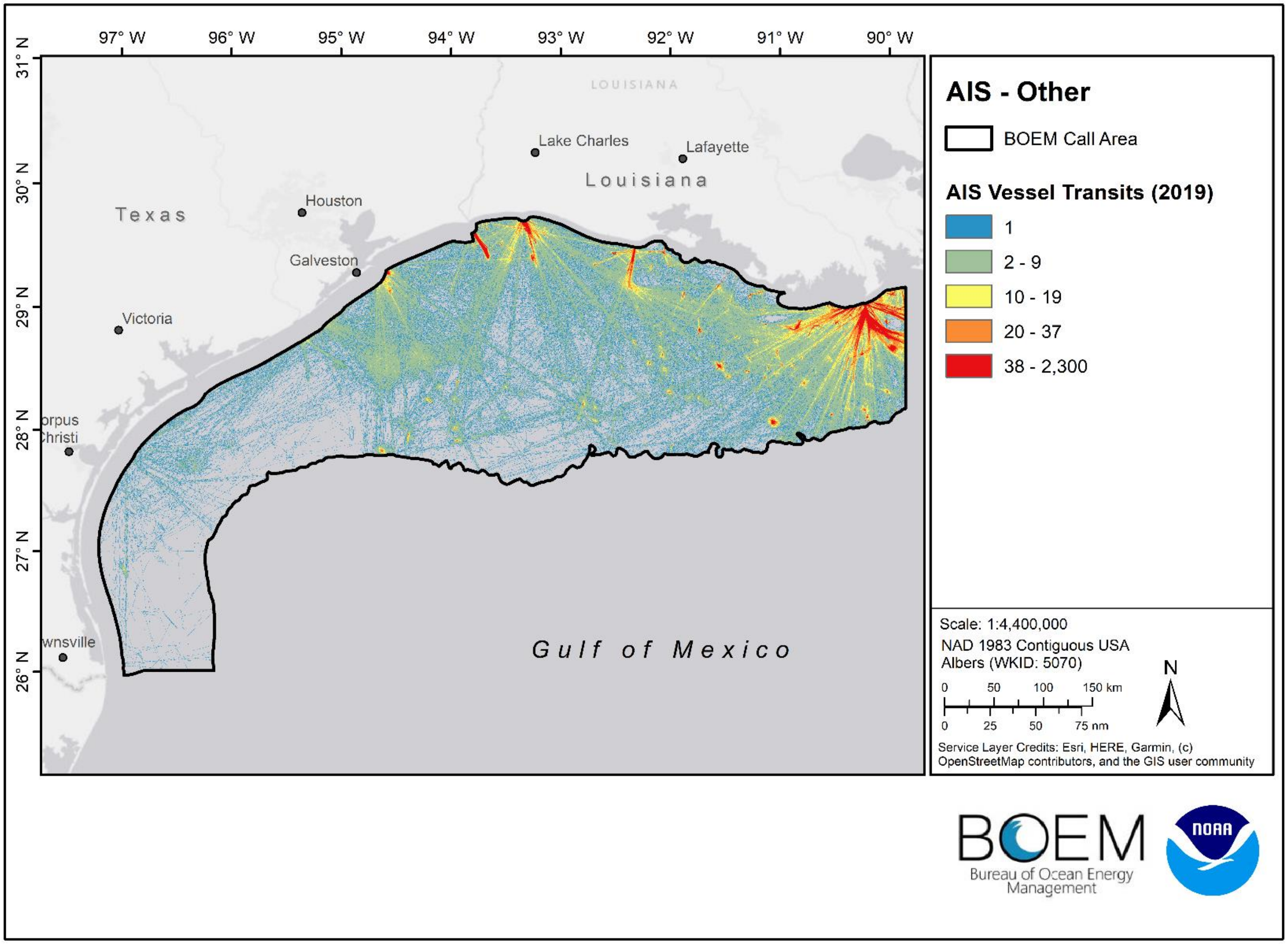

Figure 3.16. *Automatic Identification System Vessel transit data from 2019 for vessels classified as other in the Call Area.*

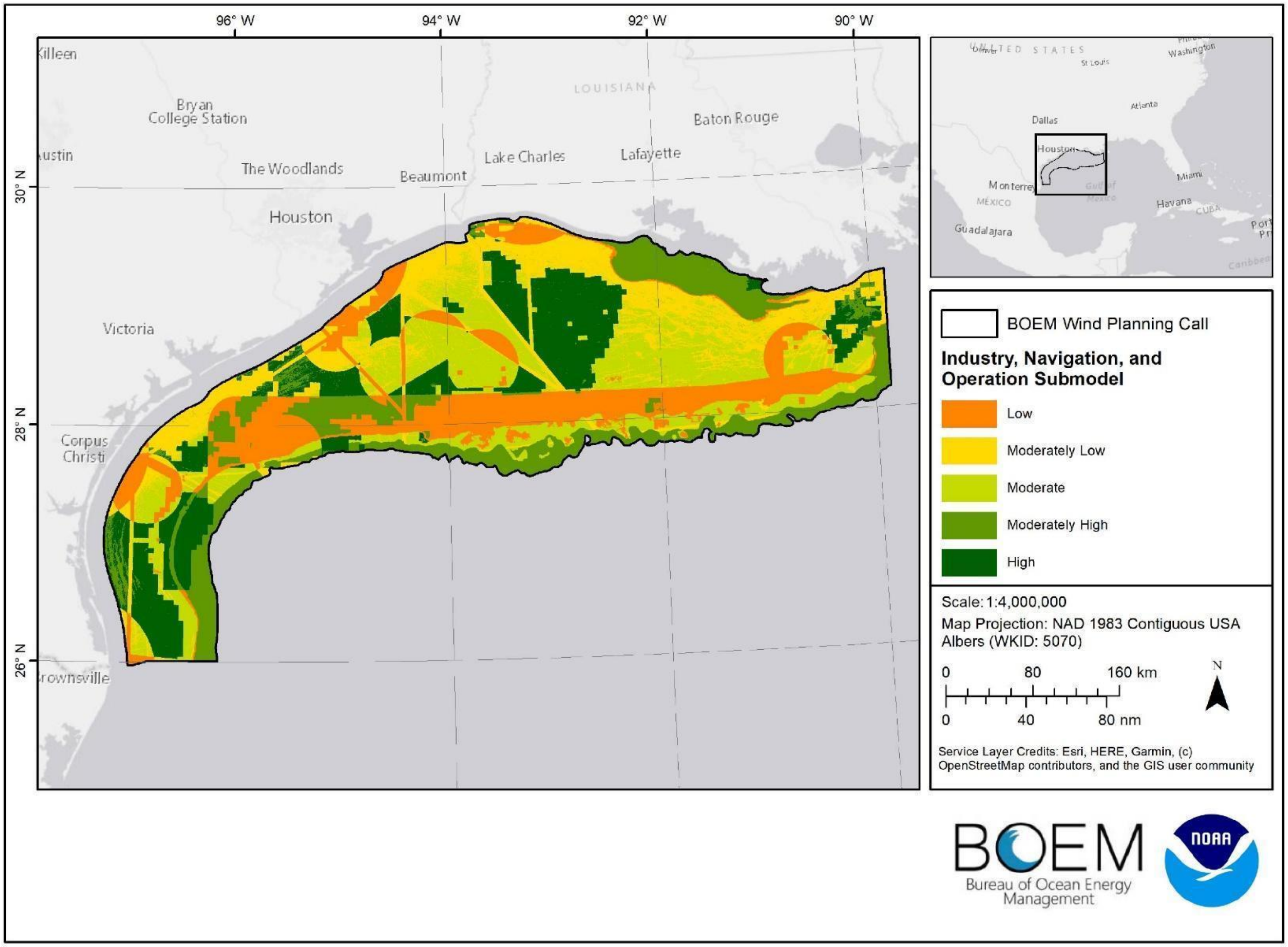

Figure 3.17. *Industry and operations submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color green indicates areas of higher suitability.*

3.4 LOGISTICS

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. Shallower depths will generally make installation easier and more cost effective. Suitability results for the logistics submodel are presented in **Figure 3.19**.

Table 3.5. Logistics 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	Score	Percent Overlap
Distance to shore	Linear function (Closer to shoreline is better)	100%
Distance to principal ports	Linear function (Closer to principal port is better)	100%
Depth	Linear function (Shallower depth is better)	100%

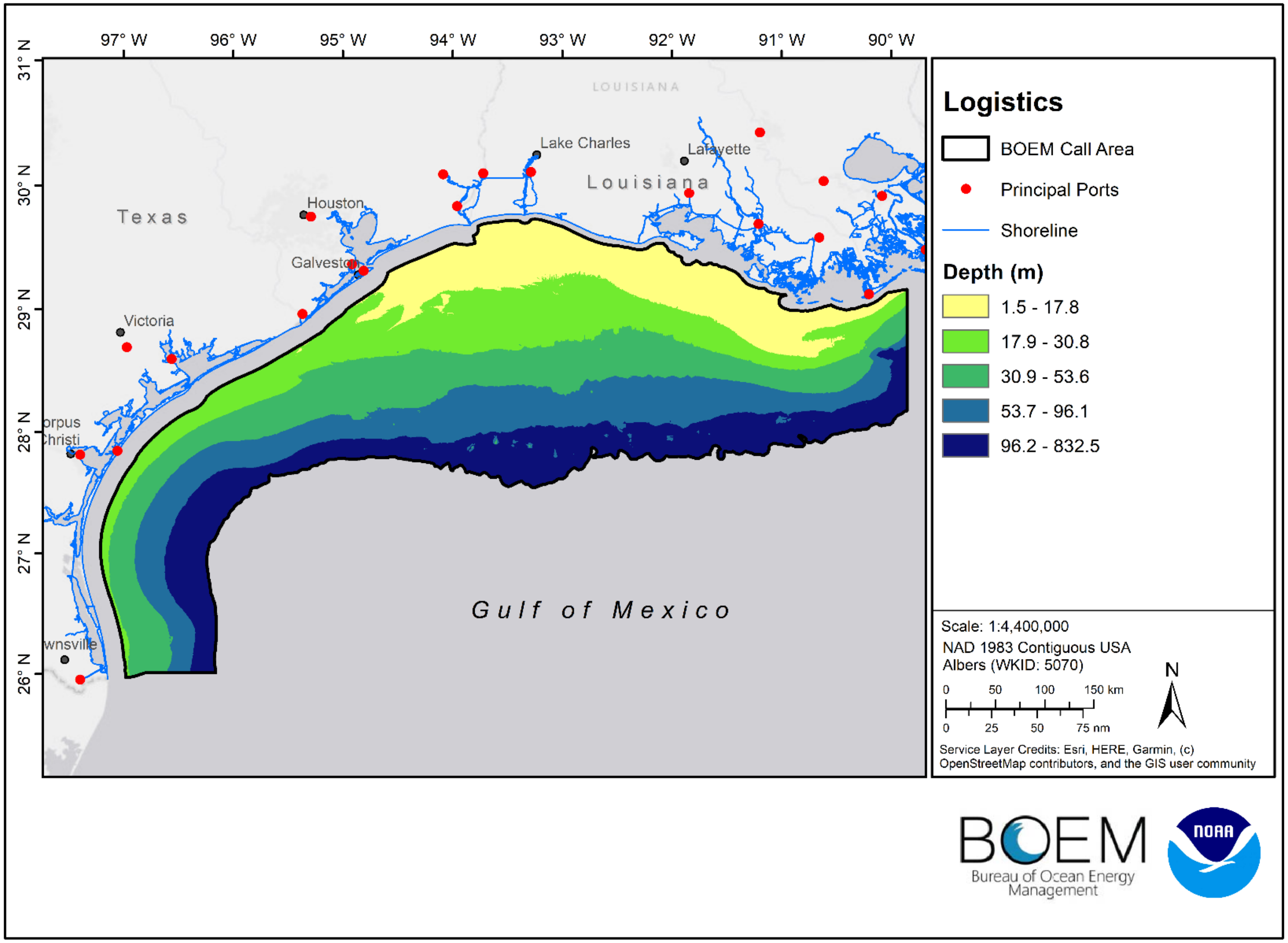

Figure 3.18. *Logistics considerations for the Call Area. Considerations include distance to shore, distance to principal ports, and depth.*

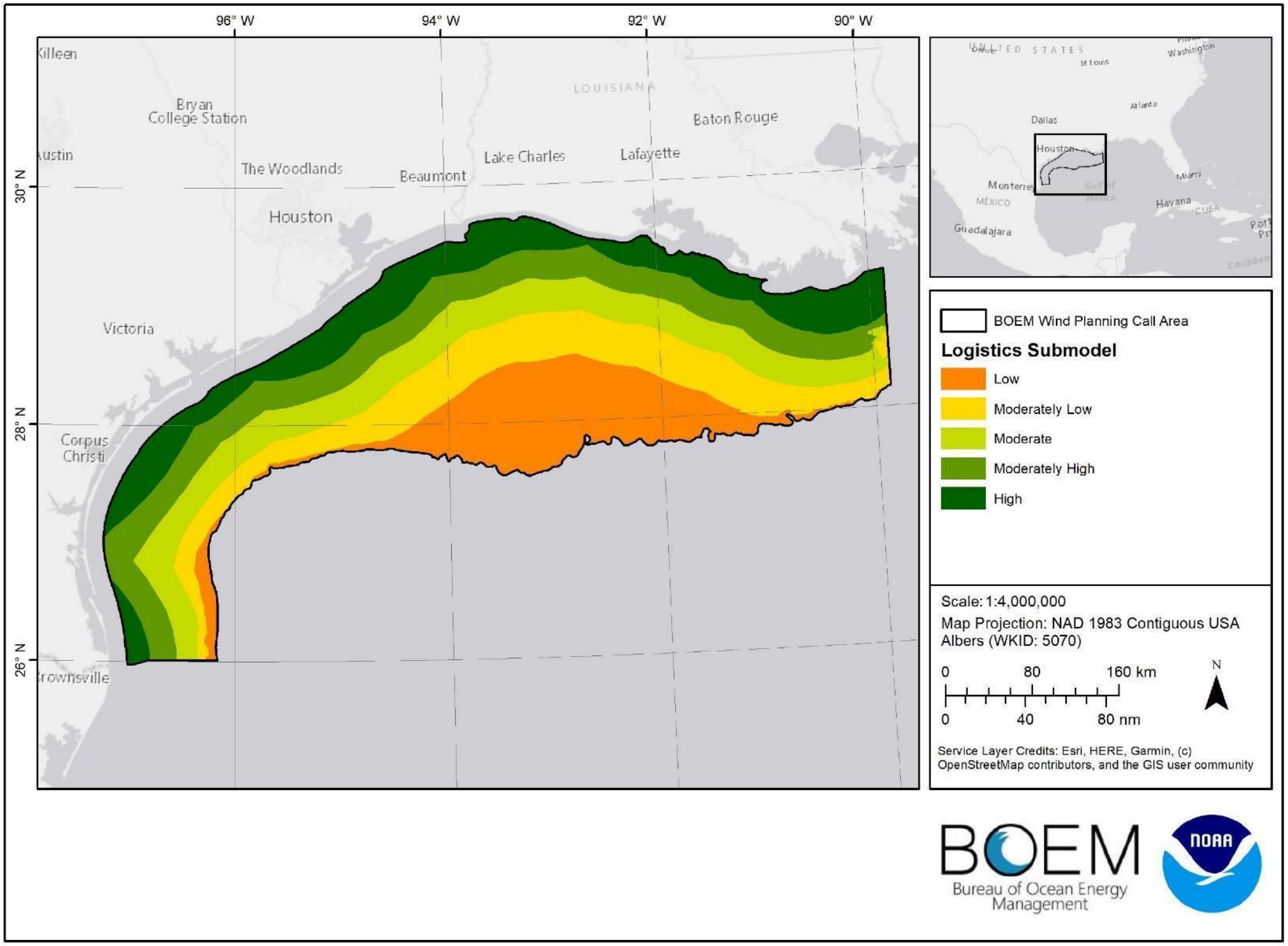

Figure 3.19. *Logistics submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color green indicates areas of higher suitability.*

3.5 ECONOMICS

The economics submodel included the National Renewable Energy Laboratory's (NREL) net value (2015) and BOEM's competitive lease blocks data layers. In 2017, NREL published a report in which they assessed the economic feasibility of developing offshore wind energy in different regions of the United States, including the Gulf of Mexico (Beiter et al 2017).[13] The data and results from that analysis were incorporated into a data layer by NREL using a net value assessment based on installing an offshore wind farm in 2015 (**Figure 3.20**). The competitive lease blocks data layer used in this submodel was created by BOEM and includes any lease block in which industry interest was identified during the RFI. Competitive lease blocks overlapped with 13.4% of the Call Area (**Table 3.6** and **Figure 3.20**). Suitability results for the economic submodel are presented in **Figure 3.21**.

Table 3.6. Economics 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	Score	Percent Overlap
NREL - Net Value 2015	Linear function (Higher net value is more suitable)	100%
Competitive Lease Blocks	Cells outside =0.5, Cells inside =1	13.4%

[13] https://www.nrel.gov/docs/fy17osti/67675.pdf

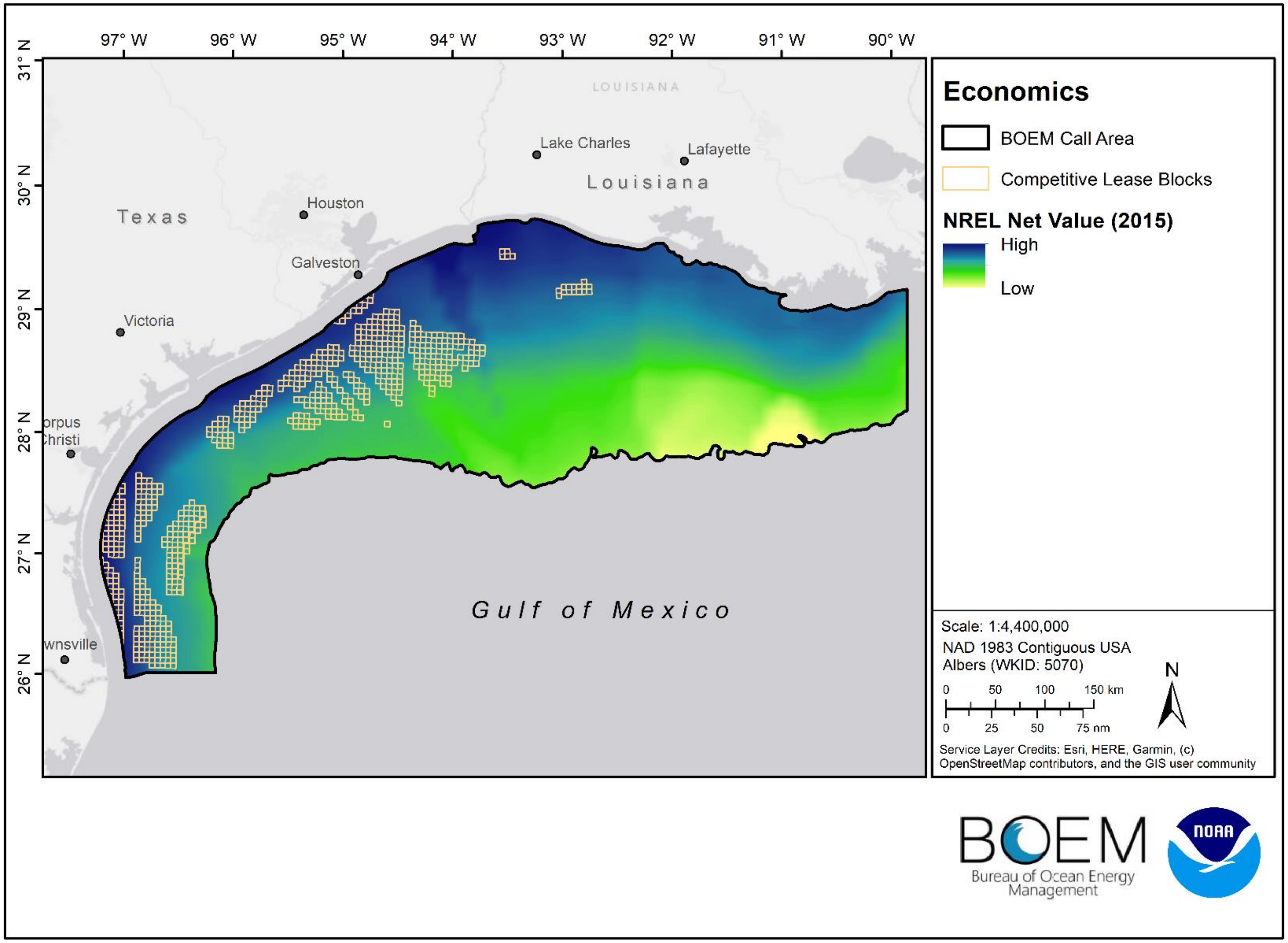

Figure 3.20. *Economics considerations for the Call Area. Considerations include BOEM lease blocks with competitive interest and NREL wind net values.*

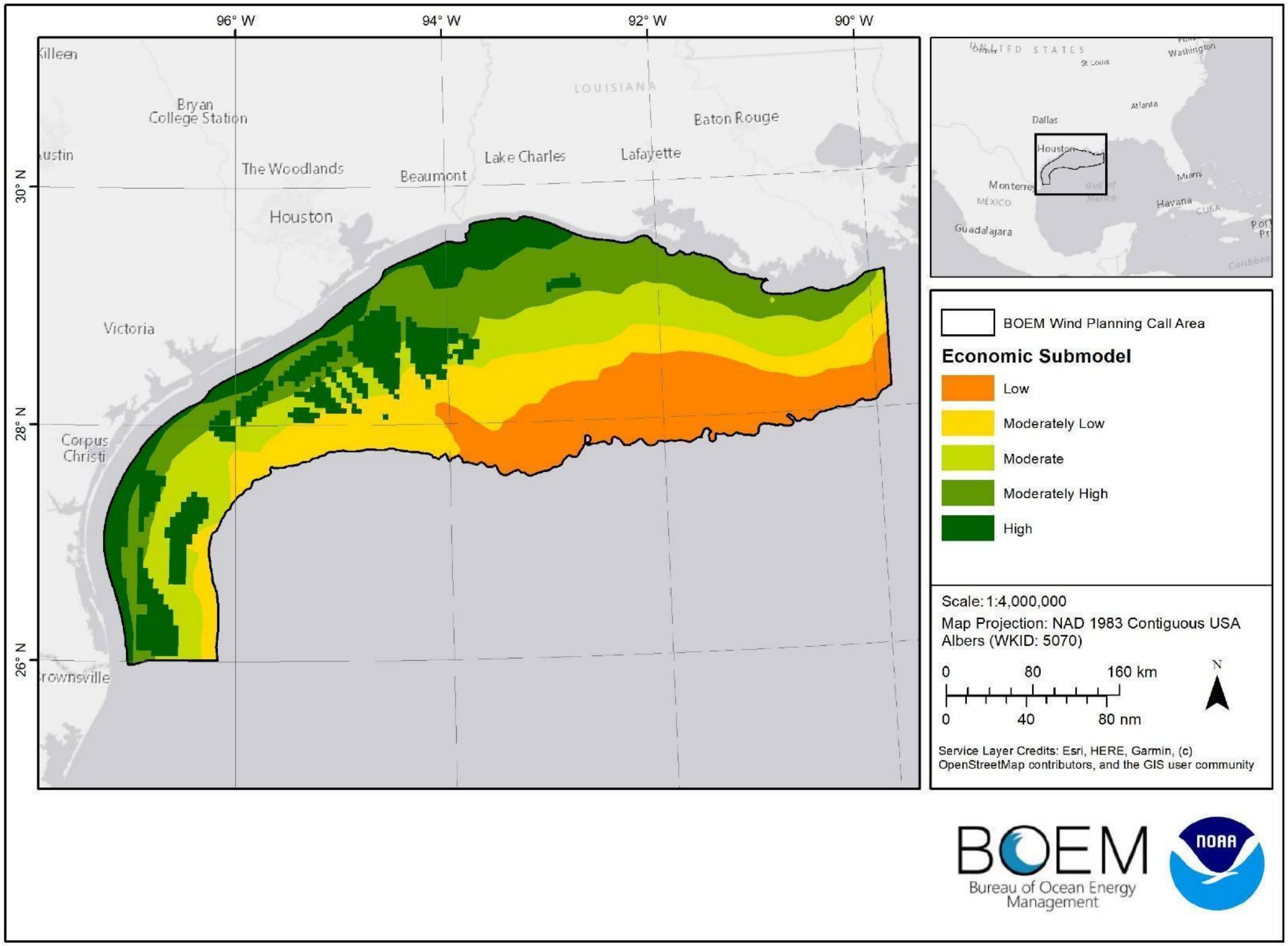

Figure 3.21. *Economics submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color green indicates areas of higher suitability.*

3.6 FISHERIES

Both recreational and commercial fisheries data were included in the fisheries submodel. The commercial penaeid shrimp fishery data used in this analysis (i.e., 2015-2019) had the largest overlap with the Call Area at 68.4%, especially in areas closer to shore. The menhaden fishery had 5.6% overlap with the Call Area and was predominantly present off the coast of LA. Highly Migratory Species Pelagic Longline Gear (2011-2020) had extremely low overlap of only 0.6% and is located primarily in deeper waters in the Gulf of Mexico. Both bandit gear fishing and longline gear fishing of reef fish (2007 - 2021) had similar amounts of overlap with the study area with the longline gear occurring in deeper waters than the bandit gear fishing (**Table 3.7**). The only recreational fishing data included was the Southeast Region Headboat Survey (SRHS) (2014 - 2020) trips, which identified the highest area utilized by headboat fishing off the coast of Corpus Christi, TX. Individual fisheries data not shown due to confidentiality. Suitability results for the fisheries submodel are presented in **Figure 3.22**.

Table 3.7**.** Fisheries 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	Score	Percent Overlap
Commercial Shrimp Electronic Logbook Data (2015 - 2019)	Z membership function - The moderate, mod/high, and high effort data categories (Natural Breaks) are included in the constraints model	68.4%
Menhaden Fishery Data (2000 - 2016)	Z membership function - Area between 90° - 91° strata (coastal Louisiana) out to 20 miles would be used in the constraints model.	5.6%
Highly Migratory Species Pelagic Longline Gear (2011-2020)	Z membership function	0.6%
Reef Fish Bandit Gear Fishing Data (2007 - 2021)	Z Membership Function	2.3%
Reef Fish Longline Gear Fishing Data (2007 - 2021)	Z Membership Function	2.7%
Southeast Region Headboat Survey Data (2014 - 2020)	Z Membership Function	7.8%

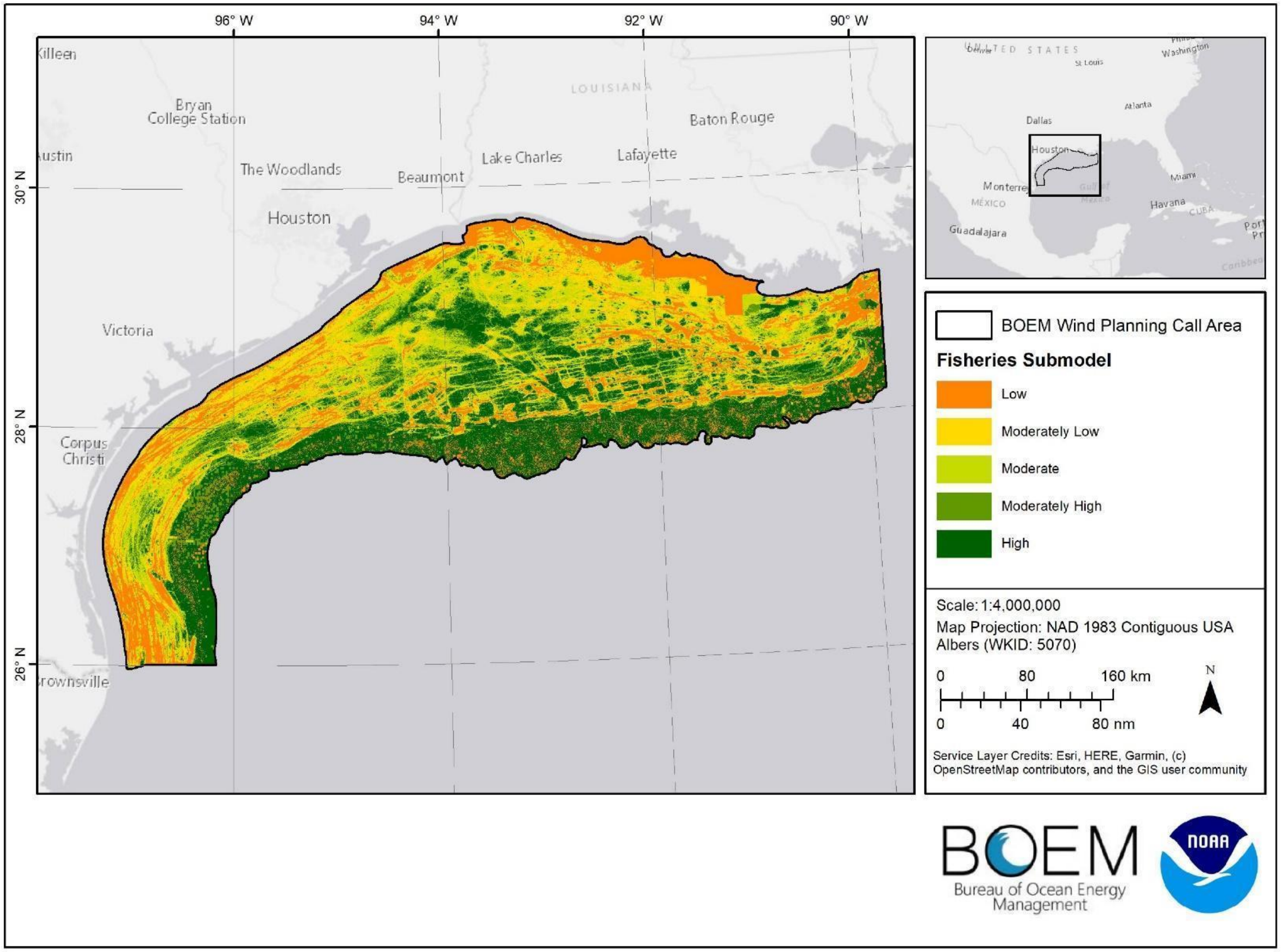

Figure 3.22. Fisheries submodel utilized in the relative suitability model. The color orange represents areas of lower suitability, while the color green indicates areas of higher suitability.

3.7 FINAL SUITABILITY

The final suitability results for all submodels are presented in **Figure 3.23**. Several suitable areas were distributed off of the east coast of Texas to southwest Louisiana. It is important to note that these suitability results are reflective of the planning objective to identify wind energy areas. In the Gulf of Mexico region, wind energy opportunities may exist under different planning objectives or at different scales than suitable for WEAs (< 39,000 ac).

3.8 CLUSTER ANALYSIS AND WEA OPTIONS

The cluster analysis identified 2,398,150 ac of high-high clusters, which are groups of cells with high values that are statistically significant. Overall, fourteen WEA options, ranging from 39,836 ac to 546,645 ac, all containing at least seven lease blocks (>39,000 ac) were identified (**Figure 3.24**). The ranking of WEA options is provided to show relative comparisons among the options to aid decision making (**Table 3.8**). For example, Option F had the highest overall score with high and middle of the road suitability scores for all submodels relative to the other options.

Option J, the second highest scoring option, had higher suitability scores for many of the submodels, however had a very low score for the Industry and Operation submodel. Upon further review (Found in the Characterization **Tables 3.18**), Option J contains lightering zones, and thus had the most tanker vessel traffic relative to the other options. A decision maker may deem that more of an obstacle to overcome than another conflict and may decide not to go with Option J.

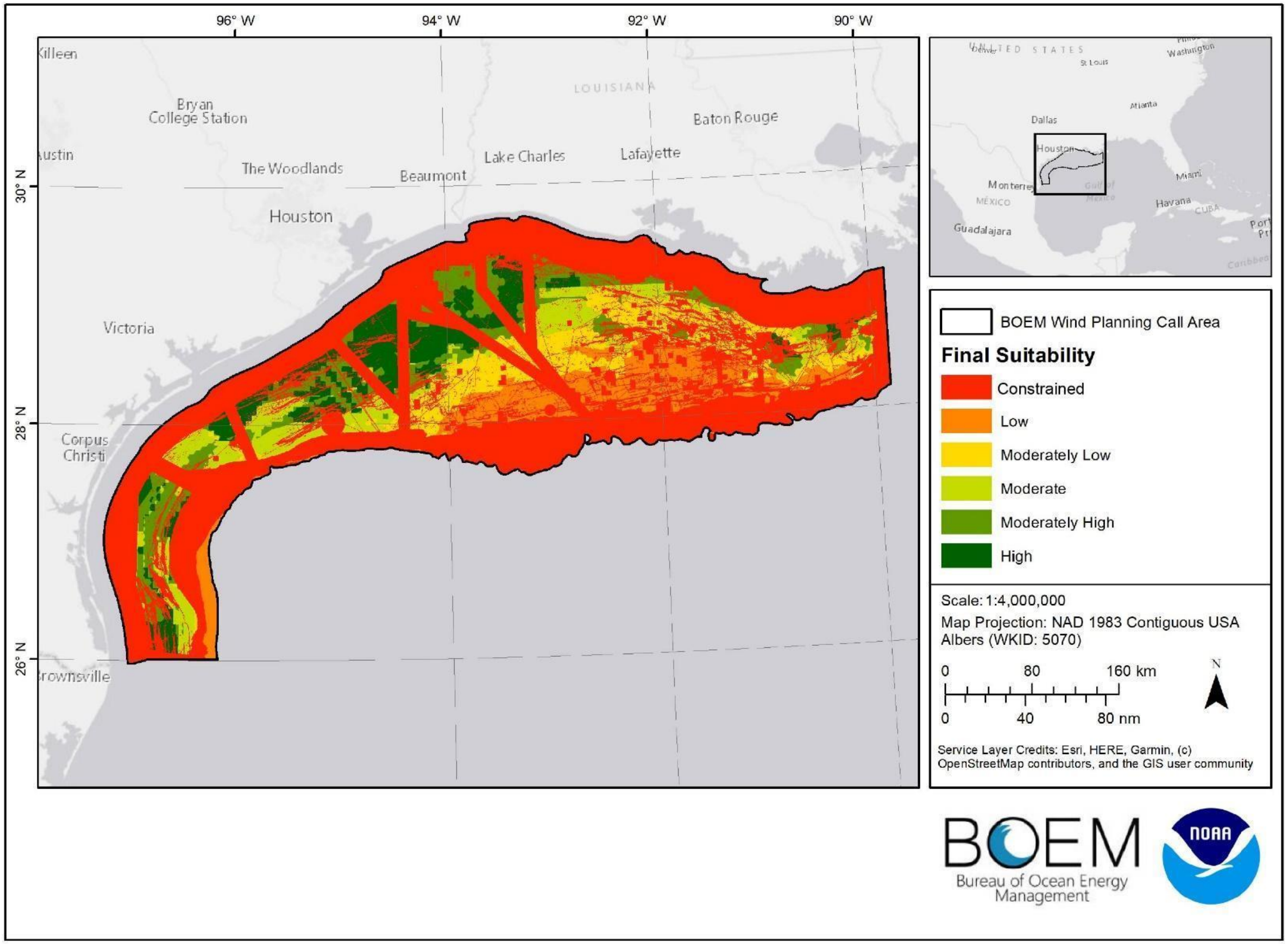

Figure 3.23. *Final suitability modeling results for the Call Area. Red color indicates those areas where layers with a score of 0 occurred due to conflict with ocean activity. Green color indicates areas of highest suitability.*

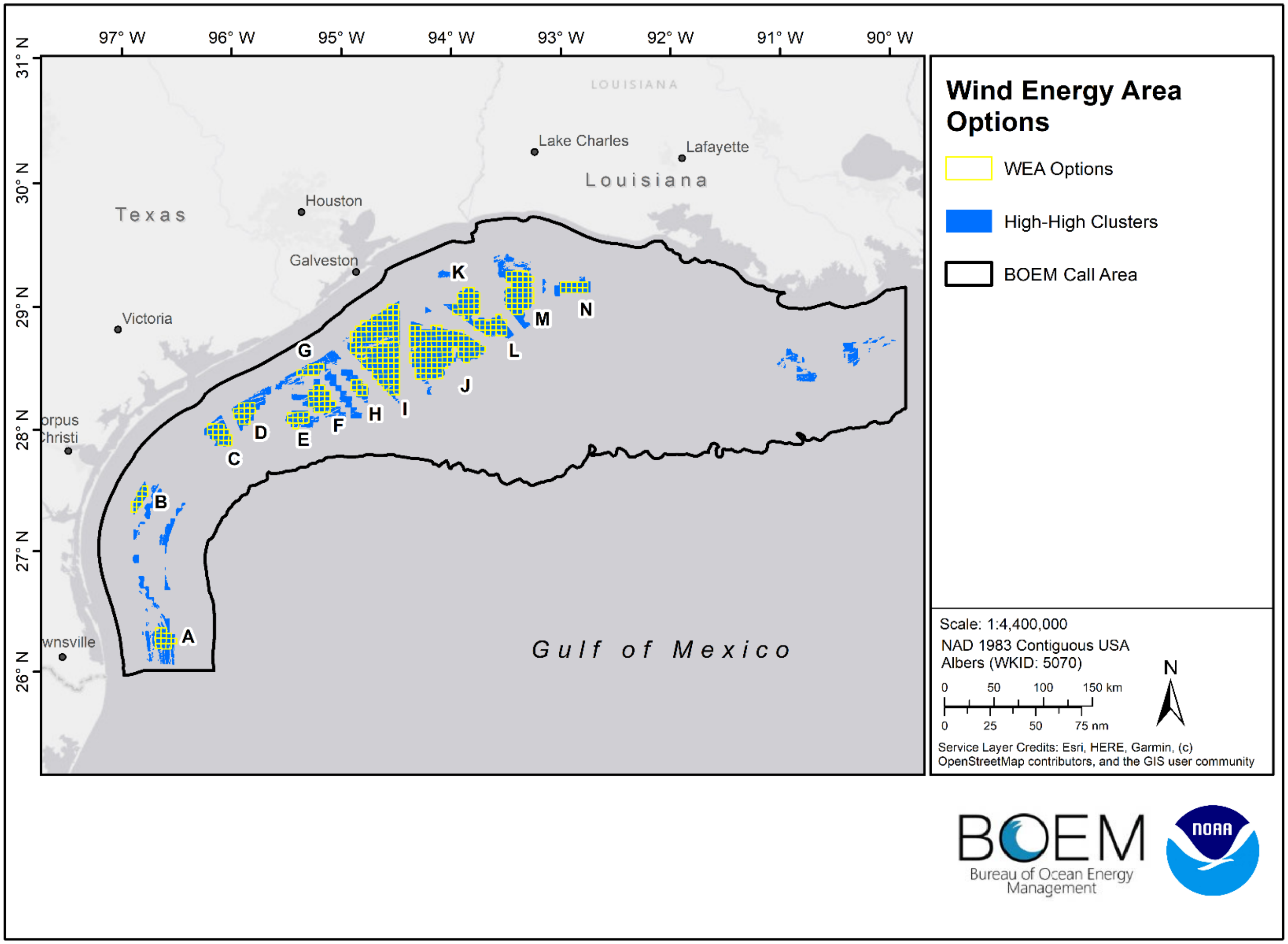

Figure 3.24. *Cluster analysis of the Call Area. Blue areas indicate areas determined to have the highest suitability (i.e., high-high clusters). The yellow grids represent the lease blocks that comprise the 14 WEA options.*

Table 3.8. Option ranking model results with scores for each WEA option. Top ranked options were F, J, and A. All scores in the table are between 0 and 1, with 0 being less suitable and 1 being more suitable for wind energy.

Option	Rank			Submodel				Final
		National Security	Natural Resources	Industry & Operations	Logistics	Economics	Fisheries	Score
F	1	0.79	0.59	0.91	0.41	0.52	0.65	0.62
J	2	1	0.81	0.02	0.55	0.62	0.99	0.43
A	3	0.63	0.08	0.98	0.19	0.62	0.85	0.41
C	4	0.79	0.53	0.04	0.39	0.62	0.89	0.37
D	5	0.79	0.25	0.04	0.59	0.85	0.68	0.37
K	6	0.79	0.72	0.01	0.63	0.70	0.99	0.34
M	7	0.79	0.56	<0.001	0.67	0.66	1	0.27
H	8	0.79	0.52	0.89	0.35	0.54	0.01	0.27
I	9	0.63	0.58	<0.001	0.89	0.85	0.94	0.26
G	10	0.79	0.28	0.002	0.80	0.93	0.08	0.17
N	11	0.63	<0.001	0.48	0.22	0.89	0.87	0.15
B	12	0.63	<0.001	0.88	0.63	1	<0.001	0.08
L	13	1	0.99	0.78	<0.001	0.55	0.99	0.04
E	14	0.79	0.78	0.86	0.001	<0.001	0.07	0.03

3.9 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 3.25 - 3.36**). 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. An options location in proximity to social vulnerability or points of interconnection may aid in option selection (**Figure 3.35-3.36**).

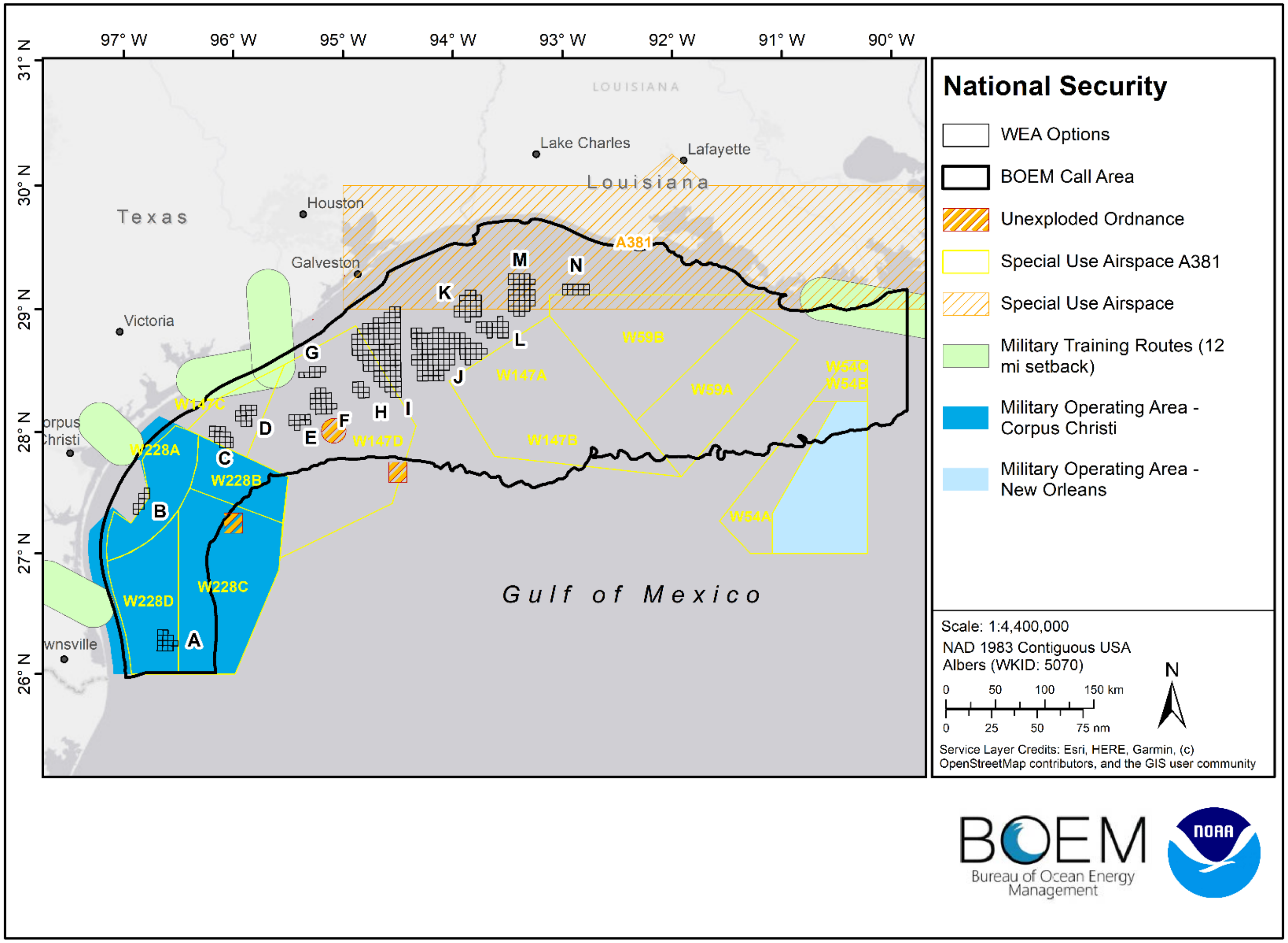

Figure 3.25. *National security considerations in relation to the final WEA options.*

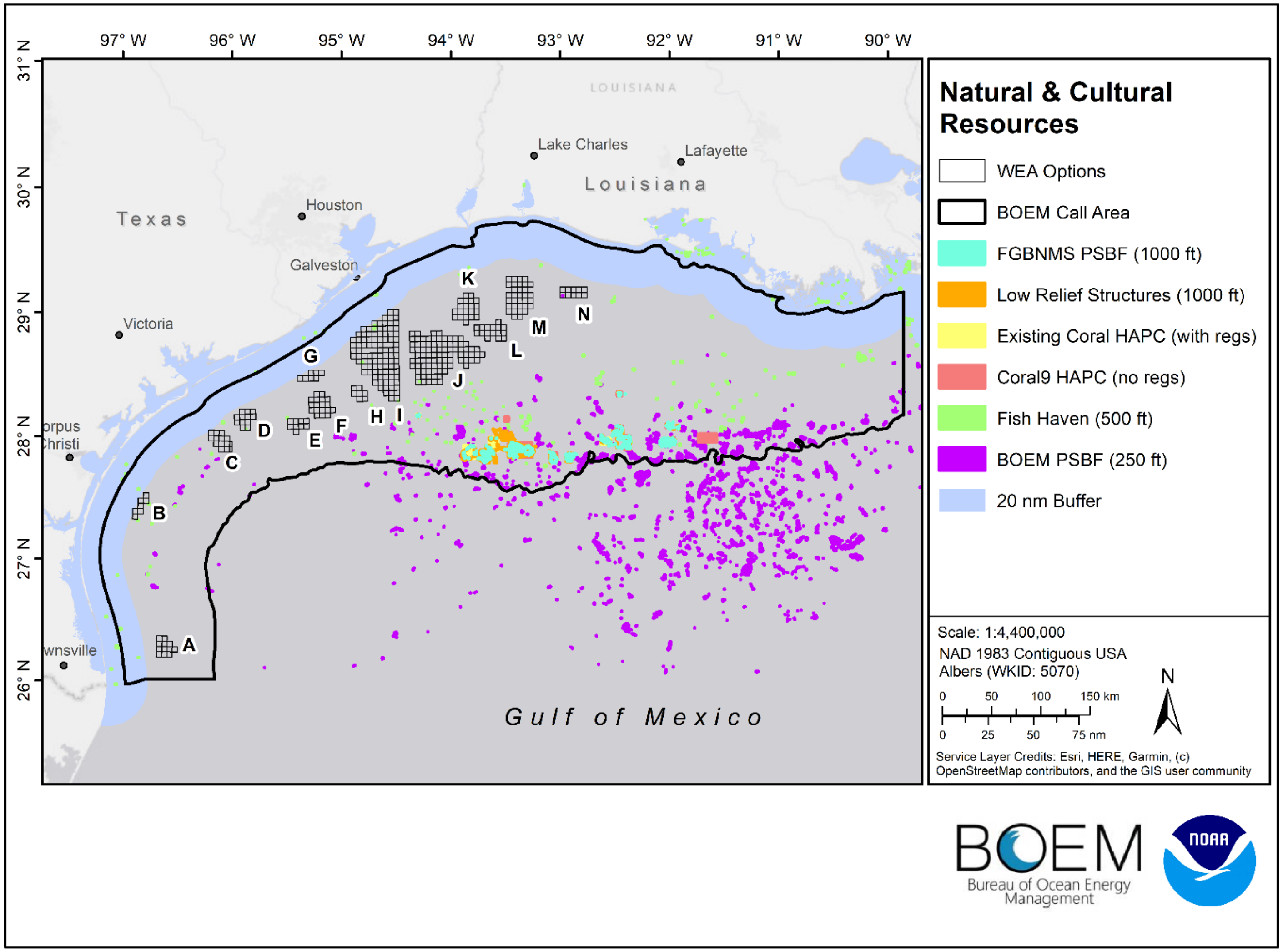

Figure 3.26. Natural and cultural resource considerations in relation to the final WEA options.

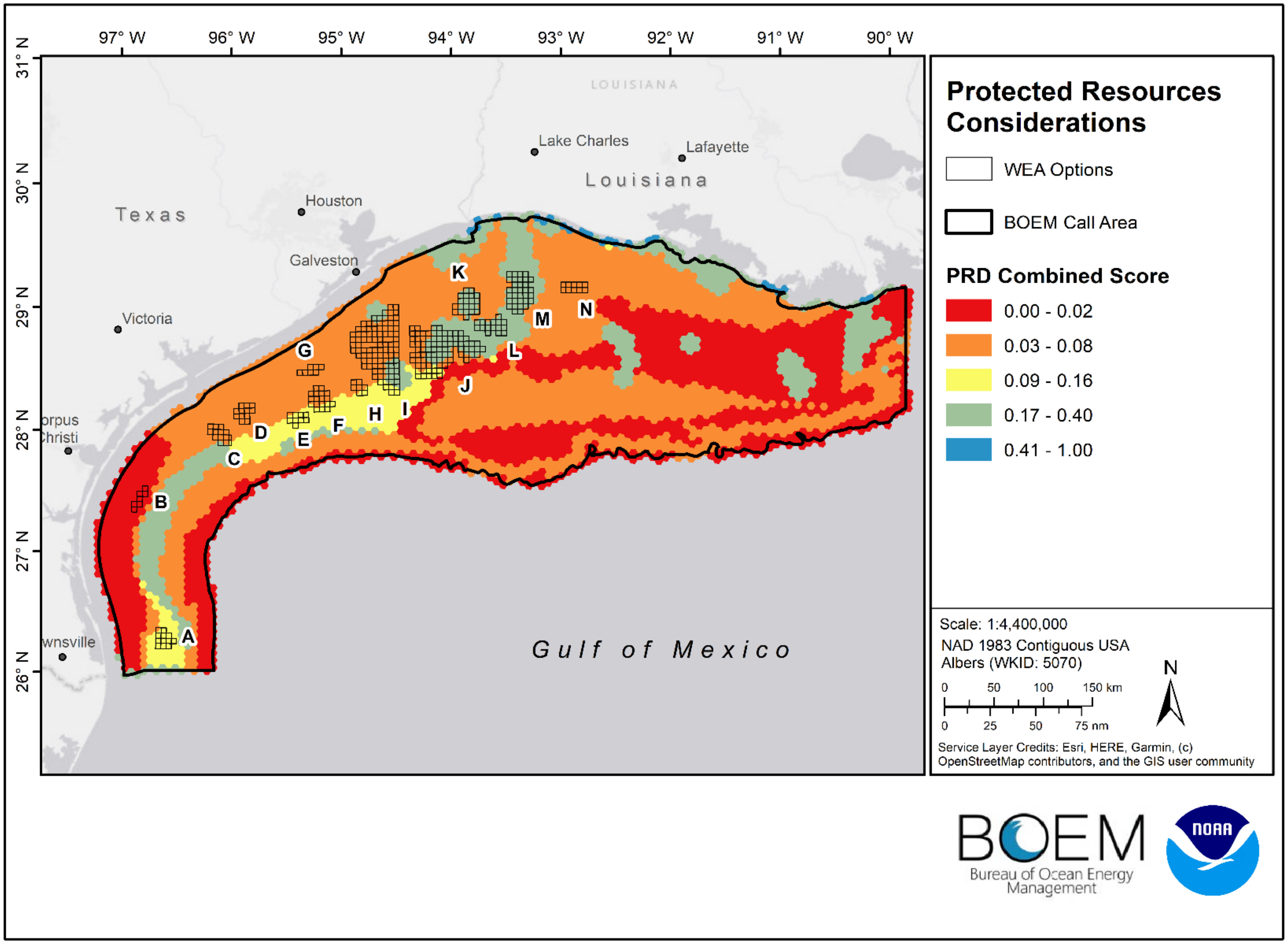

Figure 3.27. *Protected resources considerations in relation to the final WEA options.*

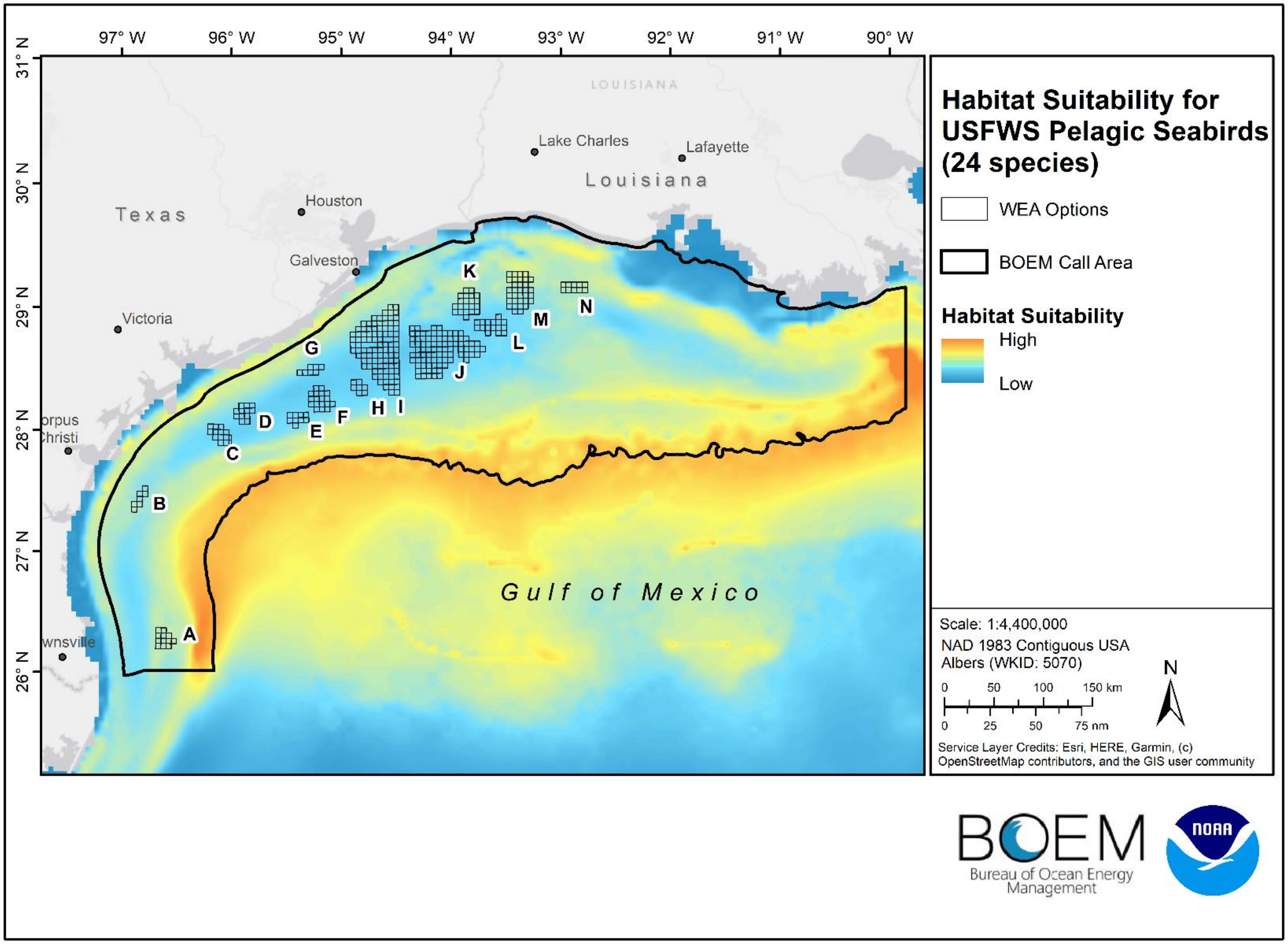

Figure 3.28. *USFWS GoMMAPPS pelagic seabird (24 species) combined habitat suitability in relation to the final WEA options.*

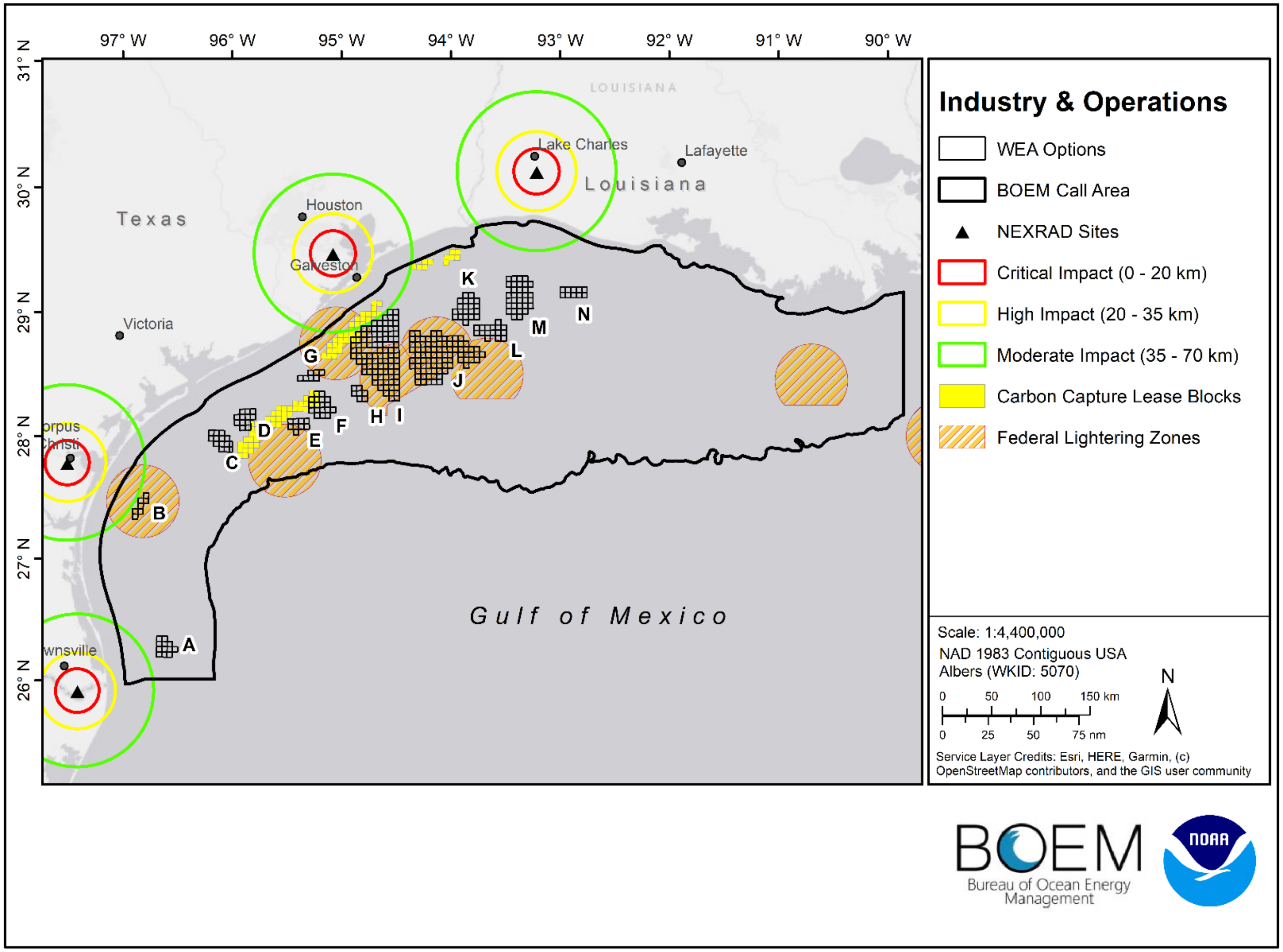

Figure 3.29. *Industry and operations considerations in relation to the final WEA options.*

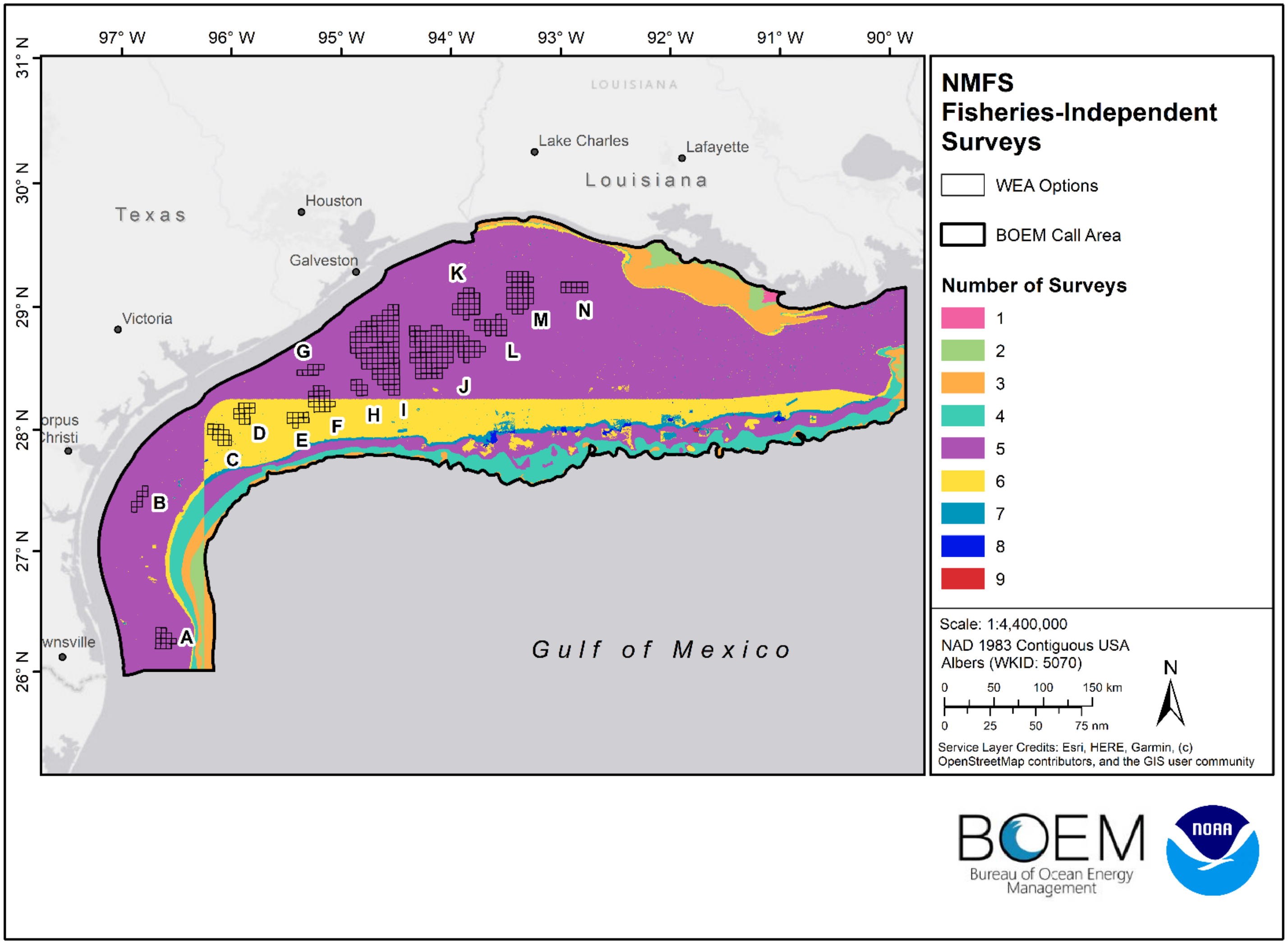

Figure 3.30. *NMFS fishing surveys in relation to the final WEA options.*

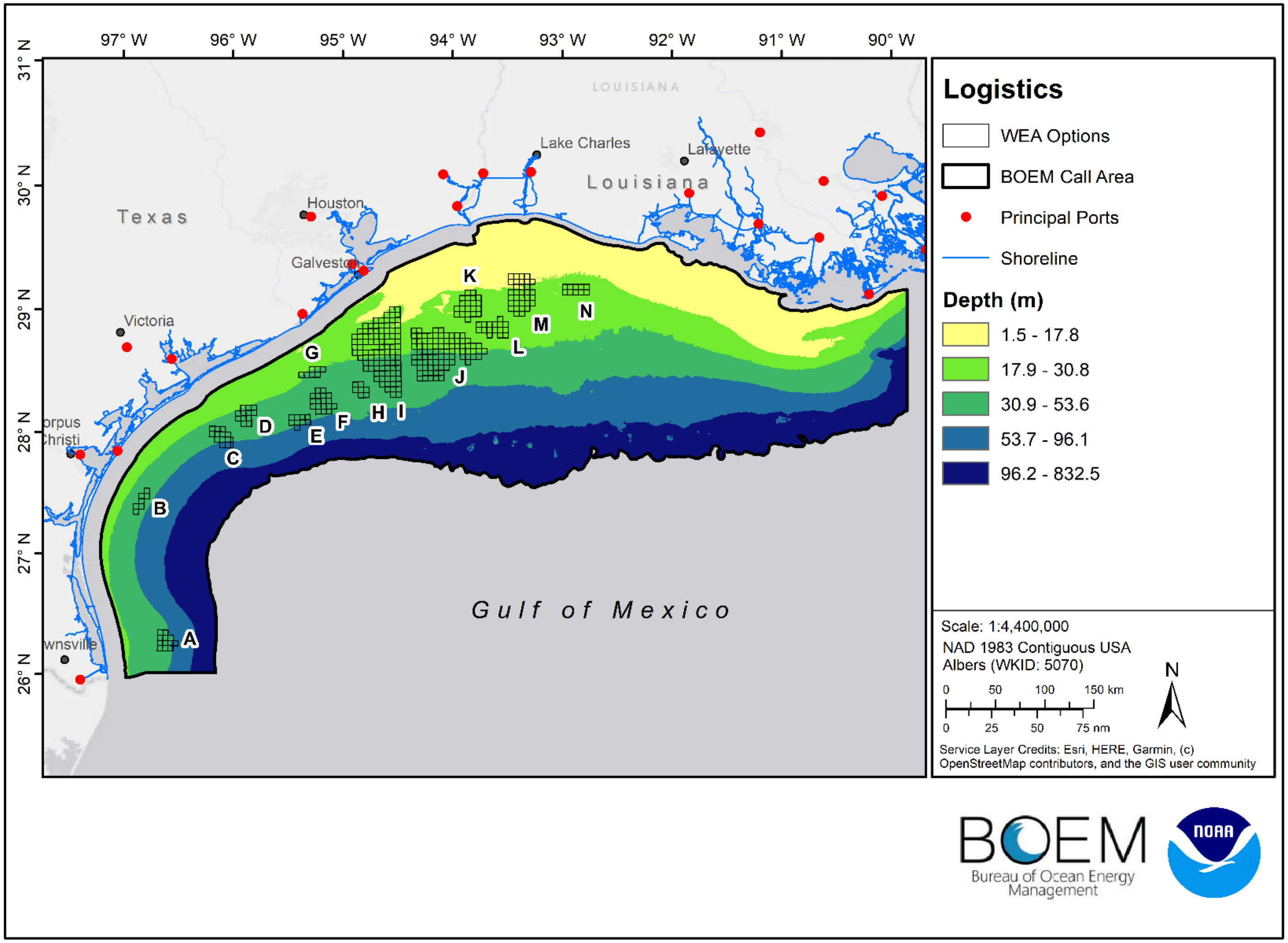

Figure 3.31. *Logistics considerations in relation to the final WEA options.*

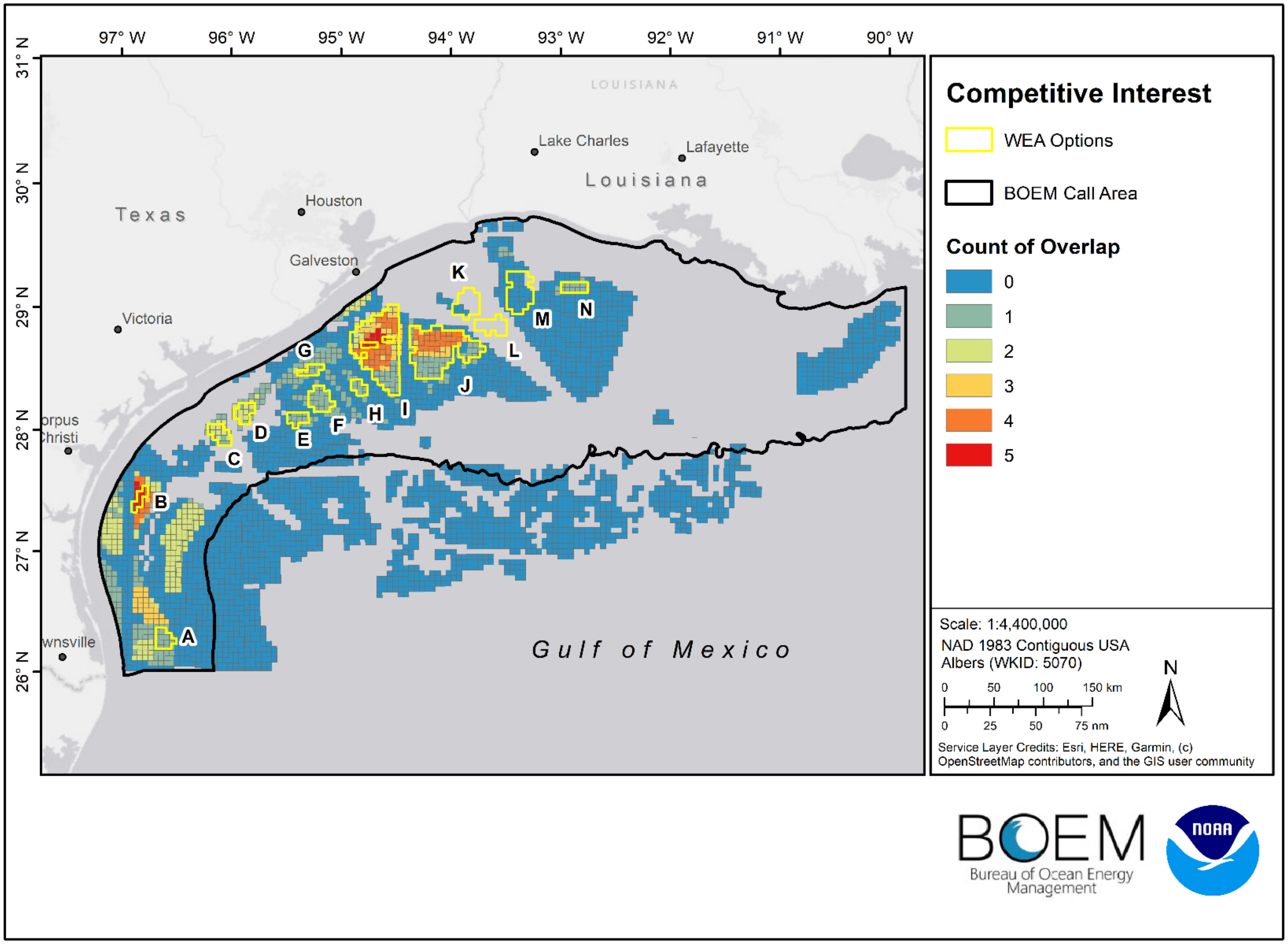

Figure 3.32. *Competitive lease blocks in relation to the final WEA options.*

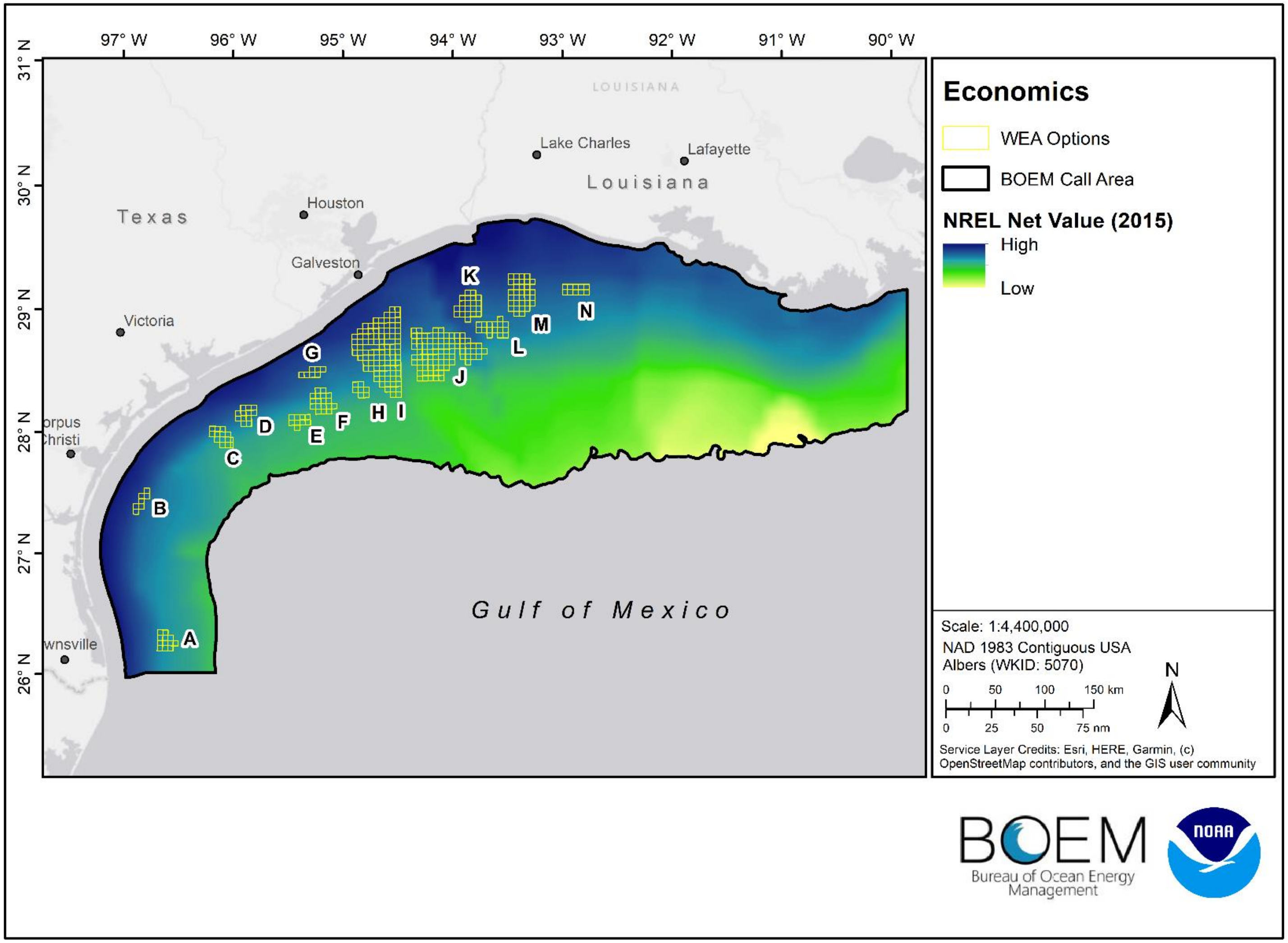

Figure 3.33. *Economics considerations in relation to the final WEA options.*

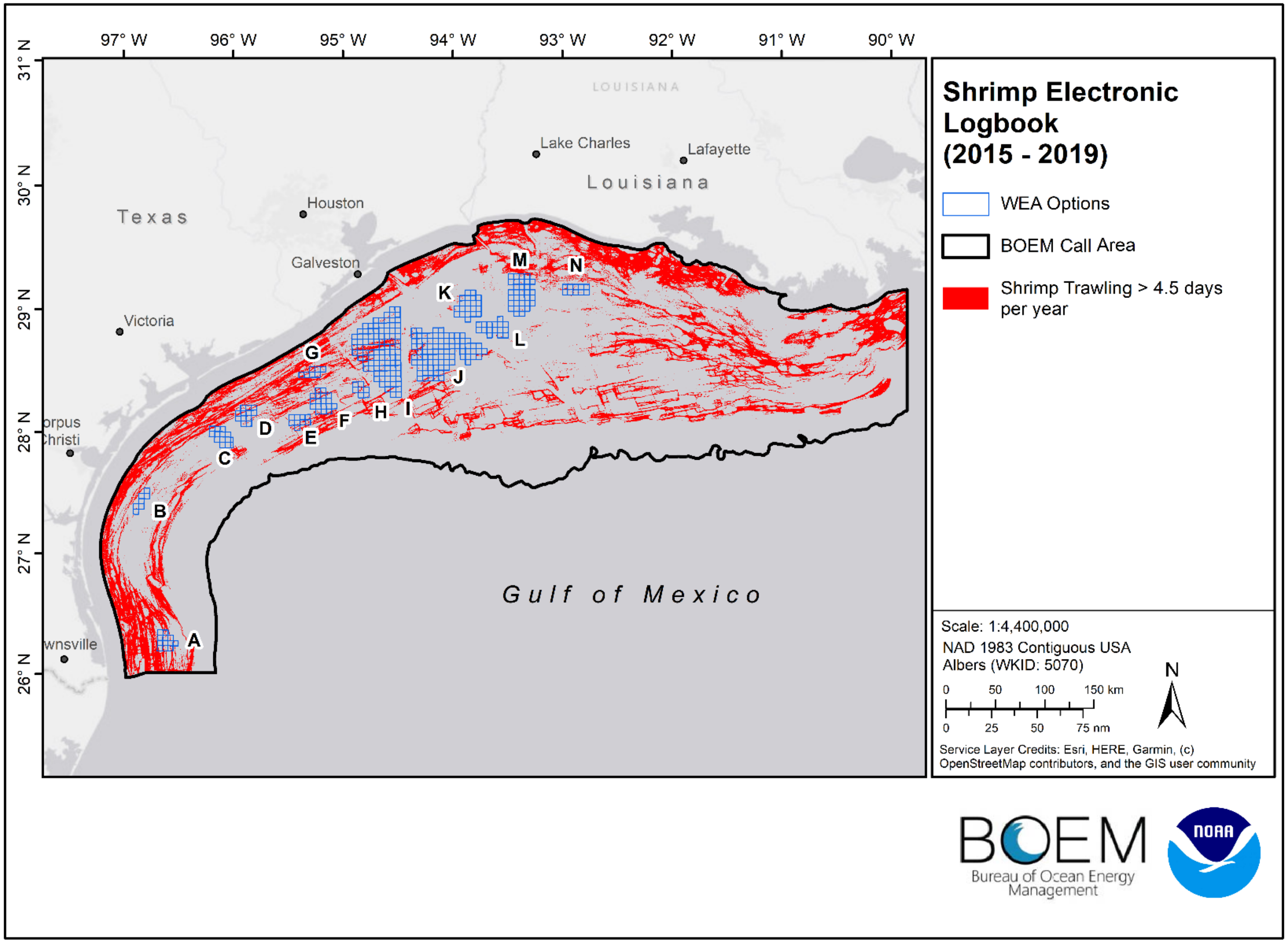

Figure 3.34. *Mean days of shrimp trawling > 4.5 days (2015 through 2019) in relation to the final WEA options. This is the medium to high shrimp effort category and is what was used in the constraints model.*

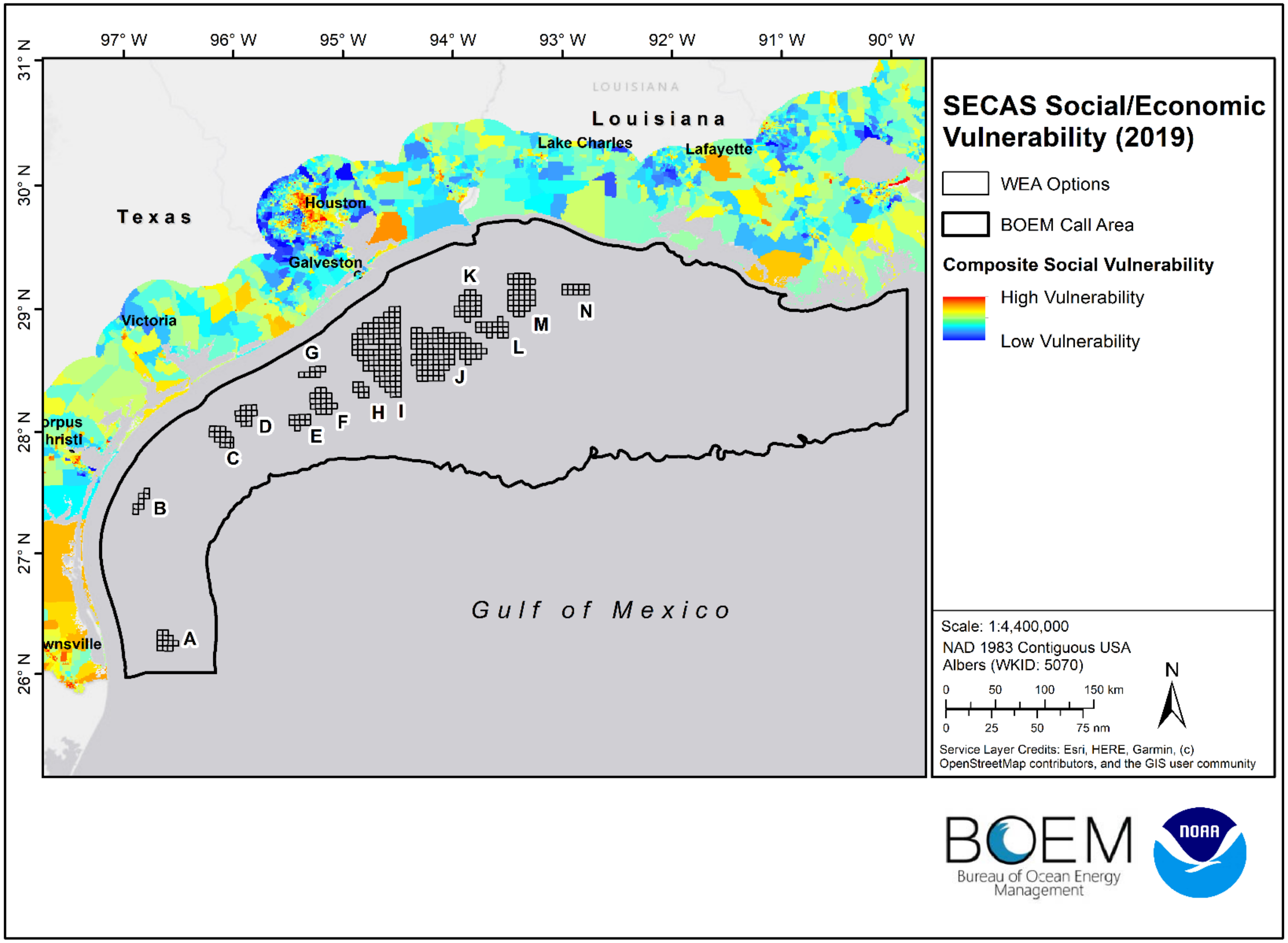

Figure 3.35. *Southeast Conservation Adaptation Strategy (SECAS) composite social and economic vulnerability data. Areas in red have a higher degree of vulnerability, while areas in blue have a lower degree of vulnerability.*

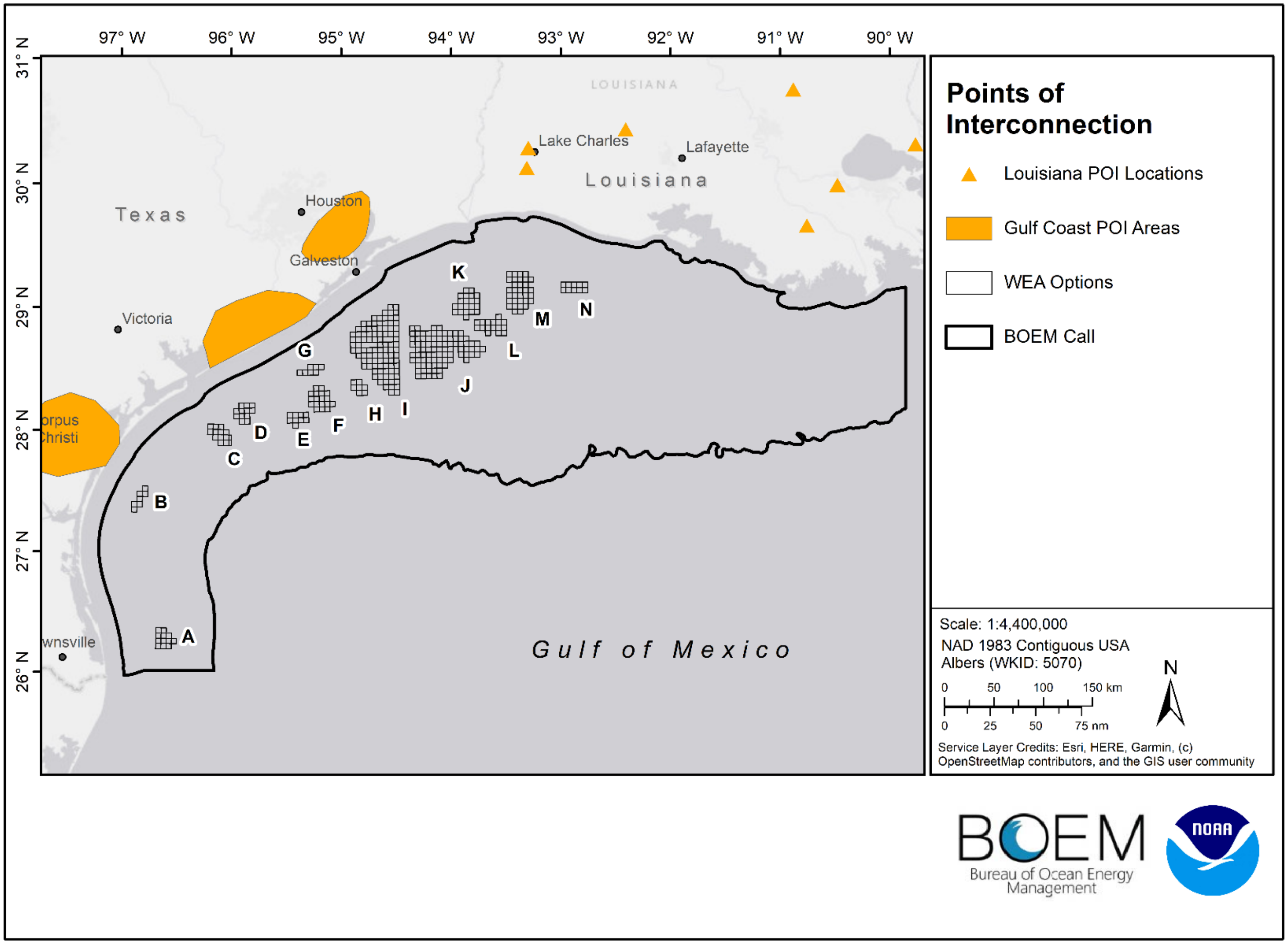

Figure 3.36. *Points of interconnection in relation to the final WEA options.*

3.10 CHARACTERIZATION OF WEA OPTIONS

All fourteen WEA options are characterized below. The characterizations provide option specific details regarding the geographic location, national security, natural and cultural resources, industry and operations, logistics, and economics. Fisheries metrics are not provided due to the confidential nature of the data.

3.10.1 WEA Option A Characterization

WEA option A was the southernmost option identified in the Call Area. The 68,278 acre site is located offshore approximately 75.9 km northeast of the Port of Brownsville, Texas (**Figure 3.37**). The mean depth across the entire option is 51 m, with a maximum depth of 63 m and a minimum of 45 m (**Table 3.9; Figure 3.38**).

Table 3.9. Characterization summary for Wind Energy Area option A.

Logistics	Value
Size (acres)	68,278
Distance to port (km)	Port of Brownsville; 75.9 km
Distance to shore (km)	48.2
Depth (m) (minimum, maximum, mean)	min = 45 m, max = 63 m, mean = 51 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	16.4% coverage
Oil and Gas Boreholes, Test Wells, and Wells	2 southeast, outside of option
Aids to Navigation (beacons and buoys)	1 east; outside of option
National Security	
Military operating areas	Overlaps with Corpus Christi
Special use airspace	Overlaps with SUA W228D
Natural and Cultural Resources	
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle
Industry and Operations	
NOAA NMFS Fishing Surveys	5

AIS 2019 Cargo Vessel Transits per acre	0.05
AIS 2019 Fishing Vessel Transits per acre	0.17
AIS 2019 Other Vessel Transits per acre	0.01
AIS 2019 Passenger Vessel Transits per acre	0.01
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.002
AIS 2019 Tanker Vessel Transits per acre	0.01
AIS Tug Tow Vessel Transits per acre	0.02
Economics	
NREL - Net Value 2015	-161.5
Count of Competitive Lease Block Overlap	1

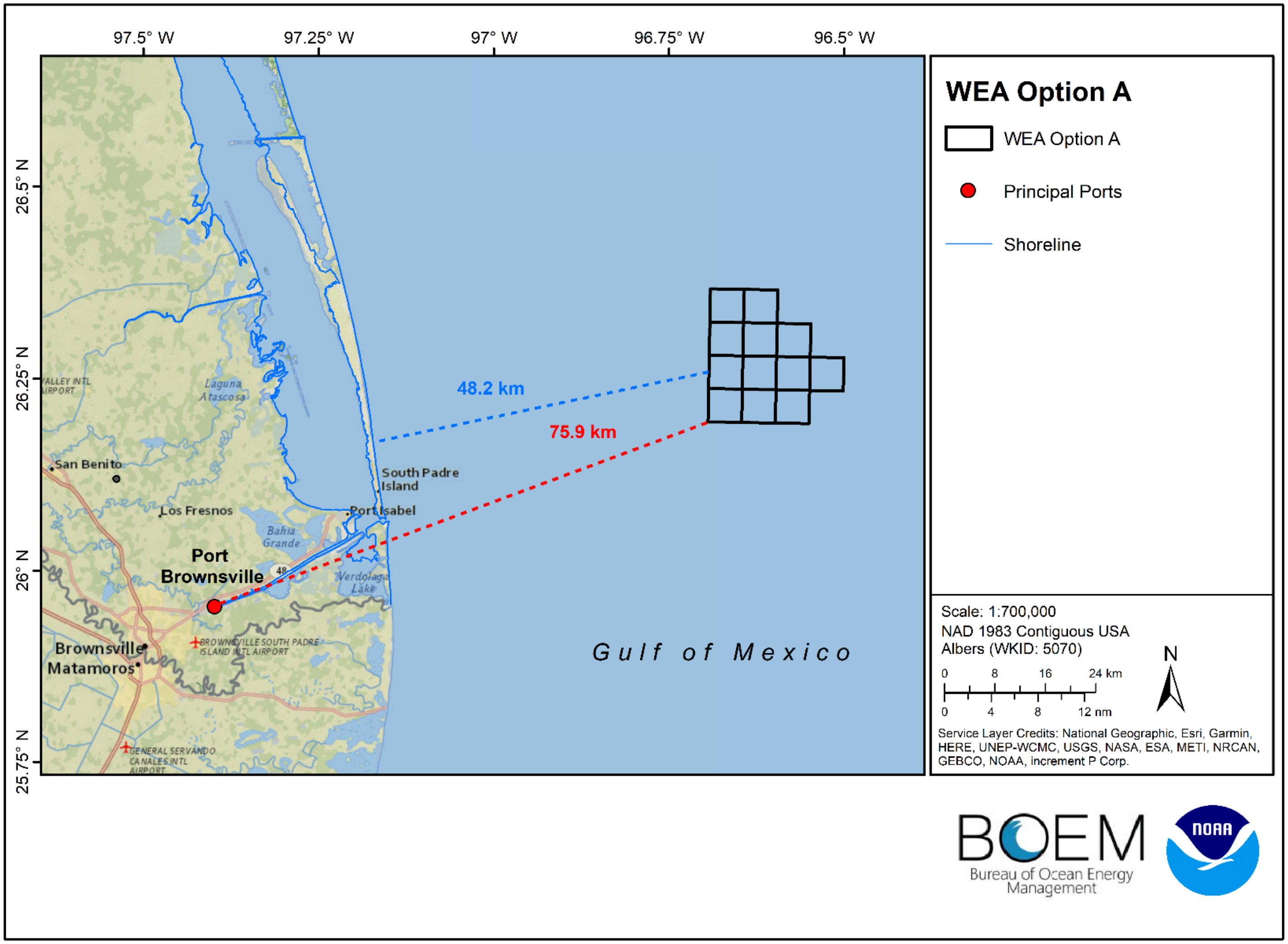

Figure 3.37. *WEA option A (black outlined box) and distance to the Port of Brownsville, Texas.*

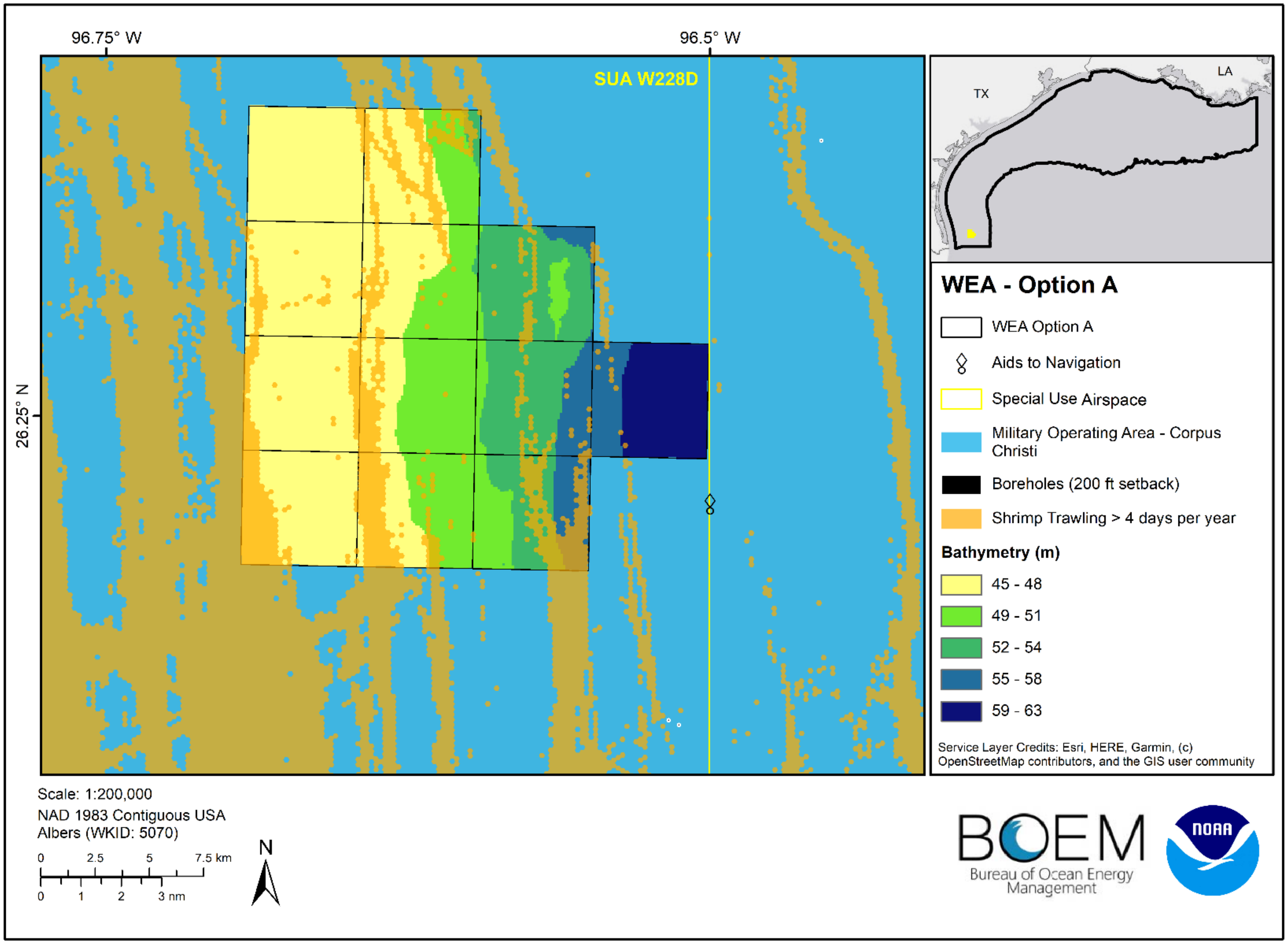

Figure 3.38. *Map depicting noteworthy characterization features for Wind Energy Area option A.*

3.10.2 WEA Option B Characterization

Option B is 39,840 acres in size and is located off of Corpus Christi. The closest principal ports include Port Aransas (47 km) and Corpus Christi, Texas (**Figure 3.39**). The mean depth across the entire area is 43.0 m, with a maximum depth of 49.8 m and a minimum of 37.3 m (**Table 3.10; Figure 3.40**).

Table 3.10. Characterization summary for Wind Energy Area option B.

Logistics	Value
Size (acres)	39,840
Distance to port (km)	Port Aransas; 47 km
Distance to shore (km)	35.7
Depth (m) (minimum, maximum, mean)	min = 37.3 m, max = 49.8 m, mean = 43 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	0.7% coverage
Shipping Fairways and Regulations	2 southwest lease blocks intersect with the 3,219 m setback
Oil and Gas Pipelines	2 inactive pipelines intersect option
Oil and Gas Boreholes, Test Wells, and Wells	6 within option
Oil and Gas Drilling Platforms	5; outside of option
TX permitted artificial reefs	1; outside of option
National Security	
Military operating areas	Overlaps with Corpus Christi
Special use airspace	Partially overlaps with SUA W228A
Natural and Cultural Resources	
NOAA Fish Havens	1; outside of option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle Loggerhead sea turtle

Industry and Operations	
Federal Lightering Rendezvous Areas	Completely within
NEXRAD Sites	Close proximity to moderate impact area; no overlap
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.01
AIS 2019 Fishing Vessel Transits per acre	0.62
AIS 2019 Other Vessel Transits per acre	0.13
AIS 2019 Passenger Vessel Transits per acre	0.01
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.02
AIS 2019 Tanker Vessel Transits per acre	0.16
AIS Tug Tow Vessel Transits per acre	0.05
Economics	
NREL - Net Value 2015	-134.8
Count of Competitive Lease Block Overlap	5

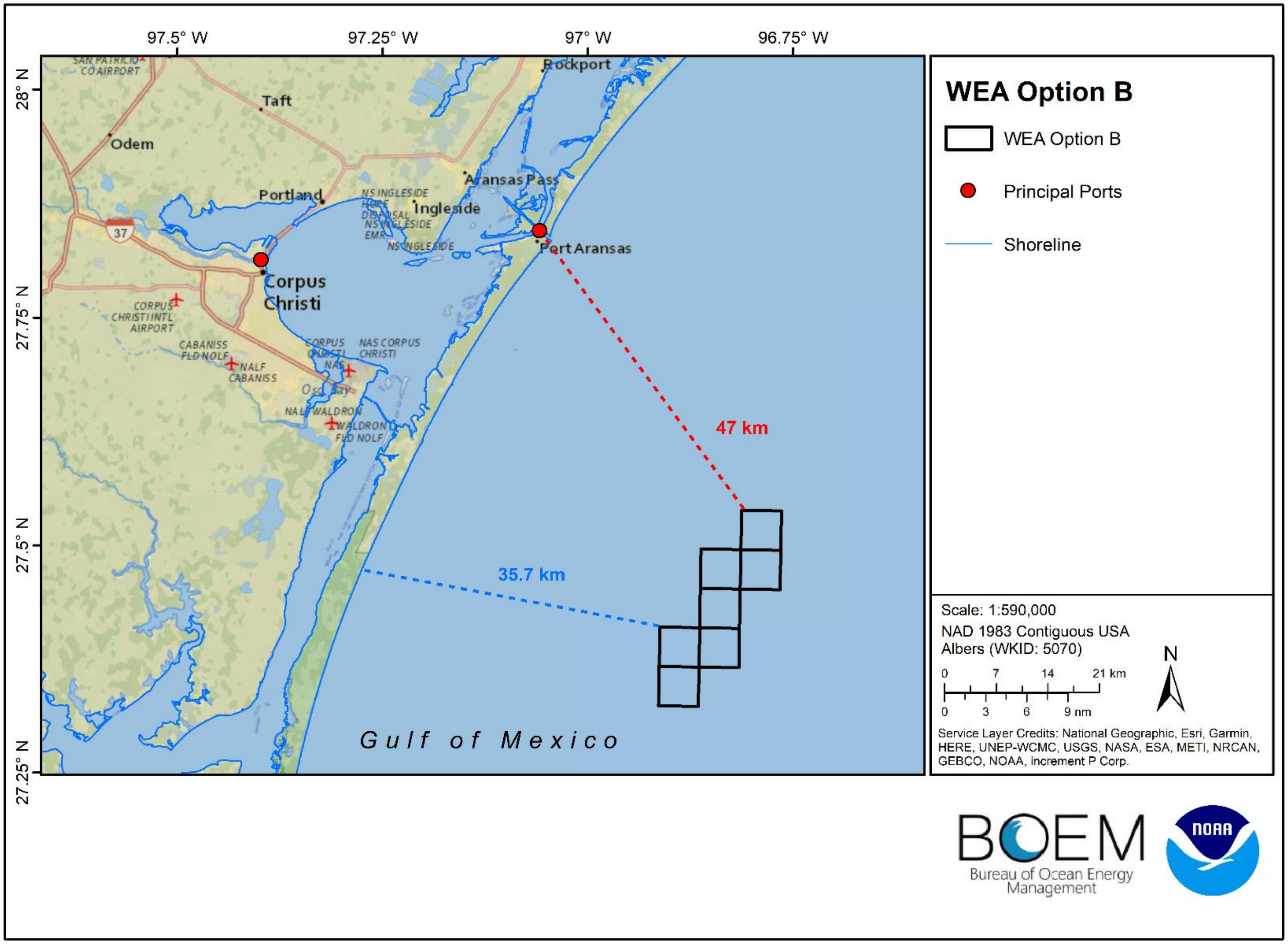

Figure 3.39. *WEA option B (black outlined box) and distance to Port Aransas, Texas.*

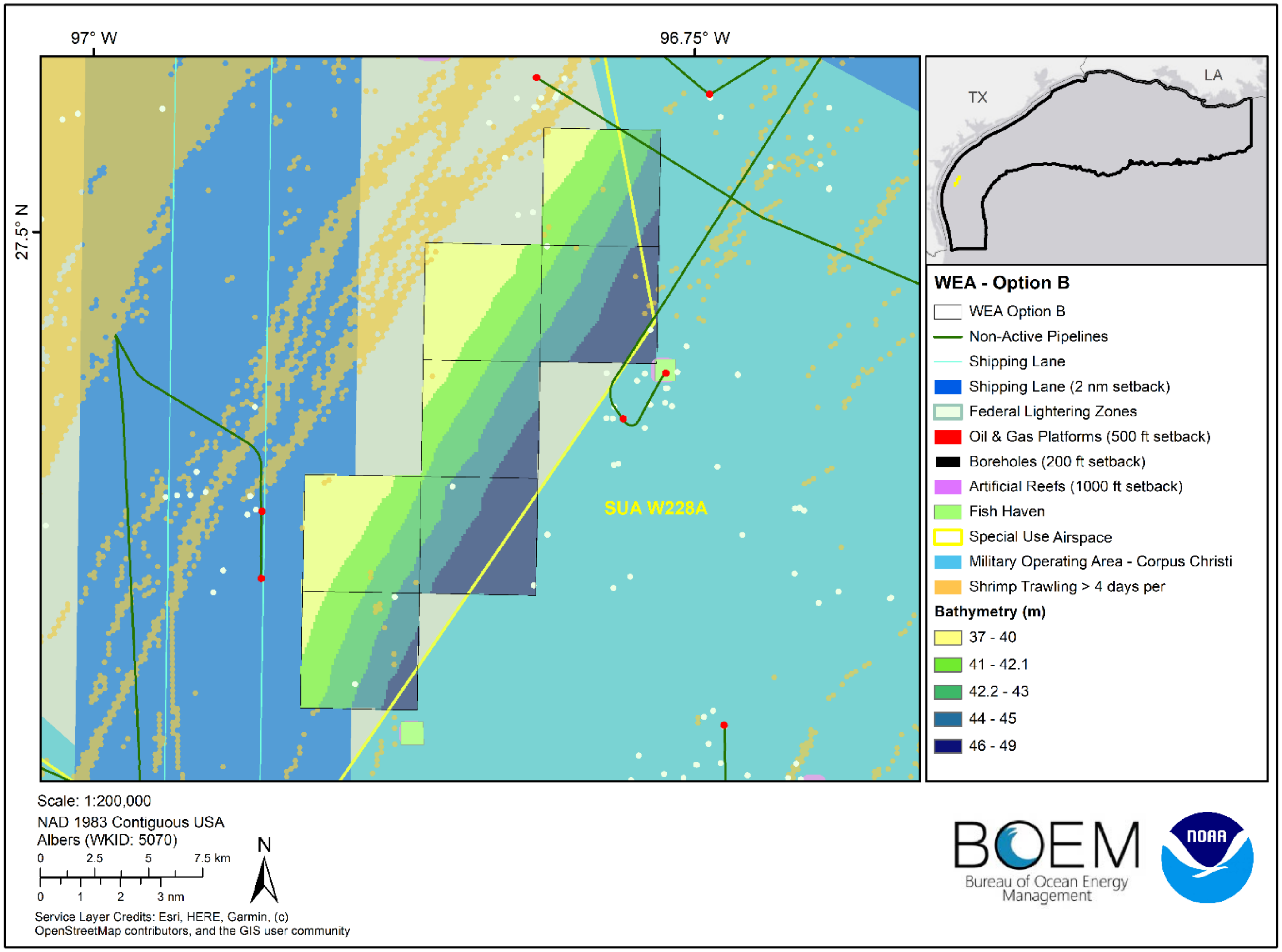

Figure 3.40. *Map depicting noteworthy characterization features for Wind Energy Area option B.*

3.10.3 WEA Option C Characterization

Option C is 74,113 acres in size and is located off of Matagorda Bay. The closest principal ports include Port Lavaca (79 km) and Port Aransas, Texas (94.6 km) (**Figure 3.41**). The mean depth across the entire area is 43.0 m, with a maximum depth of 49.8 m and a minimum of 37.3 m (**Table 3.11; Figure 3.42**).

Table 3.11. Characterization summary for Wind Energy Area option C.

Logistics	Value
Size (acres)	74,113
Distance to port (km)	Port Lavaca 79 km; Port Aransas 94.6 km
Distance to shore (km)	37.3
Depth (m) (minimum, maximum, mean)	min = 34.3 m, max = 60.8 m, mean = 47.6 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	3.4% coverage
Shipping Fairways and Regulations	2 eastern lease blocks intersect with the 3,219 m setback
Oil and Gas Pipelines	1 active; 2 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	7 within option
Oil and Gas Drilling Platforms	17 outside of option
National	Security
Military operating areas	Partially overlaps with Corpus Christi
Special use airspace	Overlaps with SUA W147C
Natural and	Cultural Resources
NOAA Fish Havens	1; southwest outside of option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp's ridley sea turtle
Industry and	Operations
NOAA NMFS Fishing Surveys	6
AIS 2019 Cargo Vessel Transits per acre	0.01

AIS 2019 Fishing Vessel Transits per acre	0.19
AIS 2019 Other Vessel Transits per acre	0.14
AIS 2019 Passenger Vessel Transits per acre	0.18
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	0.03
AIS Tug Tow Vessel Transits per acre	0.02
Economics	
NREL - Net Value 2015	-161.3
Count of Competitive Lease Block Overlap	2

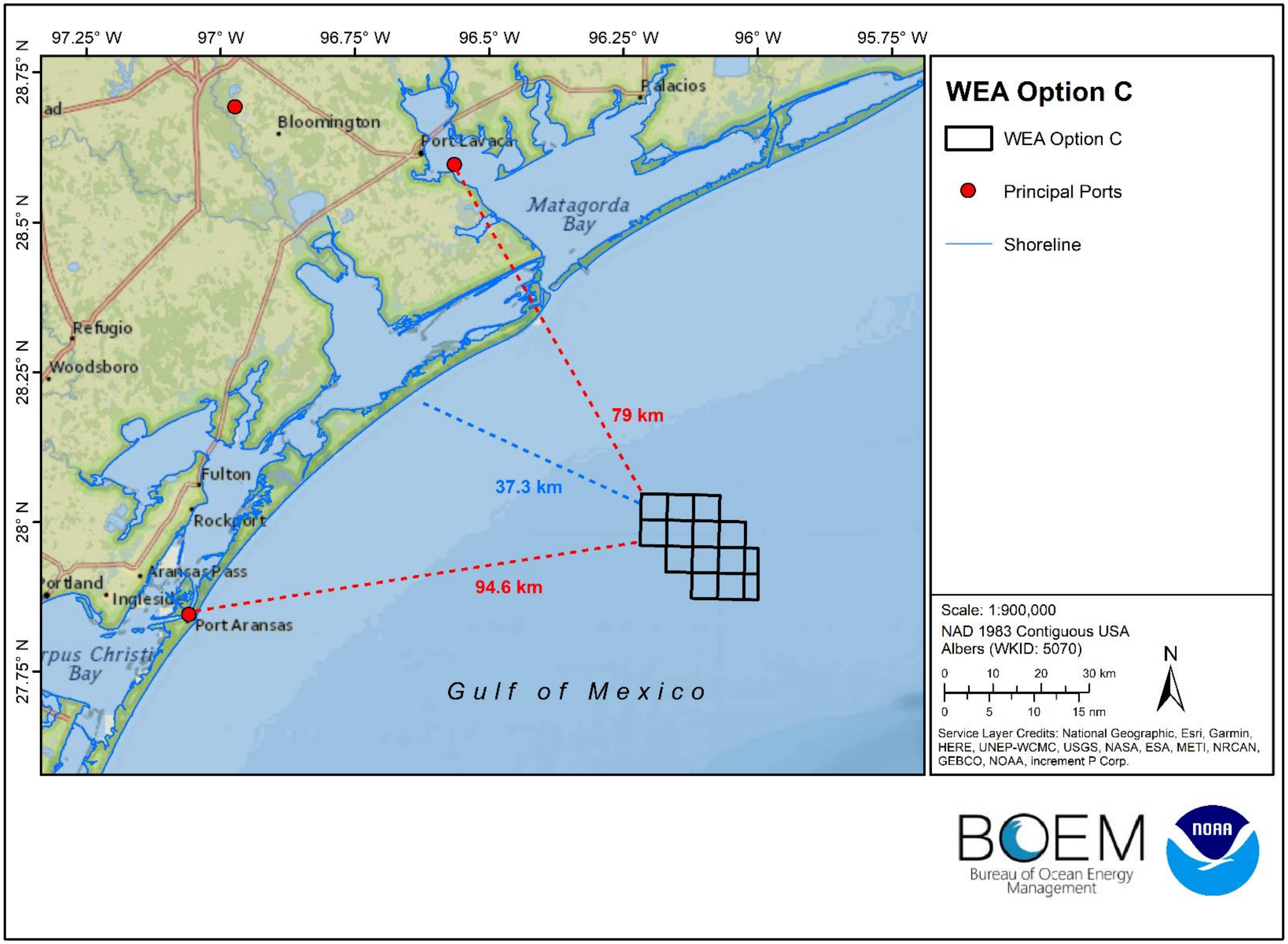

Figure 3.41. *WEA option C (black outlined box) and distance to Port Lavaca and Port Aransas, Texas.*

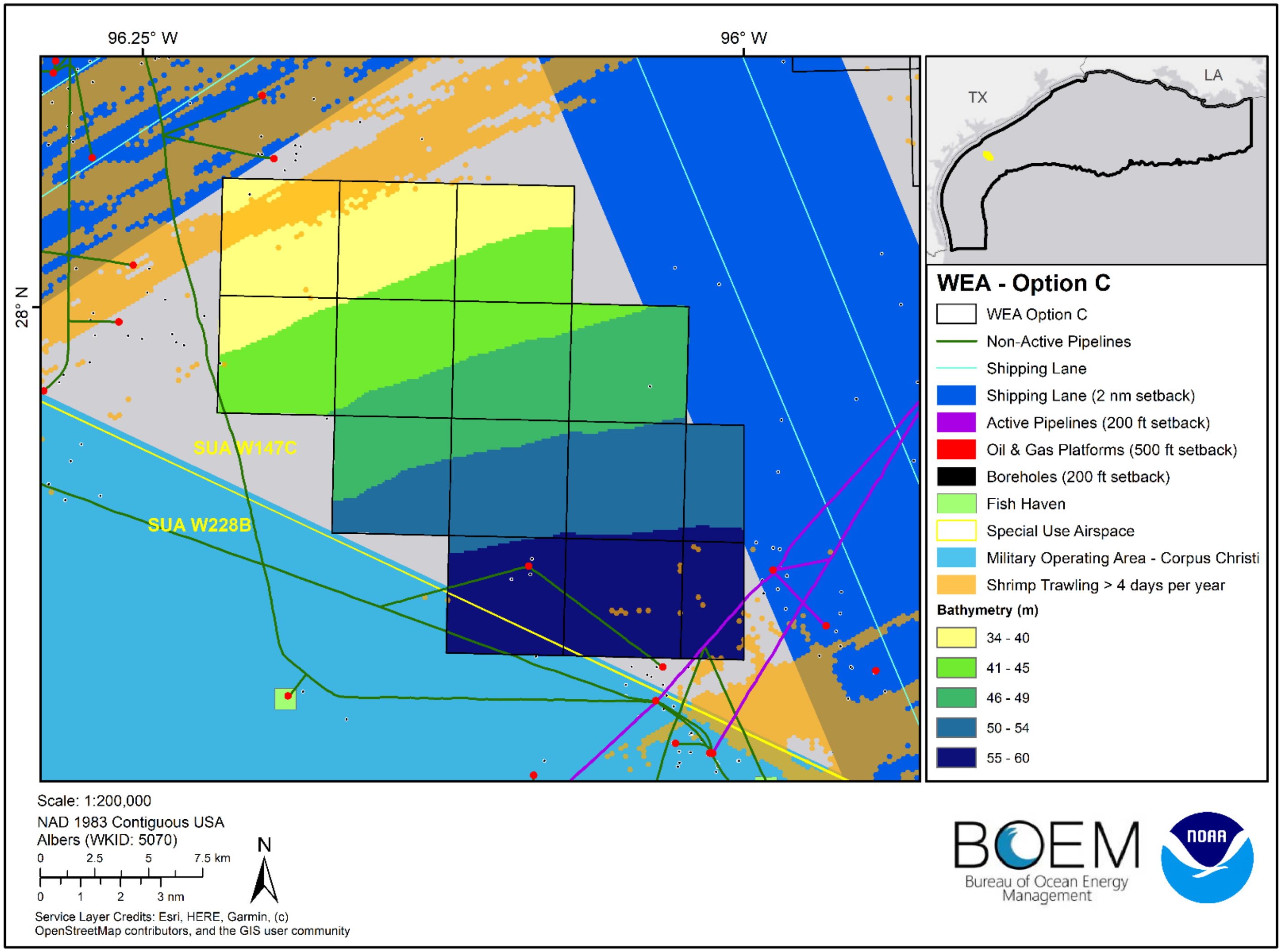

Figure 3.42. *Map depicting noteworthy characterization features for Wind Energy Area option C.*

3.10.4 WEA Option D Characterization

Option D is 68,239 acres in size and is located off of Matagorda Bay. The closest principal port is Port Lavaca, Texas (**Figure 3.43**). The mean depth across the entire area is 36.1 m, with a maximum depth of 44.7 m and a minimum of 28.9 m (**Table 3.12; Figure 3.44**).

Table 3.12. Characterization summary for Wind Energy Area option D.

Logistics	Value
Size (acres)	68,239
Distance to port (km)	Port Lavaca; 83.8 km
Distance to shore (km)	39.8
Depth (m) (minimum, maximum, mean)	min = 28.9 m, max = 44.7 m, mean = 36.1 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	11.8% coverage
Shipping Fairways and Regulations	1 western lease block intersects with the 3,219 m setback
Oil and Gas Pipelines	1 active; 1 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	23 within option
Oil and Gas Drilling Platforms	1 within option
TX permitted artificial reefs	1 within option
National Security	
Special use airspace	Overlaps with SUA W147C
Natural and Cultural Resources	
NOAA Fish Havens	1 within option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle
Industry and Operations	
NOAA NMFS Fishing Surveys	6
AIS 2019 Cargo Vessel Transits per acre	0.01
AIS 2019 Fishing Vessel Transits per acre	0.85
AIS 2019 Other Vessel Transits per acre	0.13
AIS 2019 Passenger Vessel Transits per acre	0.09

AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	0.05
AIS Tug Tow Vessel Transits per acre	0.02
Economics	
NREL - Net Value 2015	-146.5
Count of Competitive Lease Block Overlap	2

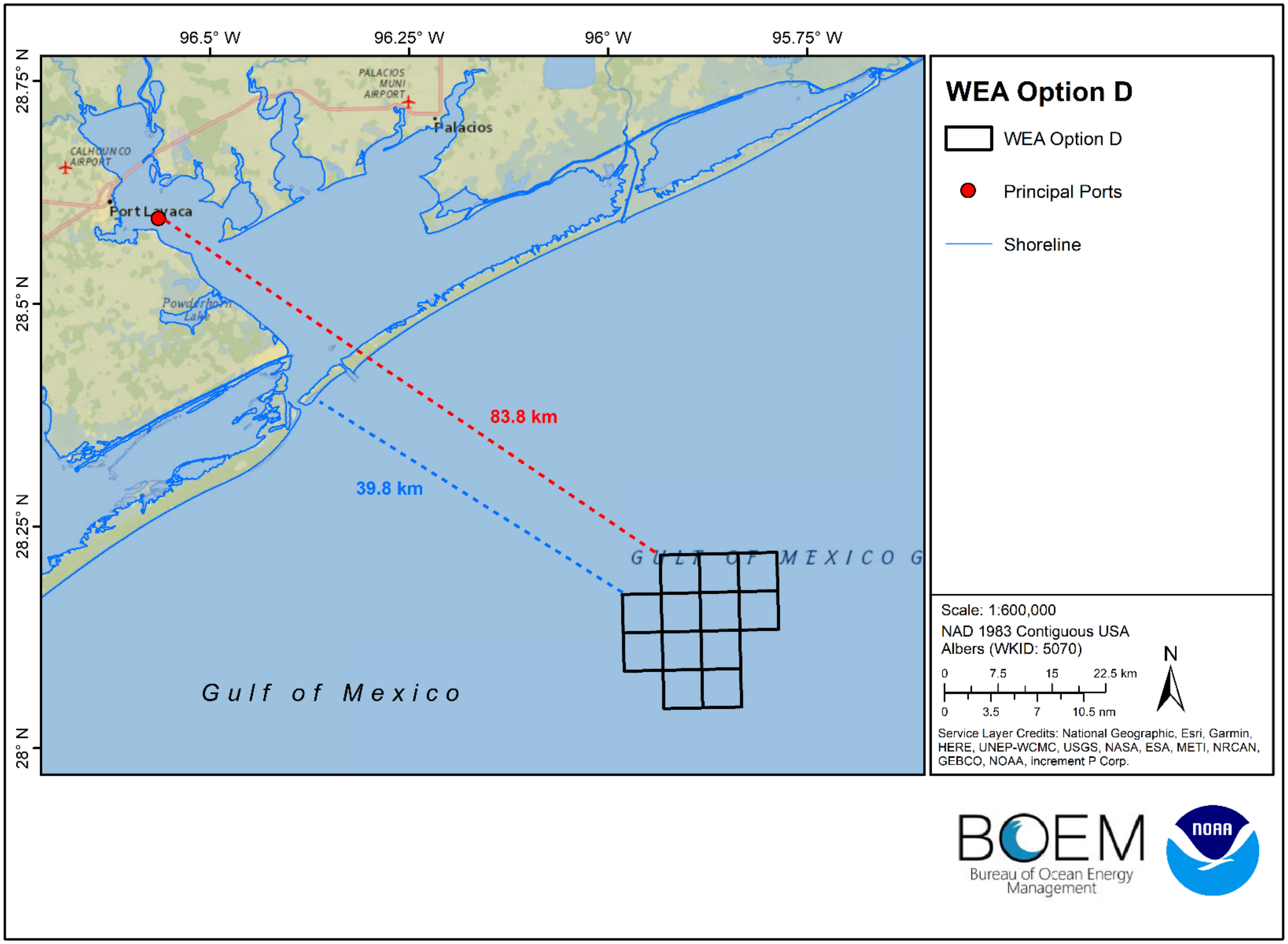

Figure 3.43. *WEA option D (black outlined box) and distance to Port Lavaca, Texas.*

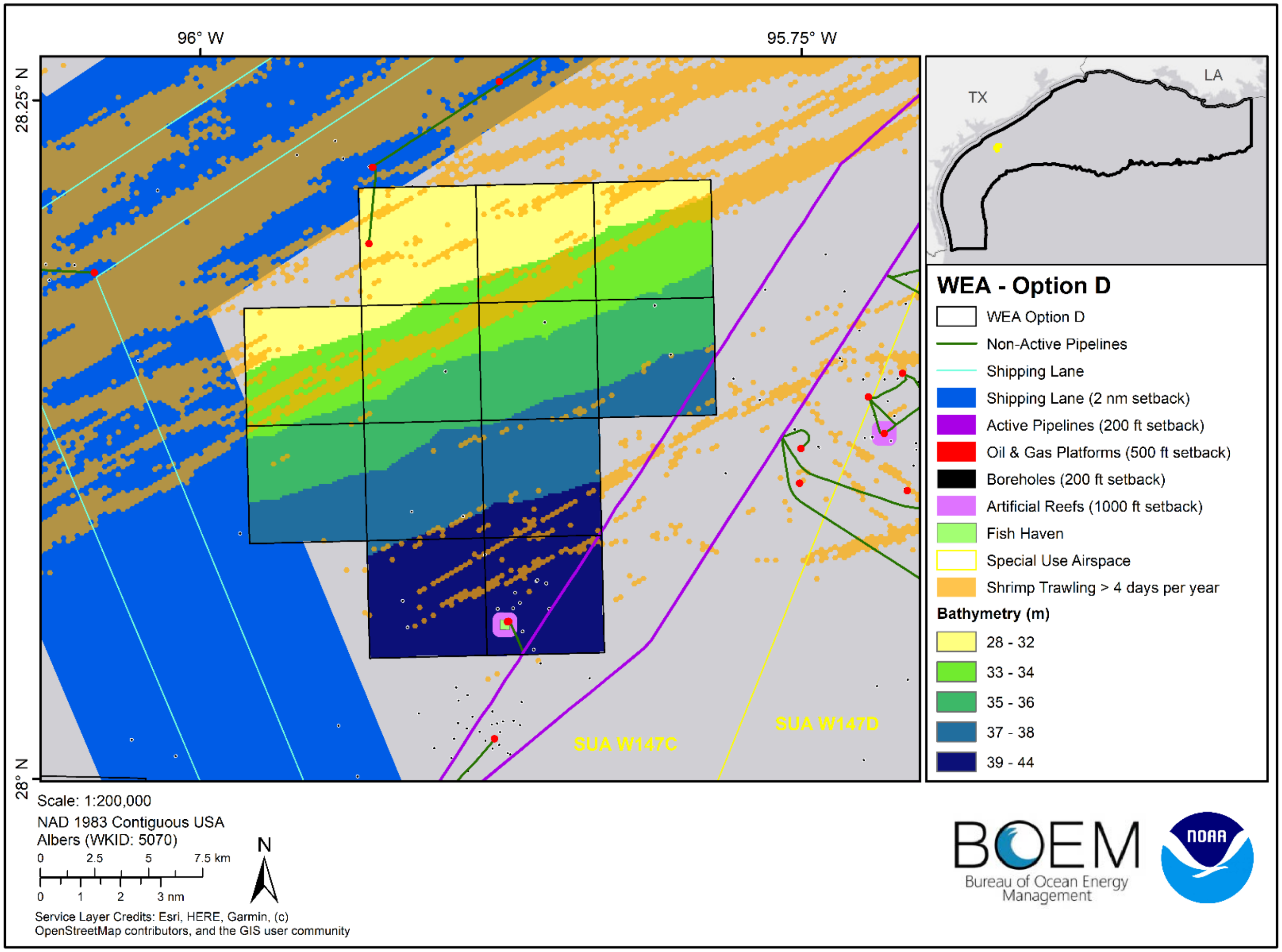

Figure 3.44. *Map depicting noteworthy characterization features for Wind Energy Area option D.*

3.10.5 WEA Option E Characterization

Option E is 51,210 acres in size and is located off of Matagorda Bay. The closest principal ports include Port Freeport and Port Lavaca, Texas (**Figure 3.45**). The mean depth across the entire area is 51.3 m, with a maximum depth of 57.2 m and a minimum of 46.6 m (**Table 3.13; Figure 3.46**).

Table 3.13. Characterization summary for Wind Energy Area option E.

Logistics	Value
Size (acres)	51,210
Distance to port (km)	Port Freeport 101.8 km; Port Lavaca 132.4 km
Distance to shore (km)	66
Depth (m) (minimum, maximum, mean)	min = 46.6 m, max = 57.2 m, mean = 51.3 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	14.3% coverage
Oil and Gas Pipelines	1 active; 3 non-active outside of option
Oil and Gas Boreholes, Test Wells, and Wells	4 within option
Oil and Gas Drilling Platforms	5 outside of option
TX permitted artificial reefs	1 outside of option
National Security	
Special use airspace	Overlaps with SUA W147D
Natural and Cultural Resources	
NOAA Fish Havens	1 outside of option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp's ridley sea turtle
Industry and Operations	
Federal Lightering Rendezvous Areas	Partially overlaps
NOAA NMFS Fishing Surveys	6
AIS 2019 Cargo Vessel Transits per acre	0.03
AIS 2019 Fishing Vessel Transits per acre	0.43
AIS 2019 Other Vessel Transits per acre	0.09
AIS 2019 Passenger Vessel Transits per acre	0.001
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	0.03

AIS Tug Tow Vessel Transits per acre	0.02
Economics	
NREL - Net Value 2015	-178.2
Count of Competitive Lease Block Overlap	1

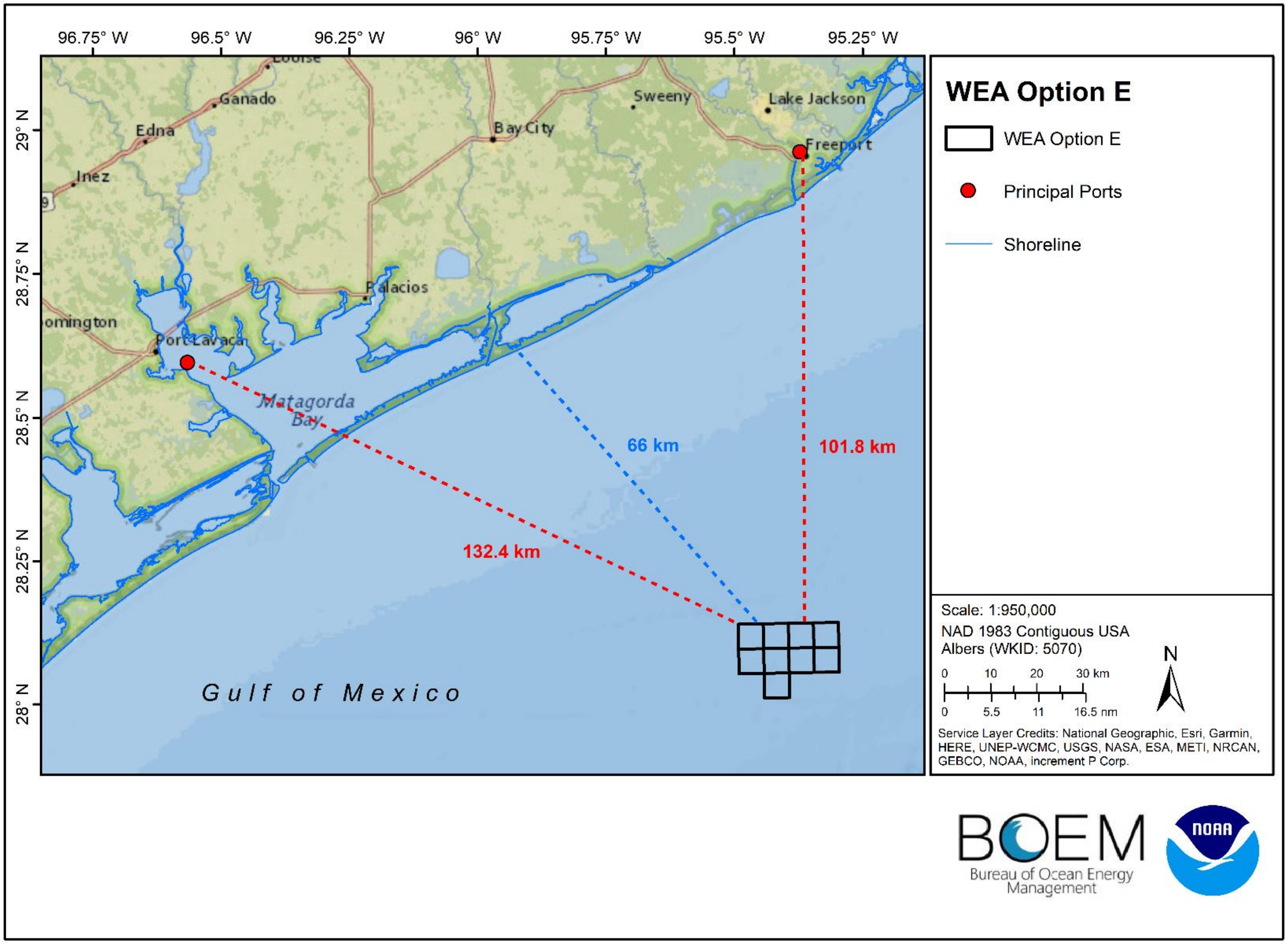

Figure 3.45. *WEA option E (black outlined box) and distance to Port Freeport and Port Lavaca, Texas.*

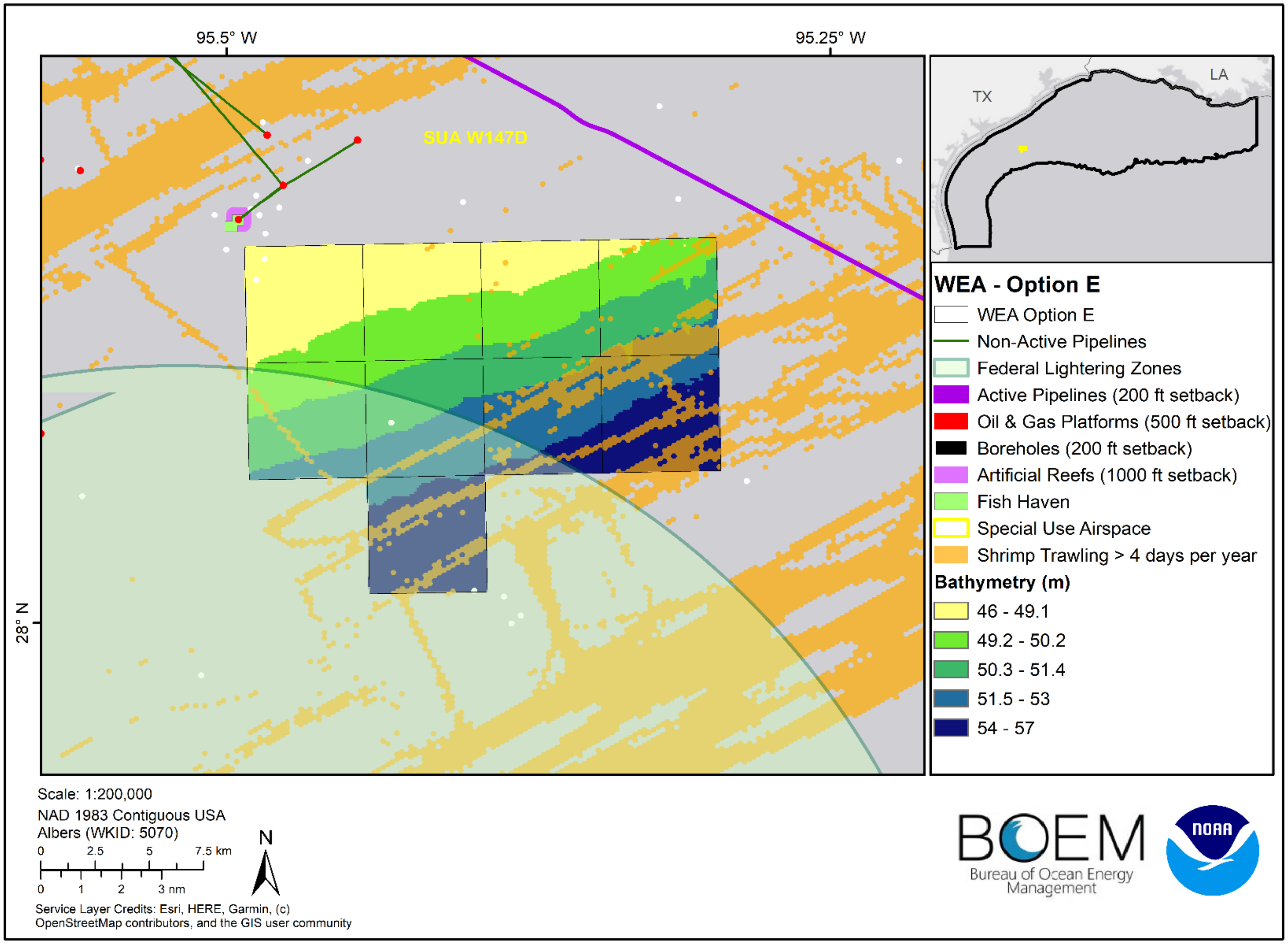

Figure 3.46. *Map depicting noteworthy characterization features for Wind Energy Area option E.*

3.10.6 WEA Option F Characterization

Option F is 102,445 acres in size and is located off of Matagorda Bay. The closest principal ports include Port Freeport and Port Lavaca, Texas (**Figure 3.47**). The mean depth across the entire area is 44.5 m, with a maximum depth of 53.5 m and a minimum of 34.6 m (**Table 3.14; Figure 3.48**).

Table 3.14. Characterization summary for Wind Energy Area option F.

Logistics	Value
Size (acres)	102,445
Distance to port (km)	Port Freeport 76.2 km; Port Lavaca 125.8 km
Distance to shore (km)	56.9
Depth (m) (minimum, maximum, mean)	min = 34.6 m, max = 53.5 m, mean = 44.5 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	1.4% coverage
Oil and Gas Pipelines	2 active; 3 non-active outside of option
Oil and Gas Boreholes, Test Wells, and Wells	22 within option
Oil and Gas Drilling Platforms	6 outside of option
Unexploded Ordnance (UXO) polygon	1 south of option; 4.5 km
National Security	
Special use airspace	Overlaps with SUA W147D
Natural and Cultural Resources	
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp's ridley sea turtle
Industry and Operations	
Number of Lease Blocks Outside of Carbon Capture WEAs	5
NOAA NMFS Fishing Surveys	5 - 6
AIS 2019 Cargo Vessel Transits per acre	0.04
AIS 2019 Fishing Vessel Transits per acre	0.62
AIS 2019 Other Vessel Transits per acre	0.09
AIS 2019 Passenger Vessel Transits per acre	0.01
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.05
AIS 2019 Tanker Vessel Transits per acre	0.21

AIS Tug Tow Vessel Transits per acre	0.03
Economics	
NREL - Net Value 2015	-166.3
Count of Competitive Lease Block Overlap	1

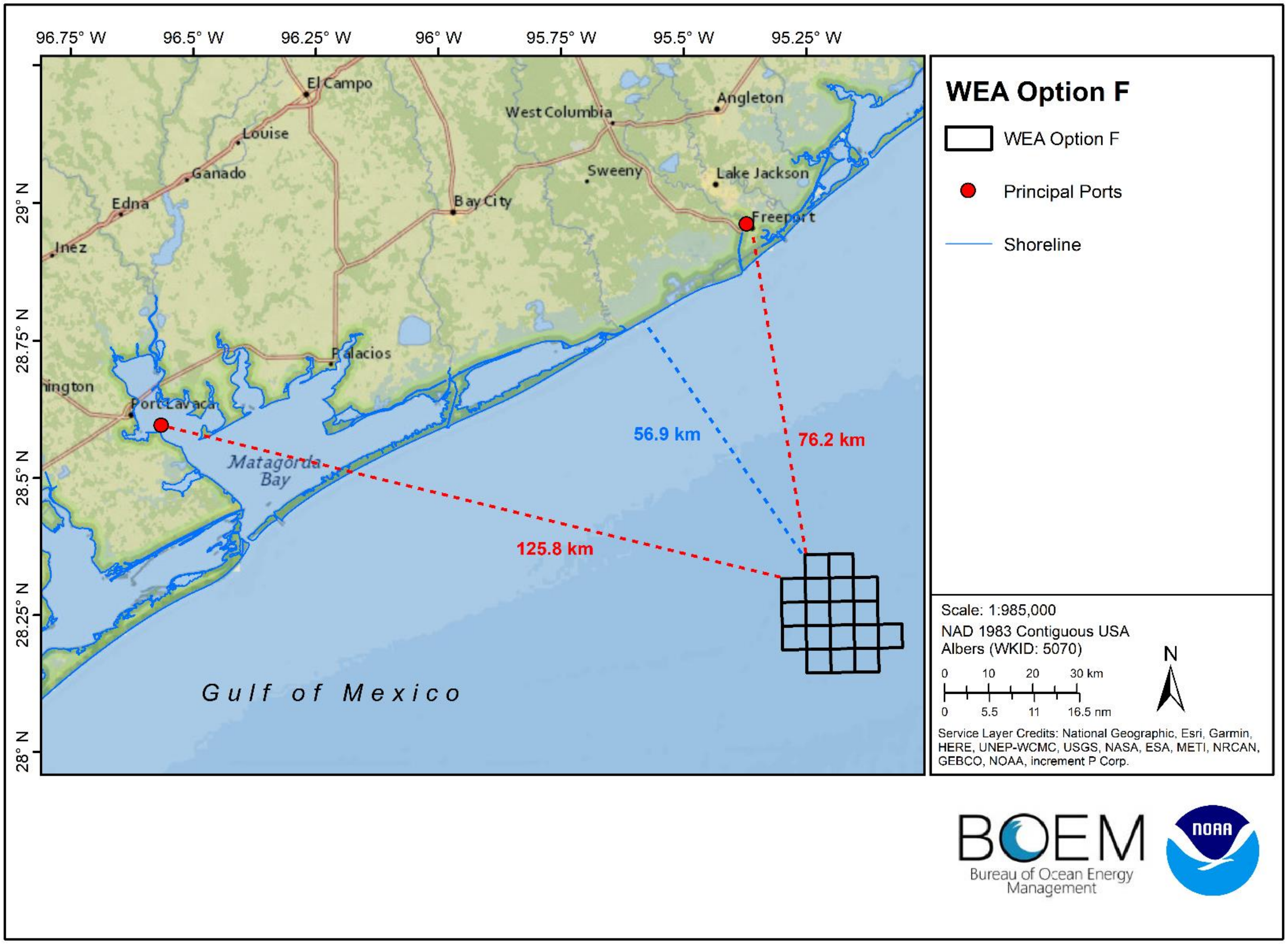

Figure 3.47. *WEA option F (black outlined box) and distance to Port Freeport and Port Lavaca, Texas.*

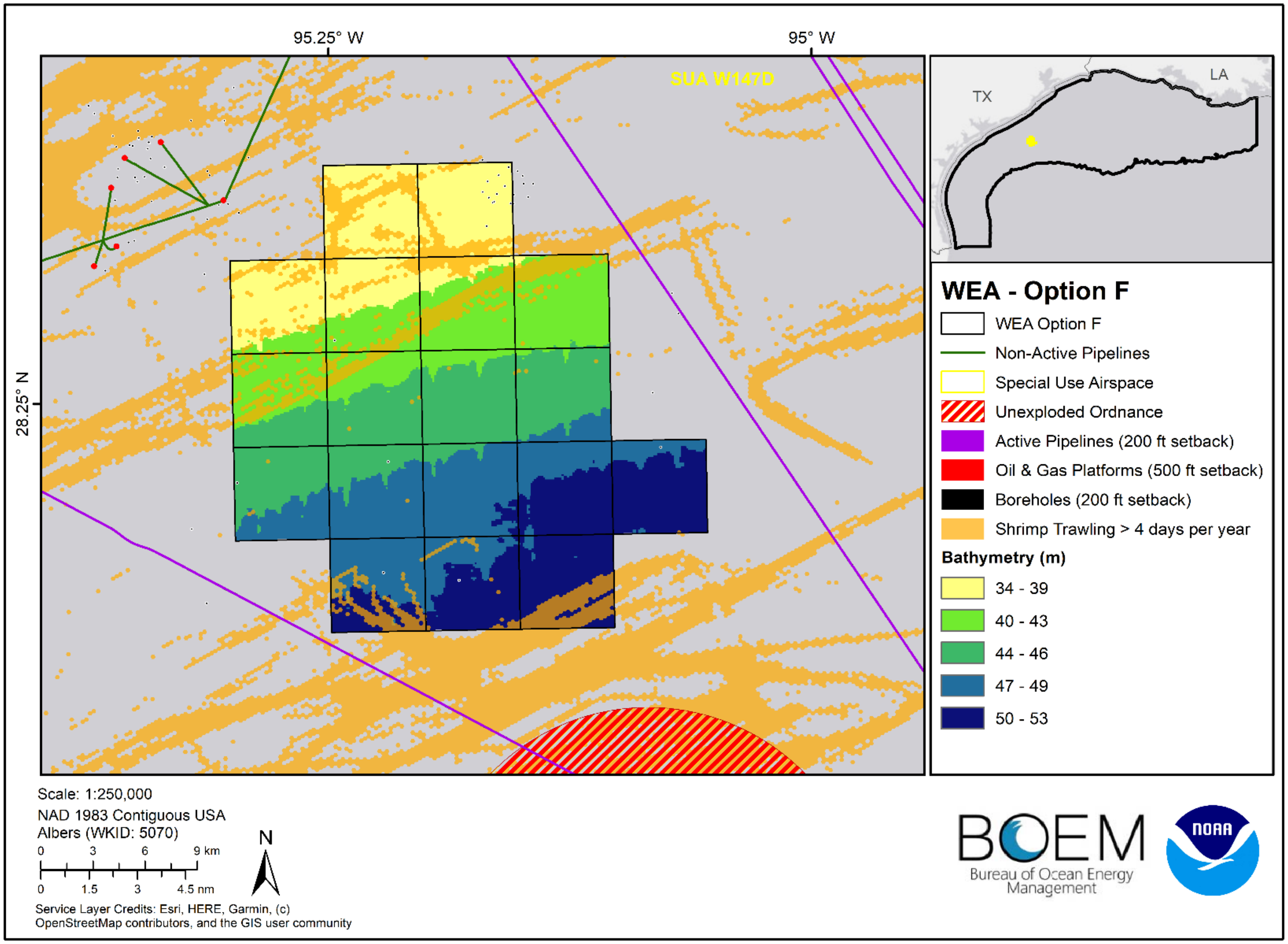

Figure 3.48. Map depicting noteworthy characterization features for Wind Energy Area option F.

3.10.7 WEA Option G Characterization

Option G is 39,836 acres in size and is located off of Freeport, Texas. The closest principal port is Port Freeport, Texas (**Figure 3.49**). The mean depth across the entire area is 31.8 m, with a maximum depth of 34.8 m and a minimum of 28.5 m (**Table 3.15; Figure 3.50**).

Table 3.15. Characterization summary for Wind Energy Area option G.

Logistics	Value
Size (acres)	39,836
Distance to port (km)	Port Freeport 54.1 km
Distance to shore (km)	37.3
Depth (m) (minimum, maximum, mean)	min = 28.5 m, max = 34.8 m, mean = 31.8 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	23.2% coverage
Shipping Fairways and Regulations	Outside of option; 3.5 km
Oil and Gas Pipelines	1 active; 2 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	10 within option
Oil and Gas Drilling Platforms	1 within option
National	Security
Special use airspace	Overlaps with SUA W147D
Natural and	Cultural Resources
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle
Industry and	Operations
Federal Lightering Rendezvous Areas	Partially within
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.03
AIS 2019 Fishing Vessel Transits per acre	2.89
AIS 2019 Other Vessel Transits per acre	0.2
AIS 2019 Passenger Vessel Transits per acre	0.06
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.09
AIS 2019 Tanker Vessel Transits per acre	0.03

AIS Tug Tow Vessel Transits per acre	0.03
Economics	
NREL - Net Value 2015	-140.7
Count of Competitive Lease Block Overlap	1 - 2

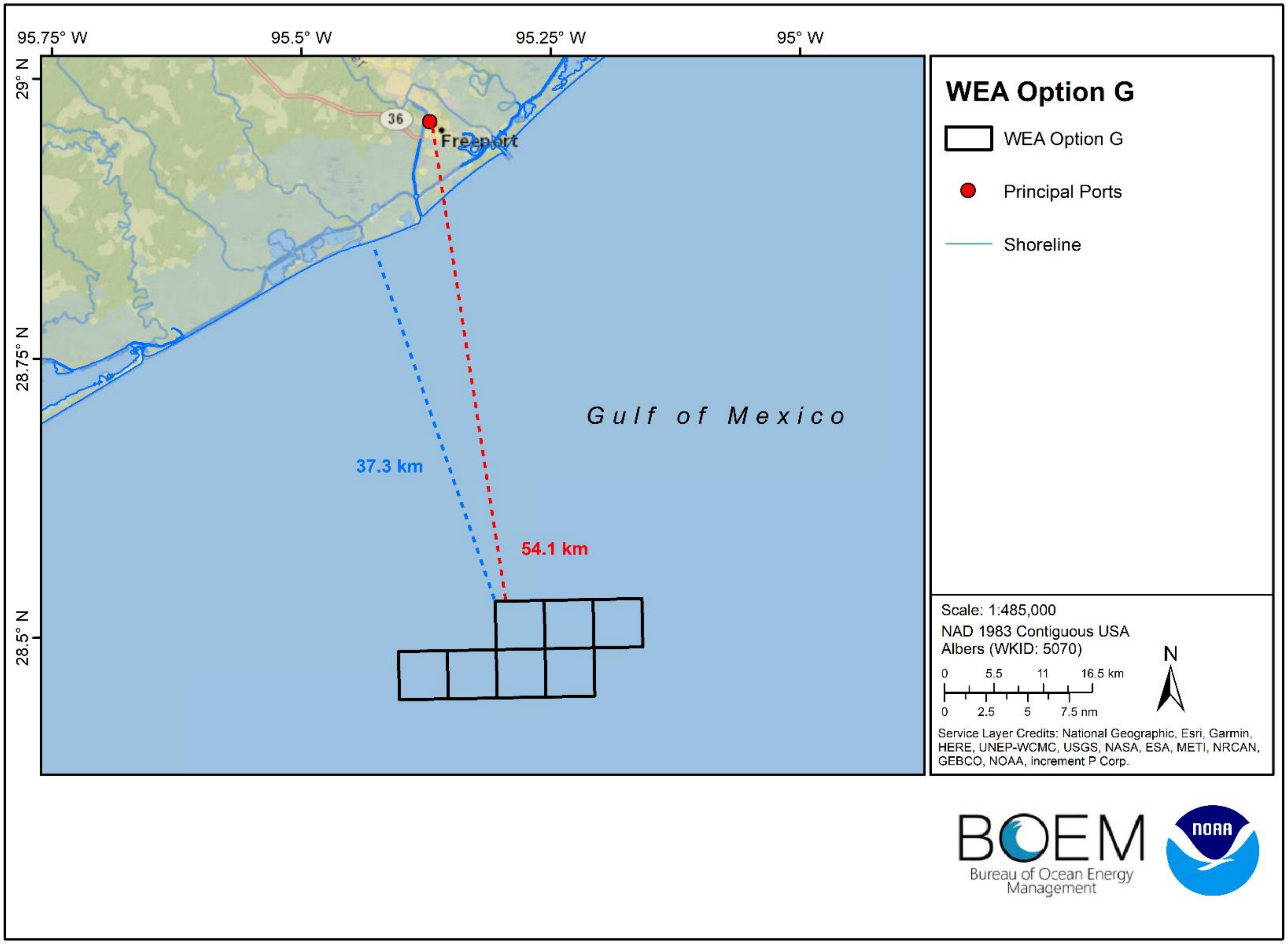

Figure 3.49. *WEA option G (black outlined box) and distance to Port Freeport, Texas.*

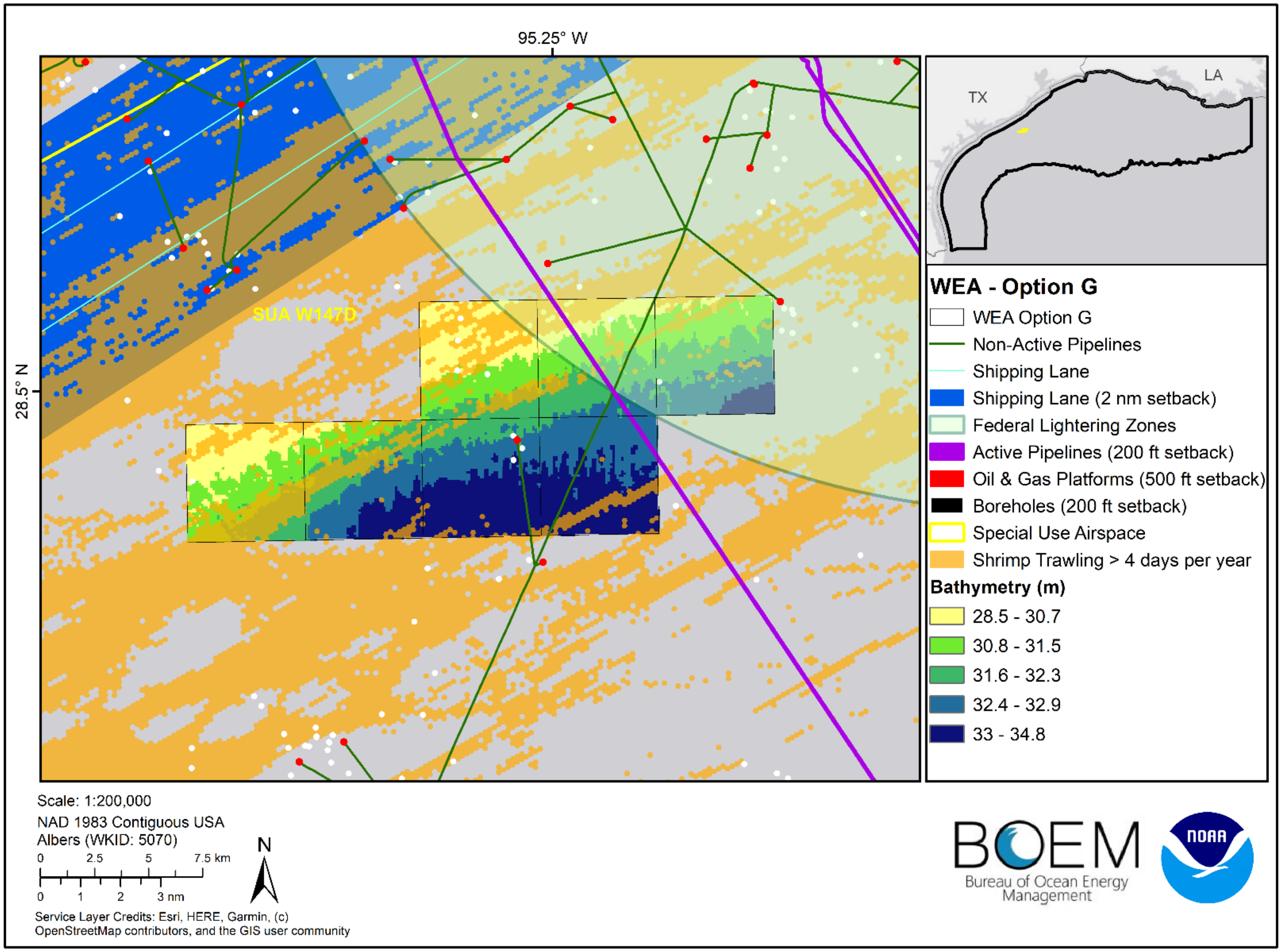

Figure 3.50. *Map depicting noteworthy characterization features for Wind Energy Area option G.*

3.10.8 WEA Option H Characterization

Option H is 39,853 acres in size and is located off of Freeport, Texas. The closest principal port is Port Freeport, Texas (**Figure 3.51**). The mean depth across the entire area is 42.2 m, with a maximum depth of 47.3 m and a minimum of 37.4 m (**Table 3.16; Figure 3.52**).

Table 3.16. Characterization summary for Wind Energy Area option H.

Logistics	Value
Size (acres)	39,853
Distance to port (km)	Port Freeport 86.1 km
Distance to shore (km)	68.9
Depth (m) (minimum, maximum, mean)	min = 37.4 m, max = 47.3 m, mean = 42.2 m
Constraints	
VMS Shrimp Fishing areas of Moderate-High Fishing	6.4% coverage
Shipping Fairways and Regulations	Partially overlaps with 2 northeast lease blocks
Oil and Gas Pipelines	2 active outside of option
Oil and Gas Boreholes, Test Wells, and Wells	11 within option
Oil and Gas Drilling Platforms	8 outside of option
TX permitted artificial reefs	1 outside of option
Environmental Sensors and Buoys	1 within options; northwest corner
National Security	
Special use airspace	Overlaps with SUA W147D
Natural and Cultural Resources	
NOAA Fish Havens	1 outside of option
Protected Resource Division Combined Layer Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp's ridley sea turtle
Industry and Operations	
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.06
AIS 2019 Fishing Vessel Transits per acre	0.57
AIS 2019 Other Vessel Transits per acre	0.20
AIS 2019 Passenger Vessel Transits per acre	0.07
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01

AIS 2019 Tanker Vessel Transits per acre	0.38
AIS Tug Tow Vessel Transits per acre	0.02
Economics	
NREL - Net Value 2015	-165.8
Count of Competitive Lease Block Overlap	1

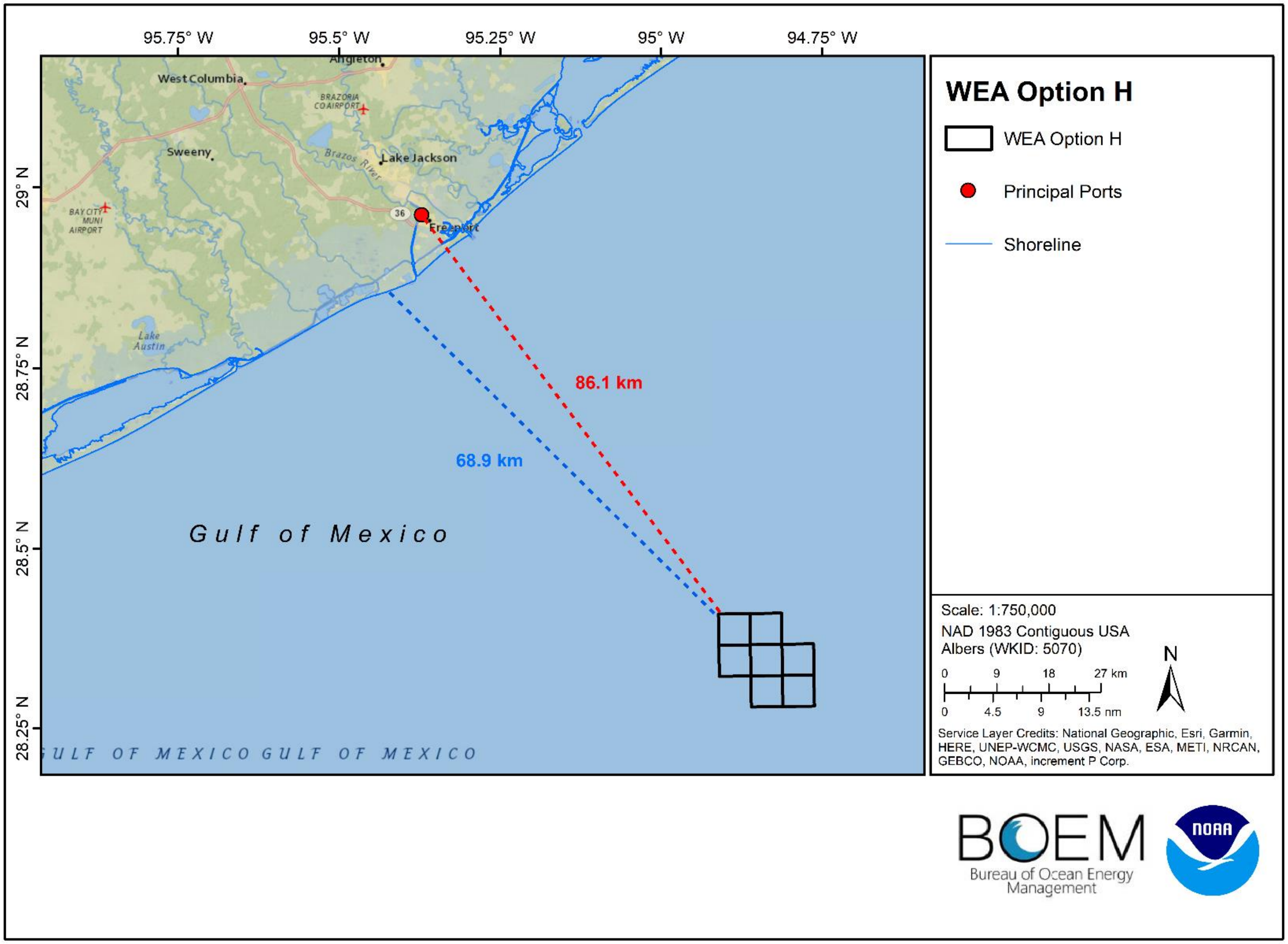

Figure 3.51. *WEA option H (black outlined box) and distance to Port Freeport, Texas.*

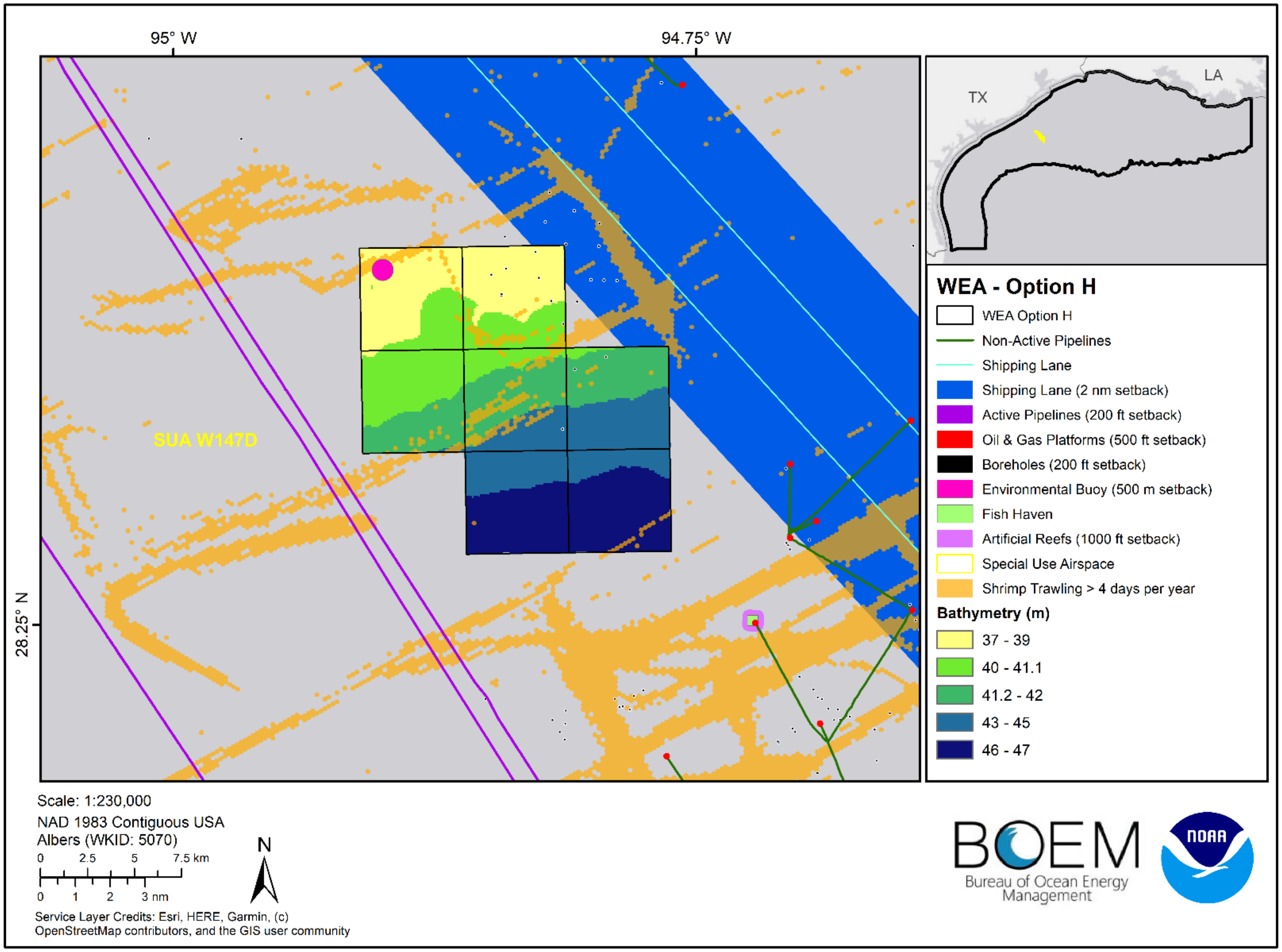

Figure 3.52. *Map depicting noteworthy characterization features for Wind Energy Area option H.*

3.10.9 WEA Option I Characterization

Option I is 546,645 acres in size and is located off of Galveston, Texas. The closest principal port is Port of Galveston, Texas (**Figure 3.53**). The mean depth across the entire area is 28.4 m, with a maximum depth of 252.7 m and a minimum of 15.8 m (**Table 3.17; Figure 3.54**).

Table 3.17. Characterization summary for Wind Energy Area option I.

Logistics	Value
Size (acres)	546,645
Distance to port (km)	Port of Galveston 45.2 km
Distance to shore (km)	35.1
Depth (m) (minimum, maximum, mean)	min = 15.8 m, max = 252.7 m, mean = 28.4 m
VMS Shrimp Fishing areas of Moderate-High Fishing	7.1% coverage
Shipping Fairways and Regulations	Surrounded by shipping lane on all sides of option; intersects 16 lease blocks
Oil and Gas Pipelines	1 active; 68 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	173 within option
Anchorage Areas (used/disused)	1 outside of option to the northwest
Oil and Gas Drilling Platforms	41 within option
Aids to Navigation (beacons and buoys)	1 within option
TX permitted artificial reefs	4 within option
	Security
Special use airspace	Overlaps with SUA W147D and A381
	Cultural Resources
NOAA Fish Havens	3 within option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp's ridley sea turtle

	Operations
Federal Lightering Rendezvous Areas	Partially within 2 areas
NEXRAD Sites	Close proximity to moderate impact area
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.19
AIS 2019 Fishing Vessel Transits per acre	0.45
AIS 2019 Other Vessel Transits per acre	1.27
AIS 2019 Passenger Vessel Transits per acre	0.49
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.03
AIS 2019 Tanker Vessel Transits per acre	2.13
AIS Tug Tow Vessel Transits per acre	0.03
NREL - Net Value 2015	-147.0
Count of Competitive Lease Block Overlap	1 - 5

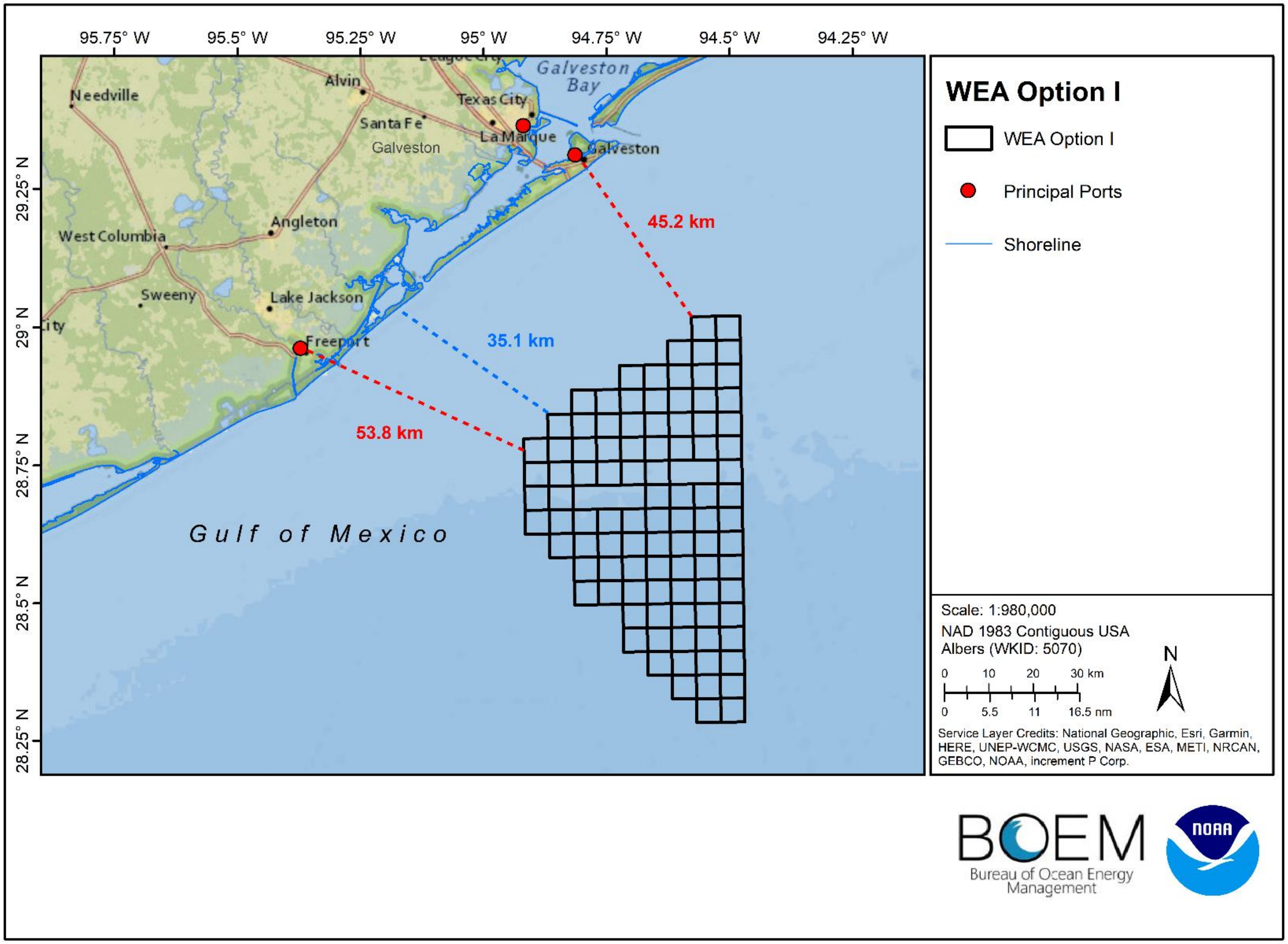

Figure 3.53. *WEA option I (black outlined box) and distance to the Port of Galveston, Texas.*

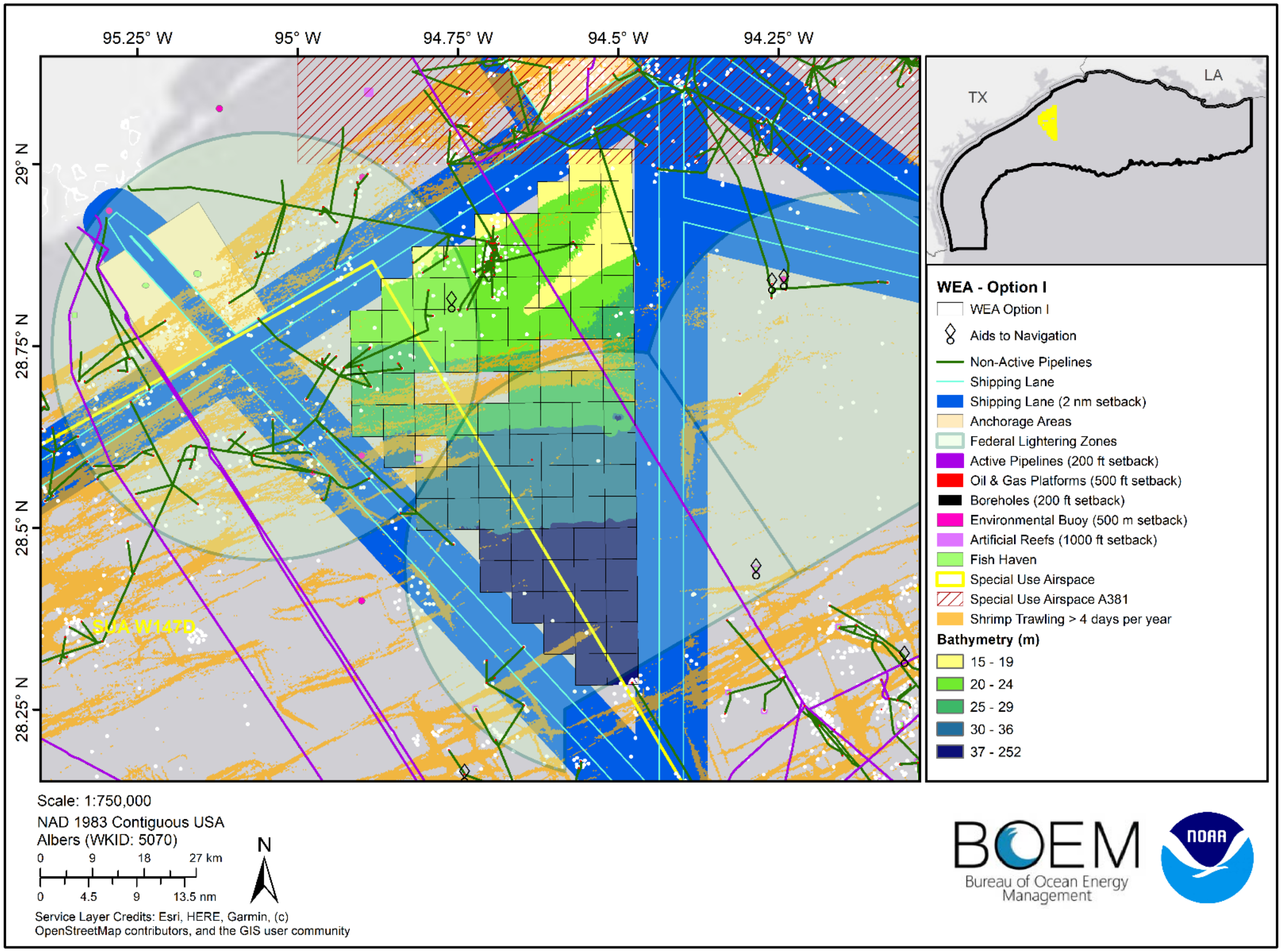

Figure 3.54. *Map depicting noteworthy characterization features for Wind Energy Area option I.*

3.10.10 WEA Option J Characterization

Option J is 495,567 acres in size and is located off of Galveston, Texas. The closest principal port is Port of Galveston, Texas (**Figure 3.55**). The mean depth across the entire area is 31.3 m, with a maximum depth of 46 m and a minimum of 22.5 m (**Table 3.18; Figure 3.56**).

Table 3.18. Characterization summary for Wind Energy Area option J.

Logistics	Value
Size (acres)	495,567
Distance to port (km)	Port of Galveston 76 km
Distance to shore (km)	114.3 km
Depth (m) (minimum, maximum, mean)	min = 22.5 m, max = 46 m, mean = 31.3 m
VMS Shrimp Fishing areas of Moderate-High Fishing	2.9% coverage
Shipping Fairways and Regulations	Intersects with 14 lease blocks on west and north sides
Oil and Gas Pipelines	1 active; 9 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	37 within option
Oil and Gas Drilling Platforms	5 within option
Aids to Navigation (beacons and buoys)	1 within option
TX permitted artificial reefs	1 within option
	Cultural Resources
NOAA Fish Havens	1 within option
Protected Resource Division Combined Layer - Species overlap	Atlantic spotted dolphin (coastal) Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle Leatherback sea turtle
	Operations
Federal Lightering Rendezvous Areas	Intersects with 3 areas
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.09
AIS 2019 Fishing Vessel Transits per acre	0.16
AIS 2019 Other Vessel Transits per acre	0.97
AIS 2019 Passenger Vessel Transits per acre	0.42
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	2.26

AIS Tug Tow Vessel Transits per acre	0.04
NREL - Net Value 2015	-161.4
Count of Competitive Lease Block Overlap	1 - 4

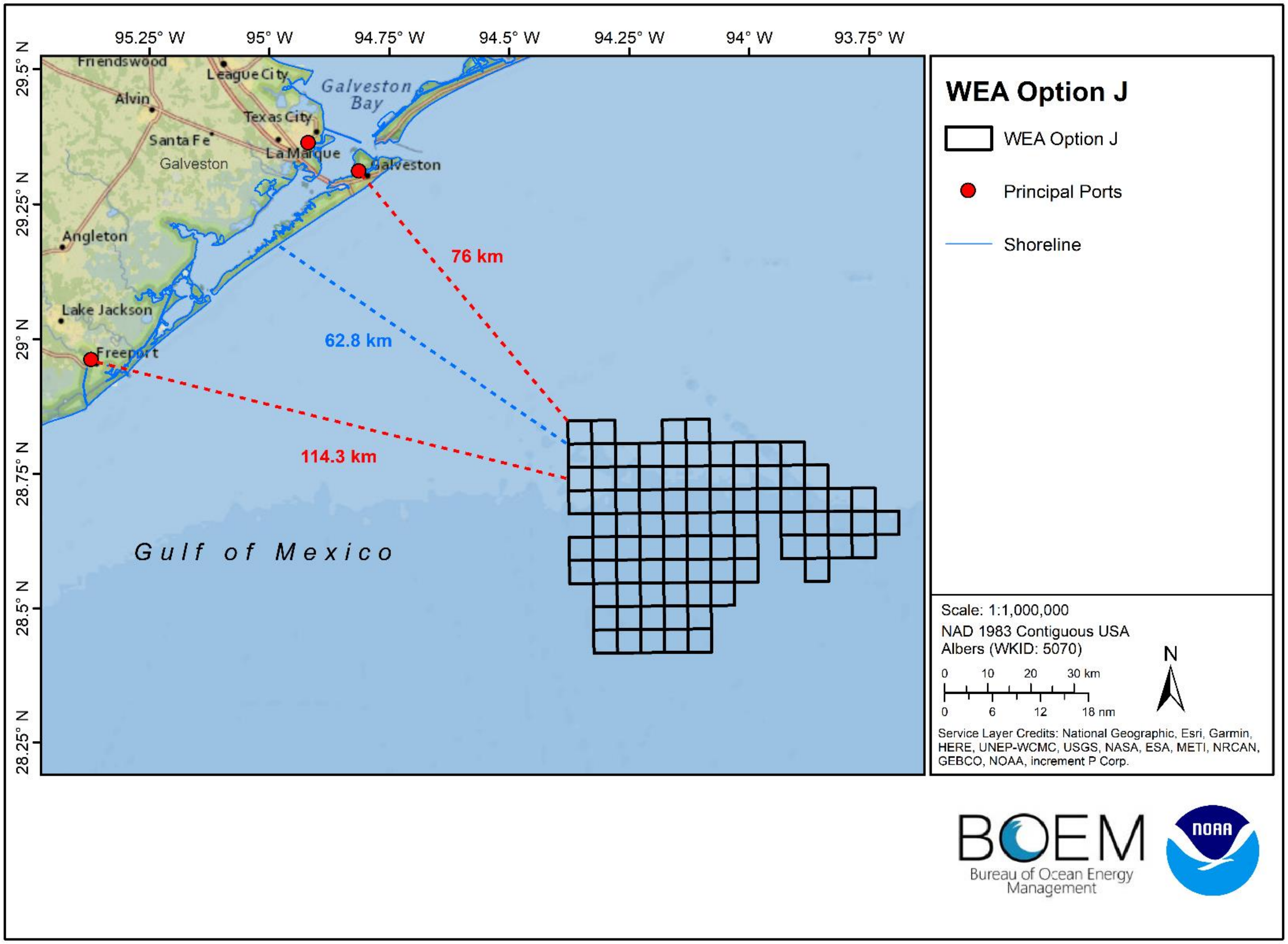

Figure 3.55. *WEA option J (black outlined box) and distance to the Port of Galveston, Texas.*

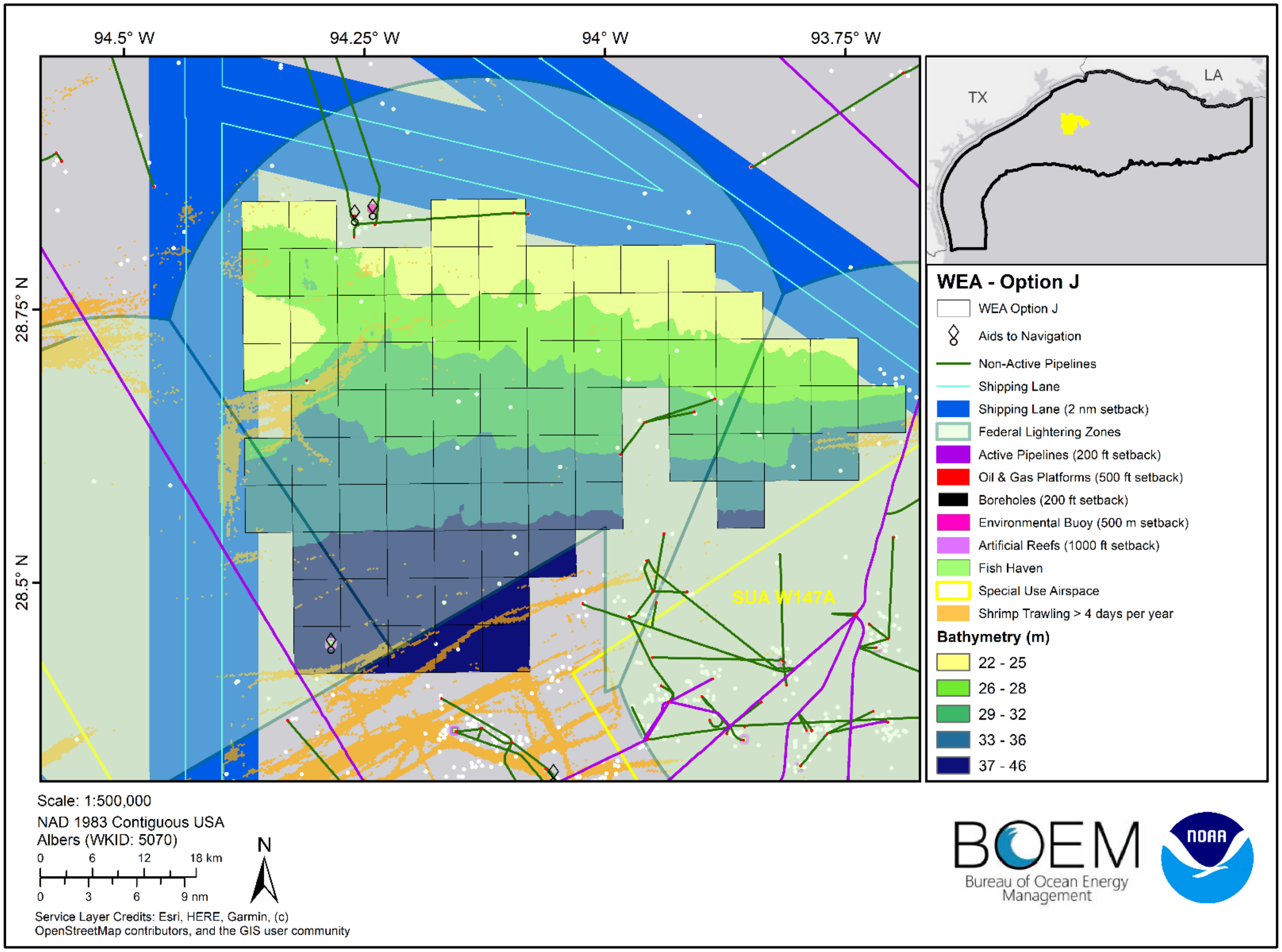

Figure 3.56. *Map depicting noteworthy characterization features for Wind Energy Area option J.*

3.10.11 WEA Option K Characterization

Option K is 119,635 acres in size and is located off of Galveston, Texas. The closest principal ports include the Port of Galveston, Texas and Port Arthur, Louisiana (**Figure 3.57**). The mean depth across the entire area is 19.9 m, with a maximum depth of 23.8 m and a minimum of 17.4 m (**Table 2.1; Figure 3.58**).

Table 3.19. Characterization summary for Wind Energy Area option K.

Logistics	Value
Size (acres)	119,635
Distance to port (km)	Port of Galveston 98.9 km; Port Arthur 133.3 km
Distance to shore (km)	57.2 km
Depth (m) (minimum, maximum, mean)	min = 17.4 m, max = 23.8 m, mean = 19.9 m
VMS Shrimp Fishing areas of Moderate-High Fishing	0.7% coverage
Shipping Fairways and Regulations	Intersects with 2 lease blocks in the south
BOEM Lease Blocks with Significant Sediment Resources	Close proximity to the west of the option
Oil and Gas Pipelines	1 active; 15 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	23 within option
Oil and Gas Drilling Platforms	10 within option
	Security
Special use airspace	Overlaps with SUA A381
	Cultural Resources
Protected Resource Division Combined Layer - Species overlap	Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle
	Operations
Outside of Carbon Capture WEAs	16
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.19
AIS 2019 Fishing Vessel Transits per acre	0.13
AIS 2019 Other Vessel Transits per acre	0.58
AIS 2019 Passenger Vessel Transits per acre	0.82

AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	1.29
AIS Tug Tow Vessel Transits per acre	0.10
NREL - Net Value 2015	-136.1
Count of Competitive Lease Block Overlap	0

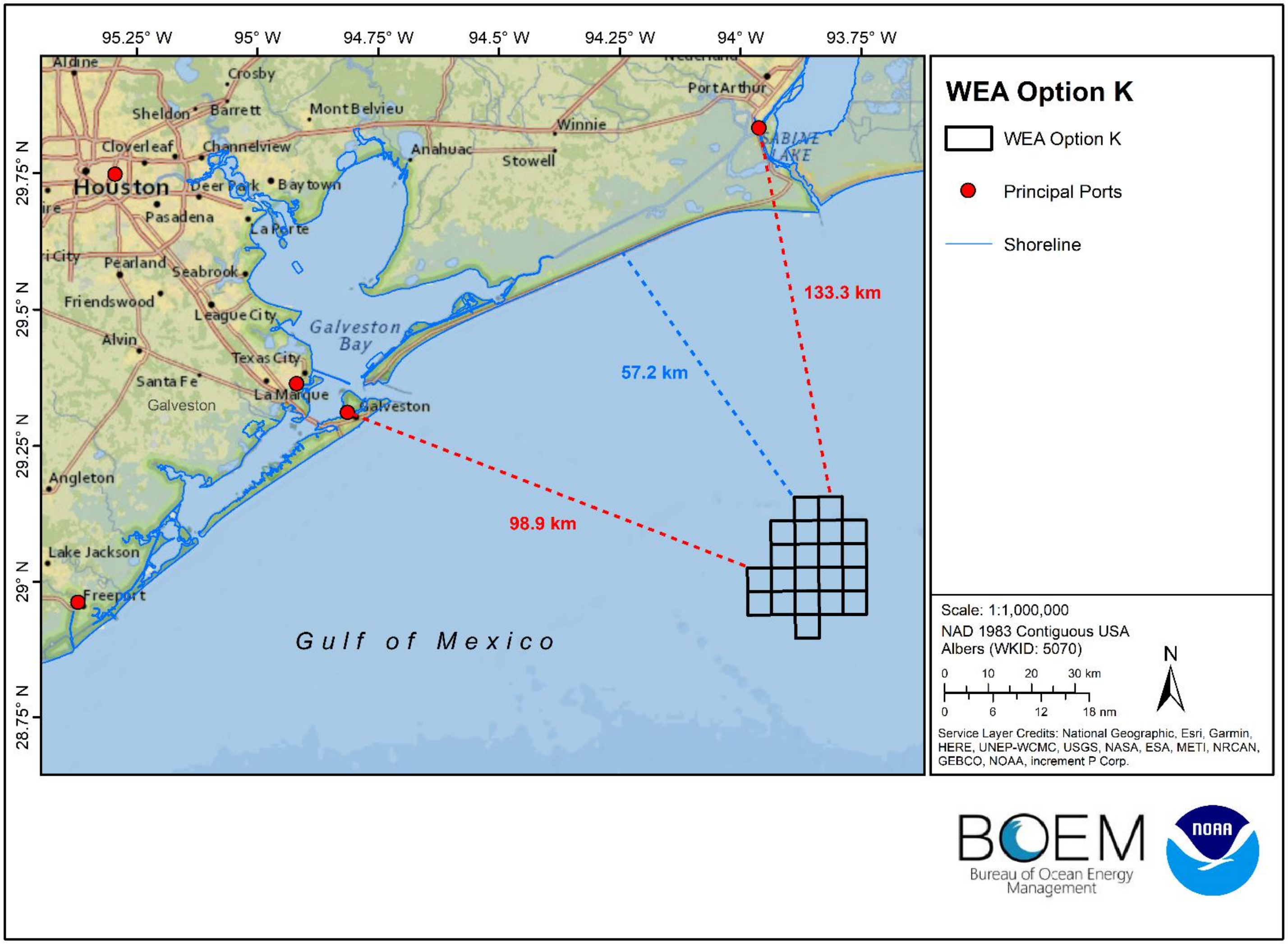

Figure 3.57. *WEA option K (black outlined box) and distance to the Port of Galveston, Texas and Port Arthur, Louisiana.*

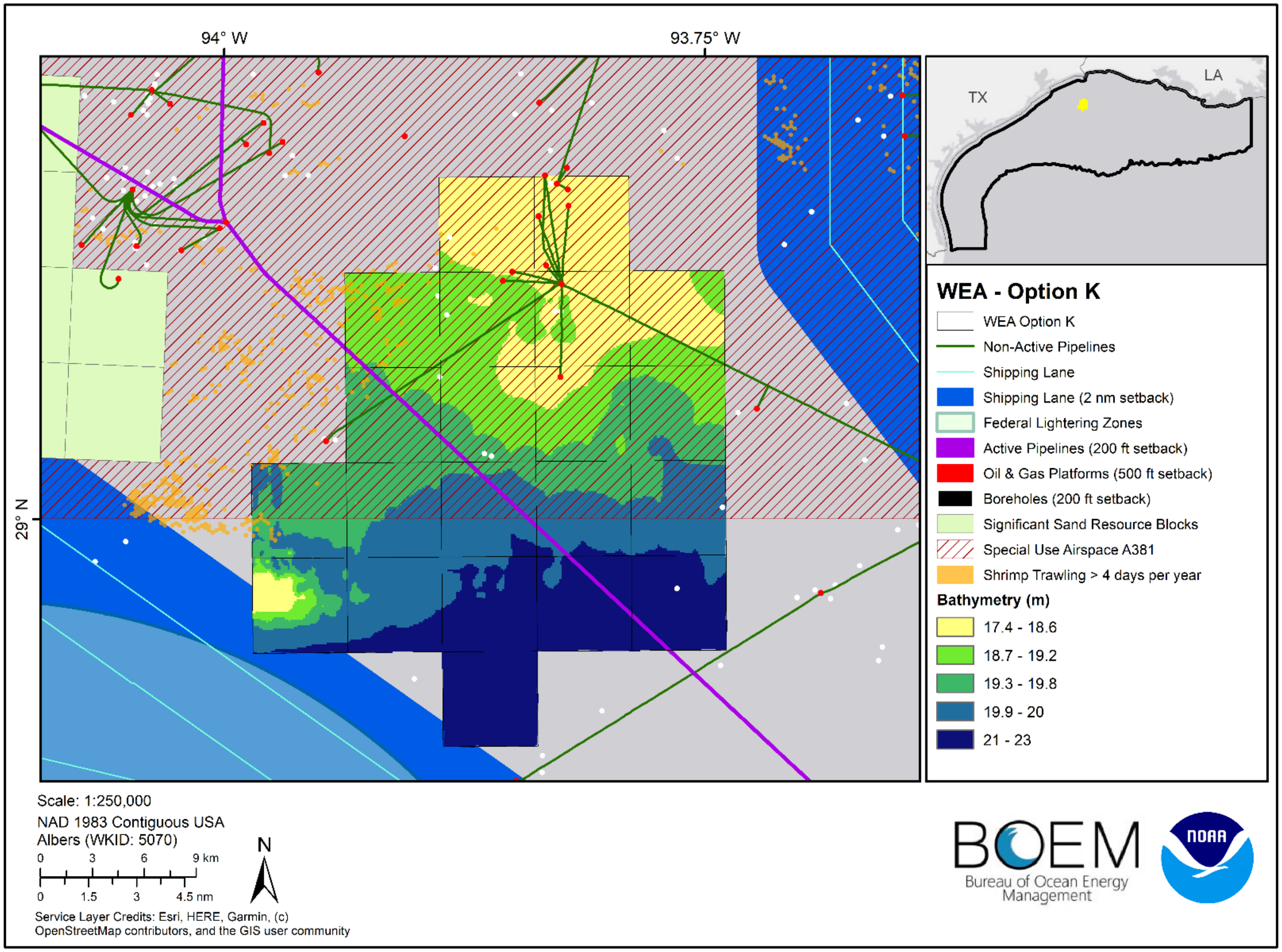

Figure 3.58. *Map depicting noteworthy characterization features for Wind Energy Area option K.*

3.10.12 WEA Option L Characterization

Option L is 91,157 acres in size and is located off of Galveston, Texas. The closest principal ports include the Port of Galveston, Texas and Port Arthur, Louisiana (**Figure 3.59**). The mean depth across the entire area is 22.8 m, with a maximum depth of 29.0 m and a minimum of 18.3 m (**Table 3.20; Figure 3.60**).

Table 3.20. Characterization summary for Wind Energy Area option L.

Logistics	Value
Size (acres)	91,157
Distance to port (km)	Port of Galveston 125.6 km; Port Arthur 151 km
Distance to shore (km)	85.2
Depth (m) (minimum, maximum, mean)	min = 18.3 m, max = 29.0 m, mean = 22.8 m
VMS Shrimp Fishing areas of Moderate-High Fishing	0.1% coverage
Shipping Fairways and Regulations	Intersects 5 lease blocks on the west and east sides
Oil and Gas Pipelines	2 active; 5 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	12 within option
Oil and Gas Drilling Platforms	4 within option
	Cultural Resources
Protected Resource Division Combined Layer - Species overlap	Bottlenose dolphin (coastal) Giant manta ray
	Operations
Federal Lightering Rendezvous Areas	Intersects 1 area
Outside of Carbon Capture WEAs	Completely outside of carbon capture
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.07
AIS 2019 Fishing Vessel Transits per acre	0.05
AIS 2019 Other Vessel Transits per acre	0.35
AIS 2019 Passenger Vessel Transits per acre	0.25
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.01
AIS 2019 Tanker Vessel Transits per acre	0.75

AIS Tug Tow Vessel Transits per acre	0.05
NREL - Net Value 2015	-151.5
Count of Competitive Lease Block Overlap	0

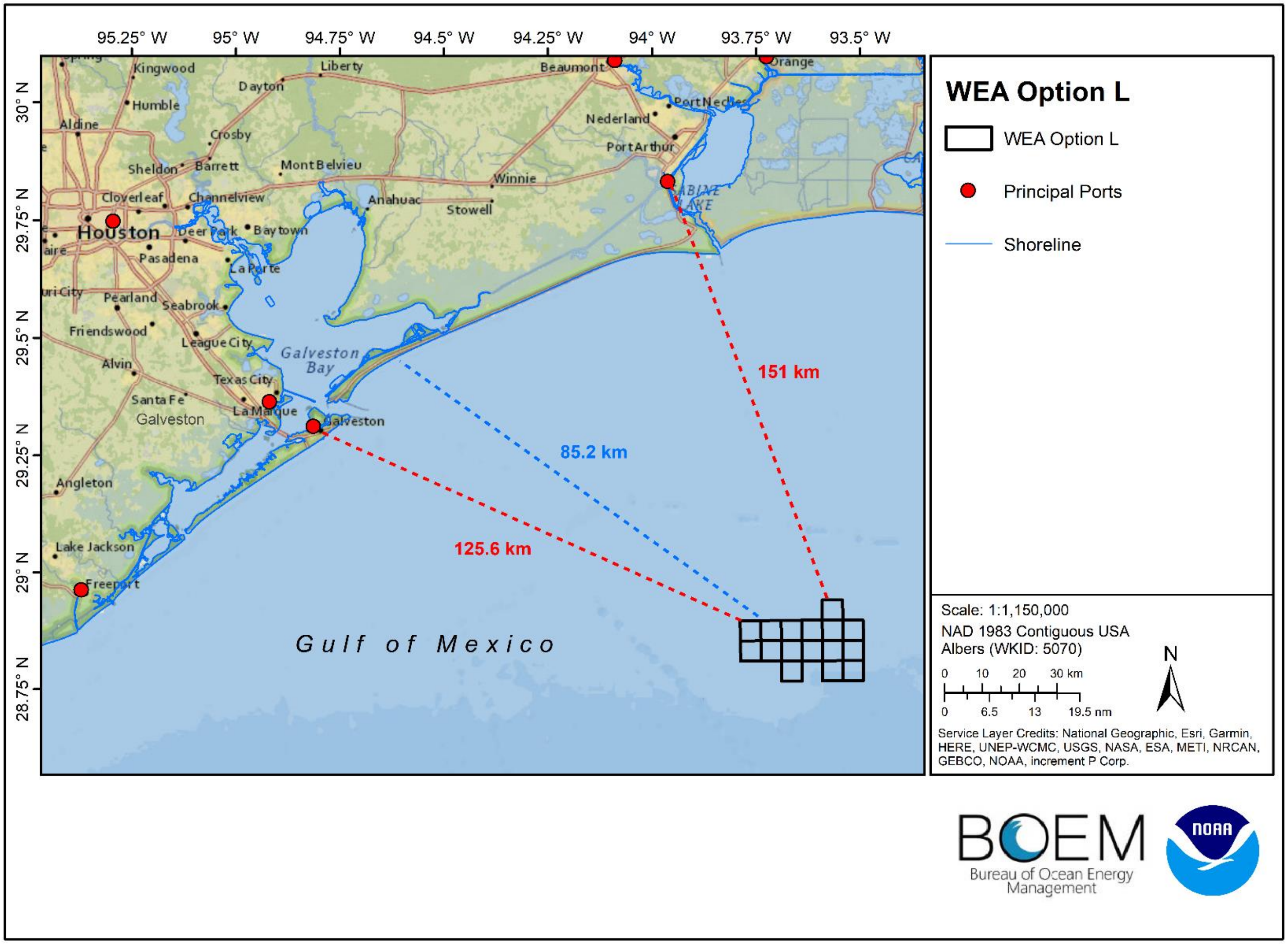

Figure 3.59. *WEA option L (black outlined box) and distance to the Port of Galveston, Texas and Port Arthur, Louisiana.*

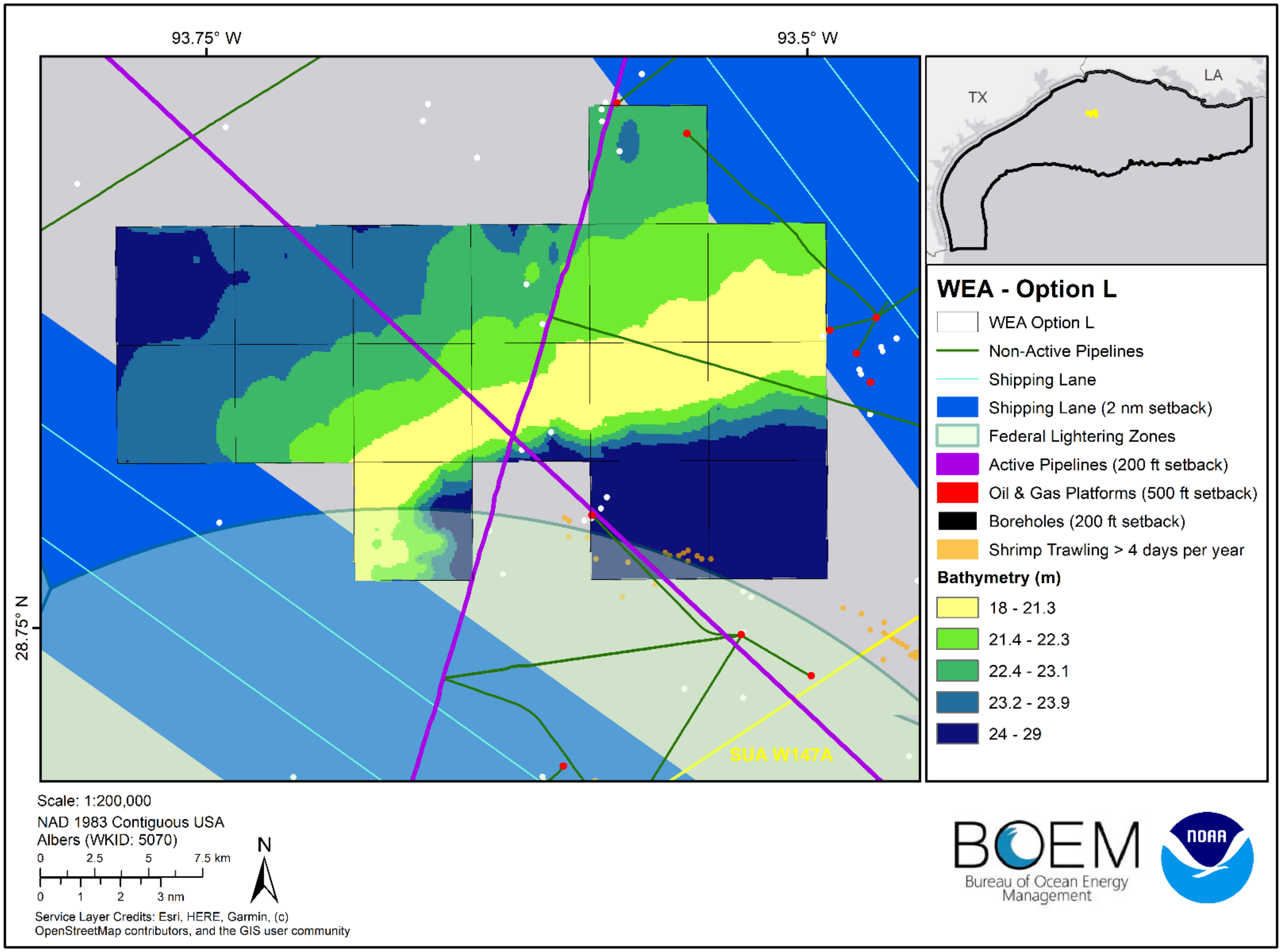

Figure 3.60. *Map depicting noteworthy characterization features for Wind Energy Area option L.*

3.10.13 WEA Option M Characterization

Option M is 188,023 acres in size and is located off of Lake Charles. The closest principal ports include thePort of Galveston, Texas and Lake Charles and Port Arthur, Louisiana (**Figure 3.61**). The mean depth across the entire area is 19.7 m, with a maximum depth of 24.5 m and a minimum of 10.3 m (**Table 3.21; Figure 3.62**).

Table 3.21. Characterization summary for Wind Energy Area option M.

Logistics	Value
Size (acres)	188,023
Distance to port (km)	Lake Charles 104.3 km; Port of Galveston 146.9 km
Distance to shore (km)	52.3
Depth (m) (minimum, maximum, mean)	min = 10.3 m, max = 24.5 m, mean = 19.7 m
VMS Shrimp Fishing areas of Moderate-High Fishing	2.1% coverage
Shipping Fairways and Regulations	Intersects with 6 lease blocks on the east and south sides
Oil and Gas Pipelines	2 active; 47 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	165 within option
Anchorage Areas (used/disused)	1 area to the southeast; outside of option
Oil and Gas Drilling Platforms	42 within option
	Security
Special use airspace	Overlaps with SUA A381
	Cultural Resources
Protected Resource Division Combined Layer - Species overlap	Bottlenose dolphin (coastal) Giant manta ray
	Operations
Outside of Carbon Capture WEAs	5
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.02
AIS 2019 Fishing Vessel Transits per acre	0.63
AIS 2019 Other Vessel Transits per acre	0.34

AIS 2019 Passenger Vessel Transits per acre	0.27
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.02
AIS 2019 Tanker Vessel Transits per acre	0.21
AIS Tug Tow Vessel Transits per acre	0.14
NREL - Net Value 2015	-140.0
Count of Competitive Lease Block Overlap	0

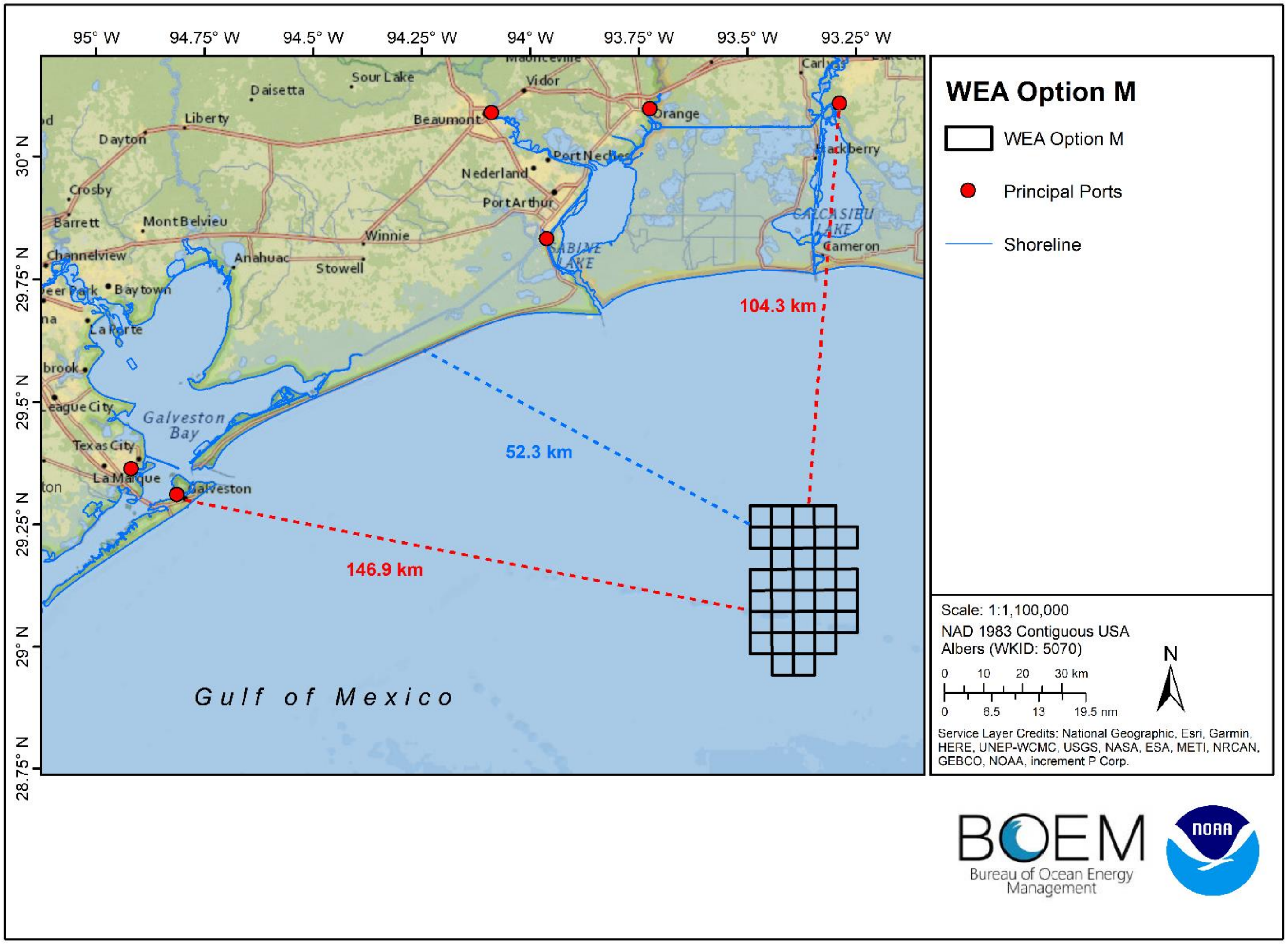

Figure 3.61. *WEA option M (black outlined box) and distance to the Port of Galveston, Texas and Lake Charles, Louisiana.*

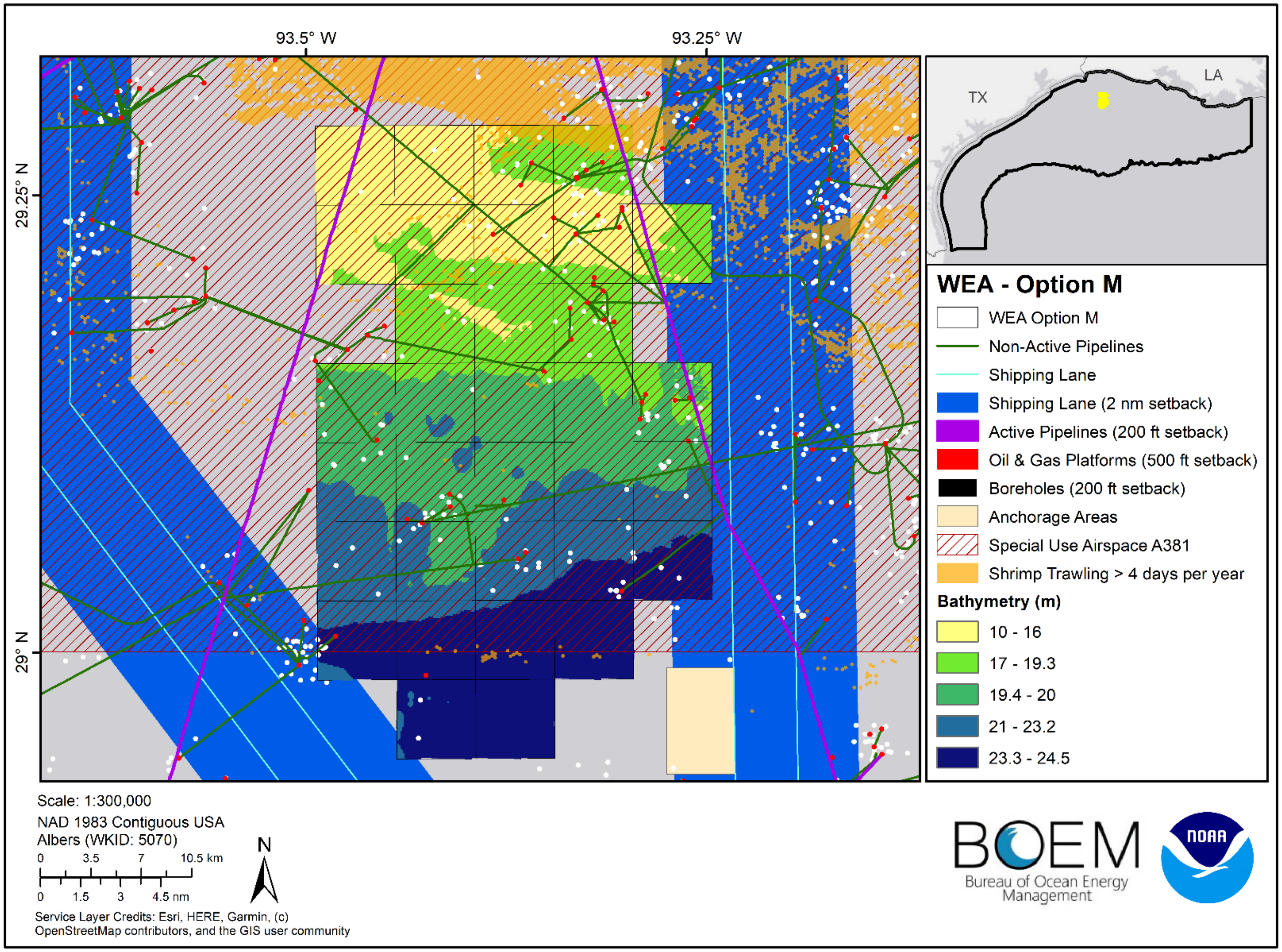

Figure 3.62. *Map depicting noteworthy characterization features for Wind Energy Area option M.*

3.10.14 WEA Option N Characterization

Option N is 56,978 acres in size and is located off of Cameron, Louisiana. The closest principal port is Port Arthur, Louisiana (**Figure 3.63**). The mean depth across the entire area is 20.0 m, with a maximum depth of 21.9 m and a minimum of 16.8 m (**Table 3.22; Figure 3.64**).

Table 3.22. Characterization summary for Wind Energy Area option N.

Logistics	Value
Size (acres)	56,978
Distance to port (km)	Port Arthur 132.5 km
Distance to shore (km)	42.5
Depth (m) (minimum, maximum, mean)	min = 16.8 m, max = 21.9 m, mean = 20.0 m
VMS Shrimp Fishing areas of Moderate-High Fishing	4.2% coverage
Oil and Gas Pipelines	9 non-active within option
Oil and Gas Boreholes, Test Wells, and Wells	47 within option
Oil and Gas Drilling Platforms	8 within option
	Security
Special use airspace	Overlaps with SUA A381
	Cultural Resources
Protected Resource Division Combined Layer - Species overlap	Bottlenose dolphin (coastal) Giant manta ray Green sea turtle Kemp’s ridley sea turtle
	Operations
NOAA NMFS Fishing Surveys	5
AIS 2019 Cargo Vessel Transits per acre	0.02
AIS 2019 Fishing Vessel Transits per acre	0.72
AIS 2019 Other Vessel Transits per acre	0.86
AIS 2019 Passenger Vessel Transitsper acre	0.61
AIS 2019 Pleasure Craft / Sailing Vessel Transits per acre	0.06
AIS 2019 Tanker Vessel Transits per acre	0
AIS Tug Tow Vessel Transits per acre	0.11

NREL - Net Value 2015	-143.8
Count of Competitive Lease Block Overlap	1

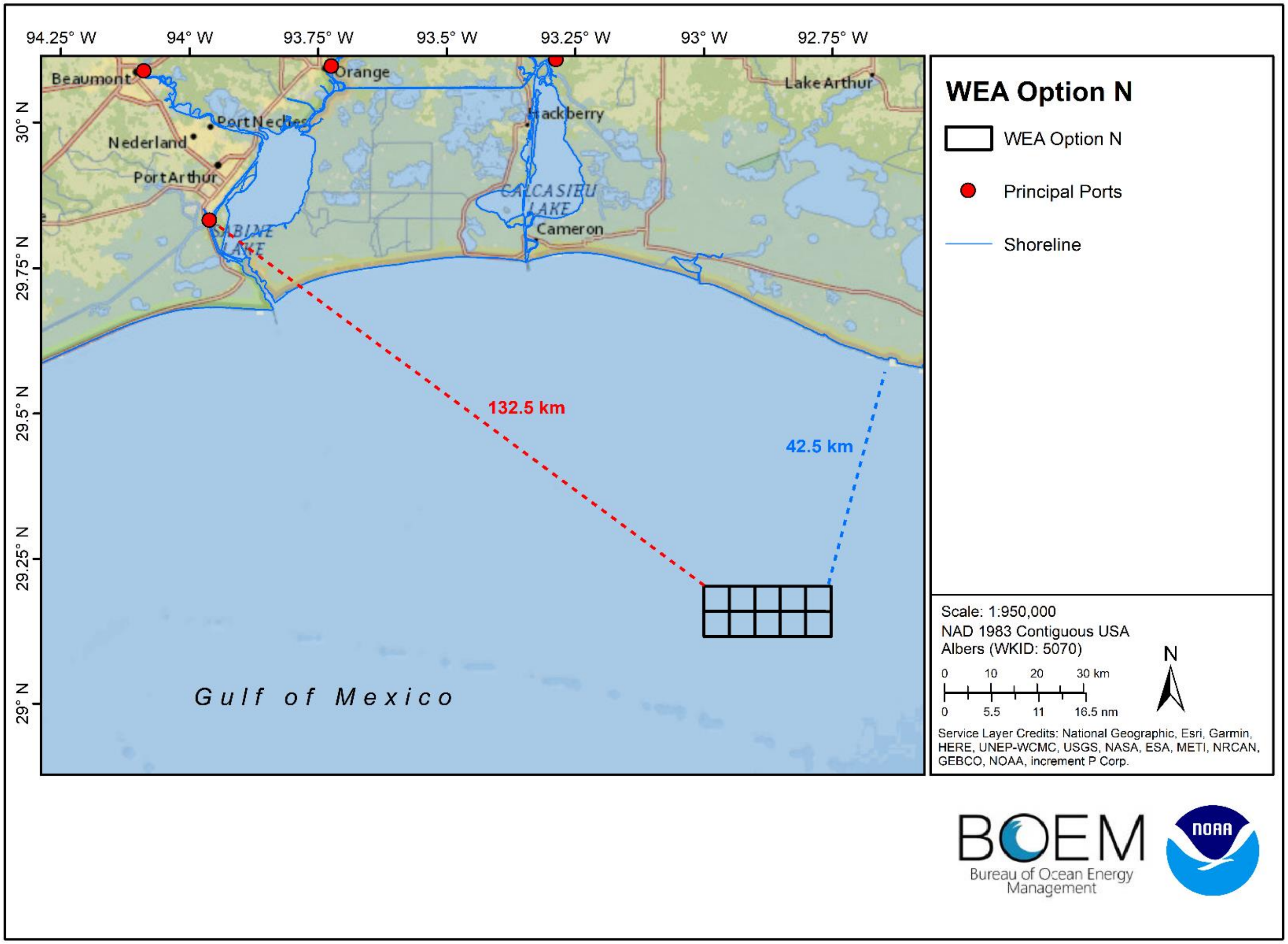

Figure 3.63. *WEA option N (black outlined box) and distance to Port Arthur, Louisiana.*

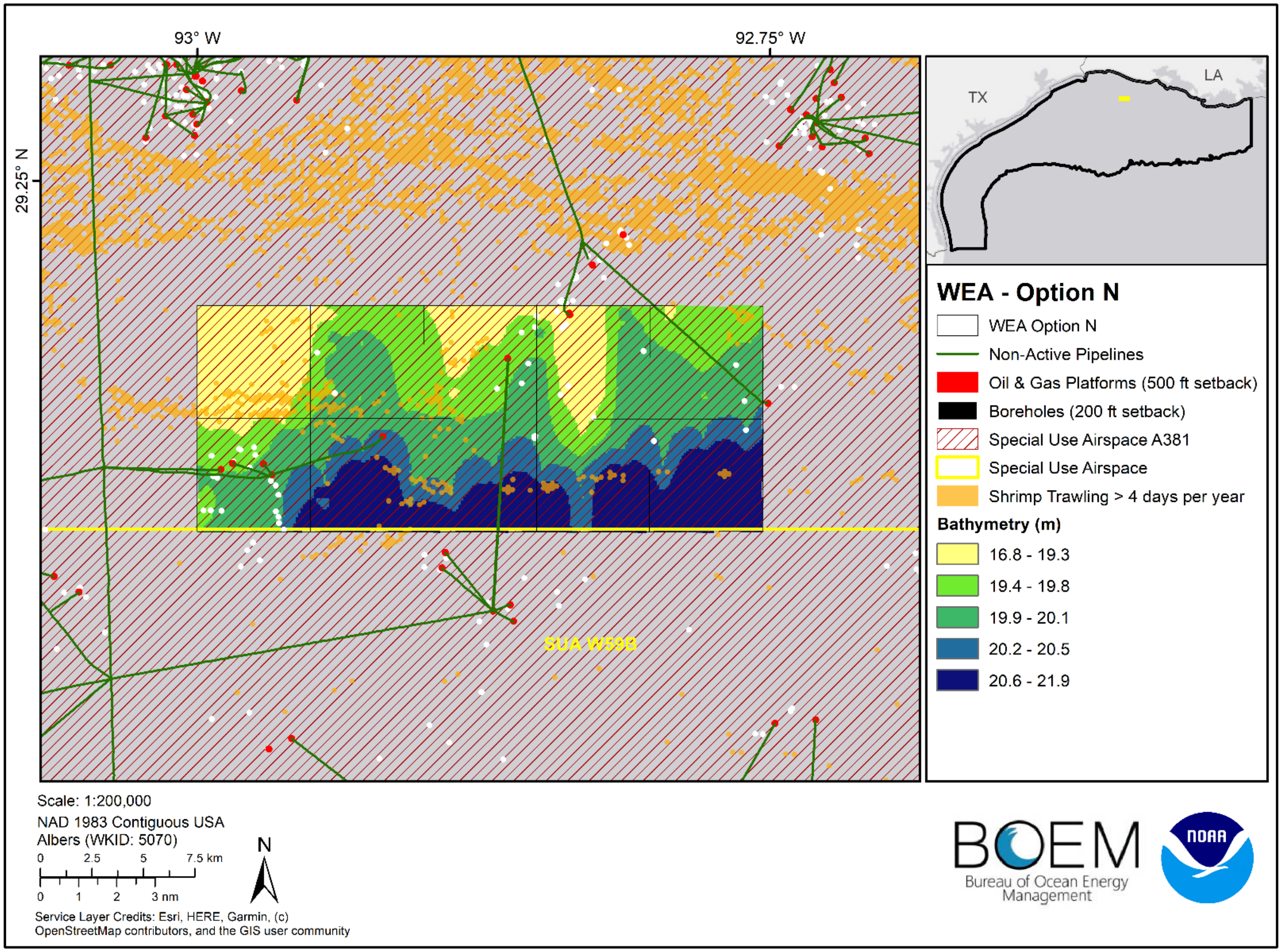

Figure 3.64. *Map depicting noteworthy characterization features for Wind Energy Area option N.*

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1. APPENDICES

A DATA INVENTORY

Table A-1. National security data layers

Data Layer	Source	Source/link	Metadata link
	National Security		
Military Operating Area (MOA) - Corpus Christi	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/d ownloads/data/mc/MilitaryAr eas.zip	https://www.fisheries.noaa.gov/inport/ite m/55364
Military Operating Area (MOA) - New Orleans	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/d ownloads/data/mc/MilitaryAr eas.zip	https://www.fisheries.noaa.gov/inport/ite m/55364
Military Training Routes (MTR) - Flight Corridors	FAA	https://ais-faa.opendata.arcgis.com/dat asets/0c6899de28af447c80 1231ed7ba7baa6_0/explore ?location=24.433179%2C-6.411290%2C2.52	https://www.arcgis.com/sharing/rest/cont ent/items/0c6899de28af447c801231ed7 ba7baa6/info/metadata/metadata.xml?for mat=default&output=html
Special Use Airspace (SUA) - W59A, W59B, W54A, W54B, W54C, W92, W147A, W147C, W147D, A381, A632B, A632F, W228A, W228B, W228C, W228D	MAIASC	https://hub.arcgis.com/datas ets/dd0d1b726e504137ab3c 41b21835d05b_0/explore?lo	https://www.arcgis.com/sharing/rest/cont ent/items/dd0d1b726e504137ab3c41b21 835d05b/info/metadata/metadata.xml?for mat=default&output=html

		cation=31.783141%2C2.89 1 673%2C2.40	
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/ite m/66206

Table A-2. Natural and cultural resources data layers

Data Layer	Source	Source/link	Metadata link
	Natural & Cultural Resources		
Flower Garden Banks National Marine Sanctuary	NOAA NMS	https://sanctuaries.noaa.g ov/media/gis/fgbnms_py.zip	https://sanctuaries.noaa.gov/media/gis/fgb nms_py.pdf
FGBNMS lease blocks	BOEM	Received from BOEM	OCS lease blocks that intersect with the expanded FGBNMS boundaries. These exclusions reflect a setback of 1000 m from the FGBNMS boundaries.
Rice's whale suitable habitat (100 m to 400 m depth)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Leatherback sea turtle high use area	NOAA NMFS	PRD Combined Data Layer	Unpublished
Hawksbill sea turtle migratory corridor	NOAA NMFS	PRD Combined Data Layer	Unpublished
Kemp's ridley sea turtle high use area	NOAA NMFS	PRD Combined Data Layer	Unpublished
Loggerhead (Northwest Atlantic Ocean DPS) sea turtle high use area	NOAA NMFS	PRD Combined Data Layer	Unpublished
Giant manta ray predicted species distribution model area above median maximum probability of presence	NOAA NMFS	PRD Combined Data Layer	Unpublished
Green (Northwest Atlantic Ocean DPS) sea turtle high use area	NOAA NMFS	PRD Combined Data Layer	Unpublished
GoMAPPS pelagic seabird habitat suitability (24 species)	USFWS	Received from USFWS	https://www.boem.gov/gommapps

Atlantic spotted dolphin (coastal)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Atlantic spotted dolphin (oceanic)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Beaked whale	NOAA NMFS	PRD Combined Data Layer	Unpublished
Bottlenose dolphin (coastal)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Bottlenose dolphin (oceanic)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Clymene dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Blackfish (False killer, Pygmy killer, and Melon-headed whale)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Gulf sturgeon	NOAA NMFS	PRD Combined Data Layer	Unpublished
Kogia (Dwarf and Pygmy sperm whale)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Oceanic whitetip shark	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
Smalltooth sawfish (US DPS)	NOAA NMFS	PRD Combined Data Layer	Unpublished
Sperm whale	NOAA NMFS	PRD Combined Data Layer	Unpublished

Spinner dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
Striped dolphin	NOAA NMFS	PRD Combined Data Layer	Unpublished
USFWS Avian Flyways	USFWS	Received from BOEM	Received from BOEM
Louisiana Artificial Reefs - 500-ft setback	BOEM/BSEE	Received from BOEM	https://www.wlf.louisiana.gov/page/artificial-reefs
Texas Artificial Reefs - 1000-ft setback	BOEM/BSEE	Received from BOEM	https://tpwd.texas.gov/gis/ris/artificialreefs/
NOAA Fish Havens - 500-ft setback	NOAA NOS	https://encdirect.noaa.gov /	https://www.fisheries.noaa.gov/inport/item/ 39976
BOEM No Activity Zones - 1000-m setback	NOAA and BOEM	https://www.boem.gov/sites/default/files/oil-and-gas-energy-program/Leasing/Regi onal-Leasing/Gulf-of-Mexico-Region/Topographic-Features-Stipulation-Map-Package.pdf	https://flowergarden.noaa.gov/protection/ managementzones.html#:~:text=No%20A ctivity%20Zone%20(NA Z),NAZ)%20at%20 the%20topographic%20features
Potentially Sensitive Biological Features (PSBF) FGBNMS - 1000 ft setback	NOAA NOS ONMS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
Low Relief Structures - 1000-ft setback	NOAA NOS ONMS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
FMA Flower Garden Banks EFH HAPC	NOAA NMFS	https://www.fisheries.noaa.gov/resource/map/west-and-east-flower-garden-banks-hapc-fishery-management-area-map-gis-data	https://www.fisheries.noaa.gov/res ource/m ap/west-and-east-flower-garden-banks- hapc-fishery-managem ent-area-map-gis- data
Coral 9 HAPC	NOAA NMFS	https://www.fisheries.noaa.gov/resource/map/reef-	https://www.fisheries.noaa.gov/res ource/m ap/reef-banks-essential-fish-habitat-

		banks-essential-fish-habitat-efh-habitat-area-particular-concern-hapc -map-gis	efh- habitat-area-particular-conc ern-hapc-m ap- gis
Coral 9 HAPC (Regulated Areas)	GMFMC	https://portal.gulfcouncil.org/coralhapc.html	https://portal.gulfcouncil.org/coralhapc.ht m l
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.g ov/protect/ppw/wrecks_regions.html	https://nmssanctuaries.blob.core.windows. net/sanctuaries-prod/media/archive/ prot ect/ppw/pdfs/2013 _potentiallypollutingwrecks.pdf

Table A-3. Industry, transportation, and navigation data layers

Data Layer	Source	Source/link	Metadata link
Industry, Navigation, and Transportation			
Federal Lightering Rendezvous Areas	NOAA and BOEM (i.e.,marinecadastre.gov)	https://marinecadastre.gov/downloads/data/mc/LighteringZone.zip	https://www.fisheries.noaa.gov/inport/item/66149
AIS Vessel Traffic 2019 – Cargo	NOAA and BOEM (i.e.,marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Fishing	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Military	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Other	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Passenger	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Pleasure and Sailing	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Tanker	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161
AIS Vessel Traffic 2019 – Tug and Tow	NOAA and BOEM (i.e., marinecadastre.gov) and USCG	https://marinecadastre.gov/ais/	https://www.fisheries.noaa.gov/inport/item/53161

BOEM’s Lease Blocks with Significant Sediment Resources	BOEM	https://mmis.doi.gov/boemmmis/downloads/layers/GOMSigSedBlocks_fgdb.zip	https://mmis.doi.gov/boemmmis/metadata/PlanningAndAdministration/GOMSigSedBlocks.xml
Oil and Gas Drilling Platforms - 500-m setback	BOEM and BSEE	https://www.data.bsee.gov/Main/RawData.aspx	https://www.data.bsee.gov/Platform/PlatformStructures/FieldDefinitions.aspx
Oil and Gas Boreholes, Test Wells, and Wells - 500-m setback	BSEE	https://www.data.bsee.gov/Main/RawData.aspx	https://www.data.bsee.gov/Well/Borehole/FieldDefinitions.aspx
Oil and Gas Pipelines - 500-m setback	BOEM and BSEE	https://www.data.boem.gov/Main/Pipeline.aspx#ascii	https://www.data.boem.gov/Mapping/Files/ppl_arcs_meta.html
Active Oil and gas Lease Block polygons	BOEM	https://www.data.boem.gov/Main/Mapping.aspx	https://www.data.boem.gov/Mapping/Files/actlease_meta.html
Submarine Cables - 500-m setback	NOAA and BOEM (i.e., marinecadastre.gov	Confidential; version for public distribution available at https://marinecadastre.gov/downloads/data/mc/SubmarineCable.zip	Confidential; version for public distribution available at https://www.fisheries.noaa.gov/inport/item/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.gov/downloads/data/mc/AtoN.zip	https://www.fisheries.noaa.gov/inport/item/56120
Anchorage Areas (used/disused)	NOAA and BOEM (i.e., marinecadastre.gov	https://marinecadastre.gov/downloads/data/mc/Anchorage.zip	https://www.fisheries.noaa.gov/inport/item/48849
Shipping Fairways and Regulations -- 2nm buffer	NOAA NOS	http://encdirect.noaa.gov/theme_layers/data/shipping_lanes/shippinglanes.zi p	https://www.fisheries.noaa.gov/inport/item/39986

Table A-4. Commercial and recreational fishing data layers

Data Layer	Source	Source/link	Metadata link
	Commercial and Recreational Fishing		
Commercial Shrimp Electronic Logbook Data (2004 - 2019)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
Highly Migratory Species Pelagic Longline Gear Observer Data (1993 - 2019)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
Menhaden Fishery Data (2000 - 2016)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
Reef Fish Bandit Gear Fishing Data (2007 - 2019)	NOAA NMFS	Controlled Unclassified Information (CUI)	Controlled Unclassified Information (CUI)
Reef Fish Longline Gear Fishing Data (2007 - 2019)	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)

B PROTECTED RESOURCES DATA

A combined protected species data layer to inform marine spatial planning in the U.S. Gulf of Mexico: A case study for offshore wind energy development.

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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.

B.1 INTRODUCTION

NOAA Fisheries' Southeast Regional Office (SERO) seeks to inform the Bureau of Ocean Energy Management (BOEM)'s draft Programmatic Environmental Assessment (PEA) to consider offshore wind leasing in federal waters of the Gulf of Mexico (GOM). It is our understanding that the draft PEA will consider the potential environmental consequences of site characterization activities (i.e., biological, archeological, geological, and geophysical surveys and core samples) and site assessment activities (i.e., installation of meteorological buoys) associated with issuing multiple wind energy leases in the GOM Call Area.

As an agency responsible for the stewardship of the nation's ocean resources and their habitat, our core goals include using science-based decision making to maximize fishing opportunities and resource development, ensuring sustainability of fisheries and fishing communities, and conserving and recovering protected species. SERO's Protected Resources Division is primarily responsible for the implementation of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.) and the Marine Mammal Protection Act (MMPA) of 1972 (50 CFR 216). The ESA requires Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat; The MMPA provides protection to all marine mammals regardless of their listing status under the ESA and provides for NMFS to authorize the incidental take of marine mammals under specified statutory and regulatory circumstances.

The GOM Call Area consists of nearly 30-million acres just west of the Mississippi River to the Texas/Mexico border, extending seaward and roughly following the 400-meter depth contour line. It is our understanding that in the draft PEA, BOEM intends to evaluate the potential impacts from the following proposed actions in the GOM Call Area, including (1) BOEM's issuance of commercial wind energy lease(s), which includes areas in federal waters that might be used for energy production, collection, and transmission; (2) BOEM's authorization of site characterization activities, including biological, geological, geotechnical, and archeological surveys; and (3) BOEM's authorization of site assessment activities, including meteorological and oceanographic buoy deployment.

Offshore wind development activities may include: pre-construction surveys; installation operations as well as maintenance of an offshore wind facility; running cables among the turbines, and from the lease to shore; electromagnetic fields (EMFs) from the cables; increases in vessel traffic; and shoreside infrastructure needs, such as the potential for port expansions and/or channel deepening. These activities may adversely affect protected species through entanglement; vessel strikes; increased runoff of chemicals and toxic pollutants to the marine environment via increased vessel traffic and shoreside activities; impacts to habitat from site assessment and characterization activities, in the nearshore from cables and shoreside infrastructure, and offshore to benthic habitats and deep sea corals from turbine installation, anchors, cable laying, cable EMFs, and toxic runoff from turbine maintenance; noise from offshore wind energy activities, offshore and nearshore, at a level that could cause harm and/or overall disturbance via increased acoustic pollution that could impact biologically significant behaviors (e.g., foraging, migrating, resting, reproduction); impacts that could cause changes in abundance, distribution, or migration patterns; and impacts of EMFs on marine animal sensory systems and movements.

There is currently an effort underway to establish an agreement between the U.S. Department of the Interior (DOI), BOEM, and the U.S. Department of Commerce (DOC), NOAA, NMFS, and National Ocean Service (NOS) for the purpose of partnership building and funding support for marine spatial planning and environmental review. This NOAA-BOEM partnership would provide increased marine spatial planning services including development of a Wind Energy Atlas to inform all aspects of the wind development process.

The Wind Energy Atlas would capture regional spatial data by reviewing the 200+ data layers included within the Gulf of Mexico Aquaculture Opportunity Area Atlas relevant to wind energy and will be used to identify offshore wind opportunities with consideration and science-based analysis of potential impacts to commercial and recreational fisheries, sensitive biological habitat, protected resources, and archeological/cultural resources. The resulting suitability models will provide heatmaps of the most suitable areas for wind energy development. The Wind Energy Atlas would also become a living data source and reference guide, integrating together new information and data in the GOM to further the understanding of the long-term effects of offshore wind energy development to NOAA trust resources.

To support the inclusion of protected resources concerns in the Wind Energy Atlas, SERO-PRD and Southeast Fishery Science Center (SEFSC) collaborated to develop protected species layers for ESA- and MMPA-listed species in the Gulf of Mexico. We then combined those layers using approaches pioneered for the Gulf of Mexico Aquaculture Atlas and described in Farmer et al. (in prep).The approach is conceptually simple (i.e., guide activities to unused or underutilized areas); however, in application it is challenging to determine an integrated approach for the many protected species existing in U.S. waters. The final combined protected species data layer provides generalized guidance for avoiding development conflicts with protected species in the Gulf of Mexico marine environment.

B.2 METHODS

Data layers for Gulf sturgeon, Oceanic whitetip shark, Rice's whale, and Smalltooth sawfish (US DPS) were generated by combining designated critical or essential fish habitat layers; high-use areas determined by sightings and acoustic detections, relocations of tagged animals; and generalized layers containing suitable habitat, as described below.

Data layers for the remaining species were derived from the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) final products. GoMMAPPS methods are available in the final report (Rappucci et al. in prep). Briefly, 3 line-transect aerial surveys and 3-line transect vessel surveys were conducted over the continental shelf and oceanic waters, respectively, during 2017 and 2018. Mark-recapture distance sampling methods employing the independent observer approach were used to estimate detection probability within the survey strip and account for perception bias and tag data was used to account for availability bias. Data were combined with data from similar previous surveys conducted during 2003, 2004, and 2009 to develop spatially explicit density models with environmental predictors describing oceanographic conditions derived from remotely sensed data and hydrographic models. For this analysis, these models were used to predict species density in each month during 2015–2018 over a hexagonal grid (cell area = 40 km^2) encompassing the Gulf of Mexico. The maximum predicted density for each spatial cell was selected from these predictions to represent potential occurrence for each species. The spatial cells were then coded as above or below the median of this likely occurrence to indicate high vs. low use areas, respectively. For the critically endangered Rice's whales, the habitat model predicted potential occurrence (at varying densities) throughout areas of the northern Gulf of Mexico bounded by the 100–400m isobaths. Given the small population size of this species, the occurrence area was defined as a polygon enclosed by these bathymetry lines rather than identifying high vs. low use areas.

Following Farmer et al. (in prep), we applied a generalized scoring system to measure protected species vulnerability based on species status under the ESA or MMPA, population size, and population trajectory for species to inform relative risk in spatial modeling (**Table B-1**). 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 0.8 (least vulnerable species). Species and stocks are ranked according to factors that are more or less likely to affect their ability to withstand mortality, serious injury, or other impacts to the species' ability to survive and recover. Scores of 0.5 and 1 were applied to lower-use areas for ESA-listed species and MMPA-listed species, respectively. The generalized score of 0.5 was used in the spatial model for data where suitability of a location for potential wind energy activities is uncertain (i.e., not incompatible, but certainty of high compatibility is low). A score of 1 reflects an area with no protected species conflict whereas a score of 0 reflects an area that is unsuitable for a wind energy development given protected species vulnerability.

Table B-1. A generalized scoring system for endangered and threatened species data layers.

Status	Trend	Converted scores for model
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).

In Farmer et al. (in prep), the generalized scoring system and combined protected species data layer approaches were developed and described for eight ESA-listed species. For this application, we expanded to 23 ESA- and MMPA-listed species, scored as described in **Table B-2**. Note, Hawksbill sea turtle (*Eretmochelys imbricata*) were not included in this analysis because their primary documented high-use habitat in the Gulf of Mexico is a narrow migratory corridor through the Straits of Florida that is well-isolated from the proposed WEA.

Table B-2. Scores based on species status and trend assigned to protected species in the U.S. Gulf of Mexico.

Common name	Scientific name	Score
Atlantic spotted dolphin (coastal)	*Stenella frontalis*	0.8
Atlantic spotted dolphin (oceanic)	*Stenella frontalis*	0.7
Beaked whale	*Ziphius spp. / Mesoplodon spp.*	0.7
Bottlenose dolphin (coastal)	*Tursiops truncatus truncatus*	0.8

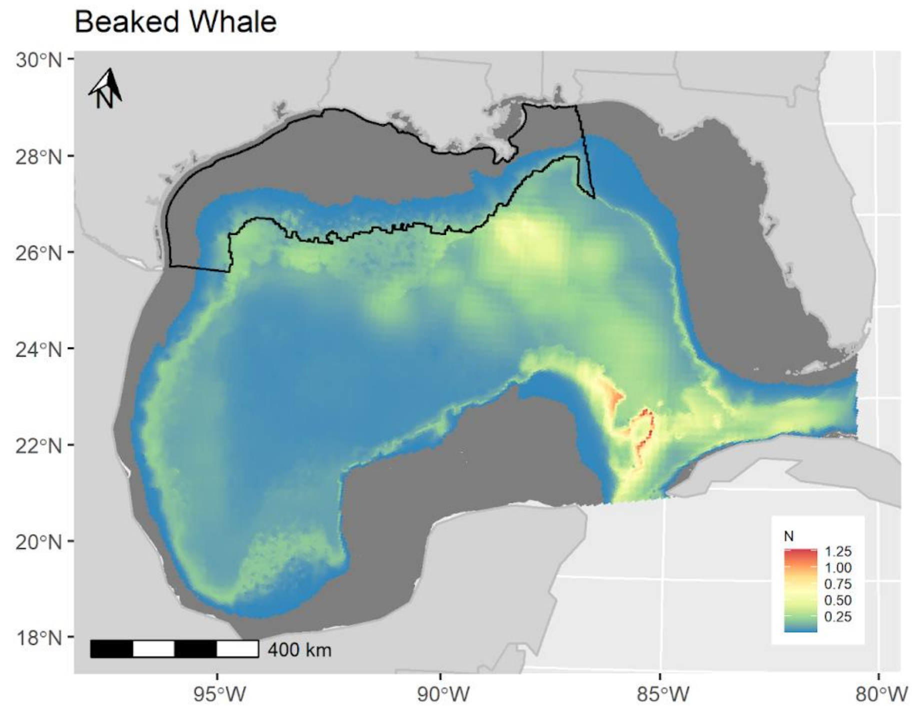
Bottlenose dolphin (oceanic)	*Tursiops truncatus truncatus*	0.7
Clymene dolphin	*Stenella clymene*	0.6
Blackfish (False killer, Pygmy killer, & Melon-headed whale)	*Pseudorca crassidens, Feresa attenuata, Peponocephala electra*	0.7
Giant manta ray	*Manta birostris*	0.4
Green sea turtle	*Chelonia mydas*	0.5
Gulf sturgeon	*Acipenser oxyrhynchus desotoi*	0.5
Hawksbill sea turtle	*Eretmochelys imbricata*	0.2
Kemp's ridley sea turtle	*Lepidochelys kempii*	0.2
Kogia (Dwarf and Pygmy sperm whale)	*Kogia spp.*	0.7
Leatherback sea turtle	*Dermochelys coriacea*	0.1
Loggerhead sea turtle	*Caretta caretta*	0.4
Oceanic whitetip shark	*Carcharhinus longimanus*	0.4
Pantropical spotted dolphin	*Stenella attenuata*	0.7
Pilot whale	*Globicephala spp.*	0.7
Rice's whale	*Balaenoptera ricei*	0.1
Risso's dolphin	*Grampus griseus*	0.7
Smalltooth sawfish (US DPS)	*Pristis pectinata*	0.3
Sperm whale	*Physeter macrocephalus*	0.2
Spinner dolphin	*Stenella longirostris*	0.6
Striped dolphin	*Stenella coeruleoalba*	0.6

The original data layers and rationale for scoring, by species, are presented below, relative to the proposed Wind Energy Call Area (black polygon in **Figures B-1 - B-23**). All analyses and images were generated in R (v. 4.2) or ArcMap (v. 10.8) in projection UTM NAD83 Zone 17N.

Beaked whales

Beaked whales (Figure B-1) were scored at 0.7 (MMPA, not strategic, trend unknown), based on info from the latest NOAA Fisheries Stock Assessment Report (SAR): *"STATUS OF STOCK Cuvier's beaked whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA because PBR is likely a severe underestimate due to the long dive times of this species and because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill is based on all* *beaked whale species combined and cannot be apportioned to individual species. No fishery-related mortality or serious injury has been observed; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of Cuvier's beaked whales in the northern Gulf of Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock."*

https://media.fisheries.noaa.gov/2021-07/Atlantic%202020%20SARs%20Final.pdf?null%09



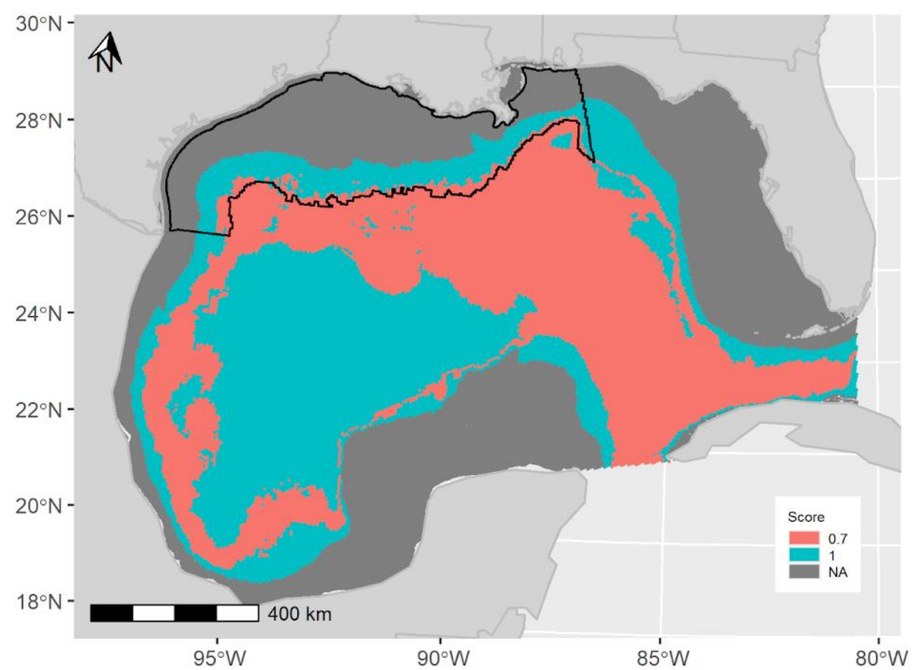


Figure B-1. Beaked whale distribution and score. A) Estimated abundance of beaked whales in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for beaked whales showing areas above (red) and below (blue) median predictions from distribution model.

Blackfish

Blackfish (**Figure B-2**) were scored at 0.7 (MMPA, not strategic, trend unknown), based on the latest SAR:

"False killer whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of false killer whales in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown."

"Pygmy killer whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the Marine Mammal Protection Act. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of pygmy killer whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock"

"Melon-headed whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the Marine Mammal Protection Act. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of melon-headed whales in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown."

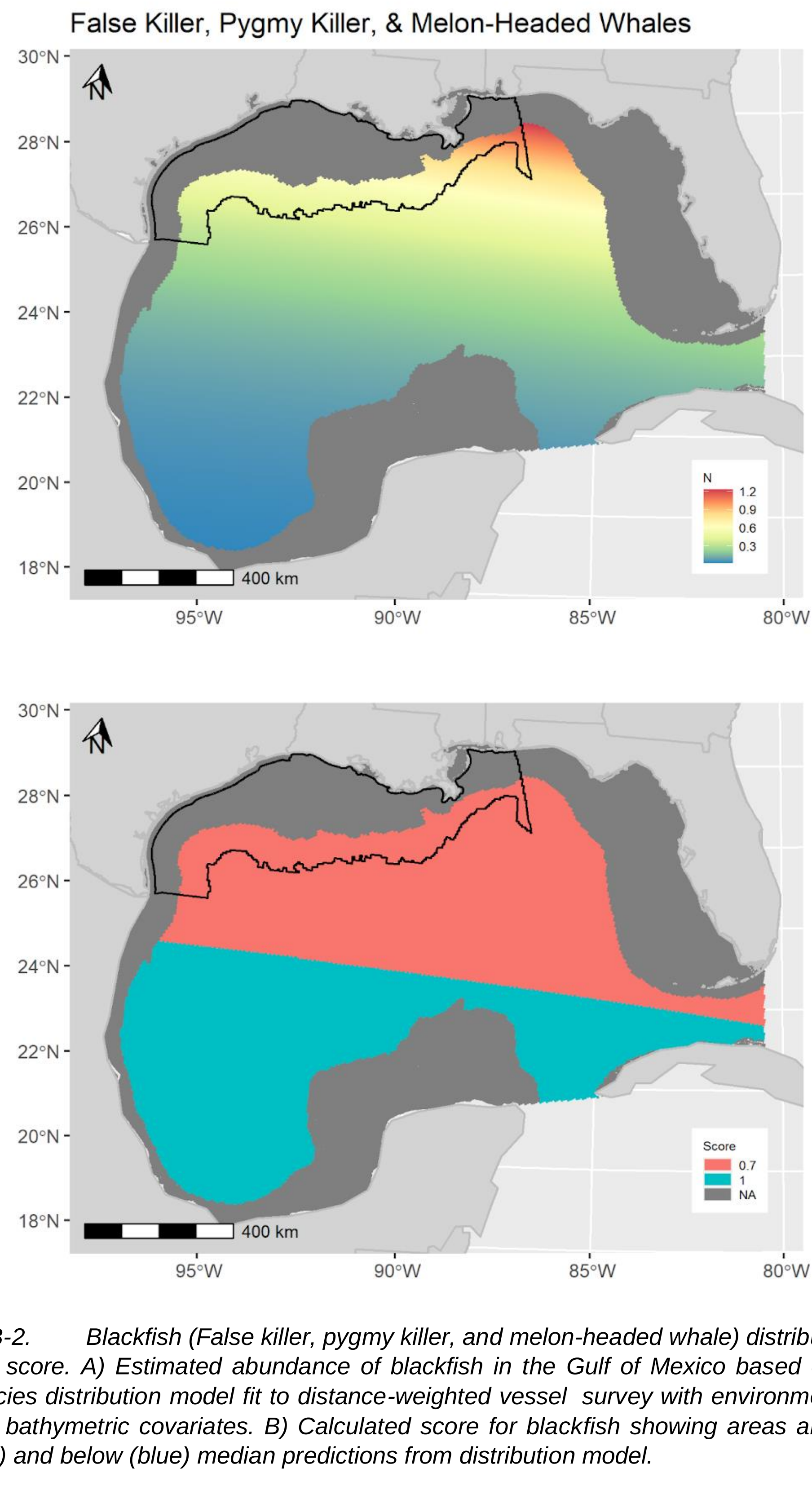


Figure B-2. Blackfish (False killer, pygmy killer, and melon-headed whale) distribution and score. A) Estimated abundance of blackfish in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for blackfish showing areas above (red) and below (blue) median predictions from distribution model.

Clymene dolphin

Clymene dolphin (**Figure B-3**) were scored as 0.6 (MMPA Strategic) based on the latest SAR: *"Clymene dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of Clymene dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown."*

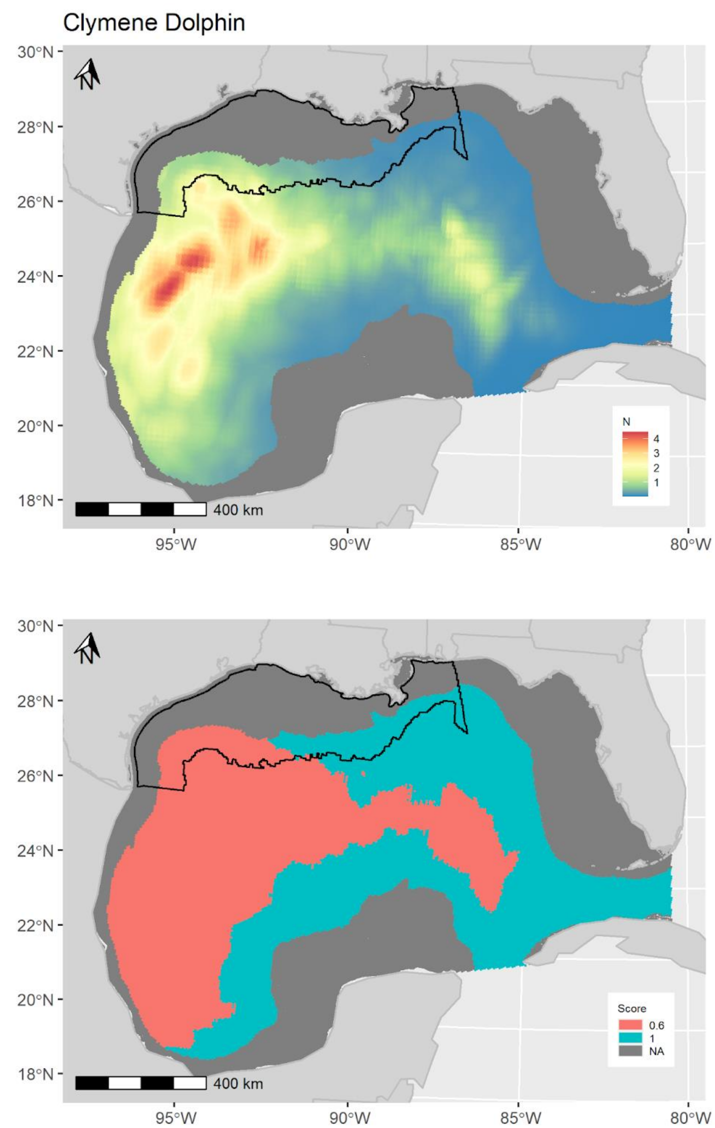


Figure B-3. Clymene dolphin distribution and score. A) Estimated abundance of Clymene dolphin in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Clymene dolphin showing areas above (red) and below (blue) median predictions from distribution model.

Giant manta ray

Giant manta ray (**Figure B-4**) were scored as 0.4 (ESA Threatened, declining) and modeled as described in Farmer et al. (in prep).

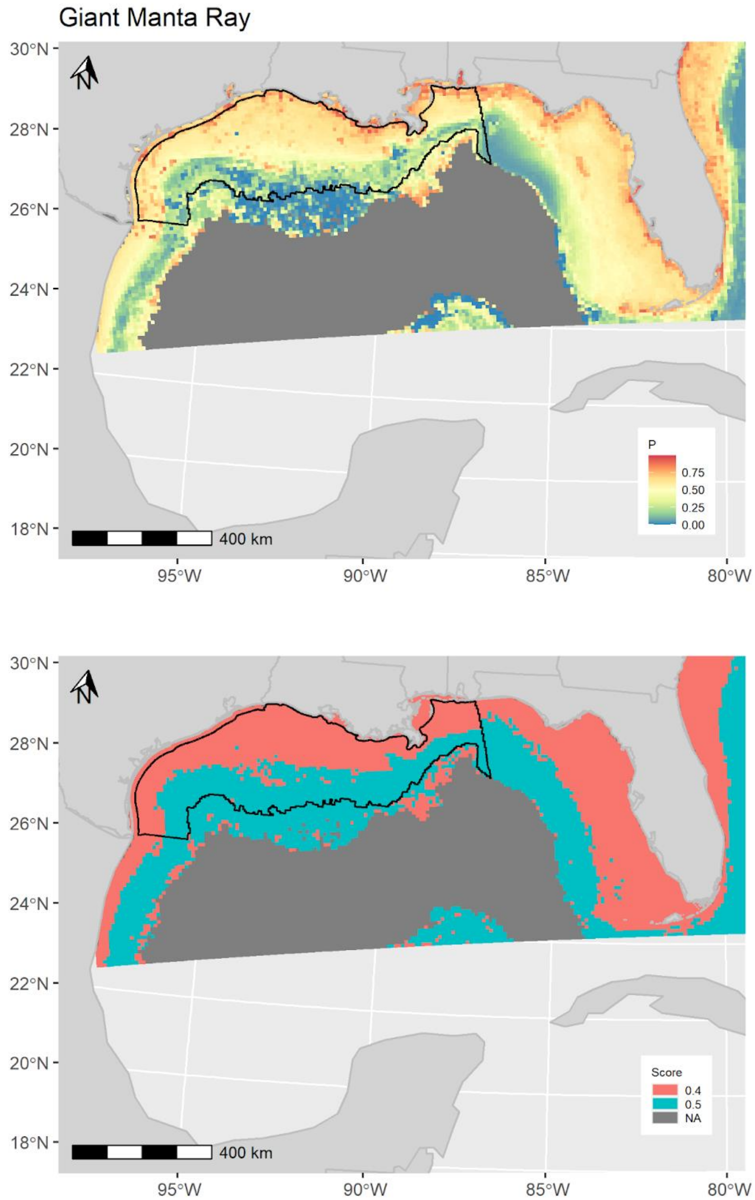


Figure B-4. Giant manta ray distribution and score. A) Estimated probability of occurrence for Giant manta ray in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Giant manta ray showing areas above (red) and below (blue) median predictions from distribution model.

Green sea turtle

Green sea turtle (**Figure B-5**) were scored as 0.5 (ESA Threatened, increasing) as described in Farmer et al. (in prep).

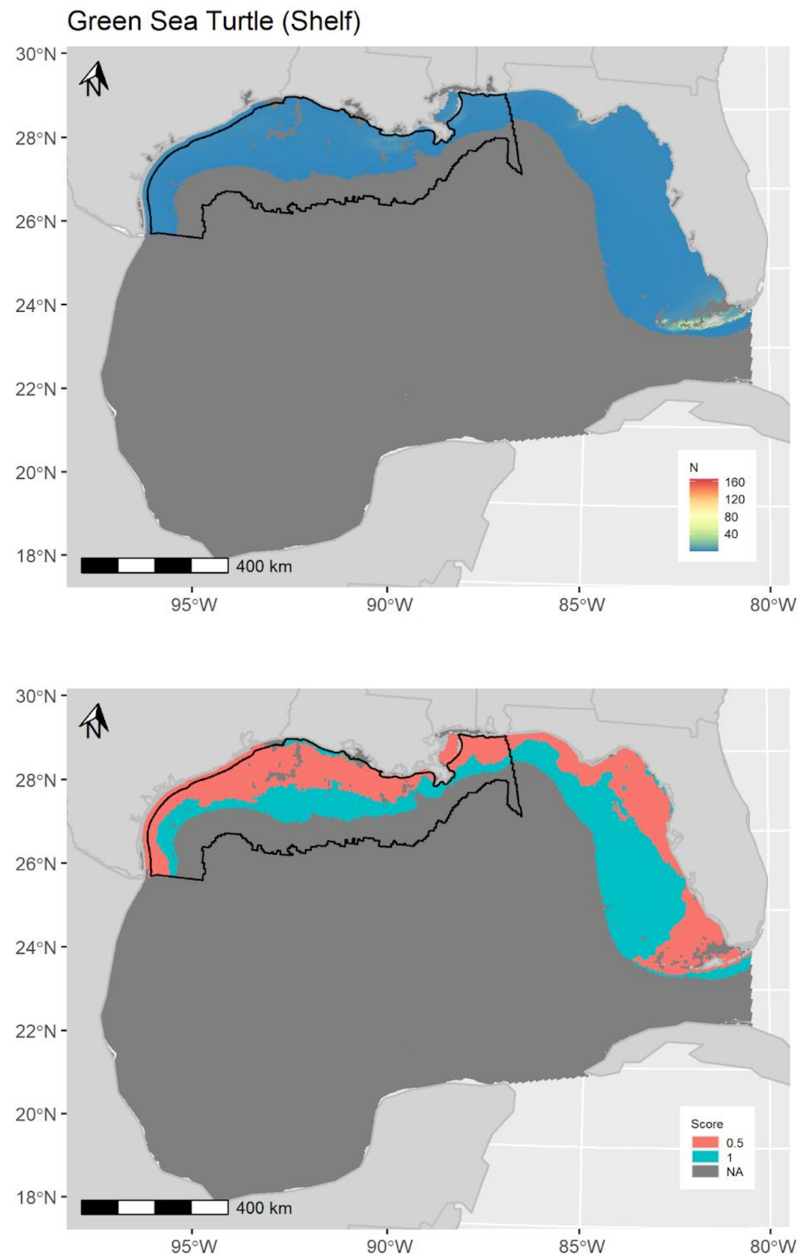


Figure B-5. Green sea turtle distribution and score. A) Estimated abundance of Green sea turtle in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Green sea turtle showing areas above (red) and below (blue) median predictions from distribution model.

Gulf sturgeon

Gulf sturgeon (**Figure B-6**) were scored as 0.5 (ESA Threatened, increasing) based on the most recent 5-Year Review (in press). The Gulf sturgeon layers were the defined critical habitat (**Figure B-6: blue**) and the recently developed NOAA Fisheries SERO “Section 7 Mapper” consultation layer (**Figure B-6: yellow**); a public-facing tool allowing action agencies to specify the location of their project activities and determine which species require consultation. Because Gulf sturgeon received a score of 0.5, only the consultation layer was scored, as it was inclusive of the critical habitat layer.

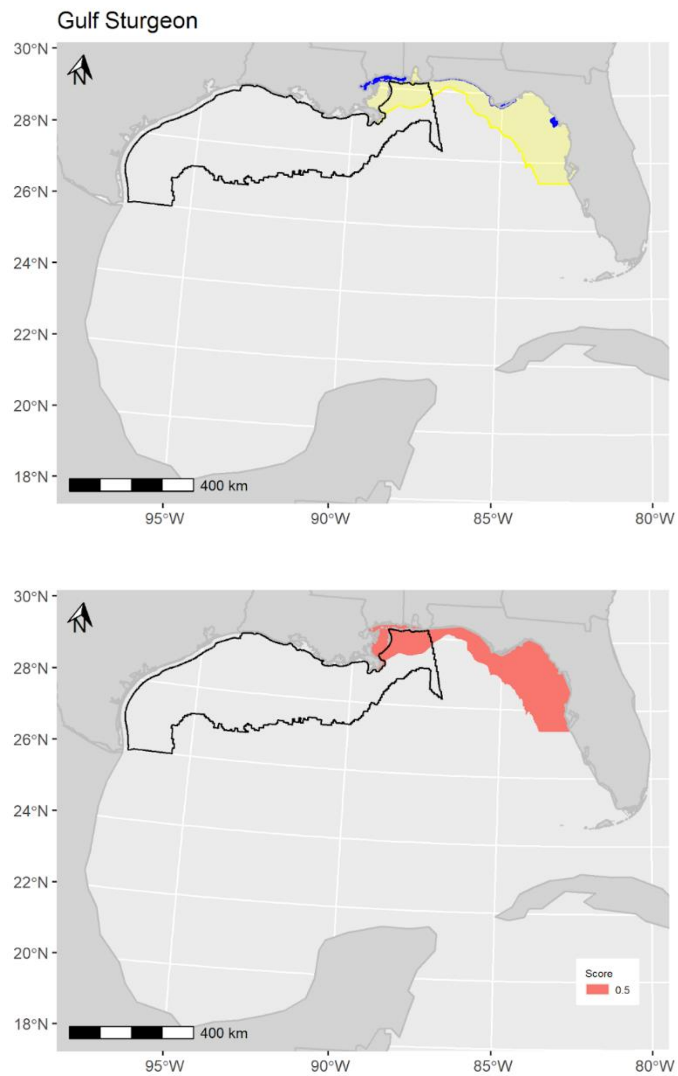


Figure B-6. Gulf sturgeon distribution and score. A) Section 7 consultation layer (yellow) and defined critical habitat (blue) for Gulf sturgeon. B) Calculated score for Gulf sturgeon showing areas receiving a score.

Kemp's ridley sea turtle

Kemp's ridley sea turtle (**Figure B-7**) were scored as 0.2 (ESA Endangered, unknown) as described in Farmer et al. (in prep).

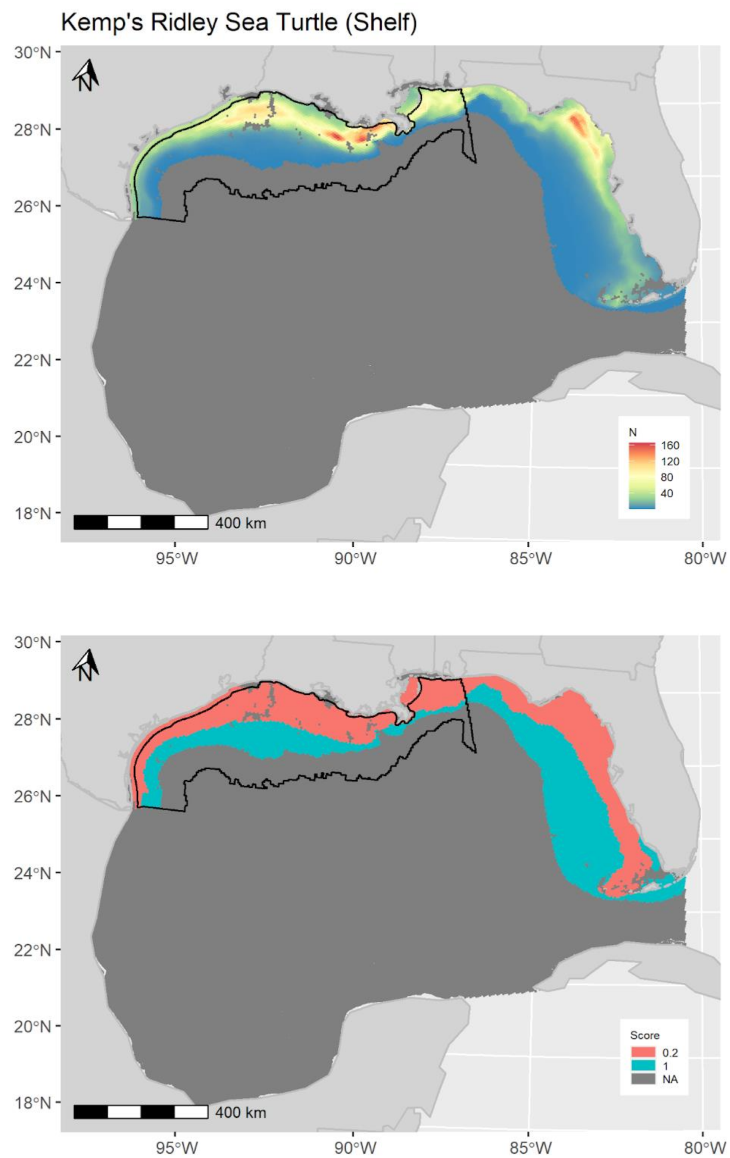


Figure B-7. Kemp's ridley sea turtle distribution and score. A) Estimated abundance of Kemp's ridley sea turtle in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Kemp's ridley sea turtle showing areas above (red) and below (blue) median predictions from distribution model.

Kogia

Kogia (**Figure B-8**) were scored as 0.7 (MMPA, unknown trend) based on the latest SAR:

" *Dwarf sperm whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA because PBR is likely a severe underestimate due to the long dive times of this species and because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill is based on all dwarf and pygmy sperm whales combined and cannot be apportioned to individual species. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of dwarf sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock."*

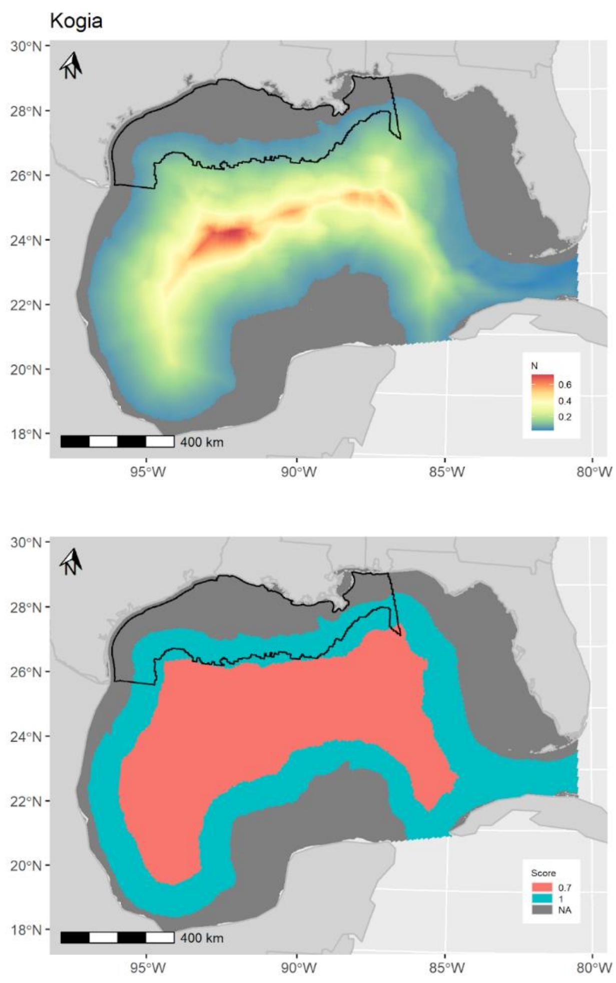


Figure B-8. Kogia distribution and score. A) Estimated abundance of Kogia in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Kogia showing areas above (red) and below (blue) median predictions from distribution model.

Leatherback sea turtle

Leatherback sea turtle (**Figure B-9**) were scored as 0.1 (ESA Endangered, declining) as described in Farmer et al. (in prep).

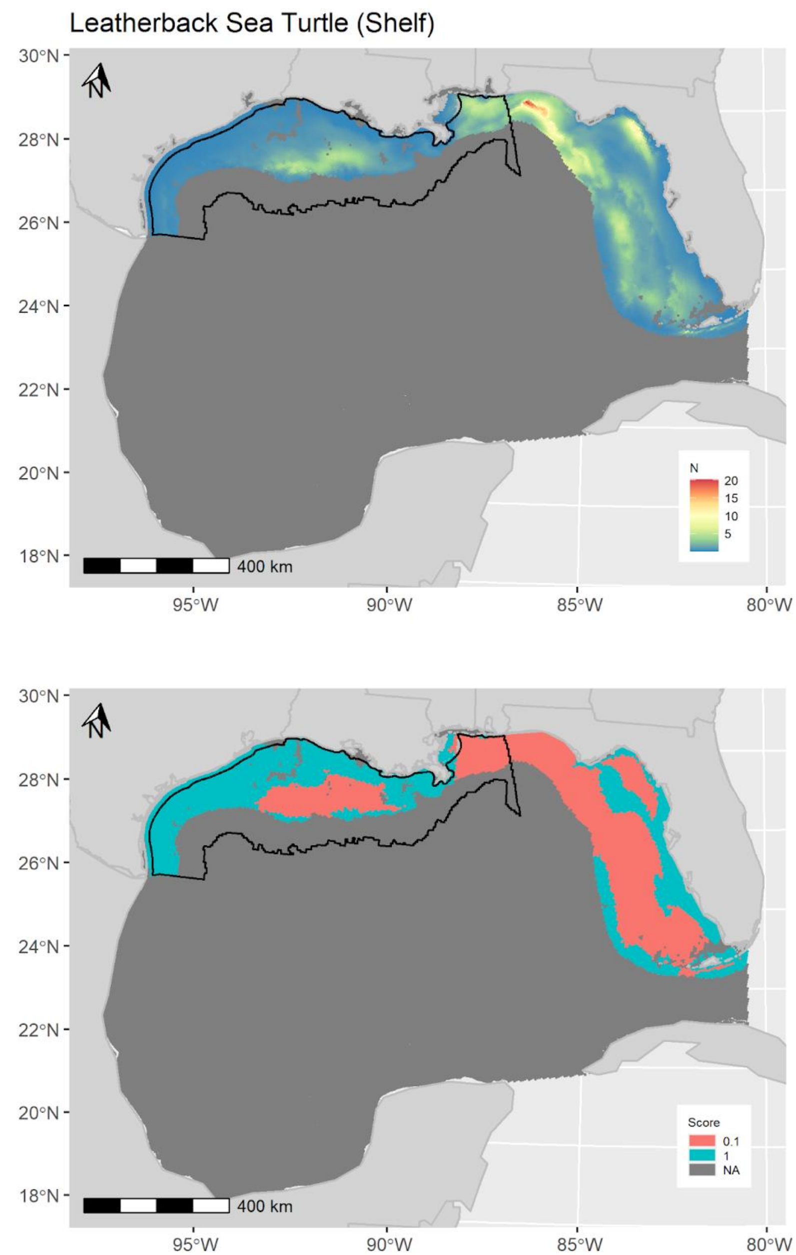


*Figure B-9***.** *Leatherback sea turtle distribution and score. A) Estimated abundance of Leatherback sea turtle in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Leatherback sea turtle showing areas above (red) and below (blue) median predictions from distribution model.*

Loggerhead sea turtle

Loggerhead sea turtle (**Figure B-10**) were scored as 0.4 (ESA Threatened, unknown/stable) as described in Farmer et al. (in prep).

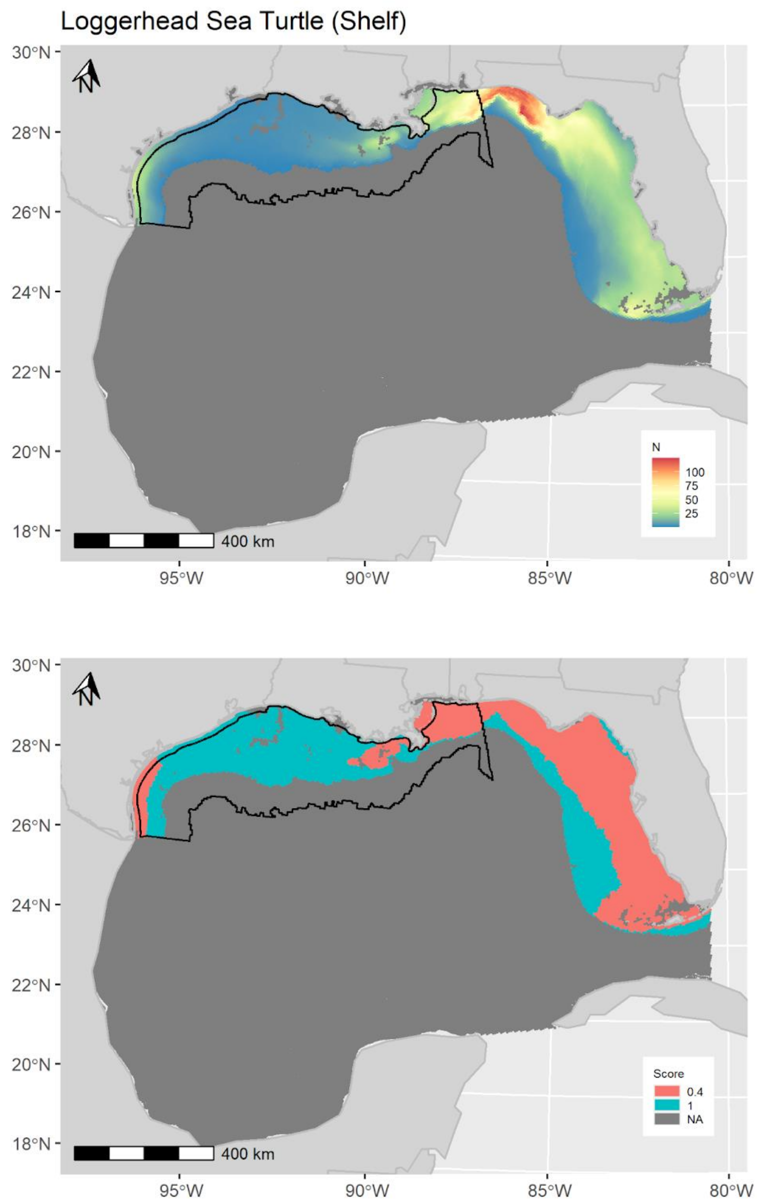


Figure B-10. Loggerhead sea turtle distribution and score. A) Estimated abundance of Loggerhead sea turtle in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Loggerhead sea turtle showing areas above (red) and below (blue) median predictions from distribution model.

Atlantic spotted dolphin (oceanic)

Atlantic spotted dolphin (oceanic) (**Figure B-11**) were scored at 0.7 (MMPA not strategic, unknown trend); no info was available in the most recent SAR.

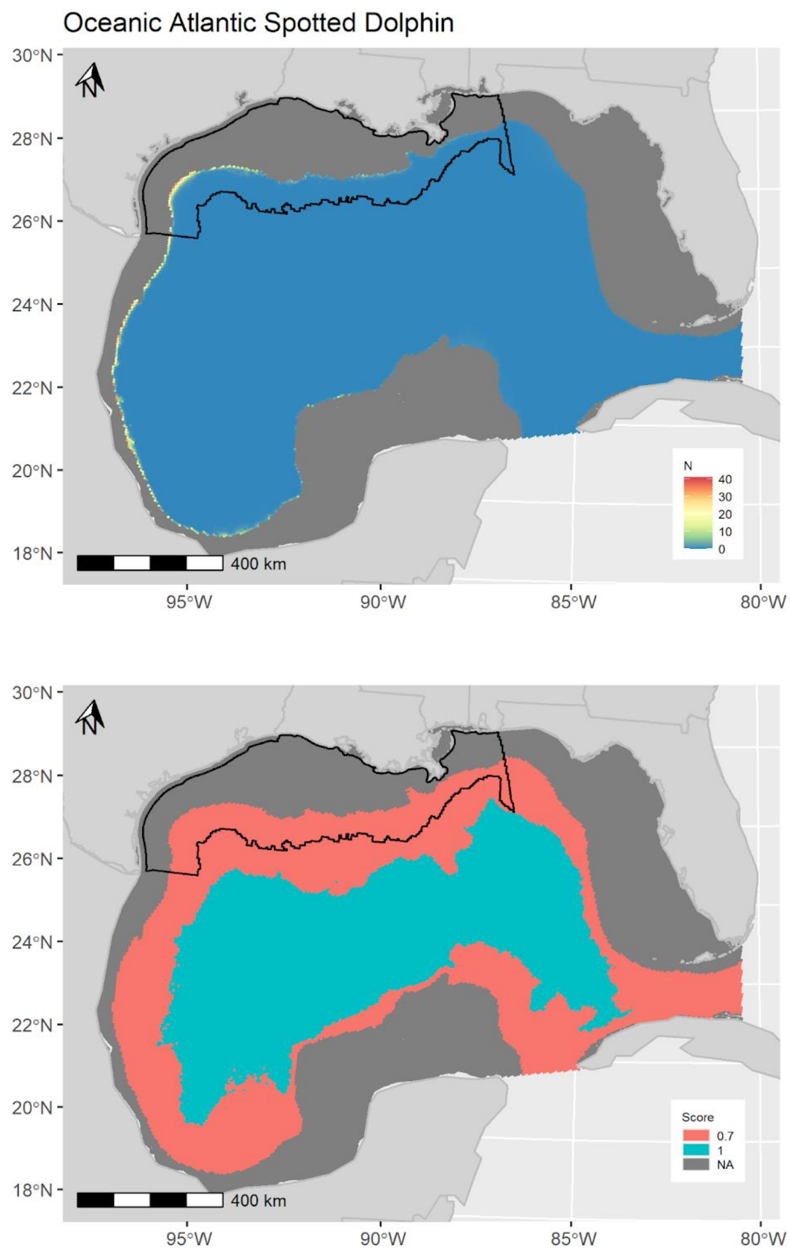


Figure B-11. *Atlantic spotted dolphin (oceanic) distribution and score. A) Estimated abundance of Atlantic spotted dolphin (oceanic) in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Atlantic spotted dolphin (oceanic) showing areas above (red) and below (blue) median predictions from distribution model.*

Bottlenose dolphin (oceanic)

Bottlenose dolphin (oceanic) (**Figure B-12**) were scored at 0.7 (MMPA not strategic, unknown trend); based on the most recent SAR: *"Common bottlenose dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico Oceanic Stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of bottlenose dolphins, relative to OSP, in the northern Gulf of Mexico oceanic waters is unknown. There was no statistically significant trend in population size for this stock."*

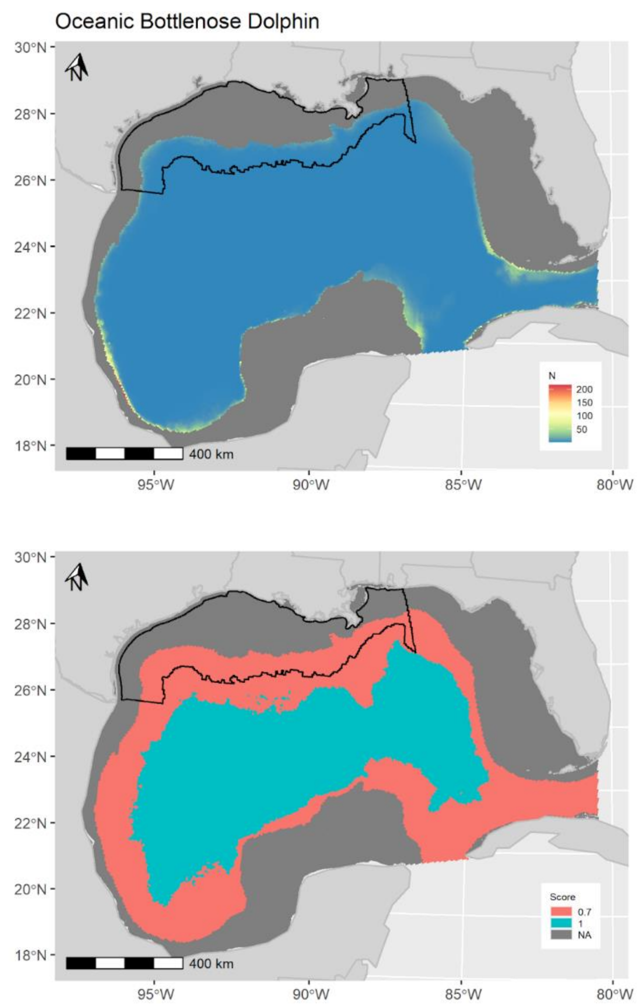


Figure B-12. *Bottlenose dolphin (oceanic) distribution and score. A) Estimated abundance of Bottlenose dolphin (oceanic) in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Bottlenose dolphin (oceanic) showing areas above (red) and below (blue) median predictions from distribution model.*

Pantropical spotted dolphin (oceanic)

Pantropical spotted dolphin (oceanic) (**Figure B-13**) were scored at 0.7 (MMPA not strategic, unknown trend); based on the most recent SAR: *"Pantropical spotted dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of pantropical spotted dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown."*

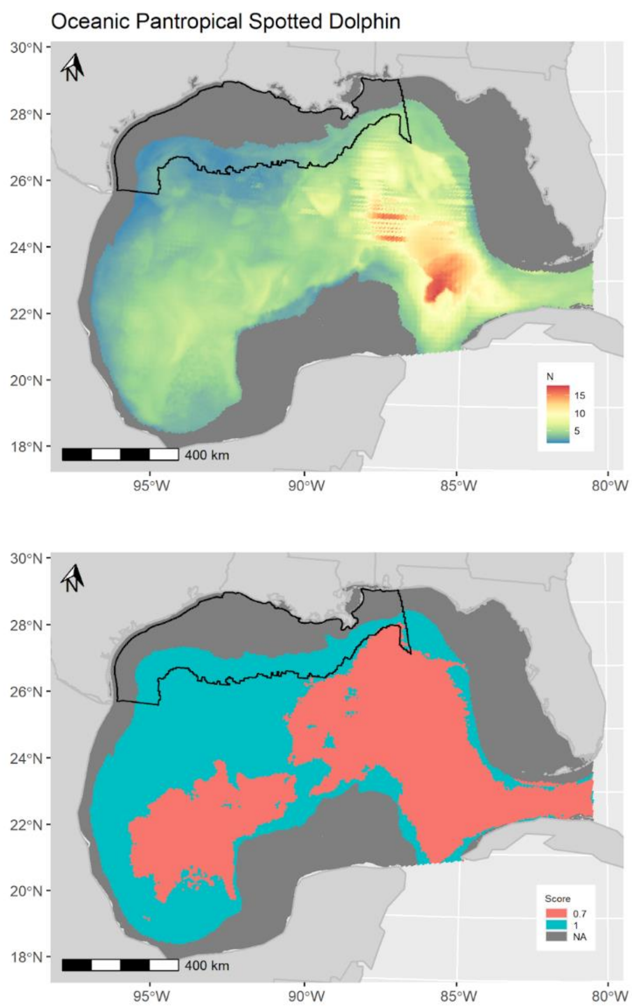


Figure B-13. *Pantropical spotted dolphin (oceanic) distribution and score. A) Estimated abundance of Pantropical spotted dolphin in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Pantropical spotted dolphin showing areas above (red) and below (blue) median predictions from distribution model.*

Pilot whale

Pilot whale (**Figure B-14**) were scored at 0.7 (MMPA not strategic, unknown trend); based on the most recent SAR: *"Short-finned pilot whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. Total fishery-related mortality and serious injury for this stock is less than 10% of PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of short-finned pilot whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock.*"

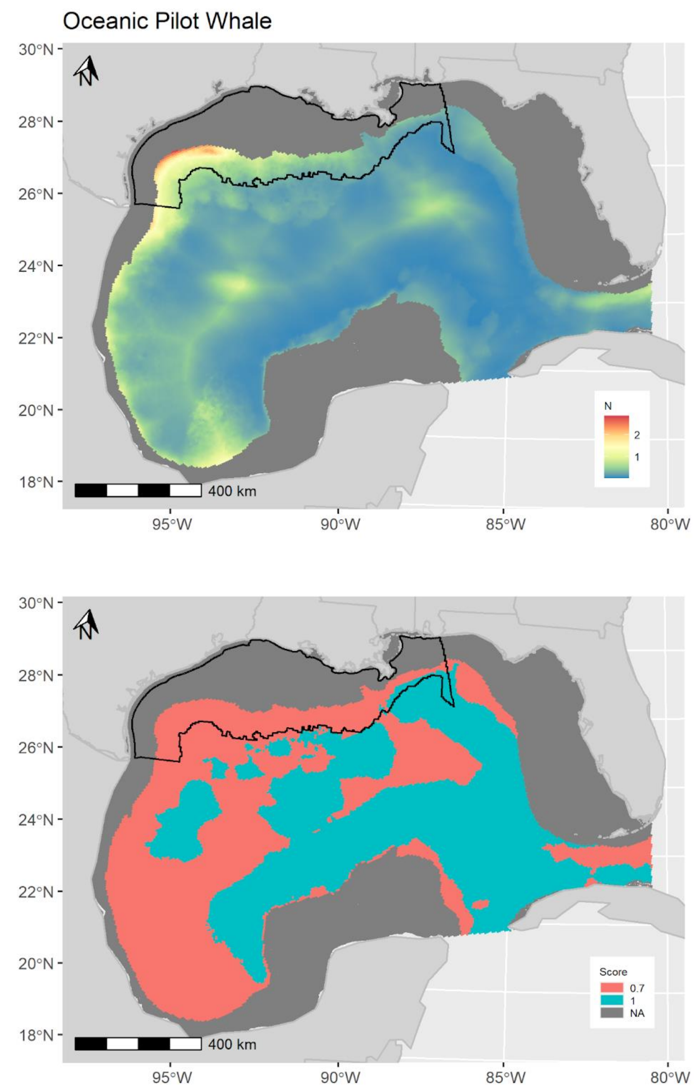
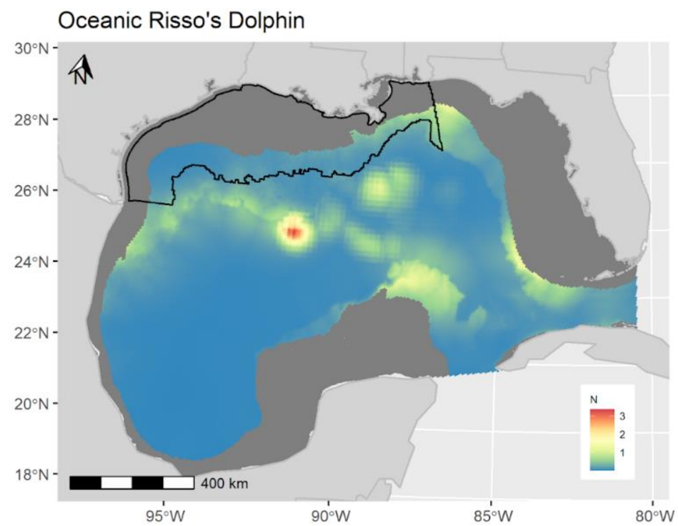


Figure B-14. *Pilot whale (oceanic) distribution and score. A) Estimated abundance of Pilot whale in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Pilot whale showing areas above (red) and below (blue) median predictions from distribution model.*

Risso's dolphin

Risso's dolphin (**Figure B-15**) were scored at 0.7 (MMPA not strategic, unknown trend); based on the most recent SAR: *"Risso's dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of Risso's dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown."*



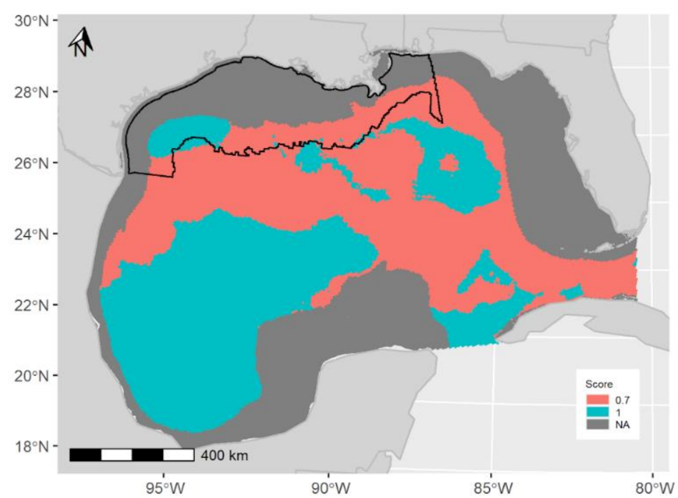


Figure B-15. *Risso's dolphin (oceanic) distribution and score. A) Estimated abundance of Risso's dolphin in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Risso's dolphin showing areas above (red) and below (blue) median predictions from distribution model.*

Oceanic whitetip shark

Oceanic whitetip shark (**Figure B-16**) was scored as 0.4 (ESA-listed, unknown/declining). The Oceanic whitetip shark layers were the defined essential fish habitat (EFH; **Figure B-16: blue**) and the recently developed NOAA Fisheries SERO "Section 7 Mapper" consultation layer (**Figure B-16: yellow**). The final Oceanic whitetip shark layer was developed in ArcMap using Analysis>Overlap>Erase to erase EFH from the consultation layer, then Analysis>Overlap>Union to combine the EFH with the erased layer, then assigning the score of 0.4 to the EFH and the default score of 0.5 to the Section 7 layer (minus the EFH).

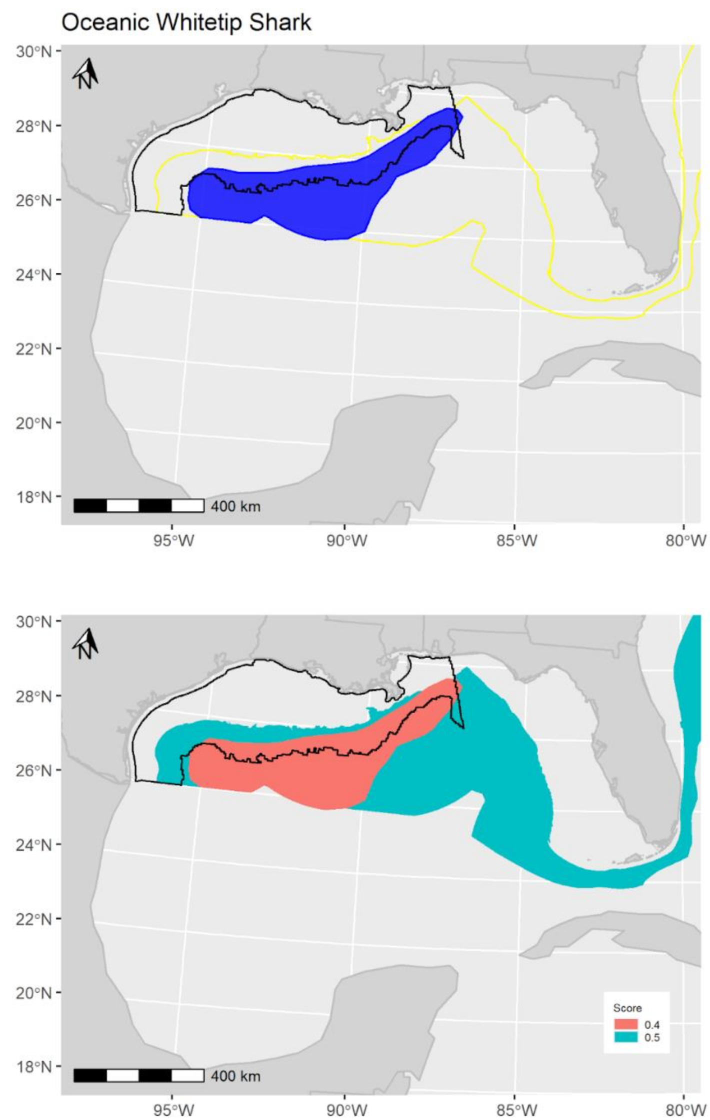


Figure B-16. Oceanic whitetip distribution and score. A) Section 7 consultation layer (yellow) and defined essential fish habitat (blue) for Oceanic whitetip shark. B) Calculated score for Oceanic whitetip shark showing areas receiving a score.

Rice's whale

Rice's whale (**Figure B-17**) were scored as 0.1 (ESA Endangered, small population) as described in Farmer et al. (in prep). Briefly, a core area determined from visual sightings and the movements of tagged animals (**Figure B-17: red**) was joined to a suitable habitat layer supported by passive acoustic monitoring and habitat distribution modeling (**Figure B-17: blue**). The non-overlapping union of these layers was assigned a score of 0.1.

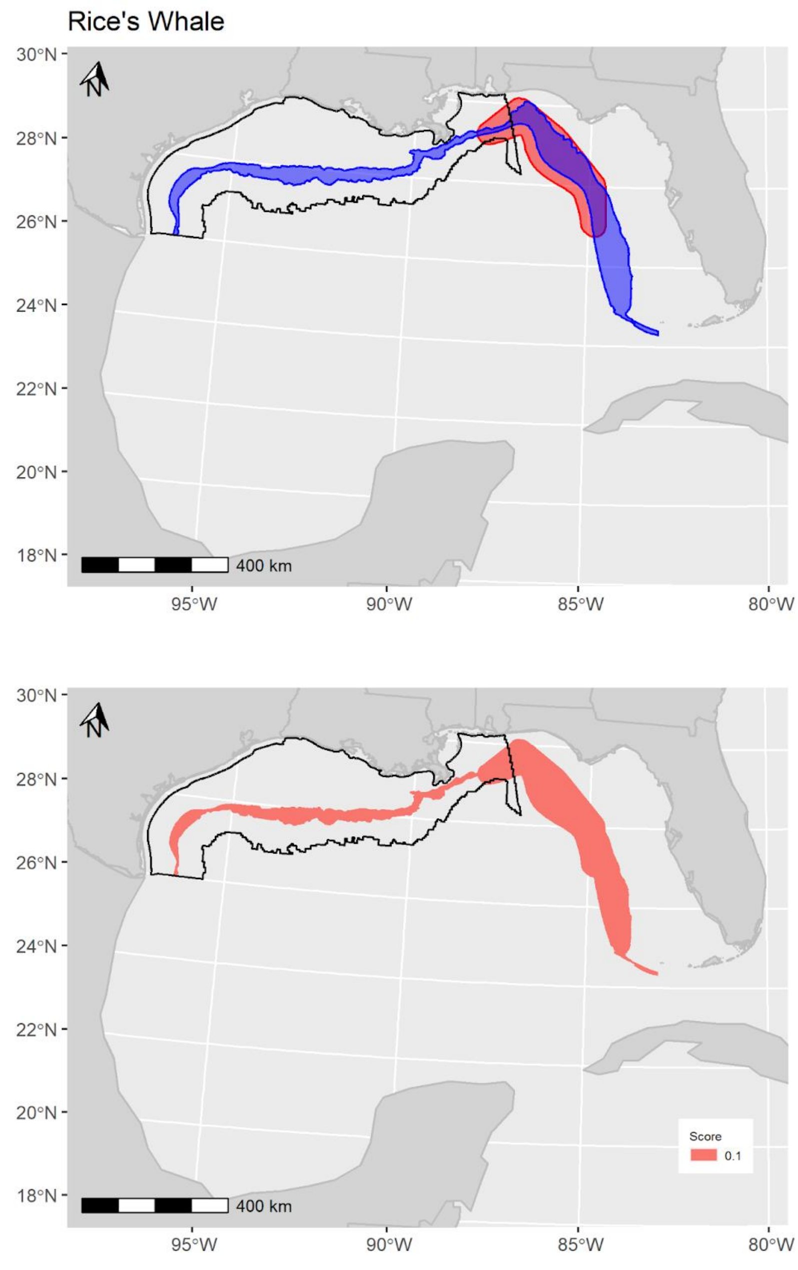


Figure B-17. Rice's whale distribution and score. A) Core area (red) and suitable habitat (blue) for Rice's whale. B) Calculated score for Rice's whale showing areas receiving a score.

Smalltooth sawfish (US DPS)

Smalltooth sawfish (US DPS) (**Figure B-18**) were scored as 0.3 (ESA Endangered, increasing population) as described in Farmer et al. (in prep). Briefly, a high-use area determined from visual sightings and the movements of tagged animals (**Figure B-18: red**) was joined to defined critical habitat (**Figure B-18: blue**) and the sawfish Section 7 consultation layer (**Figure B-18: yellow**). These layers were joined in a non-overlapping union following procedures described above for Oceanic whitetip shark. The high-use area and critical habitat were assigned a score of 0.3; the remaining non-overlapping consultation layer was assigned a score of 0.5.

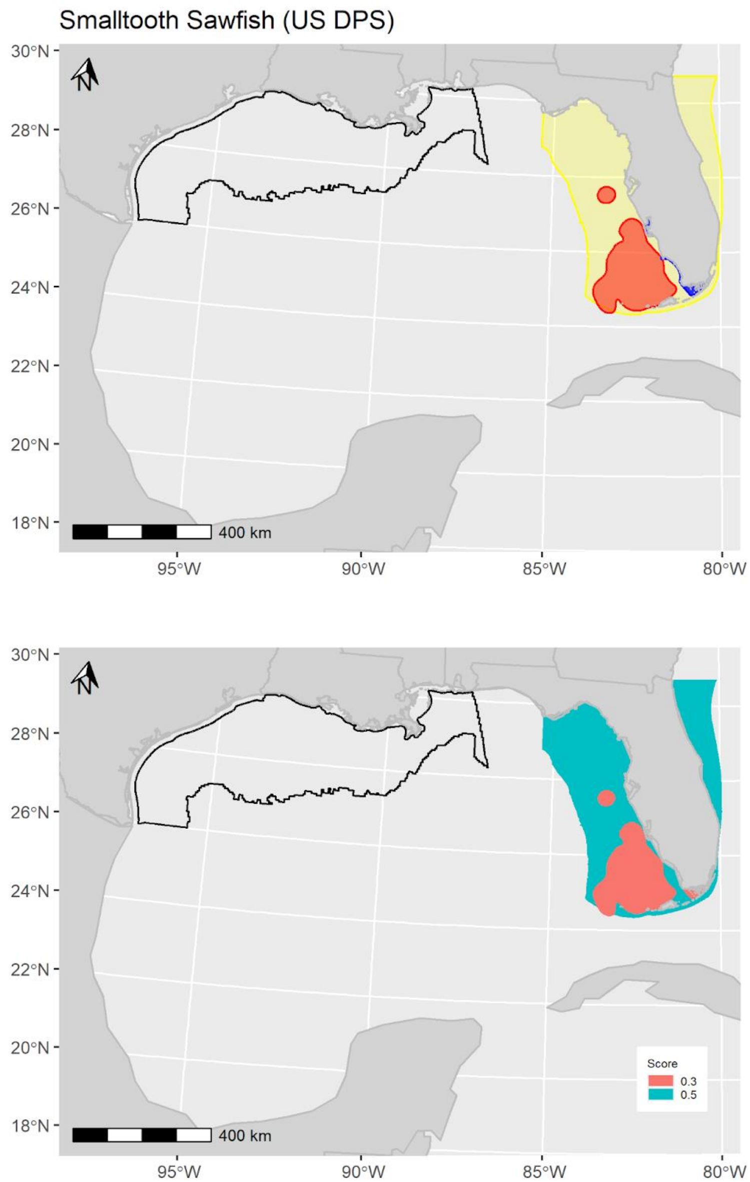


Figure B-18. *Smalltooth sawfish (US DPS) distribution and score. A) High-use area (red), critical habitat (blue), and Section 7 consultation layer (yellow) for Smalltooth sawfish (US DPS). B) Calculated score for Smalltooth sawfish (US DPS) showing areas receiving a score.*

Atlantic spotted dolphin (shelf)

Atlantic spotted dolphin (shelf) (**Figure B-19**) were scored at 0.8 (MMPA not strategic, large population); no information was available in the most recent SAR.

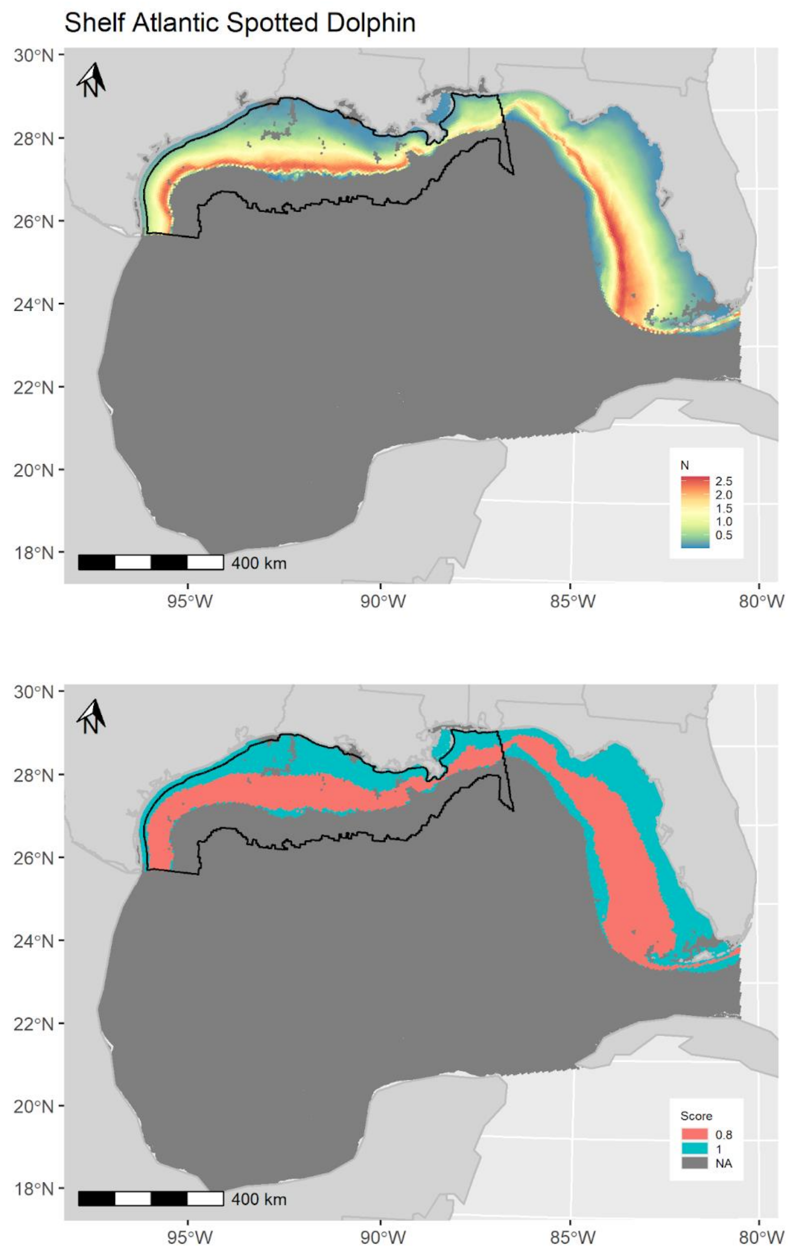


Figure B-19. *Atlantic spotted dolphin (shelf) distribution and score. A) Estimated abundance of Atlantic spotted dolphin (shelf) in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Atlantic spotted dolphin (shelf) showing areas above (red) and below (blue) median predictions from distribution model.*

Bottlenose dolphin (shelf)

Bottlenose dolphin (shelf) (**Figure B-20**) were scored at 0.8 (MMPA not strategic, large population); no information was available in the most recent SAR.

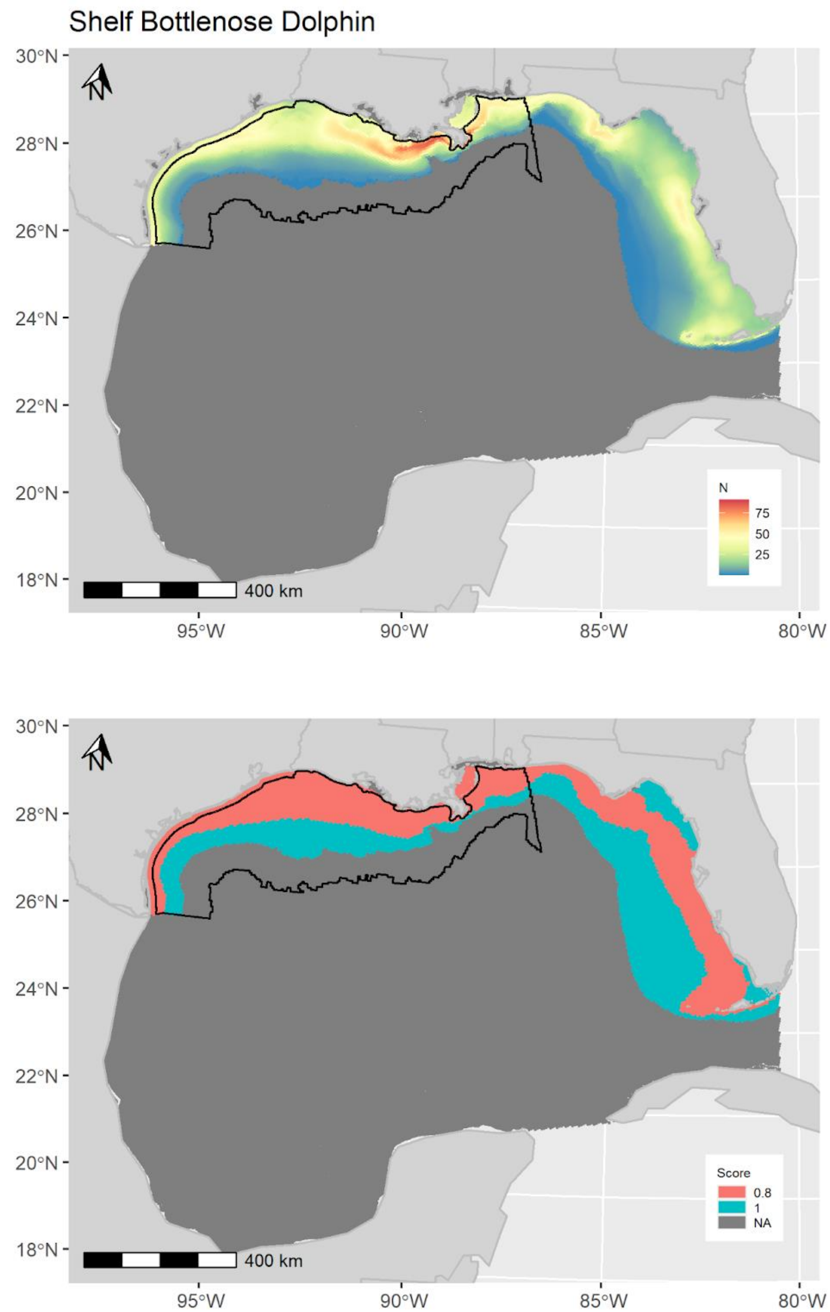


Figure B-20. *Bottlenose dolphin (shelf) distribution and score. A) Estimated abundance of Bottlenose dolphin (shelf) in the Gulf of Mexico based on a species distribution model fit to distance-weighted aerial survey with environmental and bathymetric covariates. B) Calculated score for Bottlenose dolphin (shelf) showing areas above (red) and below (blue) median predictions from distribution model.*

Sperm whale

Sperm whale (**Figure B-21**) was scored at 0.2 (ESA Endangered; unknown trend); based on information in the most recent SAR: *"The sperm whale is listed as endangered under the Endangered Species Act, and therefore the northern Gulf of Mexico stock is considered strategic under the MMPA. In addition, the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR for this stock. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock in the northern Gulf of Mexico."*

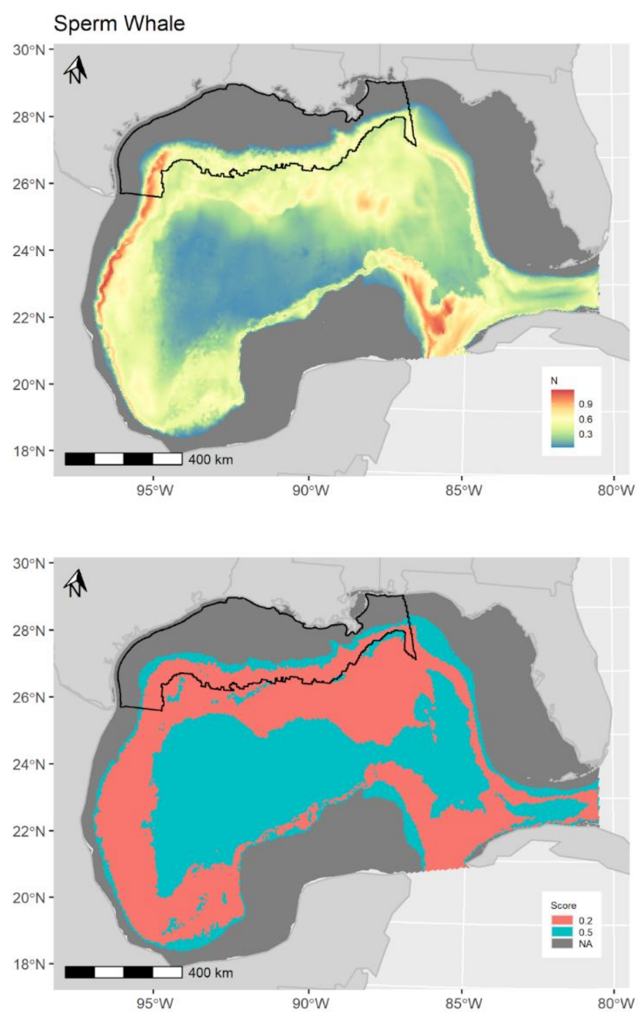


Figure B-21. *Sperm whale distribution and score. A) Estimated abundance of Sperm whale in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Sperm whale showing areas above (red) and below (blue) median predictions from distribution model.*

Spinner dolphin

Spinner dolphin (**Figure B-22**) was scored at 0.6 (MMPA Strategic); based on information in the most recent SAR: *"Spinner dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of spinner dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock."*

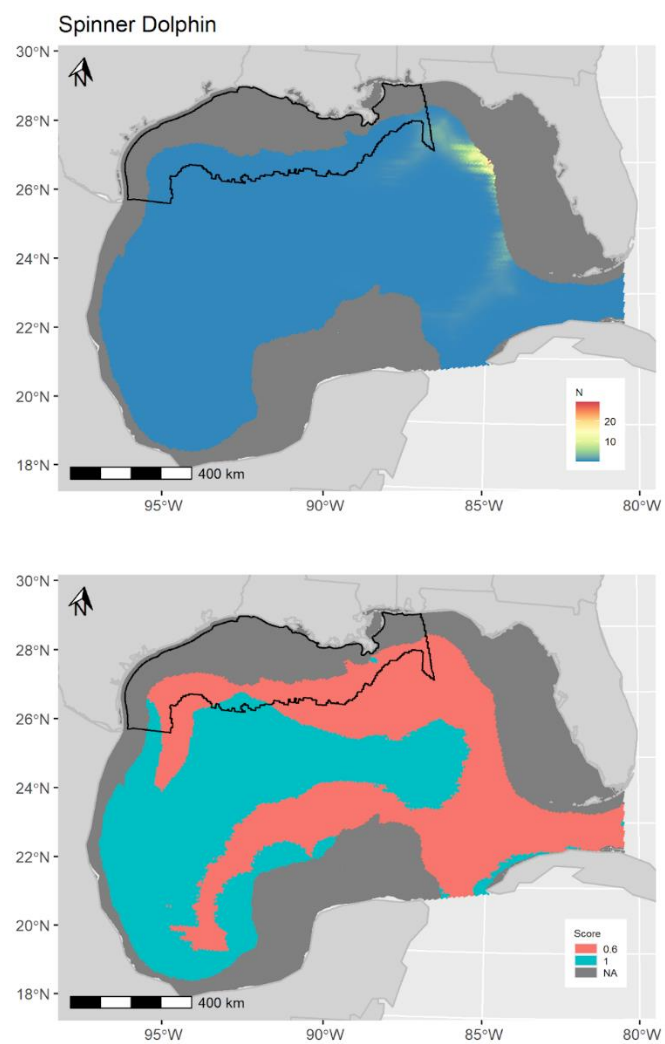


*Figure B-22**.** Spinner dolphin distribution and score. A) Estimated abundance of Spinner dolphin in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Spinner dolphin showing areas above (red) and below (blue) median predictions from distribution model.*

Striped dolphin

Striped dolphin (**Figure B-23**) was scored at 0.6 (MMPA Strategic); based on information in the most recent SAR: "*Striped dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused 211 mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of striped dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock.*"

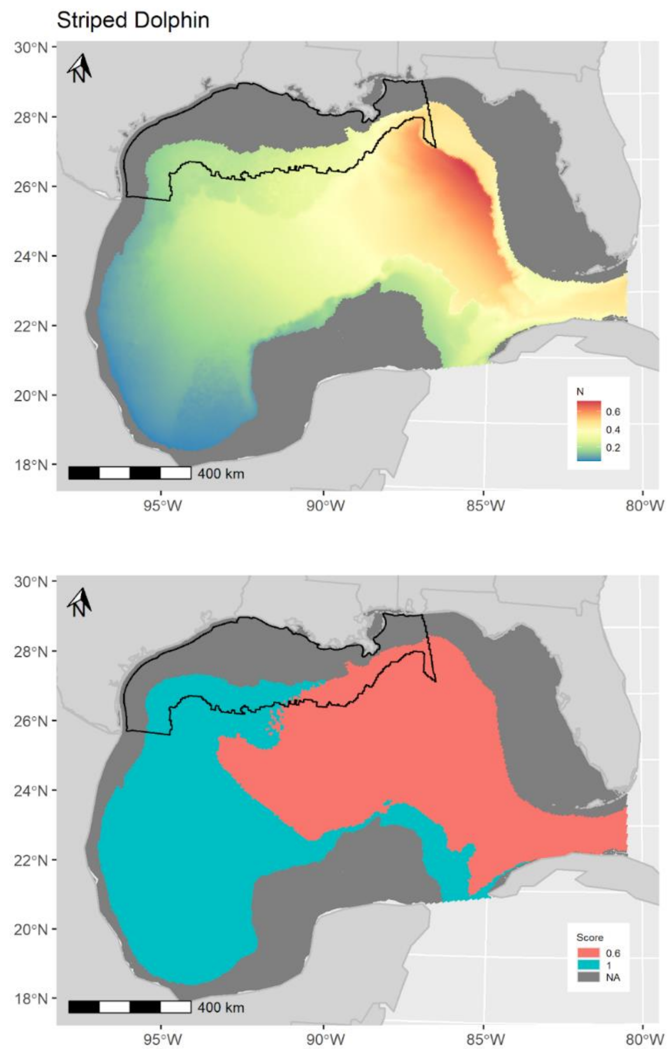


Figure B-23. *Striped dolphin distribution and score. A) Estimated abundance of Striped dolphin in the Gulf of Mexico based on a species distribution model fit to distance-weighted vessel survey with environmental and bathymetric covariates. B) Calculated score for Striped dolphin showing areas above (red) and below (blue) median predictions from distribution model.*

Combined Data Layer

Using ArcMap, all layers were spatially joined in sequence to the hexagonal Gulf-wide grid developed for the SEFSC survey species distribution models, 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 40 km^2 cell. Cells without scores for a species were assigned a score of 1 (e.g., “suitable”). All resultant layers are presented in **Figure B-24**. We compared four approaches to combining protected species data layers across species: 1) Product, 2) Geometric mean, 3) Arithmetic mean, and 4) Lowest scoring species in a given cell, using a custom R script. We evaluated the dispersion and ordering of the resultant scores across these methods.

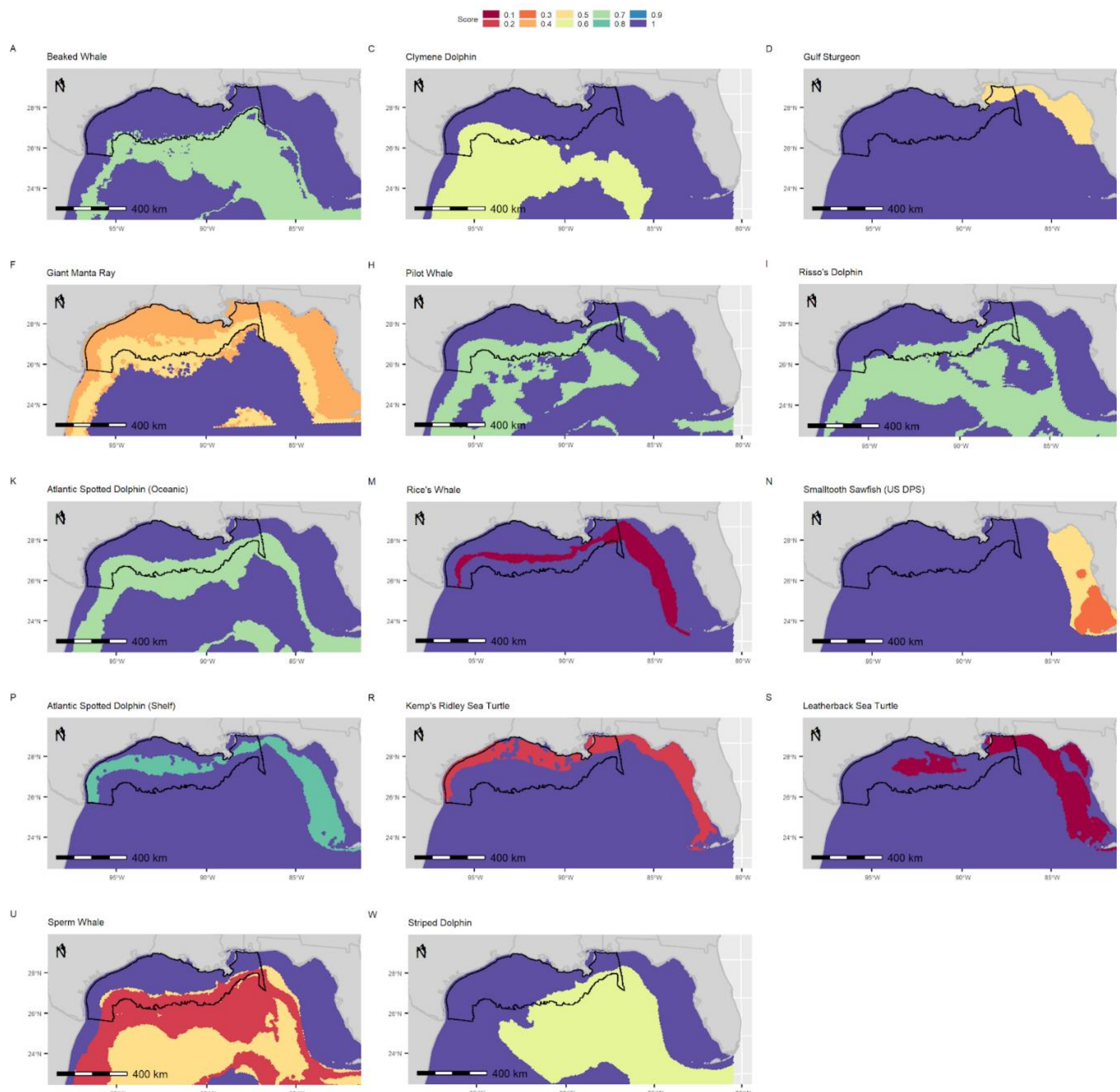


Figure B-24. *Scores across all 23 protected species data layers. Calculated scores for all species.*

B.3 RESULTS

Combined data layer

As previously demonstrated in Farmer et al. (in prep), the Product approach provides the correct ordering of cells with regards to overlapping protected species concerns and provides the widest overall range of scores (**Figure B-25**). The Lowest scoring layer approach also provided useful dispersion and contrast between cells but failed to account for overlapping concerns. The arithmetic mean and geometric mean approach failed to order cells correctly and provided a limited range of final scores.

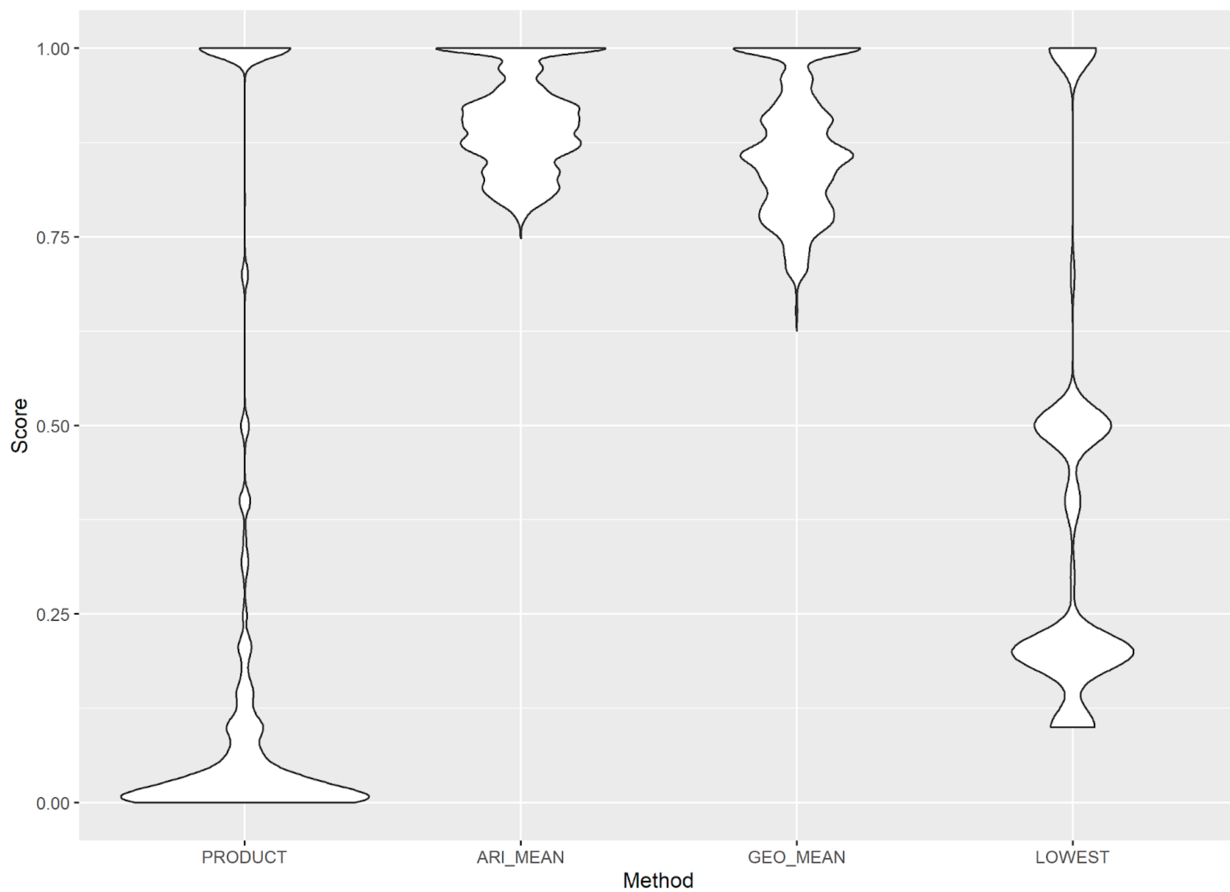


Figure B-25. Violin plot showing distribution of final scores. Distribution of scores within model cells across Gulf of Mexico under four different approaches to combining protected species data. Note that the Product and Lowest scoring layer approaches provide the greatest spread and contrast in final outcomes; however, the Lowest scoring layer approach fails to account for overlapping concerns.

The final combined protected species data layer generated using the Product method shows substantially higher vulnerabilities for protected species in the shelf environments of the eastern Gulf of Mexico and the offshore (>100 m depth) environments of the western Gulf of Mexico (**Figure B-26A**). The lowest vulnerabilities are in the very nearshore environments off Texas and Louisiana and midshelf environments off Texas. The final combined protected species data layer generated using the lowest scoring layer method emphasizes that the risk to Rice's whales is a primary driver for the Product method outcomes, with the core area and suitable habitat isobath (100-400 m depth) flagging as highly vulnerable (**Figure B-23, B-26B**). Similarly, activities in coastal Texas and Louisiana would pose risk to the highly vulnerable Kemp's ridley sea turtle (**Figure B-23, B-26B**).

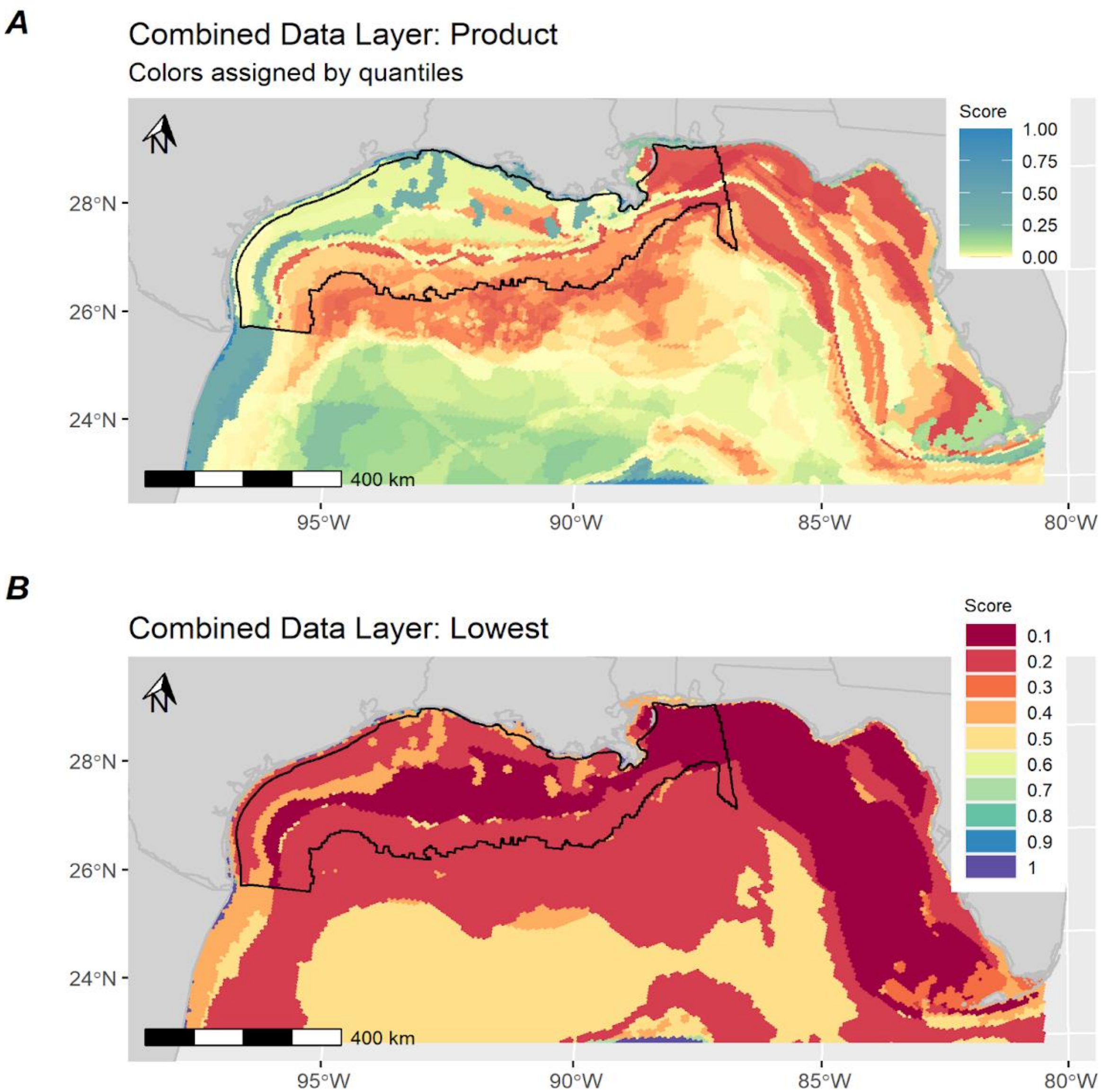


Figure B-26. Final combined protected species data layers for Gulf of Mexico. Spatial distribution of consultation risk for protected species based on vulnerability and trend, with layers combined using two different approaches: A) Product of risk scores across all 23 species considered and B) Lowest scoring layer within a given cell across all 23 species considered. Note that the latter approach does not consider cumulative risk associated with overlapping protected species concerns.

B.4 DISCUSSION

Considerations for stationary protected resources, such as seagrass, corals, or marine protected areas, are often included in marine spatial planning models (MSP) (Perez et al 2005, Longdill et al 2008, Lester et al 2018). However, mobile or transient protected resources, such as marine mammals, are generally excluded from MSP. For mobile species, there is often uncertainty as to the impacts of ocean industries during the early planning stages, coupled with uncertainty regarding species distributions, sparse location data, or highly variable location data. However, in some cases sufficient data are available for summary and integration into an MSP modeling approach. Early integration into planning processes reduces the likelihood of future conflict. Transparency about potential conflicts in the early planning stages can also avoid contentious and time-consuming permitting and legal battles during project design and implementation. In this study, we demonstrate how different forms of data for mobile protected resources may be summarized to inform MSP. We integrate across protected species layers using a generalized approach that is portable across species and MSP considerations. We identify the Product methods as the most appropriate approach for combining data layers that have an internally consistent ranking scheme. Finally, we demonstrate the successful application of this approach to inform MSP for Gulf of Mexico Wind Energy Planning.

Spatial data from megafauna is used regularly by managers and policy makers to inform decisions regarding regulations and marine protected area boundaries (Hays et al 2019). Tracking data and utilization density of olive ridley sea turtles in Pongara National Park, Gabon, was used for marine park and zone boundary designation (Dawson et al 2017). In Augé et al (2018), 36 species distribution layers of seabirds and pinnipeds were combined into a single composite megafauna layer using a weighted arithmetic mean to inform marine spatial planning around the Falkland Islands. In the presented case study here, data layers for 23 species were combined into a single composite layer for use within the Gulf of Mexico Wind Energy Atlas suitability model.

Data layers generated using the Section 7 consultation layers were highly generalized and conservative; as such, they were assigned the generalized score of 0.5 to mark that consultation for that species would be anticipated in that area. High-use areas determined by observations and tag returns were biased towards areas where sampling efforts were highest; as such, they should be interpreted with caution.

Data layers derived from the GoMMAPPS vessel and aerial surveys were subject to both perception and availability bias that may be especially problematic for small, cryptic, or diving animals such as sea turtles and manta rays. The two-team recapture approach taken with the GoMMAPPS surveys helped control for perception bias and the distribution models accounted for underlying aerial and vessel survey effort. The species distribution model framework linked sightings per unit effort to environmental and bathymetric drivers of distribution, providing an adaptive, statistically-robust predictive framework for species distribution. Generalized guidance was provided for MSP by predicting the maximum abundance or probability of occurrence within a given model cell across time (Giant Manta Ray: Jan 2003 to Dec 2019; others: Jan 2015 to Dec 2018). As such, the final maps were necessarily conservative for the distribution of the species at any given point. The locations above the median prediction of the distribution model were given the “high-use area” score associated with **Table B-2**; the areas below the median were assigned the generalized score for the species (e.g., 0.5 for ESA-listed and 1.0 for MMPA-listed species). This facilitates necessary contrast between high- and low-use areas to inform MSP for distribution models that cover the entire potential consultation area. It should be noted that these outputs are static; whereas robust seasonal or monthly models could be used during the Planning and Design Phases to identify and utilize environmental windows where probability of interactions with protected species is further reduced. It should also be noted that changes in the environment may result in shifts to predicted distributions; as such, models should be updated through time. Continuing the GoMMAPPS surveys at regular intervals is critical to providing additional, updated data needed for model refinement to ensure predictive models for protected species encompass the variety of oceanographic conditions these species experience to provide the best available science for environmental impact assessments. It should also be noted that layers were fit separately for shelf and oceanic stocks, meaning that there are some potential fitting artifacts along the border of those two layers which are apparent in **Figure B-26A**.

B.5 ACKNOWLEDGEMENTS

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Lester SE, Stevens JM, Gentry RR, Kappel CV, Bell TW, Costello CJ, Gaines SD, Kiefer DA, Maue CC, Rensel JE, Simons RD (2018) Marine spatial planning makes room for offshore aquaculture in crowded coastal waters. Nature Communications 9(1):1-13.

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C SCORING RATIONALE

Table C-1. Data for suitability model, scoring, and rationale

Data Layer	Score	Rationale for Score
National Security Submodel		
Military Operating Area (MOA) - Corpus Christi	0.3	MOA Corpus Christi overlaps with SUAs W228A, W228B, W228C, and W228D, is used by Fleet Area Control and Surveillance Facility, and is directly adjacent to five other SUAs. The area was assigned a score of 0.3 as the area is more suitable for wind, but has greater military activity.
Military Operating Area (MOA) - New Orleans	0.5	MOA New Orleans overlaps with SUA W92 (used by FACSFAC) and is adjacent to W54A, W54B, and W54C SUAs. The area was assigned a score of 0.5 as the details of the current and future training portfolio need further examination.
Military Training Routes (MTR) - Flight Corridors - 12 mi setback	0.3	MTRs (areas of low-level combat tactics training) include the required maneuvers and high speeds needed for such tactics. These tactics and this aspect of visual flight rules are more difficult to track without increased vigilance in areas containing such operations. [14] The area was assigned a score of 0.3 as the Corpus Christi area is more suitable for wind, but has greater military activity.
Special Use Airspace (SUA) - W59A, W59B, W59C, W54A, W54B, W54C, W92, W147A, W147B, W147C, W147D, A381, A632B, A632F, W228A, W228B, W228C, W228D	0.5	SUA intersecting the Call Area are not within a danger zone or restricted area, but are still used for military training. The area was assigned a score of 0.5 as the details of the current and future training portfolio need further examination.
Natural & Cultural Resources Submodel		
NOAA Fish Havens - 500 ft setback	0.7	Fish havens are artificial reefs deliberately constructed or placed on the seabed to emulate some functions of a natural reef.[15] A 500-ft setback was applied to each

[14] https://w ww.faa.gov/air_traffic/publications/atpubs/aip_html/part2_enr_section_5.2.html

[15] https://nauticalcharts.noaa.gov/publications/docs/us-chart-1/UnderstandingFishHavens-2016Feb.pdf

		polygon, and both were assigned a score of 0.7 as there are no indications that offshore wind developments are highly incompatible with fish haven sites.
Potentially Sensitive Biological Features provided by FGBNMS - 1,000 ft setback	0.5	The features represent important conservation areas with live bottom habitat. A 1000- m setback was applied to each polygon, and both were assigned a score of 0.5 because PSBFs in this layer are likely encompassed in the “BOEM No Activity Zone” and the “FGBMNS Boundary” layers that are already included in the constraints model. Small, scattered features are compatible for development of large-scale projects given the BOEM process for review and mitigation (avoidance) of potential effects.
Low Relief Structures provided by FGBNMS - 1,000 ft setback	0.5	Low relief structures represent potentially important habitat that is protected for conservation. A 1000-m setback was applied to each polygon, and both were assigned a score of 0.5 because low relief structures in this layer are likely encompassed in the “BOEM No Activity Zone” and the “FGBMNS Boundary” layers that are already included in the constraints model. Small, scattered features are compatible for development of large-scale projects given the BOEM process for review and mitigation (avoidance) of potential effects.
BOEM’s Potentially Sensitive Biological Features - 250 ft setback	0.2	The features represent important conservation areas with live bottom habitat. A 250-ft setback distance is used in the oil and gas industry for PSBFs and was applied to each polygon, and both were assigned a score of 0.2 due to hardbottom habitats and associated organisms being sensitive to bottom disturbing activities.
Existing Coral HAPC (with regulations and without regulations)	0.2	Coral HAPC are protected coral reef habitats; protection of corals is provided through designation of EFH HAPC, or designating deep-water coral areas via section 303(b)(2)(B). Due to the presence of coral habitat, areas were assigned a score of 0.2. Most if not all of the features covered by these HAPC data layers are already accounted for as constraints to the model (i.e., FGBNMS Lease Blocks and BOEM No Activity Zones) and or as data layers in the suitability model (i.e., BOEM's Potentially Sensitive Biological Features) data layers. In addition to these WEA siting considerations, BOEM will apply mitigations to avoid impacts to benthic hard bottom habitats from offshore wind development that are similar to those regularly applied to oil and gas exploration and development.
Coral9 HAPC (no regulations and regulated areas)	0.2	An additional 13 regulated areas for protection of coral areas were established in 2020 as HAPC. Due to the presence of coral habitat, areas were assigned a score of 0.2. Most if not all of the features covered by these HAPC data layers are already accounted for as constraints to the model (i.e., FGBNMS Lease Blocks and BOEM No Activity Zones) and or as data layers in the suitability model (i.e., BOEM's Potentially Sensitive Biological Features) data layers. In addition to these WEA siting considerations, BOEM will apply

		mitigations to avoid impacts to benthic hard bottom habitats from offshore wind development that are similar to those regularly applied to oil and gas exploration and development.
Gulf of Mexico Leatherback sea turtle high use area	0.1	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. NOAA NMFS Protected Resources identified critical residence data to assess HUAs for leatherback sea turtles within the Gulf of Mexico. To develop the leatherback sea turtle HUAs, satellite telemetry data80 from resident areas were converted to polygons by buffering the point data by 18.98 km, ultimately defining the HUAs. Due to the endangered and declining population status of this species, the area was assigned a score of 0.1 to provide a more conservative model value throughout the range.
Gulf of Mexico Hawksbill sea turtle migratory corridor	0.2	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. Hawksbill sea turtle migratory corridor data were based on previous satellite telemetry studies.The hawksbill sea turtle migratory corridor was assigned a score of 0.2 for conservation purposes based on the species' endangered status and unknown population trends.
Gulf of Mexico Kemp's ridley sea turtle high use area	0.2	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. NOAA NMFS Protected Resources evaluated critical residence data to assess HUAs for Kemp's ridley sea turtles within the Gulf of Mexico. To develop the HUAs, satellite telemetry data from resident areas were converted to polygons by buffering the point data by 18.98 km, ultimately defining the HUAs. Each HUA was assigned a score of 0.2 for conservation purposes based on the species' endangered status and unknown population trends.
Loggerhead (Northwest Atlantic Ocean DPS) sea turtle high use area	0.4	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. NOAA NMFS Protected Resources identified critical residence data to assess HUAs for loggerhead sea turtles within the Gulf of Mexico Call Area. To develop the HUAs, satellite telemetry data, representing resident areas were converted to polygons by buffering the point data for presence by 18.98 km, ultimately defining the HUAs. The loggerhead HUA was assigned a score of 0.4 for conservation purposes based on the species' endangered status and unknown population trend.
Gulf of Mexico Giant manta ray predicted species distribution model area above median maximum probability of presence	0.4	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. NOAA NMFS Protected Resources generated a giant manta ray distribution model in the Gulf of Mexico, which was determined through a combined species distribution model (SDM) fitting survey data to monthly distillations of habitat parameters (e.g., water clarity, current speed, bathymetry) from January, 2003 to

		December, 2019. The maximum predicted species presence across all months was retained in a final predictive grid (10 x 10 km). To provide meaningful contrast to inform the WEA identification process, SERO-PRD evaluated several potential cutoffs based on quantiles for maximum probability of presence. Because predictions from the giant manta ray SDM are not normally distributed, the median was used, as it is a better measure of central tendency. The area was assigned a score of 0.4 to areas above the median maximum predicted value from the SDM to provide conservation measures for the species.
Gulf of Mexico Green (North Atlantic Ocean DPS) sea turtle high use area	0.5	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. NOAA NMFS Protected Resources identified critical residence data to assess HUAs for green sea turtles within the Gulf of Mexico Call Area. To develop the HUAs, satellite telemetry data from resident areas were converted to polygons by buffering the point data by 18.98 km, ultimately defining the HUAs within the Call Area. Each green sea turtle HUA was assigned a score of 0.5 for conservation purposes based on the species' threatened status but increasing population trends.
Atlantic spotted dolphin (coastal)	0.8	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.8 for conservation purposes based on the species MMPA not strategic status and large population.
Atlantic spotted dolphin (oceanic)	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA strategic status and unknown population trend.
Beaked whale	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. Cuvier's beaked whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA because PBR is likely a severe underestimate due to the long dive times of this species and because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill is based on all beaked whale species combined and cannot be apportioned to individual species. No fishery-related mortality or serious injury has been observed; therefore, total fishery- related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of Cuvier's beaked whales in the northern Gulf of

		Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock [16].
Bottlenose dolphin (coastal)	0.8	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.8 for conservation purposes based on the species MMPA not strategic status and large population.
Bottlenose dolphin (oceanic)	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. Common bottlenose dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico Oceanic Stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery- related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of bottlenose dolphins, relative to OSP, in the northern Gulf of Mexico oceanic waters is unknown. There was no statistically significant trend in population size for this stock.
Clymene dolphin	0.6	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.6 for conservation purposes based on the species MMPA strategic status and unknown population trend. Clymene dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of Clymene dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown.
Blackfish (False killer, Pygmy killer, and Melon-headed whale)	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. False killer, Pygmy killer, and melon-headed whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of

[16] https://media.fisheries.noaa.gov/2021-07/Atlantic%202020%20SARs%20Final.pdf?null%09

		Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery- related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of Blackfish in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for False killer and Melon-headed whale stock is also unknown. There was no statistically significant trend in population for the Pygmy killer stock.
Gulf sturgeon	0.5	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.5 for conservation purposes based on the ESA threatened status and increasing population trend based on the most recent 5-year review. The Gulf sturgeon layers were the defined critical habitat and the recently developed NOAA Fisheries SERO “Section 7 Mapper” consultation layer; a public-facing tool allowing action agencies to specify the location of their project activities and determine which species require consultation. Because Gulf sturgeon received a score of 0.5, only the consultation layer was scored, as it was inclusive of the critical habitat layer.
Kogia (Dwarf and Pygmy sperm whale)	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA status and unknown population trend. Dwarf sperm whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA because PBR is likely a severe underestimate due to the long dive times of this species and because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill is based on all dwarf and pygmy sperm whales combined and cannot be apportioned to individual species. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of dwarf sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock.
Oceanic whitetip shark	0.4	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.4 for conservation purposes based on the ESA listed status and unknown/declining population trend.

Pantropical spotted dolphin	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. Pantropical spotted dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of pantropical spotted dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown.
Pilot whale	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. Short-finned pilot whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. Total fishery-related mortality and serious injury for this stock is less than 10% of PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of short-finned pilot whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock.
Risso’s dolphin	0.7	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.7 for conservation purposes based on the species MMPA not strategic status and unknown population trend. Risso's dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of Risso’s dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. The population trend for this stock is also unknown.
Smalltooth sawfish (US DPS)	0.3	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.3 for conservation purposes based on the ESA Endangered status and increasing population trend. A high-use area determined from visual sightings and the movements of tagged animals was joined to defined critical habitat and the sawfish Section 7 consultation layer.

Sperm whale	0.2	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.2 for conservation purposes based on the ESA Endangered status and unknown population trend. The sperm whale is listed as endangered under the Endangered Species Act, and therefore the northern Gulf of Mexico stock is considered strategic under the MMPA. In addition, the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR for this stock. Total fishery- related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock in the northern Gulf of Mexico.
Spinner dolphin	0.6	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.6 for conservation purposes based on the species MMPA strategic status and unknown population trend. Spinner dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery- related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of spinner dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock.
Striped dolphin	0.6	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. This area was assigned a score of 0.6 for conservation purposes based on the species MMPA strategic status and unknown population trend. Striped dolphins are not listed as threatened or endangered under the Endangered Species Act, but the northern Gulf of Mexico stock is considered strategic under the MMPA because the mean modeled annual human-caused 211 mortality and serious injury due to the DWH oil spill exceeds PBR. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery- related mortality and serious injury can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of striped dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock.

GoMMAPPS 24 Pelagic Bird Habitat Suitability	Cont.	As habitat suitability increases, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Industry, Navigation, & Transportation Submodel		
Federal Lightering Rendezvous Areas	0.5	Federal lightering rendezvous areas in the Gulf of Mexico involve oil and hazardous material transfer operations.[17] Rendezvous areas are where lightering can begin and can continue for a given time and speed of craft. Due to this activity, these areas were assigned a score of 0.5.
Outside of Carbon Capture WEAs	0.5	Areas outside of the carbon capture designated lease blocks were assigned a score of 0.5. Areas where carbon capture has been identified are more desirable for wind development.
NEXRAD Sites	0 or 0.5	NEXRAD sites and a 0 to 35 km setback were assigned a score of 0 for complete avoidance. Sites 35 - 70 km were assigned a score of 0.5 to minimize impacts to radar operations.
NMFS Fishing Surveys	Cont.	As the number of fishing surveys conducted in that area increases, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Cargo	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Fishing	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Other	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Passenger	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Pleasure and Sailing	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
AIS Vessel Traffic 2019 – Tanker	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.

[17] https://w ww.fisheries.noaa.gov/inport/item/54387

AIS Vessel Traffic 2019 – Tug and Tow	Cont.	As vessel transits increase, compatibility with wind planning decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Fisheries Submodel		
Commercial Shrimp Electronic Logbook Data (2015 - 2019) Low-Moderate Fishing Effort	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Highly Migratory Species Pelagic Longline Gear Observer Data (1993 - 2019)	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Menhaden Fishery Data (2000 - 2016)	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Reef Fish Bandit Gear Fishing Data (2007 - 2019)	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Reef Fish Longline Gear Fishing Data (2007 - 2019)	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Southeast Region Headboat Survey Data (2014 - 2020)	Cont.	As fishing activity increases, compatibility decreases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Economics Submodel		
NREL - Net Value 2015	Cont.	As net value increases, compatibility increases. Rescaling was conducted using the fuzzy logic Z-shaped membership function from 0-1.
Competitive Lease Blocks	0.5	Lease blocks outside of the identified competitive lease blocks were assigned a score of 0.5. Lease blocks inside of the identified competitive lease blocks are desirable and were therefore assigned a score of 1.
Logistics Submodel		
Distance to shore	Cont.	As distance to shore increases, compatibility decreases. Rescaling was conducted using a linear function from 0-1.
Distance to ports	Cont.	As distance to port increases, compatibility decreases. Rescaling was conducted using a linear function from 0-1.
Depth	Cont.	As depth increases, compatibility decreases. Rescaling was conducted using a linear function from 0-1.

Constraints submodel		
Unexploded Ordnance (UXO) polygon	0	These are areas containing explosive weapons (bombs, bullets, shells, grenades, mines, etc.) that did not explode when they were employed and still pose a risk of detonation, potentially decades after being discarded. These areas were scored a 0 for avoidance.[18]
Texas Artificial Reefs - 1,000 ft setback	0	Artificial reefs (e.g., concrete pyramids, shipwrecks) are man-made structures that emulate some functions of natural reefs.[19] They generally fall in fish haven boundaries, but do exist outside of these areas in some cases. Artificial reefs are point data, so a 1,000 ft setback was applied to the point data and both were assigned scores of 0 as no other infrastructure is allowed within permitted reef boundaries. Setback distances were developed by MMS and the states.
Louisiana Artificial Reefs - 500 ft setback	0	Artificial reefs (e.g., concrete pyramids, shipwrecks) are man-made structures that emulate some functions of natural reefs. They generally fall in fish haven boundaries, but do exist outside of these areas in some cases. Artificial reefs are point data, so a 500 ft setback was applied to the point data and both were assigned scores of 0 as no other infrastructure is allowed within permitted reef boundaries. Setback distances were developed by MMS and the states.
BOEM No Activity Zones and FGBNMS Lease Blocks - 1000 m setback	0	At East and West Flower Garden Banks, Sanctuary boundaries closely follow the original No Activity Zone designations set by Minerals Management Service to restrict oil and gas exploration around the reefs. An additional layer representing lease blocks that intersect with the FGBNMS expanded boundary was merged and included in this dataset. These areas are incompatible with development because of sensitive habitat and were assigned a score of 0 for complete avoidance.
Rice's whale suitable habitat[20] (100 m to 400 m depth)[21]	0	This layer was used within the protected resources consideration combined species layer for the WEA suitability model. Rice's whales are protected under the MMPA and are under the ESA. This data layer represents the distribution of Rice's whales in the greater Gulf of Mexico region. The suitable habitat area was inferred from strategically placed long-term passive acoustic monitors, positioned at the median depth range of 122 m, from the core distribution area at the shelf break in the De Soto Canyon, east to

[18] https://w ww.fisheries.noaa.gov/inport/item/54407

[19] https://oceanservice.noaa.gov/facts/artificial-reef.html

[20] https://w ww.fisheries.noaa.gov/species/gulf-mexico-brydes-w hale#:~:text=For%20the%20past%2025%20years,et%20al.%2C%202015)%20

[21]https://www.researchgate.net/publication/316315634_Spatial_distribution_and_dive_behavior_of_Gulf_of_Mexico_Bryde%27s_whales_Potential_risk_of_vessel_strikes_ and_fisheries_interactions

		Grand Isle, and west at Flower Garden Banks NMS. Using low-frequency acoustic recording packages to detect stereotypical Rice's whale calls, along with survey data and habitat preference models, NOAA NMFS SERO formulated the final area. The final habitat conservation area runs from 100 m to 400 m depth throughout the U.S. Gulf of Mexico. Due to the endangered, small, and declining population status of this species, the area was assigned a score of 0 for complete avoidance.
BOEM Lease Blocks with Significant Sediment Resources	0	This BOEM data layer is used to assist in the management of Outer Continental Shelf (OCS) sediment resources, reduce multiple use conflicts, minimize interference with existing oil and gas leases and rights-of-way, and help avoid sensitive areas (e.g., archeological sites, protected habitat). These OCS blocks represent areas within the OCS protraction grid where sand resources have been identified through reconnaissance and/or design-level OCS studies.[22] These areas were assigned a score of 0 for complete avoidance.
Oil and Gas Drilling Platforms - 500 ft setback	0	Drilling platforms are structures used to drill into the seabed for mineral exploration or to bring resources to the surface, particularly oil and gas.[23] Due to the nature of this ocean activity, and that drilling platforms are continuously added and modified, these structures and a 500 ft setback from the structure were both assigned a score of 0 for complete avoidance.
Oil and Gas Boreholes, Test Wells, and Wells - 200 ft setback	0	Surface boreholes are drilled into the ocean floor for purposes of mineral exploration and mining. Some boreholes are angled and all wells (active or inactive) are being considered as oil and gas infrastructure already in place. The point data along with a 200 ft setback were both assigned a score of 0 for complete avoidance.
Oil and Gas Pipelines (only active) - 200 ft setback	0	Submerged structures transporting oil and gas from offshore platforms or terminals to inshore facilities.[24] These structures vary in size and carry hazardous material. Active pipelines, along with a 200 ft setback, were both assigned a score of 0 for complete avoidance.
Active Oil and Gas Lease Blocks (including FGBNMS blocks)	0	Active leases are those BOEM OCS Lease Blocks which are currently leased out to private entities for oil and/or gas mining rights.[25] Active leases include those that are exploratory, non-producing (i.e., suspended), and producing. Due to the nature of activities, as well as oil and gas infrastructure within each active lease block, these areas

[22] https://www.boem.gov/marine-minerals/marine-minerals-mapping-and-data

[23] https://metadata.boem.gov/geospatial/OCSplatforms-GOMR-NAD27.

[24] https://metadata.boem.gov/geospatial/OCSpipelines-GOMR-NAD27.xml

[25] https://metadata.boem.gov/geospatial/GOM_Active_OG_Leases.xml

		were assigned a score of 0 for complete avoidance. The FGBNMS blocks reflect a setback of 1,000 m from the sanctuary boundary.
Submarine Cables - 500 ft setback	0	Comprehensive submarine cable data were obtained from the U.S. Naval Seafloor Cable Protection Office. Submarine cables are responsible for many international and national communications as they are quicker than satellites. Many cables are also high voltage. These cable areas, along with a 500-m setback, were both assigned a score of 0 for complete avoidance.
Environmental Sensors and Buoys - 500 m setback	0	Marine observation and monitoring infrastructure (i.e., sensors and buoys) provide important information on changing oceanographic and/or meteorological conditions at sea. These buoys and environmental sensors, along with a 500 m setback, were both assigned a score of 0 for complete avoidance.
Aids to Navigation (beacons and buoys) - 500 m setback	0	Aids to Navigation provide a vessel with information in determining location, getting from one place to another, or staying out of danger.[26] Aids range from lighthouses to minor lights, day beacons, range lights and sound signals, and lighted or unlighted buoys.[27] The goal of the U.S. Aids to Navigation System is to promote safe navigation on the waterway. Due to the importance of these structures for navigation, a 500 m setback was applied to each structure, and both were assigned a score of 0 for complete avoidance.
Anchorage Areas (used/disused)	0	An anchorage area is a place where boats and ships can safely drop anchor. A variety of designations refer to types of anchorage areas or restrictions, or even to alerts of potential dangers within an anchorage area.[28] Due to the nature of activities, and the possibility of change in use, these areas were assigned a score of 0 for complete avoidance.
Shipping Fairways and Regulations - 2 nm setback	0	These areas delineate activities and regulations for marine vessel traffic. Traffic lanes define specific traffic flow, and separation zones assist opposing streams of traffic. Recommended routes are predetermined routes for shipping adopted for reasons of safety. Due to regulations, high and variable use, and needed avoidance, a 3,219 m setback was applied to all fairways. Both were assigned a score of 0 for complete avoidance.

[26] https://www.navcen.uscg.gov/pdf/navRules/US_ATON_Guide.pdf

[27] https://www.pacificarea.uscg.mil/Portals/8/District_13/dpw/docs/usaidstonavigationbooklet.pdf?ver=2018-10-15-154501-363#:~:text=Aids%20to%20Navigation%20can%20provide,to%20lighted%20or%20unlighted%20buoys

[28] https://marinecadastre.gov/news/load.php?url=posts/anchorage-areas.html

Shrimp Electronic Logbook 2015-2019 Moderate-High Fishing Effort	0	Moderate, moderately high, and high shrimp effort (sum of days trawled) areas using the natural breaks classification was treated as categorical data. These categories were assigned a score of 0 for avoidance. The remaining effort data was treated as continuous, and the fuzzy logic function was used which treats the data as less suitable as effort increases.
Menhaden Fishing	0	An area between the 90° - 91° strata (coastal Louisiana) out to 20 miles was assigned a score of 0 for avoidance. The remaining data was treated as continuous and the fuzzy logic function was applied, which treats the data as less suitable as fishing effort increases.
Recommended 20 nm Coastal Buffer	0	A 20 nm buffer from the coastline was scored a 0 for complete avoidance. This area was identified as an important area for a number of coastal bird species.